EPA/ROD/R04-04/007
2004

EPA Superfund
Record of Decision:

SAVANNAH RIVER SITE (USDOE)
EPA ID: SC1890008989
OU 25
AIKEN, SC
03/10/2004

United States Department of Energy

Savannah River Site

Record of Decision for the R-Area Reactor Seepage Basins (904-57G, -58G, -59G, -60G, -103G, -104G) and 108-4R Overflow Basin Operable Unit (U)

WSRC-RP-2003-4093

Revision 1

October 2003

Prepared by:
Westinghouse Savannah River Company LLC
Savannah River Site
Aiken, SC 29808

Prepared for U.S. Department of Energy under Contract No. DE-AC09-96SR18500

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Prepared for
U.S. Department of Energy
and
Westinghouse Savannah River Company LLC
Aiken, South Carolina

DECISION SUMMARY (U)

R-Area Reactor Seepage Basins (904-57G, -58G, -59G, -60G, -103G, -104G) and 108-4R Overflow Basin Operable Unit

WSRC-RP-2003-4093
Revision 1

October 2003

Savannah River Site
Aiken, South Carolina

Prepared by:

Westinghouse Savannah River Company LLC
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Savannah River Operations Office
Aiken, South Carolina

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DECLARATION FOR THE RECORD OF DECISION

Unit Name and Location

R-Area Reactor Seepage Basins (904-57G, -58G, -59G, -60G, -103G, -104G) and 108-4R Overflow Basin Operable Unit (OU)

Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Identification Number: OU- 25

Savannah River Site (SRS)

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Identification Number: SC1 890 008 989

Aiken, South Carolina

United States Department of Energy

The R-Area Reactor Seepage Basin (RRSB)/108-4R Overflow Basin OU is listed as a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) unit in Appendix C of the Federal Facility Agreement (FFA) for the SRS. The FFA is a legally binding agreement between the regulatory agencies (United States Environmental Protection Agency (USEPA) and South Carolina Department of Health and Environmental Control (SCDHEC)) and the regulated entity (SRS) that establishes responsibilities and schedules for the comprehensive remediation of SRS. The media associated with this OU are soil, process and sanitary sewer lines, surface water, sediment, and groundwater.

Statement of Basis and Purpose

This decision document presents the selected remedy for the RRSB OU at SRS in Barnwell County near Aiken, South Carolina. The remedy was chosen in accordance with CERCLA, as amended by the Superfund Amendments Reauthorization Act (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Contingency Plan (NCP). This decision is based on the Administrative Record File for this site.

Assessment of the Site

There has been a release of radioactive purgewater containing primarily cesium-137 and strontium-90, from the RRSB OU to the environment. The response action selected in this Record of Decision (ROD) is necessary to protect the public health and welfare or the environment from actual or threatened releases of hazardous substances into the environment.

Description of the Selected Remedy

The RRSB OU is one of many waste units undergoing remediation at SRS in accordance with the FFA. The selected remedy for the RRSB is Alternative 2 - Reinforced Concrete Intruder Barrier System over the principal threat source material (PTSM) with Granitic Monuments, Excavation of PTSM outside boundary fence and Disposal on-unit, Excavation and On-unit Disposal of contaminated vegetation, Installation of an asphalt bioturbation barrier, Mixing Zone for groundwater, and Institutional Controls. The future land use for the RRSB OU will be industrial land use.

The selected remedy entails the following:

- Place a reinforced concrete intruder barrier over all principal threat source material (PTSM) and contaminated pipelines inside the OU boundary fence. The barrier will be placed above the existing asphalt cover. This barrier will prevent inadvertent human intrusion into the PTSM.

- Excavate all contaminated process and sanitary sewer lines and associated soil above PTSM levels located outside of the OU boundary fence, dispose of on-unit and cover with the intruder barrier.

- Dispose of (bury) contaminated vegetation on-unit.

- Place a biobarrier over areas where contaminated vegetation was discovered to prevent the growth of any new contaminated vegetation.

- Place granitic monuments around the perimeter of the intruder barrier to warn potential intruders of the presence of hazardous material.

- Monitored natural attenuation by radioactive decay for contaminated groundwater, with mixing zone established for contaminated area.

- Implement institutional controls via access controls, deed notification, deed restriction upon transfer and field walkdown/maintenance to maintain the site for industrial activities and prevent unauthorized access to the unit.

The construction time to complete this remedy is approximately 18 months after approval of the Remedial Action Implementation Plan.

Statutory Determinations

Based on the unit Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation/Baseline Risk Assessment (RFI/RI/BRA) report, the RRSB OU poses a threat to human health and the environment. Therefore, a response action is required. The selected remedy for the RRSB OU is Alternative 2 – Reinforced Concrete Intruder Barrier System with Granitic Monuments, Excavation, Onsite Disposal, Mixing Zone, and Institutional Controls. The future land use for the RRSB OU will be industrial land use.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unrestricted use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

The selected remedy is protective of human health and the environment under the industrial land use scenario, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes pemanent solutions and alternative removal technologies to the maximum extent practicable. However, because treatment of the principal threat source material was not found to be technically practicable, this remedy does not satisfy the statutory preference for treatment as a principal element.

In-situ stabilization of the PTSM has been used to treat other SRS reactor seepage basins. However, at the RRSB OU in-situ stabilization of the PTSM would not be technically feasible due to it being located at a significant depth below land surface, the quantity of overburden required to be removed to access the PTSM, the large volume of PTSM (approximately 15,800 yd^3), and the presence of hard clay at the OU. The hard clay prevents thorough mixing, which is required for successful in-situ stabilization. It also acts as a natural barrier which reduces migration of contaminants of concern and should not be disturbed. In addition, excavation of the overburden and/or in-situ stabilization of the PTSM would increase worker exposure to soil contaminated with cesium-137 which is a gamma emitting radionuclide. While this alternative does not meet the NCP's preference for treatment, the use of a concrete intruder barrier provides protection similar to that provided by in-situ stabilization.

In the long term, if the property is ever transferred to nonfederal ownership, the U.S. Government will take those actions necessary pursuant to Section 120(h) of CERCLA. Those actions will include a deed notification disclosing former waste management and disposal activities as well as remedial actions taken on the site. The contract for sale and the deed will contain the notification required by CERCLA Section 120(h). The deed notification shall, in perpetuity, notify any potential purchaser that the property has been used for the management and disposal of waste.

The deed shall also include deed restrictions precluding residential use of the property. However, the need for these deed restrictions may be reevaluated at the time of transfer in the event that exposure assumptions differ and/or the residual contamination no longer poses an unacceptable risk under residential use. Any reevaluation of the need for the deed restrictions will be done through an amended ROD with USEPA and SCDHEC review and approval.

In addition, if the site is ever transferred to nonfederal ownership, a survey plat of the OU will be prepared, certified by a professional land surveyor, and recorded with the appropriate county recording agency.

The selected remedy for the RRSB OU leaves hazardous substances in place that pose a potential future risk and will require land use restrictions for an indefinite period of time. As agreed on March 30, 2000, among the USDOE, USEPA, and SCDHEC, SRS is implementing a Land Use Control and Assurance Plan (LUCAP) to ensure that the Land Use Controls (LUCs) required by numerous remedial decisions at SRS are properly maintained and periodically verified. The unit-specific Land Use Control Implementation Plan (LUCIP) incorporated by reference into this ROD will provide details and specific measures required to implement and maintain the LUCs selected as part of this remedy. USDOE is responsible for implementing, maintaining, monitoring, reporting upon, and enforcing the LUCs selected under this ROD. The LUCIP, developed as part of this action, will be submitted concurrently with the Remedial Action Implementation Plan (RAIP), as required in the FFA for review and approval by USEPA and SCDHEC. This LUCIP will be a stand-alone document. After review and approval of the LUCIP, concurrently with the RAIP, the LUCIP will be referenced in all subsequent post-ROD documents (i.e., PCR and FRR). After completion of construction, the survey plat will be developed with the as-built data for the OU and submitted concurrently with the PCR for review and approval by USEPA and SCDHEC. Upon approval of the survey plat, it will be inserted in the already approved LUCIP. No further review or approval of the LUCIP will be required. The approved LUCIP including the survey plat will be appended to the LUCAP and considered incorporated by reference into the ROD, establishing LUC implementation and maintenance requirements enforceable under CERCLA. The approved LUCIP will establish implementation, monitoring, maintenance, reporting, and enforcement requirements for the unit. The LUCIP will remain in effect unless and until modifications are approved as needed to be protective of human health and the environment. LUCIP modification will only occur through another CERCLA document.

Data Certification Checklist

This is to certify that this ROD provides the following information:

- Constituents of concern (COCs) and their respective concentrations (see Section VII in the Decision Summary)
- Baseline risk represented by the COCs and the basis for the levels (see Section VII in the Decision Summary)
- Cleanup levels established for the COCs (see Section VIII in the Decision Summary)
- Current and future land and groundwater use assumptions used in the Baseline Risk Assessment (BRA) and ROD (see Section VI in the Decision Summary)
- Potential land and groundwater use that will be available at the site as a result of the selected remedy (see Section VI in the Decision Summary)
- Estimated capital, operation and maintenance, and total present worth cost; discount rate; and the number of years over which the remedy cost estimates are projected (see Section XI in the Decision Summary)
- Key decision factors that led to selecting the remedy (see Section X in the Decision Summary)
- How source materials constituting principal threats will be addressed (see Section XI in the Decision Summary)

Date	Jeffrey M. Allison Manager U.S. Department of Energy Savannah River Operations Office
Date	Winston A. Smith Director Waste Management Division U.S. Environmental Protection Agency - Region 4
Date	R. Lewis Shaw Deputy Commissioner Environmental Quality Control South Carolina Department of Health and Environmental Control

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RECORD OF DECISION (U)

R-Area Reactor Seepage Basins and Overflow Basin Operable Unit

WSRC-RP-2003-4093
Revision 1

October 2003

Savannah River Site
Aiken, South Carolina

Prepared By:

Westinghouse Savannah River Company LLC
for the
U. S. Department of Energy under Contract DE-AC09-96SR18500
Savannah River Operations Office
Aiken, South Carolina

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LIST OF ACRONYMS AND ABBREVIATIONS

ac	acre
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
bls	below land surface
BRA	Baseline Risk Assessment
CAB	Citizens Advisory Board
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
Ci	curie
cm	centimeter
CMCOC	contaminant migration constituent of concern
CMS	Corrective Measures Study
COC	constituent of concern
COPC	constituent of potential concern
CPT	cone penetration test
CSM	conceptual site model
EPC	exposure point concentration
FFA	Federal Facility Agreement
FRR	Final Remediation Report
FS	Feasibility Study
ft	feet or foot
ft^3	cubic feet
g	gram
gal	gallon
HBL	health based limit
HCM	hydrogeological conceptual model
HEAST	Health Effects Assessment Summary Table
HHCOC	human health constituent of concern
RGO	remedial goal option
HI	hazard index
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments
in	inch
IRIS	Integrated Risk Information System
JCW	job control waste
km	kilometer
km^2	square kilometer
L	liter
LAZ	Lower Aquifer Zone
LTR	Lower Three Runs
LUC	land use control
LUCAP	Land Use Controls Assurance Plan
LUCIP	Land Use Controls Implementation Plan
m	meter

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

m^3	cubic meter
MCL	maximum contaminant level
mi	mile
mi^2	square mile
Mrem	millirem
msl	mean sea level
NCP	National Oil and Hazardous Substances Contingency Plan
NEPA	National Environmental Policy Act
NPL	National Priorities List
O&M	operation and maintenance
OSHA	Occupational Health and Safety Agency
OU	operable unit
pCi	picocuries
PCR	Post-Construction Report
PHA	pulse height analysis
PP	Proposed Plan
PPE	personal protective equipment
PTSM	principal threat source material
PVC	polyvinyl chloride
RAIP	Remedial Action Implementation Plan
RAO	remedial action objective
RBA	risk-based activity
RBC	risk-based concentration
RCO	Radiological Control Operation
RCOC	refined constituent of concern
RCRA	Resource Conservation and Recovery Act
REM	roentgen equivalent man
RfD	reference dose
RFI	RCRA Facility Investigation
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RGO	remedial goal option
RI	Remedial Investigation
ROD	Record of Decision
RRSB	R-Area Reactor Seepage Basin
SARA	Superfund Amendments Reauthorization Act
SCDHEC	South Carolina Department of Health and Environmental Control
SCHWMR	South Carolina Hazardous Waste Management Regulations
SRS	Savannah River Site
SSL	soil screening level
SVOC	semivolatile organic compound
TAL	target analyte list
TBC	to-be-considered
TCL	target compound list
TES	threatened & endangered species
TSD	treatment, storage and disposal
UAZ	Upper Aquifer Zone
USC	unit-specific constituent

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

U.S.C	United States Code
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
UST	underground storage tank
UTR	Upper Three Runs
WSRC	Westinghouse Savannah River Company
yd^2	square yard
yd^3	cubic yard

I. SAVANNAH RIVER SITE AND OPERABLE UNIT NAME, LOCATION, AND DESCRIPTION

Unit Name, Location, and Brief Description

R-Area Reactor Seepage Basins and Overflow Basin Operable Unit (OU)

Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Identification Number: OU- 25

Savannah River Site (SRS)

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Identification Number: SC1 890 008 989

Aiken, South Carolina

United States Department of Energy (USDOE)

SRS occupies approximately 800 km^2 (310 mi^2) of land adjacent to the Savannah River, principally in Aiken and Barnwell counties of South Carolina (Figure 1). SRS is located approximately 40 km (25 mi) southeast of Augusta, Georgia, and 32 km (20 mi) south of Aiken, South Carolina.

USDOE owns SRS, which historically produced tritium, plutonium, and other special nuclear materials for national defense and the space program. Chemical and radioactive wastes are byproducts of nuclear material production processes. Hazardous substances, as defined by CERCLA, are currently present in the environment at SRS.

The Federal Facility Agreement (FFA) (FFA 1993) for SRS lists the R-Area Reactor Seepage Basins (RRSB) OU as a CERCLA unit requiring further evaluation. The RRSB OU was evaluated through an investigation process that integrates and combines the Resource Conservation and Recovery Act (RCRA) corrective action process with the CERCLA remedial process to determine the actual or potential impact of releases of hazardous substances to human health and the environment.

Releases of radioactive contaminants at nonpermitted waste units are subject only to CERCLA requirements. The RRSB OU did not receive RCRA hazardous wastes.

Figure 1. Location of R-Area at SRS

II. SITE AND OPERABLE UNIT COMPLIANCE HISTORY

SRS Operational and Compliance History

The primary mission of SRS has been to produce tritium, plutonium, and other special nuclear materials for our nation's defense programs. Production of nuclear materials for the defense program was discontinued in 1988. SRS has provided nuclear materials for the space program as well as for medical, industrial, and research efforts up to the present. Chemical and radioactive wastes are byproducts of nuclear material production processes. These wastes have been treated, stored, and, in some cases, disposed of at SRS. Past disposal practices have resulted in soil and groundwater contamination.

Hazardous waste materials handled at SRS are managed under RCRA, a comprehensive law requiring responsible management of hazardous waste. Certain SRS activities require South Carolina Department of Health and Environmental Control (SCDHEC) operating or post-closure permits under RCRA. SRS received a RCRA hazardous waste permit from SCDHEC, which was most recently renewed on September 5, 1995. Module IV of the Hazardous and Solid Waste Amendments (HSWA) portion of the RCRA permit mandates corrective action requirements for non-regulated solid waste management units subject to RCRA 3004(u).

On December 21, 1989, SRS was included on the National Priorities List (NPL). The inclusion created a need to integrate the established RCRA Facility Investigation (RFI) program with CERCLA requirements to provide for a focused environmental program. In accordance with Section 120 of CERCLA, 42 United States Code (U.S.C.) Section 9620, USDOE has negotiated an FFA (FFA 1993) with United States Environmental Protection Agency (USEPA) and SCDHEC to coordinate remedial activities at SRS as one comprehensive strategy to fulfill these dual regulatory requirements. USDOE functions as the lead agency for remedial activities at SRS, with concurrence by the USEPA - Region IV and the SCDHEC.

Operable Unit Operational and Compliance History

R-Area is located in the east-central portion of SRS, west of Par Pond near the intersection of SRS Roads 6 and 7. The RRSB OU is located at the northern portion of the R-Reactor Area (Figures 2 and 3). The RRSB OU is located north of the R Reactor and straddles the boundary between the Upper Three Runs (UTR) and Lower Three Runs (LTR) watersheds. All six basins were constructed between June 1957 and March 1958 and received an estimated 5-million gallons of purge water from the R-Reactor disassembly basin. A non-routine discharge due to a calorimeter test failure in 1957 released approximately 2,700 curies (Ci) of radionuclides primarily to Basin 1 with Basins 2 through 5 receiving a lesser amount. Primary radionuclides present were strontium-90 (Sr-90) and cesium-137 (Cs-137). The abandoned process sewer lines extend from the R-Reactor disassembly basin to Basins 1 and 6. A sanitary sewer system was breached during the construction of Basins 1 and 5 and received the contaminated water discharged to the basins.

Basins 1 through 5 were all deactivated and backfilled by 1960. Basin 6 was deactivated in 1964 and backfilled in 1977. In addition, between 1960 and 1963 (exact date unknown), clay dikes and caps were constructed around Basin 1 and northwest of Basin 3 to contain lateral movement of radionuclides and reduce infiltration. Currently, the RRSB consists of the following (shown in Figures 2 and 3):

- Seepage Basins 1 through 6
- Abandoned Process Sewer Lines
- Sanitary Sewer System (sewer lines and sanitary discharge lagoon)
- Surface Water and Sediment

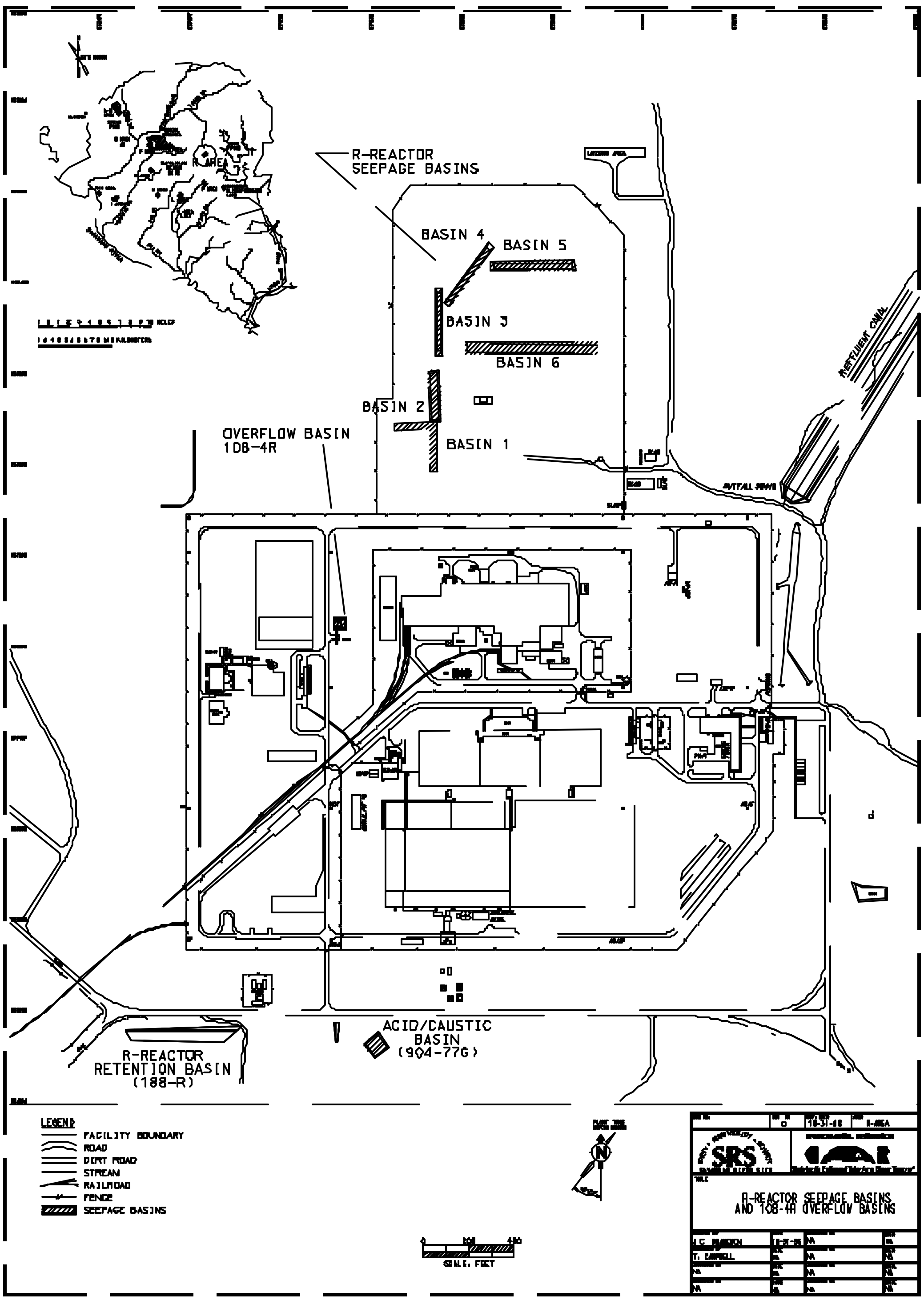

Figure 2. R-Area Reactor Seepage Basins Operable Unit

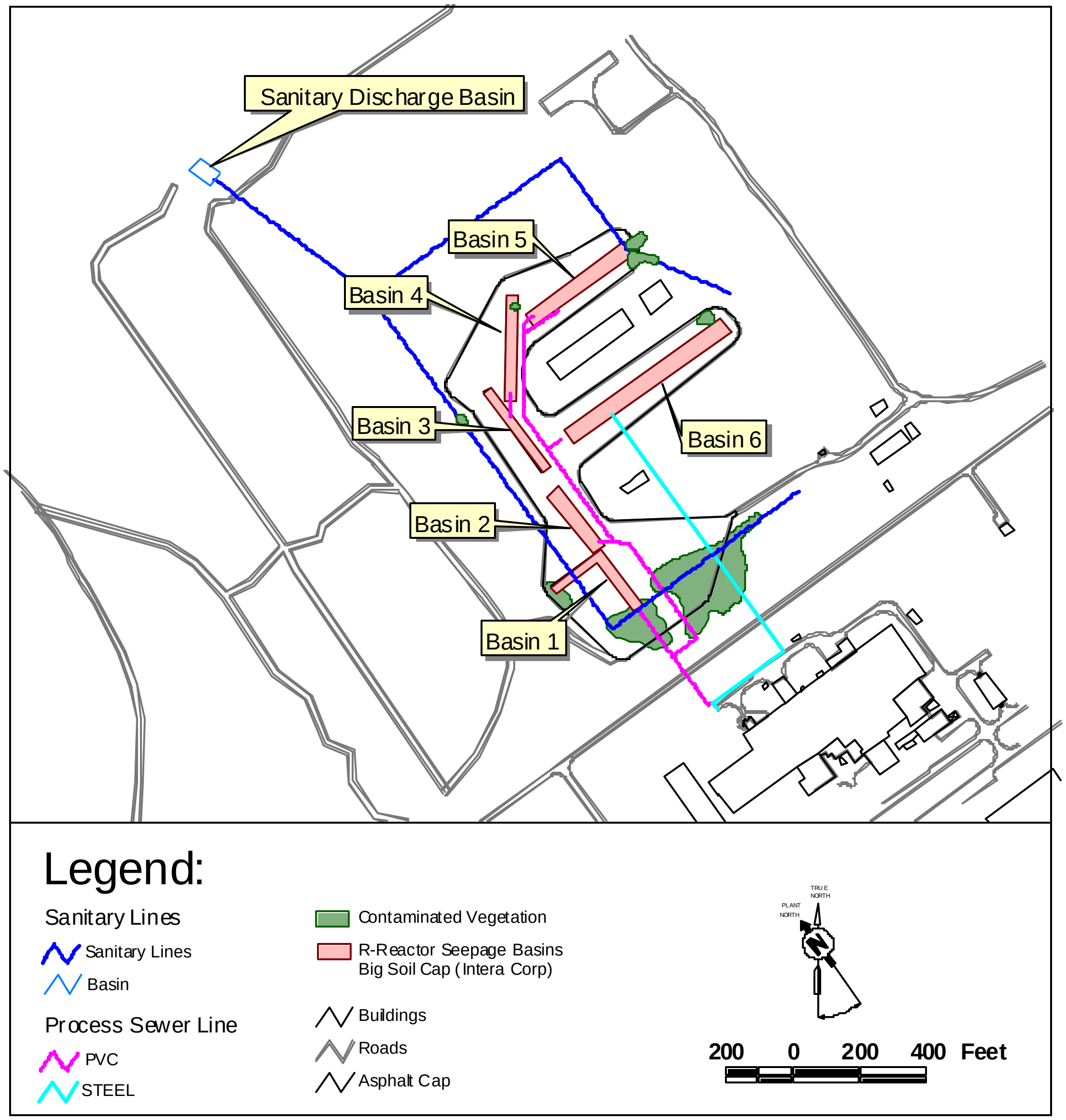

Figure 3. General Layout of the RRSB OU with Pipelines

- RRSB Groundwater, and

- 108-4R Overflow Basin

Surface drainage from the northwestern portion of the unit moves towards Mill Creek, in the UTR watershed; and surface drainage from the southeastern portion of the unit moves towards the R-Area Effluent Canal, which discharges into the LTR watershed.

The 108-4R overflow basin was constructed to collect overflow from two adjacent underground storage tanks (USTs) within a vault (108-3R) that stored diesel fuel for standby generators in the R Reactor. The USTs were removed in March 1990 and associated piping was abandoned in place after being flushed and purged as directed by SCDHEC. Groundwater samples taken during excavation of the USTs indicated no detectable levels of contamination.

Site Characteristics

The RRSB OU lies north of, and adjacent to, R Reactor on an elevated divide between Mill Creek and the R-Effluent Canal, northeast of the R-Area perimeter fence. The entire area, 11 hectares (27 ac), is fenced and approximately 45%, 5 hectares (12 ac), is paved. Topographic relief is low, generally between elevations of 88 m (290 ft) and 91 m (300 ft) above mean sea level (msl). The OU is situated between drainage to Par Pond to the southeast and the headwaters of Mill Creek, located to the northwest. Mill Creek is a tributary of UTR Creek, which is located north of the OU.

There are no wetlands on or near the OU. There are no unusual geographic or topological features associated with the OU that would influence remedy selection.

During the summer of 1996, a removal action was performed to control the spread of radioactively contaminated soil from bioturbation and vegetation and to reduce infiltration of rainwater and erosion. The RRSB was treated with the herbicides

Roundup™ and Garland 4™ and with the insecticides Amdro™ and Spike™ prior to placing approximately 0.5 m (1.5 ft) of clean soil over the existing asphalt emulsion and recontouring the surface to promote drainage. Following compaction, a 10-cm (4-in) layer of asphalt was placed over the clean soil, bringing the unit to its present condition. The area of the existing asphalt cover is 10.7 acres. No other removal action or remedial action has been conducted at the RRSB OU under CERCLA or any other authorities.

III. HIGHLIGHTS OF COMMUNITY PARTICIPATION

The public has been given the opportunity to review and comment on the draft permit modification and proposed remedial alternative. Public participation requirements are listed in South Carolina Hazardous Waste Management Regulation (SCHWMR) R.61-79.124 and Sections 113 and 117 of CERCLA 42 USC Sections 9613 and 9617. These requirements include establishment of an Administrative Record File that documents the investigation and selection of the remedial alternative for addressing the RRSB OU. The Administrative Record File must be established at or near the facility at issue.

The SRS Public Involvement Plan (USDOE 1994) is designed to facilitate public involvement in the decision-making process for permitting, closure, and selection of remedial alternatives. The SRS Public Involvement Plan addresses the requirements of RCRA, CERCLA, and the National Environmental Policy Act (NEPA), 1969. SCHWMR R.61-79.124 and Section 117(a) of CERCLA, as amended, require the advertisement of the draft permit modification and notice of any proposed remedial action and provide the public an opportunity to participate in the selection of the remedial action. The *Proposed Plan (PP) for the R-Area Reactor Seepage Basins/108-4R Overflow Basin Operable Unit (U)* (WSRC 2003), a part of the Administrative Record File, highlights key aspects of the investigation and identifies the preferred action for addressing the RRSB OU.

The FFA Administrative Record File, which contains the information pertaining to the selection of the response action, is available at the following locations:

U.S. Department of Energy
Public Reading Room
Gregg-Graniteville Library
University of South Carolina – Aiken
171 University Parkway
Aiken, South Carolina 29801
(803) 641-3465

Thomas Cooper Library
Government Documents Department
University of South Carolina
Columbia, South Carolina 29208
(803) 777-4866

The RCRA Administrative Record File for SCDHEC is available for review by the public at the following locations:

The South Carolina Department of
Health and Environmental Control
Bureau of Land and Waste
Management
8901 Farrow Road
Columbia, South Carolina 29203
(803) 896-4000

Lower Savannah District
Environmental Quality Control Office
206 Beaufort Street, Northeast
Aiken, South Carolina 29801
(803) 641-7670

The public was notified of the public comment period through the *SRS Environmental Bulletin*, a newsletter sent to citizens in South Carolina and Georgia, and through notices in the *Aiken Standard*, the *Allendale Citizen Leader*, the *Augusta Chronicle*, the *Barnwell People-Sentinel*, and *The State* newspaper. The public comment period was also announced on local radio stations.

The Proposed Plan (WSRC 2003) 30-day public comment period began on June 9, 2003, and ended on July 8, 2003. A Responsiveness Summary, prepared to address the comment received during the public comment period, is provided in Appendix A of this Record of Decision (ROD).

IV. SCOPE AND ROLE OF THE OPERABLE UNIT WITHIN THE SITE STRATEGY

RCRA/CERCLA Programs at SRS

The FFA integrates the corrective action requirements of RCRA with CERCLA as outlined in the FFA (FFA 1993). The RCRA/CERCLA processes are summarized below:

- investigation and characterization of potentially impacted environmental media (such as soil, groundwater, and surface water) comprising the waste site and surrounding areas
- evaluation of risk to human health and the local ecological community
- screening of possible remedial actions to identify the selected technology that will protect human health and the environment
- implementation of the selected alternative
- documentation that the remediation has been performed competently
- evaluation of the effectiveness of the technology

The steps of this process are iterative in nature and include decision points that require concurrence between USDOE as owner/manager and USEPA and SCDHEC as regulatory oversight agencies. The public is given the opportunity to review and comment on the regulatory documents. Figure 4 is a flow chart presenting the process logic and documentation.

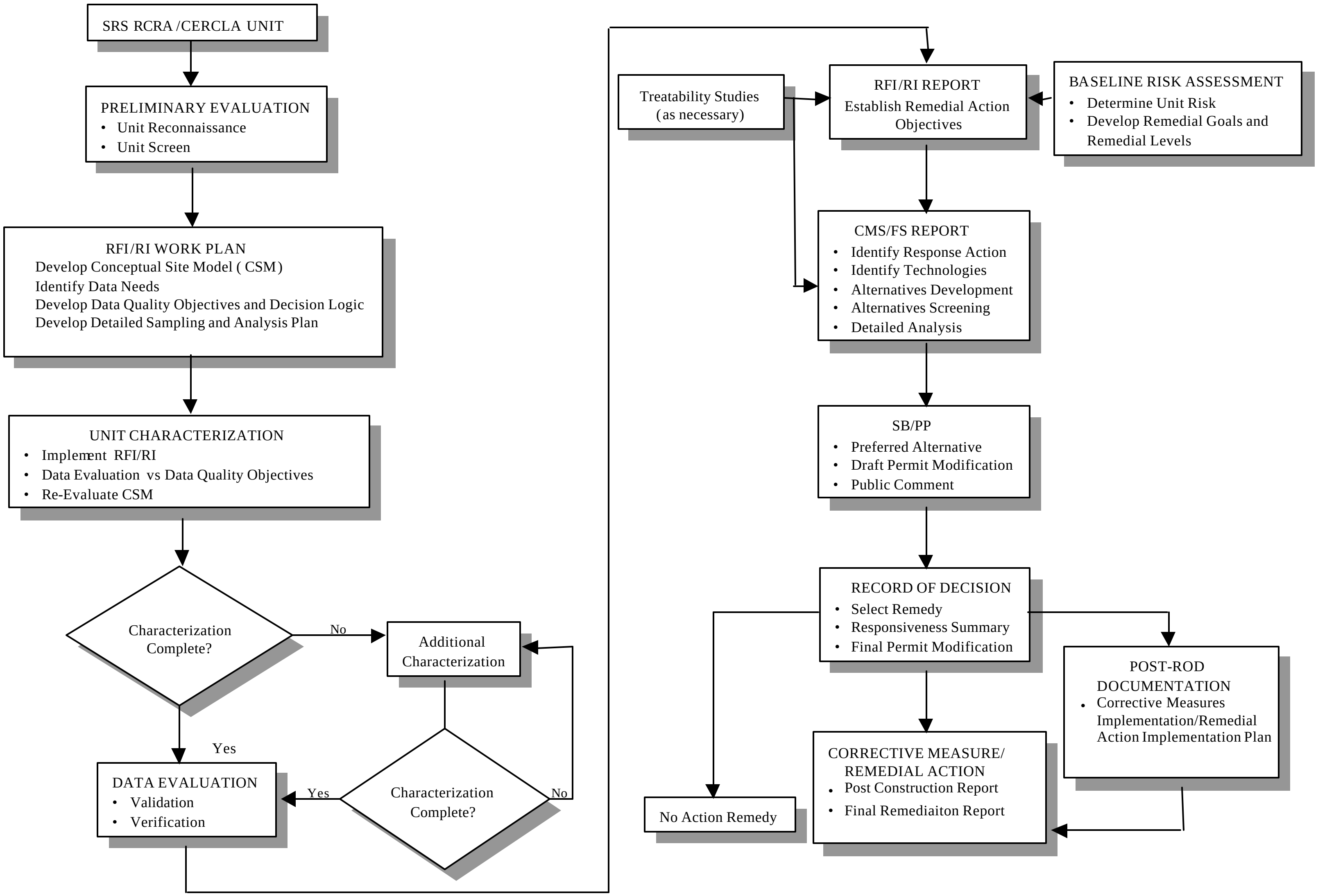

Figure 4. RCRA/CERCLA Logic and Documentation

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Operable Unit Remedial Strategy

The overall strategy for addressing the OU was to (1) characterize the waste unit, delineating the nature and extent of contamination and identifying the media of concern (perform the remedial investigation (RI)); (2) perform a baseline risk assessment (BRA) to evaluate media of concern and exposure pathways and to characterize potential risks and identify refined constituents of concern (RCOCs); and (3) identify and perform a final action to remediate as needed, the identified media of concern.

The RFI/RI/BRA identified contamination that warrants remediation in RRSB Seepage Basins 1 through 6, the Abandoned Process Sewer Line, portions of the Sanitary Sewer Line, and RRSB Groundwater. This ROD identifies the final action for these subunits. The Core Team has agreed that there are no problems warranting action (i.e., no constituents of concern (COCs)) for the surface water and sediment and the 108-4R Overflow Basin subunits; therefore, no action is proposed for these subunits. The Core Team is composed of decision-makers representing USEPA, SCDHEC, and USDOE.

The RRSB contains principal threat source material (PTSM) in the soil associated with Basins 1 through 6, in the process lines and associated soil, and in the contaminated sanitary sewer line and associated soil. The remedial action places an intruder barrier over the PTSM to deter inadvertent human intrusion. The barrier will be placed above the existing asphalt cover. Institutional controls will be made part of the remedial action in order to limit the RRSB OU area to industrial uses in the future.

The RRSB OU straddles the UTR and LTR watersheds. Several source control and groundwater OUs within these watersheds will be reevaluated to determine impacts, if any, to associated streams and wetlands. SRS will manage all OUs to mitigate impact to these watersheds. Upon disposition of all OUs, a final comprehensive ROD for the watersheds will be pursued with additional public involvement.

The response action for the RRSB will not impact the response action of other OUs at SRS.

V. OPERABLE UNIT CHARACTERISTICS

This section presents the conceptual site model (CSM) for the RRSB OU, provides an overview of the characterization activities conducted at RRSB OU, presents the characterization results and COCs, and provides an overview of the contaminant transport analysis.

Conceptual Site Model for the RRSB OU

The CSM for the RRSB OU is presented in Figure 5. The exposure routes and the known and potential human and ecological receptors presented in the CSM are discussed in the summary of OU risks in Section VII.

Primary and Secondary Sources of Contamination

The primary source of contamination from, and within, the RRSB is purge water that was released to the seepage basins via process sewer lines. The purge water, containing tritium, Cs-137, Sr-90, and other radionuclides, originated from the reactor disassembly basin. An estimated total of 18,200,000 L (4,808,000 gal) of purge water containing approximately 3,276 Ci total activity was released to the seepage basins during their operation (WSRC 1997a). Because of the large quantity of radioactivity in these historical releases, it has been concluded that the subsurface soil associated with the basin bottoms, the process sewer lines, and the contaminated sections of the sanitary sewer line be considered PTSM.

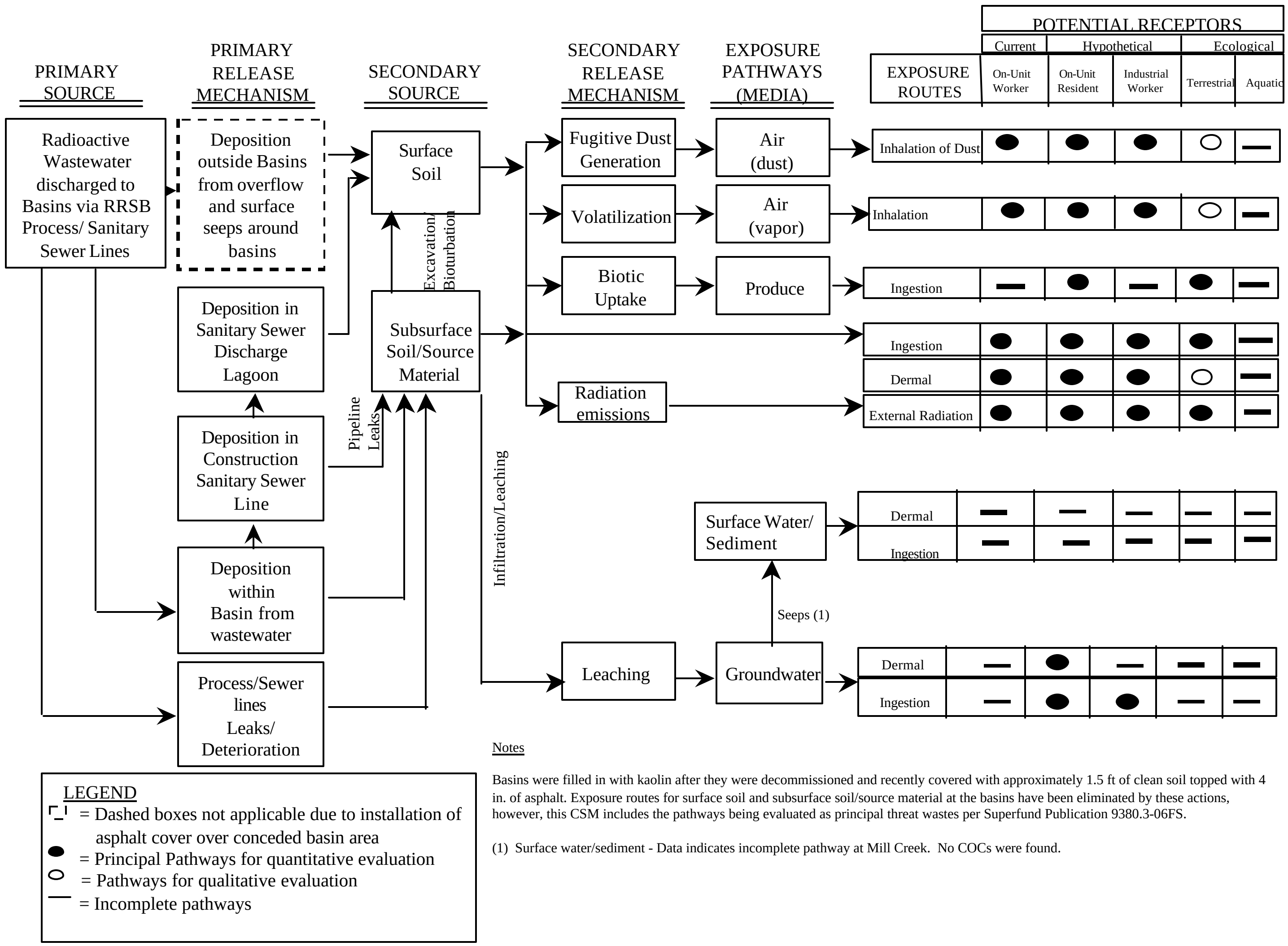

Figure 5. Conceptual Site Model for the RRSB OU

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Primary Release Mechanisms

The primary contaminant release mechanisms at the RRSB OU include the following:

- deposition of purge water within basins via process sewer pipelines
- deposition of purge water on surface soil around basins via overflow or surface seeps
- leakage of purge water from RRSB-associated process sewer pipelines
- deposition of purge water in the sanitary sewer discharge lagoon
- deposition of purge water in the construction sanitary sewer line

Secondary Sources of Contamination

Environmental media impacted by the release of contamination from the primary sources of contamination are secondary sources. Secondary sources of contamination at the RRSB OU include surface (0 to 0.3 m [0 to 1 ft]) and subsurface soil (0.3 m [1 ft] to water table) adjacent to the basins.

Secondary Release Mechanisms

The secondary sources may release contaminants to other media through a variety of secondary release mechanisms. At the RRSB OU, secondary release mechanisms include the following:

- leaching caused by infiltration/percolation of rainwater through contaminated soils
- bioturbation and excavation of surface/subsurface soil

- erosion and transport of surface soil via stormwater runoff
- fugitive dust generation
- biotic uptake
- potential discharge of contaminated groundwater to wetlands and streams
- potential transport of contaminants via surface water and sediments
- infiltration/percolation and leaching of contaminants from subsurface soils to groundwater

Exposure Media

Contact with contaminated environmental media creates an exposure pathway for both human and ecological receptors. At RRSB OU, the following exposure media were evaluated:

- surface soils (0 to 0.3 m [0 to 1 ft]) and subsurface soils (0.3 m[1ft] to water table)
- water table groundwater

Media Assessment

The *RFI/RI/BRA for the R-Area Reactor Seepage Basins/108-4R Overflow Basin Operable Unit (U)* (WSRC 1998c) contains the detailed information and analytical data for all the investigations conducted and samples taken in the media assessment of the RRSB OU. This document is available in the Administrative Record File (see Section III of this document).

For the purpose of RI and risk assessment, the RRSB OU components were grouped into the following subunits. The subunits are as follows:

- Seepage Basins 1 through 6
- Abandoned Process Sewer Lines
- Sanitary Sewer System
- Surface Water and Sediment
- 108-4R Overflow Basin
- Groundwater

The investigations conducted to characterize RRSB OU subunits are described in the following sections.

Soil Investigation

Detailed results of historical soil sampling performed at the RRSB OU are presented in the RRSB RFI/RI/BRA (WSRC 1998c). Gamma probe/cone penetrometer test (CPT) was used to determine gamma-emitting radionuclides and their activities in subsurface soil within and in the vicinity of the RRSB (see Figure 6). Background gamma-probe measurements were taken at three locations outside the RRSB perimeter. The background and primary source investigation was conducted from October 17 through December 19, 1997, and is described in the Phase II Field Summary Report of the RRSB/108-4R OU (WSRC 1998a). The primary source investigation consisted of a radiological survey and sampling of the interior of the sanitary sewer lines to determine the location and extent of potentially transferable radioactive contamination. The radiological survey of the interior

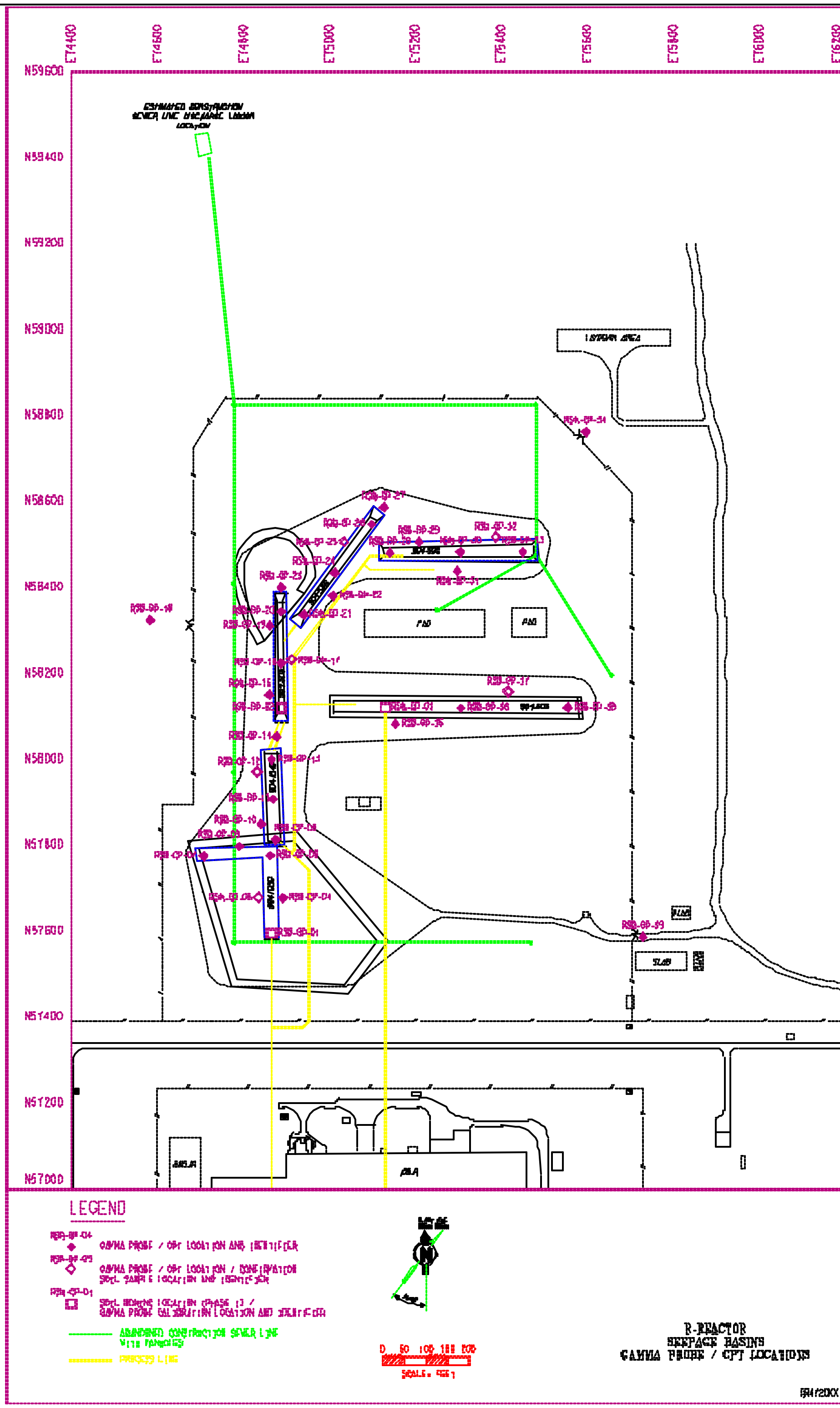

Figure 6. Gamma Probe and CPT Locations for the RRSB OU

portions of the sanitary sewer lines consisted of the following: 1) initial field surveys for radioactivity using a portable rate meter/scaler (i.e., gamma) and for alpha and beta/gamma activities using SRS Radiological Control Operations (RCO) instrumentation and procedures; 2) collection and analysis of smears from the inside of the pipelines to determine the presence of transferable radioactive contamination; and 3) the collection/analysis of sediment/water that could be present inside the pipelines.

The secondary source investigation was conducted during the Phase I and II unit assessments. During the Phase I assessment, additional surface and subsurface soil samples were collected at locations within Basins 1, 3, and 6. Soil samples were at ground surface to 0.3 m (1 ft) depth, 0.3 m (1 ft) above the bottom of the basin to 0.3 m (1 ft) below the bottom of the basin, 0.3 m (1 ft) below the bottom of the basin to 0.9 m (3 ft) below the bottom of the basin, and 0.6m (2 ft) core segment above the water table. Phase II soil samples were taken at six locations adjacent to gamma probe/CPT pushes as confirmation samples, and at locations adjacent to the abandoned sanitary sewer line and process pipeline. Each location was sampled at depth intervals corresponding to the gamma probe intervals at the basin bottom and below the basin bottom. All confirmatory soil samples were screened during sample collection for radionuclides using a portable rate meter/scaler, and for gross alpha and beta activity using SRS RCO implementation procedures. If gross alpha or nonvolatile beta screening activities in any sample exceeded the screening levels of 20 and 50 pCi/g for gross alpha and nonvolatile beta, respectively, then that sample was analyzed by SRS laboratories for gross alpha and nonvolatile beta activities and for gamma pulse height analysis (PHA).

Subsurface soil sampling was conducted along the sanitary sewer line, within the sewer line discharge lagoon, and at four locations along the process pipelines. In the event SRS sample screening and analysis indicated the presence of radionuclides in any one sample at an initial location, samples were collected from a second, “stepped-out” location approximately 3 m (10 ft) from the original location and away from pipeline. The identification of contamination at initial sampling locations along the sanitary sewer line necessitated expanding the soil sampling to stepped-out locations to determine the extent of contamination resulting from pipeline leaks and/or breaks. Soil sampling continued away from the sanitary sewer line until the extent of the contamination was determined. During collection, all samples were screened for radionuclides with a portable count rate meter/scaler, and for alpha and beta with RCO instrumentation. Subsequent to collection, all soil samples that exceeded the gross alpha or nonvolatile beta screening levels of 20 and 50 pCi/g, respectively, were analyzed by an onsite SRS laboratory for gross alpha, nonvolatile beta, and gamma PHA.

A postcharacterization soil investigation was conducted in July 2000 to collect additional soil samples. CPT locations were selected both inside and outside of the RRSB area. The CPT soil samples were analyzed for gross alpha, nonvolatile beta, and 16 radiological constituents.

The 108-4R Overflow Basin was characterized under a separate soil investigation from the RRSBs. The Phase I Unit Assessment of the 108-4R Overflow Basin was conducted during February and April 1996. Phase I investigation activities included the following:

- collection and analysis of surface and subsurface soil samples from one location within the 108-4R, and

- collection and analysis of groundwater samples from existing piezometer well RSP-1D located downgradient of the 108-4R.

The Phase I soil investigation was designed to identify 108-4R surface and subsurface soil contaminants. A soil boring was conducted in the 108-4R using Vibracore™ technology. Because the 108-4R Overflow Basin is small, one boring was deemed adequate to characterize the nature of contamination. Samples were collected from the soil boring in 0.6-m (2-ft) intervals from the top of the sediment to a depth of approximately 0.6 m (2 ft) below basin bottom. The total sample depth to refusal was 1.3

m (4.4 ft). Phase I surface and subsurface soil samples from 108-4R were analyzed for the following parameters: target compound list (TCL) volatiles and semivolatiles, pesticides/polychlorinated biphenyls (PCBs), target analyte list (TAL) inorganics, herbicides, gross alpha and nonvolatile beta, gamma PHA, and radionuclide speciation.

Groundwater Investigation

Background groundwater samples were taken from monitoring well clusters at three locations outside the RRSB perimeter fence. Wells in these clusters represent the same aquifer zones represented in unit monitoring wells and piezometers. The background groundwater samples were analyzed for TCL volatiles and semivolatiles, pesticides/PCBs, TAL inorganics, physical parameters, and gross alpha and nonvolatile beta radionuclide indicators.

Groundwater investigations were conducted as part of Phases I and II and postcharacterization investigations. During Phase I, nineteen new groundwater monitoring wells/piezometers were installed, developed, sampled, and tested. These well locations include four 3-well clusters, and seven individual shallow piezometer locations. As part of the Phase I groundwater investigation, groundwater samples were collected from pre-existing monitoring wells located in the nonvolatile beta plume "hot spots" and from the background wells, as previously described. Phase I groundwater samples were analyzed for the following parameters: TCL volatiles and semivolatiles, pesticides/PCBs, TAL inorganics, specified analyses (e.g. chloride, fluoride, sulfate, total organic carbon), gross alpha and nonvolatile beta radionuclide indicators, and gamma PHA.

The Phase II groundwater investigation included CPT groundwater sampling and the installation and sampling of groundwater monitoring wells (see Figure 7). CPT groundwater samples were collected from the surface soil/"A Horizon" at locations inside and adjacent to the RRSB as well as from locations outside the RRSB perimeter fence. Eighteen monitoring wells were installed in nine clusters located outside the RRSB perimeter fence. At each cluster, one well was installed in the surface soil/"A Horizon,"

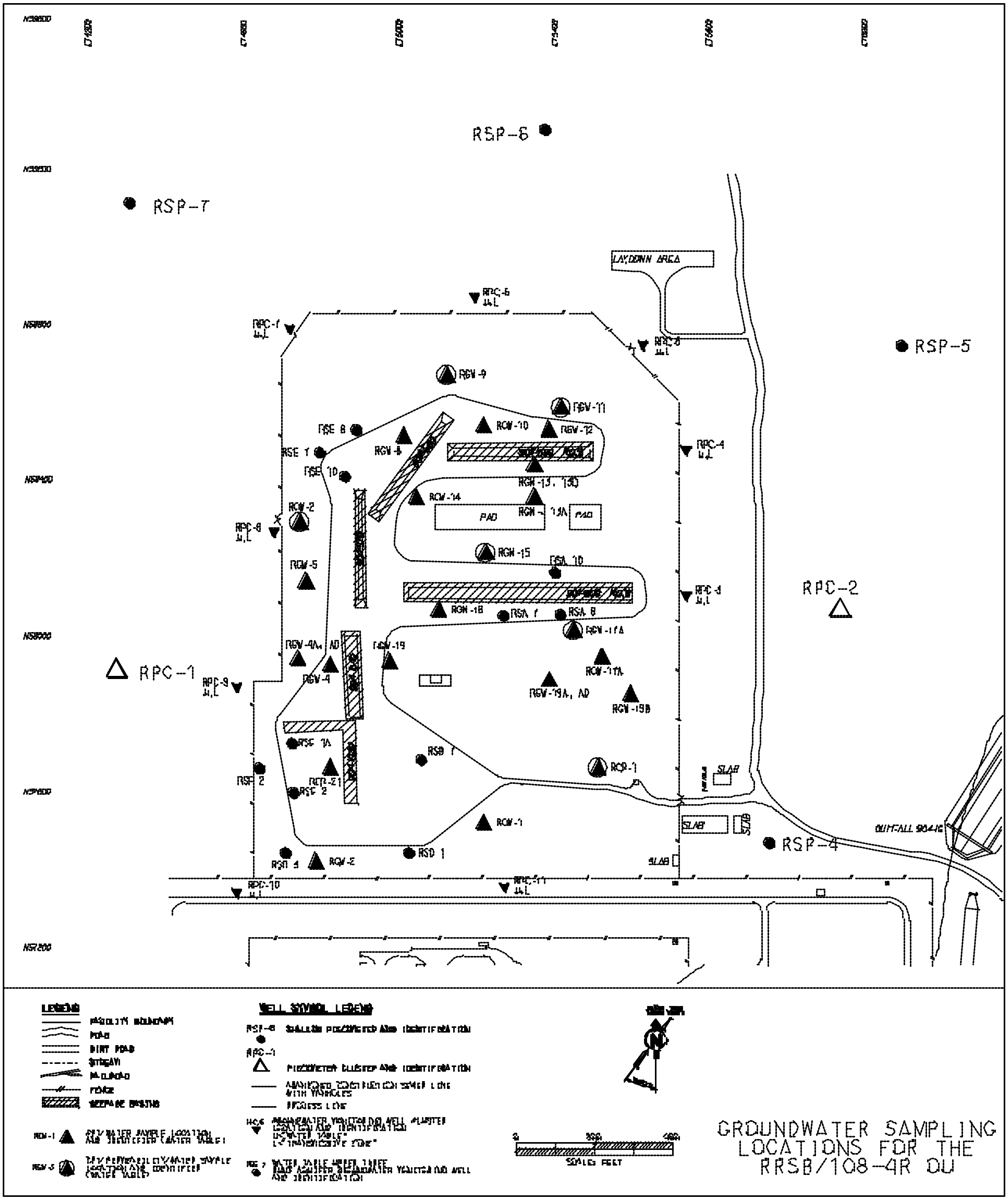

Figure 7. Groundwater Sampling Locations at the RRSB OU during Phase II

and the second well was installed in the transmissive zone. The additional CPT groundwater samples were collected at perimeter locations and screened for gross alpha, nonvolatile beta, tritium, gamma PHA, and Sr-90. Groundwater samples from the surface soil/"A Horizon" were also collected from 24 CPT locations inside the RRSB.

During the Postcharacterization CPT and Groundwater Sampling, monitoring wells were analyzed for various constituents including gross alpha, nonvolatile beta, C-14, and Sr-90. In July 2000, additional groundwater samples were collected onsite and analyzed for nonvolatile beta. Additional groundwater sampling from 19 new and existing wells was conducted in October and November 2000. The samples were analyzed for gross alpha, nonvolatile beta, Sr-90, and tritium.

Surface Water and Sediment

Surface drainage from the northwest portion of the unit moves toward Mill Creek, in the UTR watershed; and surface drainage from the southeastern portion of the unit moves toward the R-Area Effluent Canal, which discharges into the LTR watershed. Historical sampling data indicate that the RRSB has not contributed any contamination to Mill Creek. Seep line samples were collected at locations along Mill Creek to investigate the effects of potential discharge of contaminant groundwater. Water samples were collected and analyzed for the Phase II focused analyte list. Surface water and sediments in the R-Area Effluent Canal will be addressed as a separate OU.

Media Assessment Results

Soils

An analysis of contaminant concentrations and patterns of contaminant distributions in the soil near the RRSB was performed. Detected analytes were screened against the twice-average background levels to determine the nature and extent of contamination. Those analytes for which maximum concentrations/activities exceeded twice-average background levels were identified as unit-specific constituents (USCs). The contaminants identified as USCs in RRSB soil samples included eight volatile organic compounds (VOCs), three semivolatile organic compounds (SVOCs), two pesticides, nine inorganic constituents, two radiological indicators, and 17 radionuclides.

Based on gamma probe results and soil sampling results, radiological contamination is largely confined to a 0.9- to 3.0-m (3- to 10-ft) layer within the basins. The highest concentrations occur at the interface of the backfill material and the top of the original basin soil. The relative concentration of the radionuclides is consistent with basin operation history. Basin 1 has the highest concentrations of radionuclides because it received the initial discharge following the failed calorimeter experiment. Radionuclide concentrations are high in Basins 2 and 3, but lower than in Basin 1. The concentrations in Basin 4 are lower than in the first three basins since Basin 4 only received discharge that had passed through Basins 2 and 3. Basin 5 had concentrations higher than Basin 4 because it received discharge directly from the Emergency Disassembly Basin. Basin 6 had the lowest concentrations since it received very little discharge associated with a failed calorimeter experiment.

PTSM corresponds to a threshold value of 85 pCi/g for Cs-137. This threshold value corresponds to the Cs-137 concentration in soil that would produce a human health risk of 1 x 10^{-3}. For this specific operable unit, PTSM was assumed to be source material that presents a potential human health risk of 1 x 10^{-3} or greater if exposure should occur. PTSM occurs in each basin as a layer located at the basin floor. The thickness usually is between 1 and 1.5 m (3 to 5 ft), but reaches a maximum of 3 m (10 ft). Based on their history of use, the contaminated portions of the process sewer line and the sanitary sewer line are considered PTSM. The total estimated volume of PTSM at the OU is 17,200 yd^3.

Groundwater

Sr-90 exceeds the maximum contaminant level (MCL) in the shallow water table aquifer. The lateral extent of contamination is limited to the immediate vicinity of the basins.

Vertical contaminant migration is retarded by very low-permeability sediment and minimal infiltration. Further discussion on the extent of Sr-90 is presented in Section 2.2.3.4 of the RI/BRA.

Although Americium-241 (Am-241) was identified as a human health COC in groundwater, it is not a significant concern because it has been detected only three times in a total of 85 samples collected since 1995 at a maximum concentration of 1.3 pCi/L. This concentration is well below the gross alpha MCL of 15 pCi/L.

Site-Specific Factors

There are no site-specific factors at the OU that require special consideration that might affect the remedial action for the RRSB OU.

Contaminant Transport Analysis

Contaminant migration depends on site geology, hydrogeology, and groundwater-surface water relationships. For the inorganic, organic, and radiological compounds, the transport processes include adsorption, volatilization, transport with soil water, and biotic uptake. The saturated zone from the water table surface to the top of the "Tan Clay" interval is defined as the upper aquifer zone (UAZ) and is of significance with respect to RRSB contaminant migration. The saturated thickness of the UAZ ranges from approximately 30 to 37 m (100 to 120 ft). As described by the hydrogeological conceptual model (HCM) (Figure 8), the UAZ (the water table) includes the surface soil, the "A Horizon," the "AA Horizon," and the transmissive zone. The surface soil and the "A Horizon" have a low permeability while the transmissive zone has a comparably higher permeability. The significance of the UAZ with respect to RRSB contaminant migration is illustrated by the HCM.

Large fluctuations in the water table elevation occur as a result of changes in precipitation. Extreme wet periods, as in 1998, increase the elevation of the water table, resulting in periodic interface between groundwater and contaminated soil. Data indicates the groundwater is at least 3 m (10ft) below the contaminated soil at this time. Due to a large vertical component in the hydraulic gradient of the "A/AA Horizons," groundwater flows predominantly downward in the vicinity of the RRSB.

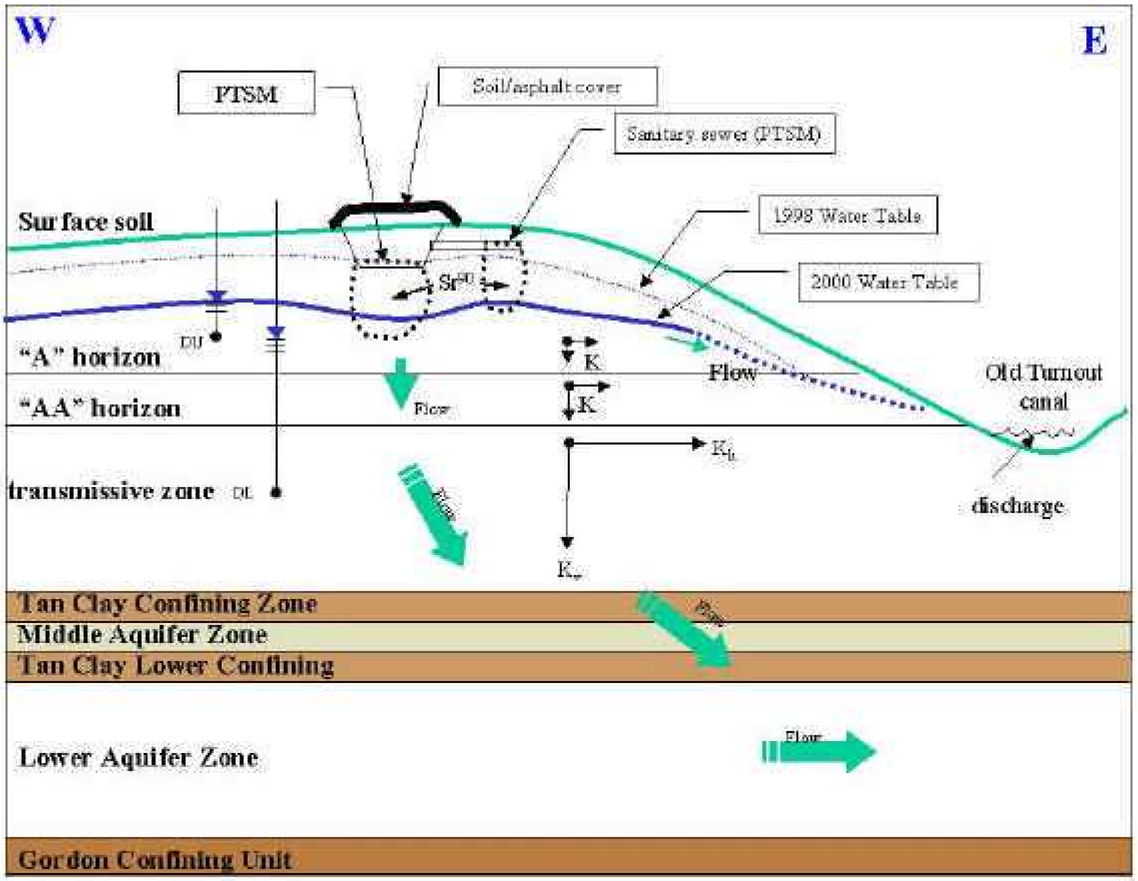

Figure 8. RRSB Hydrogeological Conceptual Model

A detailed, three-dimensional, numerical groundwater flow and transport model (WSRC 2002) was developed for the RRSB OU. This includes a flux model for transport from the vadose zone to the water table, a saturated zone flow model, and a transport model with several cover scenarios simulated. Results indicate that the Sr-90 plume is not migrating toward discharge locations.

For the 108-4R Overflow Basin, lindane, 2-methylnathalene and dichloromethane are the only contaminant migration constituents of potential concern (CMCOPCs). A leachability analysis was completed for lindane and dichloromethane using the Multimedia Environmental Pollutant Assessment System (Rabin 1998). The results show that estimated maximum groundwater concentrations for lindane and dichloromethane do not exceed MCLs.

VI. CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

Land Uses

Current Land Use

The RRSBs and 108-4R Overflow Basin lie in an industrial use area that is currently inactive. Access to SRS is controlled by USDOE. Once within the SRS boundaries, access to the R-Reactor Area is restricted. A locked gate exists at the unpaved road leading to the R Reactor to prevent vehicular access, and the site is bounded by a fence that restricts access by foot. The surrounding area is undeveloped and wooded although access is not restricted from the R-Reactor Area. On-unit workers do not currently consume groundwater in the vicinity of the R-Reactor Area. The potentially exposed receptors that are evaluated for the current land-use scenario are the known on-unit workers who visit the area on an infrequent or occasional basis. The known on-unit workers are defined as SRS employees who work at or in the vicinity of the RRSB OU under current land use conditions and include, but are not limited to, researchers, environmental samplers, or personnel in close proximity to the unit. However, these receptors, who may be involved in the excavation or collection of contaminated media, would be following the SRS procedures and protocols for sampling at contaminated waste units.

Future Land Use

According to the *Savannah River Site: Future Use Project Report* (USDOE 1996), residential uses of SRS land should be prohibited. In this report, the R-Reactor Area is identified as a "heavy industrial (nuclear)" area. The report's future-use recommendation is for future industrial (nuclear) land use, which is essentially unchanged from the current land use. Under industrial land use, the most likely human receptors will be industrial workers. Although residential development is unlikely, a hypothetical residential exposure scenario for both adults and children has been evaluated to allow comparison in accordance with USEPA – Region IV guidance (USEPA 1995a), which states that residential development cannot be entirely ruled out. However, future use of the land is not likely to change from current use.

Groundwater Uses/Surface Water Uses

SRS does not use the water table aquifer for drinking water or irrigation purposes and currently controls any drilling in this area. Therefore, as long as USDOE maintains control of SRS, the aquifer beneath the RRSB OU will not be used as a potential drinking water source or for irrigation. Surface water from the unit may enter drainages that bound the unit. However, these drainages are not being used for irrigation or other uses.

VII. SUMMARY OF OPERABLE UNIT RISKS

Baseline Risk Assessment

As a component of the RFI/RI process, a BRA, which included both human health and ecological risk assessments, was performed to evaluate risks associated with the RRSB OU. The BRA estimates what risks the site poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. The BRA includes human health and ecological risk assessments. This section of the ROD summarizes the results of the BRA for this

OU. Table 1 presents the final COCs which have become the basis of and the focus for the remediation.

Summary of Human Health Risk Assessment

Seepage Basins 1 through 6

All human health risk calculations are based on the future land use assumption that the property will remain restricted for industrial uses. Based on the potential exposure risks to Cs-137 and the leachability of Sr-90, the soil at the bottom of the six seepage basins represents PTSM.

Table 1. Final Constituents of Concern Retained for the RRSB

Human Health Final COCs
Soil Americium-241 Cesium-137 Cobalt-60 Plutonium-238 Plutonium-239/240 Strontium-90 **Groundwater** Americium-241 Strontium-90
Ecological Final COCs
Soil Americium-241 Cesium-137 Strontium-90
Contaminant Migration Final COCs
Soil Americium-241 Carbon-14 Plutonium-239/240 Strontium-90

PTSM with a risk greater than or equal to 1 x 10^{-3} for a hypothetical, future industrial worker is present at the RRSB. Based on the presence of Cs-137 at PTSM levels, remedial action is necessary. A risk of 1 x 10^{-3} means that for every 1,000 people thatcould be exposed, one extra cancer may occur as a result of exposure to site contaminants. An extra cancer case means that one more person could get cancer than would normally be expected to from all other causes.

Table 2 identifies the baseline risks for all COCs in the RRSB subsurface soil. Subsurface soil evaluated in the RRSB risk assessment is located at the bottom of the basins, covered by at least 2.4 m (8.0 ft) of fill. An asphalt cover currently lies above the RRSB.

Table 2. Baseline Risks for COCs in Subsurface Soils at the RRSB

COCs	**Baseline Risk**[1]
Cesium-137	9.0x 10^{-2}
Americium-241	2.0x10^{-4}
Cobalt-60	2.0x10^{-5}
Plutonium-238	2.0x10^{-6}
Plutonium-239/240	1.0x10^{-5}
Strontium-90	1.0x 10^{-4}

[1]Baseline risk for hypothetical future industrial workers for soils at depths of 8.0 to 14.5 ft.

Abandoned Process Sewer Lines

The abandoned process sewer lines extend from the R-Reactor building to Basins 1 and 6. The pipelines to Basins 1 through 5 are 7.6-cm (3-in) polyvinyl chloride (PVC). The pipeline to Basin 6 is 10.2-cm (4-in) steel. The total length of the process lines from the reactor fence is about 909.2 m (2,983 ft), of which 345.9 m (1,135 ft) is steel and 563.3 m (1,848 ft) is PVC. Approximately 400.2 m (1,313 ft) of pipeline lies outside the boundary of the existing asphalt cap.

The abandoned process sewer line was not evaluated quantitatively for risk. Based on the history of its use for conveyance of large quantities of purge water containing tritium, Cs-137, Sr-90, and other radionuclides, it has been concluded that the contaminated portion of the abandoned process sewer line be considered PTSM.

Sanitary Sewer System

The sanitary sewer system comprises the sanitary sewer lines and sanitary discharge lagoon that supported the housing camp during construction of R Reactor. The sewer line consists of 0.15- and 0.3-m (6 and 12-in) terra cotta pipe. It was accidentally breached during the construction of Basin 1 in 1957 and Basin 5 in 1958 and received contaminated water. Manholes were filled with concrete and the sanitary sewer line between the lagoon and nearest manhole to the lagoon was broken and backfilled to eliminate discharge to the lagoon. Radiological surveys of soil and vegetation indicate surficial contamination around Basin 5 and the sanitary sewer line east of Basin 1. Based on its history of use, only the contaminated portion of the sanitary sewer line is considered as PTSM. Subsurface soil adjacent to the contaminated portions of the sanitary sewer line is contaminated. Bioturbation has resulted in contaminated vegetation. The total length of contaminated sanitary sewer line is about 499.2 m (1,638 ft). Approximately 42% of this already is under the asphalt cap. Contaminated subsoil and vegetation associated with the sewer line is included in the scope of this subunit. No final COCs were identified for the uncontaminated portion of the sanitary sewer line and the sanitary discharge lagoon.

Surface Water and Sediment

Surface drainage from the northwestern portion of the unit moves towards Mill Creek, in the UTR watershed; and surface drainage from the southeastern portion of the unit moves towards the R-Area Effluent Canal. Historical sampling data and seep samples indicate that the RRSB has not contributed any contamination to Mill Creek. There are no COCs for the surface water and sediment subunit. Therefore, there is no problem warranting action at this sub-unit.

Surface water and sediment in the R-Area Effluent Canal will be addressed as a separate OU and, therefore, are not addressed in this ROD.

108-4R Overflow Basin

No final COCs were identified for soil or groundwater associated with this subunit. Therefore, there is no problem warranting action at this subunit. With the approval of SCDHEC and USEPA, this subunit was backfilled and covered by a vegetative layer.

RRSB Groundwater

Data collected between 1995 and 2001 are used to determine the lateral and vertical extent of Sr-90 contamination in groundwater. This data was gathered from samples from 51 different wells and 25 temporary CPTs, or 76 different locations. The lateral extent of Sr-90 groundwater contamination above the MCL is centered in the immediate vicinities of Basins 1, 2, and 3, with a lobe of contamination extending approximately 152 m (500 ft) eastward from Basin 1. A maximum concentration of 1,910 pCi/L was detected in a monitoring well while higher concentrations up to 4,500 pCi/L were detected in CPTs and temporary piezometers.

Groundwater data collected from numerous wells and CPT points that are deeper than 14.6 m (48 ft) indicated that the vertical extent of Sr-90 contamination exceeding the MCL is limited to the shallow water table. Groundwater modeling (WSRC 2002) indicates that Sr-90 will not reach the lower aquifer zone (LAZ) at concentrations above the MCL. Concentrations are expected to fall below the MCL in the transmissive zone after approximately 300 to 400 years.

Forty-seven wells were sampled in 2002 for gross alpha, nonvolatile beta, Sr-90, and tritium, and 11 wells were sampled for additional parameters, including Am-241. Data indicate that the Sr-90 plume is essentially unchanged from previous years. One new transmissive zone well (RSE 26DL), installed within the asphalt cap near Basin 1, was nondetect for Sr-90, which confirms modeling predictions that groundwater migration is very slow.

Although Am-241 was identified as a human health COC in groundwater, it is not a significant concern because it has been detected only three times out of a total of 85 samples collected since 1995 at a maximum concentration of 1.3 pCi/L. This concentration is well below the gross alpha MCL of 15 pCi/L. Therefore, groundwater remedial strategies for Am-241 currently are not addressed in this ROD.

Tritium above MCLs was found in three transmissive zone wells. This contamination could be derived from other waste sites in the R-Reactor area. The tritium contamination will be managed under the R-Area Groundwater OU.

Exposure Assessment

The following table presents the COCs and exposure point concentration (EPC) for each of the COCs detected in soil (i.e., the concentration that will be used to estimate the exposure and risk from each COC in the soil). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the EPC, and how the EPC was derived. EPCs are the concentrations of constituents in a given medium to which human receptors are exposed at the point-of-contact. EPCs are used to calculate the constituent intakes, or doses, for human receptors based on methodology provided US EPA risk assessment guidance. Table 3 provides the EPCs for RCOCs for each media.

Table 3. Summary of RCOCs and Medium-Specific Exposure Point Concentrations

Future Industrial Worker							
Exposure Route	**Analyte**	**Frequency of Detection**	**Minimum Detection**	**Maximum Detection**	**Exposure Point Concentration**	**Units**	**Statistical Measure**
Subsurface	Americium-241	3/6	2.77E+00	2.31E+03	2.31E+03	pCi/g	Max
Soil	Cesium-137	6/7	4.87E-02	9.89E+03	9.89E+03	pCi/g	Max
8 to 14.5 ft	Cobalt-60	3/6	7.26E-02	3.78E-01	3.78E-01	pCi/g	Max
	Plutonium-238	4/6	9.14E-02	1.67E+01	1.67E+01	pCi/g	Max
	Plutonium-239/240	3/7	3.02E+00	9.86E+01	9.86E+01	pCi/g	Max
	Strontium-90	5/7	1.35E+00	5.75E+03	5.75E+03	pCi/g	Max
Water Table	Americium-241	1/38	1.33E+00	1.33E+00	1.33E+00	pCi/L	Max
Aquifer	Strontium-90	9/38	2.32E+00	1.91E+03	1.91E+03	pCi/L	Max
Key:							
Max: maximum concentration							

The dominant exposure pathways from constituent sources and exposure media to human receptors potentially exposed to COPCs at the unit are presented in a graphical form as a CSM (see Figure 5). The possible receptor for the current land-use scenario is the known, on-unit worker. The known, on-unit workers could be exposed to surface soil at the OU. Surface soil available for contact by the known, on-unit workers is located at the Abandoned Sanitary Sewer Line and the 108-4R; RRSB surface soil is covered with asphalt and not available for contact. The possible receptors under the future, land-use scenario include the on-unit industrial worker and the on-unit residents, both adult and child. The hypothetical, on-unit industrial worker is an adult working primarily in an outdoor industrial setting that is in direct proximity to the contaminated media. The hypothetical on-unit resident assumes that residents live on-unit and are chronically exposed, both indoors and outdoors, to unit-related constituents.

Toxicity Assessment

Toxicity Information was obtained, when possible, from the Integrated Risk Information System (IRIS) (US EPA 1998). If values were not available from IRIS, the Health Effects Assessment Summary Tables (HEAST) (US EPA 1995b), or the Superfund

Health Risk Technical Support Center, the National Center for Environmental Assessment of US EPA is consulted (US EPA 1997).

Table 4 provides cancer toxicity data that is relevant to the (COCs) in both soil and groundwater. At the time, slope factors were not available for the dermal route of exposure. Thus, the dermal slope factors extrapolated from oral values were used in the assessment. An adjustment factor is sometimes applied depending upon how well the chemical is absorbed via the oral route. Adjustments are particularly important for chemicals with less than 50% absorption via the ingestion route. However, adjustment is not necessary for the chemicals evaluated at this site.

Table 4. Cancer Toxicity Data Summary

Pathways: Ingestion, Inhalation, Dermal

Constituent of Concern	Oral Cancer Slope Factor	Inhalation Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (M/D/Y)
Americium-241	3.28E-10	3.85E-08	6.56E-11	Risk/pCi	A	HEAST	7/1/95
Cesium-137	3.16E-11	1.91E-11	6.32E-12	Risk/pCi	A	HEAST	7/1/95
Cobalt-60	1.89E-11	6.88E-11	3.78E-12	Risk/pCi	A	HEAST	7/1/95
Plutonium-238	2.95E-10	2.74E-08	5.90E-11	Risk/pCi	A	HEAST	7/1/95
Plutonium-239/240	3.16E-10	2.78E-08	6.32E-11	Risk/pCi	A	HEAST	7/1/95
Strontium-90	5.59E-11	6.93E-11	1.12E-11	Risk/pCi	A	HEAST	7/1/95

Pathway: External (Radiation)

Constituent of Concern	Cancer Slope or Conversion Factor	Exposure Route	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (M/D/Y)
Americium-241	6.74E-06	External exposure	Risk/yr per pCi/g	A	HEAST	7/1/95
Cesium-137	3.09E-06	External exposure	Risk/yr per pCi/g	A	HEAST	7/1/95
Cobalt-60	9.76E-06	External exposure	Risk/yr per pCi/g	A	HEAST	7/1/95
Plutonium-238	1.94E-11	External exposure	Risk/yr per pCi/g	A	HEAST	7/1/95
Plutonium-239/240	1.87E-11	External exposure	Risk/yr per pCi/g	A	HEAST	7/1/95
Strontium-90	--	External exposure	Risk/yr per pCi/g	A	HEAST	7/1/95

Key
HEAST: Health Effects Summary Table USEPA
A: Human carcinogen

Risk Characterization

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. These risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6}). An excess lifetime cancer risk of 1×10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. EPA's generally acceptable risk range for site-related exposures is 10^{-4} to 10^{-6}.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all COCs that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI<1 indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI> 1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD

where: CDI = Chronic daily intake`

RfD = reference dose

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Table 5 provides risk estimates for the significant routes of exposure. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of a future industrial worker's exposure to soil and groundwater, as well as the toxicity of the COCs. The total risk to a future industrial worker from direct exposure to contaminated soil and groundwater at this site is estimated to be 9 x 10^{-2}. The COCs contributing most to this risk level are Cs-137, Am-241 and Sr-90 in soil and Sr-90 in groundwater. This risk level indicates that if no cleanup action is taken, an individual would have an increased probability of 9 in 100 of developing cancer as a result of site-related exposure to the COCs.

Summary of Ecological Risk Assessment

The ecological setting of the OU is not unique or significant. There are no threatened or endangered species (TES) species in the vicinity that are likely to be dependent on or affected by the habitat at the OU. The species that inhabit the OU are not rare in the region and generally are not considered to be of special public value. The area of the OU is small, and the habitat it provides appears to be relatively low in diversity and productivity.

A hierarchy of assessment endpoints was selected to assess both proximate and ultimate risks that might be associated with unit-related chemicals. The proximate assessment endpoint was chosen to provide protection of the population levels of terrestrial species that utilize the area to a significant extent. These populations are important as indicators of potential effects on the health of the community. Several receptors (i.e., earthworm, eastern cottontail, short-tailed shrew, American robin, mourning dove, and red-tailed hawk) were selected to represent terrestrial populations at the OU. Although toxic effects that are deleterious to this assessment endpoint in the immediate vicinity of the OU are significant to the receptor itself, they are not necessarily significant to the more important, ultimate assessment endpoint; that is, the community of species that occupies the OU and surrounding area.

Table 5. Risk Characterization Summary - Carcinogens

Scenario Timeframe: Future
Receptor Population: Industrial
Receptor Age: Worker

Medium	Exposure Medium	Exposure Route	Constituent of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)[1]	Exposure Routes Total
Soil (8 - 14.5 ft)	Soil	Soil Onsite-Direct Contact	Americium-241	2×10^{-4}	1×10^{-5}	3×10^{-6}	5×10^{-5}	2×10^{-4}
		Soil Onsite-Direct Contact	Cesium-137	1×10^{-4}	3×10^{-8}	1×10^{-6}	9×10^{-2}	9×10^{-2}
		Soil Onsite-Direct Contact	Cobalt-60	2×10^{-9}	4×10^{-12}	3×10^{-11}	2×10^{-5}	2×10^{-5}
		Soil Onsite-Direct Contact	Plutonium-238	2×10^{-6}	7×10^{-8}	2×10^{-8}	1×10^{-9}	2×10^{-6}
		Soil Onsite-Direct Contact	Plutonium-239/240	1×10^{-5}	4×10^{-7}	1×10^{-7}	8×10^{-9}	1×10^{-5}
		Soil Onsite-Direct Contact	Strontium-90	1×10^{-4}	6×10^{-8}	1×10^{-6}	--	1×10^{-4}
							Soil Risk Total =	9×10^{-2}
Ground-water	Ground-water	Water Table	Americium-241	3×10^{-6}	NA	NA	NA	3×10^{-6}
		Water Table	Strontium-90	7×10^{-4}	NA	NA	NA	7×10^{-4}
							Groundwater Risk Total =	7×10^{-4}
							Total Risk =	9×10^{-2}

Key
--: Toxicity criteria are not available to quantitatively address this route of exposure.
NA: Route of exposure is not applicable to this medium.

The ultimate assessment endpoint, maintenance of the health and diversity of the natural community in the area, is the most important ecological component to be protected with regard to this OU. Therefore, the potential COCs estimated to pose a potential for adverse effects to proximate assessment endpoints are subsequently evaluated with regard to the risk they could pose to the ultimate assessment endpoint.

No final ecological COCs were retained for the surface soil under current conditions. There is no complete exposure pathway for contaminated subsurface soil since it is located at least 2.4 m (8 ft) below ground surface (bgs). Am-241, Cs-137, and Sr-90 are identified as final ecological COCs for the subsurface because if the subsurface soils were to be exposed in the future, they would present an ecological risk. Risk assessment for this unit was conducted with the assumption that contaminated buried soils were exposed at the surface. This was done to ensure that risks were not underreported, and to minimize uncertainty about potential risk if the soils were to be disturbed in the future. However, present site conditions pose no ecological risk. Table 6 presents the ecological exposure pathways of concern. Table 7 presents the COC concentrations that are expected to be protective of ecological receptors.

Summary of Contaminant Fate and Transport Analysis

The full contaminant fate and transport analysis is documented in Section 5.0 of the RFI/RI/BRA (WSRC 1998c). A contaminant fate and transport analysis was performed independently for the RRSB to evaluate the potential for soil constituents to adversely impact human health and the environment. Soil screening and numerical groundwater modeling were used to evaluate potential contaminant movement from source areas to receptor locations.

A background screening was completed to eliminate compounds from further study that had a maximum concentration less than the twice average background concentration or that were not considered toxic. A soil leachability screening analysis was performed, which entailed a comparison of the maximum detected contaminant concentrations with

Table 6. Ecological Exposure Pathway of Concern

Exposure Medium: Soil	**Sensitive Environment Flag:** N
Receptors: Earthworm, Eastern Cottontail, Short-Tailed Shrew, Red-Tailed Hawk, American Robin, Mourning Dove	**Exposure Routes:** ingestion, respiration, and direct contact with constituents
Assessment Endpoint 1: No reduction in numbers of any state or federally designated TES (flora and fauna) and no adverse impacts to their critical habitats.	**Measurement Endpoint 1 for Assessment Endpoint 1:** Biosurveys for TES plants and animals; COPC concentration in physical media and predicted concentration in prey species
Assessment Endpoint 2: Protection of soil invertebrate communities to maintain species diversity and nutrient cycling; to provide a food source for organisms at higher trophic levels, and to ensure that contaminant levels in invertebrate tissues are low enough to minimize the risk of bioaccumulation and/or other negative effects to higher trophic levels.	**Measurement Endpoint 2 for Assessment Endpoint 2:** Lowest chronic, dietary, non-lethal effect level of COPCs on earthworms
Assessment Endpoint 3: Protection of herbivorous mammal and avian communities to ensure that ingestion of contaminants in forage and soils does not have a negative impact on growth, survival, and reproduction; to provide a food source for organisms at higher trophic levels; and to ensure that contaminant levels in tissues are low enough to minimize risk of bioaccumulation and/or other negative effects to higher trophic levels.	**Measurement Endpoint 3 for Assessment Endpoint 3:** Lowest chronic, dietary, non-lethal effect level of COPCs on eastern cottontails and mourning doves
Assessment Endpoint 4: Protection of omnivorous mammal communities to ensure that ingestion of contaminants in prey, forage, and soils does not have a negative impact on growth, survival, and reproduction; to provide a food source for organisms at higher trophic levels; and to ensure that contaminant levels in tissues are low enough to minimize risk of bioaccumulation and/or other negative effects to higher trophic levels.	**Measurement Endpoint 4 for Assessment Endpoint 4:** Lowest chronic, dietary, non-lethal effect level of COPCs on short-tailed shrew
Assessment Endpoint 5: Protection of omnivorous bird communities to ensure that ingestion of prey, forage, and soils does not have a negative impact on growth, survival, and reproduction.	**Measurement Endpoint 5 for Assessment Endpoint 5:** Lowest chronic, dietary, non-lethal effect level of COPCs on American robins
Assessment Endpoint 6: Protection of top-predator (carnivorous bird) communities to ensure that ingestion of contaminants in prey and soils does not have a negative impact on growth, survival, and reproduction.	**Measurement Endpoint 6 for Assessment Endpoint 6:** Lowest chronic, dietary, non-lethal effect level of COPCs on red-tailed hawks

Table 7. COC Concentrations Expected to Provide Adequate Protection of Ecological Receptors

Habitat Type / Name	Exposure Medium	COC	Protective Level	Units	Basis
RRSB OU	Soil	Americium-241	332	pCi/g	Hazard Quotient = 6.9
		Cesium-137	1,830	pCi/g	Hazard Quotient = 5.4
		Strontium-90	2,420	pCi/g	Hazard Quotient = 2.4

calculated soil screening levels (SSLs) and mass-limit SSLs. These SSLs were calculated based upon site-specific hydrogeological parameters, the contaminant MCLs, USEPA Region 3 risk-based concentrations (RBCs) for tap water, and the Residential Water Ingestion Risk-Based Activity (RBA) for radionuclides. Contaminants with the maximum detected concentration less than the SSL or mass-limit SSL were eliminated from further consideration. Additionally, the elimination of some contaminants was justified due to evidence supporting false positive measurements.

Analyses from a vadose zone transport model (WSRC 1997b) identified Am-241, C-14, Pu-239/240, and Sr-90 as CMCOCs since they are estimated to leach from the soil in the future at an activity level that exceeds their RBA. The vertical extent of contamination (as evidenced by Sr-90 in shallow groundwater) is limited to about 30 feet below the basin bottoms and is retarded by minimal infiltration and very low permeability sediments in the first 60 feet below ground. Modeling indicates that Sr-90 will not reach the LAZ at levels above MCLs.

Summary of Principal Threat Source Material Evaluation

The purpose of the PTSM evaluation was to determine whether the RRSB OU contains source materials that could pose a significant threat to human health or the environment due to highly toxic or mobile properties. The evaluation indicated that Cs-137 is present at levels that pose a risk greater than or equal to 1×10^{-3} for a hypothetical, future industrial worker, and is considered PTSM.

PTSM is found in the footprint of the basins and limited vertically from about 1.5 m (5 ft) above the basin bottoms to about 0.6 m (2 ft) below the basin bottoms. The extent of Cs-137 at this subunit is contained within the footprint of the existing asphalt cover. Contamination is typically found at 1.5 m (5 ft) below the existing asphalt cover to about 1.5 m (5 ft) below basin bottom. The volume of PTSM in the seepage basins was estimated to be approximately 12,606 m^3 (16,488 yd^3). Total volume of impacted soil at the seepage basins is approximately 33,426 m^3 (43,720 yd^3). The inactive process sewer lines are assumed to be PTSM based on their history of use.

Sr-90, based on its leachability, is also considered PTSM. Sr-90 has been identified as a CMCOC that reaches groundwater in less than 10 years. Although Sr-90 has been identified as PTSM, the extent and volume of PTSM has been determined using only Cs-137 because the extent of Sr-90 is encompassed by that of Cs-137.

Conclusion

Actual or threatened releases of hazardous substances from this waste unit, if not addressed by the Preferred Alternative or one of the other active measures considered, may present a current or potential threat to public health, welfare, or the environment. Remedial action is warranted at this OU because the cumulative excess carcinogenic risk to an individual exceeds the acceptable risk range for current and future land use.

VIII. REMEDIAL ACTION OBJECTIVES AND REMEDIAL GOALS

The following section lists the remedial action objectives (RAOs) for the four subunits that require remedial action.

Seepage Basins

- minimize transport of soil contaminants to groundwater above MCLs,

- prevent industrial worker exposure to contamination (including contaminated vegetation) in the long-term,
- consider treatment or removal to address PTSM to the extent practicable, and
- prevent residential development within the OU and any exposure to basin contents.

Abandoned Process Sewer Lines

- prevent industrial worker exposure to the pipelines,
- consider treatment alternatives to address PTSM (pipelines) to the extent practicable, and
- prevent residential development within the OU and any exposure to the pipelines.

Sanitary Sewer System

- prevent industrial worker exposure to the sanitary sewer lines and associated subsurface soil contaminants,
- prevent industrial worker exposure to contaminated vegetation,
- prevent future transfer of subsurface soil contaminants towards the surface through biotic uptake or bioturbation,
- consider treatment alternatives to address PTSM (sanitary sewer line) to the extent practicable, and
- prevent residential development within the OU and any exposure to the sewer lines.

Groundwater

- prevent industrial worker exposure to groundwater contaminated above MCLs,
- reduce Sr-90 concentrations in groundwater to below MCLs,
- minimize the spread of groundwater contamination and prevent discharge of contaminated groundwater to surface water, and
- prevent residential development within the OU and any exposure to contaminated groundwater.

Remedial Goal Options

Unit-specific remedial goal options (RGOs) have been developed for RRSB soil and groundwater and are shown in Table 8. RGOs are the concentration goals for individual chemicals for specific medium and land-use considerations. Human health RGOs were not generated for produce due to the major uncertainties associated with the risk estimates for the produce exposures.

For the human health RGOs, the tables indicate that radionuclides need to be considered. Human health RGOs are presented for several different human receptors under both current and future land use and for a range of target cancer risks. RGOs for future residents are included for comparison purposes even though the future land use for the OU will be industrial.

In addition to derived RGOs, MCLs and MCL goals could serve as human health RGOs for groundwater. Ecological RGOs were not calculated since no ecological final COCs were identified for the appropriate receptor and exposure scenarios. All of the appropriate RGOs are presented in this section. Applicable or relevant and appropriate requirements (ARARs) are classified as either applicable, or relevant and appropriate. Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated

Table 8. Human-Health Risk-Based Remedial Goal Options by Receptor, R-Area Reactor Seepage Basins - Soil and Groundwater

	Final Constituents of Concern (1)		Concentration at Target Cancer Risk (pCi/g)			Concentration at Target Hazard Quotient (pCi/g)		
Medium and Receptor	**Primary**	**Secondary**	**1.00E-04**	**1.00E-05**	**1.00E-06**	**3**	**1**	**0.1**
Surface Soil (2)								
Hypothetical Industrial Worker		Cesium-137	1.05E+01	1.05E+00	1.05E-01	--	--	--
Hypothetical Resident-Adult		Cesium-137	4.12E+00	4.12E-01	4.12E-02	--	--	--
Hypothetical Resident-Child		Cesium-137	1.38E+01	1.38E+00	1.38E-01	--	--	--
Subsurface Soil(2)								
Hypothetical Industrial Worker	Americium-241		7.75E+02	7.75E+01	7.75E+00	--	--	--
	Cesium-137		1.05E+01	1.05E+00	1.05E-01	--	--	--
	Cobalt-60		2.25E+00	2.25E-01	2.25E-02	--	--	--
	Plutonium-238		1.04E+03	1.04E+02	1.04E+01	--	--	--
	Plutonium-239/240		9.69E+02	9.69E+01	9.69E+00	--	--	--
	Strontium-90		5.65E+03	5.65E+02	5.65E+01	--	--	--
Hypothetical Resident - Adult	Americium-241		2.98E+02	2.98E+01	2.98E+00	--	--	--
	Cesium-137		4.12E+00	4.12E-01	4.12E-02	--	--	--
	Cobalt-60		8.83E-01	8.83E-02	8.83E-03	--	--	--
	Plutonium-238		3.95E+02	3.95E+01	3.95E+00	--	--	--
	Plutonium-239/240		3.69E+02	3.69E+01	3.69E+00	--	--	--
	Strontium-90		2.11E+03	2.11E+02	2.11E+01	--	--	--
Hypothetical Resident - Child	Americium-241		6.47E+02	6.47E+01	6.47E+00	--	--	--
	Cesium-137		1.38E+01	1.38E+00	1.38E-01	--	--	--
	Cobalt-60		2.97E+00	2.97E-01	2.97E-02	--	--	--
	Plutonium-238		8.01E+02	8.01E+01	8.01E+00	--	--	--
	Plutonium-239/240		7.48E+02	7.48E+01	7.48E+00	--	--	--
	Strontium-90		4.25E+03	4.25E+02	4.25E+01	--	--	--
Water Table Aquifer(3)			**Concentration at Target Cancer Risk (pCi/L)**					
Hypothetical Industrial Worker	Americium-241		4.88E+01	4.88E+00	4.88E-01	--	--	--
	Strontium-90(4)		2.86E+02	2.86E+01	2.86E+00	--	--	--
Hypothetical Resident - Adult	Americium-241		1.81E+01	1.81E+00	1.81E-01	--	--	--
	Strontium-90(4)		1.06E+02	1.06E+01	1.06E+00	--	--	--
Hypothetical Resident - Child	Strontium-90(4)		8.52E+02	8.52E+01	8.52E+00	--	--	--

Note:

1. Remedial goal options are calculated for the final constituents of concern (COCs).
2. Calculations for hypothetical future receptors include exposure to soil via ingestion, dermal contact, and inhalation of particulates. Ingestion of produce is not included for the resident due to uncertainty associated with derivation of hazards/risks.
3. Calculations for hypothetical future receptors include exposure to groundwater via ingestion, dermal contact, and inhalation.
4. Strontium-90 has an MCL of 8 pCi/L.

under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law. In addition to ARARs, many federal and state environmental and public health programs develop criteria, guidance, and proposed standards that are not legally binding but provide useful information or recommendation procedures. To be considered (TBC) requirements are nonpromulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of ARARs. However, TBC requirements can be considered along with ARARs in determining the level of cleanup for protection of human health or the environment. The action-specific, location-specific, and chemical-specific ARARs and TBCs for this OU are shown in Tables 9, 10 and 11.

Table 9. Action-Specific ARARs and TBCs for the RRSB

ARAR Applies to Alternative*	Action	Citation	Title	Synopsis	ARAR or TBC Guidance	Comments
Alternative 4	Offsite treatment/ storage/disposal	40 CFR 264 SC R61-79	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (TSDs)	General performance standards for TSDs	Applicable	Applies to management of soil that is classified as hazardous waste.
Alternative 1 Alternative 2 Alternative 3 Alternative 4	Soil handling/ construction	40 CFR 61	National Emissions Standards for Hazardous Air Pollutants	Identifies annual effective radiation dose limits for the public from US DOE activities at a particular site (e.g., SRS)	Applicable	For members of the public in the vicinity of a USDOE site, the maximum permissible whole body effective dose from all USDOE activities is 25 mrem/yr, with a 75 mrem/yr effective dose limit for any critical organ.
Alternative 4	Disposal of nonhazardous wastes	40 CFR Part 257-258 SC R61-107	South Carolina Solid Waste Management Standards	Governs the management of non-hazardous solid waste (sanitary and construction/demolition)	Applicable	Applies to offunit disposal of nonhazardous solid waste
Alternative 2 Alternative 3 Alternative 4	Well construction or remediation	SC R61-58.2	Construction and Operation Permits - Groundwater Sources and Treatment	Prescribes minimum standards for the construction of treatment facilities	Applicable to installing monitoring wells	Groundwater wells must be installed/abandoned and drilling wastes disposed of in a manner to prevent cross-contamination of aquifers.
Alternative 2 Alternative 3 Alternative 4	Remedial excavation/ construction of treatment system	SC R61-62.6	Control of Fugitive Particulate Matter	Identifies statewide controls on fugitive particulate matter	Applicable	Applies to emissions of particulates (dust) generated during excavation or other remedial construction activities
Alternative 2 Alternative 3 Alternative 4	Worker Protection	29 CFR 1910	Occupational Worker Safety Administration (OSHA)	Identifies health and safety requirements for remediation workers.	Applicable	Worker activities involving hazardous materials must be conducted according to a project health and safety plan.
Alternative 1 Alternative 2 Alternative 3 Alternative 4	Erosion Control	SC R72 and SC R61.9.122.26		Erosion and runoff control measures	Relevant and appropriate	ARAR

* Alternative 1 - No Action
Alternative 2 - Reinforced-concrete intruder barrier system with granitic monuments extended over PTSM and pipelines inside the boundary fence, excavate all contaminated process and sewer lines and associated soils above PTSM levels outside of the boundary fence, dispose of pipelines and associated soils on site under the intruder barrier system, removal and on-unit disposal of contaminated vegetation, installation of an asphalt bioturbation barrier, a mixing zone to address groundwater, with land use controls.
Alternative 3 - In situ stabilization of the PTSM and a low-permeability cover system, excavate all contaminated process and sewer lines and associated soils above PTSM levels, dispose on site under the low-permeability cover system, and mixing zone to address groundwater, with land use controls.
Alternative 4 - Excavate all PTSM and contaminated pipelines, dispose of offsite, and a mixing zone for groundwater with land use controls.

Table 10. Location-Specific ARARs and TBCs for the RRSB

ARAR Applies to Alternative*	Site-Feature/Location	Citation	Requirement Synopsis	Consideration in this ROD
State				
Alternative 2 Alternative 3 Alternative 4	Classification and potential use of an aquifer	SC Water Classification Standards (R61-68)	State aquifer classification must be considered in the assessment of remedial action objectives.	ARAR
Alternative 1 Alternative 2 Alternative 3 Alternative 4	Mixing Zone	SC Water Classification Standards (R61-68)	Establishes criteria for a mixing zone application.	TBC
Alternative 1 Alternative 2 Alternative 3 Alternative 4	Erosion control	SC R72 and SC R61.9.122.26	Measures must be taken to control erosion and runoff.	ARAR

Table 11. Chemical-Specific ARARs and TBCs for the RRSB

ARAR Applies to Alternative*	Citation	Title	Synopsis	ARAR or TBC Guidance	Comments
Alternative 1 Alternative 2 Alternative 3 Alternative 4	10 CFR 835	Occupational Radiation Protection	Establishes radiation standards and limits for worker protection from ionizing radiation	ARAR	Applies to workers and members of the public during direct on-site access
Alternative 2 Alternative 3 Alternative 4	40 CFR 141 SC R.61-58.5	Safe Drinking Water Act	Establishes MCLs and MCLGs for groundwater that may be a source of drinking water	ARAR	Cleanup goals for groundwater under the CERCLA program
Alternative 1 Alternative 2 Alternative 3 Alternative 4	DOE Order 5480.11	Radiation Protection for Occupational Workers	Establishes annual maximum radiation exposure limit of 5.0 rem for workers	TBC	SRS Administrative Control Level for 2003 has been set at 1.0 rem/yr for all individual workers at SRS to optimize ALARA in accordance with DOE Order 5480.11.
Alternative 1 Alternative 2 Alternative 3 Alternative 4	OSWER No. 9200.4-18	Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination	Establishes 15 mrem/yr effective dose equivalent for humans	ARAR	Dose limit equates to a risk of 3 x 10-4 increased lifetime risk and is consistent with levels generally considered protective in other governmental actions.

IX. DESCRIPTION OF ALTERNATIVES

The Corrective Measures Study/Feasibility Study (CMS/FS) evaluated numerous remedial actions that would meet the RAOs for the RRSB. Four remedial actions were considered for the RRSB soils and pipelines. These were 1) No Action, 2) Intruder Barrier over the PTSM (includes relocation of some contaminated pipelines), 3) In Situ

Stabilization of the PTSM (includes relocation of some contaminated pipelines), and 4) Excavation and Offsite Disposal of PTSM. The CMS/FS evaluated numerous combinations of Intruder Barriers including reinforced-concrete on the surface, reinforced-concrete beneath a soil cover, modified asphalt on the surface, modified asphalt under a soil cover, wire mesh, and a geotextile layer (colored to serve as a warning). Various methods for reducing infiltration were also considered to show the relative impact on transport of contaminant migration COCs (CMCOCs) to groundwater.

The Core Team reviewed these options and selected what they thought was the best intruder barrier alternative: concrete barrier at the surface. This ROD compares this intruder barrier alternative with the No Action, In Situ Stabilization, and Excavation alternatives. All of the alternatives include a Mixing Zone for groundwater and include LUCs because hazardous material will be left in place. A mixing zone is defined as an allocated impact zone or limited area where initial discharge occurs. Numeric water quality data apply at the boundaries of the mixing zone and not within the mixing zone itself. The legal authority is established in South Carolina Water Classifications and Standards, Regulation 61-68, with respect to groundwater mixing zones.

The four alternatives considered for the RRSB are described in the following sections. The costs listed are present value costs determined by using a discount rate of 3.9% over a 200-year time period. There is no limit to the number of five-year remedy reviews required; however, for comparison purposes, a duration of 200 years was used because the present value cost does not change significantly for longer times. A summary of the present value for each alternative is shown in Table 12. All of the alternatives assume future industrial land use.

Table 12. Summary of the Present Value Costs of the Alternatives

Alternative	Present Value
Alternative 1 - No Action	$88,362
Alternative 2 – Reinforced-concrete intruder barrier system with granitic monuments extended over PTSM and pipelines inside the boundary fence, excavate all contaminated process and sewer lines and associated soils above PTSM levels outside of the boundary fence, dispose of pipelines and associated soils on site under the intruder barrier system, a mixing zone to address groundwater, with land use controls.	$19,144,554
Alternative 3 - In situ stabilization of the PTSM and a low-permeability cover system, excavate all contaminated process and sewer lines and associated soils above PTSM levels, dispose on site under the low-permeability cover system, and mixing zone to address groundwater, with land use controls.	$47,717,000
Alternative 4 - Excavate all PTSM and contaminated pipelines, dispose of offsite, and a mixing zone for groundwater with land use controls.	$81,952,000

Alternative 1, No Action

Remedy, time for construction and to achieve remedial goals

This alternative leaves the RRSB in its current state with no additional remedial action performed.

Evaluation of the No Action alternative is required by the National Oil and Hazardous Substances Contingency Plan (NCP) to serve as a baseline for comparison with other remediation alternatives.

- Time for Construction: N/A
- Time to achieve remedial goals: Remedial goals are not achieved.

Cost (Capital and O&M)

- Capital Cost: $0

- O&M Cost: $88,000 (including 5-year remedy review costs)

- Total present worth cost: $88,000 (Present worth cost based on a 3.9% discount rate over 200 years.)

ARARs

- No ARARs are associated with this remedy.

Whether waste will be removed and disposed of offsite

- No waste removal or disposal.

Expected land use/groundwater use upon achieving remedial goals

- Remedial goals will not be met. Groundwater is not used for any purpose.

Alternative 2, Reinforced concrete intruder barrier system with granitic monuments extended over PTSM and contaminated pipelines inside the boundary fence, excavate all contaminated process and sewer lines and associated soils above PTSM levels outside of the boundary fence, dispose of pipelines and associated soils on site under the intruder barrier system, a mixing zone to address groundwater, with land use controls.

Remedy, time for construction and to achieve remedial goals

This alternative will entail placing a reinforced-concrete intruder barrier over all PTSM. The extent of PTSM has been determined using only Cs-137 because the extent of Sr-90 is encompassed by that of Cs-137. All contaminated process and sanitary sewer lines and associated soil located outside of the boundary will be excavated and disposed of on-unit and covered with the intruder barrier. Contaminated vegetation will also be disposed of (buried) on-unit. A biobarrier will be placed over areas where contaminated vegetation was discovered to prevent the creation of any new contaminated vegetation. Monuments will be placed around the perimeter of the intruder barrier to warn potential intruders of the presence of hazardous material. A Mixing Zone application will be used for the groundwater at the OU. A mixing zone will be established via submittal of a mixing zone application. A mixing zone ensures public protection is maintained by monitoring the natural attenuation of radionuclides and by ensuring groundwater does not exceed MCLs beyond compliance points. The alternative also includes land use controls (LUCs) through use of a Land Use Control Implementation Plan (LUCIP). LUCs include the Site Use Program, Site Clearance Program, regulatory notification of land use changes, granitic monuments, fences, control entry systems, and warning signs.

- Time for Construction: 18 months

- Time to achieve remedial goals: 12 months to achieve remedial action objectives for soil, 300 to 400 years to achieve groundwater remediation goals

Cost (Capital and O&M)

- Capital Cost: $5,356,000

- O&M Cost: $13,789,000 (including 5-year remedy review costs)

- Total present worth cost: $19,145,000 (Present worth cost based on a 3.9% discount rate over 200 years.)

ARARs

- Erosion controls are required to prevent sediment and contaminant runoff to surface water (SC R72 and SC R61-9.122.26). Fugitive dust generation will be controlled during construction of an asphalt cover at RRSB (SC R61-62.6). The disposal and transportation of small amounts of waste generated during these procedures will be handled in accordance with federal and state regulations (40 Code of Federal Regulations [CFR] 141, 143, and 260-268; and SC R61-79.253). A mixing zone will be established in accordance with the SCDHEC criteria to ensure MCLs are not exceeded (40 CFR 141 and SC R61-58.5).

Whether waste will be removed and disposed of offsite

- No waste removal or disposal.

Expected land use/groundwater use upon achieving remedial goals

- Expected land use will be industrial after remedial goals have been met. Groundwater is not used for any purpose. The land and groundwater will remain under institutional controls until Sr-90 concentrations in the groundwater are below MCLs (approx. 300 – 400 years).

Alternative 3, In situ stabilization of the PTSM and a low-permeability cover system, excavate all contaminated process and sewer lines and associated soils above PTSM levels, dispose on site under the low-permeability cover system, and mixing zone to address groundwater, with land use controls.

Remedy, time for construction and to achieve remedial goals

This alternative will entail in situ stabilization of all of the PTSM soil in the basins. PTSM pipelines and associated soil will be excavated, disposed of on-unit, and grouted in place. Contaminated vegetation will also be disposed of (buried) on-unit. A low-permeability soil cover will be placed over the stabilized grout mass. An asphalt biobarrier will be placed over areas where contaminated vegetation was discovered to prevent the creation of any new contaminated vegetation. A Mixing Zone application will be submitted to establish a mixing zone for the groundwater at the OU. A mixing zone ensures public protection is maintained by monitoring the natural attenuation of radionuclides to ensure groundwater does not exceed MCLs beyond compliance points. The alternative also includes establishment of LUCs through use of a LUCIP. LUCs include the Site Use Program, Site Clearance Program, regulatory notification of land use changes, granitic monuments, fences, control entry systems, and warning signs.

- Time for Construction: 18 months

- Time to achieve remedial goals: 3 to 5 years to achieve RAOs for soil, 300 to 400 years to achieve groundwater remediation goals

Cost (Capital and O&M)

- Capital Cost: $34,852,000

- O&M Cost: $12,865,000 (including 5-year remedy review costs)

- Total present worth cost: $47,717,000 (Present worth cost based on a 3.9% discount rate over 200 years.)

ARARs

- Erosion controls are required to prevent sediment and contaminant runoff to surface water (SC R72 and SC R61-9.122.26). Fugitive dust generation will be controlled during construction of an asphalt cover at RRSB (SC R61-62.6). The disposal and transportation of small amounts of waste generated during these procedures will be handled in accordance with federal and state regulations (40 Code of Federal Regulations [CFR] 141, 143, and 260-268; and SC R61-79.253). A mixing zone will be established in accordance with the SCDHEC criteria to ensure MCLs are not exceeded (40 CFR 141 and SC R61-58.5).

Whether waste will be removed and disposed of offsite

- No waste removal or disposal.

<u>Expected land use/groundwater use upon achieving remedial goals</u>

- Expected land use will be industrial after remedial goals have been met. Groundwater is not used for any purpose. The land and groundwater will remain under institutional controls until Sr-90 concentrations in the groundwater are below MCLs (approx. 300 – 400 years).

Alternative 4, Excavate all PTSM and contaminated pipelines, dispose offsite, and a mixing zone for groundwater with land use controls.

<u>Remedy, time for construction and to achieve remedial goals</u>

This alternative entails excavating all PTSM and disposing of it off site. A major concern is that the excavated material may not meet the acceptance criteria of a licensed disposal facility, rendering off-site disposal impossible. Contaminated vegetation will be disposed of (buried) on-unit. A biobarrier will be placed over areas where contaminated vegetation was discovered to prevent the creation of any new contaminated vegetation. A Mixing Zone application will be submitted to establish a mixing zone for the groundwater at the OU. A mixing zone ensures public protection is maintained by monitoring the natural attenuation of radionuclides to ensure that groundwater does not exceed MCLs beyond compliance points. The alternative also includes LUCs through use of a LUCIP. LUCs include the Site Use Program, Site Clearance Program, regulatory notification of land use changes, granitic monuments, fences, control entry systems, and warning signs.

- Time for Construction: 3 to 5 years

- Time to achieve remedial goals: 3 to 5 years to achieve RAOs for soil, 300 to 400 years to achieve groundwater remediation goals

Cost (Capital and O&M)

- Capital Cost: $69,822,000

- O&M Cost: $12,130,000 (including 5-year remedy review costs)

- Total present worth cost: $81,952,000 (Present worth cost based on a 3.9% discount rate over 200 years.)

ARARs

- Erosion controls are required to prevent sediment and contaminant runoff to surface water (SC R72 and SC R61-9.122.26). Fugitive dust generation is controlled during construction of an asphalt cover at RRSB (SC R61-62.6). The disposal and transportation of small amounts of waste generated during these procedures is handled in accordance with federal and state regulations (40 Code of Federal Regulations [CFR] 141, 143, and 260-268; and SC R61-79.253). A mixing zone is established in accordance with the SCDHEC criteria to ensure MCLs are not exceeded (40 CFR 141 and SC R61-58.5).

Whether waste will be removed and disposed of offsite

- PTSM-level soils, excavated process and sanitary sewer lines, and secondary waste will be removed and disposed of offsite.

Expected land use/groundwater use upon achieving remedial goals

- Expected land use will be industrial after achieving remedial goals. Groundwater is not used for any purpose. The land and groundwater will remain under institutional controls until Sr-90 concentrations in the groundwater are below MCLs (approx. 300 – 400 years).

X. COMPARATIVE ANALYSIS OF ALTERNATIVES

All of the four alternatives have been evaluated against the nine CERCLA evaluation criteria that provide the basis for evaluating the alternatives and selecting a remedy. The nine criteria are categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria.

The nine criteria are listed below:

- Threshold criteria
    - Overall protection of human health and the environment
    - Compliance with ARARs
- Balancing criteria
    - Long-term effectiveness and permanence
    - Reduction of toxicity, mobility, or volume through treatment
    - Short-term effectiveness
    - Implementability
    - Cost
- Modifying criteria
    - State acceptance
    - Community acceptance

The threshold criteria must be satisfied in order for an alternative to be eligible for selection. The primary balancing criteria are used to weigh major tradeoffs among the alternatives. Generally, the modifying criteria are taken into account after public comment is received on the PP. (See Table 13 for more detailed description of evaluation criteria.)

Threshold Criteria

Overall Protection of Human Health and the Environment

The preferred remedial alternative should be protective of future industrial workers. Alternative 1 (No Action) provides limited protection because some vegetation on the outer edges of the current asphalt cover has been contaminated. This vegetation and associated soil could easily be contacted by intruders, animals, or plants growing in this area. Alternatives 2, 3, and 4 each provide protection of human health and the environment. Alternatives 2 (intruder barrier) and 3 (in situ stabilization) both make it more difficult for an intruder to contact the PTSM. Alternative 2 provides a concrete barrier that would have to be breached in order to contact the PTSM. Alternative 3 solidifies the PTSM within a grout matrix. Alternative 4 (excavation) provides the greatest level of protection because the contaminated soil, pipelines, and vegetation are removed from the OU. Alternative 1 does not provide any modeling to confirm compliance of the groundwater. Groundwater is protected equally well by alternatives 2, 3, and 4 because modeling has indicated that the Sr-90 will not migrate to the LAZ at levels above the MCLs. The Mixing Zone application requires groundwater monitoring to ensure that the groundwater is not contaminated above MCLs beyond compliance points. For groundwater, remediation levels should generally be attained everywhere within the plume, or at and beyond the waste management area when waste is left in place. Due to the well understood nature of radioactive decay and the estimated 300 to 400 years for decay to achieve the MCLs, the interior of the plume can be monitored less frequently than the leading edges.

Table 13. Evaluation Criteria for Superfund Remedial Alternatives

THRESHOLD CRITERIA
Overall Protection of Human Health and the Environment determines whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment.
Compliance with ARARs evaluates whether the alternative meets federal and state environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified.
BALANCING CRITERIA
Long-Term Effectiveness and Permanence considers the ability of an alternative to maintain protection of human health and the environment over time.
Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.
Short-Term Effectiveness considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation.
Implementability considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.
Cost includes estimated capital and annual operations and maintenance costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to –30 percent.
MODIFYING CRITERIA
State/Support Agency Acceptance considers whether the State agrees with the analyses and recommendations, as described in the RI/FS and Proposed Plan.
Community Acceptance considers whether the local community agrees with the analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance.

Compliance with ARARs

There are no chemical-specific ARARs limiting the levels of radionuclides in the soil and pipelines. However, risk-based remedial goals are set to limit exposure to within specified limits. Generally, levels yielding a risk lower than 1×10^{-6} additional cancer cases require no further action. Risk levels above 1×10^{-4} usually require remedial action to achieve risk reduction to levels between 1 x 10^{-4} and 1 x 10^{-6} with the latter being used as the point of departure in determining remediation goals in accordance with the NCP.

Alternatives 2, 3, and 4 all meet the risk-based goals of reducing risk to future industrial workers to 1 x 10^{-6}. Alternative 1 provides limited risk reduction as the current asphalt cover reduces industrial worker contact with the contaminated soil; however, this alternative does not meet the risk-based goals for PTSM.

For groundwater, alternatives 2, 3, and 4 all meet ARARs equally well because of the Mixing Zone application and the groundwater monitoring associated with it. Alternative 1 does provide limited protection against migration to groundwater with the current asphalt cover; however, it does not meet the groundwater ARAR because groundwater monitoring is not included to ensure compliance.

Primary Balancing Criteria

Long-Term Effectiveness and Permanence

Alternative 1 does not provide any long-term effectiveness and permanence. Alternatives 2 and 3 provide approximately equal long-term protection based on the life of the cement intruder barrier and the grout used for the in situ stabilization. Alternative 4 (excavation) provides the greatest long-term effectiveness and permanence because the PTSM is permanently removed from the OU. Alternatives 1, 2, and 3 require LUCs to maintain protection because waste will be left in place.

The Mixing Zone will provide long-term effectiveness and permanence via providing long term monitoring to ensure that the groundwater does not exceed the MCLs beyond the compliance points.

Reduction of Toxicity, Mobility, or Volume through Treatment

No feasible treatment methods are available to reduce the toxicity of the radionuclides beyond natural decay. Alternative 1 does not provide any reduction of toxicity, mobility, or volume of contaminants through treatment. Alternative 2 places an intruder barrier over the PTSM as an added measure to reduce the availability of the PTSM to potential receptors. Alternative 2 includes monitored natural attenuation in the form of natural radiological decay, thus reducing the toxicity and volume of contaminants. Alternative 3 (in situ stabilization) is considered a treatment that reduces the availability (mobility) of the PTSM to potential receptors. Alternative 4 does not treat the PTSM but only removes it from the OU.

The Mixing Zone application does not directly reduce toxicity, mobility, or volume of contaminants through treatment; however, it does ensure that protection is maintained until natural radioactive decay reduces the toxicity and volume of radioactive contaminants to groundwater cleanup levels established in this ROD.

Short-Term Effectiveness

Alternative 1, No Action, provides the greatest level of protection to remedial workers because no remedial activities are required. At the same time, this alternative provides the greatest risk to current workers who may perform maintenance activities on the OU (mowing, sign maintenance, groundwater sampling, etc.). Alternative 2, intruder barrier, provides the next highest level of short-term effectiveness because the remedial activity poses a risk to the remedial workers only during the pipeline excavation, vegetation extraction, and on-unit disposal. Alternative 3 has the greatest levels of potential exposure to the remedial workers because in situ stabilization requires workers to spend relatively long periods in close proximity to the contaminated media. Estimates showed that the workers could receive their maximum allowable annual dose within as little as three weeks. This would require the use and exposure of numerous crews through the expected 18 months of operation that may be required to stabilize the OU. Alternative 4 has a reduced level of short-term effectiveness because remedial workers would be exposed to PTSM directly during excavation. In addition, transportation of the contaminated media also exposes the public to potential contamination.

For groundwater, Alternative 1 is the most effective in the short-term because it does not require groundwater sampling, which presents a contamination risk to remedial workers (samplers). Alternatives 2, 3, and 4 provide equal lower levels of short-term effectiveness; however, the slight risk posed to the groundwater samplers will be sufficiently reduced to acceptable levels through the use of site procedures and personal protective equipment (PPE).

Implementability

Alternative 1 is the easiest alternative to implement because it does not require any significant activity.

Alternative 2 should be relatively easy to implement. Excavation of pipelines and the vegetation are activities that have been performed before at SRS. While there are strict procedures to follow to prevent potential worker contamination, there should be no problem in implementing these tasks. . Installation of the intruder barrier is a task similar to the concrete work commonly done in the construction industry.

Alternative 3 may be difficult to implement due to the nature of the soil at the OU. The very hard clay found at the OU makes it difficult to operate in situ stabilization augers. The sticky clay also prevents thorough mixing, which is required to perform the operation successfully.

Implementation of alternative 4 may be the most problematic because of the limited number of available licensed facilities and the stringent acceptance criteria associated with those facilities. If the soil was found to be contaminated with something like a pesticide, the waste would be declared mixed waste and disposal at these facilities would be prohibited. This alternative also requires transporting waste across the country using approved containers and meeting all United States Department of Transportation requirements for radioactive material shipments.

Cost

Alternative 1 has the lowest present value cost of $88,362 (Table 14). Alternative 2 has a present value cost of $19,144,554. The capital cost and O&M cost for Alternative 2 are $5,356,000 and $13,789,000, respectively. Alternative 3 has a present value cost of $47,717,000. The capital cost and O&M cost for Alternative 3 are $34,852,000 and $12,864,000, respectively. Alternative 4 has the highest present value cost of $81,952,000. The capital cost and O&M cost for Alternative 4 are $69,822,000 and $12,130,000, respectively. Detailed cost estimates of these alternatives can be found in Appendix B of the CMS/FS (WSRC 1998b).

Table 14. Summary of the Present Value Costs of the Alternatives

Alternative	Present Value
Alternative 1 - No Action	$88,362
Alternative 2 - Reinforced-concrete intruder barrier system with granitic monuments extended over PTSM and pipelines inside the boundary fence, excavate all contaminated process and sewer lines and associated soils above PTSM levels outside of the boundary fence, dispose of pipelines and associated soils on site under the intruder barrier system, a mixing zone to address groundwater, with land use controls.	$19,144,554
Alternative 3 - In situ stabilization of the PTSM and a low-permeability cover system, excavate all contaminated process and sewer lines and associated soils above PTSM levels, dispose on site under the low-permeability cover system, and mixing zone to address groundwater, with land use controls.	$47,717,000
Alternative 4 - Excavate all PTSM and contaminated pipelines, dispose offsite, and a mixing zone for groundwater with land use controls.	$81,952,000

***Present worth cost based on a 3.9% discount rate over 200-years**

Modifying Criteria

State Acceptance

The approval of the proposed action by SCDHEC constitutes acceptance of the selected alternative.

Community Acceptance

The PP (WSRC 2003) public comment period began on June 9, 2003, and ended on July 8, 2003. The Citizens Advisory Board agrees with and supports the remedial action (specifically the mixing zone) at the RRSB OU (Appendix A).

A comparative analysis summary of the alternatives is shown in Table 15.

Table 15. Comparison of Alternatives against the Nine CERCLA Criteria

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost
Alternative 1 – No Action	Not protective.	Does not meet risk-based goals for soil. Groundwater not monitored to ensure MCLs are met	No long-term effectiveness or permanence	No reduction of toxicity, mobility, or volume through treatment	No risk to remedial workers	Easily implemented	$88,362
Alternative 2 – Reinforced-concrete intruder barrier system with granitic monuments extended over PTSM and pipelines inside the boundary fence, excavate all contaminated process and sewer lines and associated soils above PTSM levels outside of the boundary fence, dispose of pipelines and associated soils on site under the intruder barrier system, a mixing zone to address groundwater, with land use controls	Protective	Meets risk-based goals for soil. Mixing zone application ensures that the groundwater does not exceed the MCLs beyond the compliance points	Effective with land use controls. Natural radioactive decay permanently reduces risk	No actual treatment provided. Intruder barrier effectively makes the PTSM less accessible to an intruder, thus reducing toxicity and mobility	Low/moderate level of risk to remedial workers during pipeline removal, vegetation removal, and on-unit disposal. Installation of intruder barrier poses very low risk	Easily implemented; installing the intruder barrier is standard construction activity; excavation of pipelines requires following strict procedures, but relatively common activities.	$19,144,554
Alternative 3 - In situ stabilization of the PTSM and a low-permeability cover system, excavate all contaminated process and sewer lines and associated soils above PTSM levels, dispose on site under the low-permeability cover system, and mixing zone to address groundwater, with land use controls.	Protective	Meets risk-based goals for soil; mixing zone application ensures that the groundwater does not exceed the MCLs beyond the compliance points	Effective with land use controls; natural radioactive decay permanently reduces risk	In situ stabilization places the PTSM in a form that is less accessible to an intruder thus reducing toxicity and mobility	Highest level of risk to remedial workers because treatment requires work in close proximity to PTSM for extended periods	May incur severe implementability problems due to the nature of the soil; difficult to auger through and thoroughly mix with grout	$47,717,000
Alternative 4 - Excavate all PTSM and contaminated pipelines, dispose offsite, and a mixing zone for groundwater with land use controls.	Protective	Meets risk-based goals for soil; mixing zone application ensures that the groundwater does not exceed the MCLs beyond the compliance points	Effective and permanent because PTSM is removed; requires land use controls; natural radioactive decay permanently reduces risk	No treatment provided, but PTSM is removed from the OU	High level of risk to remedial workers because treatment requires work in close proximity to PTSM; also potential exposure of public during transportation.	Very limited number of licensed facilities for disposal; if any other contaminants such as pesticides are found could fail acceptance criteria	$81,952,000

XI. THE SELECTED REMEDY

The selected remedy for the RRSB is Alternative 2 - Reinforced concrete intruder barrier system with granitic monuments extended over PTSM and contaminated pipelines inside the boundary fence, excavate all contaminated process and sewer lines and associated soils above PTSM levels outside of the boundary fence, dispose of pipelines and associated soils on site under the intruder barrier system, a mixing zone to address groundwater, with land use controls.

This alternative will entail placing a reinforced-concrete intruder barrier over all PTSM. The barrier will be placed above the existing asphalt cover. The extent of PTSM has been determined using only Cs-137 because the extent of Sr-90 is encompassed by that of Cs-137. All contaminated process and sanitary sewer lines and associated soil located outside of the OU boundary will be excavated and disposed of on-unit and covered with the intruder barrier. Contaminated vegetation will also be disposed of (buried) on-unit under an asphalt biobarrier. An asphalt biobarrier will be placed over areas where contaminated vegetation was discovered to prevent the creation of any new contaminated vegetation. Monuments will be placed around the perimeter of the intruder barrier to warn potential intruders of the presence of hazardous material. A Mixing Zone application will be used for the groundwater at the OU. Monitored natural attenuation by radioactive decay is the selected remedy for groundwater. Under South Carolina Water Classifications and Standards, Regulation 61-68, a mixing zone will establish an area that encompasses the contaminated groundwater. This mixing zone shall be monitored to ensure that the contamination does not migrate beyond its established boundaries, and to follow the progress of radioactive decay in bringing contamination to MCLs. This process is calculated to take approximately 300 to 400 years.

Figure 9 is a conceptual model of the alternative while Figure 10 shows the approximate areas where the asphalt biobarrier will be added.

Institutional controls will be implemented by:

- Access controls and groundwater land use controls to prevent exposure to on-site workers via the Site Use Program, Site Clearance Program, work control, worker training, worker briefing of health and safety requirements and identification signs located at the waste unit boundaries.

- Access controls to prevent exposure to trespassers, including security procedures and equipment, 24-hour surveillance system, artificial or natural barriers, control entry systems, and warning signs in place at the SRS boundary.

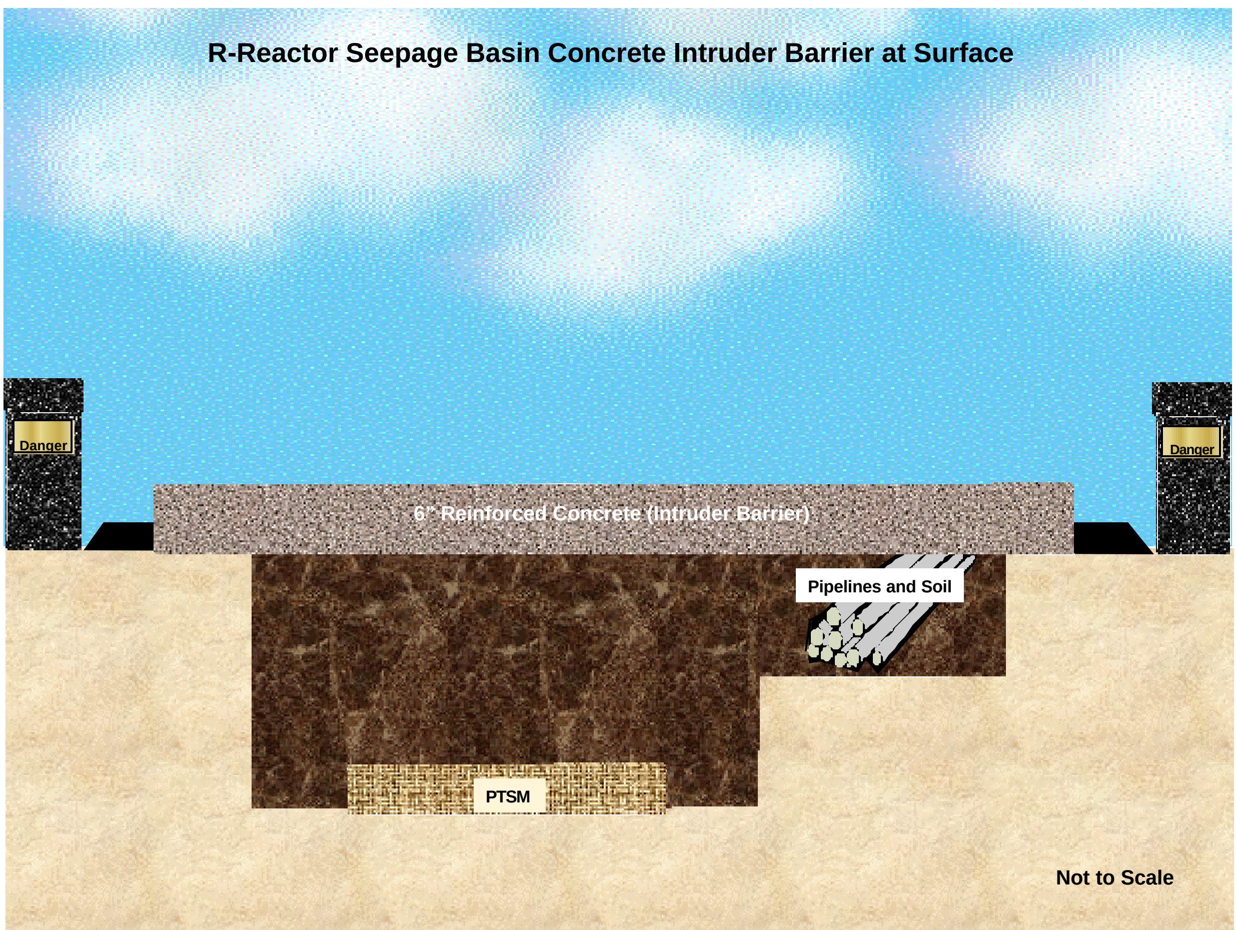

Figure 9. Conceptual Layout of the Selected Remedy

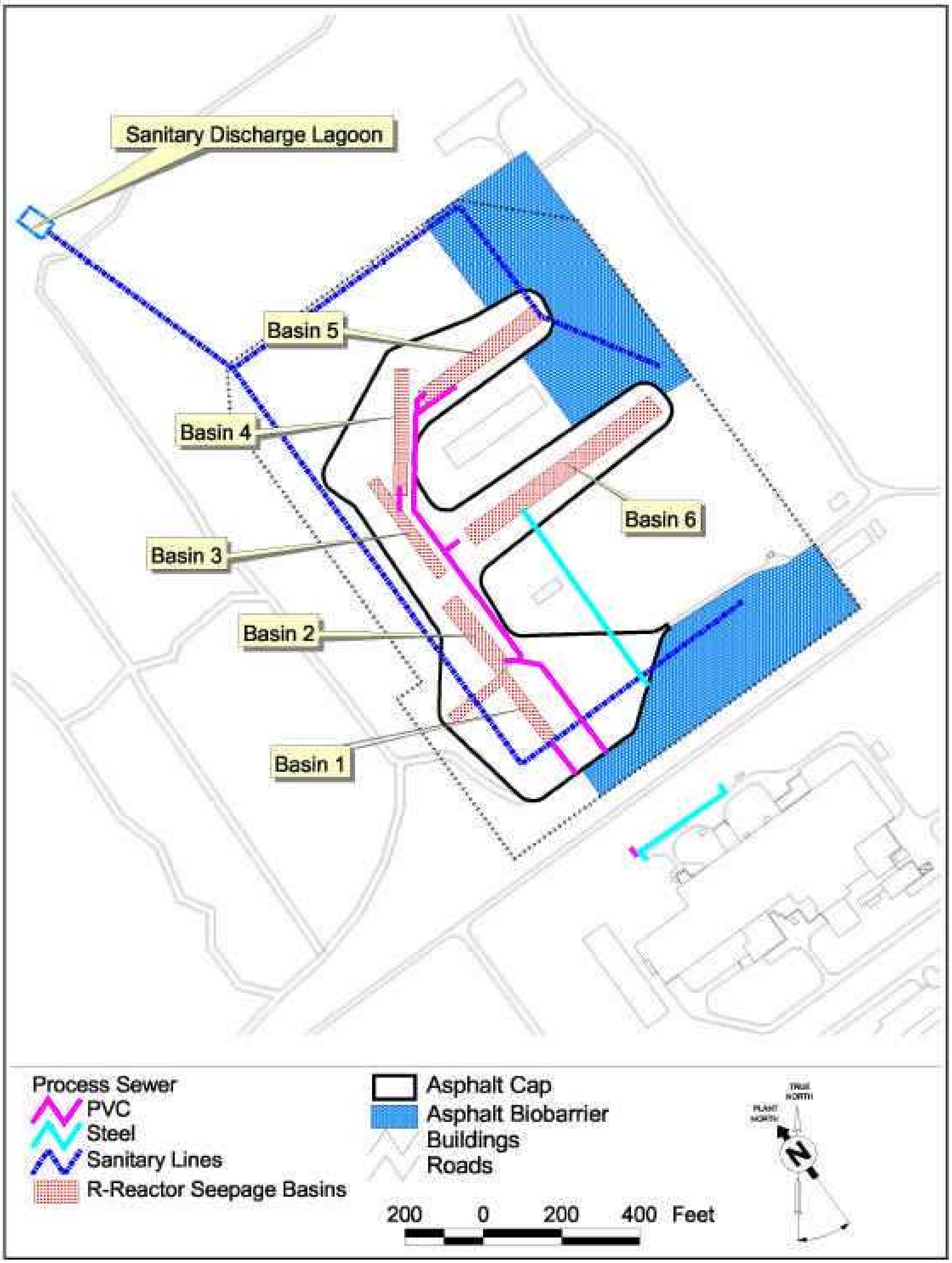

Figure 10. General Layout of the RRSB OU with the Expanded Biobarrier

USDOE has recommended that residential use of SRS land be controlled; therefore, future residential use and potential residential water usage will be restricted to ensure long-term protectiveness. LUCs, including institutional controls, will restrict the RRSB OU to future industrial use and will prohibit residential use of the area. Unauthorized excavation will also be prohibited and the waste unit will remain undisturbed. LUCs selected as part of this action will be maintained for as long as they are necessary, and any termination of any LUC will be subject to CERCLA requirements for documenting changes in remedial actions.

The LUC objectives necessary to ensure the protectiveness of the selected remedy are

- prevent contact, removal, or excavation of contaminated soil and pipelines
- preclude residential use of the area; and
- prevent unauthorized access to contaminated groundwater in the area.

In the long term, if the property is ever transferred to nonfederal ownership, the U.S. Government will take those actions necessary pursuant to Section 120(h) of CERCLA. These actions will include a deed notification disclosing former waste management and disposal activities as well as remedial actions taken on the site. The contract for sale and the deed will contain the notification required by CERCLA Section 120(h). The deed notification shall, in perpetuity, notify any potential purchaser that the property has been used for the management and disposal of waste.

The deed shall also include groundwater land use controls and deed restrictions precluding residential use of the property. However, the need for these deed restrictions may be reevaluated at the time of transfer in the event that exposure assumptions differ and/or the residual contamination no longer poses an unacceptable risk under residential use. Any reevaluation of the need for the deed restrictions will be done through an amended ROD with USEPA and SCDHEC review and approval.

In addition, if the site is ever transferred to nonfederal ownership, a survey plat of the OU will be prepared, certified by a professional land surveyor, and recorded with the appropriate county recording agency. The plat shall indicate location of the boundaries of contamination, including the known extent of the groundwater plume.

The selected remedy for the RRSB leaves hazardous substances in place that pose a potential future risk and will require land use restrictions for an indefinite period of time. As agreed on March 30, 2000, among the USDOE, USEPA, and SCDHEC, SRS is implementing a Land Use Control and Assurance Plan (LUCAP) to ensure that the Land Use Controls (LUCs) required by numerous remedial decisions at SRS are properly maintained and periodically verified. The unit-specific LUCIP referenced in this ROD will provide details and specific measures required to implement and maintain the LUCs selected as part of this remedy. USDOE is responsible for implementing, maintaining, monitoring, reporting upon, and enforcing the LUCs selected under this ROD. Quarterly monitoring will be performed initially; however, the monitoring frequency may change in the future pending periodic evaluation by the Three Parties. The LUCIP, developed as part of this action, will be submitted concurrently with the Remedial Action Implementation Plan (RAIP), as required in the FFA for review and approval by USEPA and SCDHEC. This LUCIP will be a stand-alone document. After review and approval of the LUCIP, concurrently with the RAIP, the LUCIP will be referenced in all subsequent post-ROD documents (i.e., PCR and FRR). After completion of construction, the survey plat will be developed with the as-built data for the OU and submitted concurrently with the PCR for review and approval by USEPA and SCDHEC. Upon approval of the survey plat, it will be inserted in the already approved LUCIP. No further review or approval of the LUCIP will be required. The approved LUCIP including the survey plat will be appended to the LUCAP and is considered incorporated by reference into the ROD, establishing LUC implementation and maintenance requirements enforceable under CERCLA. The approved LUCIP will establish implementation, monitoring, maintenance, reporting, and enforcement requirements for the unit. The LUCIP will remain in effect unless and until modifications are approved as needed to be protective of human health and the environment. LUCIP modification will only occur through another CERCLA document.

Cost Estimate for the Selected Remedy

Estimated costs associated with the selected remedy based on 3.9% discount rate over a 200-year period are summarized below:

- Total Capital Costs: $5,356,000
- Total O&M Costs: $13,789,000
- Total Present Worth Cost: $19,145,000

For a detailed cost estimate, refer to Appendix B, Table B-1. The information in the cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Difference, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to –30 percent of the actual project cost.

Estimated Outcomes of the Selected Remedy

When implemented, the selected remedy will result in the following major outcomes:

- All PTSM (contaminated process and sanitary sewer lines and associated soils) will be removed from outside the boundary fence and placed on-unit.
- A reinforced-concrete intruder barrier will be placed over all PTSM to prevent inadvertent human exposure to PTSM.

- Contaminated vegetation will be disposed (buried) of on-unit and covered with an asphalt biobarrier. An asphalt biobarrier will be placed over areas where vegetation has been removed and will prevent growth of new contaminated vegetation.

- A mixing zone will ensure that groundwater does not exceed MCLs beyond compliance points.

- Institutional controls will prevent human exposure to contaminated media.

- The site is expected to be available for industrial land use eighteen months after construction start as a result of the remedy.

Waste Disposal and Transport

- All unused environmental samples may be returned to the waste site, within the Area of Contamination. This only includes samples that have had no preservatives added.

- Waste generated as a result of removal of the process and sanitary sewer lines and associated soil will be managed as low-level radioactive waste under CERCLA.

- Since primary waste will be disposed of as non-listed CERCLA low-level waste, all secondary waste generated (metal/wooden shack, PPE, etc.) will be managed as CERCLA low-level waste or CERCLA sanitary waste. Job control waste (JCW) would be evaluated and potentially dispositioned under the routine JCW waste stream. Low-level secondary waste will be disposed of with the primary waste under the concrete. CERCLA sanitary waste will be disposed of as appropriate.

- Equipment will be decontaminated and verified not to be characteristically hazardous prior to release for unlimited use.

- Environmental sampling boreholes may be abandoned by backfilling with native soil. This is regardless of the level of contamination. The soil will be placed in the borehole in the reverse order as removed, to maintain the original stratigraphy.

A Waste Management Plan, which will provide additional details concerning waste disposal and transport, will be developed prior to implementing the remedial action.

XII. STATUTORY DETERMINATIONS

Based on the unit RFI/RI/BRA report, the RRSB OU poses a threat to human health and the environment. Alternative 2 has been selected as the remedy for the RRSB OU. The selected remedy is protective of human health and the environment under the industrial land use scenario, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial actions, is cost-effective, and utilizes permanent solutions to the maximum extent practicable. However, because treatment of the principal threats of the site was not found to be technically practicable, this remedy does not satisfy the statutory preference for treatment as a principal element.

In-situ stabilization of the PTSM has been used to treat other SRS reactor seepage basins. However, at the RRSB OU in-situ stabilization of the PTSM would not be technically feasible due to it being located at a significant depth below land surface, the quantity of overburden required to be removed to access the PTSM, the large volume of PTSM (approximately 15,800 yd^3), and the presence of hard clay at the OU. The hard clay prevents thorough mixing, which is required for successful in-situ stabilization. In addition, excavation of the overburden and/or in-situ stabilization of the PTSM would increase worker exposure to soil contaminated with cesium-137 which is a gamma emitting radionuclide. While the selected remedy does not satisfy the statutory preference for treatment as a principal element, the use of a concrete intruder barrier provides protection similar to that provided by in-situ stabilization. The selected remedy complies with key ARARs (Table 16) by meeting risk-based goals for soil and ensuring groundwater does not exceed MCLs beyond compliance points. PTSM with a risk greater than or equal to 1 x 10^{-3} for a hypothetical, future industrial worker is present at the RRSB OU.

Table 16. Action Specific, Chemical-Specific, and Location-Specific ARARs and TBCs for the Selected Remedy

Citation	Synopsis
40 CFR 61	Identifies annual effective radiation dose limits for the public from US DOE activities at a particular site (e.g., SRS)
SC R61-58.2	Prescribes minimum standards for the construction of treatment facilities
SC R61-62.6	Identifies statewide controls on fugitive particulate matter
29 CFR 1910	Identifies health and safety requirements for remediation workers.
SC R72 and SC R61.9.122.26	Erosion and runoff control measures
SC Water Classification Standards (R61-68)	State aquifer classification must be considered in the assessment of remedial action objectives. Mixing zone criteria are estabilished.
10 CFR 835	Establishes radiation standards and limits for worker protection from ionizing radiation
40 CFR 141 SC R.61-58.5	Establishes MCLs and MCLGs for groundwater that may be a source of drinking water
DOE Order 5480.11	Establishes annual maximum radiation exposure limit of 5.0 rem for workers
OSWER No. 9200.4-18	Establishes 15 mrem/yr effective dose equivalent for humans

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unrestricted use and unrestricted exposure, a statutory review will be conducted every five years as necessary, after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

XIII. EXPLANATION OF SIGNIFICANT CHANGES

The remedies selected in this ROD do not contain any significant changes from the Preferred Alternative remedies presented in the Proposed Plan. The only public comment received on the Proposed Plan supported its Preferred Alternative remedies. (See Appendix A.)

XIV. RESPONSIVENESS SUMMARY

The Responsiveness Summary is provided in Appendix A of this document.

XV. POST-ROD DOCUMENT SCHEDULE AND DESCRIPTION

A detailed schedule for the ROD and post-ROD activities is shown in Figure 11.

The forecast schedule for the post-ROD documentation is provided below.

- RAIP Rev. 0 for the RRSB OU will be developed and submitted for USEPA/SCDHEC review after receipt of Revision 0 ROD comments.
- USEPA/SCDHEC review of Rev. 0 RAIP - 90 days
- SRS revision of the RAIP will be completed 60 calendar days after receipt of all regulatory comments
- USEPA/SCDHEC final review and approval of RAIP - 30 days
- Proposed Remedial Action start date 1Q 05 (15 months after ROD approval)
- Combined Post-Construction Report/Final Remediation Report (PCR/FRR) Rev. 0, will be submitted to USEPA/SCDHEC after completion of the remedial action in accordance with the implementation schedule in the approved RRSB RAIP.

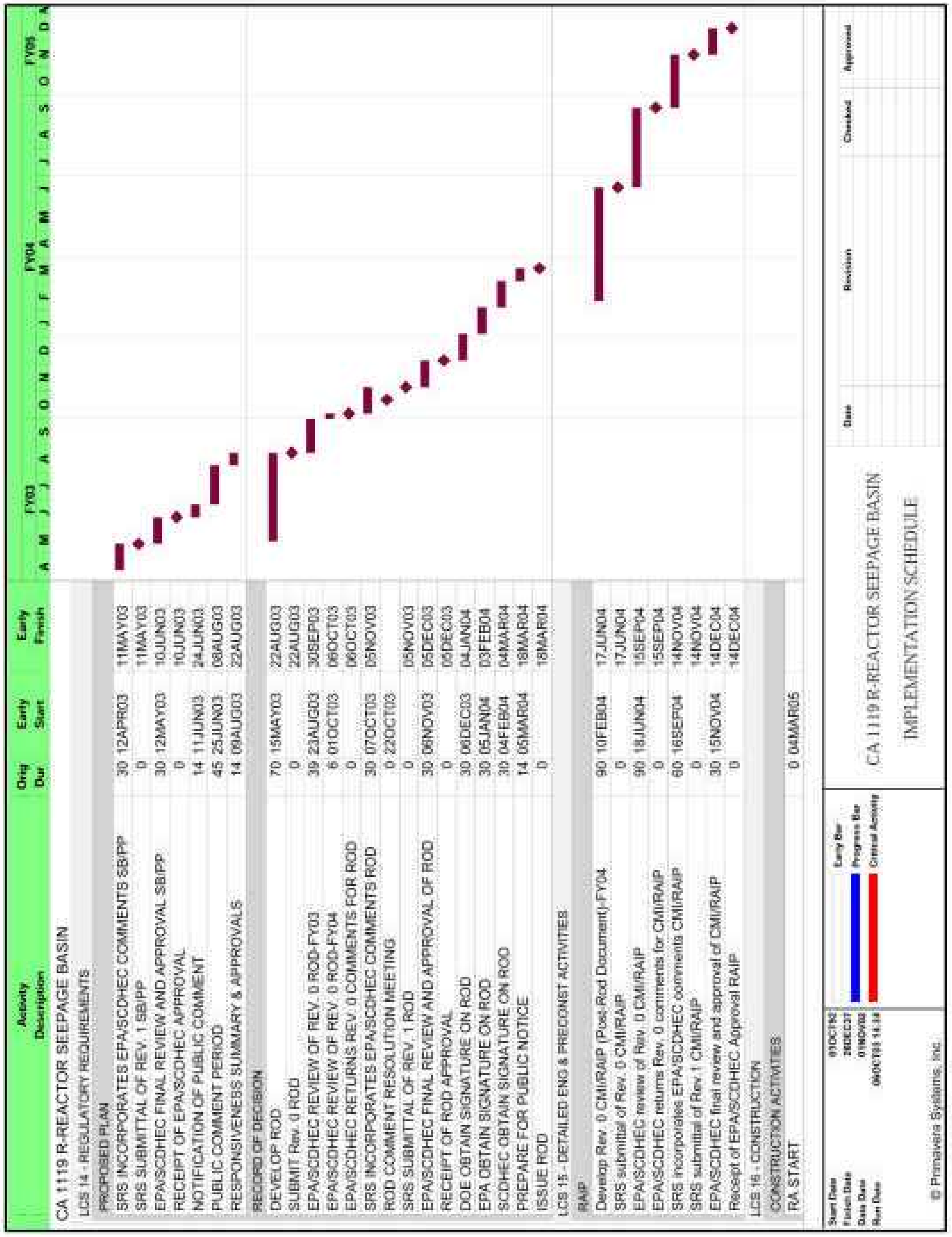

Figure 11. RRSB OU Implementation Schedule

XVI. REFERENCES

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APPENDIX A. RESPONSIVENESS SUMMARY

Responsiveness Summary

The 30-day public comment period for the *Proposed Plan for the R-Area Reactor Seepage Basins/108-4R Overflow Basin Operable Unit* began on June 9, 2003, and ended on July 8, 2003.

Public Comment

The following recommendation was received from the Citizens Advisory Board (CAB).

"The SRS CAB supports the R-Area Reactor Seepage Basins Proposed Plan and the preferred alternatives. We support the use of mixing zones, where applicable, for remedial actions. Therefore we recommend and encourage continued cooperation between SRS and SCDHEC to avoid any costly and ineffective remedial system, such as pump and treat and re-inject, for contaminated groundwater in the R-Area Reactor Seepage Basins area."

Response

USDOE agrees with the recommendation and will proceed forth with the remedial action.

APPENDIX B. COST ESTIMATE FOR THE SELECTED REMEDY

Table B-1. Detailed Cost Estimate for Alternative 2

Alternative 2 - Reinforced-concrete intruder barrier system with granitic monuments extended over PTSM and pipelines inside the boundary fence, excavate all contaminated process and sewer lines and associated soils above PTSM levels outside of the boundary fence, dispose of pipelines and associated soils on site under the intruder barrier system, a mixing zone to address groundwater, with land use controls.

Item	Quantity	Units	Unit Cost	Total Cost
Direct Capital Costs				
Institutional Controls				
Land use control implementation plan	1	ea	$15,000	$15,000
Deed restrictions	1	ea	$30,000	$30,000
Access controls (signs)	30	ea	$50	$1,495
Construct mixing zone monitoring system				
Install additional monitoring wells	20	ea	$7,200	$144,000
Site Preparation				
Soil erosion & sediment control plan	1	ea	$15,000	$15,000
Clearing of brush and small trees	2	acre	$2,300	$4,600
Excavation and on-unit disposal process lines				
Excavation of process sewer lines outside the Fence	650	lin ft	$70	$45,500
Excavation of on-unit disposal pit	1305	cy	$4.26	$5,559
Handling of potentially hazardous waste	290	cy	$20	$5,800
Soil sampling, analysis, data report	4	samples	$3,351	$13,404
Stabilization of sewer material and soil	290	cy	$91.23	$26,457
Backfill sewer line excavation	290	cy	$6.78	$1,966
Backfill on-unit disposal pit	1,305	cy	$6.78	$8,848
Extend asphalt cover	0.3	acre	$52,342	$15,703
Extend Asphalt Cover Over Bioturbation Areas				
Extend asphalt cover	1	acre	$52,342	$52,342
Intruder Barrier				
6 inch concrete structural slab on grade	8.1	acre	$192,970	$1,563,057
Granitic monuments	32	each	$2,500	$80,000
Subtotal – direct Capital cost				$2,028,731
Mobilization/Demobilization	5% of subtotal direct capital			$101,437
Site Preparation	5% of subtotal direct capital			$101,437
Total Direct Capital				**$2,231,604**
Indirect Capital Costs				
Engineering & design	20% of direct capital			$446,321
Project/construction management	25% of direct capital			$557,901
Health & safety	50% of direct capital			$1,115,802
Overhead & profit	30% of direct capital			$669,481
Contingency	15% of direct capital			$334,741
Total Indirect Capital Cost				**$3,124,245**
Total Estimated Capital Cost				**$5,355,849**
Direct O&M Costs	3.9% Discount Rate			
Annual costs	200 year O&M period			
Access controls	1	ea	$10,000	$10,000
Monitoring system maintenance	31	ea	$800	$24,800
Groundwater monitoring (annual)	62	ea	$3,351	$207,762
Mixing zone performance analysis report	1	ea	$30,000	$30,000
Asphalt cover maintenance	4.5	acre	$4,292	$19,314
Concrete barrier maintenance	8.1	acre	$3,475	$28,148
Subtotal – Annual Costs				$320,024
Present Worth Annual Costs				$8,201,831
Additional annual groundwater monitoring costs				
Additional sampling during the first year	62	ea	$3,351	$207,762
Present Worth of Additional Annual Costs				$927,524
Five Year Report costs				
Remedy review	40	ea	$13,312	$13,312
Subtotal – Five Year O&M Costs				$13,312
Present Worth Five Year Costs				$63,115
Total Present Worth Costs				**$9,192,470**
Indirect O&M Costs				
Project/administration Management	10% of direct O&M			$919,247
Health & safety	10% of direct O&M			$919,247
Overhead & profit	30% of direct O&M			$2,757,741
Total Present Worth Indirect O&M Cost				**$4,596,235**
Total Estimated Present Worth O&M Cost				**$13,788,705**
TOTAL ESTIMATED COST				**$19,144,554**

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