United States Department of Energy

Savannah River Site

Removal Site Evaluation Report / Engineering Evaluation /Cost Analysis (RSER/EE/CA) for In Situ Decommissioning of the 105-C Disassembly Basin (U)

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Prepared by:
Savannah River Nuclear Solutions, LLC
Savannah River Site
Aiken, SC 29808

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Prepared for
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and
Savannah River Nuclear Solutions, LLC
Aiken, South Carolina

EXECUTIVE SUMMARY

The 105-C Reactor Building is identified in Appendix K, "*Facilities to be Decommissioned*", of the Federal Facility Agreement (FFA 1993). This RSER/EE/CA addresses only the 105-C Disassembly Basin (105-C DB) which is a subunit of the 105-C Reactor Building. The preferred removal action includes transferring water from the sand filter, settler tank, Emergency Cooling System (ECS) tank (904-89G-1), and other sources (approximately 300,000 gallons) to the 105-C DB for forced evaporation and In Situ Decommissioning of the disassembly basin. Water from miscellaneous sources associated with waste water and storm water from within C-Reactor Operable Unit may also be directed to the disassembly basin for treatment as part of this removal action. Sampling data indicate there are approximately 17 curies of radioactivity associated with the disassembly basin sediments and approximately 814 curies associated with the basin water. There is also a large quantity of activated reactor equipment, scrap metal, and debris on the basin floor. Some of the activated reactor components exceed 200 roentgens/hour. A human health risk evaluation was performed on a recent water sample and determined the total cumulative risk from all pathways to be 1.6E-02 or 1.6 excess cases of cancer per 100 exposed individuals. This level of risk for the industrial worker justifies the implementation of a removal action.

Three removal action alternatives were evaluated in this RSER/EE/CA: 1). No Action, 2). In Situ Decommissioning of the DB with Water Removal by Forced Evaporation, and 3). In Situ Decommissioning of the DB with Basin Water Removal by Trucking to the SRS Effluent Treatment Project. ISD in Alternatives 2 and 3 consists of stabilization/isolation of any remaining contaminated water, sediment, activated reactor equipment, and scrap metal by filling the DB with flowable, nonstructural grout. The roof over the DB would be preserved for historical significance and would also prevent the infiltration of precipitation. Forced evaporation is a form of treatment that will reduce the volume of contaminated basin water. Irradiated materials and sediment will be treated by solidification/isolation thus reducing their mobility and reducing radiation exposure of future industrial workers, and creating an engineered barrier to prevent access to the contaminants by the future receptors. Grouting the basin will also provide a low permeability matrix to retard pore-water velocity through the basin. The alternative analysis compared effectiveness, implementability, cost, regulatory, and community acceptance criteria for each of the three alternatives. The analysis concluded that Alternative 2, Basin Water Removal by Forced Evaporation and In Situ Decommissioning (ISD) of the DB, was the most effective alternative to remediate the 105-C DB.

A preliminary NESHAPs calculation (SRNS 2009e) for Alternative 2 determined the total amount of radioisotopes released to the atmosphere to a maximally exposed individual at the SRS boundary from forced evaporation has an estimated potential effective dose equivalent (PEDE) of 0.036 mrem/year. This dose is less than the regulatory threshold of 0.1 mrem/year established by National Emission Standards for Hazardous Air Pollutants (NESHAPs) and South Carolina Department of Health and Environmental Control air pollution regulations. Since the PEDE is less than the regulatory threshold established for release of radionuclides, a permit for hazardous air emissions from the evaporators is not required and the evaporator equipment is exempt. The fate of all radioactive isotopes is conservatively assumed to be 100% dispersible in ambient air. The cumulative PEDE is 0.036 mrem/year, which is an inconsequential contribution to the receptor dose threshold. Any negative impacts to remedial workers or to risk receptors associated with the proposed removal would be so small that their potential contribution to an overall effect on- or offsite would be negligible. Cesium-137 is the primary contributor (78%) of the PEDE (0.028 mrem/year of the total 0.036 mrem/year) and tritium is a 5% contributor (0.002 mrem/yr). There is no human or ecological risk receptor exposure to radioisotopes since the evaporator emission dose is extremely low and will be in the form of water vapor. The water vapor emissions will flow to an above-grade stack from the evaporators into the atmosphere where it will be immediately dispersed in the ambient air.

The preferred removal action for the 105-C DB will protect human health and the environment from potential exposure to radioisotopes, immobilize contaminants remaining in the disassembly basin, and prevent industrial worker or intruder access to hazardous and radiological substances. As has been the case with previous SRS decommissioning projects, to the extent practicable and not to impact human health and the environment, efforts will be made to preserve the historical significance of the C-Reactor Area in accordance with the National Historic Preservation Act. The proposed removal action will not adversely impact the historical significance of the 105-C Reactor Building since the building itself will not be demolished and will remain unchanged in appearance with the exception of filling the disassembly basin with grout, which mitigates the associated hazards to human health and the environment. Above-grade modifications to the interior of the disassembly basin needed to support construction activities related to dewatering and grouting of the basin will be minimized to the extent practicable.

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LIST OF ACRONYMS AND ABBREVIATIONS

105-C DB	105-C Reactor Building Disassembly Basin
ac	acre
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COPC	Constituent of Potential Concern
COC	Constituent of Concern
Cs+D	cesium (+D signifies daughter products associated with cesium)
Ci	Curies
DB	Disassembly Basin
DL	Detection Limit
ECS	Emergency Cooling System
EE/CA	Engineering Evaluation/Cost Analysis
ETP	Effluent Treatment Project
FFA	Federal Facility Agreement
ft	feet
ft^2	square feet
ft^3	cubic feet
ha	hectare
HH	human health
HI	Hazard Index
ISD	In Situ Decommissioning
km	kilometer
km^2	square kilometer
LLC	Limited Liability Company
LUCAP	Land Use Control Assurance Plan
LUCs	Land Use Controls
m	meter
MCL	maximum contaminant level
MDA	Minimum Detectable Activity
mi	mile
mi^2	square mile
mrem	millirem or one one-thousandth of a rem. (1000 mrem = 1 rem)
msl	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NEPA	National Environmental Policy Act
NTCR	non-time critical removal
OU	operable unit
pCi or pCi/g	picocuries or picocuries per gram
pCi/L	picocuries per liter
PRG	Preliminary Remediation Goal
R/hr	Roentgens per hour
RAO	removal action objectives

LIST OF ACRONYMS AND ABBREVIATIONS *(Continued/End)*

RBC	Reactor Building Complex
RCOC	refined constituent of concern
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man, a unit of radiation dose
RL	Reporting Limit
RSER	Removal Site Evaluation Report
RSL	Regional Screening Level
SCDHEC	South Carolina Department of Health and Environmental Control
SRNS	Savannah River Nuclear Solutions, LLC
SRS	Savannah River Site
TAL	USEPA Target Analyte List
TCL	USEPA Target Compound List
TBC	to be considered
UCL	Upper Confidence Limit
USDOE	U.S. Department of Energy
USEPA	U.S. Environmental Protection Agency
WSRC	Washington Savannah River Company LLC (October 2005-present)
WSRC	Westinghouse Savannah River Company LLC (before October 2005)
yd	yard
yd^3	cubic yard
yr	year

1.0 INTRODUCTION

The U.S. Department of Energy (USDOE) is proposing to perform a non-time critical removal (NTCR) action at the 105-C Disassembly Basin (105-C DB) which is a portion of the 105-C Reactor Building. This Removal Site Evaluation Report (RSER)/Engineering Evaluation/Cost Analysis (RSER/EE/CA) identifies the objectives of the removal action for the 105-C DB subunit and compares alternatives that mitigate the potential threats of release of contaminants to the environment and provides a vehicle for public comment in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) 300.415.

The Savannah River Site (SRS) encompasses 310 mi^2 of land adjacent to the Savannah River, principally in Aiken and Barnwell counties of South Carolina. SRS is located approximately 25 mi southeast of Augusta, Georgia, and 20 mi south of Aiken, SC (Figure 1). SRS is owned by USDOE while Savannah River Nuclear Solutions, LLC (SRNS) provides management and operating services. SRS has historically produced tritium, plutonium, and other special nuclear materials for national defense. Chemical and radioactive wastes are by-products of nuclear material production processes. Hazardous substances, as defined by Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), are present in the SRS environment.

The public is encouraged to comment on the alternatives presented in this RSER/EE/CA. Following the public comment period, an Action Memorandum will be prepared by USDOE and added to the SRS Administrative Record, which is accessible by the public. All responses to the public comments will be included in an Action Memorandum.

Copies of this RSER/EE/CA and the Administrative Record for SRS are 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, SC 29208 (803) 777–4866

Hard copies of this RSER/EE/CA are available at the following locations:

Reese Library Augusta State University 2500 Walton Way Augusta, GA 30910 (706) 737–1744	Asa H. Gordon Library Savannah State University Tompkins Road Savannah, GA 31404 (912) 356–2183

To submit comments or request a public meeting during the public comment period, contact:

Paul Sauerborn Savannah River Nuclear Solutions, LLC Public Involvement Savannah River Site Building 730–1B Aiken, South Carolina 29808 (803)-952-6658 paul.sauerborn.@srs.gov	

2.0 SITE CHARACTERIZATION

2.1 Facility Description and Background

The 105-C DB is part of the 105-C Reactor Building located in C-Area (Figures 1 and 2). C-Area which is located in the Fourmile Branch watershed is approximately 2.7 miles west of the geographical center of SRS and approximately 6 miles east of the nearest site boundary and is in the west central portion of SRS (see Figure 2). The 105-C Reactor Building, other associated facilities, and related units in C-Area will be considered together as part of the closure of the C-Area Operable Unit (CAOU).

The 105-C Reactor Building is identified in Appendix K, "*Facilities to be Decommissioned*", of the Federal Facility Agreement (FFA 1993). This RSER/EE/CA addresses the 105-C DB which is a portion of the 105-C Reactor Building. The 105-C Reactor Building has been declared an excess facility by USDOE, and its disposition is under evaluation. The proposed action includes transferring water from the sand filter, settler tank, and the ECS tank (about 300,000 gallons) to the 105-C DB for forced evaporation and In Situ Decommissioning of the disassembly basin. In addition, water from miscellaneous sources (such as the 106-C, 107-C, and 109-C structures) associated with other C-Reactor Operable Unit subunits

or the 105-C facility may also be directed to the disassembly basin for treatment as part of this removal action. The 106-C, 107-C and 109-C structures are shown on Figure 4.

2.2 Previous Operation

The 105-C reactor achieved criticality in March of 1955 and was shut down in 1985 for maintenance. The reactor was placed on cold standby in 1987, followed by shutdown with no possibility of restart (ESH 1996).

Similar to other SRS reactors, the 105-C reactor produced special nuclear materials (mainly plutonium and tritium) for defense purposes. The 105-C Reactor Building consists of four main operating facilities at ground level: the assembly area, the process room, the purification wing, and the disassembly basin (See Figure 3).

Prefabricated fuel and target elements were shipped from M-Area at the SRS and were received in the reactor assembly area where they were cleaned and tested prior to insertion in the reactor vessel. The fuel and targets were activated in the reactor vessel during a production cycle and then transferred to the disassembly basin where they were stored underwater to allow for thermal cooling and high activity radioactive isotopes to decay. Afterwards, the fuel and target elements were transported to other facilities at SRS for further chemical processing and isotope extraction.

To generate these special nuclear materials, the reactors utilized a process of neutron irradiation of either Uranium-238 or Lithium-6 targets to produce Plutonium-239 and tritium, respectively. The source of neutrons came from the fission of enriched Uranium-235, which is an isotope present in the uranium reactor fuel. The fission of Uranium-235 is a process whereby the uranium nucleus disintegrates to emit a large quantity (flux) of energy in the form of neutrons which causes heat and intense radiation, which generates many radioactive fission isotopes that form the predominant basis of radioactive waste products. The fuel and target elements were clad with aluminum, which was intended to contain fission products from escaping until isotope extraction (ESH 1996).

The transfer of targets and spent fuel from the reactor vessel into the disassembly basin resulted in accumulation of tritium within the disassembly basin water and sediment. Other fission products in the disassembly basin came from underwater cutting operations and failed fuel elements stored in the basin. The fission products are primarily tritium, Cesium-137 (+D), and Strontium-90 isotopes. When fuel and target elements were moved from the reactor vessel to the disassembly basin, tritium on the surface of the

elements was flushed into the basin. Fission products were also added to the basin water when failed fuel and target elements were discharged and leaked in the disassembly basin.

The neutron bombardment in the reactor vessel during operations activated the metal (such as 304 stainless steel) of the reactor components and target and fuel elements. Some of these activated reactor components became very radioactive due to their proximity to the neutron flux and were stored after use in the disassembly basin for shielding where they currently reside.

Disassembly basin water was filtered through a sand filter to remove solids and reduce radioactivity within the basin water. When the inlet-outlet sand filter pressure head reached a pre-determined differential pressure, the sand filter was backwashed into the settler tank allowing the suspended particles in the backwash to settle by gravity. Tritiated water was occasionally discharged to seepage basins to protect workers in the reactor building as radioactivity accumulated in the disassembly basin water during operations.

All fuel and target elements have been removed from the 105-C DB (WSRC 1998, WSRC 2001, WSRC 2002).

2.3 Land Use

C-Area is in an area currently designated for industrial use. The projected future development of the 105-C Reactor Building is planned for historical use under the National Historic Preservation Act which is concerned with identifying and preserving historic property. The 105-C Reactor Building is being preserved for historical significance and may be used as museum in the future. Future industrial land use will be controlled in accordance with the SRS Land Use Control Assurance Plan (LUCAP) (WSRC 1999). The *Early Action Record of Decision Remedial Alternative Selection for the C-, K-, L-, and R-Reactor Complexes* (SRNS 2009a) has selected In-Situ Decommissioning (ISD) as the preferred end-state for the reactor complexes. The Land Use Control Implementation Plan (LUCIP) for that action specifies continuation of current land use controls in the reactor areas (SRNS 2009c). An industrial land use scenario was selected as the risk assessment exposure scenario for the protection of human health and the environment (USDOE 1996).

The 105-C Reactor Building is an industrial building and provides no ecological habitats within proximity of the building.

2.4 Physical Configuration

The 105-C DB is a portion of and located within the 105-C Reactor Building. The 105-C DB is composed of six primary operating compartments (See Figure 5):

1. Vertical Tube Storage
2. Machine Area
3. Dry Cave Section
4. Monitor (Pin) Basin
5. Transfer Area
6. Final Storage Section

The following table provides approximate areas and volumes for the above compartments.

Table 1 Disassembly Basin Compartments, Areas, Depths, and Volume

Compartment	Area (ft^2)	Floor Depth (ft)	Volume (ft^3)
Vertical Tube Storage	3.36E+03	30.0	1.01E+05
Machine Area	8.80E+03	30.0	1.63E+05
Dry Cave Section	3.91E+03	30.0	1.17E+05
Monitor Pin Basin	7.70E+02	30.0	2.31E+04
Transfer Area	6.46E+02	20.67 (average)	1.26E+04
Final Storage Section	3.38E+03	17.0	5.75E+04
TOTALS	**1.75E+04**		**4.75E+05**

The total estimated empty volume of the 105-C DB is 4.75E+05 ft^3 or 3.55 million gallons (Rucker 2010). The basin level on January 5, 2010 was -76 inches (-6.33 feet) below 0 elevation (Reedy 2010), therefore, the basin currently contains approximately 2.72 million gallons of water (Rucker 2010).

In late 2001 and early 2002 the sediment contained in the settler tank was pumped back into the 105-C DB. A conservative estimate (Rucker 2010) of total sediment volume is 2530 ft^3 for the 105-C DB based on earlier observations (FDD 2002) of sediment depth in the disassembly basin and refined estimates of the DB volume. Sediment mass was estimated to be 1.41E+08 grams, (141,000 kilograms) which was calculated using the total solids percentage (8%) measured in the 105-P DB. The mass of sediment in grams is used to estimate the total curie content of the sediment layer.

The 105-C DB also contains 4 "pits or deep wells" which measured from grade level (0 feet elevation) would terminate approximately -51 feet below grade level (see Figure 5). The deep pits will be filled with grout during the removal action. The bottom of these pits is located approximately 20 feet above the

potentiometric surface of the water table which is located at approximately 70 feet (below ground surface) bgs.

Generally, the disassembly basin walls and floors below grade level are constructed of steel-reinforced concrete. The concrete basin walls and floors range in thickness from 2.5 feet to 7 feet with a separate 7.5 foot thick reinforced concrete construction mat beneath the floors. The walls between the individual basin compartments have narrow vertical openings called "slots" that permit the transfer of material from one section to another. There is an overhead monorail system inside the disassembly basin which was used to move activated reactor components, fuel and target elements, equipment, and scrap buckets through the various basin compartments utilizing hangers that extended underwater.

105-C DB has a current approximate liquid volume of 2.72 million gallons. Basin water levels are measured regularly for signs of leakage and there is no indication of any water loss which might indicate the release of contaminated water into the environment based on these measurements.

Two groundwater monitoring wells CDB-1 and CDB-2 are located adjacent to the disassembly basin (see Figure 4). The general direction of groundwater flow in the vicinity of the DB is site west, so CDB-2 is located most downgradient. Historically, the highest tritium level detected in either of the two groundwater monitoring wells is in CDB-1. The highest tritium activity detected was 9,130 pCi/ml from a sample collected on May 12, 2009. Based on additional characterization conducted subsequent to that detection (SRNS, 2009d), the source of these elevated tritium levels is believed to be an historic spill up gradient of CDB-1. Tritium levels in CDB-1 have since declined to 101 pCi/ml on October 18, 2010 indicating the basin does not leak; otherwise, higher levels of tritium would constantly be present in groundwater with an associated loss of basin water.

2.5 Nature and Extent of Contamination

Activated Reactor Components and Scrap Metal Survey 2002

An extensive radiation survey was conducted prior to May 2002 of the disassembly basin floor using an RO-7 radiation detector (FDD 2002). The purpose of the survey was to identify any "hot spots" which could represent radiological hazards caused primarily by radionuclides associated with activated reactor components and metal (304 stainless steel) including Iron-55, Nickel-59, Nickel-63, Cobalt-60, and Carbon-14.

The RO-7 is a beta/gamma radiation measuring instrument which provides a means for underwater measurement of low to high range beta and gamma fields. The RO-7 can be used with either a low range detector (gamma only) 0.001R/hour to 1.999 R/hour, a mid-range detector (beta/gamma) 0.1 R/hour to 199.99 R/hour, or a high range detector (beta/gamma) 0.01 kR/hour to 19.99 kR/hour. Because Nickel-59, Nickel-63, Cobalt-60, and Carbon-14 are all beta or beta/gamma emitters, the RO-7 is an effective instrument to measure the beta/gamma radiation field from the previously mentioned radioisotopes found in activated stainless steel. The RO-7 is also an excellent tool to determine radioactive emissions from Cesium-137+D (a beta/gamma emitter) which is one of the most common by-products of nuclear fission.

The RO-7 detector was lowered into the basin water until it was 3 to 6 inches above the top of the sediment layer so as not to cause agitation of sediment. Objects lying on the floor of the basin that were not covered by the sediment were approached even closer. The instrument was moved above the surface of the floor to all locations that were accessible. The survey report noted that a significant portion of the basin bottom could not be surveyed due to physical interference at the top of the basin because there was insufficient clearance to move the detector around the cable hangers on the overhead monorail system.

The survey indicated 54 locations, of which 10 were greater than 200 R/hr (see Figure 6). Thirty-five locations indicated measurements between 1 and 200 R/hr. The remaining 9 locations were between 0.1 and 1.0 R/hr. Most, if not all the spots, represent equipment or activated metal as opposed to "hot" particles in the sediment (FDD 2002). There is no estimate of the curie inventory for the activated reactor components or scrap metal in basin which is likely to be the single greatest source of radioactivity in the basin.

The basin contains a significant amount of metal scrap, debris, used reactor components, tools, cables, and high activity containment devices. Some of the equipment is suspended by cable hangers from the overhead rails and other scrap and equipment is lying on the basin floor.

105-C Disassembly Characterization Sampling Plan 2002

A sampling plan for the 105-C DB was prepared in May 2002 (FDD 2002) and both sediment and water samples were collected on July 8 and July 23, 2002 respectively, within the various compartments of the DB. The upper portion of the dry cave section was sampled, but the enclosed portion of the dry cave was not included in the sampling. The water in the dry cave section is connected by canals and slots to the remainder of disassembly basin and both the water and sediment should be representative of the remainder of the DB.

The analytical data report (WSRC 2003a, 2003b, 2003c) for the 2002 sampling event meets the requirements of the National Environmental Laboratory Accreditation Conference (NELAC). In the following tables, sediment and water data is summarized from the 2002 and 2009 sampling events and is compared to the November 2010 (most recent) USEPA Regional Screening Levels (RSLs), radiological PRGs, and MCLs.

Data from the 2002 and 2009 characterization event contain analytes having reporting limits (RLs), detection limits (DLs), or minimum detected activities (MDAs) which exceed their respective RSL, PRG, or MCL used for screening purposes in this RSER/EE/CA. Primarily, these RLs, DLs, or MDAs exceed screening limits because the analytical methods were based on data quality objectives (DQOs) for waste determination. These results were not intended to be compared to risk-based thresholds. The analytical results were intended to be compared to waste determination limits, waste acceptance criteria, or treatment requirements rather than drinking water standards or industrial worker screening levels. However, since one of the objectives of this RSER/EE/CA is to determine the basis for a removal action, comparisons have been made to industrial worker thresholds and drinking water criteria.

In the following tables, the lower of the two PRGs for each of two isotopes of the same element (example: Plutonium-239/240) was used for comparison purposes to be conservative. This approach ensures the lowest risk-based threshold of a radioisotope is accounted for during the screening comparisons.

The number, type and location of sediment samples from the 2002 basin characterization are listed below:

2002 Basin Sediment Samples

Analytical Class	Number of Analytes	Data Package	Number of Samples	Basin Location*
Organic Compounds	28	WSRC 2003a & b	9 Grab	1,2,3,4,5,6A,7A,7B,8
Metals	23	WSRC 2003a & b	9 Grab	1,2,3,4,5,6A,7A,7B,8
Radiological Analytes	34	WSRC 2003a & b	1 Composite	1&2
	34	WSRC 2003a & b	1 Composite	3,4,5,6A,7A,7B,8

The number, type and location of water samples from the 2002 basin characterization are listed below:

2002 Basin Water Samples

Analytical Class	Number of Analytes	Data Package	Number of Samples	Basin Location*
Organic Compounds	28	WSRC 2003c	5 Grab	1,4,7,7A,8
Metals	22	WSRC 2003c	4 Grab	1,4,7,8
Radiological Analytes	34	WSRC 2003c	1 Composite	1,4,7,8

*Basin Location (see Figure 7)
Area 1 - Final Storage
Area 2 - Final Storage
Area 3 - Final Storage
Area 4 - Final Storage
Area 5 - Transfer Bay
Area 6A - Machine Area and Monitor Basin
Area 7A and 7B - Vertical Tube (temporary) Storage
Area 8 - Dry Cave Area

Summary of 2002 Basin Sediment Data

Organics
Toluene was the only organic contaminant detected in basin sediment samples; however, no toluene concentration exceeded its respective RSL. No other volatile or semi-volatile organic analytes were detected in basin sediment (see Table 2).

Metals
All 23 metals were detected at least once in basin sediment samples. None of the mean concentrations of metals exceeded their respective RSL, although the maximum arsenic detection did exceed its respective RSL (see Table 3).

Radioisotopes
Numerous radioisotopes were detected in basin sediments with several radiological PRGs being exceeded (see Table 4). Radioisotopes exceeding their respect PRG include: Americium-241, Carbon-14, Cesium-137, Cobalt-60, Curium-244, Europium-154, Plutonium-238, Plutonium-239/240, Strontium-90, and tritium. In the case of Plutonium-239/240, the lower of each of the two PRGs of the radioisotopes was used for comparison purposes to be conservative.

Radioisotopes which were not detected but whose MDA was greater than the respective PRG included: Americium-243, Antimony-125, Cesium-134, Europium-152, Europium-155, Neptunium-237, Niobium-94, Radium-226, and Selenium-79.

Although the primary radionuclides associated with activated metal (304 stainless steel) in the 105-C DB include Iron-55, Nickel-59, Nickel-63, Cobalt-60, and Carbon-14; Iron-55 and Nickel-63 were not included in the 2002 analysis plan for sediment media. Based on data from P-Area disassembly basin Nickel-63 activities are expected to be about 200 times greater than Nickel-59. Iron-55 has a comparatively short half-life (2.7 years), and thus will not contribute significant activity in the future.

Summary of 2002 Basin Water Data

Organics

There were no detections of volatile or semi-volatile organic analytes in basin water samples. Organic analytes which were not detected but whose RL was greater than the respective PRG included: 1,1-Dichloroethene, 1,2-Dichloroethene, 2,4,-Dinitrotoluene, Benzene, Carbon tetrachloride, Hexachlorobenzene, Hexachlorobutadiene, Hexachloroethane, Nitrobenzene, Pentachlorophenol, Tetrachloroethylene, Trichloroethylene, and Vinyl chloride (see Table 5).

Metals

The mean concentration of antimony exceeded its respective MCL as did the maximum detection of antimony. Metallic analytes which were not detected but whose MDL was greater than the respective MCL/RSL included: arsenic, lead, and thallium (see Table 6).

Radioisotopes

Numerous radioisotopes were detected in basin water with several radioisotope MCLs/PRGs being exceeded (see Table 7). Radioisotopes exceeding their respective MCL/PRG include: Carbon-14, Cesium-137, Cobalt-60, Gross Alpha, Plutonium-238, Tritium, Uranium-234, and Uranium-235. It is unclear why Strontium-90 was not detected in the 2002 sampling event.

Radioisotopes which were not detected but whose MDA was greater than the respective MCL/PRG included: Iodine-129 and Selenium-79.

All 2002 and 2009 uranium data for basin water was reported in activity concentration units (activity/volume [pCi/L]) for U-234, U-235, and U-238 isotopes, instead of mass concentration units (mass/volume [μg/L]) for total uranium. In order to directly compare the activity concentrations to the mass-based uranium MCL, an estimate of the uranium isotopic activities equivalent to the 30 μg/L uranium MCL was used for screening in the RSER/EE/CA. The equivalents are U-234 – 10.0 pCi/L, U-235 – 0.47 pCi/L, and U-238, 10.0 pCi/L = 30 μg/L uranium (Rucker 2001).

Although the primary radionuclides associated with activated metal (304 stainless steel) in the 105-C DB include Iron-55, Nickel-59, Nickel-63, Cobalt-60, and Carbon-14; Iron-55 and Nickel-63 were not included in the 2002 analysis plan for water media. Based on data from P-Area disassembly basin Nickel-63 activities are expected to be about 200 times greater than Nickel-59. Iron-55 has a comparatively short half-life (2.7 years), and thus will not contribute significant activity in the future.

Table 2 2002 Data Summary for Organic Analytes in the 105-C DB Sediment

Analyte (mg/kg)	Non-Dects	Detects	Minimum	Maximum	Mean	RSL	Mean>RSL?
1,1 Dichloroethene	9	0	0.1	0.1	0.05	1,100	No
1,2 Dichloroethane	9	0	0.1	0.1	0.05	2.2	No
1,4-Dichlorobenzene	9	0	0.33	0.33	0.165	12	No
2,4 Dinitrotoluene	9	0	0.33	0.33	0.165	5.5	No
2,4,5 Trichlorophenol	9	0	0.33	0.33	0.165	62,000	No
2,4,6 Trichlorophenol	9	0	0.33	0.33	0.165	160	No
2-Butanone	9	0	0.1	0.1	0.05	200,000	No
2-Methylphenol	9	0	0.33	0.33	0.165	NA	No
4-Methylphenol	9	0	0.33	0.33	0.165	NA	No
Benzene	9	0	0.1	0.1	0.05	5.4	No
Carbon tetrachloride	9	0	0.1	0.1	0.05	3	No
Chlorobenzene	9	0	0.1	0.1	0.05	1,400	No
Chloroform	9	0	0.1	0.1	0.05	1.5	No
Ethylbenzene	9	0	0.1	0.1	0.05	27	No
Hexachlorobenzene	9	0	0.33	0.33	0.165	1.1	No
Hexachlorobutadiene	9	0	0.33	0.33	0.165	22	No
Hexachloroethane	9	0	0.33	0.33	0.165	120	No
m,p-Xylenes	9	0	0.1	0.1	0.05	3,400	No
Nitrobenzene	9	0	0.33	0.33	0.165	24	No
o-Xylene	9	0	0.1	0.1	0.05	3,800	No
Pentachlorophenol	9	0	0.33	0.33	0.165	9	No
Pyridine	9	0	0.33	0.33	0.165	1,000	No
Tetrachlorethene	9	0	0.1	0.1	0.05	2.6	No
Toluene	0	9	0.315	6	2.324	45,000	No
Total Cresol	9	0	0.33	0.33	0.165	91,000	No
Trichloroethyene	9	0	0.1	0.1	0.05	14	No
Vinyl chloride	9	0	0.1	0.1	0.05	2	No
Xylenes total	9	0	0.1	0.1	0.05	630	No

½ RL used as a surrogate for non-detected analytes to derive mean summary statistics
RSL values from November 2010 listing from USEPA website http://epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

Table 3 2002 Data Summary for Metallic Analytes in the 105-C DB Sediment

Analyte (mg/kg)	Non-Dects	Detects	Minimum	Maximum	Mean	RSL	Mean>RSL?
Aluminum	0	9	2400	6690	4373	990,000	No
Antimony	7	2	0.0528	8.8	1.91	410	No
Arsenic	6	3	0.0249	7.51	1.55	1.6	No
Barium	0	9	5.13	10.8	8.78	190,000	No
Beryllium	0	9	0.05	0.099	0.075	2,000	No
Cadmium	0	9	0.49	1.67	1.02	800	No
Calcium	0	9	244	678	422.22	NA	
Chromium	0	9	6.8	36.7	17.1	NA	
Cobalt	0	9	0.299	1.27	0.83	300	No
Copper	0	9	18.6	39.6	26.93	41,000	No
Iron	0	9	4660	24,800	10,367.78	725,000	No
Lead	0	9	20.8	83.8	41.51	NA	
Magnesium	0	9	13.8	50.9	32.79	NA	
Manganese	0	9	46	192	102.43	23,000	No
Mercury	1	8	0.0002	0.083	0.048011	NA	
Nickel	0	9	7.03	27.9	15.43667	44,000	No
Potassium	0	9	27.8	61.3	40.95556	NA	
Selenium	2	7	0.0022	0.584	0.297356	5,100	No
Silver	8	1	0.0081	1.36	0.154711	5,100	No
Sodium	0	9	40.5	55.4	45.18889	NA	
Thallium	3	6	0.0609	12.5	6.074594	NA	
Vanadium	0	9	0.915	3.63	1.649444	5,200	No
Zinc	0	9	307	3820	990	315,000	No

½ MDL used as a surrogate for non-detected analytes to derive mean summary statistics
RSL values from November 2010 listing from USEPA website http://epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

Table 4 2002 Data Summary for Radioisotopes in the 105-C DB Sediment

Analyte (pCi/g)	Non-Dects	Detects	Minimum	Maximum	Mean	PRG	Mean>PRG?
Americium-241	0	4	73.6	147	107.6	4.82	Yes
Americium-243	2	0	2.73	3.22	1.4875*	0.288	
Antimony-125	2	0	26	31.2	14.3*	0.688	
Carbon-14	0	2	95.9	4060	2077.95	1,110	Yes
Cesium-134	2	0	9.8	11.8	5.4*	0.24	
Cesium-137	0	2	600	865	732.5	0.103	Yes
Cobalt-60	0	2	2280	8260	5270	0.0578	Yes
Curium-242	2	0	3.07	3.63	1.675	2,870	No
Curium-244	0	2	37	47.8	42.4	34.1	Yes
Europium-152	2	0	26.8	34.4	15.3*	0.0643	
Europium-154	0	2	46.3	62.2	54.25	0.0735	Yes
Europium-155	2	0	20	27.5	11.875*	5.41	
Gross Alpha	0	2	1040	1100	1070	NA	
Gross Beta	0	2	4200	8580	6390	NA	
Iodine-129	1	1	1.11	3.21	1.3575	9.49	No
Neptunium-237	2	0	2.33	2.45	1.195*	0.225	
Nickel-59	0	2	77.8	172	124.9	11,100	No
Niobium-94	2	0	10.3	13.4	5.925*	0.0279	
Plutonium-238	0	2	658	662	660	14.4	Yes
Plutonium-239/240	0	2	132	134	133	12.5	Yes
Plutonium-242	2	0	2.2	2.33	1.1325	13.3	No
Radium-226	2	0	17.2	22.3	9.875*	0.0223	
Ruthenium-103	1	1	13	15.9	11.2	15.7	No
Ruthenium-106	2	0	101	122	55.75	3,750,000	No
Selenium-79	2	0	1940	1970	977.5*	297	
Strontium-90	0	2	454	750	602	8.91	Yes
Technetium-99	1	1	3.5	4.23	2.99	796	No
Thorium-228	2	0	2.18	2.68	1.215	109	No
Thorium-230	2	0	1.45	1.57	0.755	18	No
Thorium-232	2	0	1.45	1.75	0.8	17	No
Tritium	1	1	18.3	99500	49754.58	1.27	Yes
Uranium-234	0	2	6.03	6.46	6.245	29.1	No
Uranium-235	0	2	1.39	3.56	2.475	30.9	No
Uranium-238	2	0	1.1	1.92	0.755	1.49	No

½ MDA used as a surrogate for non-detected analytes to derive mean summary statistics
PRG values from December 2010 listing from USEPA website http://epa-prgs.ornl.gov/radionuclides/download.shtml
*MDA was greater than radiological PRG.

Table 5 2002 Data Summary for Organic Analytes in the 105-C DB Water

Analyte (µg/L)	Non-Detects	Detects	Minimum	Maximum	Mean	MCL/RSL	Mean>MCL/RSL?
1,1 Dichloroethene	5	0	100	100	50*	7	
1,2 Dichloroethane	5	0	100	100	50*	5	
1,4 Dichlorobenzene	5	0	10.8	11.8	5.59	75	No
2,4 Dinitrotoluene	5	0	10.8	11.8	5.59*	0.22	
2,4,5 Trichlorophenol	5	0	10.8	11.8	5.59	3,700	No
2,4,6 Trichlorophenol	5	0	10.8	11.8	5.59	6.1	No
2-Butanone	5	0	100	100	50	7,100	No
2-Methylphenol	5	0	10.8	11.8	5.59	NA	
4-Methylphenol	5	0	10.8	11.8	5.59	NA	
Benzene	5	0	100	100	50*	5	
Carbon tetrachloride	5	0	100	100	50*	5	
Chlorobenzene	5	0	100	100	50	100	No
Chloroform	5	0	100	100	50	80	No
Ethylbenzene	5	0	100	100	50	700	No
Hexachlorobenzene	5	0	10.8	11.8	5.59*	1	
Hexachlorobutadiene	5	0	10.8	11.8	5.59*	0.86	
Hexachloroethane	5	0	10.8	11.8	5.59*	4.8	
m,p-Xylenes	5	0	100	100	50	17,000	No
Nitrobenzene	5	0	10.8	11.8	5.59*	0.12	
o-Xylene	5	0	100	100	50	1,200	No
Pentachlorophenol	5	0	10.8	11.8	5.59*	1	
Pyridine	5	0	10.8	11.8	5.59	910	No
Tetrachloroethylene	5	0	100	100	50*	5	
Toluene	5	0	100	100	50	1000	No
Total Cresol	5	0	10.8	11.8	5.59	930	No
Trichloroethylene	5	0	100	100	50*	5	
Vinyl chloride	5	0	100	100	50*	2	
Xylenes Total	5	0	100	100	50	10,000	No

½ RL used as a surrogate for non-detected analytes to derive mean summary statistics
RSL values from November 2010 listing from USEPA website http://epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
*RL greater than the MCL/RSL.

Table 6 2002 Data Summary for Metallic Analytes in the 105-C DB Water

Analyte (µg/L)	Non-Detects	Detects	Minimum	Maximum	Mean	MCL/RSL	Mean>MCL/RSL?
Aluminum	0	4	94	1230	430.25	37,000	No
Antimony	3	1	52.8	123	50.55	6	Yes
Arsenic	4	0	24.9	24.9	12.45*	10	
Barium	0	4	10	11.3	10.475	2,000	No
Beryllium	1	3	0.21	0.21	0.18375	4	No
Cadmium	4	0	3.4	3.4	1.7	5	No
Calcium	0	4	9300	9540	9400	NA	
Chromium	3	1	8	9.9	5.475	100	No
Cobalt	4	0	3	3	1.5	11	No
Copper	2	2	5.1	6.5	4.3	1,300	No
Iron	0	4	61	451	176.9	26,000	No
Lead	4	0	48.9	48.9	24.45*	15	
Magnesium	0	4	88.2	111	99.325	NA	
Manganese	0	4	1.4	52.4	14.625	NA	
Mercury	4	0	0.2	0.2	0.1	2	No
Nickel	3	1	10.2	12.1	6.85	730	No
Potassium	0	4	17700	18400	17925	NA	
Selenium	4	0	25.7	25.7	12.85	50	No
Silver	4	0	8.1	8.1	4.05	180	No
Thallium	4	0	60.9	60.9	30.45*	2	
Vanadium	4	0	4.3	4.3	2.15	2.6	No
Zinc	0	4	23.2	137	52.975	11,000	No

½ MDL used as a surrogate for non-detected analytes to derive mean summary statistics
RSL values from November 2010 listing from USEPA website http://epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
*MDL was greater than the MCL/RSL.

Table 7 2002 Data Summary for Radioisotopes in the 105-C DB Water

Analyte (pCi/L)	Non-Detects	Detects	Minimum	Maximum	Mean	MCL/PRG	Mean>MCL/PRG
Americium-241	1	1	-2.18	6.9	2.905	15.00	No
Americium-243	1	0	0.105	0.105	0.0525	15.00	No
Antimony-125	1	0	-23.2	-23.2	-11.6	300.00	No
Carbon-14	0	1	1,840,000	1,840,000	1,840,000	2,000.00	Yes
Cesium-134	1	0	9.08	9.08	4.54	80.00	No
Cesium-137	0	1	30,400	30,400	30,400	200.00	Yes
Cobalt-60	0	1	1910	1910	1910	100.00	Yes
Curium-242	1	0	-0.131	-0.131	-0.0655	15.00	No
Curium-244	0	1	2.57	2.57	2.57	15.00	No
Europium-152	1	0	-43.5	-43.5	-21.75	60.00	No
Europium-154	1	0	32.1	32.1	16.05	200.00	No
Europium-155	1	0	18.4	18.4	9.2	600.00	No
Gross Alpha	0	1	553	553	553	15.00	Yes
Gross Beta	0	1	72,300	72,300	72,300	NA	No
Iodine-129	1	0	9.79	9.79	4.895*	1.00	
Neptunium-237	1	0	0.315	0.315	0.1575	15.00	No
Nickel-59	0	1	23.3	23.3	23.3	300.00	No
Niobium-94	1	0	2.95	2.95	1.475	6.81	No
Plutonium-238	0	1	181	181	181	15.00	Yes
Plutonium-239/240	0	1	12.5	12.5	12.5	15.00	No
Plutonium-242	1	0	0.118	0.118	0.059	15.00	No
Radium-226	1	0	-14.2	-14.2	-7.1	5.00	No
Ruthenium-103	1	0	2.34	2.34	1.17	13.70	No
Ruthenium-106	1	0	-79.6	-79.6	-39.8	1.25	No
Selenium-79	1	0	4940	4940	2470*	7.26	
Strontium-90	1	0	-173	-173	-86.5	8.00	No
Technetium-99	1	0	17.8	17.8	8.9	900.00	No
Thorium-228	1	0	0.726	0.726	0.363	15.00	No
Thorium-230	1	0	0.605	0.605	0.3025	15.00	No
Thorium-232	1	0	-0.242	-0.242	-0.121	15.00	No
Tritium	0	1	79,700,000	79,700,000	79,700,000	20,000.00	Yes
Uranium-234	0	1	16.1	16.1	16.1	10.00+	Yes
Uranium-235	0	1	2.54	2.54	2.54	0.47+	Yes
Uranium-238	0	1	0.742	0.742	0.742	10.00+	No

½ MDA used as a surrogate for non-detected analytes to derive mean summary statistics
PRG values from December 2010 listing from USEPA website http://epa-prgs.ornl.gov/radionuclides/download.shtml
MCL for each beta/photon emitter is based upon and average annual concentration which produces an annual dose equivalent of 4 mrem/year.
*MDA was greater than radiological MCL/PRG.
+Isotopic activities of naturally occurring uranium equivalent to the 30.0 µg/L MCL for total uranium (Rucker 2001).

2005 Water Disposal from L-Area

In 2005, 13,400 gallons of waste water (containing about 680 curies) from L-Area was transferred to the 105-C DB. The water was sampled for beta/gamma emitting radioisotopes prior to transfer to the 105-C DB. The radiological concentrations of constituents detected in the water from L-Area are listed in Table 8.

Table 8 2005 Data Summary for Radiological Content of L-Area Water Disposal

Isotope	Concentration (pCi/L)
Carbon-14	5.34E+07
Cesium-137	2.31E+04
Cobalt-60	1.70E+03
Tritium	1.33E+10

2009 Basin Water Data

A single water sample was collected on April 6, 2009 from the 105-C DB. The basin water was analyzed for TCL volatile and TAL analytes plus a radiological suite. The 2009 sampling plan did not contain the same list of analytes as the 2002 sampling event and is more comprehensive than the 2002 list of analytes. The 2009 water data includes the 2001/2002 settler tank sediment and 2005 L-Area additions into the 105-C DB. The 2009 water sample included Nickel-59 and Nickel-63. Strontium-90 was also detected in this sample at a concentration of 15,200 pCi/L.

In the 2009 sampling event, analytes may have detection limits (DLs) or minimum detected activities (MDAs) which exceed the respective PRGs or MCLs used for screening purposes in this EE/CA. Some DLs and MDAs may exceed screening limits because the analytical methods were based on data quality objectives (DQOs) for waste determination. These reporting limits were never intended to be compared to risk-based thresholds. The analytical results were intended to be compared to waste determination limits, waste acceptance criteria, or treatment requirements rather than drinking water standards or industrial worker screening levels. Regardless, one of the objectives of this EE/CA is to determine the basis for a removal action, comparisons have been made to industrial worker risk thresholds and drinking water criteria. In the following tables, the lower of the two PRGs for each isotope (example: Plutonium-239/240) was used for comparison purposes to be conservative. This approach ensures the lower of both radioisotopes are accounted for during the screening comparisons.

The results for detected and non-detected constituents in the 105-C DB basin water are listed in Tables 9, 10, and 11 and are compared to MCL/PRG and RSL values. The results of this sample are used later in the Human Health Risk Evaluation because it is the most recent sampling of the 105-C DB basin water; therefore, it is the most representative and reflects the current water quality.

Table 9 2009 Data Summary for Volatile Organic Analytes in the 105-C DB Water

Analyte (µg/L)	Qualifier	Result	DL	MCL/RSL	>MCL/RSL?
1,1,1-Trichloroethane	U	0	0.325	200	No
1,1,2,2-Tetrachloroethane	U	0	0.25*	0.067	
1,1,2-Trichloroethane	U	0	0.25	5	No
1,1-Dichloroethane	U	0	0.3	5	No
1,1-Dichloroethylene	U	0	0.3	7	No
1,2,4-Trichlorobenzene	U	0	0.3	70	No
1,2-Dibromo-3-chloropropane	U	0	0.3*	0.2	
1,2-Dibromomethane	U	0	0.25*	0.05	
1,2-Dichlorobenzene	U	0	0.25	600	No
1,2-Dichloroethane	U	0	0.25	5	No
1,2-Dichloropropane	U	0	0.25	5	No
1,3-Dichlorobenzene	U	0	0.25	NA	
1,4-Dichlorobenzene	U	0	0.25	75	No
2-Butanone	U	0	1.25	7,100	No
2-Hexanone	U	0	1.25	47	No
4-Methyl-2-pentanone	U	0	1.25	2,000	No
Acetone	U	0	1.5	22,000	No
Benzene	U	0	0.3	5	No
Bromodichloromethane	U	0	0.25	80	No
Bromoform	U	0	0.25	80	No
Bromomethane	U	0	0.5	8.7	No
Carbon disulfide	U	0	1.25	1,000	No
Carbon tetrachloride	U	0	0.26	5	No
Chlorobenzene	U	0	0.25	100	No
Chloroethane	U	0	0.3	21,000	No
Chloroform	U	0	0.25	80	No
Chloromethane	U	0	0.3	190	No
cis-1,2-Dichloroethylene	U	0	0.3	70	No
cis-1,3-Dichloropropylene	U	0	0.25	NA	
Cyclohexane	U	0	0.3	13,000	No
Dibromochloromethane	U	0	0.26	80	No
Dichlorodifluoromethane	U	0	0.5	390	No
Ethylbenzene	U	0	0.25	700	No
Isopropylbenzene	U	0	0.25	680	No
Methyl acetate	U	0	1.25	37,000	No
Methylcyclohexane	U	0	0.25	NA	
Methylene chloride	U	0	2	5	No
Styrene	U	0	0.25	100	No
tert-Butyl-methyl ether	U	0	0.25	12	No
Tetrachloroethylene	U	0	0.45	5	No
Toluene	U	0	0.25	1,000	No
trans-1,2-Dichloroethylene	U	0	0.3	100	No
trans-1,3-Dichloropropylene	U	0	0.25	NA	
Trichloroethylene	U	0	0.25	5	No
Trichlorofluoromethane	U	0	1	1,300	No
Vinyl chloride	U	0	0.5	2	No
Xylenes Total	U	0	0.6	10,000	No

RSL values from November 2010 listing from USEPA website http://epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
*DL exceeds MCL/RSL

Table 10 2009 Data Summary for Metallic Analytes in the 105-C DB Water

Analyte (µg/L)	Qualifier	Result	DL	MCL/RSL	>MCL/RSL?
Aluminum	U	26.7	680	37,000	No
Antimony	U	-2.0	30*	6	
Arsenic	U	-4.44	50*	10	
Barium	J	15.8	10	2,000	No
Beryllium	U	1.47	10*	4	
Cadmium	U	2.62	10*	5	
Calcium		11,700	300	NA	
Chromium	U	5.69	20	100	No
Cobalt	U	1.53	10	11	No
Copper	U	-14.8	30	1,300	No
Iron	U	20.4	250	26,000	No
Lead	U	6.21	25*	15	
Magnesium	U	373	850	NA	
Manganese	U	-2.17	20	NA	
Mercury	U	0.119	0.67	2	No
Nickel	J	14	10	730	No
Potassium		28,000	500	NA	
Selenium	U	17.5	50	50	No
Silver	U	3.46	10	180	No
Sodium		26,900	450	NA	No
Thallium	U	7.12	50*	2	
Vanadium	J	11.8	10*	2.6	Yes
Zinc	J	44.1	20	11,000	No

RSL values from November 2010 listing from USEPA website http://epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
*DL exceeds MCL/RSL

Table 11 2009 Data Summary for Radioisotopes for the 105-C DB Water

Analyte (pCi/L)	Qualifier	Result	DL	MCL/PRG	>MCL/PRG?
Actinium-228	U	5.97	15.9	26.6	No
Americium-241	U	-0.0575	0.616	15	No
Americium-243	U	0.0352	0.698	15	No
Antimony-124	U	3.51	10	60	No
Antimony-125	U	-9.61	110	300	No
Barium-133	U	-17.5	43.6	7.77	No
Bismuth-212	U	-12.9	29.4	74.5	No
Bismuth-214	U	-13.6	41.7	276	No
Californium-249	U	5.7	43	15	No
Californium-251	U	-45.8	119	15	No
Carbon-14		1,700	42.3	2,000	No
Cerium-141	U	-7.64	51.2	300	No
Cerium-144	U	-54.7	193	1.5	No
Cesium-134	U	1.87	5.34	80	No
Cesium-137		36,100	19.5	200	Yes
Cobalt-57	U	9.06	24.7	1,000	No
Cobalt-58	U	-1.56	3.64	9,000	No
Cobalt-60	U	51	4.18	100	No
Curium243/244	U	0.0383	0.454	15	No
Europium-152	U	7.19	96.9	60	No
Europium-154	U	-4.3	8.92	200	No
Europium-155	U	1.77	98.9	60	No
Gross Alpha		119	2.69	15	Yes
Gross Beta		41,200	3.93	NA	
Iodine-129	U	1.33	1.7	1	Yes
Iodine-131	UV	1.62	0.47	3	No
Lead-212	U	-7.07	53.5	2.12	No
Manganese-54	U	0.495	3.79	300	No
Neptunium-237	U	0.508	0.738	15	No
Neptunium-239	U	31.3	186	300	No
Nickel-59	U	-2.96	21.3	300	No
Nickel-63	J	371	257	50	Yes
Niobium-94	U	1.33	3.8	6.81	No
Plutonium-238	U	2.41	0.423	15	No
Plutonium-238/239	J	1.69	0.423	15	No
Plutonium-241	U	6.04	28.2	30.1	No
Plutonium-242	U	0.163	0.828	15	No
Potassium-40	U	18.5	55.8*	2.14	
Promethium-144	U	0.952	4.04	15.8	No
Promethium-146	U	7.76	56.8	12.7	No
Protactinium-233	U	-5.23	62.8	300	No
Radium-226	U	0.263	0.532	5	No
Radium-228		18.4	1.97	5	Yes
Ruthenium-103	U	-0.865	37	200	No
Ruthenium-106	U	-2.6	201	30	No
Selenium-79	U	-2.9	117	7.26	No
Sodium-22	U	-1.61	3.15	400	No
Strontium Total		15,700	1.97	NA	No
Strontium-90		15,200	1.11	8	Yes
Technetium-99	U	63.5	291	900	No
Thallium-208	U	-0.653	24.9	NA	No
Tin-113	U	-3.86	46.6	300	No
Tin-126	U	-16.1	61.2	2.07	No
Tritium		7.90E+07	16,100	20,000	Yes
Uranium-232	U	0.00678	1.11	0.181	No
Uranium-233/234		13.6	1.28	10.0+	Yes
Uranium-235/236	J	2.63	1.08	0.47+	Yes
Uranium-238	U	0.876	1.07	10.0+	No
Yttrium-88	U	-0.509	3.34	12.7	No
Zinc-65	U	0.132	8.99	300	No
Zirconium-95	U	3.39	7.35	200	No

*DL exceeds MCL/PRG
PRG values from December 2010 listing from USEPA website http://epa-prgs.ornl.gov/radionuclides/download.shtml
MCL for each beta/photon emitter is based upon and average annual concentration which produces an annual dose equivalent of 4 mrem/year.
+Isotopic activities of naturally occurring uranium equivalent to the 30.0 µg/L MCL for total uranium (Rucker 2001).

2009 Water Data for Emergency Cooling System Tank Water

The ECS Tank contains tritiated water. The concentrations of analytes detected in the water from the ECS Tank are listed in Table 12. The ECS Tank was sampled for complete Target Analyte List, Target Compound List (TAL/TCL), and a radiological suite of analytes on August 26, 2009. The Emergency Cooling System Tank water is proposed to be pumped into the 105-C DB and evaporated with the basin liquid.

Table 12 Data Summary for ECS Tank Water Sample Results

Analyte	Result	ssEQL	Qualifier	MCL/RSL/PRG	>MCL/RSL/PRG
Arsenic	35.4	50*	UJ	10	
Barium	87.8	50		2,000	No
Boron	42.9	150	J	7,300	No
Calcium	2300	2000		NA	
Chromium	10.9	50	J	100	No
Iron	336	1000	J	26,000	No
Magnesium	326	150		NA	
Nonvolatile Beta	16	3.1		NA	
Potassium	60900	3000		NA	
Potassium-40	74.8	190.1	J	2.14	Yes
Sodium	36300	2500		NA	
Strontium	46.3	100	J	22,400	No
Thallium	4.75	10	J	2	Yes
Toluene	2.18	1		1,000	No
Tritium	2,030,000	81000.03		20,000	Yes

Units in µg/L except radioisotopes which are pCi/L
RSL values from November 2010 listing from USEPA website http://epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
*ssEQL exceeds MCL/RSL/PRG.

2010 Cask Additions

In 2010 two casks (radiological material containers) used for transporting radiological material were to be rinsed with water and drained into the disassembly basin. Both casks contained a total of 0.0176 curies of tritium and 0.549 curies of Cesium-137. The total volume of water added to the basin is unknown but is estimated to be several hundred gallons which is negligible when compared to the basin volume of 2.7 million gallons. Based on the 2009 water sampling results, the total tritium activity of the basin water was 813 curies. With the addition of 0.0176 curies from the casks, the total tritium activity is now approximately 813.02 curies. Based on the 2009 water sampling results, the total Cesium-137 activity of the basin water was 0.372 curies. With the addition of 0.549 curies from the casks, the total Cesium-137 content would increase to 0.921 curies.

Human Health Risk Evaluation

The result from the water sample collected from the disassembly basin in April 2009 was used for the Human Health Risk Evaluation. This evaluation and the data processing are presented in Appendix C, *Streamlined Risk Evaluation*. A summary of the human health risk assessment is presented below. The risk from exposure to the ECS tank water was not calculated because the risk exposure from tank water is insignificant when compared to the risk from the basin water. The tritium concentrations in the disassembly basin are forty times greater than the ECS tank water.

Table 13 105-C Disassembly Basin Water External Exposure Risk

Future Industrial Worker Scenario

Analyte	Result[a] (pCi/L)	Converted Result[b] (pCi/ml) (pCi/g)	External Exposure PRG[c] (pCi/g)	External Exposure Risk[d]	COC?[e]
C-14	1.70E+03	1.70E+00	2.68E+04	6.34E-11	
Co-60	5.10E+01	5.10E-02	6.43E-02	7.93E-07	
Cs-137 (+D)	3.61E+04	3.61E+01	1.15E-01	3.14E-04	COC
H-3	7.90E+07	7.90E+04	na	na	
Ni-63	3.71E+02	3.71E-01	na	na	
Pu-238	2.41E+00	2.41E-03	2.97E+03	8.11E-13	
Pu-239/240	1.69E+00	1.69E-03	9.75E+02	1.73E-12	
Sr-90 (+D)	1.52E+04	1.52E+01	1.32E+01	1.15E-06	COC
U-233/234	1.36E+01	1.36E-02	1.99E+02	6.83E-11	
U-235/236	2.63E+00	2.63E-03	3.91E-01	6.73E-09	
External Exposure Risk Total =				**3.16E-04**	

a- Results from table Appendix C, Table C-1
b- Results converted to pCi/g, assumes 1ml water = 1g
c- PRG from Appendix C, Attachment 1
d- Risk = (Converted Result / PRG) x 1E-06
e- Constituent identified as a COC if risk > 1E-06

Table 14 105-C Disassembly Basin Water Inhalation Risk

Future Industrial Worker Scenario

Analyte	Result[a] (pCi/L)	Converted Result[b] (pCi/ml) (pCi/g)	Inhalation PRG[c] (pCi/g)	Inhalation Risk[d]	COC?[e]
H-3 (organic)	7.90E+07	7.90E+04	1.41E+00	5.60E-02	COC
H-3 (vapor)	7.90E+07	7.90E+04	4.99E+00	1.58E-02	COC

a- Results from table Appendix C, Table C-1
b- Results converted to pCi/g, assumes 1ml water = 1g
c- Organically bound H-3 PRG from Ap pendix C, Attachment 2; vapor phase H-3 PRG per calculation
d- Risk = (Converted Result / PRG) x 1E-06
e- Constituent identified as a COC if risk > 1E-06

Table 15 105-C Disassembly Basin Water Total Cumulative Risk

Future Industrial Worker Scenario

COC[a]	Result (pCi/L)	Converted Result (pCi/ml) (pCi/g)	External Exposure Risk[b]	Inhalation Risk[c]	Total Risk[d]
Cs-137 (+D)	3.61E+04	3.61E+01	3.14E-04	na	3.14E-04
Sr-90 (+D)	1.52E+04	1.52E+01	1.15E-06	na	1.15E-06
H-3 (vapor)	7.90E+07	7.90E+04	na	1.58E-02	1.58E-02
					Total Cumulative Risk = 1.61E-02

a- COCs from Appendix C, Tables C-2 and C-3. Vapor-phase H-3 assumed (Table C-3)
b- External exposure risk from Table C-2
c- Inhalation risk from Appendix C, Table C-3
d- Total risk = external exposure risk + inhalation risk

Conclusion

The total cumulative risk to the future industrial worker from all pathways is 1.6E-02. Quantitatively, the risk evaluation indicates the disassembly basin water exceeds the USEPA carcinogenic target risk range of 1.0E-06 to 1.0E-4 for the industrial worker and there is basis to proceed with the removal action for the 105-C DB. The DB water can also be considered principal threat source material (PTSM), as the risk exceeds the 1.0E-03 toxicity risk threshold that defines PTSM.

Based on the 2002 basin sediment characterization data, Americium-241, Carbon-14, Cesium-137, Cobalt-60, Curium-244, Europium-154, Plutonium-238, Strontium-90, and tritium mean activities exceeded their respective radiological PRG in the 105-C DB.

Based on 2009 water sample data, Thallium and Vanadium exceeded their respective MCL/RSL. Based on the 2009 water sample data, Cesium-137, Gross Alpha, Nickel-63, Radium-228, Strontium-90, tritium, Uranium-233/234, and Uranium-235/236 exceeded their respective radiological drinking water MCL/PRG. Because the previously listed analytes exceed their respective MCL/RSL/PRG, there is a possibility of exceeding drinking water standards in groundwater if there was ever a release of basin water into the environment.

Based on the 2002 analytical data and sediment volume estimate there are an estimated 17.5 curies of radioactivity present in the basin sediment. Based on the 2009 analytical data and water volume estimate there is 814 curies of radioactivity present in the basin water. Based on a refined volume estimate of 300,000 gallons of water from the settler tank, ECS tank, sand filter, and other sources there is approximately 2.3 curies of radioactivity present in miscellaneous water sources.

One data gaps were identified after evaluation of the characterization information:

1. An estimate of the total curie inventory of activated reactor components and scrap metal should be performed.

The total curie inventory for the activated reactor components and scrap metal will be used to develop a comprehensive radiological inventory for the disassembly basin to perform a fate and transport analysis.

3.0 REMOVAL ACTION SCOPE AND OBJECTIVES

The removal action scope and objectives for this RSER/EE/CA are consistent with those removal objectives listed in the *Early Action Record of Decision Remedial Alternative Selection for the C-, K-, L-, and R-Reactor Complexes* (SRNS 2009a). The basic premise of ISD is that the most cost-effective approach to isolating and containing residual radioactivity from past nuclear operations is internment of the radiological contamination in place to allow natural radioactive decay to reduce hazards to manageable levels. This method limits release of radiological contamination to the environment, minimizes radiation exposure to workers, prevents human access to hazardous substances, and allows for ongoing monitoring of the decommissioned facility. The

details of how ISD will be implemented at the C-Reactor Building Complex will be determined in a future decision document at the time the Reactor Complex is addressed. However, for the removal alternative proposed in this RSER/EE/CA for the 105-C DB, the existing water will be removed from the disassembly basin and the below-grade structure of the disassembly basin will be grouted. Since the C-Reactor Building Complex is being preserved because of its historical significance, the above-grade portions of the disassembly basin structure (including the roof and walls) will remain intact. Preservation of the roof will also prevent the infiltration of precipitation into the disassembly basin. This action is expected to be consistent with the final ISD remedy for the C-Reactor Building Complex.

3.1 Justification for the Proposed Removal Action

USDOE, as the lead agency, is mandated to take action to reduce the adverse effects of man-made contamination on human health and the environment. The NCP states that if the lead agency determines a release or potential release poses a threat to public health or welfare or the environment, the lead agency may take any appropriate removal action to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release. This determination is based on the criteria identified in 40 CFR Section 300.415(b) (2).

The 105-C DB subunit of the CAOU is a candidate for a removal action to reduce risk to human health and the possible release of contaminants into the environment. The elevated levels of hazardous substances (radioisotopes and metals) meet the criteria in 40 CFR Section 300.415(b) (2) *(iv.)*. - Hazardous substances or pollutants or contaminants in drums, barrels, tanks, or other bulk storage containers that may pose a threat of release. In this case, the release of water within the 105-C DB can mobilize radioisotopes and metals which could potentially migrate to the aquifer and contaminate the groundwater and exceed MCLs. The basin water needs to be removed and the remaining sediment and reactor components need to be stabilized/isolated by grouting to prevent unacceptable radiation exposure to the future industrial worker.

3.2 Removal Action Objectives

The removal action objectives listed below are consistent with the *Early Action Record of Decision for Remedial Alternative Selection for the C-, K-, L-, and R-Reactor Complexes* (SRNS 2009a):

- Prevent the migration of radionuclides from the disassembly basin structure, water, and/or sludges to the groundwater at concentrations that exceed regulatory standards (i.e., MCLs) to the extent practicable.

- Prevent industrial worker exposure to disassembly basin water, sludge, and activated reactor components and metal scrap exceeding 1E-06 industrial worker risk and 1E-03 PTSM risk thresholds.

- Prevent adverse impact to the historical significance of the 105-C Reactor Building by preserving its original configuration to the extent practicable while protecting human health and the environment.

It is anticipated the preferred removal action for the 105-C DB will be In Situ Decommissioning (ISD). This remedy would leave hazardous substances in place that pose a potential future risk and will require land use restrictions for an indefinite period of time. Given that the 105-C DB is a portion of the C-Reactor Building Complex, the disassembly basin will be in the area that will be managed by land use controls for the C-Reactor Building Complex as described in the early action LUCIP (SRNS 2009c).

4.0 IDENTIFICATION OF REMOVAL ACTION ALTERNATIVES

In accordance with CERCLA, the following alternatives for the 105-C DB removal action were evaluated:

- **Alternative 1 – No Action**: Contaminated water, sediment, activated reactor components, and scrap metal in the 105-C DB remain in their present state without implementation of a removal action. The "No Action" alternative is required to be evaluated by the NCP as a baseline for alternatives comparison.

- **Alternative 2 - In Situ Decommissioning (ISD) and Basin Water Removal by Forced Evaporation.** Alternative 2 consists of transferring water from the sand filter, settler tank, ECS tank, and other sources (such as 106-C, 107-C and 109-C structures - estimated 300,000 gallons) to the 105-C DB for forced evaporation and In Situ Decommissioning of the disassembly basin. Water from miscellaneous sources associated with waste water and storm water from within C-Reactor Operable Unit may also be directed to the disassembly basin for treatment as part of this removal action. Evaporation will address the volatile radioisotopes present in the

water, primarily tritium. Those radioisotopes that are present as dissolved ions, such as Strontium-90 and Cesium-137, will remain in the returns after evaporation and will ultimately be returned back to the basin. ISD will consist of stabilization/isolation of remaining contaminated water, sediment, activated reactor equipment, and scrap metal by filling the DB, including the four deep wells, with flowable, nonstructural grout. The roof over the DB would be preserved for historical significance and would also prevent the infiltration of precipitation. Evaporation is a form of treatment that will reduce the volume of contaminated basin water. Irradiated materials and sediment will be treated by solidification/isolation thus reducing their mobility and reducing radiation exposure of future industrial workers, and creating an engineered barrier to prevent access to the contaminants by the future industrial worker and intruders. The grouting in the basin will also provide a low permeability barrier to retard pore-water velocity beneath the basin, thus minimizing any potential transport of contaminants to the aquifer. It is anticipated that the volume of water to be evaporated is approximately 3.0 million gallons, assuming 2.7 million gallons currently in the disassembly basin and an estimated additional 300,000 gallons from other sources. It is anticipated that the disassembly basin water will be evaporated to a level of about -16 feet below grade, which will provide shielding to protect removal action workers from external exposure to irradiated scrap present at the -17 foot level. An underwater grout will then be used to first fill the basin to the -16 foot elevation. Then any residual water and evaporator returns will be incorporated into the final grout. Finally, the grout will be filled to the base of the wooden floors over the basin compartments. The dewatering and grouting sequencing details for the disassembly will need to be kept flexible because of radiological conditions and basin configuration within the facility.

A preliminary National Emission Standards for Hazardous Air Pollutants (NESHAPs) evaluation was performed to determine whether emissions from the evaporators would be protective of a maximally exposed individual located at the SRS boundary. The total amount of radioisotopes released to the atmosphere from forced evaporation has an estimated potential effective dose equivalent (PEDE) of 0.036 mrem/year at the site boundary, which is less than the regulatory threshold of 0.1 mrem/year established by NESHAPs and South Carolina Department of Health and Environmental Control air pollution regulations. The fate of all radioactive isotopes is conservatively assumed to be 100% dispersible in ambient air, although only tritium would be 100% dispersible. Based on these assumptions, Cesium-137 is the primary contributor (78%) of the PEDE (0.028 mrem/year of the total 0.036 mrem/year); and tritium contributes 5%. Thus, the risk to the public or ecological receptor from exposure to radioisotopes is extremely low since the evaporator emission dose is so low (0.036

mrem/year). The evaporator emissions (water vapor) will flow to a stack designed to an adequate height to disperse emissions and minimize worker exposure.

- **Alternative 3 –In Situ Decommissioning (ISD) and Removal of Basin Water by Trucking to the Effluent Treatment Project (ETP).** This alternative differs from Alternative 2 because instead of forced evaporation; the contaminated water in the DB, sand filter, settler tank, and ECS tank or other sources would be pumped to tanker trucks and treated in the Effluent Treatment Project (ETP) at SRS. ETP is a permitted facility which discharges to Upper Three Runs Creek and ultimately drains into the Savannah River. The removal action would proceed as above in Alternative 2, only contaminated basin water would be removed by trucking to ETP instead of being evaporated. It is anticipated that the volume of water to be trucked is approximately 3.0 million gallons, assuming 2.7 million gallons currently in the disassembly basin and as estimated additional 300,000 gallons from other sources. It is anticipated that the disassembly basin water will removed to a level of about -16 feet below grade, which will provide shielding to protect removal action workers from external exposure to irradiated scrap present at the -17 foot level. An underwater grout will then be used to first fill the basin to the -16 foot elevation. Then any residual water and evaporator returns will be incorporated into the final grout. Finally, the grout will be filled to the base of the wooden floors over the basin compartments. The dewatering and grouting sequencing details for the disassembly will need to be kept flexible because of radiological conditions and basin configuration within the facility.

Alternatives 2 and 3 are consistent with the additional work and remediation activities that will be conducted within the CAOU as a part of area closure. Alternatives 2 and 3 are specific for the 105-C DB and do not apply as a final remedy for the entire CAOU.

Since this RSER/EE/CA is not a final action for the CAOU and only pertains to the removal action for the 105-C DB, Land Use Controls (LUCs) are not included as part of the removal action, but will be included in the final Record of Decision for the CAOU. Given that the 105-C DB is a part of the 105-C Reactor Building Complex, the disassembly basin will be managed using the existing LUCs identified in the early action LUCIP (SRNS 2009c).

5.0 ANALYSIS AND COMPARISION OF REMOVAL ACTION ALTERNATIVES

Alternatives 1, 2, and 3 are evaluated in this RSER/EE/CA alternatives analysis. According to the NCP, the No Action Alternative, Alternative 1, must be evaluated as a baseline condition for comparison to the other alternatives. The removal actions, Alternatives 2 and 3, propose to remove the contaminated DB water and stabilize the remaining basin water, sediment, activated reactor equipment, and scrap metal.

Guidance on conducting NTCR actions under CERCLA recommends that each alternative be reviewed against three broad criteria: effectiveness, implementability, and cost.

Regulatory acceptance and community acceptance are usually not known until after the comment periods. However, during the alternative analysis a judgment as to acceptance may be included based on previous regulatory decisions or on public comment to other related documents. Evaporation of the DB water and grouting of the below-grade portion of the DB was previously agreed to by USDOE, USEPA, and SCDHEC (WSRC 2008) for the closure of the 105-P disassembly basin. The final impact of these modifying criteria can be assessed only after the comment period and after subsequent responses are developed.

5.1 Effectiveness

Alternative 1, No Action, does not meet the effectiveness criteria. Leaving the 105-C DB without remedial action does not reduce the risk of radiation exposure of the future industrial worker and does not mitigate the potential of a release of contaminants to the aquifer; therefore, it does not provide overall protection of human health or the environment. The basin water is a potential threat for groundwater contamination, since the water is both contaminated and a mobile source of contaminants. If a release of basin water occurred, it would readily transport contaminants to the aquifer and potentially exceed MCLs in groundwater. This alternative does not contribute to a reduction of toxicity, mobility, or volume and no treatment is involved. In summary, the levels of radioisotopes of reactor equipment, scrap metal, sediment, and contaminated water in the 105-C DB exceed the CERCLA target risk range for future workers, so the No Action alternative would not be acceptable to USEPA and SCDHEC.

Alternative 2, ISD with Forced Evaporation of Basin Water, meets the effectiveness criteria. Alternative 2 is composed of two components: 1.) transferring water from the sand filter, settler tank, ECS tank, and other sources (about 300,000 gallons) to the 105-C DB for forced evaporation and 2.) In Situ Decommissioning of the disassembly basin. ISD will consist of stabilization and isolation of any

remaining contaminated water, sediment, or activated metal by filling the DB including the deep wells, with flowable, nonstructural grout. Water from miscellaneous sources associated with waste water and storm water from within C-Reactor Operable Unit may also be directed to the disassembly basin for treatment as part of this removal action. The roof over the disassembly basin would be preserved for historical significance and would also prevent the infiltration of precipitation. Removal of contaminated basin water and grouting the disassembly basin will isolate all the activated reactor components, scrap metal, and sediment.

Under this alternative the water from the disassembly basin, sand filter, settler tank, and Emergency Cooling System (ECS) Tank and other sources would be evaporated. Evaporation is a method to reduce the volume of contaminated water. A preliminary National Emission Standards for Hazardous Air Pollutants (NESHAPs) evaluation was performed to determine whether emissions were protective of a maximally exposed individual located at the SRS boundary. The total amount of radioisotopes released to the atmosphere from forced evaporation has an estimated potential effective dose equivalent (PEDE) of 0.036 mrem/year at the site boundary, which is less than the regulatory threshold of 0.1 mrem/year established by NESHAPs and South Carolina Department of Health and Environmental Control air pollution regulations. The fate of all radioactive isotopes is conservatively assumed to be 100% dispersible in ambient air, although only tritium would be 100% dispersible. Based on these assumptions, Cesium-137 is the primary contributor (78%) of the PEDE (0.028 mrem/year of the total 0.036 mrem/year); and tritium contributes 5%. Thus, the risk to the public or ecological receptor from exposure to radioisotopes is extremely low since the evaporator emission dose is so low (0.036 mrem/year). The evaporator emissions (water vapor) will flow to a stack designed to an adequate height to disperse emissions and minimize worker exposure. Activated metals and sediment will be treated by grout stabilization thus reducing their mobility and reducing radiation exposure of future industrial workers and creating an engineered barrier to prevent exposure to contaminants by the future industrial worker or intruders. Basin grouting and preservation of the above-grade disassembly basin structure (roof) will also provide a barrier to reduce infiltration through the basin, thus minimizing any potential transport of contaminants to aquifer.

Alternative 3, ISD and Removal of Basin Water by Trucking to the Effluent Treatment Project (ETP), does not meet the effectiveness criteria. The only difference between Alternative 3 and Alternative 2 is the method of contaminated water removal from the disassembly basin. Alternative 3 proposes to remove about 3 million gallons of tritiated water from the disassembly basin, sand filter, settler tank, ECS tank, and other sources by pumping to tanker trucks and transporting the contaminated

water to the ETP. ETP is a SCDHEC permitted waste water facility. The contaminated water may be treated at ETP and discharged in accordance with National Pollution Discharge Elimination System permit requirements.

The discharge limits are contained in the National Pollution Discharge Elimination System permit SC0000175, outfall designation TH1 and the ETP Waste Acceptance Criteria. The basin water, when processed, will meet the specified permit limits for chemical constituents; however, the basin water exceeds the Waste Acceptance Criteria for tritium. ETP has a decontamination factor of 20 which corresponds to a removal efficiency of 95 percent. Since the volume of contaminated water is reduced and the basin is grouted to grade level, Alternative 3 provides the same level of effectiveness as Alternative 2 for chemicals, but is not effective for tritium. Since there is no feasible technology to treat or destroy the volume of tritiated water, tritium concentrations in the Savannah River would be expected to increase.

5.2 Identification of ARARs

In accordance with the NCP [40 CFR 300.415(j)] and USDOE guidance, onsite removal actions conducted under CERCLA are required to meet applicable or relevant and appropriate requirements (ARARs) "to the extent practicable, considering the exigencies of the situation." ARARs include only federal and state environmental or facility siting laws or regulations; they do not include occupational safety or worker radiation protection requirements. Additionally, according to 40 CFR 300.405(g)(3), other advisories, criteria, or guidance may be considered in determining remedies, the so-called "to-be-considered" (TBC) category.

Under Section 121 of CERCLA, any material remaining on site must reach a level or standard of control equal to that of any other applicable or relevant and appropriate standard or requirement promulgated under any federal or more stringent state environmental statute. The term "promulgated" means that the requirement generally is applicable and legally enforceable. The ARAR concept is pertinent only to onsite actions; offsite actions must comply with all applicable federal and state requirements. A requirement under other environmental laws may be either "applicable" or "relevant and appropriate," but not both. The first step in identifying ARARs is to determine if a requirement is applicable.

ARARs are identified for the 105-C DB NTCR action in Appendix A. This RSER/EE/CA does not propose to waive any ARARs. As previously stated, the final disposition of the entire 105-C Reactor

Building will be addressed as part of the CAOU area completion activities. The *Early Action Record of Decision for the C-, K-, and L-Area Reactor Complexes* (SRNS 2009) selected In Situ Decommissioning as the action for these facilities and identified preliminary ARARs.

Consideration of NEPA Values

This RSER/EE/CA conforms to USDOE policy (i.e., DOE Order 451.1B, "National Environmental Policy Act Compliance Program") to incorporate NEPA values in USDOE CERCLA documents. Human health risk evaluation has been performed as prescribed by USEPA risk assessment guidance and SRS protocols in this document. CERCLA risk evaluation and the associated RAOs are protective of hypothetical future workers at the site, and thus are necessarily protective of offsite receptors. Any potential environmental releases resulting from implementation of the preferred removal alternative would be minimal and limited to the vicinity of the project area. Impacts beyond the SRS boundary would be negligible, ensuring that there are no environmental justice concerns associated with the proposed removal action.

The 105-C Reactor Building qualifies as a historically significant structure within the SRS Cold War Historic District per Section 3.3.1.1 of the SRS's Cold War Built Environmental Cultural Resource Management Plan (CRMP) (DOE 1995).

In accordance with the Programmatic Agreement among the USDOE, South Carolina State Historic Preservation Office (SHPO), and the Advisory Council on Historic Preservation, the USDOE has the responsibility for the Cultural Management of all historic properties at SRS. As has been the case with previous SRS decommissioning projects, to the extent practicable and not to impact human health and the environment, efforts will be made to preserve the historical significance of the reactor complex in C-Reactor Area in accordance with the National Historic Preservation Act.

Furthermore, C-Reactor Area is of special interest because 13 excess facilities, including the 105-C Reactor Building, have been identified in the Savannah River Site's Cold War Built Environment Cultural Resources Management Plan (USDOE 2005). Since the CAOU project has not begun the planning and design phases for final closure, some uncertainty exists regarding the extent and details of preservation for the 13 facilities. Consistent with the Area Completion approach, CAOU planning and design efforts will address this uncertainty. At that time, the USDOE will have a better understanding of the site

characterization and risks, and can better formulate the engineering details of ISD to ensure protection of human health and the environment while preserving, to the extent practicable, the historic significance of those C-Area facilities.

The proposed removal action of the 105-C DB will protect human health and the environment from potential exposure to radioisotopes remaining in the disassembly basin and prevent intruder or industrial worker access to hazardous substances. The proposed removal action will not adversely impact the historical significance of the 105-C Reactor Building since the building itself will not be demolished and will remain unchanged in appearance with the exception of filling the disassembly basin with grout, which mitigates the associated hazards to human health and the environment. Since the C-Reactor Building must be preserved for historical significance it may also need to be protective of visitors since the preserved facility may be used as a museum in the future. Above-grade modifications to the interior of the disassembly basin needed to support construction activities related to dewatering and grouting of the basin will be minimized to the extent practicable and mitigated where necessary. For example, it is anticipated that holes will be drilled through the exterior concrete walls to allow for the DB water to be transferred to evaporators located outside the DB. These openings would be filled with concrete as part of the completion of the action.

The proposed removal action is located within a declared industrial land use area. Any previously existing archaeological or cultural resource(s) in the project area would have been destroyed by extensive land alterations and modern construction-related activities associated with development of the C-Area Reactor Complex. Implementation of the proposed removal action would have a negligible impact on SRS archaeological or cultural resources.

As one of many cleanup actions being proposed as part of the American Reinvestment and Recovery Act (ARRA) mission at SRS, implementation of the removal action for the 105-C DB will create an engineered barrier breaking the pathway between radioactive/hazardous substance sources and human or ecological receptors. Therefore, contaminated basin water removal and ISD would contribute cumulatively to reducing risk to site workers and the public. Additionally, the expenditure of funds for the proposed closure action would contribute cumulatively to an overall positive economic impact within the site's region of influence. It would also represent progress toward the completion of the 515 waste units and 15 areas where environmental restoration work is required under the Federal Facility Agreement at SRS.

In summary, the cumulative negative impacts associated with the proposed removal action are insignificant when compared to the beneficial effects, including protection of the environment, reduction of risk for potential on- and off-site receptors, and economic stimulus in proximity to SRS.

5.3 Implementability

Implementability of each alternative was assessed against the criteria below:

- Technical feasibility with regard to available techniques and demonstrated methods for accomplishing the proposed alternative
- Administrative feasibility with regard to operations personnel and other resources to complete the alternative's implementation; also the availability of specific equipment and technical specialists
- Regulatory acceptance of the preferred alternative
- Community acceptance of the preferred alternative. USDOE–Savannah River will provide for a public comment period, and comments concerning the proposed remedy will be incorporated into the comment responses and included with the action memorandum.

Alternative 1, No Action, is the current condition and, therefore, would not require any additional resources to implement.

Alternative 2, ISD with Forced Evaporation of Basin Water, can be implemented without any major technical, construction, or administrative impediments. Both fuel-oil fired evaporation and grouting equipment are readily available and the implementation techniques are fundamental and well understood.

Currently, the 105-P DB is undergoing a similar removal action using ISD and forced evaporation for dewatering. Lessons learned on the operation of the evaporators will be applied to the 105-C DB. Grout is a cement product and is readily available, easy to make, and simple to procure. The construction implementation for grout application is well established and the experience from grouting of the 105-P DB and 105-R DB can be transferred to the 105-C DB. Based on experiences from both 105-P and -R DBs, a specially formulated underwater flowable grout will be used. The grout has physical properties of density greater than water and is highly flowable to allow the grout to settle into the deep wells and fill voids present in the activated scrap and equipment.

In order to operate the evaporators, a preliminary NESHAPs evaluation was performed to determine whether emissions would be protective of the maximally exposed individual at the SRS boundary. The estimated amount of tritium to be released to the atmosphere is about 816 Ci, including the ECS tank water. The total amount of radioisotopes released to the atmosphere from forced evaporation has an estimated potential effective dose equivalent (PEDE) of 0.036 mrem/year, which is less than the regulatory threshold of 0.1 mrem/year established by NESHAPs and South Carolina Department of Health and Environmental Control air pollution regulations. Since the PEDE is less than the regulatory threshold established for releases of radionuclides, a permit for hazardous air emissions from the evaporators is not required and the evaporator equipment is exempt. An air pollution source permit and Industrial Wastewater Treatment permit will need to be obtained from the SCDHEC for operating the evaporators, monitoring emissions, and reporting purposes. However, all these tasks are feasible and were previously completed for P- and R-Areas and should present no impediment to implementation at the CAOU. Qualified personnel are currently available to operate and maintain the evaporators.

Alternative 2 is essentially the same ISD alternative as approved by both USEPA and SCDHEC for both the 105-P and 105-R disassembly basins. The major difference between Alternative 2 for 105-C DB and 105-P and -R DBs is the above grade disassembly basin section of the 105-C Reactor Building will be preserved at this time. The dewatering of the 105-P DB by forced evaporation was evaluated for the 105-P Reactor Building and was approved by the USEPA and SCDHEC as the preferred alternative for P-Area (WSRC 2008).

It is assumed since both 105-P and -R DBs used a similar action, the details of which were available for public comment, that this removal action will also be acceptable to the community as well as USEPA and SCDHEC.

Alternative 3, ISD with Removal of Basin Water by Trucking to the ETP, can be implemented without any major technical or transportation impediments. The only difference between Alternative 2 and Alternative 3 is the method of contaminated water removal from the disassembly basin. Alternative 3 proposes to pump the contaminated water from the disassembly basin, ECS tank, sand filter, and settler tank and other sources to tanker trucks which will transport the water to the ETP for treatment and eventual discharge. Both the trucking and grouting equipment are readily available and the implementation techniques are well understood and were previously employed to remove water for the 105-R DB.

The ETP has a National Pollutant Discharge and Elimination System permit SC0000175. The transfer equipment, pumps, trucks, and capacity of the ETP are available to make this portion of the removal action feasible.

Administratively and technically, there is an impediment to dewatering the basin by trucking and subsequent treatment at ETP. The DB water does not meet the waste acceptance criteria for tritium. Based on a preliminary evaluation comparing the ETP Radiological Waste Acceptance Criteria to the basin water analytical data from the 105-C DB, the result indicates the basin water exceeds the ETP waste acceptance criteria for tritium. Unacceptability for treatment of tritium in basin water by ETP prevents the implementation of this alternative.

Regulatory acceptance for contaminated basin water disposal at ETP in Alternative 3 has a high probability of being unacceptable to USDOE, USEPA, and SCDHEC. If the basin water could meet the waste acceptance limits of the ETP, there will still be discharges of tritium from the ETP. Tritium activity within the basin water is on the order of 7.94E+07 pCi/L. If the volume of 2.7 million gallons of basin water is discharged via the ETP, there would be an estimated 814 curies of tritium released to Upper Three Runs Creek, which enters the Savannah River.

In addition to the tritium from the basin water, there is also about 300,000 gallons of tritiated water from the ECS tank proposed for dewatering, including contaminated water from the sand filter and settler tank and any additional water which may require disposal. The water within the ECS tank has been sampled once and was found to have a tritium activity of 2.03E+06 pCi/mL. Based on this concentration and volume, the contribution from all sources would be an estimated 2.3 curies of tritium discharged from the ETP to Upper Three Runs Creek and the Savannah River.

ETP tritiated water discharges are approximately 300 curies annually (SRNS 2009b). If the 105-C DB and other waste water sources are trucked to ETP for disposal, this would be an additional 816 curies of tritium discharged from ETP. The contribution from the 105-C DB and other water sources would increase total discharge from ETP by approximately 3-fold (approximately 814 curies from the DB, plus 2.3 curies from other sources) during the 1 year period of time the disassembly basin is being dewatered. The basin water does not meet the specified waste acceptance criteria for tritium.

There is high probability this dewatering disposal option will not be acceptable to USDOE, USEPA, or SCDHEC since the activity of tritium from the disassembly basin will cause an increase of tritium concentration in the downstream waters of the Savannah River. The communities downstream of SRS

have a high probability of finding the dewatering portion of Alternative 3 unacceptable, since their communities will be exposed to the increased tritium activity discharged to the Savannah River by SRS. Since some of the municipalities downstream have water system intakes on the Savannah River, it is assumed the dewatering portion of Alternative 3 is unacceptable by communities downstream of the discharge point.

5.4 Cost

The cost for Alternative 1 is $0 for the No Action alternative, while Alternative 2, ISD with Forced Evaporation of Basin Water is estimated to be approximately $19,741,979. Alternative 3, ISD with Basin Water Trucked to ETP has a lower estimated cost of approximately $11,414,403. Cost estimate details are provided in Appendix B.

The cost estimates for Alternatives 2 and 3 are based on an estimate for removal of 3 million gallons of contaminated water from the disassembly basin, sand filters, settler tank, and other miscellaneous waste water sources. Grout volume and construction costs in both Alternatives 2 and 3 are estimated to be the same and therefore, are identical in each estimate. Grouting is estimated for a basin volume of approximately 475,000 ft^3. Costs will vary depending upon the price of fuel oil for Alternative 2 and diesel fuel for Alternative 3.

- Alternative 1, No Action, $0
- Alternative 2, ISD with Forced Evaporation of Basin Water, $19,741,979
- Alternative 3, ISD with Basin Water Trucked to ETP, $11,414,403

5.5 Comparison of Removal Action Alternatives

A comparative evaluation of the alternatives is presented below.

Table 16 Comparative Analysis of Alternatives

	Effectiveness	Implementability	Cost
Alternative 1 No Action	Poor	Not Applicable	$0
Alternative 2 ISD with Forced Evaporation of Basin Water	Good	Good	$19,741,979
Alternative 3 ISD with Basin Water Trucked to ETP	Unacceptable	Unacceptable	$11,414,403

6.0 PREFERRED REMOVAL ACTION ALTERNATIVE

The preferred removal action is **Alternative 2, ISD with Forced Evaporation of Basin Water,** which meets the effectiveness, implementability, cost, and acceptance criteria better than Alternative 3.

Alternative 2 has "Good" effectiveness because removing contaminated basin water and stabilization of the remaining radioactive materials in the basin reduces contaminant volume and mobility. The grouting of the basin and deep wells will stabilize and isolate all the remaining radioactive materials and make an engineered barrier, thereby preventing radiation exposure to human receptors by breaking the exposure pathway. The stabilization also provides radiation shielding to remedial and industrial workers and retards pore-water velocity beneath the basin, delaying any potential contaminant transport to the aquifer and increasing the decay time in the vadose zone. Stabilization also constitutes treatment of the basin contents satisfying the USEPA "bias for treatment" requirement.

Implementability of Alternative 2 is rated "Good" because it is an engineering approach which creates a durable and long-term protective barrier. The evaporator equipment and the grouting equipment are readily available and there is not a need for highly skilled technical personnel or operators since the implementation employs standard construction implementation and operation methods. Additionally, SRS has significant construction experience in grouting the 105-P- and -R Reactor Buildings, 105-P and -R disassembly basins.

Regulatory and community acceptance of Alternative 2 is "Good" because both SCDHEC and USEPA have approved previous uses of ISD on PAOU and RAOU Area Completion Projects such as the 105-P and 105-R Reactor Buildings. There will be no adverse impact to the surrounding communities when Alternative 2 is implemented. There will be no significant physical change of the 105-C Reactor Building (except dewatering and filling the disassembly basin with grout to grade), thus preserving its architectural significance and original exterior appearance since the structure over the disassembly basin will not be demolished.

This alternative will not preclude any additional remediation of the CAOU and is consistent with the *Early Action Record of Decision Remedial Alternative Selection for the C-, K-, L-, and R-Reactor Complexes* (SRNS 2009a).

The waste streams generated as part of the selected alternative will be transported to the appropriate disposal facilities. The contaminated waste anticipated to be generated includes job control waste,

personal protective equipment, and miscellaneous items. Radioactive contaminated waste will be characterized in accordance with USDOE requirements for disposal and will be sent to the SRS E-Area LLWF where CERCLA Off-Site Rules are approved. Prior to the transfer of these wastes to their final disposal facility, SRS will obtain an acceptability determination from the appropriate Regional Off-site Rule Coordinator for disposal of CERCLA waste.

7.0 IMPLEMENTATION SCHEDULE

This RSER/EE/CA will be submitted to USEPA and SCDHEC for review and comment. The RSER/EE/CA will be available for public comment following this review. The removal action draft schedule is presented below:

Submit RSER/EE/CA for Regulatory Comment	September 30, 2010
Issue RSER/EE/CA for Public Comment	March 13, 2010
Submit Action Memorandum to USEPA and SCDHEC	May 10, 2011
Anticipated removal action start of RSER/EE/CA activity	May 10, 2011
Anticipated start of evaporation	September 21, 2011
Anticipated start of ECS Tank water transfer	March 26, 2012
Anticipated completion of evaporation	June 7, 2012
Anticipated completion of RSER/EE/CA activity	September 30, 2012
Submit Removal Action Report	March 30, 2013
Anticipated closeout letter issued	June 30, 2015

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9.0 APPENDICES

Appendix A. Potential ARARs and TBC Criteria for 105-C Disassembly Basin

Appendix B. Detailed Cost Estimates

Appendix C. Streamlined Risk Evaluation

10.0 GLOSSARY

Applicable or Relevant and Appropriate Requirement (ARAR): The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) requires compliance with any promulgated standard requirements, criteria, or limitation under Federal and more stringent State environmental laws. Examples include the Clean Water Act, Endangered Species Act, etc.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA): A Federal law, known as Superfund passed in 1980 and reauthorized by the Superfund Amendments and Reauthorization Act (SARA) in 1986. The law authorizes the Federal government to respond directly to releases of hazardous substances that may endanger public health or the environment.

Curie: A unit of radioactivity that represents the amount of radioactivity associated with one gram of radium. To say that a sample of radioactive material exhibits one curie of radioactivity means that the element is disintegrating at the rate of 37 billion times per second.

Deactivation: The process of placing a facility in a stable and known condition including the removal of hazardous and radioactive materials to ensure adequate protection of the worker, public health and safety, and the environment, thereby limiting the long-term cost of surveillance and maintenance. Actions include the removal of fuel, draining and/or de-energizing nonessential systems, removal of stored radioactive and hazardous materials, and related actions. Deactivation does not include all decontamination necessary for the dismantlement and demolition phase of decommissioning, e.g., removal of contamination remaining in the fixed structures and equipment after deactivation.

Decommissioning: Decommissioning is inclusive of activities that take place after a facility has been deactivated and placed in an ongoing surveillance and maintenance program. Decommissioning can include decontamination and dismantlement. Decontamination encompasses the removal or reduction of radioactive or hazardous contamination from facilities. Dismantlement involves the disassembly or demolition, and removal, of any structure, system, or component and the interim or long-term disposal of waste materials in compliance with applicable requirements.

Decommissioned Material (DM): Structural materials and soil from decommissioned radiological facilities that have been surveyed/sampled and determined to meet state and federal cleanup standards. These materials have therefore been determined to be suitable for unrestricted use. These materials may or may not have low levels of residual contamination exceeding background. In 2002, California issued a moratorium on the disposal of decommissioned material above background levels at Class III or unclassified (unlined) waste disposal sites.

Decontamination: The removal or reduction of residual radioactive and hazardous materials by mechanical, chemical or other techniques to achieve a stated objective or end condition.

Excess Cancer Risk: A figure that calculates the risk of contracting cancer on a probability scale based on current and future use exposure pathways (i.e., activities that may result in an individual contacting soil, sediment, etc.). Exposure pathways consider how frequently the individual is exposed to the constituent of concern (COC), the quantity of COC that is ingested, inhaled, or absorbed through skin contact, and the period of time for which the individual is exposed to the COC. Based on the NCP, the Environmental Protection Agency's (EPA) regulations for the evaluation of risk at Superfund sites, the acceptable excess cancer risk range for residential areas is from 10^{-4} (one in ten thousand) to 10^{-6} (one in a million excess risk of developing cancer).

Executive Order 12580: An order entitled "Superfund Implementation" signed on January 23, 1987 by the President of the United States. This document delegates authority and responsibility to implement certain provisions of CERCLA to a number Federal departments (including the Department of Energy (DOE)) and agencies.

Low-Level Waste (LLW): Low-level radioactive waste is defined as any radioactive waste that does not belong in one of the following three categories for radioactive waste: high-level waste (spent nuclear fuel or the highly radioactive waste produced if spent fuel is reprocessed), uranium milling residues, and waste with greater than specified quantities of elements heavier than uranium. Low-level radioactive waste is generated at commercial facilities such as nuclear power plants, hospitals, and research institutions. It includes radioactive materials used in various processes as well as supplies and equipment that have been contaminated with radioactive materials.

Low-Level Waste Disposal Site: Low-level waste disposal occurs at facilities licensed by the Nuclear Regulatory Commission (NRC). The facilities must be designed, constructed, and operated to meet safety standards. The operator of the facility must also extensively characterize the site on which the facility is located and analyze how the facility will perform for thousands of years into the future.

Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM): A document developed by the DOE, the Department of Defense (DOD), EPA, and NRC to provide detailed guidance for planning, implementing, and evaluating environmental and facility radiological surveys conducted to demonstrate compliance with a dose- or risk-based regulation. MARSSIM focuses on the demonstration of compliance during the final status survey following scoping, characterization, and any necessary remedial actions.

National Oil and Hazardous Substances Pollution Contingency Plan (NCP): The federal government's blueprint for responding to both oil spills and hazardous substance releases. The NCP is the result of our country's efforts to develop a national response capability and promote overall coordination among the hierarchy of responders and contingency plans.

Non-Time Critical Removal Action: This is a type of response action recognized by the EPA as appropriate for addressing hazardous substance threats where a planning horizon of six months or more is appropriate. Under an EPA/DOE agreement, DOE uses a non-time critical removal action approach tailored for decommissioning DOE facilities. That approach is comprised of: a threat assessment; identification, analysis, and documentation of decommissioning alternatives; opportunities for public participation in the decommissioning decision; and planning and performance of decommissioning activities.

Picocurie (pCi): One one-trillionth (1/1,000,000,000,000) of a curie.

Removal Action: When DOE identifies a threat of exposure to, or migration of, hazardous substances that poses a risk to health, welfare, or the environment, DOE is authorized by CERCLA to exercise removal action authority to implement an appropriate response to the risks posed. Activities that may be taken under CERCLA removal action authority include any activity that reduces risks or potential risks in a relatively short time frame and can be identified as appropriate with a relatively limited analysis of alternatives. Removal actions are not limited to immediate action, or action in response to an emergency. (See non-time critical removal action.)

Surveillance and Maintenance: These activities are conducted through-out the facility life cycle phase including when a facility is not operating and is not expected to operate again and continues until phased out during decommissioning. Activities include providing in a cost effective manner periodic inspections and maintenance of structures, systems and equipment necessary for the satisfactory containment of contamination and protection of workers, the public and the environment.

Survey Unit: A physical area consisting of structure or land areas of specified size and shape for which a separate decision will be made as to whether or not that area exceeds the release criterion. The size and shape of the survey unit are based on factors, such as the potential for contamination, the expected distribution of contamination, and any physical boundaries (e.g., buildings, fences, soil type, surface water body) at the site.

Principal Threat Source Material (PTSM): wastes are those source materials considered to be highly toxic or highly mobile and generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. If a contaminant poses a probability of more than 1 excess case of cancer in 1,000 (risk=1.0E-3) it is generally considered PTSM.

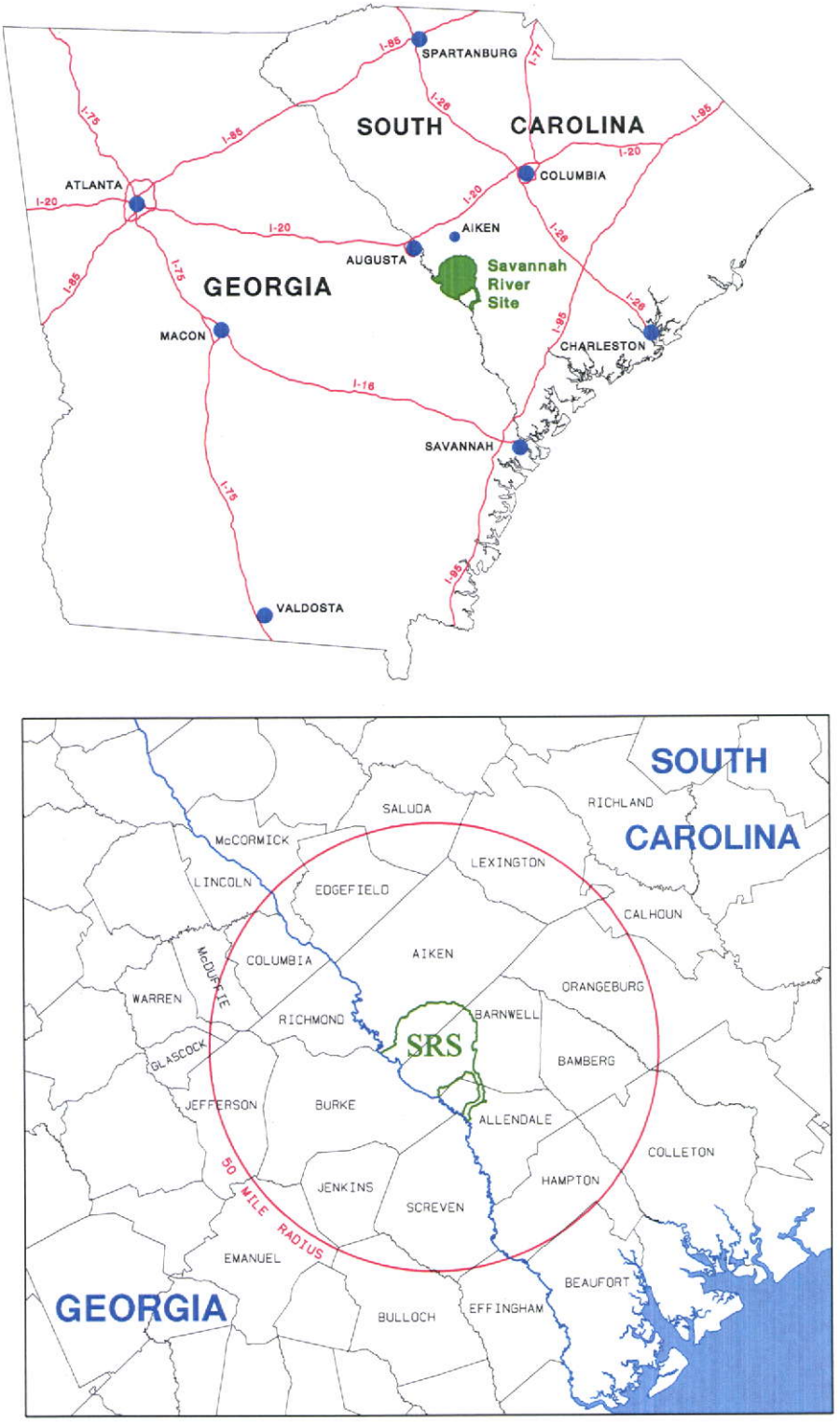

Figure 1. Location of the Savannah River Site

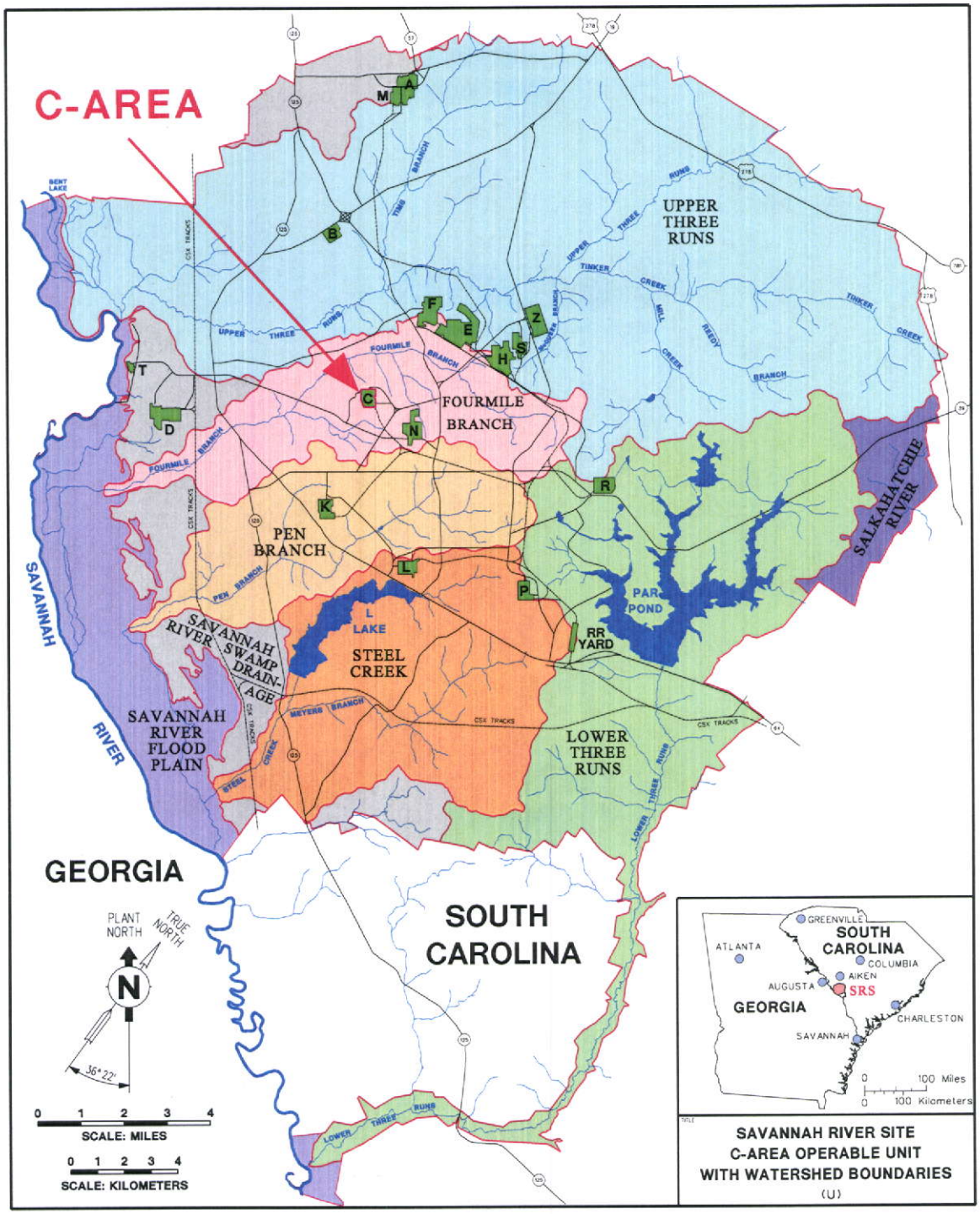

Figure 2. SRS Site Map Showing the Relative Location of C Area Operable Unit

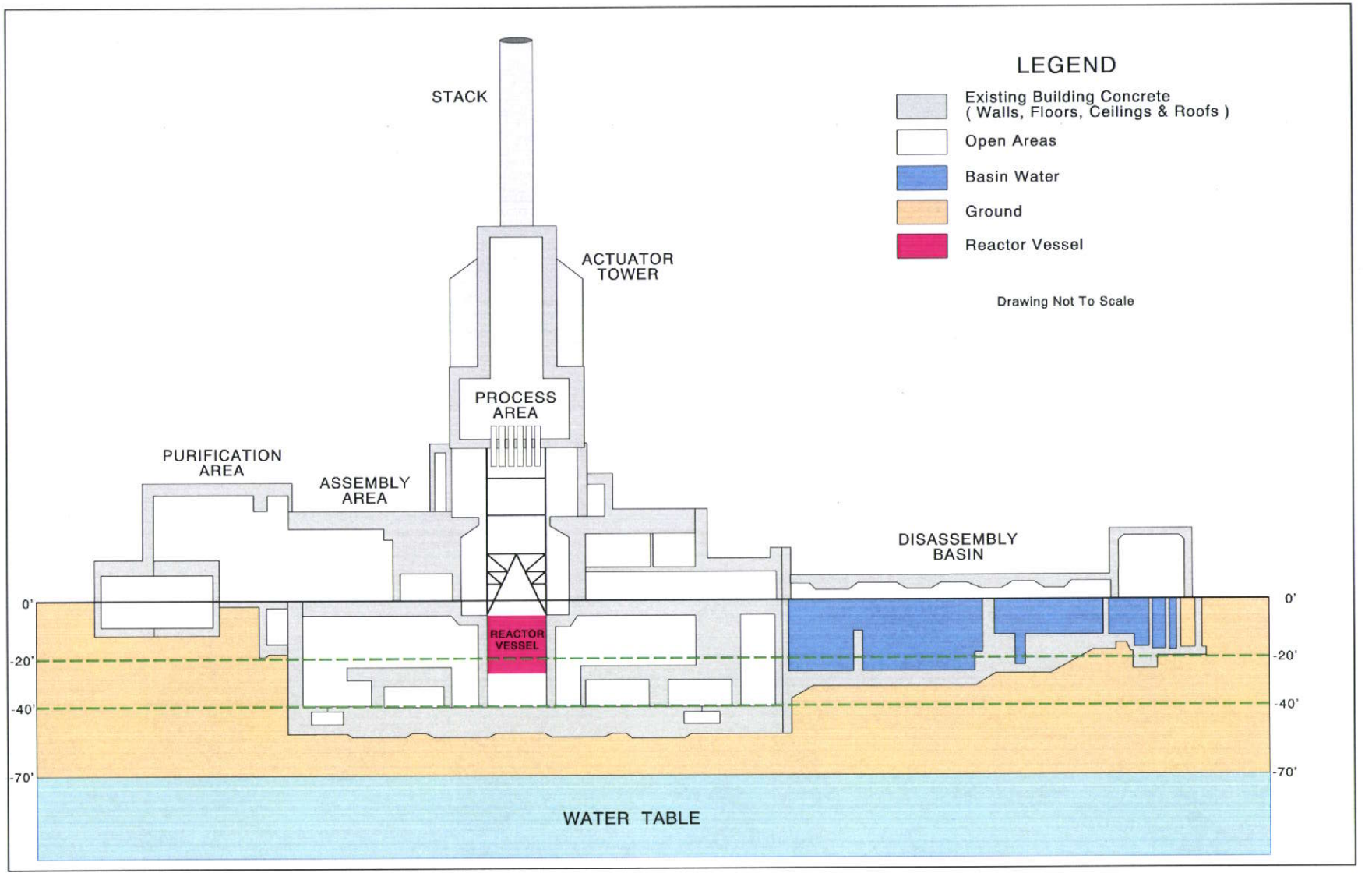

Figure 3. Layout of a Reactor Building at SRS Showing Disassembly Basin

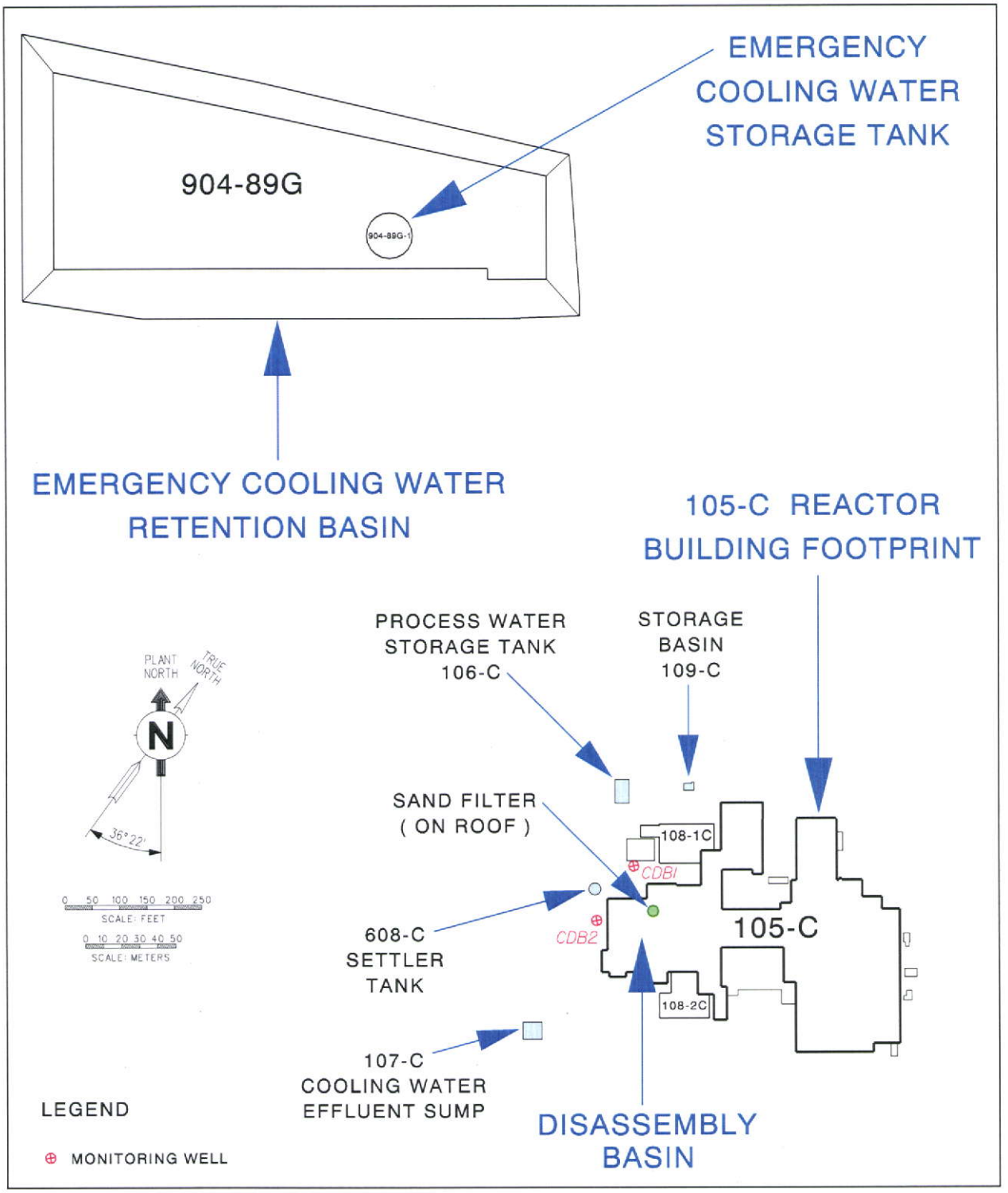

Figure 4. Schematic Illustration of C-Area and Relevant Facilities

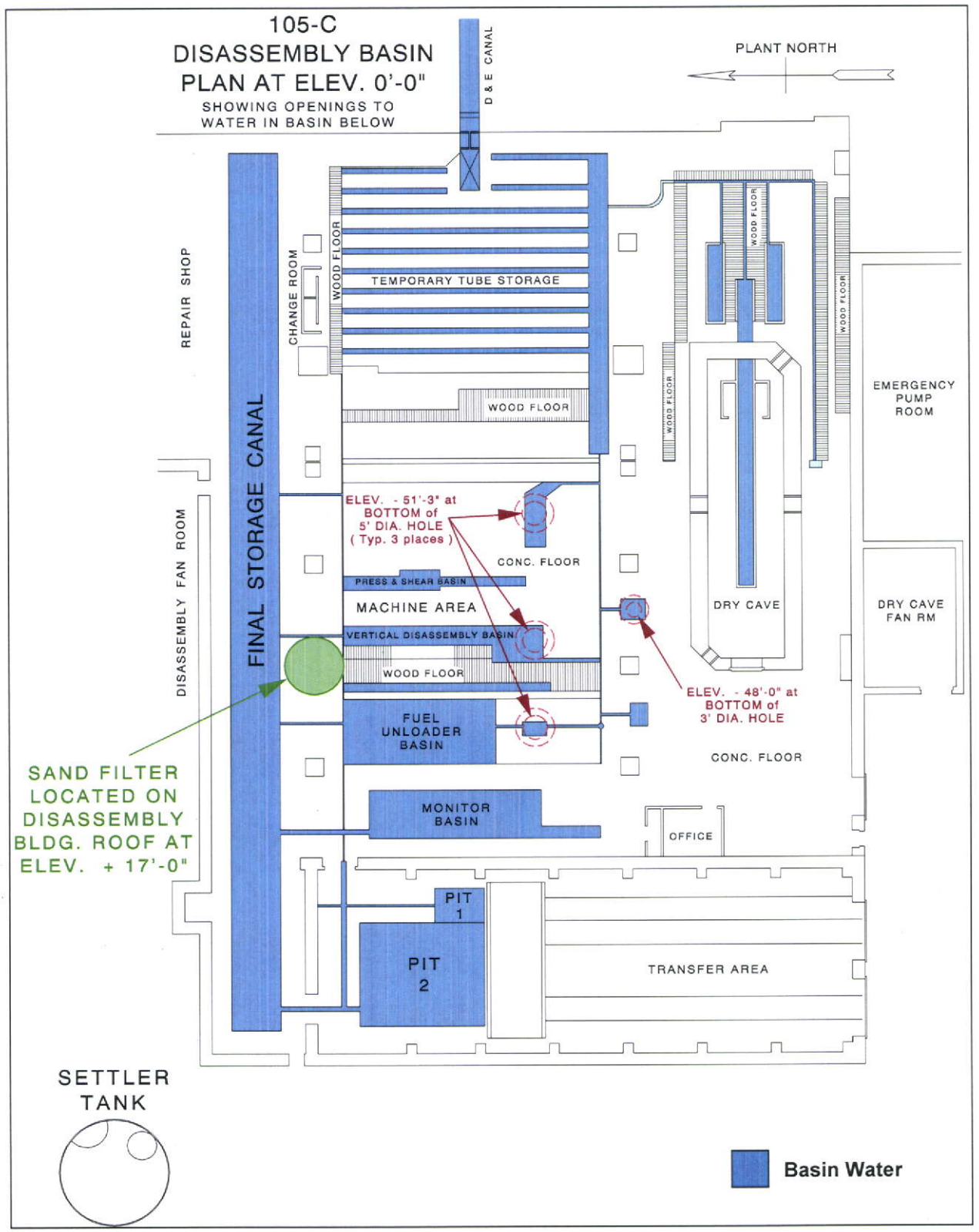

Figure 5. 105-C Disassembly Basin Configuration (not to scale)

Figure 6. Location of Hot Spots in the 105-C Disassembly Basin

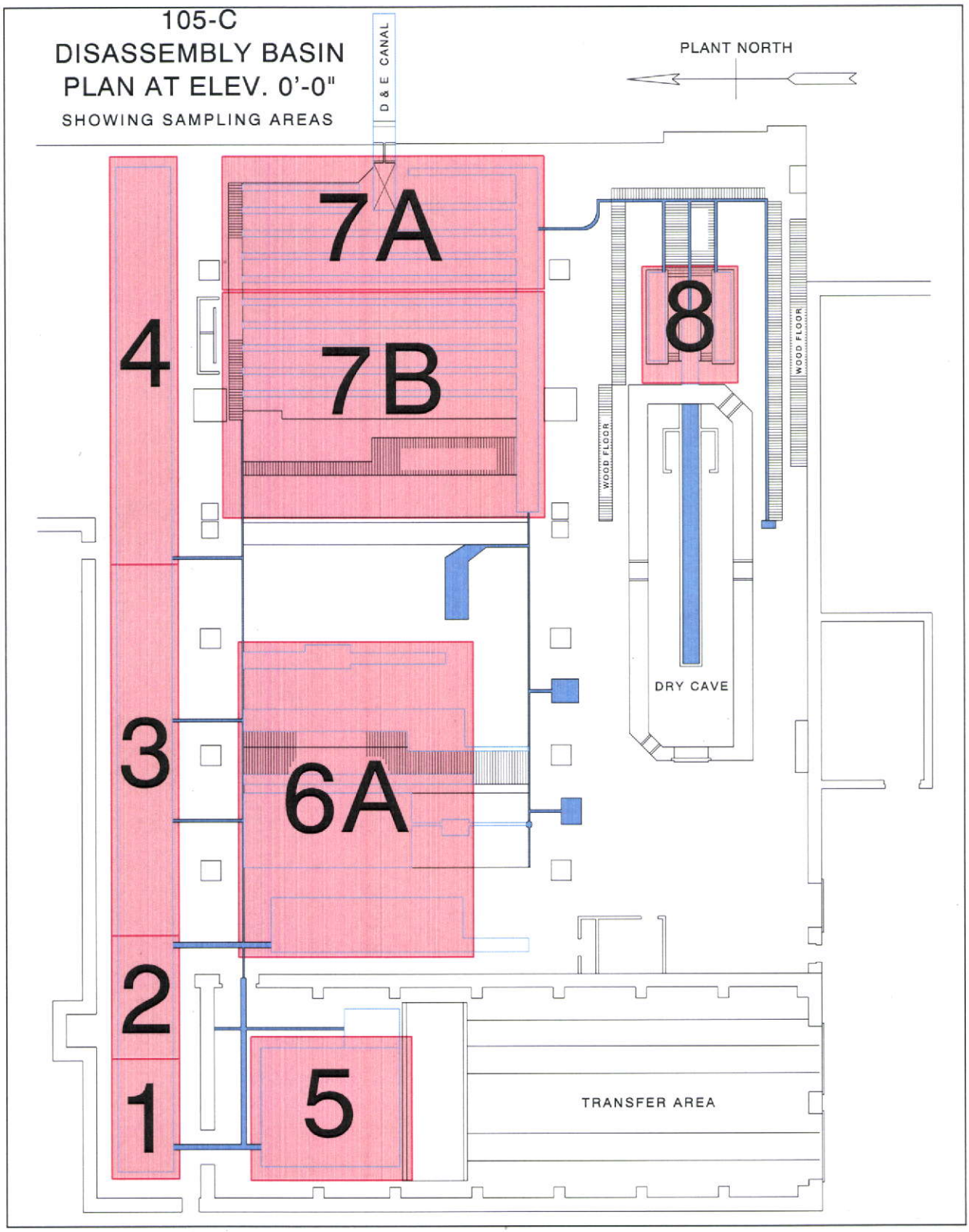

Figure 7. Sampling Areas in the 105-C Disassembly Basin

APPENDIX A. Potential ARARs and TBC Criteria for the Proposed Remedy

Action	Requirements	Prerequisite	Citation(s)
ACTION - SPECIFIC			
Site Preparation, Construction, and Excavation Activities			
Evaporating Disassembly Basin water.	A wastewater treatment construction permit is required for the onsite evaporation system.	Wastewater treatment facility must meet the standards for general and technical design requirements for use by the SCHEC in reviewing Engineering Reports, establishing Reliability Classifications and issuing State Construction Permits or other approval actions as outlined in R.61-67. – **applicable**	SCDHEC R61-67.100.A.
Evaporating Disassembly Basin Water	All wastewater treatment facilities shall be closed out within one hundred (180) days when the facility is closed or the effluent disposal permit is inactivated, terminated, or revoked, unless otherwise determined by the SCDHEC. The closure of water evaporation system necessitates the submittal of a closure plan and approval of the plan by the Department in accordance with R.61-82 prior to closure of than y wastewater treatment unit(s).	Waste treatment facilities not defined as lagoons and package plants shall be closed out in accordance with guidelines issued by DHEC on an individual basis. These guidelines shall be designed to prevent health hazards and to promote safety in and around the abandoned sites. – **applicable**	SCDHEC R61-82 IV
Evaporating Disassembly Basin Water	Evaporation system requires a construction air permit issued by the SCDHEC Bureau of Air prior to putting the water evaporation system into operation	Except as allowed under paragraphs (c) and (d) below, any person who plans to construct, alter or add to a source of air contaminants, including installation of any device for the control of air contaminant discharges, shall first obtain a construction permit from the Department prior to commencement of construction. – **applicable**	SCDHEC R61-62.1, Section II.A.1.b.

Action	Requirements	Prerequisite	Citation(s)
ACTION - SPECIFIC			
Site Preparation, Construction, and Excavation Activities			
Evaporating Disassembly Basin Water	Evaporation system requires an operating air permit issued by the SCDHEC Bureau of Air prior to putting the water evaporation system into operation	The owner or operator shall submit written notification to the Department of the actual date of initial startup of each new or altered source, postmarked within 15 days after such date. Any source that is required to obtain an air quality construction permit issued by the Department must obtain an operating permit when the new or altered source is placed into operation and shall comply with the requirements of this section. - **applicable**	SCDHEC R61-62.1, Section II.F.1.

CHEMICAL - SPECIFIC			
Site Preparation, Construction, and Excavation Activities			
Utilize work practices that minimize or control airborne radionuclide emissions during the water removal and grouting activities at the disassembly basin.	Emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem.	Disassembly Basin is a designated facility subject to NESHAP 40 CFR 61.90 - **applicable**	NESHAP 40 CFR 61.92
Activities that generate radioactive waste at a DOE facility.	All DOE radioactive waste is managed in a manner that protects the worker, public safety, and the environment.	Manage the secondary radioactive waste destined for final disposal in accordance with SRS radioactive waste disposal facilities waste acceptance criteria. – **TBC**	DOE Order 435.1

CHEMICAL - SPECIFIC			
Site Preparation, Construction, and Excavation Activities			
All activities associated with water removal and grouting of the disassembly basin.	Due to the presence of radionuclides within the disassembly basin, worker radiation dose limits are regulated with monitoring and recordkeeping. In addition, exposure of the radionuclide to members of the public will be controlled and minimized.	(a) Except for planned special exposures conducted consistent with §835.204 and emergency exposures authorized in accordance with §835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year: (1) A total effective dose of 5 rems (0.05 Sv); – **applicable** (2) The sum of the equivalent dose to the whole body for external exposures and the committed equivalent dose to any organ or tissue other than the skin or the lens of the eye of 50 rems (0.5 Sv); – **applicable** (3) An equivalent dose to the lens of the eye of 15 rems (0.15 Sv); – **applicable** (4) The sum of the equivalent dose to the skin or to any extremity for external exposures and the committed equivalent dose to the skin or to any extremity of 50 rems (0.5 Sv). – **applicable**	10 CFR 835.202

CHEMICAL - SPECIFIC			
Site Preparation, Construction, and Excavation Activities			
Final condition of the grouted basin.	The final condition of the grouted basin will not contaminate the potential sources of drinking water above the maximum contamination levels established by the Safe Drinking Water Act.	Establishes the requirements and standards for chemicals and radionuclides to protect human health form the potential effects of drinking water contamination.	National Primary Drinking Water Regulations 40CFR 141 SC R.61-58 State Primary Drinking Water Regulations SC R.61-68 Water Classification and Standards

APPENDIX B. Detailed Cost Analysis for Alternative

Alternative 1
No Action
In Situ Decommissioning with Forced Evaporation of Basin Water
105-C Disassembly Basin
C-Area Operable Unit
Savannah River Site

Direct Capital Costs	Quantity	Units	Unit Cost	Total Cost
No Action		Item		
		Item		
		Item		
		Item		
		Item		
		Item		
		Item		
Total Direct Capital Costs				$0
Indirect Capital Costs				
Engineering & Design Support	3%		of S/C design	$0
Project/Construction Management	3%		of direct capital cost	$0
Health & Safety	6%		of direct capital cost	$0
Overhead	30%		of direct capital cost	$0
Contingency	15%		of direct capital cost	$0
Total Indirect Capital Cost				$0
TOTAL ESTIMATED CAPITAL COSTS				$0

Alternative 2
In Situ Decommissioning with Forced Evaporation of Basin Water
105-C Disassembly Basin
C-Area Operable Unit
Savannah River Site

	Direct Capital Costs	Quantity	Units	Unit Cost	Total Cost
1	Procurement, Sight Preparation, Pre-Construction Activities	1	Item	$265,033.00	$265,033.00
2	Design Activities	1	Item	$363,888.00	$363,888.00
3	Install Evaporators	1	Item	$3,198,414.50	$3,198,414.50
4	Evaporator Materials	1	Item	$1,135,000.00	$1,135,000.00
5	Transfer 300,000 gallons Tritiated from ECS Tank	1	Item	$270,877.00	$270,877.00
6	Evaporator Operation	1	Item	$2,759,446.00	$2,759,446.00
7	Grout Disassembly Basin to ~0 feet elevation	1	Item	$4,862,596.00	$4,862,596.00
8	Sampling and Analysis, Planning, Interpretation	40	samples	$1,200.00	$48,000.00
	Total Direct Capital Costs				**$12,903,255**

Indirect Capital Costs			
Engineering & Design Support	3%	of S/C design	$387,098
Project/Construction Management	3%	of direct capital cost	$387,098
Health & Safety	2%	of direct capital cost	$258,065
Overhead	30%	of direct capital cost	$3,870,976
Contingency	15%	of direct capital cost	$1,935,488
Total Indirect Capital Cost			**$6,838,725**

TOTAL ESTIMATED CAPITAL COSTS **$19,741,979**

Alternative 3
In Situ Decommissioning with Basin Water Trucked to Effluent Treatment Project
105-C Disassembly Basin
C-Area Operable Unit
Savannah River Site

	Direct Capital Costs	Quantity	Units	Unit Cost	Total Cost
1	Procurement, Sight Preparation, Pre-Construction Activities	1	Item	$265,033.00	$265,033.00
2	Design Activities	1	Item	$363,888.00	$363,888.00
3	Truck DB Water to ETP	3,000,000	gallons	$0.50	$1,500,000.00
4	Transfer 300,000 gallons Tritiated Water from ECS Tank	1	Item	$270,877.00	$270,877.00
5	Truck 300,000 gallons Water to ETP	300,000	gallons	$0.50	$150,000.00
6	Grout Disassembly Basin to ~0 feet elevation	1	Item	$4,862,596.00	$4,862,596.00
7	Sampling and Analysis, Planning, Interpretation	40	samples	$1,200.00	$48,000.00
	Total Direct Capital Costs				**$7,460,394.00**

Indirect Capital Costs			
Engineering & Design Support	3%	of S/C design	$223,812
Project/Construction Management	3%	of direct capital cost	$223,812
Health & Safety	2%	of direct capital cost	$149,208
Overhead	30%	of direct capital cost	$2,238,118
Contingency	15%	of direct capital cost	$1,119,059
Total Indirect Capital Cost			**$3,954,009**

TOTAL ESTIMATED CAPITAL COSTS

$11,414,403

APPENDIX C. Human Health Risk Assessment

Streamlined Risk Evaluation

for the

105-C Disassembly Basin Water

C.1 Introduction

This appendix contains the following information relative to the water that is present in the 105-C Disassembly Basin: 1) a baseline human health (HH) risk evaluation for the standard future industrial worker scenario; 2) a comparison of off-site receptor risk results to assist in the analysis of alternatives, and; 3) a maximum contaminant level (MCL) comparison.

A baseline risk for the standard future industrial worker scenario was estimated using the characterization results from a water sample taken from the 105-C Disassembly Basin. The risk assessment is presented in Section C.2. The purpose of this evaluation was to assess the potential for adverse effects associated with exposure to residual radionuclides and chemicals in the basin water and to provide a basis for determining the need for a removal action from a human health risk perspective.

The *RSER/EE/CA for the Disposition of Water in the 105-P Disassembly Basin* (WSRC 2008) describes nontraditional exposure scenarios (i.e., maximally exposed off-site individuals) that were evaluated to assist in the analysis and comparison of alternatives for that facility. The evaluation presented in this appendix for the C-Area Disassembly Basin does not include a formal assessment of maximally exposed off-site individuals; however the results of the P-Area risk evaluation were used to draw conclusions for the off-site exposure scenarios for C-Area (Section C.3).

This evaluation does not include a formal analysis of fate and transport of contaminants to groundwater. Although the walls and foundation in the C-Area Disassembly Basin are rather thick and contaminant migration to groundwater is not expected, the concentrations of analytes in the basin water were compared to maximum contaminant levels (MCLs) in Section C.4 for information purposes.

C.2 Human Health Risk Assessment

Receptors

The future industrial worker scenario was chosen to document the analysis of the potential for adverse human health effects. This is a standard USEPA scenario which addresses long-term risks to workers who are exposed to unit contaminants within an industrial setting as described in the protocol for *Human Health Receptors and Scenarios* (WSRC 2006). The future industrial worker

is an adult who hypothetically works on-unit for the majority of time. The evaluation of the future industrial worker assumes exposure to constituents for 25 years, 225 days per year, and 8 hours per day.

The evaluation for this scenario assumes that there is no ventilation and that the worker accesses the area without the benefit of personnel protective equipment or radiological controls that are required by SRS protocols. Therefore this is considered a conservative evaluation since currently there is not a complete exposure pathway for human receptors since access to the facility is controlled.

It is assumed that there will be no incidental ingestion or dermal contact with the Disassembly Basin water by the worker and there are no complete exposure pathways for the chemical contaminants in the water. Complete pathways include external exposure from radionuclides in the basin water and inhalation of tritiated water vapor in the unventilated air.

Sources of Risk Threshold Values

USEPA's Superfund Radionuclide Preliminary Remediation Goal (PRG) website (http://epa-prgs.ornl.gov/radionuclides/) provides a database tool with which to derive risk-based PRGs that are calculated using default parameters and the latest toxicity values to estimate contaminant concentrations in various media that the agency considers protective of humans over a lifetime. The database tool also allows the user to modify input parameters to create site-specific PRGs. Although this website is primarily designed for soil media, the inhalation and external exposure slope factors that are used in the PRG calculation for water media are the same. The following input parameters were modified from the standard defaults to obtain site-specific PRGs for water media:

1) For calculation of the external exposure PRGs, the ingestion and inhalation pathways were nullified (set to 0). The output from the EPA website is provided in Attachment 1; these are the PRG values that were used in the risk estimates for the external radiation pathway (Table C-2).

2) For calculation of the inhalation pathway PRG for tritium, the ingestion pathway was nullified (set to 0). Note that the website only allows for calculation of the organically bound tritium PRG based on an inhalation slope factor of 1.99E-13 risk/pCi. The output from the EPA website is provided in Attachment 2. However, it is expected that the route of exposure at the facility would

be tritium that is in the vapor phase. Vapor phase tritium has a slope factor of 5.62E-14 risk/pCi, but the website does not allow the user to modify this parameter. Therefore the PRG calculated for vapor phase tritium was obtained via ratio of the slope factors (SF) and the PRG calculated by the website:

SF organically bound H-3 = 1.99E-13 risk/pCi; SF vapor phase H-3 = 5.62E-14; 1.99E-13 / 5.62E-14 = 3.54

H-3 organically bound PRG (from website) = 1.41 pCi/g; Calculated H-3 vapor phase = 1.41 pCi/g x 3.54 = 4.99 pCi/g

The organically bound tritium PRG produced by the website and the calculated PRG for the vapor phase tritium are the values that were used in the risk estimates for the inhalation pathway (Table C-3).

Methods

Radiological and non-radiological data from a water sample are available for the C-Area Disassembly Basin. The results are presented in Table C-1 of this appendix.

The evaluation of the water media in the C-Area Disassembly Basin is not typical and the methodology used in this assessment deviates slightly from the methodologies described in the human health risk assessment protocols (WSRC 2006). More specifically, a constituent of potential concern (COPC) screen as described in the protocols was not performed. The evaluation simply provides a risk estimate for all constituents (i.e., no COPC screening). Constituents with risk greater than 1E-06 were identified as HH constituents of concern (COCs). In addition, a refinement of constituents of concern evaluation was not performed. The uncertainty introduced by not performing these steps is negligible since all of the constituents are carried through the process. This is considered a conservative approach. Deviations from the protocols were implemented in the risk assessment not only to streamline the document to some degree but also to provide a conservative assessment that provides an adequate basis for decision making at this unit. The streamlined approach does not alter any of the conclusions presented in the assessment.

For radionuclides, the risk estimate = ([Analytical Result] / [PRG]) x 1E-06. Constituents with an individual cancer risk ≥ 1E-06 are identified as HH COCs. Site-specific PRGs for water media were used in this evaluation.

Results of the Human Health Risk Assessment

The results of the risk estimate for the external exposure pathway are presented in Table C-2. Cesium-137 (+D) (risk = 3.1E-04) and strontium-90 (+D) (risk = 1.2E-06) were identified as COCs with a total external exposure risk = 3.2E-04 for the future industrial worker scenario.

The results of the risk estimate for the inhalation pathway are presented in Table C-3. The risk estimate for organically bound tritium is 5.6E-02; the estimate for tritium that is in the vapor phase for the future industrial worker scenario is 1.6E-02. It is expected that exposure to tritium at the facility would be in the vapor phase - therefore the vapor phase estimate is most appropriate for this scenario.

The total cumulative risk from the external exposure (Cs-137 [+D] and Sr-90 [+D], risk = 3.2E-04) and inhalation (H-3 vapor phase, risk = 1.6E-02) pathways for the future industrial worker scenario is 1.6E-02 (Table C-4).

C.3 Maximally Exposed Off-Site Individual Comparison

The *RSER/EE/CA for the Disposition of Water in the 105-P Disassembly Basin* (WSRC 2008) describes nontraditional exposure scenarios (i.e., maximally exposed off-site individuals) that were evaluated to assist in the analysis and comparison of alternatives for that facility. The P-Area results were used as a basis for comparison of the forced evaporation and discharge through the Effluent Treatment Project (ETP) alternatives that are considered in this document.

Forced Evaporation

This alternative proposes to remove approximately 4 million gallons of water from the 105-P Disassembly Basin and discharge it to the atmosphere by forced evaporation using commercially available fuel oil fired evaporators (WSRC 2008). Predominately tritium would be released to the atmosphere during this operation. All other contaminants (radiological and chemical) are not considered to be available for release via evaporation because the suspended and dissolved solids are concentrated as sludge in the evaporator pan where they are returned to the basin.

For this alternative it was assumed that an offsite maximally exposed individual lives at the SRS boundary 365 days per year and consumes milk, meat and vegetables produced at that location.

The maximum radiological risk to an offsite maximally exposed individual was estimated to be 7.5E-09 (5.4E-09 from food ingestion and 2.1E-09 from inhalation).

Table C-5 provides a comparison of the concentrations of the water in the 105-P Disassembly Basin that were used to generate the risk estimate cited above to the concentrations in the 105-C Disassembly Basin. The activities of all of the radiological constituents, except U-233/234 and U-235/236, are greater in the P-Area Disassembly Basin water. Most notably for this evaluation, the activity of tritium is less in the C-Area Disassembly Basin water. The estimated volume of water is also less at C-Area (2.7 million gallons) than at P-Area (4 million gallons).

These results can be extrapolated to conclude that the maximally exposed off-site individual risk estimate for the forced evaporation alternative would be less for C-Area than that calculated for P-Area (risk = 7.5E-09).

Discharge through ETP

This alternative proposes to remove approximately 4 million gallons of water from the P-Area Disassembly Basin by trucking it to ETP, which is an existing permitted, reverse osmosis water treatment plant at SRS (WSRC 2008). Tritium would not be removed during treatment, because there is no realistic treatment technology for tritium. For all other contaminants, a 95% treatment efficiency was assumed.

For this alternative it was assumed that an offsite person lives just downriver of the SRS boundary 365 days per year and consumes untreated Savannah River water and fish from that location. The maximum radiological risk to an offsite maximally exposed individual from this alternative was estimated to be 1.1E-07 (7.5E-08 from water ingestion and 4.0E-08 from fish ingestion). The total noncancer HI was estimated to be 6.0E-06 (5.1E-06 from water ingestion and 9.5E-07 from fish ingestion).

Table C-5 provides a comparison of the concentrations of the water in the 105-P Disassembly Basin that were used to generate the risk/hazard estimates cited above to the concentrations in the 105-C Disassembly Basin. All constituents, except barium, nickel, uranium-233/234 and uranium-235/236 are greater in the P-Area. Most notably, the tritium concentration is less at C-Area. The estimated volume of water is also less at C-Area (2.7 million gallons) than at P-Area (4 million gallons).

These results can be extrapolated to conclude that the maximally exposed off-site individual risk estimate for the disposal through the ETP alternative would be less for C-Area than that calculated for P-Area (risk = 1.1E-07, HI = 6.0E-06).

C.4 MCL/RSL Comparison

The concentrations of analytes in the 105-C Disassembly Basin water were compared to MCLs (or regional screening level [RSL] for tapwater in the absence of an MCL) in Table A-6. Gross alpha, cesium-137, tritium, nickel-63, strontium-90, uranium-233/234 and uranium-235/236 are above the MCL.

C.5 References

Rucker, Gregory G. 2001. *Calculation of the Isotopic Activities of Naturally Occurring Uranium in Drinking Water Equivalent to Uranium Maximum Contaminant Level*, Q-CLC-B-00019, Rev. 1 and ERTEC-2001-0001, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

WSRC, 2006. *Regulatory Document Handbook*, ERD-AG-003, Rev. 16, Washington Savannah River Company, Aiken, SC (September).

WSRC 2008. *Disposition of Water in the 105-P Disassembly Basin Removal Site Evaluation Report / Engineering Evaluation and Cost Analysis (RSER/EE/CA)*. V-ESR-P-00022, Rev. 1 (March).

Table C-1. C-Area Disassembly Basin Analytical Results (Basin Water)

Analyte	Result	Result Units	Qualifier
Inorganics[a]			
Barium	1.58E+01	ug/L	J
Calcium	1.17E+04	ug/L	
Nickel	1.40E+01	ug/L	J
Potassium	2.80E+04	ug/L	
Sodium	2.69E+04	ug/L	
Vanadium	1.18E+01	ug/L	J
Zinc	4.41E+01	ug/L	J
Radionuclides[b]			
Gross Alpha	1.19E+02	pCi/L	
Gross Beta	4.12E+04	pCi/L	
Carbon-14	1.70E+03	pCi/L	
Cobalt-60	5.10E+01	pCi/L	
Cesium-137	3.61E+04	pCi/L	
Tritium	7.90E+07	pCi/L	
Nickel-63	3.71E+02	pCi/L	J
Plutonium-238	2.41E+00	pCi/L	
Plutonium-239/240	1.69E+00	pCi/L	J
Strontium-90	1.52E+04	pCi/L	
Uranium-233/234	1.36E+01	pCi/L	
Uranium-235/236	2.63E+00	pCi/L	J

a - GEL Laboratories, dated April 29, 2009
b - GEL Laboratories, dated May 5, 2009

Table C-2. C-Area Disassembly Basin Water External Exposure Risk

Future Industrial Worker Scenario

Analyte	Result[a] (pCi/L)	Converted Result[b] (pCi/ml) (pCi/g)	External Exposure PRG[c] (pCi/g)	External Exposure Risk[d]	COC?[e]
C-14	1.70E+03	1.70E+00	2.68E+04	6.34E-11	
Co-60	5.10E+01	5.10E-02	6.43E-02	7.93E-07	
Cs-137 (+D)	3.61E+04	3.61E+01	1.15E-01	3.14E-04	**COC**
H-3	7.90E+07	7.90E+04	na	na	
Ni-63	3.71E+02	3.71E-01	na	na	
Pu-238	2.41E+00	2.41E-03	2.97E+03	8.11E-13	
Pu-239/240	1.69E+00	1.69E-03	9.75E+02	1.73E-12	
Sr-90 (+D)	1.52E+04	1.52E+01	1.32E+01	1.15E-06	**COC**
U-233/234	1.36E+01	1.36E-02	1.99E+02	6.83E-11	
U-235/236	2.63E+00	2.63E-03	3.91E-01	6.73E-09	
External Exposure Risk Total =				**3.16E-04**	

a- Results from table C-1
b- Results converted to pCi/g, assumes 1ml water = 1g
c- PRG from Attachment 1
d- Risk = (Converted Result / PRG) x 1E-06
e- Constituent identified as a COC if risk > 1E-06

Table C-3. C-Area Disassembly Basin Water Inhalation Risk

Future Industrial Worker Scenario

Analyte	Result[a] (pCi/L)	Converted Result[b] (pCi/ml) (pCi/g)	Inhalation PRG[c] (pCi/g)	Inhalation Risk[d]	COC?[e]
H-3 (organic)	7.90E+07	7.90E+04	1.41E+00	5.60E-02	**COC**
H-3 (vapor)	7.90E+07	7.90E+04	4.99E+00	1.58E-02	**COC**

a- Results from table C-1
b- Results converted to pCi/g, assumes 1ml water = 1g
c- Organically bound H-3 PRG from Attachment 2; vapor phase H-3 PRG per calculation
d- Risk = (Converted Result / PRG) x 1E-06
e- Constituent identified as a COC if risk > 1E-06

Table C-4. C-Area Disassembly Basin Water Total Cumulative Risk

Future Industrial Worker Scenario

COC[a]	Result (pCi/L)	Converted Result (pCi/ml) (pCi/g)	External Exposure Risk[b]	Inhalation Risk[c]	Total Risk[d]
Cs-137 (+D)	3.61E+04	3.61E+01	3.14E-04	na	3.14E-04
Sr-90 (+D)	1.52E+04	1.52E+01	1.15E-06	na	1.15E-06
H-3 (vapor)	7.90E+07	7.90E+04	na	1.58E-02	1.58E-02
					Total Cumulative Risk = 1.61E-02

a- COCs from Tables C-2 and C-3. Vapor-phase H-3 assumed (Table C-3)
b- External exposure risk from Table C-2
c- Inhalation risk from Table C-3
d- Total risk = external exposure risk + inhalation risk

Table C-5. C-Area Disassembly Basin Analytical Results Comparison to P-Area

Analyte	C-Area Result[a]	P-Area Result[b]	C-Area > P-Area ?
Inorganics (ug/L)			
Barium	1.58E+01	9.45E+00	YES
Calcium	1.17E+04	2.03E+04	no
Nickel	1.40E+01	8.31E+00	YES
Potassium	2.80E+04	na	na
Sodium	2.69E+04	3.46E+04	no
Vanadium	1.18E+01	na	na
Zinc	4.41E+01	4.66E+02	no
Radionuclides (pCi/L)			
Carbon-14	1.70E+03	2.12E+03	no
Cobalt-60	5.10E+01	3.13E+02	no
Cesium-137	3.61E+04	1.27E+05	no
Tritium	7.90E+07	2.21E+08	no
Nickel-63	3.71E+02	na	na
Plutonium-238	2.41E+00	8.02E+01	no
Plutonium-239/240	1.69E+00	6.99E+00	no
Strontium-90	1.52E+04	3.91E+04	no
Uranium-233/234	1.36E+01	4.20E+00	YES
Uranium-235/236	2.63E+00	3.86E-01	YES

na = not available
a - Results from Table C-1
b - Results from *RSER/EE/CA for the Disposition of Water in the 105-P Disassembly Basin* (WSRC 2008)

Table C-6. C-Area Disassembly Basin Analytical Results Comparison to MCLs/RSLs

Analyte	Result[a]	MCL / RSL[b]	Result > MCL / RSL?
Inorganics (ug/L)			
Barium	1.58E+01	2.00E+03	no
Calcium	1.17E+04	na	no
Nickel	1.40E+01	7.30E+02	no
Potassium	2.80E+04	na	no
Sodium	2.69E+04	na	no
Vanadium	1.18E+01	1.80E+02	no
Zinc	4.41E+01	1.10E+04	no
Radionuclides (pCi/L)			
Gross Apha	1.19E+02	1.50E+01	YES
Gross Beta	4.12E+04	na	no
Carbon-14	1.70E+03	2.00E+03	no
Cobalt-60	5.10E+01	1.00E+02	no
Cesium-137	3.61E+04	2.00E+02	YES
Tritium	7.90E+07	2.00E+04	YES
Nickel-63	3.71E+02	5.00E+01	YES
Plutonium-238	2.41E+00	1.50E+01	no
Plutonium-239/240	1.69E+00	1.50E+01	no
Strontium-90	1.52E+04	8.00E+00	YES
Uranium-233/234	1.36E+01	1.00E+01*	YES
Uranium-235/236	2.63E+00	4.70E-01*	YES

a - Results from Table C-1
b - MCL / RSL - maximum contaminant level or regional screening level. RSL for tapwater used in absence of MCL.
na = not applicable
*From Rucker 2001

Attachment 1

PRGs for External Exposure Pathway
USEPA Preliminary Remediation Goals for Radionuclides

http://epa-prgs.ornl.gov/radionuclides/
website accessed 12-16-10

Site-Specific	
Outdoor Worker Equation Inputs for Soil	
Variable	**Value**
Slab size for ACF (area correction factor) m^2	10000
TR (target cancer risk) unitless	0.000001
t_{ow} (time - outdoor worker) yr	25
ED_{ow} (exposure duration - outdoor worker) yr	25
ET_{ow} (exposure time - outdoor worker) hr/day	8
EF_{ow} (exposure frequency - outdoor worker) day/yr	225
IR_{ow} (soil intake rate - outdoor worker) mg/day	0
IRA_{ow} (inhalation rate - outdoor worker) m^3/day	0
GSF_o (gamma shielding factor - outdoor) unitless	1
Output generated 16DEC2010:08:52:21	

Site-Specific

Outdoor Worker PRGs for Soil

Isotope	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Adult Soil Ingestion Slope Factor (risk/pCi)	Particulate Emission Factor (m^3/kg)	Lambda	Area Correction Factor	External Exposure PRG (pCi/g)
C-14	7.07E-12	7.84E-12	1.38E-12	1.36E+09	1.21E-04	9.27E-01	2.68E+04
Co-60	3.58E-11	1.24E-05	7.33E-12	1.36E+09	1.31E-01	8.34E-01	6.43E-02
Cs-137+D	1.19E-11	2.54E-06	3.17E-11	1.36E+09	2.31E-02	8.77E-01	1.15E-01
H-3	1.99E-13	0.00E+00	2.20E-13	1.70E+01	5.61E-02	0.00E+00	-
Ni-63	1.64E-12	0.00E+00	3.50E-13	1.36E+09	7.22E-03	0.00E+00	-
Pu-238	3.36E-08	7.22E-11	1.17E-10	1.36E+09	7.90E-03	9.99E-01	2.97E+03
Pu-239	3.33E-08	2.00E-10	1.21E-10	1.36E+09	2.88E-05	9.99E-01	9.75E+02
Pu-240	3.33E-08	6.98E-11	1.21E-10	1.36E+09	1.06E-04	9.99E-01	2.80E+03
Sr-90+D	1.13E-10	1.96E-08	5.92E-11	1.36E+09	2.38E-02	1.00E+00	1.32E+01
U-233	1.16E-08	9.82E-10	5.22E-11	1.36E+09	4.37E-06	9.98E-01	1.99E+02
U-234	1.14E-08	2.52E-10	5.11E-11	1.36E+09	2.83E-06	9.98E-01	7.74E+02
U-235	1.01E-08	5.19E-07	4.92E-11	1.36E+09	9.85E-10	9.60E-01	3.91E-01
U-235+D	1.01E-08	-	5.03E-11	1.36E+09	9.85E-10	9.60E-01	-
U-236	1.05E-08	1.25E-10	4.85E-11	1.36E+09	2.96E-08	9.99E-01	1.56E+03

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Attachment 2

PRGs for Inhalation Pathway

USEPA Preliminary Remediation Goals for Radionuclides

http://epa-prgs.ornl.gov/radionuclides/

website accessed 12-16-10

Site-Specific

Outdoor Worker Equation Inputs for Soil

Variable	Value
Slab size for ACF (area correction factor) m^2	10000
TR (target cancer risk) unitless	0.000001
t_{ow} (time - outdoor worker) yr	25
ED_{ow} (exposure duration - outdoor worker) yr	25
ET_{ow} (exposure time - outdoor worker) hr/day	8
EF_{ow} (exposure frequency - outdoor worker) day/yr	225
IR_{ow} (soil intake rate - outdoor worker) mg/day	0
IRA_{ow} (inhalation rate - outdoor worker) m^3/day	60
GSF_o (gamma shielding factor - outdoor) unitless	1

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Site-Specific

Outdoor Worker PRGs for Soil

Isotope	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Adult Soil Ingestion Slope Factor (risk/pCi)	Particulate Emission Factor (m^3/kg)	Lambda	Inhalation PRG (pCi/g)
H-3	1.99E-13	0.00E+00	2.20E-13	1.70E+01	5.61E-02	1.41E+00

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