DOE/EIS-0120D

Draft
Environmental Impact Statement

Waste Management Activities for Groundwater Protection Savannah River Plant Aiken, South Carolina Volume 1

April 1987
United States Department of Energy

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COVER SHEET

RESPONSIBLE AGENCY: U.S. Department of Energy

ACTIVITY: Draft Environmental Impact Statement, Waste Management Activities for Groundwater Protection at the Savannah River Plant, Aiken, South Carolina.

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ABSTRACT: The purpose of this environmental impact statement (EIS) is to assess the environmental impacts of proposed modifications, and their alternatives, to hazardous, low-level radioactive, and mixed waste management activities at the Savannah River Plant. The EIS, which is both a programmatic and a project-specific document, considers the following modifications:

- Implementation of remedial and closure actions at hazardous, low-level radioactive, and mixed waste sites
- Establishment of new onsite disposal facilities for hazardous, low-level, and mixed wastes
- Potential changes in the discharge of disassembly-basin purge water from C-, K-, and P-Reactors to seepage basins

This EIS assesses the impacts of the modifications to waste management activities on air and water quality,

especially on groundwater; ecological systems; health risk; archaeological resources; endangered species; and wetlands. Emphasis is given to the requirements of the Resource Conservation and Recovery Act, as amended, the Comprehensive Environmental Response, Compensation and Liability Act, as amended, and DOE Orders related to hazardous, low-level radioactive, and mixed wastes.

COMMENT PERIOD: DOE will consider written comments addressed to Mr. Wright and postmarked by June 30, 1987, in the preparation of the final environmental impact statement. Public hearings will be held during the week of June 1, 1987, at locations to be announced.

FOREWORD

The purpose of this environmental impact statement (EIS) is to assess the environmental impacts of the proposed modification of waste management activities for hazardous, low-level radioactive, and mixed wastes for the protection of groundwater, human health, and the environment at the Savannah River Plant (SRP) in Aiken, South Carolina. The Savannah River Plant is a major U.S. Department of Energy (DOE) installation engaged in the production of defense nuclear materials. The production of these materials and the operation of fabrication, separation, and support facilities on the Plant result in the generation of hazardous, low-level radioactive, and mixed wastes (radioactive and hazardous).

DOE has prepared this EIS, which is both programmatic and project-specific, to support broad decisions on future actions on SRP waste management activities and to provide project-related environmental input and support for project-specific decisions on proceeding with cleanup activities at existing waste sites in the F- and R-Areas at SRP, establishing new waste disposal facilities, and discharging disassembly-basin purge water. The disassembly basins receive irradiated reactor fuel and targets at the reactors for disassembly prior to transfer to reprocessing facilities. The deionized water in the basins is purified continuously by filtration and demineralization, but must be purged periodically to maintain tritium oxide concentrations, and consequent worker exposures, as low as reasonably achievable. These purges are discharged to seepage basins at each reactor site and to the containment basin in K-Area.

The purpose of the proposed action and the alternative modifications considered in the EIS is to identify and select a waste management strategy for the treatment, storage, and disposal of SRP hazardous, low-level radioactive, and mixed wastes that can be implemented to comply with groundwater-protection and other requirements. These waste management activities have the greatest potential for causing effects on groundwater resources. This EIS assesses modifications for each waste management activity, which represents broadly defined strategies that DOE could select to implement specific future hazardous, low-level radioactive, and mixed waste management, following interaction with regulatory agencies.

This dual-purpose EIS considers four waste management alternative strategies, including "No Action," as required by the Council on Environmental Quality (CEQ) regulations for implementing the procedural aspects of the National Environmental Policy Act (NEPA; 40 CFR 1502). These strategies differ in the concepts proposed for existing waste sites, new disposal facilities, and discharge of disassembly-basin purge water, and in the degree to which they require dedication of land areas, long-term monitoring, and oversight to ensure adequate protection of groundwater resources, human health, and the environment. They are based on combinations of closure and remedial actions at existing waste sites, the construction of new storage and disposal facilities, and the discharge of disassembly-basin purge water. Modification of a single waste management activity (e.g., closure and remedial actions at existing waste sites) might require the modification of another activity (e.g., the number, size, and design of new disposal facilities).

This EIS uses the terms "hazardous," "low-level radioactive," and "mixed" (i.e., hazardous and low-level radioactive) in their common sense, without regard to specific regulatory definitions, except as indicated. The EIS is not intended to be a permit application for existing SRP facilities or a vehicle to resolve the applicability of requirements of the Resource Conservation and Recovery Act (RCRA), as amended, to existing SRP facilities or waste sites. Ongoing regulatory activities and the expanded SRP groundwater monitoring and characterization program will provide the bases for the application of requirements to specific existing facilities and waste sites.

The scope of this EIS does not include high-level radioactive wastes, for which DOE prepared five previous NEPA documents; domestic and sanitary waste facilities; or transuranic wastes, for which DOE is preparing a separate NEPA document.

Following the public comment period on this draft EIS and publication of the final EIS, DOE will identify its selected strategy and related project-level decisions in a Record of Decision. The strategy decision will precede any project-specific decision. Research activities to reduce waste generation, reduce waste toxicity, and increase its isolation from the biosphere are continuing. In addition, interactions with regulatory agencies are continuing. As a result, decisions on implementing portions of the overall strategy or some specific actions discussed in the EIS might be delayed. If necessary, DOE will prepare additional NEPA documents to support the implementation of project activities that are not specifically addressed in this EIS.

Regulatory requirements for waste management necessitated changes to SRP waste management activities. In response to these requirements and the Fiscal Year 1984 Supplemental Appropriations Act (Public Law 98-181, enacted in November 1983), DOE developed and submitted to Congress (June 13, 1984) the Groundwater Protection Plan for the Savannah River Plant. This plan and its supporting appendixes provide strategies, funding requirements, and schedules for remedial and closure actions at hazardous, low-level radioactive, and mixed waste sites to ensure the continued protection of groundwater, human health, and the environment.

DOE published a Notice of Intent to prepare this EIS in the Federal Register on April 26, 1985 (50 FR 16534), to solicit comments and suggestions for consideration in the preparation of the statement.

In response to the Notice of Intent, 16 individuals, organizations, and representatives of Government agencies provided comments. Appendix K presents the issues raised in the comment letters and in testimony received at two public scoping meetings held on May 14 and 16, 1985; this appendix also includes DOE responses to the comments and cross-references to appropriate EIS sections. Figure 1 shows the NEPA process followed for this EIS.

DOE and its contractors (under the direction of DOE) have prepared this EIS in accordance with the CEQ's NEPA regulations (40 CFR 1500-1508) and DOE's NEPA guidelines (45 FR 20694, March 28, 1980). The EIS explicitly identifies the methodologies that were used and the scientific and other sources of information that were consulted. In addition, it incorporates available results of ongoing studies.

Extensive reference material, including Environmental Information Documents (EIDs), used to prepare this EIS is available for review in the U.S. Department of Energy's Public Reading Room, University of South Carolina, Aiken Campus, University Library, 2nd Floor, University Parkway, Aiken, South Carolina, and the Department's Freedom of Information Reading Room, Forrestal Building, 1000 Independence Avenue, S.W., Washington, DC.

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SUMMARY

PURPOSE

The U.S. Department of Energy (DOE) has prepared this environmental impact statement (EIS) to assess the environmental consequences of the implementation of modified waste management activities for hazardous, low-level radioactive, and mixed wastes for the protection of groundwater, human health, and the environment at its Savannah River Plant (SRP) in Aiken, South Carolina. This EIS, which is both programmatic and project-specific, has been prepared in accordance with Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969, as amended; it is intended to support broad decisions on future actions on SRP waste management activities, and to provide project-related environmental input and support for project-specific decisions on proceeding with cleanup activities at existing waste sites in the R- and F-Areas, establishing new waste disposal facilities, and discharging disassembly-basin purge water. In preparing this dual-purpose EIS, the U.S. Department of Energy (DOE) has considered the comments submitted by Government agencies, private organizations, and individuals during the public scoping meetings and comment period in May 1985.

BACKGROUND AND NEED FOR ACTION

The Savannah River Plant is a major DOE installation that produces nuclear materials for national defense. SRP operations generate hazardous, radioactive, and mixed (radioactive and hazardous) wastes. Previously acceptable waste disposal practices have included the use of seepage basins for liquids; disposal pits and waste piles for solids; and solid waste burial grounds for low-level radioactive wastes.

Groundwater contamination of some water-table aquifers has occurred occasionally at some sites because of these waste management practices. The detected contaminants include volatile organic compounds (degreasing solvents), heavy metals (lead, chromium, mercury, and cadmium), radionuclides (tritium, uranium, fission products, and plutonium), and other miscellaneous chemicals (e.g., nitrates); measurements of these substances have exceeded maximum contaminant levels (MCLs) and other regulatory standards or guideline concentrations.

This EIS uses the terms "hazardous," "low-level radioactive," and "mixed" (i.e., hazardous and low-level radioactive) in their most common everyday sense, without specific regard to technical or regulatory definitions, unless indicated. DOE does not intend this EIS to be a permit application for existing SRP facilities or a vehicle to resolve the applicability of the requirements of the Resource Conservation and Recovery Act (RCRA), the Hazardous and Solid Waste Amendments (HSWA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Superfund Amendments and Reauthorization Act (SARA) to existing SRP facilities or waste sites. Ongoing regulatory activities and the expanded SRP groundwater monitoring and characterization program will provide the bases for the application of specific regulations to existing facilities and waste sites following the publication of a Record of Decision.

As a result of legislative actions [Public Law 98-181; RCRA; CERCLA; and the South Carolina Hazardous Waste Management Act (SCHWMA)], their implementing regulations, and DOE Administrative Orders, as well as concerns to protect the environment, many remedial or corrective actions have been under way on the Savannah River Plant. These actions include the removal and storage of buried wastes and soils; the design, construction, and operation of liquid effluent treatment facilities; the use of recovery wells and an air stripper to remove volatile organic compounds from groundwater; the design of a two-stage, rotary-kiln incinerator to detoxify hazardous wastes; and waste disposal demonstration programs.

Current demonstration programs that affect waste management activities include the "ashcrete" facility, which solidifies sludge from the effluent treatment facilities; a "beta-gamma" incinerator; a box/drum compactor; and a greater confinement disposal (GCD) demonstration. DOE expects these programs to result in improved methods of disposal for mixed and low-level radioactive wastes or reduction in waste volumes to meet applicable regulations.

DOE plans to close existing waste sites and seepage basins; construct new waste disposal or storage facilities to manage hazardous, low-level radioactive, and mixed wastes that might be removed from existing waste sites or that might result from ongoing and planned operations; and consider alternative methods for the treatment of reactor-area disassembly-basin purge water.

PROPOSED ACTION AND ALTERNATIVE

The proposed action considered in this EIS is the modification of waste management activities for hazardous, low-level radioactive, and mixed wastes to protect groundwater, human health, and the environment. The alternative to the proposed action is a "No-Action" alternative, as required by the guidelines of the Council on Environmental Quality (CEQ). DOE does not consider No Action to be a "reasonable" alternative, because parts of the existing waste management program would not comply with current groundwater protection requirements.

ALTERNATIVE STRATEGIES

DOE could use several alternative strategies to modify the SRP waste management program for hazardous, low-level radioactive, and mixed wastes; this is the upper-tier decision level for implementing the proposed action. These strategies differ in the actions proposed for existing waste sites, new disposal facilities, and discharge of disassembly-basin purge water, and in the degree to which they require dedication of land areas, long-term monitoring, and oversight to ensure that groundwater resources, human health, and the environment are protected adequately. The disassembly basins receive irradiated reactor fuel and targets at the reactors for disassembly prior to transfer to reprocessing facilities. The deionized water in the basins is purified continuously by filtration and demineralization, but must be purged periodically to maintain tritium oxide concentrations, and consequent worker exposures, as low as reasonably achievable. These purges are discharged to seepage basins at each reactor site and to the containment basin in K-Area.

For example, RCRA reflects these differences by requiring the owner of a RCRA-regulated hazardous waste site that is releasing waste constituents to remove and control contaminants from the soil, surface water, and groundwater outside the site, or to remove the source of contamination from the site to achieve background levels or agreed-to alternative concentration limits. If the owner removes and controls the contaminants in environmental media outside a waste site, that site remains dedicated to waste management; long-term monitoring and oversight are required to ensure environmental protection. If the owner removes the source of contamination (i.e., the waste material and contaminated soil within the site), the site no longer requires dedication to waste management purposes, nor does it require long-term monitoring and oversight.

The requirement for dedicating land areas for waste management purposes and committing resources to long-term monitoring and oversight is also reflected in the choice between disposing of or storing wastes. The disposal of wastes that retain their hazardous or radioactive characteristics requires permanent or long-term dedication and monitoring. Alternatively, the use of storage as an isolation technique implicitly assumes that research and development will provide acceptable alternatives for treatment of the stored waste before its ultimate disposal.

The following paragraphs describe alternative strategies for modifications of SRP hazardous, low-level radioactive, and mixed waste management activities. These strategies are based on combinations of closure and remedial actions at existing waste sites, the construction of new storage and disposal facilities, and the discharge of disassembly-basin purge water. The modification of a waste management activity, such as a closure and remedial action at an existing waste sites, might require the modification of another activity (e.g., the number, size, and design of new disposal facilities). The following paragraphs also present combinations of various activities and analyses to provide an overview of the environmental effects of proposed modifications of the SRP waste management program. See Figure S-1.

In this EIS, DOE presents analyses of the environmental impacts of alternative waste management strategies. DOE, in its Record of Decision (ROD) on this EIS, will select a single strategy from those described below. Actions at a site-specific or project-specific level will be based on ongoing investigations and interactions with appropriate regulatory agencies.

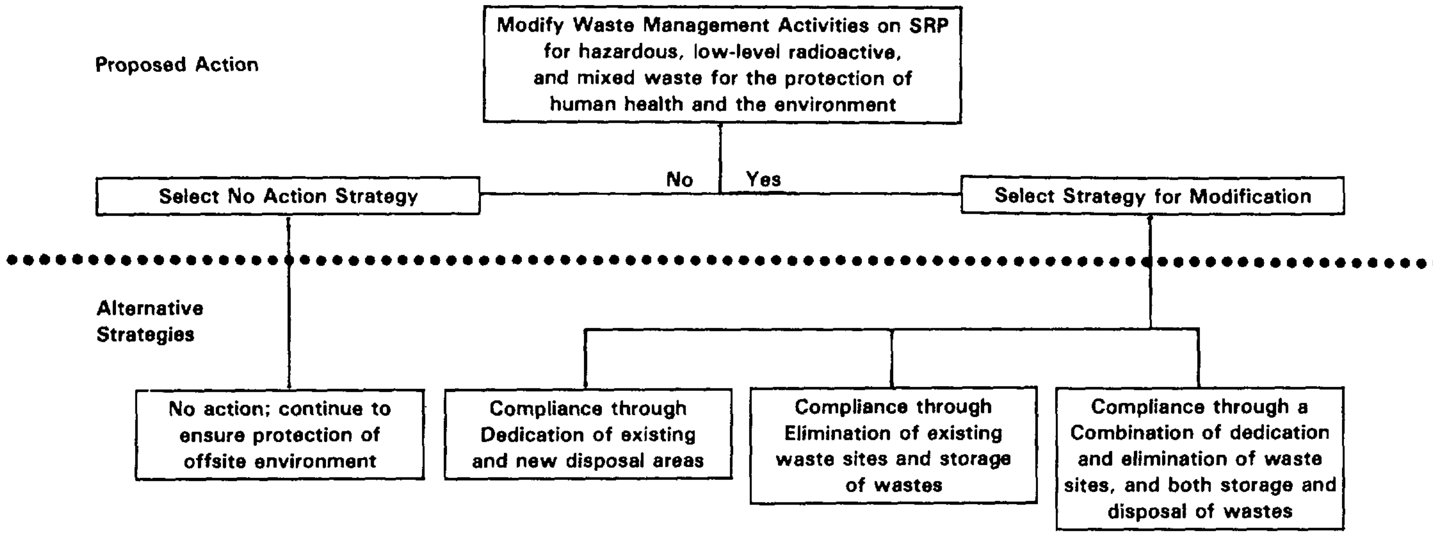
NO-ACTION STRATEGY

The regulations of the Council on Environmental Quality (40 CFR 1502.14) require an EIS to evaluate the environmental consequences of "no action." As a potential implementation strategy, No Action would not involve changes in current practices; it would consist of the following:

- No removal of waste at existing waste sites, and no closure or remedial actions

- No construction of new facilities for the storage or disposal of hazardous, low-level radioactive, or mixed wastes

- Continuation of periodic discharges of disassembly-basin purge water to seepage basins



Legend:

[a] RCRA = Resource Conservation and Recovery Act
[b] CFM = Cement Flyash Matrix
[c] ELLT = Engineered Low-Level Trench
[d] AGO = Above Ground Operation
[e] GCD = Greater Confinement Disposal

Figure S-1. Project Specific Components of Alternative Strategies (page 1 of 3)

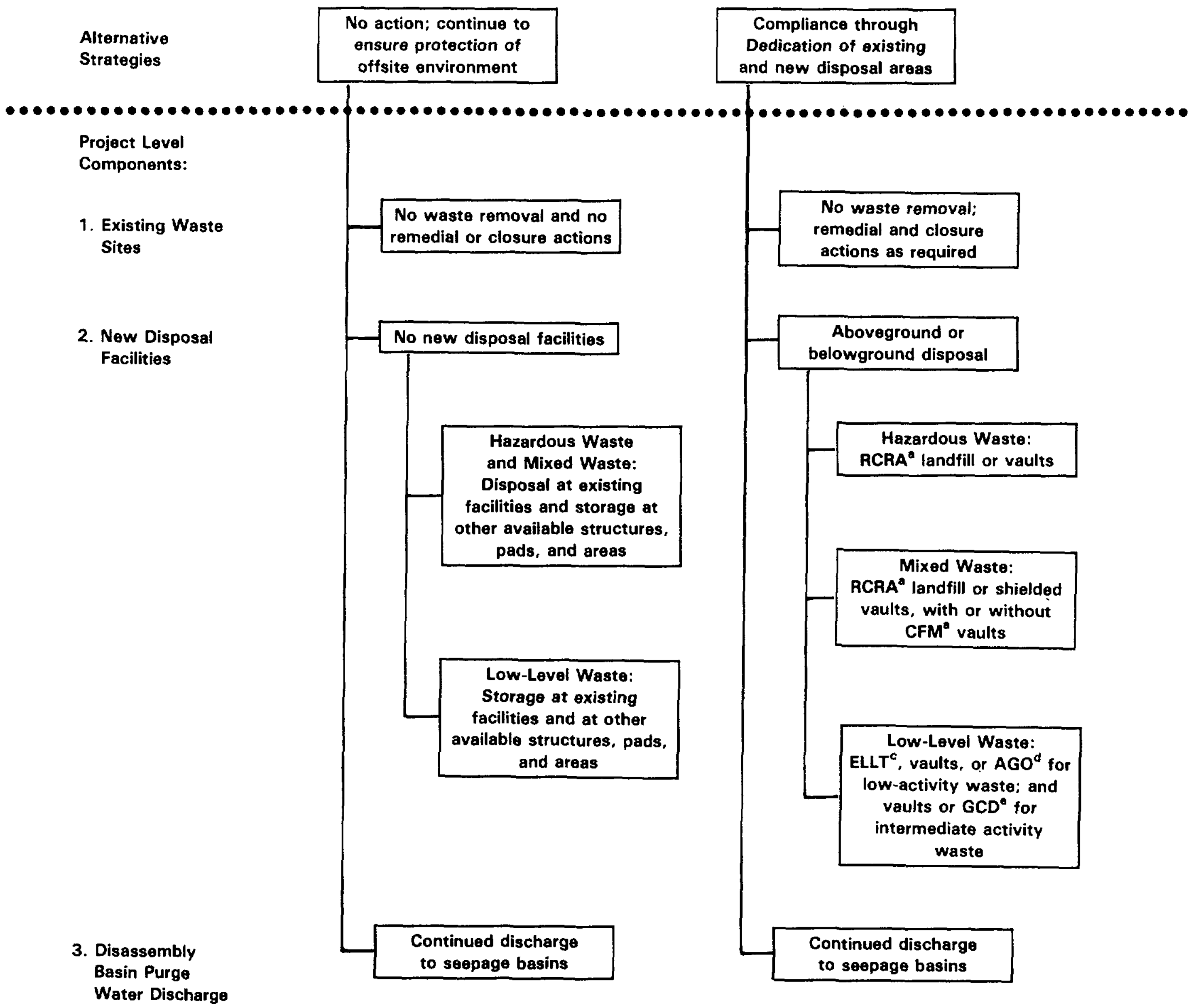


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Figure S-1. Project Specific Components of Alternative Strategies (page 2 of 3)

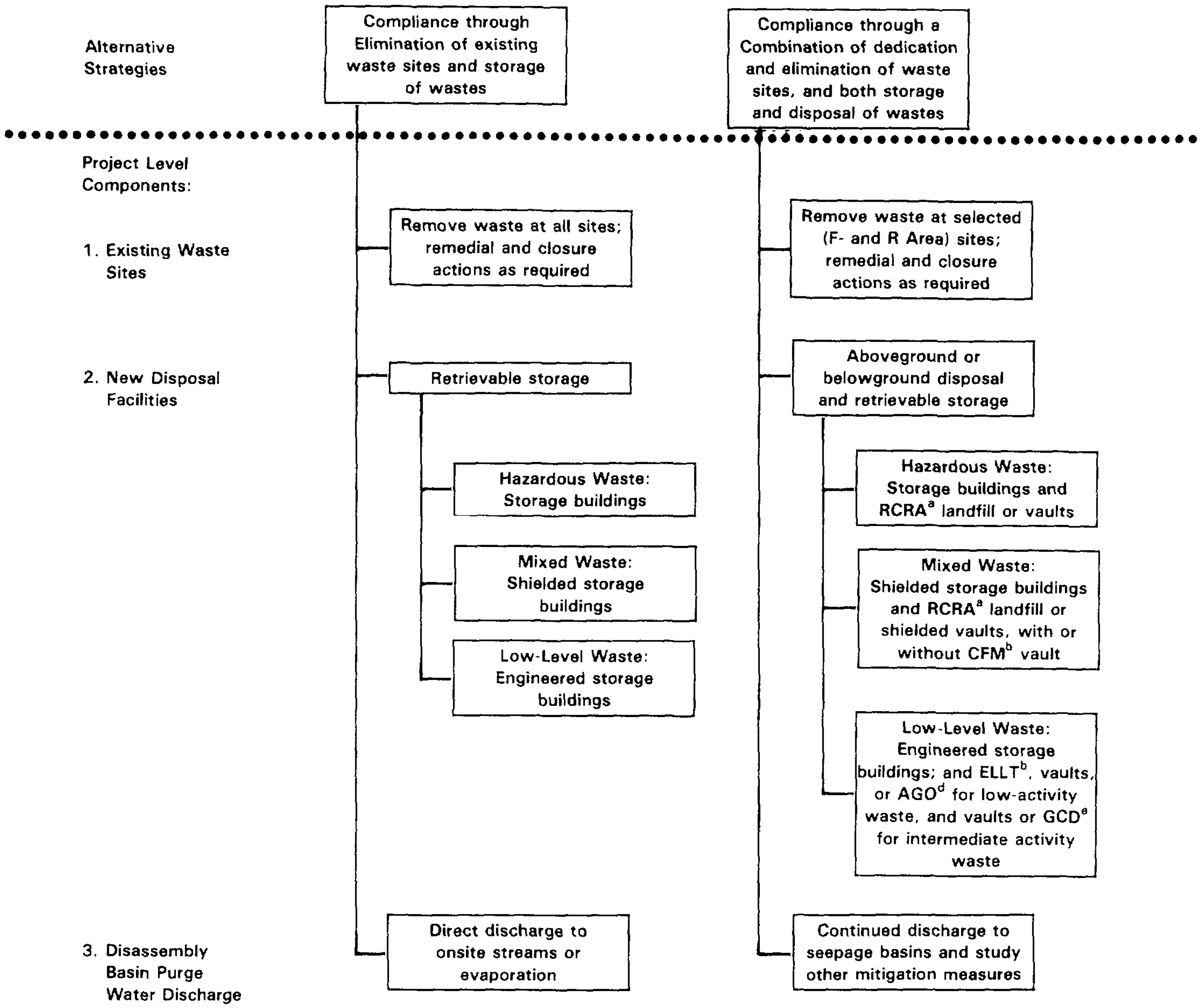

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Figure S-1. Project Specific Components of Alternative Strategies (page 3 of 3)

Parts of the existing program would not comply with groundwater-protection requirements. DOE does not consider the continuation of noncomplying program activities to be a "reasonable" alternative strategy.

DEDICATION STRATEGY

Under the Dedication strategy, DOE would modify its waste management activities to comply with all groundwater-protection requirements, including those pursuant to RCRA, by:

- Implementing closure (dewatering, stabilizing, capping) and groundwater corrective (installing grout curtains or barrier walls, as required) actions to control contamination from existing waste sites in accordance with applicable standards

- Establishing new disposal facilities (e.g., above- or belowground disposal)

- Continuing the use of seepage and containment basins for the periodic discharge of reactor disassembly-basin purge water

Under this strategy, DOE would dedicate for waste management purposes those waste sites and contaminated areas that could not be returned to public use after a 100-year institutional control period. At least 300 acres of land would be dedicated for these purposes; this is less than 0.2 percent of the total SRP land area. DOE would control releases of hazardous substances from existing waste sites that contain hazardous or mixed wastes through the closure of such sites pursuant to applicable requirements, corrective actions to control groundwater contaminant plume migration and restore groundwater quality, and other corrective actions (excluding removal) at the sites.

To accommodate hazardous, low-level radioactive, and mixed wastes generated from ongoing SRP operations, those presently in interim storage, and those from existing and planned waste management actions (e.g., sludges from new effluent treatment facilities), DOE would establish new disposal facilities at SRP, which would meet applicable requirements.

The periodic discharges of filtered and deionized disassembly-basin water from C-, K-, and P-Reactors to seepage and containment basins would continue. The use of basins for these discharges, which are not hazardous but are contaminated with small quantities of radionuclides (principally tritium), would allow time for the radionuclides to decay while migrating through shallow groundwater formations to outcrops along onsite streams. DOE would dedicate for waste management purposes those seepage and containment basins and radioactively contaminated areas that could not be returned to public use after a 100-year institutional control period.

ELIMINATION STRATEGY

Under the Elimination strategy, DOE would modify its waste management program to comply with all groundwater-protection requirements, including those pursuant to RCRA, by:

- Removing wastes to the extent practicable from all existing waste sites and implementing closure and groundwater corrective actions, as required
- Establishing new retrievable storage facilities
- Directly discharging disassembly-basin purge water to onsite streams, or evaporating such discharges through the use of a small commercially available boiler, vent stack, and dispersion fan

Under this strategy, DOE would not dedicate any land areas for hazardous, low-level radioactive, and mixed waste management purposes. Such wastes, including contaminated soils, would be removed from all existing waste sites to the extent practicable. After a maximum 100-year institutional control period, these sites could be used for purposes other than waste management.

DOE would store wastes removed from existing waste sites and those generated from ongoing SRP operations and existing and planned waste management actions, such as sludges from new effluent treatment facilities, in facilities from which they could be retrieved. Hazardous and mixed wastes in interim storage at SRP would remain in the interim-storage buildings. DOE would research new technologies for the permanent disposal of hazardous, low-level radioactive, and mixed wastes.

DOE would discharge the filtered and deionized disassembly-basin purge water from C-, K-, and P-Reactors to onsite streams within National Pollutant Discharge Elimination System (NPDES) permit limits, or would evaporate such discharges with a small commercially available boiler, vent stack, and dispersion fan. In either case, DOE would eliminate the seepage and containment basins now used for the discharge of disassembly-basin purge water. DOE would take closure and remedial actions at these basins, if necessary, to ensure that contaminated areas could be returned to public use after a 100-year institutional control period.

COMBINATION STRATEGY

Under the Combination strategy, DOE would modify the SRP waste management program to comply with all groundwater-protection requirements, including those pursuant to RCRA, by:

- Removing wastes at eight selected existing waste sites to the extent practicable and implementing closure and groundwater remedial actions, as required by applicable regulations
- Establishing a combination of retrievable storage, aboveground, and belowground disposal facilities
- Continuing the use of seepage and containment basins for the periodic discharge of reactor disassembly-basin purge water

Under this alternative, DOE would remove hazardous, low-level radioactive, and mixed wastes (including contaminated soils) to the extent practicable from selected existing waste sites based on cost-effectiveness and environmental/human health risk evaluations. After a maximum 100-year institutional control period, the areas from which waste material and contaminated soil had been removed (about 30 acres) could be used for purposes other than waste management. Sites from which waste material and contaminated soil were not removed (about 270 acres) would be dedicated for waste management purposes if they could not be returned to public use after the 100-year control period.

DOE would establish new retrievable storage and disposal facilities to accommodate wastes removed from existing waste sites and those generated from ongoing SRP operations and existing and planned waste management actions. Disposal facilities for hazardous or mixed waste would be permitted in accordance with applicable regulations. The combination of new retrievable-storage and disposal facilities would allow DOE to research new technologies for permanent disposal. DOE would dedicate for waste management purposes the disposal facilities established for these wastes.

Under this strategy, periodic discharges of filtered and deionized disassembly-basin purge water from C-, K-, and P-Reactors to seepage and containment basins would continue; DOE would continue to assess the feasibility of alternative mitigation measures at SRP. If DOE determines that detritiation or another mitigation measure is appropriate in an overall waste management strategy, it would discontinue the use of these basins and evaluate actions to return the basin areas to public use after a 100-year institutional control period.

PROJECT-SPECIFIC ACTIONS

NO ACTION

In this EIS, DOE has assumed that the SRP would continue to operate and generate wastes. Under No Action, current waste management activities would continue at existing waste sites, no wastes would be removed from the sites, and no remedial or closure actions would occur.

No Action would not establish any new facilities, such as sites, buildings, landfills, vaults, engineered trenches, or boreholes. Existing SRP facilities would be used until their capacities were reached, after which unpermitted structures, pads, or areas with minimal preparation for indefinite waste storage would be used.

No Action would continue the present practice of periodic discharges of disassembly-basin purge water to active reactor seepage and containment basins.

EXISTING WASTE SITE REMEDIAL AND CLOSURE ACTIONS, WITH AND WITHOUT WASTE REMOVAL

A range of project-specific actions can be applied at SRP for existing hazardous, low-level radioactive, and mixed waste sites. These actions include allowing waste to remain in sites and providing some type of closure, such as backfilling and capping. Wastes and contaminated soils would be removed at selected sites in the R- and F-Areas. Remedial actions, if required to correct groundwater contamination, could include groundwater recovery and treatment, or the installation of barrier walls or grout curtains, along with suitable closure actions.

ESTABLISHMENT OF NEW DISPOSAL FACILITIES

A number of waste storage and disposal technologies that meet standards can be applied at SRP for hazardous, low-level radioactive, and mixed wastes. These include above- and belowground double-lined vaults or RCRA-type landfills with double liners and leachate collection systems for hazardous and mixed wastes. Low-level radioactive wastes would be disposed of in facilities meeting the requirements of DOE Orders, including engineered low-level trenches (ELLTs) for low-activity wastes, in GCD for intermediate-activity wastes, in a shielded above- or below-grade vault, or by stacking contained wastes in an above-grade operation (AGO) constructed at grade on a pad without a building or vault.

The retrievable-storage technologies for hazardous and mixed wastes, which are similar, would meet applicable standards. These facilities would be designed for essentially zero releases. For mixed waste, in addition to meeting RCRA requirements, such facilities would provide shielding of radiation sources. The technologies for low-level waste would consist of engineered storage of waste with varying degrees of isolation and shielding to accommodate different levels and types of radioactivity. These facilities would be designed to meet the as-low-as-reasonably-achievable (ALARA) requirements of DOE Orders.

DISCHARGE OF DISASSEMBLY-BASIN PURGE WATER

Project-specific actions for managing the discharge of disassembly-basin purge water would discontinue the use of the active reactor seepage and containment basins. The purge water would be discharged directly to surface streams, which currently receive purge water via outcrops, or it would be evaporated to the atmosphere through commercially available equipment. Releases to surface streams caused by residual seepage from prior use would continue for several years.

AFFECTED ENVIRONMENT

The Savannah River Plant is a 780-square-kilometer (192,700-acre), controlled-access area near Aiken, South Carolina. This major DOE installation was established in the early 1950s for the production of nuclear materials for national defense. More than 90 percent of the site is forested.

A very complex geohydrologic regime underlies SRP. This regime contains a series of Coastal Plain sediments (Coastal Plain Mosaic) interspersed with clay and sandy clay layers. Two major regional aquifers, the Congaree and the Middendorf/Black Creek (Tuscaloosa), lie beneath the site, overlain by several shallower formations that produce smaller quantities of water. The deep regional aquifer (the Middendorf/Black Creek), which becomes shallower to the north and northwest of the SRP, forms the base for most municipal and industrial supplies in Aiken County. Farther south, this formation deepens and shallower aquifers such as the Congaree and McBean provide water for municipal, industrial, and agricultural uses. The Barnwell aquifer, located above the Congaree and McBean aquifers, also supplies limited quantities of domestic water in the SRP vicinity.

The water table is fairly shallow beneath most of the Plant, ranging from 10 to 20 meters below the surface. SRP draws water from the Middendorf/Black Creek Formation, with the exception of some low-volume shallow domestic water wells.

Total groundwater use at the Plant is about 40,000 cubic meters per day. Large users of water within 32 kilometers of the center of the Plant withdraw about 135,000 cubic meters per day for municipal, industrial, and agricultural needs. Withdrawals by small users such as schools, mobile home parks, and small communities total about 2000 cubic meters daily.

The flow of groundwater at SRP is generally toward discharge zones along the onsite surface streams. Water-table aquifers discharge to Upper Three Runs Creek, Four Mile Creek, Tims Branch, and Steel Creek. The flow direction of these creeks is generally toward the southwest, except near the Savannah River where some flow to the southeast. Groundwater from the Middendorf/Black Creek Formation discharges to the Savannah River. Wells near the river are under artesian pressure. Extensive recharge areas for the Middendorf/Black Creek Formation lie to the north and northwest of the SRP and generally to the south of the Fall Line, which separates the Coastal Plain from the Piedmont geologic province.

Groundwater quality in the Coastal Plain sediments is good and requires minimal treatment for industrial and municipal use. The water is soft, slightly acidic (pH range 5.5 to 6.5), and has a low total dissolved solids (TDS) content. The quality of the groundwater varies slightly from aquifer to aquifer.

Researchers have evaluated groundwater quality on the basis of geographic and functional groupings for most of the sites considered in this EIS. These sites received or might have received hazardous constituents, low-level radioactive wastes, or mixed wastes. This EIS describes these sites.

Surface water at SRP consists of the Savannah River, surface streams that transect the Plant and drain to the Savannah River, and two cooling lakes, Par Pond and L-Lake. (One small onsite stream flows to the east and joins tributaries of the Salkehatchie River.) A swamp borders the river along most of the southwestern Plant boundary. Surface-water quality is characterized by low mineral content, low TDS, and a pH range of 5.6 to 8.4.

ENVIRONMENTAL CONSEQUENCES

The determination of the environmental consequences associated with the alternative waste management strategies is based on a combination of data and analyses derived from:

- Groundwater monitoring

- Groundwater flow and transport modeling

- Estimation of waste site inventories

- Estimation of onsite and offsite health effects and risks for radionuclides and hazardous chemicals through surface and groundwater, atmospheric, and occupational pathways

- Estimation of ecological impacts

- Estimation of risks to onsite occupants following a 100-year period of institutional control

These assessment methodologies required the use of flow and solute transport models for groundwater, atmospheric dispersion models for radiological and nonradiological constituents, and estimation of health risks through radiological and/or chemical health risk models.

Groundwater monitoring has been performed at SRP routinely and data from these efforts have been made available in many reports, most recently in the Environmental Information Documents (EIDs) prepared for this EIS. Several groundwater flow and transport models were used, in particular the PATHRAE model. Other codes were used in health effects assessments. One-meter and 100-meter downgradient wells were used as hypothetical receptors for groundwater modeling at existing waste sites. Boundary wells were assumed at proposed new disposal facilities for the same purpose. Onsite surface streams and the Savannah River were assumed as receptor locations for assessing ecological impacts and offsite drinking-water radiological dose and chemical substance exposures.

Modeling calculations to determine atmospheric exposures to radioactive and hazardous waste materials were made for the EIS using a number of computer codes for soil and airborne contaminant loadings, transport of radioactive and hazardous materials, population exposures, including evaluation data, and food uptake. Another code was used to calculate airborne risks for the population and the maximally exposed individual. Onsite worker exposure was also estimated.

Existing waste site inventories for transport modeling efforts were established using physical records or calculations involving either groundwater monitoring results or soil core sampling results. These data resulted in estimates of potential waste inventories (waste disposal mass) for comparisons of alternative removal, remedial, or closure actions. Historic information on operations and waste disposal and storage activities was used to estimate the mass or volumes of waste that would be contained in proposed new disposal facilities. A computer code modeled these sites for boundary wells, surface streams, and future site-occupant scenarios, as in existing waste site modeling.

COMPARISON OF ALTERNATIVE WASTE MANAGEMENT STRATEGIES

This EIS compares the alternative waste management strategies, as well as the project-specific actions. It evaluates health effects, doses, and exposures to the general population or workers, the level of environmental impact, volumes and kinds of wastes, and retrievability of wastes for future treatment.

NO-ACTION STRATEGY

No major onsite environmental benefits are expected from the No-Action alternative strategy; however, the offsite environment would be protected as a result of continuing waste management practices. This strategy would result in the following:

- Onsite groundwater (water-table) impacts
- Elevated concentrations of tritium and nitrate in Four Mile Creek
- Potential terrestrial impacts from open pits and basins
- Accidental releases from stored wastes with possible minor impacts on aquatic and terrestrial ecology
- Continued minor habitat and wetlands impacts
- Occupational exposures and risks of fires, spills, and leaks due to waste transportation and accidents

This strategy would not produce any impacts to archaeological or historic resources, endangered species, or socioeconomic resources; in addition, noise associated with this strategy would not produce any impacts. This strategy probably would require the dedication of about 300 acres at existing waste sites plus a significant amount of land in areas receiving adverse impacts, primarily from shallow-aquifer groundwater contamination. In the future, occupants of the SRP site would be exposed to the largest areas of unmitigated contamination.

The estimated total capital cost to continue current practices totals about $160 million. Estimated total annual operating costs for the No-Action alternative strategy range from about $7 to 13 million. Estimated lifetime maintenance and monitoring costs are about $670 million.

DEDICATION STRATEGY

The major environmental benefits predicted to occur from the implementation of the Dedication strategy include improvement of onsite groundwater quality from remedial and closure actions at existing waste sites; improvement of onsite surface-water quality; reduction of potential public health effects; and reduction in atmospheric releases. A disadvantage would be the removal of some sites from public use through their dedication for waste management purposes; as much as 700 acres would be affected. Environmental impacts under this strategy could include the following:

- Local and transitory onsite groundwater drawdown effects
- Minor short-term terrestrial impacts due to the use of borrow pits for backfill
- Impacts to wildlife habitat due to land clearing and development

- The dedication of about 400 acres of land to new above- and belowground disposal facilities

- The dedication of about 300 acres at existing waste sites

There would be no impacts to archaeological or historic resources, socioeconomic resources, or endangered species; there would be no impacts from noise. Accidents and occupational risks could occur due to nonwaste material transportation and handling, which could result in spills, leaks, or fires.

The total capital cost for implementation of this alternative strategy ranges from about $350 million to $460 million. Total annual operating costs range from about $12 to $20 million. Estimated lifetime maintenance and monitoring costs are about $670 million. The cost ranges are based on the types of facilities that would be selected. Estimated costs for closure and postclosure care range from about $270 to $800 million.

ELIMINATION STRATEGY

The environmental benefits expected from the implementation of the Elimination strategy include improvement to onsite groundwater and surface-water quality from the removal and closure of all existing waste sites and remedial actions, as required; reduction of potential public health effects and atmospheric releases (except increased tritium air releases under the evaporation option); and no requirement for dedication of sites at SRP. Disadvantages include higher occupational risks than with other strategies and the absence of assurance of the future availability of disposal sites in other areas. Environmental impacts that could occur under this strategy include the following:

- Onsite groundwater drawdown effects (local and transitory)

- Added tritium releases to surface streams from direct discharge or increased atmospheric (evaporation) releases

- The highest occupational risks of all the alternative strategies during waste removal, closure, and remedial actions

- Terrestrial impacts at borrow pits that were greater than those for other strategies

- Some loss of habitat (about 400 acres) due to land clearing and development during the construction of the retrievable-storage facilities

- The greatest risk of spills, leaks, and fires, and the greatest worker exposures due to waste removal and transportation

There would be no impacts to archaeological or historic resources, socioeconomic resources, or endangered species; there would be no impacts from noise. This strategy would result in the lowest future risks to future occupants at the waste sites and contaminated areas following the extensive removal, remedial, and closure actions.

The total capital cost for implementation of this strategy would be about $12.7 billion. Total annual operating costs would range from about $5.5 to

$9.8 million. Estimated lifetime maintenance and monitoring costs are about $670 million.

COMBINATION STRATEGY

Major environmental benefits to be derived from implementation of the Combination strategy include secure storage and disposal of wastes; improvement to onsite surface water and groundwater from removal of wastes at selected sites, closure of selected waste sites, and remedial actions, as required; reduction of potential public health effects; and reduction of atmospheric releases. The dedication of some sites for waste management purposes would be required. This strategy could cause the following impacts:

- Local and transitory groundwater drawdown effects
- Some habitat disruption on the approximately 400 acres of land required by the new disposal facilities

There would be no impacts to archaeological or historic resources, socioeconomic resources, or endangered species; there would be no impacts from noise. Waste removal and handling would pose fewer occupational risks from accidents, fires, spills, and leaks because fewer waste sites would be involved. Potential impacts to future occupants would be between the extremes of the No-Action and Elimination strategies.

The estimated total capital cost of implementation of the Combination strategy ranges from about $0.5 to $2.0 billion. Total annual operating costs range from about $18 million to $26 million. Estimated lifetime maintenance and monitoring costs are about $670 million. Closure and postclosure costs range from about $100 million to $800 million.

SUMMARY

Considering all environmental factors and costs, a combination alternative strategy (i.e., compliance through a combination of site dedication, elimination of some existing waste sites, and disposal/storage of wastes) would be DOE's preferred alternative. The Combination strategy includes project-specific actions of waste removal at selected existing waste sites, and remedial and closure actions as required; above- and belowground disposal and retrievable storage for new disposal and storage facilities; and continuation of the discharge of disassembly-basin purge water to seepage basins, with continued studies on detritiation or other mitigation measures.

CHAPTER 1

PURPOSE AND NEED

The Savannah River Plant (SRP) near Aiken, South Carolina, is a major installation of the U.S. Department of Energy (DOE). The Plant, which began operation in the early 1950s, is the nation's primary source of reactor-produced defense materials.

Since the beginning of Plant operations, DOE and its predecessor agencies have conducted waste management activities to protect public health and the environment. An assessment of SRP waste management activities (ERDA, 1977) resulted in the adoption of a program to make improvements to the existing waste management practices in accordance with Energy Research and Development Administration (ERDA, now DOE) policies and standards. This program included regular assessments and improvements to waste management practices, studies of improved waste storage techniques, and studies to reduce the volume of waste generated.

The adoption of this program also resulted in the continuation of several waste management activities and practices at SRP, including the use of seepage basins for the disposal of low-level radioactive liquid wastes and chemicals. Although these practices resulted in localized contamination of groundwater and land areas (Marine and Bledsoe, 1985), this contamination does not affect the offsite environment (i.e., releases to the offsite environment are within environmental and health protection standards and criteria); and the contaminated areas are dedicated to waste management activities (ERDA, 1977).

DOE's waste management practices, especially those for hazardous waste, have been subject to increasing scrutiny. On April 13, 1984, a U.S. District Court ruled that DOE's facilities in Oak Ridge, Tennessee, were subject to the hazardous waste requirements under the Resource Conservation and Recovery Act (RCRA); DOE extended this ruling to all its Atomic Energy Act (AEA) facilities. The 1981 discovery of groundwater contamination under one seepage basin at SRP resulted in the passage of Public Law 98-181 in 1983, which required DOE to discontinue use of that basin and to develop a plan for the protection of groundwater at SRP. Subsequent enforcement actions pertaining to DOE's hazardous waste management program have been taken by Federal and State regulatory agencies, citizens' suits, and Congressional hearings.

In response to these events, DOE began a number of waste management activities on the Plant to comply with the newly emerging RCRA hazardous waste requirements at applicable AEA facilities. These activities included the preparation of a Groundwater Protection Plan for the Savannah River Plant (DOE, 1984); remedial action for contaminated groundwater discovered in M-Area in 1981 and the construction and operation of a wastewater effluent treatment plant in M-Area in lieu of the M-Area settling basin; the planning and design for the construction and operation of wastewater effluent treatment plants for F- and H-Areas (Separations Areas) and TNX-Area to discontinue the use of seepage basins in these areas; the removal of buried wastes and contaminated soil at the Chemicals, Metals, and Pesticides (CMP) pits; the construction of hazardous and mixed waste storage facilities; the preparation of RCRA permit applications for hazardous waste facilities; and an expanded monitoring program to characterize groundwater quality and geohydrology on the Plant.

Demonstration programs that will improve waste management activities are also under way; these include the "ashcrete" facility, which solidifies sludge from the effluent treatment facilities; a "beta-gamma" incinerator; a box/drum compactor; and a greater confinement disposal (GCD) demonstration. DOE expects these programs to result in improved methods of disposal for mixed and low-level radioactive wastes or reduction in waste volumes to meet applicable regulations.

Although DOE has started these and other modified waste management activities on the Plant, additional actions are needed to modify the waste management program to comply with current groundwater protection requirements, including recently enacted provisions for wellhead protection under the Safe Drinking Water Act (SDWA), as amended.

1.1 NEED

Operations at SRP generate a variety of hazardous, low-level radioactive, and mixed wastes; these include hazardous wastes such as spent degreasing solvents; low-level radioactive wastes such as contaminated gloves, wipes, and liquid discharges from disassembly basins in the reactor areas; and mixed wastes such as condensate from the evaporation of high-level waste (mercury with radionuclides), process water and laboratory wastes (solvents with uranium), tritiated waste oil, and solutions used in measuring radiation (liquid scintillation solvents).

Because of past SRP waste management activities, such as the use of seepage basins and the disposal of wastes in unlined pits, water-table aquifers in the vicinity of several waste sites have been contaminated by a variety of substances, including volatile organics, nitrates, heavy metals (lead, chromium, cadmium, and mercury), pesticides, and radionuclides.

To comply with recently enacted groundwater-protection requirements, including RCRA, the Hazardous and Solid Waste Amendments (HSWA) to RCRA, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Superfund Amendments and Reauthorization Act (SARA), and SDWA, DOE actions at existing waste sites and new disposal or storage facilities are required.

Several SRP locations have been used for the disposal or storage of hazardous, low-level radioactive, and mixed wastes. Many of the waste sites identified on the Plant contain or might have received hazardous, low-level radioactive, or mixed wastes. Although only a few sites currently receive low-level radioactive or permitted mixed waste, corrective actions might be required by RCRA/HSWA at waste sites releasing hazardous constituents, regardless of when such a site received the waste. These corrective actions would prevent the potential migration of contamination beyond the boundaries of the waste site by removing contaminants from soil, surface water, and groundwater, by removing the source of the contamination, or both.

Current groundwater protection and other regulations also require the establishment of new waste disposal or storage facilities. New facilities provide the needed capacity for hazardous, low-level radioactive, and mixed waste resulting from removal or exhumation actions at existing waste sites under RCRA requirements; sludges from new effluent treatment facilities that are planned or are in operation to discontinue the use of seepage basins; and wastes from interim storage facilities and ongoing SRP operations. Adequate capacity is not available in existing facilities to store or dispose of these wastes. At present, hazardous and mixed wastes are stored on an interim basis in permitted storage facilities, and the facility for the disposal of low-level radioactive waste has less than 2 years of capacity remaining.

1.2 PURPOSE

At present, DOE is proceeding with waste management activities to comply with applicable requirements on a priority and project basis; these activities include the submittal of Part B permits under RCRA for individual hazardous waste facilities and the implementation of remedial actions and closure plans pursuant to RCRA permits for individual waste facilities. DOE is committed to full compliance with applicable RCRA hazardous waste requirements on the Savannah River Plant.

These priority and compliance waste management activities will continue; however, DOE recognizes that there is also a need for a comprehensive evaluation of the cumulative effects of individual actions. There is also a need for integrating and evaluating the effects of individual actions with other actions or projects. For example, RCRA might require the removal of hazardous waste from an existing waste site, but the removal is predicated on the availability of a permitted hazardous waste disposal or storage facility that has the capacity to accept the waste. Recognizing this need for a more comprehensive framework to evaluate its future waste management and groundwater-protection projects, DOE announced its intent to prepare this environmental impact statement (EIS) on April 26, 1985 (50 FR 16534).

The proposed action to which this dual-purpose EIS provides environmental input is the modification of waste management activities on the Savannah River Plant for hazardous, low-level radioactive, and mixed wastes for the protection of groundwater, human health, and the environment. The EIS considers the following modifications to the SRP waste management program:

- Removal, remedial, and closure actions at active and inactive hazardous, low-level radioactive, and mixed waste sites

- Establishment of new waste disposal facilities for hazardous, low-level radioactive, and mixed wastes

- Alternative means for discharge of disassembly-basin purge water from C-, K-, and P-Reactors

The purpose of this proposed action is to identify and select a waste management strategy and project-specific actions for the treatment, storage, and disposal of SRP hazardous, low-level radioactive, and mixed wastes that will protect groundwater resources and comply with applicable regulatory requirements. These activities have the greatest potential for affecting groundwater resources. This EIS assesses modifications for each waste management activity that represent broadly defined strategies that DOE could select to implement future management actions regarding hazardous, low-level radioactive, and mixed waste.

This EIS, which is both programmatic and project-specific, supports the selection of a broadly defined waste management strategy and provides project-level environmental input for project-specific decisions on proceeding with future hazardous, low-level radioactive, and mixed waste management activities. Following the public comment period on this draft EIS and publication of the final EIS, DOE will identify its selected strategy in a Record of Decision. The strategy decision will precede any project-specific actions. Research activities to reduce waste generation, reduce waste toxicity, and increase its isolation from the biosphere are continuing. Interactions with regulatory agencies also are continuing. As a result, decisions on implementing portions of the overall strategy or some specific actions discussed in the EIS might be delayed. Additional National Environmental Policy Act documents will be prepared if necessary to support the implementation of project activities that are not addressed specifically in this EIS. Federal (RCRA, CERCLA, and SDWA, as amended) and State (South Carolina Hazardous Waste Management Act) regulations and DOE Orders will provide the bases for project-specific decision.

REFERENCES

DOE (U.S. Department of Energy), 1984. Groundwater Protection Plan for the Savannah River Plant, Savannah River Operations Office, Aiken, South Carolina.

ERDA (Energy Research and Development Administration), 1977. Final Environmental Impact Statement, Waste Management Operations, Savannah River Plant, Aiken, South Carolina, ERDA-1537, Washington, D.C.

Marine, I. W., and H. W. Bledsoe, 1985. Supplemental Technical Data Summary, M-Area Groundwater Investigation, DPST-84-112, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, South Carolina.

CHAPTER 2

PROPOSED ACTION AND ALTERNATIVES

Waste management activities have been under way at the Savannah River Plant (SRP) since operations began in the early 1950s. Periodic reviews of these activities and the results of research and development programs were used to update and refine these activities. In 1977, the SRP reviewed its waste management activities and chose to continue those that were consistent with the requirements at the time (ERDA, 1977). Because of changing environmental concerns and regulations [including the Resource Conservation and Recovery Act (RCRA), the Hazardous and Solid Waste Amendments (HSWA) to RCRA, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Superfund Amendments and Reauthorization Act (SARA), and the Safe Drinking Water Act (SDWA)], some of these activities are no longer acceptable. Accordingly, the U.S. Department of Energy (DOE) is proposing to modify its waste management activities.

This dual-purpose environmental impact statement (EIS) is both a programmatic and a project-specific document. It considers broad waste management strategies and associated project-specific actions. The EIS does not preempt the regulatory decisionmaking process, but is a prerequisite to the DOE Record of Decision. It provides an analysis based on available data and information that describes the range of environmental impacts - beneficial and adverse - that accompany each strategy and project-specific action.

The action proposed in this EIS is the modification of waste management activities on the Savannah River Plant for hazardous, low-level radioactive, and mixed wastes for the protection of human health and the environment. The alternative to the proposed action is "no action," or not modifying existing waste management activities, and continuing current activities for managing low-level radioactive and chemical wastes. Because these activities would not comply with current applicable requirements and might affect activities that already protect groundwater resources, DOE does not consider the continuation of ongoing activities, or "no action," to be a "reasonable" alternative as defined in Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA) of 1969.

DOE could implement several alternative waste management strategies for SRP hazardous, low-level radioactive, and mixed waste to comply with applicable requirements. Section 2.1 describes the alternative strategies from which DOE will select a preferred alternative strategy in its Record of Decision on this EIS. Sections 2.2, 2.3, and 2.4 describe the strategies for closing existing waste sites in the R- and F-Areas at the SRP, for new disposal facilities, and for managing the discharge of disassembly-basin purge water. Section 2.5 summarizes the environmental consequences of the alternative strategies.

The alternative strategies are based on combinations of project-specific actions. Such actions represent the lower tier of actions evaluated in this EIS; they are represented by such decisions as a conceptual design for a facility for the disposal of low-level radioactive waste, or the disposal of disassembly-basin purge water by direct discharge or by discharge to seepage basins. Figure 2-1 shows the project-specific components of the upper-tier alternative strategies.

2.1 ALTERNATIVE WASTE MANAGEMENT STRATEGIES

In considering modifications to SRP waste management activities for hazardous, low-level radioactive, and mixed wastes, DOE could select one of several alternative strategies. These strategies differ in the waste management concepts proposed for existing waste sites, new disposal facilities, and discharge of disassembly-basin purge water and in the degree they require dedication of land areas, long-term monitoring, and control to ensure that releases from SRP facilities are within applicable standards.

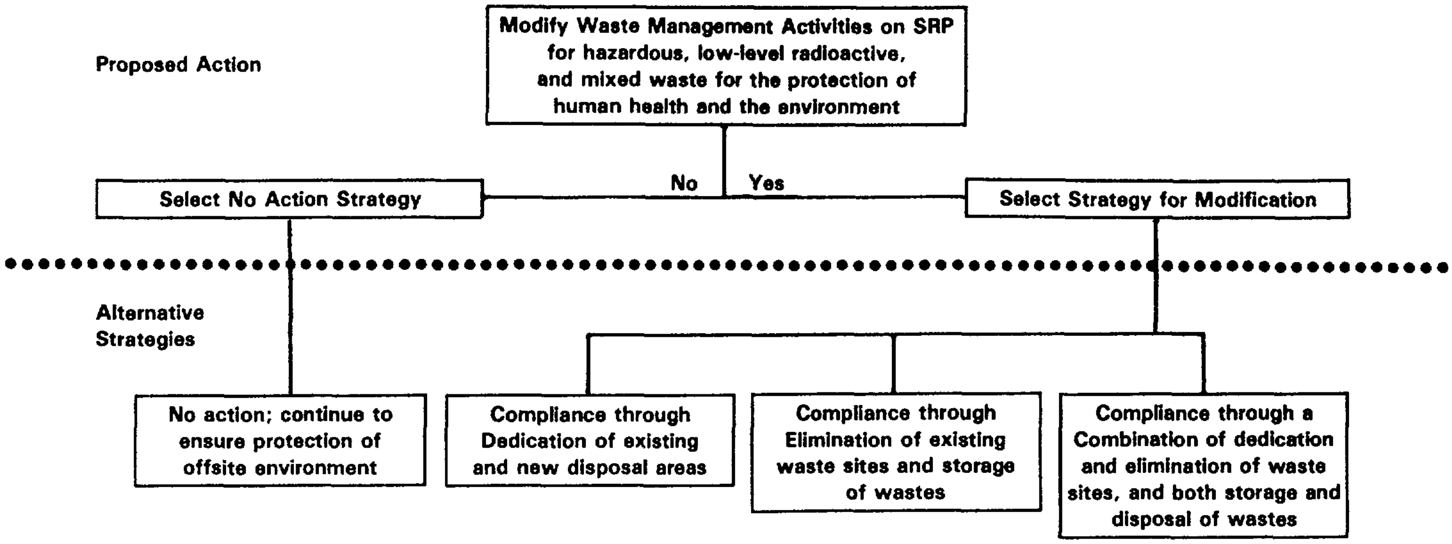
RCRA, as amended, reflects these differences by requiring the owner of a hazardous waste site having continuing releases either to remove and control contaminants from the soil, surface water, and groundwater outside the site, or to remove the source of contamination from the site to within background levels or agreed-to alternative concentration limits. If the contaminants in environmental media outside a waste site were removed and controlled, the waste site land area would remain dedicated to waste management; long-term monitoring and oversight would be essential to ensure environmental protection. If the source of contamination (i.e., the waste material and contaminated soil within the site) were removed, the site would no longer need to be dedicated to waste management purposes, nor would it require long-term monitoring and oversight.

This difference in the need to dedicate land areas for waste management purposes and to commit resources to long-term monitoring and oversight is also reflected in the choice of disposing of or storing hazardous, low-level radioactive, or mixed waste. Disposal requires the permanent or long-term dedication of land areas. Storage, on the other hand, requires neither permanent nor long-term dedication; storage implicitly assumes that research and development will provide better methods for disposal than those currently available.

The management of hazardous and mixed waste on the SRP is regulated by RCRA, HSWA, and DOE Orders. RCRA and HSWA provide a national program to minimize the present and future threat to human health and the environment from the transportation, treatment, storage, and disposal of hazardous waste. RCRA is administered by the South Carolina Department of Health and Environmental Control (SCDHEC), under the authority of the U.S. Environmental Protection Agency (EPA). At present, SCDHEC is not authorized to administer HSWA. DOE Orders set forth policy, guidelines, and criteria for the management of hazardous, mixed, and low-level radioactive wastes generated by DOE facilities.

The following sections discuss alternative strategies for the modification of hazardous, low-level radioactive, and mixed waste management activities; and for existing waste sites, new storage and disposal facilities, and disassembly-basin purge-water discharge. In accordance with NEPA implementing regulations, a No-Action strategy is also discussed.

Table 2-1 summarizes the alternative strategies for SRP hazardous, low-level radioactive, and mixed waste management activities; this table illustrates a central consideration of this EIS: The modification of a single waste



Legend:

[a] RCRA = Resource Conservation and Recovery Act
[b] CFM = Cement Flyash Matrix
[c] ELLT = Engineered Low-Level Trench
[d] AGO = Above Ground Operation
[e] GCD = Greater Confinement Disposal

Figure 2-1. Project Specific Components of Alternative Strategies (page 1 of 3)

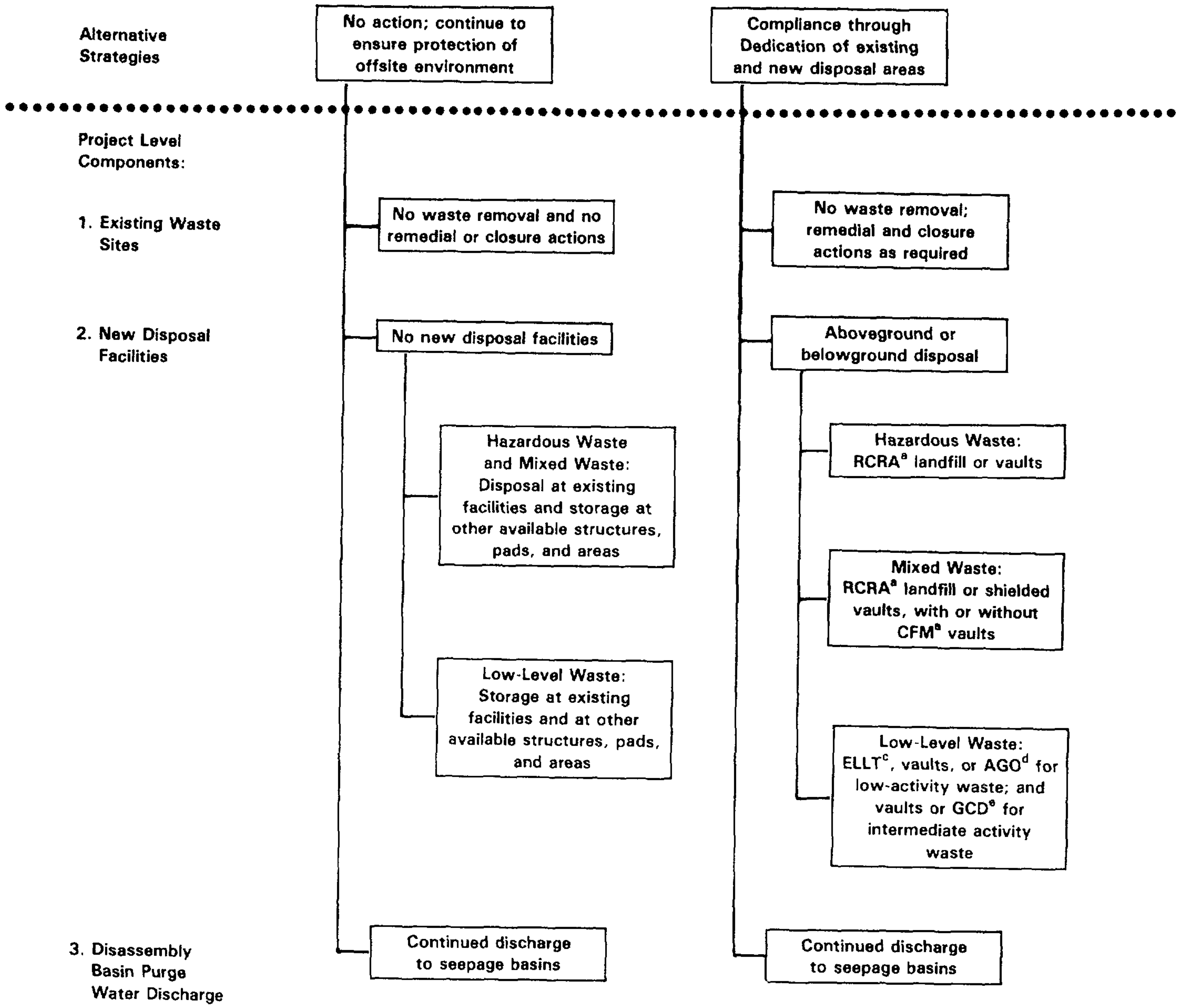


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Figure 2-1. Project Specific Components of Alternative Strategies (page 2 of 3)

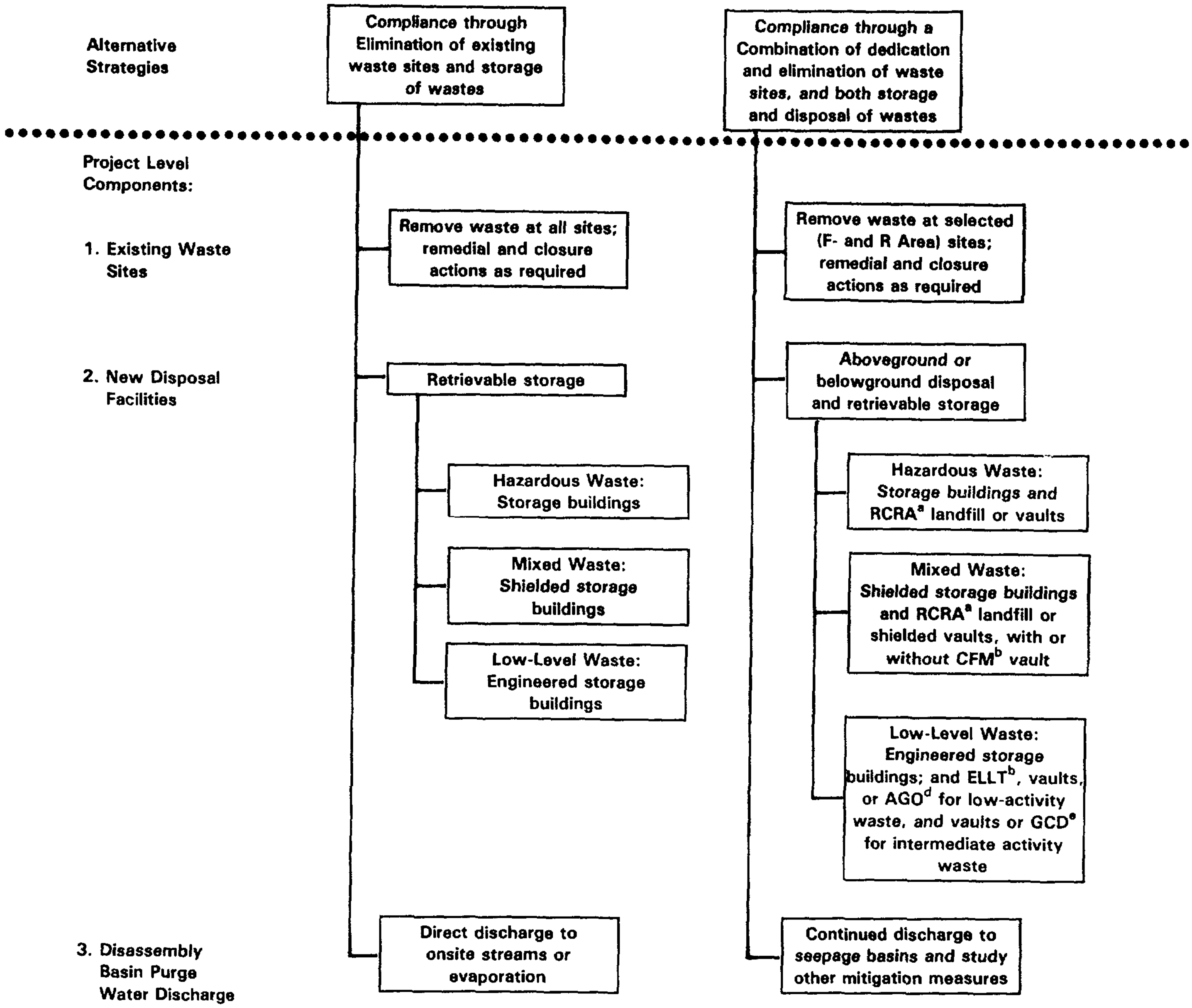

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Figure 2-1. Project Specific Components of Alternative Strategies (page 3 of 3)

Table 2-1. Alternative Waste Management Strategies

Alternative strategy	Section	Facility Category: Existing waste sites	Facility Category: New disposal facilities	Facility Category: Disassembly-basin purge water discharge
No action; continue to ensure protection of offsite environment	2.1.1	No waste removal and no remedial or closure actions	No new disposal facilities	Continued discharge to seepage basins
Compliance through Dedication of existing and new disposal areas	2.1.2	No waste removal; remedial and closure actions as required	Aboveground or below-ground disposal	Continued discharge to seepage basins
Compliance through Elimination of existing waste sites and storage of wastes	2.1.3	Remove waste at all sites; remedial and closure actions as required	Retrievable storage	Direct discharge to onsite streams or evaporation
Compliance through a Combination of dedication and elimination of waste sites, and both storage and disposal of wastes	2.1.4	Remove waste at selected sites; remedial and closure actions as required	Aboveground or belowground disposal and retrievable storage	Continued discharge to seepage basins and study of other mitigation measures

management activity might require modification of another. For example, the removal and disposal of all waste materials at all existing waste sites would not be consistent with a no-action strategy for the construction of no new storage and disposal facilities. Conversely, selection of a no-waste-removal (Dedication) strategy for existing waste sites would not be consistent with the construction of many large, new storage and disposal facilities.

The development of the waste management strategies described in this EIS is a logical outgrowth of needed SRP waste management activities and recently enacted regulations. These individual activities are analyzed and evaluated as mutually exclusive and independent. The following discussions combine modifications that are consistent with the alternative strategies for the overall management of SRP hazardous, low-level radioactive, and mixed waste.

2.1.1 NO-ACTION STRATEGY - CONTINUED PROTECTION OF OFFSITE ENVIRONMENT

CEQ guidelines (40 CFR 1502.14) require an EIS to evaluate the environmental consequences of "No action." As a potential strategy for this EIS, "No action" would consist of:

- No removal of waste at existing waste sites, and no closure or remedial actions

- No construction of new facilities for the storage or disposal of hazardous, low-level radioactive, or mixed wastes

- Continuation of periodic discharges of disassembly-basin purge water to active seepage and containment basins

The No-Action strategy would include the continuation of current activities for management of low-level radioactive and chemical wastes. Because the existing program would not comply with current groundwater and other environmental protection requirements, DOE does not consider it to be a "reasonable" alternative strategy.

2.1.2 DEDICATION STRATEGY - COMPLIANCE THROUGH DEDICATION OF EXISTING AND NEW DISPOSAL AREAS

For this strategy, the SRP hazardous, low-level radioactive, and mixed waste management activities could be modified to comply with applicable requirements by:

- Implementing closure (dewatering, stabilization, capping) and groundwater corrective (installing grout curtains or barrier walls) actions, as required, to control contamination from existing waste sites in accordance with applicable standards

- Establishing new disposal facilities (e.g., vaults or trenches) above or below the ground

- Continuing the use of seepage and containment basins for the periodic discharge of reactor disassembly-basin purge water

Releases of hazardous substances from existing waste sites that contain hazardous or mixed wastes would be controlled through the closure of such sites (if not already closed) under RCRA requirements, remedial actions to control groundwater contaminant plume migration and to restore groundwater quality, and other corrective actions (excluding removal) at the sites to prevent further releases of hazardous substances. Under this strategy, DOE would dedicate for waste management purposes those waste sites and contaminated (hazardous and radioactive) areas that could not be returned to public use after a 100-year institutional control period.

To accommodate hazardous, low-level radioactive, and mixed wastes generated from ongoing SRP operations, those presently in interim storage, and those from existing and planned waste management activities to comply with groundwater protection requirements (e.g., sludge from new effluent treatment facilities), new disposal facilities meeting applicable requirements would be established on the SRP.

The periodic discharges of filtered and deionized disassembly-basin water from C-, K-, and P-Reactors to active seepage and containment basins would continue. The use of basins for these discharges, which are not hazardous but are contaminated with tritium, would allow time for decay while migrating through groundwater to outcrops along onsite streams. If the seepage and containment basins and contaminated areas could not be returned to public use after a 100-year institutional control period, DOE would dedicate such areas permanently for waste management purposes.

2.1.3 ELIMINATION STRATEGY - COMPLIANCE THROUGH ELIMINATION OF EXISTING WASTE SITES AND STORAGE OF WASTES

The SRP hazardous, low-level radioactive, and mixed waste management activities could be modified to comply with all groundwater protection requirements by:

- Removing wastes to the extent practicable from all existing waste sites and implementing closure and groundwater remedial actions, as required
- Establishing new retrievable storage facilities
- Directly discharging disassembly-basin purge water to onsite streams, or evaporating such discharges through the use of a small commercially available boiler, vent stack, and dispersion fan

Under this strategy, no land areas would be dedicated for hazardous, low-level radioactive, and mixed waste management purposes. Such wastes, including contaminated soils, would be removed from all existing waste sites to the extent practicable. After an assumed 100-year institutional control period, most of these sites could be used for purposes other than waste management.

Wastes removed from existing waste sites and those generated from ongoing SRP operations and existing and planned waste management activities to comply with groundwater-protection requirements would be stored in facilities from which they could be retrieved. Hazardous and mixed wastes currently in interim storage at SRP would remain in the interim storage buildings. A research program would be initiated to develop new technologies for the permanent disposal of hazardous, low-level radioactive, and mixed wastes. Once these new technologies were developed and proven to be cost-effective, stored wastes would be permanently disposed of.

The filtered and deionized disassembly-basin water from C-, K-, and P-Reactors would be discharged to onsite streams in accordance with a National Pollutant Discharge Elimination System (NPDES) permit, or evaporated in a small commercially available boiler, vent stack, and dispersion fan. Seepage and containment basins used for the discharge of disassembly-basin purge water would be eliminated. Closure and remedial actions would be taken at these basins, if necessary, to ensure that contaminated areas could be returned to public use after a 100-year institutional control period.

2.1.4 COMBINATION STRATEGY - COMPLIANCE THROUGH A COMBINATION OF DEDICATION AND ELIMINATION OF EXISTING WASTE SITES, AND BOTH STORAGE AND DISPOSAL OF WASTES

For this strategy, the SRP's hazardous, low-level radioactive, and mixed waste management activities could be modified to comply with all groundwater protection and other environmental requirements by:

- Removing wastes at selected existing waste sites to the extent practicable and implementing closure and groundwater remedial actions, as required by applicable regulations

- Establishing a combination of retrievable storage and aboveground or belowground disposal

- Continuing the use of seepage and containment basins for the periodic discharge of reactor disassembly-basin purge water, while continuing investigations of source mitigation measures

Under this strategy, hazardous, low-level radioactive, and mixed wastes (including contaminated soils) would be removed to the extent practicable from selected existing waste sites in R- and F-Areas based on cost-effectiveness and on environmental and human health risks. After a maximum 100-year institutional control period, the areas from which waste material and contaminated soil had been removed could be used for purposes other than waste management. Sites from which waste material and contaminated soil had not been removed would be dedicated for waste management purposes if they could not be returned to public use after the 100-year control period.

New retrievable storage and disposal facilities would be established to accommodate waste removed from existing waste sites and those generated from ongoing SRP operations and existing and planned waste management activities to comply with groundwater protection requirements. Disposal facilities for hazardous or mixed waste would be permitted in accordance with applicable requirements. The combination of new storage and disposal facilities [e.g., greater confinement disposal (GCD) vaults and engineered low-level trenches] would minimize the amount of hazardous, low-level radioactive, and mixed waste placed in disposal facilities, and would allow DOE to initiate a research program to develop new technologies for permanent disposal. DOE would dedicate disposal facilities established for these wastes for waste management purposes.

Under this strategy, periodic discharges of filtered and deionized disassembly-basin water from C-, K-, and P-Reactors to the active seepage and containment basins would continue. DOE would continue to assess the general applicability of other mitigation measures at SRP. If DOE were to determine that detritiation or another approach is applicable, it would discontinue the use of these basins and evaluate actions to return the basin areas to public use after a 100-year institutional control period.

2.1.5 OTHER ALTERNATIVE STRATEGIES

In addition to the No-Action strategy and the three alternative strategies described above, other strategies considered included discontinuing SRP operations or shipping and disposing of hazardous, low-level radioactive, and mixed wastes at another (offsite) facility.

Discontinuing SRP operations, which would affect only the volume of future hazardous, low-level radioactive, and mixed waste to be stored or disposed of, was not considered, because such a strategy would not allow DOE to meet established requirements for production of defense nuclear materials.

Strategies for the shipment and management of hazardous, low-level radioactive, and mixed wastes at an offsite facility were also eliminated because of increased environmental and human health risks due to the transportation of wastes (ERDA, 1977) as well as the uncertainties associated with SRP operational dependence on the continued availability and capacity of offsite waste disposal sites.

2.2 EXISTING WASTE SITES

Under the alternative strategies discussed in Section 2.1, DOE could take four possible actions at existing waste sites that contain or might contain hazardous, low-level radioactive, and mixed waste:

- No removal of waste at existing waste sites, and no closure or remedial actions (No action)

- No removal of waste at existing waste sites, and implementation of cost-effective closure and remedial actions as required (Dedication)

- Removal of waste to the extent practicable from all existing waste sites, and implementation of cost-effective closure and remedial actions as required (Elimination)

- Removal of waste to the extent practicable at selected existing waste sites, and implementation of cost-effective closure and remedial actions as required (Combination)

The following sections describe existing SRP waste sites that contain or might contain hazardous, low-level radioactive, and mixed wastes, and the project-specific actions that DOE could take under each strategy.

2.2.1 EXISTING WASTE SITES CONSIDERED

Operations on the SRP result in the generation of hazardous wastes; low-level radioactive wastes; mixed wastes, which contain both hazardous and radioactive materials; and other solid wastes such as sanitary and domestic wastes and rubble.

At the SRP, 168 waste sites have been or are being used for the disposal or storage of wastes. This section considers 77 of these 168 sites in detail as existing waste sites. Six active reactor seepage basins and the K-Area containment basin receive periodic low-level radioactive discharges from the disassembly basins at C-, K-, and P-Reactor. These basins are considered in Section 2.4, which examines the alternatives for managing disassembly-basin purge water. The L-Reactor seepage basin was analyzed in the Final EIS for L-Reactor operation. The remainder of the 168 waste sites contain sanitary waste, solid waste, and/or rubble, or are otherwise not appropriate for consideration in this EIS (see Appendix B).

The 77 waste sites that are considered in detail consist of 37 sites that have or might have received hazardous waste, 19 sites that have or might have received low-level radioactive waste, and 21 sites that have or might have received mixed waste. In general, these 77 sites are near the facilities from which they receive wastes. This results in several clusters, or groupings, of waste sites rather than individual sites distinctly separated from each other.

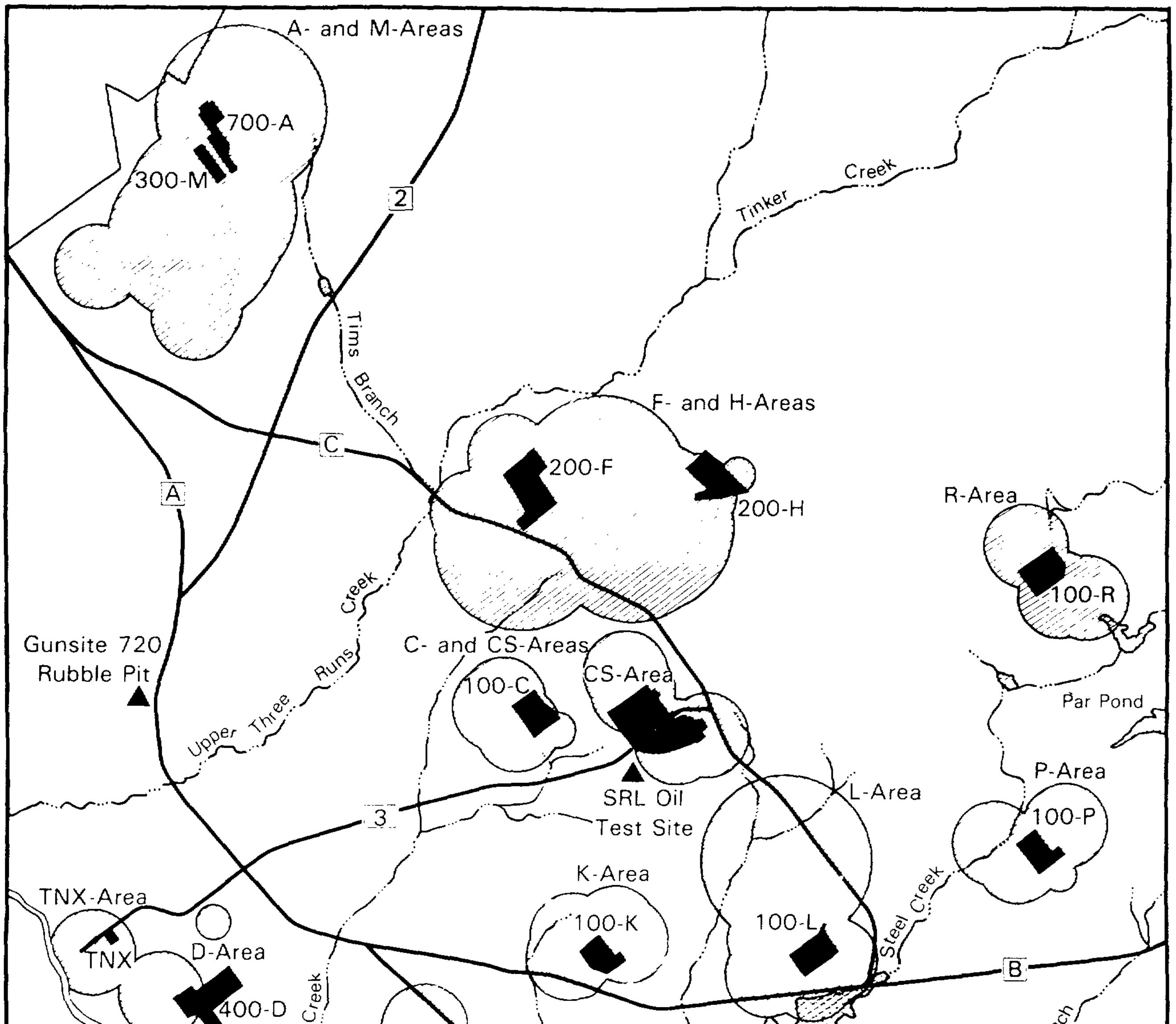
Because actions taken at a waste site, including groundwater withdrawal, might affect the groundwater transport of waste in other sites, a conservative boundary of influence was calculated for each waste site based on the planned actions, extent of data availability, and type of waste (Du Pont, 1984a). The intersection and overlapping of the individual waste site boundaries led to the identification of ten geographic groupings of waste sites and two miscellaneous areas - each containing a single waste site - where actions taken for waste sites in one geographic grouping would not be expected to interact with actions taken in another grouping. Figure 2-2 shows the ten geographic groupings and two miscellaneous areas.

Table 2-2 lists the waste sites within each of the ten geographic groupings and the miscellaneous areas. This table also indicates, for each of the 77 waste sites, the potential category of waste that is or might be contained in the site and if the site is currently receiving waste material. The 77 waste sites listed in Table 2-2 are characterized in Appendix B, together with a brief description of other waste sites not considered in this EIS.

2.2.2 ALTERNATIVE STRATEGIES FOR EXISTING WASTE SITES

This section summarizes the four project-specific actions that DOE could take for the waste sites listed in Table 2-2. Each action is included in one of the alternative strategies discussed in Section 2.1.

The details for each project-specific action are preliminary, presented for the purpose of approximating its costs and environmental consequences. Specific actions such as the selection of sites for waste removal (see Section 2.2.2.4), the volume of waste removed, site capping, or groundwater remedial



Source: Adapted from Du Pont, 1984a.

Scale (kilometers)
0 1 2 3 4 5

Figure 2-2. Grographic Groupings of Waste Sites

Table 2-2. Existing Waste Sites by Geographic Grouping

	Waste sites	Building	Receiving waste	Potential category[a]
		A- AND M-AREAS		
1-1[b]	716-A motor shop seepage basin	904-101G	No	Hazardous
1-2	Metals burning pit	731-4A	No	Hazardous
1-3	Silverton Road waste site	731-3A	No	Hazardous
1-4	Metallurgical laboratory basin	904-110G	No	Hazardous
1-5	Miscellaneous chemical basin	731-5A	No	Hazardous
1-6	A-Area burning/rubble pit	731-A	No	Hazardous
1-7	A-Area burning/rubble pit	731-1A	No	Hazardous
1-8	SRL seepage basin	904-53G	No	Mixed
1-9	SRL seepage basin	904-53G	No	Mixed
1-10	SRL seepage basin	904-54G	No	Mixed
1-11	SRL seepage basin	904-55G	No	Mixed
1-12	M-Area settling basin	904-51G	No	Mixed
1-13	Lost Lake	904-112G	No	Mixed
		F- AND H-AREAS		
2-1	F-Area acid/caustic basin	904-74G	No	Hazardous
2-2	H-Area acid/caustic basin	904-75G	No	Hazardous
2-3	F-Area burning/rubble pit	231-F	No	Hazardous
2-4	F-Area burning/rubble pit	231-1F	No	Hazardous
2-5	H-Area retention basin	281-3H	No	Low-level radioactive
2-6	F-Area retention basin	281-3F	No	Low-level radioactive
2-7	Radioactive waste burial ground	643-7G	Yes	Low-level radioactive
2-8	Mixed-waste management facility	643-28G	No	Mixed
2-9	Radioactive waste burial ground	643-G	No	Mixed
2-10	F-Area seepage basin	904-41G	Yes	Mixed
2-11	F-Area seepage basin	904-42G	Yes	Mixed

Footnotes on last page of table.

Table 2-2. Existing Waste Sites by Geographic Grouping (continued)

	Waste sites	Building	Receiving waste	Potential category[a]
2-12	F-Area seepage basin	904-43G	Yes	Mixed
2-13	F-Area seepage basin (old)	904-49G	No	Mixed
2-14	H-Area seepage basin	904-44G	Yes	Mixed
2-15	H-Area seepage basin	904-45G	Yes	Mixed
2-16	H-Area seepage basin	904-46G	No	Mixed
2-17	H-Area seepage basin	904-56G	Yes	Mixed
		R-AREA		
3-1	R-Area burning/rubble pit	131-R	No	Hazardous
3-2	R-Area burning/rubble pit	131-1R	No	Hazardous
3-3	R-Area acid/caustic basin	904-77G	No	Hazardous
3-4	R-Area Bingham pump outage pit	643-8G	No	Low-level radioactive
3-5	R-Area Bingham pump outage pit	643-9G	No	Low-level radioactive
3-6	R-Area Bingham pump outage pit	643-10G	No	Low-level radioactive
3-7	R-Area seepage basin	904-57G	No	Low-level radioactive
3-8	R-Area seepage basin	904-58G	No	Low-level radioactive
3-9	R-Area seepage basin	904-59G	No	Low-level radioactive
3-10	R-Area seepage basin	904-60G	No	Low-level radioactive
3-11	R-Area seepage basin	904-103G	No	Low-level radioactive
3-12	R-Area seepage basin	904-104G	No	Low-level radioactive
		C- AND CS-AREAS		
4-1	CS burning/rubble pit	631-1G	No	Hazardous
4-2	CS burning/rubble pit	631-5G	No	Hazardous
4-3	CS burning/rubble pit	631-6G	No	Hazardous
4-4	C-Area burning/rubble pit	131-C	No	Hazardous
4-5	Hydrofluoric acid spill area	631-4G	No	Hazardous
4-6	Ford Building waste site	643-11G	No	Low-level radioactive
4-7	Ford Building seepage basin	904-91G	No	Mixed

Footnotes on last page of table.

Table 2-2. Existing Waste Sites by Geographic Grouping (continued)

	Waste sites	Building	Receiving waste	Potential category[a]
		TNX-AREA		
5-1	D-Area burning/rubble pit	431-D	No	Hazardous
5-2	D-Area burning/rubble pit	431-1D	No	Hazardous
5-3	TNX burying ground	643-5G	No	Low-level radioactive
5-4	TNX seepage basin (old)	904-76G	No	Mixed
5-5	TNX seepage basin (new)	904-102G	Yes	Mixed
		D-AREA		
6-1	D-Area oil seepage basin	431-D	No	Hazardous
		ROAD A AREA		
7-1	Road A chemical basin	904-111G	No	Mixed
		K-AREA		
8-1	K-Area burning/rubble pit	131-K	No	Hazardous
8-2	K-Area acid/caustic basin	904-80G	No	Hazardous
8-3	K-Area Bingham pump outage pit	643-1G	No	Low-level radioactive
8-4	K-Area seepage basin	904-65G	No	Low-level radioactive
		L-AREA		
9-1	L-Area burning/rubble pit	131-L	No	Hazardous
9-2	L-Area acid/caustic basin	904-79G	No	Hazardous
9-3	CMP pit	080-17G	No	Hazardous
9-4	CMP pit	080-17.1G	No	Hazardous
9-5	CMP pit	080-18G	No	Hazardous
9-6	CMP pit	080-18.1G	No	Hazardous
9-7	CMP pit	080-18.2G	No	Hazardous
9-8	CMP pit	080-18.3G	No	Hazardous
9-9	CMP pit	080-19G	No	Hazardous

Footnotes on last page of table.

Table 2-2. Existing Waste Sites by Geographic Grouping (continued)

	Waste sites	Building	Receiving waste	Potential category[a]
9-10	L-Area Bingham pump outage pit	643-2G	No	Low-level radioactive
9-11	L-Area Bingham pump outage pit	643-3G	No	Low-level radioactive
9-12	L-Area oil and chemical basin	904-83G	No	Mixed
		P-AREA		
10-1	P-Area burning/rubble pit	131-P	No	Hazardous
10-2	P-Area acid/caustic basin	904-78G	No	Hazardous
10-3	P-Area Bingham pump outage pit	643-4G	No	Low-level radioactive
		MISCELLANEOUS AREAS		
11-1	SRL oil test site	080-16G	No	Hazardous
11-2	Gunsite 720 rubble pit	N80,000; E27,350[c]	No	Hazardous

[a]This EIS uses the terms "hazardous," "low-level radioactive," and "mixed" (i.e., hazardous and low-level radioactive) in their most common everyday sense, without specific regard to technical or regulatory definitions, unless indicated.
[b]The numbering system arbitrarily identifies the geographic group and each site within that group. For example, site 1-1 represents the first site in the first geographic group.
[c]No building number; located by SRP map coordinate system.

actions, if any, would be based on detailed site-specific modeling, actual monitoring results, and decisions resulting from regulatory interactions.

Section 4.2 describes the potential environmental consequences associated with these actions at existing waste sites; Appendix F describes them in more detail on a site-by-site basis.

2.2.2.1 No Action

Under the No-Action strategy, waste removal, closure, and remedial actions would not take place on the SRP, but measures considered necessary to protect the offsite environment would continue. More specifically, waste sites would be maintained for erosion protection, weed control, and grass mowing; additional groundwater monitoring wells would be installed; existing and new wells would be monitored; and fences would be installed where necessary to exclude animals and unauthorized personnel. The ongoing program to remove volatile organics from the groundwater in the Tertiary (shallow) sediments in M-Area through a system of recovery wells routed to an air stripper would continue. The monitoring and protective activities described for No Action would also be included in the closure and remedial actions described in Sections 2.2.2.2 through 2.2.2.4.

Under No Action, some hazardous and radioactive constituents would exceed applicable standards in the groundwater in the Tertiary sediments, and would not comply with current groundwater-protection requirements. Small supply wells could be screened into these aquifers after the period of institutional control, when most constituents in the groundwater would have decayed or dispersed to concentrations that would be below regulatory, human health, and environmental concern. Dedication of the existing waste sites and areas where groundwater constituents were still above these levels of concern would be necessary to ensure the protection of human health and the environment.

While No Action would have cost advantages and reduced occupational risks, it would not comply with current groundwater protection requirements and could render parts of the SRP unsuitable for public use after the 100-year institutional control period. Table 2-3 lists details assumed for the purpose of assessing No Action.

2.2.2.2 Dedication

Releases of hazardous substances from existing waste sites would be controlled through the closure of such sites (if not already closed). Groundwater corrective actions (such as recovery, treatment, and installation of barrier vaults or grout curtains) could be implemented to control groundwater contaminant plume migration. Dedication of those sites and contaminated areas that could not be returned to public use after a 100-year institutional control period would be required for waste management purposes; about 300 acres of SRP land would be involved.

Under the Dedication strategy, existing basins that have not previously been filled would be backfilled after dewatering. Wastes and sludges would be stabilized and impermeable barriers (caps) would be installed as required. Berms or other structures to prevent runon or runoff would be installed as required. Preliminary cost estimates and modeling of contaminant transport are based on the assumptions identified in Table 2-4.

Preliminary modeling indicates that the number of remedial actions that could be required under the Dedication strategy would be greater than those required under a strategy that included waste removal. Chapter 4 presents predicted concentrations of contaminants.

The primary disadvantages of this strategy are the extent of groundwater remediation potentially required and the need to dedicate the waste sites for waste management purposes. This strategy, however, would have significant advantages over the Elimination strategy (Section 2.2.2.3) with respect to cost, terrestrial ecology impacts, and occupational risks.

Table 2-3. No Action Strategy - Existing Waste Site Program Modifications for No Action (No Removal of Waste and No Closure or Remedial Action)

Site	Waste site	Install new monitoring well	Monitoring and site upkeep cost (million $)	Site preparation cost (million $)
A- & M-Areas				
1-1	716-A motor shop seepage basin		0.15	0.00
1-2	Metals burning pit		0.40	0.00
1-3	Silverton road waste site		2.10	0.10
1-4	Metallurgical laboratory basin		0.20	0.00
1-5	Miscellaneous chemical basin	Yes	0.27	0.00
1-6	A-Area burning/rubble pit		0.30	0.00
1-7	A-Area burning/rubble pit		0.00	0.00
1-8 to 1-11	SRL seepage basins		0.26	0.00
1-12	M-Area settling basin		2.00	0.00
1-13	Lost Lake		0.00	0.00
F- & H-Areas				
2-1	F-Area acid/caustic basin		0.30	0.00
2-2	H-Area acid/caustic basin		0.30	0.00
2-3	F-Area burning/rubble pit		0.30	0.00
2-4	F-Area burning/rubble pit		[a]	0.00
2-5	H-Area retention basin	Yes	0.20	0.00
2-6	F-Area retention basin	Yes	0.20	0.00
2-7 to 2-9	Radioactive and mixed waste burial grounds	Yes	650.00	0.00
2-10 to 2-12	F-Area seepage basins		1.10	0.40
2-13	F-Area seepage basin (old)		0.15	0.00
2-14 to 2-17	H-Area seepage basins		4.40	1.50
R-Area				
3-1	R-Area burning/rubble pit		0.30	0.00
3-2	R-Area burning/rubble pit		[a]	0.00
3-3	R-Area acid/caustic basin		0.30	0.00
3-4	R-Area Bingham pump outage pit		1.20[b]	0.13[b]
3-5	R-Area Bingham pump outage pit		[b]	[b]
3-6	R-Area Bingham pump outage pit		[b]	[b]
3-7	R-Area seepage basin		1.80	0.00
3-8	R-Area seepage basin		[a]	0.00
3-9	R-Area seepage basin		[a]	0.00
3-10	R-Area seepage basin		[a]	0.00
3-11	R-Area seepage basin		[a]	0.00
3-12	R-Area seepage basin		[a]	0.00
C- & CS-Areas				
4-1	CS burning/rubble pit		0.30	0.00
4-2	CS burning/rubble pit		[a]	0.00
4-3	CS burning/rubble pit		[a]	0.00
4-4	C-Area burning/rubble pit		0.30	0.00
4-5	Hydrofluoric acid spill area		0.30	0.00
4-6	Ford building waste site	Yes	0.30	0.02
4-7	Ford building seepage basin		0.09	0.00
TNX Area				
5-1	D-Area burning/rubble pit		0.30	0.00
5-2	D-Area burning/rubble pit		[a]	0.00
5-3	TNX burying ground	Yes	0.75	0.00
5-4	TNX seepage basin (old)		0.50	0.00
5-5	TNX seepage basin (new)		0.40	0.03
D-Area				
6-1	D-Area oil seepage basin		0.30	0.00

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Table 2-3. No Action Strategy - Existing Waste Site Program Modifications for No Action (No Removal of Waste and No Closure or Remedial Action) (continued)

Site	Waste site	Install new monitoring well	Monitoring and site upkeep cost (million $)	Site preparation cost (million $)
Road A Area				
7-1	Road A chemical basin		0.12	0.00
K-Area				
8-1	K-Area burning/rubble pit		0.30	0.00
8-2	K-Area acid/caustic basin		0.30	0.00
8-3	K-Area Bingham pump outage pit			
8-4	K-Area seepage/basin		0.12	0.00
L-Area				
9-1	L-Area burning/rubble pit		0.30	0.00
9-2	L-Area acid/caustic basin		0.30	0.00
9-3 to 9-9	CMP pits		0.90	0.00
9-10	L-Area Bingham pump outage pit	Yes		
9-11	L-Area Bingham pump outage pit			
9-12	L-Area oil and chemical basin		0.12	0.00
P-Area				
10-1	P-Area burning/rubble pit		0.30	0.00
10-2	P-Area acid/caustic basin		0.30	0.00
10-3	P-Area Bingham Pump outage pit	Yes		
Miscellaneous Area				
11-1	SRL oil test site	Yes	0.38	0.02
11-2	Gunsite 720 rubble pit	Yes	0.35	0.00
TOTAL			674.84	2.20

[a]Included in group total above.
[b]Total cost of all seven Bingham Pump outage pits listed at site 3-4.

Table 2-4. Dedication Strategy - Existing Waste Site Program Modifications for No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Site	Waste site	Basin liquid disposal required	Infil-tration barrier	Closure cost (million $)	Monitoring and site upkeep cost (million $)
A- & M-Areas					
1-1	716-A motor shop seepage basin			0.05	0.20
1-2	Metals burning pit		Yes	2.00	0.40
1-3	Silverton road waste site		Yes	1.70	2.10
1-4	Metallurgical laboratory basin	Yes		0.05	0.20
1-5	Miscellaneous chemical basin		Yes	0.10	0.27
1-6	A-Area burning/rubble pit			0.00	0.30
1-7	A-Area burning/rubble pit			0.00	[a]
1-8 to 1-11	SRL seepage basins	Yes		2.10	0.29
1-12	M-Area settling basin		Yes	12.00	2.00
1-13	Lost Lake			[a]	[a]
F- & H-Areas					
2-1	F-Area acid/caustic basin	Yes		0.01	0.30
2-2	H-Area acid/caustic basin	Yes		0.02	0.30
2-3	F-Area burning/rubble pit			0.00	0.30
2-4	F-Area burning/rubble pit			0.00	[a]
2-5	H-Area retention basin		Yes	0.30	0.20
2-6	F-Area retention basin		Yes	0.30	0.20
2-7 to 2-9	Radioactive and mixed waste burial grounds		Yes	100.00	650.00
2-10 to 2-12	F-Area seepage basins	Yes	Yes	7.80	1.10
2-13	F-Area seepage basin (old)	Yes	Yes	2.40	0.15
2-14 to 2-17	H-Area seepage basins	Yes	Yes	19.00	4.40
R-Area					
3-1	R-Area burning/rubble pit			0.00	0.30
3-2	R-Area burning/rubble pit			0.00	[a]
3-3	R-Area acid/caustic basin	Yes		0.01	0.30
3-4	R-Area Bingham pump outage pit			0.13[b]	1.20[b]
3-5	R-Area Bingham pump outage pit			[b]	[b]
3-6	R-Area Bingham pump outage pit			[b]	[b]
3-7	R-Area seepage basin		Yes	17.40	1.80
3-8	R-Area seepage basin		Yes	[a]	[a]
3-9	R-Area seepage basin		Yes	[a]	[a]
3-10	R-Area seepage basin		Yes	[a]	[a]
3-11	R-Area seepage basin		Yes	[a]	[a]
3-12	R-Area seepage basin		Yes	[a]	[a]

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Table 2-4. Dedication Strategy - Existing Waste Site Program Modifications for No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required (continued)

Site	Waste site	Basin liquid disposal required	Infil-tration barrier	Closure cost (million $)	Monitoring and site upkeep cost (million $)
C- & CS-Areas					
4-1	CS Burning/rubble pit			0.00	0.30
4-2	CS Burning/rubble pit			0.00	[a]
4-3	CS Burning/rubble pit			0.00	[a]
4-4	C-Area burning/rubble pit			0.00	0.30
4-5	Hydrofluoric acid spill area			0.00	0.30
4-6	Ford building waste site			0.28	0.30
4-7	Ford building seepage basin			0.07	0.09
TNX Area					
5-1	D-Area burning/rubble pit			0.00	0.30
5-2	D-Area burning/rubble pit			0.00	[a]
5-3	TNX burying ground		Yes	0.25	0.75
5-4	TNX seepage basin (old)		Yes	6.50	0.50
5-5	TNX seepage basin (new)	Yes	Yes	2.30	0.40
D-Area					
6-1	D-Area oil seepage basin			0.00	0.30
Road A Area					
7-1	Road A chemical basin		Yes	0.19	0.13
K-Area					
8-1	K-Area burning/rubble pit			0.00	0.30
8-2	K-Area acid/caustic basin	Yes		0.02	0.30
8-3	K-Area Bingham pump outage pit			[b]	[b]
8-4	K-Area seepage/basin	Yes	Yes	0.26	0.12
L-Area					
9-1	L-Area burning/rubble pit			0.00	0.30
9-2	L-Area acid/caustic basin	Yes		0.01	0.30
9-3 to 9-9	CMP pits			0.00	0.90
9-10	L-Area Bingham pump outage pit			[b]	[b]
9-11	L-Area Bingham pump outage pit			[b]	[b]
9-12	L-Area oil and chemical basin	Yes	Yes	0.50	0.12

Footnotes on last page of table.

Table 2-4. Dedication Strategy - Existing Waste Site Program Modifications for No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required (continued)

Site	Waste site	Basin liquid disposal required	Infil-tration barrier	Closure cost (million $)	Monitoring and site upkeep cost (million $)
P-Area					
10-1	P-Area burning/rubble pit			0.00	0.30
10-2	P-Area acid/caustic basin	Yes		0.02	0.30
10-3	P-Area Bingham pump outage pit			[b]	[b]
Miscellaneous Area					
11-1	SRL oil test site		Yes	0.35	0.40
11-2	Gunsite 720 rubble pit			0.03	0.35
TOTAL				176.15	673.67

[a]Included in group total above.
[b]Total cost of all seven Bingham pump outage pits listed at site 3-4.

2.2.2.3 Elimination

The Elimination strategy includes removal of hazardous, low-level radioactive, and mixed waste (including contaminated soil) from all existing waste sites to the extent practicable and the closure of each site (see Section 2.2.2.2). After a maximum 100-year institutional control period, these areas could be returned to public use. Further remedial actions to control the migration of hazardous and radioactive substances from some sites would be required.

Table 2-5 lists preliminary details on removal, closure, and remedial actions. Approximately 3.3 million cubic meters of waste and potentially contaminated soil could be excavated and transported to an acceptable onsite storage/disposal facility (see Section 2.3). After waste removal, all sites would be backfilled.

This strategy would require the fewest groundwater corrective actions, if any. Predicted concentrations of contaminants are presented in Chapter 4.

The primary advantages of this strategy are that the removal of waste and subsequent closure and remedial actions would eliminate the waste sites, the need to dedicate these areas for waste management purposes, and the number of sites requiring monitoring after closure. Significant disadvantages include the extremely high cost of removing, transporting, and disposing of or storing the waste in a new disposal or storage facility; the potential adverse effects on the terrestrial ecology during these activities; and significant occupational risks due primarily to transportation accidents and worker exposure to radioactive substances during waste removal activities.

2.2.2.4 Combination

Under this strategy, wastes (including contaminated soil) would be removed from existing waste sites selected on a basis of environmental and human health benefits and cost-effectiveness, and all sites would be closed. The areas from which waste had been removed could be returned to public use after the institutional control period. Sites from which waste was not removed would be dedicated for waste management purposes if they were not suitable for public use after the institutional control period. Releases from existing waste sites would be controlled through closure (as described in Section 2.2.2.2), with or without waste removal; and applicable requirements would be met. Groundwater corrective actions could be required in addition to closure to control groundwater contaminant plume migration.

Sites where modeling indicates significant reductions in groundwater contaminants due to waste removal include the old F-Area seepage basin and the six R-Area seepage basins. Transport modeling predicts that the concentrations of contaminants in the groundwater at those sites would be reduced extensively (e.g., by factors of 15 and greater) due to waste removal. This strategy assumes, for cost and assessment purposes, waste removal at these sites. The other 70 sites are assumed to receive the same closure actions as the Dedication strategy described in Section 2.2.2.2. Required groundwater corrective action under this option could be less than that required for the no-waste-removal action because of the removal of waste at the selected sites.

Table 2-5. Elimination Strategy - Existing Waste Site Program Modifications for Removal of Waste to the Extent Practicable from All Sites, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Site	Waste site	Basin liquid disposal required	Assumed volume of soil & waste removed (m^3)	Backfill volume (m^3)	Infil-tration barrier	Removal & closure cost (million $)	Monitoring and site upkeep cost (million $)
A- & M-Areas							
1-1	716-A motor shop seepage basin	Yes	675	2,025		0.12	0.20
1-2	Metals burning pit		21,600	21,600		75.00	0.30
1-3	Silverton road waste site		26,288	26,288	Yes	115.00	2.10
1-4	Metallurgical laboratory basin	Yes	340	960		1.25	0.20
1-5	Miscellaneous chemical basin		72	72		0.56	0.00
1-6	A-Area burning/rubble pit		22,386	22,386		21.10	0.30
1-7	A-Area burning/rubble pit		6,718	6,718		[a]	[a]
1-8 to 1-11	SRL seepage basins	Yes	1,900	1,900	Yes	8.70	0.29
1-12	M-Area settling basin		34,740	30,000		150.00	2.00
1-13	Lost Lake		16,900	0		[a]	[a]
F- & H-Areas							
2-1	F-Area acid/caustic basin	Yes	200	700		1.70	0.30
2-2	H-Area acid/caustic basin	Yes	200	700		2.80	0.30
2-3	F-Area burning/rubble pit		6,494	6,494		54.30	0.03
2-4	F-Area burning/rubble pit		10,889	10,889		[a]	[a]
2-5	H-Area retention basin		6,080	6,750	Yes	21.10	0.20
2-6	F-Area retention basin		9,154	9,924	Yes	30.90	0.20
2-7 to 2-9	Radioactive and mixed waste burial grounds		3,000,000	3,000,000	Yes	10,700.00	650.00
2-10 to 2-12	F-Area seepage basins	Yes	8,000	122,000	Yes	39.00	1.10
2-13	F-Area seepage basin (old)	Yes	5,230	5,230	Yes	13.70	0.15
2-14 to 2-17	H-Area seepage basins	Yes	20,870	265,000	Yes	119.40	4.40
R-Area							
3-1	R-Area burning/rubble pit		1,902	1,902		15.18	0.30
3-2	R-Area burning/rubble pit		2,948	2,948		[a]	[a]
3-3	R-Area acid/caustic basin	Yes	200	700		1.70	0.30
3-4	R-Area Bingham Pump outage pit		1,600	27,000		95.00[b]	1.20[f]
3-5	R-Area Bingham Pump outage pit		1,200	1,200		[f]	[a]
3-6	R-Area Bingham Pump outage pit		4,200	4,200		[f]	[a]
3-7	R-Area seepage basin		710	7,000	Yes	45.00	1.80
3-8	R-Area seepage basin		560	[a]	Yes	[a]	[a]
3-9	R-Area seepage basin		1,090	[a]	Yes	[a]	[a]
3-10	R-Area seepage basin		1,590	[a]	Yes	[a]	[a]
3-11	R-Area seepage basin		2,050[b]	[a]	Yes	[a]	[a]
3-12	R-Area seepage basin		1,080	[a]	Yes	[a]	[a]

Footnotes on last page of table.

Table 2-5. Elimination Strategy - Existing Waste Site Program Modifications for Removal of Waste to the Extent Practicable from All Sites, and Implementation of Cost-Effective Remedial and Closure Actions as Required (continued)

Site	Waste site	Basin liquid disposal required	Assumed volume of soil & waste removed (m^3)	Backfill volume (m^3)	Infil-tration barrier	Removal & closure cost (million $)	Monitoring and site upkeep cost (million $)
C- & CS-Areas							
4-1	CS Burning/rubble pit		2,276	2,276		40.04	0.30
4-2	CS Burning/rubble pit		5,146	5,146		[a]	[a]
4-3	CS Burning/rubble pit		3,298	3,298		[a]	[a]
4-4	C-Area burning/rubble pit		3,325	3,325		10.40	0.30
4-5	Hydrofluoric acid spill area		280	230		0.85	0.30
4-6	Ford building waste site		345	345		1.50	0.30
4-7	Ford building seepage basin		76	643		0.66	0.09
TNX Area							
5-1	D-Area burning/rubble pit		4,302	4,302		24.34	0.30
5-2	D-Area burning/rubble pit		3,509	3,509		[a]	[a]
5-3	TNX burying ground		896	896	Yes	4.40	0.80
5-4	TNX seepage basin (old)		594	4,654		2.70	0.50
5-5	TNX seepage basin (new)	Yes	359	2,807	Yes	3.38	0.40
D-Area							
6-1	D-Area oil seepage basin		5,742	5,742		0.45	0.30
Road A Area							
7-1	Road A chemical basin		1,000	5,500	Yes	4.00	0.00
K-Area							
8-1	K-Area burning/rubble pit		2,615	2,615		8.17	0.30
8-2	K-Area acid/caustic basin	Yes	200	700		2.20	0.30
8-3	K-Area Bingham pump outage pit		7,700	7,700		[b]	[b]
8-4	K-Area seepage basin	Yes	260	0	Yes	2.20	0.12
L-Area							
9-1	L-Area burning/rubble pit		2,529	2,529		7.90	0.30
9-2	L-Area acid/caustic basin	Yes	200	700		1.70	0.30
9-3 to 9-9	CMP pits		5,500	1,500		13.30	0.80
9-10	L-Area Bingham pump outage pit		4,100	4,100		[b]	[b]
9-11	L-Area Bingham pump outage pit		4,200	4,200		[b]	[b]
9-12	L-Area oil and chemical basin	Yes	675	3,500	Yes	2.80	0.12

Footnotes on last page of table.

Table 2-5. Elimination Strategy - Existing Waste Site Program Modifications for Removal of Waste to the Extent Practicable from All Sites, and Implementation of Cost-Effective Remedial and Closure Actions as Required (continued)

Site	Waste site	Basin liquid disposal required	Assumed volume of soil & waste removed (m^3)	Backfill volume (m^3)	Infil-tration barrier	Removal & closure cost (million $)	Monitoring and site upkeep cost (million $)
P-Area							
10-1	P-Area burning/rubble pit		4,802	4,802		14.98	0.30
10-2	P-Area acid/caustic basin	Yes	200	700		1.70	0.30
10-3	P-Area Bingham pump outage pit		3,800	3,800		[f]	[f]
Miscellaneous Area							
11-1	SRL oil test site		140	140		0.06	0.00
11-2	Gunsite 720 rubble pit		35	35		0.15	0.35
TOTAL			3,285,970	3,664,280		11,659.39	672.72

[a]Included in group total above.
[b]Total cost of all seven Bingham pump outage pits listed at site 3-4.

Table 2-6 presents details for assessing the Combination strategy. Approximately 12,300 cubic meters of waste and potentially contaminated soil could be removed from the selected sites; this is less than 0.5 percent of that required for the Elimination strategy (Section 2.2.2.3). The excavated waste and potentially contaminated soil would be transported to an acceptable onsite storage or disposal facility (see Section 2.3).

The magnitude of remedial actions potentially required probably would not be significantly greater than that of the Elimination strategy (removal at all sites), and less than that of no removal. Modeling predicts that the concentration of uranium-238 would be reduced by a factor of 15 by removal of waste from the old F-Area seepage basin. Concentrations of strontium-90 and yttrium-90 would be reduced by a factor of 100 by removal of waste at the R-Area seepage basins.

In comparison with the Elimination strategy, the Combination strategy significantly reduces the cost, ecological impacts, occupational hazards, and new storage/disposal capacity requirements of waste removal. Its primary disadvantage is that DOE would have to dedicate for waste management purposes those sites where waste had not been removed and that were not suitable for public use after the 100-year institutional control period.

2.3 NEW DISPOSAL/STORAGE FACILITY STRATEGIES

Section 2.1 describes the alternative waste management strategies for SRP waste management activities. Each of the alternative strategies includes a disposal and storage alternative that, in turn, includes one or more project-specific actions. This section describes these actions and the manner in which they can be combined as part of the selected strategy.

2.3.1 PROJECT-SPECIFIC TECHNOLOGIES

The Notice of Intent (NOI) to prepare this EIS (50 FR 16534) listed five alternatives for hazardous, mixed, and low-level radioactive waste facilities. Project-specific technologies derived from these five alternatives provide the basis for the waste management strategies. Table 2-7 lists the alternatives and their corresponding technologies.

Requirements under RCRA, HSWA, and DOE Orders cover all aspects of waste management, including the siting of facilities, facility design, facility permits and operations, limits on the release of waste constituents from facilities, design requirements for waste containers, leak detection systems, leachate recovery systems, runoff and runon control systems, liners, waste segregation, and waste acceptance. These site-specific, project-specific actions will be addressed in future planning and in response to the regulatory permitting and decisionmaking processes that will ensure that new facilities meet all applicable requirements. To provide DOE an environmental basis for selecting a waste management strategy, this EIS describes the technologies for new facilities and presumes that they are designed to comply with all applicable requirements.

The following sections describe each technology, its function, and its inherent technological features. Design details such as construction materials,

Table 2-6. Combination Strategy - Existing Waste Site Program Modifications for Removal of Waste to the Extent Practicable from Selected Sites, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Site	Waste site	Basin liquid disposal required	Soil & waste removed (m^3)	Backfill volume (m^3)	Infil-tration barrier	Removal & closure cost (million $)	Monitoring and site upkeep cost (million $)
			SITES SELECTED FOR WASTE REMOVAL				
F- & H-Areas							
2-13	F-Area seepage basin (old)	Yes	5,230	5,230	Yes	13.70	0.15
R-Area							
3-7	R-Area seepage basin		710	7,000	Yes	45.00	1.80
3-8	R-Area seepage basin		560	[a]	Yes	[a]	[a]
3-9	R-Area seepage basin		1,090	[a]	Yes	[a]	[a]
3-10	R-Area seepage basin		1,590	[a]	Yes	[a]	[a]
3-11	R-Area seepage basin		2,050[b]	[a]	Yes	[a]	[a]
3-12	R-Area seepage basin		1,080	[a]	Yes	[a]	[a]
Subtotal			12,310	12,230		58.70	1.95

Footnotes on last page of table.

Table 2-6. Combination Strategy - Existing Waste Site Program Modifications for Removal of Waste to the Extent Practicable from Selected Sites, and Implementation of Cost-Effective Remedial and Closure Actions as Required (continued)

Site	Waste site	Basin liquid disposal required	Infil-tration barrier	Closure cost (million $)	Monitoring and site upkeep cost (million $)
	SITES NOT SELECTED FOR WASTE REMOVAL				
A- & M-Areas					
1-1	716-A motor shop seepage basin			0.05	0.20
1-2	Metals burning pit		Yes	2.00	0.40
1-3	Silverton road waste site		Yes	1.70	2.10
1-4	Metallurgical laboratory basin	Yes		0.05	0.20
1-5	Miscellaneous chemical basin		Yes	0.10	0.27
1-6	A-Area burning/rubble pit			0.00	0.30
1-7	A-Area burning/rubble pit			0.00	[a]
1-8 to 1-11	SRL seepage basins	Yes	Yes	2.10	0.29
1-12	M-Area settling basin		Yes	12.00	2.00
1-13	Lost Lake			[a]	[a]
F- &H-Area					
2-1	F-Area acid/caustic basin	Yes		0.01	0.30
2-2	H-Area acid/caustic basin	Yes		0.02	0.30
2-3	F-Area burning/rubble pit			0.00	0.30
2-4	F-Area burning/rubble pit			0.00	[a]
2-5	H-Area retention basin		Yes	0.30	0.20
2-6	F-Area retention basin		Yes	0.30	0.30
2-7 to 2-9	Radioactive and mixed waste burial grounds		Yes	100.00	650.00
2-10 to 2-12	F-Area seepage basins	Yes	Yes	7.00	2.70
2-14 to 2-17	H-Area seepage basins	Yes	Yes	7.80	1.10

Footnotes on last page of table.

Table 2-6. Combination Strategy - Existing Waste Site Program Modifications for Removal of Waste to the Extent Practicable from Selected Sites, and Implementation of Cost-Effective Remedial and Closure Actions as Required (continued)

Site	Waste site	Basin liquid disposal required	Infil-tration barrier	Closure cost (million $)	Monitoring and site upkeep cost (million $)
	SITES NOT SELECTED FOR WASTE REMOVAL (continued)				
R-Area					
3-1	R-Area burning/rubble pit			0.00	0.30
3-2	R-Area burning/rubble pit			0.00	[a]
3-3	R-Area acid/caustic basin	Yes		0.01	0.30
3-4	R-Area Bingham pump outage pit			0.13[c]	1.20[c]
3-5	R-Area Bingham pump outage pit			[c]	[c]
3-6	R-Area Bingham pump outage pit			[c]	[c]
C- & CS-Areas					
4-1	CS Burning/rubble pit			0.00	0.30
4-2	CS Burning/rubble pit			0.00	[b]
4-3	CS Burning/rubble pit			0.00	[b]
4-4	C-Area burning/rubble pit			0.00	0.30
4-5	Hydrofluoric acid spill area			0.00	0.30
4-6	Ford building waste site			0.28	0.30
4-7	Ford building seepage basin			0.07	0.09
TNX Area					
5-1	D-Area burning/rubble pit			0.00	0.30
5-2	D-Area burning/rubble pit			0.00	[a]
5-3	TNX burying ground		Yes	0.25	0.75
5-4	TNX seepage basin (old)		Yes	6.50	0.50
5-5	TNX seepage basin (new)	Yes	Yes	2.30	0.40
D-Area					
6-1	D-Area oil seepage basin			0.00	0.30
Road A Area					
7-1	Road A chemical basin		Yes	0.19	0.13

Footnotes on last page of table.

Table 2-6. Combination Strategy - Existing Waste Site Program Modifications for Removal of Waste to the Extent Practicable from Selected Sites, and Implementation of Cost-Effective Remedial and Closure Actions as Required (continued)

Site	Waste site	Basin liquid disposal required	Infiltration barrier	Closure cost (million $)	Monitoring and site upkeep cost (million $)
	SITES NOT SELECTED FOR WASTE REMOVAL (continued)				
K-Area					
8-1	K-Area burning/rubble pit			0.00	0.30
8-2	K-Area acid/caustic basin	Yes		0.02	0.30
8-3	K-Area Bingham pump outage pit			[c]	[c]
8-4	K-Area seepage/basin	Yes	Yes	0.26	0.12
L-Area					
9-1	L-Area burning/rubble pit			0.00	0.30
9-2	L-Area acid/caustic basin	Yes		0.01	0.30
9-3 to 9-9	CMP pits			0.00	0.90
9-10	L-Area Bingham pump outage pit			[c]	[c]
9-11	L-Area Bingham pump outage pit			[c]	[c]
9-12	L-Area oil and chemical basin	Yes	Yes	0.50	0.12
P-Area					
10-1	P-Area burning/rubble pit			0.00	0.30
10-2	P-Area acid/caustic basin	Yes		0.02	0.30
10-3	P-Area Bingham Pump outage pit			[c]	[c]
Miscellaneous Area					
11-1	SRL oil test site		Yes	0.35	0.40
11-2	Gunsite 720 rubble pit			0.03	0.35
Subtotal				156.35	671.72
TOTAL				215.05	673.67

[a]Included in group total above.
[b]Includes 430 cubic meters at abandoned sewer line.
[c]Total cost of all seven Bingham Pump outage pits listed at site 3-4.

Table 2-7. NOI Alternatives and Corresponding Technologies

NOI Alternative	Technology	Waste Applications
Retrievable storage	Storage buildings	Hazardous, mixed, or low level
Shallow land disposal	RCRA landfill	Hazardous or mixed
	Belowground vault (RCRA)	Hazardous or mixed
	CFM[a] vault	Mixed
	Engineered low-level trench	Low level
	Belowground vault (DOE)	Low level
	GCD trench	Low level
	GCD borehole	Low level
Aboveground disposal	Aboveground vault (RCRA)	Hazardous or mixed
	Aboveground vault (DOE)	Low level
	Abovegrade operation	Low level
Combination	All of the above	As applicable
No action	No new facilities	Hazardous, mixed, or low level

[a]Cement/flyash matrix (solidification)

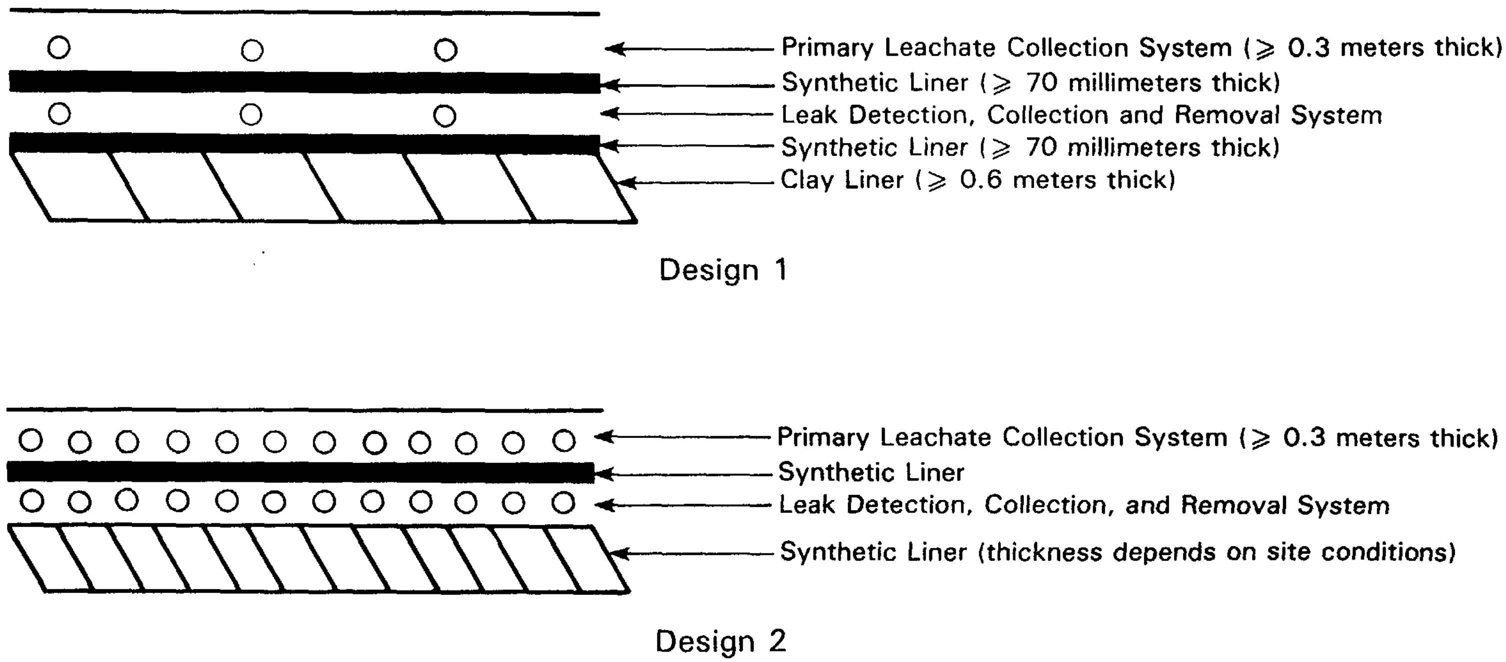
dimensions, and siting are not included, because regulatory compliance will be specified during the permitting process. The description focuses on the basic capabilities, long-term reliability, and effectiveness of each technology for waste management as it applies to each alternative strategy.

2.3.1.1 Storage Buildings

Storage buildings are being considered for retrievable storage of hazardous, mixed, and low-level radioactive wastes. They would be used to hold containerized wastes safely and securely for as long as 20 years. The design would include segregation of noncompatible hazardous wastes; radiation shielding as necessary; liquid recovery drains and alarmed sumps; smoke, fire, vapor, and radiation detection systems; ventilation systems; and automatic fire existinguishing systems. Operational controls would include site security, periodic inspections of the waste containers and the facility, personnel training, emergency preparedness and procedures, and recordkeeping.

2.3.1.2 RCRA Landfill

The RCRA landfill is being considered for hazardous and mixed waste disposal. It would employ a double-lined (primary and secondary liners) trench with double leachate-collection systems (above the primary liner and between the primary and secondary liners). Figure 2-3 shows two liner systems. Waste in containers would be stacked in the trench. As it is filled, the trench would be covered by a membrane sealed to the primary liner to form a watertight



Source: EPA, 1985

Figure 2-3. Schematic Diagram of Two Double-Liner Designs for Landfills

envelope. A low-permeability cap over the facility would divert percolating water laterally away from the closed trench.

The landfill would not contain an engineered structure; it would rely on the sides of the trench, on the waste containers, and on fill soil for stability. Placement below the surface of the ground would provide all necessary radiation shielding (for mixed waste) following closure.

When sited, designed, and operated in accordance with RCRA regulations, this type of hazardous and mixed waste disposal should provide many decades of reliable service. The primary leachate-collection system would provide warning and a means of recovering the waste if the containers failed. The secondary leachate-collection system would provide warning and the means to recover the wastes if the primary liner failed. If a secondary liner of clay were employed, its design would delay leachate penetration for at least 30 years (EPA, 1985). Although the hazardous and mixed wastes being disposed of could outlast the disposal facilities described in this EIS, the integrated systems would provide the early warning necessary to take mitigative action so that releases to the environment would not occur (i.e., zero release).

2.3.1.3 RCRA Vault

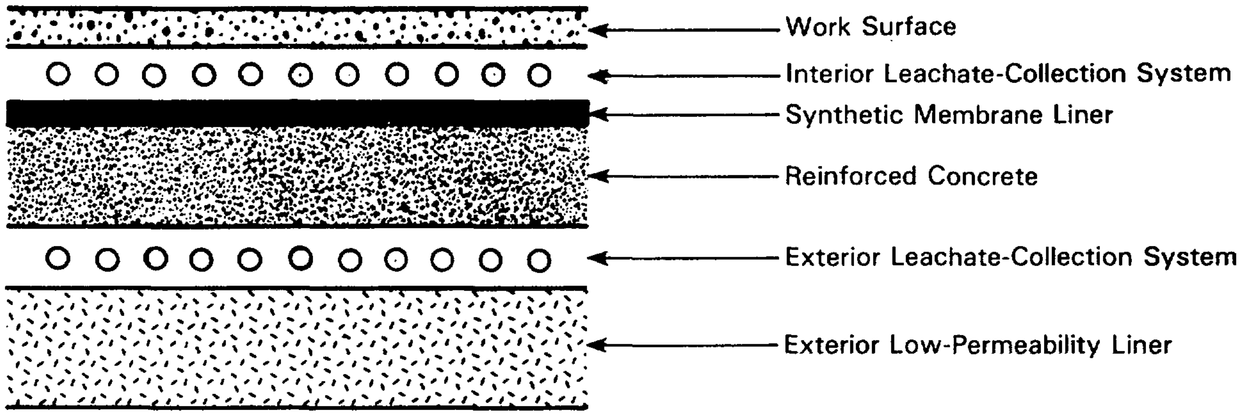
DOE is considering the use of RCRA vaults (vaults that comply with RCRA) for the disposal of hazardous and mixed waste at SRP. A typical hazardous or mixed waste disposal vault is a building-size, watertight, reinforced-concrete box set on or below the ground surface. An exterior leachate-collection system and secondary liner envelop the bottom of the facility. An interior liner and leachate-collection system are within the concrete structure. Figure 2-4 shows an arrangement of barriers used in this technology.

Containerized wastes would be segregated and stacked in the chambers of the facility. Empty spaces could be filled with sand or grout, and the facility would be sealed by a sloped, reinforced-concrete roof. If the facility were constructed belowground, it would then be covered with soil to grade. If aboveground, it could remain exposed or be mounded with soil to provide additional radiation shielding.

Vaults rely on the waste containers, the interior and exterior leachate-collection systems, and the concrete structure to ensure long-term isolation of wastes and no releases to the environment.

2.3.1.4 Cement/Flyash Matrix Vault

The cement/flyash matrix (CFM) vault is a technology for the disposal of selected mixed wastes. This technology involves segregating the mixed waste sludge emanating from such facilities as the M-Area effluent treatment facility (ETF), the F- and H-Area ETF, the Fuel Production Facility (FPF), and the Naval Fuel Materials Facility wastewater treatment plant, plus ash from incinerators in which hazardous, mixed, and low-level radioactive waste may have been burned. These wastes would be blended into a cement/flyash matrix and discharged as a slurry directly into reinforced-concrete vaults, where it would cure to a hard, concrete-like substance. This solidification process should render the waste nonhazardous and eligible for possible delisting under RCRA regulations.



Source: EPA, 1985

Figure 2-4. Schematic Diagram of Liner Systems for Below Ground Vaults (RCRA Type)

The CFM vault technology differs from the RCRA-type vault in that it would contain no liners and no leachate-collection system. Instead, this technology would rely on the solidification of the waste in conjunction with the concrete structural barrier to preclude the release of waste constituents and maintain environmental standards.

2.3.1.5 Engineered Low-Level Trench

The engineered low-level trench (ELLT) is being considered for the disposal of low-activity (less than 300 millirem per hour), low-level radioactive waste. The trench would have a crushed-stone floor on which containerized wastes would be stacked. The empty spaces between the containers would be filled with sand to improve stability, and the trench would be covered. A low-permeability cap above the waste would divert percolating water away from the containers. The cap would be covered with soil to grade for protection, and the surface would be contoured to channel the runoff away from the site.

The low-activity portion of the low-level radioactive waste stream which would be disposed of using ELLTs would account for approximately 95 percent of the waste by volume but would contain less than 2 percent of the radioactivity (Cook et al., 1987). With the relatively low radioactivity of this waste, ELLTs would require no engineered structure, liners, or leachate-collection systems. Rather, this technology would rely on appropriate site conditions, waste containers, a low-permeability cap, and postclosure site maintenance to minimize the intrusion of water into the closed trench and to prevent excessive migration of radionuclides into the environment.

2.3.1.6 Low-Level Waste Vault

Vault technology (other than that for RCRA vaults) that complies with DOE Orders is also being considered for disposal of low-level, low-activity (less than 300 millirem per hour) and intermediate-activity (greater than 300 millirem per hour) radioactive waste. A typical low-activity vault would consist of a building-size, reinforced concrete box set on or below the surface of the ground. Containerized wastes would be closely packed in the vault and, when filled, the vault would be closed with a concrete cap or roof. The vault would be covered with soil to grade for the belowground design or mounded with soil for the aboveground design to provide added shielding (Cook, Towler, and Grant, 1987).

As with the ELLT, the relatively low radioactivity of this waste would permit a design requiring no liners or leachate-collection system. Suitable performance would be achieved through proper siting, waste containers, and a sealed concrete structure to minimize the intrusion of water and the migration of radionuclides.

The design of the vault for intermediate-activity waste would be similar to that for the low-activity vault except that it would include an exterior, low-permeability liner and leachate-collection system. Increased stability would be achieved by structural design or by filling any empty spaces in the interior with grout prior to closure (Cook, Towler, and Grant, 1987).

2.3.1.7 Abovegrade Operation

DOE is considering abovegrade operation (AGO) for the disposal of low-activity, low-level radioactive waste. This technology would consist of a stable stack of waste-filled containers enclosed within a low-permeability membrane. It would be situated on a subbase of clay or other low-permeability material and would include interior and exterior leachate-collection systems.

Containerized waste would be stacked in the prepared facility. Empty spaces would be filled with sand to improve stability and minimize subsidence. When the stack was completed, it would be mounded with additional sand and sealed with a cover membrane. The entire mound would then be covered with soil and stabilized with vegetation.

AGO technology involves no engineered structure, but derives its structural stability from the arrangement and integrity of the waste containers. The contoured shape, low-permeability membrane enclosure, high-integrity containers, and double leachate-collection systems would effectively prevent migration of radionuclides from the low-activity waste into the surrounding environment.

2.3.1.8 Greater Confinement Disposal

DOE is considering GCD technologies (boreholes and trenches) for the disposal of low-level, intermediate-activity radioactive waste (greater than 300 millirem per hour).

In a typical design, a large hole about 3 meters in diameter would be bored to a depth of 9 or 10 meters. After a leachate-collection system was installed, the lower 6 meters would be lined with concrete and an interior liner of fiberglass. Containerized wastes would be placed in the lined hole, and any empty spaces would be filled with grout. A concrete cover would seal the waste inside the cylindrical capsule. Closure would include construction of a low-permeability cap to divert percolating water, and surface contouring to channel runoff away from the facility.

GCD trenches would have the same shielding and stability objectives as boreholes. A typical design would consist of a concrete-lined trench divided into cells and underlain by a leachate-collection system. Containerized or bulk waste would be placed in the cells and grouted in place. When filled, the cells would be sealed by a concrete cover. A low-permeability cap and surface contouring would be added.

GCD technology would rely on a combination of several features to prevent migration of radionuclides from the facility. These would include proper siting, a sealed concrete structure, grout encapsulation of waste in place, a low-permeability cap, and a leachate-collection system.

2.3.2 WASTE VOLUMES

This section describes the waste and contaminated material generated on the SRP that require treatment and disposal or storage. Appendix E describes in more detail the types and potential quantities of waste generated.

The SRP generates five types of waste:

- Hazardous waste
- Low-level radioactive waste
- Mixed waste (combined hazardous and low-level radioactive wastes)
- High-level radioactive [including transuranic (TRU)] waste
- Nonhazardous and nonradioactive waste

This EIS considers only the first three waste types; the others have been considered in other NEPA documents. These waste materials are derived from plant operations, maintenance, and planned renovations; from waste held in storage pending treatment or disposal before the startup of new facilities; and contaminated materials from closure or remediation activities at existing waste sites.

Liquid, solid, and semisolid operations waste is generated by plant processes; maintenance, renovation, and demolition of facilities; and offsite defense waste. Interim-storage waste is liquid, solid, and semisolid waste held in storage pending the startup of new treatment or disposal facilities. Closure-action waste includes contaminated soil or soil-waste mixtures exhumed in the remediation or closure of existing waste sites.

Hazardous, mixed, and low-level radioactive wastes generated at SRP include:

- Hazardous and mixed waste combustible oils, solvents, and solids

- Mixed and low-level radioactive solvents, scintillation solutions, contaminated equipment, building rubble, and job control waste

- Mixed waste sludges from effluent-treatment facilities

- Hazardous, mixed, and low-level radioactive ash and scrubber blowdown from incinerators

- Hazardous, mixed, and low-level radioactive waste exhumed from existing waste sites, including contaminated soil

Treatment by effluent treatment facilities using ion exchange, reverse osmosis, neutralization, and filtration to detoxify SRP waste streams is ongoing or planned. In this EIS, this activity is considered "operations." The residuals from these treatment operations are among the wastes considered in this EIS.

All hazardous, mixed, and low-level radioactive wastes are suitable for the application of one or more predisposal treatment technologies. "Predisposal treatment" is the treatment of waste before storage or disposal to reduce volume or alter the chemical or physical characteristics of the waste, rendering it less toxic or more stable.

The following predisposal technologies could be applied to SRP wastes prior to storage or disposal:

- Incineration - Reduces volume, destroys certain hazardous constituents and chemically stabilizes combustible wastes or a combustible fraction. Shredding might be used before incineration.

- Compaction - Reduces volume for compressible wastes; sometimes used in conjunction with shredding.

- Evaporation - Reduces volume and physically stabilizes by removing water or other volatile liquid from a waste until a dry salt remains.

- Solidification - Chemically and physically stabilizes by incorporating waste materials in an insoluble solid or crystalline matrix such as grout or concrete. In this EIS, it is assumed to double the volume of waste.

- Encapsulation - Physically stabilizes waste by enclosing it in a jacket or membrane of impermeable, chemically inert, water-resistant material; increases the disposal volume.

Predisposal treatment substantially affects the volume of waste to be disposed of as well as its characteristics.

Waste disposal and storage volumes and characteristics are important considerations in the design and sizing of a waste management facility. Project-specific detail will be developed during a later stage of planning, in conjunction with the regulatory permitting process and could have a substantial effect on waste disposal and storage volumes. These includethe following:

- A list of existing waste sites at which removal actions are to occur

- A determination based on site field testing and examination of the quantity of waste and/or contaminated soil to be removed to a hazardous, mixed, or low-level facility

- The future availability or integration of predisposal treatment technologies into the management of SRP wastes (see Appendix D)

This EIS describes maximum and minimum waste volumes from assumptions regarding waste removal from existing sites and the volume reduction or expansion effects of predisposal treatment. Table 2-8 indicates the estimated 20-year minimum and maximum volumes of waste as generated.

2.3.3 ALTERNATIVE TECHNOLOGICAL STRATEGIES

The waste management strategies - No Action, Dedication, Elimination, and Combination - could be carried out using many different technologies. The basis for determining the magnitude of environmental impacts limits these technologies to those described in Section 2.3.1. The current planning for new facilities limits the specification of the technologies associated with each strategy; the waste disposal and storage capacities required; the application of predisposal treatment technologies; and costs. This EIS identifies two or

Table 2-8. Estimated Range of Hazardous, Mixed, and Low-Level Radioactive Waste Volumes (cubic meters)

Waste type/source	20-year waste volume generated	Minimum disposal/ storage volume	Maximum disposal/ storage volume
Hazardous			
Operations	2,600	90	2,600
Interim storage	300	60	300
Removal/closure	145,000	0	145,000
Total	147,900	150[a]	147,900[a]
Mixed			
Operations	420,700	34,340	509,700
Interim storage	1,100	160	1,100
Removal/closure	90,400	0	90,400
Total	512,200	34,500[a]	601,200[b]
Low-Level Radioactive			
Operations	403,500	356,690	441,000
Interim storage	200	10	200
Removal/storage	50,600	0	101,200
Total	454,300	356,700[a]	542,400[c]
Waste Total	1,114,400	391,350	1,291,400

[a]Assumes no removal at existing waste sites and maximum volume reduction through predisposal treatment.
[b]Assumes maximum removal at existing waste sites, solidification of ETF sludges, and no volume reduction for remaining waste.
[c]Assumes maximum removal at existing waste sites, solidification where applicable, and no volume reduction for remaining waste.

more technologies, a range of disposal and storage volume capacities, and assumptions on the use and effects of predisposal treatment. The environmental impacts of implementing a strategy (Chapter 4) lie within a range defined for this EIS as the worst case and the best case. If the worst-case (No Action) strategy were to ensure regulatory compliance and an acceptable level of environmental protection, then all others would be acceptable as well. Table 2-9 lists the waste management strategies and their associated technologies (see Sections 2.3.3.1, 2.3.3.2, 2.3.3.3, and 2.3.3.4).

With new waste management facilities, the chosen strategy would involve planning to determine the relationships between waste generators and storage, treatment, and disposal facilities. Planning during the regulatory-permitting process would ensure that designs meet applicable regulations and achieve environmental compliance.

The following sections describe each strategy. Estimates were made of the range of potential disposal and storage capacities required. Costs were estimated on the basis of current planning. Cost ranges are provided only as an indication of the magnitude of potential costs of a strategy, along with a list of additional cost considerations. Costing detail will be considered during planning for the implementation of the chosen strategy. The following sections describe the major advantages and disadvantages of each strategy. (See Appendix E.)

2.3.3.1 No Action

The No-Action strategy, the inclusion of which in this EIS is required by NEPA regulations, discloses the consequences of not constructing new facilities to accommodate future waste management needs. Under this strategy, the SRP would continue to operate and generate wastes, such that applicable regulations and criteria would not be met. Current facilities would be used until capacity is reached, after which containerized waste would be stored indefinitely in existing structures, on existing pads, or in other secure and safe areas.

Under the No-Action strategy, the total 20-year waste volume would range from about 828,300 to 1,114,500 cubic meters, based on the volume of removal from existing waste sites.

Cost estimates for the No-Action strategy bracket the range of waste volume but do not reflect specific costs of the preparation and use of existing structures and areas for storage. These facilities have not been specifically identified or assessed for such use. The estimated waste-management costs for 20 years of the No-Action strategy range from about $160 million to about $290 million. Life-cycle costs cannot be estimated, but they would include the cost of continued storage or of waste retrieval, treatment, and disposal, including closure and postclosure costs of the disposal facility.

The major advantages of the No-Action strategy are a delay in future expenditures for waste-management facilities and the use of structures on the SRP that otherwise would remain unused.

The disadvantages include an unquantified risk of potentially adverse releases of waste due to the lack of adequate waste management facilities. This lack of facilities would not comply with RCRA, DOE Orders, and other applicable

Table 2-9. New Disposal/Storage Facility Alternatives

Waste management strategy	Disposal/storage objective	Disposal/storage technologies		
		Hazardous waste	Mixed waste	Low-level waste
No action	No new facilities	Storage at existing facilities and at other available structures, pads, and areas	Same	Disposal at existing facilities and storage at other available structures, pads, and areas
Dedication	Disposal facilities	RCRA landfill or vaults[a]	RCRA landfill or shielded vaults, with or without CFM vaults	ELLT, vaults, or AGO for low-activity waste; and vaults or GCD for intermediate activity waste
Elimination	Retrievable storage facilities	Storage buildings	Shielded storage buildings	Engineered storage buildings
Combination	Disposal/storage combination	Storage buildings and RCRA landfill or vaults	Shielded storage buildings and RCRA landfill or shielded vaults, with or without CFM vault	Engineered storage buildings; and ELLT, vaults, or AGO for low-activity waste, and vaults or GCD for intermediate activity waste

[a]All vaults may be aboveground or belowground.

regulations. The No-Action strategy is not "reasonable." Finally, No Action would delay expenditures for waste management facilities and require a future investment in waste management.

2.3.3.2 Dedication

The Dedication strategy would involve waste management by construction and operation of waste disposal facilities (i.e., nonretrievable) as listed in Table 2-9. These technologies are described in Section 2.3.1.

Table 2-9 indicates that there are technologies for each waste category. To provide an environmental assessment (see Chapter 4), this section discusses impacts in terms of the best and worst cases.

For hazardous and mixed wastes, RCRA landfills and vault technology were considered to be equal in providing adequate groundwater protection. However, under the mixed waste category, CFM vault technology is potentially less protective of groundwater and was identified for environmental evaluation.

For low-level waste, the vault and GCD technologies for intermediate-activity waste disposal were considered equal for groundwater protection. Among the technologies for low-activity waste disposal, the ELLT technology was considered to be the worst case and was used in the evaluations of environmental impacts.

Dedication would allow the use of predisposal treatment for volume reduction, detoxification, and solidification. The total 20-year disposal volume, therefore, could range between 391,300 and 1,291,500 cubic meters, depending on the predisposal treatments and the volume of waste removed from existing sites.

Cost estimates for the Dedication strategy bracket the waste volume and technologies described above. The 20-year costs are estimated to range from about $143 million to about $1.3 billion, while the life-cycle costs, including postclosure monitoring and maintenance for as long as 100 years, would range from about $275 million to about $1.7 billion. These costs do not include predisposal treatment, with the exception of the CFM vaults, in which cement/flyash solidification is an integral part of the disposal process. There is a cost tradeoff between predisposal treatment to reduce waste volume and the construction and the operation of larger disposal facilities. The lower disposal cost estimate, which assumes predisposal treatment, is low by an amount equal to the cost of such treatment.

The major advantage of the Dedication waste management strategy is that treated or untreated wastes would be disposed of permanently to comply with applicable regulations and environmental standards. The major disadvantages are that the facilities would be costly to construct and operate, the land for disposal would be dedicated in perpetuity, and, in the event of a failure, retrieval of waste packages might be difficult or impossible if practices such as in-place grouting have occurred.

2.3.3.3 Elimination

Waste management under the Elimination strategy would involve construction and operation of retrievable storage facilities for all containerized wastes using storage buildings, as listed in Table 2-9 and described in Section 2.3.1.

The Elimination strategy would supply a benefit from the use of predisposal treatment for volume reduction. An objective is to delay permanent placement in anticipation of future methods of treatment, recycling, or disposal. Caution must be used in the application of predisposal treatment to avoid closing future waste management processes. At present, the predisposal techniques applicable for this EIS produce reductions in volume (compaction).

For waste removed from existing waste sites plus compaction for volume reduction, the total 20-year storage volume is estimated to be between 781,500 and 1,114,500 cubic meters.

The estimated cost for the Elimination strategy ranges from about $1.2 billion to about $1.5 billion for 20 years of storage, excluding the cost of predisposal treatment assumed in the lower figure. Life-cycle costs cannot be estimated, but the 20-year costs would include the cost of continued storage (beyond 20 years) or the cost of waste retrieval, treatment, and disposal, including closure and postclosure costs of the disposal facility.

The major advantages of the Elimination strategy are that no land would be dedicated to waste disposal in perpetuity and that, if a failure occurs, waste recovery and retrieval would be relatively simple. If regulatory waivers were granted, the facilities would be constructed and operated to comply with applicable regulations and environmental standards.

The disadvantages of the Elimination strategy are that the facilities would be costly to construct and operate, and that the waste would not be destroyed, requiring additional expenditures for waste retrieval, treatment, and disposal.

2.3.3.4 Combination

While the management of all waste by disposal (Dedication) or storage (Elimination) is feasible, the management of specific wastes might be more economical, technologically feasible, or more environmentally reliable by combining several strategies into a single strategy. Waste management under the Combination strategy would include the best mix of the disposal and storage technologies listed in Table 2-9 (trenches, vaults, and storage facilities). Section 2.3.1 describes the technologies evaluated in this EIS.

Under the Combination strategy, predisposal treatment for volume reduction, detoxification, and solidification could aid the disposal operations. Compaction is the only predisposal treatment currently applicable to the storage part of the waste management operations. Based on the mix of disposal and storage technologies, the application of predisposal treatment, and volume of waste removed from existing waste sites, the 20-year total disposal/storage volume would range from about 391,300 to 1,291,500 cubic meters of treated and untreated waste.

Cost estimates for the Combination strategy bracket the waste volume and technologies described above. The 20-year costs are estimated to range from about $143 million to about $1.9 billion. Life-cycle costs, assuming a mix of technologies favoring disposal, would range from about $275 million to about $1.7 billion plus the cost of predisposal treatment. Life-cycle costs favoring storage technologies would be the 20-year costs plus the cost of continued storage (beyond 20 years) or the cost of waste retrieval, treatment, and disposal, including postclosure costs of the disposal facility.

The primary advantage of the Combination strategy is that it would select a mix of disposal and storage technologies to optimize performance, recover and retrieve waste, minimize costs, and comply with applicable regulations and environmental standards. The major disadvantages are that some land would be dedicated to waste disposal in perpetuity, it would require future expenditures for treatment and disposal of stored wastes, and all of the facilities would be costly to construct and operate.

2.4 DISCHARGE OF DISASSEMBLY-BASIN PURGE WATER

SRP periodically purges water contaminated with radioactivity from the C-, P-, and K-Reactor disassembly basins, thereby reducing tritium concentrations in the reactor disassembly areas to keep occupational exposures as low as reasonably achievable.

Disassembly-basin water becomes contaminated when tritium and other radionuclides are carried over in process water that adheres to the fuel and target assemblies, and when tritium, as water of hydration, is retained in aluminum oxide on the assemblies. Disassembly-basin water is recirculated through sand filters and deionizers to clarify it and to remove radionuclides; this process does not remove tritium, however, and small residues of other radionuclides also remain. The purge is not continuous, but occurs at a frequency that depends on the type of reactor assemblies and the frequency of assembly discharge operations; typically, the basins are purged twice yearly.

Currently, reactor disassembly-basin water is discharged to C- and P-Area seepage basins and to the K-Area containment basin. The K-Area basin effectively behaves as a seepage basin, and the following discussions treat it as such. Water discharged to the seepage basins either evaporates, carrying tritium to the atmosphere, or migrates to the shallow groundwater, which transports it laterally to outcrop areas along onsite surface streams.

Section 2.4.1 describes the waste management strategies evaluated for the discharge of disassembly-basin purge water.

2.4.1 WASTE MANAGEMENT STRATEGIES

DOE is considering the following strategies for the discharge of reactor disassembly-basin purge water:

- No Action, or continued discharge of disassembly-basin purge water to active reactor seepage and containment basins

- Dedication, the same as No Action

- Elimination, either evaporation of disassembly-basin water or direct discharge to onsite streams

- Combination, (the preferred strategy), continued discharge of disassembly-basin purge water to active reactor seepage basins, and assessment of the applicability of mitigating measures such as moderator detritiation

The following sections describe these strategies:

2.4.1.1 No Action

Under the No-Action waste management strategy, water discharged from reactor disassembly basins would continue to go to reactor area seepage basins. Approximately 30 percent of the tritium released to seepage basins would evaporate, and the remaining tritium and other radionuclides would seep into the groundwater. The other radionuclides would be retarded by adsorption and radioactive decay to insignificant amounts by the time they reached surface water. Tritium, however, would travel directly with the groundwater, decaying during the 4 to 11 years of subsurface transport to outcrops along surface streams.

2.4.1.2 Dedication

The Dedication strategy, like the No-Action strategy, would continue the current practice of periodically discharging disassembly-basin purge water to active reactor seepage and containment basins.

2.4.1.3 Elimination

The Elimination strategy would include evaporation or direct discharge to onsite streams.

Purge water from the reactor disassembly basins could be evaporated with small, commercially available evaporators or with waste heat from the reactors. Tritium would be the only radionuclide released to the atmosphere. Liquid discharges to seepage basins would be discontinued. The only liquid releases to the environment would be residual seepage to streams released to seepage basins before the initiation of the evaporation process.

Small, commercially available equipment, consisting of a storage tank, filters, an evaporator, and a stack with a blower, could be installed in each reactor area. Disassembly-basin water would be purged into large storage tanks, from which the water would be pumped through sand filters and ion-exchange beds to the evaporator. Steam would be used to heat the water, and the tritiated water vapor would be vented to a stack. Air would be added to dilute and disperse the vapor, which would be visible from the stack under all atmospheric conditions.

If reactor waste heat were used, lined evaporation ponds would be constructed in each reactor area. Disassembly-basin purge water discharged to these ponds would evaporate to the atmosphere, carrying tritium with it. Other radionuclides would not evaporate. Evaporation would be accelerated through the use of a grid of underwater pipes heated by waste heat from the area's reactor (Du Pont, 1984b).

As for direct discharge, disassembly-basin purge water, diluted with cooling water, could be discharged to nearby onsite streams. Evaporative losses to the atmosphere would be small. However, the main advantage of seepage-basin use, radioactive decay, would be lost. This would be especially significant for those radionuclides that would have exceptionally long travel times. Concentrations of tritium and other radionuclides in onsite streams and the Savannah River would reach maximums during purges and drop to lower levels afterward.

2.4.1.4 Combination

The Combination waste management strategy includes continued assessment of mitigation measures and discharges of disassembly-basin purge water to seepage basins, as in the No-Action strategy. DOE has considered detritiation of heavy-water reactor moderator at a central facility as a means of mitigating tritium releases from the Savannah River Plant, including those from disassembly-basin discharges. A moderator-detritiation plant (MDP), constructed to process moderator from each SRP reactor, would effectively reduce equilibrium-moderator tritium concentrations. Inasmuch as reactor moderator is the source of disassembly-basin-water contamination, a corresponding reduction in basin-water tritium concentrations, and therefore releases, would be expected.

2.5 SUMMARY AND COMPARISON OF ALTERNATIVE WASTE MANAGEMENT STRATEGIES

This section summarizes and compares the four alternative waste management strategies listed in Table 2-1. It encompasses the range of project-level strategies discussed in this EIS for existing waste sites, new disposal facilities, and disassembly-basin purge water. The No-Action strategy would continue current waste management practices and would not include the establishment of new disposal or storage facilities.

Table 2-10 compares the alternative waste management strategies, including the potential environmental impacts; capital, annual operating, lifetime maintenance and monitoring costs; and closure and postclosure costs where applicable. The table does not list schedules for implementation of any of the alternatives, including the preferred alternative, because of the need to establish priorities for implementation and to pursue further onsite studies and interactions with regulatory agencies. Final remedial and closure actions would be based on more detailed site-specific modeling and monitoring results and regulatory interactions. The strategy decision will precede any project-specific decisions.

DOE has identified the Combination waste management strategy as its preferred alternative. This strategy complies with applicable environmental regulations and guidelines through a combination of Dedication at some existing waste sites and Elimination of other selected waste sites, and combined storage and disposal of hazardous, low-level radioactive, and mixed wastes. DOE's preferred strategy is based on project-specific actions, including removal of wastes at selected existing waste sites; groundwater remedial and closure

Table 2-10. Comparison of Alternative Waste Management Strategies

Impact		No action	Dedication	Elimination	Combination (preferred alternative)
Preliminary capital cost (million $)	EWS[a]	$2.2	$180	$11,700	$215
	NDF[b]	$160	$170-280, plus cost of pretreatment	$1,100-1,600, plus cost of pretreatment	$170-1,900, plus cost of pretreatment.
	DBPW[c]	$0	$0	$0-Direct discharge $7.5-Evaporation	$125
Estimated annual operating cost increases (million $)	EWS	[d]	[d]	[d]	[d]
	NDF	$7-13, plus cost of cleanup and damages from accidents	$12-20	$5.5-9.8	$12-20
	DBPW	$0	$0	$0-Direct discharge $0.3-Evaporation	$6
Lifetime maintenance and monitoring (million $)	EWS	$670	$670	$670	$670
	NDF	Cost of waste management eventually required	-	Cost of retrieval, treatment, and disposal after 20 years	-
	DBPW	-	-	-	-
Closure and post-closure	NDF	-	$270-800	-	$100-800, plus cost of retrieval and disposal.
Site dedication	EWS	Dedication of currently inactive sites required if groundwater constituents exceeded regulatory limits and sites could not be returned to public use.	Existing waste sites and contaminated areas that could not be returned to public use after a 100-year institutional period period would become dedicated sites.	No site dedication (except outfall delta at TNX) is expected because waste and contaminated soil would be be removed to the extent practical.	Sites from which waste would be removed could be returned to public use after 100-year control period; sites from which waste would not be removed would be dedicated for waste management purposes if they could not be returned to public use.

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Table 2-10. Comparison of Alternative Waste Management Strategies (continued)

Impact		No action	Dedication	Elimination	Combination (preferred alternative)
	NDF	Indefinite period of waste storage; site dedication would be required as long as wastes remained in the storage facility or if site were to become contaminated by accidental release.	Site dedication would require up to 400 acres, plus buffer zones around the facilities. These areas are 0.2 percent of total SRP natural area.	Site dedication not required. Sites used for storage would be returned to a natural condition or reclaimed for other nonrestricted uses.	Disposal facilities would be dedicated for waste management purposes. Up to 400 acres, plus buffer zones, would be required. Sites for the retrieval storage portion available for other use after wastes are removed to permanent facilities.
	DBPW	Seepage and containment basins would be dedicated as needed.	Same.	Site dedication not needed; seepage basins for discharge would eventually be eliminated under either modification. Closure and remedial actions, as required, would return these areas to public use after the 100-year control period.	Seepage and containment basins would be dedicated as needed.
Groundwater	EWS	Hazardous and radionuclide constituents might exceed applicable standards or guidelines in water-table aquifers at certain sites, but offsite groundwater quality would be protected.	Closure and groundwater remedial actions as required would reduce contaminant concentrations to acceptable standards. Groundwater drawdown effects would be localized and transitory. Observation of these effects would be performed. Observation of these effects would be performed.	Removal of hazardous and radioactive wastes from all sites, closure, and remedial actions as required would reduce contaminant concentrations to acceptable standards. Groundwater drawdown effects would be localized and transitory. Observation of these effects would be performed.	Removal of hazardous and radioactive wastes from selected sites, closure, and remedial actions as required would reduce contaminant concentrations to acceptable standards. Groundwater drawdown effects would be localized and transitory.

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Table 2-10. Comparison of Alternative Waste Management Strategies (continued)

Impact		No action	Dedication	Elimination	Combination (preferred alternative)
	NDF	Wide range of short-term impacts possible.	New aboveground and belowground disposal facilities would be designed to meet applicable EPA or DOE standards or guidelines (essentially zero release or ALARA). No adverse groundwater effects expected.	Retrievable storage facilities would be designed with zero release or ALARA features to detect and contain spills and leaks. No adverse groundwater effects expected.	All new disposal and storage facilities would be designed for essentially zero or ALARA releases. No adverse groundwater effects expected.
	DBPW	Existing discharge to groundwater and effects would continue.	Same.	Either direct discharge to onsite streams or evaporation would eliminate added impact on groundwater.	Existing discharges to groundwater and effects would continue or, with detritiation, be reduced by about a factor of 2 on the average over the 26-year period.
Surface water	EWS	Four Mile Creek expected to show elevated concentrations of nitrate and tritium.	Some improvement in surface-water quality as a result of closure and remedial actions.	Improvement in surface-water quality as a result of waste removal, closure, and remedial actions.	Same.
	NDF	Surface streams could be affected by accidental releases of stored wastes.	No significant impacts expected.	Same.	Same.
	DBPW	Existing surface water effects from groundwater outcrops at onsite streams would continue.	Same.	The direct discharge alternative would increase surface-water tritium concentrations due to loss of decay period; the evaporation alternative would decrease surface-water tritium concentrations.	Existing surface water effects from groundwater outcrops at onsite streams would continue.
Health effects	EWS	Adverse health effects are predicted to occur to a hypothetically maximally exposed individual onsite after a 100-year period of institutional control.	No significant increase in health effects with implementation of closure and groundwater remedial actions.	No significant increase in health effects, but occupational exposure would be high at all sites with waste removal closure and remedial actions.	No significant increase in health effects with waste removal at selected sites and closure and remedial actions.

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Table 2-10. Comparison of Alternative Waste Management Strategies (continued)

Impact		No action	Dedication	Elimination	Combination (preferred alternative)
	NDF	Health effects would result from accidental releases of hazardous chemicals or radionuclides from stored wastes. Level of risk has wide range.	The essentially zero or ALARA release design would prevent radionuclide and hazardous chemical health effects.	Same.	Same.
	DBPW	No significant health effects from continued discharge to seepage basins.	Same.	Health effects not expected to change significantly.	No significant health effects from continued discharge to seepage basins.
Aquatic ecology	EWS	Offsite ecosystems would not be significantly affected. Onsite ecosystems would continue to function with minor impacts.	Closure and groundwater remedial actions as required would reduce potential impacts.	Removal of wastes from all sites to secure disposal facilities and closure and groundwater remedial actions as required would reduce potential impacts.	Removal of wastes at selected sites, closure and remedial actions as required would reduce potential impacts.
	NDF	A range of short-term aquatic impacts possible under the accidental release scenarios.	No impacts expected.	No impacts expected.	No impacts expected.
	DBPW	Minor aquatic impacts would continue under continued discharge to seepage basins.	Same.	No impacts expected.	Minor aquatic impacts would continue under continued or reduced discharge to seepage basins.
Terrestrial ecology	EWS	Offsite terrestrial ecology would be protected. Onsite natural succession would continue. Open sites might cause some floral and faunal impacts.	Direct exposures to open waste sites and groundwater associated impacts would be eliminated as a result of closure and remedial action as required. Use of borrow pits would create minor short-term impacts.	Direct exposures and groundwater-associated impacts would be eliminated as a result of waste removal closure and remedial actions as required. Large backfill requirements would increase potential impacts at borrow pits.	Terrestrial impacts due to direct exposure to open waste sites and groundwater-associated impacts would be eliminated as a result of waste removal at selected sites and closure and remedial actions as required. Use of borrow pits for backfill in closure actions would create minor short-term impacts.

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Table 2-10. Comparison of Alternative Waste Management Strategies (continued)

Impact		No action	Dedication	Elimination	Combination (preferred alternative)
	NDF	A range of short-term terrestrial impacts possible assuming accidental releases of present and future wastes stored.	New belowground and aboveground disposal facilities would require clearing and development of land. No contaminant-related impacts expected.	Construction of retrievable storage sites would require clearing and development of land. No contaminant-related impacts expected.	Combination modifications would require clearing and development of land. No contaminant-related impacts expected, due to zero release or ALARA design features.
	DBPW	No significant impacts.	No significant impacts.	Minor impacts to terrestrial ecosystems could result from liquid releases to onsite streams through direct discharge.	No significant impacts.
Habitats/wetlands	EWS	Previously disturbed habitats would be impacted further. Some recovery of habitat could occur at inactive sites. Minor wetlands impacts from some sites could continue.	Short-term habitat disruption could occur at borrow pit areas. Some sites could require erosion control measures during closure.	Same.	Same.
	NDF	Accidental releases of hazardous chemicals and radionuclides could have short-term impacts on wetlands and habitat.	Loss of habitat of up to 400 acres, or 0.2 percent of total SRP natural area.	Same.	Same.
	DBPW	No significant impacts.	No significant impacts.	Increased liquid releases through direct discharge could have minor impacts on existing habitat and wetlands.	No significant impacts.
Endangered species	EWS	No impacts.	No impacts.	No impacts.	No impacts.

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Table 2-10. Comparison of Alternative Waste Management Strategies (continued)

Impact		No action	Dedication	Elimination	Combination (preferred alternative)
	NDF	No impacts.	No impacts.	No impacts.	No impacts.
	DBPW	No impacts.	No impacts.	No impacts.	No impacts.
Archaeological and historic sites	EWS	No impacts.	No impacts expected from remedial and closure action.	Same.	Same.
	NDF	No impacts.	One candidate site would require additional archaeological survey.	Same.	Same.
	DBPW	No significant impacts.	No significant impacts.	No significant impacts.	No significant impacts.
Socioeconomics	EWS	No impacts.	No impacts.	No impacts.	No impacts.
	NDF	No impacts.	No impacts.	No impacts.	No impacts.
	DBPW	No impacts.	No impacts.	No impacts.	No impacts.
Noise	EWS	No significant impacts.	No significant impacts.	No significant impacts.	No significant impacts.
	NDF	No significant impacts.	No significant impacts.	No significant impacts.	No significant impacts.
	DBPW	No significant impacts.	No significant impacts.	No significant impacts.	No significant impacts.
Accidents/occupational risks	EWS	Waste transport disposal at unpermitted and storage sites includes risks of fires, spills, leaks, and exposure of onsite workers.	Accidents are related to transportation of back-fill and capping materials for closure modifications. No wastes would be transported.	Waste removal and transport to retrievable storage sites by vehicle includes risks of fires, spills, leaks, and exposure of onsite workers. Significant worker exposures possible.	Waste removal and transport to storage and disposal sites by vehicle includes risks of fires, spills, leaks, and exposure of onsite workers.
	NDF	Waste transport to storage facilities includes risks of fires, spills, leaks, and exposure of onsite facility workers.	Accidents involving spills, leaks, and fires could occur during handling.	High-integrity containers, spill recovery, and other secure provisions would reduce impacts from accidents.	Same.

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Table 2-10. Comparison of Alternative Waste Management Strategies (continued)

Impact	No action	Dedication	Elimination	Combination (preferred alternative)
DBPW	No significant occupational risks.	Same.	Same.	Same.

[a]EWS = existing waste sites.
[b]NDF = new disposal/storage facilities.
[c]DBPW = disassembly-basin purge water.
[d]No operating costs for existing waste sites; the only costs would be for maintenance and monitoring.

actions at existing waste sites, as required; construction of a combination of retrievable storage, aboveground, and belowground disposal facilities for hazardous, mixed, and low-level radioactive wastes; management of periodic discharges of disassembly-basin purge water from active reactors by discharging filtered, deionized disassembly-basin purge water to seepage and containment basins; and continuing evaluation of tritium-mitigation measures. Tables 2-11 and 2-12 list the project-specific actions for new low-level radioactive waste disposal facilities and the discharge of disassembly-basin purge water, respectively.

The following sections provide summaries and more detailed comparisons of the ranges of environmental impacts and costs associated with each of the waste management strategies.

2.5.1 SUMMARY OF ALTERNATIVE WASTE MANAGEMENT STRATEGIES

2.5.1.1 No-Action Strategy

The No-Action strategy would continue current activities for existing hazardous, low-level radioactive, and mixed waste sites. It would be inconsistent with DOE's policy of complying with all applicable requirements, including groundwater protection. Therefore, it is not considered a "reasonable" approach for those waste sites that are within the scope of this EIS.

New Disposal Facilities

The No-Action alternative would involve no new facilities, such as sites, buildings, landfills, vaults, engineered trenches, and boreholes. For the purposes of this analysis, DOE assumed that the SRP would continue to operate and generate wastes. Existing SRP facilities would be used until their capacities were reached, and then structures, pads, or areas with minimal preparation for indefinite waste storage would be used.

Due to the risk of environmental releases of waste, and because the waste management practices described for No-Action would not comply with applicable regulations, the No-Action alternative strategy is not considered acceptable.

Discharge of Disassembly-Basin Purge Water

The No-Action alternative would continue the present practice of periodic discharges of disassembly-basin purge water to active reactor seepage and containment basins. This would allow retardation on soil and radioactive decay during travel through groundwater to reduce radioactive releases to the environment. The maximum individual and collective doses of the No-Action alternative would be low and would amount to a very small fraction of the dose from natural background radiation. Because seepage basins are already in use for this purpose, there would be no additional cost of implementation.

2.5.1.2 Dedication Strategy

Existing Waste Sites

Closure with no removal of waste (Dedication strategy) would have the least cost, the lowest occupational risks, and the least disturbance of terrestrial ecology. The Dedication strategy would have the greatest potential to require

Table 2-11. Comparison of Project-Specific Actions - New Disposal Facilities

Impact	No action	Action		
	No new disposal facilities	Aboveground or below-ground disposal	Retrievable storage	Aboveground or below-ground disposal and retrievable storage
Preliminary capital cost (million $)	$160	$170-280, plus cost of pretreatment.	$1,100-1,600, plus cost of pretreatment.	$170-1,900, plus cost of pretreatment.
Estimated annual operating cost increases (million $)	$7-13, plus cost of cleanup and damages from accidents	$12-20	$5.5-9.8	$12-20
Lifetime maintenance and monitoring (million $)	Cost of waste management eventually required.	-	Cost of retrieval, treatment, and disposal after 20 years.	-
Closure and post-closure (million $)	-	$270-800	-	$100-800, plus cost of retrieval and disposal.
Site dedication	Indefinite period of waste storage; site dedication would be required as long as wastes remained in the storage facility or if site were to become contaminated by accidental release.	Site dedication would require up to 400 acres, plus buffer zones around the facilities. These areas are 0.2 percent of total SRP natural area.	Site dedication not required. Sites used for storage would be returned to a natural condition or reclaimed for other nonrestricted uses.	Disposal facilities would be dedicated for waste management purposes. Up to 400 acres, plus buffer zones, would be required. Sites for the retrieval storage portion available for other use after wastes are removed to permanent facilities.
Groundwater	Wide range of short-term impacts possible.	New aboveground and belowground disposal facilities would be designed to meet applicable EPA or DOE standards or guidelines (essentially zero release or ALARA). No adverse groundwater effects expected.	Retrievable storage facilities would be designed with zero release or ALARA features to detect and contain spills and leaks. No adverse groundwater effects expected.	All new disposal and storage facilities would be designed for essentially zero or ALARA releases. No adverse groundwater effects expected.

Table 2-11. Comparison of Project-Specific Actions - New Disposal Facilities (continued)

Impact	No action: No new disposal facilities	Action: Aboveground or below-ground disposal	Retrievable storage	Aboveground or below-ground disposal and retrievable storage
Surface water	Surface streams could be affected by accidental releases of stored wastes.	No significant impacts expected.	Same.	Same.
Health effects	Health effects would result from accidental releases of hazardous chemicals or radionuclides from stored wastes. Level of risk has wide range.	The essentially zero or ALARA release design would prevent radionuclide and hazardous chemical health effects.	Same.	Same.
Aquatic ecology	A range of short-term aquatic impacts possible under the accidental release scenarios.	No impacts expected.	No impacts expected.	No impacts expected.
Terrestrial ecology	A range of short-term terrestrial impacts possible assuming accidental releases of present and future wastes stored.	New belowground and aboveground disposal facilities would require clearing and development of land. No contaminant-related impacts expected.	Construction of retrievable storage sites would require clearing and development of land. No contaminant-related impacts expected.	Combination modifications would require clearing and development of land. No contaminant-related impacts expected, due to zero release or ALARA design features.
Habitats/wetlands	Accidental releases of hazardous chemicals and radionuclides could have short-term impacts on wetlands and habitat.	Loss of habitat of up to 400 acres, or 0.2 percent of total SRP natural area.	Same.	Same.
Endangered species	No impacts.	No impacts.	No impacts.	No impacts.
Archaeological and historic sites	No impacts.	One candidate site would require additional archaeological survey.	Same.	Same.
Socioeconomics	No impacts.	No impacts.	No impacts.	No impacts.
Noise	No significant impacts.	No significant impacts.	No significant impacts.	No significant impacts.

Table 2-11. Comparison of Project-Specific Actions - New Disposal Facilities (continued)

Impact	No action	Action		
	No new disposal facilities	Aboveground or below-ground disposal	Retrievable storage	Aboveground or below-ground disposal and retrievable storage
Accidents/occupational risks	Waste transport to storage facilities includes risks of fires, spills, leaks, and exposure of onsite facility workers.	Accidents involving spills, leaks, and fires could occur during handling.	High-integrity containers, spill recovery, and other secure provisions would reduce impacts from accidents.	Same.

Table 2-12. Comparison of Project-Specific Actions - Discharge of Disassembly - Basin Purge Water

Impact	No action	Action		
	Continued discharge to seepage basins	Continued discharge to seepage basins	Direct discharge to onsite streams or evaporation	Continued discharge to seepage basins and study of other mitigation measures
Preliminary capital cost (million $)	$0	$0	$0-Direct discharge $7.5 Evaporation	$125 (moderator detritiation)
Estimated annual operating cost increases (million $)	$0	$0	$0-Direct discharge $0.3-Evaporation	$6
Site dedication	Seepage and containment basins would be dedicated as needed.	Same.	Site dedication not needed; seepage basins for discharge would eventually be eliminated under either modification. Closure and remedial actions, as required, would return these areas to public use after the 100-year control period.	Seepage and containment basins would be dedicated as needed.
Groundwater	Existing discharge to groundwater and effects would continue.	Same.	Either direct discharge to onsite streams or evaporation would eliminate added impact on groundwater.	Existing discharges to groundwater and effects would continue or, with detritiation, be reduced by about a factor of 2 on the average over the 26-year period.
Surface water	Existing surface water effects from groundwater outcrops at onsite streams would continue.	Same.	The direct discharge alternative would increase surface-water tritium concentrations due to loss of decay period; the evaporation alternative would decrease surface-water tritium concentrations.	Existing surface water effects from groundwater outcrops at onsite streams would continue.
Health effects	No significant health effects from continued discharge to seepage basins.	Same.	Health effects not expected to change significantly.	No significant health effects from continued discharge to seepage basins.

Table 2-12. Comparison of Project-Specific Actions - Discharge of Disassembly - Basin Purge Water (continued)

Impact	No action	Action		
	Continued discharge to seepage basins	Continued discharge to seepage basins	Direct discharge to onsite streams or evaporation	Continued discharge to seepage basins and study of other mitigation measures
Aquatic ecology	Minor aquatic impacts would continue under continued discharge to seepage basins.	Same.	No impacts expected.	Minor aquatic impacts would continue under continued or reduced discharge to seepage basins.
Terrestrial ecology	No significant impacts.	No significant impacts.	Minor impacts to terrestrial ecosystems could result from liquid releases to onsite streams through direct discharge.	No significant impacts.
Habitats/wetlands	No significant impacts.	No significant impacts.	Increased liquid releases through direct discharge could have minor impacts on existing habitat and wetlands.	No significant impacts.
Endangered species	No impacts.	No impacts.	No impacts.	No impacts.
Archaeological and historic sites	No significant impacts.	No significant impacts.	No significant impacts.	No significant impacts.
Socioeconomics	No impacts.	No impacts.	No impacts.	No impacts.
Noise	No significant impacts.	No significant impacts.	No significant impacts.	No significant impacts.
Accidents/occupational risks	No significant occupational risks.	Same.	Same.	Same.

groundwater corrective action, and as many as 77 waste sites that were not suitable for public use after the institutional control period would have to be dedicated to waste management uses, involving about 300 acres of SRP land.

New Disposal Facilities

The Dedication strategy would involve deposition of hazardous, mixed, and low-level radioactive wastes in permanent disposal facilities constructed on or under the ground surface. Hazardous and mixed waste would be disposed of in above- or below-ground double-lined vaults or RCRA-type landfills with double liners and leachate-collection systems and other features meeting the requirements of RCRA, HSWA, and DOE Orders. A technology applicable to a select portion of the mixed waste stream involves solidification of the waste and discharge into cement/flyash matrix vaults. This technology assumes that the mixed waste can be rendered nonhazardous by solidification and delisted under RCRA. Low-level radioactive wastes would be disposed of in facilities meeting the requirements of DOE Orders, including ELLTs for low-activity wastes (less than 300 millirem per hour), in GCD for intermediate-activity wastes (greater than 300 millirem per hour), in a shielded above- or below-grade vault, or by stacking contained wastes in an AGO constructed at grade on a pad without a building or vault.

Discharge of Disassembly-Basin Purge Water

The Dedication strategy for the discharge of disassembly-basin purge water would continue the current practice of discharging the purge water to active reactor seepage and containment basins.

2.5.1.3 Elimination Strategy

Existing Waste Sites

Removal of wastes at all waste sites (Elimination strategy) would involve very high closure expense, occupational risks, disturbance of terrestrial ecology, and cost of new retrievable storage facilities for the exhumed materials. No SRP land would be required for dedication to waste management uses, however, other than an outfall delta near the old TNX seepage basin.

New Disposal Facilities

The retrievable-storage alternative (Elimination strategy) encompasses technologies using structures designed to accommodate a specific type of waste (e.g., hazardous, mixed, and low-level waste). The retrievable-storage alternatives for hazardous and mixed wastes are similar in technology and would meet applicable standards. These facilities would be designed to achieve essentially zero releases, thereby producing no significant adverse environmental impacts. In the case of mixed waste, in addition to meeting RCRA requirements, they would shield radiation sources. The technologies for low-level waste would consist of engineered storage of waste with various degrees of isolation and shielding to accommodate different levels and types of radioactivity. These facilities would meet the ALARA requirements of DOE Orders.

Discharge of Disassembly-Basin Purge Water

Under the Elimination strategy, use of the active reactor seepage and containment basins would be discontinued and the purge water would be either discharged directly to surface streams currently receiving purge water via outcrops, or evaporated to the atmosphere. Although discharges to seepage basins would be discontinued immediately, releases to surface streams from residual seepage from prior use would continue for several years. The maximum individual dose from direct discharge would be low but would average about four times the corresponding No-Action or the evaporation doses. Average collective dose for direct discharge would be more than double that of No-action, while evaporation would produce about one-third the No-Action collective dose. The advantages of direct discharge are ease of implementation, insignificant cost, and no need to dedicate the seepage basins and surrounding areas.

2.5.1.4 Combination Strategy

Existing Waste Sites

The primary considerations in choosing the Combination strategy (the DOE-preferred alternative) are the reduced environmental effects and occupational risks from remedial and closure actions, the cost of remedial and closure actions, the capacity and cost of new storage and disposal facilities, and the amount of land, if any, that would be dedicated for waste management purposes at the end of the institutional control period.

Waste removal prior to closure is identified on a preliminary basis for those selected sites at which such removal is predicted to reduce significantly the peak concentrations of waste constituents in groundwater; other waste sites would be closed without waste removal and dedicated for waste management purposes. All sites would receive groundwater corrective actions as required. This strategy would provide the same degree of environmental protection and produce fewer ecological and occupational risks at a substantially lower cost than the Elimination strategy. Substantially less land area would have to be dedicated for waste management purposes than under the Dedication strategy.

New Disposal Facilities

The Combination strategy for new disposal facilities would apply a combination of retrievable storage and aboveground or belowground disposal technologies. Its objective would be to optimize the management of wastes with different characteristics within the hazardous, mixed, and low-level radioactive waste streams generated at the SRP. This strategy would comply with the requirements of RCRA, HSWA, and DOE Orders.

The technologies available for shallow land disposal of hazardous, mixed, and low-level wastes involve permanent deposition of wastes below the ground surface. Hazardous and mixed waste facilities are required to meet RCRA and HSWA minimum technology standards, while low-level waste facilities must meet the technology standards under DOE Orders.

Discharge of Disassembly-Basin Purge Water

The Combination strategy includes continued discharge of disassembly-basin purge water to active reactor seepage and containment basins and the continuation of the pursuit of studies of reactor moderator detritiation or other mitigation measures. Moderator detritiation is discussed below to provide an upper boundary of costs.

2.5.2 COSTS

The costs for each waste management strategy include preliminary capital costs, estimated annual operating costs, and lifetime maintenance and monitoring costs, along with closure and postclosure costs where applicable.

Existing Waste Sites

For existing waste sites, capital costs for removal of wastes and closure actions, as required, range from about $2.2 million for the No-Action strategy to about $11.7 billion for removal of waste to the extent practicable at all sites (Elimination strategy). The major part of the estimated cost is for the removal of wastes at the low-level radioactive burial grounds. The estimated costs for existing waste site removal and closure do not include potentially required groundwater corrective actions (e.g., recovery and treatment, installation of barrier walls, or grout curtains). Unit costs for these operations are available but, because site-specific remedial action requirements have not been determined, they have not been calculated.

Annual operating, lifetime maintenance, and monitoring costs for existing waste sites are the same for any of the alternative strategies. Lifetime maintenance and monitoring costs are estimated at $670 million for existing waste sites. Most of this cost ($650 million) is for the low-level radioactive waste burial grounds.

New Disposal Facilities

Estimated capital costs for new disposal facilities range from about $22 million for the No-Action strategy to about $1.6 billion for the Combination strategy, including both retrievable storage and disposal technologies.

Estimated operating costs at new disposal facilities range from about $5.5 million for the Elimination strategy to a maximum of about $20 million for the Combination strategy, excluding costs for predisposal treatment.

Discharge of Disassembly-Basin Purge Water

There would be no increase in costs for the direct discharge of disassembly-basin purge water to onsite streams or to the active reactor seepage basins. Costs for capital installations are estimated to be about $7.5 million for evaporation, with annual operating costs estimated at about $0.3 million.

The estimated capital cost of constructing and operating a detritiation facility is about $125 million, with an annual operating cost of about $6 million. In a 20-year operating period, total facility costs would be about $250 million. The detritiation facility would serve four reactors (C, K, L, and

P). Because this EIS addresses only three of these reactors, (C, K, and P), about 75 percent of the total amount is applicable to this analysis. On the basis of these cost values and the dose commitments of this and the No-Action strategy over the entire 26-year study period (see Section 4.4.1), the cost per person-rem averted would exceed $3 million.

2.5.3 SITE DEDICATION

2.5.3.1 Existing Waste Sites

Under the No-Action strategy, dedication of currently inactive sites would be required if groundwater constituents exceeded regulatory limits.

The Dedication strategy would require that contaminated areas remaining at existing waste sites not be returned to public use; they would be dedicated for waste management purposes. About 300 acres of SRP land would be involved.

For the Elimination strategy at existing waste sites, no site dedication is expected (except for an outfall delta adjacent to the old TNX seepage basin) because waste and contaminated soil would be removed to the extent practicable. Sites could be used for purposes other than waste management after the 100-year institutional control period.

Under the Combination strategy, sites from which waste had been removed could be returned to public use after the 100-year control period; sites from which waste had not been removed would be dedicated for waste management purposes if they could not be returned to public use.

2.5.3.2 New Disposal Facilities

The No-Action strategy includes an indefinite period of waste storage; site dedication is required only as long as wastes remain in the storage facility or potentially in the event of an accidental release.

Under the Dedication strategy, new disposal facilities would require up to 400 acres, plus buffer zones around the facilities. These areas are insignificant (0.2 percent) in terms of total available SRP natural areas.

Site dedication is not required under the Elimination strategy. Stored wastes would be retrieved and disposed of permanently. The sites used for storage could be returned to a natural condition or be reclaimed for other nonrestricted uses after waste retrieval is completed, although land would be required for disposal sites.

Under the Combination strategy, disposal facilities would be dedicated for waste management purposes. Up to 400 acres, plus buffer zones, would be required. The retrieval storage portion could be returned to other use after wastes are removed to permanent disposal facilities, which would require additional (but currently unknown) land areas.

2.5.3.3 Discharge of Disassembly-Basin Purge Water

Under the No-Action strategy, active reactor seepage and containment basins would continue operating as at present. At the end of the 100-year control period, the basins would be dedicated for waste management purposes as needed if they could not be returned to public use.

Seepage basins for discharge of disassembly-basin purge water would eventually be eliminated under the direct-discharge or the evaporation alternative. Closure and remedial actions could return these areas to public use after the 100-year institutional control period.

2.5.4 GROUNDWATER IMPACTS

Under the No-Action strategy, groundwater in Tertiary (shallow) formations would continue to show chemical and radionuclide concentrations exceeding applicable standards or guidelines in some onsite areas. In addition to any removal and closure actions implemented at existing waste sites, remedial actions could be required to bring groundwater constituent concentrations into compliance with the applicable standards or guidelines.

Groundwater withdrawal as part of a required remedial action could have small effects on Tertiary aquifers under the three waste management strategies. Observations of a number of wells in areas involved in groundwater pumping would be maintained to determine the extent of drawdown effects.

New disposal and storage facility construction and operations are not expected to affect groundwater under any of the waste management strategies, because they would be designed to be essentially zero or ALARA. No Action, by comparison, would pose the greatest risk of short-term groundwater impacts from accidental releases of stored wastes.

Only implementation of the Elimination strategy for disassembly-basin purge-water discharges would halt the release of tritium to the groundwater; other strategies would continue the present minor onsite groundwater impacts.

Offsite groundwater impacts are not expected under any of the waste management strategies for existing waste site removal, closure, and remedial actions or for construction or operation of new disposal and storage facilities, because groundwater flow paths are intercepted by onsite surface streams and the Savannah River; under the No-Action strategy, DOE is committed to maintaining offsite groundwater quality.

2.5.5 SURFACE-WATER IMPACTS

Surface-water quality would be improved under the three waste management strategies because of groundwater remedial actions at existing waste sites. Under the No-Action strategy, nitrate and tritium would exhibit elevated levels in Four Mile Creek.

New disposal-facility construction and operation are not expected to impact surface streams because of essentially zero or ALARA designs. The No-Action strategy (i.e., continued temporary storage of wastes) has the greatest potential to impact surface streams as a result of accidental releases of stored wastes.

Concentrations of tritium in surface water would increase with direct discharge of disassembly-basin purge water because of a loss of delay time in transit. Under the No-Action, Dedication, or Combination strategy, releases would remain at existing levels.

2.5.6 PUBLIC HEALTH EFFECTS

At existing waste sites, adverse health effects to a hypothetical maximally exposed individual resulting from the No-Action strategy are estimated to occur onsite in the year 2085, assuming termination of institutional control at that time. The Dedication, Elimination, or Combination strategy coupled with potentially required groundwater remedial actions would pose no significant increase in health effects.

A wide range of health effects from accidental releases of stored wastes could occur under the No-Action strategy. The essentially zero or ALARA release designs of new disposal or storage facilities would greatly reduce both hazardous chemical and radiological health effects.

No significant adverse health effects would result from continued discharge of disassembly-basin purge water to seepage basins.

2.5.7 AQUATIC ECOLOGY

Under the No-Action strategy, offsite ecological systems would be protected and onsite streams would continue to show some minor impacts. The Dedication, Elimination, or Combination waste management strategy at existing waste sites would have an overall benefit by eliminating any minor impacts to onsite aquatic ecosystems.

The Dedication, Elimination, and Combination waste management strategies (essentially zero or ALARA designs) for new disposal facilities preclude aquatic ecosystem impacts, but the No-Action strategy could cause a range of short-term aquatic effects from accidental releases.

The Elimination waste management strategy (direct discharge of disassembly-basin purge water to onsite streams) has the greatest potential for aquatic impact. Evaporation to the atmosphere would reduce potential aquatic impacts. Continuation of discharges to seepage basins (No-action, Dedication, or Combination waste management strategy) would continue the current minor level of impacts.

2.5.8 TERRESTRIAL ECOLOGY

Under the No-Action strategy for existing waste sites, offsite terrestrial ecosystems would be protected. Existing open or active sites could have some floral or faunal impacts. The Dedication, Elimination, or Combination waste management strategy would eliminate impacts due to direct exposure to contaminated materials or groundwater. Clearing and development of land are required for construction of new disposal facilities; however, no impacts are expected from hazardous or radioactive contaminants at these facilities because of the essentially zero or ALARA designs of these strategies. Short-term impacts could result from accidental releases of wastes stored under the No-Action strategy.

The discharge of disassembly-basin purge water to seepage basins would cause no significant impacts to terrestrial ecosystems. Under the Elimination waste management strategy, direct discharge of disassembly-basin purge water to onsite streams would increase tritium concentrations and potential impacts, but evaporation would increase atmospheric releases and decrease liquid releases.

2.5.9 HABITAT/WETLANDS

Under the No-Action strategy, previously disturbed habitats would not be disturbed further. Some habitat recovery could occur at closed and inactive waste sites, and potentially minor impacts to wetlands could occur from some sites. Short-term habitat disruption could occur under the Dedication, Elimination, or Combination waste management strategy because of the use of borrow pits for backfill. Wetlands are sufficiently removed from most existing waste sites that any impacts would be minimal. Some sites could require special erosion-control measures during closure to prevent impacts.

DOE estimates that habitat losses from new waste management facility construction could range from less than 50 acres to about 400 acres, depending on the technology adopted and the waste volumes.

Impacts to habitat and wetlands would be insignificant under the No-Action strategy for discharge of disassembly-basin purge water. Direct discharge (Elimination waste management strategy) would increase tritium releases to onsite streams.

2.5.10 ENDANGERED SPECIES

No impacts to endangered species are expected as a result of the implementation of any of the strategies, because no species have been observed in the vicinity of existing waste sites.

Sites being considered for locations of new disposal facilities are not near any known critical habitat for endangered species; such species have not been sighted near storage facilities, and no impacts are expected.

No impacts to endangered species are expected through any of the disassembly-basin purge-water strategies, because the basins do not serve as habitats for these species.

2.5.11 ARCHAEOLOGICAL AND HISTORIC SITES

No archaeological or historic sites are located near existing waste sites. One archaeological site is near a candidate site for a new disposal/storage facility and would require an additional survey. No archaeological or historic sites would be affected by disassembly-basin purge-water discharge actions; there are no sites in the vicinity of seepage basins.

2.5.12 SOCIOECONOMICS

No impacts are expected for any of the waste management strategies for existing waste sites, new disposal facilities, or disassembly-basin purge-water discharge. The peak workforce is not expected to exceed 200 workers, all of whom would be drawn from the existing workforce.

2.5.13 NOISE

Noise impacts on the Plant from the implementation of the waste management strategies would be minor and short-term. Offsite impacts would be insignificant, due to the distance to the SRP boundary and buffering effects. The No-Action strategy would not increase noise above its current level.

2.5.14 ACCIDENTS/OCCUPATIONAL RISKS

Accident probabilities and occupational risks result from the transport of wastes from existing waste sites where removal would occur; from movement of backfill and capping materials; from fires, spills, and leaks; and from exposure of onsite workers. Special precautions would be required for protection of workers at the low-level radioactive waste burial grounds if the wastes were removed. Accidents at new disposal facilities could involve spills, leaks, and fires; the range of impacts would depend on the volumes and types of wastes handled. The use of high-integrity containers, spill recovery, and other secure waste-disposal provisions would reduce the numbers and impacts of accidents.

No significant occupational risks are expected under any strategy for the discharge of disassembly-basin purge water.

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CHAPTER 3

AFFECTED ENVIRONMENT

This chapter describes the existing environment of the Savannah River Plant (SRP) and the nearby region that would be affected by the following modifications considered in this environmental impact statement (EIS):

- Implementation of remedial and closure actions at hazardous, low-level radioactive, and mixed waste sites.
- Establishment of new onsite disposal facilities for hazardous, low-level radioactive, and mixed wastes.
- Potential changes in the discharge of disassembly-basin purge water from C-, K-, and P-Reactors to seepage basins.

3.1 GEOGRAPHY

3.1.1 LOCATION

The Savannah River Plant is located in southwestern South Carolina and occupies an almost circular area of approximately 780 square kilometers (192,700 acres). Figure 3-1 shows the SRP location in relation to major population centers in South Carolina and Georgia. The major physiographic feature is the Savannah River, which forms the southwestern boundary of the Plant and is also the South Carolina-Georgia border. The Plant occupies parts of three South Carolina counties (Aiken, Barnwell, and Allendale).

3.1.2 SITE DESCRIPTION AND LAND USE

The U.S. Government established the SRP area in the 1950s for the production of nuclear materials for national defense. The Plant is a controlled area with limited public access. The facilities, which can be characterized as heavy industry, occupy less than 5 percent of the SRP area.

Figure 3-2 shows the locations of major SRP facilities. C-, P-, K-, and L-Reactors are operating, and R-Reactor is in standby status. The facilities for fabricating fuel and the target elements to be irradiated in SRP reactors are in M-Area. Two chemical-separations areas (F and H) process irradiated materials. One centrally located site, the Burial Ground, is used to store solid low-level radioactive waste; it occupies approximately 200 acres between F- and H-Areas. The Savannah River Laboratory (SRL), adjacent to A-Area, is a process-development laboratory that supports production operations. Other facilities include a heavy-water extraction and recovery plant (D-Area) in standby condition, except for rework; production-design test facilities (CMX-TNX Area); construction shops (CS-Area) for support; and administration areas (A-Area).

In addition, the U.S. Department of Energy (DOE) is constructing two facilities near the chemical-separations areas. The Defense Waste Processing Facility (DWPF) will immobilize high-level radioactive waste into a solid,

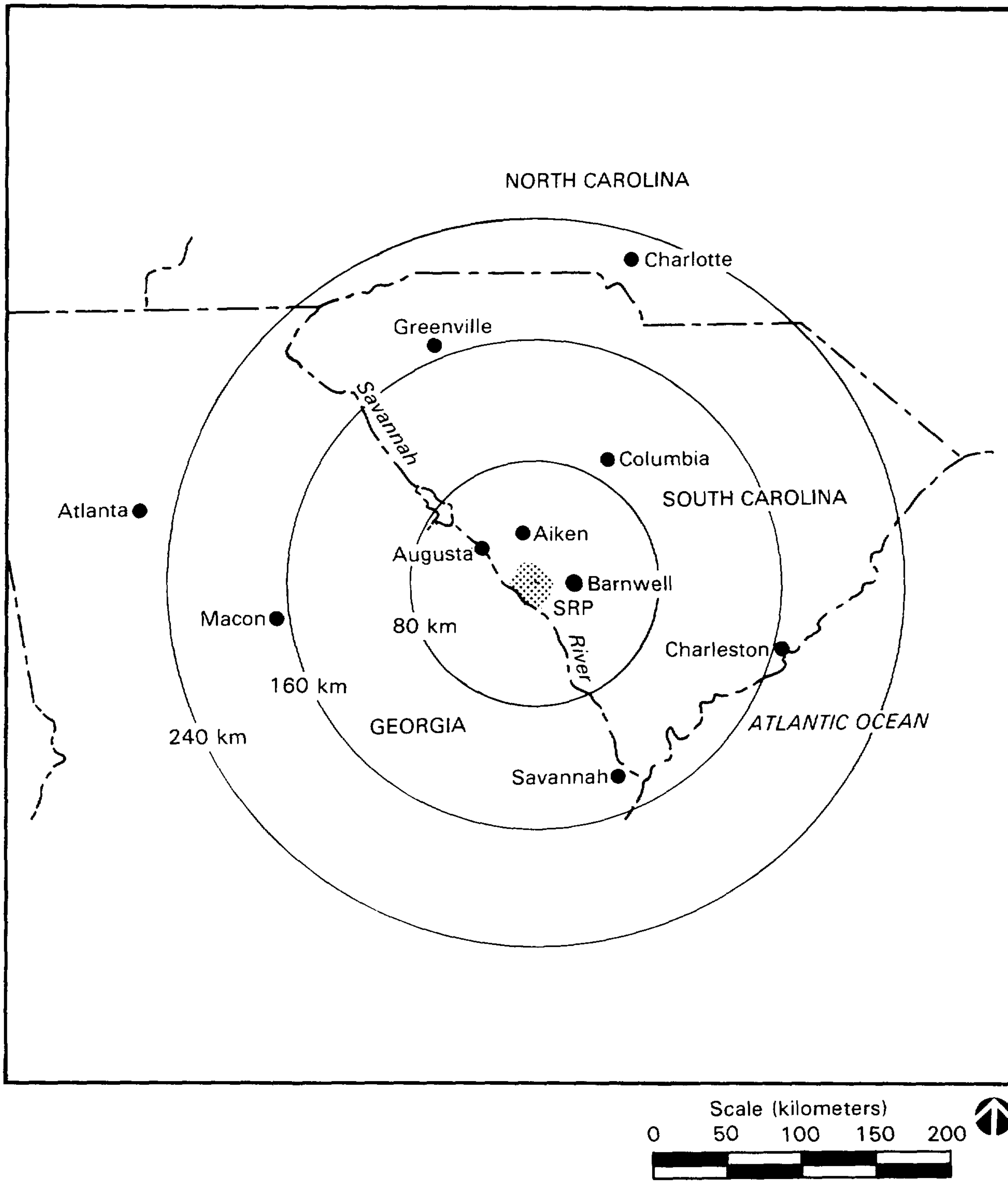
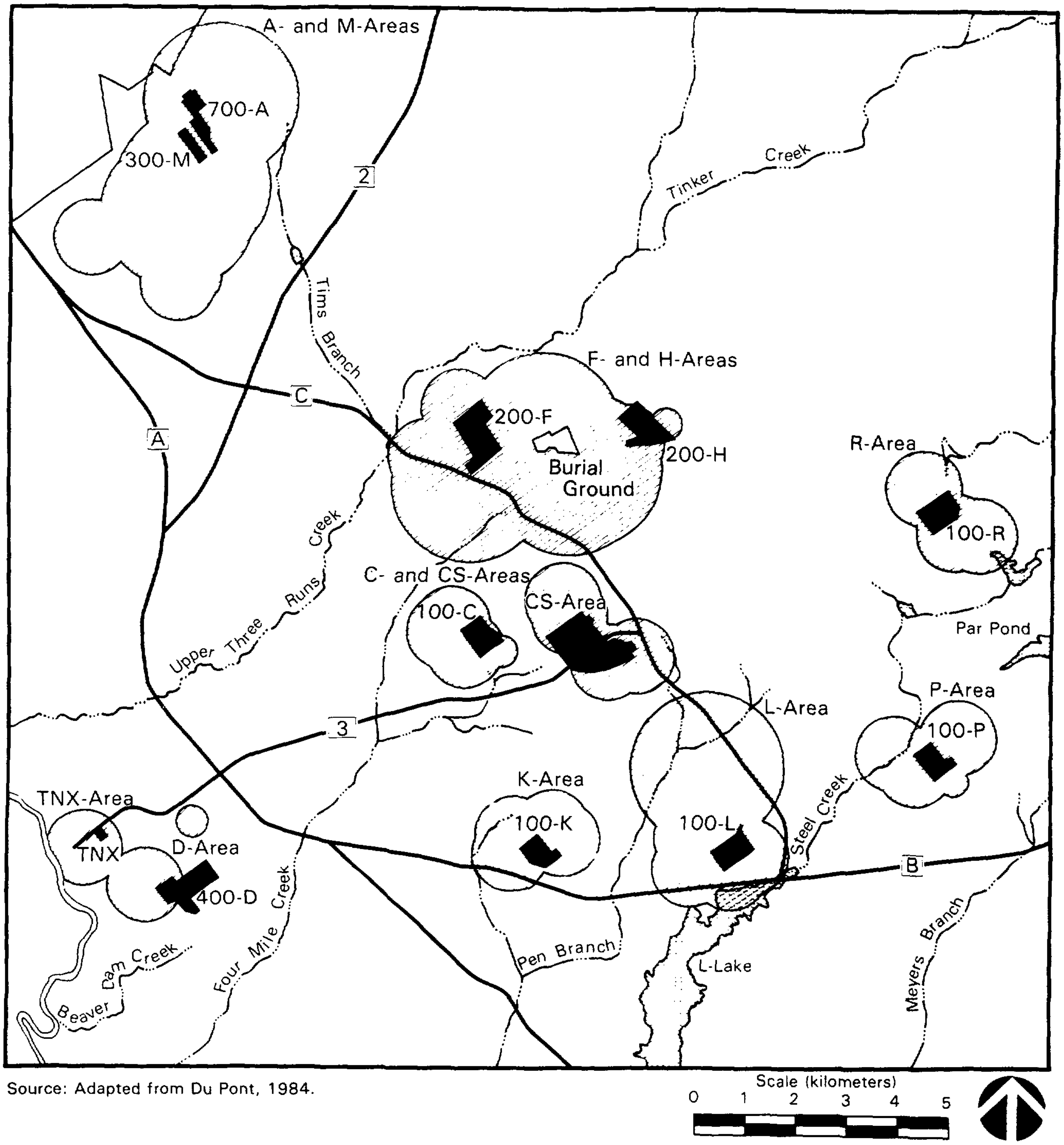


Figure 3-1. SRP Location in Relation to Surrounding Population Centers



Source: Adapted from Du Pont, 1984.

Figure 3-2. Portion of Savannah River Plant Site

nonleachable borosilicate glass waste form. The Naval Reactor Fuel Material Facility (FMF) will produce nuclear fuel for the U.S. Navy.

(Present and previous land use characteristics of the SRP are described in Dukes, 1984.)

3.1.3 SOCIOECONOMIC AND COMMUNITY CHARACTERISTICS

DOE produced a comprehensive description of socioeconomic and community characteristics for the area around the Savannah River Plant in Socioeconomic Baseline Characterization for the Savannah River Plant Area, 1981 (ORNL, 1981). The information in this report was updated in Socioeconomic Data Base Report for Savannah River Plant (DOE, 1984a), and additional information on the topics presented in this section can be found in the updated report.

3.1.3.1 Study Area

Approximately 97 percent of SRP employees reside in a 13-county area around the Plant. Of these 13 counties, 9 are in South Carolina and 4 are in Georgia. The operating and construction force on the Plant has averaged 7500, ranging from a low of 6000 in the 1960s to the current 15,500 (August 1985). About 97 percent of this total are employed by E. I. du Pont de Nemours and Company and its subcontractors; the remainder are employed by the U.S. Department of Energy, the University of Georgia, the U.S. Forest Service, and Wackenhut Services, Inc.

The area that has felt the greatest impact of the Savannah River Plant has been Aiken County, especially the City of Aiken and the small towns immediately around the SRP site. SRP workers and families comprise roughly one-half of the City of Aiken's 15,000 people and account in large measure for the high median family incomes in Aiken County.

The greatest percentage of employees reside in the six-county area of Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia. Together, these six counties house approximately 89 percent of the total SRP workforce. DOE chose these six counties as the study area for the assessment of potential socioeconomic and community effects of the proposed waste management alternatives because the percentage of employees residing in them has remained essentially the same since the early 1960s.

3.1.3.2 Demography

Table 3-1 lists the 1980 populations in the study area for counties and places of more than 1000 persons. The largest cities in the study area are Augusta in Georgia, and Aiken, North Augusta, and Barnwell in South Carolina. Of the 31 incorporated communities in the study area, 16 have populations under 1000 persons, and 11 have populations between 1000 and 5000 persons. Aiken, Columbia, and Richmond Counties, which comprise the Augusta Standard Metropolitan Statistical Area (SMSA), have a total population of about 327,400; however, most of this population resides outside cities or towns. About two-thirds of the total six-county population reside in rural or unincorporated areas.

Table 3-1. 1980 Population for Counties and Places of 1000 Persons or More[a]

Location	1980 population
Aiken County, South Carolina	105,625
City of Aiken	14,978
Town of Jackson	1,771
City of North Augusta	13,593
City of New Ellenton	2,628
Allendale County, South Carolina	10,700
Town of Allendale	4,400
Town of Fairfax	2,154
Bamberg County, South Carolina	18,118
Town of Bamberg	3,672
City of Denmark	4,434
Barnwell County, South Carolina	19,868
City of Barnwell	5,572
Town of Blackville	2,840
Town of Williston	3,173
Columbia County, Georgia	40,118
City of Grovetown	3,384
City of Harlem	1,485
Richmond County, Georgia	181,629
City of Augusta	47,532
Town of Hephzibah	1,452
Study area total	376,058

[a]Adapted from Bureau of the Census, 1982a,b.

In 1980, the estimated population in the 80-kilometer area around the Savannah River Plant was approximately 563,300 persons. The estimated population for the year 2000 in this area is 852,000 persons. This estimate was calculated using the 1970-to-1980 growth rate of each county in the 80-kilometer area and assuming these growth rates would continue in the future. For counties that experienced a negative population growth rate between 1970 and 1980, the calculation assumed that continued population decline would not occur. This total county population estimate for the year 2000 is approximately 12 percent higher than the estimates prepared by the States, based on a comparison with projections prepared by Georgia and South Carolina (ORNL, 1981).

3.1.3.3 Land Use

In the study area near SRP, less than 8 percent of the existing land use is devoted to urban and built-up uses. Most such uses are in and around the Cities of Augusta and Aiken. Agriculture accounts for about 21 percent of total land use; forests, wetlands, water bodies, and unclassified lands that are predominantly rural account for about 70 percent.

The projected future land uses of the study area are similar to existing land-use patterns. Developed urban land is projected to increase by 2 percent in the next 20 years. The largest percentage of this growth is expected to occur in Aiken and Columbia Counties as a result of the expansion of the Augusta metropolitan area (ORNL, 1981).

3.1.3.4 Public Services and Facilities

The study area has nine public school systems. Each county has a county-wide school district except Bamberg, which has two districts, and Barnwell, which has three. In 1982, these districts could accommodate an estimated 3642 new students.

Of the 120 public water systems in the study area, 30 county and municipal systems serve about 75 percent of the population. The other 90 systems are generally smaller and serve individual subdivisions, mobile home parks, or commercial and industrial enterprises. All but four of the municipal and county water systems - the Cities of Aiken, Augusta, and North Augusta, and Columbia County - obtain their water from deep wells. Aiken obtains some of its water from Shaws Creek and Shiloh Springs, while Columbia County and the Cities of Augusta and North Augusta obtain water from the Savannah River upstream of SRP. Restrictions in system capabilities for municipal and county water systems that use groundwater as their supply are due primarily to storage and treatment capacity rather than availability of groundwater.

Most municipal and county wastewater-treatment systems have the capacity to treat additional sewage. Some rural municipalities in Allendale, Bamberg, and Columbia Counties and the City of Augusta in Richmond County have experienced problems in treatment-plant capacities. Programs to upgrade facilities are under way or planned in most of these areas.

3.1.3.5 Housing

Since 1970, the largest increases in the number of housing units have occurred in Columbia, Richmond, and Aiken Counties. Columbia County has grown the fastest, more than doubling its number of housing units. Between 1970 and 1980, Aiken and Richmond Counties both experienced about a 36-percent increase in the number of housing units. In Aiken County, one-fourth of this increase resulted from the high growth rate in the number of mobile homes.

The vacancy rate for owner-occupied housing units for the six-county area in 1980 was 2.3 percent. Individual county rates ranged from 3.6 percent in Columbia County to 0.8 percent in Barnwell County. Vacancy rates for rental units in 1980 ranged from 14.8 percent in Columbia County to 7.1 percent in Bamberg County; the rate in 1980 for the study area was 10.5 percent.

3.1.3.6 Economy

The results of the 1980 Census of Population indicate, between 1970 and 1980, a 35-percent increase in total employment, from 75,732 to 102,326, in establishments with payrolls in the six-county area. Service sector employment increased at these establishments by 65 percent, mirroring a national trend toward a service-based economy. Employment in manufacturing increased by 27 percent, adding more than 9000 employees. Most of the overall expansion in the number of employment positions occurred in Richmond and Aiken Counties.

About 31 percent of the workforce in the six-county area in 1980 was employed in the service sector, and 27 percent in the manufacturing sector. Retail trade was the third largest category, accounting for 15 percent of the workforce. The remaining 25 percent of the workforce was distributed among the seven additional categories of employment reported by the Census. In 1980, fewer than 2 percent of workers in the study area were employed in the category of agriculture, forestry, and fishing, while nearly 4 percent were employed in that category in 1970.

Employed residents of Richmond and Aiken Counties accounted for about 77 percent of the study area's employed population in 1980. The largest sectors of employment for these counties were services and manufacturing. The three counties with the smallest populations and workforce numbers (Allendale, Bamberg, and Barnwell) are also more rural and had a higher proportion of workers engaged in agriculture. In these three counties, however, agriculture employs 11 percent or less of the workforce, while the service and manufacturing sectors employ relatively large percentages of the workforce.

The study area's per capita income level increased from 22 percent below the national average in 1969 to 18 percent below in 1979. Of the six counties, all but Richmond showed a gain in per capita income relative to the national average during the 10-year period.

3.1.4 HISTORIC AND ARCHAEOLOGICAL RESOURCES

As of February 1986, 76 sites in the six-county study area were listed in the National Register of Historic Places. Richmond County had the largest number of sites (27), most of which are in the City of Augusta. Thirty-five National Register sites are in Aiken and Allendale Counties. The remaining 14 sites are scattered throughout the remaining three-county area.

A recent effort undertaken for this environmental impact statement (EIS) involved an intensive archaeological and historical survey of 82 waste sites, which was conducted from October 1985 through January 1986. This survey discovered one prehistoric site (38BR584), represented by an isolated, Early Archaic hafted biface from an area adjacent to the P-Area Burning/Rubble Pit. Due to its limited extent and disturbed context, this site is not considered to be potentially eligible for the National Register of Historic Places. DOE has requested concurrence with its determination of "no effect" on any archaeological or historic resources resulting from activities associated with the proposed closure of the 82 waste sites to the State Historic Preservation Officer (Brooks, 1986).

3.2 METEOROLOGY AND CLIMATOLOGY

This section describes of the meteorology of the Savannah River Plant, based on data collected at SRP and at Bush Field, Augusta, Georgia (Du Pont, 1980a, 1982a; Hoel, 1983; NOAA, 1985). Meteorological tapes for 1975 through 1979 from the onsite meteorological program provided additional data for this characterization.

3.2.1 REGIONAL CLIMATOLOGY

The SRP has a temperate climate, with mild winters and long summers. The region is subject to continental influences, but it is protected from the more severe winters in the Tennessee Valley by the Blue Ridge Mountains to the north and northwest. The SRP and the surrounding area are characterized by gently rolling hills with no unusual topographical features that would significantly influence the general climate.

Winters are mild and, although cold weather usually lasts from late November to late March, less than one-third of the days have a minimum temperature below freezing.

3.2.2 LOCAL METEOROLOGY

3.2.2.1 Average Wind Speed and Direction

The average wind speed measured in Augusta from 1951 to 1981 was 3.0 meters per second. The average recorded at a height of 10 meters on the WJBF-TV tower near Beech Island, about 15 kilometers northwest of the SRP, from 1976 to 1977 was 2.5 meters per second. Table 3-2 lists the average monthly wind speed for Augusta, Georgia, along with the prevailing wind direction for each month. This table also lists the monthly and annual average wind speeds for three levels of the television tower.

On an annual basis, the predominant wind direction is west-northwest to east-southeast, with a secondary maximum of east-northeast to west-southwest. In general, seasonal transport is as follows: winter, northwest to southeast; spring, west to east; summer, toward the southwest through north to northeast; and autumn, toward the southwest and southeast. Because pollutant dispersion depends on atmospheric stability, annual wind roses are available for each SRP tower for seven Pasquill-type stability classes; seasonal wind roses are also available (Hoel, 1983).

3.2.2.2 Precipitation

The average annual rainfall at the SRP from 1952 through 1982 was about 122 centimeters (Table 3-3). The average at Augusta's Bush Field from 1951 to 1980 was about 112 centimeters (NOAA, 1985). The maximum monthly precipitation was about 31.3 centimeters, recorded in August 1964. Hourly observations in Augusta show that the intensity of rainfall is normally less than 1.3 centimeters per hour.

Table 3-2. Average Monthly Wind Speed for Bush Field, Augusta, Georgia, 1951-1981, and WJBF-TV Tower, 1976-1977[a]

Month	Bush Field: Mean speed (m/sec)	Bush Field: Prevailing direction	WJBF-TV Tower elevation (m): 10	36	91
Jan.	3.2	W	3.0	4.5	6.1
Feb.	3.4	WNW	2.9	4.6	5.8
Mar.	3.6	WNW	3.3	4.5	5.9
Apr.	3.4	SE	2.8	4.2	5.4
May	2.9	SE	2.5	3.7	5.0
June	2.8	SE	2.4	4.0	4.8
July	2.6	SE	2.0	3.1	4.4
Aug.	2.5	SE	2.1	3.2	4.3
Sept.	2.5	NE	2.1	3.3	4.7
Oct.	2.6	NW	2.4	4.1	5.6
Nov.	2.8	NW	2.4	4.1	5.6
Dec.	3.0	NW	2.7	4.4	6.3
Annual	3.0	SE	2.5	3.9	5.3

[a]Source: Du Pont, 1983a.

3.2.3 SEVERE WEATHER

3.2.3.1 Extreme Winds

The strongest winds in the SRP area occur in tornadoes, which can have wind speeds as high as 116 meters per second. The next strongest surface winds occur during hurricanes. During the history of the SRP, only Hurricane Gracie, in September 1959, had winds in excess of 34 meters per second. Winter storms with winds as high as 32 meters per second have been recorded occasionally (Du Pont, 1982a). Thunderstorms can generate winds as high as 18 meters per second and even stronger gusts. The highest 1-minute wind speed recorded at Augusta between 1951 and 1984 was 28 meters per second. Table 3-4 lists the extreme wind speeds for 50- and 100-year return periods for three locations about equally distant from the SRP (Simiu, Changery, and Filliben, 1979).

3.2.3.2 Thunderstorms

There is an average of 54 thunderstorm days per year at the SRP. The summer thunderstorms occur primarily during the late afternoon and evening; they may be accompanied by strong winds, heavy precipitation, or, less frequently, hail (NOAA, 1985). Summer thunderstorms are attributable primarily to convective activity resulting from solar heating of the ground and radiational cooling of cloud tops. Thunderstorm activity in the winter months is attributable mainly to frontal activity.

Table 3-3. Precipitation at Savannah River Plant, 1952-1982[a]

Month	Monthly precipitation (cm) Maximum	Minimum	Average
Jan.	25.5	2.3	10.7
Feb.	20.2	2.4	11.2
Mar.	27.8	3.8	13.0
Apr.	20.8	1.4	9.1
May	27.7	3.4	10.6
June	27.7	3.9	11.2
July	29.2	2.3	12.5
Aug.	31.3	2.6	11.8
Sept.	22.1	1.4	10.2
Oct.	27.6	0.0	6.2
Nov.	16.4	0.5	6.2
Dec.	24.3	1.2	9.5
Annual			122.2

[a]Source: Du Pont, 1983a.

Table 3-4. Extreme Wind Speeds for SRP Area (meters per second)[a]

Station	Return period 50-Year	100-Year
Greenville, S.C.	35	38
Macon, Ga.	30	31
Savannah, Ga.	35	39

[a]Adapted from Simiu, Changery, and Filliben, 1979.

3.2.3.3 Tornadoes

In the Southeastern United States, most tornadoes occur in early spring and late summer, with more than 50 percent occurring from March through June. In South Carolina, the greatest percentage of tornadoes occurs in April and May, about 20 percent (Pepper and Schubert, 1978) in August and September. The latter are spawned mainly by hurricanes. One or two tornadoes can be expected in South Carolina during April and May, with one expected each in March, June, July, August, and September (Purvis, 1977).

Weather Bureau records show 278 tornadoes in Georgia over the period from 1916 to 1958 and 258 in South Carolina for the period from 1950 to 1980 (Table 3-5) (Hoel, 1983). The general direction of travel of confirmed tornado tracks in Georgia and South Carolina is southwest to northeast.

Table 3-5. Tornado Occurrence by Month[a]

Month	Georgia (1916-1958)		South Carolina (1950-1980)	
	Number	Percent	Number	Percent
Jan.	24	8.6	6	2.3
Feb.	23	8.3	14	5.4
Mar.	49	17.6	26	10.1
Apr.	93	33.5	40	15.5
May	20	7.2	53	20.5
June	14	5.0	20	7.8
July	5	1.8	17	6.6
Aug.	10	3.6	25	9.7
Sept.	8	2.9	23	8.9
Oct.	2	0.7	8	3.1
Nov.	15	5.4	11	4.3
Dec.	15	5.4	15	5.8
Total	278		258	

[a]Source: Hoel, 1983.

Occasional tornadoes occur in the SRP area. Investigations of tornado damage near the SRP in 1975 and 1976 indicated wind speeds varying from 45 to 78 meters per second (Du Pont, 1980b). The most recent occurrence of a tornado striking the SRP was on April 23, 1983 (Garrett, 1983).

3.2.3.4 Hurricanes and High Winds

Thirty-eight damaging hurricanes have occurred in South Carolina during the 272 years of record (1700 to 1972); the average frequency was one storm every 7 years. These storms occurred predominantly during August and September. At the SRP, 160 kilometers inland, hurricane wind speeds are significantly lower than those observed along the coast. Winds of 34 meters per second were measured on the 61-meter towers only once during the history of the SRP, when Hurricane Gracie passed to the north on September 29, 1959 (Du Pont, 1982b).

3.2.3.5 Precipitation Extremes

Heavy precipitation can occur in the SRP area in association with either localized thunderstorms or hurricanes. The maximum 24-hour total was about 15.2 centimeters, which occurred during August 1964 in association with Hurricane Cleo.

3.2.4 ATMOSPHERIC DISPERSION

3.2.4.1 Atmospheric Stability

The transport and dispersion of airborne material are direct functions of air movement. Transport direction and speed are governed by the general patterns of airflow (and by the nature of the terrain), whereas the diffusion of airborne material is governed by small-scale, random eddying of the atmosphere (i.e., turbulence). Turbulence is indicated by atmospheric stability classification. The atmosphere in the SRP region is unstable approximately 25 percent of the time, it is neutral 25 percent of the time, and it is stable about 50 percent of the time.

3.2.4.2 Air Quality

The States of South Carolina and Georgia have established air-quality-sampling networks. The SRP operates an onsite sampling network. These networks monitor suspended particulates, sulfur dioxide, and nitrogen dioxide. In 1984, ambient concentrations of these pollutants near the SRP were below the local air-quality standards in effect at that time (Du Pont, 1985a).

3.3 GEOLOGY AND SEISMOLOGY

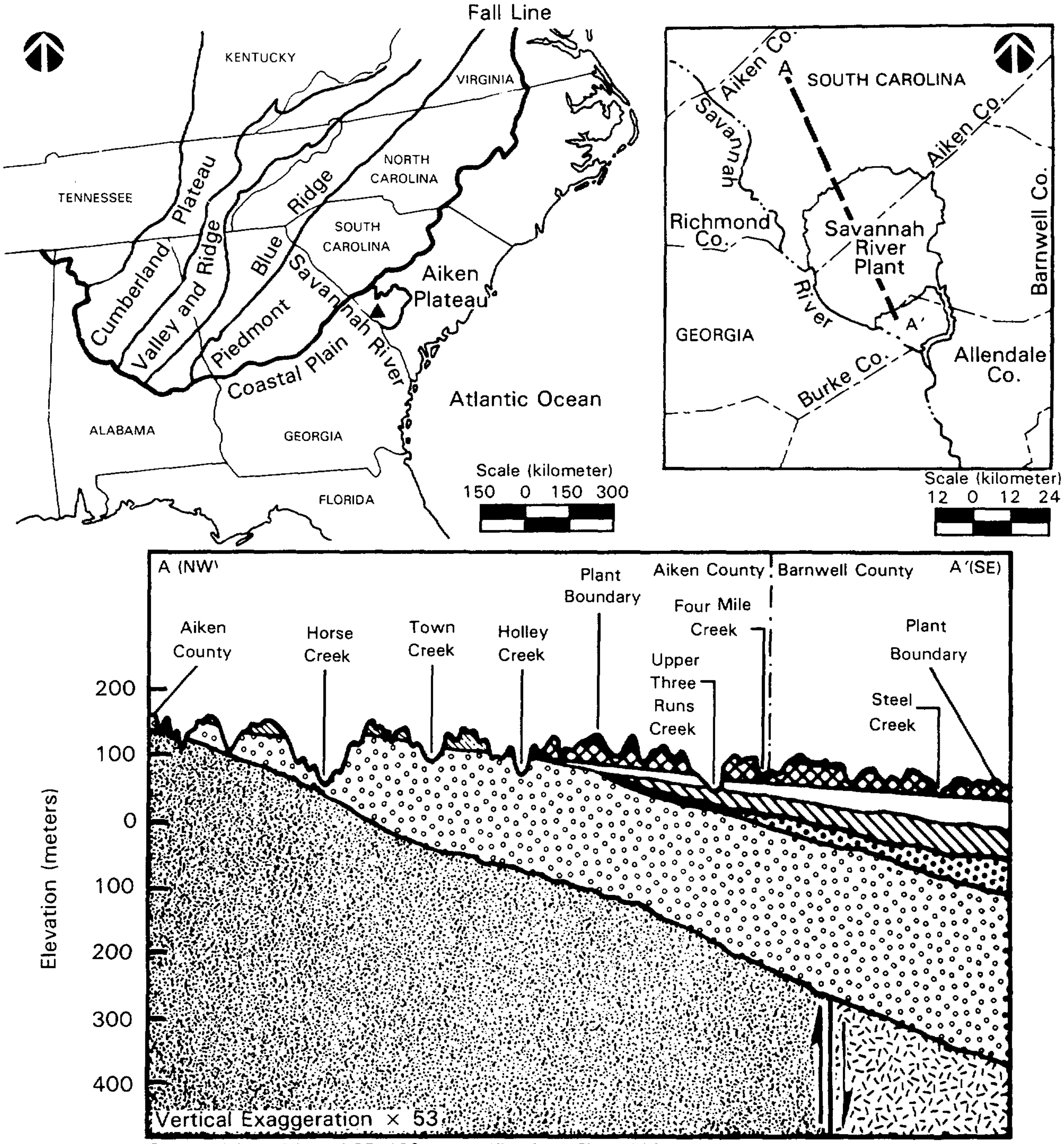
This section describes the important geologic features in the region surrounding the SRP. These features include the regional geologic setting, seismology, and geologic hazards. Appendix A contains more detailed information.

3.3.1 REGIONAL GEOLOGIC SETTING

3.3.1.1 Tectonic Provinces

The North American continent is divided tectonically into foldbelts of recent or ancient deformation, and into platform areas where flat-lying or gently tilted rocks lie on basements of earlier foldbelts (King, 1969). The Southeastern United States contains two platform areas, the Cumberland Plateau province and the Coastal Plain province, and three foldbelts, the Blue Ridge province, the Valley and Ridge province, and the Piedmont province (Figure 3-3).

The SRP is located in the Aiken Plateau physiographic division of the Upper Atlantic Coastal Plain province of South Carolina (Cooke, 1936; Du Pont, 1980a). The center of the Plant is about 40 kilometers southeast of the Fall Line (Davis, 1902) that separates the Atlantic Coastal Plain tectonic province from the Piedmont tectonic province. Crystalline rocks of Precambrian and Paleozoic age underlie a major portion of the gently seaward-dipping Coastal Plain sediments of Cretaceous and younger age. Sediment-filled basins of Triassic and Jurassic age (exact age is uncertain) occur within the crystalline basement throughout the coastal plain of Georgia and the Carolinas (Du Pont, 1980a). One of these, the Dunbarton Triassic Basin, underlies parts of the Plant (Marine and Siple, 1974; Du Pont, 1980a; Stephenson, Talwani, and Rawlins, 1985).



Source: Adapted from DOE, 1984b; modified from Siple, 1967; formation terminology after Siple, 1967; see Figure 3-4.

Scale (kilometer)
0 8 16

Legend:

- Hawthorn (Fluvial Upland Unit)
- McBean
- Ellenton
- Barnwell
- Congaree
- Tuscaloosa
- Tertiary rocks undifferentiated
- Crystalline metamorphic rock
- Dunbarton Triassic Basin

Figure 3-3. Generalized Northwest to Southeast Geologic Profile and SRP Regional Site Locator

3.3.1.2 Stratigraphy*

Coastal Plain sediments in South Carolina range in age from Cretaceous to Quaternary; they form a seaward-dipping, thickening, mostly unconsolidated wedge. Near the center of the Plant at H-Area, these sediments are approximately 280 meters thick (Siple, 1967). The base of the sedimentary wedge rests on a Precambrian and Paleozoic crystalline basement, which is similar to the metamorphic and igneous rocks of the Piedmont, and on the siltstone, claystone, and conglomerates of the down-faulted Dunbarton Triassic Basin. Immediately overlying the basement is the Middendorf/Black Creek (Tuscaloosa) Formation (175 meters thick), which is of the Upper Cretaceous age, and which is composed of water-bearing sands and gravels separated by prominent clay units. Overlying the Middendorf/Black Creek is the Ellenton Formation, which is about 18 meters thick and consists of sands and clays interbedded with coarse sands and gravel. Four of the formations shown in Figure 3-3, the Congaree, McBean, Barnwell, and Hawthorn (formation terminology after Siple, 1967), comprise the Tertiary (Eocene and Miocene) sedimentary section, which is about 85 meters thick and consists predominantly of clays, sands, clayey sands, and sandy marls. A calcareous zone in the lower portion of the McBean Formation is associated with void spaces in locations south and east of Upper Three Runs Creek (COE, 1952). The near-surface sands of the Barnwell and Hawthorn Formations generally are loosely consolidated; they can contain thin, sediment-filled fissures (clastic dikes) (Siple, 1967; Du Pont, 1980a). Quaternary alluvium is found at the surface in floodplain areas and as terrace deposits.

3.3.1.3 Geomorphology

The SRP is on the Aiken Plateau (Cooke, 1936), which slopes from an elevation of approximately 200 meters at the Fall Line to an elevation of about 75 meters to the southeast. The surface of the Aiken Plateau, which is highly dissected, is characterized by broad, interfluvial areas and narrow, steep-sided valleys. Because of SRP's proximity to the Piedmont region, it has somewhat more relief than the near-coastal areas, with onsite elevations ranging from 27 to 128 meters above sea level. Relief on the Aiken Plateau is as much as 90 meters locally (Siple, 1967). The plateau is generally well-drained although small, poorly drained depressions occur; these depressions are similar to Carolina bays.

The Aiken Plateau has several southwest-flowing tributaries to the Savannah River. These streams commonly have asymmetrical valley cross-sections, with

*The accepted names for stratigraphic units have evolved over the years as additional information on the age of the units and their correlation with similar units in other areas has surfaced. This is reflected in the different names used by authors to identify subsurface units. The stratigraphic nomenclature used in this document is the same as the usage of the various authors whose works have been referenced. Therefore, different portions of the text might use different names for the same geologic units. Similarly, the same name might be used for geologic units or portions of units that are otherwise different. Figure 3-4 shows the correlation of the units used by the various authors. The terminology used in this document is largely that of Siple (1967).

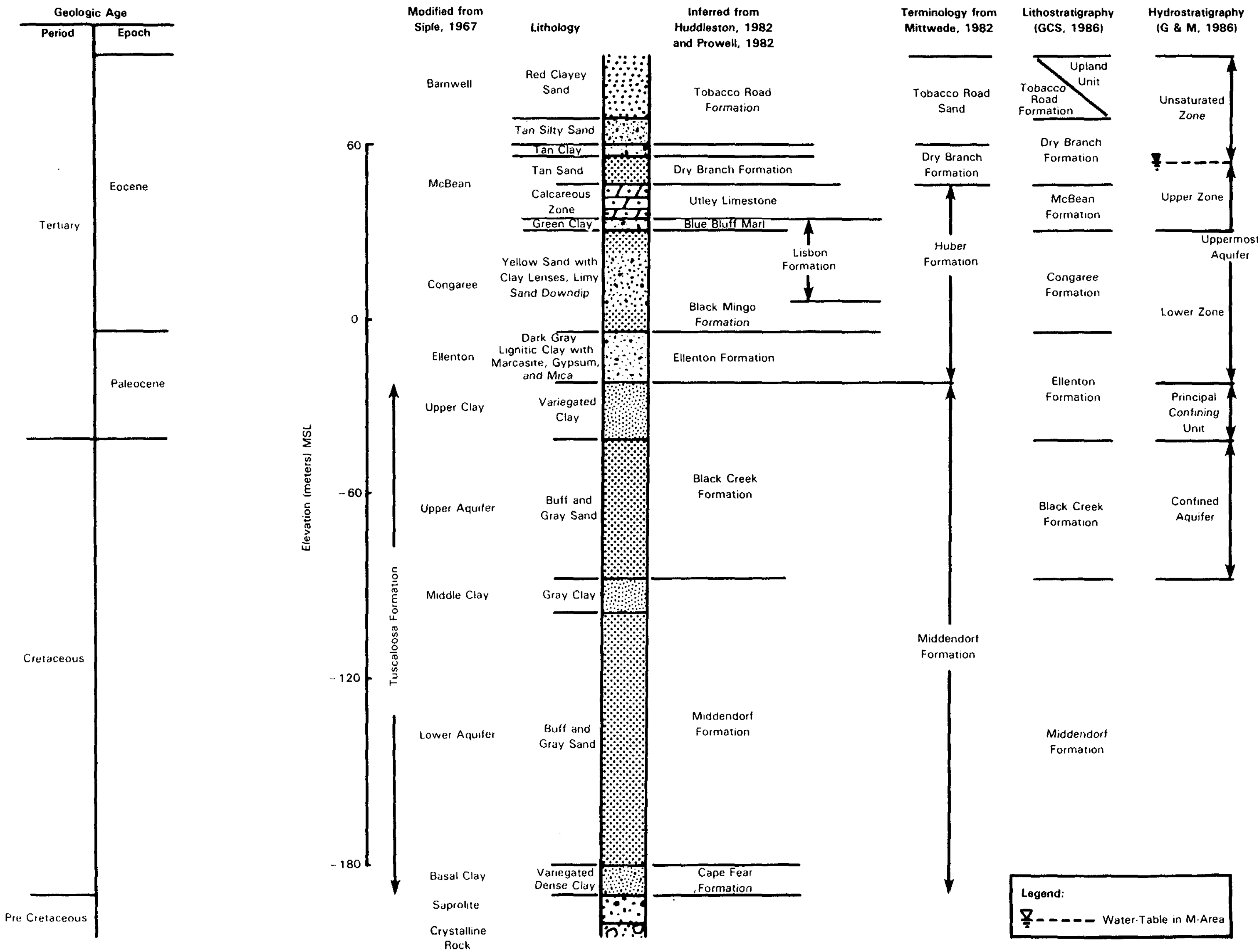


Figure 3-4. Tentative Correlation of Stratigraphic Terminology of Southwestern South Carolina Coastal Plain

the northwest slope gentler than the southeast slope. This is caused by stream courses that generally parallel the strike of the Coastal Plain formations. Erosion by the water course results in gentle dip slopes on the northwest, or updip, sides of the valleys. The land forms produced by these geomorphic processes are gentle cuestas.

3.3.2 SEISMOLOGY AND GEOLOGIC HAZARDS

The down-faulted Dunbarton Triassic Basin, which underlies the Savannah River Plant, contains several interbasinal faults. However, the sediments overlying these faults show no evidence of basin movement since their deposition during the Cretaceous Period (Siple, 1967; Marine, 1976; Du Pont, 1980a). Other Triassic-Jurassic basins have been identified in the Coastal Plain tectonic province of South Carolina and Georgia; these features can be associated with the South Georgia Rift (Du Pont, 1980a; Popenoe and Zietz, 1977; Daniels, Zietz, and Popenoe, 1983). The Piedmont, Blue Ridge, and Valley and Ridge tectonic provinces, which are associated with Appalachian Mountain building, are northwest of the Fall Line (Figure 3-3). Several fault systems occur in and adjacent to the Piedmont and the Valley and Ridge tectonic provinces; the closest is the Belair Fault Zone, about 40 kilometers from the Plant, which is not capable of generating major earthquakes (Case, 1977). Surface mapping, subsurface boring, and geophysical investigations at the Plant have not identified any faulting of the sedimentary strata that would affect SRP facilities.

Two major earthquakes have occurred within 300 kilometers of the Savannah River Plant: the Charleston earthquake of 1886, which had an epicentral modified Mercalli intensity (MMI) of X, and which occurred about 145 kilometers away; and the Union County, South Carolina, earthquake of 1913, which had an epicentral shaking of MMI VII to VIII, and which occurred approximately 160 kilometers away (Langley and Marter, 1973). An estimated peak horizontal shaking of 7 percent of gravity (0.07g) was calculated for the site during the 1886 earthquake (Du Pont, 1982c). DOE has published site intensities and accelerations for other significant earthquakes (DOE, 1982).

On June 8, 1985, a minor earthquake with a local magnitude of 2.6 (maximum intensity MMI III) and a focal depth of 0.96 kilometer occurred at the Plant. The epicenter was just to the west of C- and K-Areas. The acceleration produced by the earthquake was less than 0.002g (Stephenson, Talwani, and Rawlins, 1985). Appendix A contains detailed discussion of earthquakes and other geologic hazards.

3.4 GROUNDWATER RESOURCES

This section discusses the groundwater resources at SRP in terms of the hydrostratigraphy and groundwater hydrology. Appendix A contains more detailed discussions of groundwater resources. Section 3.6 and Appendix A describe relationships between groundwater and surface water.

3.4.1 HYDROSTRATIGRAPHY

Three distinct hydrogeologic systems underlie the SRP: (1) the Coastal Plain sediments, where groundwater occurs in porous sands and clays; (2) the crystalline metamorphic rock beneath the Coastal Plain sediments, where groundwater occurs in small fractures in schist, gneiss, and quartzite; and (3) the Dunbarton Basin within the crystalline metamorphic complex, where groundwater occurs in intergranular spaces in metamudstones and sandstones. The latter two systems are relatively unimportant as groundwater sources near the Plant. Figure 3-4 shows the lithology and water-bearing characteristics of the hydrostratigraphic units underlying the SRP. Appendix A contains additional detail.

In the central part of the SRP, the McBean Formation (formation terminology after Siple, 1967; see Figure 3-4) is separated from the underlying Congaree Formation by a layer known as the "green clay" (Figure 3-4). This layer, which exhibits a low permeability, is continuous over most of the SRP and thickens towards the southeast. The green clay unit is significant hydrogeologically because it supports a large head differential between the McBean and Congaree Formations. North and west of Upper Three Runs Creek the green clay is discontinuous and is effective only locally as an aquitard (hydrogeologic confining unit).

In the central part of the SRP, the Barnwell Formation is separated from the underlying McBean Formation by a thin layer known locally as the "tan clay" (Figure 3-4). The tan clay is discontinuous in F- and H-Areas and, where present in the vicinity of M-Area, is not an important hydrogeologic unit.

The lack of continuous aquitard units in the Barnwell, McBean, and Congaree Formations north and west of Upper Three Runs Creek suggests that groundwater in these three units is interconnected hydraulically. However, the clay at the base of the Congaree and the upper clay layer of the Ellenton Formation together form a confining unit that appears to be continuous under the entire SRP. This confining layer provides an effective barrier to downward migration into the sands of the Ellenton-Black Creek (upper Cretaceous Sediments) aquifer.

The South Carolina Hazardous Waste Management Regulations (SCHWMR) and the Resource Conservation and Recovery Act (RCRA) require that the hydrogeologic zones that are most susceptible to impacts from waste management units be determined. These zones have been defined as the unsaturated zone, the uppermost aquifer, the principal confining unit, and the principal confined aquifer (shallowest confined aquifer beneath the SRP). Figure 3-4 shows the relationship of these zones to one another and the correlation of these zones with other stratigraphic nomenclature. The following paragraphs summarize each hydrogeologic zone. The formational terminology used in this discussion is largely that of Geological Consulting Services (GCS, 1986).

The unsaturated zone is a 25- to 45-meter-thick sandy unit containing clay lenses. This zone is comprised of the Upland Unit and, in some areas of the Plant, the Tobacco Road and Dry Branch Formations.

The uppermost aquifer is a 35-meter-thick sandy unit composed of two zones. The upper water-table zone, composed primarily of the clay-rich, fine-grained sands of the McBean Formation (in some areas of the Plant, areas of higher water table) includes portions of the Dry Branch and Tobacco Road Formations. The lower zone, composed of the coarse-grained Congaree Formation and the upper sand and clay of the Ellenton Formation.

Based on an evaluation of hydraulic properties as well as head differences between subsurface zones, the lower three units of the Ellenton Formation are believed to form the principal confining zone beneath the Plant. These units form a section approximately 15 meters thick composed of two clay beds (middle and lower Ellenton) and the lower Ellenton sand lenses. The sands in these lenses are commonly coarse grained, but generally are supported by a clay matrix that impedes fluid movement. The middle clay is generally a dense, low-permeability clay that can be locally discontinuous or more permeable. The lower clay, however, is an average of 3 meters thick (maximum of 15 meters), is dense, has a low permeability, and is believed to be continuous over the SRP area. Table 3-6 summarizes hydraulic conductivity of the Ellenton Formation.

The confined aquifer is a sandy zone averaging about 30 meters in thickness. This zone is capped by the overlying Ellenton Formation confining unit. In this text, the shallowest confined aquifer will be referred to as the Black Creek aquifer. The aquifer beneath the Black Creek will be referred to as the Middendorf aquifer (see Figure 3-4).

3.4.2 GROUNDWATER HYDROLOGY

Groundwater beneath the SRP generally occurs under confined (artesian) conditions, meaning that the groundwater rises to a potentiometric level above the top of the hydrogeologic unit. The water table in the vicinity of the central portion of the SRP generally occurs in the Barnwell Formation at depths of 5 to 15 meters, whereas in the McBean Formation it occurs near A- and M-Areas at depths of 30 to 40 meters.

3.4.2.1 Hydrologic Properties

The flow of groundwater in the natural environment depends strongly on the three-dimensional configuration of hydrogeologic units through which flow takes place. The geometry, spatial relations, and interconnections of the pore spaces determine the effective porosity (percentage of void space effectively transmitting groundwater) and the hydraulic conductivity of the hydrogeologic unit. These factors largely control groundwater flow through geologic media. In fact, the velocity of groundwater flow is directly proportional to the hydraulic conductivity and to the hydraulic gradient, and is inversely proportional to effective porosity.

The Coastal Plain sediments beneath the SRP are heterogeneous and isotropic with respect to the hydrologic properties controlling groundwater flow. One of the most recognized properties, hydraulic conductivity, is generally 10 to 100 times greater in the direction parallel to the subsurface units than in the direction perpendicular to these units (Freeze and Cherry, 1979). This results in significantly greater groundwater flow laterally within hydrostratigraphic units than between units (see Tables A-4 and A-5).

3.4.2.2 Head Relationships

The elevation of the free-standing groundwater above a sea-level datum is referred to as the hydraulic head. The heads in the Ellenton and Middendorf/ Black Creek (Tuscaloosa) Formations are higher than that in the Congaree in the central portion of the SRP, thus preventing the downward movement of water

Table 3-6. Hydraulic Conductivity (cm/sec) of the Ellenton Formation

Geologic Unit	Vertical conductivity		Horizontal conductivity	
	Range	Average	Range	Average
Middle Clay	2.2×10^{-9} – 1.4×10^{-5}	1.1×10^{-7}	1.6×10^{-9} – 7.3×10^{-5}	8.61×10^{-5}
Lower Sand	3.5×10^{-9} – 3.9×10^{-4}	4.4×10^{-5}	1.1×10^{-8} – 2.6×10^{-4}	9.39×10^{-5}
Lower Clay	1.8×10^{-8} – 4.0×10^{-7}	1.9×10^{-7}	2.3×10^{-8} – 6.7×10^{-7}	3.12×10^{-7}

from the Congaree to the Ellenton (see Figure A-5). These relationships are general and might not be valid in the vicinity of production wells. Figure 3-5 shows the approximate area of upward head differential, which in effect was computed by subtracting the potentiometric map of the Congaree (see Figure A-10) from that of the Middendorf/Black Creek (see Figure A-9).

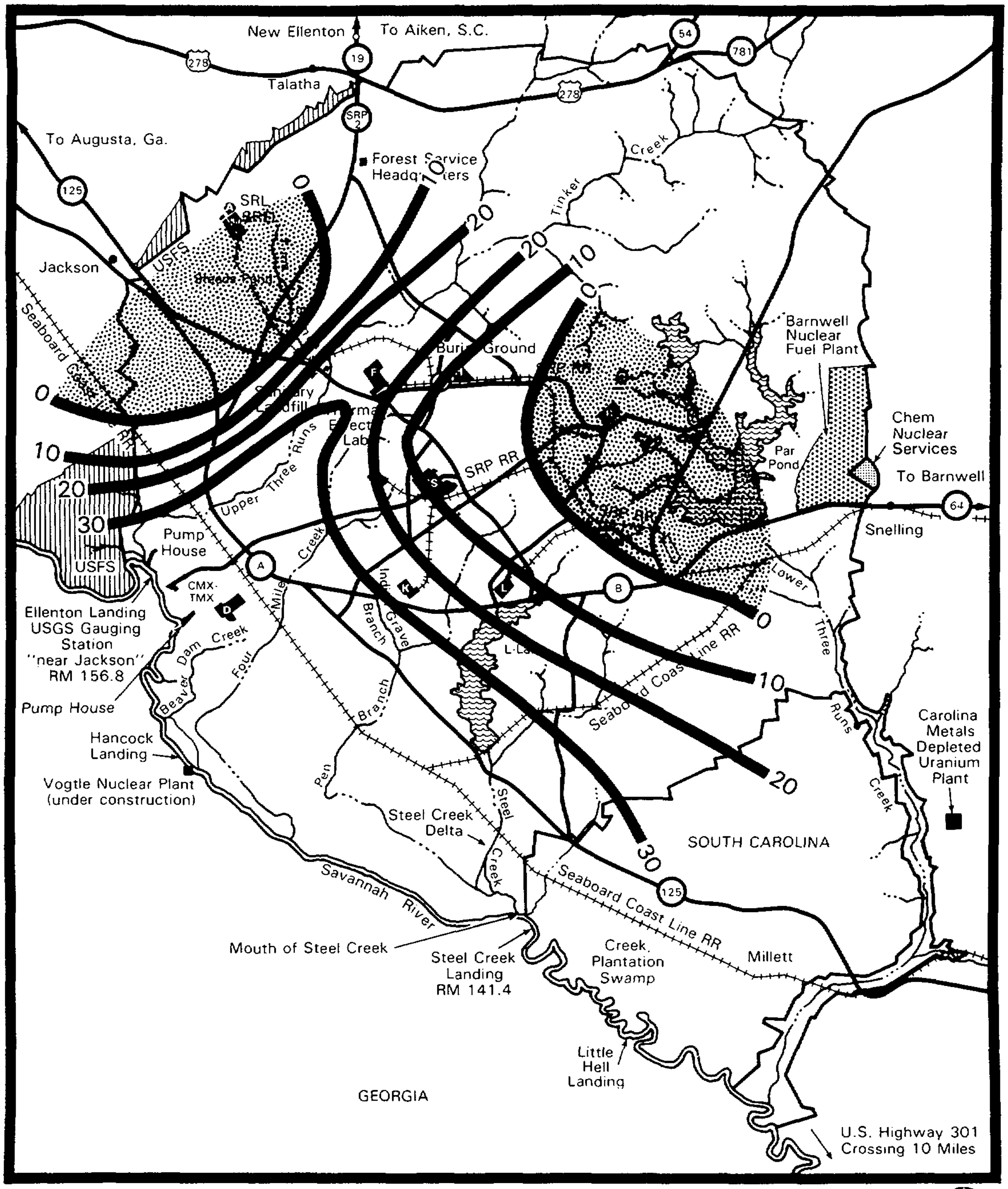
The Separations Areas, Burial Grounds, Central Shops, C-, K-, and L-Reactor Areas, TNX-Area, and the D-Area powerhouse are in the area of upward head differential between the groundwater in the Congaree and that in the Middendorf/ Black Creek (Tuscaloosa) Formation. However, A-, M-, and P-Areas are in a region of downward head differential (see Figure A-20). Because of flow directions and head relationships, the potential for offsite impacts on water quality in the Black Creek aquifer is extremely small. The most important factor for offsite impacts is the prevailing flow direction for water in the Black Creek toward the Savannah River, not toward municipalities that border the Plant. The most important factor for onsite impacts is a significant upward gradient between the Congaree and the Upper Tuscaloosa over most of the SRP.

Impacts on the Black Creek aquifer have been confirmed in only one well cluster on the SRP. This cluster is in the western recharge area (A- and M-Areas), where the clay barrier thins beneath an area where spillage from rail cars and transfer facilities took place during the early days of SRP operation. The migration of these constituents is being defined; their source has been under remediation for nearly 2 years. Data analyzed to date do not define any flow paths for these constituents toward offsite water users. The area of final discharge of the groundwater originating from these sources is the Savannah River. These constituents would require at least several hundred years to reach the river. The pumpage of recovery wells (and supply wells for process water) in A- and M-Areas increases this travel time.

Where the upward gradient exists between the Black Creek and the Congaree, water is prevented from flowing into the Black Creek aquifer. An exception occurs in areas where large volumes of water are pumped from the Black Creek; in these areas, pumpage could reverse the upward gradient. The area most susceptible to these impacts is H-Area, where the head differential is relatively small and pumpage is great. A modeling study (Duffield, Buss, and Spalding, 1987) indicates that a maximum head differential (downward potential) of about 5 feet has developed in the eastern portion of H-Area (see Figure A-5). Moderate pumpage from the Black Creek also occurs in U-Area, the Central Shops Area, TNX-Area, the Classification Yard, and the U.S. Forest Service offices. The potential for reversing the upward gradient that occurs naturally in these areas is significantly less than that in H-Area. Any contaminants that would be drawn into the Black Creek by this pumpage would flow to the pumping well and, therefore, would not impact offsite areas.

3.4.2.3 Groundwater Flow

Groundwater moves from areas of high potential energy (usually measured as head) to areas of lower energy. Thus, flow is in the direction of decreasing hydraulic gradient. In general, on the Coastal Plain, the gradient is seaward from the higher areas of the Aiken Plateau toward the shore. Of major significance is the modification of this general southeastward movement caused by the incision of the Savannah River and its tributaries.



Source: DOE, 1984b

Scale (kilometers)

0 2 4 6 8

Legend:

C, K, R, L, P Reactor Areas (C,P,K, and L are operating)
F, H Separation Areas
M Fuel and Target Fabrication
D Heavy Water Production
A Savannah River Laboratory and Administration Area
CS Central Shops
RM River Mile

Road A = Highway 125

Note: Contours and water levels in feet above mean sea level. 1.0 foot = 0.3048 meter.

Area where the Congaree head exceeds the Tuscaloosa head.
Contour showing locations where the head in the Tuscaloosa is 10 feet (1.0 foot = 0.3048 meter) above the head in the Congaree.

Figure 3-5. Head Difference Between Upper Tuscaloosa and Congaree Formations at Savannah River Plant (May 11, 1982)

The groundwaters in the regions of the river and onsite streams are diverted toward hydraulic head lows caused by natural discharge to the surface water. Each stream dissects the hydrogeologic units differently; the smallest streams become natural discharge points for groundwater in the Barnwell Formation, and the Savannah River does the same for groundwater in the Middendorf/Black Creek (Tuscaloosa). Thus, discrete groundwater subunits are created, each with its own recharge and discharge areas. Appendix A describes natural aquifer recharge and discharge areas, and water budgets at the SRP.

3.4.3 GROUNDWATER QUALITY

3.4.3.1 Regional Groundwater Quality

The water in the Coastal Plain sediments is generally of good quality, suitable for industrial and municipal use with minimal treatment. It is characterized as soft, slightly acidic, and low in both dissolved and suspended solids (Table 3-7).

3.4.3.2 Groundwater Monitoring Results

A substantial amount of groundwater monitoring data has been generated from SRP monitoring wells over the past several years. Data from groundwater sampling since 1982 was reported in the Technical Summary of Groundwater Quality Protection Program at Savannah River Plant (Christensen and Gordon, 1983), the SRP Environmental Report for 1985 (Zeigler, Lawrimore, and Heath, 1986), and in the environmental information documents (EIDs) prepared for this EIS effort, which are referenced in Appendixes B and F.

This section of the EIS characterizes the affected groundwater environment (e.g., groundwater at the waste site monitoring wells) based on the data reported. The data for all waste site wells have been compiled into a single summary for SRP with the objective of providing the reader a general understanding of waste site groundwater quality in relation to applicable standards or other criteria.

Groundwater is monitored at potentially hazardous and mixed waste sites. Parameters analyzed at these sites include heavy metals, nutrients, pesticides, organic solvents, and radiological parameters. Table 3-8 summarizes the results of 39 groundwater-quality parameter measurements in relation to applicable standards or criteria. For example, 672 tests for silver were reported, none of which exceeded the National Interim Primary Drinking Water Standard of 50 micrograms per liter. Table 3-8 lists the number of values exceeding a standard or criterion (if any) and the number of values not exceeding the standard. In addition, this table lists the maximum value reported for comparison with the standard.

The summary indicates that many groundwater constituents analyzed do not exceed the applicable standard or criterion. On the other hand, several constituents are shown to exceed groundwater standards or criteria at one or more waste site well locations on the SRP.

Exceedance of a standard or criterion does not always indicate contamination from a waste disposal site or operation. Certain constituents can occur naturally at concentrations that exceed standards. Also, contamination associated

Table 3-7. Average Chemical Analysis of Groundwater From Coastal Plain Formations at the Savannah River Plant[a]

Chemical properties/ chemical constituent[b]	Barnwell Formation	McBean Formation	Congaree Formation	Middendorf/Black Creek (Tuscaloosa) Formation
pH (standard units)	5.6	6.5	6.3	5.4
Total dissolved solids	25.0	46.8	71.0	21.0
Specific conductance (micromhos)	27	57	130[c]	30
Calcium	2.9	8.2	19.6	0.6
Magnesium	0.2	2.5	0.3	2.1
Potassium	0.9	1.2	0.8	1.8
Sodium	2.3	4.2	1.5	4.0
Iron	0.2	0.1	0.2	0.1
Silicon	4.6	5.9	10.1	0.6
Aluminum	0.7	0.6	1.0	NM[d]
Manganese	<0.1	<0.1	<0.1	0.5
Bicarbonate	12.7	31.0	57.4	4.3
Chlorine	3.5	2.8	3.4	0.7
Nitrate (as N)	3.1	0.1	0.1	0.1
Phosphate (as P)	0.1	0.3	0.1	0.2
Fluoride	TR[e]	<0.1	0.1	NM

[a]Adapted from Du Pont, 1983b. Formational terminology after Siple, 1967; see Figure 3-4.
[b]Units are milligrams per liter (except pH and specific conductance).
[c]Only one analysis.
[d]NM - No measurement.
[e]TR - Trace.

Table 3-8. Summary of SRP Groundwater Monitoring Data[a]

Parameter	Units	Standard or criterion (S/C)	Values reported	Values exceeding S/C	Values not exceeding S/C	Maximum value
pH-acid	units	6.5[b]	1018	955	63	2.3
pH-alkaline	units	8.5[b]	1018	23	995	12.5
Silver	mg/L	0.05[c]	672	0	672	(d)
Arsenic	mg/L	0.05[c]	654	0	654	(d)
Barium	mg/L	1[c]	597	4	593	2.29
Beryllium	mg/L	0.011[e]	568	29	539	0.31
Cadmium[f]	mg/L	0.010[c]	703	83	620	0.15
Chromium	mg/L	0.050[c]	874	51	823	6.30
Copper	mg/L	1[b]	527	0	527	(d)
Iron[f]	mg/L	0.3[b]	750	302	448	280.00
Mercury	mg/L	0.002[c]	816	53	763	3.074
Manganese	mg/L	0.05[b]	714	218	496	91.76
Lead[f]	mg/L	0.05[e]	780	114	666	4.88
Selenium	mg/L	0.01[c]	653	2	651	.054
Zinc[f]	mg/L	5[b]	616	32	584	49.92
Chloride	mg/L	250[b]	835	0	835	(d)
Fluoride	mg/L	1.4[c]	680	1	679	2
Nitrate-N	mg/L	10[c]	734	127	607	370
Sulfate	mg/L	400[g]	752	1	751	765
Hydrogen sulfide	mg/L	0.002[h]	465	1	464	3.00
Cyanide	mg/L	0.20[b]	200	0	200	(d)
Phenol	mg/L	3.5[i]	631	0	631	(d)
TOH	mg/L	0.0007[j]	846	706	140	94.00
Endrin	mg/L	0.0002[c]	580	0	580	(d)
Lindane	mg/L	0.004[c]	580	1	579	0.011
Methoxyclor	mg/L	0.1[c]	580	0	580	(d)
Toxaphene	mg/L	0.005[c]	580	0	580	(d)
2,4-D	mg/L	0.1[c]	592	4	588	0.74

Footnotes on last page of table.

Table 3-8. Summary of SRP Groundwater Monitoring Data[a] (continued)

Parameter	Units	Standard or criterion (S/C)	Values reported	Values exceeding S/C	Values not exceeding S/C	Maximum value
2,4,5-TP	mg/L	0.01[e]	592	0	592	(d)
1,1-dichloroethane	mg/L	4.05[k]	24	0	24	(d)
1,1,1-trichloroethane	mg/L	0.2[l]	359	4	355	0.257
Tetrachloromethane	mg/L	0.0003[m]	150	6	144	0.144
1,1-dichloroethylene	mg/L	0.007[l]	44	1	43	0.011
Trans 1,2-dichloroethylene	mg/L	0.27[n]	35	0	35	(d)
Trichloroethylene	mg/L	0.005[k]	417	187	230	161.00
Tetrachloroethylene	mg/L	0.0007[o]	411	146	265	269.00
Gross alpha	pCi/L	15[c]	769	104	665	11,460
Gross beta	pCi/L	0.2[p]	704	476	228	21,051
Radium	pCi/L	5[c]	618	88	530	128

[a]Data compiled from 26 Existing Waste Site Environmental Information Documents which reported analytical results for samples taken from 1982 to third quarter 1985.

[b]National Secondary Drinking Water Regulations (40 CFR 143).

[c]National Interim Primary Drinking Water Regulations (40 CFR 141).

[d]All values reported below standard or criterion.

[e]EPA, 1976. (Maximum concentrations for protection of freshwater aquatic life.)

[f]Results of metals analyses performed between 1982 and 1984 might be inaccurate because of problems with well construction and sampling protocol. Actual groundwater concentration levels of these metals were probably somewhat less.

[g]50 FR 46958.

[h]EPA, 1976. (Maximum concentration for protection of freshwater aquatic life; detection limit of analysis procedure was 3 milligrams per liter.)

[i]EPA, 1986a.

[j]No standard or criterion available, conservatively set at standard for tetrachloroethylene (see footnote k below).

[k]EPA, 1986b.

[l]50 FR 46904.

[m]50 FR 48949 (detection limit of analysis procedure was 0.008 milligram per liter).

[n]EPA, 1981.

[o]50 FR 48950 (detection limit of analysis procedure was 0.001 milligram per liter).

[p]No standard or criterion available, set for comparative purposes at the detection limit of 0.2 picocuries per liter.

with a particular site can occur in the wells of another site located hydraulically downgradient. A site-specific evaluation of the data using comparisons of upgradient versus downgradient wells is necessary to determine the constituent contributions of a waste site. Such comparisons are described in detail (in the 26 waste site EIDs and in Looney et al., 1986) for the purposes of selecting waste site modeling parameters and comparing appropriate alternative actions for specific waste sites.

In addition, exceedance of a standard or criterion does not automatically indicate a risk to human health or the environment. For example, the standard for iron of 300 micrograms per liter is a secondary drinking-water standard established for aesthetic purposes and is not health-related. Thus, the origin of the standard or criterion listed is important.

Finally, the results of groundwater monitoring to date are considered preliminary because of indications that earlier results (1982-1984) might have been questionable. In 1984, improvements were made in the procedures for obtaining and preserving samples. Where manual bailing had been used, pumps now ensure adequate flushing of the wells before a sample is taken; also, samples for metal analyses are filtered to remove suspended solids before preservatives are added. In addition, wells constructed of galvanized casings were removed from service and replaced with wells constructed of PVC plastic. These problems (now corrected) are thought to have been responsible for excessively high concentrations of several metals, including zinc, cadmium, lead, and iron, in earlier samples (Zeigler, Lawrimore, and Heath, 1986).

Table 3-9 summarizes recent groundwater monitoring data for radiological constituents for the SRP; it provides the total number of samples reported and the maximum and minimum values for 12 radiological parameters.

3.4.4 GROUNDWATER USE

3.4.4.1 Important Aquifers

As noted in Section 3.4.1, subsurface waters in the vicinity of SRP include six major hydrostratigraphic units. The geohydrologic characteristics of these units, their areal configurations, and their recharge/discharge relationships control the vertical and horizontal movement of groundwater at SRP (see Appendix A).

At present, SRP does not withdraw groundwater from the crystalline, metasediment basement rocks and overlying saprolite. The Middendorf/Black Creek (Cretaceous Sediments) hydrostratigraphic unit, which is 170 to 250 meters thick at SRP, is the most important regional aquifer in the vicinity of the SRP. At SRP, the Middendorf/Black Creek consists of two aquifers separated by a clay layer or aquitard, which impedes movement of groundwater between the two aquifers. The lower aquifer (Middendorf) consists of about 90 meters of medium to coarse sand; the overlying aquifer (Black Creek) consists of about 45 meters of well-sorted medium-to-coarse sand. Beneath SRP, these two aquifers join only by way of wells that withdraw water from both permeable zones.

Table 3-9. SRP Groundwater Monitoring Data - Radiological Constituents[a]

Parameter	Units	Number of samples	Maximum	Minimum
Alpha[b]	pCi/L	1,539	360	<DL[c]
Nonvolatile beta	pCi/L	1,539	24,000	<DL[c]
Tritium[d]	pCi/mL	1,379	7,000,000	<DL[c]
Cerium-144	pCi/mL	42	0.18	<DL[c]
Cesium-134	pCi/mL	42	0.07	<DL[c]
Cesium-137	pCi/mL	42	0.02	<DL[c]
Chromium-51	pCi/mL	42	2.4	<DL[c]
Cobalt-60	pCi/mL	42	0.25	<DL[c]
Ruthenium-103	pCi/mL	42	0.10	<DL[c]
Ruthenium-106	pCi/mL	42	0.22	<DL[c]
Antimony-125	pCi/mL	42	0.01	<DL[c]
Strontium-89, -90	pCi/mL	31	140	<DL[c]

[a]Data compiled from Zeigler, Lawrimore, and Heath, 1986.
[b]The National Interim Primary Drinking Water Standard for gross alpha is 15 picocuries per liter (40 CFR 141).
[c]Detection limits.
[d]The National Interim Primary Drinking Water Standard for tritium is 20,000 picocuries per liter (40 CFR 141).

The upper Middendorf/Black Creek clay unit and the Ellenton clays form an aquitard over most of SRP. In some areas, the Ellenton and the sands appear to be connected hydrologically.

The Congaree is another important local aquifer. Locally, only the Middendorf/Black Creek exceeds the Congaree's water-producing potential. The Congaree's intermediate depth also makes it attractive for water wells. An extensive clay layer at the base of this unit forms a confining bed that separates the permeable sands of the Congaree hydrologically from the sands in the underlying Ellenton and Middendorf/Black Creek units. The green clay (Figure 3-4), a marker bed at the top of the Congaree, exhibits very low hydraulic conductivity; therefore, it is a significant aquitard, particularly south and east of Upper Three Runs Creek. SRP does not withdraw large quantities of groundwater from the McBean, Barnwell-Hawthorn, or stream valley alluvium deposits (formation terminology after Siple, 1967). The McBean, however, becomes increasingly more important as an aquifer to the east of SRP.

The water table is usually in the stream valley alluvium deposits and in the Barnwell. The McBean is usually under semiconfined conditions. In contrast, groundwaters in the Congaree (to the south and east of Upper Three Runs Creek) and the Middendorf/Black Creek are under confined conditions. Middendorf/Black Creek water wells near the Savannah River (e.g., in D-Area) often flow because the potentiometric level of the groundwater is greater than the elevation of the land surface.

3.4.4.2 Regional and Local Groundwater Use

The Middendorf/Black Creek (Tuscaloosa) aquifer, which occurs at shallower depths as it approaches the Fall Line, forms the base for most municipal and industrial water supplies in Aiken County. In Allendale and Barnwell Counties, the Middendorf/Black Creek occurs at increasingly greater depths. Consequently, the shallower Congaree and McBean aquifers (formation terminology after Siple, 1967), or their limestone equivalents, supply some municipal, industrial, and agricultural users. The Barnwell, McBean, and Congaree Formations are the primary sources for domestic water supplies in the vicinity of the SRP.

DOE has identified 56 major municipal, industrial, and agricultural groundwater users within 32 kilometers of the center of SRP (Appendix A). The total pumpage for these users is about 135,000 cubic meters per day.

Talatha community, the closest municipal user (about 11 kilometers from the center of SRP), uses about 480 cubic meters per day. The Town of Jackson, about 16 kilometers from the center of SRP, pumps about 1070 cubic meters per day. Of the total municipal pumpage (52,605 cubic meters per day), the Middendorf/Black Creek aquifer supplies about 34,270 cubic meters; the remainder (about 18,335 cubic meters per day) comes from the McBean and the Congaree. Total industrial/agricultural pumpage from the Middendorf/Black Creek aquifer is about 71,940 cubic meters per day; this includes 38,550 cubic meters per day drawn by SRP.

In addition to the large users discussed above, the South Carolina Department of Health and Environmental Control (SCDHEC) lists 25 small communities and mobile home parks, 4 schools, and 11 small commercial interests as groundwater users. Generally, shallow wells equipped with pumps with capacities of 54 to 325 cubic meters per day serve these and other miscellaneous users; thus, they do not draw large quantities of water. The total estimated withdrawal for these 40 users is less than 2000 cubic meters per day (DOE, 1984b).

A number of domestic wells near SRP also draw from the shallow aquifers. Two South Carolina state parks (Aiken State Park, with seven wells, and Barnwell State Park, with two) are within a 32-kilometer radius of the Plant (DOE, 1984b). Several shallow wells produce small quantities of water for SRP guardhouses.

3.4.4.3 Relationship of Precipitation and Groundwater Use to Water Levels

Figure 3-6 shows hydrographs of five Middendorf/Black Creek (Tuscaloosa) wells and one Ellenton well. Five of these wells are on SRP. The sixth, AK-183, is 29 kilometers northwest of the center of SRP in the Middendorf/Black Creek outcrop area; pumpage in the vicinity of SRP does not influence this well. Winter (December, January, and February) precipitation (plotted at the top of Figure 3-6) is the principal source of groundwater recharge. Generally high water levels occurred in the Middendorf/Black Creek (Tuscaloosa) in 1974, but from then until 1982 these levels declined. Winter precipitation declined from 1972 to 1981, which might account partially for the declining water levels shown by well AK-183; in addition, since 1975 SRP pumping has increased by about 80 percent, from 14.9 to 26.8 cubic meters per minute. Because of higher winter precipitation in 1982 and 1983, groundwater levels have increased.

Figure 3-6 shows the total SRP pumping rate; the highest rates are toward the bottom of the plot to facilitate their comparison to water levels in monitoring wells. Calculations show that the decline in water levels at monitoring wells P7A, P54, and P3A is related primarily to increased SRP groundwater withdrawals (DOE, 1984b). The drawdowns at these wells reflect adjustments in equilibrium levels rather than aquifer depletion (Du Pont, 1983b). Near-equilibrium water levels occur quickly (within 100 days) when pumping rates change (Mayer et al., 1973).

Withdrawals from the Middendorf/Black Creek (Tuscaloosa) at SRP could reach about 38 cubic meters per minute without appreciably affecting water levels in existing (1960) production wells (Siple, 1967). In addition, this aquifer could produce more water with better-designed well fields. In 1960, the SRP pumpage from the Middendorf/Black Creek was about 19 cubic meters per minute (Siple, 1967); currently, the estimated SRP groundwater use is 27 cubic meters per minute.

3.5 SURFACE-WATER RESOURCES

3.5.1 SURFACE-WATER SYSTEMS

The Savannah River is the principal surface-water system near the SRP. It adjoins the Plant along its southwestern boundary. The total drainage area of the river, 27,388 square kilometers, encompasses all or parts of 41 counties in Georgia, South Carolina, and North Carolina. Over 77 percent of the drainage area is upriver of the SRP (Lower, 1985).

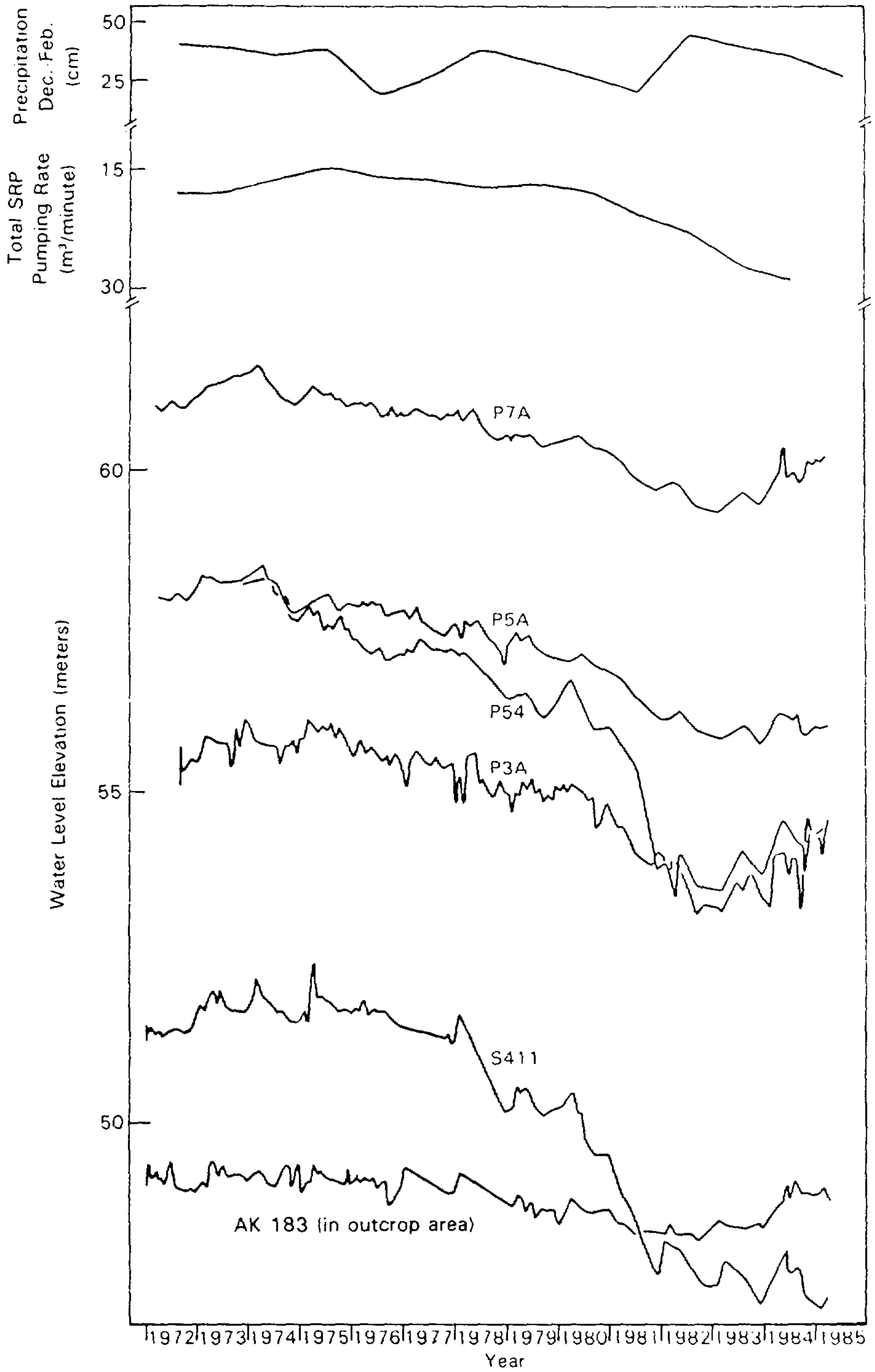
On the Plant, a swamp lies in the floodplain along the Savannah River for a distance of about 16 kilometers; its average width is about 2.4 kilometers. A small embankment or natural levee has built up along the north side of the river from sediments deposited during periods of flooding. On the SRP side of the levee, the ground slopes downward, is marshy, and contains large stands of cypress-tupelo forest and bottomland hardwoods.

The SRP is drained almost entirely by six streams: Upper Three Runs Creek, Four Mile Creek, Beaver Dam Creek, Pen Branch, Steel Creek, and Lower Three Runs Creek (Figure 3-2). These streams rise on the Aiken Plateau and descend 30 to 60 meters before discharging to the Savannah River.

3.5.2 SURFACE-WATER HYDROLOGY

Streamflow in the Savannah River is regulated by five large reservoirs upriver of the SRP: Clarks Hill, Russell, Hartwell, Keowee, and Jocassee (DOE, 1984b; Duke Power Company, 1977). The average annual flow has been stabilized by these reservoirs to 288.8 cubic meters per second near Augusta (Bloxham, 1979) and 295 cubic meters per second near the SRP (DOE, 1984b).

Natural discharge patterns in the Savannah River are cyclic: maximum river flows typically occur in the winter and spring and the lowest flows occur in the summer and fall (Figure 3-7).



Source: Du Pont 1983b; updated by Marine, 1985.

Note: Figure A-22 shows the well locations; well S411 is screened in the Ellenton Formation; the remaining wells are screened in the Middendorf/Black Creek.

Figure 3-6. Hydrographs of Tuscaloosa and Ellenton Wells

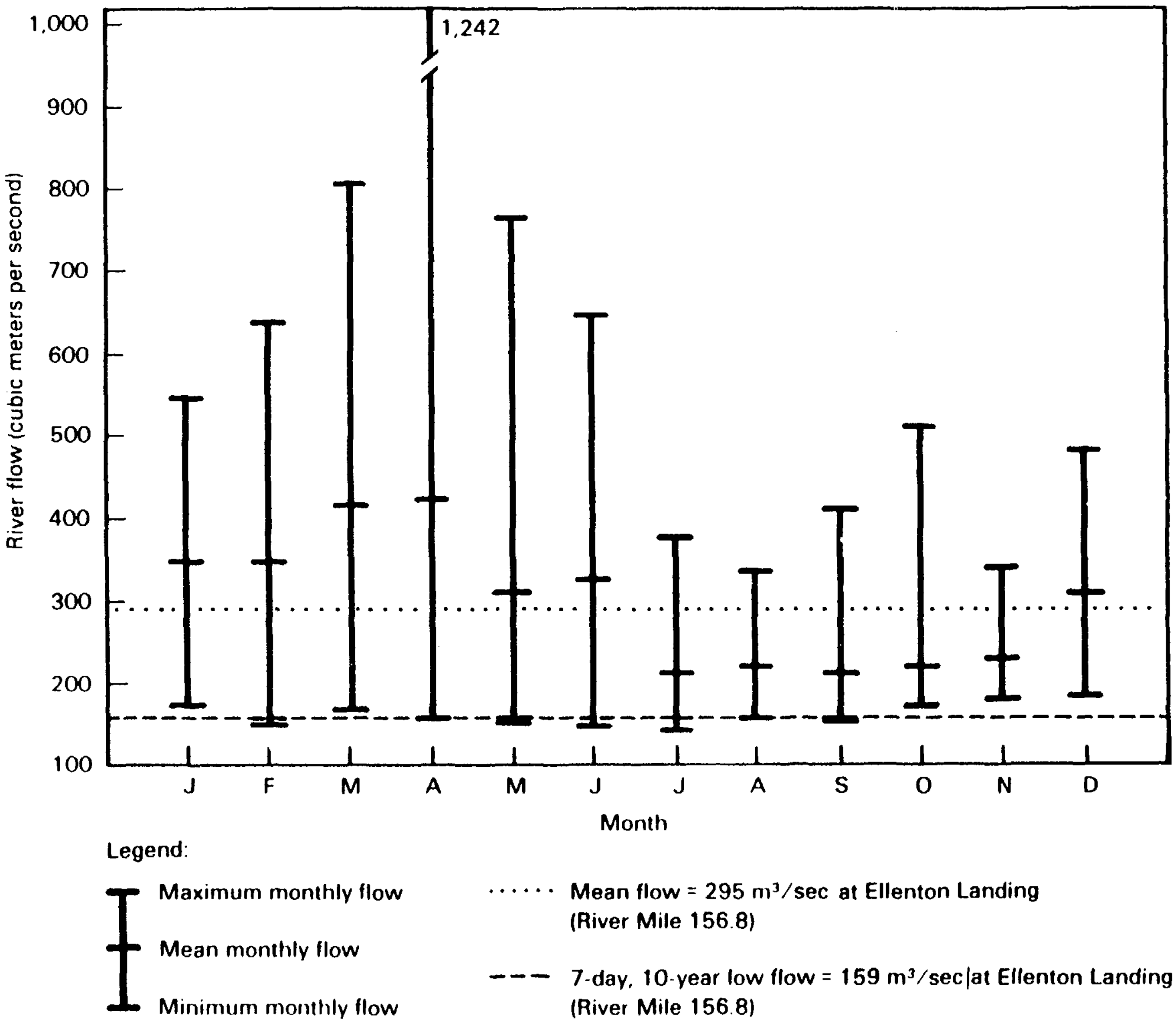


Figure 3-7. Mean Monthly Flow Rates of the Savannah River from 1964-1981 at River Mile 187.5 (Data Derived from USGS Gaging Station Near Augusta, Georgia)

Since 1963, the U.S. Army Corps of Engineers has attempted to maintain a minimum flow of 178.4 cubic meters per second below the New Savannah River Bluff Lock and Dam at Butler Creek (River Mile 187.4, near Augusta, Georgia) (COE, 1981). During the 18-year period from 1964 to 1981 (climatic years ending March 31), the average of the 7-day low flow for each year measured at the New Savannah River Bluff Lock and Dam was 181 cubic meters per second (Watts, 1982), or about 2.3 cubic meters per second less than at the SRP (Ellenton Landing, River Mile 156.8).

3.5.3 SURFACE-WATER QUALITY

In the vicinity of the SRP, the Savannah River is classified as a Class B stream under the State of South Carolina's Water Classification Regulations. Class B waters are broadly defined as suitable for secondary-contact recreation and as a source of drinking water after conventional treatment according to approved regulatory regimes (SCDHEC, 1981).

The onsite streams have not been classified by name. However, the regulations provide that "in any case where streams are not otherwise classified and are tributaries to a classified stream, they shall meet the quality standards of the classified stream" (SCDHEC, 1981). Thus, onsite streams at the SRP that are tributaries to the Savannah River are considered to be Class B streams. Routine analyses of samples from onsite stream locations since 1973 indicate that SRP discharges have complied with Class B water classification standards except for those streams receiving thermal discharges where temperature and occasionally dissolved oxygen standards are exceeded.

A 2-year Comprehensive Cooling Water Study was initiated in July 1983 to ascertain the effects of thermal discharges on the Savannah River and onsite stream water quality (Du Pont, 1985b). The discussions that follow provide a summary of the water quality of the Savannah River and six major onsite streams.

3.5.3.1 Savannah River

Historically, the Augusta, North Augusta, and Aiken County areas have provided the major sources of pollution to the Savannah River in the area around the SRP. The City of Augusta did not have a secondary sewage treatment facility until 1975. Before 1975, most domestic and industrial wastes were discharged untreated or inadequately treated into the river or into Hawks Gully, Butler Creek, and Spirit Creek, which flow into the river. In the North Augusta and Aiken County areas, domestic and industrial effluents entered the Savannah River directly and via Horse Creek and Little Horse Creek (Matthews, 1982). Treatment facilities for the North Augusta and Aiken County areas did not begin operation until 1979. The SRP also discharges wastewater into the Savannah River under National Pollutant Discharge Elimination System (NPDES) Permit SC0000175. These discharges are primarily thermal effluents, but include domestic and industrial wastes (Lower, 1985).

Variability of water chemistry test results of Savannah River samples has diminished over the past 20 years, primarily because of improved waste treatment and flow stabilization provided by upstream dams. The pH of the river has remained slightly acidic. The river water is relatively soft and well oxygenated. Water temperature ranges from an average winter low of 8°C to more than 24°C during summer months. In the vicinity of the SRP, South Carolina Class B stream water classification standards are met in the Savannah River (Lower, 1985).

Based on samples collected as part of the Comprehensive Cooling Water Study from 1983 to 1985 at monitoring stations upriver of the confluence of the Savannah River with Upper Three Runs Creek and downriver of the confluence of the river with Steel Creek, mean water chemistry data indicated relatively no change in pH values, total suspended solids, alkalinity, chlorides, sulfates, phosphorus species, nitrate-nitrogen and nitrite-nitrogen, and trace metals. Mean dissolved oxygen, ammonia-nitrogen, and total kjeldahl nitrogen concentrations were slightly reduced at the downriver sampling station (Lower, 1985).

3.5.3.2 Onsite Streams

Data collected during recent studies indicate that the major factors affecting the water chemistry of onsite streams include a natural chemical gradient, thermal and current velocity conditions, addition of Savannah River water for reactor secondary cooling, natural transport and transformation processes, and point-source discharges related to SRP operations (Du Pont, 1985b). The following paragraphs describe results of recent water-chemistry samples associated with each onsite stream.

Upper Three Runs Creek

Upper Three Runs Creek tributaries are Tinker Creek and Tims Branch. Typical permitted surface discharges to Tims Branch from the A- and M-Areas include nonprocess cooling water, steam condensates, process effluents, and treated groundwater effluents (M-Area air stripper). In addition, three unnamed tributaries of Upper Three Runs Creek receive permitted ambient-temperature cooling water, steam condensate, powerhouse washdown waters, and ash basin effluents from the Separations Areas (Lower, 1985).

Upper Three Runs Creek is a slightly acid stream, low in nutrients. The water of this stream is soft (low in calcium). Suspended solids concentrations increase from the upper to lower reaches but are low in value at all monitoring stations. The stream has little, if any, capacity to neutralize acids. The temperature of the stream ranges from approximately 8° to 24°C, with lows occurring from December through February. July and August normally constitute the period of highest temperature and lowest flows. The dissolved oxygen content is relatively constant at 8 milligrams per liter, varying slightly with the temperature of the stream; at all stations the water is saturated or nearly saturated with oxygen and exhibits a low chemical oxygen demand (less than 2 milligrams per liter) (Lower, 1984; Du Pont, 1985b). Temperature, pH, and dissolved oxygen each meet South Carolina water-classification standards for Class B streams. Concentrations of metals throughout Upper Three Runs Creek reflect both the softness of the stream and the absence of any major industrial discharges (Lower, 1985).

Table 3-10 lists mean results of water chemistry samples of Upper Three Runs Creek from 1983 through 1985 at four sampling stations.

Table 3-10. Mean Water Chemistry of Upper Three Runs Creek and Tims Branch, 1983-1985[a]

Parameter/units	Station location: Road F	Station location: Upstream of Road C	Station location: Tims Branch upstream of confluence with Upper Three Runs Creek	Station location: Mouth
Temperature (°C)	16.1	15.0	15.9	14.7
pH (-)	6.06	6.22	6.66	6.65
Dissolved oxygen (mg/L)	8.13	7.91	8.17	7.84
Suspended solids (mg/L)	8.70	19.0	6.70	28.8
Chlorides (mg/L)	1.60	1.70	1.80	2.10
Sulfates (mg/L)	0.35	0.53	0.26	1.24
Organic carbon (mg C/L)	6.0	8.30	7.10	7.9
Phosphorus (mg P/L)	0.03	0.05	0.04	0.05
Nitrites (mg N/L)	<0.05	<0.05	<0.05	<0.05
Nitrates (mg N/L)	0.18	0.12	0.16	0.11
Arsenic (μg As/L)	1.51	1.20	1.35	1.51
Cadmium (μg Cd/L)	0.26	0.32	0.28	0.49
Chromium (μg Cr/L)	13.5	17.9	9.97	13.5
Copper (μg Cu/L)	2.48	2.47	2.40	2.48
Lead (μg Pb/L)	2.69	2.85	2.08	2.69
Mercury (μg Hg/L)	0.05	0.06	0.07	0.05

[a]Source: Du Pont, 1985b.

Four Mile Creek

From the Separations Areas, the upper reach of Four Mile Creek receives permitted powerhouse wastewater, cooling water, steam condensate, and sanitary-treatment-plant wastewater discharges. C-Reactor cooling water is discharged to Four Mile Creek. Small quantities of ambient-temperature cooling water and automotive shop effluents are also discharged to Four Mile Creek from the Central Shops (CS) Area.

Since 1973, the water chemistry of Four Mile Creek has been monitored at SRP Road A-7, a station downstream of 200-F and 200-H Area effluents but upstream of thermal effluents from C-Reactor Area. Like Upper Three Runs Creek, waters along this reach of Four Mile Creek have low alkalinity, suspended solids, and chemical oxygen demand (Lower, 1984). However, concentrations of nutrients, particularly nitrates (as nitrogen), are higher in Four Mile Creek than in Upper Three Runs Creek. Nitrate-nitrogen concentrations at this station were generally an order of magnitude greater (mean 2.3 milligrams per liter of nitrate-nitrogen) than at all other onsite stream stations and were attributed to outcropping of nitrates from shallow groundwaters in the vicinity of the 200-F and 200-H Area seepage basins, which have received large volumes of nitrates.

Downstream of the C-Reactor cooling water discharge, mean temperatures of Four Mile Creek exceeded those of the Savannah River from 13°C at the creek mouth to 39°C at the cooling water discharge. The pH of thermally affected waters in the Creek, as well as trace element concentrations of major ions and metals, reflected the higher pH and concentrations of Savannah River water used as cooling water for C-Reactor. Temperature and dissolved oxygen both did not meet Class B water-classifications standards during periods of C-Reactor operation (Lower, 1985).

Table 3-11 lists mean results of water chemistry samples at five stations along Four Mile Creek from 1983 through 1985.

Beaver Dam Creek

DOE placed the heavy-water production facility on standby in 1982. Since then, Beaver Dam Creek has received permitted condenser cooling water from the coal-fired powerhouse in D-Area, neutralization wastewater, sanitary wastewater, ash basin effluent waters, and various laboratory wastewaters.

In relation to onsite nonthermally or postthermally affected streams, water-quality data downstream of the 400-D Area near the onsite swamp exhibits chemical characteristics of a stream impacted by industrial point-source discharges. Historic water-quality data indicate Beaver Dam Creek near the swamp did not meet South Carolina Class B water-classification standards for temperature, although it met all other Class B requirements routinely. In relation to data collected at Upper Three Runs Creek, historic data also indicate that Beaver Dam Creek was higher in pH and concentrations of alkalinity, chemical oxygen demand, suspended solids, chlorides, sulfates, nutrients, and selected metals (Lower, 1984).

Table 3-12 lists mean results of water chemistry samples at three stations along Beaver Dam Creek from 1983 through 1985.

Table 3-11. Mean Water Chemistry of Four Mile Creek, 1983-1985[a]

Parameter/units	Station location: Upstream of Road 4	Road 3	C-Reactor effluent canal	Road A-12.21	Mouth
Temperature (°C)	16.2	16.4	54.7	39.3	28.4
pH (-)	6.34	6.82	7.29	7.29	7.03
Dissolved oxygen (mg/L)	7.04	7.96	4.81	5.82	5.90
Suspended solids (mg/L)	7.50	8.30	11.9	9.50	9.30
Chlorides (mg/L)	2.60	2.90	5.30	5.00	5.70
Sulfates (mg/L)	0.61	7.70	5.10	4.90	5.70
Organic carbon (mg C/L)	9.70	6.10	9.10	7.80	7.10
Phosphorus (mg P/L)	0.02	0.02	0.10	0.09	0.11
Nitrites (mg N/L)	<0.05	<0.05	0.01	0.01	0.01
Nitrates (mg N/L)	0.02	2.27	0.28	0.44	0.39
Arsenic (μg As/L)	1.58	1.66	3.08	1.89	1.97
Cadmium (μg Cd/L)	0.46	0.35	0.25	0.26	0.21
Chromium (μg Cr/L)	11.7	15.1	17.4	11.9	12.4
Copper (μg Cu/L)	2.02	3.98	3.78	4.65	5.17
Lead (μg Pb/L)	3.09	2.03	2.78	2.13	2.05
Mercury (μg Hg/L)	0.06	0.05	0.05	0.05	0.06

[a]Source: Du Pont, 1985b.

Table 3-12. Mean Water Chemistry of Beaver Dam Creek, 1983-1985[a]

Parameter/units	Station location: Downstream of coal-fired powerhouse	Station location: Downstream of ash basin effluent	Station location: Onsite swamp upstream of confluenced with the Savannah River
Temperature (°C)	25.7	24.8	21.7
pH (-)	7.03	6.90	6.81
Dissolved oxygen (mg/L)	7.43	7.25	5.61
Suspended solids (mg/L)	10.7	13.6	15.1
Chlorides (mg/L)	6.20	6.30	5.70
Sulfates (mg/L)	6.82	11.2	7.10
Organic carbon (mg C/L)	11.1	9.80	9.20
Phosphorus (mg P/L)	0.13	0.13	0.09
Nitrites (mg N/L)	0.02	0.02	0.01
Nitrates (mg N/L)	0.31	0.33	0.29
Arsenic (μg As/L)	2.27	3.75	2.02
Cadmium (μg Cd/L)	0.35	0.44	0.23
Chromium (μg Cr/L)	15.9	12.6	19.0
Copper (μg Cu/L)	7.71	8.95	4.45
Lead (μg Pb/L)	4.18	2.34	2.24
Mercury (μg Hg/L)	0.07	0.07	0.06

[a]Source: Du Pont, 1985b.

Pen Branch

The only significant tributary to Pen Branch is Indian Grave Branch, which flows into Pen Branch about 8 kilometers upstream from the onsite swamp. Indian Grave Branch receives K-Reactor cooling water discharge. Other permitted discharges to Pen Branch and Indian Grave Branch include nonprocess cooling water, ash-basin effluent waters, powerhouse wastewater, waste-treatment-plant overflow, reactor process wastewater, and sanitary wastewater, all of which are associated with K-Area operations. The only additional continuous surface discharge to Pen Branch is a small overflow from the sewage-treatment basin at the Central Shops Area near the Pen Branch headwaters (Lower, 1985).

Data from the nonthermal mainstream of Pen Branch indicate water chemistry conditions generally similar to those of Upper Three Runs Creek. Like Upper Three Runs Creek and nonthermal Four Mile Creek waters, nonthermal Pen Branch waters meet South Carolina Class B stream requirements for temperature, pH, and dissolved oxygen. Concentrations of chlorides, sulfates, phosphorous species, and organic carbon are comparable in each of these streams (Lower, 1985).

The water chemistries of thermal Pen Branch and Four Mile Creek waters, particularly for trace-level metals, are comparable due to the discharges of large volumes of cooling water withdrawn from the Savannah River. In relation to the Savannah River, thermal Pen Branch waters were slightly higher in pH and lower in dissolved oxygen content; the latter is attributable to elevated stream temperature. Nitrate-nitrogen concentrations closely resembled those of upriver Savannah River water. Conductivity, turbidity, suspended solids, and alkalinity analyses showed the same comparable trend (Lower, 1985).

Table 3-13 lists mean results of water chemistry samples at five stations along Indian Grave Branch and Pen Branch from 1983 through 1985.

Steel Creek

Discharges to Steel Creek, before the operation of L-Reactor, included those from the P- and L-Areas and the Railroad Yard. These effluents were discharged either to Steel Creek or to Meyers Branch, its principal tributary. The permitted discharges include ash-basin effluent water, nonprocess cooling water, powerhouse wastewater, reactor process effluents, sanitary-treatment-plant effluents, water-treatment-plant wastewaters, and vehicle wash waters (Lower, 1985).

Temperature and dissolved oxygen data from 1960 to 1968 in Steel Creek at Road A, when the Creek received thermal discharges, indicated conditions similar to those in Four Mile Creek and Pen Branch (Jacobsen et al., 1972). Temperature values and dissolved oxygen concentrations for the latter half of 1968 show a return to nonthermal temperature and dissolved oxygen conditions following the placement of L-Reactor on standby in February 1968.

Recent sampling indicates that all major constituent groups - standard parameters, nutrients, major cations, and metals - fall in ranges associated with streams where natural drainage rather than point-source discharges is the dominant input. Calcium concentrations are slightly increased in relation to those in Upper Three Runs Creek, reflecting the natural chemical gradient

Table 3-13. Mean Water Chemistry of Indian Grave Branch and Pen Branch, 1983-1985[a]

Parameter/units	Station location: Road B	Indian Grave Branch at Road B below K-Reactor effluents	Road A-13	Onsite swamp near Road A-17 and above Pen Branch Boardwalk	Onsite swamp above confluence with Steel Creek
Temperature (°C)	14.6	46.5	42.4	33.2	17.0
pH (-)	6.92	7.43	7.40	8.07	6.91
Dissolved oxygen (mg/L)	8.22	5.38	5.71	7.48	6.76
Suspended solids (mg/L)	10.0	10.4	14.4	4.90	3.20
Chlorides (mg/L)	2.50	5.90	5.60	6.00	5.80
Sulfates (mg/L)	2.60	5.10	4.80	5.00	5.10
Organic carbon (mg C/L)	7.20	7.60	7.60	7.70	8.50
Phosphorus (mg P/L)	0.04	0.11	0.08	0.10	0.06
Nitrites (mg N/L)	<0.05	0.02	0.02	0.01	<0.05
Nitrates (mg N/L)	0.05	0.27	0.30	0.23	0.09
Arsenic (μg As/L)	1.49	3.40	3.56	2.78	1.46
Cadmium (μg Cd/L)	0.22	0.30	0.25	0.21	0.24
Chromium (μg Cr/L)	9.74	15.7	16.5	11.1	11.1
Copper (μg Cu/L)	3.16	5.14	3.47	4.10	3.23
Lead (μg Pb/L)	2.31	3.15	2.07	3.55	1.99
Mercury (μg Hg/L)	0.06	0.06	0.06	0.05	0.05

[a]Source: Du Pont, 1985b.

existing from the northwest to the southeast borders of SRP (Du Pont, 1985b). South Carolina Class B water-classification standards for temperature, pH, dissolved oxygen, and fecal coliform counts were met routinely (Lower, 1985).

Table 3-14 lists mean results of water chemistry samples at stations along Steel Creek from 1983 through 1985.

DOE identified the construction of L-Lake on Steel Creek as the preferred method for thermal mitigation of the cooling water from L-Reactor heat exchangers after restart (DOE, 1984). Fifty percent of this 1000-acre lake is maintained below 32.2°C to support a balanced biological community. The lake is about 1200 meters wide at its widest point and extends about 7000 meters along the Steel Creek valley. The normal pool elevation of the lake is 58 meters above mean sea level (MSL). The storage volume at normal pool elevation is about 31 million cubic meters.

The lake is formed by an embankment approximately 800 meters upstream from the Seaboard Coast Line Railroad Bridge across Steel Creek or 1700 meters upstream from Road A. It is 1200 meters long at the crest, which includes approximately 600 meters of low embankment connecting the west end of the main embankment to the natural ground at elevation 61 meters above MSL. The main embankment is about 26 meters high, 12 meters wide at the top, and 200 meters wide at the base. An outlet structure with gates controls the discharge from the lake to a conduit running 220 meters under the embankment. This conduit discharges into a stilling basin to reduce the water's velocity before its release into Steel Creek.

Lower Three Runs Creek

Lower Three Runs Creek is the second largest watershed of the SRP streams. In 1958, its headwaters were impounded to form Par Pond for the recirculation of cooling water from P- and R-Reactors. Cooling water from P-Reactor was discharged to Steel Creek until 1963, when it was diverted to Par Pond. Temperature data from just downstream of Par Pond indicate an average temperature about 2°C higher than other nonthermal streams. In addition, reduced dissolved oxygen concentrations, especially during summer months, are observed at this station. Calcium concentrations are higher in the waters of Lower Three Runs Creek than in other onsite streams. Higher concentrations of calcium and total iron indicate that Lower Three Runs Creek is less soft than the other onsite stream waters. Portions of Lower Three Runs Creek are underlain by calcareous deposits (Langley and Marter, 1973), which increase the hardness of the water. These historic water-chemistry trends have been con- firmed by more recent water-quality studies (Du Pont, 1985b).

Table 3-15 lists mean results of water chemistry samples at stations along Lower Three Runs Creek from 1983 through 1985.

3.5.4 SURFACE-WATER USE

The Savannah River upstream from the SRP supplies municipal water for Augusta, Georgia, and North Augusta, South Carolina. Downstream, the Beaufort-Jasper Water Authority in South Carolina (River Mile 39.2) withdraws about 19,700 cubic meters per day (0.23 cubic meter per second) to supply domestic water for a population of about 51,000. The Cherokee Hill Water Treatment Plant at

Table 3-14. Mean Water Chemistry of Meyers Branch and Steel Creek, 1983-1985[a]

Parameter/units	Station location				
	Road B	Above confluence with Meyers Branch	Meyers Branch above confluence with Steel Creek	Road A-19.1	Below delta after confluence with Pen Branch
Temperature (°C)	17.7	17.2	15.3	15.6	17.2
pH (-)	7.08	7.01	6.93	7.01	6.91
Dissolved oxygen (mg/L)	8.44	8.05	8.03	7.54	6.82
Suspended solids (mg/L)	28.0	16.9	4.60	10.7	2.50
Chlorides (mg/L)	5.20	5.30	2.70	4.50	5.20
Sulfates (mg/L)	4.30	5.20	0.90	3.40	4.50
Organic carbon (mg C/L)	6.00	8.60	8.50	8.70	9.00
Phosphorus (mg P/L)	<0.05	0.06	0.02	0.05	0.05
Nitrites (mg N/L)	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrates (mg N/L)	0.19	0.20	0.09	0.14	0.07
Arsenic (μg As/L)	2.69	2.89	1.90	2.50	2.05
Cadmium (μg Cd/L)	0.20	0.26	0.22	0.21	0.24
Chromium (μg Cr/L)	7.15	9.23	10.8	12.1	6.48
Copper (μg Cu/L)	4.46	2.65	2.36	3.47	3.02
Lead (μg Pb/L)	2.13	4.88	1.74	4.62	1.72
Mercury (μg Hg/L)	0.05	0.07	0.05	0.07	0.05

[a]Source: Du Pont, 1985b.

Table 3-15. Mean Water Chemistry of Par Pond and Lower Three Runs Creek, 1983-1985[a]

Parameter/units	Station location				
	Near bubble-up	Pumphouse intakes	Road B	Pattersons Mill	Highway 125
Temperature (°C)	30.3	20.9	18.7	15.7	15.5
pH (-)	7.33	7.28	6.92	7.17	7.17
Dissolved oxygen (mg/L)	6.56	8.27	7.14	7.63	7.45
Suspended solids (mg/L)	2.18	3.65	4.30	5.60	4.50
Chlorides (mg/L)	6.25	6.02	6.10	3.70	3.60
Sulfates (mg/L)	5.02	4.97	3.40	1.60	0.70
Organic carbon (mg C/L)	6.46	7.47	10.2	7.90	9.00
Phosphorus (mg P/L)	0.04	0.02	0.04	0.03	0.05
Nitrites (mg N/L)	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrates (mg N/L)	0.05	0.03	0.04	0.09	0.13
Arsenic (µg As/L)	2.42	1.56	2.58	1.94	1.95
Cadmium (µg Cd/L)	0.20	0.31	0.22	0.12	0.26
Chromium (µg Cr/L)	13.6	8.94	10.9	10.8	6.88
Copper (µg Cu/L)	3.12	4.29	3.46	2.45	2.60
Lead (µg Pb/L)	1.58	3.17	1.74	1.25	2.24
Mercury (µg Hg/L)	0.09	0.07	0.06	0.05	0.06

[a]Source: Du Pont, 1985b.

Port Wentworth, Georgia (River Mile 29.0) withdraws about 116,000 cubic meters per day (1.35 cubic meters per second) to supply a business-industrial complex near Savannah, Georgia, that has an estimated consumer population of about 20,000 (Du Pont, 1982b). Plant expansions for both systems are planned for the future (i.e., Beaufort-Jasper Water Authority to supply domestic water to 117,000 people and Cherokee Hill Water Treatment Plant to supply a domestic equivalent of 200,000 people in the year 2000).

With the restart of L-Reactor, the maximum SRP withdrawal rate from the river has increased to about 37 cubic meters per second, primarily for use as cooling water in production reactors and coal-fired steam plants. Almost all this water returns to the river via SRP streams; consumptive water use is about 0.85 cubic meter per second at C- and K-Reactors, 1.25 cubic meters per second at L- and P-Reactors, and about 0.3 cubic meter per second at the D-Area powerhouse (DOE, 1984b).

A cooling water withdrawal of about 2.6 cubic meters per second and a discharge of 0.7 cubic meter per second for both units of the Alvin Vogtle Nuclear Power Plant is expected late in the 1980s (NRC, 1985).

The Urquhart Steam Generating Station at Beech Island, South Carolina, withdraws approximately 7.4 cubic meters per second of once-through cooling water. Upstream, recreational use of impoundments on the Savannah River, including water-contact recreation, is more extensive than it is near the SRP and downstream. No uses of the river for irrigation have been identified in either South Carolina or Georgia (Du Pont, 1982b).

3.6 ECOLOGY

The United States Government acquired the 780-square-kilometer Savannah River Plant in 1951. At that time the land was approximately two-thirds forested and one-third cropland and pasture. The U.S. Forest Service allowed the abandoned fields to pass through vegetational succession or planted them with various pine species. Today, more than 90 percent of the SRP is forested. Table 3-16 lists recent SRP land utilization, other than the land used for chemical or nuclear processes and support facilities. SRP, which was designated as a National Environmental Research Park in 1972, is one of the most extensively studied environments in this country (Dukes, 1984).

3.6.1 TERRESTRIAL ECOLOGY

3.6.1.1 Soils

A general soils map of the Savannah River Plant (Aydelott, 1977) groups the soil types into 23 mapping units. The dominant types are Fuquay/Wagram Soils (27.3 percent), Dothan/Norfolk soils (9.6 percent), Savannah River swamp and Lower Three Runs corridor (9.4 percent), Troop Loamy Sand, Terrace phase (8.4 percent), Gunter Sand (7.5 percent), and Vaucluse/Blaney Soils (6.5 percent). Together, these units account for approximately 70 percent of the soil types on SRP.

Table 3-16. Land Utilization, 1983[a]

Land	Area (acres)
Open fields	650
Slash pine	35,000
Longleaf pine	37,500
Loblolly pine	48,000
Pine-hardwood (60% pine)	4,000
Hardwood-pine (60% hardwood)	6,300
Scrub oak	2,000
Upland hardwoods	4,500
Bottomland hardwoods	29,000
Other pine	100
Subtotal	167,050
Wetlands	
Creeks/floodplains	24,500
Savannah River swamp	10,000
Par Pond	2,700
Carolina bays	1,000
Other	1,000
Subtotal	39,200
Total	206,250[b]

[a]Adapted from Dukes, 1984.
[b]Exceeds total SRP acreage due to overlap in wetlands and bottomland hardwood acres.

3.6.1.2 Vegetation

The SRP is near the line that divides the oak-hickory-pine forest and the southern mixed forest. Consequently, it has species representative of each forest association. Prior to its acquisition by the Government, approximately one-third of the SRP was cropland. Except for the production areas and their support facilities, the U.S. Forest Service has reclaimed many previously disturbed areas through natural plant succession or by planting with pine trees. No virgin forest remains in the region (Braun, 1950).

A variety (150 families, 1097 species) of vascular plants occur on the Plant (Dukes, 1984). Typically, a scrub oak community covers the drier sandy areas; longleaf pine, turkey oak, bluejack oak, blackjack oak, and dwarf post oak with ground cover of three awn grass and huckleberry dominate such communities.

Oak-hickory hardwoods are prevalent on more fertile, dry uplands. The characteristic species are white oak, post oak, southern red oak, mockernut hickory, pignut hickory, and loblolly pine with an understory of sparkleberry, holly, greenbriar, and poison ivy.

3.6.1.3 Wildlife

The diversity and abundance of wildlife that inhabit SRP reflect the interspersion and heterogeneity of the habitats occurring on the Plant. Because of its mild climate and the variety of aquatic and terrestrial habitats, SRP contains a varied and abundant herpetofauna (DOE, 1984b). (Gibbons and Patterson, 1978). The species on the Plant include 31 snakes, 26 frogs and toads, 17 salamanders, 10 turtles, 9 lizards, and 1 alligator (Dukes, 1984).

Species collected during intensive field studies on Steel Creek, particularly during 1981 and 1982, are representative of species occurring in similar creeks and wetland areas (Dukes, 1984). Biologists have identified more than 213 species of birds on SRP. Gamebird populations such as quail and dove were abundant initially but have declined since the 1960s because the conversion of agricultural fields to forests has resulted in a reduced carrying capacity. Waterfowl at SRP are mainly winter migrants. Wood ducks are the only waterfowl species to breed consistently in the SRP region, although mallards and hooded mergansers occasionally breed on SRP.

3.6.1.4 Commercially and Recreationally Valuable Biota

The ecosystems on SRP support many commercially and recreationally valuable game populations; however, DOE restricts recreational use to controlled hunts for white-tailed deer and feral hogs. Many species are highly mobile and migrate offsite where activities such as hunting are allowed. Other resident species that are edible and that migrate offsite include the wood duck, bullfrog, and various species of turtles. The slider turtle is the most abundant turtle known to migrate offsite; other common species that move offsite include the Florida cooter and the snapping turtle (DOE, 1984b). Commercially valuable plant biota on the Savannah River Plant include approximately 175,000 acres of timber managed by the U.S. Forest Service.

3.6.1.5 Endangered and Threatened Species

Four species listed as endangered by the U.S. Fish and Wildlife Service - the American alligator, the bald eagle, the wood stork, and the red-cockaded woodpecker - have been identified on the SRP. In addition, one plant species, smooth coneflower (*Echinacea laevigate*), found on the Plant, is currently under status review by the U.S. Fish and Wildlife Service. The smooth coneflower occurs along Burma Road, which parallels Upper Three Runs Creek between F-Area and TNX-Area. To date, the U.S. Fish and Wildlife Service has not identified any "critical habitat" on SRP.

3.6.2 AQUATIC ECOLOGY

3.6.2.1 Aquatic Flora

The Savannah River is the dominant water body at SRP. Biologists have identified approximately 400 species of algae in the river, with diatoms predominating. Blue-green algae are sometimes common upstream from the site; their abundance is attributed to organic loading from municipal sources. Algal diversity has decreased since 1951, probably because of increased organic loading in the Savannah River upriver of SRP (ANSP, 1961, 1974).

Aquatic macrophytes in the river, most of which are rooted, are limited to shallow areas of reduced current and to areas along the shallow margins of tributaries. Eight species of vascular plants have been identified in the river adjacent to SRP, the most abundant being water milfoil, hornwort, alligatorweed, waterweed, and duck potato (DOE, 1984b).

3.6.2.2 Aquatic Fauna

Shallow areas and quiet backwaters and marshes of the Savannah River near SRP support a diverse aquatic invertebrate fauna. However, the bottom substrate of most open portions of the river consists of shifting sand that does not provide the best habitat for bottom-dwelling organisms. During the 1950s, the river experienced a decrease in the total number of invertebrate species; this decrease has been attributed primarily to the effects of dredging (Patrick, Cairns, and Roback, 1967). The groups most affected are those sensitive to the effects of siltation and substrate instability. Mayflies and dragonflies predominated among insect fauna in earlier surveys. In more recent surveys, true flies have been dominant (DOE, 1984b).

Mollusks, such as snails and clams, are an important component of the Savannah River invertebrate community, but they do not occur in the drift communities, presumably because their relatively high density (weight) prevents them from floating. The Asiatic clam, Corbicula, is found in the Savannah River and larger tributary streams in the vicinity of the SRP (DOE, 1984b).

The Savannah River and its associated swamp and tributaries are typical of southeastern Coastal Plain rivers and streams; they support a diverse fish fauna. Sixty-six adult fish species were collected as part of the Comprehensive Cooling Water Study (Du Pont, 1985b). The dominant small fishes (excluding minnows) were sunfishes (especially redbreast) and flat bullheads. The dominant large fishes were bowfin, spotted suckers, and channel catfish. Other important species were largemouth bass, American eel, white catfish, longnose gar, striped mullet, silver redhorse, chain pickerel, and quillback carpsucker. The most abundant small forage species were shiners and brook silverside.

3.6.2.3 Commercially and Recreationally Valuable Biota

The Savannah River supports both commercial and sport fisheries. Most fishing is confined to the marine and brackish waters of the coastal regions of South Carolina and Georgia. The only commercial fish of significance near the SRP are the American shad, the channel catfish, and the Atlantic sturgeon. (The commercial catch of American shad from the Savannah River during 1979 was 57,600 kilograms.)

3.6.2.4 Endangered and Threatened Species

Recent fisheries surveys on the Savannah River revealed that the endangered shortnose sturgeon spawn in the vicinity of the Savannah River Plant (Du Pont, 1985b). A biological assessment of the potential effects of SRP operations on the shortnose sturgeon in the Savannah River (Muska and Matthews, 1983) was submitted to the National Marine Fisheries Service (NMFS). The NMFS and DOE have concurred that the population of the shortnose sturgeon in the Savannah River would not be jeopardized by SRP operations (Oravetz, 1983).

3.7 RADIATION AND HAZARDOUS CHEMICAL ENVIRONMENT

3.7.1 RADIATION ENVIRONMENT

Environmental radiation consists of (1) natural background radiation from cosmic and terrestrial sources and internally deposited natural radionuclides; and (2) man-made radiation from medical diagnosis and therapy, weapons test fallout, consumer and industrial products, and nuclear facilities. The following sections briefly describe the current radiation environment from natural and other offsite sources and radioactivity in the atmospheric, water, and soil environments as a result of SRP activities, as summarized in Table 3-17.

3.7.1.1 Radiation Levels from Natural and Other Offsite Sources

Natural radiation sources contribute about 93 millirem per year in the SRP vicinity, about 48 percent of the annual dose of 195 millirem received by an average member of the public in this area from all sources. The contribution of cosmic radiation to this dose varies with both latitude and altitude, but averages about 40 millirem per year to an unshielded individual in Georgia and South Carolina (EPA, 1972); this is reduced to about 80 percent of that value (or 32 millirem per year) by buildings.

Local gamma radiation exposure from naturally radioactive daughters of uranium and thorium, and naturally radioactive potassium-40 present in the ground within 80 kilometers of SRP ranges between 6 and 385 millirem per year (Langley and Marter, 1973). The average unshielded external terrestrial background radiation in the vicinity of SRP averages about 55 millirem per year, and is reduced by buildings and the body to about 33 millirem per year.

Internal radiation from natural sources arises primarily from potassium-40, carbon-14, rubidium-87, and daughters of radium-226 deposited in various organs of the body. The estimated average radiation exposure in the United States from these natural radionuclides internal to the body is 28 millirem per year (BEIR, 1980).

Radiation received as a consequence of medical diagnosis and therapy represents the largest single contribution of man-made origin to the average individual dose. In the United States, this dose, averaged over the population, is about 93 millirem per year, or about the same as that received from natural background in the vicinity of SRP. All other man-made sources, including such sources as weapons test fallout, consumer and industrial products, nuclear facilities, and air travel, account collectively for less than 10 millirem per year, or about 5 percent of the total annual dose to an average individual (BEIR, 1980).

The only other nuclear facility operating within 80 kilometers of SRP is the low-level radioactive waste burial site operated by Chem-Nuclear Systems, Inc., near the eastern SRP boundary. This facility, which began operating in 1971, releases essentially no radioactivity to the environment, and the incremental radiation dose to the public both from normal operations and from the transportation of waste to the burial site is negligible.

The Alvin W. Vogtle Nuclear Power Plant is currently under construction on the Georgia bank of the Savannah River across from the SRP. Based on radionuclide

Table 3-17. Major Sources of Radiation Exposure in the Vicinity of the SRP[a]

Source of exposure	Dose to average individual (mrem/yr)	Percent of exposure
Natural background radiation		
Cosmic radiation	32.0	
External terrestrial gamma	33.0	
Internal	28.0	
Subtotal	93.0	47.6
Medical radiation		
Diagnostic X-rays	78.4	
Radiopharmaceuticals	13.6	
Medical and dental personnel	0.5	
Subtotal	92.5	47.3
Weapons test fallout	4.6	2.4
Consumer and industrial products	4.5	2.3
Air travel	0.5	0.3
Nuclear facilities (other than SRP)	<0.1	<0.1
SRP environmental radioactivity - 1985	0.1	0.1
Total	195.2	

[a]Source: Zeigler, Lawrimore, and Heath, 1986.

releases reported from 71 commercial power reactors operating at 48 sites in 1981, the average per capita dose to residents within 80 kilometers was about 0.0016 millirem (NRC, 1985). Assuming average performance by the Vogtle plant, the total environmental radiation dose from natural and other offsite sources would not change significantly.

3.7.1.2 SRP Radiation Environment

As noted in Table 3-17, SRP releases in 1985 contributed about 0.1 millirem to the average individual within 80 kilometers of the Plant, less than 0.1 percent of the total individual radiation dose from all sources.

Atmospheric Environment

Table 3-18 lists the releases of radioactive materials to the atmosphere from SRP operations in 1985. This table also compares the average concentrations of these materials in the air at the SRP perimeter to DOE concentration guides. These guides are recommended concentration limits for continuous

Table 3-18. Atmospheric Releases and Concentrations at SRP Perimeter, 1985[a]

Nuclide	Curies released at emission source	Calculated average concentration at Plant perimeter, (Ci/cm^3)	DOE derived concentration guide, (Ci/cm^3)[b]	Percent of DOE derived concentration guide
		Gases and Vapors		
H-3 (oxide)	4.9×10^{5}	1.9×10^{-10}	2.0×10^{-7}	9.3×10^{-2}
H-3 (elemental)	1.8×10^{5}	6.9×10^{-11}	-[c]	-
H-3 (total)	6.7×10^{5}	2.5×10^{-10}	-	-
C-14	7.6×10	2.9×10^{-14}	5.0×10^{-7}	1.0×10^{-5}
Ar-41	5.2×10^{4}	8.5×10^{-12}	-	-
Kr-85m	1.3×10^{3}	3.5×10^{-13}	-	-
Kr-85	6.5×10^{5}	2.5×10^{-10}	-	-
Kr-87	1.1×10^{3}	1.2×10^{-13}	-	-
Kr-88	1.3×10^{3}	2.9×10^{-13}	-	-
Xe-131m	5.0×10	1.9×10^{-15}	-	-
Xe-133	4.6×10^{3}	1.7×10^{-12}	-	-
Xe-135	1.8×10^{3}	5.8×10^{-13}	-	-
I-129	6.5×10^{-2}	2.2×10^{-17}	7.0×10^{-11}	3.0×10^{-5}
I-131	6.0×10^{-2}	2.1×10^{-17}	4.0×10^{-10}	1.0×10^{-5}
		Particulates		
Se-75	9.3×10^{-6}	3.2×10^{-21}	1.0×10^{-9}	1.0×10^{-5}
Sr-89,90	1.8×10^{-3}	6.1×10^{-19}	9.0×10^{-12}	1.0×10^{-5}
Zr-95	2.9×10^{-2}	1.0×10^{-17}	6.0×10^{-10}	1.0×10^{-5}
Nb-95	4.9×10^{-2}	1.7×10^{-17}	3.0×10^{-9}	1.0×10^{-5}
Ru-103	1.1×10^{-2}	3.8×10^{-18}	2.0×10^{-9}	1.0×10^{-5}
Ru-106	4.3×10^{-2}	1.5×10^{-17}	3.0×10^{-11}	5.0×10^{-5}
Cs-134	3.0×10^{-5}	1.0×10^{-20}	2.0×10^{-10}	1.0×10^{-5}
Cs-137	5.2×10^{-3}	1.8×10^{-18}	4.0×10^{-10}	1.0×10^{-5}
Ce-141	3.7×10^{-3}	1.3×10^{-19}	1.0×10^{-9}	1.0×10^{-5}
Ce-144	5.1×10^{-2}	1.8×10^{-17}	3.0×10^{-11}	6.0×10^{-5}
Os-185	5.8×10^{-4}	2.0×10^{-19}	1.0×10^{-9}	1.0×10^{-5}
U-235,238	2.6×10^{-3}	9.1×10^{-19}	1.0×10^{-13}	9.1×10^{-4}
Pu-238	5.4×10^{-4}	1.9×10^{-19}	3.0×10^{-14}	6.3×10^{-4}
Pu-239	5.1×10^{-4}	1.8×10^{-19}	2.0×10^{-14}	8.8×10^{-4}
Cm-242,244	2.5×10^{-4}	8.5×10^{-20}	4.0×10^{-14}	2.1×10^{-4}
Am-241,243	4.3×10^{-4}	1.5×10^{-19}	2.0×10^{-14}	7.4×10^{-4}

[a]Source: Du Pont, 1986.
[b]Derived air concentration guide is that concentration breathed continuously at a rate of 8,400 cubic meters per year that will result in an annual dose rate of 100 mrem/year.
[c]Not applicable to elemental tritium and inert noble gases.

inhalation exposure for persons in uncontrolled areas beyond the SRP boundary, based on a prolonged exposure (expected to last 5 years) of 100 millirem per year. The concentrations at the SRP boundary of all radionuclides released to the atmosphere from the Plant in 1985 were less than 1 percent of the DOE concentration guides.

Tritium from the SRP was detectable at offsite stations. The maximum tritium oxide concentration observed at an SRP perimeter station was 530 picocuries per cubic meter, which is 0.27 percent of the DOE concentration guides. The concentration in air at all SRP perimeter stations averaged 120 picocuries per cubic meter - 0.06 percent of the concentration guide - compared to 10 picocuries per cubic meter at 160-kilometer-radius stations (Zeigler, Lawrimore, and Heath, 1986).

The small amount of particulate alpha and beta radioactivity released to the atmosphere, primarily from the fuel separations areas, generally is obscured in the area surrounding SRP by worldwide fallout. The four sampling location groups (onsite, SRP perimeter, 40-, and 160-kilometer radius) had essentially the same monthly average particulate alpha and beta concentrations in 1985. The 1985 average alpha activity range at these four location groups was 0.00098 to 0.0012 picocurie per cubic meter, which was similar to the 1984 range of 0.0012 to 0.0014 picocurie per cubic meter.

In 1985, the particulate beta-gamma concentrations for all sample groups averaged 0.013 to 0.015 picocurie per cubic meter. This was similar to the average beta-gamma activity reported in 1984. Since 1981, however, there has been a fourfold decline in the average beta activity in air. This decreased activity is attributed to a decline in worldwide fallout from atmospheric nuclear weapons testing. The last announced atmospheric weapons test occurred in China in 1980 (Zeigler, Lawrimore, and Heath, 1986).

In 1985, environmental gamma radiation measurements at the air-monitoring stations were within the ranges observed at these stations during the past several years. Variations in background radiation levels in the vicinity of the Plant are caused by differences in the natural radium and thorium content of the soil and the presence of rocks on or near the earth's surface (rocks contain more radium and thorium than soil). The variations in background radiation are reflected in the data listed in Table 3-19.

Table 3-19. Air Monitoring Station Radiation Measurements, 1985[a]

Locations	Radioactivity measurements (millirem per year)		
	Maximum	Minimum	Average
Plant perimeter	84	51	66
40-km radius	84	55	66
160-km radius	117	62	88

[a]Source: Zeigler, Lawrimore, and Heath, 1986.

Groundwater Environment

Solid and liquid low-level radioactive waste is treated and disposed of on the SRP. Radioactive releases from disposal operations enter the groundwater at specific operating areas on the Plant. The migration of radionuclides to groundwater occurs via seepage basins that have received low-level radioactive liquid waste streams and via leachates from buried solid low-level radioactive wastes. The groundwater that contains radioactivity eventually outcrops to onsite streams (Stone and Christensen, 1983).

Tritium is the most abundant and mobile radionuclide that enters the shallow groundwater. Others include strontium-90, cesium-137, and plutonium-238 and -239. However, because the latter radionuclides tend to adsorb on soil beneath the seepage basins and burial grounds, they migrate very slowly. The soil column acts as a filter to remove many radionuclides from groundwater. However, technetium-99 and iodine-129 are long-lived and mobile in the groundwater environment. These radionuclides have been detected in groundwater, although at very low levels that cannot be measured by accepted routine monitoring procedures (Stone and Christensen, 1983).

Waste sites that are the principal contributors of tritium to shallow groundwater include the K-Area containment basin, the F- and H-Area seepage basins, and the radioactive waste Burial Grounds (Stone and Christensen, 1983).

Tritium is the only radionuclide detected migrating via groundwater from the K-Area containment basin to Pen Branch. Weekly flow measurements combined with tritium concentrations indicated the migration of 7500 curies in 1984 (Du Pont, 1985a). Tritium concentrations in groundwater exceed the EPA drinking-water standard of 20,000 picocuries per liter (Stone and Christensen, 1983). In 1984, the total measured migration of tritium was 2320 curies from the F-Area seepage basins and 12,500 curies from the H-Area seepage basins and the low-level radioactive waste burial grounds. The tritium from these sources mix and cannot be distinguished from each other. The amounts of strontium-90 migration from F- and H-Area seepage basins are 0.20 and 0.12 curie, respectively (Du Pont, 1985a).

A tritium plume in groundwater is present at all active reactor seepage basins. The basin in L-Area and the backfilled basins in R-Area have been inactive for many years. tritium plumes already have reached surface streams in these areas (Pekkala and Holmes, 1985). Tritium concentrations in groundwater around the P- and C-Area seepage basins exceed the EPA drinking-water standard of 20,000 picocuries per liter. Groundwater in R-Area contains strontium-90 in excess of the EPA drinking-water standard (8 picocuries per liter). Elevated levels of nonvolatile beta activity in monitoring wells near the P- and C-Area seepage basins suggest that groundwater near these basins contains strontium-90 above 8 picocuries per liter. Radionuclides have also been detected in shallow groundwater at the L-Area oil and chemical basin and the Savannah River Laboratory seepage basins (Stone and Christensen, 1983). Additional waste site groundwater monitoring and groundwater transport modeling data and information are given in the 26 Environmental Information Documents (EIDs) prepared in support of this EIS. These documents are referenced in Appendixes B and F.

SRP operations have not added detectable levels of radionuclides to the Middendorf/Black Creek (Tuscaloosa) aquifer. Wells in this aquifer provide drinking water for many areas of the Plant. Monitoring data indicate that alpha and nonvolatile beta concentrations are essentially the same as those detected before SRP startup. Tritium concentrations are generally near or at the minimum detectable level, 300 picocuries per liter (Stone and Christensen, 1983).

In 1985, drinking-water supplies from 26 onsite deep well facilities were sampled and analyzed for alpha, nonvolatile beta, and tritium; the results are listed in Table 3-20. Occasional alpha and nonvolatile beta values greater than the minimum detectable concentrations were attributed to ambient radium and thorium that exist in groundwater in the SRP area (Zeigler, Lawrimore, and Heath, 1986).

Radioactivity levels in groundwater in areas adjacent to the Plant are not affected by SRP operations. Monitoring wells are located in shallow aquifers at five gate areas at the SRP boundary. Monitoring data show that alpha and nonvolatile beta concentrations are essentially the same as those detected before SRP startup. Tritium concentrations are generally at or near the minimum detectable level (300 picocuries per liter) for routine environmental monitoring. SRP activities have not added detectable amounts of radioactivity to aquifers at the Plant boundary, as measured by routine monitoring procedures (Stone and Christensen, 1983).

In 1984, drinking water supplies from 10 surrounding towns that use groundwater as a potable water source were sampled and analyzed for alpha, nonvolatile beta, and tritium; the results are presented in Table 3-21. Occasional alpha and nonvolatile beta values in excess of the minimum detectable concentrations are attributed to naturally occurring radium and thorium present in groundwater in the SRP area (Du Pont, 1985a).

Surface-Water Environment

Table 3-22 lists liquid releases from SRP and resulting concentrations in surface water for 1985 together with their Derived Concentration Guides (DCGs). The release of tritium accounts for more than 99 percent of the total radioactivity introduced into streams and rivers from SRP activities; 25,000 curies were transported in the Savannah River in 1985. After dilution by SRP streams and the Savannah River, tritium concentrations averaged 3700 picocuries per liter in the river below the Plant at Highway 301.

Concentrations of radionuclides in onsite streams include both releases directly to the streams and migration in groundwater from seepage basins. Table 3-23 lists mean concentration values reported for 1985 with their DCGs. Even before dilution in the Savannah River, these concentrations in onsite streams are very small percentages of their respective DCGs.

Soil Environment

Radioactive materials are found in surface soils on and in the vicinity of the SRP as a result of deposition processes from the atmosphere. A major portion of the area-wide deposit has resulted from atmospheric nuclear weapons testing. The cumulative deposit of strontium-90 and cesium-137 in the 30°-40°

Table 3-20. Radioactivity in Drinking Water from Deep Wells at Onsite Locations[a]

Location	Alpha (pCi/liter)			Nonvolatile beta (pCi/liter)			Tritium (pCi/liter)		
	No. of Samples	Maximum	Minimum	No. of Samples	Maximum	Minimum	No. of Samples	Maximum	Minimum
A-Area	1	0.00	ND[b]	1	1.6	1.6	2	10	ND
Emergency Operations	1	0.31	0.31	1	1.2	1.2	2	20	ND
Center	2	0.16	ND	2	0.39	0.26	2	130	ND
Barnwell Gate	2	0.08	ND	2	0.56	ND	2	70	ND
C-Area	2	0.62	0.57	2	1.6	0.78	4	130	ND
Central Shops	2	0.39	ND	2	1.7	0.73	3	110	ND
Classification Yard	2	0.62	0.33	2	2.0	0.97	2	130	ND
TNX	2	0.62	0.23	2	3.1	2.8	2	0	ND
D-Area	2	0.08	ND	2	1.7	1.2	2	390	360
F-Area	2	0.16	0.16	2	2.2	1.8	2	0	ND
Firing Range	2	2.6	2.5	2	3.6	3.6	2	1600	1500
Forestry Building	2	1.6	0.47	2	2.0	0.59	2	1400	1000
681-1G	2	0.41	0.31	2	3.8	3.2	2	20	ND
H-Area	2	1.9	1.8	2	4.7	4.6	2	1400	ND
Jackson Gate	2	0.47	0.00	2	1.1	0.38	2	20	ND
K-Area	2	0.94	0.08	2	1.6	1.0	4	280	ND
L-Area	2	0.39	0.31	2	1.1	0.87	4	170	ND
P-Area	2	0.49	0.23	2	1.5	1.3	2	20	ND
TC	2	2.6	1.3	2	2.7	1.9	2	480	220
Williston Gate	2	0.08	0.00	2	0.65	0.20	2	80	ND
Par Pond Lab 905-89G	2	0.39	ND	2	1.1	0.73	1	0	ND

[a]Source: Du Pont, 1985a.
[b]ND = Not detectable.

Table 3-21. Radioactivity in Drinking Water at Offsite Locations[a,b]

Location and Source	Alpha (pCi/liter)		Nonvolatile beta (pCi/liter)		Tritium (pCi/liter)	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Aiken (stream and well)	0.62	0.55	1.2	0.36	480	280
Allendale (well)	0.23	ND[c]	1.5	0.78	40	ND
Barnwell (well)	0.39	0.00	1.1	ND	120	120
Bath (well)	0.32	0.15	0.15	0.00	260	130
Blackville (well)	0.27	ND	1.7	1.5	150	ND
Jackson (well)	0.86	0.39	1.1	0.78	360	120
Langley (well)	0.55	0.47	1.3	1.2	170	ND
New Ellenton (well)	0.24	0.16	0.20	0.00	180	40
Sardis (well)	0.16	ND	1.9	0.44	120	ND
Williston (well)	0.70	0.47	1.3	0.20	180	10

[a]Source: Du Pont, 1985a.
[b]Results based on two samples.
[c]ND = Not detectable.

Table 3-22. Liquid Releases and Concentrations for 1985[a]

Nuclide	Curies released at emission source	Derived conc. guide (pCi/L)[b]	Below SRP[c] Conc. (pCi/L)	Beaufort-Jasper[d] Conc. (pCi/L)	Port Wentworth[e] Conc. (pCi/L)
H-3	2.5×10^{4}[f]	2,000,000	3,700[g]	2,900[g]	3,000[g]
Sr-89,-90	1.8×10^{-1}	1,000	1.5×10^{-4}	2.1×10^{-2}	2.2×10^{-2}
I-129	2.2×10^{-2}	500	3.0×10^{-3}	2.5×10^{-3}	2.6×10^{-3}
Cs-137	1.0×10^{-1}	3,000	7.0×10^{-2}	1.2×10^{-2}	1.2×10^{-2}
Uranium	1.4×10^{-3}	600	1.8×10^{-4}	1.6×10^{-4}	1.6×10^{-4}
Pu-239	7.0×10^{-3}	300	9.5×10^{-4}	8.1×10^{-4}	8.4×10^{-4}

[a]Source: Du Pont, 1986.
[b]Derived water concentration guide is the concentration that when consumed at a rate of 730 liters per year will result in an annual dose rate of 100 mrem.
[c]Savannah River just downriver from SRP.
[d]Beaufort-Jasper drinking water.
[e]Port Wentworth drinking water.
[f]Includes releases to streams and groundwater migration from seepage basins.
[g]Measured concentrations. All other concentrations were calculated using models that were verified using tritium measurements.

Table 3-23. Radioactivity in Onsite Streams[a]

Radionuclide	Derived concentration guide[b] (pCi/L)	Savannah River, upstream of plant	Concentration, Mean (pCi/L)					
			Upper Three Runs Creek[c]	Four Mile Creek[c]	Beaver Dam Creek[d]	Pen Branch[c]	Steel Creek[c]	Lower Three Runs Creek[e]
H-3	2,000,000	4600	2700	120,000	28,000	20,000	8600	3300[c]
Cr-51		1.3	f	21	f	26	14	12
Co-60	5,000	0.59	f	1.7	f	2.2	1.5	1.6
Zn-65		0.76	f	2.7	f	2.6	2.3	2.1
Sr-89, 90	1,000[g]	0.1	f	2.6	f	0.11	0.22	0.06[c]
Zr-95, Nb-95	40,000	0.2	f	1.8	f	0.63	0.32	1.0
Ru-103, 106	6,000[h]	1.4	f	3.4	f	1.1	0.00	2.2
I-131	3,000	1.5	f	90	f	120	920	73
Cs-134	2,000	0.8	f	2.4	f	1.7	1.7	1.8
Cs-137	3,000	0.1	f	0.43	f	0.42	0.28	0.56
Ce-141, 144	7,000[i]	0.5	f	0.80	f	3.4	0.00	2.1
U/Pu	300[j]	f	0.12	0.10	f	0.09	0.11	0.12

[a]Source: Du Pont, 1986.
[b]DOE Interim Order DOE 5480.1A.
[c]Measured at Road A.
[d]400-D Effluent.
[e]Measured at Patterson Mill.
[f]Not reported.
[g]DCG for Sr-90.
[h]DCG for Ru-106.
[i]DCG for Ce-144.
[j]DCG for Pu-239.

north latitude band (where SRP is located) has been estimated to be about 63 and 101 millicuries per square kilometer, respectively (United Nations, 1982). Corresponding cumulative deposition values for plutonium-238 and -239 are 0.03 and 1.15 millicuries per square kilometer, respectively.

Releases from SRP have contributed to soil radionuclide concentrations. Appendix B describes such contributions from waste management activities in subsurface soils. Airborne materials have been deposited primarily in proximity to the F- and H-Area stacks. Sampling onsite and in the SRP vicinity have produced the deposition values for 1985 listed in Table 3-24. These values are similar to or less than those estimated from nuclear weapons testing. The measured strontium-90 outside the SRP represents only a small fraction of the estimated worldwide deposition rate; cesium-137 is measured at about 30 percent of the estimated deposition rate, and the values for plutonium-238 and -239 are very close to those estimated on a worldwide basis. This confirms the observation that deposited cesium-137 is retained on soils more strongly than strontium-90, but less so than plutonium-238 and -239.

Table 3-24. Radioactivity Deposited in Soil, 1985[a]

Location	Deposition[b] (mCi/km^2, 5-cm depth)			
	Sr-90	Cs-137	Pu-238	Pu-239[c]
F-Area[c] average[d]	12 ± 3	30 ± 48	0.5 ± 0.6	6 ± 9
H-Area[c] average[d]	13 ± 22	63 ± 57	2 ± 4	5 ± 4
SRP perimeter average[d]	9 ± 5	31 ± 21	0.03 ± 0	0.9 ± 0.3
160-km radius average[d]	4 ± 4	28 ± 6	0.08 ± 0	0.8 ± 0

[a]Source: Du Pont, 1986.
[b]The ± value = 2-sigma counting error.
[c]F- and H-Area samples collected 2000 feet from 200-foot stack in each cardinal direction.
[d]The ± value = mean 2 standard deviation.

Table 3-24 also indicates that the only detectable contribution of plant origin to surface soil radioactivity occurs around the Separations (F- and H-Area) stacks (Zeigler, Lawrimore, and Heath, 1986). Appendix B describes subsurface soil contamination by radionuclides in detail.

3.7.2 HAZARDOUS CHEMICAL ENVIRONMENT

Hazardous chemicals are used and produced as byproducts of certain SRP operations. Also, hazardous or potentially hazardous chemicals have been disposed of at known sites on the Plant. The following sections describe the existing hazardous chemical environment on SRP for the atmosphere, groundwater, surface water, and soils.

3.7.2.1 Atmospheric Environment

Emissions from the seven SRP coal-fired powerplants include sulfur dioxide, nitrous oxides, and smoke. All were within applicable emission standards in 1985 (see Section 3.2.4.2).

3.7.2.2 Groundwater Environment

At the Plant, 168 waste sites have been identified that have been or are being used for the disposal or storage of wastes. The majority of these sites contain nonradioactive wastes. Criteria waste sites are described in detail in Appendix B. Thirty-seven sites might have received hazardous wastes or potentially contain hazardous wastes; 19 are low-level radioactive sites; and 21 potentially are mixed waste sites. Appendix B includes a history of waste disposal; evidence of past and existing contamination; waste characteristics (i.e., the types, forms, quantities, and concentrations of waste); the chemical and physical properties of the waste; and the potential for transport (volatility, mobility in soil, and solubility in water).

The nonradioactive wastes disposed of at the Plant include the following categories (Christensen and Gordon, 1983):

Nonhazardous solids	- Wood, lumber, concrete blocks and slabs, bricks, glass, fenceposts, tires, rubber, and trash
Nonvolatile organics	- Fuel, motor oil and grease, waste oil, and paint
Anions	- Coal pile runoff, acids, caustics, ash sluice, liquid chemicals, hydrofluoric acid
Pesticides	- Biocidal compounds used either in plant operation or plant maintenance
Metals	- Heavy and reactive metals, metal shavings, and mercury
Volatile organics	- Chlorinated hydrocarbons, chlorinated biphenyls, solvents, other organics

Groundwater at 46 of the waste disposal sites was monitored for hazardous constituents in 1984. Types of potential groundwater contaminants include chlorinated organics, heavy metals, and nitrates. Levels of contamination range from detectable limits to greater than drinking-water standards. About half the radioactive, nonradioactive, and mixed waste sites for which groundwater monitoring data exist have some contaminants that exceed drinking-water standards.

Groundwater contaminants have been identified in the F-, H-, and M-Area seepage basins. These basins have been used to dispose of a variety of industrial chemicals. Suspected contaminants include the following (Du Pont, 1985a):

F-Area seepage basins	-	Acid, cadmium, copper, manganese, iron, lead, sodium, nickel, zinc, fluoride, nitrate, radium, foaming agents, and phenol
H-Area seepage basins	-	Acid, chloride, iron, mercury, manganese, nitrate, and radium
M-Area seepage basin	-	Chloride, organics, cadmium, copper, manganese, nickel, nitrate, radium, and phenol

Extensive monitoring of the M-Area settling basin site has defined a plume of organic compounds in groundwater (Du Pont, 1985a). Maximum concentrations of 269,000 parts per billion of trichloroethene, 161,000 parts per billion of tetrachloroethylene, and 260 parts per billion of 1,1,1-trichloroethane were detected in monitoring wells in 1983 (Du Pont, 1984). None of the organic compounds has been detected in offsite groundwater (Zeigler, Lawrimore, and Heath, 1986). A groundwater treatment (air stripping) program has been initiated in this area (Du Pont, 1985a).

Since organic compounds were detected in the M-Area groundwater, all SRP drinking-water supplies are analyzed for these constituents. No significant concentrations were detected in 1984. However, trichloroethylene at 1 to 8 parts per billion (slightly above the minimum detectable concentration) was detected on a few occasions in 1984 in the 3/700-Area (Du Pont, 1985a).

At several of the remaining waste disposal sites monitored in 1984, preliminary data indicate that concentrations of some chemicals and metals might be higher than ambient levels. Groundwater monitoring has indicated the presence or possible presence of groundwater contaminants at the following sites:

Silverton Road waste site	-	Volatile organics (trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane), barium, cadmium, chromium, and mercury (which were found infrequently in excess of EPA drinking-water standards) (Scott et al., 1985)
Chemicals, metals, and pesticides (CMP) pits	-	Volatile organics (methylene chloride, tetrachloroethylene, toluene, benzene) and bis(2-ethylhexyl)phthalate (Killian, Kolb, and Price, 1985)
Savannah River Laboratory seepage basins	-	Chromium and lead (occasionally detected in excess of EPA drinking-water standards), and volatile organics (trichloroethylene, tetrachloroethylene) (Fowler and Simmons, 1985)
Old TNX basin	-	Acid, mercury, manganese, nickel, and nitrate (Kingley and Simmons, 1985)

Radioactive waste burial grounds	-	Mercury (Jaegge et al., 1985)
Metals burning pit/ miscellaneous chemical basin site	-	Trichloroethylene (Muska and Pickett, 1985)

Additional waste site groundwater monitoring and groundwater transport modeling data and information in chemical contaminants are available in the 26 Environmental Information Documents prepared in support of this EIS in 1986. They are referenced fully in Appendixes B and F.

3.7.2.3 Surface-Water Environment

Water-quality monitoring for nonradioactive parameters was initiated for SRP onsite streams as early as 1959. Routine water-quality monitoring of the streams began in 1971. An extensive sampling program was conducted in 1985 (see Chapter 5). The results of this monitoring indicate that concentrations of pesticides, herbicides, and polychlorinated biphenyls (PCBs) in Savannah River and onsite stream water were below the limits of detection in 1984 and 1985. In 1984, aldrin, 2,4-dichlorophenoxyacetic acid, and malathion were detected in river sediment; however, with the exception of 2,4-dichlorophenoxyacetic acid, concentrations were near the detection limit (Du Pont, 1985a, 1986). Also, sediment from Lower Three Runs Creek and Par Pond contained higher than normal concentrations of silvex, 2,4-dichlorophenoxyacetic acid, heptachlor, and endrin aldehyde. The presence of these compounds is attributed to forestry and agricultural applications. Other compounds detected in sediment from SRP streams include aldrin and gamma-benzene hexachloride = 1,2,3,4,5,6-hexachlorocychlohexane (Du Pont, 1985a). In 1985, detectable quantities of beta-benzene hexachloride and alpha-benzene hexachloride were reported in river sediment. Concentrations of alpha-benzene hexachloride were near the minimum detectable concentration, while those for beta-benzene hexachloride were somewhat higher (Zeigler, Lawrimore, and Heath, 1986).

Sediments from the Par Pond pumphouse and most locations in the onsite streams contained detectable levels of beta-benzene hexachloride. Other chemicals reported in measurable quantities in sediments from SRP streams were the pesticides 4,4-DDD, 4,4-DDE, and heptachlor. There is no significant difference between upriver and downriver concentrations. These data indicate that the occasional positive pesticides, herbicides, and PCB concentrations detected in SRP water and sediments originate off the site (Zeigler, Lawrimore, and Heath, 1986).

3.7.2.4 Soils Environment

At the existing waste sites, information on soil contaminated with hazardous material is limited primarily to the soil underlying nonradioactive or mixed waste sites. Potential soil contaminants are those associated with the wastes disposed at nonradioactive or mixed waste sites; these include nonvolatile organics, anions, pesticides, heavy metals, and volatile organics (Stone and Christensen, 1983). Suspected soil contaminants or contaminants identified from borings or sediment sampling and analyses at waste sites include the following:

M-Area settling basin and vicinity (above reference background levels) (mixed waste site)	- Barium, chromium, copper, lead, manganese, magnesium, nickel, bis(2-ethyl hexyl)phthalate, tetrachloroethylene, 1,1,1-trichloroethylene, methylene chloride, toluene, di-n-octyl phthalate, tetrachlorobiphenyl, pentachlorobiphenyl, and hexachlorophenyl (Colven, Muska, and Pickett, 1985)
Old TNX seepage basin	- Silver, chromium, copper, mercury, nickel, and cyanide (Kingley and Simmons, 1985)
H-Area seepage basins	- Chromium and mercury (Killian et al., 1985b)
F-Area seepage basins	- Mercury (Killian et al., 1985a)
CMP Pits (following soil excavation)	- Volatile organics (mostly less than 1 part per million) and pesticides (less than 10 part per million) (Killian, Kolb, and Price, 1985)

3.8 CONTROL AND SECURITY

Access to the SRP is controlled at primary roads by permanently manned barricades. Other roads are closed to traffic by gates or fixed barricades. The entire perimeter of the SRP, with the exception of its Savannah River boundary, is fenced. Additionally, the site is posted against trespass under State of South Carolina and Federal statutes. Operating areas are separately fenced and patrolled continuously by armed security personnel.

The following sections present site-specific information on site location and accessibility. Table 3-25 lists the existing waste sites and indicates if they are enclosed by perimeter fence lines.

3.8.1 NEW FACILITIES

Although specific sites have not been approved for the new facilities described below, all proposed sites are inside the SRP perimeter fence. The proposed security measures for each facility would be the same regardless of the exact site selected.

One or two security fences would be constructed surrounding the facilities, depending on the security regulations in effect at the expected time of operation of the facilities. Normal access to the area would be through a main gate that would be controlled by operating personnel. Other gates, including any railroad gates, would remain locked during normal operation.

A perimeter road would be constructed adjacent to the outer fence suitable for all-weather travel by security patrols and maintenance personnel. Additional roads would be installed as required so patrol personnel would be able to observe clearly all operating areas of the storage/disposal facility. Tall

Table 3-25. Fenced/Unfenced SRP Waste Sites

Area	Fenced	Unfenced
A- and M-Areas		
Silverton Road waste site		X
Waste oil basins		X
Metals burning pit/miscellaneous chemical basin		X
Metallurgical laboratory basin		X
Burning/rubble pits[a]		X
M-Area settling basin	X	
SRL seepage basins	X	
F- and H-Areas		
Acid/caustic basins[b]		X
F-Area seepage basins		X
Old F-Area seepage basin		X
H-Area seepage basins		X
Mixed waste management facility	X	
Separations area retention basins[c]	X	
Radioactive waste burial grounds	X	
R-Area		
Reactor seepage basins	X	
Bingham pump outage pits		X
C- and CS-Areas		
Hydrofluoric acid spill area		X
Ford Building seepage basin	X	
Ford Building waste site		X
TNX Area		
Old TNX seepage basin	X	
New TNX seepage basin		X
TNX burying ground	X	
Road A Area		
Road A chemical basin		X
L-Area		
CMP pits		X
L-Area oil and chemical basin	X	
Miscellaneous areas		
SRL oil test site		X
Gun site 720 rubble pit		X

[a]Only the F-Area burning/rubble pit is fenced.
[b]Only the H-Area basin is fenced.
[c]Only the H-Area retention basin is fenced.

lighting poles would be constructed to make the entire area visible at night. The lights should be connected to an emergency power supply.

3.8.2 INSTITUTIONAL CONTROLS

The period of institutional control is not defined in either DOE Order 5820.2 or in NRC regulation 10 CFR 61. The period of control for radioactive waste is generally accepted to be 100 years - during which stable governmental control is assumed. The minimum period of monitoring required by the EPA regulations for hazardous waste is 30 years after the closure of the site.

The facility would be designed with a goal of "zero maintenance." During the period of institutional control, any repairs that might be necessary are expected to be minor. After the institutional control period, the system should continue to perform well for many years.

3.8.3 POSTINSTITUTIONAL CONTROL

Postinstitutional control is the period after about 100 years during which control of access to the disposal site is assumed to be lost. For calculational purposes, the general population is assumed to occupy the site and build houses, farm the land, etc.

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CHAPTER 4

ENVIRONMENTAL CONSEQUENCES

This chapter describes the potential environmental consequences of adopting several strategies for the modification of the management of existing waste sites, the construction of new storage/disposal facilities, and the management of disassembly-basin purge water, for hazardous, low-level radioactive, and mixed wastes at the Savannah River Plant (SRP), and of adopting the "No-Action" strategy, as required by the National Environmental Policy Act (NEPA).

4.1 ALTERNATIVE WASTE MANAGEMENT STRATEGIES

The alternative strategies for the modification of the SRP waste management program that have been identified involve combinations of various actions or the management of existing waste sites, the construction of new storage/disposal facilities, and the management of disassembly-basin purge water. These strategies also consider the implications for the long-term dedication of SRP land areas, institutional control, and monitoring.

These waste management strategies are interrelated; modifications of one can affect another. For example, a modification that calls for the removal of waste from all existing waste sites for disposal elsewhere cannot be paired with the No-Action alternative strategy for new disposal facilities. Thus, the alternative strategies listed in Table 2-1 and described throughout this environmental impact statement (EIS) as integral entities are logical outgrowths of needed SRP waste management actions and recently enacted regulatory requirements.

This EIS characterizes these alternative strategies as:

- No Action - continuation of the present program for waste management to provide protection of the offsite environment
- Dedication - compliance with groundwater protection requirements by dedication of existing and new disposal areas
- Elimination - compliance through the elimination of existing waste sites and the provision of retrievable storage of wastes
- Combination - compliance by a combination of dedication and elimination of waste sites and storage and disposal of wastes

This chapter treats, in turn, the environmental consequences of adopting alternative strategies to the modification of the waste management program. Section 4.2 describes alternative strategies for managing existing waste sites. These strategies are complex; they are represented in this analysis by preliminary field data and atmospheric, groundwater, and health effects modeling information presented to bound the environmental consequences and costs. The implementation of specific actions at individual locations would be determined by interactions with regulatory agencies based on future site-specific modeling and monitoring results not currently available for the majority of the sites.

Section 4.3 presents the environmental consequences of the construction of new disposal/storage facilities; Section 4.4 describes the effects of modifications to the discharge of disassembly-basin purge water; and Section 4.5 presents the consequences of potential accidents associated with remedial, removal, and closure actions at existing waste sites. Section 4.6 presents the effects of the decontamination and decommissioning of potential new facilities; Section 4.7 describes cumulative effects; Section 4.8 describes mitigation measures; and Section 4.9 describes unavoidable/ irreversible impacts. Section 4.10 summarizes the environmental consequences of the preferred strategy.

4.2 ALTERNATIVE WASTE MANAGEMENT STRATEGIES AT EXISTING WASTE SITES

This section describes the environmental consequences of the implementation of four strategies for the management of existing waste sites that contain or might contain hazardous, low-level radioactive, or mixed waste. They represent the strategies described fully in Section 2.1; they consist of the following:

- No Action - No removal of waste at existing sites, and no closure or remedial actions

- Dedication - No removal of waste at existing waste sites, and implementation of cost-effective closure and remedial actions, as required

- Elimination - Removal of waste to the extent practicable from all existing waste sites, and implementation of cost-effective closure and remedial actions, as required

- Combination - Removal of waste to the extent practicable at selected existing waste sites, and implementation of cost-effective closure and remedial actions, as required

The following sections describe these strategies. The description of each summarizes the scope of the range of actions that are considered feasible for the existing sites; identifies the predicted effects of these actions on contaminants in groundwater and surface water in each geographic grouping of sites (see Section 2.2) and compares them to relevant standards; assesses public exposures to and health risks from chemical and radioactive waste constituents; and presents impacts on aquatic, terrestrial, archaeological and historic, and socioeconomic resources.

The assessments in these sections are based on groundwater and surface-water concentrations of waste constituents that are likely to be present at existing waste sites, and that are predicted by computer codes to exceed applicable standards.

The transport models used in these analyses (predominantly the PATHRAE code; see Appendix H) consider a variety of pathways from the waste source to the human environment, including the following:

- Groundwater movement to water wells (hypothetically assumed to be 1 meter and 100 meters downgradient from each waste site) and to actual surface streams
- Erosion of waste materials from a site and movement to a surface stream
- Consumption of food produced from farmland reclaimed over a waste site and consumption of crops produced through natural biointrusion on land over a waste site
- For radioactive constituents, direct exposure to gamma radiation
- Inhalation of volatile gaseous or particulate material in the air
- Ingestion of foodstuffs containing waste materials deposited from the atmosphere on the ground surface

PATHRAE modeling is applied to an individual waste site (e.g., metallurgical laboratory basin); to contiguous sites modeled as a single group (e.g., SRL seepage basins); and as the worst-case impact analysis (based on hydrogeology and source conditions) of a class of sites that serve similar functions but are in several different SRP areas (e.g., acid/caustic basins).

The analyses in this section are based on individual waste site source-term information (Looney et al., 1986) and the 1- and 100-meter well concentrations presented in Appendix F. The initial emphasis is on potential cumulative groundwater effects within geographic groupings. Cumulative effects could occur of groundwater contaminated from an upgradient waste site travels beneath another waste site and receives additional leachate from the second site.

Potential plume interaction is determined by summing the predicted peak concentrations at all 100-meter wells in a geographic grouping regardless of the time of peak occurrence. This summation is conservative and is used as a screening device to establish an upper bound to potential cumulative effects. Actually, as the groundwater travels slowly beyond the 100-meter well, the peak concentration would be attenuated by dilution with uncontaminated groundwater recharge and the spreading that occurs as a contaminant flows through the porous media. In addition, one site probably would not be located precisely downgradient from another, and the centroid of the original contaminant plume probably would not be under the second site at the same time the peak contaminant flux was entering the groundwater from that site.

Therefore, this method establishes a conservative upper bound to potential interactions because it does not consider the spatial or temporal nature of contaminant plumes or the decay and dilution that occur as they travel. If the sum (for each constituent) of the peak concentrations at each 100-meter well does not exceed standards, no further examination is made. If the summation exceeds standards, the specific pathways, time of occurrence, and source conditions of the affected waste sites are examined to see if realistic cumulative effects could occur. The 100-meter well concentrations were used in this analysis because they reflect at least the initial attenuation that occurs in this process.

With the potential for plume interaction established in Section 4.2.1.1, Sections 4.2.2.1, 4.2.3.1, and 4.2.4.1 examine groundwater impacts under remedial and closure actions that are consistent with the Dedication, Elimination, and Combination strategies. Closure generally reduces predicted peak concentrations. However, in these sections the absolute peak concentrations (i.e., the 1-meter well) are presented to identify the potential for postclosure groundwater remedial actions under each of these three closure strategies. The listed values in these sections might be higher, and more constituents might be presented, because the concentrations at the 1-meter well are reported, rather than those at the 100-meter well.

The time periods for analysis of potential environmental consequences are based on two assumptions: first, the U.S. Department of Energy (DOE) will not relinquish control of the SRP for 100 years beyond 1985, which is reasonable in light of current production planning and projected scheduling for site decommissioning; and second, analyses to 1000 years are sufficient to bound the long-term consequences, as suggested by guidelines of the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Environmental Protection Agency (EPA).

The sites and constituents to be modeled for this EIS were determined as follows: first, available data were reviewed to determine the materials disposed of at each site and the constituents found in soil or groundwater; second, in the absence of measured values, soil and groundwater concentrations were predicted from site inventories; and third, measured or predicted soil and groundwater concentrations were compared to threshold selection criteria established for each constituent, corresponding to or less than EPA maximum contaminant levels (MCLs). If the quantities or concentrations were less than the selection criteria values, no pathway modeling or environmental assessments were made.

The following sections present peak groundwater concentrations that are predicted to exceed MCLs or other standards for each strategy and waste site grouping. These sections contain tables (e.g., Table 4-2) that list the predicted peak concentrations and corresponding applicable standards of modeled constituents for combinations of strategy and waste site groupings. The "applicable standard" values in these tables are derived from several sources, primarily the National Primary Drinking Water Regulations (40 CFR 141; EPA, 1985a). A methodology of the International Commission on Radiological Protection (ICRP, 1978) was used to determine radionuclide concentrations that yield an effective whole-body dose of 4 millirem per year, calculated on a basis of 2 liters per day for drinking-water intake. Drinking-water regulations based on this methodology are anticipated (EPA, 1986a). For consistency, all radionuclide MCLs were calculated in this manner. Current drinking-water regulations, however, use 1963 dose rate limits that cause different values (e.g., tritium and strontium-90 MCLs are 20,000 and 8 picocuries per liter, respectively). In addition, if two or more radionuclides are present, the sum of the doses, not the individual doses, cannot exceed 4 millirem per year.

The following sections also present risk assessments for each strategy and waste grouping in terms of carcinogenic risks from radioactive and nonradioactive wastes, and noncarcinogenic risks from other hazardous chemicals. Carcinogenic risks are the product of exposure (either chemical or radiological) and the unit cancer risk (UCR). These risks are additive; that is, the risks from chemical exposures can be summed and equivalent radiological risks added to obtain a combined risk estimate expressed as the increase in probability for fatal cancer in an individual (with a value between 0 and 1). In these evaluations, risks from chemical carcinogens have been determined as lifetime risks from exposures over a period of 50 years, which encompasses the year of peak exposure. Radiological risks, however, were calculated for an exposure period of the peak year only. Thus, to produce a common risk basis for both chemical and radiological carcinogenesis, radiological risks calculated as lifetime risk per year of exposure are multiplied by 50 to produce a conservative estimate of lifetime-exposure risk comparable to that originally calculated for chemical carcinogenesis. This EIS considers lifetime carcinogenic risks calculated to be less than 1 in 100 million (1×10^{-8}) for individual constituents to be not significant.

As a perspective on carcinogenic risks, the average risk in the United States of a person dying from cancer is about 1.9×10^{-3} (or almost 2 chances in 1000) per year. However, rates in individual states range from a low of about 0.76×10^{-3} (in Alaska, with a very young population on average) to a high of 2.4×10^{-3} (in Florida, which has an older average population). The average risk of dying from lung cancer is about 5×10^{-4} per year; about one in four cancer deaths arise from this cause. The lifetime (age-adjusted) average risk of death by cancer is about 9×10^{-2} (or 9 chances in 100).

EPA has adopted a lifetime risk value of 1×10^{-6} as a reference point for the management and regulation of carcinogens in the environment. Thus, an incremental risk from an environmental carcinogen at the EPA guideline limit would raise the risk to an average U.S. resident of death by cancer from 0.09 to 0.090001. Similarly, at an incremental annual risk of 1×10^{-4} from a particular exposure, the total annual risk to an average individual of death by cancer would rise from 0.0019 to 0.0020.

A noncarcinogenic risk from chemical constituents is defined as the ratio of the average daily lifetime dose to the acceptable daily intake (ADI) for chronic exposure. Because noncarcinogenic effects are assumed to occur only if the exposure exceeds a threshold value defined by the ADI, any value of calculated risk less than 1 means that no health effect is likely; the smaller the value the greater the margin of safety. Individual noncarcinogenic risk values can be summed to form a hazard index that also is compared conservatively to a threshold of 1. Because SRP waste sites do not have more than (at most) several dozen waste constituents, individual constituent noncarcinogenic hazard index values of less than 1 in 100 (1×10^{-2}) are considered not significant in these assessments; that is, the sum of several dozen risks of 0.01 each would still be much less than 1, and hence no health effect would be expected.

Finally, the evaluations of alternatives in this section are based for the most part on preliminary information and simplified modeling assumptions, which predict groundwater and/or surface-water concentrations to exceed current standards at some time in the future (or at present). However, these concentrations cannot be compared directly to monitoring results at these sites. These predictions represent a preliminary indication of the probable need for, or benefit from, closure or remedial actions under defined circumstances, for bounding estimates in this EIS. In practice, the need for and types of closure or remedial actions will be determined by direct interaction with regulatory authorities, based on detailed site-specific data and evaluations, and in conformance with the standards then in effect.

4.2.1 NO-ACTION STRATEGY (NO REMOVAL OF WASTE AND NO CLOSURE OR REMEDIAL ACTION)

Under No Action, existing waste at all sites would remain in place and each site would be retained in its present condition, except the addition of wastes to currently active sites would be discontinued as treatment facilities became available. Existing basins would not be backfilled and liquids contained in these basins, including periodic rainfall, would continue to dissipate by evaporation or infiltration into the soil.

Remedial actions would be taken to protect the offsite environment. Additional groundwater monitoring wells would be installed at the sites listed in Table 4-1 to ensure the detection of contaminant plumes. All existing and new wells would be monitored as required.

Table 4-1. Additional Groundwater Monitoring Wells

Site Group Number	Site	Buildings	Number
1-5	Miscellaneous chemical basin	731-5A	5
2-2	H-Area acid/caustic basin	904-75G	4
2-5	H-Area retention basin	281-3H	2
2-6	F-Area retention basin	281-3F	4
3-4 to 6	R-Area Bingham pump outage pits	643-8G to 10G	4
4-6	Ford Building waste site	643-11G	a
5-3	TNX burying ground	643-5G	16
8-3	K-Area Bingham pump outage pit	643-1G	4
9-10, 11	L-Area Bingham pump outage pits	643-2G, 3G	4
10-3	P-Area Bingham pump outage pit	643-4G	4
11-1	SRL oil test site	080-16G	4
11-2	Gunsite 720 rubble pit	N80,000: E27,350[b]	4

[a]Number unknown
[b]SRP map coordinates

Fences, pylons, and signs would be installed to keep out animals and unauthorized persons, and all waste sites would be inspected periodically for erosion or subsidence. Weed control, grass mowing, and maintenance of signs and fences would be provided, as in other SRP areas.

4.2.1.1 Groundwater Impacts

The primary impact posed by existing waste sites is on groundwater and its potential uses, either directly or after movement to surface waters. The following paragraphs discuss these impacts at various waste sites by geographic groups. The sites or parameters discussed (and included in the corresponding tables) are those for which the model predicts exceedances of appropriate MCLs or comparable criteria.

Table 4-2 summarizes no-action peak 100-meter well constituent concentrations (and their respective years of occurrence) for the 12 modeled waste sites in the A- and M-Areas, with the corresponding MCLs. This table lists each constituent with a sum exceeding its MCL. These exceedances clearly are due to individual waste sites that exceed their MCLs, except for chromium and lead.

An analysis of the specific pathways and inventory of the affected waste sites demonstrated that there is also little, if any, potential for cumulative effects from chromium and lead. Groundwater beneath the M-Area settling basin, Lost Lake, and the miscellaneous chemical basin is postulated to travel southeastward to outcrops in Upper Three Runs Creek while the water-table aquifer beneath the other sites in this area has a westward gradient. Therefore, the chromium and lead plumes from the M-Area settling basin and vicinity would not be expected to converge with those from the other sites. This results in a potential cumulative concentration from the other sites of 0.0408 milligram per liter for chromium and 0.0674 milligram per liter for lead.

The peak concentrations listed for the A-Area burning/rubble pits are from a "worst-case" modeling of the C-Area burning/rubble pit. However, the estimated disposal mass of chromium and lead at the A-Area pits is zero. When the burning/rubble pit values are subtracted from the above subtotals, the realistic potential cumulative concentrations are 0.0138 milligram per liter for chromium and 0.0294 milligram per liter for lead. These are well below the MCLs of these constituents (0.05 milligram per liter for both).

For the F- and H-Areas, a three-dimensional flow model (McDonald and Harbaugh, 1984) and a transport model, the Sandia Waste Isolation and Flow Transport (SWIFT), have been used to simulate the variable hydrostratigraphic and boundary conditions that exist throughout the F- and H-Areas (Killian et al., 1987). In general, the models predict that a contaminant released from the F-Area seepage basin would travel through the Barnwell and McBean aquifers before outcropping at Four Mile Creek. A contaminant released from the H-Area seepage basins would travel only through the Barnwell aquifer before reaching Four Mile Creek. From the radioactive waste burial grounds, the contaminant would travel through the Barnwell, McBean, and Congaree aquifers to an outcrop at Upper Three Runs Creek.

Contaminants from other waste sites in F- and H-Areas travel in a direction influenced by the water-table divide that bisects the radioactive waste burial grounds. Groundwater in the northern part of the area travels toward Upper Three Runs Creek, and in the southern part of the area toward Four Mile Creek. The modeling results and the vertical head relationships between aquifers discussed in Appendix A indicate a low potential for contaminants to enter the Middendorf/Black Creek (Tuscaloosa) aquifer from waste sites in F- and H-Areas.

Table 4-2. Peak Concentrations at 100-Meter Well for No Action, A- and M-Areas

Waste management facility	Site number	PATHRAE peak concentrations[a]: Chemicals (mg/L)										Radionuclides (pCi/L)
		As	Ba	Cd	Cr	Pb	NO_3	Tetrachloroethylene	Tetrachloromethane	1,1,1-Trichloroethane	Trichloroethylene	H-3
Metals burning pit	1-2	(b)	(b)	(b)	(b)	(b)	(b)	0.0022[c] (1994)	(b)	(b)	0.1[c] (1989)	(b)
Silverton Road waste site	1-3	(b)	(b)	(b)	(b)	0.0055 (1969)	(b)	0.052[c] (1974)	(b)	(b)	0.051[c] (1971)	(b)
Metallurgical laboratory	1-4	(b)	(b)	(b)	0.0078 (1993)	0.0160 (1993)	(b)	(b)	1.6[c] (1994)	0.52[c] (1994)	0.026[c] (1994)	(b)
Misc. chemicals basins	1-5	(b)	(b)	(b)	(b)	(b)	(b)	300[c] (1999)	(b)	(b)	(b)	(b)
A-Area burning/ rubble pit[d]	1-6, 1-7	(b)	(b)	(b)	0.027 (1981)	0.038 (1981)	(b)	(b)	(b)	(b)	1.7[c] (1985)	(b)
SRL seepage basins	1-8 to 1-11	0.21[c] (2135)	(b)	0.0024 (2295)	0.006 (1988)	0.0079 (1988)	(b)	(b)	(b)	(b)	(b)	200,000[c] (1968)
M-Area settling basin	1-12, 1-13	(b)	2.3[c] (2272)	0.017[c] (2325)	0.012 (1991)	0.064[c] (1991)	1700[c] (1991)	280[c] (1993)	(b)	3.5[c] (1992)	53[c] (1992)	(b)
Cumulative concentration[e]		0.21[c]	2.3[c]	0.019[c]	0.053[c]	0.13[c]	1700[c]	580[c]	1.6[c]	4.0[c]	54.9[c]	200,000[c]
Standard[f]		0.05	1.0	0.010	0.050	0.050	10	0.0007	0.005	0.200	0.005	87,000

[a]Year of peak concentration shown in parentheses. Years prior to 1985 are indications of present conditions.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling.
[c]Concentration exceeds regulatory standards.
[d]Concentrations are from PATHRAE modeling for largest inventory waste management unit in this functional grouping; actual peak concentrations are dependent on the inventory of this unit.
[e]Cumulative concentrations reflect worst case (no dilution) groundwater concentrations calculated by summation of individual contaminant concentrations.
[f]Source: 40 CFR 141, except as follows: 1,1,1-trichloroethane, tetrachloromethane, trichloroethylene (EPA, 1985b). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an effective whole-body dose of 4 millirem.

Table 4-3 lists the summation of peak constituent concentrations that exceed their applicable standards and the predicted contaminant concentrations associated with individual waste sites in the F- and H-Areas under the no-action option. The radioactive waste burial grounds, F-Area seepage basins, and H-Area seepage basins are the primary sources of groundwater contaminants in F- and H-Areas. Of the 15 constituents identified in Table 4-3, an individual waste site is the primary source of 12. The three remaining constituents (nitrate, tritium, and iodine-129) arise from several waste sites in F- and H-Areas; however, the groundwater flows from these sites are unlikely to mix, considering their separation distances and different directions of groundwater flow before reaching onsite streams. Therefore, the individual contaminant concentrations associated with each waste site in Table 4-3 appropriately identify potential groundwater-quality impacts for No Action.

There are 12 sites in the R-Area grouping; the three Bingham pump outage pits (sites 4 to 6) and the six reactor seepage basins (sites 7 to 12) are treated as single sites for analysis purposes, as are the two burning/rubble pits.

Table 4-4 lists peak 100-meter well concentrations (with the year of occurrence) and their sums for each contaminant exceeding its applicable standard in the R-Area group under No Action. As indicated in the table, essentially all of the radioactive contamination derives from the seepage basins; tritium, strontium, and cesium-137 all exceed their standards. In addition, trichloroethylene exceeds the standard at the burning/rubble pits.

The cumulative concentration of lead in R-Area is above its MCL due to the summing of concentrations from several sites. However, the R-Area burning/rubble pits (which are represented in this group by modeled results from the worst-case C-Area burning/rubble pit) do not actually list lead in the estimated waste inventory, and are approximately 0.33 kilometer from the acid/caustic basin. Because of the distance between the sites, the absence of lead in the R-Area waste inventory, and the marginal exceedance of the standard (0.06 milligram per liter versus a standard of 0.05 milligram per liter), the actual cumulative concentration of lead would not be expected to exceed the standard. In this area, groundwater flows to Lower Three Runs Creek, with the exception of the groundwater beneath the R-Area seepage basins, which travels to Upper Three Runs Creek.

Of the seven sites considered in C-Area and the Central Shops (CS) Area, three have evidence of contamination: C-Area burning rubble pit (site 4), hydrofluoric acid spill area (site 5), and the Ford Building seepage basin (site 7).

Table 4-5 lists peak 100-meter well concentrations and their sums (over all sites) and regulatory standards for all contaminants reported in the C- and CS-Area under No Action. Tritium exceeds the standards at the Ford Building seepage basin. Trichloroethylene exceeds the standard at the C-Area burning/rubble pit. The cumulative concentration for lead in C- and CS-Areas is above its MCL due to the summing of concentrations from several sites. The C-Area burning/rubble pit, however, is approximately 2 kilometers from the hydrofluoric acid spill area and 3 kilometers from the Ford Building seepage basins. Beneath the Ford Building seepage basin, groundwater flows toward Pen Branch, and beneath the C-Area burning/rubble pit it flows toward Four Mile Creek. Therefore, the plume from the burning/rubble pit is not likely to interact with the plumes from the other waste sites. This fact, coupled with

Table 4-3. Peak Concentrations at 100-Meter Well for No Action, F- and H-Areas

Waste management facility	Site number	PATHRAE - Peak contaminant concentrations[a]														
		Chemicals (mg/L)					Radionuclides (pCi/L)									
		Pb	Hg	NO_3	Xylene	Trichloro-ethylene	Co-60	Cs-137	H-3	I-129	Ni-63	Pu-238	Sr-90	Tc-99	U-238	Np-
F-Area acid/caustic basin[b]	2-1	0.022 (1957)	(c)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	
H-Area acid/caustic basin[b]	2-2	0.022 (1957)	(c)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	
F-Area burning/rubble pits[b]	2-3, 2-4	0.038 (1981)	(d)	(d)	(d)	1.7[e] (1985)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	2.9 (1981)	
H-Area retention basin	2-5	(d)	(d)	(d)	(d)	(d)	(d)	46 (1984)	(d)	(d)	(d)	5.1 (1985)	16 (1983)	(d)	(d)	
F-Area retention basin	2-6	(d)	(d)	(d)	(d)	(d)	(d)	0.21 (1971)	(d)	(d)	(d)	(d)	5.3 (1971)	(d)	(d)	
Rad/mixed waste burial ground	2-7, 2-8 2-9	0.78[e] (1961)	0.0026[e] (1961)	(d)	3.9[e] (1965)	(d)	620[e] (1961)	370[e] (1961)	6.8×10^{8}(e) (1961)	(c)	170,000[e] (1961)	240[e] (1969)	2.2 (2300)	5200[e] (1961)	16 (1961)	
F-Area seepage basins	2-10, 2-11 2-12	0.003 (1987)	0.0001 (1987)	1000[e] (1987)	(d)	(d)	(c)	3.1 (1967)	2.7×10^{7}(e) (1964)	220[e] (1990)	(d)	0.13 (1969)	8.5[e] (2105)	(d)	52[e] (2985)	
F-Area seepage basin (old)	2-13	(c)	(c)	69[e] (1964)	(d)	0.023[e] (1965)	(d)	(d)	(d)	(d)	(d)	(d)	(c)	(d)	0.9 (1964)	
H-Area seepage basins	2-14, 2-15 2-16, 2-17	0.005 (1985)	0.0002 (1985)	480[e] (1985)	(d)	(d)	(c)	1.4 (1963)	1.4×10^{7}(e) (1962)	220[e] (1987)	(d)	(c)	27 (2058)	66 (1983)	1.7 (2027)	(
Cumulative concentration[f]		0.87[e]	0.0029[e]	1500[e]	3.9[e]	1.7[e]	620[e]	420[e]	7.2×10^{8}(e)	440[e]	170,000[e]	250[e]	59[e]	5300[e]	74[e]	
Standard[g]		0.05	0.002	10	0.62	0.005	210	110	87,000	20	10,000	14	42	4200	24	

[a]Year of occurrence given in parentheses; years prior to 1985 are indications of present conditions.
[b]Concentrations are from PATHRAE modeling for largest inventory waste management unit in this functional grouping; actual peak concentrations are dependent on the inventory of this unit.
[c]Modeled concentration is insignificant (<1/100 of standard).
[d]Constituent did not meet threshold selection criteria for PATHRAE modeling.
[e]Concentration exceeds regulatory standards.
[f]Cumulative concentrations reflect worst case groundwater concentrations, calculated by summation of individual contaminant concentrations.
[g]Applicable standards obtained from the following sources: Pb, Hg, and NO_3 (40 CFR 141); trichloroethylene (EPA, 1985a); xylene (EPA, 1981, "Advising Opinion for Xylenes"); radionuclides, ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-4. Peak Concentrations at 100-Meter Wells for No Action, R-Area

Waste management facility	Site number	PATHRAE peak concentrations[a] Chemicals (mg/L) Pb	Trichloro-ethylene	Radionuclides (pCi/L) H-3	Sr-90	Cs-137
R-Area burning/ rubble pit[b]	3-1, 3-2	0.038 (1981)	1.7[c] (1985)	(d)	(d)	(d)
R-Area acid/ caustic basin[b]	3-3	0.022 (1957)	(d)	(d)	(d)	(d)
R-Area bingham pump outage pits	3-4, 3-5, 3-6	(d)	(d)	(d)	0.31 (2109)	0.56 (1961)
R-Area seepage basins	3-7 to 3-12	(c)	(c)	6.5×10^{7}[(c)] (1969)	370[2(c)] (1970)	1700[(c)] (1970)
Cumulative concentration[e]		0.060[d]	1.7[b]	6.5×10^{7}[(c)]	370[c]	1700[(c)]
Standard[f]		0.050	0.005	87,000	42	110

[a]Year of peak concentration is in parentheses; years prior to 1985 are indications of present conditions.
[b]Concentrations are from PATHRAE modeling for largest inventory waste management unit in this functional grouping; actual peak concentrations are dependent on the inventory of this unit.
[c]Concentration exceeds regulatory limits.
[d]Constituent did not meet threshold selection criteria for PATHRAE modeling.
[e]Cumulative concentrations reflect worst case (no dilution) groundwater concentrations calculated by summation of individual contaminant concentrations.
[f]Standards obtained from following sources: trichloroethylene (EPA, 1985a). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-5. Peak Concentrations at 100-Meter Well for No Action, C-Area and Central Shops

Waste management facility	Site number	PATHRAE peak concentrations[a] Chemicals (mg/L) Pb	Trichloro-ethylene	Radionuclides (pCi/L) H-3
C-Area burning/ rubble pit	4-4	0.038 (1981)	1.7[b] (1985)	(c)
Hydrofluoric acid spill area	4-5	0.014 (2025)	(c)	(c)
Ford Building seepage basin	4-7	0.001 (1986)	(c)	7.0×10^{6} (b) (1973)
Cumulative concentration[d]		0.053[b]	1.7[b]	7.0×10^{6} (b)
Standard[e]		0.05	0.005	87,000

[a]Year of peak concentrations shown in parentheses; years prior to 1985 are indications of present conditions.
[b]Concentration exceeds regulatory standards.
[c]Constituent did not meet threshold selection criteria for PATHRAE modeling.
[d]Cumulative concentrations reflect worst case (no dilution) groundwater concentrations calculated by summation of individual contaminant
[e]Standards obtained from the following sources: Pb (40 CFR 141); trichloroethylene (EPA, 1985a). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.
concentrations.

the marginal exceedance of the drinking water standard (0.053 milligram per liter versus a standard of 0.05 milligram per liter) suggests that the cumulative concentration of lead would not exceed the standard.

Table 4-6 lists the summations of constituent concentrations that exceed applicable standards and the predicted contaminant concentrations associated with individual sites in the TNX-Area group for No Action. Concentrations of nitrate, tetrachloromethane, and trichloroethylene are predicted to exceed applicable standards in groundwater at the TNX-Area. Individual waste sites are the primary source of contamination for two of these three constituents: the old TNX seepage basin for tetrachloromethane and the D-Area burning/rubble pits for trichloroethylene. Nitrate concentration is predicted to exceed standards from both the new and old TNX seepage basins. Potentially, nitrate plumes from these two sites could interact.

The direction of groundwater flow in the TNX-Area is toward the Savannah River. In this area, the potentiometric levels generally increase with depth, indicating that groundwater moves vertically upward from the Middendorf/Black Creek to the Congaree, and from the Congaree to the water-table aquifer (Kingley et al., 1987). Therefore, there is a low potential for contaminants to enter the Middendorf/Black Creek and Congaree aquifers from waste sites in the TNX-Area.

The D-Area oil seepage basin (Building 631-G) is the only waste site in D-Area for which estimates of environmental impacts and health effects were not determined, because chemical constituents did not exceed the threshold selection criteria. No adverse environmental impacts are anticipated from this facility for No Action or any of the other closure actions.

The Road A chemical basin is the only potential source of groundwater impacts in the Road A Area. Groundwater monitoring data for water-table wells at the Road A chemical basin indicate that lead, gross alpha, and radium were detected in June 1984 at levels above regulatory standards or guidelines. However, quarterly groundwater sampling since June 1984 has not detected levels of these constituents above the applicable standards (Muska, Pickett, and Bledsoe, 1987). PATHRAE simulations, based on estimated inventories for lead, tetrachloroethylene, and uranium-238, project that the concentrations of these constituents in the water-table aquifer for No Action would remain within regulatory standards at a distance of 100 meters from the basin (see Appendix F).

The direction of flow in the water-table aquifer near the basin is to the west, toward the bottomland wetlands of Four Mile Creek approximately 200 meters from the basin and about 15 meters lower in elevation. Although there is a potential for a downward flow of water in the water-table aquifer to the Congaree Formation, the more probable discharge for the water-table aquifer is the wetlands.

Four sites are considered in K-Area: burning/rubble pit (site 1), acid/caustic basin (site 2), Bingham pump outage pit (site 3), and K-Area seepage basin (site 4). Table 4-7 lists for the No-Action strategy the peak 100-meter well concentrations, their sum over all the sites, and the applicable regulatory standards. Trichloroethylene exceeds its standard at the burning/rubble pit. Tritium from the K-Area seepage basin exceeds its standard.

Table 4-6. Peak Concentrations at 100-Meter Well for No Action, TNX-Area

Waste management facility	Site number	PATHRAE - Peak contaminant concentrations[a]: Chemicals (mg/L): NO_3	Tetrachloromethane	Trichloroethylene
D-Area burning/ rubble pits[b]	5-1, 5-2	(c)	(c)	1.7[d] (1985)
TNX burying ground	5-3	0.53 (2016)	(c)	(c)
TNX seepage basin (old)	5-4	410[d] (2038)	0.14[d] (2051)	0.0085[d] (2045)
TNX seepage basin (new)	5-5	1900[d] (1990)	(c)	(c)
Cumulative concentration[e]		2300[d]	0.14[d]	1.7[d]
Standard[f]		10	0.005	0.005

[a]Year of peak concentration is shown in parentheses; years prior to 1985 are indications of present conditions.
[b]Concentrations are from PATHRAE modeling for largest inventory waste management unit in this functional grouping; actual peak concentrations are dependent on the inventory of this unit.
[c]Constituent did not meet threshold selection criteria for PATHRAE modeling.
[d]Concentration exceeds regulatory standards.
[e]Cumulative concentrations reflect worst case (no dilution) groundwater concentrations, calculated by summation of individual contaminant concentrations.
[f]Applicable standards obtained from the following sources: NO_3 and Pb (40 CFR 141); tetrachloromethane and trichloroethylene (EPA, 1985a); U-238, ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-7. Peak Concentrations at 100-Meter Well for No Action, K-Area

Waste management facility	Site number	PATHRAE peak concentrations[a] Chemicals (mg/L) Pb	Trichloro-ethylene	Radionuclides (pCi/L) H-3
K-Area burning/rubble pit[b]	8-1	0.038 (1981)	1.7[c] (1985)	(d)
K-Area acid/caustic basin[b]	8-2	0.022 (1957)	(d)	(d)
K-Area seepage basin	8-4	(d)	(d)	$4.4 \times 10^{6(b)}$ (1967)
Cumulative concentration[e]		0.06[b]	1.7[b]	$4.4 \times 10^{6(b)}$
Standard[f]		0.05	0.005	87,000

[a]Year of peak concentration shown in parentheses; years prior to 1985 are indications of present concentration.
[b]Concentrations are from PATHRAE modeling for largest inventory waste management unit in this functional grouping; actual peak concentrations are dependent on the inventory of this unit.
[c]Concentration exceeds regulatory standard.
[d]Constituent did not meet threshold selection criteria for PATHRAE modeling.
[e]Cumulative concentrations reflect worst case (no dilution) groundwater concentrations calculated by summation of individual contaminant concentrations.
[f]Source: trichloroethylene (EPA, 1985a); ICRP Publication 30 (ICRP, 1979) methodology was used to determine concentrations that yield an annual effective whole body dose of 4 millirem.

Table 4-7 indicates that the cumulative concentration of lead exceeds its MCL. The information presented in the table represents an upper bound cumulative impact result, assuming that the K-Area burning/rubble pit and acid/caustic basins have the same inventory as their C-Area counterparts. The estimated disposal mass for lead at K-Area burning/rubble pit and acid/caustic basin is zero (Looney et al., 1986). Therefore, concentrations contributed from these waste sites would be expected to be essentially zero. Groundwater flow in this area travels to Pen Branch.

Table 4-8 lists the peak concentrations from the 12 waste sites in L-Area under No Action for constituents exceeding appropriate standards, with the respective standards. The cumulative concentrations in L-Area for the 14 constituents listed are all above their MCLs as the result of single waste site sources rather than cumulative effects.

Groundwater flow beneath the majority of the waste sites in this area is toward Pen Branch. However, the groundwater beneath the L-Area acid/caustic basin and the L-Area oil and chemical basin would travel to Steel Creek.

There are three sites in P-Area: the burning/rubble pit (site 1), acid/caustic basin (site 2), and Bingham pump outage pit (site 3). Table 4-9 lists peak concentrations at the 100-meter well for No Action, the sum for all sites of these concentrations, and the applicable regulatory standards. Trichloroethylene from the burning/rubble pit exceeds applicable standards, and the cumulative concentration of lead is above its MCL due to the summing of concentrations from the two listed sites. However, the P-Area burning/rubble pit is more than 1 kilometer from the acid/caustic basin. In addition, the estimated waste inventory of lead for the P-Area acid/caustic basin is zero (Looney et al., 1986). Because of the estimated zero inventory, the distance between sites, and the marginal exceedance of the standard (0.06 milligram per liter versus a standard of 0.05 milligram per liter), the actual cumulative concentration of lead is not expected to exceed the standard. Groundwater flow in P-Area is generally toward Lower Three Runs Creek except beneath the burning/rubble pit, where the groundwater flow is toward Steel Creek.

The SRL oil test site (Building 080-16G) and the Gunsite 720 rubble pit (at SRP coordinates N80,000:E27,350) are miscellaneous waste sites; Appendix F describes their environmental impacts and health effects in detail. Estimates of the environmental releases were not determined at either site because chemical constituents did not exceed threshold selection criteria. No adverse environmental impacts are anticipated from these facilities for any closure action.

Summary of Groundwater Impacts Under No-Action Strategy

Based on the analyses described above for the No-Action strategy, and as indicated in Tables 4-2 through 4-9, MCLs in groundwater at the hypothetical 100-meter wells conservatively will be exceeded at 66 of the individual waste sites. The constituents predicted to exceed MCLs are the following:

- Radionuclides, principally tritium
- Organic chemicals, principally trichloroethylene and tetrachloroethylene
- Metals, principally lead and mercury
- Nitrate

Table 4-8. Peak Concentrations at 100-Meter Well for No Action, L-Area

Waste management facility	Site number	PATHRAE peak concentrations[a] Chemicals (mg/L)											Radionuclide (pCi/L)
		Cr	Pb	Benzene	Chloro-ethylene	2,4-D	Dichloro-methane	Endrin	Silvex	Tetrachloro-ethylene	Toxaphene	Trichloro-ethylene	H-3
L-Area burning/ pits[b]	9-1	0.027 (1981)	0.038 (1981)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	1.7[d] (1985)	(c)
L-Area acid/ caustic basins[b]	9-2	0.0038 (3053)	0.022 (1957)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
CMP pits	9-3 to 9-9	0.001 (1995)	0.061[d] (1995)	0.19[d] (1997)	0.2[d] (1995)	0.38[d] (1997)	0.2[d] (1996)	0.0005[d] (2848)	1.3[d] (2019)	44[d] (2002)	0.12[d] (2009)	1.1[d] (1998)	(c)
L-Area bingham pump outage pits	9-10, 9-11	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
L-Area oil and chemical basin	9-12	0.098[d] (2495)	0.017 (1979)	(c)	(c)	(c)	(c)	(c)	(c)	0.016[d] (1979)	(c)	(c)	3.2×10^{8}[d] (1967)
Cumulative concen-tration[e]		0.13[d]	0.14[d]	0.19[d]	0.2[d]	0.38[d]	0.2[d]	0.0005[d]	1.3[d]	44[d]	0.12[d]	2.8[d]	3.2×10^{8}[d]
Standard[f]		0.05	0.05	0.005	0.001	0.1	0.06	0.0002	0.01	0.0007	0.005	0.005	87,000

[a] Year of peak concentration shown in parentheses. Years prior to 1985 are indications of present conditions.
[b] Concentrations are from PATHRAE modeling for largest inventory waste management unit in this functional grouping; actual peak concentrations are dependent on the inventory of this unit.
[c] Constituent did not meet threshold selection criteria for PATHRAE modeling.
[d] Concentration exceeds regulatory standards.
[e] Cumulative concentrations reflect worst case (no dilution) groundwater concentrations calculated by summation of individual contaminant concentrations.
[f] Source: 40 CFR 141, except as follows: benzene, trichloroethylene, and chloroethylene (EPA, 1985b); tetrachloroethylene and dichloromethane (EPA, 1985b). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-9. Peak Concentrations at 100-Meter Well for No Action, P-Area

Waste management facility	Site number	PATHRAE peak concentrations[a] Chemicals (mg/L) Pb	 Trichloro-ethylene
P-Area burning/ rubble pit[b]	10-1	0.038 (1981)	1.7[c] (1985)
P-Area acid/ caustic basin[b]	10-2	0.022 (1957)	(d)
Cumulative concentration[e]		0.06	1.7[c]
Standard[f]		0.05	0.005

[a]Year of peak concentration shown in parentheses; years prior to 1985 are indications of present concentration.
[b]Concentrations are from PATHRAE modeling for largest inventory waste management unit in this functional grouping; actual peak concentrations are dependent on the inventory of this unit.
[c]Concentration exceeds regulatory standard.
[d]Constituent did not meet threshold selection criteria for PATHRAE modeling.
[e]Cumulative concentrations reflect worst case (no dilution) groundwater concentrations calculated by summation of individual contaminant concentrations.
[f]Source: trichloroethylene (EPA, 1985a). Lead (40 CFR 141).

4.2.1.2 Surface-Water Impacts

The impacts evaluated by PATHRAE from surface-water pathways are (1) groundwater movement to the Savannah River via surface streams and (2) erosion of waste materials and movement to surface streams. PATHRAE contaminant releases for the erosion pathway were predicted to be zero for most sites and minimal releases for all others because of low erosion rates (approximately 0.2 millimeter per year).

The projected peak concentrations in the streams were evaluated against the MCLs or criteria for protection of public health. The results of these assessments are summarized in Table 4-10 for Upper Three Runs Creek, Four Mile Creek, Pen Branch, Steel Creek, Lower Three Runs Creek, and the Savannah River. In a number of instances, constituents are listed for which there are no MCLs or comparable criteria.

Table 4-10. Waste Constituents[a] in Surface Water for No Action

Stream	Contaminant	Current instream concentration[b]	Projected peak instream concentration	Maximum contaminant level[c]
Upper Three Runs Creek	Tetrachloroethylene	LLD[d]	0.002	0.0004
	Phosphate	NA[e]	4.6×10^{-7}	NS
Four Mile Creek	Nitrate	1.1	26	10
	Phosphate	0.017	0.025	NS[f]
	Naphthalene	LLD	0.004	NS
	Dibutylphosphate	NA	7.9×10^{-7}	NS
	N-dodecane	LLD	0.003	NS
	Trimethybenzene	LLD	0.002	NS
	Tributylphosphate	LLD	0.021	NS
	Tritium	8.5×10^{5}	8.4×10^{5}	8.7×10^{4}
Pen Branch	Phosphate	0.017	0.017	NS
	Freon	NA	1.7×10^{-6}	NS
Steel Creek	Phosphate	0.012	0.012	NS
Lower Three Runs Creek	Phosphate	NA	4.4×10^{-6}	NS
Savannah River	Phosphate	NA	7.3×10^{-5}	NS
	Dibutyl phosphate	NA	9.3×10^{-10}	NS
	Freon	NA	1.6×10^{-9}	NS
	Naphthalene	NA	4.3×10^{-6}	NS
	N-dodecane	NA	3.1×10^{-5}	NS
	Tributylphosphate	NA	2.5×10^{-5}	NS
	Trimethylbenzene	NA	2.8×10^{-6}	NS

[a]Chemicals in mg/L, radionuclides in pCi/L.
[b]Sources: Upper Three Runs Creek (Colven et al., 1987); Four Mile Creek (Killian et al., 1987); Pen Branch (Pekkala et al., 1987); Steel Creek (Ward et al., 1986).
[c]Source: 40 CFR 141.
[d]LLD = instream concentration less than lower limit of detection.
[e]NA = instream concentration not available.
[f]NS = drinking water standard not available.

Contaminants to be released under No Action are predicted not to exceed their respective MCLs (or criteria) in Pen Branch, Steel Creek, Lower Three Runs Creek, or the Savannah River, although criteria do not exist for a number of the constituents listed. Tetrachloroethylene is the only contaminant predicted to exceed standards in Upper Three Runs Creek.

Contaminant releases to Four Mile Creek are projected to include 13 inorganics, 9 organics, and 20 radionuclides, of which only 2, nitrate and tritium, are projected to exceed MCLs, although six constituents do not have comparable criteria. The nitrate concentration is projected to peak at 26 milligrams per liter, respectively. The current instream concentration and MCL are 1.1 and 10 parts per million. The current instream concentration of tritium is 850,000 picocuries per liter, a concentration that exceeds the MCL (Killian et al., 1987). The projected peak concentration of tritium in Four Mile Creek is approximately equal to this current instream level. In addition to tritium, the release of radionuclides (not listed in Table 4-10) to Four Mile Creek was projected. The sum of the projected instream concentrations for these radionuclides, excluding tritium, results in an annual dose of 5.1 millirem to a hypothetical consumer of drinking water from Four Mile Creek, which exceeds the EPA community drinking-water standard of 4 millirem per year.

4.2.1.3 Radiological Doses

Table 4-11 lists peak annual doses to the maximally exposed individual resulting from releases from each of the 21 low-level radioactive and mixed waste sites, and their years of occurrence, under the No-Action strategy. These doses are based on the maximally exposed individual residing on the SRP after institutional control is relinquished, assumed to be in the year 2085. The groundwater-well pathway is the most significant, contributing at least 85 percent of the total dose at all sites except one, with peak annual doses of 25 millirem or more. The exception is the F-Area seepage basin, where direct gamma contributes all the 1000-millirem dose. The atmospheric pathway is responsible for all the doses from the old TNX seepage basin, the SRL seepage basins, and the M-Area settling basin and Lost Lake.

Four sites would exceed the DOE dose limit of 100 millirem from all pathways and the 4-millirem EPA drinking-water dose limit under No Action: the R-Area seepage basins (2900 millirem in 2094), the F-Area seepage basins (1000 millirem in 2085), the old F-Area seepage basin (400 millirem in 2312), and the L-Area oil and chemical basin (190 millirem in 2098). All sites would comply individually with the 25-millirem DOE dose limit for the atmospheric pathway.

Four sites would exceed the 4-millirem EPA drinking-water dose limit: the H-Area retention basin (73 millirem from the 1-meter well in 2085), the radioactive waste burial grounds (29 millirem from the 1-meter well in 2182), the H-Area seepage basin (29 millirem from the 1-meter well in 2104), and the Road A chemical basin (30 millirem from the 1-meter well in 2985).

The cumulative annual dose currently received from all pathways by the maximally exposed individual residing at the SRP boundary is 14.4 millirem; it would increase to 3900 millirem in 2085. The cumulative annual doses received

Table 4-11. Peak Annual Dose to Maximally Exposed Individual from Radiological Releases for No Action

Low-level and mixed waste sites	Maximum individual dose (mrem)	Year of peak dose
H-Area retention basin	73	2085
F-Area retention basin	0.38	2313
R-Area Bingham pump outage pits	0.12	2085
R-Area seepage basins	2900	2094
Ford Building waste site	0	
TNX burying ground	0.016	2085
K-Area Bingham pump outage pit	0.12	2085
K-Area seepage basin	0.30	2085
L-Area Bingham pump outage pits	0.12	2085
P-Area Bingham pump outage pit	0.12	2085
SRL seepage basins	0.69	1985
M-Area settling basin and Lost Lake	2.1	1985
Radioactive waste burial ground, mixed waste management facility (new), and radioactive waste burial ground (old)	29	2182
F-Area seepage basins	1000	2085
F-Area seepage basin (old)	400	2312
H-Area seepage basins	34	2104
Ford Building seepage basin	1.4	2334
TNX seepage basin (old)	10.7	1985
TNX seepage basin (new)	3.2	2563
Road A chemical basin	30	2985
L-Area oil and chemical basin	190	2098

by the population in the SRP region* in 1985 and 2085 are 34 and 22 person-rem, respectively.

4.2.1.4 Health Effects

This section discusses health effects resulting from No Action, which are divided into effects from radiological and chemical releases. Appendix I describes the methodology employed for estimating and assessing health risks of the waste management strategies.

*The atmospheric pathway contribution to the population dose is based on an exposed population of 585,000 within an 80-kilometer radius of the SRP. The groundwater-to-river pathway contribution to the population dose is based on a user population of 100,000.

Radiological

Table 4-12 lists lifetime health risks to the maximally exposed individual resulting from the peak annual radioactive releases from 21 low-level and mixed waste sites, and the corresponding peak years, for the No-Action strategy. The health risk is assumed eventually to total 280 radiation-induced excess fatal cancers and genetic disorders as a result of a collective dose of 1 million person-rem.

Table 4-12. Radiological Health Risks to the Maximally Exposed Individual from the Peak Annual Doses for No Action

Low-level and mixed waste sites	Maximum individual risk (HE for peak year dose)	Lifetime exposure risk[a]
H-Area retention basin	2.1×10^{-5}	1.1×10^{-3}
F-Area retention basin	1.1×10^{-7}	5.5×10^{-6}
R-Area Bingham pump outage pits	3.4×10^{-8}	1.7×10^{-6}
R-Area seepage basins	8.1×10^{-4}	4.1×10^{-2}
Ford building waste site	0	0
TNX burying ground	4.5×10^{-9}	2.2×10^{-7}
K-Area Bingham pump outage pit	3.4×10^{-8}	1.7×10^{-6}
K-Area seepage basin	8.5×10^{-8}	4.2×10^{-6}
L-Area Bingham pump outage pits	3.4×10^{-8}	1.7×10^{-6}
P-Area Bingham pump outage pit	3.4×10^{-8}	1.7×10^{-6}
SRL seepage basins	1.9×10^{-7}	1.0×10^{-5}
M-Area settling basin and Lost Lake	5.9×10^{-7}	3.0×10^{-5}
Radioactive waste burial ground, mixed waste management facility (new), and radioactive waste burial ground (old)	8.1×10^{-6}	4.1×10^{-4}
F-Area seepage basins	2.9×10^{-4}	1.4×10^{-2}
F-Area seepage basin (old)	1.1×10^{-4}	5.5×10^{-3}
H-Area seepage basins	9.5×10^{-6}	4.8×10^{-4}
Ford Building seepage basin	3.9×10^{-7}	2.0×10^{-5}
TNX seepage basin (old)	3.1×10^{-6}	1.5×10^{-4}
TNX seepage basin (new)	9.0×10^{-7}	4.5×10^{-5}
Road A chemical basin	8.4×10^{-6}	4.2×10^{-4}
L-Area oil and chemical basin	5.3×10^{-5}	2.7×10^{-3}

[a]Assumed 50-year exposure at peak year dose.

Under No Action, health risks to the maximally exposed individual as a result of exposures during 1985 at the SRP boundary, and to an onsite resident during 2085, total 4.0×10^{-6} and 1.1×10^{-3}, respectively. The corresponding maximum lifetime risks from 50 years of exposure at the peak rate would be 2.0×10^{-4} and 5.5×10^{-2}, respectively.

The health effects predicted to occur in the population in the SRP region from the collective doses delivered in 1985 and 2085 under No Action are 9.5×10^{-3} and 6.2×10^{-3} excess cancer deaths, respectively. Effects of lifetime exposure at the same rate in that population would total 0.48 and 0.31 excess cancer deaths, respectively.

Chemical

Total carcinogenic risk is the lifetime risk associated with concurrent exposure to multiple carcinogenic substances, assuming a whole-body additive model for carcinogenesis. Total noncarcinogenic risk, similarly, is defined by the hazard index, which is the summation of the fractional ADIs for each substance at the receptor at a specified time (see Appendix I). The following paragraphs present groundwater/surface-water pathway risks in relation to geographic groupings. Atmospheric and occupational pathway risks are discussed on a facility-wide basis.

Groundwater and Surface-Water Pathway

Tables 4-13 and 4-14 summarize the risks posed under the No-Action strategy by the sites in each geographic group via the groundwater/surface-water pathway, assuming relinquishment of DOE control in 2085.

A- and M-Area Geographic Grouping. The maximum total nonradiological carcinogenic risk for 50-year exposures peaking in 2085 is 4.5×10^{-3} at the 1-meter well in M-Area. The maximum risk for the dominant carcinogenic chemical is 2.3×10^{-1}, posed by tetrachloroethylene at the 1-meter well in 1993.

The M-Area settling basin also poses the maximum total noncarcinogenic hazard index for 2085 (1.02 at the 100-meter well). The maximum hazard index for the dominant noncarcinogenic chemical (2.1×10^{3}) is due to phosphate at the 1-meter well in 2154.

F- and H-Area Geographic Grouping. The maximum total nonradiological carcinogenic risk from 50-year exposures peaking in 2085 for this grouping is posed by the 100-meter well at the F-Area burning/rubble pit (2.0×10^{-9}). The maximum risk for the dominant carcinogenic chemical is 4.2×10^{-4} from trichloroethylene at the 1-meter well, peaking in 1980. The risk from trichloroethylene at the 100-meter well peaked in 1985 at 3.4×10^{-4}.

The highest total noncarcinogenic hazard index in 2085 is 4.6, posed by the mixed waste management facility and old radioactive waste burial grounds at the 100-meter well. The maximum hazard index (3.1×10^{2}) for the dominant noncarcinogenic chemical is presented by nitrates at both the 1- and 100-meter wells at the F-Area seepage basin in 1987. Mercury creates risks of 5.0 to the reclaimed farm receptors in 2085 at the F-Area seepage basin, 4.6 at the H-Area seepage basins, and 1.4 at the mixed waste management facility/radioactive waste burial grounds.

R-Area Geographic Grouping. All strategies present the same carcinogenic risks for the groundwater/surface-water pathway. The R-Area burning/rubble pits total carcinogenic risks are not significant for exposures peaking in 2085. Trichloroethylene presented risks of 4.2×10^{-4} at the 1-meter well and 3.4×10^{-4} for the 100-meter well from exposures peaking in 1980 and

Table 4-13. Total Noncarcinogenic Risks for No-Action, Groundwater/Surface-Water Pathway in Each Geographic Grouping

Worst-case site	Hazard index, 2085 exposures				Maximum risk for dominant noncarcinogenic chemical Hazard index (year of peak exposure)			
	1-meter well	100-meter well	River outfall	Reclaimed farm	1-meter well	100-meter well	River outfall	Reclaimed farm
M-Area settling basin	5.7×10^{-2}	1.02	0	2.1×10^{-1}	2.1×10^{3} (2154) Phosphate	3.8×10^{2} (1991) Nitrate	NS[a]	9.0×10^{-2} (2085) Mercury
Mixed waste management facility and old radioactive waste burial grounds	7.5×10^{-1}	4.6	NS	1.4	3.1×10^{2}[(b)] (1987) Nitrate	3.1×10^{2}[(b)] (1987) Nitrate	NS	5.0[(b)] (2085) Mercury
R-Area acid/caustic basin[c]	NS	3.7×10^{-2}	NS	NS	6.1×10^{-1}[(d)] (1977) Lead	4.9×10^{-1}[(d)] (1981) Lead	NS	NS
Ford building seepage basin	NS	NS	NS	NS	2.8[e] (1975) Fluoride	9.2×10^{-1}[(e)] (2025)	NS	1.2×10^{-2} (2085) Mercury
Old TNX seepage basin	5.1×10^{-1}	1.1×10^{2}	NS	7.2×10^{-1}	5.5×10^{2} (1983) Nitrate	1.2×10^{2} (2038) Nitrate	NS	7.2×10^{-1} (2085) Mercury
Road A chemical basin	NS	NS	NS	NS	5.4×10^{-1} (1975) Lead	4.1×10^{-1} (1980) Lead	NS	NS
K-Area acid/caustic basin[c]	NS	3.7×10^{-2}	NS	NS	6.1×10^{-1}[(d)] (1977) Lead	4.9×10^{-1}[(d)] (1981) Lead	NS	NS
L-Area oil & chemical basin	2.2	2.1×10^{-1}	NS	2.0×10^{-2}	5.9×10^{0}[(f)] (1996) Silvex	4.0×10^{1}[(f)] (2002) PCE[g]	NS	NS
P-Area acid/caustic basin[c]	NS	3.7×10^{-2}	NS	NS	6.1×10^{-1}[(d)] (1977) Lead	4.0×10^{-1}[(d)] (1981) Lead	NS	NS

[a]NS = Not significant; risk is less than 1.0×10^{-2}.
[b]Values reported are for the F-Area seepage basins.
[c]Values are for L-Area acid/caustic basin.
[d]Values are for C-Area burning/rubble pit.
[e]Values reported are for the hydrofluoric acid spill area.
[f]Values reported are for the CMP pits.
[g]PCE = tetrachloroethylene.

Table 4-14. Total Nonradiological Carcinogenic Risks for No Action, Groundwater/Surface-Water Pathway in Each Geographic Grouping

Worst-case site	Risks[a], 2085 Exposures[b]				Maximum risk[a] for dominant carcinogenic chemical, (year of peak exposure)			
	1-meter well	100-meter well	River outfall	Reclaimed farm	1-meter well	100-meter well	River outfall	Dominant chemical
M-Area settling basin	4.5×10^{-3}	2.5×10^{-3}	0	3.6×10^{-8}	2.3×10^{-1} (1993)	2.1×10^{-1} (1993)	1.8×10^{-8} (2932)	Tetrachloroethylene
F-Area burning/rubble pit[c]	NS[d]	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
R-Area burning/rubble pit[c]	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene[c]
C-Area burning/rubble pit	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
Old TNX seepage basin	2.2×10^{-6}	3.3×10^{-4}	NS	0	1.8×10^{-3} (1983)	3.4×10^{-4} (2051)	NS	Tetrachloromethane
Road A chemical basin	0	0	0	0	0	0	0	
K-Area burning/rubble pit[c]	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
CMP pits	1.0×10^{-5}	1.3×10^{-4}	NS	NS	9.7×10^{-2} (1997)	4.1×10^{-2} (2002)	NS	Tetrachloroethylene
P-Area burning rubble pit[c]	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene

[a]Risk = incremental lifetime probability of death from cancer.
[b]50-year exposure period following 2085.
[c]Values reported are for C-Area burning/rubble pit.
[d]NS = Not significant; risk is less than 1.0×10^{-8}

1985, respectively. No carcinogenic risks associated with the groundwater/surface-water pathway are predicted for the R-Area acid/caustic basin.

The R-Area acid/caustic basin presents the highest noncarcinogenic hazard index of 3.7×10^{-2} in 2085 at the 100-meter well. Lead is the dominant noncarcinogenic chemical; it reached a peak hazard index of 6.1×10^{-1} at the 1-meter well in 1977.

C-Area and CS-Area Geographic Grouping. The carcinogenic risks for the groundwater/surface-water pathway are identical for all four strategies. Carcinogenic risks for this pathway are predicted only for the burning/rubble pits (three in CS-Area and one in C-Area), which are identical. The total carcinogenic risks for 50-year exposures following 2085 are not significant. The dominant carcinogenic chemical is trichloroethylene, which created a peak risk in 1980 at the 1-meter well (4.2×10^{-4}), and in 1985 at the 100-meter well (3.4×10^{-4}).

The highest total noncarcinogenic risk in 2085 is posed by the Ford Building seepage basin, but it is not significant in this grouping. The dominant noncarcinogenic chemical in the geographic grouping is fluoride, which posed a maximum hazard index of 2.8 at the hydrofluoric acid spill area 1-meter well in 1975.

TNX-Area Geographic Grouping. The highest total carcinogenic risk under No Action for 50-year exposures following 2085 is 3.3×10^{-4} presented by the 100-meter well at the old TNX seepage basin. The maximum risk for the dominant carcinogenic chemical was presented by tetrachloromethane from hypothetical exposures at the 1-meter well (1.8×10^{-3}), peaking in 1983. These conditions are the same under all strategies. The only site in this grouping where risks varied is the new TNX seepage basin.

The old TNX seepage basin also presents the highest noncarcinogenic hazard index in this grouping. In 2085, this index peaks at the 100-meter well (1.1×10^{2}). In the same year, mercury creates a hazard index of 7.2×10^{-1} at the assumed reclaimed farm receptor. The risk for the dominant noncarcinogenic chemical, nitrate, peaked at the 1-meter well in 1983 (hazard index of 5.5×10^{2}), and will peak in the 100-meter well in 2038 (hazard index of 1.2×10^{2}). The noncarcinogenic risks vary from option to option only for the new TNX seepage basin.

Road A Chemical Basin. The carcinogenic and noncarcinogenic risks for all strategies are the same. The basin poses no carcinogenic risk.

The highest total noncarcinogenic risk in 2085 is not significant. The peak chemical-specific hazard index was posed by lead at the 1-meter well in 1975 (5.4×10^{-1}) and is predicted to reach 4.1×10^{-1} at the 100-meter well in 1980.

K-Area Geographic Grouping. The carcinogenic risks in this grouping are the same for all strategies. Carcinogenic risks via the groundwater/surface-water pathway are predicted only for the K-Area burning/rubble pit. The highest total carcinogenic risk for 50-year exposures following 2085 is not significant. The maximum risks presented by trichloroethylene, the dominant carcinogenic chemical, were 4.2×10^{-4} in 1980 at the 1-meter well and 3.4×10^{-4} in 1985 at the 100-meter well.

The only significant noncarcinogenic risk under No Action for 2085 is 3.7×10^{-2} at the 100-meter well. Lead is the dominant noncarcinogenic chemical, with a hazard index of 6.1×10^{-1} in 1977 at the 1-meter well of the K-Area burning/rubble pit.

L-Area Geographic Grouping. The carcinogenic risks are identical for all strategies. The CMP pits pose the highest total carcinogenic risk for 50-year exposures following 2085 at the 100-meter well (1.3×10^{-4}). The maximum risk for tetrachloroethylene, the dominant carcinogenic chemical, was 9.7×10^{-2}, posed at the 1-meter well in 1997.

Under No Action, the L-Area oil and chemical basin poses the greatest noncarcinogenic hazard index for 2085 of 2.2 at the 1-meter well. This is the highest risk in that year for any strategy. The peak risk for the dominant noncarcinogenic chemical is from tetrachloroethylene, with a hazard index of 4.0×10^{1} in 2002 at the 100-meter well at the CMP pits.

P-Area Geographic Grouping. The carcinogenic risks for the groundwater/surface-water pathway are identical for all four strategies. The P-Area burning/rubble pit presents the highest (but not significant) total carcinogenic risk for 50-year exposures following 2085. The highest chemical-specific carcinogenic risks were due to trichloroethylene at the 1-meter (4.2×10^{-4}) and 100-meter (3.4×10^{-4}) wells in 1980 and 1985, respectively.

The P-Area acid/caustic basin poses the highest noncarcinogenic risks, under No Action. In 2085, the noncarcinogenic hazard index, 3.7×10^{-2}, is predicted to peak at the 100-meter well. The maximum hazard index for the dominant noncarcinogenic chemical is 6.1×10^{-1}, created by lead in 1977 at the 1-meter well of the P-Area burning/rubble pit.

Atmospheric Releases

Table 4-15 lists risks to the maximally exposed individual and to the population due to atmospheric carcinogenic releases and the major chemical contributors. These risks are presented for each waste site for three selected exposure years: 1985 (start of remedial actions), 2085 (assumed start of public occupation of the SRP), and 2985 (end of 1000-year period). Noncarcinogenic atmospheric releases are all predicted to produce insignificant risks, both individually and collectively (i.e., hazard index less than 1×10^{-2}).

The major contributors to total risk due to airborne carcinogen releases are associated with the metallurgical laboratory basin, the SRL seepage basins, the M-Area air stripper, and the H-Area seepage basin. The major chemical contributors to the risk are chromium-VI, trichloroethylene, and nickel; Table 4-15 indicates that risks are generally higher for 2085 than for 1986 because the maximally exposed individual is assumed to be closer to the waste site. This results in higher exposures, even though the source strength might have decreased due to leaching over the previous 100 years.

Table 4-15. Risks[a] to the Population and the Maximally Exposed Individual Attributable to Atmospherically Released Nonradiological Carcinogens for No Action

Site	1985 releases			2085 releases			2985 releases		
	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor
SRL seepage basins	1.33×10^{-3}	2.3×10^{-8}	Chromium VI, arsenic	6.51×10^{-6}	1.61×10^{-8}	Chromium VI	NS[b]	NS	–
F-Area seepage basins	NS	NS	–	NS	NS		NS	NS	–
Radioactive burial grounds	0	0	–	0	0	–	0	0	–
R-Area	0	0	–	0	0	–	0	0	–
P, C, K-Areas	NS	NS	–	NS	NS	–	0	0	–
Silverton Road waste site	NS	NS	–	NS	NS	–	NS	NS	–
F-Area retention basin	0	0	–	0	0	–	0	0	–
H-Area retention basin	0	0	–	0	0	–	0	0	–
HFI spill area	0	0	–	0	0	–	0	0	–
CMP pit 19G	0	0	–	0	0	–	0	0	–
CMP pit 18.3G	NS	NS	–	NS	NS		0	0	–
CMP pits 18.1G or 18.2G	NS	NS	–	NS	0	–	0	0	–
CMP pit 17.1G	0	0	–	0	0	–	0	0	–
CMP pit 17G	NS	NS	–	NS	NS	–	0	0	–
Bingham pump outage pits	0	0	–	0	0	–	0	0	–
Ford Building waste site	NS	NS	–	NS	NS	–	NS	NS	–
Old TNX seepage basin	0	0	–	0	0	–	0	0	–
Old TNX seepage basin outfall	9.27×10^{-4}	1.36×10^{-8}	Chromium VI	2.15×10^{-4}	5.33×10^{-8}	Chromium VI	NS	NS	–
Waste oil basins	0	0	–	0	0	–	0	0	–
SRP oil test site	0	0	–	0	0	–	0	0	–
Gunsite 720 rubble pit	0	0	–	0	0	–	0	0	–
Metallurgical laboratory basin	9.55×10^{-4}	1.29×10^{-8}	Chromium VI	5.97×10^{-4}	1.48×10^{-7}	Chromium VI	NS	NS	–
Lost Lake	NS	NS	–	7.42×10^{-5}	1.84×10^{-8}	Chromium VI	NS	NS	–
M-Area overflow ditch and adjacent seepage area	NS	NS	–	2.60×10^{-4}	6.44×10^{-8}	Nickel, Chromium	NS	NS	–

Footnotes on last page of table.

Table 4-15. Risks[a] to the Population and the Maximally Exposed Individual Attributable to Atmospherically Released Nonradiological Carcinogens for No Action (continued)

	1985 releases			2085 releases			2985 releases		
Site	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor
M-Area air stripper	8.98×10^{-4}	1.51×10^{-8}	Trichloroethylene	–	–	–	–	–	–
M-Area settling basin and process sewerline	NS	NS	–	2.29×10^{-4}	5.69×10^{-8}	Nickel	1.78×10^{-8}	NS	Nickel
H-Area seepage basin	2.25×10^{-3}	3.29×10^{-8}	Chromium	5.52×10^{-4}	1.37×10^{-7}	Chromium	NS	NS	
Ford Building seepage basin	NS	NS	–	NS	NS	–	NS	NS	–
Road A chemical basin	NS	NS	–	NS	NS	–	0	0	–
TNX burying ground	0	0	–	0	0	–	0	0	–
Acid/caustic basins	NS	NS	–	NS	NS	–	NS	NS	–
Old F-Area seepage basin	NS	NS	–	NS	NS	–	NS	NS	–
New TNX seepage basin	NS	NS	–	NS	NS		NS	NS	–
Burning/rubble pits – composite site 1	NS	NS	–	7.50×10^{-5}	1.86×10^{-8}	Chromium VI	NS	NS	–
Burning/rubble pits – composite site 2	NS	NS	–	NS	NS	–	0	0	–
Metals burning pit	NS	NS	–	NS	NS	–	NS	NS	–
TOTAL[c]	1.07×10^{-2}	1.63×10^{-7}		2.63×10^{-3}	6.53×10^{-6}		4.50×10^{-8}	NS	

[a]Risks to the population are the number of excess cancers; risks to the maximally exposed individual are the excess lifetime cancer probabilities.
[b]NS = Not significant, incremental lifetime risk to the maximally exposed individual is less than 1.0×10^{-8}; associated risk to the population is also not significant.
[c]Total risks include contributions from sites designated NS.

4.2.1.5 Ecological Impacts

Potential impacts of No Action on aquatic ecosystems could result from the contamination of groundwater and subsequent outcrop to SRP streams. Results from PATHRAE-based analyses indicate that, except for Four Mile Creek, No Action will not affect existing onsite stream water quality significantly. Aquatic ecosystems in Four Mile Creek might be affected adversely by concentrations of cadmium, chromium, lead, and mercury that exceed water-quality criteria for aquatic life (EPA, 1986). Reported levels of chromium, lead, and mercury in Four Mile Creek already exceed these criteria, as do lead and mercury levels in Pen Branch, Steel Creek, Upper Three Runs Creek, and the Savannah River.

Potential aquatic impacts from No Action might also result from direct exposure of organisms to standing water in open basins. Standing water might exhibit elevated levels of constituents through contact with basin sediments and through concentration by evaporation.

Because no activities are planned under No Action, impacts to terrestrial resources resulting from noise and habitat disruption are not expected. However, use of open basins by wildlife (including waterfowl, except at acid/caustic basins, which are too small to attract waterfowl in significant numbers) can be expected. Under varying water levels, organisms can be expected to drink basin water, burrow in basin sediments, or feed on vegetation growing in the basin. Uptake of wastes by deep-rooted plants growing at backfilled waste sites can also affect terrestrial ecosystems.

Endangered species reported on the SRP include the American alligator, bald eagle, red-cockaded woodpecker, wood stork, and shortnose sturgeon. However, none of these species has been sighted in the immediate vicinity of SRP waste sites. Surveys found no suitable habitats for endangered species within 200 meters of the sites. In addition, no critical habitats as defined by the U.S. Fish and Wildlife Service have been designated anywhere on the SRP. Available information on the shortnose sturgeon indicates little potential for its presence in onsite streams. Because No Action would not lead to a significant change in Savannah River water quality, it is not expected to affect endangered species or their habitats.

Because no activities are planned under No Action, no impacts on SRP wetlands are expected, except near the SRL seepage basins, the M-Area settling basin, and the old TNX seepage basin. Wetland areas immediately adjacent to the SRL and M-Area basins could be affected by general basin overflows during heavy rains. During operation of the old TNX seepage basin, overflows from the basin were directed to the TNX swamp, creating an outfall delta approximately 30 meters inside the swamp. A swamp water sample contained approximately 150 and 250 times the EPA criteria levels for mercury and gross beta, respectively (Kingley et al., 1987). Adverse impacts from these wastes are expected to continue under No Action.

4.2.1.6 Other Impacts

No significant archaeological and/or historic sites are known to exist within, or immediately adjacent to, the existing waste site areas (Brooks, 1986). However, during an intensive field survey, one prehistoric site was discovered adjacent to the P-Area burning/rubble pit. This site is represented by a single, isolated surface find. Two selective shovel tests in the vicinity of the find have confirmed that it was from an isolated, disturbed context. Insufficient content and integrity of deposits indicates little potential for yielding additional information to enhance understanding of the prehistory of the region. Consequently, this site is not considered eligible for inclusion in the National Register of Historic Places (Brooks, 1986). Therefore, (1) none of the proposed P-Area burning/rubble pit closure actions would have an adverse effect on this archaeological site, and (2) no further archaeological work is recommended, either at this site or at any existing waste site surveyed. A request will be made to the South Carolina State Historical Preservation Officer (SHPO) for concurrence with a determination of "no effect" for the proposed actions at the 77 waste sites.

This strategy would have no socioeconomic impacts because it would not require any additional workers for construction.

4.2.2 DEDICATION STRATEGY (NO REMOVAL OF WASTE AT EXISTING WASTE SITES, AND IMPLEMENTATION OF COST-EFFECTIVE REMEDIAL AND CLOSURE ACTIONS AS REQUIRED)

This section describes modifications at existing waste sites that include closure and could include further remedial actions, consistent with the Dedication strategy in which waste is not removed at any of the existing waste sites, and the sites, with buffer zones, are dedicated for waste management purposes.

Closure would be applied to inactive waste sites to reduce infiltration, control surface-water runoff, and reduce erosion and leachate generation. Closure techniques include capping, grading, and revegetation; runoff diversion and collection; and leachate control systems. Although individual site remediation would be determined by interactions with regulatory agencies, for this EIS, remedial actions refer to measures that are applied in addition to closure to control past or continuing releases of contaminants. Remedial actions include in situ treatment, groundwater pumping and treatment, and containment or diversion. Appendix C presents more information on remedial, treatment, and closure techniques.

Under the Dedication strategy, all existing basins that had not been filled previously would be backfilled after any water has been removed. Table 4-16 lists the basins containing water and methods of disposal for the contained liquids. Bottom sediments or sludges would be stabilized before backfilling.

Low-permeability infiltration barriers would be installed to cap selected waste sites (Table 4-17) to minimize the migration of material remaining in the ground into the groundwater. These selections are based on projections of constituent migration made for the No-Action strategy (Section 4.2.1) to provide a basis for preliminary cost estimates for this EIS.

Remedial actions would be performed as needed to conform to groundwater protection requirements resulting from interactions with regulatory agencies and on detailed site-specific information. Additional groundwater monitoring wells would be installed and existing and new wells would be monitored in conformance with requirements.

Table 4-16. Basin Liquid Disposal Methods

Site			
Number	Name	Building	Method
1-4	Metallurgical laboratory basin	904-110G	Batch neutralization and discharge to stream
1-8	SRL seepage basin	904-53G	Allow to drain and dry
1-9	SRL seepage basin	904-53G	Allow to drain and dry
1-10	SRL seepage basin	904-54G	Allow to drain and dry
1-11	SRL seepage basin	904-55G	Allow to drain and dry
1-12	M-Area settling basin	904-51G	Decant to Lost Lake
1-13	Lost Lake	904-112G	Allow to drain
2-1	F-Area acid/caustic basin	904-74G	Neutralize and discharge to stream
2-2	H-Area acid/caustic basin	904-75G	Neutralize and discharge to stream
2-5	H-Area retention basin	281-3H	Disposed to operating H-Area retention basin
2-10	F-Area seepage basin	904-41G	Allow to drain and dry
2-11	F-Area seepage basin	904-42G	Allow to drain and dry
2-12	F-Area seepage basin	904-43G	Allow to drain and dry
2-13	F-Area seepage basin (old)	904-49G	Allow to drain and dry
2-14	H-Area seepage basin	904-44G	Allow to drain and dry
2-15	H-Area seepage basin	904-45G	Allow to drain and dry
2-16	H-Area seepage basin	904-46G	Allow to drain and dry
2-17	H-Area seepage basin	904-56G	Allow to drain and dry
3-3	R-Area acid/caustic basin	904-77G	Neutralize and discharge to stream
5-5	TNX seepage basin (new)	904-102G	Transfer to TNX effluent treatment plant
8-2	K-Area acid/caustic basin	904-80G	Neutralize and discharge to stream
8-4	K-Area seepage basin	904-65G	Allow to dry
9-2	L-Area acid/caustic basin	904-79G	Neutralize and discharge to stream
9-12	L-Area oil and chemical basin	904-83G	Remove water
10-2	P-Area acid/caustic basin	904-78G	Neutralize and discharge to stream

Fences, pylons, and signs would be erected at appropriate sites as needed. Inspection and maintenance (mowing, etc.) would be performed routinely as part of overall good housekeeping practices.

Table 4-17. Waste Sites Assumed To Be Capped with Low-Permeability Barriers

A- and M-Areas		**R-Area**	
1-2	Metals burning pit	3-7	R-Area seepage basin
1-3	Silverton Road waste site	3-8	R-Area seepage basin
1-5	Miscellaneous chemical basin	3-9	R-Area seepage basin
1-12	M-Area settling basin	3-10	R-Area seepage basin
		3-11	R-Area seepage basin
		3-12	R-Area seepage basin
F- and H-Areas		**TNX-Area**	
2-5	H-Area retention basin	5-3	TNX burying ground
2-6	F-Area retention basin	5-4	TNX seepage basin (old)
2-7	Radioactive waste burial ground	5-5	TNX seepage basin (new)
2-8	Mixed-waste management facility		
2-9	Radioactive waste burial ground	**Road A Area**	
2-10	F-Area seepage basin	7-1	Road A chemical basin
2-11	F-Area seepage basin		
2-12	F-Area seepage basin	**K-Area**	
2-13	F-Area seepage basin (old)	8-4	K-Area seepage basin
2-14	H-Area seepage basin		
2-15	H-Area seepage basin	**L-Area**	
2-16	H-Area seepage basin	9-12	L-Area oil and chemical basin
2-17	H-Area seepage basin		
		Miscellaneous Areas	
		11-1	SRL oil test site

4.2.2.1 Groundwater Impacts

The following paragraphs describe groundwater impacts from implementation of no-removal-and-closure actions at the various waste sites in each geographic group.

The results of the model analyses indicate that remedial actions might be required at some sites to reduce the predicted concentration of certain constituents in the groundwater to within the applicable standards. A number of actions could provide remediation (see Appendix C). The selection of action(s) would be based on site-specific studies and on interactions with regulatory agencies. One corrective action would be groundwater extraction and treatment to remove constituents, such as volatile organic compounds. Such a system is now in operation in M-Area. For this EIS, the feasibility of groundwater extraction at appropriate sites is assumed to apply to the waste sites discussed in the sections that follow. However, the actual choice of remedial action would depend on the results of site-specific investigations and regulatory agreement.

Groundwater pumping is an accepted method for the extraction of contaminants and, in certain cases, is also a cost-effective method for the limitation of contaminant transport into surrounding water bodies. However, such pumping can affect groundwater extraction at other wells. For recovery wells currently operating at M-Area, the calculated drawdown at 122 meters horizontally from a 1.9-liter-per-second pumping well is 0.15 meter after 30 days of pumping (Gordon, 1982), a minimal impact.

Another impact that could result from groundwater extraction is ground surface subsidence; that is, the elevation of the ground surface could be reduced measurably as the water table is lowered or as the pressure in a confined aquifer is reduced. However, due to the limited drawdown expected, such effects are considered to be insignificant.

Hydraulic effects of groundwater pumping could be limited through the use of reinjection in conjunction with the pumping. Extracted and treated groundwater meeting applicable National Pollutant Discharge Elimination System (NPDES) requirements also could be discharged to nearby surface streams.

The potential need for groundwater corrective action in a geographic group following the implementation of the Dedication strategy is predicted by peak constituent concentrations in the 1- and 100-meter wells that exceed MCLs or comparable criteria. This differs from No Action, which protects the offsite environment but does not necessarily meet criteria for the protection of onsite groundwater. Further, because these exceedances can occur at either a 1-meter or a 100-meter well, individual site contributions are not added to determine if there is a potential for cumulative effects in a geographic grouping. Actual monitoring data and more detailed site-specific modeling would be required to determine the extent and nature of groundwater corrective actions in an area.

The predicted peak concentrations for the acid/caustic basins and the burning/rubble pits are from PATHRAE modeling for the site in each of these two functional groups that has the largest inventory of contaminants. These upper bound impact predictions are for the L-Area acid/caustic basin and the C-Area burning/rubble pit. Actual peak concentrations for the other acid/caustic basins and burning/rubble pits would depend on site-specific inventories, which could be considerably lower.

Table 4-18 lists constituents in A- and M-Areas that are predicted to exceed MCLs and that could require remedial action under the Dedication strategy. The predominants are trichloroethylene and tetrachloroethylene. Others that exceed MCLs are tetrachloromethane, 1,1,1-trichloroethylene, arsenic, barium, tritium, and nitrate.

Six chemical and 12 radionuclide constituents are predicted to exceed MCLs and require remedial actions in F- and H-Areas, for the Dedication strategy, as indicated in Table 4-19. The chemical constituents are chromium, lead, mercury, nitrate, xylene, and trichloroethylene. The radionuclides are strontium-90, yttrium-90, nickel-63, cobalt-60, technetium-99, cesium-134 and 137, uranium-238, plutonium-238, iodine-129, neptunium-237, and tritium.

Groundwater pumped from recovery wells would be processed to achieve concentrations within MCLs. Treated groundwater could be discharged to Four Mile Creek or Upper Three Runs Creek, the natural discharge locations for the water-table aquifer, or could be injected to recharge that aquifer. Discharge to streams would conform to NPDES requirements and would not impact these water bodies. Reinjection would essentially increase the travel time of constituents in the groundwater, which could be an effective method of reducing

Table 4-18. Peak Concentrations for Dedication Strategy, A- and M-Area

Waste management facility	Site number	PATHRAE - peak concentration[a]							
		Chemicals (mg/L)							Radionuclides (pCi/L)
		As	Ba	NO_3	Trichloro-ethylene	Tetrachloro-ethylene	Tetrachloro-methane	1,1,1-trichloro-ethane	H-3
Metals burning pit	1-2	(b)	(b)	(b)	0.068 (1999)	0.0095 (2024)	(b)	(b)	(b)
Silverton Road waste site	1-3	(b)	(b)	(b)	0.31 (1966)	0.35 (1969)	(b)	(b)	(b)
Metallurgical laboratory basin	1-4	(b)	(b)	(b)	0.018 (2008, 2009)	(b)	1.1 (2010)	0.36 (2008)	(b)
Miscellaneous chemical basin	1-5	(b)	(b)	(b)	(b)	140 (2024, 2033)	(b)	(b)	(b)
A-Area burning/rubble pits	1-6, 1-7	(b)	(b)	(b)	2.1 (1980)	(b)	(b)	(b)	(b)
SRL seepage basins	1-8, 1-9, 1-10, 1-11	0.073 (2435)	(b)	(b)	(b)	(b)	(b)	(b)	3.2×10^5 (1962)
M-Area settling basin and vicinity	1-12, 1-13	(b)	1.6 (2501)	590 (2052)	17 (2058, 2059)	82 (2071, 2073)	(b)	1.1 (2058)	(b)
Standard[c]		0.05	1.0	10	0.005	0.0007	0.1	0.2	8.7×10^4

[a]Year of occurrence in parentheses. Only the constituents with peak concentrations that exceed standards at one or more waste sites are given.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]Source: 40 CFR 141, except as follows: trichloroethylene, tetrachloromethane, and 1,1,1-trichloroethane (EPA, 1985a); and tetrachloroethylene (EPA, 1985b). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-19. Peak Concentrations for Dedication Strategy, F- and H-Area

Waste management facility	Site number	PATHRAE - Peak chemical concentrations (mg/L)[a]					
		Cr	Pb	Hg	NO_3	Xylene	Trichloro-ethylene
F-Area acid/caustic basin	2-1	0.067 (2644)	(b)	(b)	(b)	(b)	(b)
H-Area acid/caustic basin	2-2	0.067 (2644)	(b)	(b)	(b)	(b)	(b)
F-Area burning/rubble pits	2-3, 2-4	(b)	(b)	(b)	(b)	(b)	2.1 (1980)
Rad/mixed waste burial grounds	2-7, 2-8 2-9	(b)	2.7 (1958)	0.009 (1958)	(b)	14 (1960)	(b)
F-Area seepage basins	2-10, 2-11 2-12	(b)	(b)	(b)	1000 (1987)	(b)	(b)
F-Area seepage basin (old)	2-13	(b)	(b)	(b)	1600 (1956)	(b)	0.58 (1956)
H-Area seepage basin	2-14, 2-15 2-16, 2-17	(b)	(b)	(b)	480 (1983)	(b)	(b)
Standard[c]		0.05	0.05	0.002	10	0.62	0.005

Footnotes on last page of table.

Table 4-19. Peak Concentrations for Dedication Strategy, F- and H-Area (continued)

Waste management facility	Site number	PATHRAE - Peak radionuclide concentrations (pCi/L)[a]											
		Sr-90	Y-90	Ni-63	Co-60	Tc-99	Cs-134	Cs-137	U-238	Pu-238	I-129	Np-237	H-3
H-Area retention basin	2-6	3800 (2021)	3800 (2021)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Rad/mixed waste burial grounds	2-7, 2-8 2-9	(b)	(b)	6.1×10^5 (1958)	620 (1961)	1.8×10^4 (1958)	350 (1957)	1400 (1958)	56 (1958)	350 (1966)	(b)	(b)	2.9×10^9 (1957)
F-Area seepage basins	2-10, 2-11 2-12	(b)	(b)	(b)	(b)	(b)	(b)	(b)	48 (2985)	(b)	88 (2036)	(b)	4.5×10^7 (1957)
F-Area seepage basin (old)	2-13	(b)	(b)	(b)	(b)	(b)	(b)	(b)	310 (2370)	(b)	(b)	(b)	(b)
H-Area seepage basin	2-14, 2-15 2-16, 2-17	1900 (1976)	1900 (1976)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	120 (2008)	0.93 (2715)	2.0×10^7 (1956)
Standard[c]		42	550	1.0×10^4	210	4200	74	110	24	14	20	0.14	8.7×10^4

[a]Year of occurrence in parentheses. Only the constituents with peak concentrations that exceed standards at one or more waste sites are given.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]Source: 40 CFR 141, except as follows: xylene (EPA, 1981); and trichloroethylene (EPA, 1985a). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

the concentration of isotopes such as tritium. Groundwater withdrawal with discharge to surface waters would have an insignificant effect on water-table elevations in F- and H-Areas.

Table 4-20 lists chromium, trichloroethylene, cesium-137, tritium, strontium-90, and yttrium-90 as the constituents predicted to exceed MCLs in R-Area under the Dedication strategy. The R-Area seepage basins are the only sources of radionuclides that are predicted to exceed standards. Potentially all the contaminants predicted to exceed standards in the R-Area could be treated. If groundwater pumping were employed, the drawdown effects would probably be localized and transitory. If drawdown were found to be a problem, the treated water would be reinjected into the aquifer from which it was withdrawn. Otherwise, the treated water would be discharged to nearby onsite streams in compliance with NPDES requirements.

Chromium, trichloroethylene, and tritium are the only constituents in C- and CS-Areas predicted to exceed MCLs under the Dedication strategy (Table 4-21). All the contaminants identified as exceeding standards potentially could require treatment to meet regulatory standards. The considerations of drawdown effects, reinjection, or surface discharge resulting from any groundwater extraction would be the same as those described above for R-Area.

Table 4-22 lists the constituents in TNX-Area that are predicted to exceed MCLs under the Dedication strategy (lead, nitrate, trichloroethylene, and tetrachloromethane). Groundwater would be pumped from recovery wells and processed to reduce contaminant levels to within MCLs or requirements established through regulatory interactions. Treated groundwater would be discharged to the Savannah River swamp, the natural location of outcropping for the water-table aquifer. Drawdown of the water-table due to groundwater withdrawal is expected to be local and insignificant.

The peak constituent concentrations in D-Area and the miscellaneous waste sites grouping did not meet the threshold selection criteria for PATHRAE modeling. All constituents at these sites would be expected to be within MCLs under the Dedication strategy. Therefore, groundwater corrective actions are not considered likely in those areas. Under Dedication, the concentration of uranium-238 at the Road A chemical basin is predicted to be 39 picocuries per liter in the year 2085, which is above its MCL (24 picocuries per liter).

Three constituents predicted to exceed MCLs in K-Area under Dedication are chromium, trichloroethylene, and tritium (Table 4-23). Additional corrective actions, such as contaminated groundwater withdrawal and treatment, could be employed to meet regulatory standards and protect human health and the environment.

The considerations of drawdown effects, reinjection, or surface discharge resulting from any groundwater extraction would be the same as those described for R-Area above.

Table 4-24 identifies 11 chemical and five radioactive constituents in L-Area that are predicted to exceed MCLs under the Dedication strategy. Most of the chemical constituents are organics, issued to originate primarily from the CMP pits; these are 2,4,5-TP (silvex), 2,4-D, endrin, toxaphene, benzene, trichloroethylene, tetrachloroethylene, dichloromethane, and chloroethylene.

Table 4-20. Peak Concentrations for Dedication Strategy, R-Area

		PATHRAE - Peak contaminants[a]					
		Chemicals (mg/L)		Radionuclides (pCi/L)			
Waste management facility	Site number	Cr	Trichloro-ethylene	Cs-137	H-3	Sr-90	Y-90
R-Area burning/rubble pits	3-1, 3-2	(b)	2.1 (1980)	(b)	(b)	(b)	(b)
R-Area acid/caustic basin	3-3	0.67 (2644)	(b)	(b)	(b)	(b)	(b)
R-Area seepage basins	3-7 through 3-12	(b)	(b)	3300 (1965)	1.5×10^8 (1963)	9.3×10^3 (2111)	9.3×10^3 (2111)
Standard[c]		0.05	0.005	110	8.7×10^4	42	550

[a]Year of occurrence in parentheses. Only the constituents with peak concentrations that exceed standards at one or more waste sites are given.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]Source: 40 CFR 141, except trichloroethylene (EPA, 1985a). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-21. Peak Concentrations for Dedication Strategy, C- and CS-Areas

Waste management facility	Site number	PATHRAE - Peak concentrations[a] Chemicals (mg/L) Cr	PATHRAE - Peak concentrations[a] Chemicals (mg/L) Trichloro-ethylene	PATHRAE - Peak concentrations[a] Radionuclides (pCi/L) H-3
CS-Area burning/rubble pits	4-1, 4-2, 4-3	(b)	2.1 (1980)	(b)
C-Area burning/rubble pits	4-4	(b)	2.1 (1980)	(b)
Ford Building seepage basin	4-10	0.073 (2393)	(b)	1.1×10^{7} (1966)
Standard[c]		0.05	0.005	8.7×10^{4}

[a]Year of occurrence in parentheses. Only the constituents with peak concentrations that exceed standards at one or more waste sites are given.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]Source: 40 CFR 141, except: trichloroethylene (EPA, 1985a). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-22. Peak Concentrations for Dedication Strategy, TNX Area

Waste management facility	Site number	PATHRAE - Peak concentrations[a] Chemicals (mg/L)			
		Pb	NO_3	Trichloro-ethylene	Tetrachloro-methane
D-Area burning/rubble pits	5-1, 5-2	(b)	(b)	2.1 (1980)	(b)
TNX seepage basin (old)	5-4	0.05 (1983)	1800 (1983)	0.042 (1983)	0.75 (1983)
TNX seepage basin (new)	5-5	(b)	1000 (2005)	(b)	(b)
Standard[c]		0.05	10	0.005	0.005

[a]Year of occurrence in parentheses. Only the constituents with peak concentrations that exceed standards at one or more waste sites are given.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]Source: 40 CFR 141, except trichloroethylene and tetrachloromethane (EPA, 1985a). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-23. Peak Concentrations for Dedication Strategy, K-Area

		PATHRAE - Peak concentrations[a]		
		Chemicals (mg/L)		Radionuclides (pCi/L)
Waste management facility	Site number	Cr	Trichloro-ethylene	H-3
K-Area burning/rubble pit	8-1	(b)	2.1 (1980)	(b)
K-Area acid/caustic basin	8-2	0.067 (2644)	(b)	(b)
K-Area seepage basin	8-4	(b)	(b)	7.2×10^{6} (1960)
Standard[c]		0.05	0.005	8.7×10^{4}

[a]Year of occurrence in parentheses. Only the constituents with peak concentrations that exceed standards at one or more waste sites are given.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]Source: 40 CFR 141, except trichloroethylene (EPA, 1985a). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Other chemical constituents that exceed MCLs in L-Area are chromium and lead. Radioactive constituents include tritium, cobalt-60, strontium-90, yttrium-90, and americium-241.

Additional corrective actions, such as the installation of a groundwater extraction system to reduce the levels of listed contaminants, could result in impacts both individually at each site and cumulatively, as discussed above.

Chromium and trichloroethylene are predicted to exceed MCLs in P-Area under Dedication (Table 4-25).

If an action such as groundwater extraction and treatment is undertaken to meet regulatory standards, the drawdown effects are expected to be localized and transitory. If drawdown were found to be a problem, the treated water would be reinjected into the aquifer from which it was withdrawn. Otherwise, the treated water would be discharged to nearby onsite streams, probably to the natural aquifer outcrop. Such discharges would be in compliance with all pertinent standards.

Table 4-24. Peak Concentrations for Dedication Strategy, L-Area

Waste management facility	Site number	PATHRAE - Peak concentration[a] for chemicals (mg/L)										
		Cr	Pb	Silvex	Trichloro-ethylene	Tetrachloro-ethylene	Dichloro-methane	Chloro-ethylene	Benzene	2,4-D	Endrin	Toxaphene
L-Area burning/ rubble pit	9-1	(b)	(b)	(b)	2.1 (1980)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
L-Area acid/ caustic basin	9-2	0.067 (2644)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
CMP pits	9-3 through 9-9	(b)	0.14 (1992)	2.9 (2012)	2.6 (1994)	44 (2002)	0.46 (1992)	0.47 (1992)	0.44 (1993)	0.89 (1993)	0.0012 (2705)	0.29 (2003)
L-Area oil and chemical basin	9-11	(b)	(b)	(b)	(b)	0.016 (1979)	(b)	(b)	(b)	(b)	(b)	(b)
Standard[c]		0.05	0.05	0.01	0.005	0.0007	0.06	0.001	0.005	0.1	0.0002	0.005

Footnotes on last page of table.

Table 4-24. Peak Concentrations for Dedication Strategy, L-Area (continued)

Waste management facility	Site number	PATHRAE - Peak concentration[a] for Radionuclide (pCi/L)				
		H-3	Co-60	Sr-90	Y-90	Am-241
L-Area burning/ rubble pit	9-1	(b)	(b)	(b)	(b)	(b)
L-Area acid/ caustic basin	9-2	(b)	(b)	(b)	(b)	(b)
CMP pits	9-3 through 9-9	(b)	(b)	(b)	(b)	(b)
L-Area oil and chemical basin	9-11	4.6×10^{8} (1962)	7300 (1976)	2100 (1980)	2100 (1980)	5.3 (2211)
Standard[c]		8.7×10^{4}	210	42	550	2.5

[a]Year of occurrence in parentheses. Only the constituents with peak concentrations that exceed standards at one or more sites are given.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]Source: 40 CFR 141, except as follows: trichloroethylene and chloroethylene (EPA, 1985a); and tetrachloroethylene and dichloromethane (EPA, 1985b). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-25. Peak Concentrations for Dedication Strategy, P-Area

Waste management facility	Site number	PATHRAE - Peak Concentration[a]: Chemicals, mg/L: Cr	PATHRAE - Peak Concentration[a]: Chemicals, mg/L: Trichloro-ethylene
P-Area burning/ rubble pit	10-1	(b)	2.1 (1980)
P-Area acid/ caustic basin	10-2	0.067 (2644)	(b)
Standard[c]		0.05	0.005

[a]Year of occurrence in parentheses. Only the constituents with peak concentrations that exceed standards at one or more waste sites are given.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]Source: 40 CFR 141, except trichloroethylene (EPA, 1985a). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Summary of Groundwater Effects Under Dedication Strategy

This section indicates that groundwater corrective action could be required at 9 of the 11 geographic groups because of constituent concentrations in groundwater that exceed MCLs or comparable criteria. The predominant constituents predicted by PATHRAE code to exceed MCLs are nitrate, chromium, trichloroethylene, tetrachloroethylene, tritium, and strontium-90.

4.2.2.2 Surface-Water Impacts

As a result of closure and groundwater remedial actions to be conducted under this strategy, the concentrations of tritium, tetrachloroethylene, and nitrate, projected to exceed MCLs in surface water for No Action would be brought into compliance. Corrective action could consist of groundwater withdrawal and treatment, with subsequent discharge of treated groundwater to onsite streams in compliance with applicable NPDES permits.

4.2.2.3 Radiological Doses

For the Dedication strategy, Table 4-26 lists peak annual doses to the maximally exposed individual from the 21 low-level radioactive and mixed waste sites, and their years of occurrence. These doses are based on the maximally exposed individual residing on the SRP after institutional control is relinquished in 100 years. The groundwater-well pathway is the most significant, contributing more than 90 percent of the total dose at sites with peak annual doses of 0.10 millirem or more, with the exception of the old TNX seepage basin. At that site, resuspension of contaminated dust from the unvegetated outfall delta results in a first year (1985) dose of 10.7 millirem. The atmospheric pathway is also responsible for all the M-Area settling basin and Lost Lake dose of 0.033 millirem. The reclaimed-farm pathway contributes all the 0.071-millirem dose from the SRL seepage basins.

The R-Area seepage basins are predicted to exceed the 100-millirem DOE dose limit for all pathways via water consumption from the 1-meter well under the Dedication strategy (630 millirem in 2111). Five sites predicted to exceed the 4-millirem EPA drinking-water limit after closure only are the H-Area retention basin (81 millirem from the 1-meter well in 2085), the F-Area seepage basins (5.7 millirem from the 1-meter well in 2985), the old F-Area seepage basin (34 millirem from the 1-meter well in 2370), the Road A chemical basin (4.3 millirem from the 1-meter well in 2985), and the L-Area oil and chemical basin (6.1 millirem from the 1-meter well in 2185). The entire Dedication strategy (i.e., closure and remedial action as required) would reduce these doses to below the 4-millirem EPA drinking-water dose limit. All sites comply individually with the 25-millirem DOE dose limit for the atmospheric pathway.

The annual doses received from all pathways by the maximally exposed individual residing at the SRP boundary during the year of closure and onsite during the peak exposure year (2111) are 10.7 and 6.4×10^2 millirem, respectively. The latter dose neglects the implementation of postclosure groundwater remedial actions, which would reduce that dose to less than 10 millirem per year (including about 9.0 millirem from direct exposure to the unreclaimed outfall delta).

The annual collective doses received by the population during the first year and 100 years (2085) from the time of implementation of the Dedication strategy are 3.3 and 2.9 person-rem, respectively, of which the atmospheric pathway contributes more than 60 percent. Appropriate remedial actions could reduce these doses further.

4.2.2.4 Health Effects

Radiological

The health effects presented in this section are based on the Dedication strategy doses without further groundwater remedial action. Table 4-27 lists lifetime health risks to the maximally exposed individual resulting from peak annual radioactive releases from 21 low-level and mixed waste sites.

The fatal health risks to the maximally exposed individual residing at the SRP boundary from exposures during the year of closure (1985 assumed) and residing

Table 4-26. Peak Annual Dose to the Maximally Exposed Individual from Radiological Releases for the Dedication Strategy

Low-level and mixed waste sites	Maximum individual dose (mrem)	Year of Peak dose
H-Area retention basin	81	2085
F-Area retention basin	0.057	2318
R-Area Bingham pump outage pits	0.12	2085
R-Area seepage basins	630	2111
Ford Building waste site	0	
TNX burying ground	0.016	2085
K-Area Bingham pump outage pit	0.12	2085
K-Area seepage basin	0.22	2085
L-Area Bingham pump outage pits	0.12	2085
P-Area Bingham pump outage pit	0.12	2085
SRL seepage basins	0.071	2085
M-Area settling basin and Lost Lake	0.033	1985
Radioactive waste burial ground, mixed waste management facility (new), and radioactive waste burial ground (old)	2.8	2185
F-Area seepage basins	5.7	2985
F-Area seepage basin (old)	34	2370
H-Area seepage basins	1.3	2185
Ford Building seepage basin	0.57	2393
TNX seepage basin (old)	10.7	1985
TNX seepage basin (new)	1.4	2614
Road A chemical basin	4.3	2985
L-Area oil and chemical basin	6.1	2185

onsite during the peak year (2111), are 3.0×10^{-6} and 1.8×10^{-4}, respectively. The corresponding maximum lifetime risks would be 1.5×10^{-4} and 9.0×10^{-3}, respectively, assuming a 50-year exposure at the peak annual rate.

The number of fatal health effects predicted in the population in the SRP region as a result of exposures during the year of closure, and during the one-hundredth year (2085) are 9.2×10^{-4} and 8.1×10^{-4}, respectively. Lifetime effects of exposures at the same rate would total 4.6×10^{-2} and 4.0×10^{-2} cancer deaths, respectively.

Appropriate remedial actions could reduce the doses and health effects further.

Table 4-27. Radiological Health Risks to Maximally Exposed Individual from the Peak Annual Doses for the Dedication Strategy

Low-level and mixed waste sites	Maximum individual risk (HE for peak year dose)	Lifetime exposure risk[a]
H-Area retention basin	2.3×10^{-5}	1.2×10^{-3}
F-Area retention basin	1.6×10^{-8}	8.0×10^{-7}
R-Area Bingham pump outage pits	3.4×10^{-8}	1.7×10^{-6}
R-Area seepage basins	1.8×10^{-4}	9.0×10^{-3}
Ford Building waste site	0.0	0.0
TNX burying ground	4.5×10^{-9}	2.2×10^{-7}
K-Area Bingham pump outage pit	3.4×10^{-8}	1.7×10^{-6}
K-Area seepage basin	6.1×10^{-8}	3.0×10^{-6}
L-Area Bingham pump outage pits	3.4×10^{-8}	1.7×10^{-6}
P-Area Bingham pump outage pit	3.4×10^{-8}	1.7×10^{-6}
SRL seepage basins	2.0×10^{-8}	1.0×10^{-6}
M-Area settling basin and Lost Lake	9.2×10^{-9}	4.6×10^{-7}
Radioactive waste burial ground, mixed waste management facility (new), and radioactive waste burial ground (old)	7.8×10^{-7}	3.9×10^{-5}
F-Area seepage basins	1.6×10^{-6}	8.0×10^{-5}
F-Area seepage basin (old)	9.5×10^{-6}	4.8×10^{-4}
H-Area seepage basins	3.6×10^{-7}	1.8×10^{-5}
Ford Building seepage basin	1.6×10^{-7}	8.0×10^{-6}
TNX seepage basin (old)	3.0×10^{-6}	1.5×10^{-4}
TNX seepage basin (new)	3.8×10^{-7}	1.9×10^{-5}
Road A chemical basin	1.2×10^{-6}	6.0×10^{-5}
L-Area oil and chemical basin	1.7×10^{-6}	8.5×10^{-5}

[a]Assumed 50-year exposure at peak year dose.

Chemical

Groundwater/Surface-Water Pathway

Tables 4-28 and 4-29 summarize the risks posed under the Dedication strategy by the upper bound impact indicator sites in each geographic region via the groundwater/surface-water pathway.

For the A- and M-Area geographic grouping, the highest total carcinogenic risk for 50-year exposures following 2085 is 1.8×10^{-2}, presented by the M-Area settling basin at the 100-meter well. The peak risk is 6.2×10^{-2} due to tetrachloroethylene at the same site and well from exposures peaking in 2071.

The M-Area settling basin also presents the highest noncarcinogenic risks for exposures in 2085, with hazard indexes of 1.1×10^{1} at the 100-meter well and 7.5×10^{-1} at the 1-meter well. Maximum chemical-specific, noncarcinogenic hazard indexes are also posed by phosphate in these wells: 2.0×10^{2}

Table 4-28. Total Nonradiological Carcinogenic Risks for Dedication Strategy, Groundwater/Surface-Water Pathway in Each Geographic Grouping

Worst-case site	Total Risks[a], 2085 Exposures[b]				Maximum risk[a] for dominant carcinogenic chemical (year of peak exposure)			
	1-meter well	100-meter well	River outfall	Reclaimed farm	1-meter well	100-meter well	River outfall	Dominant chemical
M-Area settling basin	2.3×10^{-3}	1.8×10^{-2}	0	NS[c]	1.3×10^{-1}[d] (2024)	1.3×10^{-1}[d] (2033)	1.7×10^{-8} (2821)	Tetrachloroethylene
F-Area burning/rubble pit[c]	NS	NS	NS	NS	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
R-Area burning/rubble pit[e]	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
C-Area burning/rubble pit	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
Old TNX seepage basin	2.2×10^{-6}	3.3×10^{-4}	NS	0	1.8×10^{-3} (1983)	3.4×10^{-4} (2051)	NS	Tetrachloromethane
Road A chemical basin	0	0	0	0	0	0	0	
K-Area burning/rubble pit[e]	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
CMP pits	1.0×10^{-5}	1.3×10^{-4}	NS	NS	9.7×10^{-2} (1997)	4.1×10^{-2} (2002)	NS	Tetrachloroethylene
P-Area burning rubble pit[e]	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene

[a]Risk = incremental lifetime probability of death from cancer.
[b]50-year exposure period following 2085.
[c]NS = Not significant; risk is less than 1.0×10^{-8}
[d]Values reported are for miscellaneous chemical basin.
[e]Values reported are for C-Area burning/rubble pit.

Table 4-29. Total Noncarcinogenic Risks for Dedication Strategy, Groundwater/Surface-Water Pathway in Each Geographic Grouping

Worst-case Site	Hazard index, 2085 exposures				Maximum risk for dominant noncarcinogenic chemical hazard index (year of peak exposure)			
	1-meter well	100-meter well	River outfall	Reclaimed farm	1-meter well	100-meter well	River outfall	Reclaimed farm
M-Area settling basin	7.5×10^{-1}	1.1×10^{1}	0	NS[a]	2.0×10^{2} (2445) Phosphate	1.6×10^{2} (2459) Phosphate	NS	NS
Mixed waste management facility and old radioactive waste burial grounds	1.1×10^{0}	5.5×10^{0}	NS	NS	3.1×10^{2}[b] (1987) Nitrate	3.1×10^{2}[b] (1987) Nitrate	NS	NS
R-Area acid/caustic basin[c]	NS	3.7×10^{-2}	NS	0	6.1×10^{-1}[d] (1977) Lead	4.9×10^{-1}[d] (1981) Lead	NS	NS
Ford building seepage basin	NS	NS	NS	NS	2.8×10^{0}[e] (1975) Fluoride	9.2×10^{-1}[e] (2025)	1.4×10^{-2} (1986) Lead	NS
Old TNX seepage basin	5.1×10^{-1}	1.1×10^{2}	NS	7.2×10^{-1}	5.5×10^{2} (1983) Nitrate	1.2×10^{2} (2038) Nitrate	NS	7.2×10^{-1} (2085) Mercury
Road A chemical basin	0	0	0	NS	5.4×10^{-1} (1975) Lead	4.1×10^{-1} (1980) Lead	NS	NS
K-Area acid/caustic basin[c]	NS	3.7×10^{-2}	NS	0	6.1×10^{-1}[d] (1977) Lead	4.9×10^{-1}[d] (1981) Lead	NS	NS
L-Area oil & chemical basin	3.8×10^{-1}	2.0×10^{-1}	NS	NS	5.9×10^{0}[f] (1996) Silvex	4.0×10^{1}[f] (2002) PCE[g]	NS	NS
P-Area acid/caustic basin[b]	NS	3.7×10^{-2}	NS	0	6.1×10^{-1}[d] (1977) Lead	4.9×10^{-1}[d] (1981) Lead	NS	NS

[a]NS = Not significant; risk is less than 10^{-2}.
[b]Values reported are for the F-Area seepage basin.
[c]Values reported are for L-Area acid/caustic basin.
[d]Values reported are for the C-Area burning/rubble pit.
[e]Values reported are for the hydrofluoric acid spill area.
[f]Values reported are for the CMP pits.
[g]PCE = tetrachloroethylene.

in the 1-meter well and 1.6×10^{2} in the 100-meter well, for exposures in 2445 and 2454, respectively.

In the F- and H-Area geographic grouping, the highest total carcinogenic risk from 50-year exposures following 2085 presented under the Dedication strategy by the 100-meter well is insignificant. However, the peak risk for the dominant carcinogenic chemical (4.2×10^{-4}) was presented by trichloroethylene from hypothetical exposures peaking at the 1-meter well in 1980.

The mixed waste management facility and old radioactive waste burial grounds present the highest noncarcinogenic risks from exposures in 2085, with hazard indexes of 1.1 in the 1-meter well and 5.5 in the 100-meter well. The dominant noncarcinogenic chemicals are nitrates, presenting an ADI fraction of 3.1×10^{2} in 1987 at both the 1- and 100-meter wells at the F-Area seepage basins.

All four strategies present the same carcinogenic and noncarcinogenic risks for the groundwater/surface-water pathway for the R-, C-, CS-, TNX-, Road A, K-, and P-Area geographic groupings.

The carcinogenic risks are the same under all strategies for the L-Area geographic grouping. See Section 4.2.1.4.

The total noncarcinogenic risks for exposures in 2085 under the Dedication strategy are greatest for the 1-meter well at the L-Area oil and chemical basin (hazard index of 3.8×10^{-1}). As under the No-Action strategy, the dominant noncarcinogenic chemical risk of 4.0×10^{1} is posed by tetrachloroethylene at the CMP pits 100-meter well in 2002.

Atmospheric Pathway

Table 4-30 lists risks to the maximally exposed individual and to the population for the Dedication strategy due to carcinogenic atmospheric releases. Risks due to noncarcinogenic releases are not considered significant for the three selected years. Major contributors to total risk due to carcinogen releases are from burning/rubble pits-composite site 1 and the M-Area air stripper. The major chemical contributors to the risk are trichloroethylene and chromium-VI. Risks are generally higher for 2085 than for 1985 because the maximally exposed individual is assumed to be much closer to the waste site. This results in higher exposures, even though the source strength might have decreased due to leaching over the previous 100 years.

Occupational Exposure Pathway (During Remediation Activities)

Carcinogenic and noncarcinogenic risks have been estimated for workers at one site under the Dedication strategy; the M-Area settling basin and associated areas (overflow ditch and seepage area and Lost Lake), which are to be drained prior to closure. For unprotected workers at this site, the total carcinogenic risk would be 9.0×10^{-8} and the total noncarcinogenic risk would be 1.1×10^{-2}, whereas the corresponding risks faced by protected workers would not be significant (i.e., 1.8×10^{-9} and 2.1×10^{-4}, respectively).

Table 4-30. Risks[a] to Population and Maximally Exposed Individual Attributable to Atmospherically Released Nonradiological Carcinogens for Dedication Strategy

Site	1985 exposure			2085 exposure			2985 exposure		
	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor
SRL seepage basins	0	0	–	0	0	–	0	0	–
F-Area seepage basins	0	0	–	0	0	–	0	0	–
Radioactive burial grounds	0	0	–	0	0	–	0	0	–
R-Area	0	0	–	0	0	–	0	0	–
P-, C-, K-Areas	NS[b]	NS	–	NS	NS	–	NS	NS	–
Silverton Road waste site	0	0	–	0	0	–	0	0	–
F-Area retention basin	0	0	–	0	0	–	0	0	–
H-Area retention basin	0	0	–	0	0	–	0	0	–
HFI spill area	0	0	–	0	0	–	0	0	–
CMP pit 19G	0	0	–	0	0	–	0	0	–
CMP pit 18.3G	0	0	–	0	0	–	0	0	–
CMP pits 18.1G or 18.2G	0	0	–	0	0	–	0	0	–
CMP pit 17.1G	0	0	–	0	0	–	0	0	–
CMP pit 17G	0	0	–	0	0	–	0	0	–
Bingham pump outage pits	0	0	–	0	0	–	0	0	–
Ford Building waste site	0	0	–	0	0	–	0	0	–
Old TNX seepage basin	0	0	–	0	0	–	0	0	–
Old TNX seepage basin outfall	9.27×10^{-4}	1.36×10^{-8}	Chromium VI	2.15×10^{-4}	5.33×10^{-8}	Chromium VI	NS	NS	–
Waste oil basins	0	0	–	0	0	–	0	0	–
SRP oil test site	0	0	–	0	0	–	0	0	–
Gunsite 720 rubble pit	0	0	–	0	0	–	0	0	–
Metallurgical laboratory basin	NS	NS	–	NS	NS	–	0	0	–
Lost Lake	NS	NS	–	NS	NS	–	NS	NS	–
M-Area overflow ditch and adjacent seepage area	NS	NS	–	NS	NS	–	NS	NS	–

Footnotes on last page of table.

Table 4-30. Risks[a] to Population and Maximally Exposed Individual Attributable to Atmospherically Released Nonradiological Carcinogens for Dedication Strategy (continued)

	1985 exposure			2085 exposure			2985 exposure		
Site	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor
M-Area air stripper	8.98×10^{-4}	1.51×10^{-8}	Trichloro-ethylene	-	-	-	-	-	-
M-Area settling basin and process sewer line	0	0	-	NS	NS	-	NS	NS	-
H-Area seepage basin	0	0	-	0	0	-	0	0	-
Ford Building seepage basin	0	0	-	0	0	-	0	0	-
Road A chemical basin	0	0	-	0	0	-	0	0	-
TNX burying ground	0	0	-	0	0	-	0	0	-
Acid/caustic basins	0	0	-	0	0	-	0	0	-
Old F-Area seepage basin	0	0	-	NS	NS	-	NS	NS	-
New TNX seepage basin	0	0	-	NS	NS	-	NS	NS	-
Burning/rubble pits - composite site 1	NS	NS	-	7.5×10^{-5}	1.86×10^{-8}	Chromium VI	NS	NS	-
Burning/rubble pits - composite site 2	NS	NS	-	NS	NS	-	0	0	-
Metals burning pit	0	0	-	NS	NS	-	NS	NS	-
TOTAL[c]	1.27×10^{-3}	2.19×10^{-8}	-	7.83×10^{-5}	1.94×10^{-8}	-	NS	NS	-

[a]Risks to the population are the number of excess cancers; risks to the maximally exposed individual are the excess lifetime cancer probabilities.
[b]NS = Not significant; incremental risk to maximally exposed individual is less than 1.0×10^{-8}; associated risk to the population is also not significant.
[c]Total risks include contributions from sites designated NS.

4.2.2.5 Ecological Impacts

The Dedication strategy would reduce the potential for adverse impacts to aquatic ecosystems. Under this strategy, including possible corrective actions for contaminated groundwater, all constituents in groundwater are expected to be brought into compliance with MCLs. Thus, the quality of groundwater discharging to streams would be improved from that described in Section 4.2.1.5 for No Action. The backfilling of open basins would eliminate potential impacts from direct exposure to standing water containing elevated levels of waste constituents (see Appendix F).

Effluent from any groundwater withdrawal/treatment facilities would be discharged under applicable NPDES permits. Increased flows in streams receiving NPDES permitted discharges could cause temporary changes in the ecological structure of the streams; however, these impacts would be minimal. Further study would define potential impacts resulting from these increased flows more accurately.

Potential impacts to terrestrial ecosystems could also occur under the Dedication strategy. Disruption of terrestrial habitats and effects on natural productivity could occur as a result of planned closure activities. Noise impacts could eliminate temporarily the use of the sites by some animals. Most effects are expected to be short-term, although noise impacts could last throughout the operation of groundwater-treatment facilities.

Habitat disruption and noise impacts also could occur in other areas of the SRP from the creation of new, or the expansion of existing, borrow pits required for backfill material. Current information does not permit an accurate determination of potential impacts from borrow pit activities, although these are not expected to be significant in the context of overall site land uses.

Remedial actions would reduce the potential for other adverse impacts to terrestrial ecosystems. Where sites were backfilled and capped, the potential for direct exposures by wildlife and vegetation would be reduced. Occasional maintenance would be required to prevent the growth of deep-rooted plant species and subsequent potential bioaccumulation of waste materials.

No endangered species or critical habitats have been identified in the immediate vicinity of the SRP waste sites (see Appendix F). Adverse impacts are not expected from the Dedication strategy.

Most wetlands are sufficiently distant from SRP waste sites such that they would not be affected by closure actions (see Appendix F). Erosion control measures could be required during onsite activities to reduce the potential for impacts from erosion and sedimentation. Wetlands immediately adjacent to the SRL seepage basins and the M-Area settling basin would require special precautions to prevent sedimentation impacts. Cleanup of the outfall delta in the TNX swamp would significantly reduce potential impacts from that source.

4.2.2.6 Other Impacts

The Dedication strategy would not impact any archaeological and/or historic resources. A survey in the existing waste site areas located no significant sites requiring impact mitigation (see Section 4.2.1.6).

Socioeconomic impacts for this strategy would be insignificant because the projected peak construction workforce would not exceed 200 persons, and would be drawn from the existing construction workforce employed on the Plant. Because these workers already reside in the SRP area, no additional impacts to local communities and services due to inmigrating workers are expected to occur.

4.2.3 ELIMINATION STRATEGY (REMOVAL OF WASTE TO THE EXTENT PRACTICABLE FROM EXISTING WASTE SITES, AND IMPLEMENTATION OF COST-EFFECTIVE REMEDIAL AND CLOSURE ACTIONS AS REQUIRED)

Under the Elimination strategy, all existing waste sites would have buried waste and contaminated soil excavated, packaged, and transported to one of five SRP storage/disposal facilities: the existing sanitary landfill, a new low-level radioactive waste facility, a new hazardous waste facility, a new mixed waste facility, and the CFM facility in Y-Area. Table 4-31 lists the volumes of waste to be excavated and transported, the volumes of backfill material required, the distance from each waste site to the storage/disposal facility, and the facility utilized. The volumes and distances are preliminary values used in this EIS only to bound the impacts of the proposed actions.

Any liquids in the open basins would be managed as indicated in Table 4-17 before any excavation is begun. Low-permeability infiltration barriers would be installed to cap the excavated waste sites listed in Table 4-32.

Following waste removal and closure, additional groundwater monitoring wells would be installed as required, and existing and new wells would be monitored in accordance with requirements.

Good housekeeping practices would be continued, including the installation of new fences and pylons.

4.2.3.1 Groundwater Impacts

The following paragraphs discuss groundwater impacts from waste constituents released from the various waste sites in each geographic group. They also present peak constituent concentrations predicted by the PATHRAE computer code to exceed MCLs or comparable criteria in each geographic group following implementation of the Elimination strategy. Corrective actions could be required to bring these constituent levels to within MCLs.

Table 4-33 lists constituents in A- and M-Areas predicted to exceed MCLs or comparable criteria under the Elimination strategy. The constituents are trichloroethylene and tetrachloroethylene. Others are tetrachloromethane, 1,1,1-trichloroethylene, arsenic, barium, cadmium, nitrate, and tritium. Groundwater remediation would follow the same general pattern described in Section 4.2.2.1.

Table 4-31. Elimination Strategy Excavation and Transport Requirements

Geographic grouping/waste sites		Waste volume (m^3)	Backfill volume (m^3)	Distance (km)	Storage/disposal facility
A- and M-Areas					
1-1	716-A motor shop seepage basin	Drummed liquid		8.7	HW
		675 (soil)	2,025	7.3	Sanitary landfill
1-2	Metals burning pit	21,600	21,600	6.8[a]	HW or incinerate
1-3	Silverton Road waste site	26,288	26,288	8.9[a]	Y-Area
1-4	Metallurgical laboratory basin	340	960	13.0	HW
1-5	Miscellaneous chemical basin	72	72	6.8[a]	HW or incinerate
1-6	A-Area burning/rubble pit	22,386	22,386	6.7	HW
1-7	A-Area burning/rubble pit	6,718	6,718	6.7	HW
1-8 to 11	SRL seepage basins	1,900	1,900	16.9	LLW
1-12	M-Area settling basin	34,740	30,000	9.9	MW
1-13	Lost Lake	16,900	0	7.4	MW
F- and H-Areas					
2-1	F-Area acid/caustic basin	200	700	10.0	HW
2-2	H-Area acid/caustic basin	200	700	11.8	HW
2-3	F-Area burning/rubble pit	6,494	6,494	7.2	HW
2-4	F-Area burning/rubble pit	10,889	10,889	7.2	HW
2-5	H-Area retention basin	6,080	6,750	3.3	LLW
2-6	F-Area retention basin	9,154	9,924	2.2	LLW
2-7 to 2-9	Radioactive waste burial grounds	3,000,000	3,000,000	10.5	MW
2-10 to 2-12	F-Area seepage basins	8,000	122,000	8.7	MW/HW
2-13	F-Area seepage basin (old)	5,230	5,230	9.1	MW/HW
2-14 to 2-17	H-Area seepage basins	20,870	265,000	11.3	MW/HW
R-Area					
3-1	R-Area burning/rubble pit	1,902	1,902	19.9	HW
3-2	R-Area burning/rubble pit	2,948	2,948	19.9	HW
3-3	R-Area acid/caustic basin	200	700	19.3	HW
3-4	R-Area Bingham pump outage pit	1,600	27,000	11.8	LLW
3-5	R-Area Bingham pump outage pit	1,200	1,200	11.8	LLW
3-6	R-Area Bingham pump outage pit	4,200	4,200	11.8	LLW
3-7 to 3-12	R-Area seepage basins	7,080	7,000	12.4	LLW
C- and CS-Areas					
4-1	CS burning/rubble pit	2,276	2,276	12.8	HW
4-2	CS burning/rubble pit	5,146	5,146	13.4	HW
4-3	CS burning/rubble pit	3,298	3,298	14.5	HW
4-4	C-Area burning/rubble pit	3,325	3,325	15.5	HW/MW
4-5	Hydrofluoric acid spill area	280	230	15.0	MW/HW
4-6	Ford Building waste site	345	345	8.8	LLW
4-7 to 4-8	C-Area seepage basins	2,440	(b)	9.6	LLW
4-9	C-Area seepage basin	0	(b)	–	–
4-10	Ford Building seepage basin	76	643	15.1[a]	Appropriate onsite S/D facility

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Table 4-31. Elimination Strategy Excavation and Transport Requirements (continued)

Geographic grouping/waste sites		Waste volume (m^3)	Backfill volume (m^3)	Distance (km)	Storage/disposal facility
TNX Area					
5-1	D-Area burning/rubble pit	4,302	4,302	9.5	HW
5-2	D-Area burning/rubble pit	3,509	3,509	9.5	HW
5-3	TNX burying ground	896	896	18.7	LLW
5-4	TNX seepage basin (old)	594	4,654[c]	9.6	HW/MW
5-5	TNX seepage basin (new)	359	2,807	9.6	HW/MW
D-Area					
6-1	D-Area oil seepage basin	5,742	5,742	11.7	Sanitary landfill
Road A Area					
7-1	Road A chemical basin	1,000	5,500[d]	11.9[a]	LLW or MW/HW
K-Area					
8-1	K-Area burning/rubble pit	2,615	2,615	16.3	HW
8-2	K-Area acid/caustic basin	200	700	16.7	HW
8-3	K-Area Bingham pump outage pit	7,700	7,700	14.9	LLW
8-4	K-Area seepage basin	260	(b)	14.0[e]	Appropriate MW/HW or LLW
8-5	K-Area containment basin	0	-	-	-
L-Area					
9-1	L-Area burning/rubble pit	2,529	2,529	19.4	HW
9-2	L-Area acid/caustic basin	200	700	19.0	HW
9-3 to 9-9	CMP pits	5,500	1,500	16.7[a]	Incinerate
9-10	L-Area Bingham pump outage pit	4,100	4,100	11.9	LLW
9-11	L-Area Bingham pump outage pit	4,200	4,200	11.8	LLW
9-12	L-Area oil and chemical basin	675	3,500	19.3[a]	HW/MW and LLW
P-Area					
10-1	P-Area burning/rubble pit	4,802	4,802	22.4	HW
10-2	P-Area acid/caustic basin	200	700	21.7	HW
10-3	P-Area Bingham pump outage pit	3,800	3,800	13.7	LLW
10-4 to 10-5	P-Area seepage basins	2,750	(b)	15.0[e]	Appropriate MW/HW or LLW
10-6	P-Area seepage basin	0	(b)	-	-
Miscellaneous areas					
11-1	SRL oil test site	140	140	11.3	Sanitary landfill
11-2	Gunsite 720 rubble pit	35	35	4.4	MW/HW
	TOTAL	3,291,160			

[a]Distance is to hazardous/mixed waste facilities.
[b]Total of 30,000 m^3.
[c]4060 m^3 excavated clean material reused for backfill.
[d]4500 m^3 excavated clean material reused for backfill.
[e]Distance is to low-level radioactive waste facility.

Table 4-32. Excavated Waste Sites Assumed to be Capped with Low Permeability Barrier

A- and M-Areas		R-Area	
1-3	Silverton Road waste site	3-7	R-Area seepage basin
1-8	SRL seepage basin	3-8	R-Area seepage basin
1-9	SRL seepage basin	3-9	R-Area seepage basin
1-10	SRL seepage basin	3-10	R-Area seepage basin
1-11	SRL seepage basin	3-11	R-Area seepage basin
		3-12	R-Area seepage basin
F- and H-Areas			
2-5	H-Area retention basin	TNX Area	
2-6	F-Area retention basin	5-3	TNX burying ground
2-7	Radioactive waste burial ground	5-5	TNX seepage basin (new)
2-8	Mixed-waste management facility		
2-9	Radioactive waste burial ground	Road A Area	
2-10	F-Area seepage basin	7-1	Road A chemical basin
2-11	F-Area seepage basin		
2-12	F-Area seepage basin	K-Area	
2-13	F-Area seepage basin (old)	8-4	K-Area seepage basin
2-14	H-Area seepage basin		
2-15	H-Area seepage basin	L-Area	
2-16	H-Area seepage basin	9-12	L-Area oil and chemical basin
2-17	H-Area seepage basin		

Implementation of the Elimination strategy at all existing waste sites in F- and H-Areas is not predicted to change the concentration of chemical contaminants in the groundwater from the Dedication strategy, as indicated in Table 4-19. Table 4-34 lists the radioactive constituents predicted to exceed MCLs or comparable criteria in F- and H-Areas. Potential groundwater impacts are similar to those described in Section 4.2.2.1. Groundwater remedial action would be implemented as required to reduce the concentration of constituents to below applicable standards.

Table 4-35 lists chromium, trichloroethylene, cesium-137, tritium, strontium-90, and yttrium-90 as the constituents predicted to exceed MCLs or comparable criteria in R-Area under the Elimination strategy. The R-Area seepage basins are the sources of radionuclides that exceed standards. strontium-90 and yttrium-90 would be the only substances reduced by this strategy, compared to the No-Action strategy.

Remedial action, such as contaminated groundwater withdrawal and treatment to meet regulatory standards, could be implemented for all the contaminants determined to exceed standards.

The Elimination strategy in C- and CS-Areas results in predictions of the same peak concentrations as those under No Action (see Table 4-21), with the exception of chromium from the Ford Building seepage basin, which is reduced to below its MCL. This strategy could require contaminated groundwater withdrawal and treatment or some other action after closure to meet regulatory standards for those contaminants determined to exceed standards.

Table 4-33. Peak Concentrations for the Elimination Strategy, A- and M-Area

Waste management facility	Site number	PATHRAE - Peak concentration[a]: Chemicals (mg/L)								Radionuclide (pCi/L)
		As	Ba	Cd	NO_3	Trichloroethylene	Tetrachloroethylene	Tetrachloromethane	1,1,1-Trichloroethane	H-3
Metals burning pit	1-2	(b)	(b)	(b)	(b)	0.12 (1981)	0.0027 (1985)	(b)	(b)	(b)
Silverton Road waste site	1-3	(b)	(b)	(b)	(b)	0.31 (1966)	0.35 (1969)	(b)	(b)	(b)
Metallurgical laboratory basin	1-4	(b)	(b)	(b)	(b)	0.018 (2008, (2009[c])	(b)	1.1 (2010)	0.36 (2008)	(b)
Miscellaneous chemical basin	1-5	(b)	(b)	(b)	(b)	(b)	310 (1990)	(b)	(b)	(b)
A-Area burning/ rubble pits	1-6, 1-7	(b)	(b)	(b)	(b)	2.1 (1980)	(b)	(b)	(b)	(b)
SRL seepage basins	1-8, 1-9, 1-10, 1-11	0.073 (2405)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	3.2×10^5 (1962)
M-Area settling basin and vicinity	1-12, 1-13	(b)	3.2 (2235)	0.02 (2779)	1600 (1995)	49 (1996)	260 (1996)	(b)	3.2 (1995)	(b)
Standard[d]		0.05	1.0	0.01	10	0.005	0.0007	0.1	0.2	8.7×10^4

[a]Year of occurrence in parentheses. Only the constituents with peak concentrations that exceed standards at one or more waste sites are given. 1-meter well concentrations except where noted.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]At 100-meter well.
[d]Source: 40 CFR 141, except as follows: trichloroethylene, tetrachloromethane, and 1,1,1-trichloroethane (EPA, 1985a) and tetrachloroethylene (EPA, 1985b). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-34. Peak Concentrations for the Elimination Strategy, F- and H-Area

Waste management facility	Site number	PATHRAE - Peak radionuclide concentration (mg/L)[a]										
		Sr-90	Y-90	Ni-63	Co-60	Tc-99	Cs-134	Cs-137	U-238	Pu-238	I-129	H-3
H-Area retention basin	2-6	2200 (2021)	2200 (2021)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Rad/mixed waste burial grounds	2-7, 2-8, 2-9	(b)	(b)	6.1×10^5 (1958)	620[c] (1961)	1.8×10^4 (1958)	350 (1957)	1400 (1958)	56 (1958)	350 (1966)	(b)	2.9×10^9 (1957)
F-Area seepage basins	2-10, 2-11, 2-12	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	88 (2036)	4.5×10^7 (1957)
H-Area seepage basin	2-14, 2-15, 2-16, 2-17	1900 (1976)	1900 (1976)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	120 (2008)	2.0×10^7 (1956)
Standard[d]		42	550	1.0×10^4	210	4200	74	110	24	14	20	8.7×10^4

[a]Year of occurrence in parentheses. Only constituents with peak concentrations that standards at one or more waste sites are given. 1 meter well concentrations except where noted.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]At 100-meter well.
[d]Source: 40 CFR 141, except as follows: xylene (EPA, 1981) and trichloroethylene (EPA, 1985a). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

Table 4-35. Peak Concentrations for Elimination Strategy, R-Area

Waste management facility	Site number	PATHRAE - Peak concentration[a]					
		Chemicals (mg/L)		Radionuclides (pCi/L)			
		Cr	Trichloro-ethylene	Cs-137	H-3	Sr-90	Y-90
R-Area burning/ rubble pits	3-1 3-2	(b)	2.1 (1980)	(b)	(b)	(b)	(b)
R-Area acid/ caustic basin	3-3	0.67 (2644)	(b)	(b)	(b)	(b)	(b)
R-Area seepage basins	3-7 through 3-12	(b)	(b)	3300 (1965)	1.5×10^8 (1963)	93[c] (2111)	93[c] (2111)
Standard[d]		0.05	0.005	110	8.7×10^4	42	550

[a]Year of occurrence in parentheses. Only the constituents with peak concentrations that exceed standards at one or more waste sites are given.
[b]Constituent did not meet threshold selection criteria for PATHRAE modeling or peak concentration is within regulatory standard.
[c]The facilitated transport peak for Sr-90 and Y-90 is predicted to have been 720 pCi/L in 1965. The listed value is the predicted future peak, which is affected by waste removal and closure.
[d]Source: 40 CFR 141, except trichloroethylene (EPA, 1985a). ICRP Publication 30 (ICRP, 1978) methodology was used to determine concentrations that yield an annual effective whole-body dose of 4 millirem.

The Elimination strategy at existing waste sites in the TNX, K- and P-Areas is not predicted to reduce the peak concentrations of contaminants in the groundwater below those presented for the Dedication strategy in Tables 4-22, 4-23, and 4-25, respectively. The Elimination strategy in L-Area also leaves peak concentrations unchanged (see Table 4-24), with the exception of americium-241, which is reduced to below its MCL. Groundwater remedial action could be required to reduce the concentration of constituents listed to below applicable standards.

PATHRAE predicts the peak constituent concentrations in D-Area, the Road A Area, and the miscellaneous waste site grouping to be within MCLs or comparable criteria. Groundwater corrective action is not expected to be required in these areas under any strategy.

Summary of Groundwater Effects

Groundwater corrective action could be required at 8 of the 11 geographic groups because the constituent concentrations exceed MCLs or comparable criteria. The number of groups is unchanged from that estimated for the Dedication strategy, but the extent of required remedial actions is expected to be less under the elimination strategy. The constituents predicted by PATHRAE to exceed MCLs or comparable criteria are nitrate, chromium, trichloroethylene, tetrachloroethylene, tritium, and strontium-90.

4.2.3.2 Surface-Water Impacts

The closure and remedial actions to be conducted under this strategy would result in surface-water quality improvements similar to those identified in Section 4.2.2.2.

4.2.3.3 Radiological Doses

For the Elimination strategy, Table 4-36 lists peak annual doses to the maximally exposed individual from 21 low-level radioactive and mixed waste sites, and their years of occurrence. These doses are based on the maximally exposed individual residing on the SRP after institutional control is relinquished in 2085. The groundwater-well pathway is the most significant, responsible for the dose at all sites except the old TNX seepage basin, where resuspension of contaminated dust from the unclosed outfall delta results in a first-year (1985) dose of 10.7 millirem. The M-Area settling basin and Lost Lake and the radioactive waste burial grounds are also sites for which the atmospheric pathway is responsible. At the SRL seepage basin, the reclaimed farm pathway is responsible.

All sites comply with the 100-millirem DOE annual dose limit for all pathways. Two sites are predicted to exceed the 4-millirem EPA drinking-water limit after the implementation of the Elimination strategy (but not groundwater remediation): the R-Area seepage basins (6.3 millirem from the 1-meter well in 2111) and the H-Area retention basin (57 millirem from the 1-meter well in 2085). All sites comply individually with the 25-millirem DOE annual dose limit for the atmospheric pathway.

Table 4-36. Peak Annual Dose to Maximally Exposed Individual and Years of Occurrence for Elimination Strategy

Low-level and mixed waste site	Maximum individual dose (mrem)	Year of peak dose
H-Area retention basin	57	2085
F-Area retention basin	0.0006	2318
R-Area Bingham pump outage pits	0.12	2088
R-Area seepage basins	6.3	2111
Ford Building waste site	0	
TNX burying ground	0.016	2085
K-Area Bingham pump outage pit	0.012	2088
K-Area seepage basin	0.22	2085
L-Area Bingham pump outage pits	0.012	2088
P-Area Bingham pump outage pit	0.012	2088
SRL seepage basins	0.053	2085
M-Area settling basin and Lost Lake	0.11	1985
Radioactive waste burial ground, mixed waste management facility (new), and radioactive waste burial ground (old)	0.70	1985
F-Area seepage basins	0.45	2685
F-Area seepage basin (old)	0.48	2085
H-Area seepage basins	1.3	2185
Ford Building seepage basin	0.22	2393
TNX seepage basin (old)	10.7	1985
TNX seepage basin (new)	0.014	2614
Road A chemical basin	0.043	2985
L-Area oil and chemical basin	1.4	2085

The complete implementation of this strategy (i.e., closure and remedial action as required) would reduce the peak annual drinking-water dose to below the 4-millirem EPA limit.

The annual doses received from all pathways by the maximally exposed individual residing at the SRP boundary during the year of closure and onsite during the peak exposure year (2085) are 12 and 67 millirem, respectively.

The annual collective doses received by the population during the first year and 100 years (2085) from the time of implementation of the elimination option are 29 and 2.9 person-rem, respectively. More than 95 percent of the dose during each of these years arises from the atmospheric pathway.

4.2.3.4 Health Effects

Radiological

The health effects presented in this section are based on the Elimination strategy without further remedial action. Table 4-37 lists lifetime health

Table 4-37. Radiological Health Risks to Maximally Exposed Individual from the Peak Annual Dose for Elimination Strategy

Low-level and mixed waste sites	Maximum individual risk (HE for peak year dose)	Lifetime exposure risk[a]
H-Area retention basin	1.6×10^{-5}	8.0×10^{-4}
F-Area retention basin	1.7×10^{-10}	8.5×10^{-9}
R-Area Bingham pump outage pits	3.4×10^{-9}	1.7×10^{-7}
R-Area seepage basins	1.8×10^{-6}	9.0×10^{-5}
Ford Building waste site	0	0
TNX burying ground	4.5×10^{-9}	2.2×10^{-7}
K-Area Bingham pump outage pit	3.4×10^{-9}	1.7×10^{-7}
K-Area seepage basin	6.2×10^{-8}	3.1×10^{-6}
L-Area Bingham pump outage pits	3.4×10^{-9}	1.7×10^{-7}
P-Area Bingham pump outage pit	3.4×10^{-9}	1.7×10^{-7}
SRL seepage basins	1.5×10^{-8}	7.5×10^{-7}
M-Area settling basin and Lost Lake	3.1×10^{-8}	1.6×10^{-6}
Radioactive waste burial ground, mixed waste management facility (new), and radioactive waste burial ground (old)	2.0×10^{-7}	1.0×10^{-5}
F-Area seepage basins	1.3×10^{-7}	6.5×10^{-6}
F-Area seepage basin (old)	1.3×10^{-7}	6.5×10^{-6}
H-Area seepage basins	3.6×10^{-7}	1.8×10^{-5}
Ford Building seepage basin	6.2×10^{-8}	3.1×10^{-6}
TNX seepage basin (old)	3.0×10^{-6}	1.5×10^{-4}
TNX seepage basin (new)	3.9×10^{-9}	2.0×10^{-7}
Road A chemical basin	1.2×10^{-8}	6.0×10^{-7}
L-Area oil and chemical basin	3.9×10^{-7}	2.0×10^{-5}

[a]Assumed 50-year exposure at peak year dose.

risks to the maximally exposed individual resulting from peak annual radioactive releases from 21 low-level and mixed waste sites.

The fatal health risks to the maximally exposed individual residing at the SRP boundary from exposures during the year of closure and residing onsite during the peak year (2085) are 3.4×10^{-6} and 1.9×10^{-5}, respectively. The corresponding maximum lifetime risks would be 1.7×10^{-4} and 1.0×10^{-3}, respectively, assuming a 50-year exposure at the peak annual rate.

The number of fatal health effects that would be predicted in the population in the SRP region from exposures during the year of waste removal and closure and in 2085 are 8.1×10^{-3} and 8.1×10^{-4}, respectively.

Chemical

Groundwater and Surface-Water Pathway

Tables 4-38 and 4-39 summarize the risks under the Elimination strategy from the upper bound impact sites in each geographic grouping via the groundwater/surface-water pathway.

For the A- and M-Area geographic grouping, the highest total carcinogenic risk for 2085 occurs at the M-Area settling basin 1-meter well (4.0×10^{-3}). The peak carcinogenic risk for tetrachloroethylene (2.9×10^{-1}) occurs at both the 1- and 100-meter wells of the miscellaneous chemical basin in 1990 and 1999.

The M-Area settling basin presents the highest noncarcinogenic risk in 2085 at the 100-meter well (1.2). The peak noncarcinogenic risks are also presented by this site. Phosphate peaks in the 1-meter well at 6.2×10^{-2} in 2170, and nitrate peaks in the 100-meter well at 3.4×10^{2} in 1995.

In the F- and H-Area geographic grouping, the highest total carcinogenic risk in 2085 is presented by the F-Area burning/rubble pit; it is not significant. Trichloroethylene created the peak carcinogenic risk at the 1-meter well of the F-Area burning/rubble pit (4.2×10^{-4}) in 1980. A similar risk (3.4×10^{-4}) was presented at the 100-meter well in 1985.

The mixed waste management facility and old radioactive waste burial grounds present the highest noncarcinogenic risks. In 2085, the 100-meter well presents a hazard of 5.3. Nitrate is the dominant noncarcinogenic chemical, creating a peak hazard index of 3.1×10^{2} in 1987 for both the 1- and 100-meter wells of the F-Area seepage basins.

In the R-Area and the C- and CS-Area geographic grouping, all four strategies present the same carcinogenic and noncarcinogenic risks (see Section 4.2.1.4).

In the TNX-Area geographic grouping, the total carcinogenic risks from 50-year exposures following 2085 are highest at the old TNX seepage basin 100-meter well (3.3×10^{-4}). The risk for the dominant carcinogen, tetrachloromethane, peaked at the 1-meter well in 1983 (1.8×10^{-3}). This chemical will create a peak risk of 3.4×10^{-4} at the 100-meter well in 2051.

Noncarcinogenic risks presented under this alternative are the same as those presented under No Action (see the discussion in Section 4.2.1.4).

In the Road A and the K-Area geographic groupings, carcinogenic and noncarcinogenic risks are the same for all four strategies (see Section 4.2.1.4).

In the L-Area geographic grouping, carcinogenic risks are the same for all four strategies (see Section 4.2.1.4). The L-Area oil and chemical basin poses the highest noncarcinogenic risk in 2085 at the 1-meter well (hazard index = 2.8×10^{-1}). The peak risk for the dominant noncarcinogenic chemical is the same for all strategies (see Section 4.2.1.4).

Table 4-38. Total Nonradiological Carcinogenic Risks for Elimination Strategy, Groundwater/Surface-Water Pathway in Each Geographic Grouping

Worst-case site	Total risks[a], 2085 exposures[b]				Maximum risk[a] for dominant carcinogenic chemical (year of peak exposure)			
	1-meter well	100-meter well	River outfall	Reclaimed farm	1-meter well	100-meter well	River outfall	Dominant chemical
M-Area settling basin	4.0×10^{-3}	6.4×10^{-4}	0	NS[c]	2.9×10^{-1}[d] (1990)	2.9×10^{-1}[d] (1999)	1.6×10^{-8} (2930)	Tetrachloroethylene
F-Area burning/rubble pit[c]	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
R-Area burning/rubble pit[d]	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
C-Area burning/rubble pit	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
Old TNX seepage basin	2.2×10^{-6}	3.3×10^{-4}	NS	0	1.8×10^{-3} (1983)	3.4×10^{-4} (2051)	NS	Tetrachloromethane
Road A chemical basin	0	0	0	0	0	0	0	
K-Area burning/rubble pit[d]	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene
CMP pits	1.0×10^{-5}	1.3×10^{-4}	NS	NS	9.7×10^{-2} (1997)	4.1×10^{-2} (2002)	NS	Tetrachloroethylene
P-Area burning rubble pit[e]	NS	NS	NS	0	4.2×10^{-4} (1980)	3.4×10^{-4} (1985)	NS	Trichloroethylene

[a]Risk = Incremental lifetime probability of death from cancer.
[b]50-year exposure period following 2085.
[c]NS = Not significant; risk is less than 1.0×10^{-8}.
[d]Values reported are for the Miscellaneous Chemical Basin.
[e]Values reported are for C-Area burning/rubble pit.

Table 4-39. Total Noncarcinogenic Risks for Elimination Strategy, Groundwater/Surface-Water Pathway in Each Geographic Grouping

Worst-case site	Hazard index, 2085 exposures				Maximum risk for dominant noncarcinogenic chemical, hazards index (year of peak exposure)			
	1-meter well	100-meter well	River outfall	Reclaimed farm	1-meter well	100-meter well	River outfall	Reclaimed farm
M-Area settling basin	7.9×10^{-2}	1.2×10^{0}	0	NS[a]	6.2×10^{2} (2170) Phosphate	3.4×10^{2} (1995) Nitrate	NS	NS
Mixed waste management facility and old radioactive waste burial grounds	9.8×10^{-1}	5.3×10^{0}	NS	NS	3.1×10^{2}[b] (1987) Nitrate	3.1×10^{2}[b] (1987) Nitrate	NS	NS
R-Area acid/caustic basin[c]	NS	3.7×10^{-2}	NS	0	6.1×10^{-1}[d] (1977) Lead	4.9×10^{-1}[d] (1981) Lead	NS	NS
Ford building seepage basin	NS	NS	NS	NS	2.8×10^{0}[e] (1975) Fluoride	9.2×10^{-1}[e] (2025)	NS	NS
Old TNX seepage basin	5.1×10^{-1}	1.1×10^{2}	NS	7.2×10^{-1}	5.5×10^{2} (1983) Nitrate	1.2×10^{2} (2038) Nitrate	NS	7.3×10^{-1} (2085) Mercury
Road A chemical basin	0	0	0	NS	5.4×10^{-1} (1975) Lead	4.1×10^{-1} (1980) Lead	NS	NS
K-Area acid/caustic basin[c]	NS	3.7×10^{-2}	NS	0	6.1×10^{-1}[d] (1977) Lead	4.9×10^{-1}[d] (1981) Lead	NS	NS
L-Area oil and chemical basin	2.8×10^{-1}	2.1×10^{-1}	NS	NS	5.9×10^{0}[f] (1996) Silvex	4.0×10^{1}[f] (2002) PCE[g]	NS	NS
P-Area acid/caustic basin[b]	NS	3.7×10^{-2}	NS	0	6.1×10^{-1} (1977) Lead	4.9×10^{-1}[d] (1981) Lead	NS	NS

[a]NS = Not significant; risk is less than 1.0×10^{-2}.
[b]Values reported are for the F-Area seepage basins.
[c]Values reported are for L-Area acid/caustic basin.
[d]Values reported are for the C-Area burning/rubble pit.
[e]Values reported are for the hydrofluoric acid spill area.
[f]Values reported are for the CMP pits.
[g]PCE = Tetrachloroethylene.

In the P-Area geographic grouping, the carcinogenic and noncarcinogenic risks are the same for all options (see the discussion of these risks in Section 4.2.1.4).

Atmospheric Pathway

Table 4-40 lists risks to the maximally exposed individual and to the population for the Elimination strategy due to carcinogenic atmospheric releases. Risks due to noncarcinogenic releases are considered not significant for the three selected years.

Major contributors to total risk due to carcinogenic releases are those from the M-Area air stripper; the chemical contributor to the risk is trichloroethylene. Risks are generally higher from exposures in 2085 than in 1985 because the maximally exposed individual is assumed to be closer to the waste site. This results in higher exposures, even though the source strength could have decreased due to leaching over the previous 100 years.

4.2.3.5 Ecological Impacts

Potential impacts to aquatic ecosystems resulting from the Elimination strategy are similar to those discussed in Section 4.2.2.5.

Potential impacts to terrestrial ecosystems resulting from the Elimination strategy are similar to those discussed in Section 4.2.2.5. This alternative would reduce further the potential for adverse effects from groundwater contamination, direct exposures to wildlife, and bioaccumulation. Potential impacts at borrow pit areas would increase due to the greater amount of backfill required for closure.

Endangered species or critical habitats have not been identified in the immediate vicinity of the SRP waste sites (see Appendix F). Consequently, the Elimination strategy is not expected to affect endangered species.

Most wetland communities are sufficiently distant from SRP waste sites that no adverse impacts are expected (see Appendix F). Erosion control measures would be implemented at all sites, with special attention given to sites adjacent to wetlands to prevent sedimentation impacts.

4.2.3.6 Other Impacts

Occupational Risk

Individual and collective occupational risks to protected workers due to atmospheric releases of nonradioactive materials from waste removal and closure of sites are very low and are considered to be insignificant. Specifically:

- The total individual occupational carcinogenic risk (i.e., incremental lifetime probability of death from cancer) to an average worker is 1.3×10^{-7} for waste removal and closure of hazardous and mixed waste sites. This risk conservatively assumes that the average worker is involved in the cleanup of all the sites. The total collective occupational carcinogenic risk to all workers involved in these activities (i.e., a crew of nine persons) is 1.2×10^{-6}.

Table 4-40. Risks[a] to Population and Maximally Exposed Individual Attributable to Atmospherically Released Nonradiological Carcinogens for Elimination Strategy

Site	1985 exposure			2085 exposure			2985 exposure		
	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor
SRL seepage basins	NS[b]	NS	-	0	0	-	0	0	-
F-Area seepage basins	NS	NS	-	0	0	-	0	0	-
Radioactive burial grounds	NS	NS	-	0	0	-	0	0	-
R-Area	0	0	-	0	0	-	0	0	-
P-, C-, K-Areas	NS	NS	-	NS	NS	-	0	0	-
Silverton Road waste site	NS	NS	-	NS	NS	-	NS	NS	-
F-Area retention basin	0	0	-	0	0	-	0	0	-
H-Area retention basin	0	0	-	0	0	-	0	0	-
HFI spill area	0	0	-	0	0	-	0	0	-
CMP pit 19G	NS	NS	-	0	0	-	0	0	-
CMP pit 18.3G	NS	NS	-	NS	NS	-	0	0	-
CMP pits 18.1G and 18.2G	NS	NS	-	NS	0	-	0	0	-
CMP pit 17.1G	0	0	-	0	0	-	0	0	-
CMP pit 17G	NS	NS	-	NS	NS	-	0	0	-
Bingham pump outage pits	0	0	-	0	0	-	0	0	-
Ford Building waste site	0	0	-	0	0	-	0	0	-
Old TNX seepage basin	NS	NS	-	0	0	-	0	0	-
Old TNX seepage basin outfall	9.27×10^{-4}	1.36×10^{-8}	Chromium VI	2.15×10^{-4}	5.33×10^{-8}	Chromium VI	NS	NS	-
Waste oil basins	0	0	-	0	0	-	0	0	-
SRP oil test site	0	0	-	0	0	-	0	0	-
Gunsite 720 rubble pit	0	0	-	0	0	-	0	0	-
Metallurgical laboratory basin	NS	NS	-	NS	NS	-	0	0	-
Lost Lake	NS	NS	-	NS	NS	-	NS	NS	-
M-Area overflow ditch and adjacent seepage area	NS	NS	-	NS	NS	-	NS	NS	-

Footnotes on last page of table.

Table 4-40. Risks[a] to Population and Maximally Exposed Individual Attributable to Atmospherically Released Nonradiological Carcinogens for Elimination Strategy (continued)

Site	1985 exposure			2085 exposure			2985 exposure		
	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor	Population	Maximum exposed individual	Major contributor
M-Area air stripper	8.98×10^{-4}	1.51×10^{-8}	Trichloroethylene	-	-	-	-	-	-
M-Area settling basin and process sewer line	NS	NS	-	NS	NS	-	0	0	-
H-Area seepage basin	NS	NS	-	0	0	-	0	0	-
Ford Building seepage basin	NS	NS	-	0	0	-	0	0	-
Road A chemical basin	NS	NS	-	0	0	-	0	0	-
TNX burying ground	0	0	-	0	0	-	0	0	-
Acid/caustic basins	NS	NS	-	0	0	-	0	0	-
Old F-Area seepage basin	NS	NS	-	NS	NS	-	NS	NS	-
New TNX seepage basin	NS	NS	-	0	0	-	0	0	-
Burning/rubble pits - composite site 1	NS	NS	-	NS	NS	-	NS	NS	-
Burning/rubble pits - composite site 2	NS	NS	-	NS	NS	-	0	0	-
Metals burning pit	NS	NS	-	NS	NS	-	NS	NS	-
TOTAL[c]	9.60×10^{-4}	9.58×10^{-8}	-	NS	NS	-	NS	NS	-

[a]Risks to the population are the number of excess cancers; risks to the maximally exposed individual are the excess lifetime cancer probabilities.
[b]NS = Not significant; risk to the maximally exposed individual is less than 1.0×10^{-8}; associated risk to the population is also not significant.
[c]Total risks include contributions from sites designated NS.

- The total individual occupational noncarcinogenic risk (i.e., hazard index) to an average worker is 1.04×10^{-1} for waste removal and closure of hazardous and mixed waste sites. This risk conservatively assumes that the average worker is involved in the cleanup of all the sites.

For occupational risks to cleanup workers and transportation workers attributed to atmospheric releases of radioactive materials due to waste removal and closure of waste sites, the highest total doses and associated carcinogenic risks are as follows:

- Radioactive waste burial ground, mixed waste management facility, and radioactive waste burial ground - 4200 millirem total dose to cleanup worker (1.2×10^{-3} risk) and 2200 millirem total dose to transportation worker (6.2×10^{-4}); the collective dose to all workers involved in these activities is 31.8 person-rem with a risk of 8.9×10^{-3}.

- F-, H-, and R-Area seepage basins - 940 to 4200 millirem total dose to cleanup worker (2.6×10^{-4} to 1.2×10^{-3} risk) and 300 to 340 millirem total dose to transportation worker (8.4×10^{-5} to 9.5×10^{-5} risk); the collective dose to all workers involved in these activities is 6.6 to 26.1 person-rem with a risk of 1.8×10^{-3} to 7.3×10^{-3}.

- H-Area retention basins - 600 millirem total dose to cleanup worker (1.7×10^{-4} risk) and 240 millirem total dose to transportation worker (6.7×10^{-5} risk); the collective dose to all workers involved in these activities is 4.3 person-rem with a risk of 1.2×10^{-3}.

- L-Area oil and chemical basin - 24 millirem total dose to the cleanup worker (6.7×10^{-6} risk) and 12 millirem total dose to the transportation worker (3.4×10^{-6} risk); the collective dose to all workers involved in these activities is 0.18 person-rem with a risk of 5.0×10^{-5}.

Air Emissions Due to Transportation

The transportation of hazardous, mixed, and low-level waste from existing sites to new sites would result in the emission of small quantities of carbon monoxide and hydrocarbons from engine exhausts and truck traffic, and suspended particulates and dust from ground-surface disturbances. The effects of these emissions would be small and limited to short distances from the vehicles due to the nature of the sources, which are near-ground releases. All applicable emission standards would be met during construction.

No significant archaeological and/or historic resources have been identified; therefore no impacts would be observed (see Section 4.2.1.6).

Socioeconomic impacts for this strategy would be insignificant, because the projected peak construction workforce would not exceed 200 persons and would be drawn from the existing construction workforce employed on the Plant. Because these workers already reside in the SRP area, no additional impacts to local communities and services due to inmigrating workers are expected to occur.

4.2.4 COMBINATION STRATEGY (REMOVAL OF WASTE TO THE EXTENT PRACTICABLE FROM SELECTED EXISTING WASTE SITES, AND IMPLEMENTATION OF COST-EFFECTIVE REMEDIAL AND CLOSURE ACTIONS AS REQUIRED)

Under this strategy, waste would be removed from selected existing waste sites, all sites would be closed, and remedial actions would be implemented as required. As indicated in the preceding section, the removal of waste from all existing sites (the Elimination strategy) does not always result in a reduction of peak concentrations of waste constituents in groundwater and in consequent groundwater remedial action requirements. At the same time, the removal process introduces a degree of occupational risk not present in the Dedication strategy, a risk that should not be undertaken without a balancing benefit.

Section 4.1 indicates that decisions on specific actions at particular sites would be adopted following interactions with regulatory agencies based on detailed site-specific information and studies. This EIS assumes that waste removal before closure would be instituted at sites where the predicted concentration of at least one contaminant substantially exceeds the applicable standard and waste removal significantly reduces predicted peak groundwater concentration to the constituent.

Because this strategy combines the Dedication (i.e., closure without removal) and the Elimination (i.e., waste removal) strategies, it is called the Combination strategy.

4.2.4.1 Groundwater Impacts

Comparison of the predicted peak groundwater concentrations for the Dedication (no waste removal and closure) and Elimination (waste removal at all sites and closure) strategies indicates that waste removal reduces the peak groundwater concentration of constituents at some waste sites. Table 4-41 lists these sites and constituents. Reductions of less than a factor of 3 are not presented due to the many variables associated with these predictions (see Appendix H), and the minimal effect that these reductions might have on potential groundwater remedial actions. Similarly, constituents that exceeded their MCLs by less than a factor of 3 under the no-removal-and-closure option are not presented.

To provide a basis for comparison of the strategies, this EIS assumes, on the preliminary bases described above, that waste removal would occur at the old F-Area seepage basin and the six R-Area seepage basins. The final waste removal decision at specific waste sites would be determined through regulatory interactions and further modeling or monitoring efforts.

In the F- and H-Area geographic grouping, removal of waste to the extent practicable from the old F-Area seepage basin is predicted to reduce significantly the release of uranium-238, resulting in groundwater concentrations that are calculated to be less than applicable standards (see Appendix F). Contaminant releases to the groundwater at other waste sites in F- and H-Areas would not be affected by this action (see Section 4.2.2.1).

Table 4-41. Combination Strategy - Sites Selected for Waste Removal

Area/waste site/constituent	Peak groundwater concentration: No removal and closure (pCi/L)	Removal and closure (pCi/L)	Ratio[a]
F- and H-Areas			
Old F-Area seepage basin			
Uranium-238	310	21[b]	15
R-Area			
R-Area seepage basins			
Strontium-90	9300	93	100
Yttrium-90	9300	93[b]	100

[a]No removal concentration divided by removal concentration.
[b]Below applicable standard.

In the R-Area geographic grouping, the six inactive seepage basins would be selected for waste removal. Such an action would decrease peak strontium-90 (and yttrium-90) concentrations by a factor of 100 from those that would exist if closure was the only action taken (Section 4.2.2.1). Groundwater remedial actions would be provided as necessary to reduce contaminant (e.g., strontium-90) concentrations further to values established through regulatory interactions.

Because no waste sites would be selected for waste removal in the A and M, C and CS, TNX, D, Road A, K, L, P, and miscellaneous areas, discussions for the Dedication strategy in Section 4.2.2.1 apply.

4.2.4.2 Surface-Water Impacts

The closure and remedial actions to be conducted under this strategy would result in surface-water quality improvements similar to those identified in Section 4.2.2.2 for the Dedication strategy (no-waste-removal-and-closure).

4.2.4.3 Radiological Doses

Table 4-42 lists peak annual doses to the maximally exposed individual from the 21 low-level radioactive and mixed waste sites, and their years of occurrence, for the Combination strategy. These doses ensure that the maximally exposed individual resides on the SRP after institutional control has been relinquished in 2085. The R-Area seepage basins and the old F-Area seepage basin are the sites from which waste would be removed under this strategy. The groundwater-well pathway is the most significant, contributing more than 90 percent of the total dose at those sites with peak annual doses of 0.10 millirem or more, with the exception of the old TNX seepage basin, where

Table 4-42. Peak Annual Dose to Maximally Exposed Individual and Years of Occurrence for Combination Strategy

Low-level and mixed waste sites	Maximum individual dose (mrem)	Year of peak dose
H-Area retention basin	81	2085
F-Area retention basin	0.057	2318
R-Area Bingham pump outage pits	0.12	2085
R-Area seepage basins	6.3	2111
Ford Building waste site	0	
TNX burying ground	0.016	2085
K-Area Bingham pump outage pit	0.12	2085
K-Area seepage basin	0.22	2085
L-Area Bingham pump outage pits	0.12	2085
P-Area Bingham pump outage pit	0.12	2085
SRL seepage basins	0.071	2085
M-Area settling basin and Lost Lake	0.033	1985
Radioactive waste burial ground, mixed waste management facility (new), and radioactive waste burial ground (old)	2.8	2185
F-Area seepage basins	5.7	2985
F-Area seepage basin (old)	0.48	2085
H-Area seepage basins	1.3	2185
Ford Building seepage basin	0.57	2393
TNX seepage basin (old)	10.7	1985
TNX seepage basin (new)	1.4	2614
Road A chemical basin	4.3	2985
L-Area oil and chemical basin	6.1	2185

resuspension of contaminated dust from the unclosed outfall delta results in a first-year (1985) dose of 10.7 millirem. The atmospheric pathway is also responsible for all the M-Area settling basin and Lost Lake dose of 0.033 millirem. The reclaimed farm pathway contributes all of the 0.071-millirem dose from the SRL seepage basins.

All sites comply individually with the DOE annual dose limits of 100 millirem for all pathways and 25 millirem for the atmospheric pathway (40 CFR 61). Five sites are each predicted to exceed the 4-millirem EPA annual drinking-water limit after implementation of the Combination strategy; they are the R-Area seepage basins (6.3 millirem from the 1-meter well in 2111), the F-Area seepage basins (5.7 millirem from the 1-meter well in 2985), the H-Area retention basin (81 millirem from the 1-meter well in 2085), the Road A chemical basin (4.3 millirem from the 1-meter well in 2985), and the L-Area oil and chemical basin (6.1 millirem from the 1-meter well in 2185).

The complete implementation of this strategy, including remedial action as required, would reduce the peak annual drinking water dose to below the EPA annual 4-millirem limit.

The annual doses received from all pathways by the maximally exposed individual residing at the SRP boundary during the year of closure and onsite during the peak exposure year (2085) would be 11 and 91 millirem, respectively. The annual collective doses received by the population during the first year, and 100 years (2085) after implementation of the Combination strategy, would be 3.7 and 2.9 person-rem, respectively, of which the atmospheric pathway would contribute more than 65 percent.

4.2.4.4 Health Effects

Radiological

The health effects described in this section are based on the Combination strategy without further remedial action. Table 4-43 lists lifetime health risks to the maximally exposed individual resulting from peak annual radioactive releases from 21 low-level and mixed waste sites.

Table 4-43. Radiological Health Risks to Maximally Exposed Individual from the Peak Annual Dose for Combination Option at Selected Sites

Low-level and mixed waste sites	Maximum individual risk (HE for peak year dose)	Lifetime exposure risk[a]
H-Area retention basin	2.3×10^{-5}	1.2×10^{-3}
F-Area retention basin	1.6×10^{-8}	8.0×10^{-7}
R-Area Bingham pump outage pits	3.4×10^{-8}	1.7×10^{-6}
R-Area seepage basins	1.8×10^{-6}	9.0×10^{-5}
Ford Building waste site	0.0	0.0
TNX burying ground	4.5×10^{-9}	2.2×10^{-7}
K-Area Bingham pump outage pit	3.4×10^{-8}	1.7×10^{-6}
K-Area seepage basin	6.1×10^{-8}	3.0×10^{-6}
L-Area Bingham pump outage pits	3.4×10^{-8}	1.7×10^{-6}
P-Area Bingham pump outage pit	3.4×10^{-8}	1.7×10^{-6}
SRL seepage basins	2.0×10^{-8}	1.0×10^{-6}
M-Area settling basin and Lost Lake	9.2×10^{-9}	4.6×10^{-7}
Radioactive waste burial ground, mixed waste management facility (new), and radioactive waste burial ground (old)	7.8×10^{-7}	3.9×10^{-5}
F-Area seepage basins	1.6×10^{-6}	8.0×10^{-5}
F-Area seepage basin (old)	1.3×10^{-7}	6.5×10^{-6}
H-Area seepage basins	3.6×10^{-7}	1.8×10^{-5}
Ford Building seepage basin	1.6×10^{-7}	8.0×10^{-6}
TNX seepage basin (old)	3.0×10^{-6}	1.5×10^{-4}
TNX seepage basin (new)	3.8×10^{-7}	1.9×10^{-5}
Road A chemical basin	1.2×10^{-6}	6.0×10^{-5}
L-Area oil and chemical basin	1.7×10^{-6}	8.5×10^{-5}

[a]Assumes 50-year exposure at peak year dose.

The fatal health risks to the maximally exposed individual residing at the SRP boundary from exposures during the year of closure and residing onsite during the peak year (2085) are 3.1×10^{-6} and 2.5×10^{-5}, respectively.

The corresponding maximum lifetime risks would be 1.6×10^{-4} and 1.3×10^{-3}, respectively, assuming a 50-year exposure at the peak annual rate.

The number of fatal health effects that would be predicted in the population in the SRP region from exposures during the year of waste removal and closure and 100 years from then (2085) are 1.0×10^{-3} and 8.1×10^{-4}, respectively.

Chemical

The only waste site selected for removal of waste under the Combination strategy that would have chemical-related health effects different than those of the Dedication strategy (Section 4.2.2.4) is the old F-Area seepage basin. The health effects for this site under the Combination strategy would be the same as those presented for the Elimination strategy (Section 4.2.3.4). The only differences in these chemical-related health effects is a reduction of the peak noncarcinogenic health risks from the reclaimed farm pathway and a minimal increase in health risks to individuals due to atmospherically released carcinogens.

The peak noncarcinogenic health risk for the reclaimed farm under the Dedication strategy is 7.1×10^{-7}, which is reduced to 7.1×10^{-9} under the Elimination strategy. The health risk from atmospherically released carcinogens is zero in 1986 under the Dedication strategy, but increases to 8.4×10^{-15} under the Elimination strategy. This health risk, like all health risks due to atmospherically released carcinogens, is not considered significant.

4.2.4.5 Ecological Impacts

Potential aquatic ecosystem impacts resulting from the Combination strategy are similar to those described in Section 4.2.2.5.

Potential impacts to terrestrial ecosystems are similar to those described in Section 4.2.2.5. Short-term disruption of terrestrial habitats and effects of natural productivity could occur as a result of noise and other onsite activities. The actions would reduce the potential for effects from direct contact by wildlife and potential bioaccumulation of wastes by plant species. Removal of waste at the selected sites would further reduce the potential for effects to vegetation. Impacts at borrow pits would be bracketed by the requirements of the Dedication and Elimination strategies for backfill.

Endangered species or critical habitats have not been identified in the immediate vicinity of SRP waste sites (see Appendix F). Consequently, this strategy is not expected to affect endangered species or their habitats.

Effects on wetland communities from the Combination strategy would be similar to those for the Dedication strategy, discussed in Section 4.2.2.5. Because wetland communities are sufficiently distant from most waste sites, adverse effects are not expected. Erosion control measures during site activities would reduce potential effects on wetland communities, including those wetlands immediately adjacent to waste sites.

4.2.4.6 Other Impacts

Occupational Risk

Total occupational risks to protected workers due to atmospheric releases of nonradioactive materials from removal of waste at selected existing waste sites would be very low, and would be considered not significant. Specifically:

- The total individual occupational carcinogenic risk (i.e., incremental lifetime probability of death from cancer) to an average worker is 3.3×10^{-12} for waste removal and closure of the old F-Area seepage basin. The total collective occupational carcinogenic risk to all workers involved in these activities is 3.0×10^{-11}.

- The total individual occupational noncarcinogenic risk (i.e., hazard index) to an average worker is 1.4×10^{-5} for the removal and closure of the old F-Area seepage basin.

- No nonradiological constituents met the selection criteria for the R-Area seepage basins. Therefore, the nonradiological risks for waste removal and closure of these sites is assumed to be zero.

Individual and collective occupational risks to cleanup workers and to transportation workers due to atmospheric releases of radioactive materials from removal of waste at the selected existing waste sites are presented below:

- Old F-Area seepage basin - 3.1 millirem total dose to the cleanup worker (8.7×10^{-7} risk) and 1.6 millirem total dose to the transportation worker (4.5×10^{-7} risk); the collective dose to all workers involved in these activities is 2.3×10^{-2} person-rem with a risk of 6.6×10^{-6}.

- R-Area seepage basin - 4200 millirem total dose to the cleanup worker (1.2×10^{-3} risk) and 300 millirem total dose to the transportation worker (8.4×10^{-5} risk); the collective dose to all workers involved in these activities is 2.6×10^{1} person rem with a risk of 7.3×10^{-3}.

Archaeological and Historic Resources

This strategy would not involve any archaeological or historic resources; therefore, no impacts would be observed. (See Section 4.2.1.6.)

Socioeconomic impacts for this alternative would be insignificant, because the projected peak construction workforce would not exceed 200 persons and would be drawn from the existing construction workforce employed on the Plant. Because these workers already reside in the SRP area, no additional impacts to local communities and services due to inmigrating workers are expected.

Air Emissions Due to Transportation

The transportation of hazardous, mixed, and low-level waste from existing sites to new sites would result in the emission of small quantities of carbon monoxide and hydrocarbons from engine exhausts and truck traffic, and suspended particulates and dust from ground-surface disturbances from the vehicles, due to the nature of the sources, which are near-ground releases. All applicable emission standards would be met during construction.

4.2.5 COMPARISON OF ALTERNATIVE ACTIONS AT EXISTING WASTE SITES

This section compares the modifications to existing waste sites that would be implemented under the four alternative waste management strategies and their potential environmental consequences. The four strategies are as follows:

- No action - no removal of waste at existing waste sites, and no closure or remedial actions
- Dedication - No removal of waste at existing waste sites, and implementation of cost-effective closure and remedial actions, as required
- Elimination - Removal of waste to the extent practicable from all existing waste sites, and implementation of cost-effective closure and remedial actions, as required
- Combination - Removal of waste to the extent practicable at selected existing waste sites, and implementation of cost-effective closure and remedial actions, as required

4.2.5.1 Comparison of Strategies

The No-Action strategy presented in Section 2.1.1 provides continued protection of the offsite environment. Waste removal, closure, and remedial actions would not take place at SRP, but measures considered necessary to protect the offsite environment would be implemented. Waste sites would be protected against erosion; weeds and grass would be mowed; groundwater monitoring wells would be installed; existing and new wells would be monitored; and fences would be installed to keep out animals and unauthorized personnel. The removal of volatile organics from the groundwater in the Tertiary sediments in M-Area through a system of recovery wells routed to an air stripper would be continued. The monitoring and protective activities described for No Action would be included in the three remedial and closure actions described below.

No-removal remedial and closure actions would be included in the Dedication strategy presented in Section 2.1.2. Releases of hazardous substances from existing waste sites would be controlled through the closure of such sites (if not already closed). Further remedial actions could be required to control groundwater contaminant plume migration and other corrective actions (excluding removal) could be initiated at the sites to prevent further releases of hazardous substances. Dedication for waste management purposes of waste sites and contaminated (hazardous and radioactive) areas that could not be returned to public use after a 100-year institutional control period would be required. Existing basins that had not been filled would be backfilled after water was removed. The cost and analysis of environmental consequences for this strategy are based on the assumption that a low-permeability infiltration barrier would be installed at 34 of the 77 sites.

Waste-removal-at-all-sites remedial and closure actions would be included in the Elimination strategy presented in Section 2.1.3 (compliance through elimination of existing waste sites and storage of wastes). Under this strategy, the hazardous, low-level radioactive, and mixed waste (including contaminated soil) would be removed from all existing waste sites to the extent practicable. After a maximum 100-year institutional control period, these areas could be returned to the public. In addition to waste removal and closure, further remedial action to control the migration of hazardous and radioactive substances that have already been released from the site could be required.

Waste-removal-at-selected-sites remedial and closure actions would be included in the Combination strategy presented in Section 2.1.3 (compliance through a combination of dedication, elimination of existing waste sites, and storage of wastes). Wastes (including contaminated soil) would be removed from selected existing waste sites based on environmental and human health benefits and cost-effectiveness. The areas from which waste had been removed could be returned to the public after the institutional control period. Sites from which waste was not removed would be dedicated for waste management purposes if they were not suitable for public use after the institutional control period. As with no removal, releases from existing waste sites would be controlled through closure (with or without waste removal), and compliance with current groundwater-protection requirements would be achieved through the closure actions and, if necessary, further remedial actions and other corrective measures to control groundwater contaminant plume migration. The cost and environmental analysis for this approach are based on the preliminary evaluation that waste removal from the old F-Area seepage basin, and the six R-Area seepage basins, would be most beneficial. The sites from which waste would not be removed would receive the same closure action as those in the no-waste-removal approach. Additional remedial action under this strategy could be required, but such actions would be fewer than those for the Dedication strategy because of the removal of waste at the selected sites.

4.2.5.2 Comparison of Environmental Consequences

This section compares the environmental consequences of the four strategies at existing waste sites that contain or might contain hazardous, low-level radioactive, or mixed waste. Table 4-44 summarizes these environmental consequences. These consequences are in addition to those that are explicit in the definitions of the remedial, removal, or closure actions (e.g., waste remains in or is removed from the waste sites).

Onsite Groundwater

Under No Action, certain hazardous and radioactive constituents either exceed or are predicted to exceed applicable standards in the groundwater in Tertiary (near-surface) formations. Therefore, this strategy would not comply with current groundwater protection requirements. The hydrogeological properties of these aquifers render them generally unsuitable for drinking water. The groundwater in the Tertiary sediments is not used for the drinking-water supply at SRP. After the period of institutional control, small public supply wells could be screened into these aquifers. By that time most constituents in the groundwater would have decayed or dispersed to concentrations that are below regulatory, human health, and environmental concern. Dedication of

Table 4-44. Existing Waste Site Impacts for Each Waste Management Strategy

Environmental Category	No Action	Dedication	Elimination	Combination
Onsite Groundwater	Certain hazardous and radioactive constituents will exceed applicable standards in the tertiary formations. After period of institutional control (100 years), some areas of contaminated groundwater in the tertiary formations would remain. Dedication of these areas of contaminated groundwater would be required at the end of the institutional control period. Very low potential for contamination in the Black Creek and Middendorf Formations.	Site closure (without waste removal) would reduce the mobility and concentrations of contaminants in the groundwater. Post-closure groundwater cleanup, if required, would ensure that groundwater constituents are within regulatory human health and environmental concern by the end of the institutional control period.	Relative to Dedication, waste removal and closure would further reduce the expected peak concentrations of contaminants in the groundwater at some waste sites. Groundwater cleanup, if required, would ensure that groundwater contaminants are below levels of concern by the end of institutional control period.	Post-closure groundwater conditions would not differ significantly from the Elimination strategy. Groundwater cleanup, if required, would ensure that groundwater contaminants are below levels of concern by the end of the institutional control period.
Offsite Groundwater	Offsite groundwater quality is not affected by actions at SRP. Potentially contaminated groundwater outcrops in onsite streams or the Savannah River before leaving the plant boundary.	No impact.	No impact.	No impact.
Surface Water	Nitrate and tritium plumes are predicted to exceed regulatory limits in Four Mile Creek.	All constituent concentrations in all onsite streams and the Savannah River are predicted to be below regulatory standards.	Same as Dedication.	Same as Dedication.
Radiological Doses	Estimated current total annual offsite dose is 14.4 millirem, below the 100-millirem DOE limit. Onsite peak annual dose after institutional control period is conservatively estimated to be 3900 millirem. Dedication of such areas would be required.	Closure and groundwater cleanup actions would ensure that all doses are below the 100 millirem per year DOE limit.	Same as Dedication.	Same as Dedication.

Table 4-44. Existing Waste Site Impacts for Each Waste Management Strategy (Continued)

Environmental Category	No Action	Dedication	Elimination	Combination
Health Effects	No adverse health effects during the period of institutional control. Based on conservative assumptions, adverse health effects could occur as a result of exposures onsite beginning after the period of institutional control (i.e., dedication required).	Appropriate actions (e.g., groundwater cleanup) would be taken to ensure that the concentrations of hazardous and radioactive constituents are reduced to levels that would protect human health and the environment.	Same as Dedication.	Same as Dedication.
Ecology	Offsite ecology is protected. Slight onsite aquatic ecological effects could occur due to concentrations of tritium and nitrate in Four Mile Creek.	Closure and remedial actions would mitigate adverse effects on aquatic ecology. Slight terrestrial ecology effects would occur (e.g, at borrow areas for backfilling and capping waste sites).	Same as Dedication, plus additional effects to terrestrial ecology due to removal and transport of waste to new onsite storage facility.	Same as Elimination, but effects due to waste removal and transport would be limited to the sites selected for waste removal.
Occupational Risks	No significant risk.	Very low potential risk identified only at the M-Area settling basin and vicinity.	Risk is due to atmospheric releases of radioactive materials during waste removal and transport to new storage facility.	Risks described for elimination are limited to the sites selected for waste removal.
Site Dedication	Potentially all existing waste sites discussed in Section 4.2 (about 300 acres) plus a significant amount of adversely impacted areas (see onsite groundwater, radiological doses, and health effects).	Potentially all existing waste sites discussed in Section 4.2. Total required area of dedication is about 300 acres (i.e., less than 0.2 percent of the total area of SRP).	None.	Sites selected for waste removal would not require dedication. Total required area of dedication is about 270 acres.
Regulatory Compliance	Would not comply with current groundwater protection requirements.	Meets all applicable regulations.	Meets all applicable regulations.	Meets all applicable regulations.

areas where groundwater constituents are still above levels of concern would be necessary under No Action.

By comparison, the concentration of constituents in these Tertiary sediments generally would be lower due to the implementation of the three other strategies. Also, remedial action (i.e., groundwater cleanup) could be implemented to reduce these contaminants to concentrations that are below regulatory, human health, and environmental concern.

Remedial actions that could be required could cause adverse effects through drawdown of these shallow aquifers. If detailed studies indicate that these effects would occur, recharge of the aquifers with the treated groundwater would be considered. Another reason for returning the treated groundwater is that tritium, which is not practical to remove with current technology, would have additional time to decay until it reaches outcrops at onsite streams.

Under No Action, there is a very slight probability of contamination of the groundwater underlying the Black Creek formation, a primary source of irrigation and drinking water. An upward head reversal over most of the SRP precludes the leakage of groundwater through the Ellenton Clay, which separates the Tertiary and Black Creek formations. This head reversal does not exist in the A- and M-Areas. Here, the existing recovery wells lower the head (and the concentration of contaminants) in the shallow aquifers and, therefore, minimize the flow from the Tertiary sediments into the Black Creek formation.

Closure and remedial action would protect the major drinking-water aquifers.

Offsite Groundwater

The effects of any of the four strategies on offsite groundwater would not be significant. Groundwater flow in the Tertiary formations is almost entirely to onsite streams. One exception is a groundwater divide that passes through the A- and M-Areas. Most of the waste sites in the A- and M-Areas are west of this divide. Groundwater is believed to flow laterally to the west from these sites until it enters the Congaree Formation near the Plant boundary.

Flow in the Congaree is believed to be primarily vertical into the Black Creek Formation, occurring before potentially contaminated groundwater reaches the Plant boundary. Any hazardous or radioactive constituents entering the Black Creek Formation would be diluted to concentrations well below (health-based) regulatory limits, even under No Action.

Surface Water

Nitrate and tritium concentrations are predicted to exceed regulatory limits in Four Mile Creek under No Action. All other concentrations in the onsite streams and the Savannah River are predicted to be below regulatory standards. No constituents in surface water would exceed applicable standards under any of the three closure and remedial action strategies. Groundwater cleanup could reduce those concentrations to below regulatory limits; they would be reduced further when the outcropping groundwater is diluted in surface streams.

Radiological Releases

Total cumulative (all waste sites) annual dose from all pathways due to radiological releases at the SRP boundary under No-Action strategy is currently 14.4 millirem. This dose is well below the 100-millirem DOE limit. The corresponding onsite peak dose in 2085 is estimated conservatively to be 3900 millirem, which would be received primarily by the assumed use of an onsite shallow-aquifer drinking-water well adjacent to the R-Area and direct gamma exposure at the F-Area seepage basins. This emphasizes the need for rather extensive site dedication at the end of institutional control under the No-Action strategy. Doses for all three remedial and closure strategies would be below the 100-millirem DOE limit.

Health Effects

Under the No-Action strategy, there would be essentially no adverse health effects during the period of institutional control. Based on conservative assumptions, adverse health effects could occur as a result of exposures onsite beginning after the period of institutional control. Dedication of waste sites and nearby pathways of contamination could avoid these adverse effects. Under any of the closure and remedial action strategies, appropriate actions (e.g., groundwater cleanup) would be taken to ensure that the concentrations of hazardous and radioactive constituents in the groundwater are brought to levels below regulatory human health and ecological concern. Human health at the waste sites would be protected either by removal of the hazardous and radioactive waste and surrounding soil or by dedication, based on the specific remedial and closure action chosen.

Other Impacts

The primary environmental consequences for these strategies, other than those discussed above, include ecology and occupational risks from site closure activities.

Under the No-Action strategy, offsite ecology would be protected. Slight onsite aquatic ecological effects could occur due to releases of radioactive or hazardous constituents to surface streams. Terrestrial ecology could be affected under the Dedication, Elimination, and Combination strategies, due to closure actions (e.g., borrow areas for backfilling). Under the Elimination and Combination strategies, terrestrial ecology would be affected due to the removal and transport of the waste to suitable new onsite storage or disposal facilities.

There would also be some significant occupational risks from waste removal and/or closure of the waste sites due to worker exposure to radiological and hazardous substances during waste removal activities. In some cases, waste removal could require many crews working for short periods of time to ensure individual doses do not exceed occupational limits.

The transportation of hazardous, mixed, and low-level waste from existing sites to new sites would result in the emission of small quantities of carbon monoxide and hydrocarbons from engine exhausts and truck traffic, and suspended particulates and dust from ground-surface disturbances. The effects of these emissions would be small and limited to short distances from the vehicles due to the nature of the sources, which are near-ground releases. All applicable emission standards would be met during construction.

Accidents

The environmental impacts and risk of potential accidents associated with each strategy are discussed in Section 4.5.

Nonradioactive Air Releases

Risks and health effects from air releases are predicted to be low for all four strategies. Public risks are generally greatest at the end of institutional control because it is assumed that the maximally exposed individual would be at the waste sites rather than at the SRP boundary before 2085, when the institutional control period would end.

Risk would decrease steadily until 2985, the end of the modeling period. The second highest risk year is 1985, the assumed year of closure actions. For example, under No Action, total lifetime carcinogenic risk due to nonradioactive releases to the maximally exposed individual in 1985 is about 6×10^{-6}. In 2085, this risk is predicted to remain about 6.6×10^{-6}. By 2985, the risk would decrease to less than 1.0×10^{-8}. The three closure and remedial action values are even lower. Noncarcinogenic risks due to nonradioactive releases are not significant.

4.3 STRATEGIES FOR NEW WASTE MANAGEMENT FACILITIES

DOE is considering the construction of new waste management facilities for hazardous, mixed, and low-level radioactive wastes at the Savannah River Plant. DOE estimates that the capacity of the present low-level waste disposal facility will be exhausted by early 1989, and that the hazardous and mixed waste interim storage facilities will reach capacity by 1992.

DOE is considering four alternative strategies for future waste management at SRP:

- No Action
- Dedication
- Elimination
- Combination

Each strategy would be implemented through one or more technologies. Chapter 2 describes the alternative strategies and their technologies. Table 2-9 lists the waste management strategies and the technologies that form the basis of this environmental evaluation. Appendix E describes the technologies.

This section provides the range of potential environmental impacts associated with each strategy, and the basis for future decisions on project-specific actions and the design and location of a new low-level radioactive waste disposal facility. Each waste management strategy has been defined in terms of technologies and facilities, which would be designed and operated to comply with all applicable regulations and requirements. To ensure that the impact evaluations encompass all possible technological options, waste volumes, and waste characteristics (i.e., within the limitations set by the strategy), the EIS takes a conservative approach. Evaluations are based on worst-case and best-case impacts. If the worst case (e.g., greatest volume of waste or largest site requirement) is acceptable in terms of demonstrated regulatory compliance, all other (more protective) conditions under that strtategy are acceptable. The best case describes the maximum level of remedial or corrective action available under the Elimination strategy.

The environmental impacts described in the following sections are both quantitative and qualitative. Some analyses (i.e., atmospheric, groundwater, and surface-water modeling) were conducted at specific sites due to the need for or availability of site-related parameters. (Appendix E discusses the selection and location of candidate sites for evaluation). Some analyses, such as those for archaeological and historic resources, were conducted at the three or four highest ranked candidate sites. Other analyses (e.g., noise) were based on conditions known to exist at most SRP locations. Table 4-45 lists the bases of impact evaluations in each environmental category.

The accuracy of quantitative impacts (i.e., modeling results) is affected by assumptions, the potential ranges of significant parameters, and available project-specific details. On the average, these results within a factor of 5 level of accuracy, and form a determination of the relative performance of a strategy, a basis for comparative evaluations, and preliminary strategy selection.

4.3.1 NO-ACTION STRATEGY

The No-Action strategy was developed and evaluated in compliance with the guidelines of the Council on Environmental Quality (CEQ) for implementing NEPA regulations. It assesses the consequences of taking no action to provide the needed facilities for current and future waste management. The strategy is defined as continuing waste management with no new facilities. For evaluation purposes, the No-Action strategy can be described as a form of "makeshift" indefinite storage. Structures that are currently unused would be used to store wastes until their capacity was reached, after which waste would be stored in other available (unused or abandoned) structures and pads, followed by storage on minimally prepared open areas at existing waste sites. (Refer to Appendix E).

4.3.1.1 Groundwater and Surface Water

Wastes would be stored without pretreatment and without protection, detection, or backup containment systems, which would increase the risk of an accidental release of waste to the environment. This could range from no release to the release of all waste stored; the potential impacts to groundwater and surface water could range from no significant impacts to massive and gross contamination.

Offsite groundwater would not be affected by adopting the No-Action strategy because the groundwater flow paths in the vicinity of the low-level waste burial ground, mixed waste management facility, and other probable storage locations terminate at onsite streams or the Savannah River.

Table 4-45. Basis for New Waste Management Facility Impact Evaluations

Environmental category	Basis of evaluation
Groundwater	Worst-case impact of technology analyzed using computer model or presumption of facility compliance with regulations; assumptions include (1) candidate Site B (RCRA facilities for hazardous or mixed waste), Site L (DOE facilities for delisted mixed waste), or Site G (DOE facilities for low-level radioactive waste); (2) waste stream consists of operations and interim storage wastes; and (3) some pretreatment.
Surface water	Same as basis for groundwater.
Nonradiological air	Impacts based on the presumption that wastes are containerized at the treatment or generating facility before delivery for disposal or storage.
Ecology	Impacts based on a conservative estimate of the land area required for the most land-intensive technologies, assuming maximum waste volumes and various ecological features, as determined at the candidate sites.
Radiological releases	Same as basis for groundwater.
Archaeological and historic	Impacts based on results of an archaeological and historic field survey of candidate sites.
Socioeconomics	Impacts assume a peak construction force for new waste management facilities not exceeding 200 persons.
Noise	Impacts based on attenuation features at all possible siting locations.
Site Dedication	Impacts based on an estimate of the land area required for disposal assuming the most land intensive technologies and maximum waste volumes.
Institutional	Impacts assessed relative to applicable regulations.

4.3.1.2 Nonradioactive Atmospheric Releases

No significant air-quality impacts would result from the use of heavy equipment to prepare storage areas and handle the waste containers. However, for the reasons discussed in Section 4.3.1.1, these could range from no significant impact to severe impacts from toxic plumes resulting from a storage area fire.

4.3.1.3 Ecology

The amounts of waste releases discussed above could produce ecological impacts ranging from no significant impact to severe and detrimental impacts, depending on the type of waste involved, the location, the pathways, and the effectiveness of cleanup activities.

Construction of facilities would not occur under this strategy; therefore, impacts on the ecology from new construction (i.e., clearing and development of land) would not occur.

4.3.1.4 Radiological Releases

Although the No-Action storage operations would prevent releases of radiological contaminants to the environment, the risk of a serious release, although unquantified, is higher with No Action than with any of the other strategies.

4.3.1.5 Archaeological and Historic Resources

The No-Action strategy would not impact any archaeological or historic resources because only existing structures, pads, and disposal sites would be used for the indefinite storage of waste.

4.3.1.6 Socioeconomics

The expected socioeconomic impacts of the No-Action strategy would be negligible, because the existing workforce would not be affected significantly.

4.3.1.7 Site Dedication/Institutional Control

The No-Action strategy would not result in the permanent placement of wastes at a candidate site, but rather would include an indefinite period of makeshift storage, which would preserve the ability to retrieve the waste. Site dedication would be required only as long as the wastes remained on the site or in the event of a significant accidental release.

4.3.1.8 Noise

Noise produced by the operation of equipment during preparation and operation of the storage areas would be negligible at the nearest offsite area. In areas where workers could be exposed to equipment noise, they would wear protective equipment in accordance with applicable standards and regulations.

4.3.1.9 Other Impacts

Health Effects

With the unquantified risk of contaminant releases under No Action, there is an unquantified but directly related risk of human health effects from potential releases of hazardous chemicals and radionuclides.

Occupational Risks

With the unquantified risk of contaminant releases under No Action, there is an unquantified but directly related risk to workers due to potential interaction with hazardous chemicals and radionuclides.

Accidents

Section 4.6 describes the environmental impacts and risks of potential accidents from the movement of waste.

4.3.2 DEDICATION STRATEGY

Waste management under the Dedication strategy would include new disposal facilities to manage hazardous, mixed, and low-level radioactive wastes. Dedication implies that wastes would not be retrieved; therefore, disposal sites would be dedicated in perpetuity for waste management to ensure long-term environmental and public health protection.

Table 2-9 lists the technologies included in the Dedication strategy. The worst-case impact conditions identified for evaluation of groundwater, surface water, and radiological releases are Resource Conservation and Recovery Act (RCRA) landfills and vaults for hazardous waste; RCRA landfills and vaults, with cement/fly ash matrix (CFM) vaults for mixed waste; and engineered low-level trenches (ELLTs) and vaults or greater confinement disposal (GCD) for low-level radioactive waste.

Groundwater and atmospheric modeling conducted to quantify environmental impacts and health risks has projected exceedances of environmental or health standards, which generally result from conservative modeling assumptions. For example, if a structural failure occurred in the future and the modeling predicted contamination, this EIS assumes that DOE would take the appropriate actions to avoid or mitigate the conditions. The EIS limits the comparison of impacts to the end of the 100-year institutional control period.

4.3.2.1 Groundwater and Surface Water

Technologies for hazardous and mixed waste (i.e., RCRA landfills and vaults) would meet or exceed RCRA minimum technology standards and achieve the goal of no releases. The combined effects of high-integrity waste containers, the filling of void spaces to prevent subsidence, double liners (primary and secondary), double-leachate monitoring and collection systems, impermeable caps, surface drainage facilities, and maintenance would provide the necessary containment and backup systems to ensure that wastes or waste constituents are not released to the environment. Groundwater modeling beyond the institutional control period indicates that, given worst-case design features and sufficient time, both technologies would fail. However, during the period of monitoring and maintenance, no significant impacts should occur.

For mixed wastes, CFM vaults represent the worst-case impact (i.e., no liners, no leachate collection). Modeling indicates that no groundwater or surface-water standards would be exceeded. The model predicts that uranium-238 would exceed the derived standard, and that a peak concentration would occur after 10,000 years; however, this exceedance is qualified because the model does not include chemical solubility limits for uranium. Radionuclides are not expected to exceed their derived standards in groundwater or surface water. (Note: The derived standard is the concentration of a radionuclide that yields an annual effective whole-body or organ dose of 4 millirem/year, which is the Interim Primary Drinking Water Standard.) (Refer to Appendix G.)

Groundwater modeling for low-level radioactive waste facilities predicts that, for all radionuclides except tritium and uranium-234, the concentrations are well below derived standards. When solubility controls are considered, the uranium concentration should not exceed the derived standard.

Tritium from intermediate-activity vaults or GCD facilities is predicted to reach its peak concentration (70 times the derived standard) in the groundwater about 38 years after closure. The model conservatively assumes that facilities would contain no liners and no leachate collection. The projected groundwater peak concentration of tritium occurs 38 years after closure (i.e., during the institutional control period). An exceedance of the derived standard for tritium is not expected to occur during the 100 years after closure because vault and GCD technologies include leachate collection systems to intercept and recover tritium. Continued DOE recovery of tritium would ensure that SRP meets groundwater standards. DOE could also choose to segregate and store intermediate-activity tritium wastes for decay in place.

In summary, DOE does not expect chemical and radioactive constituents to exceed actual or derived standards in SRP groundwaters or surface waters from new hazardous, mixed, and low-level radioactive disposal facilities under the Dedication strategy.

4.3.2.2 Nonradioactive Atmospheric Releases

The construction of waste disposal facilities under the Dedication strategy would result in the emission of small quantities of carbon monoxide and hydrocarbons from engine exhausts and truck traffic, and suspended particulates and dust from ground-surface disturbances. All applicable emission standards would be met during construction.

All waste would be delivered in sealed disposal containers and, therefore, would result in no air releases. Thus, no significant air quality impacts are anticipated.

4.3.2.3 Ecology

The operation and dedication of facilities is not expected to involve constituent releases that would exceed groundwater or surface-water standards; no waste-related adverse impacts on aquatic and terrestrial ecology are expected.

Construction of the facilities could require clearing and development of as much as 400 acres for facilities and roads. Existing or potential wildlife habitat would be destroyed; however, the maximum acreage amounts to only about 0.2 percent of the available habitat on the SRP and would constitute an insignificant impact.

Although endangered species (i.e., bald eagle, red-cockaded woodpecker, wood stork, American alligator, and shortnose sturgeon) are known to exist on the SRP, none are known to occur on or near any candidate site.

Short-term soil erosion impacts could occur as a result of construction; however, these would be minimized by erosion control measures.

Belowground technologies risk uptake of waste constituents by vegetation if roots are allowed to penetrate the facilities and reach the waste. To prevent this, shallow-rooted plants would be used to stabilize soils during closure; these plants would be maintained by mowing during the postclosure institutional control period.

4.3.2.4 Radiological Releases

Modeling shows that peak radiological doses from mixed wastes exceeded the 4 millirem per year standard in groundwater, but not in the Savannah River or in food grown onsite. The model predicted that uranium-238 would not meet standards. However, if solubility controls for uranium are considered, no exceedance is expected. (See Appendix G.)

Modeling for low-level radioactive facilities showed that the sum of all radionuclides except intermediate-activity waste tritium and uranium were well below the 4 millirem per year standard. If solubility controls for uranium are considered, no exceedance of the dose standard is expected. Also, if liners and leachate collection systems for tritium are assumed, plus extended institutional control as necessary to ensure that groundwater standards are achieved, no dose exceedances due to tritium are expected.

In summary, peak doses due to releases of mixed or low-level radioactive wastes are not expected to exceed the 4 millirem per year drinking-water standard.

4.3.2.5 Archaeological and Historic Resources

The Dedication strategy would not impact any archaeological or historic resources. A survey of five of the six top-ranked candidate sites located no significant archaeological or historic sites requiring impact mitigation. However, if Candidate Site K were selected for low-level waste facilities, an archaeological survey would take place.

4.3.2.6 Socioeconomics

The socioeconomic impacts of the Dedication strategy are expected to be negligible, because no significant increase in the existing SRP construction workforce would be required.

4.3.2.7 Site Dedication/Institutional Control

Disposal of hazardous, mixed, or low-level radioactive wastes under the Dedication strategy would require the dedication of a disposal area as large as 400 acres plus a buffer zone.

Operational life and closure of the facilities would extend for at least 20 years. An institutional control period of at least 100 years would then be implemented. Beyond that, site dedication and full institutional control in perpetuity would ensure that the site would never be entered inadvertently. The placement of permanent markers to inform future generations, the implementation of security measures, and the accompanying dedication of land-use buffer zones would be key components of the site dedication program.

4.3.2.8 Noise

Noise produced by the operation of heavy equipment during construction and operation of the facilities would be negligible at the nearest SRP boundary. In the construction areas and other areas where workers could be exposed to equipment noise, they would wear protective equipment in accordance with applicable standards and regulations.

4.3.2.9 Other Impacts

Occupational Risks

Because contaminant releases to the environment are not expected to occur, and sealed waste containers would be used, risks to workers are expected to be negligible.

Accidents

The environmental impacts and risk of potential accidents from the movement of waste to the facility are discussed in Section 4.6.

4.3.3 ELIMINATION STRATEGY

Waste management under the Elimination strategy includes sufficient retrievable storage facilities to accommodate all hazardous, mixed, and low-level radioactive wastes for a 20-year period (see Table 2-9). Waste would be stored rather than disposed of, in anticipation of future methods of treatment, recycling, or disposal. Following retrieval of the waste, the land could be used for other nonrestricted purposes or returned to a natural condition.

For the period of operation, storage buildings would be monitored and inspected on a continual basis. Special design would facilitate early detection and rapid recovery of any spilled or leaked wastes. The environmental evaluation assumes that no waste would be released from the facilities.

Because the impacts are assessed for the 20 year period of operation, the evaluation of the Elimination strategy is more limited than that of the Dedication strategy. No postoperational impacts are considered and no consideration is given to impacts from the construction and operation of the future management facilities.

4.3.3.1 Ground and Surface-Water Effects

The retrievable storage facilities of the Elimination strategy would meet the zero release goals of regulations. Groundwater and surface water would not be contaminated with waste constituents.

The base floodplain of the region is confined primarily to wetlands and low terraces along the Savannah River and its primary tributaries. Siting criteria avoid such flood-prone areas; thus, no impacts due to potential flooding of storage facilities are expected.

4.3.3.2 Nonradioactive Atmospheric Releases

The construction of the retrievable-storage facilities under the Elimination strategy would result in the emission of small quantities of carbon monoxide and hydrocarbons from engine exhausts and truck traffic, and suspended particulates and dust from ground-surface disturbances. All applicable emission standards would be met during construction.

All waste would be delivered in high-integrity storage containers and, therefore, would result in no air releases. No air-quality impacts are anticipated.

4.3.3.3 Ecology

To avoid siting the facilities in sensitive areas, the retrievable-storage and all ancillary facilities described in Section 2.3.5 would comply with applicable regulations. The facilities would be constructed to minimize the impacts on habitats, wetlands, endangered and threatened species, and migratory waterfowl in the vicinity. Construction would require the clearing and development of currently undeveloped sites for structures, roads, and fences. The loss of as much as 400 acres of habitat would represent 0.2 percent of the 184,200 acres of wildlife habitat on the SRP, an insignificant ecological impact. Releases to the environment are not expected with this alternative; no contaminant-associated impacts on ecology are projected.

4.3.3.4 Radiological Releases

The retrievable-storage facilities under the Elimination strategy would meet or exceed RCRA or as low as reasonably achievable (ALARA) requirements with respect to facilities, structures, and waste containers. Because they would be properly constructed, operated, and maintained, all potential spills or leaks of mixed or low-level waste would be contained within the storage unit and a rapid and thorough cleanup response would be facilitated. Thus, radiological releases to the environment through any pathway are not expected to occur with this alternative.

4.3.3.5 Archaeological and Historic Resources

Based on field studies, the retrievable-storage facilities under the Elimination strategy would not impact any archaeological or historic resources. The archaeological survey of five of the six top-ranked candidate sites located no significant resources requiring impact mitigation. However, if Candidate Site K were selected to implement low-level waste facilities, an archaeological survey would be performed.

4.3.3.6 Socioeconomics

The socioeconomic impacts of the Elimination strategy are expected to be negligible because no significant increase in the existing SRP construction work force would be required.

4.3.3.7 Site Dedication/Institutional Control

The Elimination strategy would not require permanent site dedication. Following retrieval and removal of the waste, the facilities could be removed and the site returned to a natural condition or reclaimed for other nonrestricted use. This strategy presumes that technologies for treatment, recycling, or disposal will be available by the end of the 20-year operational life of the facilities. Under an Elimination strategy, DOE could choose to undertake the research and development, planning, engineering, and construction of these waste management technologies within the 20-year period.

4.3.3.8 Noise

Noise produced by the operation of heavy equipment during construction and operation of the waste storage facilities would be negligible at the nearest offsite area. In the construction areas and in other areas where workers could be exposed to excessive equipment noise, they would wear protective equipment in accordance with applicable standards and regulations.

4.3.3.9 Other Impacts

Occupational Risks

Because, as stated above, contaminant releases to the environment are not expected to occur, and high-integrity waste containers would be used, risks to workers are expected to be negligible.

Accidents

The environmental impacts and risks of potential accidents from the movement of waste to the facilities are discussed in Section 4.6.

4.3.4 COMBINATION STRATEGY

Waste management under the Combination strategy consists of an optimum mix of disposal and storage technologies for hazardous, mixed, and low-level radioactive waste characteristics and volumes. The technologies for implementing the Combination strategy are listed in Table 2-9. The upper bound impact technologies identified for evaluation of groundwater, surface-water, and radiological releases are the same as those for the Dedication strategy.

Modeling has been conducted for those cases in which disposal is part of the Combination strategy. Although some exceedances of environmental or health standards have been projected, they result from modeling assumptions. Impacts are evaluated to the end of the 100-year institutional control period.

Under the Combination strategy, the storage of wastes is assumed to be part of this strategy would result in no releases of waste constituents to the environment during its 20-year period of operation. The range in the technological mix of storage and disposal extends from virtually all disposal to virtually all storage.

4.3.4.1 Groundwater and Surface Water

No waste releases are expected from any storage facilities during their 20-year operational period, and releases of hazardous contaminants from hazardous and mixed waste disposal facilities are not expected to occur.

The Combination strategy assumes that tritium, carbon-14, and iodine-129 wastes would be segregated from the intermediate-activity waste streams and stored. Modeling indicates that all radionuclides, with the exception of uranium-234, remain at concentrations below derived standards in groundwater and surface water. Although uranium-234 is shown to exceed the derived standard slightly if solubility controls are considered, it is projected to remain well below its standard. Thus, no significant groundwater and surface-water impacts are expected through the institutional control period under the Combination strategy.

4.3.4.2 Nonradioactive Atmospheric Releases

The construction of storage and disposal facilities under the Combination strategy would result in the emission of small quantities of carbon monoxide and hydrocarbons from engine exhausts and truck traffic, and suspended particulates and dust from ground-surface disturbances. All applicable emission standards would be met during construction.

All waste would be delivered in sealed disposal or storage containers; therefore, there would be no air releases. Thus, there would be no air-quality impacts.

4.3.4.3 Ecology

The operation and dedication of facilities is not expected to involve constituent releases that would exceed groundwater or surface-water standards; no waste-related adverse impacts on aquatic and terrestrial ecology are expected.

Construction of the facilities could require clearing and development of as much as 400 acres for facilities and roads. Existing or potential wildlife habitat would be destroyed; however, the maximum acreage amounts to only about 0.2 percent of the available habitat on the SRP and would constitute an insignificant impact.

Although endangered species (i.e., bald eagle, red-cockaded woodpecker, wood stork, American alligator, and shortnose sturgeon) are known to exist on the SRP, none are known to occur on or near any candidate site.

Short-term soil erosion impacts could occur as a result of construction; however, these would be minimized by erosion control measures.

Belowground technologies risk uptake of waste constituents by vegetation if roots are allowed to penetrate the facilities and reach the waste. To prevent this, shallow-rooted plants would be used to stabilize soils during closure;

these plants would be maintained by mowing during the postclosure institutional control period.

4.3.4.4 Radiological Releases

Assuming that tritium, carbon-14, and iodine-129 are segregated and stored, and ignoring the model results for uranium based on previous discussions, radiological doses from mixed and low-level radioactive disposal facilities would be well below the 4-millirem-per-year standard.

4.3.4.5 Archaeological and Historic Resources

The Combination strategy would not impact any archaeological or historic resources. If Candidate Site K were selected for low-level waste facilities, an archaeological survey would be performed.

4.3.4.6 Socioeconomics

The socioeconomic impacts of the Combination strategy are expected to be negligible, because no significant increase in the existing SRP construction force would be required.

4.3.4.7 Site Dedication/Institutional Control

The disposal areas plus a buffer zone of the Combination strategy would require dedication of as much as 400 acres.

Operational life and closure of the facilities would extend for at least 20 years. An institutional control period of at least 100 years would then be implemented. Dedication and full institutional control would ensure that the sites would never be entered inadvertently. The placement of permanent markers to inform future generations, the implementation of security measures, and the accompanying dedication of land-use buffer zones would be key components of the site dedication program.

4.3.4.8 Noise

Noise produced by the operation of heavy equipment during construction and operation of the facilities would be negligible at the nearest offsite area. In the construction areas and in other areas where workers could be exposed to equipment noise, they would wear protective equipment in accordance with applicable standards and regulations.

4.3.4.9 Other Impacts

Occupational Risks

Contaminant releases to the environment are not expected to occur, and high-integrity waste containers would be used; therefore, risks to workers are expected to be negligible.

Accidents

The environmental impact and risk of potential accidents from the movement of waste to the facility are discussed in Section 4.6.

4.3.5 SUMMARY

Table 4-46 summarizes the environmental impacts of modifying SRP waste management activities with respect to new disposal facilities under each of the four strategies. This evaluation is detailed enough to include the potential impacts of each strategy. The No-Action strategy continues its potential significant environmental impacts to water resources, air, ecology, and public health, and has a potential need for dedication of land if contaminated by an uncontrolled release of waste. The No-Action strategy would not comply with environmental laws and regulations. However, no impacts would be expected in the areas of archaeological/historic resources, socioeconomics, and noise.

For the period of evaluation [i.e., 120 years for the Dedication strategy (20 years of operation plus 100 years of institutional control), 20 years for the Elimination strategy (20 years of operation only), and 120 years or 20 years for disposal and storage under the Combination strategy], Table 4-46 indicates that no significant impacts would be expected from these strategies on water resources, air, ecology, public health, archaeological and historic resources, socioeconomics, and noise. However, beyond the 100-year institutional control period, releases of waste constituents could occur under various facility designs (e.g., no low-permeability cap, RCRA landfill rather than vault). DOE could revise such designs, mitigate the problem by removing or immobilizing the wastes, or demonstrate environmental compliance through an extended period of monitoring and postclosure maintenance.

The Dedication strategy and the disposal portion of the Combination strategy could require dedication of as much as 400 acres of land to waste management in perpetuity and possible postclosure care beyond the period of institutional control. Conversely, the Elimination strategy and the storage portion the Combination strategy would require no direct dedication of land in perpetuity, but could require DOE consideration of developing and implementing the waste management technologies required to retrieve and treat or dispose of the stored waste.

4.4 STRATEGIES FOR DISCHARGING DISASSEMBLY-BASIN PURGE WATER

This section summarizes the radiological impacts associated with the strategies being considered for disassembly-basin purge-water discharges from C-, K-, and P-Reactors.

- No Action - Continued use of active reactor seepage and containment basins for discharge of disassembly-basin purge water.

- Dedication - Same as No Action.

- Elimination - Evaporation of disassembly-basin purge water through commercially available equipment or direct discharge of the purge water to onsite streams.

Table 4-46. New Waste Management Facility Impacts for Each Waste Management Strategy

Environmental category	No action	Dedication	Elimination	Combination
Groundwater/surface water	Potentially more damaging than all current existing waste sites	No significant impact through period of institutional control. Potential hazardous and radioactive releases, thereafter	No significant impact through 20-year period of operation	No significant impact through period of institutional control. Potential hazardous and radioactive releases, thereafter
Nonradioactive atmospheric	Potential dispersion of large quantities of waste due to disaster (e.g., fire)	No significant impact	No significant impact	No significant impact
Ecology	Potential substantial impacts both onsite and offsite and downstream	No significant waste related impacts. No significant loss of habitat. No impact to rare/endangered species	Some	Some
Radiological releases	Potentially damaging to the environment and public health	No significant impact through the period of institutional control. Potential impacts thereafter from tritium unless mitigated	No significant impact through 20-year period of operation	No significant impact through the period of institutional control. No significant impact from tritium thereafter
Archaeological/ historic	No impact	No impact	No impact	No impact
Socioeconomics	No impact	No impact	No impact	No impact
Noise	No impact	No impact	No impact	No impact
Site dedication	Potential site dedication of land contaminated by accidental releases	Dedication of as much as 400 acres of land for wastemanagement in perpetuity	No dedication of land in perpetuity	Dedication of as much as 400 acres of land for waste management in perpetuity
Institutional	Would result in DOE's non-compliance with environmental laws and regulations	Possible site maintenance and monitoring indefinitely beyond institutional control period	Commitment could require research and development, planning, engineering, and construction of future waste management facilities.	Possible site maintenance and monitoring indefinitely beyond institutional control period. Commitment could require research and development, planning, engineering, and construction of future waste management facilities

- Combination - Continued discharge of disassembly-basin purge water to active reactor seepage and containment basins and continued evaluation of feasible tritium mitigation measures (e.g., reactor moderator detritiation). This section contains an analysis of detritiation to provide an estimate of costs and environmental impacts.

4.4.1 BACKGROUND

Reactor disassembly-basin purge water becomes contaminated with tritium (radioactive hydrogen isotope) and other radionuclides when fuel, targets, and other irradiated components are transferred to the disassembly basin from the reactor. Each irradiated assembly brings tritium oxide into the disassembly basin. The tritium oxide is dissolved in droplets of deuterium oxide (non-radioactive "heavy water") adhering to the surface and is also absorbed in the aluminum oxide cladding of the assembly. The tritium oxide dissolves in the disassembly-basin water and becomes distributed uniformly throughout the disassembly basin.

Disassembly-basin water is recirculated through deionizers and sand filters to remove radionuclides and to improve water quality. This process does not remove tritium, and small amounts of other radionuclides also remain in the water.

The disassembly-basin water must be purged periodically to keep tritium concentrations at safe levels for workers. During purges, fresh filtered water is added to the basin at the same rate contaminated water is purged from the basin through an ion-exchange system. The purge is not continuous but occurs at a frequency that depends on the type of reactor assemblies and the frequency of discharge operations. Typically, the reactor basins are purged twice yearly.

Preliminary groundwater monitoring data recently have identified the presence of volatile organic constituents in the vicinity of the C-Area seepage basin. Because these compounds are not introduced with the disassembly-basin purge water, investigations are in progress to identify their origin as well as the effect of continued use of the basin on their distribution in the groundwater. For evaluation purposes, however, these constituents are not considered because they are unique to the C-Area and must be managed on the basis of more specific evaluations than those employed herein, and because their presence does not affect the radiological doses used as a primary factor in the comparisons.

Table 4-47 lists the average annual and cumulative amount of tritium discharged from the reactor disassembly basins, which is the same for each strategy except the Combination strategy with detritiation. Values presented for 1987 to 2000 are based on annual release rates (Du Pont, 1984a). For 2001 to 2012, the release rates are assumed to be identical to those for 2000.

The amount of discharged tritium that ultimately reaches the environment depends on which strategy is implemented. Detritiation is the only method that would reduce the total discharge of this radionuclide. Others would simply alter the pathways through which discharged tritium was released to the environment.

Table 4-47. Predicted Tritium Discharge from Reactor Disassembly Basins

Discharge alternative	Average annual release[a] (Ci/yr)	Cumulative release[a] (Ci)
Detritiation - Combination	4,000	103,000
Evaporation - Elimination	15,200	396,000
Direct discharge - Elimination	15,200	396,000
No Action - Combination, Dedication	15,200	396,000

[a]1987-2012.

Small amounts of radionuclides other than tritium remain in the disassembly-basin water at the time of purge. Annual and cumulative releases of these nuclides from reactor disassembly basins are listed in Table 4-48; these releases are assumed to be the same for each strategy.

Table 4-48. Annual and Cumulative Discharges of Non-tritium Radionuclides from Reactor Disassembly Basins[a] (Ci)

Radionuclide	Annual release (Ci)	Cumulative release[b] (Ci)
Phosphorus-32	3.6×10^{-3}	9.4×10^{-2}
Sulfur-35	2.9×10^{-2}	7.4×10^{-1}
Chromium-51	5.4×10^{-1}	1.4×10^{1}
Cobalt-58, 60	1.1×10^{-3}	2.9×10^{-2}
Strontium-89	2.1×10^{-4}	5.5×10^{-3}
Strontium-90	6.0×10^{-4}	1.6×10^{-2}
Yttrium-91	1.5×10^{-2}	4.0×10^{-1}
Zirconium-95	3.3×10^{-2}	8.6×10^{-1}
Ruthenium-106	1.0×10^{-3}	2.7×10^{-2}
Antimony-125	2.4×10^{-2}	6.2×10^{-1}
Iodine-131	2.1×10^{-2}	5.4×10^{-1}
Cesium-134	1.5×10^{-2}	4.0×10^{-1}
Cesium-137	1.3×10^{-1}	3.4
Cerium-144	5.7×10^{-2}	1.5
Promethium-147	8.4×10^{-3}	2.2×10^{-1}
Unidentified beta-gamma[c]	2.7×10^{-1}	6.9
Unidentified alpha[d]	9.6×10^{-4}	2.5×10^{-2}

[a]Adapted from DOE, 1984.
[b]1987-2012.
[c]Assumed to be strontium-90.
[d]Assumed to be plutonium-239.

Radiological doses were calculated for each year of the 26-year study period for each strategy [using methods and parameters in NRC (1977) and ICRP (1979)]. Discussions for the various strategies in the following sections present the maximum doses for any single year and annual average values over the 26-year period.

Doses presented in this analysis include organ doses and effective whole-body doses (EWBDs). EWBDs are calculated by summing doses to individual organs weighted by their relative risk (ICRP, 1977). Throughout this analysis, the term "dose," as applied to organ doses and individual EWBDs, represents a 50-year dose-equivalent commitment. The term "collective dose" refers to the 50-year dose equivalent received by the population that additionally incorporates the 100-year environmental dose-commitment concept.

The maximum individual dose is that received by an offsite individual whose location and habits maximize the dose.

Collective doses ("population doses") resulting from atmospheric releases have been calculated for the population projected to be residing within 80 kilometers of the SRP. Collective doses resulting from liquid releases include doses to the downstream water users who consume drinking water from the Beaufort-Jasper and Port Wentworth water-treatment plants (Du Pont, 1984a; DOE, 1984).

4.4.2 NO-ACTION STRATEGY (CONTINUATION OF DISCHARGE TO SEEPAGE BASINS)

With the No-Action strategy, the current practice of discharging disassembly-basin purge water to the C- and P-Area seepage basins and the K-Area containment basin would continue. Water discharged to the seepage basins would either evaporate or migrate to the groundwater, where it would be transported laterally to outcrop areas along surface streams. Tritium would be the only significant radionuclide released from seepage basins to environmental pathways.

Annual tritium releases to the environment were calculated for the 26-year study period (Du Pont, 1984a), as shown in Table 4-49.

Table 4-50 presents the highest annual and average annual EWBDs to the maximally exposed individual and the collective dose calculated over the 26-year study period.

The highest annual maximum individual dose of 0.047 millirem occurs in 1991 for the No-Action strategy; the annual average maximum individual dose is 0.04 millirem. These doses are about 0.05 percent or less of the DOE radiation protection standards. The average collective dose of 4.0 person-rem in 2012 is less than 0.004 percent of the exposure of about 103,000 person-rem to the population from natural radiation sources.

4.4.3 DEDICATION STRATEGY

The Dedication strategy is identical in concept to the No-Action strategy; that is, to continue disassembly-basin purge water discharges to active reactor seepage and containment basins.

Table 4-49. Tritium Releases to Environment Associated with the No-Action Strategy

Release pathway	Maximum annual release (Ci/yr)	Average annual release[a] (Ci/yr)	Cumulative release[a] (Ci)
Atmospheric	6,100[b]	4,570	119,000
Liquid	8,850[c]	7,110	185,000
Combined	13,200[d]	11,700	304,000

[a]1987-2012.
[b]The maximum annual atmospheric tritium release occurs during the years 1987 through 1989.
[c]The maximum annual liquid tritium release occurs in 1991.
[d]This number represents the highest annual total tritium release through the atmospheric and liquid pathways combined, and is not the sum of the maximum annual atmospheric and liquid releases; this release occurs in 1991.

Table 4-50. Highest Annual and Average Annual EWBD Associated with the No-Action Strategy

Receptor/exposure pathway	Highest annual dose[a]	Average annual dose[a]
Maximally exposed individual (mrem/year)		
Atmospheric	0.009	0.01
Liquid	0.038	0.03
Total	0.047[b]	0.04
Population (person-rem/year)		
Atmospheric	0.38	0.35
Liquid	4.94	3.70
Total	5.32[c]	4.05

[a]1987-2012.
[b]The highest annual maximum individual dose occurs in 1991.
[c]The highest annual collective dose occurs in 2012.

4.4.4 ELIMINATION STRATEGY

The Elimination strategy, as applied to the management of disassembly-basin purge water, includes either evaporation to the atmosphere or direct discharge of the purge water to onsite surface streams.

With evaporation, all disassembly-basin purge water is assumed to be evaporated to the atmosphere, as described in Section 2.4. Tritium would be the only radionuclide released to the atmosphere, because all others would be retained in the evaporator. The only liquid releases would be from residual seepage of tritium released to the seepage basins earlier. The seepage of nontritium radionuclides is negligible.

Radiation-induced health effects from releases under the No-Action strategy over the 26-year study period are calculated to total 0.029 excess fatalities.

Annual tritium releases to the environment (atmospheric and liquid pathways) were calculated for the 26-year study period (Du Pont, 1984a). Table 4-51 presents the maximum and average annual tritium releases to the environment, as well as the cumulative tritium release for the 26-year study period.

Table 4-51. Tritium Releases to Environment Associated with the Elimination Strategy (Evaporation)

Release pathway	Maximum annual release (Ci/yr)	Average annual release[a] (Ci/yr)	Cumulative release[a] (Ci)
Atmospheric	20,300[b]	15,230	396,000
Liquid	7,570[c]	1,910	49,700
Combined	27,400[d]	17,100	446,000

[a]1987-2012.
[b]The maximum annual atmospheric tritium release occurs annually during the years 1987 through 1989.
[c]The maximum annual liquid tritium release occurs in 1990.
[d]This number represents the highest annual total tritium release through the atmospheric and liquid pathways combined, and is not the sum of the maximum annual atmospheric and liquid releases; this release occurs in 1989.

Table 4-52 presents the highest annual and average annual EWBDs to the maximally exposed individual and the collective dose calculated over the 26-year study period.

The highest annual maximum individual dose of 0.074 millirem occurs in 1989 for the Elimination strategy with evaporation, and the annual average maximum individual dose is 0.041 millirem. These doses are about 0.1 percent or less of the DOE radiation protection standards. The average annual collective dose of 1.67 person-rem in 1989 is less than 0.002 percent of the exposure of about 103,000 person-rem to the same population from natural radiation sources.

Radiation-induced health effects from releases under the evaporation alternative over the 26-year study period are calculated to total 0.012 excess fatality.

Table 4-52. Highest Annual and Average Annual EWBDs Associated with the Elimination Strategy (Evaporation)

Receptor/exposure pathway	Highest annual dose[a]	Average annual dose[a]
Maximally exposed individual (mrem/yr)		
Atmospheric	0.044	0.033
Liquid	0.030	0.008
Total	0.074[b]	0.041
Collective (person-rem/yr)		
Atmospheric	1.41	1.17
Liquid	1.56	0.51
Total	2.96[b]	1.67

[a]1987-2012.
[b]The highest annual maximum individual and collective doses occur in 1989.

Radiation-induced health effects from releases under the direct discharge alternative over the 26-year study period are calculated to total 0.068 excess fatality.

Direct Discharge

With direct discharge, all disassembly-basin purge water would be discharged directly to surface-water streams. In addition, residual seepage of tritium to surface water from seepage basin use prior to the initiation of this alternative would contribute to liquid releases.

Annual tritium releases to the environment (atmospheric and liquid pathways) were calculated for the 26-year study period (Du Pont, 1984a).

Table 4-53 presents the maximum and average annual tritium releases as well as the cumulative tritium release to the environment. Radionuclides other than tritium in the disassembly-basin purge water (presented in Table 4-48) are assumed to be released directly to onsite streams.

Table 4-54 presents the highest annual and average annual EWBDs to the maximally exposed individual and the collective dose calculated over the 26-year study period.

The highest annual dose received by any single organ of an individual from releases of tritium and nontritium radionuclides is 0.265 millirem to the lower large intestine, and occurs in 1989.

Table 4-53. Tritium Releases to Environment Associated with the Elimination Strategy (Direct Discharge)

Release pathway	Maximum annual release (Ci/yr)	Average annual release[a] (Ci/yr)	Cumulative release[a] (Ci)
Atmospheric	0	0	0
Liquid	27,400[b]	17,100	446,000
Combined	27,400[b]	17,100	446,000

[a]1987-2012.
[b]The maximum annual liquid tritium release occurs in 1989.

Table 4-54. Maximum and Average Annual EWBDs Associated with the Elimination Strategy (Direct Discharge)

Receptor/exposure pathway	Highest annual dose[a]	Average annual dose[a]
Maximally exposed individual (mrem/year)		
Atmospheric	0.00	0.00
Liquid	0.204	0.16
Total	0.204[b]	0.16
Collective (person-rem/year)		
Atmospheric	0.0	0.00
Liquid	12.1	9.40
Total	12.1[c]	9.40

[a]1987-2012.
[b]The highest annual dose to the maximum individual occurs in the year 1989.
[c]The highest annual collective dose occurs in 2012.

The highest annual maximum individual dose of 0.204 millirem occurs in 1989 for the direct discharge, and the annual average maximum individual dose is 0.16 millirem. These doses are about 0.2 percent or less of the DOE radiation protection standards. The average annual collective dose of 9.4 person-rem is less than 0.009 percent of the exposure of about 103,000 person-rem to the same population from natural radiation sources.

4.4.5 COMBINATION STRATEGY

The Combination strategy includes the continuation of disassembly-basin purge water discharges to active reactor seepage and containment basins while continuing to assess tritium-mitigation measures such as reactor moderator detritiation. Other mitigation measures are discussed in Section 4.8.

The consequences of the continuation of discharging purge water to active seepage basins are discussed in Sections 4.4.1 and 4.4.2.

Detritiation of the reactor moderator in a central facility has been considered for all SRP reactors. A moderator detritiation plant (MDP) would be expected to reduce equilibrium moderator tritium levels by about a factor of 10. The moderator is the source of the tritium that contaminates the disassembly-basin water, so a corresponding reduction in disassembly-basin purge water tritium concentrations and releases from this source would be expected.

Water discharged to the seepage basins would either evaporate, carrying tritium with it to the atmosphere, or move down to the groundwater, where it would be transported laterally to outcrop areas along surface streams.

The nontritium radionuclides (see Table 4-48) would seep into the ground and experience radioactive decay and retardation by adsorption (DOE, 1984). These processes would reduce nontritium releases to surface waters to insignificant levels.

Tritium would move with the groundwater and undergo radioactive decay during travel to surface outcrops. The amount of tritium expected to be released from the seepage basins has been calculated assuming that 30 percent of tritium released to the basins evaporates and that the remaining 70 percent migrates to streams while undergoing radioactive decay.

Radiation-induced health effects from releases over the 26-year study period are calculated to total 0.014 excess fatality.

4.4.6 COMPARISON OF ENVIRONMENTAL CONSEQUENCES

When compared with No Action, detritiation would decrease the total tritium released to the environment by about a factor of 2, while the releases from evaporation and direct discharge would result in an increase in the total tritium released to the environment.

The average annual effective whole-body dose received by the maximally exposed individual for each strategy is presented in Table 4-55. The doses range from 0.022 millirem per year for detritiation to 0.16 millirem per year for direct discharge, and represent small fractions of the 93 millirem per year received by an individual from natural background radiation (DOE, 1984).

Average annual collective EWBDs associated with the various strategies range from about 1.7 person-rem per year with evaporation to 9.4 person-rem per year with direct discharge. The dose associated with natural background radiation delivered to the same population would be 103,000 person-rem per year. Collective doses associated with each strategy, therefore, represent less than

Table 4-55. Average Annual EWBD to the Maximally Exposed Individual for Each Strategy (mrem/yr)

	Combination	Elimination		Combination/ Dedication
Exposure pathway	Detritiation	Evaporation	Direct discharge	No Action
Atmospheric	0.004	0.033	0.000	0.010
Liquid	0.018	0.008	0.160	0.030
Total	0.022	0.041	0.160	0.040

0.01 percent of the dose received from natural background radiation. The corresponding health effects and doses are not significant.

The cost benefit of detritiation would be more than $3 million per person-rem averted, compared to No Action. The average annual cost benefit of the evaporation would be about $500,000 per person-rem averted, compared to No Action. There would be little difference in the cost of implementing direct discharge and the No-Action strategy for discharge of DBPW.

4.5 ACCIDENTS

The environmental impacts and risk of potential accidents associated with closure have been analyzed for each of the individual waste sites used for the disposal of hazardous and radioactive materials. The selected closure action would be implemented in such a manner that the risk to the public from accidental releases of materials from the site would be minimal.

The potential accidents and consequences associated with each action for each waste site are related to the materials at the site. The potential accident scenarios are based on the processes proposed to be used and the hazards associated with these materials.

Several of these events are defined to include spillage of waste from a steel box. These boxes are ruggedly constructed and difficult to breach. It was not considered cost-effective or necessary to do a structural analysis of the box to determine under what conditions it would fail, because the consequences of such an event were judged to be relatively minor. The probability of box failure in an accident was assumed conservatively to be 0.25.

The accident scenarios considered are natural events such as tornadoes, hurricanes, floods, and earthquakes, and industrial accidents such as falls, fires, cave-ins, and container spills. The natural events were analyzed using historical data on probability and severity. Industrial accidents were analyzed using labor-hour estimates based on commercial cost-estimating handbooks and industrial accident rate tabulations. The number of workdays of construction labor required to accomplish the waste-removal and no-waste-removal options was estimated. This estimate was used to calculate the probability of each potential accident. The major accident types are described below. (Palmiotto, 1986, provides further explanations for each accident.)

- Tornado. The major effect of a tornado would be entrainment of dust laden with contaminants, with possible dispersion off the waste site. Dispersal could occur during the excavation activities.

- Hurricane and high straight wind. If high winds occur during excavation of the waste sites, there is the potential for pickup and dispersal of waste-site contaminants.

- Flooding. Flooding of a waste site during closure options was dismissed from consideration because of the location of the waste sites and because the level of the Savannah River is controlled by three major hydroelectric dams upstream from the sites. In addition, measures would be taken on SRP to prevent flooding during heavy rains.

- Earthquake. The only effect of an earthquake pertinent to this analysis is the failure of a berm or dike at the waste site or during excavation of a site. During excavation operations, such an accident could result in injuries and equipment damage. An unusually heavy rain could leave water in a site, but the combined probability of such a rain and a major earthquake is exceedingly small. Dikes are estimated to fail in a MM IX earthquake, which has a frequency of occurrence estimated to be less than once in 10,000 years. If the earthquake were to occur while men were in an excava- tion trench, a cave-in could result in personnel injuries or fatalities.

- Industrial accident. The likelihood of personnel injuries through an industrial accident was evaluated by applying published accident rates to the number of labor-hours required for each closure option. The labor estimates were developed from the quantification of each activity required for a closure, such as the number of cubic meters of earth to be removed, the number of square meters of land to be leveled and seeded, and the number of meters of fence to be constructed. The source of data for this analysis was the back- ground information prepared for preliminary cost estimates for each waste site, and includes standard project estimating guides.

- Fire. Two causes of fire were considered: a natural forest fire, and an industrial fire initiated by material being excavated or by equipment used for site closure. The former fire has been dismissed because the forests on the Plant are managed, and controlled burning of underbrush is conducted. The SRP firefighting team would be able to protect material at an excavation site from an adjacent fire. Fires associated with fuel or hydraulic fluid occasionally occur with heavy construction equipment. This event is analyzed because dispersal of waste or employee injury could occur. Fire initiated in an excavation or by excavating equipment could easily be smothered by readily available equipment.

- Explosion. No explosive materials were identified on the waste sites or in adjacent areas. Therefore, explosion as an accident initiator was dismissed.

- Container puncture. This accident initiator applies to sites where drums are stored. During excavation these units could be punctured, potentially spreading contamination. Puncture of a container containing soil or sediment removed from the basin is discussed under other scenarios.

- Equipment collision. A collision of mobile heavy equipment could occur on any construction site. This scenario includes collisions involving any of the mobile equipment onsite (i.e., trucks, forklifts, and front-end loaders), and also covers waste-box punctures.

- Toppling of large equipment. Large excavation equipment such as draglines and backhoes could be used for closure of a site. A check of construction industry accident statistics revealed that relatively major accidents with such equipment occur often enough that they should be considered. This accident is defined to include such events as dragline structural failure, cable breaks, and grade cave-in resulting in the toppling of a backhoe or dragline.

- Employee injury during construction. During any excavation and heavy construction project of this size, there would be some employee injuries, almost all nonfatal. This scenario includes nonfatal accidents such as falls, equipment-related injuries to hand or eyes, and minor burns.

- Operator contamination. This includes any contamination to workers by exposure to or contact with hazardous materials contained on the site during closure activities.

- Waste box drop and breach. During excavation, the contaminated soil and sediment would be placed in steel boxes for transportation to a storage or disposal area. Some waste boxes could be dropped during handling by forklifts or cranes. This event is defined to include only drops that result in a breach of the box, either by puncture or by opening of its lid. Employee injuries are excluded.

- Cave-in. During excavation and closure, workers must enter the waste sites to perform tests, rig equipment, and excavate the sediment and soils. Cave-ins are a possible cause of injuries and fatalities to construction workers.

- Truck accident and fire. This includes a truck accident and fire when waste is being transported to the storage and disposal areas.

- Truck accident and spill. This includes a truck accident in which the waste box is breached or opened, resulting in spillage of waste materials.

- Truck accident and fatality. A certain percentage of truck accidents result in operator fatalities. This scenario includes truck accident fatalities during the transportation of waste materials to storage and disposal areas.

- Fall of box from truck. This includes a waste box falling from a truck during transit due to rigging or driving errors, resulting in spillage of contents.

Table 4-56 summarizes the accidents described above, including the initiator and the consequence. Risks were calculated for certain accidents in which the consequences allowed such an assessment to be made; these occurrences are (1) employee injury, (2) truck accident and fatality, and (3) fatal construction accident. The results of these assessments are presented in Tables 4-57 through 4-60 for each site for the no-action, no-waste-removal-and-closure, complete-waste-removal and closure, and selected-waste-removal options, respectively.

4.6 DECONTAMINATION AND DECOMMISSIONING

The proposed new facilities ultimately would require decontamination and decommissioning. Decontamination and decommissioning of the proposed facilities would be included in an overall site decontamination and decommissioning plan, which would be subject to environmental and public review before implementation.

Three basic decommissioning methods are defined: DECON, SAFSTOR, and ENTOMB (Calkins, 1980). DECON involves the immediate removal of all radioactive materials to levels that are considered acceptable to permit the property to be released for unrestricted use (NRC, 1981). Chemical decontamination of the structure and the internals would be followed by the dismantling, transportation, and burial of the internals. As the final step, the outer structure would be demolished and the site restored to its precommissioning status.

ENTOMB is the encasement of the facility in a material possessing long-lived structural integrity until a time when the dose level is amenable to unrestricted use. This would be the method used for sites where the radioactivity would decrease the acceptable limits within a reasonable time. A reasonable time period for ENTOMB is approximately 100 years (NRC, 1981).

SAFSTOR involves placing a facility and equipment in temporary storage within acceptable risk levels for subsequent decontamination and unrestricted facility use. SAFSTOR has six major phases:

- Chemical decontamination
- Mechanical decontamination and fixing of residual radioactivity
- Equipment deactivation
- Preparation for interim care
- Interim care (surveillance and maintenance)
- Final dismantling

In demolition and restoration, all above-grade portions of the plant structures would be demolished by conventional methods, such as explosive and impact balls. The site would then be graded and revegetated.

Table 4-56. Closure Accidents

Initiator	Accident	Consequence
Tornado	High winds disperse soil	Minimal dispersion of soil at waste site but not beyond SRP boundary; potential serious personnel injury
Straight wind	High winds disperse wet soil	Minimal dispersion of wet soil onsite, none offsite
Earthquake	Failure of excavation site (basin walls, berms, etc.)	Minimal dispersion of soil onsite; potential personnel injury
Container puncture	Waste containers at site	Loss of contents at site; cleanup initiated (Gunsite 720 rubble pit)
		A few suspected empty containers at site; no probable impact (hydrofluoric acid spill area)
Equipment collision	Mobile equipment collides; possible puncture of waste containers	Releases (where applicable) confined to the immediate area of the site; possible personnel injury
Failure of equipment	Large equipment toppling	Dispersion of waste material at site; possible personnel injury
Fall/equipment-related injuries	Employee injury	Minor personnel injury
Contamination	Inadvertent contamination to workers at site	Minor contamination; immediate decontamination; minor personnel injury
Drop and breach	Waste container dropped and puncture or lid opening occurs	Release of waste at site; cleanup initiated; minor or no personnel injury
Equipment fire	Fuel or hydraulic fuel catches fire	Minor personnel injury; damage to equipment

Table 4-56. Closure Accidents (continued)

Initiator	Accident	Consequence
Cave-in	During excavation of material with equipment	Personnel injury or possible fatality
Accident and fire	Accident resulting in fire	SRP fire department response; minimum personnel injury; damaged equipment
Accident and spill	Truck accident during transport; waste container damaged and breached	Waste release confined to accident site; cleanup initiated
Accident and fatality	Truck accident while in transit to disposal area	Fatality to driver
Fall of box from truck	Rigging or driving errors result in spillage of waste container contents	Release of waste at site of accident; cleanup initiated
Truck accident	Truck with fill and another vehicle collide, or single vehicle accident occurs	Potential personnel injury; material released at accident site; cleanup initiated
Fatal construction accident	Construction accident	Fatality

Pending the results of further studies and reviews, decommissioning of the proposed facilities and equipment is expected to be conducted via SAFSTOR. Startup of the proposed new facilities would be spread over time, as would future decontamination and decommissioning.

Impacts from decontamination and decommissioning would be very small. Projections of these impacts specific to the proposed facilities and equipment have not been made; estimates, however, have been prepared (Manion and LaGuardia, 1976) for the decontamination and decommissioning of commercial power reactors of pressurized-water-reactor (PWR) design. The estimated dose to a member of the public for the DECON option was 3.0×10^{-5} millirem per year (lung) during the period of the decontamination and decommissioning operation. Both ENTOMB and SAFSTOR were projected to result in even lower doses.

Table 4-57. Accident Risks for No Action

Location	Employee injury	Fatal truck accident	Fatal construction accident
SRL seepage basins	NA[a]	NA	NA
Metallurgical laboratory basin	NA	NA	NA
Burning/rubble pits	NA	NA	NA
R-Area	NA	NA	NA
A-Area	NA	NA	NA
C-Area	NA	NA	NA
CS-Area	NA	NA	NA
K-Area	NA	NA	NA
P-Area	NA	NA	NA
D-Area	NA	NA	NA
F-Area	NA	NA	NA
L-Area	NA	NA	NA
Metals burning pit/ miscellaneous chemical basin	NA	NA	NA
Old F-Area seepage basin	NA	NA	NA
Separations Area retention basins			
F-Area	NA	NA	NA
H-Area	NA	NA	NA
Radioactive waste burial grounds	NA	NA	NA
Bingham pump outage pits	1.3×10^{-3}[b]	NA	NA
Hydrofluoric acid spill area	NA	NA	NA
SRL oil test site	NA		
New TNX seepage basin	2.7×10^{-3}[b]	NA	NA
Road A chemical basin	NA	NA	NA
L-Area oil and chemical basin	NA	NA	NA
Waste oil basins			
D-Area	NA	NA	NA
Motor shop	NA	NA	NA
Silverton Road waste site	NA	NA	NA
F-Area seepage basin	9.2×10^{-2}[b]	NA	NA
Acid/caustic basins			
F-Area	NA	NA	NA
H-Area	NA	NA	NA
K-Area	NA	NA	NA
L-Area	NA	NA	NA
P-Area	NA	NA	NA
R-Area	NA	NA	NA
H-Area seepage basins	2.5×10^{-1}[b]	NA	NA
Reactor seepage basins			
P-Area	NA	NA	NA
R-Area	NA	NA	NA
K-Area	NA	NA	NA
Ford Building waste sites	NA	NA	NA
Ford Building seepage basin	NA	NA	NA
Old TNX seepage basin	NA	NA	NA
TNX burying ground	NA	NA	NA
CMP pits	NA	NA	NA
Gunsite 720 rubble pit	NA	NA	NA
Total risk	3.5×10^{-1}	NA	NA

[a]NA = Not applicable because of the nature of the closure option or because of the nature of the disposal site.
[b]No action at these sites reflects finite injury risks under continued use.

Table 4-58. Accident Risks for No-Waste-Removal and Closure

Location	Employee injury	Fatal truck accident	Fatal construction accident
SRL seepage basins			
(a)	8.2×10^{-1}	NA[b]	NA
(c)	NA	NA	NA
Metallurgical laboratory basin	4.5×10^{-3}	2.3×10^{-5}	NA
Burning/rubble pits			
R-Area	NA	NA	NA
A-Area	NA	NA	NA
C-Area	NA	NA	NA
CS-Area	NA	NA	NA
K-Area	NA	NA	NA
P-Area	NA	NA	NA
D-Area	NA	NA	NA
F-Area	NA	NA	NA
L-Area	NA	NA	NA
Metals burning pit/miscellaneous chemical basin	1.7×10^{-1}	NA	1.2×10^{-2}
Old F-Area seepage basin	7.2×10^{-2}	NA	5.3×10^{-4}
Separations Area retention basins			
F-Area	2.8×10^{-2}	NA	NA
H-Area	2.8×10^{-2}	NA	NA
Radioactive waste burial grounds	9.5	NA	7.0×10^{-2}
Bingham pump outage pits	1.3×10^{-3}	NA	NA
Hydrofluoric acid spill area	NA	NA	NA
SRL oil test site	1.8×10^{-1}	NA	NA
New TNX seepage basin	3.0×10^{-2}	NA	NA
Road A chemical basin	1.3×10^{-2}	NA	NA
L-Area oil and chemical basin	NA	5.0×10^{-6}	NA
Waste Oil Basins			
D-Area	2.1×10^{-3}	NA	NA
Motor shop	9.1×10^{-2}	NA	NA
Silverton Road waste site	1.7×10^{-1}	NA	NA
F-Area seepage basin	7.2×10^{-1}	NA	5.3×10^{-3}
Acid/caustic basins			
F-Area	2.9×10^{-3}	NA	2.1×10^{-5}
H-Area	3.1×10^{-3}	NA	2.3×10^{-5}
K-Area	3.6×10^{-3}	NA	2.6×10^{-5}
L-Area	8.4×10^{-3}	NA	6.1×10^{-5}
P-Area	3.6×10^{-3}	NA	2.6×10^{-5}
R-Area	3.1×10^{-3}	NA	2.3×10^{-5}
H-Area seepage basins	1.8	NA	1.8×10^{-2}
Reactor seepage basins			
K-Area	2.1×10^{-1}	NA	NA
R-Area	1.8	NA	NA
Ford Building waste sites	3.6×10^{-2}	7.4×10^{-6}	NA
Ford Building seepage basin	1.2×10^{-2}	NA	8.5×10^{-5}
Old TNX seepage basin	4.8×10^{-2}	NA	NA
TNX burying ground			
(a)	1.9×10^{-2}	NA	1.4×10^{-4}
(c)	1.5×10^{-2}	NA	1.1×10^{-4}
CMP pits	NA	NA	NA
Gunsite 720 rubble pit	6.8×10^{-3}	NA	NA
Total risk	1.6×10^{1}	3.5×10^{-5}	1.1×10^{-1}

[a]No waste removal with cap.
[b]NA = Not applicable because of the nature of the closure option or because of the nature of the disposal site.
[c]No waste removal without cap.

Table 4-59. Accident Risks for Complete Waste Removal and Closure

Location	Employee injury	Fatal truck accident	Fatal construction accident
SRL seepage basins	4.9×10^{-1}	6.1×10^{-4}	NA
Metallurgical laboratory basins	1.8×10^{-2}	1.1×10^{-4}	NA
Burning/rubble pits			
R-Area	3.0×10^{-2}	3.9×10^{-4}	NA
A-Area	1.6×10^{-1}	3.8×10^{-4}	NA
C-Area	3.7×10^{-1}	1.9×10^{-3}	NA
CS-Area	1.5×10^{-1}	3.8×10^{-4}	NA
K-Area	5.4×10^{-2}	1.4×10^{-4}	NA
P-Area	4.5×10^{-1}	1.9×10^{-3}	NA
D-Area	1.1×10^{-1}	4.2×10^{-4}	NA
F-Area	2.0×10^{-1}	2.7×10^{-4}	NA
L-Area	4.5×10^{-2}	1.6×10^{-4}	NA
Metals burning pit[a]	2.8×10^{-1}	2.0×10^{-3}	2.0×10^{-3}
Miscellaneous chemical basin[b]	6.5×10^{-1}	2.0×10^{-3}	4.7×10^{-3}
Old F-Area seepage basin			
(c)	2.0×10^{-1}	7.0×10^{-4}	1.4×10^{-3}
(d)	1.6×10^{-1}	4.4×10^{-6}	1.2×10^{-3}
Separations Area retention basins			
F-Area	2.5×10^{-1}	5.0×10^{-4}	NA
H-Area	1.1×10^{-1}	2.2×10^{-4}	NA
Radioactive waste burial grounds	4.2×10^{1}	1.4×10^{-1}	3.1×10^{-1}
Bingham pump outage pits	1.0×10^{-1}	2.7×10^{-4}	NA
Hydrofluoric acid spill area	1.2×10^{-2}	1.5×10^{-5}	NA
SRL oil test site	1.1×10^{-4}	6.3×10^{-6}	NA
New TNX seepage basin	3.2×10^{-2}	3.0×10^{-5}	NA
Road A chemical basin	1.6×10^{-1}	3.4×10^{-4}	1.5×10^{-3}
L-Area oil and chemical basin	3.2×10^{-2}	5.6×10^{-5}	
Waste oil basins			
D-Area	1.6×10^{-1}	2.8×10^{-4}	NA
Motor shop	1.3×10^{-1}	3.2×10^{-6}	NA
Silverton road waste site	9.2×10^{-1}	1.1×10^{-3}	NA
F-Area seepage basin	6.6×10^{-1}	3.3×10^{-4}	4.8×10^{-3}
Acid/caustic basins			
F-Area	8.1×10^{-3}	2.3×10^{-5}	6.0×10^{-5}
H-Area	8.3×10^{-3}	1.4×10^{-5}	6.0×10^{-5}
K-Area	9.5×10^{-3}	4.7×10^{-5}	6.9×10^{-5}
L-Area	1.4×10^{-2}	3.1×10^{-5}	1.0×10^{-4}
P-Area	9.7×10^{-3}	2.9×10^{-5}	6.8×10^{-5}
R-Area	8.3×10^{-3}	1.5×10^{-5}	6.0×10^{-5}
H-Area seepage basins	1.1	1.9×10^{-3}	7.9×10^{-3}
Reactor seepage basins			
K-Area	2.4×10^{-1}	4.5×10^{-4}	NA
R-Area	2.8	2.2×10^{-3}	NA
Ford Building waste sites	3.6×10^{-2}	4.1×10^{-5}	NA
Ford Building seepage basin	1.3×10^{-2}	5.7×10^{-6}	9.2×10^{-5}
Old TNX seepage basin	1.1×10^{-2}	4.9×10^{-5}	NA
TNX burying ground			
(e)	3.1×10^{-2}	1.4×10^{-4}	2.3×10^{-4}
(f)	3.3×10^{-2}	1.1×10^{-4}	2.4×10^{-4}
CMP pits	4.7×10^{-1}	8.8×10^{-5}	NA
Gunsite 720 rubble pit	4.8×10^{-3}	4.6×10^{-6}	NA
Total risk	5.3×10^{1}	1.6×10^{-1}	3.3×10^{-1}

[a] Disposal in hazardous waste repository.
[b] Incineration and returned to site backfill.
[c] Excavated waste sent to waste disposal facility.
[d] Excavated waste placed in basin in H-Area.
[e] Waste removed to low-level radioactive waste facility.
[f] No waste found during excavation and sampling.

Table 4-60. Accident Risks for Waste Removal and Closure at Selected Sites

Location	Employee injury	Fatal truck accident	Fatal construction accident
SRL seepage basins			
(a)	8.2×10^{-1}	NA[b]	NA
Metallurgical laboratory basin	4.5×10^{-3}	2.3×10^{-5}	NA
Burning/rubble pits			
R-Area	NA	NA	NA
A-Area	NA	NA	NA
C-Area	NA	NA	NA
CS-Area	NA	NA	NA
K-Area	NA	NA	NA
P-Area	NA	NA	NA
D-Area	NA	NA	NA
F-Area	NA	NA	NA
L-Area	NA	NA	NA
Metals burning pit/miscellaneous chemical basin	1.7×10^{-1}	NA	1.2×10^{-2}
Old F-Area seepage basin	7.2×10^{-2}	NA	5.3×10^{-4}
(c)	2.0×10^{-1}	7.0×10^{-4}	1.4×10^{-3}
(d)	1.6×10^{-1}	4.4×10^{-6}	1.2×10^{-3}
Separations Area retention basins			
F-Area	2.8×10^{-2}	NA	NA
H-Area	2.8×10^{-2}	NA	NA
Radioactive waste burial grounds	9.5	NA	7.0×10^{-2}
Bingham pump outage pits	1.3×10^{-3}	NA	NA
Hydrofluoric acid spill area	NA	NA	NA
SRL oil test site	1.8×10^{-1}	NA	NA
New TNX seepage basin	3.0×10^{-2}	NA	NA
Road A chemical basin	1.3×10^{-2}	NA	NA
L-Area oil and chemical basin	NA	5.0×10^{-6}	NA
Waste Oil Basins			
D-Area	2.1×10^{-3}	NA	NA
Motor shop	9.1×10^{-2}	NA	NA
Silverton Road waste site	1.7×10^{-1}	NA	NA
F-Area seepage basin	7.2×10^{-1}	NA	5.3×10^{-3}
Acid/caustic basins			
F-Area	2.9×10^{-3}	NA	2.1×10^{-5}
H-Area	3.1×10^{-3}	NA	2.3×10^{-5}
K-Area	3.6×10^{-3}	NA	2.6×10^{-5}
L-Area	8.4×10^{-3}	NA	6.1×10^{-5}
P-Area	3.6×10^{-3}	NA	2.6×10^{-5}
R-Area	3.1×10^{-3}	NA	2.3×10^{-5}
H-Area seepage basins	1.8	NA	1.8×10^{-2}
Reactor seepage basins			
K-Area	2.1×10^{-1}	NA	NA
R-Area	1.8	2.2×10^{-3}	NA
Ford Building waste sites	3.6×10^{-2}	7.4×10^{-6}	NA
Ford Building seepage basin	1.2×10^{-2}	NA	8.5×10^{-5}
Old TNX seepage basin	4.8×10^{-2}	NA	NA
TNX burying ground			
(a)	1.9×10^{-2}	NA	1.4×10^{-4}
(c)	1.5×10^{-2}	NA	1.1×10^{-4}
CMP pits	NA	NA	NA
Gunsite 720 rubble pit	6.8×10^{-3}	NA	NA
Total risk	1.6×10^{1}	2.9×10^{-3}	1.1×10^{-1}

[a]No waste removal with cap.
[b]NA = Not applicable because of the nature of the closure option or because of the nature of the disposal site.
[c]Excavated waste sent to waste disposal facility.
[d]Excavated waste placed in basin in H-Area.

The proposed new facilities would handle only low-level radioactive, hazardous, and mixed wastes. These proposed facilities are listed below:

1. Low-level radioactive waste storage/disposal facility
2. Hazardous mixed wastes storage/disposal facility
3. Cement/flyash matrix storage/disposal (Y-Area)

4.7 CUMULATIVE EFFECTS

Cumulative effects are discussed in the following sections for the alternative waste management strategies described in Section 2.1, in conjunction with the effects of existing and planned facilities at or near the Savannah River Plant. The discussion is based on an analysis of the best- and worst-case environmental impacts to provide minimum and maximum cumulative effects.

4.7.1 EXISTING AND PLANNED FACILITIES

4.7.1.1 Facilities Near SRP

Eight facilities located within 16 kilometers of the Savannah River Plant are included in the cumulative effects analysis. These include the Vogtle Electric Generating Plant of Georgia Power Company, directly across the Savannah River from SRP; the Chem-Nuclear Services, Inc., plant in Barnwell County, South Carolina, east of SRP; and RCRA and CERCLA sites in South Carolina, as listed in Table 4-61.

Table 4-61. RCRA and CERCLA Sites in South Carolina

Name	City	County	Direction from SRP
	CERCLA		
Admiral Home Appliances	Williston	Barnwell	East-northeast
Barnwell Seed & Supply	Barnwell	Barnwell	East
Barnwell Town Dump	Barnwell	Barnwell	East
Kimberly-Clark Corporation	Beech Island	Aiken	Northwest
Simpkins farm site	Beech Island	Aiken	Northwest
	RCRA		
Sandoz, Incorporated	Martin	Allendale	South

The Vogtle Electric Generating Plant is a two-unit nuclear powerplant under construction. It is licensed by the Nuclear Regulatory Commission. Fuel loading is scheduled at Unit 1 in 1987, with low power operation following thereafter. Chem-Nuclear Services, Inc., operates a low-level radioactive waste burial ground.

4.7.1.2 Effluent Treatment Facilities at SRP

The M-Area liquid effluent treatment facility (LETF) was designed and constructed to treat liquid effluents from the fuel and target fabrication facility. The facility eliminates the use of the M-Area settling basin. The LETF includes a chemical transfer facility, a dilute effluent treatment facility, process modifications for rinsewater reduction, and temporary storage tanks. Treatment includes physical-chemical treatment, precipitation, solids separation, evaporation, filtration, and neutralization. The treated liquid effluent from this treatment facility, which meets NPDES discharge limits, is discharged to Tims Branch.

The M-Area LETF was constructed adjacent to existing M-Area facilities in a developed and controlled area on a grassy site. Temporary construction impacts such as noise, dust, and fumes were controlled to minimal levels. Required permits for construction of this wastewater-treatment facility were issued. No adverse effects are expected to SRP wildlife, wetlands, or archaeological sites due to LETF construction or operation. Operation of the facility began in the spring of 1985. The sludges from the LETF are stored temporarily in new tanks in M-Area. A spill prevention control and countermeasure (SPCC) plan has been established.

F- and H-Area Effluent Treatment Facility

This facility, located in H-Area, would be designed, constructed, and operated to store and treat routine wastewater and spills from the chemical separations facilities in F- and H-Areas. Current planning calls for startup of the facility in early 1989. The facility would provide improved treatment of routine process effluents and contaminated cooling or storm water. Unit treatment processes consist of two stages of filtration, including iron removal and carbon filtration; reverse osmosis; neutralization; and ion exchange; with combined evaporation of filter backwash, reverse-osmosis reject streams, and ion-exchange regeneration waste. Recycling of evaporator overheads and treated effluent that exceeds discharge limits is included. Dewatered solids from the coarse filtration step would be disposed of in the burial ground or in the Y-Area facility (CMF). Evaporator bottoms (waste concentrate) would be transferred to the H-Area waste tank farm. Tritium is not removed in the treatment process. Tritiated streams, batch treated to remove hazardous components and radionuclides, can be used in the saltstone process. Storage basins are provided to contain large flows of contaminated cooling water or storm water.

TNX-Area Effluent Treatment Plant

This facility will begin operation in early 1987; it is designed to treat small-volume nonradioactive process effluents for NPDES discharge. The treatment processes include flow equalization, neutralization, and solids removal. Filter cake would be disposed of in the SRP sanitary landfill.

4.7.1.3 Waste Treatment, Storage, or Disposal Facilities at SRP

Hazardous Waste Incinerator

An incinerator would be designed and constructed to incinerate a variety of hazardous wastes (e.g., contaminated soil, sludges, and liquid and solid wastes). The incinerator would consist of a primary rotary kiln, a secondary combustion chamber, and an off-gas treatment system including evaporative coolers and particulate and chloride removal systems. The process would allow simultaneous destruction of solids and aqueous and organic liquid wastes. Plans call for upgrading the incinerator to permit mixed waste incineration.

Hazardous Waste Redrumming Facility

EPA and the South Carolina Department of Health and Environmental Control (SCDHEC) require redrumming hazardous wastes contained in leaking or inadequate drums to comply with current RCRA regulations. This facility would be used to:

- Transfer liquid hazardous waste from leaking 208-liter drums to other drums
- Overpack 208-liter drums using 314-liter drums
- Transfer liquid hazardous waste from 208-liter drums and overpack into 314-liter drums
- Solidify liquid hazardous waste with absorbent
- Compact used drums with a crusher, and overpack in 314-liter drums
- Provide space for interim material handling storage

No radioactive releases are expected. Leaks, spills, or other liquids would be contained, collected, and processed. Activated carbon filters would absorb organic vapors from the facility exhaust air before venting to the atmosphere.

Cement/Flyash Matrix (Y-Area) Waste Storage/Disposal Facility

Y-Area will be designed to treat, dispose of, or store 3.78×10^6 liters of waste per year. The waste, very low in radioactivity, will be the concentrate from several effluent-treatment facilities and incinerators. Facilities contributing to this waste load are M-Area, the F- and H-Area effluent treatment facility, the Fuel Materials Facility, the Fuel Production Facility, and the beta-gamma and hazardous waste incinerators.

The waste salt solutions and precipitated solids will be solidified in a cement/flyash matrix, similar to saltstone. Another process being considered will containerize dry waste, salts, and ash in packages with structural properties.

Environmental emissions or releases are expected to be below applicable standards, due to disposal in vaults or containers.

Z-Area Saltstone Disposal Facility

The Z-Area disposal facility is designed for disposal of both low-level radioactive and hazardous wastes, specifically partially decontaminated salt solution resulting from processing of high-level radioactive liquid wastes in the Defense Waste Processing Facility (DWPF). The solution contains sodium chromate and has a high pH, both of which cause the solution to be characterized as hazardous under SCDHEC regulations. The partially dewatered salt solution would be mixed with cement and water, or other media, to form a relatively nonleachable solid monolith saltcrete, suitable for long-term disposal in an engineered landfill. This facility has been permitted.

4.7.1.4 Other Facilities at SRP

Defense Waste Processing Facility

The DWPF is being constructed to process high-level radioactive liquid wastes currently stored as insoluble sludges, precipitated salt, and supernatant liquid in single or double tanks in the F- and H-Area tank farms. The process includes the removal of wastes from tank storage; pretreatment of sludge to remove most of the alumina and soluble salts; treatment of the salt to remove cesium, strontium, and plutonium; immobilization of the high-level sludge and recovered cesium, strontium, and plutonium in borosilicate glass; encapsulation of the waste and glass mixture in steel canisters; storage of the canisters in a surface facility until shipment to a repository; and processing of the decontaminated salt into saltcrete monoliths for intermediate-depth burial onsite as low-level radioactive waste.

Fuel Materials Facility

The Fuel Materials Facility (FMF) has been designed and constructed and would be operated to provide a second source of fuel materials employing enriched uranium for the Nuclear Navy Propulsion Program. The facility is located within F- and H-Areas. Air emissions would be controlled through the total containment concept, which consists of air locks, forced air circulation, enclosures and hoods on cabinets, high efficiency particulate air (HEPA) filters, and exhaust stack capability.

Liquid wastes include process recovery and laboratory effluents, sanitary wastes, cooling-system blowdown, and steam condensates. Process wastes would be neutralized, evaporated, mixed with concrete, and encapsulated in steel containers for burial in the SRP burial ground. Solid, low-level radioactive wastes would be placed in the SRP burial ground.

Fuel Production Facility

Construction of the Fuel Production Facility (FPF) was planned to begin in December 1986. The process involved, using an onsite uranium recycle process and powder metallurgy, would replace the current casting and machining process used to form fuel billet cores.

Solid wastes from the facility containing trace amounts of uranium, including rags, plastic bags, and gloves, would be disposed of in the burial ground or incinerated. The volume of solid waste is expected to be less than that generated by the current process.

Liquid chemical wastes such as acids or caustics from the process would be treated in the F- and H-Area ETF (see Section 4.7.1.2). Air emissions would be multiple HEPA-filtered.

Tritium-Loading Facility

This facility, also called the Replacement Tritium Facility, is designed to replace and upgrade some of the tritium processing and loading functions in the present tritium-loading facility. Groundbreaking is scheduled for April 1987; the facility will be completed in 1990.

Routine operation of the new facility would substantially reduce atmospheric releases. Tritium-contaminated solid waste generation and storage/disposal rates are expected to decrease. Mercury would be eliminated in the new process, thus eliminating storage and disposal needs for mercury-contaminated wastes. There would be no releases of liquid effluents to onsite streams or to groundwater. A beneficial cumulative impact in the reduction of radioactive releases and consequent offsite doses to the public is anticipated.

4.7.1.5 Demonstration Facilities at SRP

Among the demonstration facilities active or planned at SRP are the following:

- Abovegrade operation
- Ashcrete facility, H-Area
- Beta-gamma incinerator
- Box/drum compactor
- Greater confinement disposal

Abovegrade Operation (AGO)

This 1-year demonstration facility is designed to store solid low-level radioactive wastes over existing filled waste trenches in the SRP burial ground. The waste would be placed in stackable rigid containers on composite clay and gravel storage pads. The waste would be covered with sand, a puncture-resistant fabric, an impermeable cover, and finally a clay cover. There would be no atmospheric or solid waste releases from the site. Liquid releases would be monitored. The impermeable barriers would reduce rainwater percolation into the wastes or into the underlying waste trenches.

Ashcrete Facility, H-Area

This 2-year demonstration facility is designed to solidify low-level radioactive ash generated by the beta-gamma incinerator. The process calls for mixing the ash with Portland cement, sand, and water in 208-liter drums. The product is a leach-resistant ashcrete that would be disposed of in the SRP burial ground. There are no hazardous materials in the product or facility. There are no liquid releases from the ashcrete facility. Process water would be collected, recycled, and reused in successive drums.

Beta-Gamma Incinerator

This demonstration facility is designed to incinerate low-level radioactive waste in both liquid and solid forms. The process has two stages, using an air-deficient pyrolysis chamber at 900°C followed by an 1100°C afterburner operating in excess air. Also included in the design is a spray quench tower and HEPA filter. Capacity of the incinerator is 181 kilograms per hour of solids or 1500 liters per hour of liquid wastes.

Box-Drum Compactor

This demonstration facility is designed to handle solid low-level radioactive wastes by compaction, reducing waste volumes by factors of 4 or 5 to 1. Following compaction, the wastes would be placed in standard high-integrity 1.2-meter by 1.2-meter by 1.8-meter steel boxes for disposal in the low-level burial ground. Environmental releases from the facility are expected to be insignificant. There are no liquid releases. HEPA filters would remove and retain radioactive particulates from the facility ventilation/exhaust air system.

Greater Confinement Disposal

The GCD demonstration is designed to dispose of low-level radioactive wastes in lined 9-meter-deep auger holes or in short trenches with vertical walls and mud-mats. The wastes, in rigid containers, or contaminated metallic objects, would be stabilized in place with self-leveling grout. The facilities would be capped when filled. The potential for leachate generation is small due to the presence of grout and the cap. Monitoring of leachate is included in the design.

4.7.2 GROUNDWATER

4.7.2.1 Groundwater Withdrawal

The withdrawal of groundwater from the Middendorf/Black Creek (Tuscaloosa) aquifer in support of existing and projected SRP operations is not expected to affect offsite water levels in the aquifer (DOE, 1984). However, as discussed in Section 4.2.1, the groundwater withdrawal in support of remedial actions at the existing waste sites could physically impact the water table outside the SRP boundary. Careful monitoring of the water table during startup of any remedial action would determine if there are impacts to the water-table aquifers.

The offsite facilities identified in Section 4.7.1.1 are not expected to contribute to the SRP's withdrawal rate and its associated drawdown. The Vogtle Nuclear Plant is expected to withdraw groundwater from areas unaffected by the SRP.

The withdrawal of groundwater in support of existing and projected SRP operations is not expected to affect offsite water levels in the aquifer (DOE, 1984). Groundwater not withdrawn in support of remedial actions at the existing waste sites has no offsite effects. The offsite facilities are not expected to contribute to the SRP's withdrawal rate and its associated drawdown.

4.7.2.2 Groundwater Quality

The groundwater quality under the Plant would be improved as a result of the implementation of the Elimination alternative strategy. The remedial actions would be such that the groundwater quality from one area of the SRP would not adversely impact the groundwater in another.

Based on apparent groundwater-flow direction, groundwater from beneath the Vogtle Nuclear Plant, the Kimberly-Clark Corporation, the Simpkins farm, Barnwell Seed and Supply, the Barnwell Town Dump, and the Admiral Home Appliance site does not appear to come in contact with the groundwater from beneath the other facilities identified in Section 4.7.1, or the groundwater affected by the SRP. Therefore, these facilities should not contribute to the cumulative impact on groundwater quality.

The new retrievable-storage facilities, the ETFs, the other operating facilities, and the demonstration facilities would be designed and constructed so that they do not release contaminants to the groundwater. These facilities would be properly maintained and would not contribute to a cumulative impact on groundwater quality.

Because the Sandoz, Inc., site, is a RCRA facility, it should also have been designed and constructed so that it does not release contaminants to the groundwater; thus it should not contribute to the cumulative impact on groundwater quality. RCRA mandates that groundwater monitoring be conducted and, if contamination is detected, that cleanup activities be started to prevent groundwater contamination from migrating offsite to contribute to a cumulative impact on groundwater quality.

Under the No-Action strategy, the quality of the groundwater under the SRP would continue to be affected.

4.7.3 SURFACE WATER

4.7.3.1 Surface-Water Use

The Chem-Nuclear Services facility, the CERCLA sites, the Sandoz, Inc., RCRA site, the new disposal facilities, the ETFs, the waste treatment, storage, or disposal facilities, the other operating facilities, and the demonstration facilities are not expected to use surface water from the Savannah River. The Vogtle Nuclear Plant is expected to withdraw a few cubic meters per second from the river for use as cooling-system makeup water, a portion of which would be returned as blowdown. The SRP is estimated to withdraw 37 cubic meters per second, while the average flow of the Savannah River is 285 cubic meters per second (DOE, 1984). Under average conditions, the cumulative surface-water use is projected to be about 14 percent of the Savannah River, compared to 13 percent for just the SRP. In addition, the major portion of this withdrawal is used for cooling water and is returned to the river via onsite streams. Thus, the cumulative impact is not expected to be significant.

The surface-water use under the worst case is no different from the surface-water use in the best case, described above.

4.7.3.2 Surface-Water Quality

Existing waste sites would be remediated so that contamination from these sites does not adversely affect surface-water quality. The new retrievable-storage facilities, the ETFs, the other operating facilities, and the demonstration facilities would be designed, constructed, operated, and maintained so that discharges do not adversely impact surface-water quality. The Vogtle Nuclear Plant has been designed, constructed, and will be operated and maintained so discharges do not adversely impact surface-water quality.

Any discharge from the Sandoz, Inc., RCRA facility probably enters Lower Three Runs Creek. This facility should also be designed, constructed, operated, and maintained so that any discharge does not adversely impact the quality of the creek. In addition, because it is a RCRA facility, RCRA-mandated monitoring of the discharge would indicate if contamination would adversely impact surface-water quality; if so, corrective actions should be taken to eliminate the adverse impact.

Any contamination from the Admiral Home Appliances, the Barnwell Seed and Supply, and the Barnwell town dump CERCLA sites is expected to enter the Salkehatchie River watershed and should not be expected to contribute to cumulative impacts on the Savannah River.

Contamination from the Kimberly-Clark Corporation and the Simpkins farm CERCLA sites probably enters the Savannah River above the SRP. Considering the groundwater flow in this area, the contamination takes more than 100 years to reach the Savannah River and is not expected to contribute significantly to the water quality of the river.

There are no liquid discharges from the Chem-Nuclear Services facility to contribute to the cumulative effects on surface-water quality.

Under the No-Action strategy the quality of surface streams on the SRP would continue to be affected as a result of existing waste sites. The other facilities identified in Section 4.7.1.1 are not expected to contribute to the cumulative impact on surface-water quality.

4.7.4 HEALTH EFFECTS

4.7.4.1 Exposure to Radioactive Substances

The evaluation of health effects has considered cumulative effects from the operation of all nuclear facilities on and in the vicinity of SRP. These facilities consist of four production reactors with associated support facilities; hazardous, low-level, and mixed waste sites; and planned operations at the SRP, including the DWPF, the FMF, and the FPF. The Vogtle Electric Generating Station and the Chem-Nuclear Services, Inc., low-level radioactive disposal site are also included in the evaluation of the cumulative health effects. The risk estimator used to project health effects is 280 cancers and genetic effects per 1 million person-rem of collective dose.

Existing Waste Sites

Using the risk estimator mentioned above and the cumulative doses presented in Appendix I, Table 4-62 lists the annual cumulative health effects that could be experienced by the population in the year 2000 for the No-Action strategy (upper bound) and during the first year after implementation of the other three strategies. Remedial actions at the waste sites were not considered in calculating these health effects. The recipient population of the air component of the health effects is assumed to lie within an 80-kilometer radius of the SRP. The recipient population of the liquid component of the health effects is assumed to be the Savannah River water users downstream from the SRP.

Table 4-62. Annual Collective Cumulative Health Effects During First Year from Atmospheric and Liquid Releases at Existing Waste Sites

Component	No action	No waste removal and closure[a]	Waste removal at selected sites[a]	Waste removal and closure[a]
Atmospheric	2.3×10^{-2}	1.5×10^{-2}	1.5×10^{-2}	2.2×10^{-2}
Liquid	9.2×10^{-3}	9.2×10^{-3}	9.2×10^{-3}	9.2×10^{-3}
Combined	3.2×10^{-2}	2.4×10^{-2}	2.4×10^{-2}	3.1×10^{-2}[(b)]

[a]Remedial actions taken at appropriate sites would reduce the tabulated health effects.
[b]Waste removal and closure result in a comparatively higher cumulative health effects value than either no-waste-removal and closure or waste removal at selected sites. This is because the annual health effects are calculated for the first year after implementation of the options; due to the waste site excavation activities performed as part of waste removal and closure, additional radionuclides could be set airborne, consequently raising the atmospheric component of the cumulative health effects during the first year.

New Retrievable-Storage Facilities

The changes in the liquid component of the annual health effects that could be imparted to the water user population downstream from the SRP due to implementation of the alternative strategies discussed in Section 4.3 are insignificant. Because no atmospheric releases would result from implementation of any of the alternative strategies, the cumulative atmospheric component of the health effects would not be affected. Consequently, implementation of any of the waste storage facility alternatives would result in an insignificant change in the upper-bound number of 3.2×10^{-2} health effects.

Disassembly-Basin Purge Water

Using the health risk estimator of 280 cancers and genetic effects per 1 million person-rem of collective dose, and the peak collective annual doses resulting from the three alternative strategies (excluding No Action) for discharging disassembly-basin purge water (Section 4.4), calculations are made to determine the annual cumulative health effects that could be experienced by the population within an 80-kilometer radius of the SRP and the population using Savannah River water downstream from the SRP.

The change in the annual health effects resulting from each alternative is calculated by considering the peak dose year of a 26-year study period. The rationale for considering a time range of 26 years is presented in Sections 2.3 and 4.4. These health effects, when combined with those given in Table 4-62, result in the cumulative annual health effects that could be experienced by the population after the implementation of the alternatives. These cumulative health effects are listed in Table 4-63.

Table 4-63. Annual Collective Cumulative Health Effects in Year 2000 from Atmospheric and Liquid Releases, Disassembly-Basin Purge Water Discharge

Component	Detritiation	Evaporation	Direct discharge	No action
Atmospheric	2.3×10^{-2}	2.3×10^{-2}	2.3×10^{-2}	2.3×10^{-2}
Liquid	9.0×10^{-3}	8.2×10^{-3}	1.1×10^{-2}	9.2×10^{-3}
Combined	3.2×10^{-2}	3.1×10^{-2}	3.4×10^{-2}	3.2×10^{-2}

Conclusion

Table 4-62 indicates for the existing waste sites the alternatives that could result in the largest decrease in cumulative health effects during their first year of implementation.

For the new retrievable-storage or waste disposal alternatives, there is no significant change in the cumulative health effects given in Table 4-62 for No Action.

As indicated in Table 4-63, for the discharge of disassembly-basin purge water, evaporation is the alternative that could result in the greatest decrease in cumulative health effects during the peak year after implementation. The direct-discharge alternative results in the highest cumulative health effects.

4.7.4.2 Exposure to Hazardous Substances

This section presents the cumulative health effects from exposure to hazardous substances. The majority of the cumulative health risks are focused on the release of contaminants to the Savannah River with subsequent human exposure; however, because air and groundwater exposures could occur, they also are presented.

Existing Waste Sites

The Elimination strategy (waste removal at all sites) defines the best-case alternative for the existing waste sites at SRP. Table 4-64 summarizes the carcinogenic risks due to exposure via groundwater or surface water.

Table 4-64. Best-Case Carcinogenic Risks for Groundwater and Surface-Water Exposure

Exposure	Range of total risk (2085)		Range of maximum risk (year of occurrence)	
Groundwater	3.3×10^{-4} -	8.1×10^{-31}	9.7×10^{-2} - (1997)	7.1×10^{-7} (2044)
Surface water	4.5×10^{-10} -	0	3.4×10^{-4} - (2026)	5.2×10^{-13} (2035)

The maximum total risk associated with groundwater in 2085 occurs at the old TNX seepage basin. However, a maximum risk occurs at the CMP pits in 1997 due to the presence of tetrachloroethylene. By 2085, this risk would be reduced.

The maximum total risk for surface water in 2085 occurs at the CMP pits. The overall maximum risk is found at some of the burning/rubble pits (C- and CS-Areas). In 2026, the maximum risk would be due to the presence of trichloroethylene. These risks would be reduced by the year 2085.

Noncarcinogenic risks were also estimated under the same scenarios. Most of the ratios of dose to ADI were less than 1, indicating little risk of noncarcinogenic (toxic) health effects. The ratio of dose to ADI did not exceed 1 in any surface waters, and was usually less than 10^{-6}.

The air pathway was modeled through 2985 for both the exposed population and the maximally exposed individual. For the most part, individual health risks via the atmospheric pathway were low after implementation of the lower bound. Risks in a few areas were somewhat higher, but they decrease rapidly after 2085. These areas with high population risks include M-Area settling basin with an overall maximum risk of 2.34×10^{-3} in 2015, C-Area burning/rubble pit, and the old TNX seepage basin. Even where the risks to the population are highest, the risks for the maximally exposed individual are less than 10^{-8}. Individual risks apparently peak during site closure or waste removal activities, while the population risks peak in about 2085. After the site is reopened for habitation, risks rapidly reduce immediately and asymptotically approach 0.

New Retrievable-Storage Facilities

All new retrievable-storage facilities would be constructed to applicable (e.g., RCRA) regulations, and therefore no release of contaminants is expected. No adverse health effects are predicted.

Disassembly-Basin Purge Water

There are no releases of hazardous substances from current discharges or modifications of discharges of disassembly-basin purge water. Therefore, there would be no exposures or risks.

Worst-Case Environmental Impacts

For the No-Action strategy, carcinogenic risks are somewhat higher. These risks are summarized in Table 4-65.

Table 4-65. Worst-Case Carcinogenic Risks for Groundwater and Surface-Water Exposure

Exposure	Range of total risk (2085)	Range of maximum risk (year of occurrence)
Groundwater	7.5×10^{-3} - 8.1×10^{-31}	2.1×10^{-1} (1993) - 1.2×10^{-5} (2001)
Surface water	4.5×10^{-10} - 0	2.4×10^{-4} (2026) - 5.2×10^{-13} (2035)

The maximum total risk associated with groundwater in 2085 occurs at the M-Area settling basin. However, a maximum risk occurs in 1993 due to the presence of tetrachloroethylene. By 2085, this risk is reduced by a factor of about 100.

The maximum total risk for surface water in 2085 occurs at the CMP pits. The overall maximum risk is found at the burning/rubble pits. The maximum risk is 2.4×10^{-4} (which occurs in 2026), due to the presence of trichloroethylene. These risks are reduced by 2085.

Noncarcinogenic risks were also estimated under the worst case. Most of the ratios of dose to ADI were less than 1, indicating little risk of noncarcinogenic (toxic) health effects. The ratio of dose to ADI did not exceed 1 in any surface waters and was usually less than 10^{-9}. Most potential noncarcinogenic health effects are associated with groundwater exposures (phosphate, nitrate, and mercury) in which the ratio of dose to ADI exceeds unity.

The air pathway was modeled through 2985 for both the exposed population and the maximally exposed individual. For the most part, individual health risks via the atmospheric pathway were low (less than 10^{-7}), even without remedial action. In a few cases, risks were somewhat higher, but they decrease rapidly after 2085.

Areas with high population risks include all the geographic areas except the Road A chemical basin. The maximum risks for the exposed population range from 3.4×10^{-3} to 1.4×10^{-4}. These peaks all occur in 1985 or 1986.

New Retrievable-Storage Facilities

All new retrievable-storage facilities would be designed and constructed to applicable (e.g., RCRA) regulations, and therefore no release of contaminants is expected. No adverse health effects are predicted.

Disassembly-Basin Purge Water

There are no releases of hazardous substances from current discharges or modifications of discharges of disassembly-basin purge water; therefore, there would be no nonradiological exposures or risks.

4.7.5 OTHER CUMULATIVE EFFECTS

This section discusses cumulative impacts from waste removal and closure at existing waste sites and the establishment of new retrievable-storage facilities, in conjunction with alternatives for disassembly-basin purge-water treatment and other existing or planned disposal and treatment facilities on the SRP. It also discusses additional cumulative impacts from offsite hazardous waste facilities, and cumulative impacts affecting ecology, air quality, the socioeconomic structure, and archeological and historic resources.

4.7.5.1 Ecological

Best-Case Environmental Impacts

The Elimination strategy is not expected to have any aquatic ecological impacts, either directly or indirectly. At all existing sites, wastes would be removed, sites closed, and groundwater treated and released if required. New waste facilities would be designed on an essentially zero-release basis, so groundwater contamination would not occur.

Potential cumulative terrestrial impacts include the bioaccumulation of contaminants by plants growing in or near waste sites and the disruption of vegetation, wildlife, and their habitats. Because wastes would be removed from all existing waste sites under the Elimination strategy, the potential for bioaccumulation of contaminants by plants is insignificant. This also reduces the potential toxicological impact to wildlife that feed on the plants. Where new waste sites for retrievable storage of hazardous, mixed, or low-level wastes are proposed, land would be cleared and developed, disrupting existing vegetation, wildlife, and their habitats. The significance of these impacts cannot be determined until the areas to be disturbed are assessed ecologically. In terms of the overall SRP area, these land disruptions are insignificant. Disruption of wildlife would also occur due to the presence of human activities at existing and proposed waste sites. Such disruption would be of short duration at existing waste sites, and longer at new storage facilities.

No significant potential cumulative impacts to local wetlands are expected under the lower-bound alternative. Wetland communities of the SRP consist primarily of bottomland hardwood forests, with smaller acreages of cypress/tupelo, scrub/shrub, and emergent marsh communities (Jensen et al., 1982) along onsite streams and the Savannah River. Most waste sites are sufficiently removed from wetlands, and proposed remedial actions include erosion control measures; significant impacts to wetlands are not expected to occur.

No potential impacts are expected to occur to threatened or endangered species, because no critical habitats or species have been found in the immediate vicinity of existing or proposed facilities.

Worst-Case Environmental Impacts

Under the No-Action strategy, there is a potential for direct and indirect contamination of onsite streams, including the Savannah River. Based on the PATHRAE analysis performed for existing waste sites, particularly the radioactive waste burial ground and the F- and H-Area seepage basins, aquatic biota of Four Mile Creek could be affected adversely by concentrations of cadmium, chromium, lead, mercury, and tritium, because these are expected to exceed EPA aquatic biota criteria. Many onsite streams presently exceed these EPA criteria. The aquatic biota of these streams are probably being subjected to some stress under present conditions.

Potential cumulative terrestrial impacts under this alternative involve impacts to wildlife and vegetation that come into contact with contaminated waters and soils, which can result indirectly in a toxicological impact to wildlife if such plants are consumed. Wildlife can be impacted directly if they use standing contaminated waters at unfenced existing waste sites.

Potential minor impacts to wetlands could occur if contaminated waters in basins of existing waste sites overflow into nearby wetlands. The SRL seepage basins, the M-Area settling basin, and the old TNX seepage basin are near wetlands. Operation of the old TNX seepage basin has caused levels of mercury and gross beta to exceed the EPA aquatic biota criteria in the TNX swamp.

Onsite and Offsite Facilities

Onsite and offsite facilities include those cited in Sections 4.7.1.1 and through 4.7.1.4. The potential cumulative impacts to the environment from these facilities cannot be determined accurately, because little is known about their operations and releases. The Savannah River is presently above the aquatic biota criteria for lead, mercury, and silver, which is representative of existing water-quality conditions. Thus, aquatic biota of the river might already be subjected to stress as a result of all the facilities in the general area.

4.7.5.2 Air Quality

Air contaminants from potential sources other than the SRP are sufficiently distant that their effects on cumulative risk assessment would be negligible.

Therefore, the risk assessments due to air releases discussed in Section 4.1 are considered applicable for cumulative effects for both onsite and offsite sources.

4.7.5.3 Socioeconomic

No more than 200 workers would be required for development of any of the proposed alternatives. Because these workers would be drawn from the existing construction workforce at the Plant, cumulative effects are expected to be negligible.

4.7.5.4 Archaeological and Historic Sites

No significant archaeological and historic sites have been identified at any of the existing waste sites or at any of the proposed alternative disposal/ storage facilities. Therefore, the cumulative effects of implementing any of the alternatives are expected to be insignificant.

4.8 MITIGATION MEASURES

This section discusses mitigation measures that could reduce or offset potential environmental impacts and that are not part of the proposed action or alternatives (e.g., remedial action). Based on the identification of environmental consequences for the alternatives considered in the EIS, consideration might be given to the establishment of further programs to reduce radiological and nonradiological releases or to reduce potential ecological effects.

4.8.1 ENVIRONMENTAL CONSEQUENCES

The environmental consequences of the proposed action and alternatives are described fully in Sections 4.2, 4.3, and 4.4 for existing waste sites, new disposal facilities, and discharge of disassembly-basin purge water, respectively.

4.8.1.1 Existing Waste Sites

For the removal of wastes at selected existing waste sites, followed by closure and potentially required groundwater remedial actions (the preferred alternative), the environmental consequences, except for the No-Action strategy, during the 100-year institutional control period are largely beneficial. Health risk assessment and ecological impact modeling results generally are within or below acceptable ranges. Potential impacts to surface-water streams described in Section 4.7.5 are based on water-quality criteria that are nonenforceable concentration levels. Transient peak year health effects or established concentration standard (MCL) exceedances are fairly well defined and are postulated to occur briefly in groundwater (hypothetical wells) that is not currently used for onsite domestic supplies. Migration of these peak plume effects toward offsite receptors (i.e., the Savannah River) is predicted to occur in periods ranging from decades to centuries.

Through dilution or other physico-chemical or biological processes, it is reasonable to assume that order-of-magnitude reductions in health risk values or concentrations would occur. Modeling results for a 1000-year period have postulated these reductions. Implementation of short-term, immediate groundwater remedial actions would contain contaminated plumes, thereby preventing or reducing the extent of offsite migration of the plume.

Groundwater flow patterns mitigate any short-term migration of plumes to water supplies offsite. For example, the juncture of water-table aquifers in the northwest portion of the Plant with the deeper Middendorf/Black Creek or Congaree aquifers diverts the path of the potentially contaminated plumes through nearly a 90-degree change of flow direction that results in ultimate discharge (after 600 to 700 years) into the Savannah River or bordering swamps. Elsewhere on the Plant, water-table aquifers outcrop directly into onsite streams. Times of travel of plumes from seepage basins to outcrops vary from years to decades. Site dedication and exclusion ensure mitigation of potential environmental impacts well beyond the period of institutional control.

4.8.1.2 New Disposal Facilities

Construction and operation of new storage/disposal facilities under the preferred Combination strategy for hazardous, low-level radioactive, and mixed wastes that are designed to meet stringent regulatory requirements for essentially zero release would impose no permanent adverse impacts within the periods of operation (20 years), postclosure care and monitoring (30 years), and the remaining years of institutional control (approximately 50 more years). Site dedication following closure would ensure maximum environmental protection in the long term.

4.8.1.3 Discharge of Disassembly-Basin Purge Water

Continuation of the discharge of disassembly-basin purge water to existing seepage and containment basins continues the current level of environmental releases and offsite doses of radioactivity.

4.8.2 MITIGATION MEASURES

4.8.2.1 Existing Waste Sites

Further mitigation of environmental consequences associated with the proposed action does not appear to be economically feasible with state-of-the-art technology. However, many research and development studies are evaluating emerging technologies that show promise for future application. DOE would track these efforts to implement those technologies that offer future technical and economic feasibility. The range of technologies should be directed toward the detoxification and destruction of retrievably stored hazardous wastes rather than toward an emphasis on permanent land burial or disposal.

The nature of radioactive waste, by contrast, does not lend itself to destruction or removal of the essential inherent radioactivity by direct physical, chemical, or biological means. Isolation, shielding, burial, and immobilization are currently the most reasonable alternatives for these wastes. Nevertheless, research and development efforts in the separation and fixation of radioactivity, particularly tritium, should be followed.

4.8.2.2 New Disposal Facilities

These facilities, by the nature of their design, should be zero-release installations. Under the Combination strategy, as a mitigation measure, retrievable wastes would be available for future implementation of emerging technologies designed to destroy or detoxify hazardous wastes.

4.8.2.3 Discharge of Disassembly-Basin Purge Water

Moderator detritiation through chemical or physico-chemical methods can be considered a mitigation measure. Other mitigative approaches that have been suggested are collection of tritiated groundwater at outcrops along surface streams and recycling of the water to seepage basins to allow another cycle of radioactive decay to occur; control of primary system heat-exchanger leakage; use of waste heat from various operations for barometric evaporation of tritiated streams; and vacuum evaporation with recovery.

4.9 UNAVOIDABLE/IRREVERSIBLE IMPACTS

4.9.1 STRATEGIES FOR EXISTING WASTE SITES

This section describes the adverse impacts of the strategies for the existing waste sites that cannot be avoided by reasonable mitigation measures. It also describes irreversible and irretrievable commitments of resources and short-term use and long-term productivity impacts of these strategies.

4.9.1.1 Unavoidable Adverse Impacts

Adoption of the No-Action strategy would result in the continued release of chemical and radionuclide contaminants from the existing waste sites. These releases are projected to result in contaminant concentrations in onsite groundwater and surface-water resources that exceed maximum contaminant levels established under the Safe Drinking Water Act. The groundwater contamination would occur at the following SRP areas: A, M, L, F, H, TNX, R, C, CS, K, P, and Road A. For surface-water resources, only nitrate and tritium in Four Mile Creek are expected to exceed maximum contaminant levels (Section 4.2.1 and Appendix F).

The carcinogenic and noncarcinogenic risks resulting from the release of nonradioactive chemicals have been calculated for the No-Action strategy. The maximum total carcinogenic risk at a well 100 meters downgradient from a waste site in 2085 (the year in which institutional site control is relinquished) would be 2.5×10^{-3} health effect per year at the M-Area settling basin. The maximum risk at a 100-meter well for tetrachloroethylene, the dominant carcinogenic chemical, would be 2.1×10^{-1} health effect per year in 1993 at the M-Area settling basin. The maximum total noncarcinogenic risk at a 100-meter well in 2085 would be 1.1×10^{2} times greater than the acceptable daily intake at the old TNX seepage basin. The maximum risk at a 100-meter well for nitrate, the dominant noncarcinogenic, would be 3.8×10^{2} times greater than the acceptable daily intake in 1991 at the M-Area settling basin (Section 4.1.1.6 and Appendix J).

The adverse health effects of the nonradioactive contaminants for the atmospheric pathway have been assessed for an exposed population and a maximally exposed individual. The maximum carcinogenic risk for the exposed population under the No-Action strategy would be 3.4×10^{-3} health effect per year in 1986 at the SRL seepage basins. The maximum carcinogenic risk for the maximally exposed individual would be 1.4×10^{-7} health effect per year in 2085 at the H-Area seepage basins. The maximum total noncarcinogenic risk for an exposed population would be 1.9×10^{1} times the acceptable daily intake in 2085 at the H-Area seepage basins. The maximum total noncarcinogenic risk for a maximally exposed individual would be 4.8×10^{-3} of the acceptable daily intake in 2085 at the H-Area seepage basins (see Section 4.2.1.6 and Appendix J).

The health risks associated with the release of radioactive contaminants under the No-Action strategy have also been determined. These health risks consist of radiation-induced cancers and genetic disorders. The cumulative health risks to the maximally exposed individual residing at the SRP boundary during 1985 and within the SRP site boundary during the peak year (2085) would be 9.8×10^{-7} and 3.9×10^{-4} health effects per year, respectively. The annual cumulative number of health effects imparted to the population in the SRP region, in 1985 and in 2085, would be 9.5×10^{-3} and 5.3×10^{-3} health effects per year, respectively (see Section 4.2 and Appendix I).

Adverse impacts to ecological resources could also occur under the No-Action strategy. Analyses indicate that Four Mile Creek could be affected adversely by concentrations of several contaminants that exceed EPA water-quality criteria for aquatic life. The use of open basins by aquatic organisms and terrestrial wildlife could also result in direct exposure to contaminants. The impacts associated with chronic exposures and potential biological accumulation are unknown. Wetland areas that are immediately adjacent to the SRL and M-Area seepage basins could also be affected by basin overflow during heavy rains (see Section 4.2 and Appendix F).

The closure and remedial actions that would occur under the strategies other than No Action would reduce nonradioactive and radioactive contaminant releases via the groundwater, surface-water, and atmospheric pathways to within regulatory standards. Associated health effects would also be reduced from those anticipated under the No-Action strategy. However, adverse impacts could occur as a result of the implementation of closure and remedial actions.

Closure actions could include the backfilling of selected basins. Disruption of terrestrial habitats and effects on natural productivity could occur at the closure sites and other SRP areas from the creation of new or the expansion of existing borrow pits for backfill materials. Also, these operations would have associated occupational risks. Remedial action could include groundwater withdrawal and treatment at selected sites. Groundwater withdrawal would result in the drawdown of water-table aquifers. However, this drawdown would be small and localized and would not affect SRP drinking-water wells. The effluent from the groundwater treatment facilities could be discharged to local onsite streams. The subsequent increased flows in the receiving streams could cause changes in their ecologic structure. Further study would be required to quantify the potential impacts from closure and remedial actions.

4.9.1.2 Irreversible and Irretrievable Commitments of Resources

Resources that would be irreversibly and irretrievably committed during the implementation of the existing waste site strategies include (1) materials that cannot be recovered or recycled and (2) materials consumed or reduced to unrecoverable forms. For the actions under consideration, irretrievable resource use would include contaminated materials and equipment that could not be reused and energy consumed during the closure and remedial actions. However, the current level of planning for the existing waste site strategies does not permit a quantification of these resource consumption rates.

4.9.1.3 Short-Term Uses and Long-Term Productivity

The short-term effects of the existing waste site strategies would include the loss of upland sites for their natural productivity. The amount of uplands required for borrow pits and remedial actions has not been determined but would be expected to be minimal. In the long term, the natural vegetation at these sites could become reestablished through the process of natural succession. In addition, the land associated with certain waste sites would remain dedicated to waste disposal under the No-Action strategy and, to a lesser extent, under the others.

4.9.2 STRATEGIES FOR NEW DISPOSAL FACILITIES

This section describes the adverse impacts of the strategies for the new disposal facilities that cannot be avoided by reasonable mitigation measures. It also describes irreversible and irretrievable commitments of resources and short-term use and long-term productivity impacts of these strategies.

4.9.2.1 Unavoidable Adverse Impacts

Construction and operation of new disposal facilities would impact undeveloped upland areas on the SRP. The clearing of this land could be expected to result in the loss of wildlife habitat, the loss of animals with limited home ranges, and the redistribution of more mobile species. The land requirements for retrievable storage are 265 acres; for shallow-land burial, 405 acres; for aboveground disposal, 145 acres; for the Combination strategy, 285 acres; and for No Action, 91 acres (see Section 4.3.2.7 and Appendix E).

The unavoidable health risks of the new disposal facilities would be radiation-induced cancers and genetic disorders. In a downstream population of 100,000, the largest health risk would occur under shallow-land burial, the implementation of which would result in excess occurrence of 7.0×10^{-8} cancers and genetic disorders after a 1-year uptake of Savannah River water (see Section 4.3.2.6). The health risks under No Action have not been quantified, but they could be much greater.

Under the No-Action strategy, wastes would continue to be disposed of in existing facilities until the capacities of these facilities had been attained. After that, the wastes would be stored onsite in the safest manner possible without the construction of new facilities. The release of hazardous or radioactive constituents and the associated health and environmental effects would be insignificant as long as no leaks or spills occurred. However, because the release-containment systems required in RCRA and Atomic

Energy Act (AEA) facilities would not be present at the No-Action facilities, the risk of serious accidental release would be much greater than for any of the other strategies.

4.9.2.2 Irreversible and Irretrievable Commitments of Resources

Resources that would be irreversibly and irretrievably committed during the implementation of the new disposal facilities include materials that cannot be recovered or recycled, and materials consumed or reduced to unrecoverable forms. For the actions under consideration, irretrievable resources would include contaminated materials and equipment that could not be reused and energy consumed during the construction and operation of the facilities. However, the current level of planning for the new disposal facilities does not make it possible to quantify these resource-consumption rates.

4.9.2.3 Short-Term Uses and Long-Term Productivity

In the short term, the construction and operation of the facilities would impact from 37 to 164 acres of uplands. Over the long term, upland vegetation could become reestablished through the process of natural succession only with the retrievable-storage action. For the remaining actions, the associated land would remain dedicated to waste disposal.

4.9.3 STRATEGIES FOR DISCHARGE OF DISASSEMBLY-BASIN PURGE WATER

Four strategies are considered for the discharge of disassembly-basin purge water: No-Action, Dedication, Elimination, and Combination. They are discussed in detail in Sections 2.3 and 4.4. This section discusses impacts associated with the strategies that could not be avoided by reasonable mitigation measures. It also discusses irreversible and irretrievable commitments of resources, short-term uses, and long-term environmental implications.

4.9.3.1 Unavoidable Adverse Impacts

The discharge of disassembly-basin purge water would lead to unavoidable radiation exposure to man, regardless of which strategy is implemented. These exposures would be negligible in comparison to those associated with natural background radiation. Section 4.4 presents the estimated radiation exposures to man associated with each strategy.

4.9.3.2 Irreversible and Irretrievable Commitments of Resources

Resources that would be irreversibly and irretrievably committed with the implementation of a particular strategy include materials that cannot be recovered or recycled, and materials consumed or reduced to unrecoverable forms. The implementation of a particular strategy would require irretrievable commitments of energy. The actual amount of committed energy required would depend on the final engineering design. Small amounts of radioactive waste could require land commitment for final disposal.

4.9.3.3 Short-Term Uses and Long-Term Productivity

Short-term effects of waste management operation include the unavailability of site areas for natural productivity and wildlife habitat. Detritiation would require the greatest site area, with the construction of the moderator detritiation plant. The implementation of evaporation would also require a relatively large commitment of area for either the construction of an evaporation pond or the installation of commercial evaporators. Direct discharge would require only the area needed to pipe water from the reactors to onsite streams. No action would require the commitment of the seepage basins currently in use. Following decommissioning and decontamination, the area could revert to its natural state with minimal long-term effects.

4.10 PREFERRED ALTERNATIVE WASTE MANAGEMENT STRATEGY

4.10.1 RATIONALE FOR SELECTION

DOE has identified the Combination waste management strategy as its preferred alternative. This strategy provides compliance with applicable environmental regulations (RCRA, Hazardous and Solid Waste Amendments (of 1984), and South Carolina Hazardous Waste Management Act) and DOE guidelines through combinations of site dedication, elimination of selected waste sites, and storage and disposal of hazardous, low-level radioactive, and mixed wastes. DOE's preferred waste management strategy is based on lower tier project-level actions, including removal of wastes at selected existing waste sites; remedial and closure actions at existing waste sites, as required; the construction of retrievable storage and aboveground or belowground disposal facilities for hazardous, mixed, and low-level radioactive wastes; and the management of periodic discharges of disassembly-basin purge water from C-, K-, and P-Reactors by discharging filtered, deionized disassembly-basin purge water to active reactor seepage and containment basins.

4.10.1.1 Existing Waste Sites

The primary considerations in choosing the preferred waste management strategy are the reduced environmental effects and occupational risks from remedial and closure actions, the cost of remedial and closure actions, the capacity and cost of new storage and disposal facilities, and the amount of land, if any, that would be dedicated to waste management at the end of the institutional control period.

4.10.1.2 New Disposal Facilities

The preferred strategy would apply a combination of retrievable storage and aboveground or belowground disposal technologies to optimize the management of wastes with different characteristics within the hazardous, mixed, and low-level radioactive waste streams generated at SRP. The implementation of this strategy would comply with the general requirements of RCRA, HSWA, SCHWMA, and DOE Orders.

The Combination strategy for the construction of new storage and disposal facilities for the management of hazardous, mixed, and low-level radioactive waste consists of:

1. Retrievable storage buildings for selected wastes of all three types

2. RCRA landfill or vaults for the disposal of hazardous waste

3. RCRA landfills or vaults, with or without CFM vaults, for the disposal of mixed waste

4. ELLTs, vaults, or AGOs for the disposal of low-activity radioactive wastes

5. Vaults or GCD for the disposal of intermediate-activity, low-level radioactive wastes.

Optional technologies in Items 2 and 5 are considered equivalent in terms of groundwater protection capabilities. Options that include CFM vaults in Item 3 and ELLTs in Item 4 were selected to represent the worst case in their waste management roles. The environmental impacts of the Combination strategy lie within each of the categories listed. No preference has been determined among technologies.

4.10.1.3 Discharge of Disassembly-Basin Purge Water

The Combination strategy includes the continued discharge of disassembly-basin purge water to active reactor seepage and containment basins and the pursuit of studies to assess reactor moderator detritiation or other mitigation measures. This EIS discusses moderator detritiation to provide an estimate of costs and a description of beneficial or mitigative impacts.

4.10.2 ADVANTAGES

4.10.2.1 Existing Waste Sites

Waste removal at selected sites, closure, and remedial actions would have lower costs, insignificant ecological effects, and occupational risks than closure actions and would require lower storage and disposal capacity. At the sites tentatively selected for waste removal, the concentrations and extent of constituents in the groundwater that are above regulatory standards could be reduced significantly. Only a small fraction of SRP land would require dedication for waste management purposes at the end of the institutional control period.

4.10.2.2 New Disposal Facilities

The advantages of the preferred strategy are as follows:

- Waste disposal would be permanent.
- Disposal would comply with applicable regulations.
- Facilities would comply with environmental standards.
- Storage of wastes would comply with applicable regulations, assuming waivers on long-term storage would be granted.
- A mix of disposal and storage technologies could be selected to optimize performance and minimize cost.

4.10.2.3 Discharge of Disassembly-Basin Purge Water

The continued discharge of disassembly-basin purge water to seepage basins and the continued assessment of tritium-mitigation measures, such as reactor moderator detritiation, are advantages of the preferred strategy. Annual offsite doses due to tritium could be reduced substantially. No additional costs or equipment for continued discharge are required.

4.10.3 DISADVANTAGES

4.10.3.1 Existing Waste Sites

The primary disadvantage of the preferred strategy is that dedication for waste management purposes would be required for those sites in which waste was not removed and that could not be returned to public use after the institutional control period.

4.10.3.2 New Disposal Facilities

The disadvantages of new disposal facilities are twofold:

- The high cost of construction and operation, some land dedication, and grouting of waste packages could make retrieval difficult.

- Additional costs would be required in future for treatment and disposal of wastes placed in retrievable storage.

4.10.3.3 Discharge of Disassembly-Basin Purge Water

A disadvantage of mitigation of tritium releases is the long lead time associated with continued studies and implementation of feasible measures. Optimistic estimates for detritiation to reach its full potential range from 5 to 10 years.

4.10.4 ENVIRONMENTAL IMPACTS

4.10.4.1 Groundwater

Existing Waste Sites

The implementation of the preferred strategy at selected existing waste sites, plus closure and remedial actions as required, would reduce onsite groundwater contaminant concentration levels to meet applicable standards. Potential drawdown effects in water-table aquifers would be localized and transitory and would be observed throughout groundwater remedial actions that employed recovery wells or groundwater pumping.

New Disposal Facilities

All new disposal and storage facilities would be designed for essentially zero or ALARA releases. No significant adverse groundwater effects are expected as a result of the implementation of the preferred strategy.

Discharge of Disassembly-Basin Purge Water

The continued discharge of disassembly-basin purge water to active reactor seepage and containment basins would maintain the current level of effects to groundwater. An assessment of mitigation measures for tritium releases, such as reactor moderator detritiation, could result in the establishment of feasible technologies in the future that would reduce tritium concentrations.

4.10.4.2 Surface Water

Existing Waste Sites

The implementation of the preferred alternative could result in an improvement of surface-water quality. Waste removal, closure, and remedial activities, if required, would reduce the level of surface-water contaminant concentrations to regulatory limits or below.

New Disposal Facilities

No significant impacts to surface-water quality are expected with the implementation of the preferred alternative strategy. The goals of RCRA (i.e., essentially no releases from hazardous or mixed waste facilities) and the ALARA concept for low-level radioactive waste facilities would ensure insignificant levels of impact.

Discharge of Disassembly-Basin Purge Water

Existing surface-water effects from groundwater outcrops of reactor seepage basin subsurface flows would continue. Travel times vary from 4 to 11 years, allowing for partial radioactive decay of the tritium (12.3-year half-life). Transport modeling indicates there is little lateral dispersion of migrating tritium in these paths. Detritiation or other mitigation measures, if applicable, would result in a reduction of tritium concentrations in onsite streams.

4.10.4.3 Health Effects

Existing Waste Sites

The implementation of the preferred alternative would result in no increase in health effects with waste removal, closure, and remedial actions at existing waste sites.

New Disposal Facilities

Essentially zero release and the ALARA design would prevent radionuclide and hazardous chemical health effects.

Discharge of Disassembly-Basin Purge Water

No significant health effects would occur as a result of the continued discharge of disassembly-basin purge water to active reactor seepage and containment basins.

4.10.4.4 Ecology

Existing Waste Sites

The removal of wastes at selected sites and closure and remedial actions, as required, would reduce potential aquatic impacts as a result of the implementation of the preferred alternative strategy. Terrestrial impacts that result from direct exposure to open waste sites and groundwater-associated impacts would be eliminated by waste removal at selected sites and closure and remedial actions as required. The use of borrow pits for backfill in closure actions would create minor short-term terrestrial impacts.

New Disposal Facilities

No aquatic impacts are expected from the implementation of the preferred strategy for new disposal and storage facilities. The strategy would result in minor short-term impacts from the clearing and development of land. No contaminant-related terrestrial impacts are expected, due to zero release or ALARA designs of new facilities.

Discharge of Disassembly-Basin Purge Water

Minor aquatic impacts would continue, as at present, under continued or mitigated discharge to active reactor seepage and containment basins. No significant terrestrial ecological impacts are expected.

4.10.4.5 Other Impacts

Existing Waste Sites

Short-term disruptions of habitats could occur at borrow pit areas. Some waste sites could require erosion-control measures during site-closure activities. No impacts are expected to endangered species, archaeological and historic sites, or socioeconomic resources, or from noise as a result of the implementation of the preferred strategy.

New Disposal Facilities

Construction of disposal and storage facilities for the preferred strategy would result in a loss of habitat totaling about 400 acres, or about 0.2 percent of the entire SRP natural area. No impacts are expected for endangered species, socioeconomic resources, nor are any noise-related impacts anticipated. One candidate waste-disposal site would require an additional archaeological survey.

Discharge of Disassembly-Basin Purge Water

No significant impacts to habitats or wetlands are expected from the implementation of the preferred strategy. Endangered species, archaeological and historic sites, and socioeconomic resources would not be impacted, nor would there be noise-related impacts.

4.10.5 ACCIDENTS AND OCCUPATIONAL RISKS

4.10.5.1 Existing Waste Sites

Waste removal and transport to storage and disposal sites by vehicles involve the risks of fires, spills, leaks, and exposure of onsite workers. These are short-term risks, occurring only during waste-removal activities.

4.10.5.2 New Disposal Facilities

High-integrity containers, spill recovery, and other secure provisions would reduce contaminant-related impacts from accidents. Long-term handling of wastes (20-year estimated facility lifetimes) requires strict control measures.

4.10.5.3 Discharge of Disassembly-Basin Purge Water

No significant occupational risks are associated with the preferred alternative.

4.10.6 SITE DEDICATION

4.10.6.1 Existing Waste Sites

Sites from which waste was removed could be returned to public use after the 100-year institutional control period. Sites from which waste was not removed would be dedicated for waste management purposes if they could not be returned to public use.

4.10.6.2 New Disposal Facilities

New disposal facilities would be dedicated for waste management purposes. About 400 acres, including buffer zones, would be required, except for the retrievable-storage-facility portion, which could be returned to public use after wastes had been removed to permanent disposal facilities.

4.10.6.3 Discharge of Disassembly-Basin Purge Water

Seepage and containment basins would be dedicated as needed due to the continued discharge of disassembly-basin purge water to these basins. The implementation of feasible mitigation measures would allow DOE to discontinue the use of the basins and evaluate actions to return them and their surrounding areas to public use after the 100-year institutional control period.

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CHAPTER 5

STUDIES AND MONITORING

Since 1951, an intensive environmental surveillance program has been conducted at the Savannah River Plant (SRP). This program involves monitoring the compositions of effluents from SRP facilities, measuring radioisotope and chemical concentrations in the SRP environs, assessing the ecological health of the overall SRP environment, and determining SRP compliance with applicable standards. Analytical studies supplement the measurements and yield assessments of the impacts of operations. The results of this environmental program are reported annually to the public (e.g., Zeigler et al., 1986).

The SRP environmental monitoring program for radioactivity is one of the largest and most comprehensive in the United States. In recent years, monitoring has been performed in a 5180-square-kilometer area in the immediate vicinity of the Plant, and representative samples were collected from an additional 77,700-square-kilometer area. In this entire area of 82,880 square kilometers, 20 types of samples were collected and analyzed for all types of radioactivity. In 1985, approximately 65,000 analyses were performed on 15,000 samples. Approximately 465,000 samples and 1,685,000 analyses have been generated since the environmental radioactive monitoring program began in 1951 (Du Pont, 1985a; Zeigler et al., 1986).

The environmental surveillance program includes the monitoring of onsite and offsite air, water from SRP streams and the Savannah River, SRP groundwater, and samples of soil, vegetation, food, drinking water, animals, and fish for their radionuclide content. In addition, the U.S. Department of Energy's (DOE's) Remote Sensing Laboratory conducts periodic aerial radiological surveys of the Plant and surrounding areas. The South Carolina Department of Health and Environmental Control (SCDHEC) and the Georgia Department of Natural Resources (GDNR) also conduct independent radiological monitoring programs in the vicinity of SRP (DOE, 1984a).

In addition to monitoring for radioactivity, the Plant monitors the physical properties (e.g., temperature) and nonradioactive chemical and metal content of liquid effluents, streams, groundwater, and the Savannah River. It also monitors drinking water, sediment, and air for potential contaminants. This program generated approximately 4000 samples and 40,000 analyses in 1985. SRP laboratories performed some of the analyses, but offsite commercial laboratories have performed most groundwater and liquid effluent discharge nonradioactive analyses (Du Pont, 1985a; Zeigler et al., 1986).

The following sections describe recent studies and monitoring activities associated with the management of wastes on the Plant. (For details of other studies and monitoring programs, see Du Pont, 1985a; Zeigler, Lawrimore, and O'Rear, 1985; Zeigler et al., 1986; GDNR, 1983; and SCDHEC, 1983.)

5.1 MONITORING REQUIREMENTS AND COMMITMENTS

Much of the monitoring activities and studies are in response to specific regulations and DOE commitments. For example, the South Carolina Hazardous

Waste Management Regulations (SCHWMR), require groundwater monitoring at the F- and H-Area seepage basins and the M-Area settling basin interim-status facilities. Specifically, the uppermost aquifer must be monitored with at least one upgradient and three downgradient wells. Table 5-1 lists the three classes of monitored parameters and the sampling frequencies. The groundwater surface elevation must be determined each time a sample is taken. A groundwater sampling and analysis plan must be developed to guide these activities. This plan must include sample collection, preservation, and shipment techniques; analytical procedures; and chain-of-custody controls.

The SCHWMR and the Resource Conservation and Recovery Act (RCRA) require detection and compliance monitoring of the groundwater. Detection monitoring is monitoring performed to determine if contaminants have been introduced into the groundwater as a result of waste management facility operation. It involves a statistical evaluation of the quality of groundwater upgradient and downgradient from the facility. Such monitoring is performed at both an upgradient location and at the so-called compliance point, an imaginary surface at a specific location at which concentrations of contaminants cannot exceed established limits. Once contamination is detected, compliance monitoring is begun to assess whether the contamination exceeds the limits. If so, and the exceedance can be traced to releases from the facility, corrective actions must be taken to reduce concentrations to below standards.

On November 7, 1985, representatives of DOE and SCDHEC signed Administrative Consent Order 85-70-SW. In signing this consent order, DOE committed to the following studies and monitoring activities:

- Complete installation of monitoring wells at the compliance points at M-, F-, and H-Areas within 120 days of SCDHEC approval of locations, depths, and construction, but no later than the date specified by the SCDHEC in its approval of the Part B Permit Application. The locations, depths, and construction are to be in accordance with the requirements of SCHWMR for compliance-point monitoring wells.

- Submission of quarterly status reports on M-, F-, and H-Areas, summarizing the results of determinations made under SCHWMR. The SCDHEC will approve or comment on each report within 30 days of receipt.

Another DOE commitment concerns the funding and implementation of the Groundwater Protection Plant for the SRP pursuant to Public Law 98-181: all groundwater mitigation proposals will be subject to the National Environmental Policy Act (NEPA) review process.

Public Law 98-181 (DOE, 1984b, Appendix A), enacted in November 1983, required discontinuation of the use of the seepage basin in the 300-M Area of the Savannah River Plant within 2 years of the date of enactment and developing a plan for protecting groundwater at the Plant. The purpose of the plan was to identify components of the groundwater-protection program, as mandated by Public Law 98-181. It includes the schedule for discontinuing the use of the 300-M Area seepage basin; provisions for discontinuing the use of seepage basins associated with 200-F and 200-H Areas; provisions for the implementation of other actions to mitigate any significant adverse effects of onsite or offsite groundwater and of chemical contaminants in seepage basins and adjacent areas, including the removal of such contaminants where necessary; and

Table 5-1. South Carolina Hazardous Waste Management Regulations: Groundwater-Monitoring Analyses[a]

Parameter	Collection frequency	Concentration limit[b]
	DRINKING WATER	
Arsenic	Quarterly for first year	0.05
Barium		1.0
Cadmium		0.01
Chromium		0.05
Fluoride		1.4-2.4
Lead		0.05
Mercury		0.002
Nitrate-nitrogen		10
Selenium		0.01
Silver		0.05
Endrin		0.0002
Lindane		0.004
Methoxychlor		0.1
Toxaphene		0.005
2,4-D		0.1
2,4,5-TP Silvex		0.01
Radium		5 pCi/liter
Gross alpha		15 pCi/liter
Gross beta		4 mrem/yr
Turbidity		1 TU
Coliform bacteria		1 per 100 ml
	GROUNDWATER QUALITY	
Chloride	Quarterly for first year; at least annually thereafter	None
Iron		
Manganese		
Phenols		
Sodium		
Sulfate		
	GROUNDWATER CONTAMINATION	
pH	Quarterly for first year; at least semi-annually thereafter	None
Specific conductance		
Total organic carbon		
Total organic halogen		

[a]SCHWMR R.61-79.265.90-.94
[b]In milligrams per liter unless otherwise indicated.

provisions for continuing the expanded program of groundwater-impact monitoring, in consultation with the appropriate South Carolina agencies (DOE, 1984b).

In response to commitments made in the GWPP, DOE has accomplished the following:

- Discontinued the use of the M-Area settling basin (DOE, 1985a)
- Completed the 300-M Area effluent-treatment facility (ETF)
- Initiated cleanup of volatile organic compounds in the M-Area groundwater (DOE, 1985a) via groundwater recovery wells and an air stripper
- Submitted a preliminary engineering report for the F- and H-Area ETF
- Completed a report describing the hydrogeology of the Plant and identified groundwater contamination (Du Pont, 1983)
- Developed an implementation plan for mitigation actions at those waste sites discussed in the preceding item (DOE, 1984b, Appendix D)
- Completed Phases I and II of the SRP Baseline Hydrogeologic Investigation (Bledsoe, 1984; Zeigler et al., 1986)

An SRP Baseline Hydrogeologic Investigation Program has been implemented to address the stratigraphic and hydrogeologic data needs of the Plant. The immediate objective of this program is the installation of 17 or 18 clusters of approximately eight wells each at key locations across the Plant. The wells will (1) provide information on the lithology, stratigraphy, and hydrogeology of the Plant, and (2) serve as high-quality observation wells for monitoring the groundwater quality, hydraulic-head relationships, gradients, and flow paths, and for tracking parameter changes as water use changes on and off the Plant.

The program has three phases:

- Phase I (completed 1984) - installation of 20 observation wells at three cluster sites
- Phase II (completed 1985) - installation of 56 observation wells at eight cluster sites
- Phase III (final phase ongoing) - installation of a total of 132 wells

Phases I and II concentrated on the collection of data from SRP areas on which little or no data existed. Phase III is designed to fill data gaps. The benefit of the entire program will be the establishment of a reliable, high-quality SRP hydrogeologic data base (Bledsoe, 1984; Zeigler et al., 1986).

5.2 EXISTING WASTE SITE MONITORING

The groundwater underlying the Plant is subject to a continuing program of analysis for radioactive and nonradioactive constituents. Many monitoring wells have been installed in the water-table and underlying aquifers at waste disposal sites to gather information about the fate of materials discarded at these sites (Du Pont, 1983).

Several improvements were made in well construction and sampling technique in 1984 and 1985. In 1984, pumps were installed to provide adequate flushing of wells before sampling. In addition, all samples for metals analyses were filtered before preservation. These steps were taken because results indicated that inadequate flushing and particulate matter in the samples analyzed for metals were contributing to the questionable results that had been obtained previously (Zeigler, Lawrimore, and O'Rear, 1985).

In 1985, galvanized well casings were removed from service and replaced by polyvinyl chloride (PVC) casings. Galvanized casings contributed to apparent contamination by several metals (zinc, cadmium, lead, and iron). Subsequent sample analyses have confirmed this relationship (Zeigler et al., 1986).

Groundwater is monitored at 46 potential hazardous and mixed waste management facilities. SCDHEC has permitted 4 of the 46 locations as interim-status hazardous waste management facilities. Three of the four are seepage basins (F-Area, three basins; H-Area, four basins; and M-Area, one basin and a lake) that have been used for many years to dispose of wastewater containing a variety of industrial chemicals. The only other interim-status facility (Building 709-G) is a hazardous waste storage facility that was placed in operation in 1984.

Contamination of plants can result from the absorption of radioactive materials from the soil or from radioactivity deposited from the atmosphere. Soil and grass (generally bermuda) are analyzed routinely for radioactivity because of their year-round availability and large surface coverage.

5.2.1 F- AND H-AREAS

Routine environmental monitoring is conducted at the F- and H-Area seepage basins (Ashley, Padezanin, and Zeigler, 1984; DOE 1985b; Zeigler, Lawrimore, and O'Rear, 1985; Zeigler et al., 1986). For radiation monitoring, composite samples of the influent flow of the basins are taken from the flow proportional continuous monitor once a week. In addition, dip samples from the basins and groundwater monitoring well samples are taken once a quarter. The vegetation surrounding the basins is sampled once a year. Each sample is analyzed for gross alpha and beta, gamma spectrum, and strontium-89 and 90. The radioactivity released to the seepage basins is reported in the Health Protection Monthly Radioactive Release Report.

Monitoring wells were installed in 1951. These wells are used to measure water-table elevations in the Separations Area. They are also used to monitor any groundwater contamination within the vicinity of F- and H-Areas. These wells were sampled once in 1985 for radioactivity (Zeigler et al., 1986).

Soil samples were collected from the four quadrants around the F- and H-Areas and at the SRP boundary. In addition, two control samples were taken approximately 160 kilometers from the SRP. Soil cores were composited by location and analyzed for plutonium-238 and 239, strontium-90, and gamma-emitting radionuclides (Zeigler et al., 1986). The migration of radioactivity from the

F- and H-Area seepage basins was measured with continuous samplers and flow recorders in Four Mile Creek. Groundwater from the F-Area seepage basin flows to outcrops on Four Mile Creek (FM) between two sample locations.

Most of the H-Area seepage basin outcrop from basins 1 through 3 occurs between two sample locations. Additional outcrop from H-Area seepage basin 4 and the burial ground occurs between two other sample locations. The tritium from these two facilities mixes; beyond this mixing point the source of tritium cannot be determined.

<u>F-Area Seepage Basins</u>

In 1985, groundwater at the F-Area seepage basin was monitored routinely at eight wells. The radioactivity detected in these wells will be diluted by groundwater and eventually will either decay or flow with groundwater to Four Mile Creek. Acid, sodium, and nitrate have also been detected at the seepage basin compliance point; accordingly, detection monitoring has been replaced by compliance monitoring, as required by the SCHWMR and the RCRA.

<u>H-Area Seepage Basins</u>

Groundwater below the H-Area seepage basins was monitored routinely at 16 wells between the seepage basins and Four Mile Creek.

<u>H-Area Retention Basins</u>

In 1985, wells were installed around the two H-Area retention basins.

5.2.2 RADIOACTIVE WASTE BURIAL GROUNDS

A program to monitor the migration of radionuclides from their storage locations has been under way since the startup of the waste-disposal/storage site. The U.S. Army Corps of Engineers installed the first monitoring wells (nine perimeter wells) in 1956. Monitoring has increased over the years of operation, and additional wells were installed in 1963 and 1969. In 1972 and 1973, 11 new wells were installed in this area; in 1975, 35 wells were installed at the perimeter of the burial ground (Buildings 643-G and 643-7G). Sixteen of the wells installed between 1963 and 1975 replaced the nine original perimeter wells. In 1978 and 1979, five new cluster wells were installed at the perimeter of the burial ground outside the fenced area. Groundwater at the burial ground is analyzed quarterly for alpha, nonvolatile beta, and tritium. Routine monitoring is performed at 16 wells inside the facility and 58 wells along the perimeter. In addition, there is an extensive grid monitoring system of 73 wells for migration and modeling studies (DOE 1985b; Zeigler, Lawrimore, and O'Rear, 1985; Zeigler et al., 1986).

The area around the waste monitoring trailer has a history of contaminated vegetation that goes back to 1965, when vegetation contaminated with strontium-89 and 90 was found. Soil core samples at that time indicated high concentrations of nonvolatile beta within 0.6 meter of the surface of the soil. The area was cleared of vegetation and treated with a herbicide at that time.

During 1985, vegetation was collected inside the radioactive waste burial ground (Buildings 643-G and 643-7G). The samples were analyzed to determine if the vegetation had experienced a significant uptake of radioactivity from the waste buried there.

Vegetation collected from 51 locations inside the burial ground was composited by location for analysis. This collection method provides coverage of a large part of the facility while keeping the number of samples to a minimum. The samples were analyzed for alpha, nonvolatile beta, and gamma emitting radionuclides (DOE 1985b; Zeigler, Lawrimore, and O'Rear, 1985; Zeigler et al., 1986).

In 1985, an extensive system of 89 groundwater monitoring wells was sampled for concentrations of alpha, nonvolatile beta, and tritium in the groundwater beneath the solid waste storage facility. Some of these wells are used for routine monitoring; others are used for research to determine possible migration pathways and for development of groundwater models.

5.2.3 REACTOR SEEPAGE BASINS

Groundwater is currently monitored at 127 wells in and around the various seepage basins (Zeigler et al., 1986).

In addition, vegetation samples were collected near each reactor seepage basin. Samples from a maximum of eight locations outside the fence of each seepage basin were composited for alpha, beta, strontium-89, and strontium-90 analyses (Zeigler et al., 1986).

5.2.4 M-AREA

Compliance monitoring is presently being performed at the M-Area settling basin. This compliance monitoring is in response to the detection in 1984 and 1985 of halogenated organics, nitrate, and sodium (Zeigler et al., 1986).

5.2.5 OTHER MONITORING ACTIVITIES

Because the environmental monitoring program at the SRP is one of the largest and most comprehensive in the United States, this EIS cannot describe all of the studies and monitoring activities conducted at the SRP. More information on such activities can be obtained from Du Pont, 1985a,b; Zeigler, Lawrimore, and O'Rear, 1985; Zeigler et al., 1986; GDNR, 1983; and SCDHEC, 1983. However, in response to this EIS, the South Carolina Institute of Archaeology and Anthropology, University of South Carolina, conducted an intensive archaeological and historical survey of 82 existing hazardous, low-level radioactive, and mixed waste sites located in the upland sandhills zone of the SRP (Brooks, 1986). The Institute also carried out an intensive archaeological and historical survey and testing of six new low-level radioactive, hazardous, and mixed waste storage and disposal facilities located primarily in the same area (Brooks, Hanson, and Brooks, 1986).

5.2.5.1 Drinking-Water Monitoring

Communities near the Plant get drinking water from deep wells or surface-water bodies. Drinking-water supplies from 22 onsite facilities and 14 surrounding towns are sampled and analyzed for alpha, nonvolatile beta, and tritium. In addition, the SRP and SCDHEC routinely analyze water from 14 SRP drinking-water sources for the total number of bacteria multiplying at 35°C on an agar medium (standard plate count), total coliform bacteria, pH, and residual chlorine. They also analyze some systems for turbidity, hardness, and carbon dioxide (Zeigler et al., 1986).

5.2.5.2 Surface-Water Supplies

Two water treatment plants downstream from the Plant supply treated Savannah River water to customers in Beaufort and Jasper Counties, South Carolina, and in Port Wentworth, Georgia. The Beaufort-Jasper plant serves a consumer population of approximately 50,000. Treated water from the Port Wentworth plant is used primarily for manufacturing and other industrial purposes. The Port Wentworth water treatment plant has an effective consumer population of about 20,000.

Samples of raw and finished water at both plants are collected daily and composited for monthly alpha, nonvolatile beta, and tritium analyses. Additional monitoring of raw and finished water from the plants for low levels of cobalt-60 and cesium-137 is provided by continuous samplers. Results of 1985 analyses for alpha, nonvolatile beta, tritium, cobalt-60, and cesium-137 were reported quarterly to the plants and to the States of Georgia and South Carolina. SCDHEC performs independent tritium and nonvolatile beta analyses of water samples at the Beaufort-Jasper treatment facility. Results of these analyses are compared to SRP data. GDNR also collects drinking-water samples from the Port Wentworth facility monthly and analyzes them for alpha, nonvolatile beta, and tritium concentrations (DOE, 1984a).

5.2.5.3 Groundwater Supplies

The SRP collects groundwater samples from several monitoring wells and analyzes them for radioactivity (Du Pont, 1985a). The SCDHEC monitors for concentrations of alpha, nonvolatile beta, and tritium in groundwater from wells in six nearby communities and from additional wells around the Barnwell Nuclear Fuel Plant. The GDNR monitors for the same parameters at 10 Georgia locations. Both State programs are conducted quarterly (DOE, 1984a).

5.3 EXISTING WASTE SITES - FUTURE MONITORING

5.3.1 GROUNDWATER QUALITY ASSESSMENT PLAN

The Groundwater Quality Assessment Plan was designed to determine the extent, concentration, and rate of migration of hazardous waste constituents in the groundwater system. The plan involves monitor-well installation, water-quality sampling and analysis, hydrogeologic data collection, and data evaluation (Du Pont, 1985c).

5.3.1.1 M-Area Settling Basin

To define the extent and concentration of waste constituents in the groundwater at M-Area, a two-phase well-installation program was designed. Phase I, initiated in September 1984, consisted of the installation of 58 monitor wells in 15 clusters. The placement of the wells was designed to expand, horizontally and vertically, the existing monitoring network. The installation of the Phase I wells was completed in May 1985 (Du Pont, 1985c).

A hydrogeologic data collection program was incorporated as an integral part of the Groundwater Quality Assessment Plan (Du Pont, 1985c). The objectives of this program are to define the geometry of the pertinent hydrologic units at the site and to quantify the water retention and transmission characteristics of each unit. The hydrogeologic data collection program has three basic program elements: (1) geologic data collection and testing, (2) aquifer pump testing, and (3) potentiometric data collection.

The final element of the Groundwater Quality Assessment Plan is evaluation of the data. Graphic, analytic, and numeric techniques are used to determine the extent of groundwater contamination and the rates of contaminant migration. DOE submits annual reports of groundwater-quality assessment to SCDHEC. These assessment reports will propose and describe required additional studies.

5.3.1.2 F-Area Seepage Basins

In F-Area, 17 wells in four hydrogeologic zones will be monitored quarterly for the indicator parameters and groundwater-quality parameters listed in Table 5-1. All these parameters will be monitored annually. In addition, the indicator parameters will be monitored semiannually. This semiannual sampling will include nitrate and sodium. Other constituents identified as groundwater contaminants will be added to the monitoring program (Du Pont, 1985c).

This monitoring program will be used to detect any hazardous constituents that might enter the groundwater from the F-Area basins. Each quarter, the analyses will be studied for the appearance of hazardous constituents and changes in groundwater flow rate or direction. The annual groundwater-quality assessment reports will present the results. These reports will also propose and describe required studies (Du Pont, 1985c).

5.3.1.3 H-Area Seepage Basins

In H-Area, 28 wells in four hydrogeologic zones will be monitored quarterly for the indicator parameters and groundwater-quality parameters listed in Table 5-1, and for mercury, sodium, and nitrate. Other constituents identified as groundwater contaminants will be added to the monitoring program as identified (Du Pont, 1985c). The annual groundwater-quality assessment reports will present results of these analyses, along with information from F- and M-Areas. These reports will also describe additional studies or monitoring activities required.

5.3.2 MONITORING ASSOCIATED WITH WASTE MANAGEMENT FACILITY CLOSURE AND POSTCLOSURE

DOE submitted closure plans for the metallurgical laboratory basin (Du Pont, 1985d) and the mixed waste management facility (DOE, 1985c), and a postclosure permit application for the M-Area hazardous waste management facility (DOE, 1985a), to SCDHEC in 1985, in accordance with the SCHWMR. The following sections describe the monitoring commitments associated with these closure and postclosure plans.

5.3.2.1 Metallurgical Laboratory Basin

Monitoring commitments associated with closure of the metallurgical laboratory basin include the commitment to monitor wells 1A, 2, and 3A quarterly for the parameters listed in Table 5-1 (Du Pont, 1985d).

5.3.2.2 Mixed Waste Management Facility

The DOE will complete the following in conjunction with site closure: a borrow study to identify sources of material for the final cover; a compaction study to determine the physical characteristics of the waste and overburden; and studies of the effects of overburden on subsidence in the trenches (DOE, 1985c).

In addition, the DOE has proposed a detection monitoring program to determine if groundwater contamination is occurring. The proposed monitoring well system will determine the quality of both background groundwater (i.e., groundwater not affected by operations of low-level radioactive waste disposal facilities) and groundwater past the point of compliance. The monitoring of downgradient groundwater quality at the compliance point is required by RCRA.

The detection monitoring system will consist of 27 wells, including the upgradient wells. This system assumes three wells per cluster in the uppermost aquifer. Each cluster will have three screened zones with discrete functions: the uppermost screen will monitor the zone near the top of the water table; the middle screen will monitor the zone above the "tan clay" near the top of this subunit; and the bottom screen will monitor the lowermost strata of the aquifer near the top of the "green clay." The exact number of wells per cluster will be determined during drilling when the lithology has been assessed. To provide an accurate groundwater characterization, the background monitoring well cluster will be approximately 1370 meters from the mixed waste management facility. The remaining 24 detection monitoring wells will be downgradient wells (DOE, 1985c).

The detection well system will fulfill RCRA requirements. Data from the proposed well clusters will describe thoroughly the site hydrogeology in the uppermost aquifer for the mixed waste management facility.

5.3.2.3 M-Area Settling Basin and Lost Lake

Hazardous constituents have been detected during interim-status monitoring at the M-Area settling basin and Lost Lake. Therefore, detection monitoring is not applicable to this site, and compliance point monitoring will be performed (DOE, 1985a).

The compliance groundwater monitoring well system will consist of nine downgradient wells grouped in three clusters, and one upgradient cluster of three wells. The upgradient well cluster will be 122 meters from the M-Area settling basin on the axis of the groundwater ridge. Because the M-Area basin is approximately 30 meters above the water table, leakage from the basin might cause water-table mounding beyond the areal limits of the basin. Placing the upgradient wells 122 meters from the basin will preclude facility-induced contamination (DOE, 1985a).

5.3.3 WASTE SITE CHARACTERIZATION PROGRAM

The Savannah River Laboratory is developing and implementing characterization programs for determining the extent of chemical and/or radionuclide contamination at SRP waste sites. The data collected from these programs will provide the technical basis for the final closure of these waste sites according to applicable State and Federal regulations. Characterization programs have been completed for the Savannah River Laboratory (SRL), M-Area, Old TNX, and metallurgical laboratory seepage basins. Additional characterization programs are in progress for the L-Area oil and chemical basin and the Ford Building seepage basin and are planned for the New TNX seepage basin (Zeigler et al., 1986).

5.3.4 STUDY OF TRITIUM CONTAMINATION OF CONGAREE GROUNDWATER

To define the extent of tritium contamination of the Congaree Formation groundwater beneath H-Area, the following studies have been proposed:

- Determine if well cluster 84 is the source of well 84A contamination
- Determine the direction of Congaree flow at well 84A
- Perform upgradient resistivity and conductivity studies
- Assess the need for additional wells

5.4 NEW DISPOSAL FACILITIES

5.4.1 HAZARDOUS AND SOLID WASTE AMENDMENTS OF 1984 - CONFERENCE REPORT 98-1133 (PENDING REGULATORY ACTION)

New landfills and surface impoundments, as well as replacement units and expansions of existing facilities, were required to meet minimum technological requirements (MTRs) after November 8, 1986. These requirements include a double liner, a leachate collection system, a leak detection system for new units after May 1987, and groundwater monitoring.

The Hazardous and Solid Waste Amendments of 1984 (HSWA) nullify the current exemption from groundwater monitoring for double-lined facilities, but they permit the U.S. Environmental Protection Agency (EPA) to grant individual exemptions if stringent leakage prevention requirements are met.

With certain exceptions, existing surface impoundments operating under interim status must comply with the new MTRs by November 8, 1988. The exceptions are (1) surface impoundments with one nonleaking liner at which groundwater monitoring is conducted and which are located more than 0.4 kilometer from an underground drinking-water source, and (2) wastewater treatment impoundments that satisfy certain prescribed standards.

EPA was required to promulgate regulations by May 8, 1986, for the monitoring and control of air emissions at hazardous waste treatment, storage, and disposal facilities. Such facilities include, but are not limited to, monitored retrievable storage facilities, surface impoundments, and landfills such as the new disposal facilities for low-level radioactive wastes and mixed wastes.

To comply with the HSWA, DOE submitted an Exposure Information Report (EIR) to SCDHEC and EPA in August 1985. The EIR contained information important to assessing the potential for exposure of the public to waste disposal in the interim-status facilities (Zeigler et al., 1986).

5.4.2 PROPOSED MONITORING AT NEW DISPOSAL FACILITIES

The groundwater monitoring system at the new disposal facilities must permit determination of the impact of these facilities on groundwater in the aquifers above the Tuscaloosa. The system must have the following features:

- Well placement that will permit the collection of representative samples of groundwater, including groundwater upgradient from the facility
- Casings that will maintain the integrity of the monitoring-well bore
- Measures to prevent the contamination of groundwater samples

To meet the above requirements, the monitoring system will consist of a series of well clusters spaced about every 46 meters along the perimeter of a facility. The wells will have 6-meter screens placed at 15-meter depth intervals to the top of the Ellenton Formation (Cook and Towler, 1985, 1986).

The monitoring program will involve the collection of monthly samples from each monitoring position. The samples will be analyzed for chemical (inorganic and organic) and radionuclide species expected to be in the waste that is disposed of or stored in the facilities.

Surface water in the vicinity of the new storage and disposal facilities will be monitored for chemicals and radionuclides; it will consist of the rainwater runoff and standing water in streams that draw water from the land area around the facility. The storage and disposal facilities will have an engineered surface-water drainage system that will impound the water in one or more locations for monitoring and treatment, if needed, before releasing it to plant streams.

Air monitoring will be provided as needed, depending on the amount of rainfall in the area. Moreover, rainfall and air collection and monitoring systems will be in operation on the perimeter of the storage and disposal facilities. Such systems have been in use on the Plant for many years; they collect rainfall and examine it for radioactivity, or collect air samples on filters and examine them (Cook and Towler, 1985, 1986).

5.5 ANALYTICAL STUDIES

Analytical studies are designed to use and supplement the data gathered in the monitoring studies described previously in this chapter. Such analytical studies can be used to increase knowledge of (1) the site, (2) the impacts of site operations on the environment, and (3) actions required to mitigate the environmental impacts of site operations. Appendix H contains details on the models used in this analysis and the basis for their selection.

5.5.1 GROUNDWATER-FLOW MODELING

The SRL manages the regional groundwater-flow modeling program. This program is a management tool that helps planners make decisions about groundwater resources at the Plant. Modeling is conducted in three phases (Zeigler et al., 1986):

- System conceptualization
- Model calibration
- Simulation

Under this program, a numerical groundwater-flow model was developed for a 78-square-kilometer area that underlies the 3/700-Area. The purpose of this model is to predict and evaluate the efficacy of the groundwater remedial-action program. The model was used to simulate the flow patterns of groundwater and the effects of recovery-well operations on these patterns. After an initial model calibration, various pumping scenarios were examined. The results were used to relocate two perimeter wells of the recovery-well network to enhance chlorocarbon-plume capture.

5.5.2 ENVIRONMENTAL INFORMATION DOCUMENTS AND PATHRAE MODELING

For the preparation of this EIS, DOE requested that E. I. du Pont de Nemours and Company (Du Pont) provide technical support of groundwater modeling, human health risk assessment, and ecological impacts for the alternatives associated with the closure of hazardous, low-level radioactive, and mixed waste sites, and for the proposed disposal facilities.

Du Pont categorized the existing waste sites that were originally identified for inclusion in the EIS into 26 functional groupings. The technical approach involved preparing an Environmental Information Document (EID) for each of the 26 groupings (complete reference citations for the 26 EIDs are given in Appendixes B and E). Part I of each EID, which encompasses the nature of contaminant disposal, the geohydrologic setting, and waste site characterization, was completed in 1985. Part II, which includes estimates of environmental hazards associated with each closure option for each grouping, was completed late in 1986. Environmental Information Documents for the proposed new disposal facilities were also prepared.

The PATHRAE computer code was chosen to calculate the human health risks associated with the subsurface transport of contaminants. PATHRAE was originally developed for the EPA for performance assessment calculations at low-level radioactive waste disposal sites. The code has been modified to perform transport and risk calculations for nonradioactive constituents. Pathways modeled using PATHRAE include

- Groundwater to wells
- Groundwater to surface streams
- Waste erosion and movement to surface streams
- Consumption of food from a reclaimed farm over the waste site
- Consumption of crops from natural biointrusion into the basin
- Direct gamma exposure

Computer code calculations were also made to determine, for each waste site alternative, the risks to human populations from the atmospheric transport of contaminants. Atmospheric pathways evaluated include the inhalation of polluted air, the ingestion of contaminated foodstuffs by individuals and the off-site population, and the risks to occupational personnel from airborne contaminants generated during actual waste site closure operations. The computer codes used to model the atmospheric pathways are SESOIL, MARIAH, XOQDOQ, CONEX, TERREX, MILENIUM, MAXIGASP, and POPGASP (see Appendix H for more details).

5.5.3 TRANSPORT OF HEAVY METALS AND RADIONUCLIDES

Research continues on the development of a geochemical model for predicting the chemical speciation, mass transport, and fate of metals and radionuclides in aquatic systems on the Plant. The geochemical model MEXAMS (Metal Exposure Analysis Modeling System) has been installed on the site computer system. The basic components of MEXAMS are the geochemical model MINTEQ and an aquatic exposure assessment model, EXAMS. The interfacing of these two models provides information on the chemistry and behavior of metals, as well as the transport processes influencing their migration and ultimate fate in aquatic systems. Simulations for cadmium, copper, and nickel in SRP streams indicate that the MEXAMS model will be a useful tool in predicting the transport and fate of metals (Zeigler et al., 1986).

5.5.4 ENVIRONMENTAL RADIOMETRICS

At present, a specially constructed ultra-low-level counting facility is being used to analyze concentrations of radioactive isotopes at environmental-background levels. Other analyses are being conducted to develop specific information about the transport and fate of long-lived radionuclides such as technetium, uranium, and plutonium. A state-of-the-art underground counting facility will improve sensitivity and sample processing.

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CHAPTER 6

FEDERAL AND STATE ENVIRONMENTAL REQUIREMENTS

This chapter summarizes the Federal and State of South Carolina environmental requirements that are applicable to the implementation of the proposed action for this environmental impact statement (EIS), which is the modification of waste management activities at the Savannah River Plant (SRP) for hazardous, low-level radioactive, and mixed wastes to protect groundwater, human health, and the environment. The purpose of the proposed action and the specific modifications considered is to identify and select a waste management strategy for SRP hazardous, low-level radioactive, and mixed wastes that can be implemented to achieve compliance with groundwater-protection requirements.

Section 6.1 describes general requirements that have broad applicability to SRP operations, including statutory requirements, administrative and executive orders, and an interagency agreement. Section 6.2 describes specific requirements for hazardous, low-level radioactive, and mixed waste management, and summarizes the applicability of these requirements to U.S. Department of Energy (DOE) operations.

6.1 GENERAL ENVIRONMENTAL REQUIREMENTS

6.1.1 NATIONAL ENVIRONMENTAL POLICY ACT

The National Environmental Policy Act (NEPA) was signed on January 1, 1970 (42 USC 434-1). Its purpose was to establish (1) a national policy for the protection of the environment and (2) the Council on Environmental Quality (CEQ). The CEQ issued its Final Guidelines for implementation on August 1, 1973. Congress amended NEPA on July 3, 1975, and again on August 9, 1975. On November 29, 1978, the CEQ proposed regulations implementing NEPA; the final regulations are codified in 40 CFR 1500-1508.

The requirements of NEPA specify that if a Federal action might have a significant effect on the quality of the human environment, the agency involved must prepare a detailed environmental impact statement.

6.1.2 EXECUTIVE ORDER 12088: FEDERAL COMPLIANCE WITH POLLUTION CONTROL STANDARDS

In addition to the authority of Congress and Federal and State administrative agencies to establish and enforce environmental standards, the President of the United States has the authority to issue Executive Orders (EOs) to clarify environmental policies. EO 12088 of October 13, 1978, "Federal Compliance with Pollution Control Standards," states that the head of each executive agency is responsible for ensuring that the agency takes all necessary actions for the prevention, control, and abatement of environmental pollution with respect to Federal facilities and activities under its control. Each agency head is also responsible for compliance with applicable pollution-control standards, such as those defined under the Clean Water Act (CWA) and Clean Air Act (CAA).

6.1.3 ADMINISTRATIVE ORDERS

DOE has developed a uniform system of communicating policy and procedures to its employees. The system is based on administrative directives, or DOE Orders, which contain information on procedures, responsibilities, and authorities for performing DOE's various functions.

In general, DOE Orders establish general policy guidance and assign general responsibility for implementation. At the Savannah River Plant, DOE Orders are implemented through Savannah River Operations Office Orders, which specify procedures and responsibilities for implementation. The numbering system for these Orders parallels that of the corresponding DOE Orders.

The following DOE Orders are generally applicable to waste management activities under the environmental and health and safety protection programs on the SRP:

- DOE Order 5480.1B, Environmental Protection, Safety, and Health Protection Standards

- DOE Order 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

Chapters I, XI, and XII of DOE Order 5480.1B have the most direct applicability to this EIS. Chapter I sets forth the environmental protection, safety, and health protection standards applicable to all DOE operations. DOE policy states that the Department will comply with all legally applicable Federal and State standards. In the event of conflicts between prescribed and recommended standards, those providing the greatest protection apply. This chapter also covers responsibilities and lines of authority for DOE officials. Chapter XI of this Order provides inter alia radiation-protection standards for occupational and nonoccupational exposures, and guidance on keeping exposures as low as reasonably achievable (ALARA). It also provides concentration guides for airborne effluents, liquid effluents, and drinking water, and establishes exposure standards aimed at achieving ALARA dosage rates for individuals and population groups in uncontrolled areas. This chapter also sets monitoring requirements to ensure that these standards are met. Chapter XII establishes requirements for DOE operations to ensure (1) control of sources of environmental pollution and (2) compliance with environmental protection laws and with EO 12088. DOE Order 5484.1 establishes the requirements and procedures for reporting information having environmental protection, safety, or health-protection significance for DOE operations.

6.2 SPECIFIC REQUIREMENTS

Since the passage of the Resource Conservation and Recovery Act (RCRA) in 1976 and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980, DOE has become subject to regulatory programs for the management of solid, nonradiological hazardous waste. The following sections summarize the specific requirements of these statutes and other environmental protection requirements applicable to Federal agencies.

6.2.1 ATOMIC ENERGY ACT

6.2.1.1 Federal Statute

Congress passed the Atomic Energy Act (AEA) of 1954 to ensure that research and development of atomic energy for both peaceful and military purposes were coordinated and timely, and that the processing of source, byproduct, and special nuclear materials would be managed in the national interest. The Act established the Atomic Energy Commission (AEC) to administer its provisions.

In 1974, the Energy Reorganization Act (Public Law 93-438) divided the responsibilities of the AEC between the Energy Research and Development Administration and the U.S. Nuclear Regulatory Commission. In 1977, the DOE Organization Act (Public Law 95-91) further centralized the administration of national programs related to energy-policy formulation, research and development activities, and demonstration-project development.

With respect to agency jurisdiction over waste management activities on SRP, the AEA (42 USC 2018) confers to DOE full jurisdiction over source, special nuclear, and byproduct materials. In addition, Section 84 of the AEA requires that management of byproduct materials must be performed in conformance with general standards of EPA that are applicable to similar hazardous material.

6.2.1.2 DOE Order 5820.2

On February 6, 1984, DOE issued Administrative Order 5820.2, which establishes policies and guidelines for the management of radioactive waste, waste byproducts, and radioactively contaminated surplus facilities. The objective of this Order is to ensure that DOE operations involving the management of radioactive waste, waste byproducts, and surplus facilities adequately protect the public health and safety in accordance with radiation-protection standards. This Order defines key terms and specifies lines of authority. Chapter III establishes the policies and guidelines for managing low-level waste, and specifies site selection, design criteria, and disposal-site operations. In addition, it details requirements for disposal, site closure, and postclosure. Chapter IV deals with the management of wastes contaminated with naturally occurring radionuclides. Chapter V discusses the decontamination and decommissioning of surplus facilities.

DOE has issued radiological protection guidelines for two programs that involve radioactive waste management and decontamination: the Formerly Utilized Sites Remedial Action Program (FUSRAP) and the Surplus Facilities Management Program. These guidelines, which are limited in scope to the two programs, use the latest technical data and emphasize the need for site-specific radionuclide concentration criteria for waste management and decontamination. They do, however, present Allowable Residual Contamination Limits (ARCLs) for a number of radionuclides and materials, including naturally occurring radionuclides in soil, radon decay products in air, external gamma radiation levels, and surface contamination. The guidelines for surface contamination cover most naturally occurring and manmade radionuclides.

6.2.2 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

CERCLA (Public Law 96-510), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 (pp. 99-499), provides liability, compensation, cleanup, and emergency response by the Federal Government for hazardous substances released into the environment, and for the cleanup of inactive hazardous waste disposal sites.

6.2.2.1 Federal Statute

There are three types of Government cleanup and response actions: (1) immediate removals, where emergency action is required (e.g., to avert fire or explosion or to prevent the contamination of a drinking-water supply); (2) planned removals, where a prompt response is required to minimize danger to the public or the environment; and (3) remedial actions taken at sites identified on the National Priorities List. Section 107(g) of CERCLA specifies the liability of DOE. According to this section, Departments of the Federal Government are both "procedurally and substantively" subject to compliance with CERCLA. In other words, "remedial actions" for the equivalent of CERCLA sites are to be undertaken at all Federal facilities.

Congress enacted the Superfund Amendments and Reauthorization Act on October 17, 1986. Section 120 of the Act provides for Federal agency procedural and substantive compliance with the Act, as with CERCLA; liability provisions are included. Section 121 addresses cleanup standards, including a degree of cleanup of hazardous substances that ensures protection of human health and the environment.

6.2.2.2 Federal Regulations

The National Contingency Plan (40 CFR 300), which was established under Section 105 of CERCLA, defines responses to actual or threatened releases of oil or hazardous substances to the environment. It calls for Remedial Investigations/Feasibility Studies for all remedial actions. These studies determine the nature and extent of the threat presented by the release of a hazardous substance and evaluate proposed remedies. They include sampling, monitoring, assessing exposure as necessary, and gathering sufficient information to determine the necessity for and the proposed extent of remedial action.

6.2.2.3 DOE Order 5480.14: Comprehensive Environmental Response, Compensation, and Liability Act

DOE developed its policy on emergency response under CERCLA and issued DOE Order 5480.14 on April 26, 1985. This Order specifies official responsibilities and lines of authority. In addition, it describes a response program with five phases:

- Installation Assessment - The preliminary identification of potential sites based on records review, screening for manufacturing-process specifications, raw-materials identification, and byproduct specification; records of disposal practices, locations, and quantities disposed are used to evaluate past operations at a potential site.

- Confirmation and Site Characterization - Actual onsite sampling and modeling to confirm the presence of contamination and the extent of migration, and an analysis of pathways of exposure (exposure assessment).

- Engineering Assessment - The design of remedial-action alternatives for the site, and selection of the most cost-effective alternative that meets the site's predetermined objectives for recommendation to DOE Headquarters.

- Remedial Actions - The implementation of the selected alternative and the processing of funding documentation after DOE Headquarters concurrence.

- Compliance and Verification - Consolidation and documentation of the entire process. According to this Order, DOE is to complete this phase by April 26, 1995.

6.2.3 RESOURCE CONSERVATION AND RECOVERY ACT AND HAZARDOUS AND SOLID WASTE AMENDMENTS

In 1976, Congress passed RCRA (Public Law 94-580, 42 USC 6901 et seq.) to provide a national program for the management, transportation, treatment, and disposal of hazardous waste. In addition to RCRA, Congress passed the Hazardous and Solid Waste Amendments (HSWA) of 1984. These amendments instituted an accelerated schedule for Part B permit application submittals, banned land-based disposal of hazardous wastes, specified an annual inspection program for Federal facilities, required an inventory of Federal hazardous-waste facilities, set up a permitting program for underground storage tanks, established a waste-minimization program, and set a closure schedule for the use of surface impoundments.

6.2.3.1 Federal Statutes

RCRA enabled the States to implement EPA-approved permitting programs. It involves a detailed "cradle-to-grave" manifest tracking system for all wastes that the U.S. Environmental Protection Agency (EPA) has designated as hazardous. Wastes are hazardous if they exhibit the characteristics of ignitability, corrosivity, reactivity, or toxicity using a specified extraction procedure, and if they are listed in Subpart D of 40 CFR 261, which provides industry and EPA waste numbers, descriptions, and a hazard code, and identifies the waste source as either specific or nonspecific. Other wastes are hazardous if they are discarded commercial chemical products, off-specification species, containers, and spill residues thereof, as defined in 40 CFR 261.

Under RCRA, the permitting of treatment, storage, or disposal facilities is a two-part process. The first part involves the submittal of a Part A application, containing certain basic information about the facility. DOE filed a Part A application with EPA for the SRP that addressed waste-management activities at the F-, H-, and M-Area seepage basins, and hazardous-waste-storage buildings 710-U, 709-G, 709-2G, and 709-4G. These basins and storage buildings are defined under RCRA as hazardous-waste-management units.

The second part of the permitting process involves the submittal of a Part B application, containing substantially more detailed information about individual interim-status waste-management units. DOE-SR filed its Part B application in February 1985.

With regard to the HSWA, Table 6-1 summarizes the requirements applicable to the SRP and the status of SRP compliance.

Table 6-1. Compliance of SRP Interim-Status Facilities with 1984 Hazardous and Solid Waste Amendments

Requirements	Status of SRP compliance
Interim status of land-disposal facilities terminates unless a Part B permit application is submitted and compliance with groundwater-monitoring requirements is certified by November 8, 1985.	A Part B permit application submitted in February 1985 included F-, H-, and M-Area seepage basins. Compliance with groundwater monitoring requirements was certified by November 8, 1985.
Owners and operators of interim-status facilities other than land-disposal units and incinerators must submit Part B permit applications or lose interim status in October 1992.	A Part B permit application submitted in February 1985 included interim-status hazardous-waste-storage facilities. In July 1986, interim status was expanded to include 643-29G.
Permit applications for land-disposal facilities must provide information on public exposure to hazardous wastes.	An Exposure Information Report was submitted in August 1985.
Owners and operators of interim-status surface impoundments must apply for applicable exemptions from minimum technological requirements by November 1986 or forfeit eligibility for exemption.	SRP interim-status surface impoundments do not meet minimum criteria for exemption. They will be replaced by effluent-treatment facilities.
Surface impoundments not meeting minimum technological requirements can no longer receive, store, or treat hazardous wastes as of November 1988.	Closure dates for F- and H-Area seepage basins and the startup date for the effluent-treatment facility will be determined.

6.2.3.2 Federal Regulations

EPA regulations for implementing RCRA are codified at 40 CFR 260-265. These regulations provide a system of standards for owners and operators of hazardous-waste storage, treatment, and disposal facilities; specific procedures on the manifest-tracking system; an identification and classification of hazardous waste; listing and delisting requirements; requirements for transporters of hazardous waste; interim-status standards; closure and post-closure care requirements; standards for landfills, incinerators, and surface impoundments; and permitting requirements. They also stipulate financial-responsibility, insurance, personnel-training, and liability requirements.

The HSWA prohibit land disposal of hazardous waste unless EPA determines that such prohibition is not required to protect human health and the environment. The Amendments also require EPA to promulgate regulations specifying levels or methods of waste treatment that would substantially diminish the toxicity or reduce the migration of hazardous constituents of the waste. After such pre-treatment, the waste can be disposed of in specified types of land-disposal facilities meeting minimum technological requirements. Appendix D of this EIS addresses various pretreatment technologies considered applicable to SRP waste management activities.

In addition to the requirements described above, the HSWA impose new minimum technological requirements (MTRs) on new landfills or surface impoundments. Permits for these units require the installation of two or more liners, a leachate-collection system, and groundwater monitoring. New units and replacements or lateral expansions of existing landfills, surface impoundments, and waste piles under interim status must conform to these minimum technological requirements with respect to wastes received beginning May 8, 1985. Appendix E of this EIS describes a new hazardous/mixed waste storage/disposal facility that would meet the MTR.

6.2.3.3 State Statute

The State of South Carolina passed its Hazardous Waste Management Act (Act 436) in 1978 (Code of Laws of South Carolina, Title 44, Health, Chapter 56). This enabling statute and four subsequent amendments that were enacted through June 5, 1985, authorized SCDHEC to issue regulations equivalent to those issued by EPA, including a Hazardous Waste Contingency Fund. The South Carolina Department of Health and Environmental Control (SCDHEC) has administered the Fund and the permitting and enforcement programs since EPA granted on November 8, 1985.

6.2.3.4 State Regulations

The requirements of the hazardous-waste-management program administered by the State are described in the South Carolina Hazardous Waste Management Regulations (R.61-79.124 through R61-79.270). Hazardous-waste management at the SRP is currently being conducted under Interim Status Standards.

Under interim status, facilities must comply with Interim Status Standards (R.61-79.265) and must not engage in hazardous-waste activities or processes not specified in Part A of the application.

The SRP Groundwater Quality Assessment Plan required by the State regulations was revised and resubmitted to SCDHEC in June 1985. The submission addressed monitoring at the F-, H-, and M-Area seepage basins and contained monitoring data in fulfillment of the requirement to report these data annually.

6.2.3.5 DOE Order 5480.2: Hazardous and Radioactive Mixed Waste Management

DOE Order 5480.2 establishes hazardous-waste-management procedures for facilities operated under authority of the AEA, as amended. The requirements follow, to the extent practical, regulations issued by the EPA pursuant to RCRA. Under the provisions of DOE Order 5480.2, managers of operations offices must develop an Implementation Plan that complies with the technical hazardous-waste-management requirements of 40 CFR 260-265.

The DOE Savannah River Operations Office developed an Implementation Plan for DOE Order 5480.2 in June 1984. The hazardous-waste-management Implementation Plan requires compliance with all Federal and State permitting processes, identifies the responsibilities of DOE-SR staff and contractors in ensuring compliance with RCRA, and formalizes the program needed to achieve such compliance.

6.2.3.6 Regulations Applicable to Closure and Remedial Action Activities at Existing Waste Sites

This section summarizes closure and remedial action requirements contained in DOE Orders and EPA regulations. DOE policy requires compliance with applicable Federal and State standards. If a conflict exists between regulations, DOE applies those providing the greatest protection.

The following sections describe the regulations related to hazardous, low-level radioactive, and mixed waste management facilities at SRP.

Table 6-2 summarizes regulations that govern closure and remedial action activities at specific hazardous-waste management facilities on SRP. Hazardous-waste management facilities closed on or before November 19, 1980, are not subject to the requirements of the South Carolina Hazardous Waste Management Regulations (SCHWMR), although the Hazardous and Solid Waste Amendments of 1984 contain a continuing release provision that is applicable to waste management facilities regardless of when they were closed.

The closure of SRP hazardous waste management facilities that were active after November 19, 1980, must meet the performance standards detailed in SCHWMR Section R.61-79.264.111. DOE must submit closure plans to SCDHEC for approval in accordance with Section R.61-79.264.112. In addition, closure and postclosure care must meet specific standards, as addressed in the following sections:

- Surface Impoundments (R.61-79.264.228, Subpart K)
- Waste Piles (R.61.79.264.258, Subpart L)
- Land Treatment (R.61-79.264.280, Subpart M)
- Landfills (R.64-79.264.310, Subpart N)

6.2.4 FEDERAL SAFE DRINKING WATER ACT

The SDWA is designed to protect the quality of public water supplies and all sources of drinking water. EPA has authorized South Carolina to regulate both areas. To protect the quality of public water supplies, the State has adopted a set of primary drinking-water regulations.

Table 6-2. Regulations Applicable to SRP Waste Management Facilities

Agency	Regulation	Date of Issue	Description
DOE	Order 5480.1B, Chapter XI	09/21/84	Requirements for radiation protection
DOE	Order 5480.2	12/13/82	Hazardous and Radioactive Mixed Waste Management
DOE	Order 5480.4	05/15/84	Environmental protection, safety, and health protection standards
DOE	Order 5480.14	04/26/85	Comprehensive Environmental Response, Compensation, and Liability Act Program
DOE	Order 5484.1	02/24/81	Environmental protection, safety, and health protection information reporting requirements
DOE	Order 5820.2	02/06/84	Radioactive waste management
DOE	10 CFR 962 (10 FR 45736)	11/01/85	Byproduct material proposed rule
EPA	40 CFR 300	11/20/85	National oil and hazardous substances pollution contingency plan
EPA	PL 98-616	11/08/84	Hazardous and Solid Waste Amendments of 1984
EPA	PL 99-499	10/17/86	Superfund Amendment and Reauthorization Act of 1986
SCDHEC	R.61-79.124 to R.61-79.270	06/22/84	South Carolina hazardous waste management regulations (SCHWMR)

SCDHEC administration and enforcement of the SDWA consists of construction permits, preliminary site inspections, final construction inspections, monthly sampling collections, and regular operations-and-maintenance inspections. Another provision of the SDWA, the Underground Injection Control Program, is designed to protect groundwater quality. Injection wells are not now and have not in the past been used for the disposal of wastewater at the SRP.

The Safe Drinking Water Act Amendments of 1986 (SDWAA - Public Law 99-339) was signed into law June 1986. The law substantially broadens the Federal government's role in protecting groundwater against contamination. EPA may give grants to states to protect public drinking water supplies at the well-head. States must develop protection plans that meet minimum criteria to qualify for Federal grants. Regulation of groundwater remains the domain of the states.

The "wellhead protection area" is defined as the surface and subsurface area surrounding a well or wells supplying a public water system through which contaminants are reasonably likely to move to reach the well or wells.

6.2.5 FLOODPLAIN/WETLANDS ENVIRONMENTAL REVIEW

According to EO 11900, "Protection of Wetlands," construction in wetlands should be avoided unless there are no practicable alternatives and all practicable measures have been included in the program to minimize harm to wetlands that might result from such use. Early review of the proposed action is to be provided to the public.

According to EO 11988, "Floodplain Management," each Federal agency must review its proposed actions to determine if any action will occur in a floodplain. The potential effects of an action that will occur in a floodplain must be evaluated, and the agency shall consider alternatives to avoid adverse effects and incompatible development in floodplains.

6.2.6 OTHER REQUIREMENTS

In 1984, within 24 months of the enactment of Public Law 98-181, the U.S. Congress took action to terminate the use of "seepage basins associated with the fuel fabrication area" (M-Area) on SRP. Another provision of RCRA required the Secretary of Energy to develop a groundwater-protection plan within 6 months after enactment; DOE has complied with both of these provisions.

A closure plan for the M-Area seepage basin was submitted in September 1984. Revisions to the plan were submitted in March and July 1985, and public hearings were held in July 1986. A postclosure care permit application for this basin was submitted with the SRP Part B permit application. Interim status is in effect until final administrative disposition of the Part B permit application.

The DOE Savannah River Operations Office operates under a Memorandum of Agreement (MOA) signed April 8, 1985, with SCDHEC. This agreement sets forth the relationship between DOE and SCDHEC regarding activities at the Savannah River Plant. The MOA specifies the procedures for nondisclosure of information on the grounds of national security. It also specifies jurisdictional and enforcement issues, and recognizes the constraints of the Federal budgetary process and the requirements of the NEPA process.

Other laws and orders (Fish and Wildlife Coordination Act, Endangered Species Act, Farmland Protection Policy Act, Migratory Bird Treaty Act, Anadromous Fish Conservation Act, National Historic Preservation Act, Noise Control Act, and South Carolina Non-Game and Endangered Species Conservation Act and Executive Orders and DOE rules on floodplains and wetlands) are generally applicable to Federal actions.

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EIS RESPONSIBILITY	Coauthor of sections in Chapter 4 and Appendixes B, C, D, F, G; contributed to sections in Chapter 4 and Appendixes A and J.

NAME	Bruce H. Bradford
AFFILIATION	NUS Corporation
EDUCATION	Ph.D., Civil Engineering (Water Resources Systems), Colorado State University M.S., Civil Engineering, University of Missouri at Rolla B.S., Civil Engineering, University of Missouri at Rolla
EXPERIENCE TECHNICAL SPECIALTY	Twenty years. Hydrology, hydraulics, water resources, and other civil engineering disciplines. Registered Professional Engineer in New Jersey, Georgia, and South Carolina.
EIS RESPONSIBILITY	Assistant Principal Investigator and Task Manager for existing waste site sections, including Chapter 5 and Sections 2.2 and 4.1, and Appendixes B, C, F, and H.

NAME	Philip N. Brandt
AFFILIATION	NUS Corporation
EDUCATION	B.S., Wildlife and Fisheries Sciences, Texas A&M University
EXPERIENCE TECHNICAL SPECIALTY	Seven years. Ecological baseline studies, permitting and regulatory analyses.
EIS RESPONSIBILITY	Prepared portions of Chapter 3. Assisted in preparation of responses to scoping comments in Appendix K.

NAME	Ronald M. Burd
AFFILIATION	NUS Corporation
EDUCATION	B.S., Chemistry, Lebanon Valley College Graduate studies: Franklin and Marshall College, University of Pittsburgh
EXPERIENCE TECHNICAL SPECIALTY	Thirty-six years. Environmental science, hazardous waste, water and wastewater management.
EIS RESPONSIBILITY	Principal Investigator for EIS preparation; prepared Cover Sheet, Foreword, Summary, Section 2.5, and Chapter 1.

NAME	Jon A. Cudworth
AFFILIATION	NUS Corporation
EDUCATION	J.D., Thomas M. Cooley Law School M.S., Resource Development, Michigan State University B.S., Resource Development, Michigan State University
EXPERIENCE TECHNICAL SPECIALTY	Eight years. Environmental law and regulatory compliance, biological sciences.
EIS RESPONSIBILITY	Prepared portions of Chapter 6.

NAME	John A. Davis
AFFILIATION	NUS Corporation
EDUCATION	B.A., Environmental Studies, Edimboro State College
EXPERIENCE TECHNICAL SPECIALTY	Eight years. Land use and cultural resources; preparation of environmental reports, assessments, and impact statements; design and implementation of field studies.

EIS RESPONSIBILITY — Performed technical reviews of cultural resources baseline and impact assessments.

NAME — Raymond J. Dever

AFFILIATION — NUS Corporation

EDUCATION — M.S.E., Water Resources, Princeton University
M.S., Environmental Engineering, California Institute of Technology
B.A./B.S., Urban Studies/Civil Engineering, Brown University

EXPERIENCE TECHNICAL SPECIALTY — Twelve years. Environmental impact studies; surface and groundwater modeling and monitoring; facilities planning for water supply, wastewater, sludge, and solid waste; regulatory compliance.

EIS RESPONSIBILITY — Performed technical review of surface-water, groundwater, and regulatory sections of Chapters 3, 4, 5, and 6, and Appendixes A, B, F, G, and H.

NAME — Rachel S. Diamond

AFFILIATION — NUS Corporation

EDUCATION — M.R.P., Regional Planning, University of Pennsylvania
B.A., Ecology, Rutgers College

EXPERIENCE TECHNICAL SPECIALTY — Six years. Regulatory analysis, environmental policies, environmental impact studies, terrestrial ecology, facility siting studies.

EIS RESPONSIBILITY — Prepared sections of Chapter 6.

NAME — John A. DiMarzio

AFFILIATION — NUS Corporation

EDUCATION — M.S., Geology, George Washington University
B.S., Geology, University of Maryland

EXPERIENCE TECHNICAL SPECIALTY — Four years. Geologic studies: paleontology, stratigraphy, geomorphology, geologic mapping. Hydrogeologic studies: groundwater modeling, groundwater flow, and contaminant transport. Regulatory compliance: CERCLA, SDWA, and RCRA.

EIS RESPONSIBILITY	Prepared geology and seismology sections for Chapter 3 and Appendix A; groundwater resources section for Chapter 3; studies and monitoring - Chapter 5; ongoing and planned monitoring sections for Appendix B; three existing facility groundwater and surface-water releases descriptions for Appendix F; portions of surface-water and groundwater effects sections for Appendix G; and surface-water and groundwater impacts sections for Chapter 4.

NAME	David K. Dougherty
AFFILIATION	NUS Corporation
EDUCATION	B.S., Biochemistry, University of Delaware
EXPERIENCE TECHNICAL SPECIALTY	Thirteen years. Health physicist specializing in the assessment of environmental effects of radioactive discharges from nuclear facilities.
EIS RESPONSIBILITY	Review of radiological dose calculations and health effects, and review of new low-level radioactive waste disposal alternatives.

NAME	Kurt A. Eckerstrom
AFFILIATION	NUS Corporation
EDUCATION	B.A., Environmental Conservation, University of Colorado
EXPERIENCE TECHNICAL SPECIALTY	Two years. Staff environmental scientist/geographical information system specialist; general ecology, environmental impact assessments, and site selection studies.
EIS RESPONSIBILITY	Principal author for ecology sections of Chapter 4 and Appendix F.

NAME	Yawar H. Faraz
AFFILIATION	NUS Corporation
EDUCATION	B.S., Nuclear Engineering, University of Maryland
EXPERIENCE TECHNICAL SPECIALTY	Four years. Environmental, radiological impact assessments of normal and abnormal operations of nuclear facilities. Emphasis on dose calculations.
EIS RESPONSIBILITY	Prepared radiological dose and health effects sections for Chapter 4. Prepared portions of Appendix I. Reviewed radiological sections of Appendix F.

NAME	Peter H. Feldhausen
AFFILIATION	NUS Corporation
EDUCATION	M.S., Geology, University of Wisconsin B.S., Geology, University of Wisconsin
EXPERIENCE TECHNICAL SPECIALTY	Twenty-eight years. Registered geologist and geophysicist; environmental assessment, geology/ seismology, hydrology, radioactive cesium transport, alternative cooling water, wetlands assessment.
EIS RESPONSIBILITY	Assisted in preparation of geology, seismology, water quality and resources, and solute transport sections in Chapters 3 and 4 and Appendix A, predisposal techniques and waste volumes in Appendixes D and E.

NAME	David W. Freeman
AFFILIATION	NUS Corporation
EDUCATION	B.S., Nuclear Science, Virginia Polytechnic Institute
EXPERIENCE TECHNICAL SPECIALTY	Three years. Radiological impact assessments, radioactive waste management, radiological environmental monitoring, regulatory analysis, and licensing support.
EIS RESPONSIBILITY	Work Element Manager for disassembly basin purge-water discharge analysis (Sections 2.4 and 4.4).

NAME	Salinda J. Garvick
AFFILIATION	NUS Corporation
EDUCATION	M.S., Forest Resources (Fish Biology), University of Georgia B.S., Biology (Marine), Millersville State University
EXPERIENCE TECHNICAL SPECIALTY	Three years. Environmental research, freshwater and marine fisheries ecology, analytical chemistry, toxicology, fish physiology, and some thermal and impingement assessment effects.
EIS RESPONSIBILITY	Prepared parts of the aquatic and terrestrial ecology sections for Chapter 4 and Appendixes F and G.

NAME	Morton I. Goldman
AFFILIATION	NUS Corporation
EDUCATION	Sc.D., Massachusetts Institute of Technology M.S., Nuclear Engineering, Massachusetts Institute of Technology M.S., Sanitary Engineering, Massachusetts Institute of Technology B.S., Civil Engineering, New York University
EXPERIENCE TECHNICAL SPECIALTY	Thirty-eight years. Corporate Technical Director; senior management of site evaluation, safety and environmental assessment, and environmental impact evaluation. Professional Engineer.
EIS RESPONSIBILITY	Primary reviewer for NUS Corporation.

NAME	Jimmy Ho
AFFILIATION	NUS Corporation
EDUCATION	Ph.D., Civil and Environmental Engineering, Utah State University M.S., Civil Engineering, Colorado State University M.S., Nuclear Engineering, National Tsing Hua University (Taiwan)
EXPERIENCE TECHNICAL SPECIALTY	Ten years. Environmental monitoring of radionuclides; hydrologic and ecologic impacts of precipitation and soil erosion; computer modeling of water routing, sediment transport, and nutrient losses; thermal impact on water quality; modeling of water quality; modeling of groundwater flows and contaminant transport.
EIS RESPONSIBILITY	Prepared Appendix H, cumulative groundwater and surface-water impacts of groundwater remediation for Section 4.1, radionuclide removal for Appendix C.

NAME	Rosalind Huang
AFFILIATION	NUS Corporation
EDUCATION	M.S., Physics, University of Maryland B.S., Physics, University of Maryland
EXPERIENCE TECHNICAL SPECIALTY	Seventeen years. Computer programming for solving problems in shielding and radiation and for processing meteorological data; development of plots, users guides, and documentation; verification and quality review of programs.

EIS RESPONSIBILITY	Performed technical review of radiological impacts in Appendixes F and G and Chapters 2 and 4.

NAME	Amy E. Hubbard
AFFILIATION	NUS Corporation
EDUCATION	M.R.P., Regional Planning, University of Pennsylvania B.A., Geology, Franklin and Marshall College
EXPERIENCE TECHNICAL SPECIALTY	Seven years. Geology, health risk assessment, environmental assessment, and hydrogeology.
EIS RESPONSIBILITY	Prepared cumulative health impacts for hazardous substances.

NAME	John R. Jansen
AFFILIATION	U.S. Department of Energy, Savannah River Operations Office
EDUCATION	M.S., Geography, University of Wisconsin, Milwaukee B.A., Geography, University of Georgia
EXPERIENCE TECHNICAL SPECIALTY	Thirteen years. Ecology, environmental impact assessment, and waste management.
EIS RESPONSIBILITY	Primary reviewer for Savannah River Operations Office.

NAME	Gary J. Jellick
AFFILIATION	NUS Corporation
EDUCATION	M.S., Soil Science, The Pennsylvania State University B.S., Agronomy, The Pennsylvania State University
EXPERIENCE TECHNICAL SPECIALTY	Four years. Certified professional soil scientist. Soil and waste management, vadose zone contamination, soil and groundwater monitoring plans, and environmental assessments.
EIS RESPONSIBILITY	Contributor to Section 4.1 and Appendixes B and F.

NAME	Mary Alice Jennison
AFFILIATION	NUS Corporation
EDUCATION	B.S., Environmental Science, Florida Institute of Technology
EXPERIENCE TECHNICAL SPECIALTY	Three years. Statutory/regulatory analysis, site-specific environmental compliance plans, environmental compliance reference books, environmental assessments, and impact statements.
EIS RESPONSIBILITY	Contributed to Chapter 1.

NAME	Jasper G. Maltese
AFFILIATION	NUS Corporation
EDUCATION	M.S., Operations Research, George Washington University B.S., Mathematics, Fairleigh Dickinson University
EXPERIENCE TECHNICAL SPECIALTY	Twenty-five years overall experience, ten years experience in safety and accident studies of complex systems and operations. Several years experience in reliability and risk assessment of systems.
EIS RESPONSIBILITY	Work Element Manager, prepared accidents sections of EIS. Co-work Element Manager, prepared decontamination and decommissioning section of EIS.

NAME	Barton C. Marcy, Jr.
AFFILIATION	NUS Corporation
EDUCATION	M.S., Zoology-Ichthyology, University of Connecticut B.S., Biology, Wake Forest University
EXPERIENCE TECHNICAL SPECIALTY	Twenty-three years. Environmental impact studies, ichthyoplankton and entrainment studies, fisheries, and impingement, aquatic ecology, and marine biology.
EIS RESPONSIBILITY	Principal technical reviewer of EIS for NUS Corporation.

NAME	Robert S. Markwell
AFFILIATION	NUS Corporation
EDUCATION	B.S., Environmental Resource Management, The Pennsylvania State University

EXPERIENCE TECHNICAL SPECIALTY	Three years. Environmental risk assessment, environmental sampling, chemical fate and transport analysis, waste management assessment.
EIS RESPONSIBILITY	Prepared Section 4.1.1.6.

NAME	David C. Navecky
AFFILIATION	NUS Corporation
EDUCATION	M.S., Water Resources Management, Michigan State University B.S., Environmental Science, The Pennsylvania State University
EXPERIENCE TECHNICAL SPECIALTY	Three years. Hydrology/water quality baseline and impact assessment studies, analysis of and compliance planning with water quality regulations.
EIS RESPONSIBILITY	Assisted in the preparation of water-quality sections in Chapter 4 and Appendix F; waste site descriptions in Appendix B; and unavoidable/irreversible impacts in Chapter 4.

NAME	Daniel B. Nugent
AFFILIATION	NUS Corporation
EDUCATION	B.S., Meteorology, The Pennsylvania State University
EXPERIENCE TECHNICAL SPECIALTY	Three years. Air quality studies and risk assessment.
EIS RESPONSIBILITY	Reviewed air-quality sections.

NAME	Richard S. Nugent
AFFILIATION	NUS Corporation
EDUCATION	Ph.D., Marine Science, University of Miami M.S., Biology, Boston College B.S., Biology, Boston College
EXPERIENCE TECHNICAL SPECIALTY	Eighteen years. Environmental impact studies, aquatic ecology, marine and estuarine ecology, water quality.
EIS RESPONSIBILITY	Reviewed comparative impact sections in Chapters 2 and 4, and assisted in preparation of sections in Chapter 4.

NAME	Joseph F. O'Brien
AFFILIATION	NUS Corporation
EDUCATION	M.Engr., Water Resource Engineering, Clemson University M.S., Chemistry, Lehigh University B.A., Chemistry, Lehigh University
EXPERIENCE TECHNICAL SPECIALTY	Thirteen years. Flooding analyses; surface-water quality studies; groundwater flow and transport analyses.
EIS RESPONSIBILITY	Prepared Sections 3.5 and 3.6 and Appendix A, Section A.3.

NAME	James L. Oliver
AFFILIATION	NUS Corporation
EDUCATION	B.S., Biology, Murray State University
EXPERIENCE TECHNICAL SPECIALTY	Fifteen years. Environmental research, limnological studies, thermal effects, icthyoplankton and zooplankton studies, entrainment and impingement, and fisheries ecology.
EIS RESPONSIBILITY	Performed technical review of ecology sections in Chapters 3 and 4 and Appendixes F and G.

NAME	Jane M. Patarcity
AFFILIATION	NUS Corporation
EDUCATION	M.S., Hygiene, Health Aspects of Water Quality, University of Pittsburgh B.S., Biological Science, University of Pittsburgh
EXPERIENCE TECHNICAL SPECIALTY	Five years. Public health, water quality, aquatic biology, and risk assessment associated with exposure to chemical constituents.
EIS RESPONSIBILITY	Prepared hazardous chemical environment sections for Chapter 3, ecological impacts of proposed alternatives for Chapter 4, and impacts sections for Appendix F.

NAME	William L. Poppe
AFFILIATION	NUS Corporation
EDUCATION	Illinois Institute of Technology and University of Maryland (two years) Registered Professional Land Surveyor and Land Planner
EXPERIENCE TECHNICAL SPECIALTY	Thirty-four years. Land surveying, site planning, and civil engineering design.
EIS RESPONSIBILITY	Principal author and Work Element Manager for engineering and site description sections (2.1, 4.1, Appendixes E and F).

NAME	Amiram Roffman
AFFILIATION	NUS Corporation
EDUCATION	Ph.D., Atmospheric physics, New Mexico Institute of Mining and Technology M.Sc., Physics and Meteorology, Hebrew University (Israel)
EXPERIENCE TECHNICAL SPECIALTY	Twenty-two years. Environmental studies in the areas of air quality, meteorology, program and project management. Responsible for the development of technical tools used in air quality and meteorological studies, managing large numbers of projects including environmental analysis studies and field programs. Extensive regulatory interface and expert testimony.
EIS RESPONSIBILITY	Prepared hazardous air releases sections; reviewed entire report and had input into occupational impact sections.

NAME	Haia K. Roffman
AFFILIATION	NUS Corporation
EDUCATION	Ph.D., Geochemistry, New Mexico Institute of Mining and Technology M.Sc., Organic Chemistry, Hebrew University (Israel) B.Sc., Inorganic Chemistry, Hebrew University (Israel)
EXPERIENCE TECHNICAL SPECIALTY	Twenty-three years. Environmental studies in the areas of chemical contamination in air, water, and soils. Responsible for the preparation of environmental impact statements, environmental assessments, and remedial investigations - feasibility studies.

EIS RESPONSIBILITY	Managed the chemistry and toxicology group in the preparation of sections in Appendixes F and I and sections in Chapter 4.

NAME	Irwin J. Samec
AFFILIATION	NUS Corporation
EDUCATION	M.U.R.P., Urban and Regional Planning, Michigan State University B.A., Sociology, Illinois Wesleyan University
EXPERIENCE TECHNICAL SPECIALTY	Sixteen years. Environmental impact statements and assessments, socioeconomic and land-use analyses, transportation studies, water resources and quality.
EIS RESPONSIBILITY	Principal technical reviewer of EIS for NUS Corporation.

NAME	James R. Schinner
AFFILIATION	NUS Corporation
EDUCATION	Ph.D., Wildlife Biology, Michigan State University M.S., Zoology, University of Cincinnati B.S., Zoology, University of Cincinnati
EXPERIENCE TECHNICAL SPECIALTY	Fourteen years. Terrestrial ecosystems studies and impact evaluations for a number of industrial projects, including nuclear and fossil fuel powerplants. Work has included analysis of impacts of SO_2 and salt drift on vegetation, endangered species evaluations, and a timber harvest study.
EIS RESPONSIBILITY	Work Element Manager for the preparation of various sections of Chapter 4.

NAME	Robert L. Schlegel
AFFILIATION	NUS Corporation
EDUCATION	Degree of Nuclear Engineering, Columbia University M.S., Nuclear Engineering, Columbia University B.S., Chemical Engineering, Massachusetts Institute of Technology
EXPERIENCE TECHNICAL SPECIALTY	Twenty-four years. Radiological assessments of normal and abnormal operations of nuclear facilities. Emphasis on dose calculations and resulting health effects.

EIS RESPONSIBILITY — Coordinated and reviewed radiological sections for Chapters 3 and 4 and Appendix H. Contributed to preparation of Appendixes F and I.

NAME — Michael Septoff

AFFILIATION — NUS Corporation

EDUCATION — M.S., Meteorology/Oceanography, New York University
B.S., Meteorology, City College of New York

EXPERIENCE TECHNICAL SPECIALTY — Meteorology/air quality, impact assessments, health and risk assessments, permitting related to EPA requirements and state and federal agencies.

EIS RESPONSIBILITY — Task Leader for preparation of air sections in Chapters 3 and 4, and Appendixes F and G.

NAME — John O. Shipman

AFFILIATION — NUS Corporation

EDUCATION — A.B., English Literature, Georgetown University

EXPERIENCE TECHNICAL SPECIALTY — Twenty years. Technical publications; editing/writing/management; multidiscipline documents; environmental documents; NEPA documents. Publications quality control.

EIS RESPONSIBILITY — Edited EIS. Prepared Table of Contents, List of Preparers, Distribution List, Glossary, and Index.

NAME — Sonce A. Silvernale

AFFILIATION — NUS Corporation

EDUCATION — M.S., Oregon State University
B.S., Arizona State University

EXPERIENCE TECHNICAL SPECIALTY — Eleven years. Soil mapping and interpretations for agricultural and engineering applications. Experience with siting studies for nuclear powerplants, nuclear waste repositories, coal mines, oil shale, and hard rock mining.

EIS RESPONSIBILITY — Prepared section describing characteristics of existing low-level radioactive waste sites at SRP for Appendix B.

NAME	Dennis M. Smith
AFFILIATION	NUS Corporation
EDUCATION	B.S., Environmental Health, Colorado State University
EXPERIENCE TECHNICAL SPECIALTY	Ten years of industrial environmental health experience. Environmental chemical hazard assessment; contaminant fate and transport analysis; public, environmental, and occupational health risk assessment and risk management.
EIS RESPONSIBILITY	Wrote Appendix I; directed the preparation of sections of Chapter 4; provided technical support of various other sections.

NAME	Stephen L. Sperry
AFFILIATION	NUS Corporation
EDUCATION	B.L.A., Landscape architecture, Syracuse University M.L.A., Landscape architecture, Harvard University
EXPERIENCE TECHNICAL SPECIALTY	Fifteen years. Environmental planning, remote sensing, Geographic Information Systems (GIS) applications.
EIS RESPONSIBILITY	Technical input for Chapter 4.

NAME	Seshagirirao Tammara
AFFILIATION	NUS Corporation
EDUCATION	M.S., Chemical and Environmental Engineering, University of Maryland
EXPERIENCE TECHNICAL SPECIALTY	Thirteen years. Environmental engineering consulting, evaluations and analyses with respect to air, water, and radiological impacts; thermal performance analyses.
EIS RESPONSIBILITY	Prepared portions of Appendixes E, F, G, and I, and sections of Chapters 2 and 4.

NAME	Jerry Tkac
AFFILIATION	NUS Corporation
EDUCATION	Towson State University Frederick Community College
EXPERIENCE TECHNICAL SPECIALTY	Eighteen years. Engineering design and drafting; site planning and land development, storm water management, piping systems, highways, collection basins, building and equipment locations.
EIS RESPONSIBILITY	Prepared site maps for waste site descriptions in Chapter 2 and Appendix B.

NAME	Alan L. Toblin
AFFILIATION	NUS Corporation
EDUCATION	M.S., Chemical Engineering, University of Maryland B.E., Chemical Engineering, The Cooper Union
EXPERIENCE TECHNICAL SPECIALTY	Fifteen years. Hydrologic transport analyses.
EIS RESPONSIBILITY	Prepared portions of Appendix F and Section 4.1. Performed technical review of portions of Section 4.2 and Appendixes F, G, and I.

NAME	Richard L. Van Tassel
AFFILIATION	NUS Corporation
EDUCATION	Ph.D., Civil Engineering, Carnegie Mellon University M.S., Civil Engineering, Carnegie Institute of Technology B.E., Civil Engineering, Youngstown University
EXPERIENCE TECHNICAL SPECIALTY	Twenty-two years. Civil engineering, evaluation of site conditions, proposed remedial actions and construction.
EIS RESPONSIBILITY	Prepared sections of Chapters 2 and 4.

NAME	Robert H. Werth
AFFILIATION	NUS Corporation
EDUCATION	B.A., Physics, Gordon College
EXPERIENCE TECHNICAL SPECIALTY	Eleven years. Environmental impact studies, sound level studies, noise impact assessments, air quality analysis, permitting.
EIS RESPONSIBILITY	Prepared noise impacts sections in Chapter 4.

NAME	Patricia L. Wherley
AFFILIATION	NUS Corporation
EDUCATION	B.A., Geography, The George Washington University
EXPERIENCE TECHNICAL SPECIALTY	Fifteen years. Environmental impact studies, demographics, land use and socioeconomic studies, regulatory analyses, public participation programs.
EIS RESPONSIBILITY	Performed technical reviews of geography, archaeological, historical, and socioeconomic sections of Chapters 3 and 4 and Appendix G.

NAME	Philip C. Whitney
AFFILIATION	NUS Corporation
EDUCATION	B.S., Civil Engineering, University of Maine
EXPERIENCE TECHNICAL SPECIALTY	Thirty-eight years. Construction supervision, civil/structural design and engineering of thermal, hydroelectric, and nuclear power, HV and EHV transmission, paper mills, and other heavy industry. Site and environmental studies, investigations, and assessments.
EIS RESPONSIBILITY	Prepared portions of Appendix E.

NAME	James C. Williamson
AFFILIATION	NUS Corporation
EDUCATION	B.S., Fisheries and Wildlife Biology, Michigan State University

EXPERIENCE TECHNICAL SPECIALTY	Fifteen years. Waste treatment/pollution control research, analytical laboratory, wastewater/solid waste facilities plans, land disposal feasibility studies, environmental monitoring, NEPA documentation, siting studies, guidance documents, remedial action plans, impact assessment, mitigation, project management.
EIS RESPONSIBILITY	Work Element Manager. Prepared portions of Chapters 2, 3, and 4, Appendixes A, D, E, and G. Assisted in overall coordination and management of EIS.
NAME	William E. Wisenbaker
AFFILIATION	U.S. Department of Energy, Savannah River Operations Office
EDUCATION	M.B.A., Management, Georgia State University B.S., Chemistry, University of Georgia
EXPERIENCE TECHNICAL SPECIALTY	Twenty years. Air quality measurements, ecology, environmental impact assessment, compliance with regulations, environmental monitoring.
EIS RESPONSIBILITY	Principal reviewer of EIS for DOE.
NAME	Carl R. Yates
AFFILIATION	NUS Corporation
EDUCATION	M.S., Biology, West Virginia University B.S., Biology, University of Pittsburgh at Johnstown
EXPERIENCE TECHNICAL SPECIALTY	Four years. Radiological environmental monitoring programs, sample collection audits, land-use surveys, radiochemistry, aquatic ecology.
EIS RESPONSIBILITY	Prepared descriptive radiological sections for Chapter 3.
NAME	Gregory L. Zimmerman
AFFILIATION	NUS Corporation
EDUCATION	B.S., Environmental Engineering, The Pennsylvania State University
EXPERIENCE TECHNICAL SPECIALTY	Nine years. Data validation, contaminant transport modeling, material safety data sheet preparation, evaluation of technical feasibility and economics of various methods of treating leachate, contaminated groundwater, and other waste streams.

EIS RESPONSIBILITY

Prepared cumulative effects sections for onsite groundwater and for onsite and offsite facilities in Chapter 4; helped prepare health effects tables for Appendix I and sections on the new disposal facilities for Chapter 4.

LIST OF PREPARERS[a]

NAME	Sections							Appendix										
	S	1	2	3	4	5	6	A	B	C	D	E	F	G	H	I	J	K
C. L. Anthony				X	X													
D. L. Bonk					X			X	X	X	X		X	X			X	
B. H. Bradford			X		X	X			X	X			X		X			
P. N. Brandt	X	X	X	X														X
R. M. Burd	X	X	X															
K. S. Cohen[d]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J. A. Cudworth							X											
J. A. Davis				X	X													
R. J. Dever				X	X	X	X	X	X				X	X	X			
R. S. Diamond							X											
J. A. DiMarzio				X	X	X		X	X				X	X				
D. K. Dougherty					X								X	X		X		
K. A. Eckerstrom					X								X					
Y. H. Faraz					X								X			X		
P. H. Feldhausen				X				X			X	X						
D. W. Freeman			X		X													
S. J. Garvick																		
M. I. Goldman[b]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J. H. Ho					X					X					X			
R. Huang			X		X								X	X				
A. E. Hubbard				X	X													
J. R. Jansen[c]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
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M. A. Jennison		X																
J. G. Maltese					X													
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D. C. Navecky					X				X				X					
R. S. Nugent					X								X					
J. F. O'Brien				X				X										
J. L. Oliver				X	X								X	X				
J. M. Patarcity				X	X								X					
W. L. Poppe			X		X							X	X					
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R. L. Schlegel				X	X								X			X		
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J. O. Shipman[d]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
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LIST OF PREPARERS[a]

NAME	Area of Responsibility																	
	Sections							Appendix										
	S	1	2	3	4	5	6	A	B	C	D	E	F	G	H	I	J	K
S. R. Tammara			X		X							X	X	X		X		
S. B. Thawley[d]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J. Tkac			X						X									
A. L. Toblin					X								X	X		X		
W. D. Trimbath			X		X				X	X	X	X	X	X	X	X	X	
R. L. Van Tassel			X		X													
R. H. Werth					X													
P. L. Wherley				X	X									X				
P. C. Whitney												X						
J. C. Williamson			X	X	X			X			X	X		X				
W. E. Wisenbaker[c]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C. R. Yates				X														
J. G. Yeasted			X	X	X				X				X	X	X	X		
G. L. Zimmerman					X											X		

[a]This draft environmental impact statement was reviewed and approved in accordance with DOE Order 5440.1C, Implementation of the National Environmental Policy Act.
[b]Primary Reviewer for NUS Corporation.
[c]Primary Reviewer for DOE Savannah River Operations Office.
[d]Technical Editor.

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GLOSSARY

absorbed dose

Energy transferred to matter when ionizing radiation passes through it; measured in rads.

absorber

Material, such as concrete and steel shielding, that absorbs and diminishes the intensity of ionizing radiation.

absorption

The process by which the number and energy of particles or photons entering a body of matter are reduced by interaction with the matter.

acceptable daily intake (ADI)

The amount of toxicant intake (in milligrams per day) for a 70-kilogram person that is not expected to result in adverse effects after chronic exposure.

acclimation

Physiological and behavioral adjustments of an organism to changes in its immediate environment.

acclimatization

The acclimation or adaptation of a particular species over several generations to a marked change in the environment.

activation

The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear particles.

activation products

Nuclei formed by the bombardment of material with neutrons, protons, or other nuclear particles.

activity

A measure of the rate at which a material is emitting nuclear radiation, usually given as the number of nuclear disintegrations per unit of time. (See <u>curie</u>.)

adaptation

A change in structure or habit of an organism that produces an adjustment to the environment.

ADI

See "acceptable daily intake."

adsorption

The adhesion of a substance to the surface of a solid or solid particles.

Atomic Energy Commission (AEC)

A five-member commission established by the Atomic Energy Act of 1954 to supervise the use of nuclear energy. The AEC was dissolved in 1975 and its functions were transferred to the Nuclear Regulatory Commission (NRC) and to the Energy Research and Development Administration (ERDA), which became the Department of Energy (DOE).

air quality

A measure of the levels of pollutants in the air.

air-quality standards

The prescribed level of pollutants in the outside air that cannot be exceeded legally during a specified time in a specified area.

air sampling

The collection and analysis of air samples for detection or measurement of substances.

alpha (α) particle

A positively charged particle consisting of two protons and two neutrons that is emitted during certain radioactive decay from the nucleus of certain nuclides; it is the least penetrating of the three common types of radiation (alpha, beta, and gamma).

ambient air

The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. (It is not the air in immediate proximity to emission sources.)

anion

A negatively charged ion. (See <u>ion</u>.)

aquatic biota

The sum total of living organisms of any designated aquatic area.

aquiclude

A saturated geologic unit that is incapable of transmitting significant quantities of water under ordinary hydraulic gradients.

aquifer

A saturated geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients; the water can be pumped to the surface through a well or it can emerge naturally as a spring.

aquitard

A less permeable bed in a stratigraphic sequence.

archaeological sites (resources)

Areas or objects modified or made by man and the data associated with these features and artifacts.

arcuate

A curved or bent axial trace in a fold. (The fold would be called "arcuate.")

arenaceous limestone

Limestone with a texture or appearance of sand.

arkose

A sandstone containing 25 percent or more of feldspars, usually derived from silicic igneous rocks (e.g., granite).

artesian well

A well in a confined aquifer with a water level that rises above the top of the aquifer; if it rises above the ground surface, the well is known as a flowing artesian well.

ash

Inorganic residue remaining after ignition of combustible substances.

atmosphere

The layer of air surrounding the earth.

backfill

Material such as stone, clean rubble, or soil that is used to refill an excavation.

background exposure

See exposure to radiation.

background radiation

Ionizing radiation present in the environment from cosmic rays and from natural sources in the earth; background radiation varies considerably with location. (See natural radiation.)

bedrock

Any solid rock exposed at the earth's surface or overlain by unconsolidated surface material such as soil, gravel, or sand.

benthic region

The bottom of a body of water; this region supports the benthos.

benthos

The plant and animal life whose habitat is the bottom of a sea, lake, or river.

beta particle

An elementary particle emitted from a nucleus during radioactive decay; it is negatively charged, identical to an electron, and easily stopped, as by a thin sheet of metal.

biological dose

The radiation dose absorbed in biological material (measured in rem).

biochemical oxygen demand (BOD)

A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water; the greater the amount of organic waste, the greater the BOD.

biological shield

A mass of absorbing material placed around a radioactive source to reduce the radiation to a level safe for humans.

biosphere

The portion of the earth and its atmosphere capable of supporting life.

biostratigraphy

The study of stratigraphy via fossilized remains.

biota

The plant and animal life of a region.

borosilicate glass

A strong, chemically and thermally resistant glass made primarily of sand and borax; for waste management, high-level waste is incorporated into the glass to form a leach-resistant, nondispersible (immobilized) material.

British thermal unit (Btu)

A unit of heat; the quantity of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit. One Btu equals 1055 joules (or 252 calories).

burial ground

A place for burying unwanted materials in which the earth acts as a receptacle to prevent the dispersion of wastes in the environment and the escape of radiation.

$^{\circ}$C (degree Celsius)

The Celsius temperature scale is related to the Fahrenheit scale as follows:

$$^{\circ}F = {^{\circ}C} \times \frac{9}{5} + 32$$

calcareous cement

A calcium-carbonate-based cement.

calcareous zone or formation

A stratigraphic unit composed largely of calcium carbonate (calcite or limestone).

calcine

The process in which the water portion of slurried waste is driven off by evaporation at high temperature in a spray chamber, leaving a residue of dry solid unmelted particles, also referred to as the calcine.

cancer

The name given to a group of diseases that are characterized by uncontrolled cellular growth.

canister

A metal (steel) container into which immobilized radioactive waste is sealed.

canyon building

A heavily shielded building used in the chemical processing of radioactive materials; operation and maintenance are by remote control.

carbon dioxide (CO_2)

A colorless, odorless, nonpoisonous gas that is a normal component of the ambient air; it is an expiration product of normal plant and animal life.

carbon monoxide (CO)

A colorless, odorless gas that is toxic if breathed in high concentration over a certain period of time; it is a normal component of most automotive exhaust systems.

carcinogen

An agent capable of producing or inducing cancer.

carcinogenic

Capable of producing or inducing cancer.

Carolina bay

Ovate, intermittently flooded, marshy depression of a type occurring abundantly on the Coastal Plain from New Jersey to Florida.

cask (radioactive materials)

A heavily shielded massive container for holding radioactive material.

cation

A positively charged ion. (See ion.)

Comprehensive, Environmental Response Compensation, and Liability Act (CERCLA)

Establishes National Priority List (NPL) of abandoned hazardous waste sites ("Superfund").

clarifier

A tank or other vessel used to accomplish removal of settleable solids.

clastic dike

A sedimentary dike formed by broken rocks from overlying or underlying material.

common carriers

Vehicles, such as trucks, trains, barges, and planes, that are licensed to transport the wide assortment of goods and materials distributed regularly across the country.

concentration

The quantity of a substance contained in a unit quantity of a sample (e.g., milligrams per liter, or micrograms per kilogram).

condensate

Liquid water obtained by cooling the steam (overheads) produced in an evaporator system; also, any liquid obtained by cooling saturated vapor.

coolant

A substance, usually water, circulated through a processing plant to remove heat.

correlatable

Able to establish a connection between geological formations or events.

cretaceous

End of mesozoic era, between 136 and 65 million years ago.

crystalline metamorphic rock

Rock consisting wholly of crystals.

cuesta

A ridge formed from sedimentary rock, steep on one side, but with a gentle slope on the other.

cumulative effects

Additive environmental, health, and socioeconomic effects that result from a number of similar activities in an area.

curie (Ci)

A unit of radioactivity equal to 3.7×10^{10} (37 billion) disintegrations per second; also a quantity of any nuclide or mixture of nuclides having 1 curie of radioactivity.

daughter

A nuclide formed by the radioactive decay of another nuclide, which is called the parent.

Darcy's law

$$v = -K \frac{dh}{dl}$$

The empirical physical law that describes groundwater flow under saturated or unsaturated conditions; the darcy is a unit of permeability and is related to hydraulic conductivity.

decay heat (radioactivity)

The heat produced by the decay of radionuclides.

decay, radioactive

The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide; the process results in the emission of nuclear radiation (alpha, beta, or gamma radiation).

decommissioning

Removing facilities such as processing plants, waste tanks, and burial grounds from service and reducing or stabilizing radioactive contamination; includes the following concepts:

- The decontamination, dismantling, and return of an area to its original condition without restrictions
- Partial decontamination, isolation of remaining residues, and continued surveillance and restrictions

decomposition

The breakdown of a substance into its constituent parts.

decontamination (radioactive)

The removal of radioactive contaminants from surfaces of equipment, by cleaning or washing with chemicals, by wet abrasive blasting using glass frit and water, or by chemical processing.

Defense Waste Processing Facility (DWPF)

Facility designed to process high-level defense waste into a suitable form for permanent storage or disposal; under construction at SRP.

demography

The statistical study of human populations, including population size, density, distribution, and such vital statistics as age, sex, and ethnicity.

depositional regimes

A geologic term referring to the systematic laying or throwing down of material over a substantial area.

detritus

Dead organic tissues and organisms in an ecosystem.

dip

The angle that a structural surface (e.g., a bedding or fault plane) makes with the horizontal, measured perpendicular to the strike of the substance.

disposal

Placement of wastes in a facility such that the wastes remain isolated from the environment permanently or until decay has progressed to a point where releases pose no threat or hazard.

distillation

Separation process achieved by creating two or more coexisting zones that differ in temperature, pressure, or composition.

dose

The energy imparted to matter by ionizing radiation; the unit of absorbed dose is the rad, which is equal to 0.01 joule per kilogram of irradiated material in any medium.

dose commitment

The dose an organ or tissue would receive during a specified period of time (e.g., 50 to 100 years) as a result of intake (as by ingestion or inhalation) of one or more radionuclides from a 1-year release.

dose equivalent

The product of the absorbed dose from ionizing radiation and such factors as account for differences in biological effectiveness due to the type of radiation and its distribution in the body; it is measured in rem (Roentgen equivalent man).

dose rate

The radiation dose delivered per unit time (e.g., rem per year).

dosimeter

A small device (instrument) carried by a radiation worker that measures radiation dose (e.g., film badge or ionization chamber).

drawdown

The height difference between the water level in a formation and the water level in a well caused by the withdrawal of groundwater.

ecology

The science dealing with the relationship of all living things with each other and with the environment.

ecosystem

A complex of the community of living things and the environment forming a functioning whole in nature.

effluent

A liquid waste, discharged into the environment, usually into surface streams.

effluent standards

Defined limits of waste discharge in terms of volume, content of contaminants, temperature, etc.

electron

An elementary particle with a unit negative charge and a mass 1/1837 of the proton; electrons surround the positively charged nucleus and determine the chemical properties of the atom.

element

One of the 105 known substances that cannot be divided into simpler substances by chemical reactions; all nuclides of an element have the same atomic number.

eluate

The liquid resulting from removing the adsorbed material from an ion-exchange medium.

emission standards

Legally enforceable limits on the quantities or kinds of air contaminants that might be emitted into the atmosphere.

endangered species

Species of plants and animals that are threatened with either extinction or serious depletion in an area.

energy

The capacity to produce heat or do work. Electrical energy is measured in units of kilowatt-hours.

environmental dose commitment (EDC)

A dose representing exposure to and ingestion of environmentally available radionuclides for 100 years following a 1-year release of radioactivity.

environmental fate

The result of the physical, biological, and chemical interactions of a substance released to the environment.

environmental impact statement (EIS)

A document prepared pursuant to Section 102(2)(c) of the National Environmental Policy Act (NEPA) of 1969 for a major Federal action significantly affecting the quality of the human environment.

environmental transport

The movement of a substance through the environment; includes the physical, chemical, and biological interactions undergone by the substance.

eocene

Lower tertiary period, after paleocene but before oligocene.

epidemiology

The study of diseases as they affect populations.

epoch

Length of time (geology).

estuarine

Pertaining to an area where salt and fresh water come together; area affected by tides.

exposure to radiation

The incidence of radiation on living or inanimate material by accident or intent:

- Background - exposure to natural background ionizing radiation

- Occupational - exposure to ionizing radiation that takes place during a person's working hours

- Population - exposure to a number of persons who inhabit an area

$^{\circ}F$ (degree Fahrenheit)

The Fahrenheit temperature scale is related to the Celsius scale as follows:

$$^{\circ}C = \frac{(^{\circ}F - 32)}{1.8}$$

facies

A group of rocks that differ from surrounding rocks.

fall line

Imaginary line marking the point that most rivers drop steeply from the uplands to the lowlands.

fallout

The descent to earth and deposition on the ground of particulate matter (which can be radioactive) from the atmosphere.

fanglomerates

Sedimentary rock of water-worn heterogeneous fragments of every size, settling in an alluvial fan and cementing into rock.

fault

A fracture or a zone of fractures within a rock formation along which vertical, horizontal, or transverse slippage has occurred in the past.

faunal

Animal and plant fossils of a certain rock unit.

feldspar

Most common group of aluminum silicate minerals (containing other metals, such as potassium, sodium, and iron) that form rock.

ferruginous

Containing iron oxide.

fission

The splitting of a heavy atomic nucleus into two approximately equal parts, which are nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons; can occur spontaneously or can be induced by neutron bombardment.

fission products

Nuclei formed by the fission of heavy elements (primary fission products); also, the nuclei formed by the decay of the primary fission products, many of which are radioactive.

fluvial

Relating to, or living in or near, a river.

flux

Rate of flow through a unit area.

food chain

The pathways by which any material entering the environment passes from the first absorbing organism through plants and animals to humans.

fracture porosity

Breaking in a rock resulting in porosity.

fuller's earth

Fine grained natural earth substance; has high absorbency and consists mostly of hydrated aluminum silicates.

gamma rays (γ)

High-energy, short-wavelength, electromagnetic radiation accompanying fission and emitted from the nucleus of an atom; gamma rays are very penetrating and require dense (e.g., lead) or a thick layer of materials for shielding.

gamma spectrometry

Identification and quantification of radioisotopes by measurement of the characteristic gamma rays emitted by elements undergoing radioactive decay.

genetic effects

Radiation effects that can be transferred from parent to offspring; radiation-induced changes in the genetic material of sex cells.

geologic repository (mined geologic repository)

A facility for the disposal of nuclear waste; the waste is isolated by placement in a continuous, stable geologic formation at depths greater than 1000 feet.

geology

The science that deals with the earth: the materials, processes, environments, and history of the planet, especially the lithosphere, including the rocks, their formation and structure.

glass frit

Ground or powdered glass.

glauconitic

Mineral aggregate containing glauconite (a complex silicate mineral containing iron, aluminum, sodium, potassium, calcium, and magnesium), giving it a green color.

gneiss

Rock formed from bands of granular minerals alternating with bands of minerals that are flakey, or have elongate prismatic habits.

gradient

Slope, particularly of a stream or land surface.

groundwater

The supply of water under the earth's surface in an aquifer.

gypsum

Mineral containing hydrated calcium sulfate ($CaSO_4 \cdot 2H_2O$).

half-life (biological)

The time required for a living organism to eliminate, by natural processes, half the amount of a substance that has entered it.

half-life (effective)

The time required for a radionuclide in an organism to reduce its activity by half as a combined result of radioactive decay and biological elimination.

half-life (radiological)

The time in which half the atoms of a radioactive substance disintegrate to another nuclear form; varies for specific radioisotopes from millionths of a second to billions of years.

half-thickness

The thickness of any absorber that will reduce the intensity of a beam of radiation to one half its initial intensity.

halogens

The group of five chemically related nonmetallic elements that include fluorine, chlorine, bromine, iodine, and astatine.

health physics

The science concerned with the recognition, evaluation, and control of health hazards from ionizing radiation.

health risk

The probability that a specified health effect will occur from a defined exposure to a toxic chemical or radiation.

health risk assessment

An evaluation and interpretation of available scientific evidence on the toxicity of a substance, its presence in the environment at some level, and its accessibility for human exposure, providing a judgment and, if appropriate, an estimate of the probability that risk exists.

heating value

The heat released by combustion of a unit quantity of a fuel, measured in joules or Btus.

heavy metals

Metallic elements of high molecular weight, such as mercury, chromium, cadmium, lead, and arsenic, that are toxic to plants and animals at known concentrations; many exhibit cumulative effects.

heavy water (D_2O)

Water in which the molecules contain deuterium (D_2), an isotopic form of hydrogen that is heavier than ordinary hydrogen, and oxygen.

High-efficiency particulate air (HEPA) filter

A type of filter designed to remove 99.9 percent of the particulates as small as 0.3 micron in diameter from a flowing air stream.

high-level waste

High-level liquid waste or the products from the solidification of high-level liquid waste or irradiated fuel elements, if discarded without reprocessing.

historic resources

The sites, districts, structures, and objects considered limited and non-renewable because of their association with historic events, persons, or social or historic movements.

holocene

Epoch of quaternary period from end of pleistocene (10,000 years ago) to present time.

horneblende

Most common mineral of the amphibole group.

hydraulic conductivity

Water flow rate in volume per unit time through a unit cross-section under a unit hydraulic gradient. (See Darcy's law; hydraulic gradient.)

hydraulic gradient

The difference in hydraulic head as a function of distance between wells. (See Darcy's law.)

hydraulic (water) head

Height of water with a free surface above a subsurface point.

hydrocarbons (HC)

Organic compounds consisting primarily of hydrogen and carbon; emitted in automotive exhaust and from the incomplete combustion of fossil fuels such as coal.

hydrograph

Graph showing water characteristics such as velocity, or flow, in relation to time.

hydrologic regimen

Total quantity and characteristic behavior of water in a drainage basin.

hydrology

The science dealing with the properties, distribution, and circulation of natural water systems.

hydrosphere

The water portion of the surface of the earth, as distinguished from the solid portion (the lithosphere).

hydrostratigraphic unit (HSU)

Rock or soil body extending laterally for a considerable distance.

induced radioactivity

Radioactivity created when substances are bombarded with neutrons, as in a reactor.

indurated

Soil or rock compacted and hardened by heat, pressure, and cementation.

inert gas

A gas that is ordinarily totally unreactive such as argon, xenon, krypton. Also called noble gases.

intensity (radioactive)

The energy or the number of photons or particles of radiation incident on a unit area per unit of time; the number of atoms disintegrating per unit of time.

interfluvial

Falling in the area between two streams.

intergranular porosity

Porosity between grains of rock.

interim storage (waste)

Temporary storage of drums, sealed canisters, or other containers containing immobilized hazardous or radioactive wastes in a shielded or unshielded storage facility until transfer to a Federal repository or other permanent disposal/storage facility.

intermediate-activity waste

Low-level radioactive waste or mixed waste with radioactivity of 300 millirem per hour or more at 7.6 centimeters from the surface of the container.

intruder

A member of the public similar to the maximally exposed individual who, after a 100-year institutional control period, remains on the site 24 hours a day; lives in a house on the site; consumes all food from crops and animal products grown on the site; drinks water from a well drilled on the site; breathes the air on the site; and moves about on the site.

ion

An atom or molecule that has gained or lost one or more electrons and has, thus, become electrically charged. Negatively charged ions are anions; positively charged ions are cations.

ion exchange

The process in which a solution passes over an ion-exchange medium, which removes the soluble ions by exchanging them with labile ions from the medium; this process is reversible, so the adsorbed ions can be eluted from the medium and the medium can be regenerated.

ion-exchange resin

Polymeric spheres (usually polystyrene-divinylbenzene copolymers) containing bound groups that carry an ionic charge, either positive or negative, in conjunction with free ions of opposite charge that can be displaced.

ionization

The process whereby ions are formed from atoms or molecules; nuclear radiation can cause ionization, as can high temperatures and electric discharges.

ionizing radiation

Radiation capable of displacing electrons from atoms or molecules, thereby producing ions.

irradiation

Exposure to radiation.

isotope

An atom of a chemical element with a specific atomic number and atomic weight; isotopes of the same element have the same number of protons but different numbers of neutrons.

joule

A unit of energy or work equivalent to 1 watt per second, 0.737 foot-pound, or 4.18 calories.

kaolin

Clay mineral group characterized by a silicon-oxygen sheet and an aluminum-hydroxyl sheet alternately linked to form a two-layer crystal lattice.

kilometer

A metric unit of length equal to 0.62137 mile or 1000 meters.

leachate

Liquid that has percolated through solid waste or other media and has extracted dissolved or suspended materials from the solids into the liquids.

leaching

The process whereby a soluble component of a solid or mixture of solids is extracted as a result of percolation of a liquid around and through the solid.

leukemia

A form of cancer characterized by extensive proliferation of non-functional immature white blood cells (leukocytes).

lignite

A brownish-black coal of low Btu value between stages of peat and sub-bituminous coal.

limonite

Hydrous ferric oxides occurring naturally, but having unknown origins.

liters per second (lps)

A metric unit of flow rate equal to 15.85 gallons per minute.

lithology

Rock descriptions by color, structure, grain size, etc.

lithosphere

The solid part of the earth, composed predominantly of rock.

long-lived nuclides

Radioactive isotopes with half-lives greater than about 30 years.

low-activity waste

Low-level radioactive or mixed waste with radioactivity of less than 300 millirem per hour at 7.6 centimeters from the container.

low-level waste

Radioactive waste not classified as high-level waste, transuranic waste, spent nuclear fuel, or byproduct material.

man-rem

(See person-rem)

marine terrace

Narrow coastal strip altered by marine deposit and erosion.

maximum contaminant level (MCL)

Maximum permissible level of a contaminant in drinking water, based on a 70-kilogram adult consuming 2 liters of water a day (from National Primary Drinking Water Standards).

maximum permissible dose

That dose of ionizing radiation established by competent authorities as an amount below which there is no appreciable risk to human health; at the same time, it is below the lowest level at which a definite hazard is believed to exist.

mica

Variously colored, or colorless mineral silicates, crystallizing in monoclinic forms that separate into thin leaves.

micro (μ)

Prefix indicating one millionth. One microgram (μg) = 1/1,000,000 of a gram or 10^{-6} gram.

micrometer (μm)

A unit of length equal to one one-millionth (10^{-6}) of a meter.

micron

A micrometer (10^{-6} meter). (Note: "micrometer" is the preferred usage.)

Middendorf/Black Creek

Upper Cretaceous age formations of high water yield, colloquially referred to as the lower and upper Tuscaloosa Formations; the Middendorf Formation is separated from the overlying Black Creek Formation by a clay aquitard known as the "mid-Tuscaloosa clay."

migration

The natural travel of a material through the air, soil, or groundwater.

moderator

A material used to decelerate neutrons from fission to thermal energies.

molecule

A group of atoms held together by chemical forces; the smallest unit of a compound that can exist by itself and retain all its chemical properties.

monoclinal

Strata varying from the horizontal in one direction only.

mutagen

An agent (physical, chemical, or radioactive) capable of inducing mutation (above the spontaneous background level).

mutagenesis

The occurrence or induction of mutation, a genetic change that is passed on from parent to offspring.

mutation

An inheritable change in the genetic material (in a chromosome).

nano

Prefix indicating one thousandth of a micro unit; one trillionth; 1 nanocurie = 10^{-9} curie.

National Register of Historic Places

A list maintained by the National Park Service of architectural, historic, archaeological, and cultural sites of local, state, or national significance.

natural radiation; natural radioactivity

Background radiation: cosmic, soil, rocks.

neutron

An uncharged elementary particle with a mass slightly greater than that of the proton, found in the nucleus of every atom heavier than hydrogen-1; a free neutron is unstable and decays with a half-life of about 13 minutes into an electron and a proton.

neutron flux

Number of neutrons flowing through a unit area per unit time.

NO_x

Refers to the oxides of nitrogen, primarily NO and NO_2. These are often produced in the combustion of fossil fuels. In high concentrations, they constitute an air pollution problem.

nodes

The intersection of horizontal and vertical grids.

nuclear energy

The energy liberated by a nuclear reactor (fission or fusion) or by radioactive decay.

nuclear reaction

A reaction in which an atomic nucleus is transformed into another element, usually with the liberation of energy as radiation.

nucleus

The small positively charged core of an atom, which contains nearly all the mass of the atom.

nuclide

An atomic nucleus specified by its atomic weight, atomic number, and energy state; a radionuclide is a radioactive nuclide.

organic degreasers

Cleaning agents having organic chemical structures, such as trichloroethane, trichloroethylene, tetrachloroethylene, and tetrachloromethane (carbon terachloride).

outcrop

Part of a geologic formation above the surface of the earth.

paleocene

Epoch of tertiary period between the gulfian of the cretaceous period (65 million years ago) and before the eocene (55 million years ago).

particulates

Solid particles small enough to become airborne.

parts per million (ppm)

The unit commonly used to represent the degree of concentration. In air, ppm is usually volume pollutant per 1,000,000 volumes of air; in water, a weight per 1,000,000 weight units.

pascal

A metric unit of pressure; 101,000 pascals is equal to 14.7 pounds per square inch (psi).

pD

The negative log of the deuterium (heavy hydrogen) ion concentration in solution; analogous to the term pH, which refers to the hydrogen (protium) ion concentration.

peneplain

Almost featureless, plain land surface.

perched

A water-bearing area of small lateral dimensions lying above a more extensive aquifer.

permeability

Ability of water to flow through porous rock or soil. (See Darcy's law.)

person-rem

The radiation dose commitment to a given population; the sum of the individual doses received by a population segment.

pH

A measure of the hydrogen ion concentration activity in aqueous solution; specifically, the negative logarithm of the hydrogen ion concentration. Acidic solutions have a pH from 0 to 7, basic solutions have a pH greater than 7.

phosphatic marl

Soft, loose, earthy phosphates that crumble easily.

photon

Electromagnetic radiation; a quantum of electromagnetic energy having properties of both a wave and a particle but without mass or electric charge.

physiography

Description of earth surface features, including air, water, and land.

Piedmont province

Large area forming a plateau at the base of the Appalachian mountains, extending from New Jersey to Alabama.

piezometric maps

Lines of equal groundwater pressure drawn on a map.

piezometric surface

The surface to which water in an aquifer would rise by hydrostatic head.

pisolitic clay

Clay that exhibits an internal structure of pea-sized clay grains.

Plant (or SRP) stream

Any natural stream on the Savannah River Plant; surface drainage is via these streams to the Savannah River.

pleistocene

Epoch of the quaternary period, between pliocene (1.8 million years ago) and holocene (10,000 years ago).

pliocene

Epoch of the tertiary period, between miocene (5 million years ago) and pleistocene (1.8 million years ago).

pounds per square inch (psi)

A measure of pressure; atmospheric pressure is about 15 psi.

plume

The elongated pattern of contaminated air or water originating at a point-source emission, such as a smokestack, or a waste source, such as a hazardous waste disposal site.

pyrite

Isometric mineral: FeS_2 (iron sulfide).

quality factor (radioactive)

The factor by which absorbed dose, in rads, is multiplied to obtain a quantity expressing the irradiation incurred by various biological tissues, taking into account the biological effectiveness of the various types of radiation.

quartz

Crystalline silica: SiO_2.

quartzite

Very hard, metamorphosed sandstone.

quaternary age

The period from the end of the tertiary (1.8 million years ago) to present time.

radiation

The emitted particles or photons from the nuclei of radioactive atoms. Some elements are naturally radioactive; others are induced to become radioactive by bombardment in a reactor. Naturally occurring radiation is indistinguishable from induced radiation.

radiation absorbed dose (rad)

The basic unit of absorbed dose equal to the absorption of 0.01 joule per kilogram of absorbing material.

radioactivity

The spontaneous decay or disintegration of unstable atomic nuclei, accompanied by the emission of radiation.

radioisotopes

Nuclides of the same element (same number of protons in their nuclei) that differ in the number of neutrons, and that spontaneously emit particles of electromagnetic radiation.

recommended maximum contaminant level (RMCL)

Proposed maximum permissible level of a contaminant in drinking water.

residence time

The period of time during which a substance remains in a designated area.

Resource Conservation and Recovery Act (RCRA)

Federal legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes.

roentgen (R)

A unit of exposure to ionizing radiation equal to or producing 1 coulomb of charge per cubic meter of air.

roentgen equivalent man (rem)

The unit of dose for biological absorption; equal to the product of the absorbed dose in rads, a quality factor, and a distribution factor.

saltcrete

A mixture of partially decontaminated salts and concrete.

sandstone

Clastic rock containing large individual particles visible to the unaided eye.

sanitary landfilling

An engineered method of solid waste disposal on land in an acceptable manner; waste is spread in thin layers, compacted to the smallest practical volume, and covered with soil at the end of each working day.

saprolite

A rock that is earthy, soft, clay-rich, extremely decomposed.

Savannah River Ecology Laboratory (SREL)

An ecological research institution operated by the University of Georgia under contract from DOE.

Savannah River Laboratory (SRL)

A nuclear research facility operated by E. I. du Pont de Nemours and Company under contract from DOE.

Savannah River Plant (SRP)

A 780-square-kilometer (192,700-acre), controlled-access area near Aiken, South Carolina, containing industrial facilities that produce nuclear materials for national defense.

schist

Strongly foliated crystalline rock formed by dynamic metamorphism that can be split easily into thin slabs, or flakes.

scrubber

An air pollution control device that uses a liquid spray to remove pollutants from a gas stream by absorption or chemical reaction.

sedimentation

The settling of excess soil and mineral solids of small particle size contained in water.

seep lines

Small zone where water leachate percolates slowly to the surface; a series of groundwater or leachate springs.

seepage basin

An excavation in the ground to receive aqueous streams containing chemical and radioactive wastes. Insoluble materials settle on the floor of the basin and soluble materials seep with the water through the soil column, where they are removed partially by ion exchange or other absorption processes with the soil. Dikes prevent overflow or surface runoff.

seismic

Pertaining to any earth vibration, especially an earthquake.

seismicity

The tendency for the occurrence of earthquakes.

settling tank

A tank in which settleable solids are removed by gravity.

shield

An engineered body of absorbing material used to protect personnel from radiation.

short-lived nuclides

Radioactive isotopes with half lives no greater than about 30 years (e.g., cesium-137 and strontium-90).

siliceous cement

Cement with an abundance of silica.

siltstone

Silt having the texture and composition of shale, but lacking its fine lamination.

sink

An area from which water drains or is removed.

sludge

The precipitated solids (primarily oxides and hydroxides) that settle to the bottom of the vessels containing liquid wastes.

slurry

A suspension of solid particles (sludge) in water.

stationary source

A source of emissions into the environment that is fixed, as a stack or chimney, rather than moving, as an automobile.

storage (waste)

Retention of radioactive or hazardous waste in a man-made containment such as a drum, tank, or vault in a manner that permits retrieval, as distinguished from disposal, which implies no retrieval.

storage coefficient

Volume of water released from storage in a vertical column of 1.0 square foot when the water table declines 1.0 foot.

stratified

Formed or arranged in layers.

stratigraphy

Division of geology dealing with the definition and description of rocks and soil, both major and minor natural divisions.

strike

The direction or trend that a structural surface (e.g., a bedding or fault plane) takes as it intersects the horizontal.

sulfur dioxide (SO_2)

A heavy pungent colorless gas (formed in the combustion of coal); SO_2 in high concentration is considered a major air pollutant.

sulfur oxides (SO_x)

Primarily SO_2 and SO_3; a common air pollutant.

supernatant; supernate

The portion of a liquid above settled materials in a tank or other vessel.

surface water

All water on the earth's surface, as distinguished from groundwater.

surficial deposit

Most recent geological deposit lying on bedrock or on or near the earth's surface.

tertiary age

First period of cenozoic era, thought to be between 65 and 1.8 million years ago.

threshold dose

The minimum dose of a given substance that produces a measurable environmental response factor.

total suspended particulates (TSP)

The concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

toxicity

The quality or degree of being poisonous or harmful to plant or animal life.

tracer injection detection test

Injection of dye in water to trace water flow.

transmissivity

The rate at which water of prevailing kinematic viscosity is transmitted through a unit width under a unit hydraulic gradient.

transuranic (TRU) waste

Solid radioactive waste containing primarily alpha emitters of elements heavier than uranium.

transuranium elements

Elements above uranium in the periodic table; all 13 known transuranic elements are radioactive and are produced artificially.

triassic period

First period of the mesozoic era; thought to be between 225 and 190 million years ago.

tritium (H-3)

A radioactive isotope of hydrogen, a weak beta emitter with a half-life of 12.3 years.

turbidity

Measure of sediment or suspended foreign particle concentration in solution.

Tuscaloosa

(See Middendorf/Black Creek.)

unconsolidated

Loosely arranged or unstratified sediment.

unit cancer risk (UCR)

The excess risk due to a continuous lifetime exposure to one unit of carcinogen concentration, expressed as a probability; also called carcinogenic potency factor.

vadose zone

The unsaturated zone in soil above the water table.

vault

A reinforced concrete structure for storing canisters of immobilized high-level radioactive waste.

venting

Release of gases or vapors under pressure to the atmosphere.

volatile organic compounds

A broad range of organic compounds, often halogenated, that vaporize at ambient or relatively low temperatures, such as benzene, acetone, chloroform, and methyl alcohol.

waste, hazardous (RCRA)

Any solid waste (can also be semisolid or liquid, or contain gaseous material) having the characteristics of ignitability, corrosivity, toxicity, or reactivity, defined by RCRA and identified or listed in 40 CFR 261. For this EIS, "hazardous" refers to substances or constituents, used in their everyday sense, without specific regard to technical or regulatory definitions, unless indicated.

waste, mixed

Waste having both hazardous and low-level radioactive content.

waste, radioactive

Materials from nuclear operations that are radioactive or are contaminated with radioactive materials, and for which there is no practical use or recovery is impractical.

watershed

The area drained by a given stream.

water table

The upper surface of the groundwater.

zero release

Refers to the design of hazardous waste disposal/storage sites that meet minimum requirements for secure disposal/storage; derived from RCRA regulations.

zooplankton

Planktonic (floating) animals that supply food for fish.

LIST OF ACRONYMS AND ABBREVIATIONS

ADI	acceptable daily intake
AEC	U.S. Atomic Energy Commission
BOD	biochemical oxygen demand
Btu	British thermal unit
cc	Cubic centimeters, cm^3 or cc (1 cc = 1 milliliter)
CCDF	Complementary cumulative distribution function
CEQ	President's Council on Environmental Quality
CERCLA	Comprehensive, Environmental Response Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cfs	cubic feet per second
Ci	Curie
COE	U.S. Army Corps of Engineers
CTF	chemical transfer facility
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy - Headquarters
DOE-SR	U.S. Department of Energy - Savannah River Operations Office
DOI	U.S. Department of the Interior
DPSOL	Du Pont Savannah Operating List
DPSOP	Du Pont Savannah Operating Procedure
DWPF	Defense Waste Processing Facility
D_2O	heavy water or deuterium oxide
EA	environmental assessment
ED	Environmental Division, DOE-SR

EDC	environmental dose commitment
EIS	environmental impact statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERDA	U.S. Energy Research and Development Administration
ESA	Endangered Species Act
FEIS	final environmental impact statement
FHETF	F- and H-Area effluent treatment facility
FMF	Fuel Materials Facility
FMF-EA	Fuel Materials Facility - Environmental Assessment
FONSI	Finding of No Significant Impact
FWCA	Fish and Wildlife Coordination Act
FWS	U.S. Fish and Wildlife Service
g/L	grams per liter
HC	hydrocarbon
HEPA	high-efficiency particulate air (filter)
HSU	hydrostratigraphic unit
HSWA	Hazardous Solid Waste Amendments
HWCTR	Heavy Water Components Test Reactor
LETF	liquid effluent treatment facility
lps	liters per second
LSS	liquid scintillation solvents
MCL	maximum contaminant level
mg	milligram (one-thousandth of a gram)
ml	milliliter (one-thousandth of a liter)
mm	millimeter (one-thousandth of a meter)

MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
mrem	millirem (one-thousandth of a rem)
NAAQS	National Ambient Air Quality Standards
nCi	nanocuries (10^{-9} curie)
NEPA	National Environmental Policy Act of 1969 (42 USC 4321 et seq.)
NERP	National Environmental Research Park
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	U.S. Nuclear Regulatory Commission
NSPS	New Source Performance Standards
PCB	polychlorinated biphenyl
ppb	parts per billion (10^{-9}) (one thousandth of a part per million)
PSD	prevention of significant deterioration
R	roentgen
rad	radiation absorbed dose
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RMCL	recommended maximum contaminant level
SCDHEC	South Carolina Department of Health and Environmental Control
SCWMRD	South Carolina Wildlife and Marine Resources Department
SCWRC	South Carolina Water Resource Commission

SHPO	State Historic Preservation Office
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SPCC	Spill Prevention Control and Countermeasure
SREL	Savannah River Ecology Laboratory
SRL	Savannah River Laboratory
SRLUC	Savannah River Land Use Committee
SRP	Savannah River Plant
TRU	transuranic
TSP	total suspended particulates
TSS	total suspended solids
UCR	unit cancer risk
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VOC	volatile organic compounds

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APPENDIX A

GEOLOGY AND SUBSURFACE HYDROLOGY

This appendix discusses the geology and subsurface hydrology of the Savannah River Plant (SRP) and its surroundings. Included in the following sections are descriptions of the regional geologic setting; seismology and geologic hazards; hydrostratigraphy; groundwater hydrology; groundwater quality; groundwater use; hydrogeologic interrelationships; groundwater recharge and discharge; and water budget for the Separations area and the Burial Ground.

A.1 GEOLOGY AND SEISMOLOGY

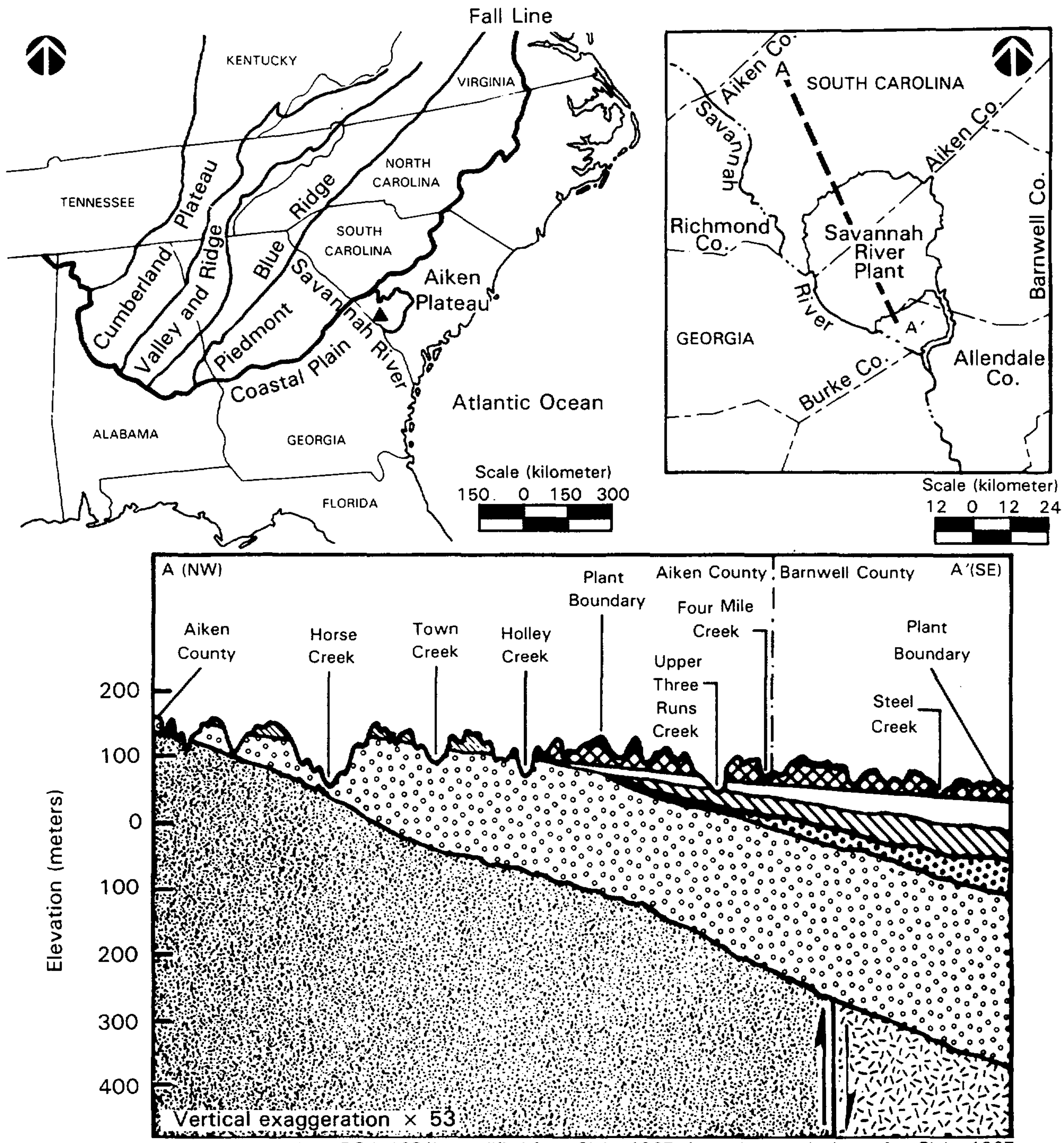
This section contains information on the important geologic features in the region surrounding the SRP and within its boundaries. The geologic features discussed include the regional geologic setting, seismology, and geologic hazards.

A.1.1 REGIONAL GEOLOGIC SETTING

A.1.1.1 Tectonic Provinces

The North American continent is divided tectonically into foldbelts of recent or ancient deformation, and platform areas where flat-lying or gently tilted rocks lie upon basements of earlier foldbelts (King, 1969). The Southeastern United States contains two platform areas (the Cumberland Plateau province and the Coastal Plain province) and three foldbelts (the Blue Ridge province, the Valley and Ridge province, and the Piedmont province) (Figure A-1).

The Savannah River Plant is located in the Aiken Plateau physiographic division of the Atlantic Coastal Plain province (Figure A-1) (Cooke, 1936; Du Pont, 1980a). The center of the Plant is approximately 40 kilometers southeast of the fall line that separates the Atlantic Coastal Plain province from the Piedmont province (Davis, 1902). Crystalline rocks of the Piedmont (Precambrian and Paleozoic age) underlie a major portion of the gently seaward-dipping Coastal Plain sediments of Cretaceous and younger age (Figure A-1). Sediment-filled basins of Triassic and Jurassic age (their exact age is uncertain) occur within the crystalline basement throughout the Coastal Plain of Georgia and the Carolinas (Du Pont, 1980a). One of these, the Dunbarton Triassic Basin, underlies parts of the Plant (Figure A-1) (Du Pont, 1980a; Stephenson, Talwani, and Rawlins, 1985).



Source: Adapted from DOE, 1984b; modified from Siple, 1967; formation terminology after Siple, 1967; see Figure A-2.

Scale (kilometer)
0 8 16

Legend:

- Hawthorn (Fluvial Upland Unit)
- Barnwell
- Tertiary rocks undifferentiated
- McBean
- Congaree
- Crystalline metamorphic rock
- Ellenton
- Tuscaloosa
- Dunbarton Triassic Basin

Figure A-1. Generalized Northwest to Southeast Geologic Profile, and SRP Regional Site Locator

A.1.1.2 Stratigraphy*

Metamorphic and Crystalline Basement Rock

Near the center of the Plant, metamorphic and crystalline rock is buried beneath about 280 meters of unconsolidated-to-semiconsolidated Coastal Plain sediments (Marine, 1967). The surface of the rock dips to the southeast at a gradient of about 6.8×10^{-3} (Siple, 1967), and the rock is exposed at the fall line about 40 kilometers northwest of the SRP.

Immediately overlying the basement rock is a layer of saprolite, which is the residual product of weathering of the crystalline and metamorphic rock. The combined saprolite and basal clay at the bottom of the Coastal Plain Sediments forms an effective seal that restricts the flow of water between the Coastal Plain sediments and the basement complex.

Triassic-Jurassic Sedimentary Rock

The Dunbarton Basin, formed by normal faulting of the crystalline and metamorphic basement rock during the Triassic-Jurassic Period, is filled by sandstones, shales, and conglomerates, and buried beneath about 370 meters of Coastal Plain sediments (Figure A-1). The northwest boundary of the basin has been well defined by seismic traverses and by a well that penetrated 490 meters of Triassic-Jurassic rock and then passed into the crystalline and metamorphic rock below. The southeast margin is not as well defined, because there are no well data similar to those defining the northwest margin (Marine, 1976). The depth to the bottom of the Dunbarton Basin is not known from well penetration. A well near the center of the basin that was drilled to a depth of 1300 meters did not penetrate the underlying crystalline rock.

The rocks of the Dunbarton Basin consist of poorly sorted shale, saltstone, sandstone, and conglomerate. The coarser material is found near the northwest margin, where fanglomerates are abundant. Nearer the center, sandstone, saltstone, and shale predominate; however, the sorting is always extremely poor (Marine and Siple, 1974).

Cretaceous Sediments

The terminology for the stratigraphic units used in this EIS is modified from that used by Siple (1967). The Middendorf and Black Creek Formations (GCS, 1986) have been determined to be more accurate nomenclature for what had been referred to as the "Tuscaloosa Formation" in many studies of groundwater at

*The accepted names for stratigraphic units have evolved over the years as additional information on the age of the units and their correlation with similar units in other areas has surfaced. This is reflected in the different names used by authors to identify subsurface units. The stratigraphic nomenclature used in this document is the same as the usage of authors whose works have been referenced. Therefore, different portions of the text might use different names for the same geologic units. Likewise, the same name may be used for geologic units or portions of units that are otherwise different. Figure A-2 shows the correlation of units used by the various authors. The terminology used in this document is largely that of Siple (1967).

the Savannah River Plant. Figure A-2 shows a tentative correlation of these units to stratigraphic terminology described in recent publications.

The Cretaceous-Age sands and sediments (Figure A-2) consist primarily of fluvial and estuarine deposits of cross-bedded sand and gravel with lenses of silt and clay. They rest directly on saprolite, a residual clay from weathering of the crystalline and metamorphic rock. The Cretaceous Sediments are overlain conformably by the Ellenton Formation but, near the Fall Line, where the Ellenton is absent, they are overlain unconformably by sediments of Tertiary and Quaternary age (Siple, 1967). The Cretaceous Sediments crop out in a belt that extends from western Tennessee to North Carolina. In South Carolina, this belt is 15 to 50 kilometers wide. The thickness of the Cretaceous Sediments ranges from 0 at the Fall Line to about 230 meters beneath the L-Reactor on the Savannah River Plant. The thickness remains fairly constant in the SRP area.

In this area, the Cretaceous Sediments consist of light gray-to-white, tan, and buff-colored, cross-bedded quartzitic-to-arkosic coarse sand and gravel, with lenses of white, pink, red, brown, and purple silt and clay (Siple, 1967). Ferruginous sandstone concretions, siderite nodules, and lenses of kaolin 0.5 to 12 meters thick are present in the Cretaceous Sediments. The chief minerals in the sediments are quartz, feldspar, and mica, which were derived from weathering of the igneous and metamorphic rocks of the Piedmont province to the northwest.

Ellenton Formation

The Ellenton Formation (terminology after Siple, 1967), which overlies the Cretaceous Sediments (Figure A-2), consists of dark lignitic clay with coarse sand units. It is thought to be Paleocene in age and is unconformably overlain by the Congaree Formation (of the Eocene Epoch). The Ellenton Formation sediments are entirely within the subsurface; they range to about 30 meters in thickness.

The lignitic clay is dark gray to black, sandy, and micaceous. It is interbedded with medium quartz sand and contains pyrite and gypsum. The upper part of the formation is characterized by gray salty-to-sandy clay with which gypsum is associated. This clay is about 3 to 5 meters thick in the central part of the Plant; it thickens to 10 meters in A- and M-Areas. The lower part consists generally of medium-to-coarse clayey quartz sand, but it contains very coarse and gravelly quartz sand in some areas (Siple, 1967).

Congaree Formation

The Congaree Formation (terminology after Siple, 1967) was included in the McBean Formation by Cooke (1936), and this usage was followed by the U.S. Army Corps of Engineers (COE, 1952) during the original foundation studies for the construction of the SRP (Marine and Root, 1978). The lower part of the original McBean was raised to formational status and called the Congaree Formation and the Warley Hill Marl by Cooke and MacNeil (1952). In discussing geology and groundwater at the Plant, Siple (1967) used the term "McBean" to include both all deposits of Claiborne age and only the upper part of these deposits. In much of the area studied by Siple, the two units could not be distinguished, either where exposed or in well logs (Marine and Root, 1978).

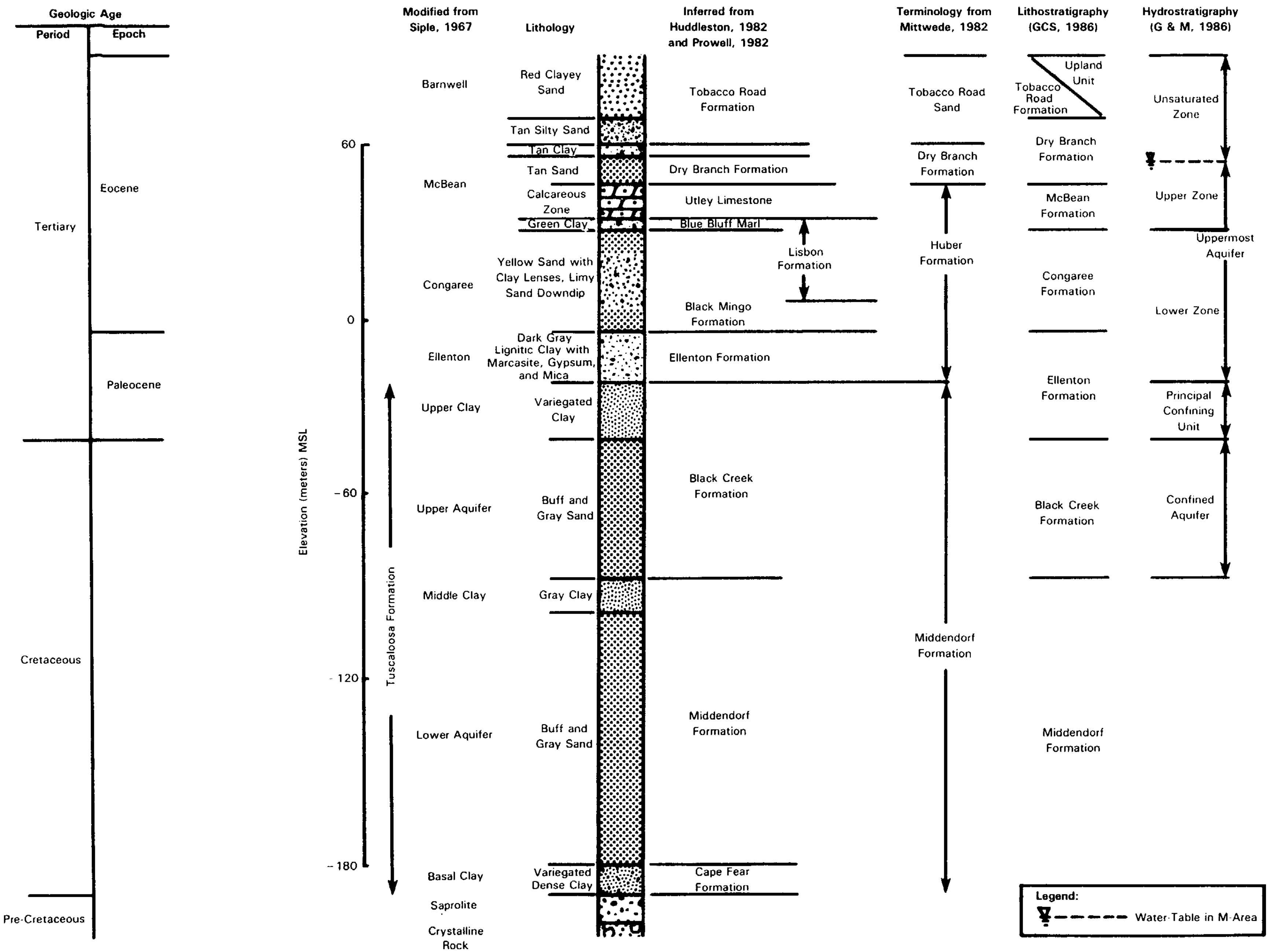


Figure A-2. Tentative Correlation of Stratigraphic Terminology of Southwestern South Carolina Coastal Plain

Subsequent investigations at the Plant have shown that it is desirable to distinguish the McBean Formation - as used in the restricted sense, rather than as used by Siple (1967) - from the Congaree Formation. These two units are separated by a clay layer informally called the "green clay" (Figure A-2).

The deposits of Claiborne age strike about N 60°E and dip at a gradient of about 1.5×10^{-3} to 1.7×10^{-3} toward the south or southeast (Siple, 1967). Their thickness ranges from zero near the fall line to about 76 meters in southeastern Allendale County. In the central part of the Plant, the Claiborne deposits are about 61 meters thick, of which about 37 meters is the Congaree Formation.

In the vicinity of the Separations Areas, the Congaree Formation consists of gray, green, and tan sand with some layers of gray, green, or tan clay (Marine and Root, 1978). In the northwest part of the Plant, it consists primarily of tan clayey sand. It is slightly glauconitic in some places and slightly calcareous in others. A pisolithic clay zone at the base of the Claiborne deposits defines the base of the Congaree Formation (Siple, 1967).

The green clay layer at the top of the Congaree Formation appears to be discontinuous in the northwest SRP area (i.e., updip). To the south, the green clay appears to thicken to about 7 meters in L-Area and 18 meters in the southeastern portions of the Plant to become what is called in Georgia the Blue Bluff Marl of the Lisbon Formation. The Marl is found at the Vogtle Nuclear Power Station in Georgia, in wells in the southern part of the Plant, and in offsite areas to the south. The green clay is gray to green, dense, and occasionally indurated (Marine and Root, 1978). The induration of the clay is caused commonly by dense compaction and siliceous cement. Calcareous cement is usually absent from this zone but, farther south, calcareous cement might be more common.

Although subdivision of the Claiborne group might be warranted in the SRP area and in other parts of South Carolina and Georgia, such subdivision appears less warranted toward the Fall Line, because the shoreward facies of each unit grade into a comparatively thin zone, and criteria for distinguishing them become doubtful (Siple, 1967). This is confirmed by drilling in M-Area, where the green clay is thin and discontinuous and the sediments of both McBean and Congaree are very similar in appearance.

McBean Formation

As discussed in Section A.1.1.2.5, the term "McBean" was originally used to designate all deposits of Claiborne age in this area; it is now used to designate only the upper part of these sediments. The McBean Formation can be divided into two subunits: an upper unit consisting of tan, clayey sands and occasionally red sand (Marine and Root, 1978), and a lower unit consisting of light, tan-to-white calcareous, clayey sand (Figure A-2). This lower unit is locally called the "calcareous zone"; in some places, it contains void spaces that could result in rod drops or lost circulation during drilling operations (COE, 1952). To the northwest, these void spaces appear to decrease, so no calcareous zone exists in M-Area. However, to the southeast, the calcium carbonate content of the zone increases, as do void spaces. Southeast of the Plant the zone becomes a limestone with only small amounts of sand.

The McBean Formation is considered the shoreward facies of the Santee limestone to the southeast (Siple, 1967). In the SRP area, the calcareous zone may represent a tongue of the Santee limestone. Toward the fall line to the northwest of the SRP, it becomes more difficult to distinguish the several Eocene formations, and Siple (1967) maps the Eocene deposits as undifferentiated. In the northwest SRP area (M-Area), the calcareous zone is replaced by a clayey sand unit.

Barnwell Formation

The Barnwell Formation (terminology after Siple, 1967) directly overlies the McBean Formation and is exposed over a considerable area of Aiken and Barnwell Counties. The formation thickens to the southeast from zero in the northeastern part of Aiken County to about 27 meters at the southeast boundary of Barnwell County. The Barnwell Formation is overlain by the Hawthorn Formation. These formations are generally difficult to distinguish from each other. In the Separations Areas, the two units combined are about 30 meters thick.

The Barnwell Formation consists mainly of deep red, fine-to-coarse clayey sand and compact, sandy clay. Other parts of the formation contain beds of mottled gray or greenish-gray sandy clay and layers of ferruginous sandstone that range in thickness from 0.03 to 1 meter. Beds of limestone occur in the Barnwell Formation in Georgia, but none have been recognized in South Carolina. Factors indicate that a considerable part of the Barnwell Formation was deposited as a calcareous sandstone in a near-shore or estuarine environment. Some evidence of the original calcareous nature of the formation is indicated by the comparatively high proportion of calcium carbonate found in groundwater circulating in this unit (Siple, 1967).

In the Separations Areas, the Barnwell Formation is divisible into three parts:

1. The lowest unit, the "tan clay," commonly consists of two thin clay layers separated by a sandy zone. The entire unit is about 3 to 4.5 meters thick and is semicontinuous over the area.

2. Above the tan clay is a silty sand unit 0 to 12 meters thick.

3. Above the silty sand is a unit of clayey sand that runs up to 30 meters thick. This sand, which may include beds of silty clay or lenses of silty sand, is slightly less permeable than the underlying silty sand.

Upland Unit

The Upland Unit (Hawthorn equivalent; Siple, 1967) is exposed over a very large area of the Atlantic Coastal Plain and is perhaps the most extensive surficial deposit of Tertiary age in this region. It is bounded on top and bottom by erosional unconformities, and is present at the surface in the higher areas of Aiken County. It ranges in thickness from 0 in northwestern Aiken County to about 25 meters near the Barnwell-Allendale County Line.

The Upland Unit consists of a fine, sandy, phosphatic marl or soft limestone, and brittle shale resembling Fuller's earth. Updip, however, in the vicinity of Aiken and Barnwell Counties, it is characterized by tan, reddish-purple, and gray sandy, dense clay that contains coarse gravel, limonitic nodules, and disseminated pods of kaolinitic material.

Tertiary Alluvium

Alluvial deposits of Late Tertiary age occur irregularly and discontinuously on the interstream divides. They are composed of coarse gravel and poorly sorted sand and have been tentatively classified by Siple (1967) as Pliocene in age. Their thickness ranges from 1.5 to 6 meters.

Terrace Deposits

Cooke (1936) recognized seven marine terraces of Pleistocene age on the Atlantic Coastal Plain in South Carolina. He indicated that the four highest terraces are present in the Savannah River Valley. The deposits that may be associated with these terraces are about 10 meters thick or less (Cooke, 1936).

Holocene Alluvium

Alluvium of Holocene age occurs in the tributary and main channels of the Savannah River. These deposits, which are generally cross-bedded and heterogeneous in composition, range in thickness from 1.5 to 9 meters (Siple, 1967).

A.1.1.3 Geomorphology

The SRP is located on the Aiken Plateau as defined by Cooke (1936). The Aiken Plateau slopes from an elevation of approximately 200 meters at the Fall Line to an elevation of about 75 meters to the southeast. The surface of the Aiken Plateau is highly dissected and is characterized by broad, interfluvial areas and narrow, steep-sided valleys. Because of the Plant's proximity to the Piedmont region, it has somewhat more relief than the near-coastal areas, with onsite elevations ranging from 27 to 104 meters above sea level. Relief on the Aiken Plateau is as much as 90 meters (Siple, 1967). The plateau is generally well drained, although small, poorly drained depressions occur. These depressions are similar in character to Carolina bays.

On the Aiken Plateau there are several southwest-flowing tributaries to the Savannah River. These streams commonly have asymmetrical valley cross sections, with the northwest slope being gentler than the southeast slope. This is because the stream courses are generally parallel to the strike of the Coastal Plain formations. Erosion of the Coastal Plain sediments by the water course results in gentle dip slopes on the northwest, or updip, sides of the valleys. The landforms produced by these geomorphic processes resemble cuestas.

Since the early 1950s, the flow rates of Four Mile Creek and Pen Branch, including Indian Grave Branch, have been increased from about 1 cubic meter per second to the present 12 cubic meters per second by the discharge of cooling water and process effluent directly into the creeks. The stream profiles of the two creeks are beginning to change owing to erosion of the stream channels and deposition near the mouths of the creeks. Depositional environments in both creeks presently extend from their deltas to approximately 2.4 kilometers below SRP Road A, where near-neutral (neither erosion nor deposition) conditions exist (Ruby, Rinehart, and Reel, 1981).

A.1.2 SEISMOLOGY AND GEOLOGIC HAZARDS

A.1.2.1 Geologic Structures and Seismicity

The down-faulted Dunbarton Triassic Basin underlies the SRP and contains several interbasinal faults. However, the sediments overlying these faults show no evidence of basin movement since their deposition during the Cretaceous Period (Siple, 1967; Du Pont, 1980a). Other Triassic-Jurassic basins have been identified in the Coastal Plain tectonic province of South Carolina and Georgia; these features may be associated with the South Georgia Rift (Du Pont, 1980a; Popenoe and Zietz, 1977; Daniels, Zietz, and Popenoe, 1983). The Piedmont, Blue Ridge, and Valley and Ridge tectonic provinces, which are associated with Appalachian Mountain building, are northwest of the fall line (Figure A-1). Several fault systems occur in and adjacent to the Piedmont and the Valley and Ridge tectonic provinces; the closest of these is the Belair Fault Zone, about 40 kilometers from the SRP is not capable of generating major earthquakes (Case, 1977).

There is no conclusive evidence of recent displacement along any fault within 300 kilometers of the SRP with the possible exception of (a) the geophysically inferred faults (Lyttle et al., 1979; Behrendt et al., 1981; Talwani, 1982; Hamilton, Berendt, and Ackermann, 1983) in the meizoseismal area of the 1886 Charleston earthquake, which occurred approximately 145 kilometers from the Plant (Du Pont, 1982a), and (b) seismically inferred strike-slip motion on the northwest flank of the Dunbarton Basin (Stephenson, Talwani, and Rawlins, 1985). Table A-1 shows the significant geologic structures and fault systems in the SRP region and gives the age of last movement.

Surface mapping, subsurface boring, and geophysical investigations at the SRP have failed to detect any faulting of the sedimentary strata that would affect SRP facilities. Several surficial faults, generally less than 300 meters in length and with displacements of less than 1 meter, have been mapped; however, none of these are considered capable, as they are overlain by younger sediments that show no evidence of faulting. The time since the last movement on these surficial faults is believed to be 0.5 million years or more (Du Pont, 1980a).

Two major earthquakes have occurred within 300 kilometers of the SRP: the Charleston earthquake of 1886, which had an epicentral modified Mercalli intensity (MMI) of X, and was located about 145 kilometers away; and the Union County, South Carolina, earthquake of 1913, which had an epicentral shaking of MMI VII to VIII, and was located approximately 160 kilometers away (Langley and Marter, 1973). An estimated peak horizontal shaking of 7 percent gravity (0.07g) was calculated for the site during the 1886 earthquake (DOE, 1982b). Site intensities and accelerations for other significant earthquakes are listed in Table A-2.

Probabilistic and deterministic analyses have established a design-basis, horizontal earthquake acceleration of 0.20g for key seismic-resistant buildings

Table A-1. Significant Geologic Structures in SRP Region[a]

Structural feature	Closest point to site: km	Closest point to site: Direction	Age of last movement
Valley and Ridge Province Faults	350	NW	Late Paleozoic
Blue Ridge Province Faults (Carterville, Whitestone, and Fries-Hayesville-Altoona Faults)	280	NW	Late Paleozoic
Cape Fear Arch	250	NE	Pleistocene
Brevard Fault Zone	225	NW	Pre-Mesozoic
Westerfield Fold-Fault System	225	NE	Pre-Eocene
Deep River Basin (N.C. and S.C.)	215	NE	Triassic-Jurassic
Gold Hill Fault	210	NW	Late Paleozoic
Columbia Triassic Basin	155	NE	Pre-Cretaceous
Towaliga Fault, Kings Mt. Belt	135	NW	Late Paleozoic
Clubhouse Crossroads Faults	115	SE	Pre-Miocene (?)
Columbia Reverse Faults and Clastic Dikes	105	NE	Late Miocene
Charleston Triassic (?) Basin	80	SE	Triassic-Jurassic
Decatur-Coffee County (Georgia) Graben and Faults	65	SE	Pre-Pliocene
Eastern Piedmont Fault System (Modoc, Flat Rock, Goat Rock, Bartletts Ferry, and Towaliga Faults)	65	NW	Late Paleozoic
Belair Fault Zone	40	NW	Pre-Miocene to Recent[b]
Langley Graben	27	NW	Pre-Miocene(?)
Dunbarton Triassic (?) Basin	Onsite	Onsite	Pre-Late Cretaceous

[a]Source: Du Pont, 1980a.
[b]NRC has determined that, although age of last movement is not precisely known, Belair Fault Zone is not capable in sense of 10 CFR 100 (Case, 1977).

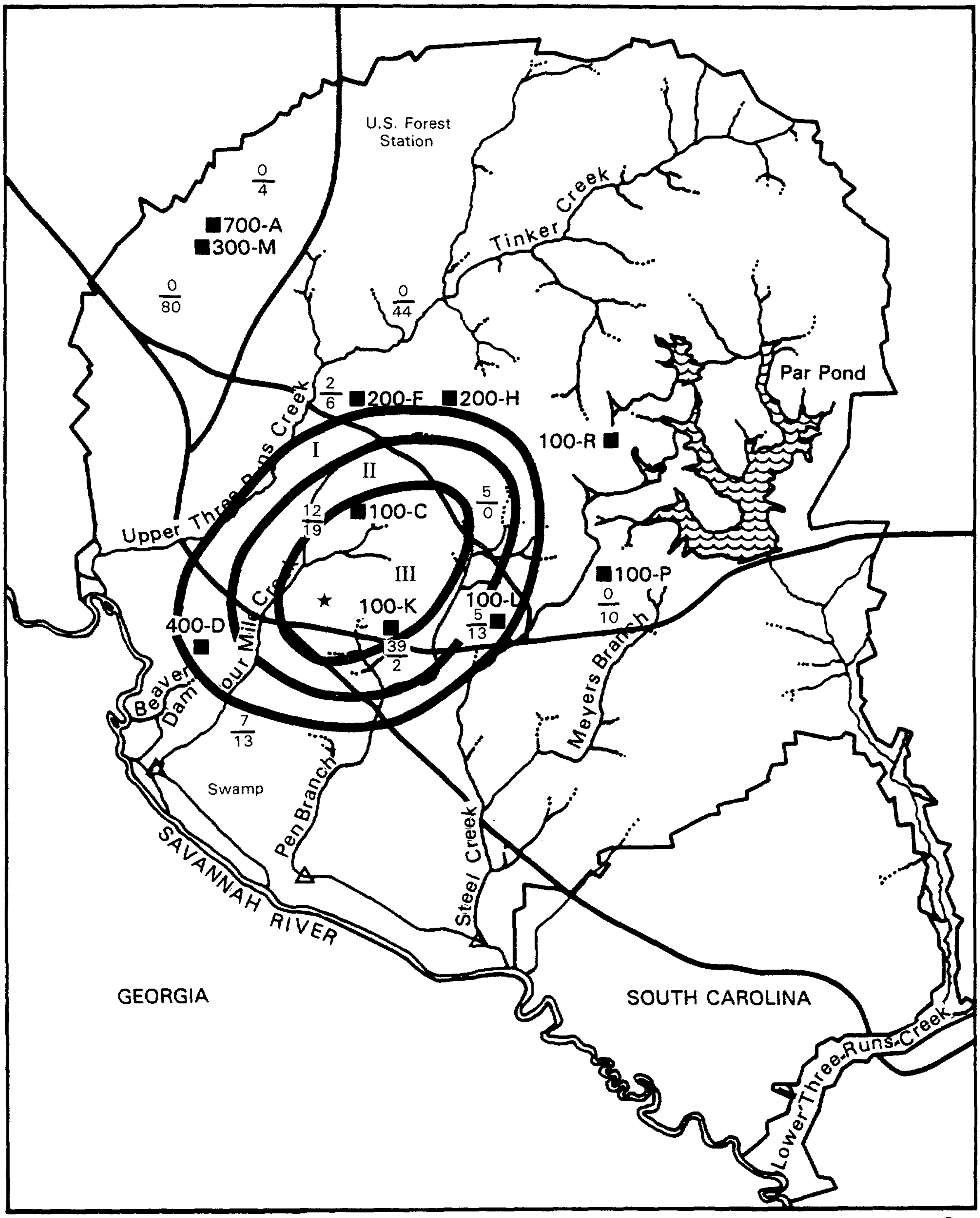
at the SRP. This acceleration has a return period of about 5000 years (Du Pont, 1982b).

On June 8, 1985, an earthquake with a local magnitude of 2.6 (maximum intensity MM III) and a focal depth of 0.96 kilometer occurred at the SRP. The epicenter was just to the west of C- and K-Areas (Figure A-3). The acceleration produced by the earthquake was less than 0.002g. No aftershocks were recorded by the SRP Seismic Network (Stephenson, Talwani, and Rawlins, 1985).

Table A-2. Site Intensities for Significant Earthquakes[a]

Earthquake					Distance from site (km)	Reported or estimated site intensity	Estimated site acceleration (g)
Date[b]	Location	Latitude	Longitude	Maximum intensity			
Jan. 13, 1811	Burke Co., Ga.	33.2	62.2	V	55	III-IV	0.02
1811-1812 (3 shocks)	New Madrid, Mo.	36.3	89.5	XI-XII	850	V-VI	0.05
Nov. 2, 1875	Lincolnton, Ga.	33.8	82.5	VI	100	III-IV	0.02
Sept. 1, 1886	Charleston, S.C.	32.9	80.0	X	145	VI	0.07
Oct. 22, 1886	Charleston, S.C.	32.9	80.0	VII	155	III-IV	0.02
May 31, 1897	Giles Co., Va.	37.3	80.7	VIII	455	III	0.01
June 12, 1912	Charleston, S.C.	33.0	80.2	VII	135	III-IV	0.02
Jan. 1, 1913	Union Co., S.C.	34.7	81.7	VII-VIII	160	IV	0.02
Aug. 1, 1920	Charleston, S.C.	33.1	80.2	VII	135	III-IV	0.02
Feb. 3, 1972	Bowman, S.C.	33.5	80.4	V	115	IV	0.02
Aug. 2, 1974	Willington, S.C.	33.9	82.5	VI	105	IV	0.02
Nov. 22, 1974	Charleston, S.C.	33.9	80.1	VI	145	III-IV	0.02

[a]Source: DOE, 1982b.
[b]Based on Greenwich Mean Time.



Source: Stephenson *et al.* (1985)

★ Instrumental Epicenter

12 Number of Felt / 17 Number of Not Felt — By Area Reporting

Scale (kilometers) 0 4 8

Figure A-3. Isoseismal Map Showing Reported Intensities for the June 1985 Earthquake at the Savannah River Plant

A.1.2.2 Seismic Events and Liquefaction Potential

Liquefaction is the transformation of water-saturated granular material from a solid or semisolid state to a liquid state; this results from an increase in the pore water pressure, which is caused by intense shaking. Earthquakes may cause liquefaction of near-surface, water-saturated silts and sands, making the materials lose their shear strength and flow (Keller, 1979).

The seismicity of the SRP is discussed in Section A.1.2.1. As noted in that section, liquefaction induced by earthquakes with a maximum horizontal acceleration of less than 0.20g is not a potential problem for SRP facilities (Du Pont, 1980a; Langley and Marter, 1973).

A.2 GROUNDWATER RESOURCES

This section discusses the groundwater resources at the SRP. For the purposes of this environmental impact statement (EIS), the definition of groundwater resources includes hydrostratigraphy, groundwater hydrology, and groundwater quality.

A.2.1 HYDROSTRATIGRAPHY

Three distinct hydrogeologic systems underlie the SRP: (1) the Coastal Plain sediments, where water occurs in porous sands and clays; (2) the crystalline metamorphic rock beneath the Coastal Plain sediments, where water occurs in small fractures in schist, gneiss, and quartzite; and (3) the Dunbarton Basin (Triassic/Jurassic Age) within the crystalline metamorphic complex, where water occurs in intergranular spaces in mudstones and sandstones. The latter two systems are unimportant as groundwater resources near the Plant.

The Coastal Plain sediments, which contain several important aquifers, consist of a wedge of stratified sediments that thickens to the southeast. Near the center of the Plant, the sediments are about 300 to 400 meters thick and consist of sandy clays and clayey sands. The sandier beds generally form aquifers and the clayier beds form aquitards. The Coastal Plain sedimentary section at the Plant consists of the Hawthorn, Barnwell, McBean, Congaree, Ellenton, and Tuscaloosa Formations, as defined by Siple, 1967. These units correlate to those used by Geological Consulting Services (GCS, 1986). Figure A-2 shows the correlation of these stratigraphic terms. Table A-3 describes the lithology and water-bearing characteristics of the hydrostratigraphic units underlying the Plant.

The Cretaceous Sediments (Middendorf and Black Creek Formations; GCS, 1986) form a particularly prolific groundwater unit because of their thickness and high permeability. In areas of the South Carolina Coastal Plain within 40 kilometers of the Fall Line, the Cretaceous Sediments are a major supplier of groundwater (Siple, 1967); wells commonly yield more than 5500 cubic meters per day of good-quality water. The Cretaceous Sediments rest on saprolite, a residual clay weathered from the crystalline metamorphic bedrock, and consist of a sequence of sand and clay units. The combined saprolite and basal clay form an effective seal that separates water in the Coastal Plain sediments from water in the crystalline metamorphic rock. The sand units combined are about 140 meters thick and supply water to the Plant.

Table A-3. Hydrostratigraphic Units Near Savannah River Plant

Geologic unit	Geologic age	Outcrop	Description	Water yield	Thickness (m)
Alluvium[a]	Recent Epoch	River and creek bottoms	Fine-to-coarse sand, silt, and clay	Very little	0 to 9
Terrace deposits[a]	Pleistocene Epoch	In floodplains and terraces of stream valleys	Tan to gray sand, clay, silt, and gravel on higher terraces	Moderate to none	0 to 9
Upland Unit[a]	Post Eocene	Surface of Aiken Plateau	Gravel and sandy clay	Little or none	0 to 10
Hawthorn Formation[a]	Post Eocene	Large part of ground surface	Tan, red, and purple sandy clay with many "clastic dikes"	Little or none	0 to 10
Barnwell Formation[a]	Eocene Epoch	Large part of ground surface near streams	Red, brown, yellow, and buff fine-to-coarse sand and sandy clay	Limited but sufficient for domestic use	0 to 27
McBean and Congaree Formations[a]	Eocene Epoch	In banks of larger streams	Yellow-brown-to-green, fine-to-coarse glauconite-quartz sand, intercalated with green, red, yellow, and tan clay, sandy marl, and lenses of siliceous limestone	Moderate to large	30 to 76
Ellenton Formation[a]	Paleocene Epoch	None on SRP	Dark-gray-to-black sandy, lignitic, micaceous clay containing disseminated crystalline gypsum and coarse quartz sand	Moderate to large; higher sulfate and iron than water from other formations	1 to 30
Tuscaloosa[a]	Cretaceous Period	None on SRP	Tan, buff, red, and white cross-bedded, micaceous, quartzitic and arkosic sand and gravel imbedded with red, brown and purple clay and white kaolin	Large (well production up to 7.6 m^3/min); soft (low in total solids)	170 to 250
Newark Series "red beds"[b]	Triassic/Jurassic Period	None on SRP	Dark-brown and brick-red sandstone, siltstone, and claystone containing gray calcareous patches; fanglomerates near border	Very little	>914
Basement rocks of Slate Belt and Charlotte Group[c]	Precambrian and Paleozoic Eras	None on SRP	Hornblende gneiss, chlorite-hornblende schist, and lesser amounts of quartzite; covered by saprolite layer derived from basement rock	Very little	Thousands

[a]Coastal Plain sediments.
[b]Dunbarton Basin sediments.
[c]Crystalline and metamorphic rock.
Note: Formation Terminology after Siple, 1967

Paleocene sediments, including the Ellenton Formation, overlie the Cretaceous Sediments and consist of clay with coarse sand units. The known Ellenton sediments are entirely within the subsurface. The clays in the Ellenton are apparently continuous enough to act as a confining bed that separates the water in the Congaree from that in the Black Creek Formation (Geraghty & Miller, 1986).

The Congaree Formation includes a lower unit of sand with clay layers and an upper clay layer known as the "green clay." The Congaree sand beds constitute an aquifer second only to the Cretaceous Sediments in importance, with yields as high as 3600 cubic meters per day (Siple, 1967). The green clay appears to be continuous and supports a large head difference between the Congaree and the overlying McBean Formation. This head difference is as much as 21 meters near the Central Shops and 24 meters in the Separations Areas, even though the clay layer is only 2 to 3 meters thick in these areas (D'Appolonia, 1980; Du Pont, 1983). North and west of Upper Three Runs Creek, the green clay is discontinuous and, therefore, is effective only locally as a confining unit (aquitard). In the southeastern part of the Plant, the green clay is believed to be about 18 meters thick (Du Pont, 1983).

The McBean Formation, as defined by SRP (Marine and Root, 1978), consists of a lower unit of calcareous clayey sand and an upper unit of clayey sands (lower part of Dry Branch Formation; GCS, 1986). Groundwater occurs in both units, but neither is a prolific aquifer. The formation is incised by Upper Three Runs Creek and Four Mile Creek.

The Barnwell Formation, which overlies the McBean Formation, consists of (1) a clay unit known as the "tan clay" (part of Dry Branch Formation; GCS, 1986), (2) a silty sand unit (upper part of Dry Branch Formation; GCS, 1986), and (3) a clayey sand unit that can include beds of silty clay or lenses of silty sand (Tobacco Road Equivalent; GCS, 1986). Borings in the Separations Areas and about 2 kilometers east of the Central Shops indicate that the tan clay is about 2 meters thick and that it commonly consists of two thin clay layers separated by a sandy zone (D'Appolonia, 1980; Du Pont, 1983). In some areas of the Plant, the tan clay is not easily identified in foundation borings, drillers' logs, or geophysical logs; however, this clay has not always been readily apparent in soil cores, even in areas where it is known to support a significant head differential.

The Barnwell and Upland Unit (Hawthorn; Siple, 1967) Formations are incised by Upper Three Runs Creek, Four Mile Creek, and their unnamed tributaries. The water table is usually within the Barnwell Formation but in low-lying areas can be in the underlying McBean or Congaree Formations. Because of the large amounts of clay and silt mixed with the sands, the Barnwell generally does not yield water to wells except from occasional sand lenses.

The South Carolina Hazardous Waste Management Regulations (SCHWMR) and the Resource Conservation and Recovery Act (RCRA) [270.14(c)(2)] require the determination of the hydrogeologic zones that are most susceptible to impacts from waste management units. These zones are the unsaturated zone, the uppermost aquifer, the principal confining unit, and the principal confined aquifer (shallowest confined aquifer beneath the SRP). Figure A-2 shows the relationship of these zones to one another and their correlation with other stratigraphic nomenclature. Each hydrogeologic zone is summarized below.

Formational terminology used in this discussion is largely that of Geological Consulting Services (GCS), 1986.

The unsaturated zone is a 25- to 45-meter-thick sandy unit containing clay lenses. This zone is comprised of the Upland unit and, in some areas of the Plant, the Tobacco Road and Dry Branch Formations.

The uppermost aquifer is a 35-meter-thick sandy unit composed of two zones. The upper water-table zone, composed primarily of the clayrich, fine-grained sands of the McBean Formation (in some areas of the Plant, areas of higher water table) includes portions of the Dry Branch and Tobacco Road Formations. The lower zone, composed of the coarse-grained Congaree Formation and the upper sand and clay of the Ellenton Formation.

Based on an evaluation of hydraulic properties as well as head differences between subsurface zones, the lower three units of the Ellenton Formation are believed to form the principal confining zone beneath the Plant. These units form a section approximately 15 meters thick composed of two clay beds (middle and lower Ellenton) and the lower Ellenton sand lenses. The sands in these lenses are commonly coarse grained, but generally are supported by a clay matrix that impedes fluid movement. The middle clay is generally a dense, low-permeability clay that can be locally discontinuous or more permeable. The lower clay, however, is an average of 3 meters thick (maximum of 15 meters), is dense, has a low permeability, and is believed to be continuous over the SRP area. Table A-4 summarizes the hydraulic conductivity of the Ellenton Formation.

The confined aquifer is a sandy zone averaging about 30 meters in thickness. This zone is capped by the overlying Ellenton Formation confining unit. In this appendix, the shallowest confined aquifer is referred to as the Black Creek aquifer. The aquifer beneath the Black Creek is referred to as the Middendorf aquifer (see Figure A-2).

A.2.2 GROUNDWATER HYDROLOGY

A.2.2.1 Hydrologic Properties

The flow of groundwater in the natural environment depends strongly on the three-dimensional configuration of hydrogeologic units through which flow takes place. The geometry, spatial relations, and interconnections of the pore spaces determine the effective porosity (percentage of void space effectively transmitting groundwater) and the hydraulic conductivity of the hydrogeologic unit. These factors largely control groundwater flow through geologic media.

The Coastal Plain sediments beneath the Plant are heterogeneous, and they are anisotropic with respect to the hydrologic properties controlling groundwater flow. Tables A-5 and A-6 list typical hydrologic properties of the Coastal Plain sediments in the Separations Areas and A/M-Areas, respectively. These tables indicate that the horizontal component of hydraulic conductivity in the Barnwell Formation is considerably greater than the vertical component. In this case, the horizontal conductivity is at least 100 times the vertical conductivity; consequently, groundwater tends to move laterally within this hydrogeologic unit. Although not shown in Tables A-5 or A-6, this general

Table A-4. Hydraulic Conductivity (cm/sec) of Ellenton Formation

Geologic Unit	Vertical conductivity		Horizontal conductivity	
	Range	Average	Range	Average
Middle clay	2.2×10^{-9} - 1.4×10^{-5}	1.1×10^{-7}	1.6×10^{-9} - 7.3×10^{-5}	8.61×10^{-5}
Lower sand	3.5×10^{-9} - 3.9×10^{-4}	4.4×10^{-5}	1.1×10^{-8} - 2.6×10^{-4}	9.39×10^{-5}
Lower clay	1.8×10^{-8} - 4.0×10^{-7}	1.9×10^{-7}	2.3×10^{-8} - 6.7×10^{-7}	3.12×10^{-7}

Table A-5. Typical Hydrologic Properties in Separations Areas[a]

Hydrogeologic unit	Hydraulic conductivity (m/day)		Effective porosity	Transmissivity (m^2/day)	Storage coefficient
	Horizontal (Kh)	Vertical (Kv)			
Barnwell Formation					
Upper	1.2	0.003	0.25	3	0.25
Lower	3	0.008	0.25	3	0.25
Tan clay	--	0.0016	--	--	--
McBean Formation					
Upper	3	--	0.25	50	0.25
Calcareous zone	3	--	0.25	50	0.25
Green clay	--	3.4×10^{-6}	--	--	--
Congaree Formation					
Upper	34	--	0.25	670	0.0002
Lower	17	--	0.25	670	0.0002
"Tuscaloosa" Formation	40.8	--	0.20	2480	0.00045

[a]Sources: Killian et al., 1986; Root, 1983; Du Pont, 1983. Terminology used for hydrogeologic units is after Siple, 1967 (see Figure A-2).

Table A-6. Typical Hydrologic Properties in A- and M-Areas[a]

Hydrogeologic unit	Hydraulic conductivity (m/day) Horizontal (Kh)	Vertical (Kv)	Effective porosity	Transmissivity (m^2/day)	Storage coefficient
McBean Formation					
Upper	3	--	0.25	6	0.25
Lower	3	--	0.25	55	0.25
Congaree Formation					
Upper	9	--	0.14	215	0.14
Lower	10	--	0.14	145	0.14
Basal clay	--	0.00018	--	--	--
Ellenton clay - Upper Tuscaloosa clay	--	0.0012	0.07	--	--
"Tuscaloosa" Formation	12.2	--	0.20	1050	0.00043

[a]Sources: DOE, 1984, 1985; Du Pont, 1983. Terminology used for hydrogeologic units is after Siple, 1967 (see Figure A-2).

relationship is expected to apply to all coastal plain sedimentary units (Freeze and Cherry, 1979).

The following paragraphs describe important hydrodynamic properties of specific geologic units beneath the Plant.

Crystalline Metamorphic Rock

Water injection and removal tests on packed-off sections of rock indicate two types of fractures in the crystalline rock (Marine, 1966). The first type consists of minute fractures that pervade the entire rock mass but transmit water extremely slowly. Rock that contains only this type of fracture is called "virtually impermeable rock." The other type of fracture is confined to definite zones that are vertically restricted but laterally correlatable and have larger openings that transmit water faster. Rock that includes this type of fracture is called "hydraulically transmissive rock."

Representative values of hydraulic conductivity are 1.2×10^{-5} meter per day for virtually impermeable rock, and 0.033 meter per day for hydraulically transmissive rock (Marine, 1975). An analysis of a two-well tracer test with tritium indicates a fracture porosity of 0.08 percent in a hydraulically transmissive fracture zone (Webster et al., 1970). Laboratory analyses of cores indicate an average intergranular porosity of 0.13 percent.

Triassic/Jurassic Sedimentary Rock

The Triassic sediments consist of poorly sorted, consolidated gravel, sand, silt, and clay. The coarser material is presumed to be near the northwest margin of the Dunbarton Basin, where fanglomerates are abundant. Nearer the center of the basin, sand, silt, and clay predominate. The sorting is extremely poor, which causes an extremely low primary porosity in the Triassic rocks (Marine and Siple, 1974). Groundwater does occur in the primary porosity of the Triassic rock, but the hydraulic conductivity is extremely low and water movement is almost nonexistent.

The hydraulic conductivity of the Triassic sedimentary rock, as determined from field tests, ranges from 4×10^{-6} to 4×10^{-9} meter per day (Marine and Siple, 1974). Average total porosity is 8.0 percent for sandstones and 3.3 percent for mudstones. Average effective porosity is 7.0 percent for sandstones and 0.53 percent for mudstones.

Cretaceous Sediments

According to a field study of the Cretaceous Sediments aquifer (Tuscaloosa or Black Creek/Middendorf equivalent), the average transmissivity is 1500 square meters per day and the median is 1400 square meters per day (Marine and Routt, 1975). Storage coefficients determined for the formation averaged 4.5×10^{-4}, and Siple (1967) assumed effective porosities of 20 to 30 percent.

Ellenton Formation

In general, Siple (1967) did not distinguish between the Ellenton and the Cretaceous Sediments aquifer in reporting the results of pumping tests. Because there is no piezometric map exclusively of the Ellenton Formation, little is known about the lateral flow of water within the formation. Table A-4 summarizes recent hydraulic conductivity data collected on the Ellenton Formation.

Congaree Formation

The results of two tests conducted near the center of the Plant indicate a hydraulic conductivity of nearly 40 meters per day in the Congaree Formation, although one of the values (0.73 meter per day) for M-Area is 50 times less than this. The median conductivity value obtained in 10 slug tests (decay or an instantaneous head change) in sandy zones of the Congaree Formation in the Separations Areas is 1.8 meters per day (Root, 1977a,b). The median conductivity, as determined in two water-level recovery tests, is 1.5 meters per day (Du Pont, 1983).

Data from laboratory tests conducted by the U.S. Army Corps of Engineers (COE, 1952) indicate a median value of 43 percent for the total porosity of the upper part of the Congaree Formation. The effective porosity is estimated to be 20 percent. A pumping test in the northwest portion of the plant yielded a value of 14 percent.

McBean Formation

The median hydraulic conductivity of the upper sand of the McBean Formation (equivalent to Lower Dry Branch Formation; GCS, 1986) has been reported to be 0.13 meter per day, about twice that of the calcareous zone (Du Pont, 1983). An effective porosity of 20 percent is reasonable.

Fluid losses during drilling operations make the calcareous zone appear very permeable. However, the results of pumping tests in the zone indicate a low hydraulic conductivity (Du Pont, 1983). Apparently, zones of higher permeability do not connect over large distances, and the regional permeability of the calcareous zone is lower than drilling observations suggest.

Barnwell Formation

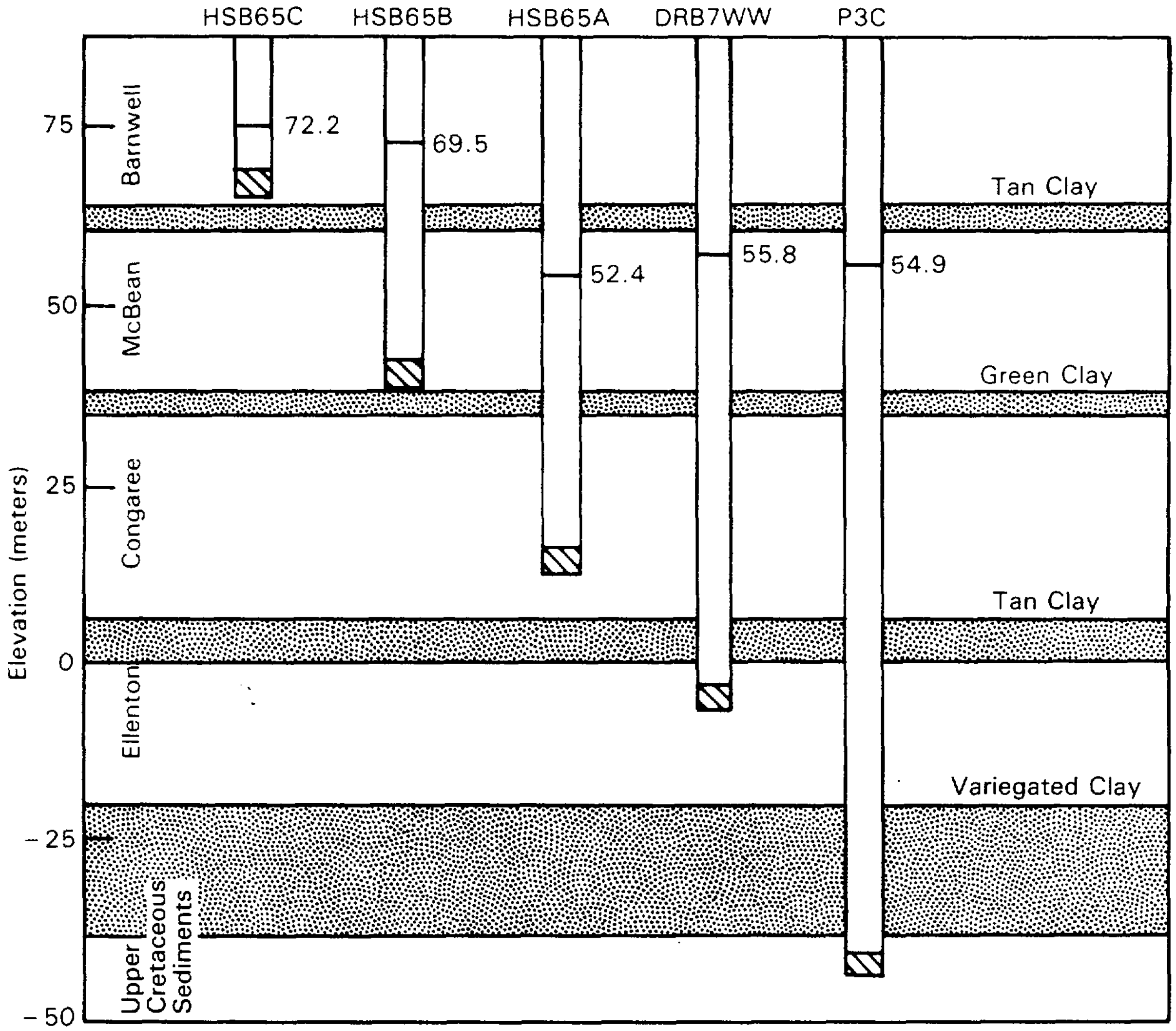
Pumping tests to determine the hydraulic conductivities of the Barnwell Formation (Du Pont, 1983) indicate the median conductivity to be 0.04 meter per day for the clayey sand unit (Tobacco Road equivalent; GCS, 1986). Although no tests were made on the silty sand unit, a pumping test in a sand lens within this unit indicated a hydraulic conductivity of 0.3 meter per day.

Upland Unit

Because the Upland Unit (Hawthorne equivalent; Siple, 1967) in the SRP area is usually unsaturated, no pumping tests have been performed. There is no piezometric map of the formation in the SRP area. Flow paths are predominantly vertical; there are only short horizontal flow paths.

A.2.2.2 Head Relationships

The elevation of the free-standing groundwater above a sea-level datum is referred to as the hydraulic head. Figure A-4 shows the hydraulic heads for the principal hydrostratigraphic units near the center of the Plant, typified



Source: Du Pont, 1985a. Hydrostratigraphic unit terminology after Siple, 1967; see Figure A-2.

Legend:

Clay layer

Screen zone

Note: Water levels in HSB65A, B, and C measured 3/8/85
Water levels in DRB7WW and P3C measured 3/18/85

Figure A-4. Vertical Head Relationship Near the H-Area Seepage Basins

by H-Area. These data are for one location in the Separations Areas where water-level differences are probably at their maximum. Near the discharge areas of creek valleys, water elevations of the several tertiary aquifers converge. Although not shown in this figure, the head in the lower part of the Cretaceous aquifer (Middendorf equivalent) is generally higher than that in the shallower aquifer (Black Creek) by at least 6 meters (DOE, 1984).

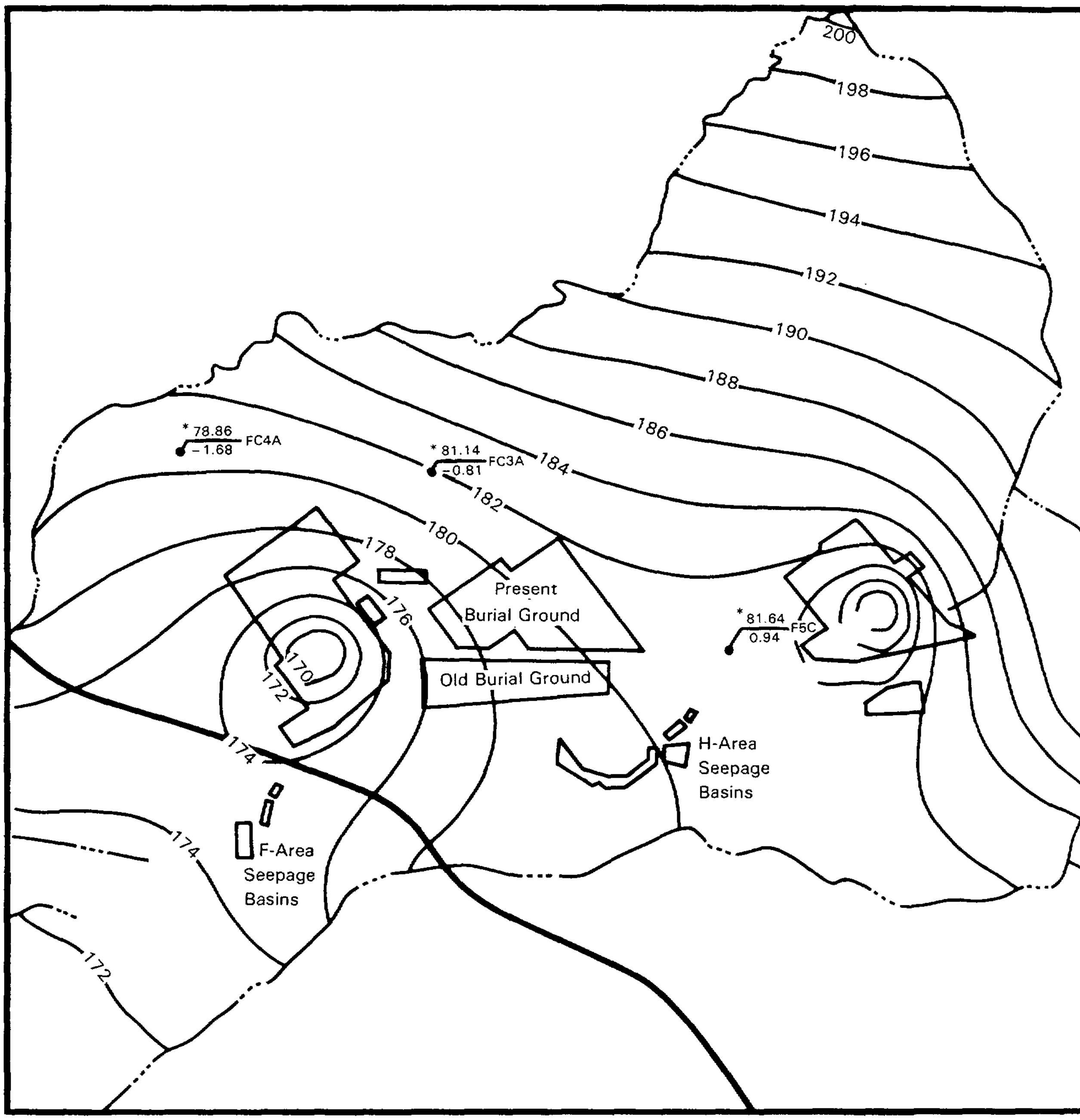
Figure A-4 indicates that the water elevation in the Ellenton Formation is above that in the Cretaceous Sediments aquifer. The cause of this appears to be continuous pumping from the Cretaceous Sediments aquifer in H-Area, which has created a cone of depression in these deeper units but probably has not affected water levels significantly in the Ellenton aquifer. Figure A-5 shows the cones of depression in the potentiometric surface of the Cretaceous Sediments aquifer in F- and H-Areas. This map was generated by a finite difference computer model that simulates 3-dimensional flow transport.

The hydraulic heads shown in Figure A-4 also indicate that there is not a direct hydraulic connection between the Ellenton and the overlying Congaree Formation. Although the clays that separate the Ellenton and the Congaree are not thick, they are apparently extensive and continuous enough to impede the hydraulic connection. A pisolitic clay at the base of the Congaree appears to be extensive and might constitute the principal confining bed that separates the Congaree and the deeper hydrologic system (Siple, 1967). The upper part of the Ellenton is a sandy clay, which also functions as a confining bed between the Ellenton and the Congaree.

Finally, Figure A-4 shows that the head in the Congaree Formation in the Separations Areas is the lowest of any hydrostratigraphic unit in the Coastal Plain system. This is attributable to two conditions: (1) the low permeability of the green clay, through which recharge must take place, and (2) the high hydraulic conductivity of the Congaree sands below the green clay, which enhances lateral movement and discharge to the deeper creek valleys. The upward recharge of water to the Congaree from the Ellenton-Cretaceous Sediments aquifer system is also impeded by clay layers at the base of the Congaree and in the Ellenton.

Figure A-6 shows areas of hydraulic head reversal between the Congaree and Cretaceous Sediments aquifer (i.e., the latter's head is higher than the former's). This head-difference map shows that the head in the Cretaceous Sediments is higher than the head in the Congaree in a broad area within about 10 kilometers of the Savannah River and Upper Three Runs Creek. The head in the Congaree is higher than that of the Cretaceous Sediments in an area surrounding A- and M-Areas and in the vicinity of P- and R-Areas and Par Pond. Figure A-7 shows the vertical-head relationships along a cross-section passing through M-Area, where the Cretaceous Sediments aquifer water elevation is below that of the Congaree. A continuous decline in head with depth indicates that this location is a recharge area for the Cretaceous Sediments aquifer, as is much of the area of the Aiken Plateau northwest of the Plant.

Because of flow directions and head relationships, the potential for offsite impacts on water quality in the Black Creek aquifer is extremely small. The most important factor for offsite impacts is the prevailing flow direction for water in the Black Creek toward the Savannah River, not toward municipalities that border the Plant. The most important factor for onsite impacts is a



Source: Killian *et al.*, 1986

Legend:

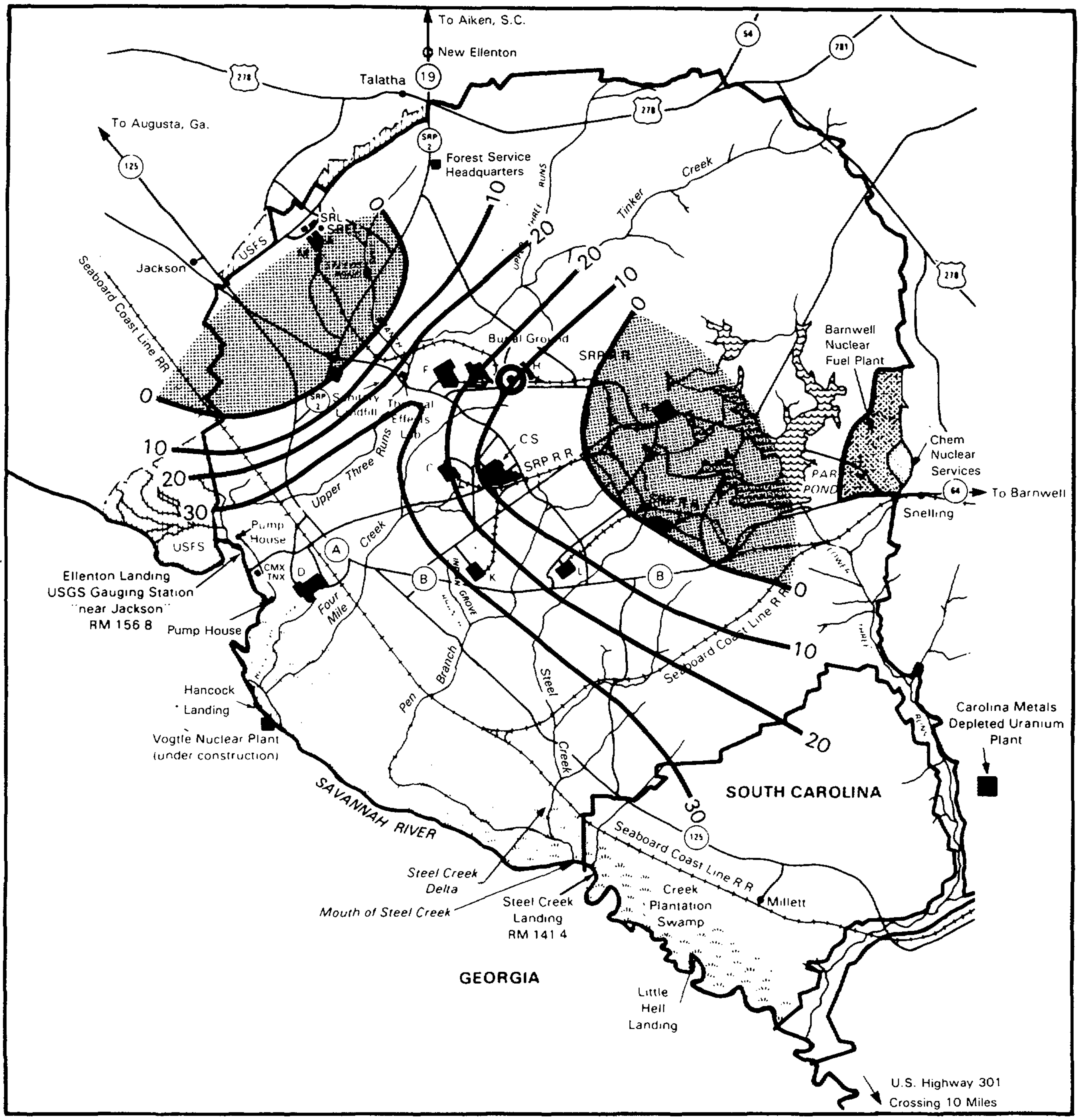
Steady-State Hydraulic Head Isopleth, ft msl 240

Well Location..... observed hydraulic head / residual* — well designation

*Residual = observed hydraulic head - calculated hydraulic head

Scale (kilometers) 0 15 30

Figure A-5. Calculated Potentiometric Surface for the Cretaceous Sediments Aquifer



Legend

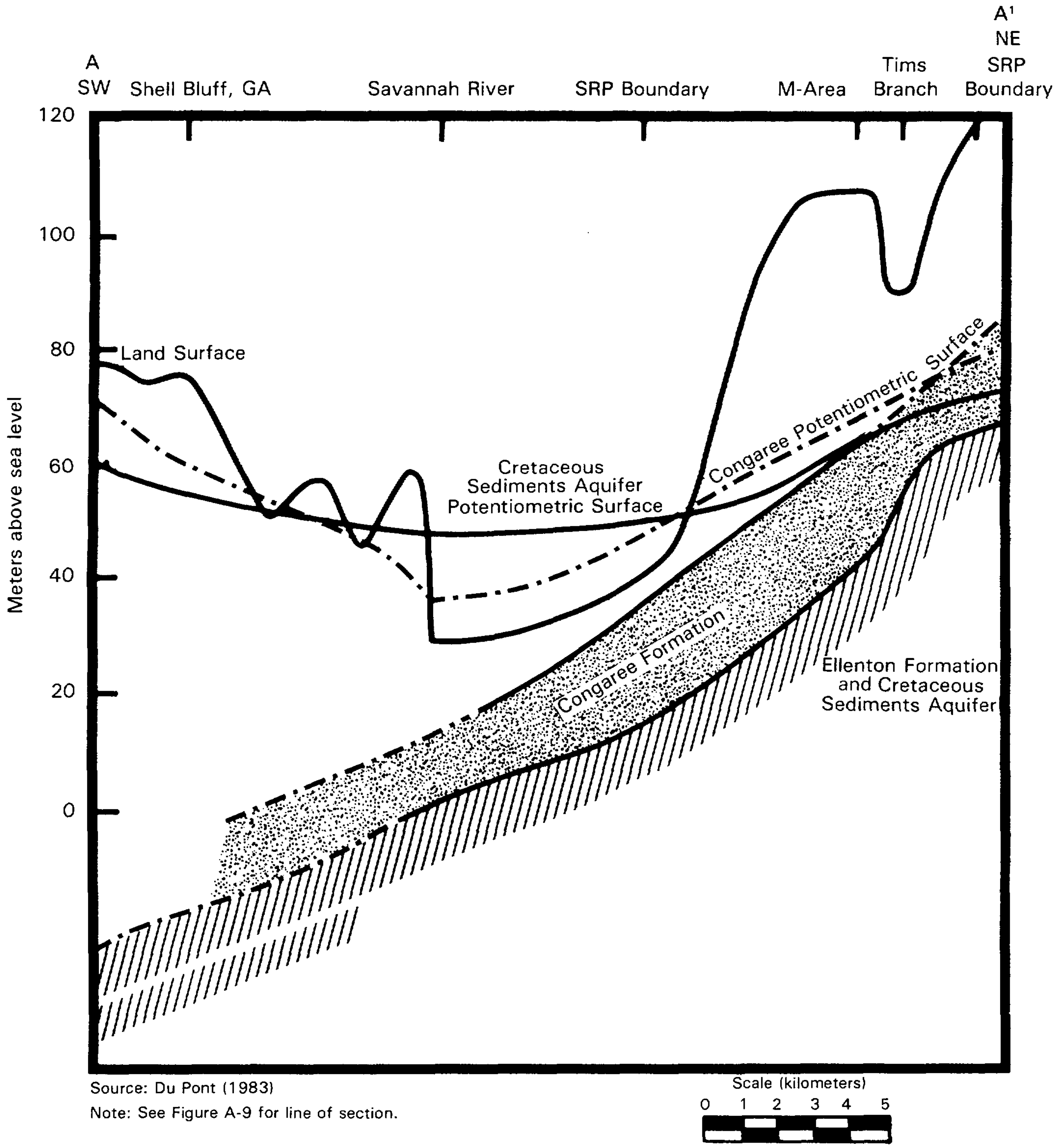
C, K, R, L, P Reactor Areas (C, P, K, and L are operating)
F, H Separations Areas
M Fuel and Target Fabrication
D Heavy Water Production
A Savannah River Laboratory and Administration Area
U Temporary construction area
RM River Mile

Road A = Highway 125

Area where the Congaree head exceeds the Cretaceous sands aquifer head.

Contour showing locations where the head in the Cretaceous sands aquifer is 10 feet. (1.0 foot = 0.3048 meter) above the head in the Congaree. Developed from Figures A-9 and A-10.

Figure A-6. Head Difference Between Upper Cretaceous Sediments Aquifer and Congaree Formations at Savannah River Plant (May 11, 1982)



Source: Du Pont (1983)

Note: See Figure A-9 for line of section.

Figure A-7. Hydrologic Section Perpendicular to Savannah River Through M-Area

significant upward gradient between the Congaree and the Upper Tuscaloosa over most of the SRP.

Impacts on the Black Creek aquifer have been confirmed in only one well cluster on the SRP. This cluster is in the western recharge area (A- and M-Areas), where the clay barrier thins beneath an area where spillage from rail cars and transfer facilities took place during the early days of SRP operation. The migration of these constituents is being defined; their source has been under remediation for nearly 2 years. Data analyzed to date do not define any flow paths for these constituents toward offsite water users. The area of final discharge of the groundwater originating from these sources is the Savannah River. These constituents would require at least several hundred years to reach the river. The pumpage of recovery wells (and supply wells for process water) in A- and M-Areas increases this travel time.

Where the upward gradient exists between the Black Creek and the Congaree, water is prevented from flowing into the Black Creek aquifer. An exception occurs in areas where large volumes of water are pumped from the Black Creek; in these areas, pumpage could reverse the upward gradient. The area most susceptible to these impacts is H-Area, where the head differential is relatively small and pumpage is great. A modeling study (Duffield, Buss, and Spalding, 1987) indicates that a maximum head differential (downward potential) of about 5 feet has developed in the eastern portion of H-Area (see Figure A-5). Moderate pumpage from the Black Creek also occurs in U-Area, the Central Shops Area, TNX-Area, the Classification Yard, and the U.S. Forest Service offices. The potential for reversing the upward gradient that occurs naturally in these areas is significantly less than that in H-Area. Any contaminants that would be drawn into the Black Creek by this pumpage would flow to the pumping well and, therefore, would not impact offsite areas.

Water elevations in the McBean Formation (includes lower portion of Dry Branch Formation; GCS, 1986) exhibit a difference of about 0.6 meter in hydraulic head between the top of the McBean and its base (Du Pont, 1983). This indicates a better hydraulic connection between the sandy unit of the McBean and the calcareous zone than that between the McBean and either the Congaree Formation below or the Barnwell Formation above. As previously noted, the green clay impedes the downward movement of water from the McBean to the Congaree in the central part of the Plant, as illustrated by a hydraulic-head differential of about 24 meters. Moreover, the tan clay in the Barnwell (Siple, 1967) impedes the vertical movement of water from the Barnwell into the McBean. Although the tan clay is not as continuous as the green clay, the head differential between the Barnwell and the McBean is only about 4 meters where the tan clay is present.

Figure A-4 shows the relationship of water elevations in the Barnwell Formation to those in the formations below. The hydraulic head decreases with depth within the Barnwell Formation. Although the tan clay impedes the downward movement of water, the McBean Formation is recharged by water that passes through this hydrostratigraphic unit.

The water table is commonly within the Barnwell Formation (equivalent to Tobacco Road and upper Dry Branch Formations, GCS, 1986), although in the creek valleys it successively occupies positions in the lower formations. Surface drainage and topography strongly influence the flow path at every point on the potentiometric surface. Even small tributaries of the larger creeks cause depressions in the water table, diverting groundwater flow toward them. Because the Upland Unit in the SRP region is usually unsaturated, a potentiometric map has not been constructed. Flow paths are predominantly vertical, although there are some short, horizontal flow paths along perched water tables.

A.2.2.3 Groundwater Flow

Water moves through the ground from areas of high head to areas of lower head. In general, on the Atlantic Coastal Plain, the gradient is seaward from the higher areas of the Aiken Plateau toward the continental shelf. Of major significance is the modification of this general southeastward movement caused by the incision of the Savannah and Congaree Rivers and their tributaries (see Figure A-8). Groundwater in the regions of these rivers and tributaries is diverted toward the hydraulic low caused by natural discharge to the surface water. The depth of dissection of streams at the SRP has a significant influence on the direction of flow in most hydrostratigraphic units. The direction of flow in the shallow groundwater is most affected by small streams; in the deeper groundwater, it is affected by major tributaries. The direction of flow in the Paleocene and deeper formations is affected mainly by the Savannah River. Locally, the direction of flow in any unit can be modified by groundwater withdrawals from wells.

The velocity (V) of groundwater flow can be calculated by the following formula:

$$V = \frac{IK}{e} \tag{A-1}$$

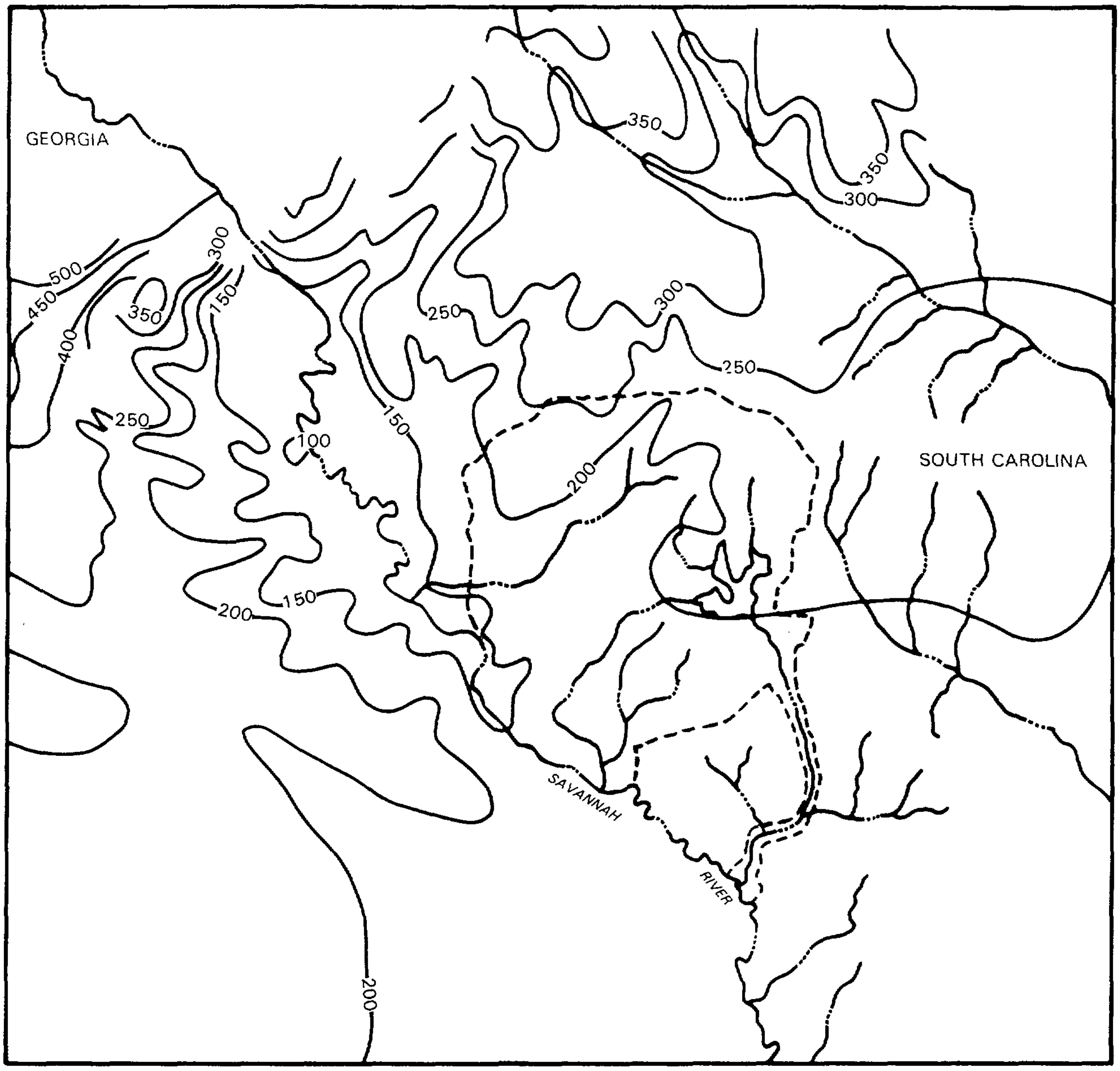
where:

- I = hydraulic gradient
- K = hydraulic conductivity
- e = effective porosity

The velocity also can be measured directly by tracers. Table A-7 lists typical vertical and horizontal groundwater velocities for important hydrogeologic units on the SRP.

Figures A-8 and A-9 show hydraulic heads of the Cretaceous Sediments, which constitute the primary aquifer in the region. Where the elevation of the outcrop area is high, as on the Aiken Plateau north of the Plant, water naturally recharged to the aquifer exceeds that naturally discharged to local streams; this excess water moves southeastward through the aquifer. Where the elevation of the outcrop area is low, as along the Savannah River Valley in the northwest section of the Plant, water naturally discharges from the aquifer to the river. Under the Plant, the direction of groundwater movement in the Cretaceous sands is southwesterly toward the Savannah River Valley.

On the Plant, the recharge of the Congaree is by groundwater flow from offsite areas and by the infiltration of precipitation; the shallower formations on the Plant are recharged by the infiltration of precipitation (about 40



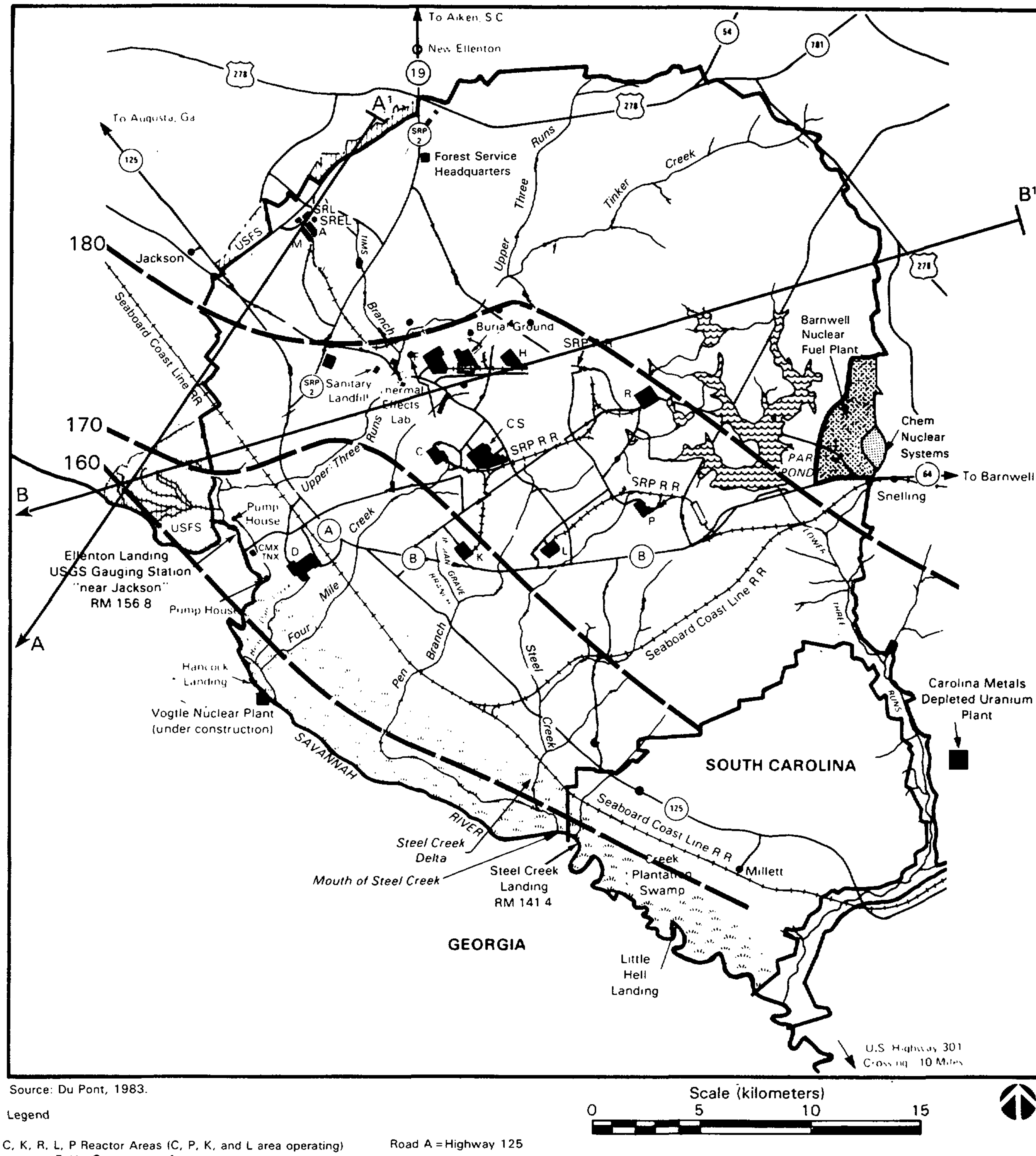
Source: Faye and Prowell, 1982.
Legend:
—100— Potentiometric surface
Contours and water elevations in feet above mean sea level; 1.0 foot = 0.3048 meter.

Figure A-8. Potentiometric Surface of the Cretaceous Sediments Aquifer

Table A-7. Typical Groundwater Velocities for Important Hydrogeologic Units on Savannah River Plant[a]

Hydrogeologic unit	Test area	Groundwater velocity (m/yr) Vertical	Horizontal
Unsaturated zone material	--	0.9-2.1	--
			4
Barnwell Formation	--	--	0.7-21.0
	BG[b]	2.1	3.0
	A/M	--	0.34-3.4
McBean Formation	F/H	--	3.8 (sand)
	F/H	--	2.2 (calcareous zone)
	F	--	22-56 (sand)
	H	--	111 (sand)
McBean and Congaree Formations	A/M	--	6.1
Congaree Formation	F/H	--	13.4
	F	--	5.15
Ellenton Formation			
Cretaceous Sediments Aquifer	--	--	54.9

[a]Sources: Haskell and Hawkins, 1964; Du Pont, 1983, 1985a; Hubbard and Emslie, 1984; Siple, 1967. Hydrogeologic unit terminology largely after Siple, 1967 (see Figure A-2).
[b]Radioactive waste burial ground.



Source: Du Pont, 1983.

Legend

C, K, R, L, P Reactor Areas (C, P, K, and L area operating)
F, H Separations Areas
M Fuel and Target Fabrication
D Heavy Water Production
A Savannah River Laboratory and Administration Area
CS Central Shop
RM River Mile

Road A = Highway 125

Note: Contours and water levels in feet above mean sea level.
1.0 foot = 0.3048 meter.

Figure A-9. Potentiometric Map of Cretaceous Sediments Aquifer at Savannah River Plant (May 11, 1982)

centimeters per year) (Root, 1983). However, discharge into Upper Three Runs Creek and the Savannah River has a dominant effect on Congaree groundwater flow (Figure A-10). Over much of the Plant area, hydraulic heads in the Congaree are lower than those in the Cretaceous Sediments aquifer, precluding downward flow into the Cretaceous Sediments in these areas (Figure A-6). However, as noted in Section A.2.2.2, in two areas this condition is reversed, indicating that the Cretaceous Sediments aquifer might receive recharge from the overlying Congaree aquifer. Also, in small local areas where the Cretaceous Sediments aquifer head normally exceeds the head in the Congaree aquifer, drawdown from water production wells in the Cretaceous Sediments aquifer might lower its head below that of the Congaree, creating a potential for localized downward flow (Figure A-5).

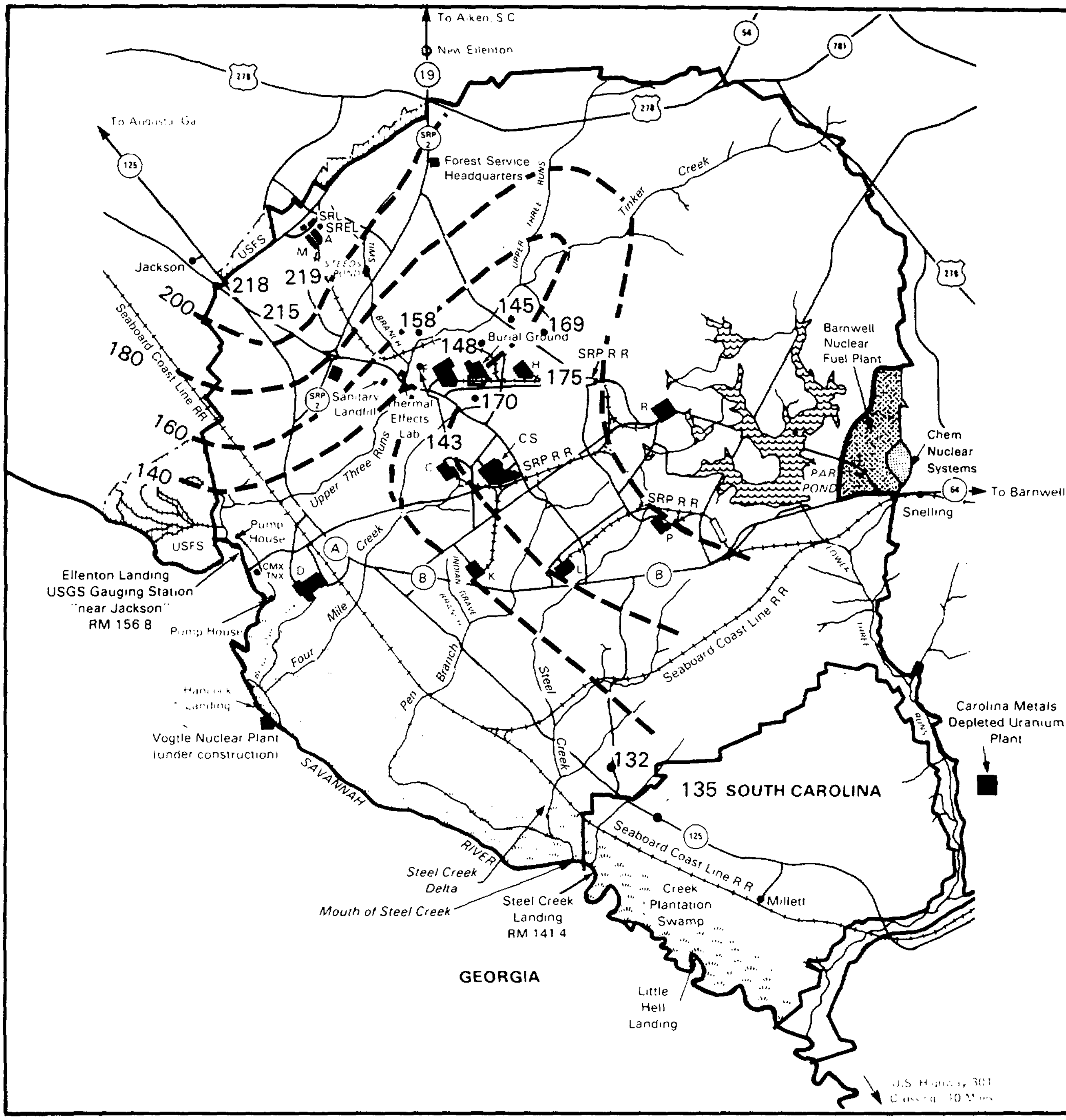
On a regional basis, the dissecting creeks divide the groundwater in the Congaree and higher formations into discrete subunits. Even though the hydraulic characteristics of the formations might be similar throughout the area, each subunit has its own natural recharge and discharge areas. In the central part of the Plant, the only stream that intersects the Congaree is Upper Three Runs Creek.

The McBean Formation (terminology from Siple, 1967) is incised by Upper Three Runs Creek, several of its larger tributaries, Four Mile Creek, Pen Branch, and Steel Creek. Thus, groundwater that enters the McBean Formation over much of the interior of the Plant is restricted to its connection with other subunits of the McBean because of stream incision.

The water table at the Plant is commonly within the Barnwell Formation (terminology from Siple, 1967), although in the creek valleys it successively occupies positions in the lower formations. Surface drainage and topography strongly influence the water-table flow path. Even small tributaries of the larger creeks cause depressions in the water table, diverting groundwater flow toward these creeks. The Upland Unit, which is perhaps the most extensive surficial deposit in this region, usually is unsaturated. Its flow paths are predominantly vertical, although there are short horizontal paths.

The overall flow pattern of the unsaturated zone at the Plant is vertical. Precipitation infiltrates into the Barnwell Formation and percolates downward, with the greatest amount eventually reaching the Congaree Formation. The tan clay diverts some water in the Barnwell laterally to creeks. The green clay diverts more water in the McBean Formation laterally to creeks. The remaining water is believed to move vertically into the Congaree Formation. The Ellenton and Cretaceous Sediments aquifer are separated hydraulically from the Congaree and are not recharged significantly on the site. Both the primary recharge and discharge controls on the water in the Cretaceous Sediments are outside the SRP area. The Cretaceous Sediments act as a conduit through which water passes beneath the SRP area en route from recharge zones in the Aiken Plateau to discharge zones in the Savannah River Valley.

Figure A-11 shows the distribution of groundwater flow between hydrologic units in the vicinity of A- and M-Areas. Although not specifically applicable to the entire SRP subsurface, the relationships shown in this figure are generally the same as those that can be expected in other parts of the Plant.



Source: Du Pont, 1983.

Scale (kilometers) 0 5 10 15

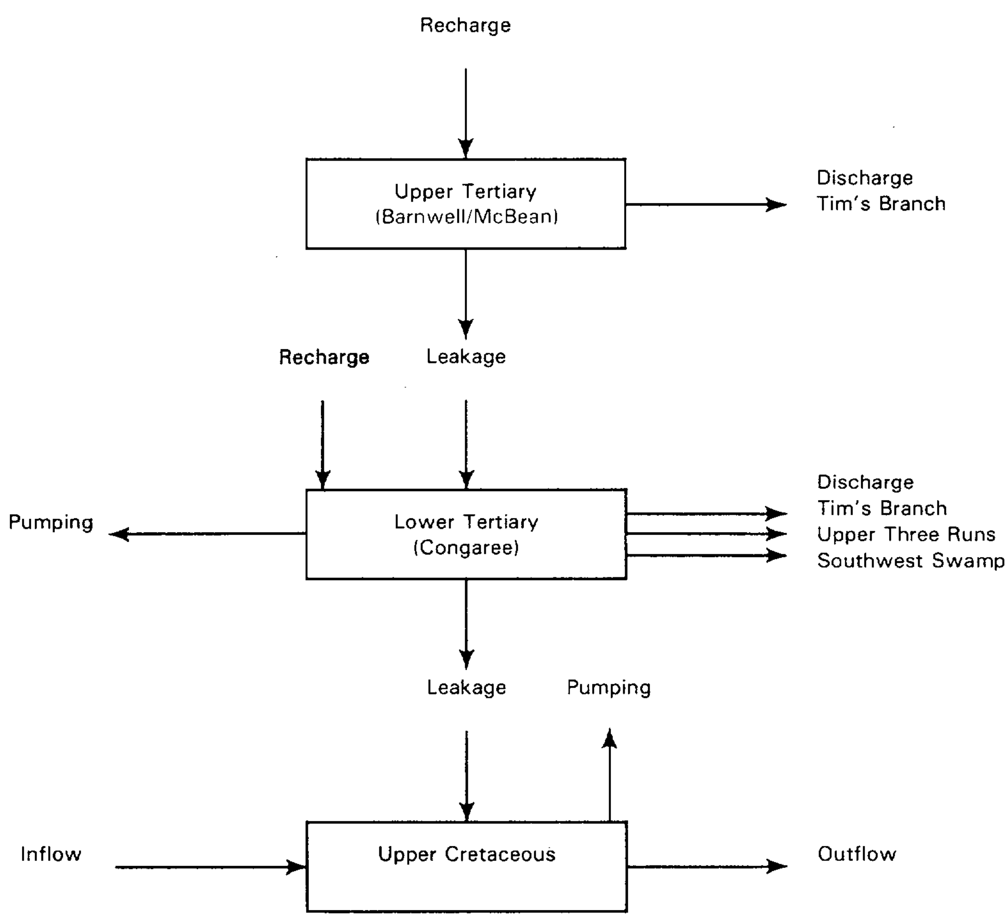
Legend

C, K, R, L, P Reactor Areas (C, P, K, and L are operating)
F, H Separations Areas
M Fuel and Target Fabrication
D Heavy Water Production
A Savannah River Laboratory and Administration Area
CS Central Shop
RM River Mile

Road A = Highway 125

Note: Contours and water levels in feet above mean sea level.
1.0 foot = 0.3048 meter

Figure A-10. Potentiometric Map of Congaree Formation at Savannah River Plant (May 11, 1982)



Source: Du Pont, 1985a. Hydrostratigraphic unit terminology after Siple, 1967; see Figure A-2.

Figure A-11. Distribution of Groundwater Flow Between Hydrologic Units in the Vicinity of A- and M-Areas

A.2.3 GROUNDWATER QUALITY

A.2.3.1 Regional Groundwater Quality

The water in the Coastal Plain sediments tends to be of good quality; hence, it is suitable for industrial and municipal use with minimal treatment. It is generally soft, slightly acidic, and low in dissolved and suspended solids (Du Pont, 1983). Table A-8 lists the results of chemical analyses of groundwater from various regional formations in the Coastal Plain sediments; the following paragraphs describe these results. The descriptions will focus on the total dissolved solids (TDS) content of the groundwater, because the amount of dissolved solids is a consideration in the suitability of the water for domestic use and because it can serve as a measure of the presence of some types of contaminants.

Crystalline Metamorphic Rock

Water from the crystalline metamorphic rock has a TDS content of about 6000 milligrams per liter, which is largely calcium (500 milligrams per liter), sodium (1300 milligrams per liter), sulfate (2500 milligrams per liter), and chloride (1100 milligrams per liter).

Triassic/Jurassic Sedimentary Rock

Two water samples from the Dunbarton Basin of Triassic/Jurassic Age had TDS contents (almost entirely sodium chloride) of about 12,000 and 18,000 milligrams per liter (Du Pont, 1983).

Cretaceous Sediments Aquifer

Water from the Cretaceous Sediments aquifer is low in TDS. Because the water is soft and acidic, it has a tendency to corrode most metal surfaces (Siple, 1967). This is especially true if the water contains appreciable amounts of dissolved oxygen and carbon dioxide. The dissolved oxygen content of water from the Cretaceous Sediments around the Separations Areas is very low (Marine, 1976), and the sulfate content is about 13 milligrams per liter. The dissolved oxygen content is inversely related to the sulfate content of the water. In the northwest part of the Plant near the recharge area, water in the Cretaceous Sediments aquifer is near saturation with dissolved oxygen while the sulfate content is very low.

Ellenton Formation

Chemical analyses of water from the Ellenton Formation (Siple, 1967) show a TDS content somewhat higher than that of water from the Cretaceous Sediments aquifer, but still very low at less than 50 milligrams per liter.

Congaree Formation

Table A-8 compares two analyses of water from sands in the Congaree Formation. The analyses are similar to those reported for Eocene limestone (Siple, 1967). The zones in the formation probably contained some calcareous cement, giving rise to relatively high concentrations of ionic species in the water.

Table A-8. Analysis of Groundwater from Coastal Plain Formations at Savannah River Plant (mg/L)[a]

	Source of water			Properties		
Date sampled	Well	Screen depth (m)	Formation	Temperature (°C)	pH[c]	Conductivity (micromhos/cm)
12/16/66	HC1E	13.1-14.6	Barnwell[b]	21.7	5.8	48
10/25/77	HC2F	22.6-24.1	Barnwell	23.0	5.04	NM
08/01/74	HC3F	16.8-18.3	Barnwell	NM	5.2	15
10/18/77	HC6B	25.9-27.4	Barnwell	22.0	6.30	NM
07/25/74	HC3E	28.3-29.9	Barnwell	NM	5.7	18
07/23/74	HC3D	36.9-38.4	McBean	NM	4.8	11
04/28/66	HC2H	40.8-43.9	McBean[c]	23.2	7.1	103
11/23/77	HC6A	42.4-43.9	McBean	21.2	6.93	NM
02/21/72	905-72G	33.5-48.8	McBean	NM	7.0	NM
07/19/74	HC3A	70.1-71.6	Congaree	NM	6.4	130
01/19/78	FC2A	70.4-71.6	Congaree	19.6	6.15	NM
02/21/72	905-31A	134.1-163.4	Cretaceous sediments	NM	5.5	17
02/29/72	905-41D	102.1-149.4	Cretaceous sediments	NM	6.6	NM
02/21/72	905-43H	201.2-259.1	Cretaceous sediments	NM	4.3	54
02/21/72	905-67U	187.5-220.2	Cretaceous sediments	NM	5.15	19

Footnotes on last page of table.

Table A-8. Analysis of Groundwater from Coastal Plain Formations at Savannah River Plant (mg/L)[a] (continued)

Date Sampled	Well	Chemical constituents[d]														
		Ca^{+2}	Mg^{+2}	K^+	Na^+	Fe	Si	Al	Mn	HCO_3^-	Cl^-	SO_4^{-2}	NO_3^-	PO_4^{-3}	F^-	TDS
12/16/66	HC1E	3.3	0.3	1.6	TR[e]	0.52	6.8	TR	0.02	12	6.0	1.0	3.8	0.0	0.0	34
10/25/77	HC2F	0.42	0.05	0.10	3.96	<0.2	3.9	<1	<0.02	NM	3.7	0.25	5.8	0.32	0.01	20
08/01/74	HC3F	1.7	0.43	0.25	2.9	<0.1	2.9	NM	NM	4.0	3.3	1.0	0.78	NM	NM	15
10/18/77	HC6B	3.72	0.03	1.91	2.20	<0.2	4.6	<1	<0.03	18.3	1.5	0.62	5.1	0.01	0.01	30
07/25/74	HC3E	5.4	0.25	0.54	2.5	<0.1	4.6	NM	NM	16.3	3.0	1.8	<0.0001	NM	NM	26
07/23/74	HC3D	0.8	0.37	0.22	1.7	<0.1	5.5	NM	NM	2.1	3.0	1.0	<0.0001	NM	NM	14
04/28/66	HC2H	11	0.4	3.0	TR	0.02	12	0.1	0.00	45	4.1	5.8	0.2	0.78	0.01	66
11/23/77	HC6A	13.8	0.02	0.64	2.57	<0.2	5.4	<1	<0.02	49.3	2.3	0.62	0.05	0.01	0.01	51
02/21/72	905-72G	7.0	9.2	0.90	12.5	0.012	0.60	NM	0.05	27.5	1.6	10.2	0.11	0.18	NM	56
07/19/74	HC3A	28	0.54	0.55	1.5	<0.1	9.4	NM	NM	72	2.8	2.2	0.001	NM	NM	81
01/19/78	FC2A	11.1	0.07	0.94	1.45	<0.2	10.7	<1	<0.03	42.7	3.92	10.5	0.05	0.12	0.01	61
02/21/72	905-31A	0.11	1.7	NM	1.75	0.01	0.56	NM	<0.05	5.4	0.8	2.3	2.3	0.06	NM	10
02/29/72	905-41D	1.4	3.5	4.3	11.0	<0.05	0.6	NM	<0.05	9.9	0.59	15.0	15.0	0.3	NM	42
02/21/72	905-43H	0.82	1.52	1.15	1.82	0.14	0.9	NM	0.05	0.97	0.60	11.3	11.3	--	NM	22
02/21/72	905-67U	0.22	1.5	0.43	1.6	0.05	0.44	NM	0.05	0.97	0.71	3.5	3.5	--	NM	10

[a]Adapted from Du Pont, 1983. Formation terminology largely from Siple, 1967 (see Figure A-2).
[b]Upper zone.
[c]Calcareous zone.
[d]Key: Ca^{+2}, calcium; Mg^{+2}, magnesium; K^+, potassium; Na^+, sodium; Fe, iron; Si, silicon; Al, aluminum; Mn, manganese; HCO_3^-, bicarbonate; Cl^-, chloride; SO_4^{-2}, sulfate; NO_3^-, nitrate; PO_4^{-3}, phosphate; F^-, fluoride; TDS, total dissolved solids; NM, not measured; TR, trace.
[e]Measured at well head.

McBean Formation*

Samples of water from Eocene sand (Lower Dry Branch equivalent; GCS, 1986) and limestone probably include some water from both the sandy and calcareous zones. The water from these zones is low in TDS, with that from sandy zones being much lower. The differences in the chemical characteristics of water from the two zones are readily apparent. Well HC3D in the upper sandy zone has a TDS content of 14 milligrams per liter and low concentrations of all other constituents. The other wells, which are screened in the calcareous zone, have a TDS content of more than 50 milligrams per liter and high concentrations of calcium and bicarbonate. The pH of water from the calcareous zone is near 7, while that of water from the sandy zone is generally less than 5.

Barnwell Formation*

Table A-8 lists five analyses of water from the Barnwell Formation (Tobacco Road and upper Dry Branch equivalents; GCS, 1986) in the Separations Areas. The TDS content is low, and the concentrations of calcium and bicarbonate ions are not as high as in the McBean and Congaree Formations. The pH of water from the Barnwell Formation is slightly acidic, similar to that of groundwater from other formations in the area.

A.2.3.2 Mixed Chemical and Radionuclide Contamination

Groundwater is monitored at 49 of the 54 SRP hazardous and mixed waste management facilities for the parameters listed in Table A-9. Nine of the 54 facilities have been designated as Resource Conservation and Recovery Act interim-status hazardous waste management facilities. These are the F-Area seepage basins (three basins), H-Area seepage basins (three basins), M-Area settling basin and Lost Lake, and the inactive Mixed Waste Management Facility (MWMF) within the operating low-level radioactive waste burial grounds between F- and H-Areas. Groundwater contamination at the F- and H-Area seepage basins and the M-Area settling basin is discussed here to provide examples of the modes of contamination, possible pathways of contaminants, and water quality within the SRP subsurface. Appendix B discusses contamination at other facilities covered in this EIS in detail.

The seven unlined basins and Lost Lake have received hazardous wastes and radioactive materials since the mid- to late-1950s. Geophysical and geochemical testing and groundwater monitoring have been performed at these sites to assess the nature, extent, and rate of migration of hazardous wastes and hazardous constituents (DOE, 1985).

Suspected contaminants were identified by a statistical comparison of upgradient and downgradient water quality known as the Student's t-test. Assuming an appropriate experimental design as well as a good sampling and analysis technique, the t-test can provide a basis for rejecting or not rejecting sampling variation as a possible factor to account for the difference between upgradient and downgradient wells when the number of samples taken is small. Rejecting sampling variation at some level of confidence means that the difference between wells is due to factors other than sampling variation. A failure to reject means that the difference between wells could be sampling variation

*Stratigraphic terminology from Siple, 1967. See Figure A-2.

Table A-9. Groundwater Monitoring Parameters

Minimum	Comprehensive	
Water-table elevation	Coliform bacteria	Zinc
Field pH	Color	Cyanide
Laboratory pH	Corrosivity	Fluoride
Conductivity	Odor	Hydrogen sulfide
Total dissolved solids	Turbidity	Nitrate
Field temperature	Silver	Sulfate
Laboratory temperature	Arsenic	Gross alpha
Chloride	Barium	Gross beta
Dissolved organic carbon	Beryllium	Radium
Total organic carbon	Cadmium	Foaming agents
Total organic halogen	Chromium	Gas-chromatograph scan
Two site-specific metals	Copper	Phenol
	Iron	Endrin
	Mercury	Lindane
	Manganese	Methoxychlor
	Sodium	Toxaphene
	Nickel	2,4-D
	Lead	2,4,5-TP Silvex
	Selenium	

among other factors. The cutoff points for f-test scores were probabilities of less than or equal to 0.05 and greater than 0.25. Values less than or equal to 0.05 were classified as probable contaminants; those greater than 0.25 were improbable contaminants. Scores between these two values were considered to be possible contaminants.

Tables A-10 and A-11 list the contaminant potential based on the t-test for selected parameters at the F-Area and H-Area seepage basins, respectively. Statistical analyses performed in 1983 identified elevated values of TDS, sodium, nitrate, gross alpha, and gross beta in relation to the values for upgradient monitoring wells at the F- and H-Area seepage basins. The low pH of the groundwater in downgradient monitoring wells also reflected the operation of the seepage basins in these two waste management areas.

The reliability of the 1983 results was evaluated when improvements were made in sampling and sample preservation methods in 1984. Pumps were installed to provide adequate flushing of the wells before sampling, and all samples for metals analyses were filtered before preservatives were added. Results following the initiation of the new techniques indicated that inadequate flushing (using a manual bailing technique) and solids in the samples analyzed were contributing to the erroneous positive results previously obtained.

Special sampling and testing for the hazardous constituents identified in 40 CFR 261, Appendix VIII, were performed in January 1985 at the F- and H-Area seepage basins (DOE, 1985). No organic compounds attributable to basin operation were observed in significant concentrations at either location. However, based on the t-test, various hazardous constituents were observed in downgradient monitoring wells at the F- and H-Area seepage basins (Table A-12) (DOE, 1985).

Contaminants from the F- and H-Area seepage basins migrate to springs along Four Mile Creek (approximately 60 to 500 meters). This migration has been verified through observations of a tritium plume from Basin 3 in the F-Area, as shown in Figure A-12. Other contaminants, except those affected by sorption properties of the site soils, are expected to follow the general behavior of the tritium plume.

Routine discharges to the M-Area settling basin (which overflowed to Lost Lake) were discontinued in July 1985. The U.S. Department of Energy (DOE) is negotiating the closure of this hazardous waste management facility with regulatory authorities (DOE, 1985). At the basin and Lost Lake, TDS, chloride, dissolved organic carbon, nitrate, gross alpha, and radium have been observed at concentrations above background values. Table A-13 lists the potential for contamination at the M-Area settling basin. Special studies for hazardous constituents in the groundwater at the settling basin have identified chlorinated hydrocarbons (degreasing compounds); metals were not detected in significant concentrations. However, the pH in downgradient monitoring wells reflects basin operation (DOE, 1985).

Extensive groundwater monitoring studies around A- and M-Areas have been conducted since chlorinated hydrocarbons were discovered in the groundwater in 1981. The distribution of these organic compounds has been determined vertically and horizontally, but assessment studies are continuing (DOE, 1985). Figure A-13 shows a cross-section through the settling basin and Lost Lake

Table A-10. F-Area Seepage Basin Contaminant Potential[a]

Parameter	Contamination potential	Known releases from process	Concentration in process streams[b]	Number of wells failing Student's t-test
pH	Probable	2-2.7	2.8-11	3
Total dissolved solids	Probable	--	--	2
Cadmium	Improbable	None known	Not detectable	2
Copper	Possible	Infrequent	<0.001-0.3 ppm	2
Manganese	Possible	Infrequent	0.0004-2 ppm	2
Sodium	Probable	Frequent[c]	0.004-30 ppm	2
Nickel	Possible	None known	<0.0007-0.3 ppm	1
Zinc	Possible	Frequent	<0.001-2 ppm	1
Fluoride	Possible	Frequent	--	1
Nitrate	Probable	Frequent[c]	43-93,000 ppm	2
Gross alpha	Probable	Frequent	<1-2,250 d/mL	2
Gross beta	Probable	Frequent	--	2
Radium	Probable	Frequent	--	2
Foaming agents	Possible	Past[d]	--	1
Phenol	Improbable	None known	--	1

[a]Adapted from Du Pont, 1985a.
[b]Key: ppm, parts per million; d/mL, disintegrations per milliliter.
[c]In excess of 454 kilograms per year.
[d]Laundry facilities discharged to basin prior to 1982.

Table A-11. H-Area Seepage Basin Contaminant Potential[a]

Parameter	Contamination potential	Known releases from process	Concentration in process streams[b]	Number of wells failing Student's t-test
pH	Probable	3.0-8.4	2.8-11	3
Conductivity	Probable	--	--	2
Total dissolved solids	Probable	--	--	2
Chloride	Possible	Frequent[c]	--	1
Iron	Possible	Frequent[c]	<0.01-1.8 ppm	1
Mercury	Probable	Infrequent	5-6 ppm	1
Manganese	Possible	Infrequent	<0.01-38 ppm	1
Sodium	Probable	Frequent[c]	<0.1-3,260 ppm	3
Nitrate	Probable	Frequent[c]	0.1-18,000 ppm	2
Gross alpha	Probable	Frequent	<5 d/ml	1
Gross beta	Probable	Frequent	--	1
Radium	Probable	Frequent	--	2

[a]Adapted from Du Pont, 1985a.
[b]Key: ppm, parts per million; d/mL, disintegrations per milliliter.
[c]In excess of 454 kilograms per year.

Table A-12. Hazardous Constituents Observed in Downgradient Monitoring Wells at F- and H-Area Seepage Basins (μg/L)[a]

Constituent	F-Area basins	H-Area basins
Arsenic	<1	<1
Barium	145	223
Cadmium	35	10
Chromium	<8	<4
Lead	167	26
Mercury	0.34	0.72
Nickel	<1	<64
Selenium	<1	<1
Silver	300	300
Cyanide	10.6	<5

[a]Source: DOE, 1985.

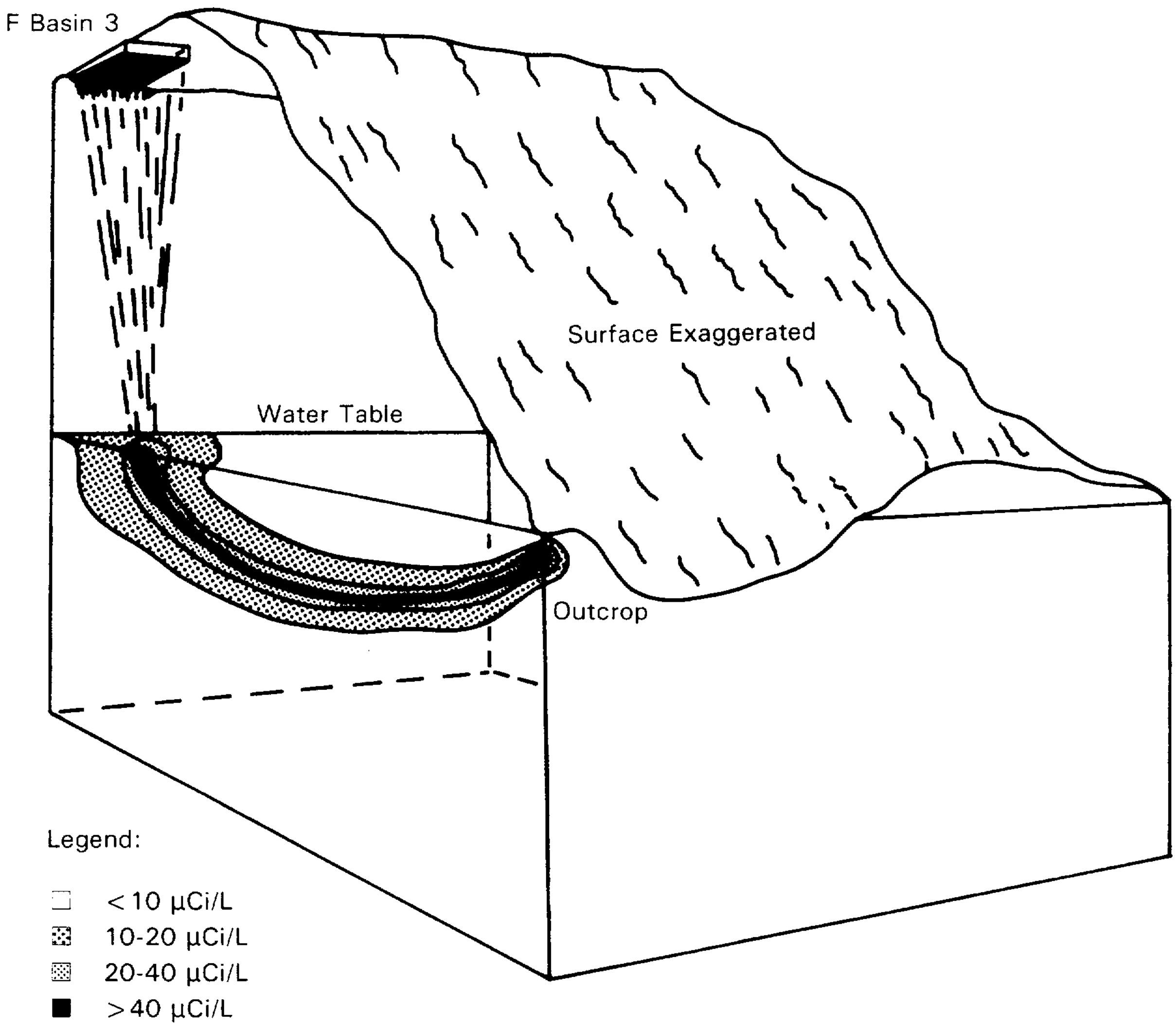
depicting isoconcentrations of total chlorinated hydrocarbons. The main body of the plume is moving slowly to the southeast at about 7 to 8 meters per year. Monitoring studies have demonstrated that volatile organics have not migrated beyond the SRP boundary.

A groundwater remediation program was initiated in A- and M-Areas in 1983 to contain the vertical and horizontal migration of the chlorinated hydrocarbon plume in the Tertiary sands and to remove the chlorocarbons from the groundwater. This project involves the use of a 1.5-cubic-meter-per-minute air stripper that is fed by 11 recovery wells (South Carolina Bureau of Air Quality Control Permit 0080-0055-CB and Bureau of Water Pollution Control Permit 10389). On the average, the air stripper has been removing more than 2600 kilograms of chlorinated hydrocarbons per month from the groundwaters.

The characteristics of the movement and extent of contamination at F-, H-, and M-Areas are expected to approximate the behavior of contamination at other waste management units. The specific characteristics of the contamination at other facilities is primarily controlled by: (1) properties of the contaminant(s), (2) depth to groundwater, (3) contaminant retention properties of the subsurface materials, (4) degree of heterogeneity of the subsurface materials, (5) groundwater flow speed and direction, (6) distance to groundwater outcrop.

Hazardous metal constituents have been observed in groundwater monitoring wells at the low-level radioactive waste burial grounds facility (643-G and 643-7G). Lead and cadmium concentrations averaged about 43 and 39 micrograms per liter (parts per billion), but ranged to 398 and 365 micrograms per liter, respectively. Although approximately 10 tons of mercury have been disposed of at these facilities, little mercury has been observed in monitoring wells.

Concentrations of mercury at the perimeter wells are generally less than 1 microgram per liter (National Primary Drinking Water Standards for lead, cadmium, and mercury are 50, 10, and 2 micrograms per liter, respectively).



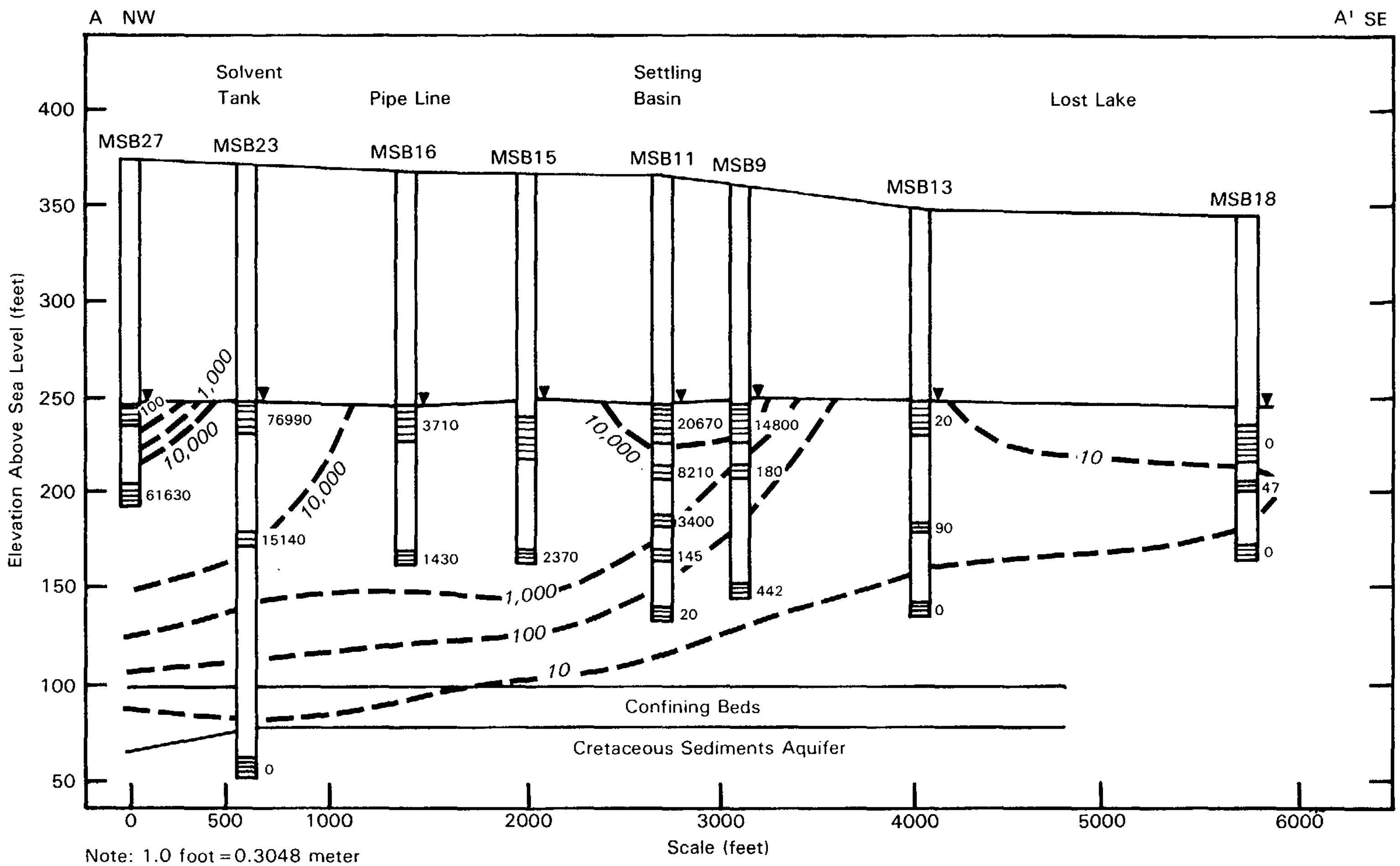
Source: Du Pont, 1983.
Note: Distance from basin 3 to outcrop is approximately 450 meters.
Depth to water-table from basin 3 is approximately 20 meters.

Figure A-12. Subsurface Flow Path from F-Area Seepage Basin 3

Table A-13. M-Area Settling Basin Contaminant Potential[a]

Parameter	Contamination potential	Known releases from process	Concentration in basin influent: Maximum	Concentration in basin influent: Average	Number of wells failing Student's t-test
Total dissolved solids	Possible	--	--	--	1
Chloride	Possible	Frequent	--	--	1
Dissolved organic carbon	Probable	Frequent	--	--	1
Cadmium	Improbable	None known	0.008 ppm	0.005 ppm	1
Copper[b]	Improbable	None known	0.04 ppm	0.04 ppm	1
Manganese	Improbable	None known	<0.005 ppm	<0.005 ppm	3
Nickel[b]	Possible	Frequent	1.55 ppm	0.68 ppm	3
Nitrate	Probable	Frequent[c]	1190 ppm	151 ppm	1
Gross alpha	Possible	Frequent	--	--	2
Radium	Possible	Frequent	--	--	3
Gas-chromatograph scan	Probable	Infrequent	--	--	2
Phenol	Improbable	None known	--	--	1

[a]Adapted from Du Pont, 1985a.
[b]In 1982, core samples 4.6 meters deep were taken from basin. Analyses of cores indicated that concentrations of this metal reached background levels at depth of 1.2 meters.
[c]In excess of 454 kilograms per year.



Note: 1.0 foot = 0.3048 meter

Legend:
▼ Water-Table Elevation
37 Screened Zone and Concentration (ppb)

Source: Adapted from Du Pont, 1985a.

Figure A-13. Cross-Section Through M-Area Showing Total Chlorinated Hydrocarbon Concentrations (ppb) in Groundwater (April-July 1984)

Because the wells used to measure these constituents were constructed of galvanized easings, the concentrations are considered questionable.

A.2.3.3 Radionuclide Contamination

Radium, tritium, and certain alpha-emitting radionuclides have been detected in the groundwater at concentrations above the standards for all geographic areas but Area 6, and a high level of concern for such contamination has been determined for Areas 2, 4, 5, 7, 8, 9, and 10. Figure 2-1 and Table 2-2 show the locations of these geographic areas.

Because of its high mobility and abundance, tritium is the most prevalent radionuclide that reaches the water table. Other radionuclides in the waste, particularly strontium-90, cesium-137, plutonium-238, and plutonium-239, tend to be adsorbed by the soil column in the groundwater flow paths beneath the seepage basins and the burial grounds. These radionuclides migrate very slowly because they are strongly adsorbed by soil particles.

Low concentrations of tritium are present in some waste streams and burial grounds leachates as tritiated water, which behaves like water and cannot be separated practically from the groundwater. Therefore, tritium travels along underground flow paths as a component of the groundwater. Based on monitoring performed at the low-level radioactive waste burial grounds, the groundwater beneath the MWMF probably has been contaminated by tritium and, to a lesser extent, by other radionuclides.

Tritium was the only radionuclide detected migrating from the K-Area containment basins to Pen Branch. Weekly water-flow measurements combined with studies of tritium concentrations in Indian Grave Branch, a tributary of Pen Branch, indicated a migration of 7500 curies in 1984.

Tritium discharged to the F- and H-Area seepage basins has migrated from the basins and contaminated the water-table aquifer to concentrations in excess of 40,000,000 picocuries per liter (Du Pont, 1983). The migration of radioactivity from the F- and H-Area seepage basins and the low-level waste burial ground was measured with continuous samplers and flow records in Four Mile Creek in 1984. The total measured migration of tritium was 2320 curies from the F-Area seepage basins and 12,500 curies from the H-Area seepage basins and the low-level waste burial grounds. The amount of strontium-90 that migrated from the F- and H-Area seepage basins was 0.20 and 0.12 curie, respectively. Because of the desorption of cesium-137 in streambeds, the migration of this radionuclide, if it occurs, cannot be measured. Table A-14 shows the 1984 migration of tritium and strontium-90 from the seepage basins.

Many laboratory and field studies of soil-to-water distribution coefficients (K_d) have been conducted on the Plant to relate soil adherence to waste migration (Prout, 1958). These studies reveal that the soil column acts to restrict the free passage of most radionuclides. Radiostrontium, radiocesium, plutonium, and many other radionuclides are largely removed from the flowing groundwater due to adsorption by clay particles. As with most physical and chemical interactions, the amount of adsorption is governed by complex equilibrium equations. Changes in the pH of the groundwater and the mass balance between other constituents are two conditions that can affect the degree of adsorption by clay particles. Changes in these conditions can cause

Table A-14. Migration of Tritium and Strontium-90 from Seepage Basins in 1984 (Ci)

Location	Tritium	Strontium-90
200-F seepage basin to Four Mile Creek (FM-A7 minus FM-4)[a]	2320	0.20
200-H seepage basins to Four Mile Creek (FM-2B minus FM-1)[a]	8020	0.12
Burial Ground and 200-H seepage basin 4 (FM-3A minus FM-3)[a]	4480	0.01
K-Area containment basin to Indian Grave Branch	7500	0.01

[a]Designators for sampling locations on Four Mile Creek.

additional contaminants to be adsorbed or some contaminants to be released from the clays, depending on the sense in which the equilibrium is shifted (Freeze and Cherry, 1979).

Two long-lived mobile radionuclides, technetium-99 and iodine-129, form stable anionic species that adhere poorly to soil and tend to migrate at about the speed of the groundwater. Preliminary data indicate that although both technetium and iodine have been found in groundwater by ultrasensitive analytical methods, neither is present in concentrations that can be measured by accepted routine monitoring procedures.

Tritium is the principal radioactive contaminant in the groundwater beneath the burial ground. According to calculations, approximately 28,000 curies of tritium are in this plume. Under 643-7G and 643-28G, the water-table aquifer exhibits concentrations that range from about 20,000 to 34,000,000 picocuries per liter. Perimeter monitoring wells generally exhibit lower concentrations, averaging about 300,000 picocuries per liter. However, tritium has reached the Congaree Formation at concentrations of about 20,000 picocuries per liter [National Primary Drinking Water Standard for tritium is 20,000 picocuries per liter] (Hubbard and Emslie, 1984). Table A-15 lists other radionuclides detected in the groundwater beneath the burial ground (Du Pont, 1983).

Approximately 80 percent of the groundwater plume from the low-level radioactive management facility flows toward outcrop springs along Four Mile Creek, in much the same manner as the plume from the F-Area seepage basins (Figure A-10). The remaining plume flows toward Upper Three Runs Creek, but extends only about 200 meters beyond 643-7G. Groundwater in the Congaree Formation in this area flows to Upper Three Runs Creek.

Table A-15. Radionuclides Other Than Tritium Detected in Groundwater Beneath Burial Ground[a] (pCi/L)

Radionuclide	Average concentration	Drinking-water standard
Cobalt-60	13	100
Strontium-90	19	8
Cesium-137	12	200
Plutonium-238	5	15[b]
Plutonium-239	3	[b]

[a]The limits for tritium, cobalt-60, strontium-90, and cesium-137 are the maximum concentration limits if only one manmade beta- or gamma-emitting radionuclide is present.
[b]Total plutonium.

A.2.4 GROUNDWATER USE

A.2.4.1 Important Aquifers

As noted in Section A.1.1., the subsurface waters in the vicinity of the SRP include six major hydrostratigraphic units. The geohydrologic characteristics of these units, their aeral configurations, and their recharge/discharge relationships control the vertical and horizontal movement of groundwater at the Plant (see Sections A.2 and A.3). Section A.1 explains the stratigraphic nomenclature used at the SRP.

At present, the Plant does not withdraw groundwater from the crystalline, metasediment basement rocks and overlying saprolite. The Cretaceous Sediments aquifer, which is 170 to 250 meters thick at the Plant, is the most important regional aquifer. At the Plant, the Cretaceous Sediments consist of two aquifers separated by a clay aquitard (Figure A-2). The lower aquifer consists of about 90 meters of medium-to-coarse sand (Middendorf); the overlying aquifer (Black Creek) consists of about 45 meters of well-sorted medium-to-coarse sand. The Ellenton Formation clays cap the Cretaceous Sediments forming an aquitard that restricts the flow of groundwater between the Cretaceous Sediments aquifer and the overlying units.

The Congaree is another important regional aquifer. In this area, only the Cretaceous Sediments exceed the Congaree's water-producing potential. The Congaree's intermediate depth (Figure A-5) also makes it attractive for water wells. An extensive clay layer at the base of the Congaree forms a confining bed that separates the permeable sands of the Congaree from the sands in the underlying Ellenton and Cretaceous Sediments units (DOE, 1984). The green clay (Figure A-4), a marker bed at the top of the Congaree, exhibits very low hydraulic conductivity; it is, therefore, a significant aquitard (Section A.2.1), particularly south and east of Upper Three Runs Creek. The SRP does not withdraw large quantities of groundwater from the McBean, Barnwell-

Hawthorn, or stream valley alluvium deposits (stratigraphic terminology from Siple, 1967; see Figure A-2). The McBean, however, becomes increasingly more important as an aquifer to the east of the Plant.

The water table is commonly located in the stream valley alluvium deposits and in the Barnwell. The McBean is usually under semiconfined conditions. In contrast, groundwater in the Congaree (to the south and east of Upper Three Runs Creek) and the Cretaceous Sediments is under confined conditions. Cretaceous Sediments water wells near the Savannah River (e.g., in D-Area) often flow because the potentiometric level of the groundwater is greater than the elevation of the land surface. Figure A-4 shows the head relationships near H-Area, close to the center of the Plant. Section A.3 discusses these relationships. Section A.3 also discusses interactions between surface water and groundwater, groundwater flow patterns, recharge/discharge, and water budgets.

A.2.4.2 Regional and Local Groundwater Use

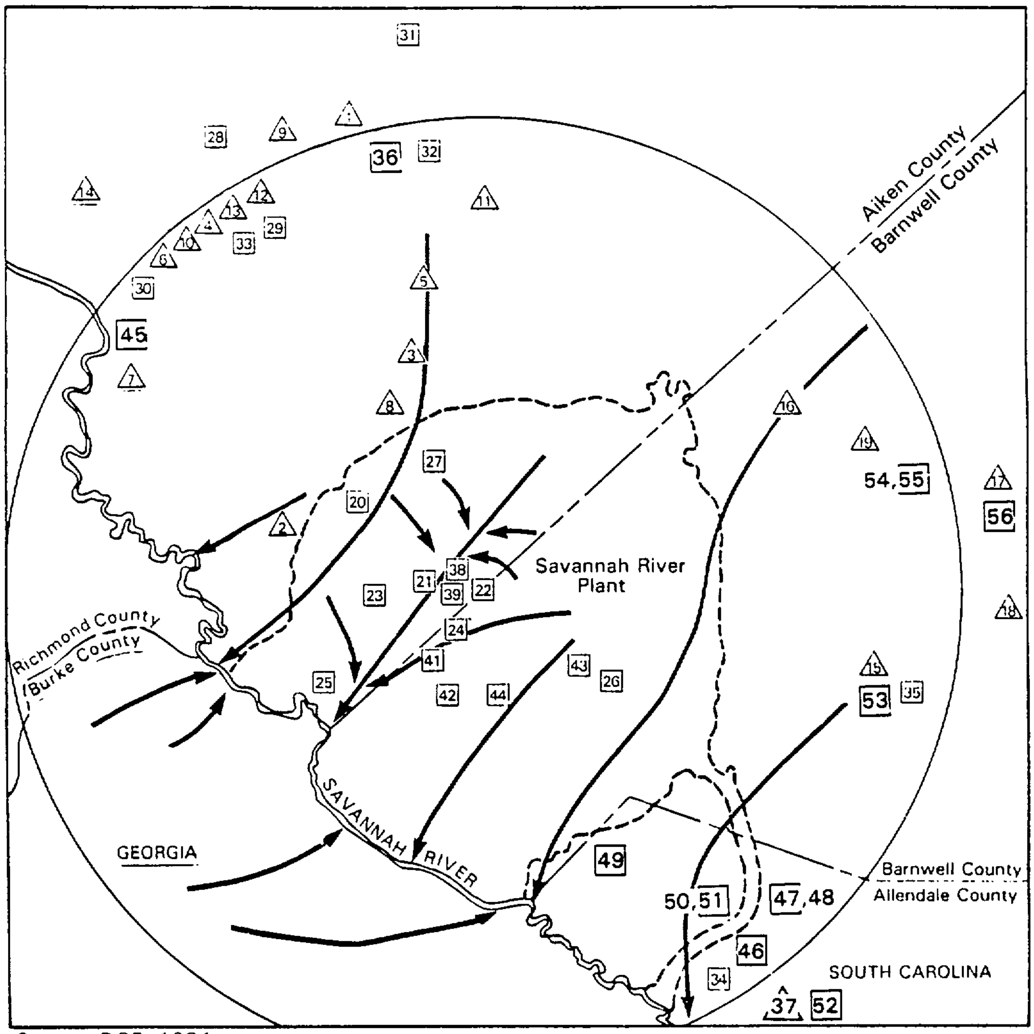
DOE surveyed groundwater use in South Carolina in an area within about 32 kilometers from the center of the SRP. DOE obtained information for this survey from the South Carolina Department of Health and Environmental Control, the South Carolina Water Resources Commission, the U.S. Geological Survey, local universities, and files at the SRP (DOE, 1984; RPI, 1985). The survey did not include users in Georgia, because the strength of groundwater flow toward the Savannah River in the area bordering the river tend to outweigh any hydrologic gradient in the Georgia direction (Du Pont, 1983). See Sections 2.2.2, 2.2.3, 3.1, and 3.2 for information on this phenomenon (Figures A-7, A-14, A-15, and A-16).

This survey found that groundwater is the primary source of water for domestic, industrial, municipal, and agricultural use in the vicinity of the SRP. The Cretaceous Sediments, which occur at shallower depths as they approach the fall line, form the base for most municipal and industrial water supplies in Aiken County. Domestic water supplies depend primarily on the Barnwell, McBean, and Congaree Formations. In Barnwell and Allendale Counties, the Cretaceous Sediments occur at increasingly greater depths; some municipal users, therefore, get their water from the shallower Congaree and McBean Formations or from their limestone equivalents (Section A.1; Du Pont, 1983). In these counties, domestic supplies come from the Barnwell and the McBean Formations.

The survey identified 56 major municipal, industrial, and agricultural groundwater users in the study area. The total estimated pumpage in this area is about 135,000 cubic meters per day. Figures A-14 and A-15 show the locations of the major users and the groundwater flow paths for the Congaree and Cretaceous Sediments aquifer, respectively. Tables A-16 and A-17 provide pertinent data.

Municipal Use

The survey identified 20 municipal users that have a combined withdrawal rate of about 52,605 cubic meters per day (Table A-16). Within the study area, the total municipal pumpage from the Cretaceous Sediments aquifer is about 36,920 cubic meters per day. Total municipal pumpage from the McBean Formation is

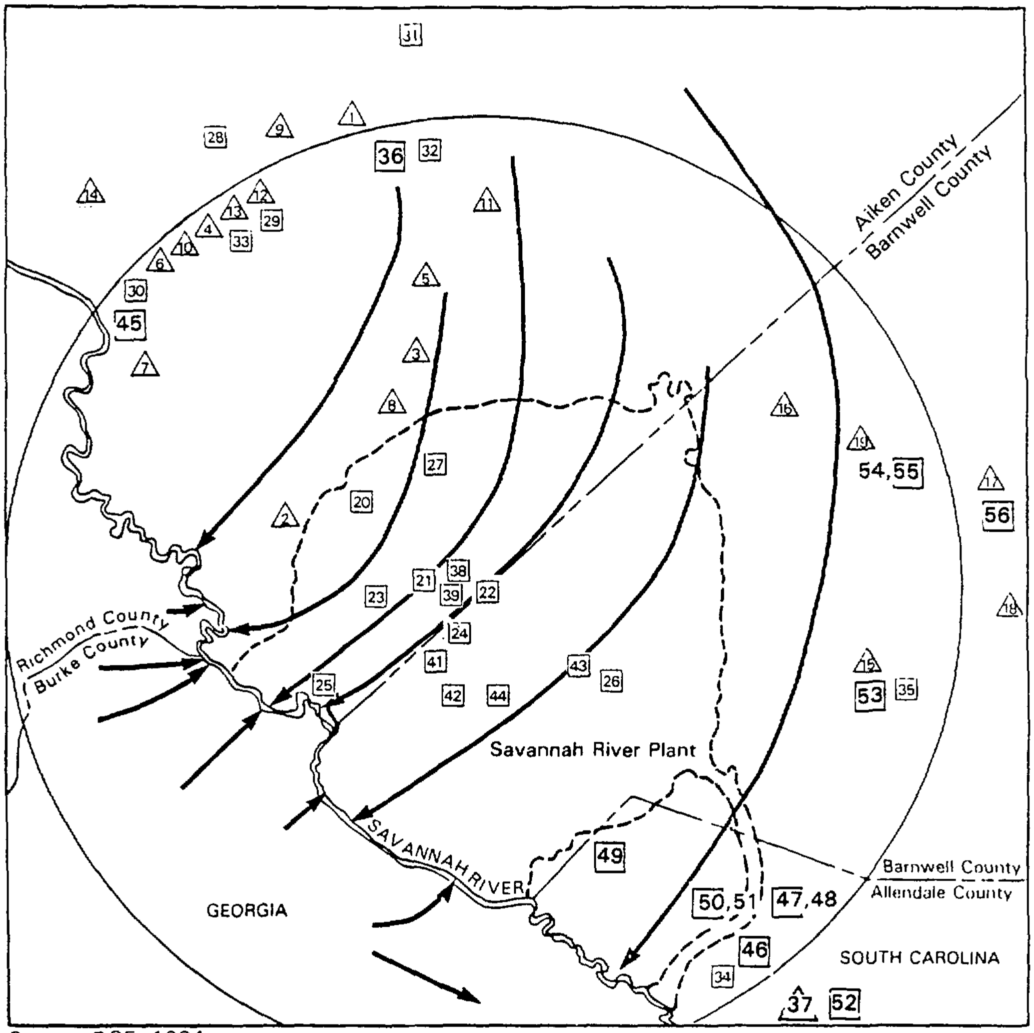


Source: DOE, 1984.
Note: Users are identifed in Tables A-16 and A-17.

Legend:
△ Municipal user
▢ Industrial/agricultural user
◀ Direction of groundwater flow in Congaree Formation

Scale (kilometers)
0 5 10 15 20

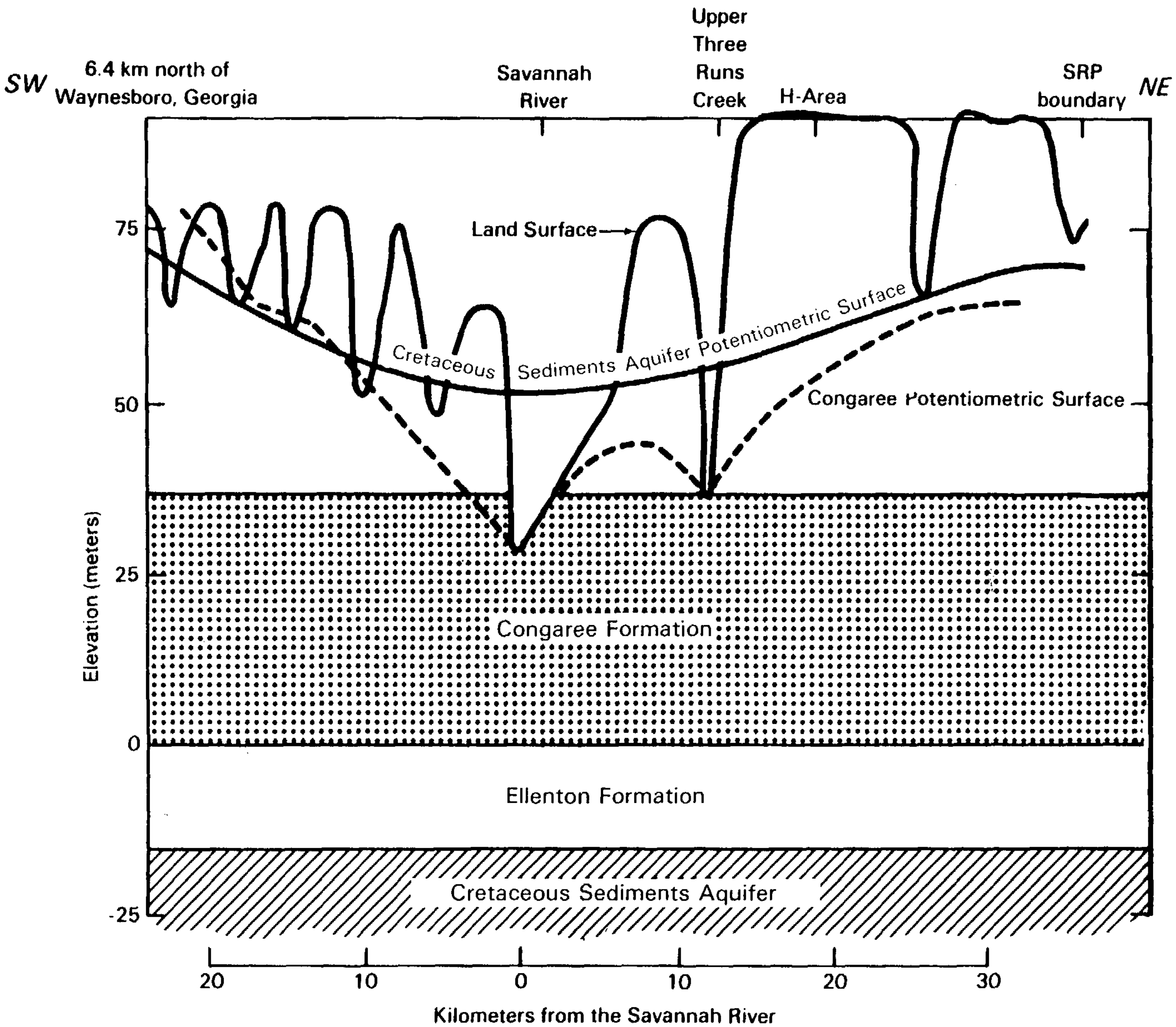
Figure A-14. Locations of Municipal and Industrial Groundwater Users Within a 32-Kilometer Radius of the Center of Savannah River Plant, Showing the Direction of Groundwater Flow in the Congaree Formation



Source: DOE, 1984.
Note: Users are identified in Tables A-16 and A-17.
Legend:
△ Municipal user
□ Industrial/agriculture user
⟵ Direction of groundwater flow in Tuscaloosa Formation

Scale (kilometers)
0 5 10 15 20

Figure A-15. Locations of Municipal and Industrial Groundwater Users Within a 32-Kilometer Radius of the Center of Savannah River Plant, Showing the Direction of Groundwater Flow in the Cretaceous Sediments Aquifer



Note: See Figure A-9. for line of section
Source: Du Pont, 1983; Cretaceous Sediments aquifer water levels from Siple, 1967; Congaree water levels from Faye and Prowell, 1982.

Figure A-16. Hydrogeologic Section Perpendicular to the Savannah River Through H-Area

Table A-16. Groundwater Pumpage for Municipal Supplies[a]

Map location[b]	User	Distance from center of SRP (km)	Population served	Average daily use (m^3/day)	Water-bearing formation	Type of source	Basis of estimate[c]
1	City of Aiken	34	28,000	9,520	Cretaceous sediments	Wells, springs	4
2	Town of Jackson	16	3,152	1,070	Cretaceous sediments	2 wells	4
3	Town of New Ellenton	13	4,000	1,360	Cretaceous sediments	2 wells	4,2
4	Town of Langley	31	1,330	490	Cretaceous sediments	2 wells	3
5	College Acres	21	1,264	430	Cretaceous sediments	3 wells	4,2
6	Bath Water District	31	1,239	1,230	Cretaceous sediments	2 wells	3
7	Beech Island	27	4,500	1,910	Cretaceous sediments	3 wells	2,4
8	Talatha	11	1,200	480	Cretaceous sediments	2 wells	4,2
9	Breezy Hill W&S	39	4,500	1,530	Cretaceous sediments	2 wells	4
10	Burnettown	31	1,200	570	Cretaceous sediments	2 wells	3
11	Montmorenci/Couchton WD	23	4,232	1,600	Cretaceous sediments	3 wells	3,5
12	Warrenville	31	788	1,135	Cretaceous sediments	4 wells	3
13	Johnston	31	1,560	545			
	Howlandville	31	1,232	420	Cretaceous sediments	1 well	4
	Gloverville	31	1,440	545			
14	Belvedere	39	6,300	2,140	Cretaceous sediments	5 wells	4
15	Barnwell	26	6,500	15,140	Congaree	11 wells[d]	3
16	Williston	19	3,800	2,650	McBean–Cretaceous sediments	4 wells	
17	Blackville	32	2,975	1,135	Cretaceous sediments	3 wells	3,4
18	Hilda	35	315	110	Cretaceous sediments	1 well	4,2
19	Elko	23	315	545	McBean	1 well	1
37	Allendale	40	4,400	8,050	Cretaceous sediments	5 wells	1

Total municipal use: 52,605 m^3/day

[a]Adapted from DOE, 1984.
[b]See Figures A-14 and A-15.
[c]Key: 1 = RPI, 1985 (reported use); 2 = RPI, 1985 (well test yield); 3 = DOE, 1984, Appendix F; 4 = per capita use of 0.34 cubic meter per day (Clark, Viessman, and Hammer, 1977); 5 = interview.
[d]Portions of this amount supply local industry.

Table A-17. Groundwater Pumpage for Industrial and Agricultural Supplies

Map location[a]	User	Distance from center of SRP (km)	Population served	Average daily use (m^3/day)	Water-bearing formation	Type of source	Basis of estimate[b]
			SAVANNAH RIVER PLANT				
20	A/M-Areas	10	2,131	7,155	Cretaceous sediments	4 wells	6
21	F-Area	3	800	10,510	Cretaceous sediments	6 wells	6
22	H-Area	0	825	11,880	Cretaceous sediments	5 wells	6
23	U-Area	6	110	330	Cretaceous sediments	3 wells	6
24	Central Shops (CS)	11	600	1,095	Cretaceous sediments	3 wells	6
25	CMX-TNX	13	50	1,355	Cretaceous sediments	3 wells	6
26	Class. Yd.	10	35	30	(c)	1 well	6
38	DWPF[d]	1	530	1,080	Cretaceous sediments	2 wells	3
39	FMF[e]	1	280	290	Cretaceous sediments	(c)	3
41	C-Area	5	(b)	1,470	Cretaceous sediments	2 wells	6
42	K-Area	9	(b)	1,470	Cretaceous sediments	3 wells	6
43	P-Area	9	(b)	1,900	Cretaceous sediments	4 wells	6
44	L-Area	9	(b)	1,355	Cretaceous sediments	2 wells	6
			AIKEN COUNTY, SOUTH CAROLINA				
27	U.S. Forest Service	11	70	20	Cretaceous sediments	1 well	3
28	Graniteville Company	32	2,156	525	Cretaceous sediments	1 well	3
29	J. M. Huber Company	29	(c)	8,440	Cretaceous sediments	1 well	3
30	Augusta Sand & Gravel	35	(c)	3,595	Cretaceous sediments	1 well	3
31	Cyprus Mines Corp.	32	(c)	1,420	Cretaceous sediments	1 well	3
32	Florida Steel Corp.	32	(c)	75	Cretaceous sediments	1 well	3
33	Valchem	29	(c)	410	Cretaceous sediments	1 well	3

Footnotes on last page of table.

Table A-17. Groundwater Pumpage for Industrial and Agricultural Supplies (continued)

Map location[a]	User	Distance from center of SRP (km)	Population served	Average daily use (m^3/day)	Water-bearing formation	Type of source	Basis of estimate[b]
36	Houndslake Country Club	33	(c)	3,380	Cretaceous sediments	2 wells	2
45	S.C. Generating Company	32	(c)	650	Cretaceous sediments	2 wells	2
		ALLENDALE COUNTY, SOUTH CAROLINA					
34	Sandoz Co.	29	(c)	4,165	Cretaceous sediments	1 well	1
46	B. Terry, Sr.	27	(c)	400	Tertiary	1 well	1
47	J. P. Stevens Company	30	(c)	95	Cretaceous sediments	1 well	1
48	Ellis Country Store	30	(c)	160	Cretaceous sediments	1 well	1
49	Duncan Farms	20	(c)	980	Cretaceous sediments	1 well	1
50	J. Furse	23	(c)	355	Cretaceous sediments	1 well	1
51	W. Smith	23	(c)	135	Tertiary	1 well	1
52	B. Oswald	40	(c)	8,175	Cretaceous sediments	1 well	1
		BARNWELL COUNTY, SOUTH CAROLINA					
35	E. T. Barwick, Inc.	26	400	945	Cretaceous sediments	2 wells	3
53	Burlington, Inc.	25	(c)	2,725	Tertiary	2 wells	1
54	Mathis Farms	28	(c)	410	Tertiary	1 well	1
55	Edisto Exp. Sta.	28	(c)	435	Congaree	1 well	1,3
56	Green Blade Turf Grass, Inc.	33	(c)	1,895	Tertiary	1 well	1
		Total industrial and agricultural use: 77,940 m^3/day					

[a]See Figures A-14 and A-15; adapted from DOE, 1984.
[b]Key: 1 = RPI, 1985 (reported use); 2 = RPI, 1985 (well test yield); 3 = DOE, 1984 Appendix F; 4 = per capita use of 0.34 m^3/day (Clark, Viessman, and Hammer, 1977); 5 = interview; 6 = Quarterly Water Use Reports submitted by DOE to South Carolina Water Resources Commission.
[c]Data not available.
[d]DWPF is under construction. Exact number of water wells and pumping requirements are not firmly established. Current plans (December 1983) indicate usage of less than 1080 cubic meters per day supplied by one or two wells, each with capacity of 5450 cubic meters per day (DOE, 1984).
[e]FMF is under construction. Pumping requirements are not firmly established (DOE, 1984).

about 545 cubic meters per day; the Congaree Formation supplies 15,140 cubic meters per day for municipal use.

Industrial and Agricultural Use

The survey identified 36 industrial and agricultural users, including 13 on the SRP. Table A-17 lists these users. Total industrial pumpage from the Cretaceous Sediments is about 71,940 cubic meters per day, including 38,550 cubic meters withdrawn daily by the SRP.

The Sandoz Plant, about 29 kilometers south of the center of the SRP, is the largest offsite industrial user. Since 1978, it has pumped about 4165 cubic meters per day from one Cretaceous Sediments well.

In 1980, irrigation from groundwater sources in Allendale and Barnwell Counties, including areas outside the study area, amounted to average annual pumping rates of 15,000 and 4100 cubic meters per day, respectively (DOE, 1984). Major growth in the use of irrigation systems in these counties has occurred during the last several years. Some of these irrigation systems draw from the Cretaceous Sediments, but some are in the limestone equivalent of the McBean and Congaree Formations. The largest agricultural user identified in the survey, B. Oswald Company, pumps about 8175 cubic meters per day from the Tuscaloosa aquifer. In Barnwell County, the Green Blade Turf Grass Farm withdraws about 1895 cubic meters per day from Tertiary aquifers.

Domestic Use

In addition to large municipal, industrial, and agricultural users, the files of the South Carolina Department of Health and Environmental Control list 25 small communities and mobile home parks, 4 schools, and 11 small commercial interests as groundwater users. Wells serving these users generally have pumps with capacities of 54 to 325 cubic meters per day; they do not draw large quantities of water. Most of these wells produce from shallow aquifers. Total withdrawal from these 40 users is estimated to be less than 2000 cubic meters per day. However, incomplete State records provide little information on screened zone, formation, or actual usage.

Two South Carolina State Parks are within the survey area: Aiken State Park, with seven wells; and Barnwell State Park, with two wells. Several shallow wells produce small quantities of water for SRP guardhouses. The pump capacity of each of these wells is less than 40 liters per minute.

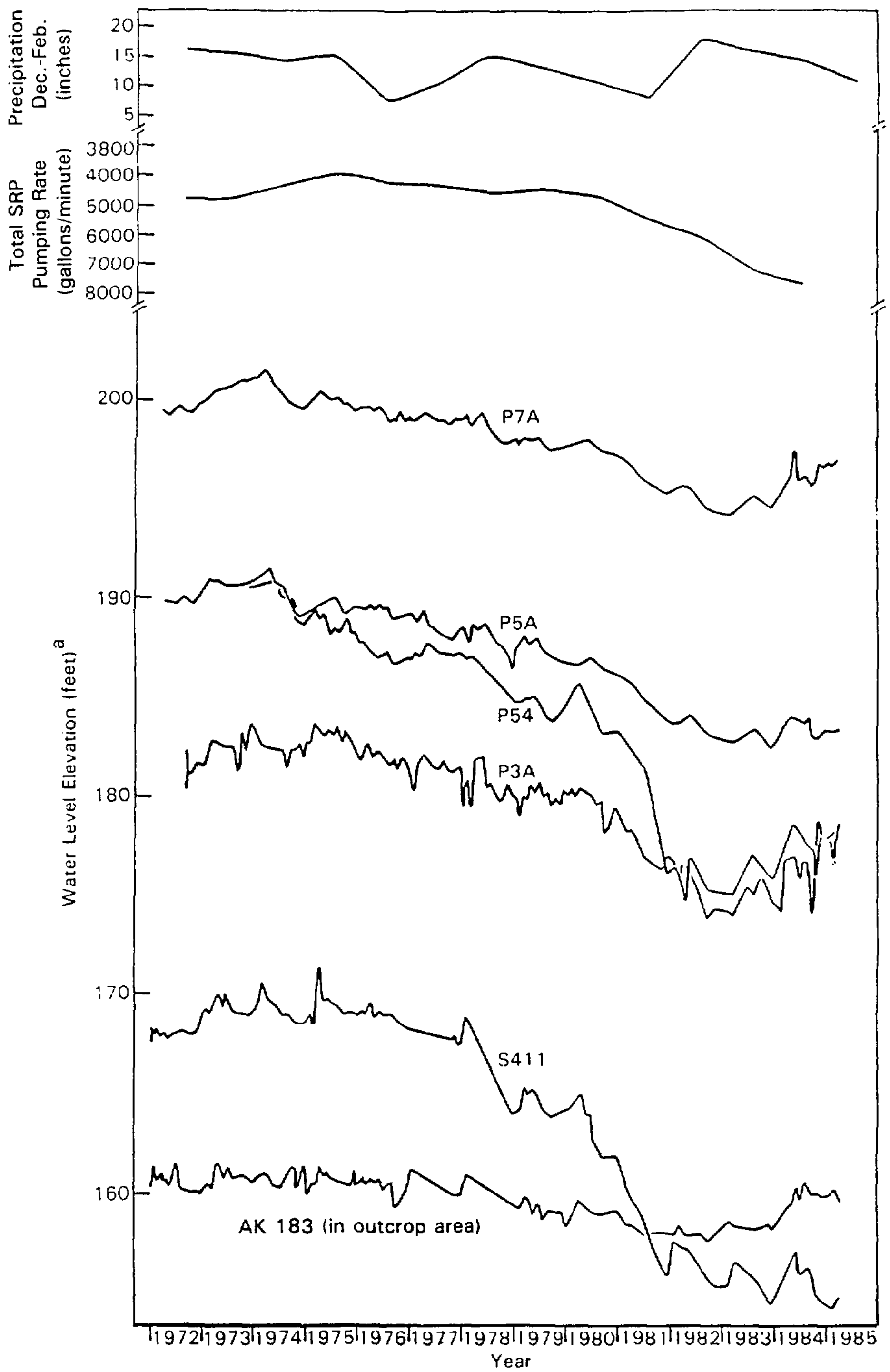
A.2.4.3 SRP Groundwater Use

Table A-18 lists pumping rates for the period 1968 to 1985 for individual areas on the Plant. Figure A-14 shows the locations of most of these areas. The greatest groundwater pumpage on the Plant occurs in A-, F-, and H-Areas. Figure A-17 shows the total pumpage on the Plant. The projected 1985 groundwater use is 26.8 cubic meters per minute. Siple (1967) concluded that (1) the Cretaceous Sediments aquifer can supply about 37.8 cubic meters per minute for SRP operation with no adverse effects on the pumping capabilities of existing 1960 wells; and (2) potentially, the aquifer could produce more water if the well fields were properly designed. In 1960, SRP pumpage from the Cretaceous Sediments was about 18.9 cubic meters per minute.

Table A-18. Average Continuous Groundwater Pumping Rates by Area at Savannah River Plant, 1968 to 1985 (m^3/min)

Area	Wells	1968-1974 (average)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985[a]
A/M	4	5.0	4.3	4.2	4.4	4.0	4.1	4.4	5.1	5.03	6.81	6.06	4.97
F	6	6.2	3.9	4.5	4.6	4.5	5.0	5.2	5.3	5.87	6.06	8.33	7.30
H	5	5.9	5.8	6.5	6.3	6.7	6.8	6.9	7.4	7.19	7.19	8.33	8.25
CS	3	0.26	0.36	0.44	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.66	0.76
D	(b)	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U	3	0.47	0.38	0.28	0.28	0.28	0.28	0.28	0.28	0.34[c]	0.34[c]	0.19[c]	9.19[c]
C	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.13	1.13	1.13	1.02
K	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.13	1.13	0.95	1.02
L	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.28	0.94	0.95	0.94
P	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.13	1.32	1.32	1.32
CMX-TNX	3	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.61	1.13	1.04	0.94
Total		18.5	14.9	16.1	16.3	16.2	16.9	17.5	20.4	23.8	27.0	29.0	26.8

[a]Projected from January-June groundwater use data.
[b]Wells are no longer in use.
[c]Includes temporary construction area.



Source: Du Pont, 1983; updated by Marine, 1985.

[a]1.0 foot = 0.3048 meter

Note: Figure A-22 shows the well locations. Well S411 is screened in the Ellenton Formation; the remaining wells are screened in the Cretaceous Sediments

Figure A-17. Hydrographs of Cretaceous Sediment Aquifer and Ellenton Formation

A.3 SURFACE WATER/GROUNDWATER RELATIONSHIP

This section provides a summary description of the interrelationships between the various hydrogeologic units that constitute the SRP groundwater system, a description of the recharge and discharge areas on the Plant, and a summary description of a water balance study on the Plant.

A.3.1 HYDROGEOLOGIC INTERRELATIONSHIPS AT SRP

As discussed in Sections A.1.1 and A.2.1, the Coastal Plain sedimentary aquifers at the Plant include the Hawthorn (upland unit), Barnwell, McBean, Congaree, Ellenton, and Cretaceous Sediments (stratigraphic terminology from Siple, 1967; see Figure A-2). Water-table (unconfined) conditions generally occur in the Barnwell aquifer. Groundwater in the underlying units generally occurs under semiconfined and confined conditions. The principal aquitards (units with low hydraulic conductivity) include the tan clay, the green clay, the basal Congaree-Ellenton clay, and clay units in the Cretaceous Sediments (Figures A-1 and A-4).

Precipitation at the Plant averages about 120 centimeters per year. Although there might be both spatial and temporal variations in the fraction of this precipitation that recharges the groundwater, the overall average recharge near the SRP Burial Ground and the Separations Areas is about 30 percent, or 38 centimeters per year. This water moves predominantly in a vertical direction through the unsaturated zone at a rate of about 0.9 to 2.1 meters per day, as determined by tracer tests, to recharge the water table (Haskell and Hawkins, 1964). Upon reaching the water table, the water travels a path that has both vertical and horizontal components. The magnitude of these two components depends on the vertical and horizontal components of the hydraulic conductivity. Clay layers of low hydraulic conductivity tend to impede vertical flow and enhance horizontal flow. If the horizontal hydraulic conductivity is low, water will tend to "pile up" above the clay, and the water table will be high. On the other hand, if the horizontal hydraulic conductivity is high, the water will be conducted more quickly away from the recharge area, and the water table will be low.

The water table is high in H-Area because the tan clay inhibits the downward movement of water and the low horizontal hydraulic conductivity of the Barnwell Formation does not permit rapid removal of the water in a horizontal direction. The hydraulic head builds up in the Barnwell Formation sufficiently to drive the water through the material of low hydraulic conductivity; some goes vertically through the tan clay and some moves laterally to nearby streams.

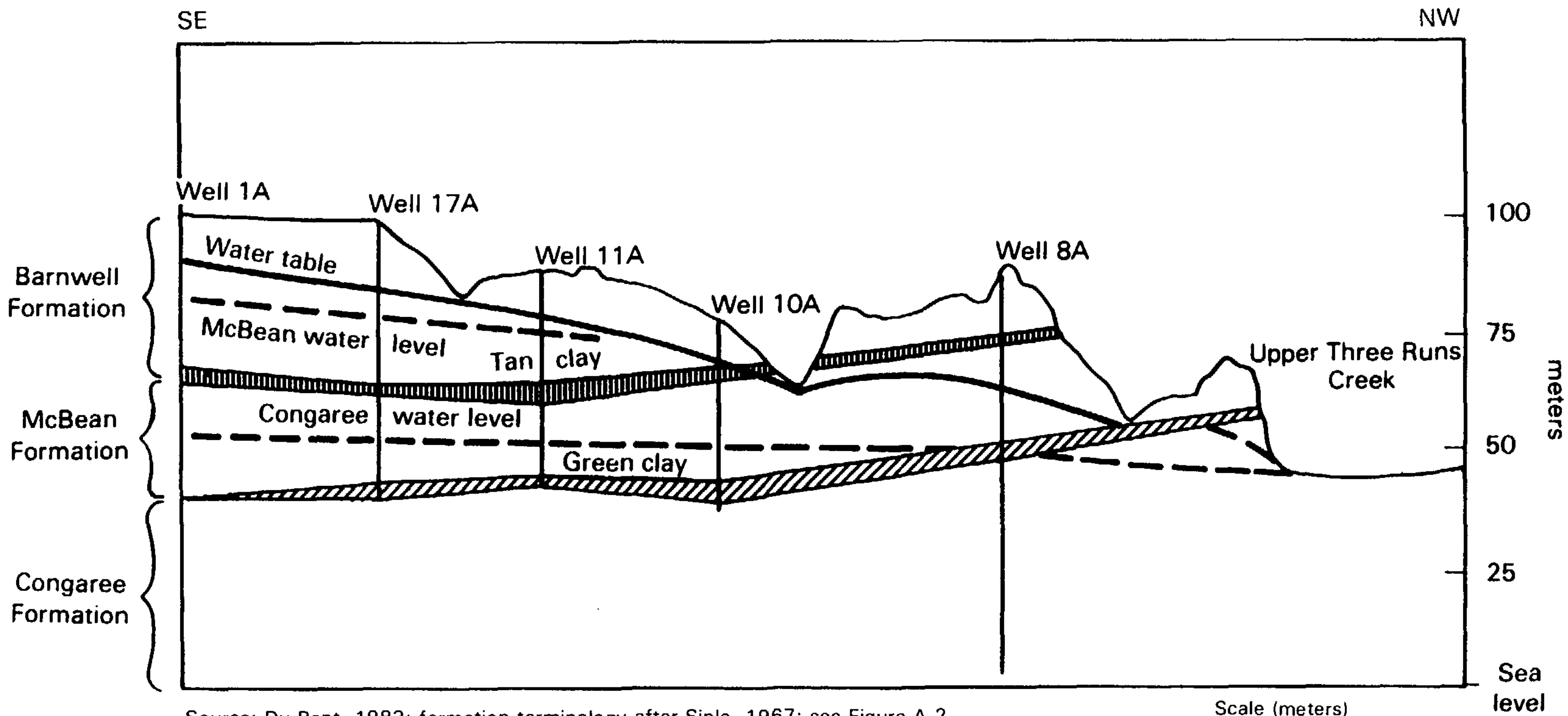
Water that enters the McBean Formation also follows a path that has both vertical and horizontal components. The water recharging this formation through the tan clay is the nominal surface recharge (38 centimeters per year) minus the amount of water that is removed from the Barnwell by lateral flow (about 25 centimeters per year; see Section A.3.3.1). The discharge points for the McBean Formation are more distant from their respective groundwater divides than those of the Barnwell Formation.

The green clay has a lower hydraulic conductivity than the materials above; as a result, recharge to the Congaree through this clay is less than the recharge to the McBean. In addition, the Congaree has a higher hydraulic conductivity than the materials above; as a result, lateral flow is enhanced, making the potentiometric levels in the Congaree much lower than those above, as shown in Figures A-4 and A-18. The discharge areas for the Congaree are the valleys of the Savannah River and Upper Three Runs Creek.

Cretaceous Sediments potentiometric levels in H-Area are above those of the Congaree (Figure A-4), indicating that in this area the Cretaceous Sediments are not recharged naturally from the Congaree. Water in the Cretaceous Sediments passing beneath H-Area is recharged through the Tertiary sediments to the north of the Plant. Some water is discharged from the Cretaceous Sediments upward into the overlying sediments in the Savannah River valley where it borders the Plant. Most of the remaining groundwater moves northeast to the outcrop area of the Cretaceous Sediments, where water discharges directly to the Savannah River and its tributaries (Figure A-9). Water levels in the Cretaceous Sediments in the Savannah River valley are commonly above land surface and wells in these areas flow naturally. Figure A-18 shows that water from either formation does not naturally flow between South Carolina and Georgia. Figure A-19 shows the vertical head relationships between the Congaree, the upper Cretaceous Sediments aquifer, and the lower Cretaceous Sediments aquifer in the southern part of the Plant. The head relationship between the Congaree and the upper Cretaceous Sediments is the same here as in H-Area, but the difference is greater. This area is greatly influenced by the drawing down of the head in the Congaree, as groundwater flows from the Congaree into the Savannah River valley.

The head relationships in the northwest part of the Plant (M-Area) are quite different, as shown on Figure A-20. In this updip area (Figure A-1), the green clay is very discontinuous and not as thick as it is farther downdip. The tan clay can be missing entirely. Thus, there is little impedance to downward vertical flow within the Tertiary sediments, and the water levels are farther below the land surface than in H-Area. Another very important factor is that the geologic character of the Congaree Formation in M-Area is different from that in H-Area; the geologic material is not as well sorted and its hydraulic conductivity is lower. As a result, the lateral flow of water in the Congaree is insufficient to draw its water level down below that of the Cretaceous Sediments aquifer in M-Area, and a downward head differential exists from the Congaree to the Cretaceous Sediments. Closer to the Savannah River, the discharge from the Congaree draws its water level down below that of the Cretaceous Sediments aquifer.

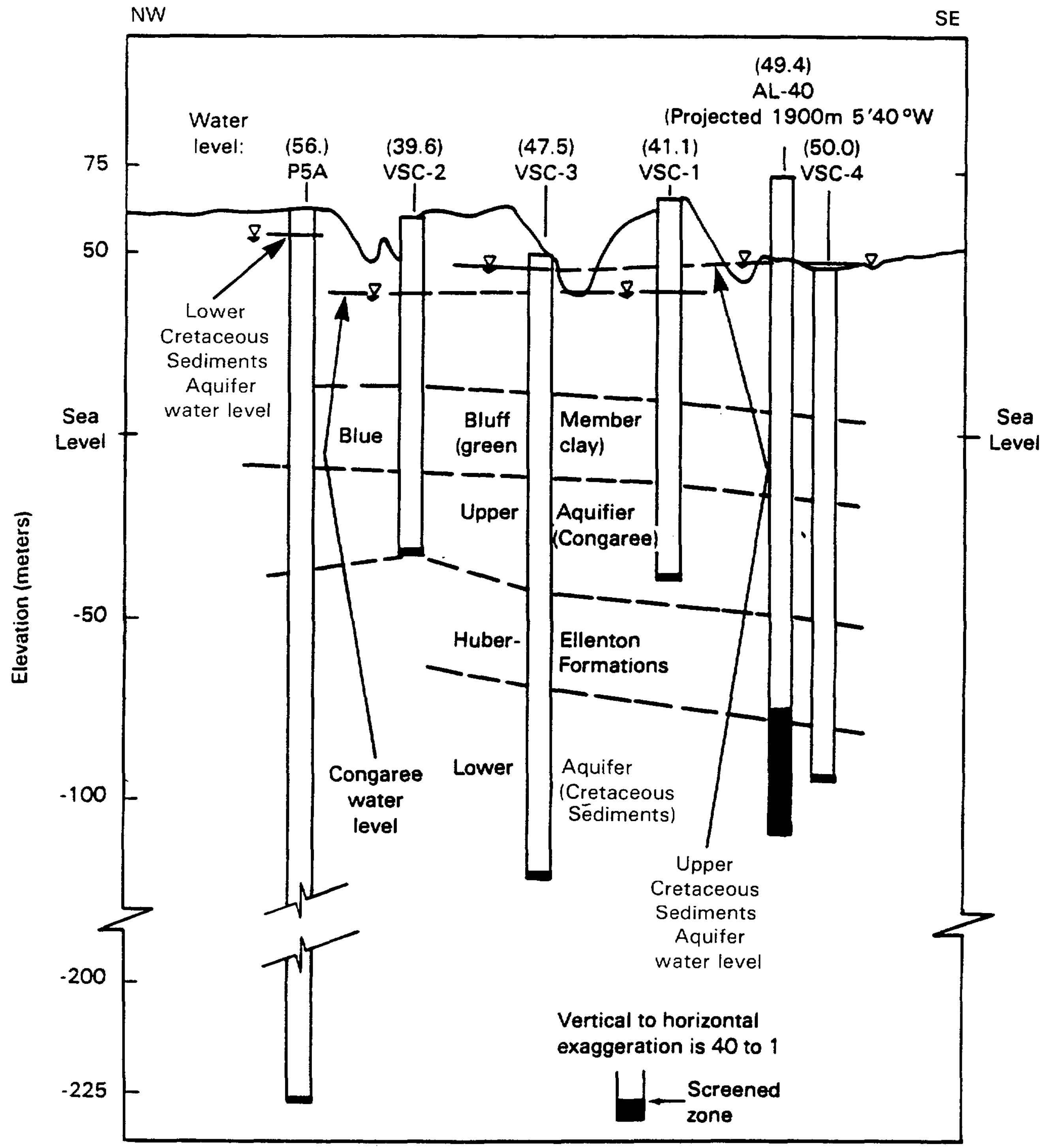
The locations of areas in which there is a head reversal between the Congaree and the Cretaceous Sediments aquifer, and areas in which there is not, were obtained from a map showing the differences between the Cretaceous Sediments and Congaree potentiometric surface maps (Du Pont, 1983). The resulting head differential map (Figure A-21) shows that the head in the Cretaceous Sediments is higher than that in the Congaree in a broad area within about 10 kilometers from the Savannah River and Upper Three Runs Creek. The head in the Congaree is higher in an area around M-Area and in the vicinity of Par Pond. This map was constructed by subtracting two potentiometric surface maps that contained limited data; thus, it should not be used to predict detailed head relationships, but only to indicate directions of expected vertical gradients in broad areas.



Source: Du Pont, 1983; formation terminology after Siple, 1967; see Figure A-2.

Note: Figure A-30 shows the location of the geohydrologic section.
Water elevations were measured on August 29, 1977.

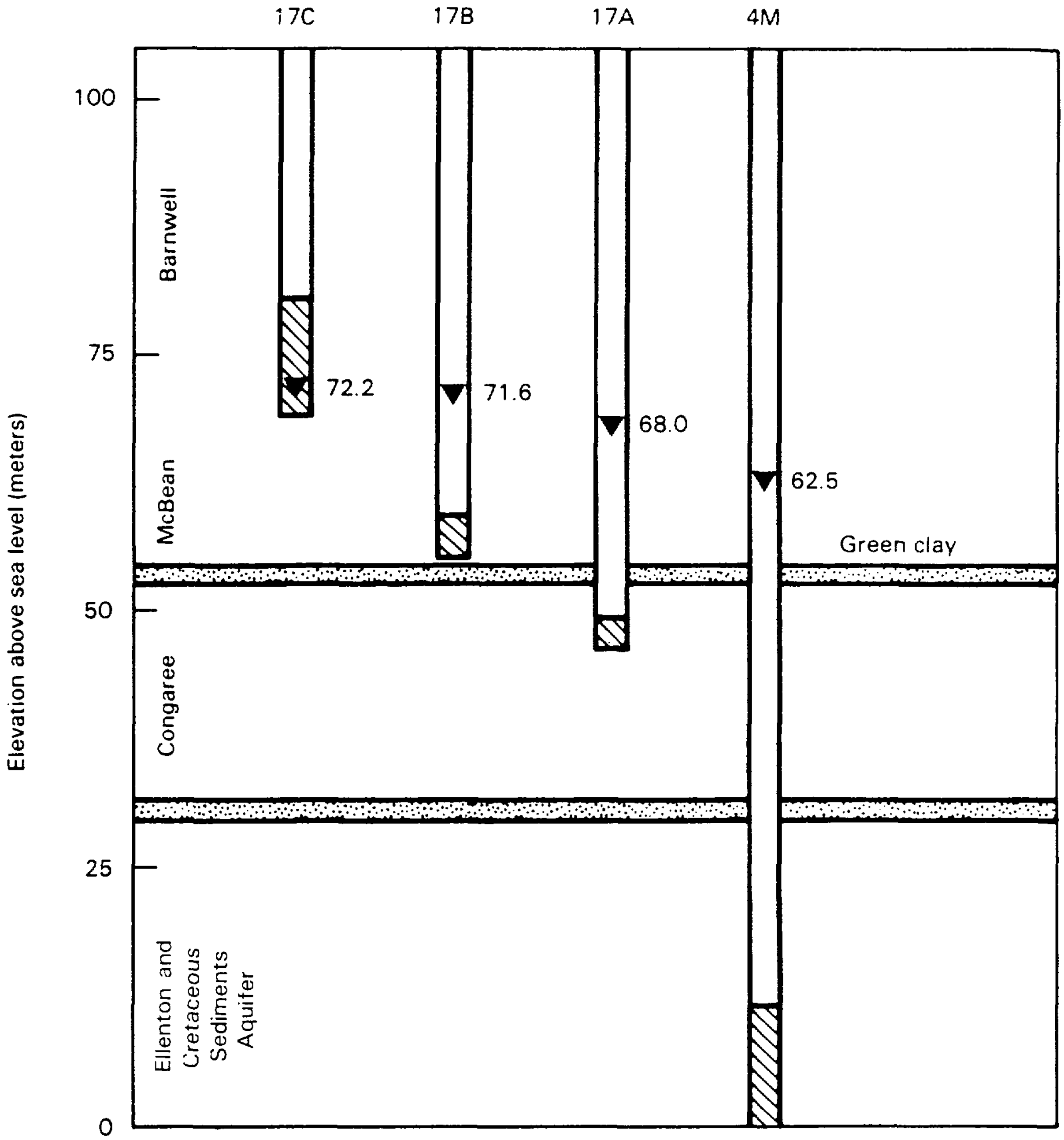
Figure A-18. Geohydrologic Section in Central Part of the Savannah River Plant



Source: Du Pont, 1983; see Figure A-2 for correlation of aquifer terminology with that of other recognized units.

Note: Figure A-22 shows the location of well cluster.

Figure A-19. Comparison of Groundwater Elevations in the Congaree Formation to Those in the Cretaceous Sediments Aquifer in the Southern Part of the Savannah River Plant (1982)



Legend:

▼ Water elevation

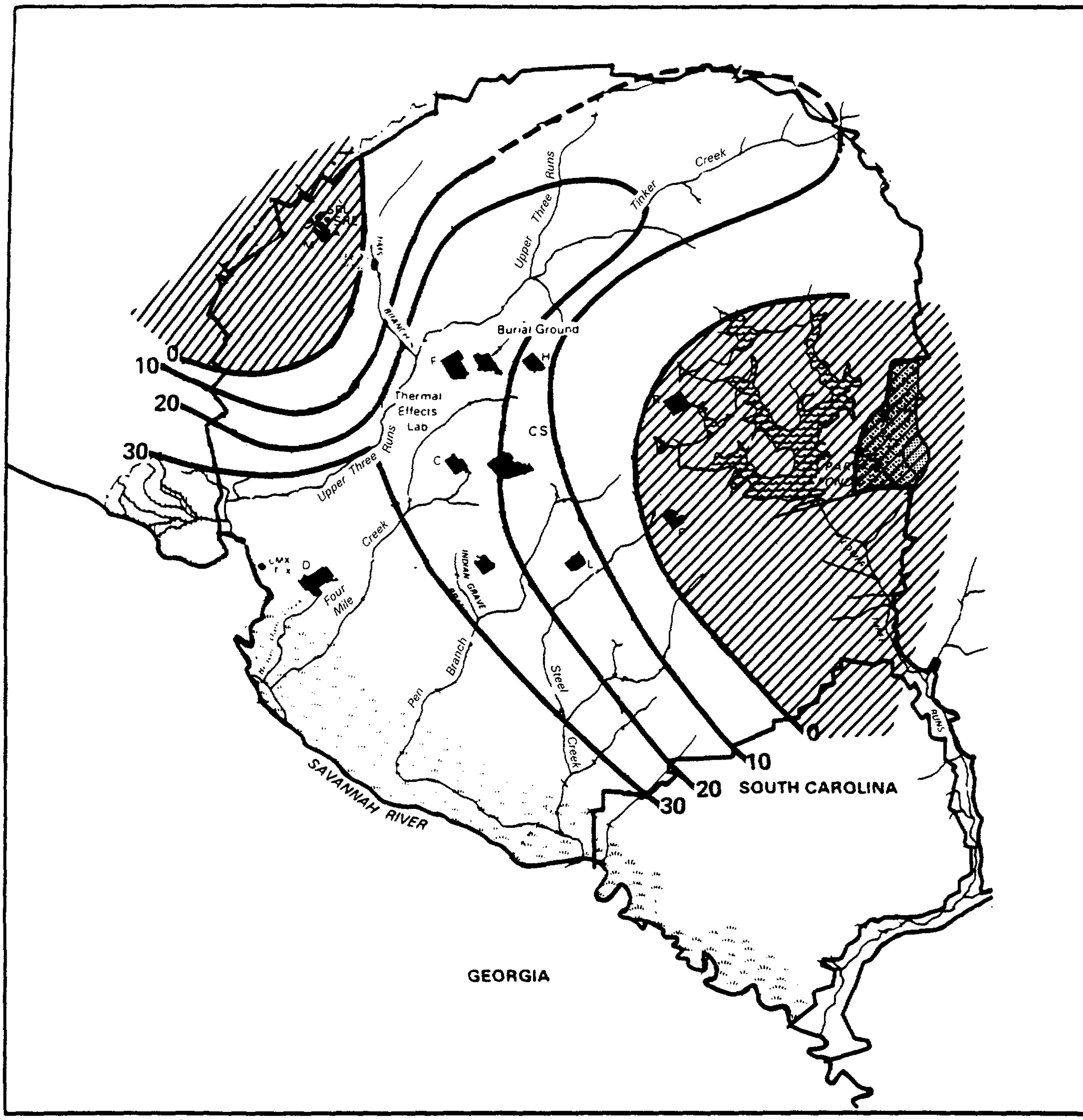
Clay layer

Screen and gravel zone

Source: Du Pont, 1983; hydrostratigraphic unit terminology after Siple, 1967; see Figure A-2.

Note: Figure A-22 shows the location of this profile.

Figure A-20. Vertical Head Relationships Near M-Area in 1982



Source: Du Pont, 1983.

Legend

C, K, R, L, P Reactor Areas (C, P, K, and L are operating)

F, H Separations Areas

M Fuel and Target Fabrication

D Heavy Water Production

A Savannah River Laboratory and Administration Area

CS Central Shop

Area where the Congaree head exceeds the Cretaceous Sediments aquifer head.

-10 — Contour showing locations where the head in the Cretaceous Sediments aquifer is 10 feet (1.0 foot = 0.3048 meter) above the head in the Congaree.

Figure A-21. Generalized Map of the Head Difference Between the Cretaceous Sediments Aquifer and Congaree Formations at the Savannah River Plant

A.3.2 GROUNDWATER RECHARGE AND DISCHARGE AT SRP

Water enters the groundwater system in recharge areas and moves through the system, as dictated by hydraulic gradients and hydraulic conductivities, to discharge areas. Groundwater moves from areas of high potential energy (usually measured by combined elevation and pressure heads) to areas of lower potential energy.

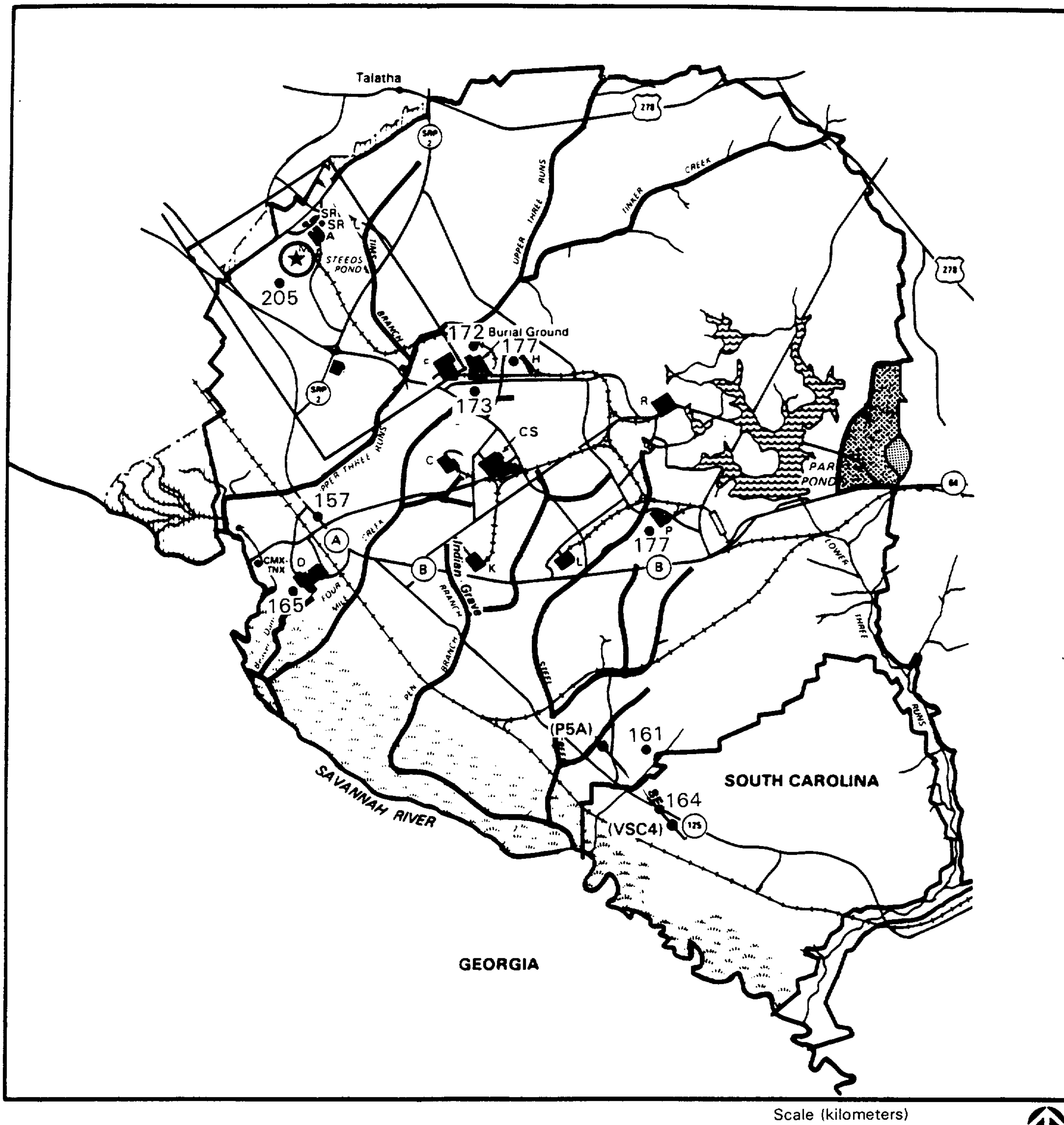
The hydraulic gradient on the Atlantic Coastal Plain is generally southeastward toward the Atlantic Ocean. The southeastward groundwater flow is modified by the incised channels of the Savannah and Congaree Rivers and their tributaries. Groundwater flows toward the areas of low potential energy (low-head areas) created by natural discharge to stream channels and wetlands.

The Savannah River Plant is drained almost entirely by five major streams: Upper Three Runs Creek, Four Mile Creek (including Beaver Dam Creek), Pen Branch, Steel Creek, and Lower Three Runs Creek (Figure A-22). The depth of dissection of these streams has a significant influence on groundwater discharge areas and the directions of groundwater flow. The flow direction in the shallow groundwater, typically in the Barnwell Formation, is most affected by small onsite streams (see, for example, Figures A-23 through A-28). Flow directions in the McBean Formation are affected by Upper Three Runs and Four Mile Creeks (Figure A-29), those in the Congaree Formation by Upper Three Runs Creek and the Savannah River (Figures A-30 and A-8), and those in the Ellenton and Cretaceous Sediments by the Savannah River only. Locally, the direction of normal groundwater flow in any hydrogeologic unit is modified by groundwater withdrawals from wells (Figure A-5). The locations of recharge and discharge areas on the Plant are summarized in Table A-19.

Figure A-14 shows the potentiometric surface of the Cretaceous Sediments aquifer near the Plant. Recharge occurs principally in offsite outcrop areas near the Fall Line. If the elevation of the outcrop area is high, as on the Aiken Plateau northeast of the Plant, precipitation recharged to the Cretaceous Sediments exceeds the groundwater naturally discharged to local streams and withdrawn by water wells. This excess moves southeastward through the aquifer. Where the elevation of the outcrop is low, as along the Savannah River valley just north of the northwest sector of the Plant, groundwater naturally discharges to the Savannah River. Under the Plant, the groundwater flow in the Cretaceous Sediments is southwesterly toward the river (Du Pont, 1983).

Recharge to the Congaree Formation is principally in offsite areas. At the Plant there is appreciable recharge from the McBean Formation in M- and A-Areas but almost none from overlying units southeast of Upper Three Runs Creek. The natural discharge areas for the Congaree on the Plant are the wetlands along Upper Three Runs Creek and the Savannah River. As shown in Figures A-18, A-30, and A-10, the water levels in the Congaree are drawn down significantly by groundwater discharge to Upper Three Runs Creek and the Savannah River.

Recharge to the McBean Formation is from the Barnwell Formation in the central areas of the Plant and in offsite areas. The natural discharge areas are Upper Three Runs and Four Mile Creeks (Figure A-29).



Legend

C, K, R, L, P Reactor Areas (C, P, K are operating)
F, H Separations Areas
M Fuel and Target Fabrication
D Heavy Water Production
A Savannah River Laboratory and Administration Area
U Temporary construction area

Cluster of wells (see Figure A-20).

Location of profile shown in Figure A-19.

Source: DOE, 1984.

Figure A-22. Location of the Cluster of Wells Shown in Figures 3-8, A-19, and A-20

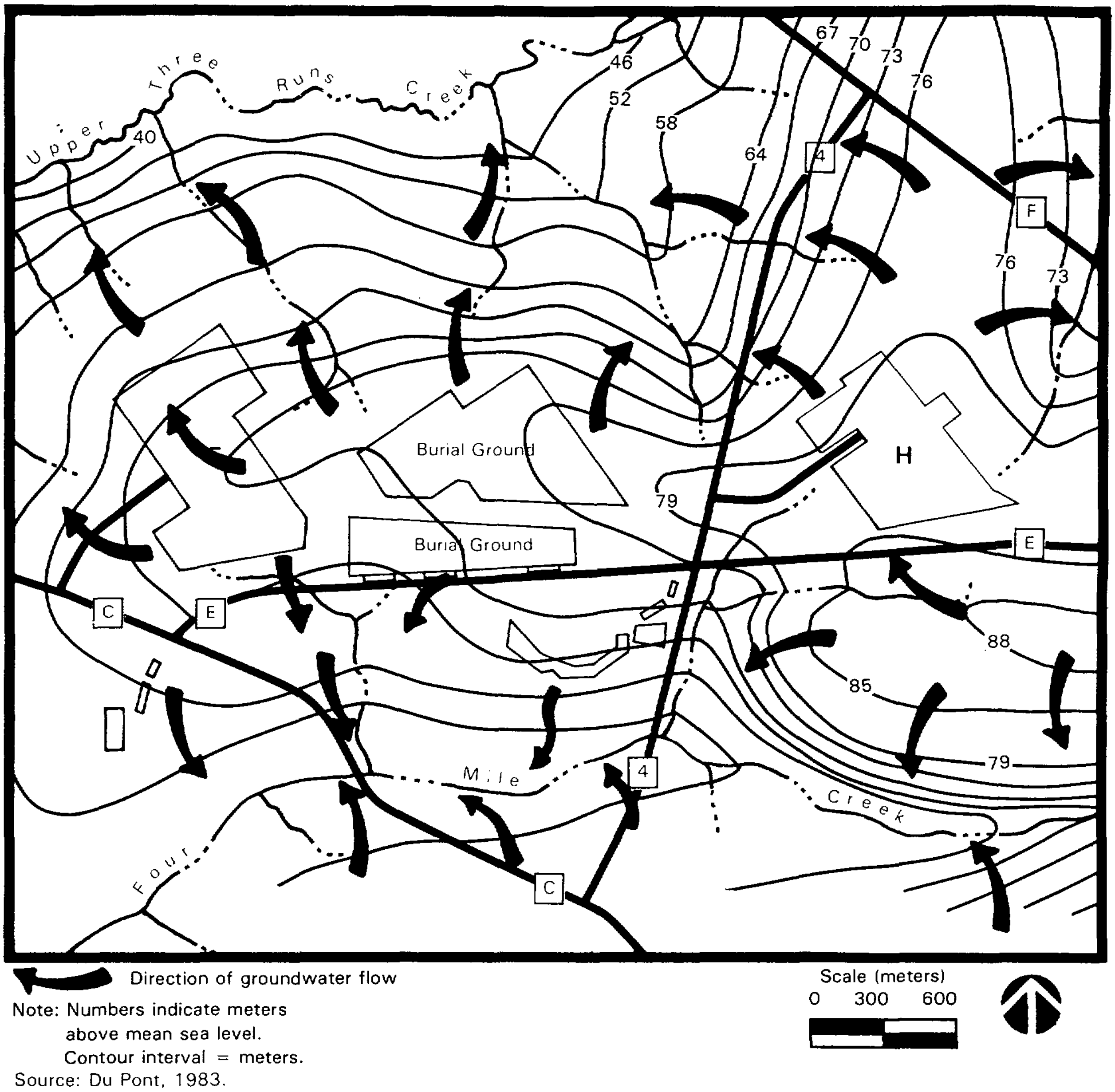


Figure A-23. Average Elevation of the Water-Table in the Separations Areas at the Savannah River Plant During (1968)

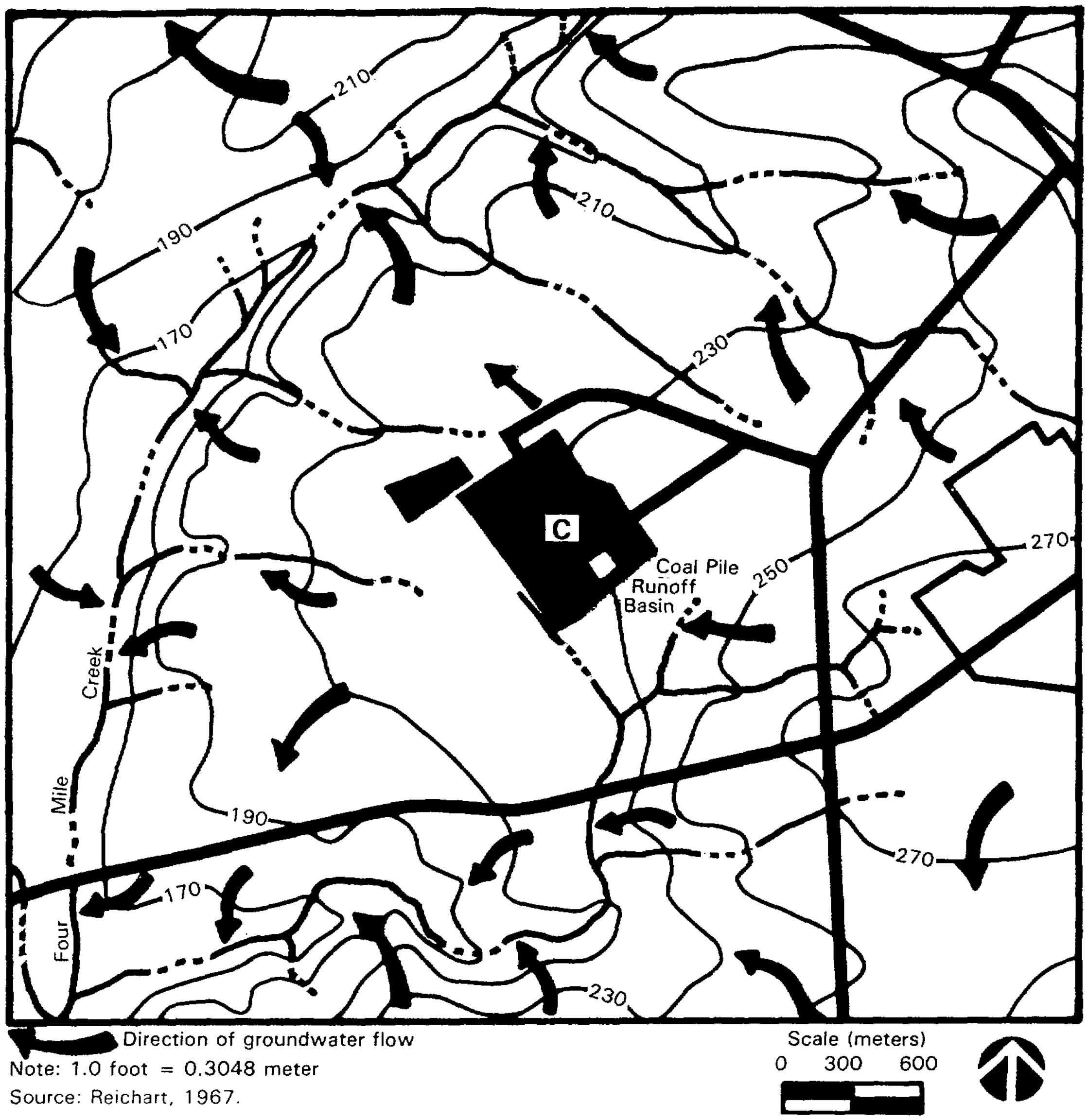


Figure A-24. Water-Table Elevation (in feet above mean sea level) at C-Area During the Period 1961-1967

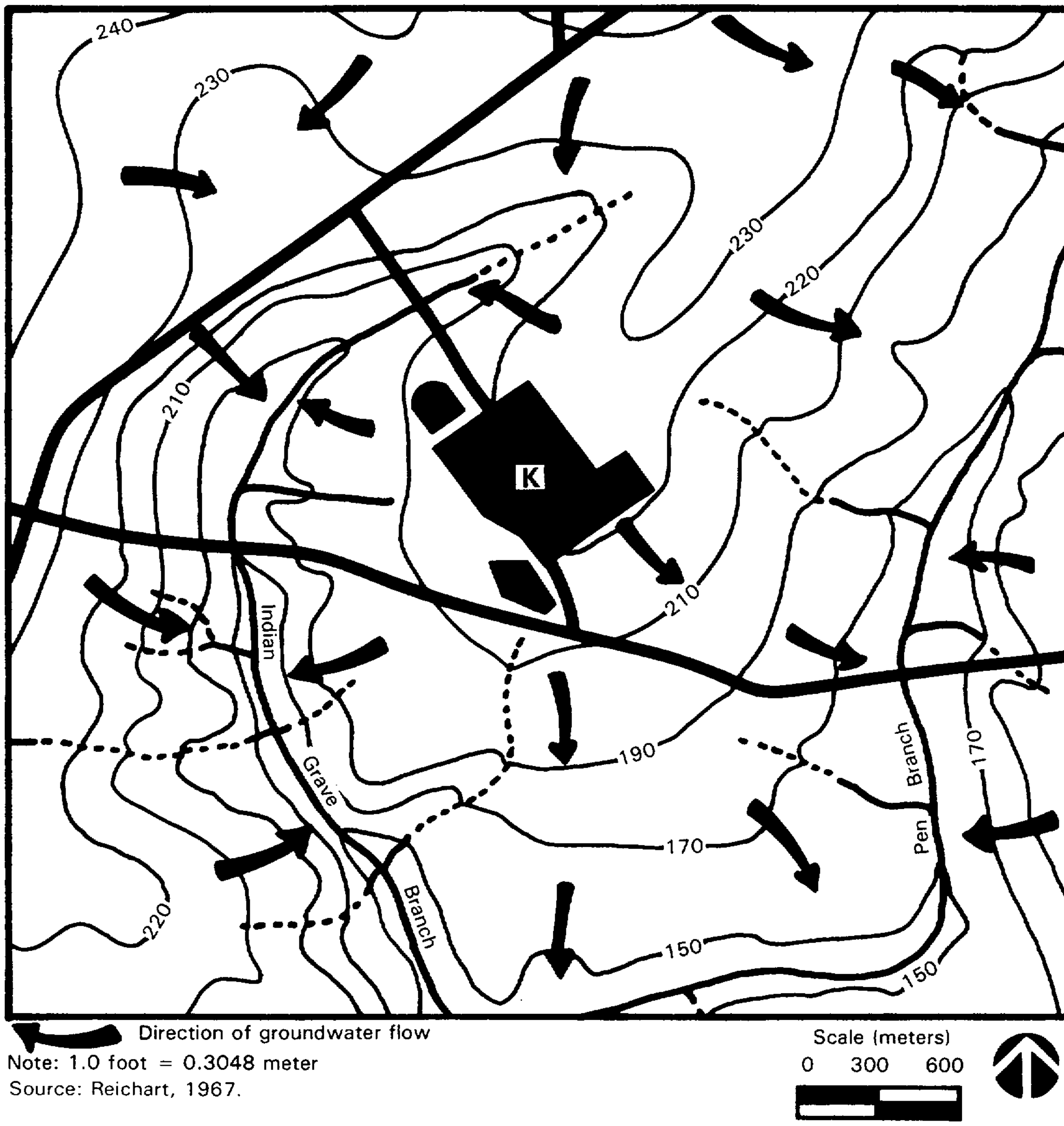


Figure A-25. Water-Table Elevation (in feet above mean sea level) at K-Area During the Period 1961-1967

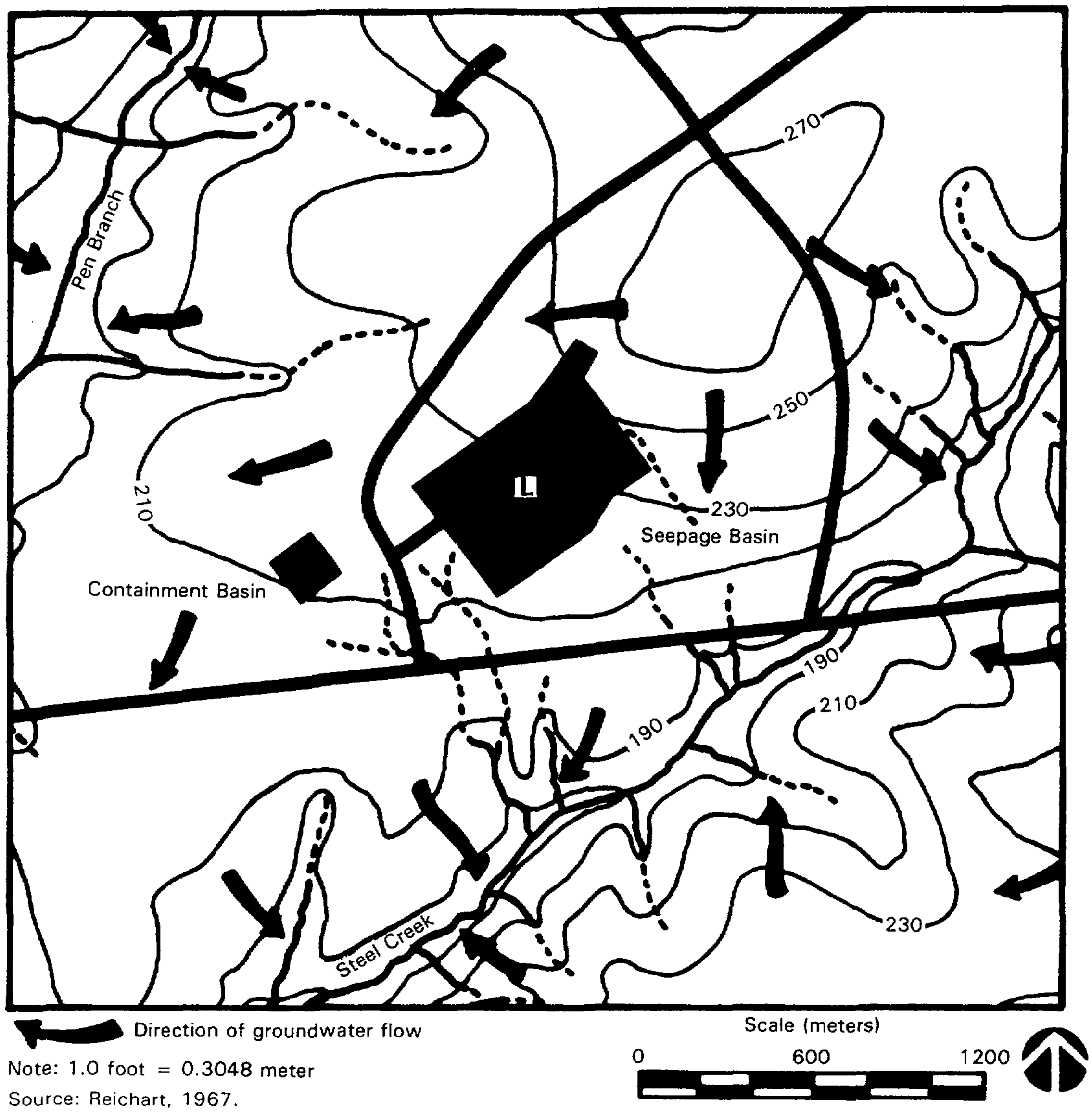


Figure A-26. Water-Table Elevation (in feet above mean sea level) at L-Area During the Period 1961-1967

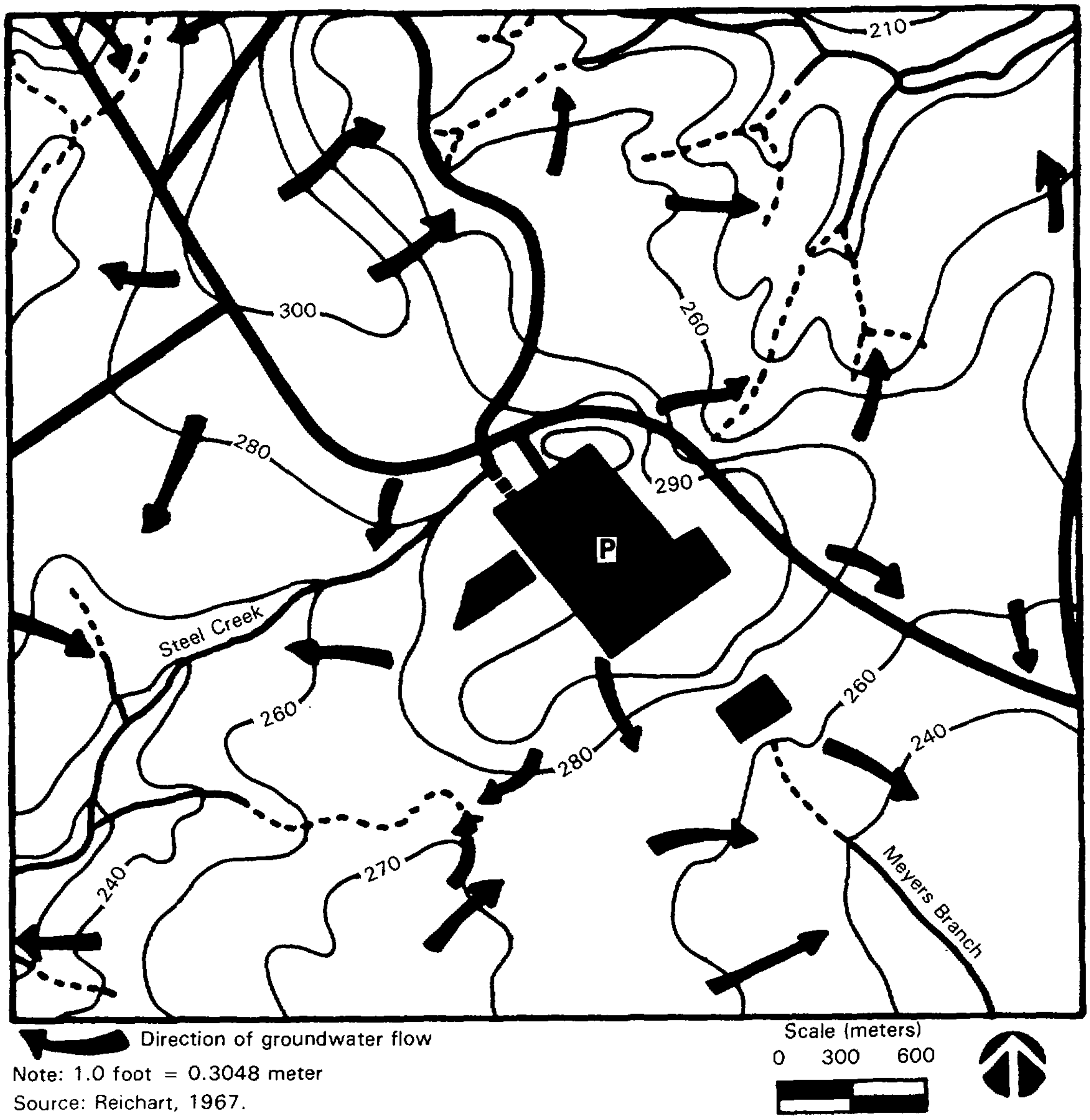
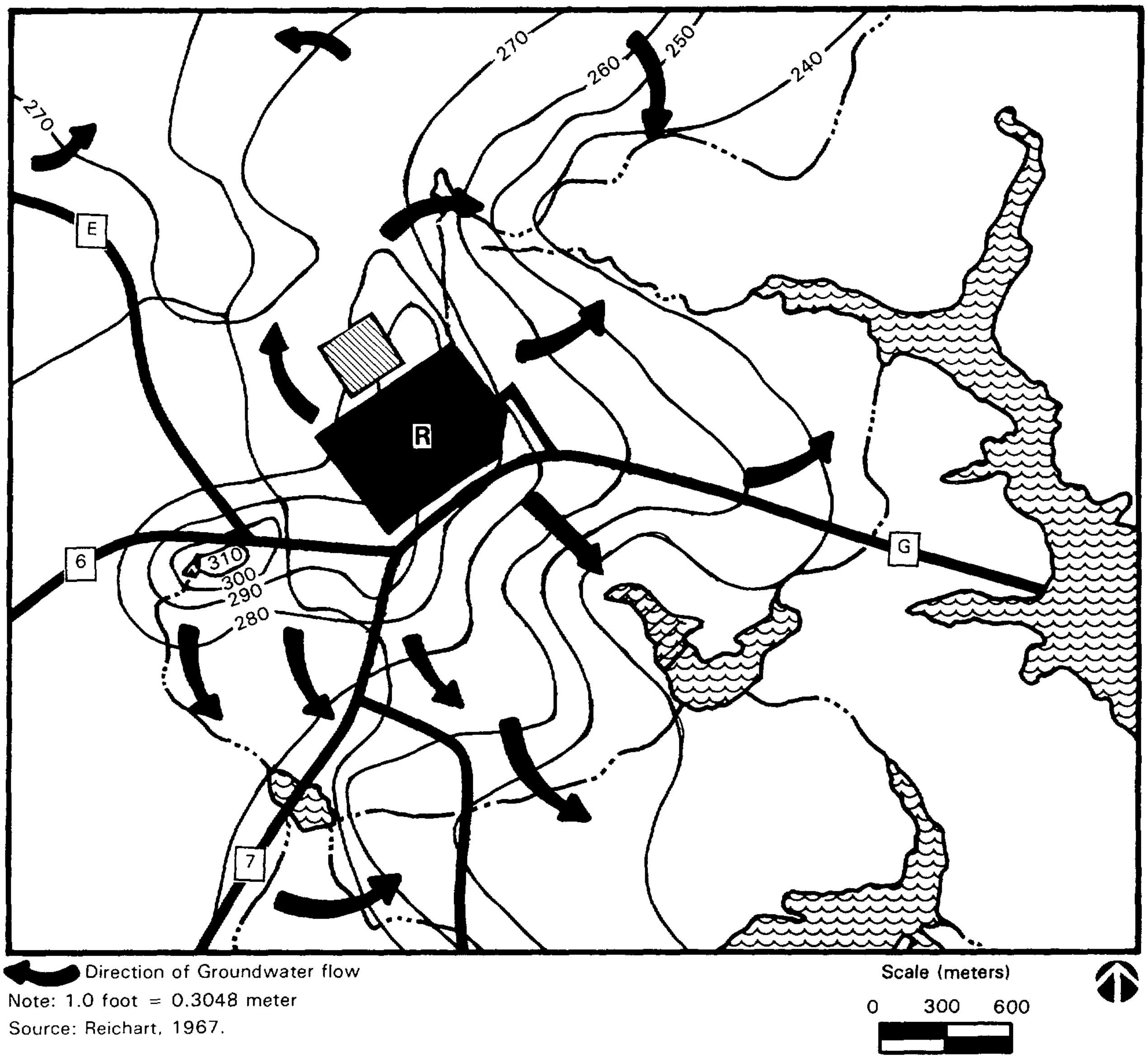
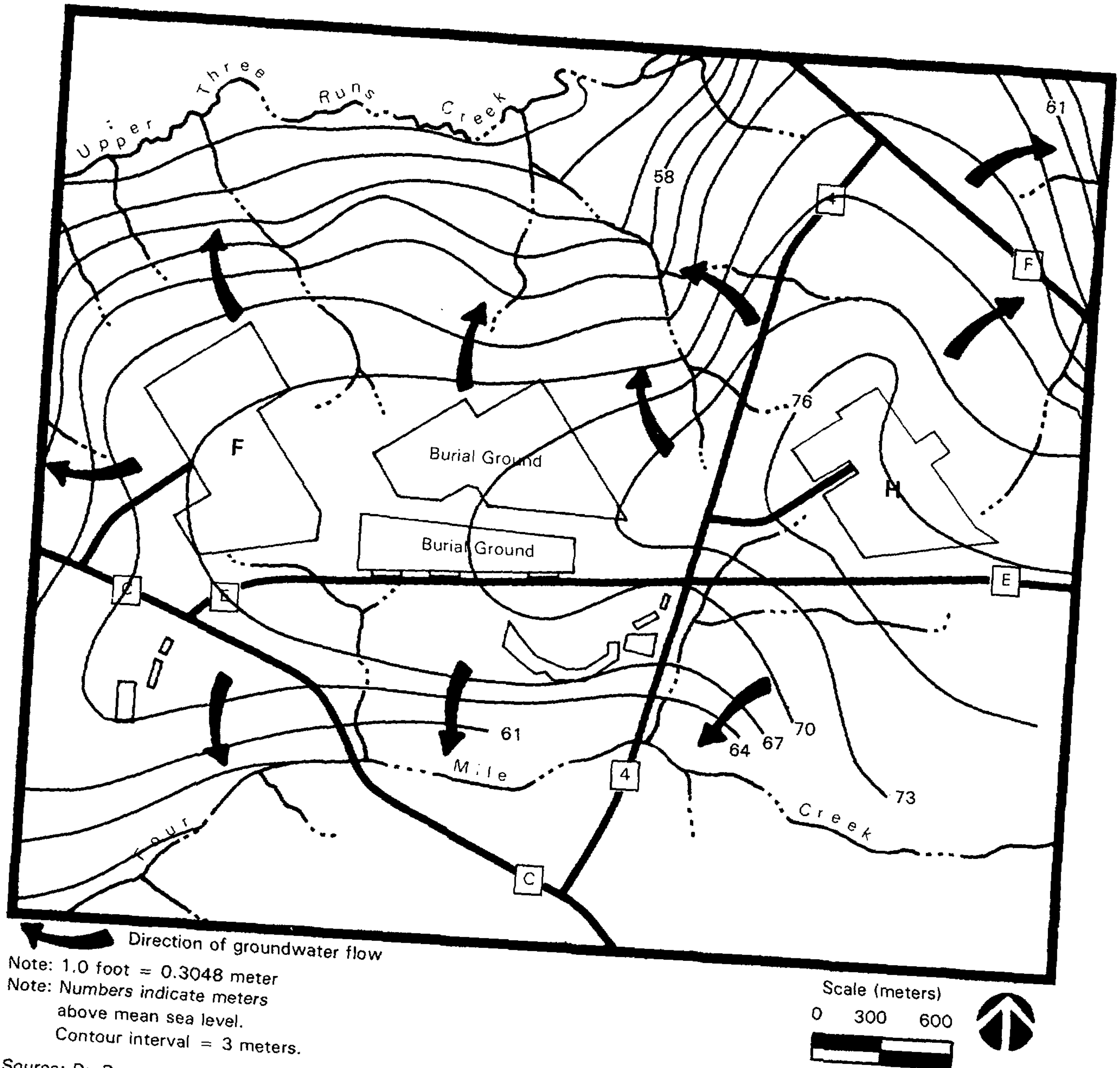


Figure A-27. Water-Table Elevation (in feet above mean sea level) at P-Area During the Period 1961-1967



Note: 1.0 foot = 0.3048 meter
Source: Reichart, 1967.

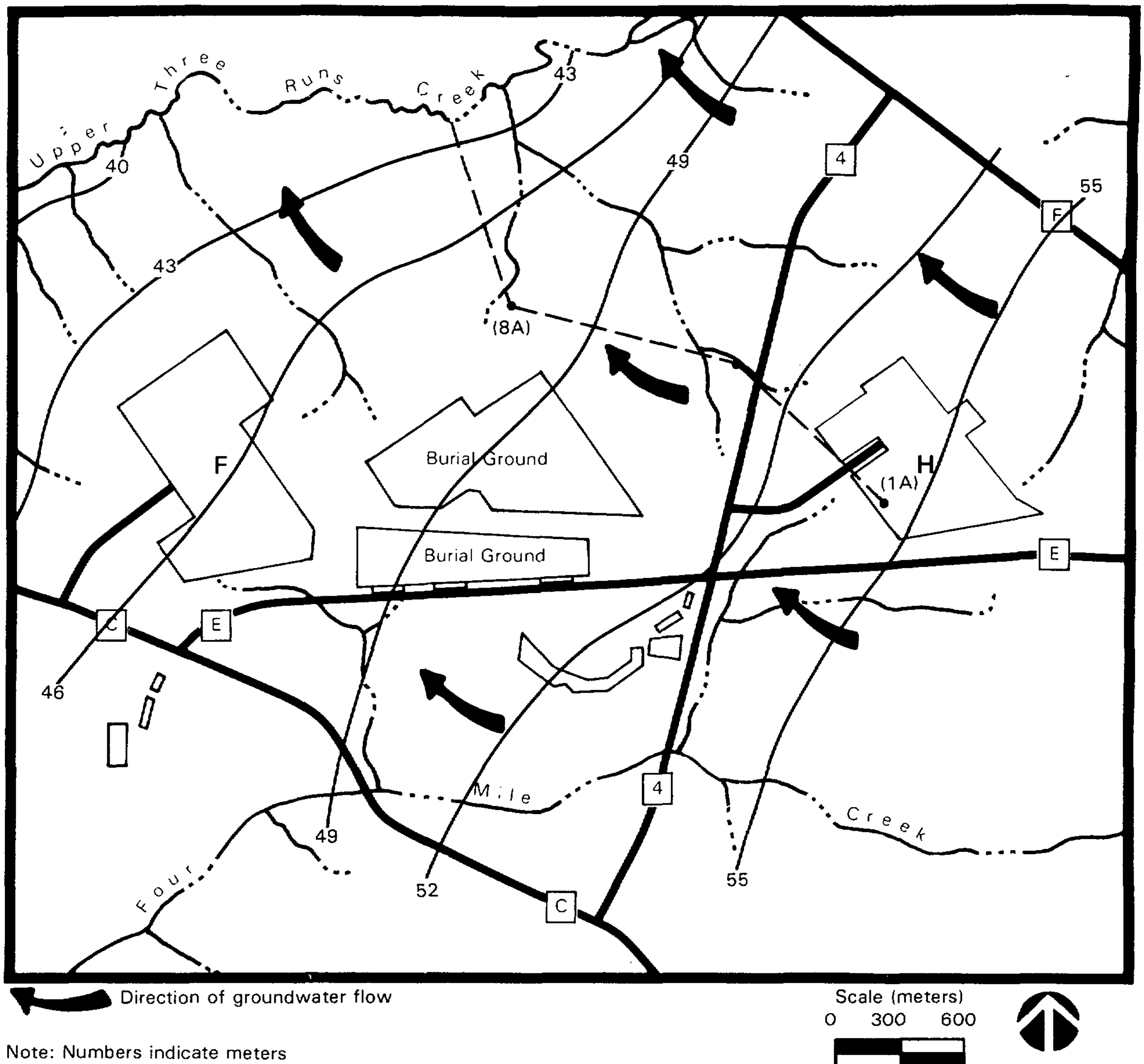
Figure A-28. Water-Table Elevation (in feet above mean sea level) at R-Area During the Period 1961-1967



Note: 1.0 foot = 0.3048 meter
Note: Numbers indicate meters above mean sea level.
Contour interval = 3 meters.

Source: Du Pont, 1983; formation terminology after Siple, 1967; see Figure A-2.

Figure A-29. Potentiometric Surface of the Upper Part of the McBean Formation in the Separations Areas at the Savannah River Plant (August 29, 1977)



Note: Numbers indicate meters above mean sea level. Contour interval = 3 meters.

(8A) (1A) Profile of geohydrologic section shown in Figure A-17.

Source: Du Pont, 1983.

Figure A-30. Potentiometric Map of the Upper Part of the Congaree Formation in the Separations Areas at the Savannah River Plant (August 29, 1977)

Table A-19. Groundwater Recharge and Discharge Zones at Savannah River Plant

Formation	Recharge	Discharge	Confining layers
Barnwell (and Upland Unit)	Winter rainfall 31.2 cm/yr; total recharge about 38 cm/yr.	Onsite streams. Recharge through tan clay to McBean.	Tan clay at base; generally absent in M-Area.
McBean	From Barnwell (through tan clay in central SRP); offsite areas.	Upper Three Runs Creek and Four Mile Creek. Almost no recharge through "green clay" to Congaree in central SRP; appreciable recharge in A- and M-Areas.	Tan clay at top; absent in A- and M-Areas. Green clay at base; discontinuous in A- and M-Areas.
Congaree	Principally in offsite areas; appreciable recharge from McBean in A- and M-Areas.	Savannah River and wetlands along Upper Three Runs Creek. Little recharge downward through basal clay and upper Ellenton clay to Ellenton sands, or upward through green clay.	Green clay at top; discontinuous in A- and M-Areas. Pisolitic clay at base. Top of Ellenton.
Ellenton	From underlying Cretaceous sediments and offsite areas; some recharge from Congaree.	Upper clay layer of Cretaceous sediments may be discontinuous or contain sandy zones that permit communication.	Lower pisolitic clay of Congaree. Upper clay layer of Ellenton. Upper clay layer of Cretaceous sediments; usually not effective confining layer.
Cretaceous sediments	Principally from offsite areas; outcrop area 15-50 km wide in South Carolina near fall line and in major stream valleys.	Upper Cretaceous sediments aquifer to lower unit of Ellenton. Groundwater beneath SRP flows to sink along Savannah River.	Upper clay layer of Ellenton. Upper clay layer of Cretaceous sediments; usually not effective confining layer. Middle clay layer. Basal clay layer.

Thus, in summary, the dissecting creeks divide the groundwater in the Congaree Formation into discrete subunits (see Figure A-22). Depending on the depth of dissection, groundwater is confined to its own subunit. Thus, even though the hydraulic characteristics of the formation might be similar throughout the area, each subunit has its own recharge and discharge areas. If dissection is through most of the formation thickness, then no water will move from one subunit to another. As with the Congaree Formation, creeks in the region dissect the McBean Formation and divide the hydrogeologic unit into separate subunits, each having its own recharge and discharge areas. Because the McBean is a shallower formation than the Congaree, smaller creeks with less deeply incised valleys make these divisions. The subunits of the McBean are, therefore, smaller than those of the Congaree. In the Separations Areas, the only stream that cuts into the Congaree is Upper Three Runs Creek, whereas the McBean is incised by Upper Three Runs Creek and several of its larger tributaries, Four Mile Creek, Pen Branch, and Steel Creek. Thus, groundwater that enters the McBean in the Separations Area cannot flow to other subunits of the McBean (Du Pont, 1983).

The water table at the Plant southeast of Upper Three Runs Creek is commonly within the Barnwell Formation, although in the creek valleys it successively occupies positions in the lower formations (e.g., Figure A-18). Recharge to the Barnwell is from precipitation. Natural discharge from the water table is to the creeks and their tributaries. The surface drainage and topography strongly influence the groundwater flow in the unconfined aquifer. Even small tributaries of the larger creeks cause depressions in the water-table elevation. The Upland Unit, which overlies the Barnwell on much of the Plant, is unsaturated; its flow paths are predominantly vertical, with only short, horizontal flow paths.

Northwest of Upper Three Runs Creek, the water table is much deeper and lies within the McBean Formation (Du Pont, 1985a,b). Discontinuous clays that are believed to correlate to the green clay mark the lower boundary of this unit. The groundwater beneath these clays is in the Congaree Formation under semiconfined conditions. Because the depth of the water table is about 33 meters, streams in this portion of the Plant exhibit little control over groundwater flow.

A.3.3 WATER BUDGET FOR SEPARATIONS AREAS AND SRP BURIAL GROUND

Precipitation falling on the earth's surface enters the groundwater system by infiltration, enters the surface water by runoff, or returns to the atmosphere by evaporation. The water budget is essentially a water-material balance used by hydrologists to determine the distribution of precipitation within the hydrosphere. Hubbard and Emslie (1984) used the water-budget method to determine whether significant groundwater flow paths exist below the Barnwell Formation at the SRP Burial Ground between F- and H-Areas (Figure A-20).

A simplified water budget for the Separations Area can be quantified as follows:

$$P - R - G - ET = S \qquad \text{(A-2)}$$

where

P = input precipitation

R = surface and subsurface runoff, water that moves rapidly to drainage ditches and streams

G = water percolated downward to recharge the groundwater at the water table

ET = evapotranspiration, evaporation from the surface and transpiration through vegetation to the atmosphere

S = storage of water, as reflected in the rising and falling of the water table

Groundwater migrates slowly toward places of lower hydraulic potential, discharging as springs, seeps, or the base flow of streams. Over sufficiently long periods, often a water-year, storage can be neglected, so discharge can be assumed to equal recharge.

Mean annual precipitation, runoff, and evapotranspiration were estimated to be 119.4, 5.1, and 76.2 centimeters, respectively. The total groundwater recharge was estimated by subtracting runoff and evaporation from the precipitation, or 38.1 centimeters.

Groundwater in most of the Burial Ground area migrates slowly westward and southward toward Four Mile Creek and its F-Effluent tributary (Figure A-23). Groundwater was seen to enter a tributary of Four Mile Creek at seeps and springs during a rain-free period in May and June 1980. At a "tan clay" outcrop 61 meters above sea level, the groundwater discharge averaged 8.2 liters per second over four measurements made during this period. This measurement, converted to other units and combined with the estimated watershed area of 2.1 square kilometers, gives the groundwater discharge above the tan clay as 0.004 cubic meter per second per square kilometer or 12.7 centimeters per year.

These discharge measurements provide the basis for inferring that a residual recharge of 25.4 centimeters per year (38.1 centimeters minus 12.7 centimeters), reaches aquifers below the tan clay, the McBean, and the Congaree. However, there is believed to be little recharge of the Congaree in this part of the Plant because of the low hydraulic conductivity of the green clay. Root (1983) showed that the assumption of zero recharge of the Congaree could be used in mathematical modeling of groundwater flow at the Burial Ground.

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APPENDIX B

EXISTING WASTE SITES

This appendix discusses the existing waste sites at the Savannah River Plant (SRP) and describes each of the waste sites considered in this environmental impact statement (EIS).

The EIS uses the terms "hazardous," "low-level radioactive," and "mixed" (i.e., hazardous and low-level radioactive) in their most common everyday sense, without specific regard to technical or regulatory definitions, unless indicated. The U.S. Department of Energy (DOE) does not intend this EIS to be a permit application for existing SRP facilities or a vehicle to resolve the applicability of Resource Conservation and Recovery Act (RCRA) requirements to existing SRP facilities or waste sites. Ongoing regulatory activities and the expanded SRP groundwater monitoring and characterization program will provide the basis for the application of requirements to existing facilities and waste sites.

B.1 <u>INTRODUCTION</u>

B.1.1 OVERVIEW OF WASTE SITES

Plant operations generate waste materials that include hazardous wastes; low-level radioactive wastes; mixed wastes* containing both hazardous and radioactive materials; and other wastes, such as sanitary and solid wastes, including rubble. On the SRP, 168 sites have received wastes. The identification and numbers of sites discussed herein are based on the facility numbering system used at SRP. For example, all the SRL seepage basins are interconnected and received the same wste. These basins were analyzed as a single unit (for modeling, risk assessment, and closure options). However, for consistency with the SRP facility numbering system, they are counted as three "waste sites" in summary tables and text. The actual number of locations used for waste disposal at SRP is 48 in contrast to the 168 sites identified herein. Of these, 74 active and inactive sites have not received hazardous, low-level radioactive, or mixed wastes. Most of these sites are rubble pits and piles, coal pile runoff containment basins, ash basins and piles, erosion control sites, and experimental sewage/sludge application sites. Table B-1 describes these 74 sites. DOE's <u>Groundwater Protection Plan for the Savannah River Plant</u> (DOE, 1984a) discusses future actions to be taken at several of the 74 sites, including groundwater monitoring and closure actions.

In addition to these 74 sites, 17 waste locations have received or could have received hazardous, low-level radioactive, or mixed wastes. These 17 sites, which are not considered in detail in the sections (2.2 and 4.1) and appendixes (B and F) of this EIS that describe existing waste sites, include

*Unless otherwise stated, in this appendix "mixed waste" is a generic term that refers to the waste's characteristics (i.e., having both a hazardous and a low-level radioactive content) rather than its regulatory definition.

Table B-1. Waste Sites Not Containing Hazardous, Low-Level Radioactive, or Mixed Wastes

Waste sites	Number of sites	Description
Rubble and scrap pits and piles (includes former military sites)	25	Contain nonhazardous and nonradioactive materials such as concrete, brick, tile, asphalt, hard plastics, glass, rubber products, scrap metal, burn wood, and nonreturnable drums. Rubble pits no longer receive waste material.
Ash basins and piles	15	Contain ash sluice water or dry ash from powerhouses. Sampling results indicate waste concentrations are not hazardous. Four ash basins and three ash piles no longer receive ash.
Experimental sewage/ sludge application sites	9	Research programs on reclamation of borrow pits and enhancement of forest productivity where sewage sludge is injected below surface of borrow pits and either disked or sprayed on experimental pine plots. Industrial solid waste permit for sites issued by SCDHEC.
Coal-pile runoff containment basins	7	Contain runoff from coal piles. Results of sampling indicate a pH greater than 2.0; waste constituents, including heavy metals, are less than the EP toxicity maximum concentrations.
Erosion control sites	7	Contain nonhazardous and nonradioactive material that includes concrete, asphalt, bricks, roofing material, stumps and spoil. Four sites no longer receive waste material.
Asbestos disposal pits	4	Contain asbestos, metal pipe, plastic bags, scrap, and piping insulation (not regulated as a water contaminant but as an inhalation hazard). Three sites are no longer active. They are permitted by SCDHEC under NESHAP.
Sanitary landfill	1	Contains material such as paper, plastics, rubber, wood, cardboard, and rags. Landfill operated under a domestic waste permit issued by SCDHEC.

Table B-1. Waste Sites Not Containing Hazardous, Low-Level Radioactive, or Mixed Wastes (continued)

Waste sites	Number of sites	Description
Sanitary sludge disposal pit	1	Contains nonhazardous and nonradioactive sanitary sewage sludge.
D-Area waste oil	1	Receives mixes, and stores waste facility oil for burning with coal at the D-Area powerhouse.
Oil-storage pad	1	Concrete pad with curbing used before February 1979 to store drums of oil and solvents. All material stored on the pad has been removed.
Fire department hose training facility	1	Facility where oil was ignited in a shallow pit surrounded by an asphalt dike. Use of training facility has been discontinued.
Gas-cylinder disposal facility	1	Contains empty gas cylinders, from which all hazardous materials were released. Area covered with asphalt.
TNX storage area	1	Contains drummed, nonhazardous waste stored on pallets that rest on crushed rock

four hazardous waste storage facilities that have been permitted by the South Carolina Department of Health and Environmental Control (SCDHEC) and meet all applicable Federal and State regulatory requirements; the L-Area seepage basin, which receives periodic low-level radioactive discharges from the L-Reactor disassembly basin, and which was discussed extensively in the Final Environmental Impact Statement, L-Reactor Operation, Savannah River Plant (DOE, 1984b); three reactor containment basins in P-, L-, and C-Areas; six active reactor seepage basins and the K-Area containment basin; and two lined retention basins in the F and H Separations Areas that would be used to store and contain radioactive water temporarily in the event of an accident or emergency.

The three 190-million-liter earthen containment basins in P-, L-, and C-Areas would receive radioactive water only if a reactor accident, such as a loss of coolant or a loss of circulation, were to occur and a 225,000-liter underground tank and a 1.9-million-liter tank in each reactor area were unable to contain the contaminated water. With completion of the F- and H-Area effluent treatment facility (see Section 1.2.1), the two lined 15-million-liter retention basins in F- and H-Areas would be used only as an emergency backup to two

9.4-million-liter basins whose purpose is to store potentially contaminated water temporarily before treatment in the effluent treatment facility. The six active reactor seepage basins and the K-Area containment basin receive periodic low-level radioactive discharges from the disassembly basins at C-, K-, and P-Reactors. These active sites are discussed in Sections 2.4 and 4.3 of this EIS, which assess various approaches to the management of disassembly-basin purge water. The sections dealing with existing waste sites assess approaches to remedial and closure actions; closure of these seven sites cannot be considered appropriately until DOE reaches a decision on the management of disassembly-basin purge water. Therefore, these sites are not characterized and assessed in Appendixes B and F and in Sections 2.2 and 4.1.

The remaining 77 active and inactive waste sites on the SRP contain or might contain hazardous, low-level radioactive, or mixed wastes. These 77 sites include 37 that have received or might have received hazardous wastes. These 37 sites, none of which currently receives waste, include 15 burning rubble pits; 7 chemicals, metals, and pesticides (CMP) pits; 6 acid/caustic basins; 2 waste-oil seepage basins; a basin that has received miscellaneous chemicals; the metals burning pit; the Silverton Road waste site; the metallurgical laboratory basin; a hydrofluoric acid spill area; the Savannah River Laboratory (SRL) oil test site; and the Gunsite 720 rubble pit.

The 77 waste sites also include 19 that have received or might have received low-level radioactive waste. These include 1 active site, the radioactive waste burial ground, which currently receives low-level radioactive waste. There are also 18 inactive sites: 7 basins that have received periodic discharges of disassembly-basin purge water, 7 Bingham pump outage pits, 2 separations area retention basins (unlined), the Ford Building waste site, and the TNX burial ground. None of the 18 sites receives low-level radioactive waste.

In addition to sites that have received or might have received either hazardous or low-level radioactive waste, 21 have received or might have received mixed waste (a combination of hazardous and low-level radioactive waste). These include six separations area seepage basins, four SRL seepage basins, the new TNX seepage basin, two separations area seepage basins, the M-Area settling basin, Lost Lake, the old TNX seepage basin, the Road A chemical basin, the L-Area oil and chemical basin, the old radioactive waste burial ground, the Ford Building seepage basin, and the mixed waste management facility.

B.1.2 GEOGRAPHIC GROUPINGS OF WASTE SITES

In general, the locations of the 77 waste sites that contain or might contain hazardous, low-level radioactive, or mixed wastes are near the facilities from which they receive or received waste. This results in several clusters, or groupings, of waste sites.

Because actions at a waste site, including groundwater withdrawal, might affect the groundwater transport of waste in other sites, SRP calculated a conservative boundary of influence for each waste site based on the planned actions, extent of data availability, and type of waste (Du Pont, 1984). The intersections and overlappings of the individual site boundaries led to the identification of 10 geographic groupings of waste sites and two miscellaneous areas, each containing a single waste site, where a crossover of actions taken for waste sites in one grouping with actions taken in another grouping would not be expected. Figure B-1 displays these geographic groupings and miscellaneous areas.

Table B-2 lists the 77 waste sites in the geographic groupings and the miscellaneous areas that contain or might contain hazardous, low-level radioactive, and mixed wastes. This table also lists the type of waste that is contained or that might be contained at each site and whether the site currently receives waste material.

B.2 A- AND M-AREA WASTE SITES

The location of this geographic grouping of waste sites is along the northwest edge of the SRP where Road 1 leads to the Administration Area (700-A). Figure B-2 shows the boundaries of this geographic grouping and the locations of the waste sites within it. The boundaries are defined primarily by the areas of influence assigned to the SRL seepage basins, the M-Area settling basin, and Lost Lake. A-Area, the Fuel and Target Fabrication (300-M) Area, and most of Road D are within these boundaries. Surface drainage is primarily to Tims Branch, a tributary of Upper Three Runs Creek.

B.2.1 POTENTIALLY HAZARDOUS WASTE SITES*

B.2.1.1 716-A Motor Shop Seepage Basin (904-101G)

The 716-A motor shop seepage basin is adjacent to Building 716-A in A-Area. The basin is about 63 meters long, 11 meters wide, and 2 meters deep. The sloping berm of adjacent railroad tracks constitutes one side of the basin while the other three are an earthen dike about 2 meters high.

History of Waste Disposal

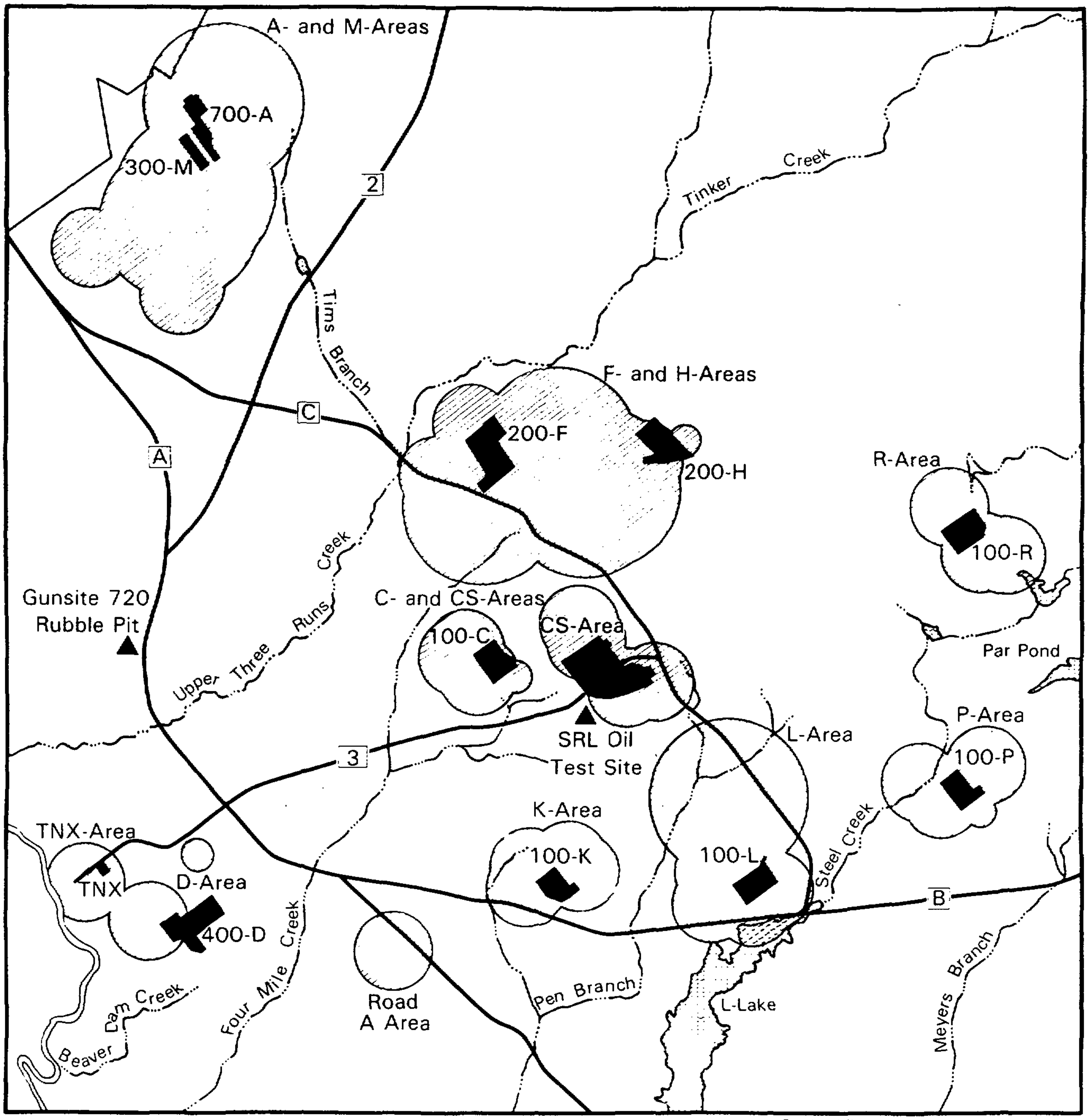
In 1977, the 716-A motor shop seepage basin began receiving liquid effluent from the 716-A motor shop oil-water separator by means of an underground drain line. Waste types in water included trace amounts of engine oil, kerosene, ethylene glycol, and soapy water. In the basin, the liquid wastes were permitted to seep naturally into the soil. In August 1983, all discharges to the basin ceased.

Evidence of Contamination

Initial sampling of the liquid remaining in the 716-A motor shop seepage basin indicated the presence of low quantities of motor oil, grease, ethylene glycol, and kerosene. The results of extraction procedure (EP) toxicity analyses found all metals were below RCRA guidelines (Huber, Johnson, and Bledsoe, 1986).

SRP installed two groundwater monitoring wells near the basin in May 1983. Well sampling began in February 1984. To date, no evaluation of the sampling data has been made available.

*See discussion of site type on page B-1.



Source: Adapted from Du Pont, 1984.

Scale (kilometers)
0 1 2 3 4 5

Figure B-1. Geographic Groupings of Waste Sites

Table B-2. Waste Sites by Geographic Grouping

	Areas/waste sites	Building	Currently receiving waste	Potential category[a]
A- and M-Areas				
1-1[b]	716-A motor shop seepage basin	904-101G	No	Hazardous
1-2	Metals burning pit	731-4A	No	Hazardous
1-3	Silverton Road waste site	731-3A	No	Hazardous
1-4	Metallurgical laboratory basin	904-110G	No	Hazardous
1-5	Miscellaneous chemical basin	731-5A	No	Hazardous
1-6	A-Area burning/rubble pit	731-A	No	Hazardous
1-7	A-Area burning/rubble pit	731-1A	No	Hazardous
1-8	SRL seepage basin	904-53G	No	Mixed
1-9	SRL seepage basin	904-53G	No	Mixed
1-10	SRL seepage basin	904-54G	No	Mixed
1-11	SRL seepage basin	904-55G	No	Mixed
1-12	M-Area settling basin	904-51G	No	Mixed
1-13	Lost Lake	904-112G	No	Mixed
F- and H-Areas				
2-1	F-Area acid/caustic basin	904-74G	No	Hazardous
2-2	H-Area acid/caustic basin	904-75G	No	Hazardous
2-3	F-Area burning/rubble pit	231-F	No	Hazardous
2-4	F-Area burning/rubble pit	231-1F	No	Hazardous
2-5	H-Area retention basin	281-3H	No	Low-level radioactive
2-6	F-Area retention basin	281-3F	No	Low-level radioactive
2-7	Radioactive waste burial ground	643-7G	Yes	Low-level radioactive
2-8	Mixed-waste management facility	643-28G	No	Mixed

Footnotes on last page of table.

Table B-2. Waste Sites by Geographic Grouping (continued)

	Areas/waste sites	Building	Currently receiving waste	Potential category[a]
F- and H-Areas (continued)				
2-9	Radioactive waste burial ground (inactive)	643-G	No	Mixed
2-10	F-Area seepage basin	904-41G	Yes	Mixed
2-11	F-Area seepage basin	904-42G	Yes	Mixed
2-12	F-Area seepage basin	904-43G	Yes	Mixed
2-13	F-Area seepage basin (old)	904-49G	No	Mixed
2-14	H-Area seepage basin	904-44G	Yes	Mixed
2-15	H-Area seepage basin	904-45G	Yes	Mixed
2-16	H-Area seepage basin	904-46G	No	Mixed
2-17	H-Area seepage basin	904-56G	Yes	Mixed
R-Area				
3-1	R-Area burning/rubble pit	131-R	No	Hazardous
3-2	R-Area burning/rubble pit	131-1R	No	Hazardous
3-3	R-Area acid/caustic basin	904-77G	No	Hazardous
3-4	R-Area Bingham Pump outage pit	643-8G	No	Low-level radioactive
3-5	R-Area Bingham Pump outage pit	643-9G	No	Low-level radioactive
3-6	R-Area Bingham Pump outage pit	643-10G	No	Low-level radioactive
3-7	R-Area seepage basin	904-57G	No	Low-level radioactive
3-8	R-Area seepage basin	904-58G	No	Low-level radioactive
3-9	R-Area seepage basin	904-59G	No	Low-level radioactive
3-10	R-Area seepage basin	904-60G	No	Low-level radioactive
3-11	R-Area seepage basin	904-103G	No	Low-level radioactive
3-12	R-Area seepage basin	904-104G	No	Low-level radioactive
C- and CS-Areas				
4-1	CS burning/rubble pit	631-1G	No	Hazardous
4-2	CS burning/rubble pit	631-5G	No	Hazardous
4-3	CS burning/rubble pit	631-6G	No	Hazardous
4-4	C-Area burning/rubble pit	131-C	No	Hazardous

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Table B-2. Waste Sites by Geographic Grouping (continued)

	Areas/waste sites	Building	Currently receiving waste	Potential category[a]
C- and CS-Areas (continued)				
4-5	Hydrofluoric acid spill area	631-4G	No	Hazardous
4-6	Ford Building waste site	643-11G	No	Low-level radioactive
4-7	Ford Building seepage basin	904-91G	No	Mixed
TNX-Area				
5-1	D-Area burning/rubble pit	431-D	No	Hazardous
5-2	D-Area burning/rubble pit	431-1D	No	Hazardous
5-3	TNX burying ground	643-5G	No	Low-level radioactive
5-4	TNX seepage basin (old)	904-76G	No	Mixed
5-5	TNX seepage basin (new)	904-102G	Yes	Mixed
D-Area				
6-1	D-Area waste oil basin	631-G	No	Hazardous
Road A Area				
7-1	Road A chemical basin	904-111G	No	Mixed
K-Area				
8-1	K-Area burning/rubble pit	131-K	No	Hazardous
8-2	K-Area acid/caustic basin	904-80G	No	Hazardous
8-3	K-Area Bingham Pump outage pit	643-1G	No	Low-level radioactive
8-4	K-Area seepage basin	904-65G	No	Low-level radioactive
L-Area				
9-1	L-Area burning/rubble pit	131-L	No	Hazardous
9-2	L-Area acid/caustic basin	904-79G	No	Hazardous

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Table B-2. Waste Sites by Geographic Grouping (continued)

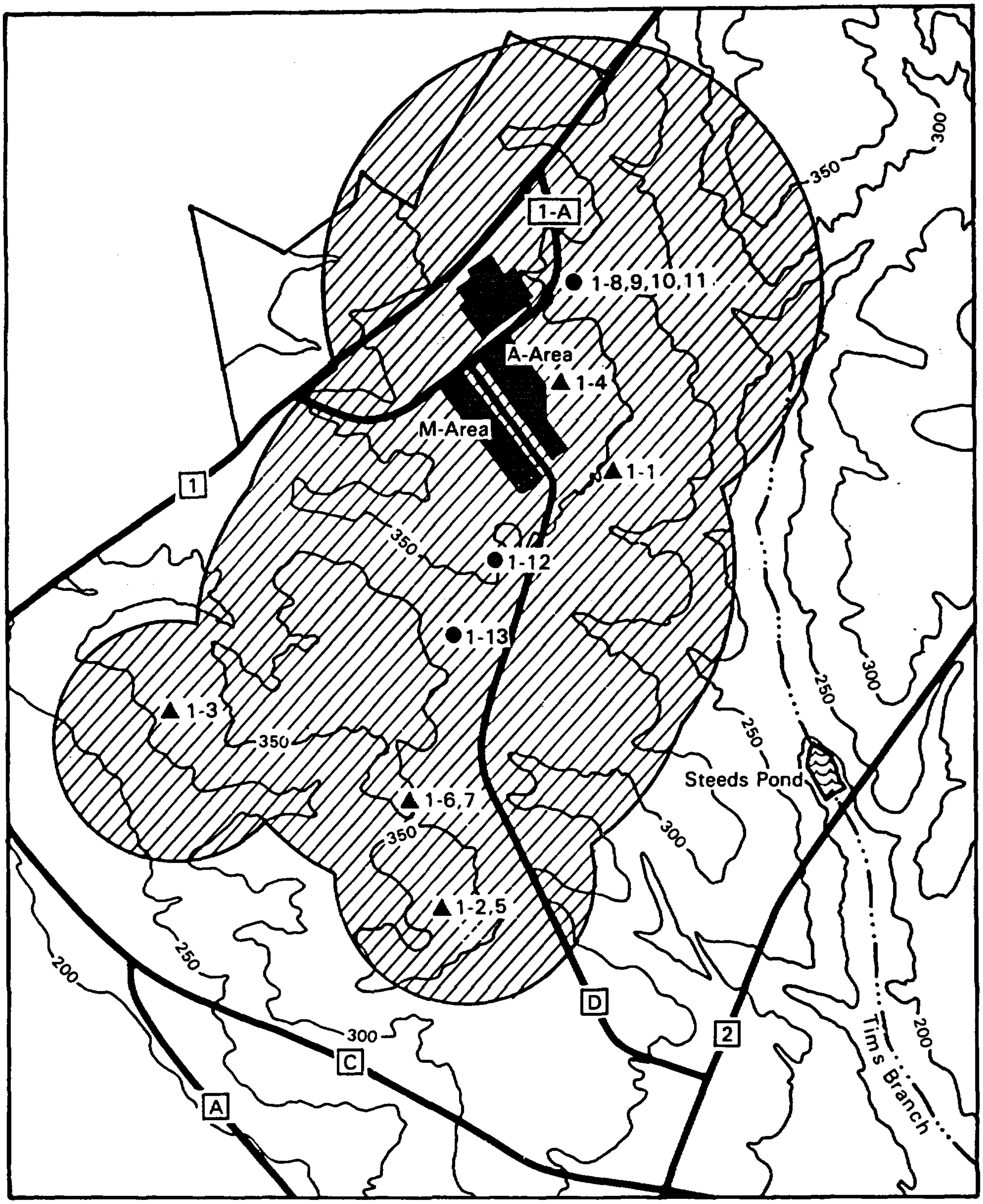
Areas/waste sites		Building	Currently receiving waste	Potential category[a]
L-Area (continued)				
9-3	CMP pit	080-17G	No	Hazardous
9-4	CMP pit	080-17.1G	No	Hazardous
9-5	CMP pit	080-18G	No	Hazardous
9-6	CMP pit	080-18.1G	No	Hazardous
9-7	CMP pit	080-18.2G	No	Hazardous
9-8	CMP pit	080-18.3G	No	Hazardous
9-9	CMP pit	080-19G	No	Hazardous
9-10	L-Area Bingham Pump outage pit	643-2G	No	Low-level radioactive
9-11	L-Area Bingham Pump outage pit	643-3G	No	Low-level radioactive
9-12	L-Area oil and chemical basin	904-83G	No	Mixed
P-Area				
10-1	P-Area burning/rubble pit	131-P	No	Hazardous
10-2	P-Area acid/caustic basin	904-78G	No	Hazardous
10-3	P-Area Bingham Pump outage pit	643-4G	No	Low-level radioactive
Miscellaneous Areas				
11-1	SRL oil test site	080-16G	No	Hazardous
11-2	Gunsite 720 rubble pit	N80,000; E27,350[c]	No	Hazardous

[a]This EIS uses the terms "hazardous," "low-level radioactive," and "mixed" (i.e., hazardous and low-level radioactive) in their most common everyday sense, without specific regard to technical or regulatory definitions, unless indicated.
[b]The numbering system arbitrarily identifies the geographic group and each site with that group. For example, site 1-1 represents the first site in geographic group 1.
[c]No building number; located by SRP map coordinate system.

The sediment beneath the basin will be sampled and characterized at a future date prior to any closure plans being finalized.

Waste Characterization

Limited data are available on the extent of contamination and the characteristics of the wastes involved at the 716-A motor shop seepage basin. Most of



Note: Elevations are in feet above mean sea level 1.0 foot = 0.3048 meter

Legend on following page

Scale (kilometers)
0 1 2

Figure B-2. A- and M-Area Waste Sites

Number	Potential Waste Type	Site Name	Building Number
1-1	▲	716-A Motor Shop Seepage Basin	904-101G
1-2	▲	Metals Burning Pit	731-4A
1-3	▲	Silverton Road Waste Site	731-3A
1-4	▲	Metallurgical Laboratory Basin*	904-110G
1-5	▲	Miscellaneous Chemical Basin*	731-5A
1-6	▲	A-Area Burning/Rubble Pit*	731-A
1-7	▲	A-Area Burning/Rubble Pit*	731-1A
1-8	●	SRL Seepage Basin	904-53G
1-9	●	SRL Seepage Basin	904-53G
1-10	●	SRL Seepage Basin	904-54G
1-11	●	SRL Seepage Basin	904-55G
1-12	●	M-Area Settling Basin	904-51G
1-13	●	Lost Lake	904-112G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
●—Mixed

Figure B-2. A- and M-Area Waste Sites (continued)

the available raw data have been gathered via groundwater monitoring (Huber, Johnson, and Bledsoe, 1986).

B.2.1.2 Metals Burning Pit (731-4A)

The metals burning pit is in A-Area to the northwest of Road C-1 and between M-Area and Road C. The site is approximately 2130 meters south of the M-Area settling basin and 3350 meters from the closest SRP boundary. It has dimensions of approximately 120 meters by 120 meters.

History of Waste Disposal

The history of the metals burning pit is uncertain. The site was originally a disposal pit for lithium-aluminum and other waste metals generated from M-Area operations, which began in 1952. According to 1974 photographs, the waste metals were burned periodically within an area of approximately 3900 square meters. Photographs of the metals burning pit taken in late 1973 and early 1974 show piles of metal shavings, pieces of aluminum metal, plastic pipe, at least 30 metal drums, and other miscellaneous metal scraps. These wastes were in two discrete areas: a large, long pile approximately 2 to 3 meters high, 10 meters wide, and 30 meters long, and a series of small piles oriented in a semicircular arc. Some of the piles appeared to contain ash from metal burning operations. The area was graded and backfilled with 1 to 2 meters of cover in the spring of 1974.

Evidence of Contamination

No characterization studies of the soils under or around the metals burning pit have been performed to date. However, soil sampling is planned. Four groundwater monitoring wells have been installed at the site (Muska, Pickett, and Marine, 1986).

Waste Characterization

Limited data are available to verify the existence or define the extent of contamination at the metals burning pit or to characterize the wastes that might be present. Most of the available raw data pertain to the groundwater. The migration potential of the waste deposited in the metals burning pit cannot be determined readily from the available data.

B.2.1.3 Silverton Road Waste Site (731-3A)

The Silverton Road waste site is just south of M-Area and north of Route 125. The nearest SRP boundary is about 1.6 kilometers northwest of the site. The site covers a total area of approximately 13,150 square meters, with dimensions of about 62 meters by 212 meters.

History of Waste Disposal

The site startup date is unknown; no records of waste disposal activities have been kept. Visual inspection and photographic documentation indicate that metal shavings, construction debris, tires, drums, tanks, and asbestos were major components of the waste. The site was closed in 1974 and is now covered with soil and vegetation.

Evidence of Contamination

Groundwater at the Silverton Road waste site has been monitored since 1981. Eleven single groundwater monitoring wells and six 3-well clusters are located near the site. To date, the contaminants identified in the groundwater are trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane. Most of the constituents found in the groundwater near the site were below Federal drinking-water standards. Infrequently, concentrations of barium, cadmium, chromium, mercury, and lead were found to exceed the standards. However, because such concentrations were observed infrequently, the data were considered to be nonrepresentative and possibly erroneous (Scott, Killian, Kolb, Corbo, and Bledsoe, 1986).

Waste Characterization

Limited data are available on the extent of contamination and characteristics of the wastes at the Silverton Road site. Most of the available raw data pertain to the groundwater (Scott, Killian, Kolb, Corbo, and Bledsoe, 1986).

Historic data from monitoring wells indicate the presence in the groundwater of chlorinated aliphatic hydrocarbons (trichloroethylene, 1,1,1-trichloroethane, and tetrachloroethylene), which have a potential for transport by advection as solutes. (See Table B-3.)

B.2.1.4 Metallurgical Laboratory Basin (904-110G)

The metallurgical laboratory basin is in A-Area adjacent to Building 745-A. The basin is approximately 31 meters long, 12 meters wide, and 1.5 meters deep.

History of Waste Disposal

The metallurgical laboratory basin received wastewater effluent from Building 723-A from 1956 to 1985. Discharges to the basin consisted of small quantities of laboratory wastes from metallographic sample preparation (degreasing, cleaning, etching) and corrosion testing of stainless steels and nickel-based alloys. The wastewater flowed to the basin via an underground process sewer pipeline. The discharge rate to the basin was 3.8 cubic meters per day. Historically, the typical wastes released to the basin were water and nitric acid. From 1983 on, hazardous substances and materials were bottled and stored. Before 1983, hazardous materials were sent to the basin only in trace amounts. Table B-4 lists the estimated composition of releases to the basin during its operational history (Michael, Johnson, and Bledsoe, 1986).

Evidence of Contamination

A characterization study of the sediments in and around the metallurgical laboratory basin has been completed, as has an analysis of the basin water and groundwater. Soil analyses indicate that all tested parameters are below EP toxicity guidelines. Analysis of water samples collected from the basin indicate that drinking standards are met for all parameters except pH and iron.

Table B-3. Organic Chemical Contaminant Mobility Parameters

Chemical contaminant	Water solubility[a] (S_w ug/l)	Octanol/water partition coefficient[b] ($\log_{10}$ Kow dimensionless)	Soil/sediment adsorption coefficient[c] ($\log_{10}$ Koc, g/g)
Ethylene glycol	Miscible[d]	-1.93[e]	2.98[f]
N-dodecane	3.7[e]	7.18[g]	5.28[f]
Tetrachloroethane	200[h]	2.88[h]	2.56[h]
Trichloromethane (chloroform)	8.2×10^3[h]	1.96[h]	1.64[h]
Trichloroethene (trichloroethylene)	1.1×10^3[h]	2.1[h]	1.99[h]
Phenol	9.3×10^4[h]	1.48[h]	1.15[h]

[a]Water Solubility - This parameter indicates the relative water-contamination potential of various chemicals. The rate at which a chemical is released from a waste deposit by infiltrating precipitation is assumed to be directly proportional to its water solubility. Furthermore, because water solubility indicates the soil/sediment adsorption potential of a compound, it also indicates how much the chemical migration is retarded in the subsurface environment.

[b]Octanol/Water Partition Coefficient - This parameter is generally presented in logarithmic form. It directly indicates the partitioning of an organic chemical between the phases of a two-phase system consisting of octanol and water. It provides insight into water solubility and soil/sediment adsorption coefficients and, perhaps more importantly, has been shown to be related linearly to the bioconcentration factor. Compounds that have high octanol/water partition coefficients generally display a marked tendency to accumulate in the lipid (fatty) tissues of aquatic and terrestrial organisms.

[c]Soil/Sediment Adsorption Coefficient - This parameter indicates the relative tendency for organic chemicals to adsorb to the organic fraction of soil and sediment particles. It directly indicates the mobility of organic compounds in the subsurface environment. Because this adsorption coefficient covers an extremely wide range of values, it is presented in logarithmic form.

[d]Merck & Co., 1976.

[e]Veschueren, 1983.

[f]From equation 4-8 (Lyman, Reekly, and Rosenblatt, 1982).

[g]From equation 1-3 (Lyman, Reekly, and Rosenblatt, 1982).

[h]Mabey et al., 1982.

Table B-4. Estimated Composition of Wastes Released to Building 723-A Metallurgical Laboratory Basin (1956-1985)[a]

Chemical	Total release over 30 years	Present release
Acetone	20 liters	Not released after 3/83
1,1,1-trichloroethane	150 liters (past 3-5 years)	Not released after 3/83
Trichloroethylene	6 liters	Not released after 1978
Carbon tetrachloride (tetrachloromethane)	500 liters	Not released after 1978
Hydrofluoric acid[b]	2 liters	Not released after 3/83
Nitraad[b] (as purchased, is composed of HF, acetic acid, and fluoride salts)	140 liters	Not released after 3/83
Potassium cyanide or sodium cyanide	1 liter	Not released after 1976
Cyanide (plating solution)[c]	4 liters	Not released after 1976
Hydrochloric acid	190 liters	45 liters/year
Nitric acid (65%)	39,800 liters	1,300 liters/year
Molybdic acid	10 grams	1 gram (rarely used)
Oxalic acid	23 liters	10 liters/year
Phosphoric acid	53 liters	1.6 liters/year
Picric acid	100 grams	0.4 liter/year
Sulfuric acid	15 liters	4 liters/year
Sodium hydroxide	3 liters	2 liters/year
Potassium hydroxide	30 liters	8 liters/year
Trisodium phosphate	60 liters	8 liters/year

Footnotes on last page of tables.

Table B-4. Estimated Composition of Wastes Released to Building 723-A Metallurgical Laboratory Basin (1956-1985)[a] (continued)

Chemical	Total release over 30 years	Present release
Sodium sulfite	270,000 grams	11,000 grams/year
Sodium carbonate/bicarbonate	45 liters	8 liters/year
Ammonium persulfate	1 liter	0.5 liter/year
Ethyl alcohol	1,300 liters	420 liters/year
Kerosene	114 liters	Not released after 2/85
Methyl methacrylate (Koldweld resin)	150 liters	6 liters/year
Ferric chloride	1,900 liters	0.4 liter/year
Water (cooling water from corrosion test, rinse water from photo process, lab rinsewater)	3,800 liters/day	3,800 liters/day

[a]Source: Michael, Johnson, and Bledsoe, 1986.
[b]Currently bottled and stored.
[c]Solution reused until all metal is depleted.

Waste Characterization

Data are available for the chemical analyses performed on the basin water, groundwater, and sediments from the metallurgical laboratory basin.

The potential for the migration of contaminants deposited in the metallurgical laboratory basin cannot be determined readily from the available data. See Table B-3 for the chemical characteristics of chlorinated hydrocarbons.

B.2.1.5 Miscellaneous Chemical Basin (731-5A)

The miscellaneous chemical basin site is located to the northeast of Road C-1 and between the A/M-Area and Road C. The site is approximately 2 kilometers south of the M-Area settling basin and 3 kilometers from the closest SRP boundary. The chemical basin is approximately 6 meters wide, 6 meters long, and 0.3 meter deep.

History of Waste Disposal

The origin and history of this site are not certain. This small, shallow basin was located in an old "borrow pit." The basin received liquid chemical wastes, presumably waste solvents and used oil. A 1974 photograph of the site shows a small, discolored (possibly from the disposal of waste oil) sandy area inside a shallow berm. Partially full drums might have been emptied at this site and the empty drums discarded in the metals burning pit. The basin was posted with a sign that read "Chemical Waste Disposal - Keep Out." The site has been regraded, although the exact date is not recorded (probably 1974).

Evidence of Contamination

There are no groundwater wells currently in place. An analysis of surface soils at the miscellaneous chemical basin in January 1986 detected several chlorinated hydrocarbons (Muska, Pickett, and Marine, 1986).

Waste Characterization

A program of soil gas sampling undertaken in January 1986 indicated the presence of volatile organic compounds (VOCs), some of which might have originated in M-Area and been disposed of at this site.

B.2.1.6 A-Area Burning/Rubble Pits (731-A and 731-1A)

The A-Area burning/rubble pits are at the northwest corner of the Plant, south of M-Area and west of Road D. The pits (731-A) are approximately 100 meters long, 55 meters wide, and 3 meters deep. Pit 731-1A measures 174 meters long, 10 meters wide, and 3 meters deep.

History of Waste Disposal

The A-Area burning/rubble pits are two of the many burning pits utilized on the Savannah River Plant. They consisted of shallow excavations, usually 3 to 4 meters deep, where burnable waste was disposed of on a continuous basis beginning in 1951. Waste types reportedly included paper, plastics, wood, rubber, rags, cardboard, oil, degreasers, and drummed solvents. The waste was burned periodically, usually monthly. Disposal of chemically contaminated oils was not permitted.

The burning of waste in the pits was discontinued in October 1973. At that time, a layer of soil was placed over the remaining waste and the pits were opened to receive rubble. Rubble disposed of at this site reportedly includes paper, lumber, cans, and empty galvanized-steel barrels and drums. As each pit reached its capacity, it was closed and covered with soil to grade level.

Evidence of Contamination

No sampling and analysis of the soil underlying these pits have been performed. However, groundwater monitoring wells were installed at all of the burning/rubble pits in 1983 and 1984. No groundwater contamination has been observed to date (Huber, Johnson, and Marine, 1986).

Waste Characterization

Limited data are available for these sites. Most of the available raw data have been gathered via groundwater monitoring. No groundwater contamination has been observed to date (Huber, Johnson, and Marine, 1986).

B.2.2 MIXED WASTE SITES*

B.2.2.1 SRL Seepage Basin - Basin 1 (904-53G)

Seepage basin 1 is one of a group of four basins associated with the SRL. These basins are south of Road A-1 and west of Road D-1. This location is in the northwestern section of the SRP about 1 kilometer from the nearest boundary. The four basins are connected sequentially in cascade via overflow channels. The final basin has no overflow; consequently, fluid losses from the SRL waste sites are from seepage through the bottom of the basins or from evaporation (Fowler et al., 1986).

History of Waste Disposal

Basins 1 (904-53G), 2 (904-53G), and 3 (904-54G) were excavated from natural soils and surrounded by perimeter dikes. By contrast, the construction of basin 4 (904-55G) required substantial filling at the north end (adjacent to Tims Branch) to achieve both the basin bottom and the dike crest elevations.

The capacity of basin 1 is 811 cubic meters; basin 2, 4000 cubic meters; basin 3, 6180 cubic meters; and basin 4, 16,400 cubic meters. Basins 1 and 2 were placed in operation in 1954, and basins 3 and 4 were added in 1958 and 1960, respectively. The basins were in operation until October 1982. The depth of water remaining varies from dry (basin 4) to 1.2 meters (basin 2).

Evidence of Contamination

Most of the radionuclides and inorganics are strongly sorbed to basin sediments. Their concentrations are elevated in the first 30 centimeters and decline to "background" levels at about 62 centimeters. The constituents include americium-241, cesium-137, cobalt-60, curium-243 and 244, plutonium-239 and 240, radium-228, strontium-90, uranium-235 and 238, cerium-144, ruthenium-106, arsenic, barium, cadmium, chromium, copper, lead, magnesium, manganese, nickel, silver, zinc, mercury, cyanide, fluoride, and sulfate. Analysis of core samples for volatile, base/neutral, and acidic organic compounds indicates very little contamination. Most elements were detected at levels below 1 microgram per gram of soil (Fowler et al., 1986).

Twelve monitoring wells have been installed around the basins. Six water-table monitoring wells were drilled in 1981 immediately adjacent to the basins. Three water-table wells and three deep wells were installed as part of a basin characterization program in 1983.

Data from the nine groundwater monitoring wells indicate the following:

- Inorganic contaminants are generally below maximum contaminant levels (MCLs).
- Trichloroethylene and tetrachloroethylene are significant organic contaminants. The pattern of contaminated wells indicates that these constituents are from sources other than the basins.

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*See page B-1 for a discussion of waste site categories.

Waste Characterization

During the A-Area basins' 28-year loading history, 128,820 cubic meters of water were discharged to them. Alpha and beta-gamma activity in the total discharge did not exceed 100 and 50 disintegrations per minute per milliliter, respectively. The average of alpha and beta-gamma activity was 50 disintegrations per minute per milliliter. Fissile content of the waste transferred to the basins in 1982 averaged 0.4 millicurie per month. The levels of uranium and plutonium in the analyses were as follows: uranium-238, 90 percent; plutonium-238, 5 percent; and plutonium-239, 5 percent.

Table B-5 compares the MCL observed in the SRL seepage basins with the U.S. Nuclear Regulatory Commission (NRC) Class A limits. The sediments are well below the limits for land disposal.

Table B-5. Measured Soil Contamination Versus NRC 10 CFR 61 Land-Disposal Limits for SRL Seepage Basins (pCi/g)

Nuclide	Maximum basin-soil measurement	NRC Class A limit
Tritium	7×10^4	3×10^7
Cobalt-60	9×10^1	5×10^8
Strontium-90	2×10^3	3×10^4
Cesium-137	2×10^3	3×10^4
Plutonium-239	2×10^2	1×10^5
Americium-241	3×10^1	1×10^5
Curium-243	4×10^2	1×10^5

The RCRA EP toxicity test establishes the guidelines for classifying a waste as hazardous or nonhazardous. Test results indicate that concentrations in the SRL seepage-basin sediments of constituents classified as hazardous by the U.S. Environmental Protection Agency (EPA) are generally low (less than 1 microgram per gram); in most cases these compounds are undetectable or are present at "laboratory-blank" levels that follow no clear source/transport pattern. The test also indicates that the sediments in the basins do not contain toxic levels of metals. No samples exceed the EPA maximum concentrations, and only mercury in basin 1 exceeds 10 percent of the EPA maximum concentration (40 CFR 261.24). The sediments in the SRL seepage basins contain very low levels of hazardous constituents. Therefore, no contamination is present other than low-level radioactivity in the sediments. Organic constituents in the groundwater do not exceed primary drinking-water standards (40 CFR 141).

B.2.2.2 SRL Seepage Basin - Basin 2 (904-53G)

The general history of all SRL seepage basins is discussed in Section B.2.2.1.

History of Waste Disposal

Basin 2 is part of the four-basin system discussed in Section B.2.2.1.

Evidence of Contamination

Evidence of contamination in the four-basin area is discussed in Section B.2.2.1.

Waste Characterization

Waste characteristics are discussed in Section B.2.2.1.

B.2.2.3 SRL Seepage Basin - Basin 3 (904-54G)

The general history of all SRL seepage basins is discussed in Section B.2.2.1.

History of Waste Disposal

Basin 3 is part of the four-basin system discussed in Section B.2.2.1.

Evidence of Contamination

Evidence of contamination in the four-basin area is discussed in Section B.2.2.1.

Waste Characterization

Waste characteristics are discussed in Section B.2.2.1.

B.2.2.4 SRL Seepage Basin - Basin 4 (904-55G)

The general history of all SRL seepage basins is discussed in Section B.2.2.1. The following sections present additional information on basin 4.

History of Waste Disposal

Basin 4 is part of the four-basin system discussed in Section B.2.2.1.

Evidence of Contamination

In August 1972, basin 4 temporarily went dry. Four 30-centimeter-deep core samples were obtained and divided into segments for gamma spectroscopy (Holmes et al., 1983). The levels of strontium-89 and 90 in the cores were determined. The top sediment sample contained from 80 to 90 percent of each of the radionuclides except strontium. The other radionuclides showed decreases in activity with increasing depth. The calculated inventories were as follows: cesium-137, about 0.46 curie; ruthenium-106, 0.41 curie; cerium-141 and 144, 0.05 curie; cobalt-60, 0.04 curie; and strontium-89 and 90, 0.01 curie.

Basin 4 refilled during 1973, went dry again in 1974, and has remained dry since 1974. Four sediment samples were collected in 1974. Table B-6 lists the results of gamma-spectroscopic analyses of these cores. The highest measured activity was near the surface, and the values decreased with depth.

Table B-6. Radioactivity of Sediment in SRL Seepage Basin 4 (nCi/g)

Radionuclide	Sediment depth (cm)	Sample site[a] 1	2	3	4
Cesium-137	0-6.4	0.714	0.044	1.100	0.215
	6.4-12.7	0.042	0.002	0.207	0.034
	12.7-19.1	0.007	0.001	0.036	0.002
	19.1-24.1	0.003	0.001	0.004	-
	24.1-30.5	0.002	-	0.001	-
Cesium-134	0-6.4	0.037	0.003	0.092	0.016
	6.4-12.7	0.003	0.001	0.009	0.001
	12.7-19.1	0.001	0.001	0.001	0.001
	19.1-24.1	0.001	0.001	0.001	0.001
	24.1-30.5	0.001	0.001	0.001	0.001
Ruthenium-106	0-6.4	Trace	Trace	Trace	Trace
Cobalt-60	0-6.4	0.050	0.007	0.078	0.020
	6.4-12.7	0.002	0.001	0.008	0.001
	12.7-19.1	0.001	0.001	0.004	0.001
	19.1-24.1	0.001	0.001	0.001	-
	24.1-30.5	0.001	-	0.001	-
Alpha	0-6.4	0.150	0.140	0.230	0.020
	6.4-12.7	0.020	0.002	0.019	0.006
	12.7-19.1	0.009	0.002	0.007	0.002
	19.1-24.1	0.003	0.002	0.006	-
	24.1-30.5	0.002	0.002	0.001	-

[a]Samples taken in 1974 at four locations in basin 4, with northwest corner designated as 1 and the others numbered counterclockwise from inlet.

Waste Characterization

Waste characteristics for all four basins are discussed in Section B.2.2.1 (Fowler et al., 1986).

B.2.2.5 M-Area Settling Basin (904-51G)

Figure B-2 shows the location of the M-Area settling basin. Waste flows from M-Area, which stopped in July 1985, entered the settling basin via a process-sewer line. A ditch conveyed overflows from the settling basin through a natural seepage area; the discharges eventually entered Lost Lake. Lost Lake has no outlet (Colven et al., 1986). The following sections discuss the history of waste disposal, evidence of contamination, and waste characteristics at the settling basin (Colven et al., 1986; Hollod et al., 1982).

History of Waste Disposal

When production started in M-Area in 1954, process waters were released to Tims Branch, a tributary of Upper Three Runs Creek. In an effort to restrict the offsite transport of enriched uranium, the settling basin was constructed in 1958 to settle out and contain the uranium (Christensen and Gordon, 1983). Process sewers continued to direct some M-Area waste flows to Tims Branch. In the fall of 1978, eleven 208-liter drums containing tetrachloroethylene were dumped into the settling basin, but the exact location of the dumping is not known. In addition, from the fall of 1978 to the spring of 1979, drums of tetrachlorethylene were dumped into the sewer line leading to the settling basin to dispose of remaining solvent after the transition to a new cleaning solvent (1,1,1-trichloroethane).

In May 1982, all discharges to Tims Branch were diverted to the settling basin. Most noncontact process effluents, such as cooling water and surface drainage, were diverted back to Tims Branch in November 1982. In late 1983, significant flow-rate reductions were implemented in the 300-M Area processes. All discharges to the settling basin stopped on July 16, 1985. The current water level in the settling basin fluctuates with rainfall events but, in general, has receded approximately 0.5 meter from the normal operating level.

Evidence of Contamination

A 1982 study of soils beneath the settling basin indicates that the top of the soil column has higher than background concentrations of such metals as zinc, lead, mercury, copper, and uranium (Hollod et al., 1982). Nickel concentrations decline to background level at about 0.3 meter. The average concentrations of metals observed in a 1985 study (Pickett, 1985) are similar, in most cases, to the results reported in the 1982 study. Uranium was detected at four locations sampled in 1985. The 1985 study also included soils next to the settling basin, which yielded no evidence of metals contamination.

The 1982 study found the concentration of each of three chlorinated hydrocarbons (trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane) in the underlying basin soil to be quite variable, both vertically and horizontally. Unlike the data on metal contaminants, the analyses for hydrocarbons in 1985 differ from those of 1982 (Pickett, 1985).

These results indicate that the more mobile hydrocarbons in the soil beneath the settling basin have migrated toward the water table, while the less mobile metals have remained fairly stationary. These results indicate that the basin and its sediments are no longer a source of organic contamination.

Analyses of samples indicate that the settling basin and process-sewer line are the major sources of organic or inorganic contamination of groundwater in M-Area. The data also indicate that the seepage and Lost Lake areas are also sources of organic or inorganic contamination, but to a lesser degree. Judging from their elevated levels in settling basin influents and the consistency of their background and downgradient concentrations, the following are probable contaminants: nitrate, sodium, total dissolved solids, and organics.

Degreaser solvents have entered the groundwater in the Tertiary sediments in M-Area from several known surface sources. The settling basin was one of three primary surface sources. The maximum concentration of such solvents occurs at the water table under the settling basin. At a greater depth (about 23 meters below the water table), the maximum concentration is only 61 parts per million but the plume occupies a larger area than it does at the water table. Near the base of the Tertiary sediments (37 meters below the water table), both the maximum concentration and the area of the plume are much smaller, being restricted to the general area beneath the surface sources. Plumes of elevated concentrations of total dissolved solids and nitrate also occur in the vicinity of the settling basin and the M-Area process area.

Waste Characterization

The waste effluents discharged to the basin during M-Area operation generally can be characterized as electroplating rinse water from aluminum forming and metal finishing processes. The waste effluents contained hydroxide precipitates of aluminum, uranium, nickel, and lead, as well as nitrates and organic solvents. Depending on the operating schedule, they might also have contained acids (nitric, phosphoric, sulfuric) or caustics (sodium hydroxide).

Estimates of total uranium discharge to the settling basin were not available until after 1975, when flow instruments were installed. From 1974 through 1983, a total of 975 millicuries (approximately 2940 kilograms) of uranium-235 and uranium-238 were released to the basin. A total of approximately 1.6×10^6 kilograms of volatile organic solvents was discharged to M-Area process sewers, with about 0.9×10^6 kilograms of the total being released to the settling basin. The remainder was discharged to Tims Branch.

The results of 1985 analyses confirm that dissolved-metal and nutrient concentrations are usually higher in the lower 3 meters of liquid in the basin. A sludge layer also exists at the bottom of the basin. The thickness of the sludge ranges from 0.15 to 0.9 meter. The sludge is composed primarily of metal hydroxide and phosphate precipitates, as well as biogenic organic sediments. It also contains the major inventories of iron (1280 kilograms), nickel (3585 kilograms), chromium (240 kilograms), and uranium (3900 kilograms) in the basin.

A number of organic compounds are also present in significant amounts in the sludge, but they were not detected at any other sampling location. The total inventory of chlorinated hydrocarbons in the sludge is approximately 1 kilogram; the inventory is approximately 20 kilograms in the basin liquid.

A closure plan for the M-Area seepage basin was submitted in September 1984. Revisions to the plan were submitted in March and July 1985, and public hearings were held in July 1986. A postclosure care permit application for this basin was submitted with the SRP Part B permit application. Interim status is in effect until final administrative disposition of the Part B permit application.

B.2.2.6 Lost Lake (904-112G)

Lost Lake, which is located in M-Area (Figure B-2), is a natural Carolina bay of about 10 to 25 acres, depending on water level. Wastewater overflowed from the M-Area settling basin and entered Lost Lake from the north via an overflow ditch and natural seepage area. The ditch is presently dry. The following sections discuss the history of waste disposal, evidence of contamination, and waste characteristics at Lost Lake (Colven et al., 1986).

History of Waste Disposal

Before construction of the settling basin, Lost Lake was dry except during periods of heavy precipitation. Water has accumulated in the Lake since the diversion of process effluents from Building 313-M to the basin in 1960. The water levels varied widely as a result of process discharges and rainfall. Lost Lake has no outlet; therefore, all wastewater that entered the area either seeped into the ground or evaporated. Section B.2.2.5 presents a more detailed discussion of previous waste disposal practices.

Discharges of waste effluents to the settling basin were discontinued on July 16, 1985. Lost Lake is expected to alternate between dry and wet, depending on precipitation.

Evidence of Contamination

The 1985 analytical results indicate that higher metal concentrations in the soils beneath Lost Lake generally correlate with the average depth of the water. Consequently, the area of the lake that has an elevation less than 102 meters, which is almost always wet, shows the highest levels of inorganic contamination. Concentrations of lead, barium, copper, nickel, manganese, and zinc exceed the M-Area background levels at both the 0.0- to 0.15-meter and the 0.15- to 0.45-meter depths. Concentrations of these metals at the 0.15- to 0.45-meter level are less than the SRP and Southeastern United States background concentrations. Magnesium concentrations are above all reference background levels at the 0.15- to 0.45-meter level. Uranium concentrations within the 102-meter contour are below the detection limit of 10 parts per billion (Colven et al., 1986).

The levels of bis(2-ethylhexyl) phthalate and di-N-butyl phthalate are above detection limits in the soils beneath Lost Lake. Of the three chlorinated hydrocarbons (trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane), only one, tetrachloroethylene, was detected in any Lost Lake soil sample.

Analyses of groundwater samples indicate that Lost Lake is not as great a source of organic or inorganic contaminants as the settling basin.

Waste Characterization

The characteristics of the wastewater discharged to Lost Lake from the settling basin overflow or effluent are similar to those described for the M-Area settling basin in Section B.2.2.5. Sampling results indicate that the contaminant levels in the settling-basin effluent are generally lower than those in its influent. Nitrate concentrations, conductivity, total dissolved solids, and concentrations of most metals (nickel, lead, copper, chromium, magnesium, iron, zinc, and manganese) are lower in the effluent.

B.2.3 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The hydrostratigraphy of the A/M-Area is similar to the generalized hydrostratigraphy discussed in Appendix A with the following exceptions: (1) the "tan clay" is only about 0.9 meter thick and lies in the unsaturated zone; (2) the "calcareous zone" is not present; (3) the "green clay" is discontinuous; (4) the Congaree Formation has fewer separated lenses of clay and lenses of sand; and (5) the Ellenton Formation is mostly a gray, clayey sand or sandy clay that contains plentiful mica and deposits of marcasite or gypsum (Michael, Johnson, and Bledsoe, 1986; Scott, Killian, Kolb, Corbo, and Bledsoe, 1986). As a result of these different geologic features, the subsurface hydrologic characteristics also differ from those described in Appendix A. Because the green clay is less continuous, it does not impede downward water flow as much as in the central part of the Plant. Head changes are more gradual because extensive layers of clay are absent from the Tertiary sediments (Barnwell, McBean, and Congaree Formations). In addition, the potentiometric head of the Tertiary sediments is greater than that of the Middendorf/Black Creek (Tuscaloosa) Formation in the A/M-Area. Therefore, heads decline continuously with depth (Figure B-3), and there is no head reversal at the Congaree-Ellenton boundary as there is in the central part of the Plant. This indicates that the A- and M-Area geographic grouping is located above a potential recharge zone of the Middendorf/Black Creek Formation (Colven et al., 1986).

The water table in the area is mainly within the McBean Formation, although locally it might be within the Barnwell. Natural discharge from the water table is to Tims Branch, the swamps along the Savannah River, and Hollow Creek northwest of the Plant. Figure B-4 is a water-table map for the A/M-Area, based on measurements obtained in July 1984. The water-table gradients in the area range from about 0.002 to 0.008 meter per meter, with the steeper gradients in the direction of Tims Branch. Results from a 30-day pump test in the A/M-Area indicate a transmissivity of 5.3 square meters per day and a storage coefficient of 0.20 for the Tertiary sediments. The test well was screened from a depth of 39.6 to 58 meters below the land surface. The researchers calculated an average hydraulic conductivity of 1.6 meters per day for the Tertiary sediments and a flow velocity ranging from about 5.8 to 22.8 meters per year for gradients of 0.002 to 0.008 meter per meter (Colven et al., 1986).

Laboratory permeability tests were performed on undisturbed samples from the clayey units of the Ellenton and upper Middendorf/Black Creek Formations (Marine and Bledsoe, 1985). The results of these tests indicate a vertical hydraulic conductivity ranging from 4.0×10^{-7} to 5.2×10^{-9} centimeter per second and a horizontal hydraulic conductivity ranging from 5.7×10^{-7} to 1.1×10^{-8} centimeter per second. The effective porosities determined for these samples range from 0.024 to 0.137 (dimensionless). These compare to average effective porosities of 0.20 and 0.30 generally used for the Tertiary sediments and the Middendorf/Black Creek, respectively. Researchers calculated an average vertical flow velocity of 0.4 meter per year across the Ellenton Formation using a hydraulic conductivity of 1×10^{-7} centimeter per second, an effective porosity of 0.07, a hydraulic head difference of 7.3 meters, and an average clay thickness of 12.2 meters (Michael, Johnson, and Bledsoe, 1986).

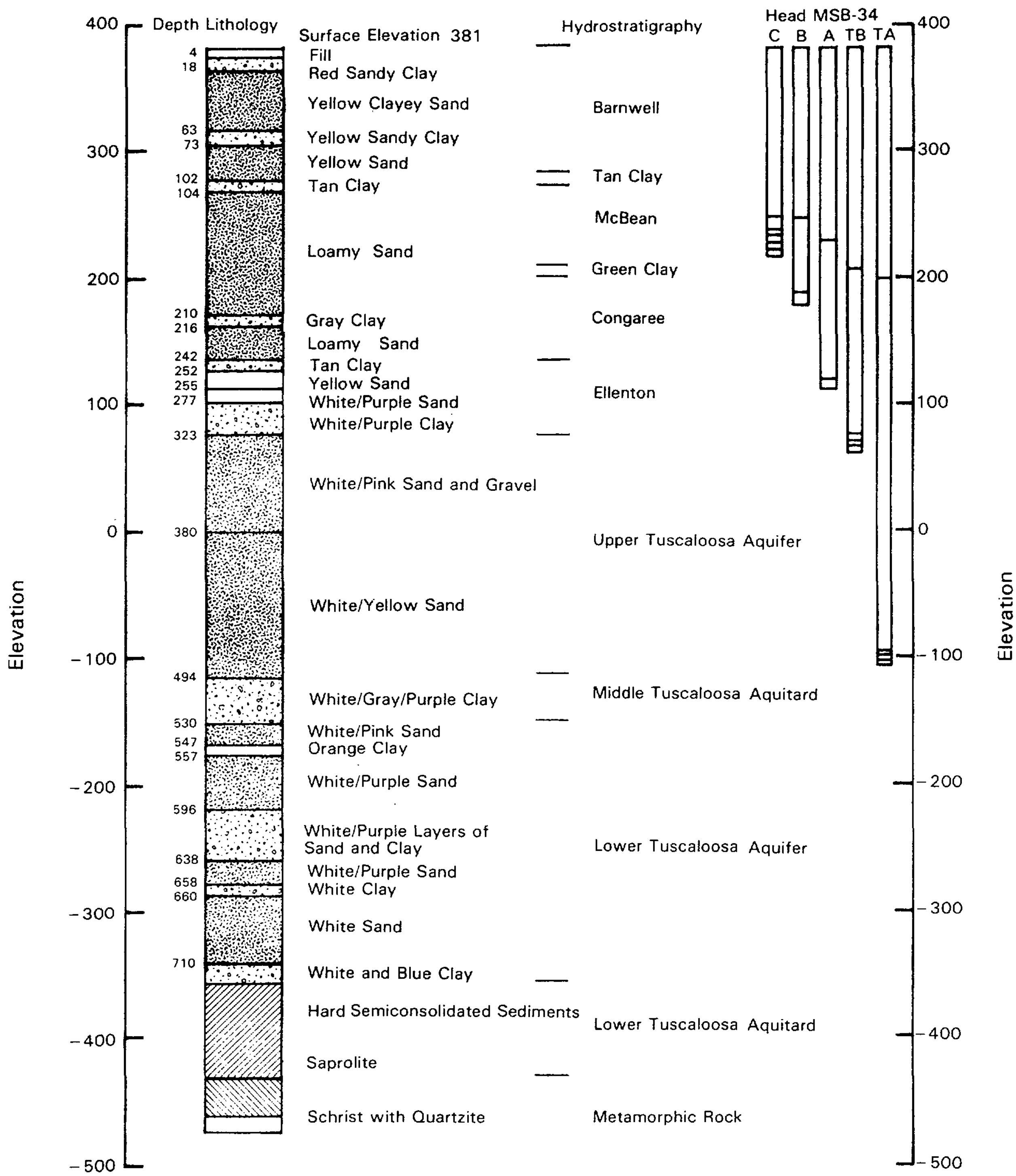
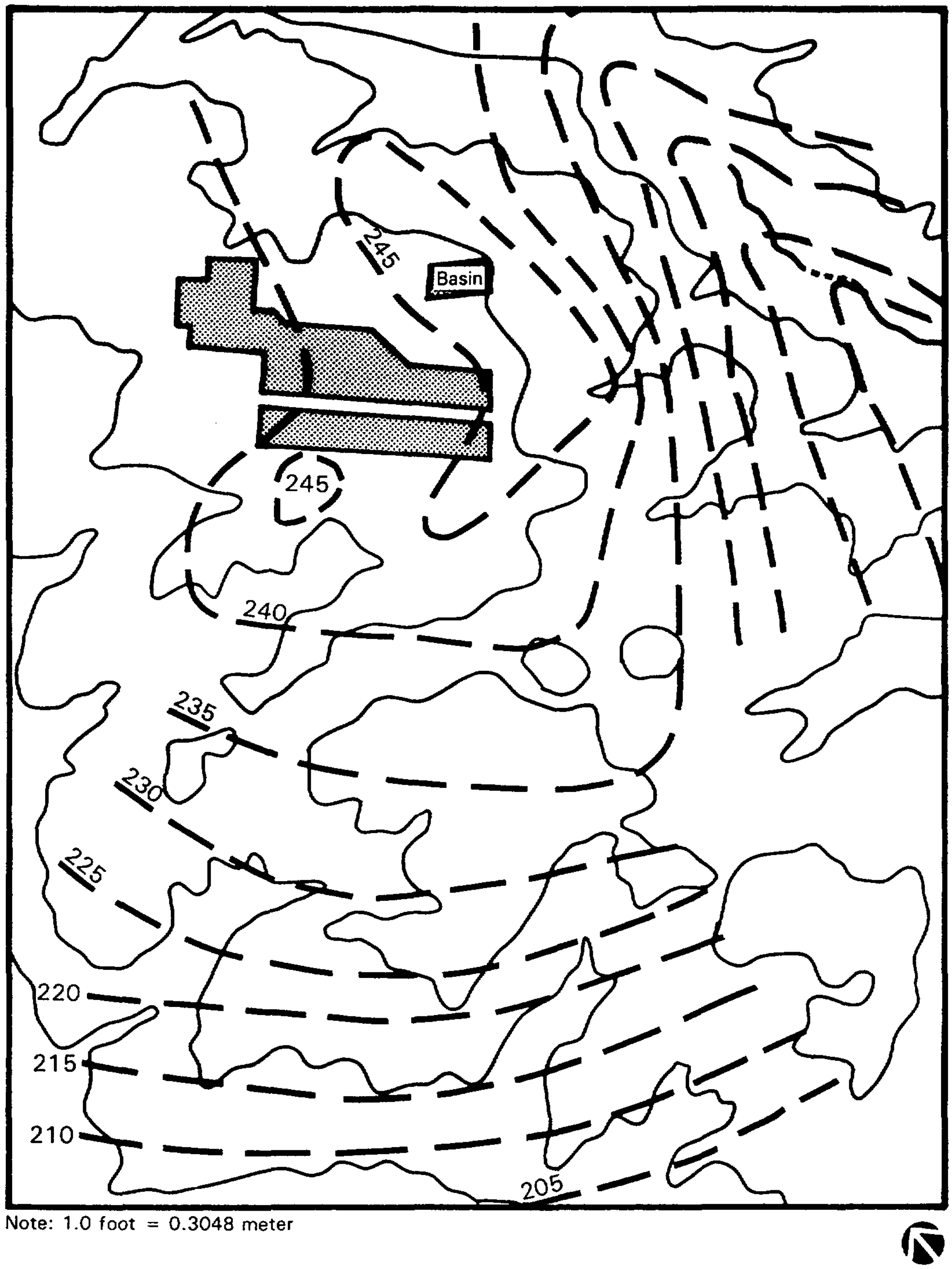


Figure B-3. Geology and Hydrology Near the Center of A- and M-Area (Geology and heads for elevation is above −280 ft. were determined at MSB-34TA; those for −280 to −355 ft. at 905-20A; and those for elevations below −355 ft. at well P8R located at MSB-17)



Note: 1.0 foot = 0.3048 meter

Figure B-4. Water-Table Map for July 1984 (For the data point, the first digit, 200, is omitted to avoid crowding the numbers)

B.2.4 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at the 13 waste management facilities in the A- and M-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and South Carolina Hazardous Waste Management Regulations (SCHWMR) parameters at hazardous and mixed waste management facilities. Typically, wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste-management facilities. At least 55 wells in this geographic area are used to monitor groundwater in the vicinity of the 13 facilities. Additional wells would obtain better definitions of subsurface conditions and any potential contamination.

Waste site characterization programs have been completed at 10 of the waste management facilities and are being implemented at three others. Characterization generally includes representative sampling of the waste, sampling of the soil and sediment under the waste site, and sampling of the soil and sediment around any existing overflow ditches and process sewers.

Table B-7 lists the representative monitoring wells at each waste management facility; the site investigations that have occurred; and the results of groundwater, soil, and vegetation monitoring.

B.3 F- AND H-AREA WASTE SITES

This geographic grouping of waste sites is about 10 kilometers southeast of A-Area. It consists of waste sites associated with the Separations (200-F and -H) Areas, which are just north of Road E. Figure B-5 shows the locations of the waste sites within this grouping. The boundaries are defined primarily by the areas of influence assigned to the F- and H-Area seepage basins, the radioactive waste burial grounds, and the mixed waste management facility. Surface drainage is to Upper Three Runs Creek on the north and to Four Mile Creek on the south.

B.3.1 POTENTIALLY HAZARDOUS WASTE SITES*

B.3.1.1 F-Area Acid/Caustic Basin (904-74G)

The F-Area acid/caustic basin is one of six basins on the SRP. These basins are unlined earthen depressions nominally 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

The acid/caustic basins were built from 1952 to 1955 to provide for mixing and neutralization of dilute sulfuric acid and sodium hydroxide solutions from water treatment facilities before their discharge to local streams.

Dilute sulfuric acid and sodium hydroxide solutions were used to regenerate ion-exchange units in water purification processes, and the spent dilute solutions were discharged to the acid/caustic basins through acid-resistant sewers. Other wastes included water rinses of the ion-exchange units (both

*See discussion of site type on page B-1.

Table B-7. Site Investigations and Monitoring at Waste Management Facilities in the A- and M-Area Geographic Grouping[a]

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
Motor-shop seepage basin (904-110G)	AOB 1 AOB 2	Wells monitored quarterly for RCRA and SCHWMR parameters. Liquid sample from basin has been analyzed. Sediment beneath basin to be characterized.	Trace quantities of following materials present in the basin liquid: • Ethylene glycol • Kerosene • Motor oil • Grease
Metals-burning pit (731-4A)/miscellaneous chemical basin (731-5A)	ABP 1A ABP 2A ABP 3 ABP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Surface soil analysis conducted in January 1986.	Trichloroethylene and tetrachloroethylene found in wells ABP-2A and ABP-3. Surface soil analysis indicates presence of: • Tetrachloroethylene • Trichloroethylene • Trans, 1,2-dichloroethylene
Silverton Road waste site (731-3A)	SRW 1 SRW 2A, 2B SRW 3A SRW 4 SRW 5 SRW 6 SRW 7 SRW 8 SRW 9A, 9B SRW 10 SRW 11 SRW 12A, 12B, 12C SRW 13A, 13B, 13C SRW 14A, 14B, 14C SRW 15A, 15B, 15C SRW 16A, 16B, 16C	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste-site sediment characterization program completed in 1983. Conductivity survey completed.	Groundwater constituents include: • Trichloroethylene • Tetrachloroethylene • 1,1,1-trichloroethane • Chloroform • Barium (Metals not observed • Cadmium in recent surveys) • Chromium • Lead • Iron Waste sediment analysis inconclusive. Soil constituents include: • Trichloroethylene • Tetrachloroethylene • 1,1,1-trichloroethane Conductivity anomalies most likely due to increased clay content or metal objects Statistical analysis of groundwater monitoring data shows the following parameters to be present: • Manganese - source unknown • Total organic halogen • Nitrate
Metallurgical-Lab basin (904-110G)	AMB 1A AMB 2 AMB 3A	Wells monitored quarterly for RCRA and and SCHWMR parameters. Soil and basin-water characterization program completed in 1985.	Sediment samples contain no organic compounds or metals above EPA guidelines. Basin-water samples pass all drinking-water standards except those for pH and iron

Footnotes on last page of table.

Table B-7. Site Investigations and Monitoring at Waste Management Facilities in the A- and M-Area Geographic Grouping[a] (continued)

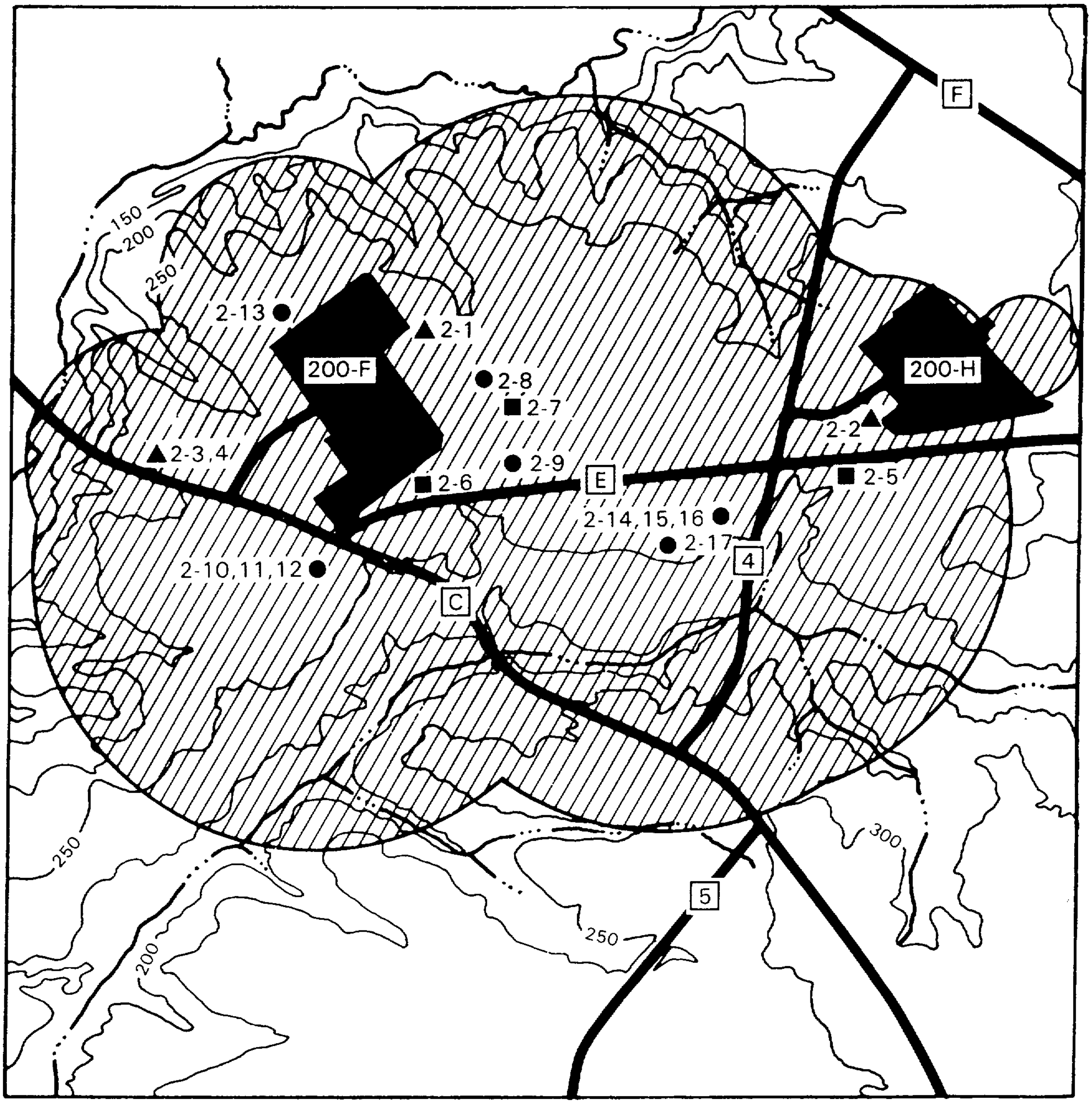
Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES (continued)	
Burning/rubble pits (731-A, 731-1A)	ARP1A ARP2 ARP3 ARP4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste-site sediment characterization program to be initiated.	Statistical analysis of groundwater monitoring data shows the following to be present: • Manganese • Sodium • Sulfate • Nitrate • Copper
		LOW-LEVEL WASTE SITES	
SRL seepage basins [904-53G (two basins), 904-54G, 904-55G]	ABS 1A ABS 2A ABS 3 ABS 4 ABS 5A	Wells monitored quarterly for RCRA and SCHWMR parameters. Seepage basin sediment characterization program completed in 1983.	Statistical analysis of groundwater data indicates the following are present: • Manganese • Sodium • Chloride Trichloroethylene and tetrachloroethylene present in groundwater but might be from another source. Analysis of sediment cores showed the following to be present: • Arsenic - from another source • Cadmium - from another source • Chromium - from another source • Copper - from another source • Fluoride - from another source • Lead • Mercury • Nickel • Phosphate • Silver • Sodium • Americium-241 • Cesium-137 • Cobalt-60 • Curium-243, -244 • Plutonium-238 • Plutonium-239, -240 • Strontium-90 • Uranium-235, -238 • Tritium

Footnotes on last page of table.

Table B-7. Site Investigations and Monitoring at Waste Management Facilities in the A- and M-Area Geographic Grouping[a] (continued)

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		MIXED WASTE SITES	
M-Area settling basin (904-51G) Lost Lake (904-112G)	MSB 1A MSB 2A MSB 3A MSB 4A MSB 5A MSB 6A MSB 7A MSB 8A Additional wells to be installed	Wells monitored quarterly for RCRA and SCHWMR parameters. Initial (1981-1982) waste-site characterization studies examined waste liquid and sludge, as well as soil under basin and in overflow ditch, seepage area, and Lost Lake. Extended characterization program (1984-1985) sought to confirm results of 1981-1982 study and provide additional data to support closure activities.	Statistical analysis of groundwater monitoring data indicates the following are present: • Conductivity • Total dissolved solids • Gross beta • Total organic halogen • pH • Gross alpha • Radium • Chromium • Manganese • Sodium • Nickel • Chloride • Cyanide • Fluoride • Nitrate • Sulfate • Dissolved organic carbon • Phenols • Total organic carbon • Zinc Soil constituents include: • Bisphthalate • Tetrachloroethylene • 1,1,1-trichloroethane • Di-n-octylphthalate • Toluene • Tetrachlorobiphenyl • Pentachlorobiphenyl • Hexachlorobiphenyl • Trichloroethylene • Methylene chloride • Uranium • Lead • Nickel • Copper • Chromium • Barium

[a]Sources: Huber, Johnson, and Bledsoe, 1986; Muska, Pickett, and Marine, 1986; Scott, Killian, Kolb, Corbo, and Bledsoe, 1985; Geraghty and Miller, 1985; Michael, Johnson, and Bledsoe, 1986; Huber, Johnson, and Marine, 1986; Fowler, Simmons, Bledsoe, and Looney, 1986; Colven, Muska, Pickett, and Bledsoe, 1986.
[b]The monitored hydrogeologic unit for these wells is the McBean.
[c]See discussion on page B-1.



Note: Elevations are in feet above mean sea level 1.0 foot = 0.3048 meter

Legend on following page

Scale (kilometers)
0 1 2

Figure B-5. F- and H-Area Waste Sites

Number	Potential Waste Type	Site Name	Building Number
2-1	▲	F-Area Acid/Caustic Basin*	904-74G
2-2	▲	H-Area Acid/Caustic Basin*	904-75G
2-3	▲	F-Area Burning/Rubble Pit*	231-F
2-4	▲	F-Area Burning/Rubble Pit*	231-1F
2-5	■	H-Area Retention Basin	281-3H
2-6	■	F-Area Retention Basin	281-3F
2-7	■	Radioactive Waste Burial Ground	643-7G
2-8	●	Mixed Waste Management Facility	643-28G
2-9	●	Radioactive Waste Burial Ground	643-G
2-10	●	F-Area Seepage Basin	904-41G
2-11	●	F-Area Seepage Basin	904-42G
2-12	●	F-Area Seepage Basin	904-43G
2-13	●	F-Area Seepage Basin (old)	904-49G
2-14	●	H-Area Seepage Basin	904-44G
2-15	●	H-Area Seepage Basin	904-45G
2-16	●	H-Area Seepage Basin	904-46G
2-17	●	H-Area Seepage Basin	904-56G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive
●—Mixed

Figure B-5. F- and H-Area Waste Sites (continued)

before and after regeneration), steam condensate from the heater in the sodium hydroxide storage tanks, and rain that collected in the storage tank spill containment enclosures. The F-Area Basin remained in service until in-process neutralization facilities became operational in 1982. All of the acid/caustic basins, including that of F-Area, are now inactive.

Evidence of Contamination

Work to identify the environmental impacts of the basins is in progress. A program to sample the contents and the soils beneath the basins is under way. Review of existing data from the monitoring wells installed around the basins shows no significant impacts on groundwater quality (Ward, Johnson, and Marine, 1986).

Waste Characterization

Limited data are available on the extent of contamination and characteristics of the wastes involved at this site. Data have been gathered via groundwater monitoring and soil sampling. Data collected to date reveal no indication of contamination.

Analytical results of the characterization program indicate elevated levels of chromium, mercury, lead, phosphate, copper, sodium, sulfate, barium, and selenium in the sediment sampled from one or more of the basins. Results of EP toxicity tests performed on the basin sediment samples from each of the basins indicate that all concentrations of each of the metals analyzed are below 1 percent of the maximum concentrations provided by the EPA (40 CFR 261.24).

B.3.1.2 H-Area Acid/Caustic Basin (904-75G)

The H-Area acid/caustic basin is one of six such basins in the Reactor and Separations Areas. These basins are unlined earthen depressions nominally 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

See Section B.3.1.1. The H-Area basin remained in service until in-process neutralization facilities became operational in 1982.

Evidence of Contamination

Groundwater monitoring wells have not been installed around the H-Area basin.

Waste Characterization

Limited data are available pertaining to any sampling or monitoring program associated with the H-Area acid/caustic basin.

B.3.1.3 F-Area Burning/Rubble Pits (231-F and 231-1F)

The F-Area burning/rubble pits are in the northwest portion of the Plant, west of F-Area and east of Road C. The configuration of the pits is approximately that of a parallelogram, each being 84 meters long, 23 meters wide, and 3 meters deep.

History of Waste Disposal

See Section B.2.1.6. Rubble disposed of at this site reportedly includes concrete, metal, lumber, and telephone poles.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

B.3.2 LOW-LEVEL RADIOACTIVE WASTE SITES

B.3.2.1 H-Area Retention Basin (281-3H)

The H-Area retention basin is southwest of the H-Area perimeter fence (Scott, Killian, Kolb, Corbo, and Marine, 1986). It is at the lip of a slope leading to a tributary of Four Mile Creek at an elevation of 81 meters. It is 36.3 meters long, 61 meters wide, and 2.1 meters deep. Its volume is 8.53×10^4 liters.

The basin is on the Four Mile Creek side of the water-table divide (Scott, Killian, Kolb, Corbo, and Marine, 1986). The groundwater beneath it migrates toward the tributary of Four Mile Creek that flows toward H-Area. The average water-table gradient from the basin to this tributary is 0.03 meter per meter.

The H-Area retention basin is fenced but not backfilled, and it is surrounded by vegetation.

History of Waste Disposal

The retention basins in the Separations Area were used from 1955 to 1973 (Scott, Killian, Kolb, Corbo, and Marine, 1986). The basins are currently not in use. These open, unlined basins provided temporary storage for potentially contaminated cooling water and contaminated storm water from the waste tank farms and, therefore, kept wastewater from discharging into nearby streams. When radioactivity was encountered in the cooling water or storm water, such water was immediately diverted from surface drainage streams to the retention basins. Leaks of process material to cooling water and spills of radioactive waste to the storm sewer could have caused the contamination. During the holding period, some water seeped into the ground. The exact quantities of water disposed of in the retention basins are unknown.

Evidence of Contamination/Waste Characterization

In 1977, researchers performed radiological surveys of soil and vegetation around the H-Area retention basins (Scott, Killian, Kolb, Corbo, and Marine, 1986). Radiation above guidelines was measured at levels up to 90 millirads per hour near the edge of the basin. Vegetation near the basin exhibited cesium-137 at 8200 to 8900 picocuries per gram and strontium-89 and 90 at 58,000 picocuries per gram. No guidelines are issued for vegetation. An area of approximately 930 square meters has shown levels of radioactivity.

B.3.2.2 F-Area Retention Basin (281-3F)

The F-Area retention basin is outside and south of the F-Area perimeter fence and east of Building 281-8F. The basin is in an area of level topography on the Aiken Plateau at an elevation of 82 meters above sea level. Surface drainage from the surrounding area flows to Four Mile Creek, about 1200 meters away. The slopes toward Four Mile Creek are very gentle in the vicinity of the basin, but they become progressively steeper approaching the creek. The basin is rectangular, with dimensions of 36.6 by 61 by 2.1 meters. Its volume is 8.53×10^4 liters (Scott, Killian, Kolb, Corbo, and Marine, 1986).

The retention basin is on the Four Mile Creek side of the water-table divide. Groundwater beneath the basin migrates toward the creek. The average water-table gradient from the basin to Four Mile Creek is 0.009 meter per meter.

History of Waste Disposal

The F- and H-Area retention basins have similar disposal histories (see Section B.3.2.1); however, F-Area was excavated to 0.6 meter from the original floor of the basin, backfilled with dirt, and covered with grass.

Evidence of Contamination/Waste Characterization

During the latter part of 1978, approximately 994 cubic meters of contaminated soil containing about 11.5 curies of cesium-137 and 0.5 curie of strontium-90 was removed from the F-Area retention basin and transported to the burial ground.

An analysis, performed in 1979, determined that most of the cesium-137 in the basin floor was in the top 30 centimeters of soil, while there were concentrations of strontium-89 and 90 at depths to 180 centimeters. Of the remaining basin soil, core samples revealed about 0.05 curie of cesium-137 and 1.3 curies of strontium-90.

B.3.2.3 Present Radioactive Waste Burial Ground (643-7G)

The present radioactive waste burial ground (643-7G) is between the F and H Separations Areas (Figure B-5). The burial ground is an area of approximately 63 acres consisting of trenches and greater confinement boreholes and pads used for the storage or disposal of low-level, intermediate-level, and transuranic (TRU) solid waste. The mixed waste management facility (643-28G), a site of approximately 56 acres used for the disposal of candidate mixed wastes, is completely within the boundaries of 643-7G. The total combined area (643-7G and 643-28G) is 119 acres. Section B.3.3.1 discusses the mixed waste management facility. This section discusses the history of disposal, evidence of contamination, and waste characteristics (Jaegge et al., 1986) at 643-7G.

History of Waste Disposal

The present burial ground (643-7G) has received wastes for disposal since April 1986. Bulky low- and intermediate-level wastes are disposed of in trenches 6 meters wide, up to 300 meters long, and 6 meters deep. The trenches are backfilled with a minimum of 1.2 meters of soil. These trenches are the shallow-land burial (SLB) type.

Since 1970, intermediate-level waste has been placed in GCD boreholes for storage; since mid-1984, low-level waste has been containerized in metal boxes and stored in engineered low-level trenches (ELLTs). Transuranic waste contaminated to greater than 10 nanocuries per gram is stored on concrete pads at ground level and covered with 1.2 meters of soil. This waste is also containerized.

Evidence of Contamination

Groundwater contamination at the combined 643-7G and 643-28G area is monitored with 23 research wells installed in 1980. The groundwater beneath the monitored portion of 643-7G and 643-28G contains an estimated 1 millicurie of nonvolatile beta emitters and 0.5 millicurie of alpha emitters. Tritium measurements suggest a total volume of tritium beneath the monitored area of 5600 curies.

The burials of tritium waste in the unmonitored eastern portion of 643-28G suggest that a plume of tritium will develop in the groundwater in that area and subsequently flow toward 643-7G.

Nonradioactive chemical species have been monitored in groundwater at 643-G and 643-7G (Jaegge et al., 1986). Detected constituents are mercury, cadmium and lead.

Waste Characterization

Examples of the materials that have been stored or might be disposed of in 643-7G include the following:

- Contaminated equipment
- Reactor hardware and resins
- Spent lithium-aluminum targets
- Incidental waste from laboratory and production operations
- Shipments from off the site

B.3.3 MIXED WASTE SITES

B.3.3.1 Mixed Waste Management Facility (643-28G)

The mixed waste management facility (MWMF) is near the F- and H-Area separations facilities (Figure B-5). With an area of approximately 56 acres, the MWMF consists of a number of individual trenches that were used for the disposal of candidate mixed wastes. The trenches are within the boundaries of a much larger facility (643-7G) known as the radioactive waste burial ground.

History of Waste Disposal

The MWMF received wastes from 1972 to March 1986. Candidate mixed wastes are disposed of in SLB trenches that are generally about 6 meters wide and 6 meters deep and have variable lengths up to 370 meters. The trenches, separated by about 3 meters, were backfilled daily during landfilling activities. See Section B.3.2.3.

Evidence of Contamination

Hazardous constituents have been identified at the boundaries of 643-7G and 643-28G. However, it has not been determined which of the waste management facilities is the source of these constituents. A monitoring program has been proposed to determine the presence and extent of groundwater contamination. Monitoring was performed during the characterization of the combined radioactive waste burial grounds (643-7G).

Waste Characterization

Candidate mixed wastes placed in the MWMF trenches consist of scintillation fluids and waste oil. The oil originated from pumps in the tritium facilities and reactor areas. Before storage, the waste oil was placed in 208-liter drums containing an absorbent material. Other wastes stored include lead shielding, cadmium, and incidental waste from laboratory and production operations. The mobility and rate of migration of these wastes have not been determined.

B.3.3.2 Old Radioactive Waste Burial Ground (643-G)

The radioactive waste burial ground (643-G) is between the F and H Separations Areas (Figure B-5). The disposal site occupies a 76-acre area and is approximately 10 kilometers from the nearest Plant boundary. The following sections describe the history of waste disposal, evidence of contamination, and waste characteristics at the site. Section B.3.2.3 discusses the newer burial ground (643-7G), which currently receives low-level radioactive wastes (Jaegge et al., 1986).

History of Waste Disposal

This burial ground is a central site used for the disposal of solid radioactive waste.

The older burial ground began to receive waste in 1952 and was filled in 1972. It was divided into sections for accommodating various levels and types of radioactivity in waste materials: TRU alpha waste, low-level waste (alpha and beta-gamma), intermediate-level beta-gamma waste (intermediate- and low-level beta-gamma solid radioactive wastes are segregated according to radiation measurement), and waste generated off the site. The burial ground was operated in compliance with U.S. Atomic Energy Commission (AEC) regulations and DOE Orders regarding radioactive waste disposal. Inorganic constituents such as lead (used to shield a variety of waste forms), mercury (from gas pumps in tritium facilities), and cadmium (from control rods) have been placed in the burial ground.

Evidence of Contamination

Past SRP burial practice resulted in direct contact between waste and soil in near-surface backfilled trenches. The annual average gross alpha concentration for all but one research well has been approximately constant and fairly low, 1 to 9 picocuries per liter (background level), since 1974. The average gross nonvolatile beta concentration increased in 1984 after having been fairly low and constant for the previous 5 years. Since 1974, the annual average gross nonvolatile beta concentrations have ranged from 13 to 76 picocuries per liter. One research well at the site remains considerably higher in gross alpha (231 picocuries per liter) and gross nonvolatile beta (15,453 picocuries per liter) activity than the other wells. The alpha and beta emitters present in this research well have been identified as primarily plutonium-238, plutonium-239, and strontium-90. The observed variations in concentration are under investigation to determine mechanisms.

Tritium is also found at the burial ground research wells but at much higher concentrations and in larger zones of contamination. The average tritium concentration rose in 1984 to 87.5 million picocuries per liter, more than twice the 1983 value, thus returning to levels observed in 1978, 1980, and 1981. Monitoring has also yielded evidence of nonradioactive chemical species. In 1984, a maximum concentration of 2.9 parts per billion of mercury was observed.

The estimated total activity of radionuclides in the groundwater beneath the 643-G burial grounds is 2.5 millicuries of alpha emitters, 16 millicuries of nonvolatile beta-gamma emitters, and 38,600 curies of tritium. As these data indicate, tritium, in contrast to alpha and nonvolatile beta emitters, is readily leached and moves freely with groundwater flow.

During the time the tributylphosphate-kerosene extraction solvents were stored in underground tanks, approximately 1600 liters of solvent were released to the groundwater as a result of tank leaks and process upsets. Some of the fission and activation products measured in monitoring wells are attributed to this source. Also, the decontamination of equipment with complexing agents might be responsible for the migration of nuclides to several research wells. See Section B.3.2.3.

Waste Characterization

Materials that have been disposed of at the burial ground include (1) contaminated equipment from the radiochemical Separations Area, (2) reactor hardware and resins, (3) spent lithium-aluminum targets, (4) oil from pumps in the tritium facilities and reactor areas, (5) mercury from gas pumps in the tritium facilities (approximately 9000 kilograms), (6) incidental waste from laboratory and production operations, (7) tritiated waste received from the Mound Laboratory, (8) plutonium process wastes from other DOE facilities, and (9) debris from U.S. military plane accidents.

Mechanisms that affect the mobility of radionuclides in groundwater are under investigation. The most likely mechanisms are (1) complex formation with organics, carbonate, and phosphate; and (2) competitive cation exchange with the soil, for groundwaters with high conductivity and high concentrations of various cations. Other conditions that might increase radionuclide migration are abnormal pH, low Eh or dissolved oxygen, and high iron concentrations.

B.3.3.3 F-Area Seepage Basin (904-41G)

Seepage basin 904-41G is one of three currently operating basins in F-Area (Figure B-5). Wastewater flowing to the basins enters basin 1 (904-41G) through a single underground pipe. It flows from basin 1 to basin 2 (904-42G) and then to basin 3 (904-43G) through underground pipelines. This section discusses the history of disposal, evidence of contamination, and waste characteristics common to all three operating basins (Killian et al., 1986a).

History of Disposal

The F-Area separations facility has released wastewater to the basins since startup in 1955. The discharges include low-level radioactive and chemical wastewaters. The purpose of the basins is to provide a controlled release and appropriate decay time for tritium and to retain other radionuclides. The three F-Area seepage basins cover an area of approximately 5.5 acres and have a capacity of about 7.6×10^7 liters. Basin 1 has side dimensions of 27 by 84 meters and a capacity of about 3.8×10^6 liters.

Evidence of Contamination

One-meter soil cores have been collected from the bottoms of the F-Area seepage basins. The cores, which were collected at two or three locations per basin, were divided into 0.15-meter intervals for analysis of the 16 radionuclides and 25 cations and anions listed in Table B-8. Approximately 90 percent of the radionuclides, cations, and anions are contained within the top 0.3 meter of the basin soils. All radionuclides listed in Table B-8 except cerium-141 were observed in the soil cores. Curium-244, cobalt-60, cerium-144, ruthenium-103, and strontium-89 were present infrequently. Silver, beryllium, lead, selenium, tungsten, cyanide, and nitrites were not observed in the cores. Chromium, iron, fluorine, manganese, sodium, nitrate, and titanium were found frequently. The remaining cations and anions were observed less frequently.

In March 1985, a well downgradient from the seepage basins was sampled for RCRA Appendix VIII parameters. This well was believed to be the most contaminated downgradient well. The only detected parameters were the following: selenium, barium, cadmium, and nickel. Since 1981, the highest alpha, nonvolatile beta, and tritium concentrations in monitoring wells have been 2700 picocuries per liter, 160,000 picocuries per liter, and 36 million picocuries per liter, respectively.

In the fall of 1984, 13 new groundwater monitoring wells were installed at the F-Area seepage basins. The well clusters are screened in the Barnwell, McBean, and Congaree aquifers. The wells were sampled first in March and April of 1985. The analyses show that, as expected, the highest levels of contamination are in the shallow water-table wells.

Strontium has been emerging in Four Mile Creek from the F-Area basins since 1964. The amount entering the creek annually is about 2 percent of the groundwater strontium inventory in F-Area. Maximum strontium-90 concentrations in groundwater and emergent seep lines range from 0.014 to 0.34 microcurie per liter (Christensen and Gordon, 1983). Alpha activity in groundwater between the basins and Four Mile Creek in the Separations Areas is attributed mainly to uranium discharged to the basins, plus a small amount of natural radioactivity. Alpha concentrations in F-Area groundwater and seep lines range from 1.4×10^{-5} to 6.5×10^{-3} microcurie per liter. Only tritium, strontium-90, and uranium have been detected routinely in groundwater between

Table B-8. Parameters Analyzed in the F- and H-Area Basins Sediment-Characterization Study[a]

Radionuclides	Cations and anions	Cations and anions
Tritium	Arsenic	Nickel
Cobalt-60	Barium	Selenium[b]
Strontium-89, -90	Beryllium[b]	Silver[b]
Niobium-95	Bismuth	Sodium
Zirconium-95	Boron	Tin
Technetium-99	Cadmium	Titanium
Ruthenium-103, -106	Chromium	Tungsten[b]
Iodine-129	Copper	Zinc
Cesium-134, -137	Iron	Nitrates
Cerium-141,[b] -144	Lead[b]	Cyanide
Thorium-232	Lithium	Fluoride
Uranium-233, -235, -238	Mercury	Nitrites[b]
Plutonium-238, -239	Manganese	
Americium-241		
Curium-244		
Promethium-147		

[a]Source: Killian et al., 1986a.
[b]Not found.

seepage basins in the Separations Areas and Four Mile Creek in concentrations greater than 10 times the natural background levels.

In 1968 and 1969, intensive groundwater monitoring studies of nitrate levels found values ranging from 100 to 300 milligrams per liter in F-Area, as opposed to concentrations of 3 milligrams per liter in natural groundwater. Values of pH were found to be in the range of 4 to 6 in the basin vicinity. Results of an April 1984 terrain conductivity survey at the F-Area seepage basins to determine areas of potential contaminant migration correlate well with the nitrate studies performed in the late 1960s; however, a new plume was suspected west of basin 3.

Waste Characterization

The primary sources of the effluent being discharged to the basins from the F-Area separations facility are the nitric acid recovery unit, the general-purpose evaporator overheads, the two waste tank farm evaporator overheads, and the overheads of several other process evaporators. Retention basin transfers are another source. The monitor upstream from basin 1 measures flows to the F-Area seepage basins and takes wastewater samples. The average daily flow into the basins for 1985 (January through June) was 364,800 liters per day.

The F-Area separations facility routinely has released wastewater containing nitrates to the seepage basins since startup in 1955. Release rates vary, but they average 234,300 kilograms per year, as measured from 1961 to 1970, in 1975, and in 1983.

F-Area operations sometimes use mercury to aid in dissolving aluminum-alloy fuels. The sodium hydroxide used in F-Area also contains trace amounts of mercury as an impurity. Most of the mercury is retained in high-level waste tanks, but some is discharged to the basins via evaporator overheads. An estimated 380 kilograms of mercury-contaminated wastewaters were released to the F-Area basins between 1955 and 1970. Between 1971 and the end of 1984, 61 kilograms of mercury were released to the basins.

In a 1983 influent characterization study, the waste stream entering the F-Area seepage basins was sampled nine times between September and December to obtain the concentrations of various chemical constituents. Table B-9 lists the results of that study. For the radionuclides, the number of curies conveyed to the seepage basins in 1982 and 1983 and the volume of effluent were used to calculate the average concentrations.

B.3.3.4 F-Area Seepage Basin (904-42G)

See Section B.3.3.3. Basin 2 (904-42G) is 27 by 161 meters with a capacity of 7.2×10^6 liters.

B.3.3.5 F-Area Seepage Basin (904-43G)

See Section B.3.3.3. Basin 3 (904-43G) has dimensions of 92 by 218 meters and a capacity of 5.3×10^7 liters.

B.3.3.6 F-Area Seepage Basin - Old (904-49G)

Seepage basin 904-49G in F-Area (Figure B-5) measures 59.4 by 91.4 meters. A berm about 1.5 meters wide at the top and about 12.2 meters wide at the bottom separates the basin into two compartments. The following sections describe the history of waste disposal, evidence of contamination, and waste characteristics at the seepage basin (Odum, Fliermans, and Marine, 1986).

History of Waste Disposal

Basin 904-49G, constructed in 1954, was the first seepage basin used on the Plant. It received wastewater from F-Area from November 1954 until mid-May 1955. The seepage rate from this basin proved to be inadequate to handle the increasing volumes of wastewater from F-Area separations operations; thus, three additional basins were constructed in 1955 and routine use of the 904-49G basin was stopped. The basin has been used intermittently since 1955 to divert rainfall runoff or process water from Outfall F-2. Preceding sections discussed the three basins that replaced 904-49G.

Currently, the basin has an accumulation of rainwater with a maximum estimated depth of less than 45 centimeters. Before the summer of 1985, very little water remained in the basin; the total estimated volume was less than 567,000 liters. Current estimates indicate that the basin is seeping very slowly and acting much like a "wet weather pond," with the level increasing during rainy weather and decreasing during periods of low rainfall and high evaporation.

Table B-9. F-Area Seepage-Basin Influent Characteristics[a]

Constituent	Average concentration (mg/liter except for pH)	Constituent	Average concentration (pCi/liter)
Sodium	790	Am-241	308
Calcium	0.5	Ce-141	1,540
Iron	1.7	Ce-144	1,540
Ammonium	24	Cm-242	154
Barium	0.01	Cs-134	6,200
Aluminum	0.78	Cs-137	62,000
Nitrate	1220	I-131	15,400
Carbonate	131	Nb-95	62,000
Nitrite	2	Pm-147	7,690
Chloride	1.2	Pu-238	308
Sulfate	4.6	Pu-239	308
Phosphorus	2.2	Ru-103	30,800
pH	2.93	Ru-106	308,000
Lead	0.12	Sr-89	3,080
Mercury	0.004	Sr-90	6,200
Chromium	0.013	Tritium[b]	1.02×10^{8} [c]
Copper	0.010	U-235	2080
Fluoride	1.5	U-238	2080
Zinc	0.3	Zr-95	62,000

[a]Source: Killian et al., 1986a.
[b]Not included in this specific study; concentration is an approximation based on 1983 data.
[c]Rounded value.

Evidence of Contamination

Recent sediment samples have been collected from the basin. Samples were collected from 41 different but unknown locations throughout the basin in June 1955. Four monitoring wells have been drilled around the basin; the most recent was installed in late 1984 and sampled during the first quarter of 1985. Sampling results for these wells indicate the presence of conductivity, turbidity, barium, chromium, copper, manganese, lead, zinc, fluoride, nitrate, gross alpha, and gross beta. Statistically significant differences between upgradient and downgradient wells for pH, conductivity, nitrate, barium, manganese, sodium, lead, gross alpha, and gross beta were observed.

Waste Characterization

See Section B.3.3.3.

During the operation of basin 904-49G, the wastes would have been sampled for radioactivity. Much of the waste probably was transferred directly to the seepage basin regardless of its chemical content.

The total radioactivity discharged to the basin has been estimated at 1.18 curies. This estimate was based on gross alpha and gross beta measurements and discharge volumes. Estimates of nonradioactive chemical releases (Table B-10) range from less than 19 kilograms of copper and 8 kilograms of nitrite to about 27,000 kilograms of nitrate.

Table B-10. Estimated Nonradioactive Chemical Releases to Basin 904-49G[a]

Cation/anion	Release (kg)
Ammonium	29
Calcium	193
Magnesium	92
Sodium	1,111
Iron	550
Copper	<19
Aluminum	72
Lead	<72
Zinc	180
Chloride	53
Nitrite	7.9
Nitrate	27,000[b]
Sulfate	886
Phosphate	48
Chromium	<72

[a]Source: Odum, Fliermans, and Marine, 1986.
[b]Rounded value.

B.3.3.7 H-Area Seepage Basin (904-44G)

Seepage basin 904-44G is one of four seepage basins in H-Area (Figure B-5). Currently, basins 1 (904-44G), 2 (904-45G), and 4 (904-56G) are in operation. Basin 3 (904-46G) has been inactive since 1962. The wastewater flowing to the basins enters through a single underground pipeline into basin 1. It travels from basin 1 to basin 2 and then to basin 4 through underground pipelines. This section discusses the history of disposal, evidence of contamination, and waste characteristics common to all four basins (Killian et al., 1986b).

History of Waste Disposal

The operating H-Area seepage basins receive low-level radioactive wastewaters from the H-Area separations facility. The purpose of these basins is to provide a controlled release and appropriate decay time for tritium and to retain other radioactive materials in the soil. The four H-Area basins cover an area of approximately 13.8 acres. Discharges to basins 1, 2, and 3 began in 1955.

In 1962, discharges to basin 3 stopped and the use of basin 4 began. Basins 1, 2, and 4 have a total capacity of about 1.3×10^8 liters while maintaining 0.6 meter of freeboard. Basin 1 has side dimensions of 28 by 75 meters and a volume of 3.8×10^6 liters.

Evidence of Contamination

Several studies performed at the F- and H-Area seepage basins to characterize the soil indicate that cesium is retained well by sediments at the Plant, and that none has migrated far enough to be detected in groundwater between seepage basins in the Separations Areas and Four Mile Creek. Plutonium is retained higher up in SRP soils than cesium; sampling of F-Area basin 3 soil in 1971 to a depth of 3.0 meters showed that more than 99 percent of the plutonium is retained in the top 20 centimeters of soil, with a maximum concentration of 1.7 nanocuries per gram.

One-meter soil cores have been collected from the bottoms of the H-Area seepage basins. Cores collected at two to five locations per basin were divided into 15-centimeter intervals for analysis for 16 radionuclides and 25 cations and anions (Table B-9). Approximately 90 percent of all the detected radionuclides, cations, and anions except tritium and nitrate are contained within the top 0.3 meter of soil. With the exceptions of cerium-144, strontium-89, niobium-95, and zirconium-95, all radionuclides listed in Table B-9 were detected in the soil samples; ruthenium-103 was detected in only two samples. With the exceptions of beryllium, cadmium, and selenium, all cations and anions listed in the table were detected in the soil samples; silver, arsenic, cyanide, tungsten, and mercury were detected in only a few samples.

Quarterly groundwater monitoring, in compliance with RCRA and SCHWMR, began in the first quarter of 1982 with seven water-table wells near the H-Area seepage basins. An evaluation of the data for the first five quarters shows that the following parameters are probable groundwater contaminants because of their elevated levels in the basin influents and the consistency of groundwater data: pH, specific conductivity, total dissolved solids, mercury, sodium, nitrate, gross alpha, gross beta, and radium.

Groundwater monitoring for radioactivity parameters has been performed since Plant operations began. Results of alpha measurements for the past several years have shown that the highest concentrations (1.1 to 49.0 picocuries per liter) of alpha emitters are near basins 1 and 2. The highest nonvolatile beta concentrations (48 to 8500 picocuries per liter) are near and downgradient from basins 1, 2, and 3. Tritium concentrations are highest (1 million to 50 million picocuries per liter) near and downgradient from basins 1, 2, and 3.

In the fall of 1984, SRP installed 21 new groundwater monitoring wells at the H-Area seepage basins to characterize contaminant migrations. The well clusters are screened in the water-table, Barnwell, McBean, and Congaree aquifers. Regular quarterly sampling began in March and April 1985. Samples were analyzed for tritium, nitrate, sodium, chromium, cadmium, and mercury. The analyses show, as expected, that the highest levels of contamination are in the shallow water-table wells. However, at one well, elevated levels of tritium, nitrate, and sodium were detected in the Congaree aquifer beneath the green clay. According to the results from the other wells screened in the

Congaree, the green clay is a significant barrier to vertical contaminant migration.

Only tritium, strontium-90, and uranium have been detected routinely in groundwater between the seepage basins in the Separations Area and Four Mile Creek in concentrations greater than 10 times the natural background. Beta activity in groundwater at H-Area is attributed mostly to strontium. Although tritium moves at the same velocity as the groundwater, strontium moves slower than the groundwater because of the ion-exchange characteristics of the soil. Maximum strontium-90 concentrations in groundwater and emergent seep lines range from 5.5×10^{-5} to 1.8×10^{-3} microcurie per liter. Alpha activity in groundwater between the basins and Four Mile Creek in the Separations Areas is attributed mostly to uranium discharged to the basins, plus a small amount of natural radioactivity.

In 1968 and 1969, intensive groundwater monitoring studies of nitrate levels found values ranging from 100 to 250 milligrams per liter at H-Area, compared with concentrations of 3 milligrams per liter in natural groundwater. Also, pH values were found to be in the range of 4 to 6 in the basin vicinity. Results of an April 1984 terrain conductivity survey at the H-Area seepage basins to determine areas of potential contaminant migration correlate well with nitrate studies conducted in the late 1960s.

Special studies have been performed to characterize any potential transport of mercury from the H-Area seepage basins. Most of the mercury released to the basins is accounted for in the basin soil. However, data on mercury in soils from the outcrop along Four Mile Creek, in bottom sediments, and in suspended solids from the creek show that mercury from the H-Area basins is migrating into the creek, but in extremely small quantities. The only measurement of the outcropping of mercury into Four Mile Creek, made in 1971, showed 0.53 gram per day above the outcrop region and 0.89 gram per day below the outcrop, indicating that the basins were contributing about 0.36 gram per day. In a 1984 study, mercury was not observed in the water column at Four Mile Creek sites downstream from the F- and H-Area seepage basins. All mercury concentrations at the Four Mile Creek sites were less than 0.2 part per billion.

Waste Characterization

Primary sources of the wastewaters being discharged to the basins are the nitric acid recovery unit overheads, the general-purpose evaporator overheads, and the overheads of the two waste tank farm evaporators. Other sources of effluent are the cooling water from the tritium facilities, the water transferred from the retention basin, and the wastewater from receiving basins for offsite fuel. The Trebler monitor upstream from basin 1 measures flows to the H-Area seepage basins and takes wastewater samples. The average daily flow into the basins for 1985 (January through June) was 490,000 liters per day.

Table B-11 summarizes an influent characterization study done in 1983. The waste stream entering the H-Area seepage basins was sampled 11 times between September and December of that year to determine the concentrations of those chemicals listed in the table. For each radionuclide, the number of curies sent to the seepage basins in 1982 and 1983 and the volume of effluent were used to calculate the average concentration.

Table B-11. H-Area Seepage Basins Influent Characteristics[a]

Constituent	Average concentration (mg/liter, except pH)	Constituent	Average concentration (pCi/liter)
Sodium	17.6	Am-241	13
Calcium	28.0	Ce-141	3,333
Iron	5.1	Ce-144	17,333
Zinc	3.1	Cm-242	6.7
Ammonia	8.0	Cm-244	6.7
Barium	0.08	Co-58	6,670
Potassium	1.0	Co-60	6,670
Aluminum	3.2	Cr-51	33,300
Manganese	0.560	Cs-134	10,000
Magnesium	1.3	Cs-137	60,000
Nitrate	538.0	I-131	3,333
Carbonate	47.0	Nb-95	13,300
Nitrite	1.0	Pm-147	10,000
Chloride	1.1	Pu-238	60
Sulfate	3.9	Pu-239	40
Fluoride	0.1	Ru-103	50,000
Silicon	6.3	Ru-106	50,000
Phosphorus	0.6	Sb-124	1,333
pH	2.37	Sb-125	1,333
Lead	0.18	Sr-89	3,300
Mercury	0.043	Sr-90	6,670
Chromium	0.072	Sr-95	6,670
Copper	0.43	Tritium[b]	6.0×10^{7}[c]
		U-235	33
		U-238	33
		Zr-65	6,670

[a]Source: Killian et al., 1986b.
[b]Not included in this specific study; concentration is an approximation tion based on 1983 data.
[c]Rounded value.

The H-Area separations facility routinely has released wastewaters containing nitrates to the seepage basins since startup in 1955. Nitric acid is the major source of nitrates released to the basins. Release rates vary, but they average 220,000 kilograms per year, according to measurements made from 1961 to 1970, in 1975, and in 1983.

Typically, the F- and H-Area basins also receive 90,800 kilograms of sodium hydroxide annually. Before mid-1982, 5450 kilograms of phosphoric acid and 544 kilograms of sodium dichromate were sent to the H-Area basins annually. Sodium hydroxide is present as a result of resin regeneration operations in H-Area. Phosphoric acid and sodium dichromate, used in lithium-aluminum target cleaning, are now sent to the waste tank farm evaporator rather than being discharged directly to the seepage basins.

The estimated cumulative chromium release to the H-Area basins for the period January 1981 through July 1983 is 740 kilograms. Chromium concentrations in wastewater going to the H-Area basins have been recorded since October 1980.

B.3.3.8 H-Area Seepage Basin 904-45G

Basin 2 has side dimensions of 34 by 141 meters and a capacity of about 1×10^7 liters. See Section B.3.3.7.

B.3.3.9 H-Area Seepage Basin (904-46G)

Basin 3 has side dimensions of 87 by 152 and 142 by 148 meters and a capacity of about 8.6×10^7 liters. See Section B.3.3.7.

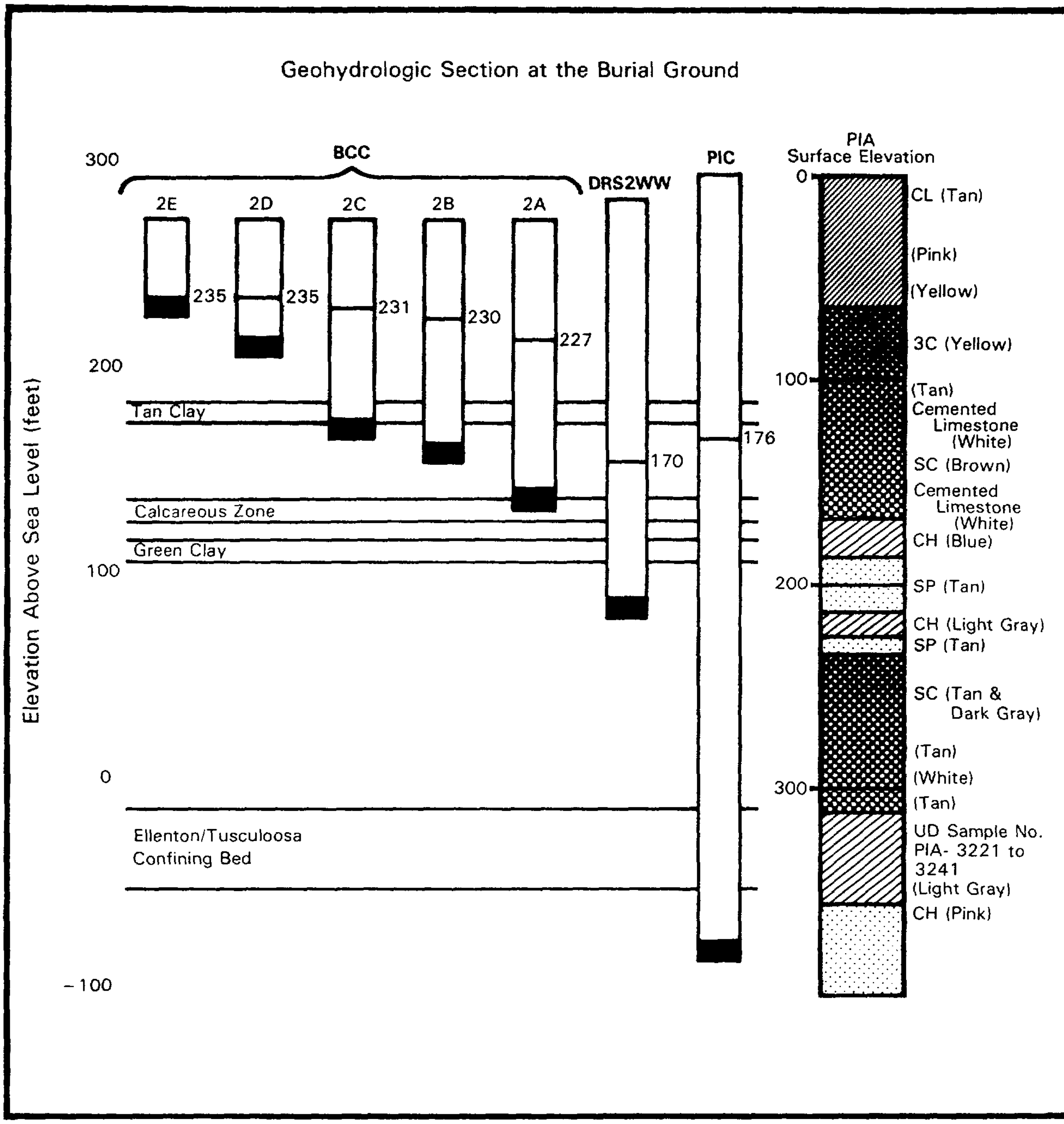
B.3.3.10 H-Area Seepage Basin (904-56G)

Basin 4 has a capacity of about 1.2×10^8 liters. See Section B.3.3.7.

B.3.4 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The information in Appendix A related to regional geohydrology was developed from investigations at these waste sites. In this geographic grouping, the Middendorf/Black Creek (Tuscaloosa) consists of two sandy aquifers separated by a confining bed of sandy clay. The Ellenton Formation acts as a confining bed above the Middendorf/Black Creek, although there are sandy parts of the Ellenton that will produce water. Below the Middendorf/Black Creek, a bed of dense clay acts as a confining bed. Locally, the Congaree Formation is 22 to 26 meters thick and consists of well-sorted sands with layers of clay. A pisolitic-clay zone defines the basal Congaree, and the green clay marks the boundary between the McBean and Congaree Formations. The McBean Formation has average thicknesses of 21 and 17 meters in H- and F-Areas, respectively. As described in Appendix A, the McBean consists of an upper clayey sand zone and a lower calcareous sandy clay zone. However, logs on the lithology in the vicinity of F-Area indicate that there is little calcareous material in the lower McBean (Killian et al., 1986a). The basal Barnwell Formation consists of a discontinuous tan clay zone, which acts as a semiconfining layer between the McBean and Barnwell Formations in some portions of the area. The thickness of the tan clay ranges from 2 to 4 meters. The local water table is generally within the Barnwell Formation, although the Barnwell yields limited quantities of water because of the large quantity of fine-grained sediments. The lithology of the Hawthorn Formation is similar to that of the Barnwell, and the two are considered a single hydrostratigraphic unit. Although the Hawthorn lies above the water table, local layers of low permeability occasionally cause perched water tables. Some studies have identified perched water tables at F-Area, 4 to 6 meters below the ground surface and extending 45 meters south toward Four Mile Creek (Killian et al., 1986a).

The vertical-head relationships for wells near the Burial Ground, shown in Figure B-6, are typical of other waste sites in this geographic grouping. The hydraulic pressure in the Congaree is the lowest in the natural hydrologic system at this location. Thus, water flows to the Congaree from both above



Source: Jaegge *et al.* (1986)

Figure B-6. Vertical-Head Relationships Around Log for Burial Ground Wells

and below, and cannot move vertically to the Middendorf/Black Creek Formation. Even with the drawdown due to pumping, the head in the Middendorf/Black Creek is 2.4 and 5 meters above that of the Congaree in H- and F-Areas, respectively.

The permanent water table at F-Area is about 18 meters below the ground surface, but at H-Area it is only 5 to 8 meters below the surface. Figure B-7 is a water-table map that is based on measurements made in June 1982. The natural discharge from the water table is to Upper Three Runs Creek and its tributaries, and to Four Mile Creek. The water-table divide between the two major creeks bisects the combined 643-7G and 643-28G area.

Hydrologic characteristics of the sediments in the Barnwell, McBean, and Congaree Formations in F- and H-Areas have been determined in a number of laboratory and field tests (Killian et al., 1986a,b). Table B-12 lists the results of small-scale pumping tests. A comparison of the values for hydraulic conductivity in Table B-12 with other values (Killian et al., 1986a,b) shows that a range of at least two orders of magnitude is reasonable for all three formations.

B.3.5 ONGOING AND PLANNED MONITORING

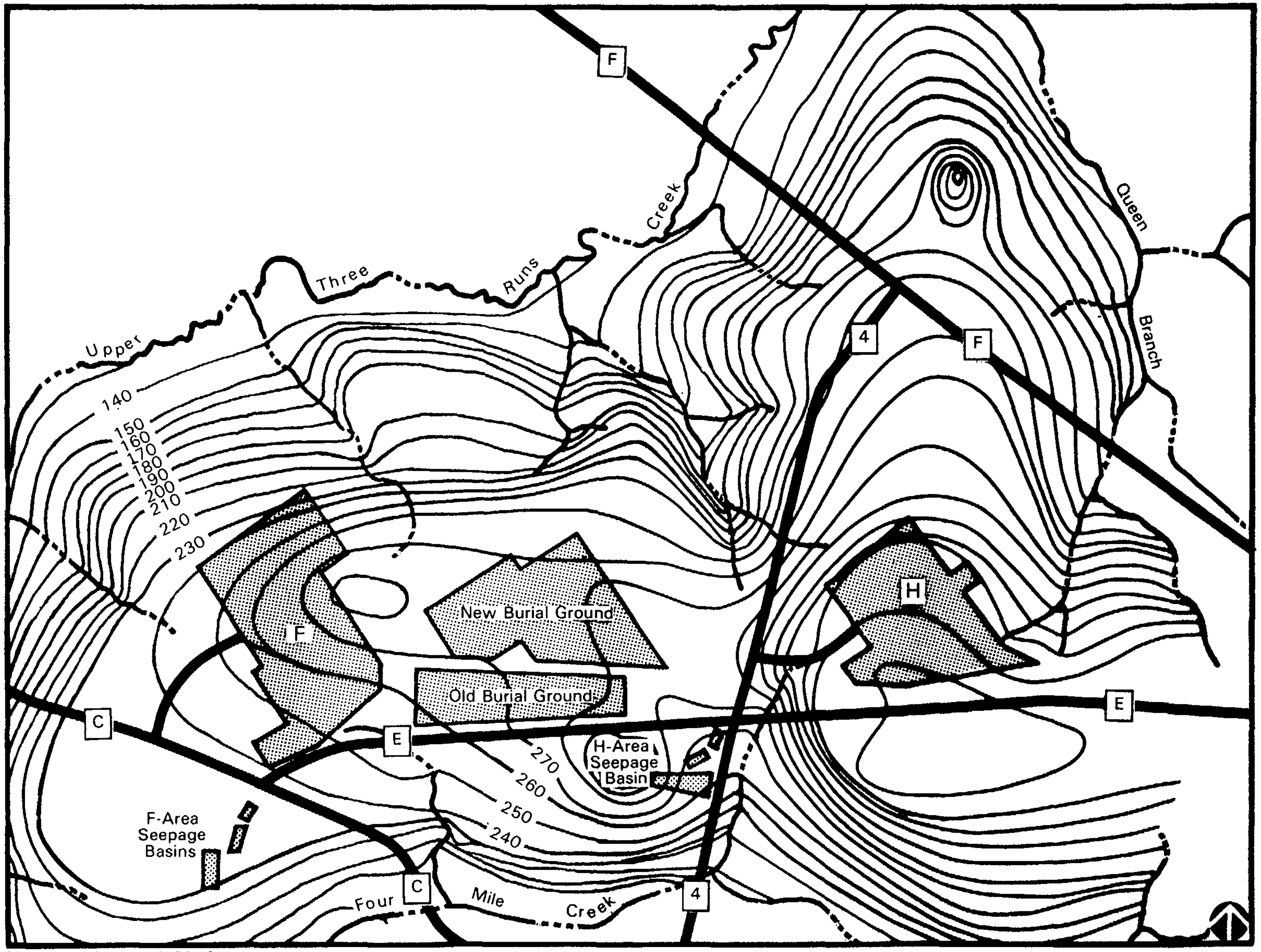
Groundwater monitoring is proceeding at 14 of the 17 waste management facilities in the F- and H-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous and mixed waste management facilities. Typically, the wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. In this geographic area there are 241 wells used to monitor groundwater. DOE plans additional wells to obtain better definition of subsurface conditions and contaminant transport.

Waste site characterization programs have been completed at some of the waste management facilities and are being implemented at others. Characterization generally includes representative sampling of the waste, sampling of the soil and sediment under the waste site, and sampling of the soil and sediment around overflow ditches and process sewers.

Table B-13 lists the representative monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring.

B.4 R-AREA WASTE SITES

This geographic grouping is approximately 6 kilometers east of H-Area. As shown on Figure B-8, the grouping contains R-Reactor, which has been on standby status since 1964, and waste sites that are typical of SRP reactor areas. The area drains primarily to Par Pond, to the southeast. The boundaries of this geographic grouping are defined by the areas of influence assigned to the reactor seepage basins, the burning/rubble pits, and the acid/caustic basin.



Note: 1.0 foot = 0.3048 meter
Source: Jaegge *et al.* (1986)

Figure B-7. Water-Table Map

Table B-12. Results of Small-Scale Pumping Tests[a]

Pumping well	Transmissivity (m^2/day)	Thickness (m)	Hydraulic conductivity (m/day)	Screened zone[b]	Location
HC 2F			0.55	UB	H-Area
H 54	2.3	13.0	0.18	LB	H-Area and Road E
ZW 4	3.6	4.9	0.73	LB	North of Burial Ground
HC 2E			0.19	LB	H-Area
HC 6B			0.13	LB	H-Area
HC 4B			0.070	LB	H-Area
BGC 1D			0.11	LB	Burial Ground
G 28			0.16	LB	Burial Ground
F 73	6.7	14.0	0.49	UM	Road F at Road 4
H 64	9.3	12.0	0.76	UM	H-Area along Road E
F 55	4.9	14.0	0.37	UN	North of Burial Ground
HC 1C			0.29	UM	H-Area
HC 3D			1.7	UM	H-Area
HC 9B			0.46	UM	Northeast of H-Area
HC 13B			0.027	UM	H-Area
HC 8C			0.15	UM	North of Burial Ground
HC 7B			0.040	UM	East of Road F
HC 4A			0.11	UM	H-Area
BGC 1C			0.030	UM	Burial Ground
F 66	0.89	7.0	0.13	LM	Road F at Road 4
H 53	6.5	13.0	0.49	LM	H-Area seepage basin
F 60	2.6	12.0	0.21	LM	F-Area seepage basin
F 65	6.1	10.0	0.61	LM	West of F-Area
HC 6A			0.073	LM	H-Area
FC 1B			0.014	LM	F-Area
HC 3A			0.79	C	H-Area
FC 2A			0.37	C	F-Area
HC 8B			0.37	C	North of Burial Ground

[a]Source: Jaegge et al., 1986.
[b]Key: UB, Upper Barnwell Formation; LB, Lower Barnwell Formation; UM, Upper McBean Formation; LM, Lower McBean Formation; C, Congaree Formation.

Table B-13. Site Investigations and Monitoring at Waste Management Facilities in the F- and H-Area Geographic Grouping[a]

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
F-Area acid/caustic basin (904-74G)	FAC 1 FAC 2 FAC 3 FAC 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program completed in 1985.	Statistical analysis of groundwater monitoring data shows the following to be present: • pH • Conductivity • Manganese • Sodium • Sulfate • Barium Sediment samples showed elevated levels of metals and other inorganics.
H-Area acid/caustic basin (904-75G)	None	Waste site characterization program, completed in 1985, consists of water, sediment, and soil sample analysis.	None.
F-Area burning/rubble pits (231-F, 231-1F)	FBP 1A FBP 2A FBP 3A FBP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site sediment characterization program to be conducted.	Statistical analysis of groundwater monitoring data shows the following to be present: • Conductivity • Total organic carbon • Total organic halogen • pH • Sodium • Chloride
		LOW-LEVEL WASTE SITES	
H-Area retention basin (281-3H)	281-3H-11[d] 281-3H-13[d]	Core samples of basin sediments taken in 1973. Radiological survey (1977) of soil and vegetation found elevated levels of radioactivity. Wells monitored for tritium, gross alpha, and gross nonvolatile beta.	Soil constituents include: • Cesium-137 • Strontium-89, -90 • Plutonium-238 Radiation measured at 90 mrad/hr. Vegetation exhibited levels of • Cesium-137 at 8200-8900 pCi/g • Strontium-89, -90 at 58,000 pCi/g Groundwater monitoring data shows elevated levels of tritium.
F-Area retention basin (281-3F)	None	In late 1978, 994 m^3 of contaminated soil removed. Core samples taken at that time.	Soil constituents include: • Cesium-137 • Strontium-89, -90

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Table B-13. Site Investigations and Monitoring at Waste Management Facilities in the F- and H-Area Geographic Grouping[a] (continued)

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		LOW-LEVEL WASTE SITES (continued)	
Radioactive waste burial ground (643-7G)	15 wells directly associated with 643-7G[c]	Wells monitored for: • Tritium • Gross alpha • Gross nonvolatile beta • Mercury • Lead • Cadmium	Groundwater constituents include: • Gross beta • Tritium • Strontium-90 • Technetium-99 • Cesium-137 • Cobalt-60 • Plutonium-238 • Curium-244 • Mercury • Lead • Cadmium
		MIXED WASTE SITES	
Radioactive waste burial ground (643-G)	125 single wells and 3 well clusters directly associated with 643-G[d]	Groundwater wells monitored for: • Tritium • Gross alpha • Gross nonvolatile beta • Mercury • Lead • Cadmium Following parameters measured for wells with history of gross alpha or gross nonvolatile beta activity • Cobalt-60 • Strontium-90 • Cesium-137 • Plutonium-238, -239 Dry boreholes used for in-situ gamma radiation measurements. Additional soil coring planned.	Groundwater constituents include: • Gross alpha • Gross beta • Tritium • Mercury • Lead • Cadmium • Strontium-90 • Technetium-99 • Cesium-137 • Cobalt-60 • Plutonium-238 • Curium-244 Tritium plume defined east of facility.
Mixed waste management facility (643-28G)	38 wells are associated with 643-28G[d]	27 new RCRA monitoring wells located in clusters of 3 will be installed with RCRA monitoring proposed as part of postclosure detection and compliance point monitoring. A compaction study will determine the physical characteristics of the waste and overburden. A borrow study will identify sources of material for the final cover.	The presence of hazardous constituents in the groundwater at the boundary of 643-28G has not been established.

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Table B-13. Site Investigations and Monitoring at Waste Management Facilities in the F- and H-Area Geographic Grouping[a] (continued)

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		MIXED WASTE SITES (continued)	
F-Area seepage basins (904-41G, 904-42G, 904-43G)	FSB 76A, B, C FSB 77 FSB 78A, B, C FSB 79A, B, C FSB 87A, B, C, D	Wells monitored quarterly for RCRA and SCHWMR parameters. 13 plume-definition wells installed in fall 1984. Soil samples from seepage basin collected during several studies (1971 and 1984). Terrain conductivity survey completed.	Statistical analysis of groundwater monitoring data shows the presence of: • Conductivity • Total dissolved solids • Turbidity • Sodium • Zinc • Nitrate • pH • Cadmium • Copper • Manganese • Nickel • Gross beta • Radium • Chromium • Fluoride (Sampling techniques or well construction may bias results.) Additional probable groundwater contaminants include • Gross alpha • Tritium • Strontium-90 • Selenium • Barium • Mercury Probable soil contaminants include • Americium-241 • Cobalt-60 • Cesium-137 • Tritium • Iodine-129 • Niobium-95 • Promethium-147 • Ruthenium-106 • Strontium-89, -90 • Uranium-234, -235, -238 • Zirconium-95 • Chromium • Sodium • Zinc • Tin • Mercury

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Table B-13. Site Investigations and Monitoring at Waste Management Facilities in the F- and H-Area Geographic Grouping[a] (continued)

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		MIXED WASTE SITES (continued)	
F-Area seepage basin (904-49G)	FNB 1 FNB 2 FNB 3 FNB 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Sediment samples collected from basin in June 1955. Wastewater samples collected in February 1985.	Statistical analysis of groundwater monitoring data indicates the presence of: • Conductivity • Nitrate • pH • Barium • Manganese • Sodium • Gross alpha • Gross beta • Radium • Lead Constituents present in groundwater include: • Mercury • Lead • Total dissolved solids
H-Area seepage basins (904-44G, 904-45G, 904-46G, 904-56G)	HSB 65A, B, C HSB 66 HSB 67 HSB 68A, B, C HSB 69 HSB 70 HSB 71 HSB 83A, B, C, D HSB 84A, B, C, D HSB 85A, B, C HSB 86A, B, C, D	Wells monitored quarterly for RCRA and SCHWMR parameters. 21 plume-definition wells installed in fall 1984. 0.9-m cores collected from bottoms of H-Area basins in 1984. Terrain conductivity survey completed.	Statistical analysis of groundwater monitoring data indicate the following to be present: • pH • Conductivity • Total dissolved solids • Manganese • Sodium • Fluoride • Nitrate • Mercury • Gross beta • Cadmium • Radium • Chloride Additional constituents present: • Gross alpha • Tritium • Strontium-90 • Lead • Barium • Antimony

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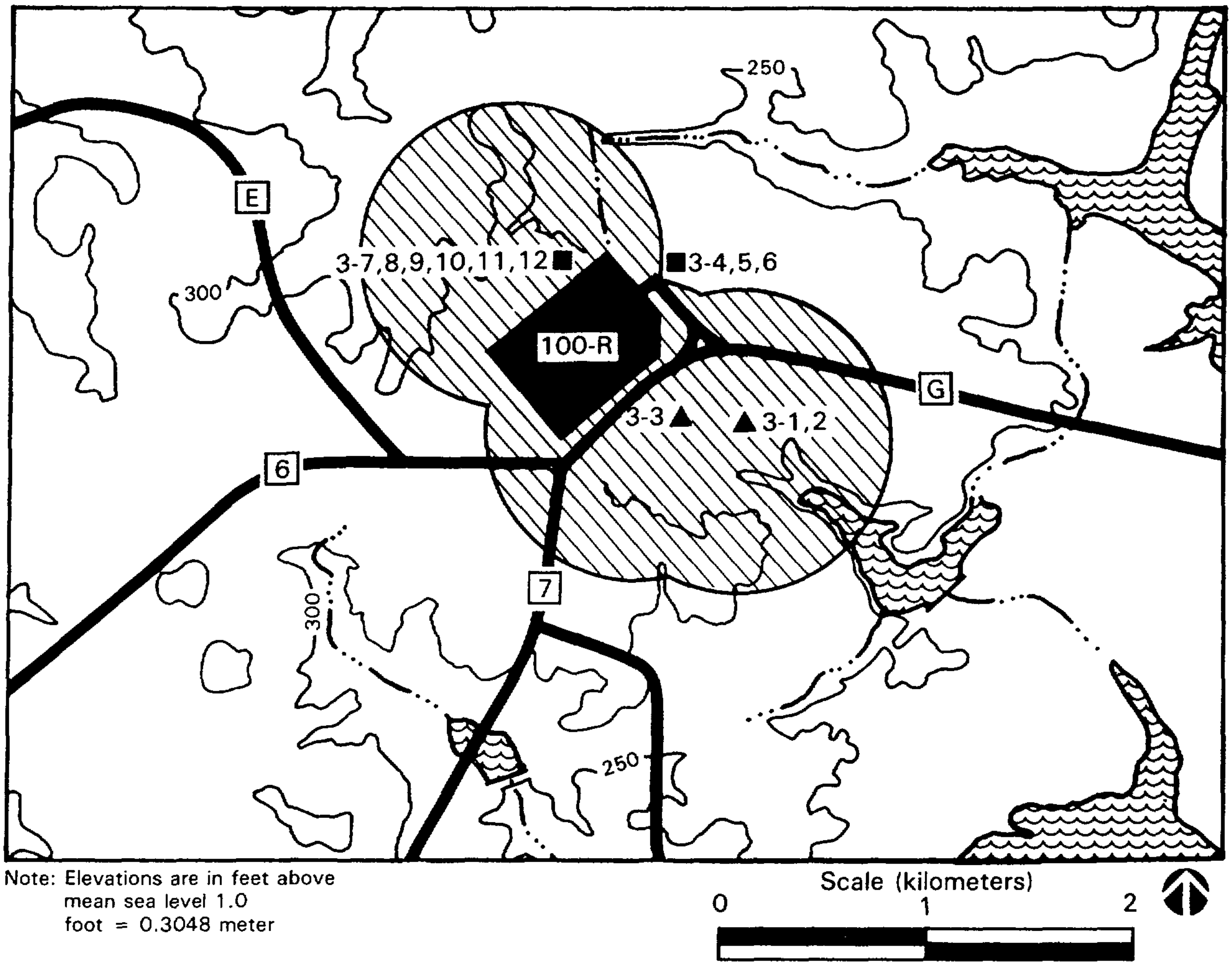
Table B-13. Site Investigations and Monitoring at Waste Management Facilities in the F- and H-Area Geographic Grouping[a] (continued)

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		MIXED WASTE SITES (continued)	
			Soil column constituents include: • Plutonium-238 • Plutonium-239, -240 • Americium-241 • Cerium-144 • Curium-244 • Cobalt-60 • Cesium-134, -137 • Tritium • Iodine-129 • Promethium-147 • Strontium-89, -90 • Ruthenium-106 • Technetium-99 • Uranium-234, -235, -238 • Zirconium-95 • Barium • Chromium • Sodium • Lead • Zinc • Mercury

[a]Sources: Ward, Johnson, and Marine, 1986; Huber, Johnson, and Marine, 1986; Scott, Killian, Kolb, Corbo, and Marine, 1986; Jaegge et al., 1986; DOE, 1985; Killian et al, 1986a,b; Du Pont, 1985; Odum, Fliermans, and Marine, 1986.
[b]Monitored hydrogeologic units for these wells are the Barnwell and McBean.
[c]See page B-1.
[d]Not RCRA monitoring wells.



Number	Potential Waste Type	Site Name	Building Number
3-1	▲	R-Area Burning/Rubble Pit*	131-R
3-2	▲	R-Area Burning/Rubble Pit*	131-1R
3-3	▲	R-Area Acid/Caustic Basin*	904-77G
3-4	■	R-Area Bingham Pump Outage Pit*	643-8G
3-5	■	R-Area Bingham Pump Outage Pit*	643-9G
3-6	■	R-Area Bingham Pump Outage Pit*	643-10G
3-7	■	R-Area Seepage Basin	904-57G
3-8	■	R-Area Seepage Basin	904-58G
3-9	■	R-Area Seepage Basin	904-59G
3-10	■	R-Area Seepage Basin	904-60G
3-11	■	R-Area Seepage Basin	904-103G
3-12	■	R-Area Seepage Basin	904-104G

*Indicates that waste type may be contained in the waste site

▲—Hazardous

■—Low-level radioactive

Figure B-8. R-Area Waste Sites

B.4.1 HAZARDOUS WASTE SITES

B.4.1.1 R-Area Burning/Rubble Pits (131-R and 131-1R)

The R-Area burning/rubble pits are near the central portion of the SRP, south of R-Area and Road G. Each site is roughly rectangular, being approximately 72 meters long, 10 meters wide, and 3 meters deep.

History of Waste Disposal

See Section B.2.1.6.

Evidence of Contamination

No groundwater contamination has been observed to date in the four wells associated with these sites. See Section B.2.1.6.

Waste Characterization

Limited data are available on the extent of contamination and characteristics of the wastes involved at this site. Most of the data have been gathered via groundwater monitoring. Data collected to date indicate no contamination (Huber, Johnson, and Marine, 1986).

B.4.1.2 R-Area Acid/Caustic Basin (904-77G)

The R-Area acid/caustic basin is one of six such basins in the Reactor and Separations Areas. These basins are unlined earthen depressions nominally 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

See Section B.3.1.1.

Evidence of Contamination

See Section B.3.1.1.

Waste Characterization

See Section B.3.1.1.

B.4.2 LOW-LEVEL RADIOACTIVE WASTE SITES

B.4.2.1 R-Area Bingham Pump Outage Pit (643-8G)

Bingham pump outage pit 643-8G is one of three inactive pits located outside the perimeter fence of R-Area (Figure B-8). Pits 1 (643-8G), 2 (643-9G), and 3 (643-10G) occupy approximately 440, 360, and 1200 square meters of land, respectively. This section discusses the history of disposal, evidence of contamination, and waste characteristics of all three R-Area Bingham pump outage pits (Pekkala, Holmes, and Marine, 1986a).

History of Waste Disposal

Normally, all radioactive solid waste generated in the reactor areas is sent to solid waste burial ground 643-G/643-7G. An exception to this practice was made during 1957 and 1958, when the reactor areas initiated major modifications to their primary and secondary cooling water systems. The outages became known as the "Bingham pump outages." The radioactive waste generated in R-Area during the outages was surveyed, and solid waste with very low levels of or no surface contamination was buried in the outage pits. No pumps are buried in these pits. Subsequently, the outage pits were backfilled with clean soil. Waste with higher levels of contamination was sent to the radioactive solid waste burial ground.

The Bingham pump outage pits have been inactive since 1958; vegetation has grown uncontrolled over the sites. In 1970, radioactivity in samples of vegetation from the surface of the pits was compared with activity in vegetation growing at the SRP perimeter. The vegetation growing above the outage pits showed little or no elevation in activity.

Evidence of Contamination

No monitoring wells have been installed at the outage pits. No core sampling has been conducted there.

Waste Characterization

The pits contain construction equipment such as pipes, cables, ladders, drums, and boxes of miscellaneous hardware (Fenimore and Horton, 1974). At the time of burial, this waste had a radiation level of less than 25 milliroentgens per hour, and no alpha activity was noted. A conservative estimate of the activity buried in R-Area is 1 curie. Table B-14 lists the estimated inventories of this activity at the time of burial and at present. Radioactive decay since the waste was placed in the pits has reduced the inventories of cobalt-60, promethium-137, and ruthenium-103 and 106 to about 5 millicuries. Only cesium-137 and strontium-90 are expected to be present in measurable amounts.

Table B-14. Estimated Radionuclide Inventory in Bingham Pump Outage Pits in R-, K-, L-, and P-Areas[a]

Radionuclide	At burial (Ci)	At present (mCi)
Cobalt-60	0.172	5
Strontium-90	0.112	60
Cesium-137	0.414	220
Promethium-147	0.172	0.1
Ruthenium-103, -106	0.130	1×10^{-6}

[a]Source: Pekkala, Holmes, and Marine, 1986a.

B.4.2.2 R-Area Bingham Pump Outage Pit 643-9G

Bingham pump outage pit 643-9G is the smallest of three inactive pits outside the R-Area perimeter fence (Figure B-8). Section B.4.2.1 discusses the history of disposal, evidence of contamination, and waste characteristics of all three pits.

B.4.2.3 R-Area Bingham Pump Outage Pit (643-10G)

Bingham pump outage pit 643-10G is the largest of the three inactive pits outside the R-Area perimeter fence (Figure B-8). Section B.4.2.1 discusses the history of disposal, evidence of contamination, and waste characteristics of all three pits.

B.4.2.4 R-Area Seepage Basins (904-57G, 904-58G, 904-59G, 904-60G, 904-103G, and 904-104G)

Six inactive and backfilled seepage basins lie outside the R-Area perimeter fence (Figure B-8). Table B-15 lists their physical dimensions. The basins were constructed by excavating below grade and backfilling around the sides at grade level to form earthen dike walls. The depths varied according to estimated needs. The basins did not overflow; rather, water was released to the environment by evaporation and seepage. This section discusses the history of disposal, evidence of contamination, and waste characteristics of all six R-Area seepage basins (Pekkala, Holmes, and Marine, 1986b).

Table B-15. Locations and Dimensions of R-Area Seepage Basins[a]

Basin	Building	Volume (m^3)	Dimensions (L x W x D, m)
1	904-103G	2.0×10^3	120 x 9 x 3
2	904-104G	2.0×10^3	40 x 14 x 3
3	904-57G	1.7×10^3	90 x 9 x 3
4	904-58G	2.1×10^3	93 x 11 x 3
5	904-59G	2.3×10^3	90 x 12 x 3
6	904-60G	6.2×10^3	150 x 14 x 5

[a]Source: Pekkala, Holmes, and Marine, 1986b.

History of Waste Disposal

Since 1957, earthen seepage basins have been used routinely and almost exclusively at the SRP for the disposal of low-level radioactive purge water from the reactor disassembly basins. This water purge is necessary to keep the tritium concentration in the disassembly-basin water at a level that ensures safe working conditions. Fourteen seepage basins in the reactor areas have received disassembly purge water (Holmes et al., 1983). Six of these basins are in R-Area.

In the late 1950s and early 1960s, the purge water from the disassembly basins in the reactor buildings was pumped directly from the disassembly basins to the seepage basins. In the 1960s, trailer-mounted, mixed-bed deionizers were used to reduce the ionic constituents of the water. The seepage basins remained in use until 1970. From 1970 through 1978, the disassembly purge water was released through mixed-bed deionizers directly to SRP streams.

In R-Area, basin 1 went into service in June 1957 and began receiving low-level radioactive purge water. Beginning in November 1957, the R-Area seepage basins received approximately 200 curies of strontium-90 and 1000 curies of cesium-137 after the failure of an experimental fuel element during a calorimeter test in the emergency section of the disassembly basin. A large portion of this radioactivity was contained in basin 1. (Basins 2 through 6 went into operation after the incident.) Basin 1 was deactivated and backfilled in January 1957 because of surface outcrop and leakage to an abandoned sewer system. In 1960, basins 2 through 5 were deactivated and backfilled. The ground surface above the five basins was treated with herbicide and covered with asphalt. In addition, a kaolinite dike (down to the clay layer) was constructed around basin 1 and the northwest end of basin 3 to contain lateral movement of the radioactive contamination. Basin 6 was last used in 1964 and was backfilled in 1977.

Evidence of Contamination

Table B-16 lists the results of analyses of soil in and beneath the backfilled basins in R-Area. Five soil cores were collected in basin 1. One core each was collected from basins 2, 3, 4, and 5. Except for that from basin 3, the cores were centered on the zone beneath the basin that exhibited the highest radiation levels. The maximum radiation level was found in a narrow zone near the bottom of the backfilled basin; only minimal migration occurred below this interface.

Table B-16. Radionuclide in R-Area Seepage Basin Soils [nCi/g soil (dry)][a]

Basin	Cesium-137, max.	Strontium-90, max.
1	8000	41
2	810	12
3[b]	0.34	<0.1
4	23	0.07
5	27	2.1

[a]Source: Pekkala, Holmes, and Marine, 1986b.
[b]Soil sampled above maximum zone of contamination.

Cesium-137 was the only gamma-emitter detected in the R-Area basins. As indicated in Table B-17, a maximum concentration of 8000 nanocuries per gram of soil (dry) was found in a segment of the core taken near the inlet discharge of basin 1. The greatest concentration of strontium-90, 41 nanocuries per

Table B-17. Radioactive Releases to R-Area Reactor Seepage Basins (Ci)[a,b]

Isotope	Release
Tritium[c]	2.0×10^{3}
Cobalt-60	7.2×10^{-2}
Strontium-90	1.0×10^{2}
Ruthenium-103, -106	5.5×10^{-8}
Cesium-137	4.7×10^{2}
Promethium-147	2.0×10^{-3}
Plutonium-239	3.0×10^{-1}

[a]Source: Pekkala, Holmes, and Marine, 1986b.
[b]Values cumulative through 1985; values decay-corrected.
[c]Most tritium believed to have left basins via atmosphere or groundwater.

gram, also was found in basin 1. According to radioassay results from a limited number of soil samples, basin 1 contains approximately 90 percent of the cesium-137 and 50 percent of the strontium-90 in the basin system.

Groundwater monitoring at the R-Area seepage basins began in 1958, when 39 wells were drilled. Strontium-90 was first detected in groundwater shortly after the basins received purge water from the emergency section of the disassembly basin following the failure of an experimental fuel element in a calorimeter test in November 1957. Because of the differing stratigraphy of the soils in which the basins were excavated, rapid movement of radioactivity from the basins to the groundwater was confined to the north end of basin 3 and the east end of basin 5.

In 1975, a substantial increase in strontium-90 activity (3400 picocuries per liter) occurred in a groundwater monitoring well on the east side of basin 1. Investigation revealed that the source of the contamination was migration through a construction sewer line that had been abandoned after the completion of R-Area. The sewer line traversed the basin 1 area. Additional wells were installed in 1976 and 1977 southeast of basin 1, but no further movement of contamination has been observed.

Only negligible amounts of tritium are believed to remain at the R-Area basins. Normally, significant amounts of alpha-emitting nuclides are not discharged to reactor seepage basins. However, the basin system in R-Area might have received a small amount of plutonium in 1957 as a result of a fuel element failure during a calorimeter test. The estimated amount of plutonium discharge to the R-Area basins is 3×10^{-1} curie. Essentially all of this plutonium would remain as current inventory.

Waste Characterization

Although many different radionuclides have been discharged to the R-Area reactor seepage basins, almost all of the radioactivity is due to tritium, strontium-90, and cesium-137. The radionuclide contaminants enter the disassembly-basin water as a water film on the irradiated components as they are discharged from the reactor tank to the disassembly basin. Table B-17 lists the inventory of radionuclides released to the seepage basins (corrected for radioactive decay through December 31, 1984).

Table B-18 lists yearly purge volumes from 1957 through 1964, when R-Reactor went on standby status. No significant amount of chemical contaminants is believed to have been discharged to the seepage basins.

Table B-18. Total Volume of Water Purged to R-Area Reactor Seepage Basins (liters)[a]

Year	Release
1957	6.813×10^6
1958	6.015×10^6
1959	7.570×10^5
1960	7.570×10^5
1961	1.136×10^6
1962	8.500×10^5
1963	1.136×10^6
1964[b]	7.570×10^5

[a]Source: Pekkala, Holmes, and Marine, 1986b.
[b]R-Reactor has been in standby status since mid-1964.

B.4.3 MAJOR GEOHYDROLOGIC CHARACTERISTICS

Waste sites in the R-Area geographic grouping are on the Aiken Plateau near the topographic divide between the headwaters of Mill Creek (a tributary of Upper Three Runs Creek) to the north and the drainage to Par Pond to the east. Site-specific geohydrologic information is not available for this area; however, this EIS assumes that the subsurface geology is similar to that near F- and H-Areas (Appendix B), where much of the geohydrologic data on the SRP has been collected. A possible difference between the two areas is the vertical-head relationships of the Congaree and Middendorf/Black Creek (Tuscaloosa) Formations, as shown in Figure B-9.

Figure B-9 shows that the head in the Middendorf/Black Creek is lower than that in the Congaree for the general area of the R-Area geographic grouping,

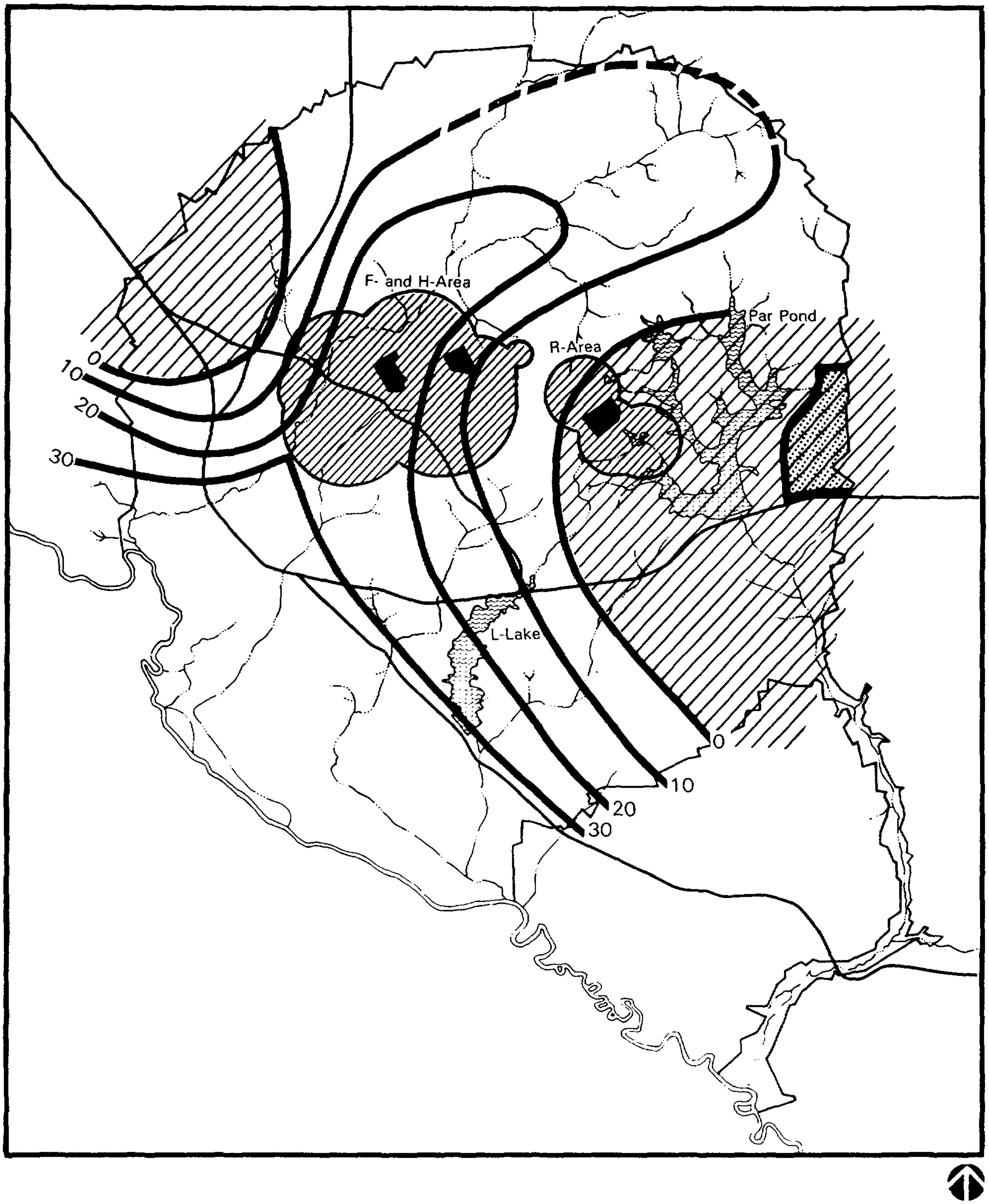


Figure B-9. Head Difference Between Tuscaloosa and Congaree Formations at SRP

whereas in the central portion of the Plant there is a head reversal between the Middendorf/Black Creek and Congaree (higher head in the Middendorf/Black Creek). Consequently, contaminants could enter the Congaree from R-Area waste sites and migrate into the Middendorf/Black Creek aquifer (Pekkala, Holmes, and Marine, 1986b). The head difference map is constructed by subtracting two piezometric maps for which data are somewhat sparse. Thus, the map is useful for indicating general areas of expected head relationships, but it might not be accurate on a site-specific basis.

Figure B-10 is a map of the local water table constructed from data on monitoring wells near R-Area. The natural discharge from the water table is to Mill Creek and several unnamed tributaries of Par Pond. The depth to the water table from the ground surface ranges from 6 to 9 meters near the R-Area seepage basins. The hydraulic gradient toward Mill Creek ranges from 0.006 to 0.009 meter per meter. (See the Glossary.)

B.4.4 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at 9 of the 12 waste management facilities in the R-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous waste management facilities. Typically, the wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. At least 56 wells in this geographic area are used to monitor groundwater in the vicinity of the 12 facilities. DOE plans additional wells to obtain a better definition of subsurface conditions and contaminant transport.

Waste site characterization programs have been completed at 7 of the 12 facilities and are being implemented at 2 others. Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-19 lists the monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring.

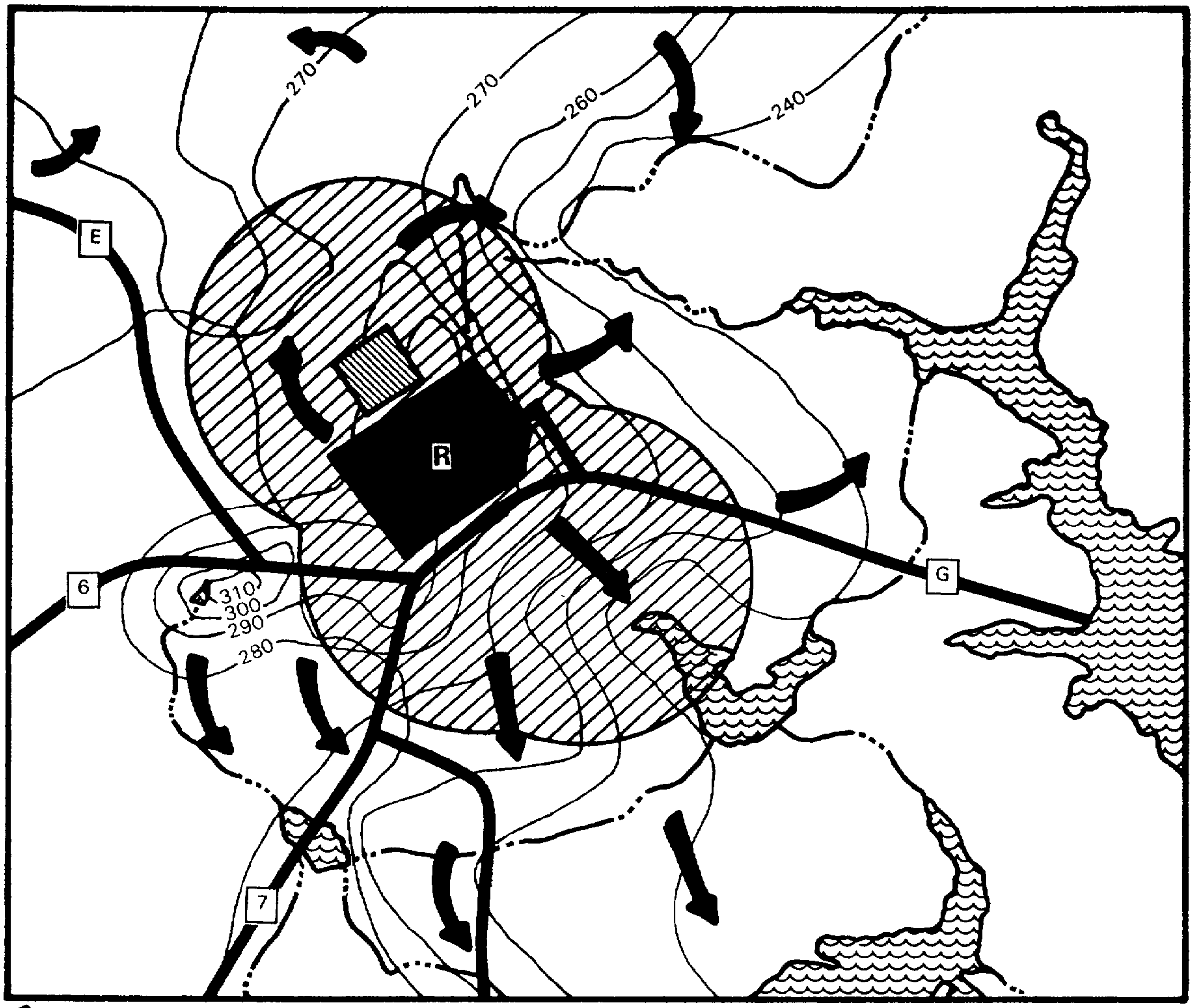
B.5 C- and CS-AREA WASTE SITES

This geographic grouping is near the center of the Plant, a short distance south of F- and H-Areas. As shown in Figure B-11, it is actually two separate but closely spaced groupings, one formed by waste sites near C-Reactor and the other containing sites in and around the Central Shops (CS) Area. Tributaries to Four Mile Creek drain most of the area. The boundaries of this grouping are formed primarily by burning/rubble pits and the Ford Building seepage basin.

B.5.1 HAZARDOUS WASTE SITES

B.5.1.1 CS-Area Burning/Rubble Pits (631-1G, 631-5G, and 631-6G)

The three CS-Area burning/rubble pits are near the central portion of the SRP, north of CS-Area and south of Road 5. Pit 631-1G is approximately 61 meters



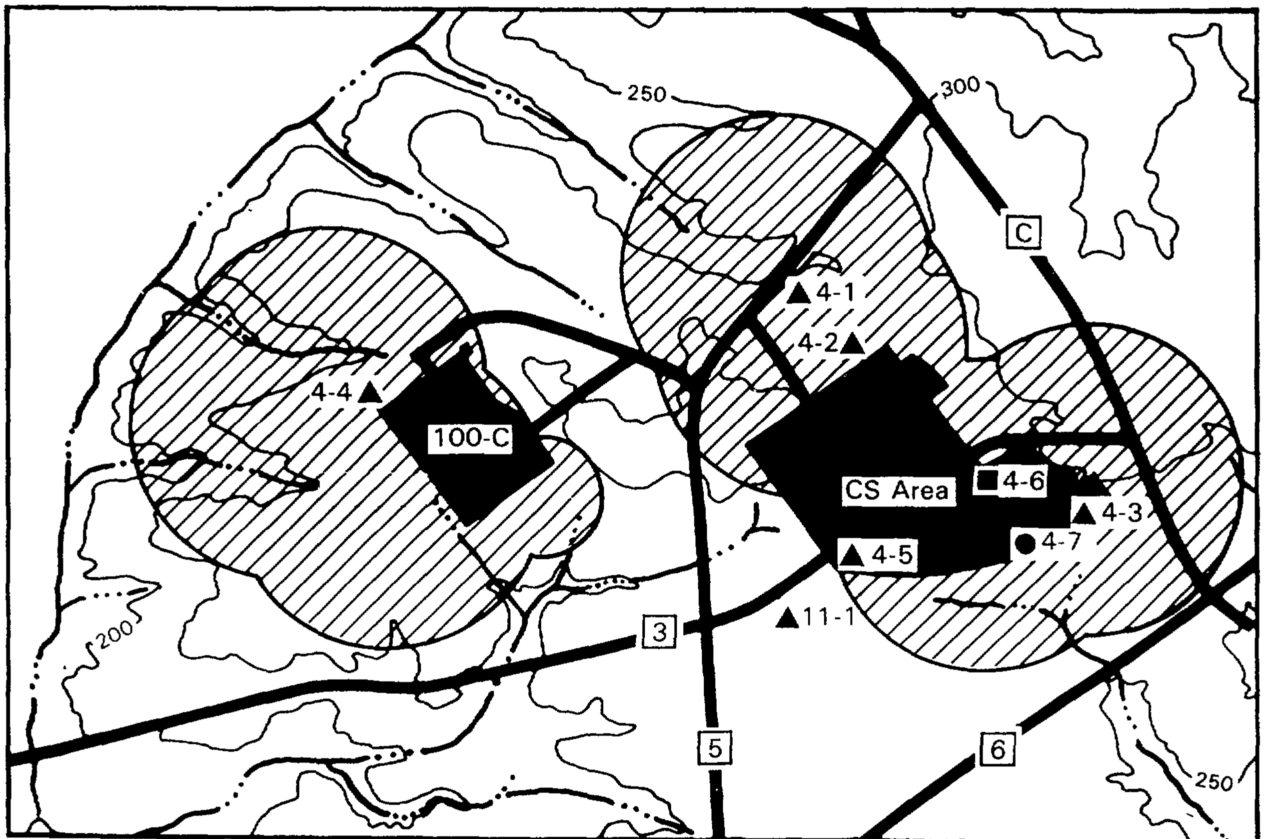
Direction of Groundwater flow
Note: 1.0 foot = 0.3048 meter
Source: Pekkala *et al.* (1986b)

Figure B-10. Water-Table Elevation (in feet above mean sea level) at R-Area During the Period 1961-1967

Table B-19. Site Investigations and Monitoring at Waste Management Facilities in the R-Area Geographic Grouping[a]

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		Hazardous Waste Sites	
R-Area burning/rubble pits (131-R, 131-1R)	RRP 1 RRP 2 RRP 3 RRP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste sediment characterization program to be conducted.	Statistical analysis of groundwater monitoring data indicates the following parameters to be present: • Sodium • Copper
R-Area acid/caustic basin (904-77G)	RAC 1 RAC 2 RAC 3 RAC 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program completed by third quarter of 1985.	Statistical analysis of groundwater monitoring data indicates the following to be present: • Conductivity • Chloride • Total dissolved solids • Sodium Sediment samples showed metals and other inorganics to be present.
		Low-Level Waste Sites	
R-Area Bingham Pump outage pits (643-8G, G43-9G, 643-10G)	None	No monitoring wells exist at outage pits, and records yield no evidence of core-sampling activity there. Radioactivity in vegetation measured in 1970.	Vegetation growing above outage pits shows little or no elevation in activity levels.
R-Area seepage basins (904-57G, 904-58G, 904-59G, 904-60G, 904-103G, 904-104G)	48 monitoring wells associated with R-Area reactor seepage basins[d]	Wells typically monitored for gross alpha, gross nonvolatile beta, and tritium. Soil borings were analyzed from sediment in and beneath backfilled basins in 1978.	Groundwater constituents include • Strontium-90 • Gross alpha • Gross beta Soil contaminants include • Cesium-137 • Strontium-90

[a]Sources: Huber, Johnson, and Marine, 1986; Ward, Johnson, and Marine, 1986; Pekkala, Holmes, and Marine, 1986a,b.
[b]The monitored hydrolgeologic unit for these wells is the Barnwell.
[c]See page B-1.
[d]Not RCRA monitoring wells.



Note: Elevations are in feet above mean sea level 1.0 foot = 0.3048 meter

Scale (kilometers)

0 1 2

Number	Potential Waste Type	Site Name	Building Number
4-1	▲	CS Burning/Rubble Pit*	631-1G
4-2	▲	CS Burning/Rubble Pit*	631-5G
4-3	▲	CS Burning/Rubble Pit*	631-6G
4-4	▲	C-Area Burning/Rubble Pit*	131-C
4-5	▲	Hydrofluoric Acid Spill Area*	631-4G
4-6	■	Ford Building Waste Site*	643-11G
4-7	●	Ford Building Seepage Basin*	904-91G
11-1	▲	SRL Oil Test Site	080-16G

*Indicates that waste type may be contained in the waste site

▲—Hazardous

■—Low-level radioactive

●—Mixed

Figure B-11. C- and CS-Area Waste Sites

long, 9 meters wide, and 3 meters deep. The two other pits measure 117 meters by 11 meters by 3 meters, and 88 meters by 9 meters by 3 meters.

History of Waste Disposal

Rubble disposed of at these sites reportedly includes paper, cans, lumber, and empty galvanized-steel barrels. See Section B.2.1.6.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

B.5.1.2 C-Area Burning/Rubble Pit (131-C)

The C-Area burning/rubble pit is near the central portion of the SRP, northwest of C-Area and north of Road A-7. The site is roughly triangular in shape, is 3 meters deep, and covers an area of about 6550 square meters.

History of Waste Disposal

Rubble disposed of at this site reportedly includes paper, wood, concrete, cans, and empty galvanized steel barrels. See Section B.2.1.6.

Evidence of Contamination

Groundwater monitoring wells were installed at all the burning/rubble pits in 1983 and 1984. Groundwater samples recently obtained from the four wells associated with this site have displayed elevated levels of total organic halogens. No sampling and analysis of the soil underlying the pit have been performed to date.

Waste Characterization

Limited data are available on this site. Most of the available raw data have been gathered via groundwater monitoring (Huber, Johnson, and Marine, 1986).

B.5.1.3 Hydrofluoric Acid Spill Area (631-4G)

The hydrofluoric acid spill area is west of the cement plant in the CS-Area south of Road 3. The site measures approximately 9 meters by 9 meters.

History of Waste Disposal

Very little is known about the hydrofluoric acid spill area, except that it predates 1970. The site is identified only by a warning sign indicating the presence of a potentially contaminated area. It is uncertain if a spill occurred at this site, or if contaminated soil or containers are buried there.

Evidence of Contamination

The posted warning sign is the only physical indication at the site that contaminants might be present in the subsurface environment. No soil sampling has been performed to date. Some groundwater sampling data are available from four monitoring wells surrounding the site.

Waste Characterization

Limited data are available for this site. Most data have been gathered via groundwater monitoring of four wells that began in January 1985 (Huber and Bledsoe, 1986a).

The potential for migration of hydrofluoric acid is based largely on the ion-exchange potential of the soil environment. In the saturated pore space of the soil compartment, hydrofluoric acid would be expected to dissociate and behave like a weak acid (Ka: 6.4×10^{-4}). The fluoride ions would be subject to reactions with colloid-size particles having the capability to exchange ionic constituents adsorbed on the particle surfaces.

Ion-exchange mechanisms (dissolution and precipitation) occur dynamically in the soil and some fluoride ions probably can be found in solution owing to their displacement by other anionic species (i.e., carbonate and bicarbonate). Soil pH is a factor in ion-exchange selectivity. The data collected from groundwater sources near the hydrofluoric acid spill area indicate that fluoride ions are present, either in solution or adsorbed on colloidal particles (fluoride was detected in four of eight samples, at an average concentration of 0.15 milligram per liter).

Accordingly, there is a potential for groundwater transport of fluoride ions by advection. However, because groundwater flow through the porous medium will introduce more sites for ionic exchange, some permanent adsorption of fluoride ions probably will occur. In acidic conditions, attenuation of the fluoride concentration in the groundwater can be expected. Consequently, while migration of fluoride ions will occur, given the relatively low concentrations detected in the groundwater to date (maximum concentration: 0.17 milligram per liter), the attenuation mechanism can be expected to prevail; fluoride concentrations should decrease with increasing distance from the spill area.

Hydrofluoric acid can react with silica (SiO_2) to liberate silicon tetrafluoride gas (SiF_4) and water. Assuming abundant amounts of silica in the soil, much of the fluoride from the hydrofluoric acid spilled at this location could have been released to the atmosphere as a gas shortly after its disposal. This mechanism could account for the rather low concentrations of fluoride detected in the groundwater.

B.5.2 LOW-LEVEL RADIOACTIVE WASTE SITE

The Ford Building waste site (643-11G) is north of the Ford Building in the CS-Area (Figure B-11). The site is rectangular, measuring approximately 7 meters by 52 meters. The following paragraphs discuss the waste site disposal history, evidence of contamination, and waste characteristics (Huber et al., 1986).

History of Waste Disposal

The site origin and history are uncertain. Only one side is chained and identified by a regulated area sign and a "Clean Pans Only" sign. Beyond the chained area are pieces of lumber and a load lugger pan containing soiled rubber gloves. Outside the chained area are weathered shoe covers, step-off pads, and coveralls. Regulated work might have been performed there and the site improperly cleaned.

Evidence of Contamination

Soil characterization studies have not been performed and no monitoring wells have been installed specifically for this waste site. Monitoring wells for the Fire Department training facility and the Ford Building seepage basin are nearby. These wells are all downgradient from the waste site.

Waste Characterization

Evidence indicates that regulated work might have been performed at the site and protective clothing worn by the personnel was improperly disposed. An oil line from the Ford Building ruptured in the vicinity of the waste site during the 1970s, releasing unknown quantities of oil.

B.5.3 MIXED WASTE SITE

The Ford Building seepage basin (904-91G) is in the CS-Area (Figure B-11). It is rectangular in shape and has an approximate 600 cubic meters capacity. The following sections discuss the history of disposal, evidence of contamination, and waste characteristics of the basin (Pekkala et al., 1986).

History of Waste Disposal

The Ford Building is used to repair the SRP's slightly contaminated process equipment. Highly contaminated equipment requiring repair is decontaminated in the individual custodial area before being transported to the Ford Building. Because of the contamination, wastewater generated at the Ford Building during the equipment repair work also contains low levels of contamination. Consequently, the wastewater was drained into a 23,000-liter retention tank adjacent to the Ford Building for sampling and radioanalysis. Then it was either released into the seepage basin or sent to Waste Management Operations (WMO) for concentration and disposal.

The amount of activity released to the seepage basin lessened and the process-water heat-exchanger repair program halted. The purchase of new heat-exchanger heads for the reactor buildings reduced the need for heat-exchanger repairs. A regulatory requirement for replacement of the retention tank believed to be leaking, coupled with the proposed closure of the seepage basin, resulted in the stoppage of wastewater transfers to the basin at the end of 1984. The basin is dry except for occasionally impounded rainwater. Presently, wastewater generated in the Ford Building is removed for concentration, disposal, or storage.

Evidence of Contamination

In 1985, a comprehensive soil sampling and analysis program was performed to characterize sediment from the floor and walls of the Ford Building seepage basin, as well as sediment beneath the underground pipeline from the retention tank to the basin. Inside the basin, the concentration levels of cesium-137, cobalt-60, and strontium-90 are significantly above background. Along the pipeline, only strontium-90 shows elevated concentration levels. Along the basin walls, none of the radionuclides show elevated concentration levels.

The concentration profiles for most metals and inorganics in the basin floor dropped rapidly to background within the first 0.6 meter of soil depth. The metals with elevated concentration levels (i.e., greater than 2 times background) in the top 8 centimeters of basin soil are aluminum, cadmium, chromium, copper, iron, mercury, nickel, selenium, and zinc. In the soil beneath the pipeline, aluminum, arsenic, cadmium, chromium, and iron have elevated concentration levels. The inorganic ions with elevated concentration levels in the top 8 centimeters of basin soil are ammonia, nitrogen, fluoride, sulfate, and total phosphates. Along the pipeline, only total phosphate levels are elevated. Along the basin walls, none of the inorganic ions show elevated concentration levels. No significant concentrations of organics were detected in the basin floor and walls or beneath the pipeline.

Three monitoring wells are near the Ford Building seepage basin. A statistical analysis of groundwater monitoring data indicates that levels of nitrate, mercury, and lead are elevated. However, the concentrations of these constituents remain below maximum contaminant levels.

Waste Characterization

Table B-20 is an inventory of the radionuclides released into the basin from 1964 to 1984, including the 1984 decay corrections. In addition to radionuclides, trace amounts of surfactants, oils, and grease might have been added to the wastewater stream. Through the end of 1984, the basin received 1440 cubic meters of wastewater.

Table B-20. Radioactive Releases to Ford Building Seepage Basin, 1964-1984 (Ci)[a]

Isotope	Original release	Decay corrected, 1984
Tritium	4.7012×10^{2}	1.5819×10^{2}
Cobalt-60	6.9000×10^{-4}	5.1477×10^{-4}
Strontium-90	7.4000×10^{-5}	7.0368×10^{-5}
Cesium-137	2.4500×10^{-4}	2.3644×10^{-4}
Alpha (unidentified)	4.9000×10^{-4}	4.9000×10^{-4}
Beta-gamma (unidentified)	1.8532×10^{-2}	1.8532×10^{-2}

[a]Source: Pekkala et al., 1986.

B.5.4 MAJOR GEOHYDROLOGIC CHARACTERISTICS

Waste sites in the C- and CS-Areas geographic grouping are on the Aiken Plateau between a tributary of Four Mile Creek and Pen Branch. Site-specific geohydrologic data for this area are sparse; the geohydrologic characteristics probably are similar to those in the F- and H-Areas geographic grouping (3.2 kilometers north). Appendixes A and B (Sections A.2 and B.3.4) discuss the geohydrology of the central portion of the Plant.

Three water supply wells are in the Central Shops area. They are located in the Middendorf/Black Creek (Tuscaloosa) Formation (904-83G), in the McBean (705-72G), and the in both the McBean and the Middendorf/Black Creek (905-71G). Figure B-12 shows a log of well 905-71G. Of particular geohydrologic significance are the three major confining beds discussed in Appendix A (i.e., the tan clay, the green clay, and the Ellenton Formation). Although no site-specific information on vertical head gradients is available, this EIS assumes the head relationships are similar to those in F- and H-Areas (Section B.3.4). Hydraulic heads decline with depth down to the Congaree Formation, then reverse and increase with depth in the Middendorf/Black Creek.

Figure B-13 is a water-table map for C-Area. The natural groundwater discharge from the Barnwell and McBean Formations near the Ford Building waste site is believed to be to Pen Branch. The discharge from the Congaree is probably to the Savannah River (e.g., to the southwest) along a gradient of about 0.002 meter per meter (Huber, Simmons, Marine, and Holmes, 1986). The water-table at the Ford Building waste site is about 14.6 meters below ground level.

B.5.5 ONGOING AND PLANNED MONITORING

Groundwater monitoring is under way at six of the seven waste management facilities in the C- and CS-Area geographic grouping. Well-water samples are analyzed quarterly at hazardous and mixed waste management facilities for RCRA and SCHWMR parameters. Typically, wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. In this geographic area, 15 wells are used to monitor groundwater. DOE plans additional wells for subsurface conditions and contaminant transport.

Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-21 lists the representative monitoring wells at each waste management facility, the site investigations, and the results of groundwater, soil, and vegetation monitoring.

B.6 TNX-AREA WASTE SITES

The TNX-Area geographic grouping is approximately 7 kilometers southwest of C-Reactor along Road 3 and about 15 kilometers south of A-Area in the southwest portion of the Plant. Drainage is to the Savannah River, which forms part of the western boundary of the area. The TNX facilities and portions of the D-Area coal-fired powerhouse are in this grouping. The old TNX seepage basin and the D-Area burning/rubble pits define the boundaries of this

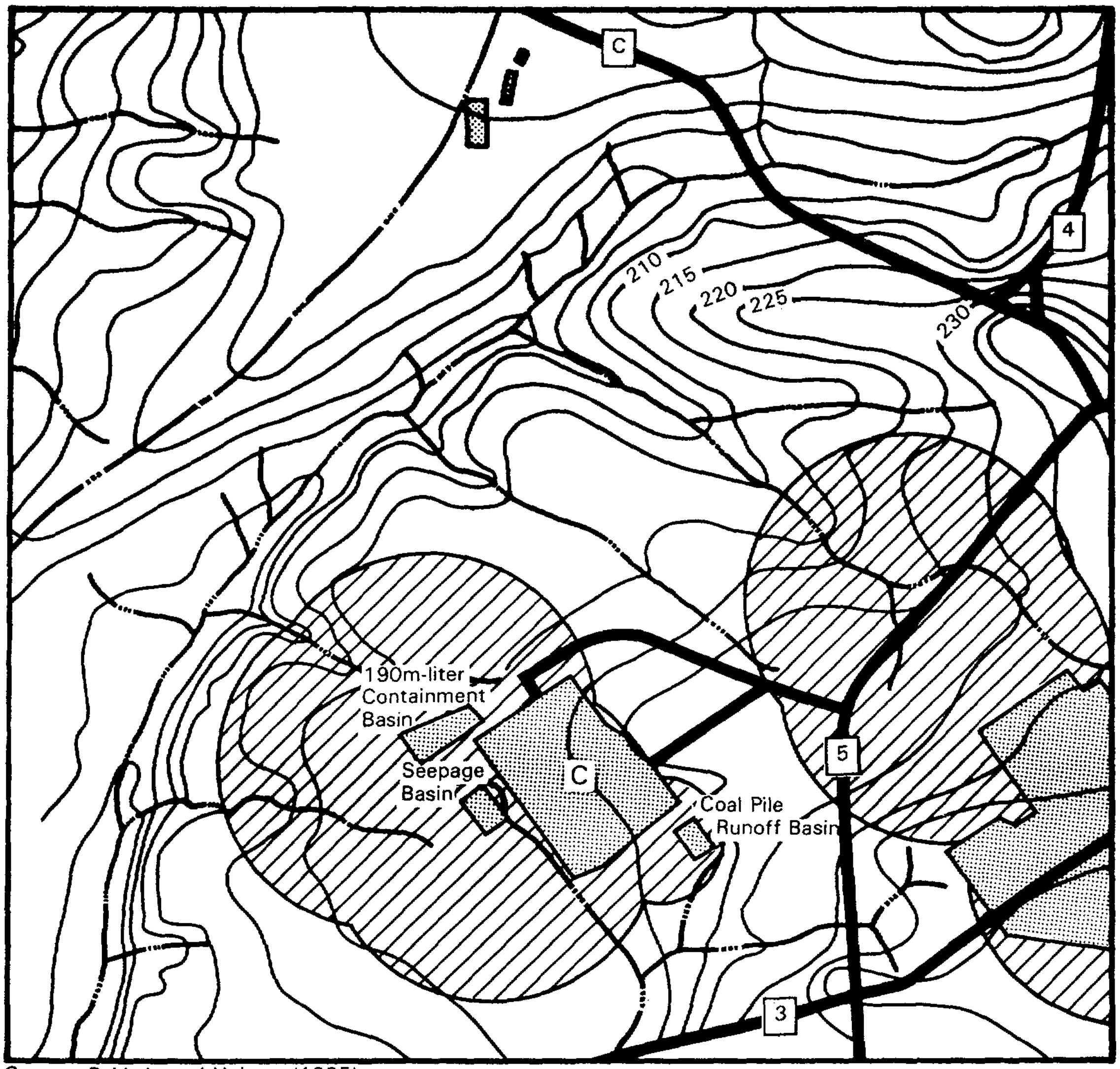
Formations and Depths of Well

Total Depth of all Strata	Depth of Each Stratum	Formation Found at Each Stratum
feet	feet	
80	20	Grey sandy clay
30	10	Yellow sandy clay
39	9	Grey sandy clay
59	30	Yellow clay and fine sand
93	34	Medium coarse sand and soft red clay
108	16	Soft white sandy clay
130	21	Medium coarse sand and white clay
135	5	Yellow clay
150	15	Chalky white clay with hard streaks of shell rock
190	40	Hard shell rock with sand and chalk
235	45	Soft yellow clay and sand with some shell
281	46	Coarse sand and little yellow clay and shell
291	30	Blue marl and firm sand
306	15	Medium course sand with blue marl
311	8	Fine sand and blue marl
358	44	Sandy blue marl
373	30	Sandy blue marl with mixture of clay
346	50	Sandy blue marl
438	80	Tight red and white clay, slow
450	15	Tight red clay, slow
476	26	Coarse white sand and gravel with streaks of clay
481	15	Chalky white clay with streaks of sand
508	17	Coarse white clay and chalky clay
518	10	Blue marl
537	10	Soft sandy blue marl
579	48	Coarse white sand with thin streaks of clay

Dimensions of Casing and Screen

Total Lengths of all Screens and Casings	Length of Each Screen and Casing	Screen or Casing	Size of Screen or Casing	Graph of Screen
feet	feet		inches	
180	180	Casing		
100	6	Casing	18	5/16
130	30	Casing	8	5/16
155	6	Slotted Pipe	8	5/16
525	420	Casing	8	5/16
575	50	Slotted Pipe	8	5/16
580	5	Casing	8	5/16

Figure B-12. Drilling Log of Well 905-71G



Source: Pekkala and Holmes (1985)

Note: 1.0 foot = 0.3048 meter

Figure B-13. Map of Water-Table Near C-Area Showing Locations of Reactor Seepage Basins and Other Waste Sites (contours expressed in feet above mean sea level)

Table B-21. Site Investigations and Monitoring at Waste Management Facilities in the C- and CS-Area Geographic Grouping[a]

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
CS-Area burning/rubble pits (631-1G, 631-5G, 631-6G)	CSR 1 CSR 2 CSR 3 CSR 4 No wells at pit 631-6G	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site sediment characterization program to be conducted.	Statistical analysis of groundwater monitoring data indicates the following to be present: • Conductivity • Sodium
C-Area burning/rubble pit (131-C)	CRP 1 CRP 2 CRP 3 CRP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site sediment characterization program to be conducted.	Statistical analysis of groundwater monitoring data indicates the following to be present: • pH • Conductivity • Lead • Manganese • Sodium • Total organic halogen • Nitrate
Hydrofluoric-acid spill area (631-4G)	CSA 1 CSA 2 CSA 3 CSA 4	Wells monitored quarterly for RCRA and SCHWMR parameters. No soil-sample analyses performed.	Groundwater-monitoring results indicate the presence of: • Barium • Manganese
		LOW-LEVEL WASTE SITES	
Ford Building waste site (643-11G)	None	None	None

Footnotes on last page of table.

Table B-21. Site Investigations and Monitoring at Waste Management Facilities in the C- and CS-Area Geographic Grouping[a] (continued)

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		MIXED WASTE SITE	
Ford Building seepage basin (904-91G)	HXB 1 HXB 2 HXB 3	Wells monitored quarterly for RCRA and SCHWMR parameters. Basin-characterization study completed in 1985.	Groundwater monitoring indicates the presence of: • Nitrate • Mercury • Lead Soil characterization data indicate the presence of: • Cesium-137 • Cobalt-60 • Strontium-90 • Aluminum • Arsenic • Cadmium • Chromium • Copper • Iron • Mercury • Nickel • Selenium • Zinc • Ammonia • Fluoride • Sulfate • Phosphate

[a]Sources: Huber, Johnson, and Marine, 1986; Huber and Bledsoe, 1986a; Huber et al., 1986; Pekkala, Holmes, and Marine, 1986b; Pekkala et al., 1986.
[b]The monitored hydrogeologic unit for these wells is the Barnwell.
[c]See page B-1.
[d]Not RCRA monitoring wells.

geographic grouping. Figure B-14 shows the locations of the five waste sites described in the following sections.

B.6.1 HAZARDOUS WASTE SITE

The D-Area burning/rubble pits are near the western perimeter of the Savannah River Plant, west of D-Area and east of Road A-4.7. The site configuration is a trapezoidal area of approximately 1050 square meters.

History of Waste Disposal

Rubble waste disposed of at these pits reportedly included concrete, metal, lumber, and telephone poles. See Section B.2.1.6.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

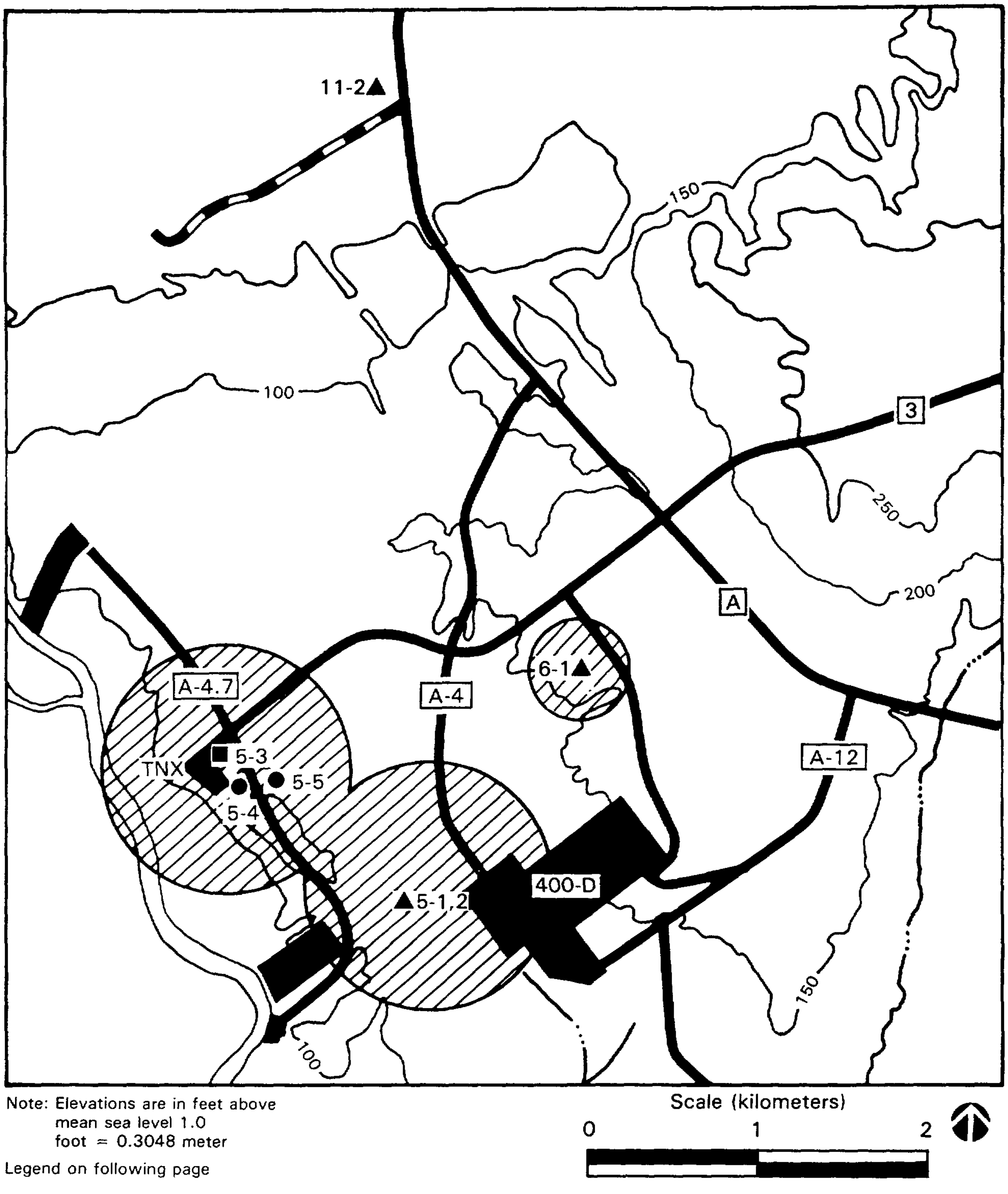
B.6.2 LOW-LEVEL RADIOACTIVE WASTE SITE

The TNX burying ground is part of the TNX facility east of the Savannah River on the terrace known as the Ellenton Plain. The burying ground consists of three known areas on a bluff 45 meters above the Savannah River swamp. The sites known to contain radioactive waste are (1) an area beneath a transformer pad by Building 673-T; (2) a rectangular area beneath Building 711-T; and (3) an L-shaped area beneath Office Trailer Building 676-8T. A fourth area is believed to be east of Building 673-T. The SRP boundary nearest any of the burial sites is the Savannah River, approximately 396 meters west. The following sections discuss the history of waste disposal, evidence of contamination, and waste characteristics of the sites (Kingley, Simmons, Bledsoe, Smith, and Johnson, 1986b).

History of Waste Disposal

In 1953, an experimental evaporator containing approximately 590 kilograms of uranyl nitrate exploded at the TNX facility. Because the SRP radioactive waste burial ground (Building 643-G) was not in operation, debris from the explosion was collected and buried at the TNX burying ground (Building 643-5G). The waste included such materials as conduit, drums, tin, and structural steel. The site also received other waste, primarily depleted uranium characteristic of that generated at the process facility. No material was buried at the site after the SRP radioactive waste burial ground became operational.

Most of the material was excavated and sent to the SRP burial ground between 1980 and 1984. The remaining TNX burying sites are beneath asphalt, buildings, and transformer pads at depths of approximately 1.8 to 2.4 meters. An estimated 27 kilograms of uranyl nitrate remain buried. This is approximately 5 percent of the initial buried amount.



Note: Elevations are in feet above mean sea level 1.0 foot = 0.3048 meter

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Figure B-14. TNX-Area Waste Sites

Number	Potential Waste Type	Site Name	Building Number
5-1	▲	D-Area Burning/Rubble Pit*	431-D
5-2	▲	D-Area Burning/Rubble Pit*	431-1D
5-3	■	TNX Burying Ground	643-5G
5-4	●	TNX Seepage Basin (old)*	904-76G
5-5	●	TNX Seepage Basin (new)*	904-102G
6-1	▲	D-Area Oil Seepage Basin	631-G
11-2	▲	Gunsite 720 Rubble Pit	N80E27.35

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive
●—Mixed

Figure B-14. TNX-Area Waste Sites (continued)

Evidence of Contamination

Uranyl nitrate is a possible contaminant of the soils surrounding the TNX burying ground, but no sediment data are available to confirm this possibility. There are no groundwater-monitoring wells in the immediate vicinity of the burying ground. Wells YSB 1A through 4A, around the new TNX seepage basin, are approximately 210 meters east; wells XSB 1 through 4, around the old TNX seepage basin, are approximately 91 meters west. Sections B.6.3.1 and B.6.3.2 discuss groundwater-monitoring data for these wells.

Waste Characterization

The original waste consists of conduit, drums, tin, and structural steel contaminated with uranyl nitrate. The site has also received depleted uranium characteristic of that generated from the process facility, as well as other undescribed waste.

B.6.3 MIXED-WASTE SITES

B.6.3.1 TNX Seepage Basin - Old (904-76G)

The old TNX seepage basin is in the southwestern section of the TNX facility (Figure B-14). The basin was constructed in two sections: an inlet section and a large main section. Together they encompassed approximately 0.3 acre. The following sections describe the history of waste disposal, evidence of contamination, and waste characteristics at the seepage basin (Kingley, Simmons, Bledsoe, Smith, and Johnson, 1986c; Simmons, Bledsoe, and Bransford, 1985).

History of Waste Disposal

The old TNX seepage basin was built in 1958 to receive wastewater from pilot-scale tests conducted at TNX in support of the Defense Waste Processing Facility (DWPF) and the Separations Areas (Kingley et al., 1986c). In 1980, the basin was closed, and the wastewater flow to the basin was diverted to the new TNX seepage basin (Section B.6.3.2). When it was in operation, the old basin received process wastewater through an underground vitrified pipeline 20 centimeters in diameter. This pipeline entered the basin through the north wall of the settling section. A 13-centimeter weir permitted effluent from the settling section to flow into the main section. A weir of comparable size across the west wall of the main section directed basin overflow down into the nearby TNX swamp along Outfall X-2. During the basin's 22-year loading history, its overflow has created an outfall delta about 30 meters wide inside the swamp.

In 1981, the west wall of the basin was breached to drain the standing free waters into the adjacent wetlands. The basin was backfilled with a sand and clay mixture. Currently, part of the top of the old basin is paved with asphalt. Office Trailer Building 675-7T is on this pavement beside an equipment laydown area. Vegetation near the basin and outside the TNX security fence primarily consists of sparse-to-thick woods. Vegetation inside the fence is primarily centipede grass.

Evidence of Contamination

A program to define the extent of chemical and radionuclide contamination in the vicinity of the old TNX seepage basin began in 1984. This program included sampling and analyses of sediment from beneath the basin and continued sampling of the groundwater from seven monitoring wells.

The sampling detected curium-243, curium-244, plutonium-239, plutonium-240, radium-228, thorium-228, uranium-235, silver, chromium, copper, mercury, nickel, and cyanide in the basin sediment. These constituents were concentrated in the northeastern section of the basin within the top 61 centimeters of bottom sediment.

Groundwater monitoring results indicate that mercury, manganese, nickel, total organic halogens, and nitrate are present.

Waste Characterization

Approximately 40 compounds were in use at the TNX facility during the basin's operation. These compounds probably were sent to the basin at some time during its 22-year loading history. Among the significant wastes discharged to the basin were mercury and depleted uranium.

B.6.3.2 TNX Seepage Basin - New (904-102G)

The new TNX seepage basin is in the southeastern section of the TNX facility (Figure B-14). The basin consists of a small inlet section and a large seepage section. An underground pipe connects the two rectangular sections that encompass approximately 1620 square meters of land. A pipe through the southeast wall of the larger section directs the basin overflow down Outfall X-13. This outfall eventually empties into the Savannah River. The following sections describe the history of waste disposal, evidence of contamination, and waste characteristics at the seepage basin (Kingley, Simmons, Bledsoe, and Johnson, 1986a).

History of Waste Disposal

The new TNX seepage basin, operating since 1980, replaced the old basin (Section B.6.3.1). It receives process wastewater from pilot-scale tests conducted at the TNX facility in support of the DWPF and the Separations Areas. Batch discharges are neutralized before release to the basin. The basin is scheduled for closure in the third quarter of 1987 when the TNX Effluent Treatment Plant begins operation. The closure of the basin will follow applicable Federal and State regulations.

Evidence of Contamination

Soil samples were collected from cores beneath and adjacent to the basin during the fourth quarter of 1985. Analytical results indicate that no significant organic contamination exists in any of the sediments sampled. Phenol and thorium were detected at low concentrations in one layer of the sediment cores outside the basin. Barium, nickel, chromium, lead, nitrates, phosphate, and sodium were detected in the top 0.15 meter of sediment.

Four groundwater monitoring wells have been installed around the new TNX seepage basin. These wells are sampled quarterly and analyzed for nutrients, anions, metals, organics, radioactivity, and standard constituents.

Waste Characterization

Most of the wastewater sent to the basin after 1983 contains simulated nonradioactive DWPF sludge and other laboratory chemicals. Before 1983, simulated nonradioactive salt supernate was sent to the basin. Tables B-22 and B-23 list the composition of the sludge and supernate, respectively, and Tables B-24 and B-25 provide chemical analyses of the basin influent and effluent, respectively. The influent and effluent data were obtained from a 12-week characterization program initiated in January 1984. Average effluent flow rates are not available.

Table B-22. Composition of Simulated DWPF Sludge (percent)[a]

Component	Weight
Ferric hydroxide	43.19
Aluminum hydroxide	17.81
Silicon dioxide	4.94
Manganese dioxide	7.41
Sodium hydroxide	4.43
Zeolite[b]	4.87
Sodium nitrate	4.43
Calcium carbonate	5.66
Nickel hydroxide	3.42
Other chemicals	3.84

[a]Source: Kingley, Simmons, Bledsoe, and Johnson, 1986a.
[b]Linde Ion-Siv IE-95.

B.6.4 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The near-surface geology of the TNX Area geographic grouping consists of river-terrace deposits of sand, silt, and clay, typically with a significant organic content. These materials are underlain successively by Tertiary sediments, which are difficult to distinguish, and the Ellenton and Middendorf/Black Creek (Tuscaloosa) Formations. Figure B-15 shows the stratigraphy in the vicinity of the old TNX seepage basin inferred from lithologic and geophysical logs developed for a nearby well (XSB-3T). In the central portion of the Plant, the McBean and Congaree Formations are separated by a confining layer described as the green clay (Appendix A).

A detailed water-table map is not available for the area. The natural discharge for the water-table aquifer is to the Savannah River swamp. The vertical head relationships in this area are similar to those in the central

Table B-23. Chemical Composition of Simulated Salt Supernate (percent)[a]

Component	Weight
Sodium nitrate	41.6
Sodium nitrite	14.8
Sodium aluminate	9.10
Sodium hydroxide	19.06
Sodium carbonate	6.55
Sodium sulfate	8.34

[a]Source: Kingley, Simmons, Bledsoe, and Johnson, 1986a.

Table B-24. Analysis of TNX Seepage Basin Influent[a,b]

Parameter	Units	Average	Maximum	Minimum	Number of samples
BOD_5	mg/liter	40	311	<6	56
TSS	mg/liter	35	296	1	53
TDS	mg/liter	124	804	54	36
TOC	mg/liter	13	86	<5	57
Grease and oil	mg/liter	<5	7	<5	8
pH	pH	7.5-8.0	12.3	2.2	1018[c]
Flow rate	m^3/min	0.099	0.33	0.0038	1018[c]

[a]Source: Kingley, Simmons, Bledsoe, and Johnson, 1986a.
[b]Values obtained from 24-hour, flow-weighted, composite samples collected from 676-3T manhole.
[c]Hourly.

section of the Plant (Section B.3.4) where the head in the Middendorf/Black Creek is consistently above that of the Congaree. Thus, water cannot move from the Congaree to the Middendorf/Black Creek Formation. The piezometric surface of the "Tuscaloosa" in the vicinity of the TNX facility is commonly above the land surface (Kingley, Simmons, Bledsoe, Smith, and Johnson, 1986b). There are no available data on the hydraulic properties of the geologic strata underlying the TNX-Area waste sites.

B.6.5 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at four of the five waste management facilities in the TNX-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous and mixed waste management facilities. Typically, wells are monitored for gross alpha, gross

Table B-25. Analysis of TNX Seepage Basin Effluent[a,b]

Parameter	Units	Average	Maximum	Minimum	Number of samples
BOD_5	mg/liter	29	133	<6	37
TSS	mg/liter	33	108	5	37
TDS	mg/liter	113	168	40	34
TOC	mg/liter	10	17	<5	37
Grease and oil	mg/liter	<5	5	4	10
pH	pH	9.8	11.6	7.5	35

[a]Source: Kingley, Simmons, Bledsoe, and Johnson, 1986a.
[b]Values from grab samples of basin overflow at Outfall X-13.

nonvolatile beta, and tritium at low-level waste management facilities. In this geographic area, 15 wells are used to monitor groundwater. DOE plans additional wells to obtain a better definition of subsurface conditions and contaminant transport.

Waste site characterization programs are completed at two of the facilities and are being implemented at two others. Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-26 lists the representative monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring.

B.7 D-AREA WASTE SITES

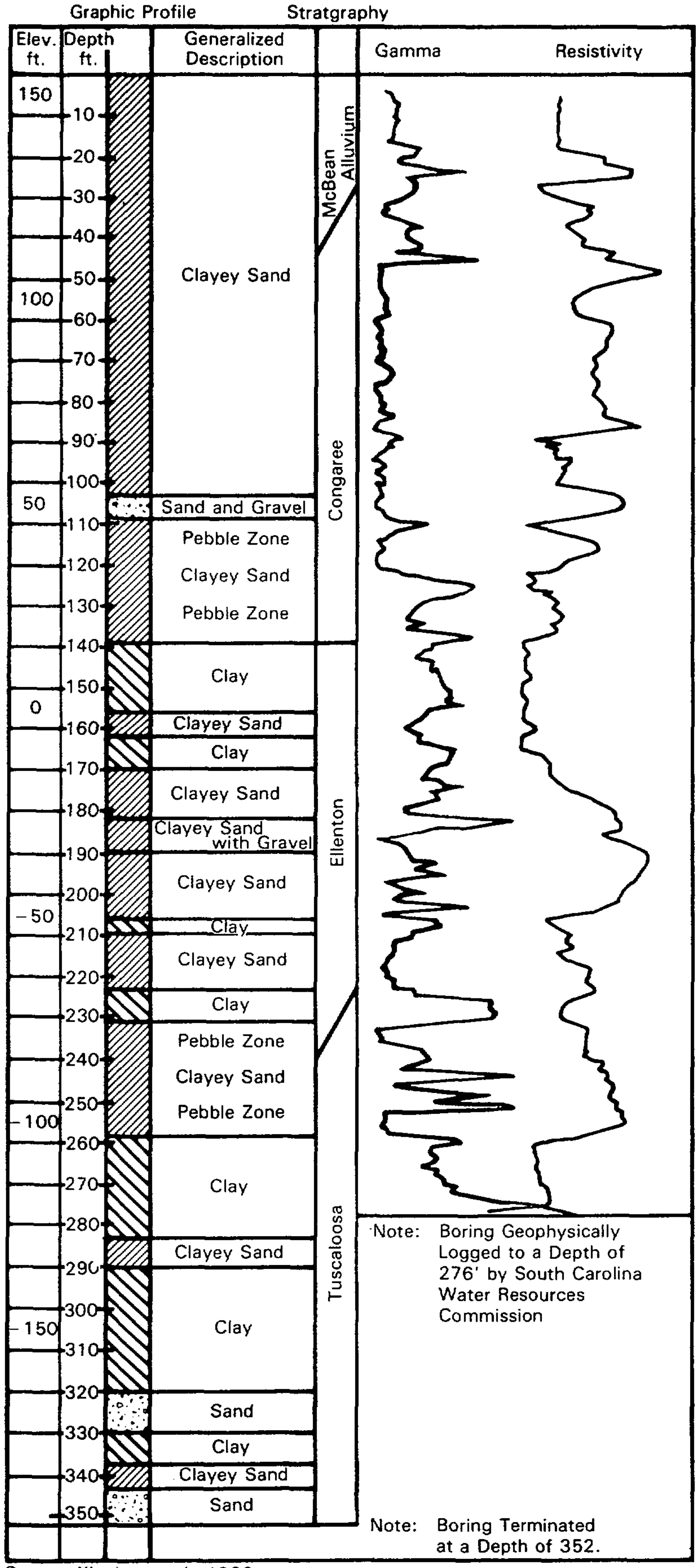
This geographic grouping is approximately 1000 meters west of Road A (South Carolina Highway 125) and 1200 meters north of the D-Area steam plant (Figure B-14).

B.7.1 HAZARDOUS WASTE SITE

The D-Area waste oil basin is in the western portion of the Plant, north of D-Area and west of Road A. The basin is approximately 117 meters long, 16 meters wide, and 2 meters deep.

History of Waste Disposal

The D-Area waste oil basin began receiving waste oil products from D-Area in 1952. Burning was not permitted at the powerhouse, but this oil might have been contaminated with hydrogen sulfide. Other liquids contaminated with toxic chemicals were brought to the oil basin. In 1973, when burning waste oil ceased plantwide, waste oils not acceptable for powerhouse incineration were deposited in the basin. The basin possibly received waste oil containing



Source: Kingley *et al.*, 1986c.

Figure B-15. Drillers Log for Monitoring Well XSB-3T

Table B-26. Site Investigations and Monitoring at Waste Management Facilities in the TNX-Area Geographic Grouping[a]

Facility	RCRA monitoring well[b]	Site investigations	Monitoring results
		HAZARDOUS WASTE SITES	
D-Area burning/rubble pits (431-D, 431-1D)	DBP 1 DBP 2 DBP 3 DBP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Sediment samples to be taken from facilities with similar inventories. If contamination is indicated, all burning/rubble pits with similar inventories will be tested.	Statistical analysis of groundwater monitoring data indicates the following to be present: • pH • Lead • Nitrate • Conductivity • Manganese • Sulfate • Copper
		LOW-LEVEL WASTE SITES	
TNX burial ground (643-5G)	None	No groundwater monitoring wells exist in immediate vicinity of TNX burying ground. No soil samples from burial area have been analyzed.	Uranyl nitrate is possible soil constituent.
		MIXED WASTE SITES	
TNX seepage basin, old (904-76G)	XSB 1[c] XSB 2[c] XSB 3A[c] XSB 4[c] XSB 5, 5A[c] XSB 3T[c]	Wells monitored quarterly for RCRA and SCHWMR parameters. Basin-sediment and swamp-sediment characterization program completed in 1984.	Statistical analysis of groundwater monitoring data indicates the following are present: • pH • Conductivity • Barium* • Chromium* • Manganese* • Zinc* • Gross beta • Gross alpha • Radium • Total organic halogen • Total dissolved solids • Cadmium* • Copper* • Iron* • Sodium *Probable sampling artifacts.

Footnotes on last page of table.

Table B-26. Site Investigations and Monitoring at Waste Management Facilities in the TNX-Area Geographic Grouping[a] (continued)

Facility	RCRA monitoring well[b]	Site investigations	Monitoring results
		MIXED WASTE SITES (continued)	
			• Nickel • Nitrate • Total organic carbon • Beryllium • Lead Basin-sediment samples contained: • Curium-243, -244 • Plutonium-239, -240 • Radium-228 • Thorium-228 • Uranium-235 • Silver • Chromium • Copper • Nickel • Mercury • Cyanide Swamp-sediment samples contain: • Radium-228 • Thorium-228 • Tritium • Uranium-235 • Chromium • Mercury Swamp water constituents include: • Gross alpha • Gross beta • Radium • Silver • Chromium • Copper • Mercury • Cyanide
TNX seepage basin, new (904-102G)	YSB 1A YSB 2A YSB 3A YSB 4A	Wells monitored quarterly for RCRA and SCHWMR parameters. Sediment-sampling program (1.5-m cores) conducted in fourth quarter of 1985.	Monitoring indicates little if any groundwater contamination. Soil characterization indicates no significant organic contamination. EP toxicity tests show basin sediments to be nonhazardous.

Footnotes on last page of table.

Table B-26. Site Investigations and Monitoring at Waste Management Facilities in the TNX-Area Geographic Grouping[a] (continued)

Facility	RCRA monitoring well[b]	Site investigations	Monitoring results
		MIXED WASTE SITES (continued)	
			The following constituents are found in soils and groundwater: • Barium • Nickel • Chromium • Lead • Nitrate • Phosphate • Sodium

[a]Sources: Huber, Johnson, and Marine, 1986; Kingley, Simmons, Bledsoe, Smith, and Johnson, 1986b,c; Kingley, Simmons, Bledsoe, and Johnson, 1986a.
[b]The monitored hydrogeologic unit for these wells is the Pleistocene alluvium.
[c]Non-RCRA wells.

chlorinated organic compounds and other organics (Huber, Johnson, and Bledsoe, 1986). The basin was closed in January 1975 and was backfilled with soil. Approximately 0.3 meter of standing oil remained in the basin when it was backfilled.

Evidence of Contamination

Sampling and analysis of the soils beneath the basin have not been performed; however, the intention to do so in the future is documented. Three groundwater monitoring wells were installed near the basin in May 1983, and groundwater sampling began in March 1984. A fourth groundwater monitoring well was installed in June 1984. Based on groundwater monitoring results, no chemical constituents were selected for environmental assessment and no inventory of contaminant substances was prepared (Huber, Johnson, and Bledsoe, 1986).

Waste Characterization

Limited information is available on the nature and extent of contamination associated with the D-Area oil seepage basin. Historic data indicate oily wastes were deposited in large volumes and some might have been contaminated with chlorinated compounds and other toxic chemicals. Paraffinic hydrocarbons, typical of petroleum-based lubricating oils, tend to be hydrophobic and exhibit strong adsorptive characteristics (Table B-3). Consequently, horizontal migration of these type compounds (i.e., n-dodecane) as solutes with groundwater flow is unlikely. Any vertical migration would tend to be retarded by adsorption.

B.7.2 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The D-Area waste oil basin is located on a terrace deposit of the Savannah River. These sands, silts, and clays are 6 to 12 meters thick and blanket the underlying Tertiary deposits (COE, 1952). No detailed geologic data are available for the immediate area; however, the subsurface geology should be similar to the hydrostratigraphy of the nearby TNX basins (Section B.6.4). A U.S. Army Corps of Engineers study in D-Area (COE, 1952) indicates that a calcareous zone, a zone of low penetration resistance and high drill-mud loss, occurs between an elevation of 35 and 21 meters.

Four RCRA-type monitoring wells have been installed near the basin at depths of 10.7 to 12.8 meters from the ground surface. The water table in these wells has a depth of about 6 meters. The natural discharge from the water-table aquifer is to the Savannah River swamp. The higher piezometric surface in the Congaree and Middendorf/Black Creek (Tuscaloosa) aquifers at this location indicates that the hydraulic gradient of groundwater in confined aquifers is upward. Groundwater movement is downward in the water table (Huber, Johnson, and Bledsoe, 1986).

B.7.3 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at the single waste-management facility in the D-Area geographic grouping. Four wells are used to monitor groundwater near this facility. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters.

A waste site characterization program is being implemented at the facility. Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-27 lists the representative monitoring wells at the waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring.

B.8 ROAD A AREA WASTE SITE

This geographic grouping is approximately 400 meters southwest of Road A near the Road 6 intersection (Figure B-16). It is about 3 kilometers east of TNX and D-Area facilities.

B.8.1 MIXED WASTE SITE

The Road A chemical basin is also known as the Baxley Road dump. It is approximately 800 meters west of the intersection of SRP Roads A and 6 (Figure B-16). The original basin was irregular in shape with average side dimensions of approximately 30 meters by 53 meters. The following sections describe the history of disposal, evidence of contamination, and waste characteristics at the basin (Muska, Pickett, and Bledsoe, 1986).

History of Waste Disposal

The history of disposal at the Road A chemical basin is vague. The basin was closed and backfilled in 1973. An area significantly larger than the original basin was graded and revegetated with vetch (Sericea lespedeza). The regraded area, about 3.6 acres, is surrounded by pines and hardwoods with a large stand of bottomland hardwood approximately 200 meters downslope.

Evidence of Contamination

No characterization studies of the soils beneath or around the basin have been performed. The analytical results from four monitoring wells provide no evidence of any organic, inorganic, or radioactive contamination of the groundwater.

Waste Characterization

The nature and quantities of materials disposed in the basin are not known. A 1983 report lists the contents as miscellaneous radioactive and chemical aqueous wastes (Ross and Green, 1983).

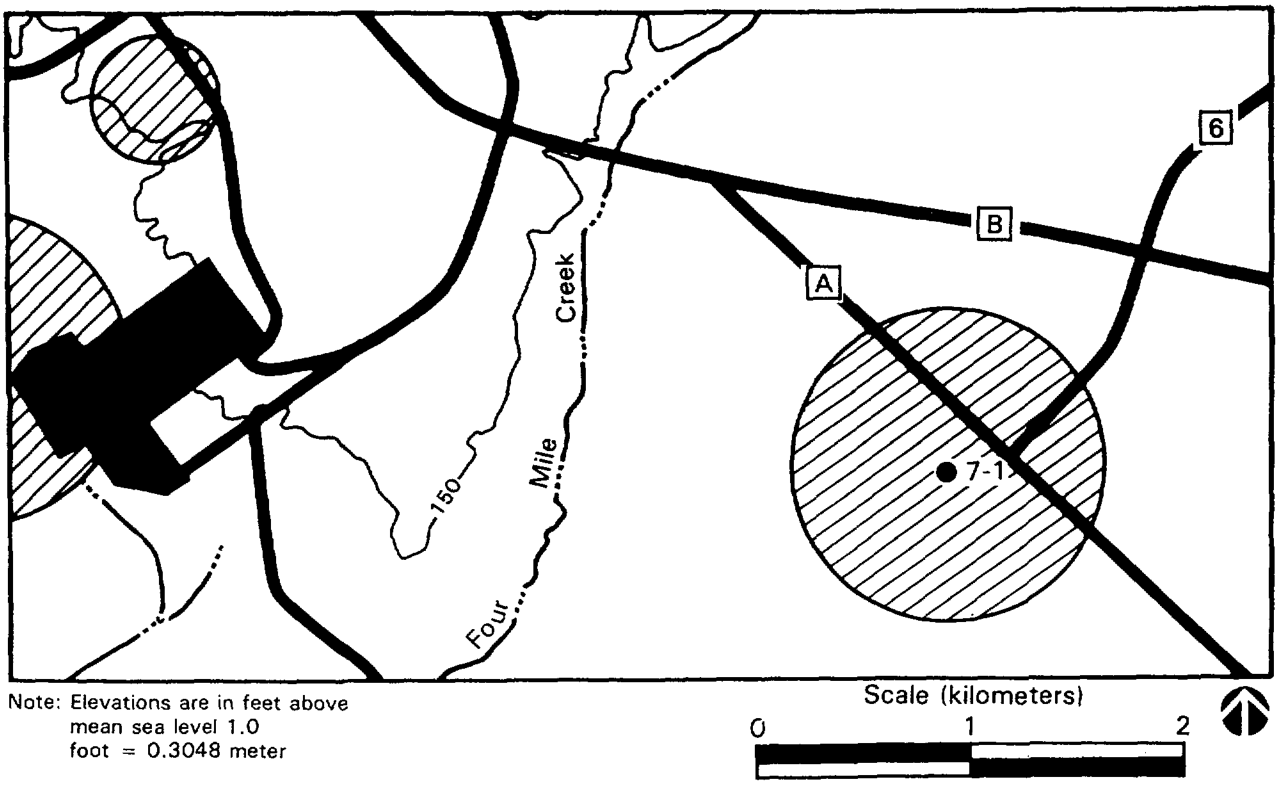
B.8.2 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The Road A chemical basin is on the Aiken Plateau close to the escarpment that separates the Plateau from the Ellenton Plain. The ground surface in the basin area slopes toward the Ellenton Plain at a gradient of about 0.08 meter per meter. Four Mile Creek, Pen Branch, and the Savannah River are located approximately 1829 meters northwest, 2134 meters east, and 5486 meters west, respectively, from the basin site (Muska, Pickett and Bledsoe, 1986).

Table B-27. Site Investigations and Monitoring at Waste Management Facility in the D-Area Geographic Grouping[a]

Facility	RCRA monitoring well[b]	Site investigations	Monitoring results
D-Area waste oil basin (631-G)	DOB 1 DOB 2 DOB 3 DOB 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Sediments beneath waste-oil basin to be characterized. Following parameters to be measured: • EP toxicity-metals • Acid-base and neutral organics • Volatile organics • Oil and grease	Groundwater monitoring data show no contamination.

[a]Source: Huber, Johnson, and Bledsoe, 1986.
[b]The monitored hydrogeologic unit for these wells is the Pleistocene alluvium.



Note: Elevations are in feet above mean sea level 1.0 foot = 0.3048 meter

Number	Potential Waste Type	Site Name	Building Number
7-1	●	Road A Chemical Basin*	904-111G

*Indicates that waste type may be contained in the waste site
●—Mixed

Figure B-16. Road A Area Chemical Basin Waste Site

No detailed geologic data are available on the vicinity of the Road A chemical basin. Four monitoring wells are near the basin; however, these wells are only about 18 meters deep. The closest borings with good geologic control include one well XSB-3T at the TNX facility, approximately 6 kilometers west-northwest of the basin (see Section B.6.4), and two wells drilled in D-Area by the U.S Army Corps of Engineers (COE, 1952). A well cluster (seven to eight wells) is currently being installed about 2.6 kilometers southeast of the basin. This well-drilling operation includes a continuously cored geologic boring at a depth of about 300 meters below the ground surface. The stratigraphy for this geographic grouping is believed to be similar to that shown in Figure B-15 for the TNX facility (Section B.6.4). The formational contacts at the Road A chemical basin would be slightly deeper than those shown in Figure B-15 because the unconsolidated coastal-plain sediments strike about N. 60°E and dip to the southeast at about 2 to 4 meters per kilometer, and the basin is geologically down-dip from well XSB-3T (Siple, 1967).

The water table at the Road A chemical basin is at an elevation of about 52 meters, or a depth of about 9 meters below the ground surface (Muska, Pickett, and Bledsoe, 1986). The water table is probably within the McBean Formation and discharges westward to the Savannah River swamp. The natural discharge of the Congaree Formation is to Pen Branch, the Savannah River, and the marshes and swamps of the river. The vertical head relationships for this area are assumed to be similar to those measured in the central portion of the Plant, where Middendorf/Black Creek (Tuscaloosa) heads are higher above and below the Congaree (Muska, Pickett, and Bledsoe, 1986). Thus, water discharges from the Middendorf/Black Creek upward into the overlying sediments in the Savannah River Valley.

B.8.3 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at the single waste management facility in the Road A Area geographic grouping. Four wells in this geographic area are used to monitor groundwater in the vicinity of this facility. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters.

Table B-28 lists the representative monitoring wells at the waste management facility, the site investigations, and the results of groundwater, soil, and vegetation monitoring.

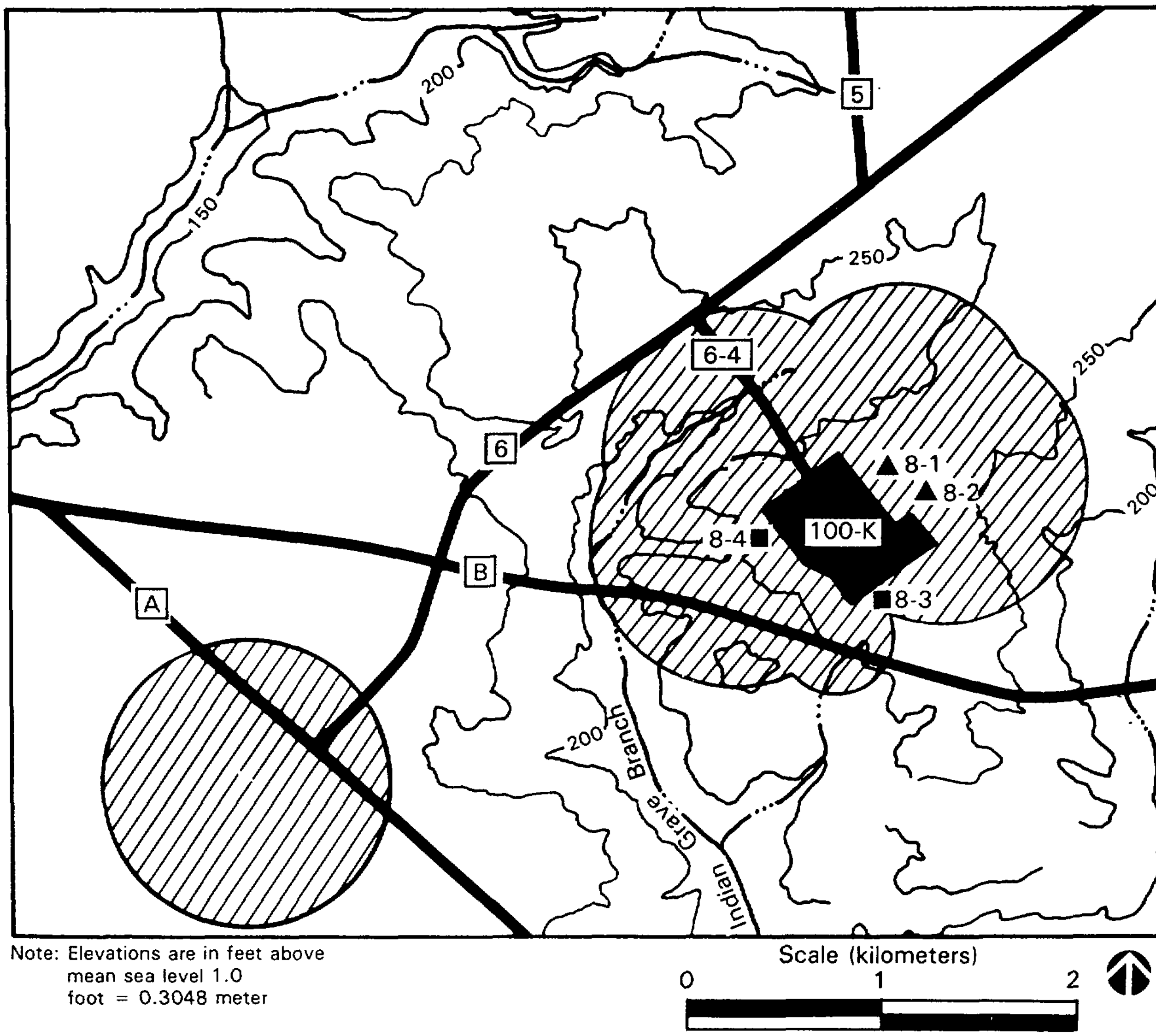
B.9 K-AREA WASTE SITES

The approximate boundaries of the K-Area geographic grouping are Road B on the south and Road 6 on the northwest. This grouping is formed by waste sites associated with K-Reactor. Drainage is primarily to Indian Grave Branch, a tributary of Pen Branch. Figure B-17 locates the waste sites in this grouping and shows its proximity to the Road A Area waste site.

Table B-28. Site Investigations and Monitoring at the Road A Area Geographic Grouping[a]

Facility	RCRA monitoring well[b]	Site investigations	Monitoring results
Road A chemical basin (904-111G)	BRD 1 BRD 2 BRD 3 BRD 4	Wells monitored quarterly for RCRA and SCHWMR parameters. No soil or sediment characterization studies have been performed.	No organic, inorganic, or radioactive contamination of groundwater is evident.

[a]Source: Muska, Pickett, and Bledsoe, 1986.
[b]The monitored hydrogeologic unit for these wells is the McBean.



Number	Potential Waste Type	Site Name	Building Number
8-1	▲	K-Area Burning/Rubble Pit*	131-K
8-2	▲	K-Area Acid/Caustic Basin*	904-80G
8-3	■	K-Area Bingham Pump Outage Pit*	643-1G
8-4	■	K-Area Seepage Basin	904-65G

*Indicates that waste type may be contained in the waste site

▲—Hazardous

■—Low-level radioactive

Figure B-17. K-Area Waste Sites

B.9.1 HAZARDOUS WASTE SITES

B.9.1.1 K-Area Burning/Rubble Pit (131-K)

K-Area burning/rubble pit is near the central portion of the Plant, east of K-Area and between Road 6-4.21 and Road 6-4.2. The site is rectangular, approximately 71 meters long, 10 meters wide, and 3 meters deep.

History of Waste Disposal

Rubble waste disposed at this site reportedly included paper, lumber, cans, empty galvanized steel drums, and scrap metal. See Section B.2.1.6.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

B.9.1.2 K-Area Acid/Caustic Basin (904-80G)

The K-Area acid/caustic basin is one of six such basins in the Reactor and Separations areas. These basins are unlined earthen depressions with nominal dimensions 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

See Section B.3.1.1.

Evidence of Contamination

See Section B.3.1.1. Identification of the environmental impacts of the basins is in progress. A program to sample the contents and the soils beneath the basins is under way. A review of existing data from the monitoring wells installed around all the basins, except that in H-Area, shows no significant impacts on groundwater quality; however, some slight increases in sulfate, conductivity, and pH levels are noted for some of the basins.

Waste Characterization

See Section B.3.1.1.

B.9.2 LOW-LEVEL RADIOACTIVE WASTE SITES

B.9.2.1 K-Area Bingham Pump Outage Pit (643-1G)

The Bingham pump outage pits are outside the perimeter fences of K-, L-, P-, and R-Areas near the center of the Plant. They are between 7.2 and 9.8 kilometers from the nearest SRP boundaries. The K-Area pit is 9 kilometers from the nearest boundary on a gentle slope above a tributary of Indian Grave Branch 290 meters away. The following sections describe the history of waste disposal, evidence of contamination, and waste characteristics at the K-Area Pit (Pekkala, Holmes, and Marine, 1986a).

History of Waste Disposal

Normally, all radioactive solid waste generated in the reactor areas is sent to solid waste burial ground 643-G/643-7G. An exception to this practice was made during 1957 and 1958 when the reactor areas initiated major modifications to their primary and secondary cooling water systems. C-Area was the first to modify, followed by K-, L-, P-, and R-Areas. The outages became known as the "Bingham pump outages." No pumps are buried in the waste pits. All radioactive waste generated was surveyed, and solid waste with very low levels of surface contamination was buried between May and September 1957 in a pit near the area. The pit contains miscellaneous construction equipment such as pipes, cables, ladders, drums, and boxes of miscellaneous hardware (Fenimore and Horton, 1974). The waste, with a volume of about 7700 cubic meters, was covered with clean backfill, including a final cover at least 1.2 meters thick.

The K-Area pit has been inactive since 1958; vegetation has uncontrollably grown over it.

Evidence of Contamination

In 1970, radioactivity in samples of vegetation from the surface of the Bingham pump outage pits was compared with activity in vegetation growing at the SRP perimeter. The vegetation from the outage pits showed little or no elevation in activity (Table B-29). There are no nearby monitoring wells to provide groundwater information on the pits, and there is no history of pit sediment characterization or core sampling. Groundwater flowing from K-Area to the closest receiving stream would have an estimated travel time of 15 to 57 years. The bottom of the pit is 12 meters above the water table.

Table B-29. Radioactivity in Vegetation at Bingham Pump Outage Pits and at Plant Boundary (pCi/g)

		Alpha				Nonvolatile beta			
		Pits		Plant boundary		Pits		Plant boundary	
Area	Facility	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.1
K	643-1G	0.2	0.3	0.2	0.6	28	34	21	31
L	643-2G	0.8	1.8	0.2	0.6	35	48	21	31
L	643-3G	0.8	1.8	0.2	0.6	35	48	21	31
P	643-4G	0.4	0.6	0.2	0.6	23	27	21	31
R	643-8G	0.2	0.5	0.2	0.6	37	51	21	31
R	643-9G	0.2	0.5	0.2	0.6	37	51	21	31
R	643-10G	0.2	0.5	0.2	0.6	37	51	21	31

Waste Characterization

The radiation level of the construction material buried at all the Bingham pump outage pits was measured at less than 25 milliroentgens per hour; no alpha activity was noted. A conservative maximum estimate of the amount of activity buried in each area is 1 curie. Table B-14 lists the radionuclide inventory.

B.9.2.2 K-Area Seepage Basin (904-65G)

Seepage basin 904-65G is outside the K-Area perimeter fence (Figure B-17). It is 41 meters long, 21 meters wide, and 2 meters deep with a volume of 1.6 x 10^3 cubic meters. The basin was constructed by excavating below grade and backfilling around the sides at grade level to form earthen dike walls. The basin did not overflow; water was released to the environment by evaporation and seepage. The following sections describe the history of disposal, evidence of contamination, and waste characteristics of the basin (Pekkala, Holmes, and Marine, 1986b).

History of Waste Disposal

See Section B.4.2.4. In addition to purge water from the K-Reactor disassembly basins, the K-Area seepage basin received very low-level radioactive wastewater from other sources in the reactor area. This water had to meet the same contamination control limits as disassembly-basin purge water before it could be released to the seepage basin. Conventional water treatment chemicals also entered the disassembly-basin water in small amounts through additions for pH control, filter promotion, algae treatment, and minimal additions of wastewater to the settler tank from other sources in the reactor buildings. The seepage basin in K-Area was active from 1957 to 1960. It has not been backfilled.

Evidence of Contamination

Core samples were obtained from the basin in 1978 and most of the radioactivity was found to be in the top 30 centimeters of the cores. The maximum cesium-137 and strontium-90 concentrations were 510 and 140 picocuries per gram, respectively.

Four groundwater monitoring wells were installed around the K-Area seepage basin in 1984. As determined from the three downgradient wells, 1985 annual average alpha and nonvolatile beta activity ranged from 0.10 to 0.23 and 0.04 to 2.9 picocuries per liter, respectively. The 1985 annual average for tritium ranged from 110,000 to 160,000 picocuries per liter.

Waste Characteristics

Although many different radionuclides have been discharged to the seepage basin, tritium, strontium-90, and cesium-137 account for almost all the radioactivity. The radionuclide contaminants entered the disassembly-basin water as a film of water on the irradiated components discharged from the reactor tank to the disassembly basin. Table B-30 is an inventory of radionuclides released to the seepage basin. No significant quantities of chemical contaminants are believed to have been discharged to the seepage basin.

Table B-30. Radioactive Releases to K-Area Reactor Seepage Basin (Ci)[a,b]

Isotope	Release
Tritium[c]	1.7×10^{3}
Cobalt-60	1.8×10^{-2}
Strontium-90	9.0×10^{-2}
Cesium-137	7.7×10^{-2}
Promethium-147	5.7×10^{-5}

[a]Source: Pekkala, Holmes, and Marine, 1986b.
[b]Values cumulative for years 1957-1960.
[c]Most tritium believed to have left basin via atmosphere or groundwater; corrected for radioactive decay through December 1984.

B.9.3 MAJOR GEOHYDROLOGIC CHARACTERISTICS

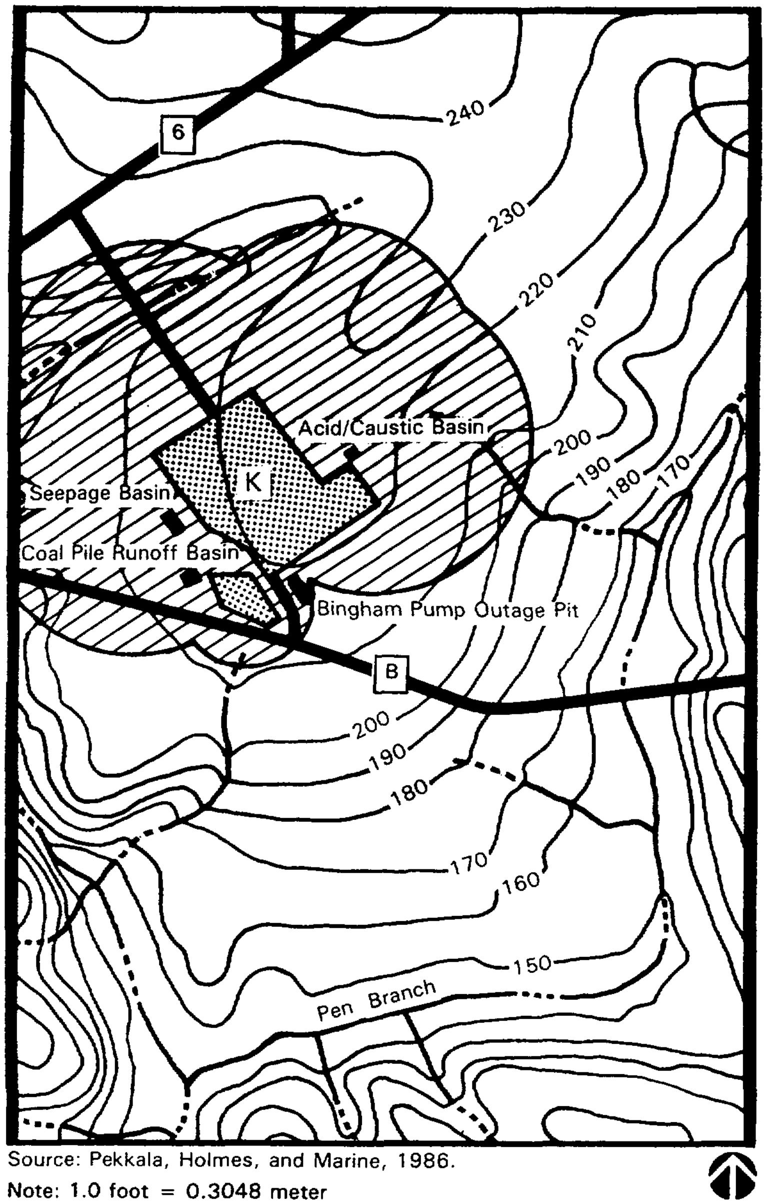
The waste sites in the K-Area geographic grouping are located with Indian Grave Branch on the west and Pen Branch on the east, where the water table below the area discharges. Little site-specific information is available for the subsurface geology; however, K-Area hydrostratigraphy is believed to be similar to the regional hydrostratigraphy discussed in Appendix A. Water-level measurements from other wells in the vicinity of K-Area have been used to construct a water-table map for the vicinity (Figure B-18).

The water-table elevation is about 60 meters. The estimated piezometric head in the Congaree Formation is about 43 meters, and about 51 meters in the Middendorf/Black Creek (Tuscaloosa). Thus, there is a downward hydraulic gradient to the Congaree, below which the gradient is upward (Ward, Johnson, and Marine, 1986).

B.9.4 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at three of the four waste management facilities in the K-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous waste management facilities. Wells are typically monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. At least 12 wells in this geographic area are used to monitor groundwater in the vicinity of the facilities. DOE plans additional wells to better define subsurface conditions and contaminant transport.

A waste site characterization program has been completed at two of the facilities and is being implemented at the other two. Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.



Source: Pekkala, Holmes, and Marine, 1986.
Note: 1.0 foot = 0.3048 meter

Figure B-18. Map of Water-Table Near K-Area Showing Locations of Reactor Seepage Basin and Other Waste Sites (contours are expressed in feet above mean sea level)

Table B-31 lists the representative monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring.

B.10 L-AREA WASTE SITES

This geographic grouping is formed by waste sites near L-Reactor, which went on standby status in 1968 and resumed operation in November 1985. This grouping is approximately 4 kilometers east of K-Reactor, north of Road B. Figure B-19 shows the locations of the waste sites in the L-Area geographic grouping. Within the boundaries of this grouping are the CMP pits and the L-Area burning/rubble pit, acid/caustic basin, and oil and chemical basin. Drainage is to Pen Branch on the west, and Steel Creek and L-Lake on the east.

B.10.1 HAZARDOUS WASTE SITES

B.10.1.1 L-Area Burning/Rubble Pit (131-L)

The L-Area burning/rubble pit is near the central portion of the Savannah River Plant, northwest of L-Area, north of Road 7, and east of Road 7-1. The site is rectangular, approximately 70 meters long, 9 meters wide, and 3 meters deep.

History of Waste Disposal

Rubble waste disposed at this site reportedly included paper, lumber, cans, empty galvanized steel drums, scrap metal, and batteries. See Section B.2.1.6.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

B.10.1.2 L-Area Acid/Caustic Basin (904-79G)

The L-Area acid/caustic basin is one of six such basins in the Reactor and Separations Areas. These basins are unlined earthen depressions with nominal dimensions of 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

See Section B.3.1.1.

Evidence of Contamination

See Section B.3.1.1.

Waste Characterization

See Section B.3.1.1.

Table B-31. Site Investigations and Monitoring at Waste Management Facilities in the K-Area Geographic Grouping[a]

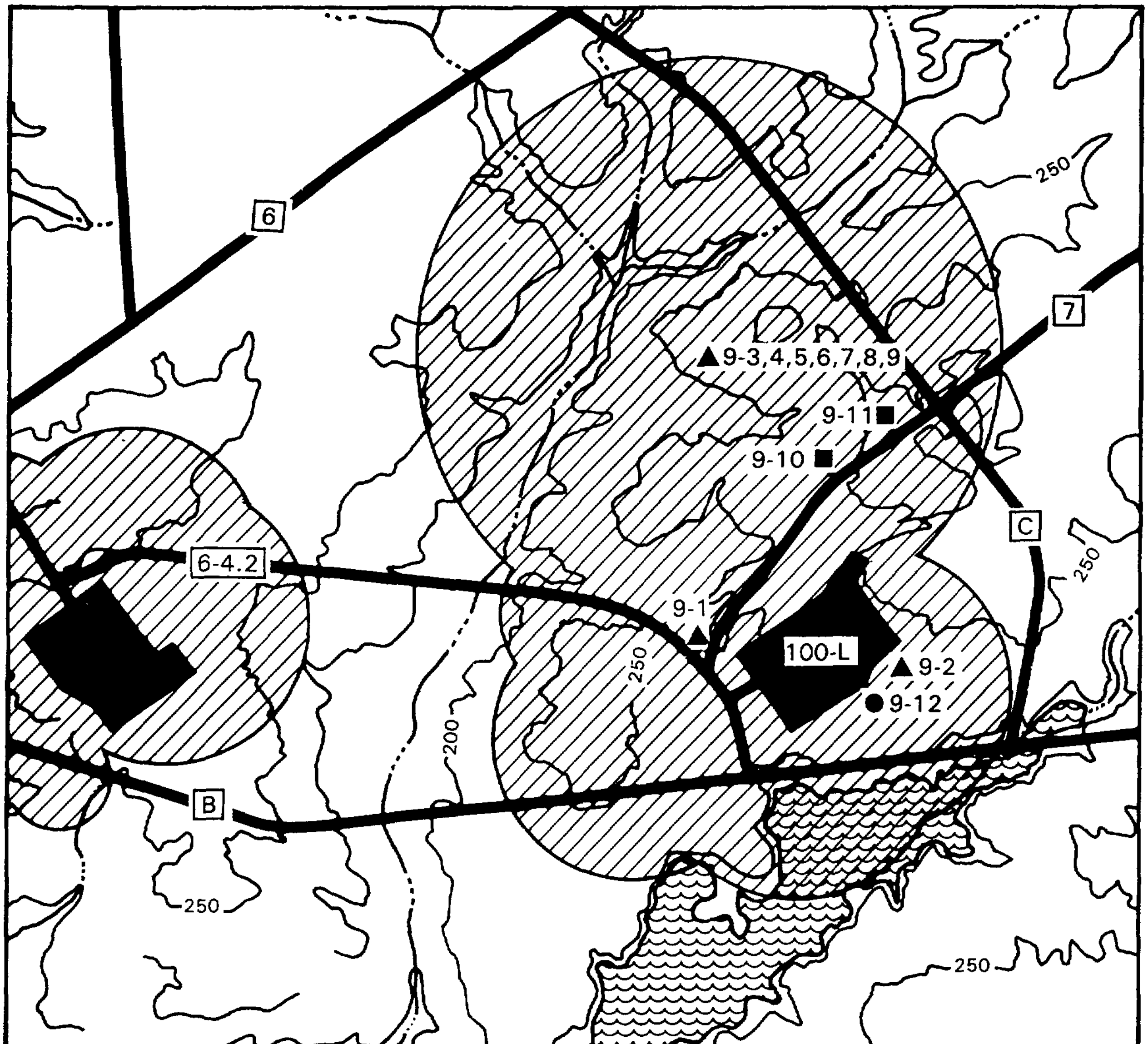
Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
K-Area burning/rubble pit (131-K)	KRP 1 KRP 2 KRP 3 KRP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program to be conducted.	Statistical analyses of ground-water monitoring data indicate the following are present: • Nickel • Conductivity • Manganese • Sodium • Total organic halogen • Sulfate
K-Area acid/caustic basin (904-80G)	KAC 1 KAC 2 KAC 3 KAC 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program completed third quarter of 1985.	Statistical analysis of ground-water monitoring data indicates the following are present: • pH • Conductivity • Chloride • Sulfate • Sodium • Total organic halogen Sediment samples showed the presence of metals and other inorganics.
		LOW-LEVEL WASTE SITES	
K-Area Bingham Pump outage pit (643-1G)	None	No monitoring wells exist at outage pits, and records yield no evidence of core-sampling activity there. Radioactivity in vegetation measured in 1970.	Vegetation growing above outage pits shows little elevation in activity levels above background.

Footnotes on last page of table.

Table B-31. Site Investigations and Monitoring at Waste Management Facilities in the K-Area Geographic Grouping[a] *(continued)*

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		LOW-LEVEL WASTE SITES (continued)	
K-Area seepage basin (904-65G)	KSB 1[d] KSB 2[d] KSB 3[d] KSB 4A[d]	Wells typically monitored for gross alpha, gross nonvolatile beta, and tritium. Analyses of soils beneath reactor-area seepage basin conducted in 1978.	Groundwater monitoring results show little evidence of contamination. Basin soils contain: • Cesium-137 • Strontium-90 • Cobalt-60

[a]Sources: Huber, Johnson, and Marine, 1986; Ward, Johnson, and Marine, 1986; Pekkala, Holmes, and Marine, 1986a,b.
[b]The monitored geohydrologic unit for these wells is the Barnwell.
[c]See page B-1.
[d]Not RCRA monitoring wells.



Note: Elevations are in feet above mean sea level 1.0 foot = 0.3048 meter

Legend on following page

Scale (kilometers)
0 1 2

Figure B-19. L-Area Waste Sites

Number	Potential Waste Type	Site Name	Building Number
9-1	▲	L-Area Burning/Rubble Pit*	131-L
9-2	▲	L-Area Acid/Caustic Basin*	904-79G
9-3	▲	CMP Pit	080-17G
9-4	▲	CMP Pit	080-17.1G
9-5	▲	CMP Pit	080-18G
9-6	▲	CMP Pit	080-18.1G
9-7	▲	CMP Pit	080-18.2G
9-8	▲	CMP Pit	080-18.3G
9-9	▲	CMP Plt	080-19G
9-10	■	L-Area Bingham Pump Outage Pit*	643-2G
9-11	■	L-Area Bingham Pump Outage Pit*	643-3G
9-12	●	L-Area Oil and Chemical Basin*	904-83G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive
●—Mixed

Figure B-19. L-Area Waste Sites (continued)

B.10.1.3 CMP Pits (080-17G, 17.1G, 18G, 18.1G, 18.2G, 18.3G, 19G)

The CMP pits consist of seven unlined pits that were used for the disposal of selected nonradioactive wastes. The pits were near the center of the Plant at the top of a hill near the head of Pen Branch. They are arranged linearly in two rows with 3 to 7 meters between the ends of adjacent pits. Each pit is 3 to 5 meters wide, 15 to 23 meters long, and 3 to 5 meters deep.

History of Waste Disposal

The CMP pits were used for waste disposal from 1971 to 1979. Typical waste disposed in the pits included drums of solvents such as trichloroethylene and tetrachloroethylene, and other liquid wastes such as fluorocarbons, oil, paint thinner, and acid. Beryllium, titanium, calcium, and cadmium metals were disposed of in a separate metals pit. Odd-shaped items such as spray cans and gas cylinders were placed in the pits in containers of various sizes. The waste in the CMP pits was excavated in 1984 and is being stored until it can be incinerated. The pits have been backfilled and closed.

Evidence of Contamination

Thirteen groundwater monitoring wells (or clusters) were installed at the site to document the extent of existing contamination. Benzene, methylene chloride, tetrachloroethylene, toluene, and bis (2-ethylhexyl) phthalate have been detected in the groundwater of monitoring well CMP-9C (Scott, Kolb, Price, and Bledsoe, 1986).

Waste Characterization

Incomplete records partially document disposed wastes at the CMP pits. Site remedial work in 1984 included removal of wastes and contaminated soils. The results of the remedial work indicate that 99.5 percent of the wastes and contaminated soils had been removed from the site. An estimated 1500 cubic meters of contaminated soil remain.

B.10.2 LOW-LEVEL RADIOACTIVE WASTE SITES

B.10.2.1 L-Area Bingham Pump Outage Pit (643-2G)

L-Area Bingham Pump Outage Pit 643-2G is outside the L-Area perimeter fence near the center of the SRP. The pit is 9 kilometers from the nearest Plant boundary. It is on a gentle slope above the nearest flowing stream, a tributary of Pen Branch that is 360 meters away. The following sections discuss the history of waste disposal, evidence of contamination, and waste characteristics at this pit (Pekkala, Holmes, and Marine, 1986a).

History of Waste Disposal

Section B.4.2.1 describes the general history of the Bingham Pump outage pits. The L-Area pit was active from September to November 1957. It has been recovered with vegetation.

Evidence of Contamination

No groundwater monitoring, sediment characterization, or core sampling has been performed at the outage pits, but vegetation sampling was performed in 1970. The vegetation showed no evidence of contamination (see Section B.4.2.1).

Groundwater flowing from the L-Area pit would require an estimated 4 to 14 years to travel 360 meters to the nearest stream. The water table is presently 2 meters below the bottom of the pit.

Waste Characterization

Section B.4.2.1 discusses the waste characteristics of the Bingham Pump outage pits.

B.10.2.2 L-Area Bingham Pump Outage Pit (643-3G)

L-Area Bingham Pump Outage Pit 643-3G is outside the L-Area perimeter fence near the center of the Plant. The pit is 9 kilometers from the nearest SRP boundary. It is situated on a gentle slope above the nearest flowing stream, a tributary of Pen Branch that is 360 meters away. The following sections discuss the history of waste disposal, evidence of contamination, and waste characteristics at this pit (Pekkala, Holmes, and Marine, 1986a).

History of Waste Disposal

Section B.4.2.1 describes the general history of the Bingham Pump outage pits. This pit was active from September 1957 to January 1958, and is overgrown.

Evidence of Contamination

See Section B.10.2.1. Groundwater 2 meters below the pit would require an estimated 3 to 12 years to travel 360 meters to the nearest stream.

Waste Characteristics

See Section B.4.2.1.

B.10.3 MIXED WASTE SITES

The L-Area oil and chemical basin is outside the L-Area perimeter fence and between the acid/caustic basin and the area seepage basin (Figure B-18). The unlined earthen basin has a surface area of 890 square meters and a capacity of approximately 2 million liters. The nearest Plant boundary is approximately 9.8 kilometers from the basin. The following sections describe the history of disposal, evidence of contamination, and waste characteristics at the basin (Pekkala, Price, and Bledsoe, 1986).

History of Waste Disposal

This basin began operation in 1961 and remained active until 1979. Although L-Reactor was placed on standby status in 1968, releases of wastewater to the basin continued. K-Area Operations was custodian of the basin until 1981. At that time, the L-Area startup team moved into the area for renovation and startup preparation.

The basin has been inactive since 1979. Rainfall has kept some water in the basin at all times. The permeability of the basin floor probably has decreased by releases of oil and chemical mixtures.

Evidence of Contamination

Nine sediment cores were taken in the basin in early 1985. Approximately 0.3 to 0.6 meter of soft black ooze with a moisture content of 50 to 90 percent, followed by the tough basin-floor material, was encountered. Preliminary analyses indicate that no samples exceeded the EP-toxicity test criteria.

The upper 10 to 20 centimeters of sludge typically contain 1,000 to 10,000 picocuries per gram (dry weight) of radioactive material, dominated by cobalt-60 and unidentified beta emitters. The next 20 centimeters typically contain about 20,000 picocuries per gram (dry weight). Below this level, the basin floor material drops rapidly to background levels for most substances. Petroleum hydrocarbons were not detected in any samples. The basin water contains tritium, strontium-90, cobalt-60, cesium-137, and nitrate.

Low levels of radioactivity have been detected in monitoring wells near the basin. Chlorinated organics (TOH) as high as 100 parts per billion have been detected in two monitoring wells, but are not detectable in the basin water.

Waste Characterization

The L-Area oil and chemical basin received about 76,000 liters of wastewater annually. The total volume discharged through 1979 was 3.9×10^6 liters. The waste liquids consisted of small volumes of oil on top of water. The wastewater usually contained some chemicals that were not appropriate for discharge to SRP streams, regular seepage basins, or the waste management system in 200-Area. The oil in the wastewater drums or 1900-liter skid containers was only a small part of the total waste. Radioactive oil on the plant site usually was mixed with the absorbent Oil-dri and sent to the Burial Ground in 190-liter drums. The waste liquids sent to the L-Area oil and chemical basin came from all over the Plant, but were primarily from the reactor areas. Wastewater from the Building 717-G Hot Shop was sent to the basin until 1967.

As indicated in Table B-32, the major nuclides discharged to the basin include tritium, cobalt-60, strontium-90, cesium-137, and unidentified alpha and beta gamma. The current inventory is decay-corrected. The inventory shows a small amount of radioactivity that was released to the basin through Works Engineering repairs at the basin or in Building 717-G. Several filters in the reactor building's distillation and purification facilities had high radiation levels and underwater work was necessary for personnel protection. A tank filled with water was placed inside the basin perimeter fence and used for shielding. After repairs were completed, including disassembly and assembly, the water was drained to the basin.

Table B-32. Summary of Radioactive Releases to L-Area Oil and Chemical Basin 904-83G (Ci)[a]

Isotope	Original release	Decay-corrected inventory
Tritium	3.4556×10^{4}	1.1553×10^{4}
Sulfur-35	1.6000×10^{-2}	7.6563×10^{-7}
Cobalt-60	3.7915	2.7935×10^{-1}
Strontium-90	3.7039×10^{-1}	2.1986×10^{-1}
Ruthenium 103, -106	3.5937×10^{1}	6.3956×10^{-5}
Cesium-134	1.0590×10^{-3}	4.4993×10^{-5}
Cesium-137	1.6210	9.9224×10^{-1}
Cerium 44, -141	9.5232×10^{-2}	1.8354×10^{-6}
Promethium-147	1.9828	8.3285×10^{-3}
Alpha (unidentified)	2.2852×10^{-3}	2.2852×10^{-3}
Beta-gamma (unidentified)	1.5550×10^{-3}	1.5550×10^{-3}

[a]Source: Pekkala, Price, and Bledsoe, 1986.

B.10.4 MAJOR GEOHYDROLOGIC CHARACTERISTICS

Waste sites in the L-Area geographic grouping are on the Aiken Plateau between Pen Branch to the west and Steel Creek to the east-southeast. Site-specific geologic investigations conducted in the vicinity of L-Area and the CMP pits reveal that the hydrostratigraphy of the area is similar to that discussed in Appendix A. Significant site-specific characteristics are as follows (Scott, Kolb, Price, and Bledsoe, 1986; Pekkala, Price, and Bledsoe, 1986; DOE, 1984a,b):

1. Upland unit. The transmissivity of gravel beds can be high but that of clays can be low.

2. Barnwell Formation. Clay lenses are nearly impermeable to downward infiltrating water. Sands should have moderate permeability.

3. McBean Formation. Limy sands and clays (calcarenite and marl) are generally of low permeability, but coarse, fossiliferous limestone lenses can be very permeable. The green clay at the base of the McBean Formation is about 7 meters thick in the vicinity of L-Area.

4. Congaree Formation. Interlayered sands, calcareous sands, and clays near the top of the formation should have moderate permeability. The thick (15-meter) clean sands near the base of this formation are very permeable and form a good aquifer.

5. Ellenton Formation. Most lithologies have low permeability; this generality can be deceiving because channel sands could provide very high permeability locally.

6. Upper Middendorf/Black Creek. The Middendorf/Black Creek section in hole CMP-11 begins at a depth of 125 meters (about 34 meters below sea level). The principal sediments are fine, silty sands with occasional layers of silty clay or coarse sand. The interval from 126 to 161 meters has four clay layers, each about 0.6 meter thick.

In general, the sands become coarser toward the bottom of this interval. The permeability of the silty sands should be low to moderate and that of the coarser sands moderate to high.

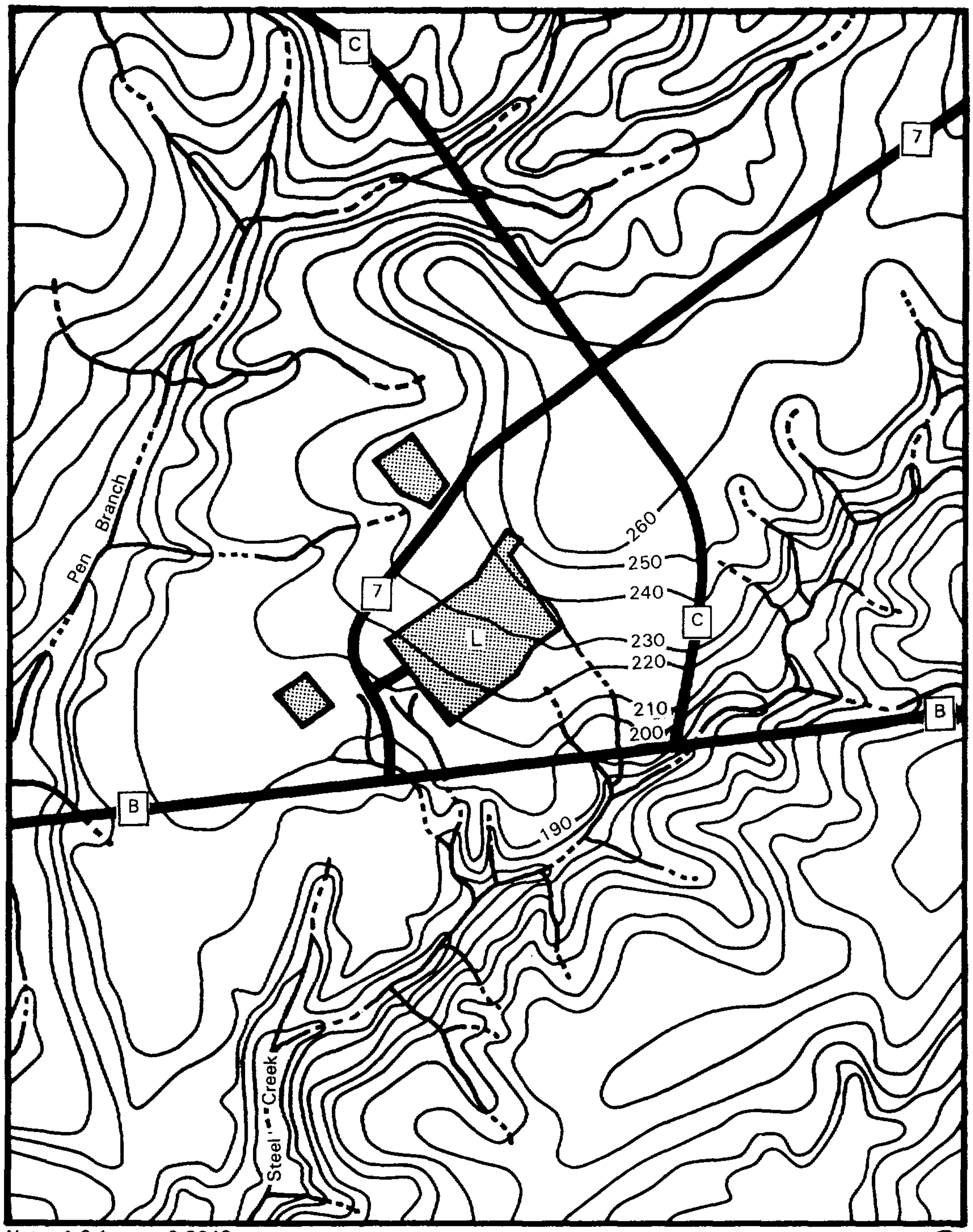
The tan clay is not readily evident in data on the area derived from foundation borings, drillers' logs, and geophysical logs; however, even in other areas of the Plant where it supports a significant head difference, this clay layer is not always apparent in soil cores. The calcareous zone is evident in the McBean Formation. At depths of 30 to 40 meters from the ground surface, solution voids can exist, as indicated by mud losses and rod drops during the drilling of observation wells near the CMP pits (Scott, Kolb, Price, and Bledsoe, 1986). These areas are patchy with little or no interconnection of void areas.

Pump tests have been performed at monitoring wells in the vicinity of the CMP pits. Transmissivity data for various strata are summarized below (Pekkala, Price, and Bledsoe, 1986):

Well	Stratum screened	Transmissivities measured (m^2/day)
CMP-8B	McBean (Aiken) fine sands	9.1
CMP-10, 11, 12, 14B, 15B	McBean moldic limestone Barnwell/Dry Branch	<185 0.5
CMP-8A, 12A, 15A	Congaree	75, 3, 0.2

Figure B-20 is a water-table map for the area. The map is from data collected in December 1963 when a number of shallow piezometers were available for the area. Recent data from several new wells (Pekkala, Price, and Bledsoe, 1986) indicate that the water table is now 1 to 2 meters lower than shown in Figure B-20.

Near the CMP pits, the hydraulic heads of three wells screened in the lower part of the Congaree are between 55.2 and 56.1 meters. Water-level measurements for one well in the upper Tuscaloosa Formation indicate a head of 52.1 meters above mean sea level. Thus, there is a downward gradient of about 4 meters of head across the Ellenton Formation near the CMP pits (Scott, Kolb, Price, and Bledsoe, 1986). In the vicinity of L-Area, the water level in the Congaree is at an elevation of 53.5 meters, and that in the Middendorf/Black Creek (Tuscaloosa) is at 52.2 meters (Ward, Johnson, and Marine, 1986).



Note: 1.0 foot = 0.3048 meter

Source: DOE, 1984a.

Figure B-20. Water-Table Contours in Vicinity of L-Area

Judging from these water-level measurements, the head reversal found in other areas of the Plant is not present in this area.

B.10.5 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at 10 of the 12 waste management facilities in the L-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous and mixed waste management facilities. Typically, wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. At least 21 wells in this geographic area are used to monitor groundwater in the vicinity of the 12 facilities. DOE plans additional wells to obtain a better definition of subsurface conditions and contaminant transport.

Waste site characterization programs are complete at nine facilities and are being implemented at another. Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-33 lists the representative monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring.

B.11 P-AREA WASTE SITES

This geographic grouping is formed by waste sites associated with P-Reactor, which is approximately 4 kilometers northeast of L-Reactor (Figure B-21). Located along Road F, P-Reactor is southwest of Par Pond, through which its cooling water is recirculated. The northeast portion of this grouping drains to Par Pond, and the southwest portion drains to the headwaters of Steel Creek.

B.11.1 HAZARDOUS WASTE SITES

B.11.1.1 P-Area Burning/Rubble Pit (131-P)

The P-Area burning/rubble pit is northwest of P-Area and south of Road C-7. The site is nearly rectangular, covers approximately 6500 square meters, and is about 3 meters deep.

History of Waste Disposal

Rubble waste disposed at this site included paper, wood, concrete, scrap metal, cans, and empty galvanized-steel barrels. See Section B.2.1.6.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

Table B-33. Site Investigations and Monitoring at Waste Management Facilities in the L-Area Geographic Grouping[a]

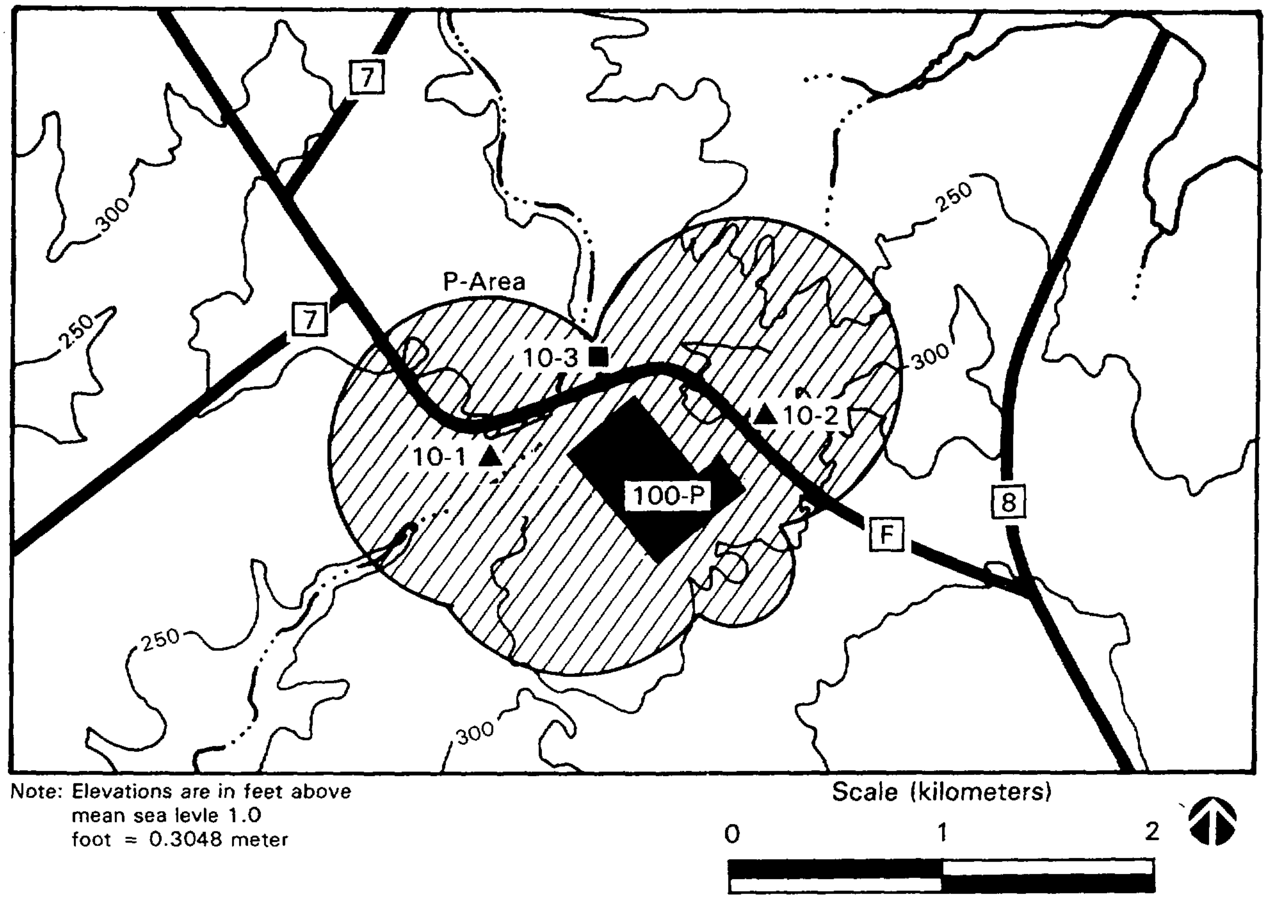
Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
L-Area burning/rubble pit (131-L)	LRP 1 LRP 2 LRP 3 LRP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site sediment characterization program to be undertaken.	Groundwater monitoring indicates no contaminants present.
L-Area acid/caustic basin (904-79G)	LAC 1 LAC 2 LAC 3 LAC 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program completed third quarter of 1985.	Statistical analysis of groundwater monitoring data indicates the following are present: • pH • Conductivity • Sulfate • Sodium Sediment samples showed presence of metals and other inorganics.
CMP pits (080-17G, 080-17.1G, 080-18G, 080-18.1G, 080-18.2G, 080-18.3G, 080-19G)	CMP 8 CMP 9 CMP 10 CMP 11 CMP 12 CMP 13 CMP 14 CMP 16	Wells monitored quarterly for RCRA and SCHWMR parameters. Soil borings taken and contaminated soil excavated from pits (1984). Area capped with impermeable plastic and soil cover.	Statistical analysis of groundwater data shows the following are present: • Conductivity • Zinc • Nitrate • Sulfate • pH • Sodium Groundwater constituents include: • Benzene • Methylene chloride • Tetrachloroethylene • Toluene • Bisphthalate • Lead • Mercury • Zinc • Copper

Footnotes on last page of table.

Table B-33. Site Investigations and Monitoring at Waste Management Facilities in the L-Area Geographic Grouping[a] (continued)

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		LOW-LEVEL WASTE SITES	
L-Area Bingham pump outage pits (643-2G, 643-3G)	None	No monitoring wells exist at outage pits, and records yield no evidence of core-sampling activity there. Radioactivity in vegetation measured in 1970.	Vegetation growing above outage pits shows little activity.
		MIXED WASTE SITES	
L-Area oil and chemical basin (904-83G)	LCO 1 LCO 2 LCO 3 LCO 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Basin water, basin sediment, and soil under basin sampled in early 1985.	Groundwater constituents include: • Cadmium • Chromium • Mercury • Nickel • Lead • Tetrachloroethylene Possible basin-soil contaminants include • Americium-241 • Antimony-125 • Cesium-137 • Cobalt-60 • Europium-152 • Europium-154 • Europium-155 • Plutonium-238 • Plutonium-239, -240 • Promethium-147 • Strontium-90 • Tritium • Uranium-235 • Uranium-238

[a]Sources: Huber, Johnson, and Marine, 1986; Ward, Johnson, and Marine, 1986; Scott, Kolb, Price, and Bledsoe, 1986; Pekkala, Holmes, and Marine, 1986b; Pekkala, Price, and Bledsoe, 1986.
[b]The monitored hydrogeologic unit is the Barnwell.
[c]See page B-1.



Number	Potential Waste Type	Site Name	Building Number
10-1	▲	P-Area Burning/Rubble Pit*	131-P
10-2	▲	P-Area Acid/Caustic Basin*	904-78G
10-3	■	P-Area Bingham Pump Outage Pit*	643-4G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive

Figure B-21. P-Area Waste Sites

B.11.1.2 P-Area Acid/Caustic Basin (904-78G)

The P-Area acid/caustic basin is one of six such basins in the Reactor and Separations Areas. These basins are unlined earthen depressions with nominal dimensions of 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

See Section B.3.1.1.

Evidence of Contamination

See Section B.3.1.1.

Waste Characterization

See Section B.3.1.1.

B.11.2 LOW-LEVEL RADIOACTIVE WASTE SITE

The P-Area Bingham pump outage pit 643-4G is outside the P-Area perimeter fence. This pit is 9.8 kilometers from the nearest Plant boundary. It is on a gentle slope just east of the divide between Steel Creek and Par Pond. The following sections describe the history of waste disposal, evidence of contamination, and waste characteristics at the P-Area pit (Pekkala, Holmes, and Marine, 1986a).

History of Waste Disposal

Section B.4.2.1 describes the general history of the Bingham pump outage pits. The P-Area pit was active from January to November 1958, then was backfilled and allowed to revegetate.

Evidence of Contamination

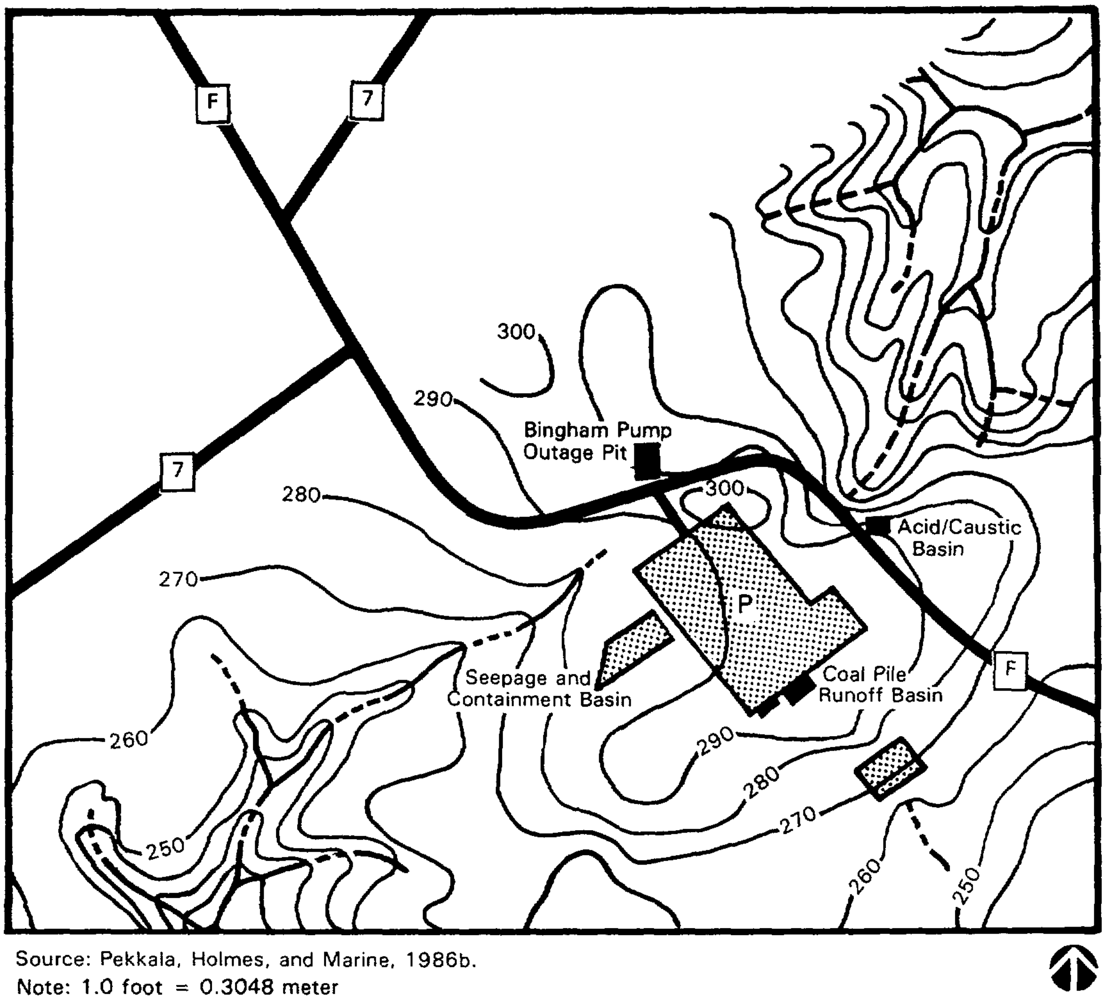
No groundwater monitoring, sediment characterization, or core sampling has been performed at the outage pits. Vegetation sampling in 1970 showed no evidence of contamination (see Section B.4.2.1). Groundwater 2 meters below the bottom of the pit and flowing an estimated P-Area would require from 6 to 24 years to travel to the nearest stream.

Waste Characterization

See Section B.4.2.1.

B.11.3 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The P-Area waste sites within this geographic grouping are on the Aiken Plateau between Steel Creek and Par Pond. Site-specific geologic investigations have not been conducted in the vicinity of P-Area; however, regional subsurface geology discussed in Appendix A is believed to be representative of the area. Four RCRA-type wells have been installed near P-Area. The depth to the water table in these wells ranges from 6.4 to 10.7 meters below the ground surface (Huber, Johnson, and Marine, 1986). Figure B-22 is a water-table map



Source: Pekkala, Holmes, and Marine, 1986b.
Note: 1.0 foot = 0.3048 meter

Figure B-22. Map of Water-Table Near P-Area Showing Location of Reactor Seepage Basins and Other Waste Sites (contours expressed in feet above mean sea level)

for the area. The natural discharge from the water-table aquifer is to Steel Creek west of P-Area and to tributaries of Par Pond to the east-northeast. This map, however, indicates expected head relationships only for general areas; site-specific information will be necessary to confirm the relationship for this area.

B.11.4 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at two of the three waste management facilities in the P-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous waste management facilities. Typically, wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. At least 8 wells in this geographic area are used to monitor groundwater in the vicinity of the six facilities. Additional wells are planned to obtain a better definition of subsurface conditions and contaminant transport.

Waste site characterization generally includes representative waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-34 lists the representative monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring.

B.12 MISCELLANEOUS AREA WASTE SITES

This section describes two waste sites, the SRL oil test site and the Gunsite 720 rubble pit, which are not within the boundaries of the 10 geographic groupings described in previous sections. The SRL oil test site is south of Road 3, a short distance from the CS-Area (see Figure B-11). The Gunsite 720 rubble pit is west of Road A, about 10 kilometers south of A-Area and 5 kilometers north of D-Area (see Figure B-14).

B.12.1 HAZARDOUS WASTE SITES

B.12.1.1 SRL Oil Test Site (080-16G)

The SRL oil test site is about 600 meters east of the intersection of Roads 3 and 5, and approximately the same distance south of the Central Shops complex near the central portion of the Plant. The site consists of 24 test plots with dimensions of 3.7 meters by 10.7 meters. Two other test plots with dimensions of 3 meters by 60 meters were reported as part of the site at one time; however, their locations are unknown.

History of Waste Disposal

The 26 test plots at the SRL oil test site were developed as part of a study to evaluate the biodegradation rate of waste oil. The plots received machine cutting oil characterized as having a viscosity similar to heavy automobile engine oil. The original 24 plots (12 test plots and 12 control plots) were constructed in 1975. Waste oil purchased offsite was sprayed onto the 12 test plots. Each oil plot received 415 liters of waste oil, was tilled to a depth

Table B-34. Site Investigations and Monitoring at Waste Management Facilities in the P-Area Geographic Grouping[a]

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
P-Area burning/rubble pit (131-P)	PRP 1A PRP 2 PRP 3 PRP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site sediment characterization to be performed.	Statistical analysis of monitoring data indicates the following to be present: • pH • Barium • Lead • Conductivity • Magnesium • Sodium • Total organic carbon • Total organic halogen
P-Area acid/caustic basin (904-78G)	PAC 1 PAC 2 PAC 3 PAC 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program completed third quarter of 1985.	Statistical analysis of groundwater monitoring data indicates the following are present: • pH • Conductivity • Sodium • Zinc • Sulfate • Total dissolved solids • Chloride Sediment samples showed metals and other inorganics to be present.
		LOW-LEVEL WASTE SITES	
P-Area Bingham pump outage pit (643-4G)	None	No monitoring wells exist at outage pits, and records yield no evidence of core-sampling activity there. Radioactivity in vegetation measured in 1970.	Vegetation growing above outage pits shows little activity.

[a]Sources: Huber, Johnson, and Marine, 1986; Ward, Johnson, and Marine, 1986; Pekkala, Holmes, and Marine, 1986a,b.
[b]The monitoring hydrogeologic unit for these wells is the Barnwell.
[c]See page B-1.
[d]Non-RCRA wells.

of 15 centimeters, received another application of 415 liters, and was tilled again. Commercial fertilizer was applied to the plots at four different rates.

In 1976 two additional plots reportedly were built, although their exact locations are unknown. One plot received 3120 liters of hydraulic fluid and the other received 4160 liters of paint thinner.

In 1978 a site use permit was requested to facilitate the disposal of about 50 drums of waste oil per year at the SRL oil test site, but the disposal of additional waste as a result of this request is not known. No waste oils were discarded at this site after 1980.

Evidence of Contamination

Two soil cores reportedly were taken from each test plot and analyzed at depths of 0 to 15 centimeters, 15 to 30 centimeters, and 30 to 45 centimeters. The plots were sampled before oil application, immediately after, 1 month after, about every 3 months after for 2 years, and then at 5 years. The results of the analysis revealed that over the 5-year period, no significant amounts of hydrocarbons were found at the 30- to 45-centimeter depth and slightly elevated hydrocarbons were found at the 15- to 30-centimeter depth (see Figure B-23). The results of an analysis of several chemical parameters revealed some increases of phosphorus, potassium, and calcium, but all concentrations (except phosphorus at the 0.15-centimeter depth) returned to background levels after 1 year.

The only contaminant that appears to be present at the site is residual waste oil that, for the most part, has been retained in the top 15 centimeters of the soil. A small amount might have migrated as deep as 30 centimeters.

Because the location of the two plots established in 1976 is not known, the extent of contamination from the materials placed in these plots is not known.

Currently, there are no groundwater monitoring wells located at this site.

Waste Characterization

A lack of specific chemical/analytical data of the waste materials present at the site makes specific evaluations difficult. However, based on the limited data available, the potential for contaminant migration appears to be small. Samples from borings taken at the sites show that hydrocarbons exist at depths of 15 to 30 centimeters below the surface and marginally at the 30- to 45-centimeter depth. None were reported in the 0- to 15-centimeter soil layer. These data suggest that the less chemically mobile species have migrated to their present locations.

B.12.1.2 Gunsite 720 Rubble Pit

The Gunsite 720 rubble pit (SRP map coordinates N80,000, E27, 350) is an open area near D-Area, west of the first northbound dirt road from Road A-2. The site covers about 6.6 square meters.

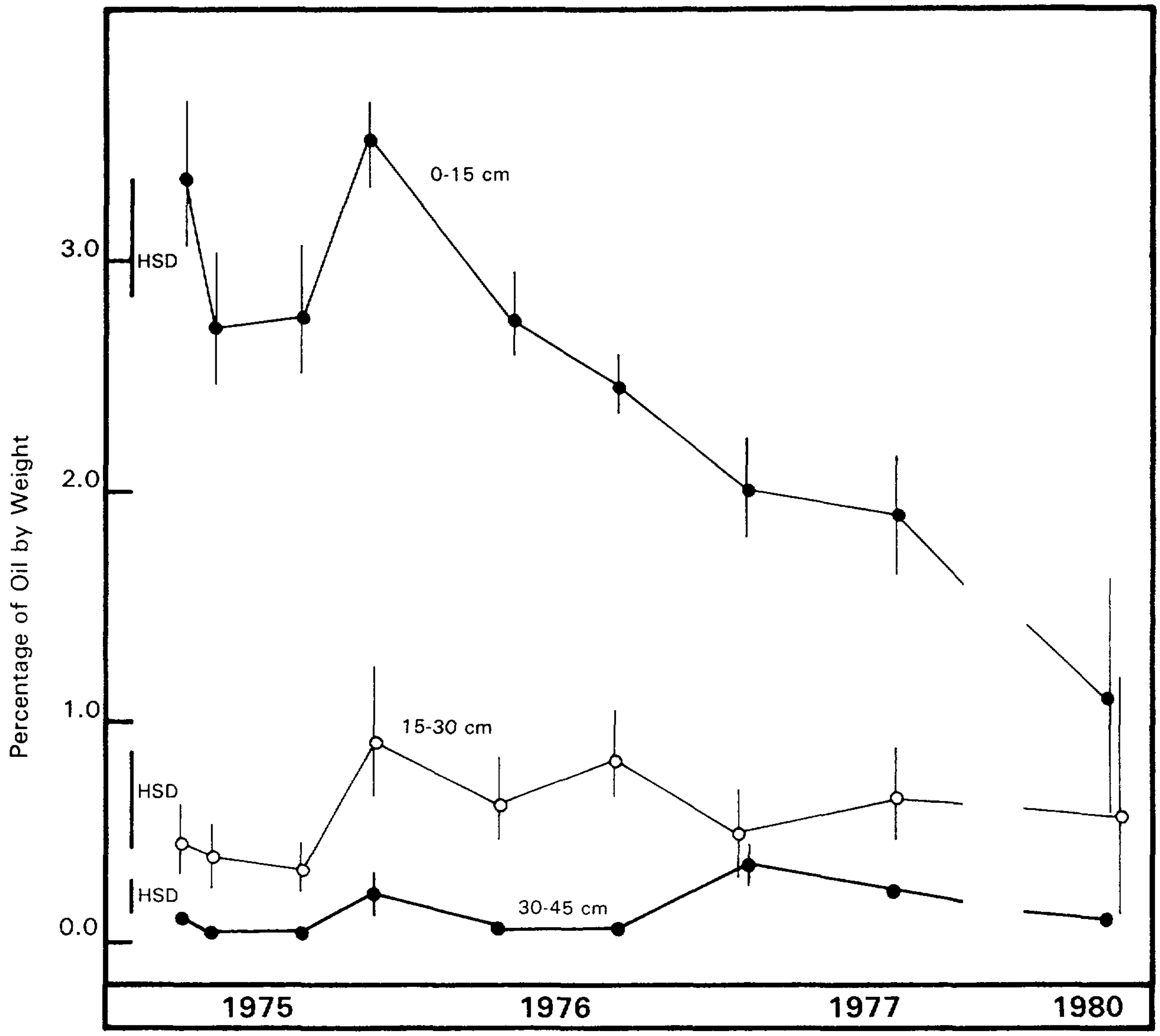


Figure B-23. Oil Content of Soil as a Function of Time for Three Soil Depths (The bars on the means are ±2 standard errors. Honestly significant differences (HSD) shown along the y-axis for each of the three soil depths.)

History of Waste Disposal

The Gunsite 720 rubble pit consists of eight semiburied, corroded, 208-liter drums of unknown origin. There are no records of the disposal; however, the drums are suspected to contain nonradioactive liquid-chemical waste.

Evidence of Contamination

To date, no studies have been performed to determine the nature of the contents of the drums or the extent and levels of contamination.

Waste Characterization

Limited data are available on possible wastes disposed at this site (Huber and Bledsoe, 1986b).

B.12.2 MAJOR GEOHYDROLOGIC CHARACTERISTICS

Waste sites in geographic grouping 11 are located throughout the Plant; Sections B.2 through B.11 contain information on the geohydrology of waste sites located near other geographic groupings. In addition, Appendix A describes the important geologic and subsurface hydrologic characteristics of the SRP. Representative data on the hazardous waste sites in geographic grouping 11 are contained in Section B.5.4 for the SRL oil test site and Section B.6.4 for the Gunsite 720 rubble pit.

B.12.3 ONGOING AND PLANNED MONITORING

Table B-35 lists the site investigations that have occurred at each facility and the results of any groundwater, soil, and vegetation monitoring.

At present, there are no monitoring wells near the SRL oil test site or the Gunsite 720 rubble pit.

Table B-35. Site Investigations and Monitoring at Miscellaneous Area Waste Management Facilities[a]

Facility	RCRA monitoring well	Site investigations	Monitoring results
SRL oil-test site (080-16G)	None	Soil beneath oil test site plots characterized at depths of 0-15, 15-30, and 30-45 cm.	Constituents present in soil include waste oil.
Gunsite 720 rubble pit	None	No studies on soil surrounding site have been performed to date.	None.

[a]Sources: Pickett and Bledsoe, 1986; Huber and Bledsoe, 1986b.

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