United States Department of Energy

Savannah River Site

Removal Site Evaluation Report / Engineering Evaluation / Cost Analysis (RSER/EE/CA) for the Early Construction and Operational Disposal Sites (ECODS) B-3 and B-5 Operable Unit (OU) (U)

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Aiken, South Carolina

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
CD	compact disk
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm	centimeter
COC	constituent of concern
COPC	constituent of potential concern
dSSL	default soil screening level
dMLSSL	default mass-limited soil screening level
ECODS	Early Construction and Operational Disposal Site
ERA	Ecological Risk Assessment
FFA	Federal Facility Agreement
ft	foot
ft^2	square foot
ft^3	cubic foot
GPR	ground penetrating radar
ha	hectare
HHRA	Human Health Risk Assessment
km	kilometer
km^2	square kilometer
LUCAP	Land Use Control Assurance Plan
m	meter
m^2	square meter
m^3	cubic meter
MCL	Maximum Contaminant Level
mi	mile
mi^2	square mile
mg/kg	milligram per kilogram
msl	mean sea level
NAPL	non-aqueous phase liquid
NPDES	National Pollution Discharge Elimination System
NCP	National Contingency Plan
NTCR	non-time critical removal
OU	Operable Unit
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PRG	Preliminary Remediation Goal
PTSM	Principal Threat Source Material
RA	removal action
RAO	remedial action objective
RAR	Removal Action Report
RCOC	refined constituent of concern

LIST OF ACRONYMS AND ABBREVIATIONS (CONT.)

RCRA	Resource Conservation and Recovery Act
RG	remedial goal
RGO	remedial goal option
RME	Reasonable Maximum Exposure
RSER/EE/CA	Removal Site Evaluation Report / Engineering Evaluation / Cost Analysis
RSL	Regional Screening Level
SCDHEC	South Carolina Department of Health and Environmental Control
SE	Site Evaluation
SER	Site Evaluation Report
SQL	sample quantitation limit
SRNS	Savannah River Nuclear Solutions, LLC
SRS	Savannah River Site
srsSSL	SRS site-specific soil screening level
srsMLSSL	SRS site-specific soil screening level
SSL	soil screening level
SVOC	semi-volatile organic compound
TAL	Target Analyte List
TCL	Target Compound List
TBC	To-Be-Considered
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
WSRC	Washington Savannah River Company
yd^3	cubic yard

EXECUTIVE SUMMARY

The U.S. Department of Energy (USDOE) is proposing to perform a non-time critical removal (NTCR) at Early Construction and Operational Disposal Sites (ECODS) B-3 and B-5 located at the Savannah River Site (SRS), in Aiken, South Carolina. From 1951 to 1955, ECODS B-3 and B-5 were used to dispose of waste material associated with the construction of B-Area. Construction waste was buried in shallow, elongated trenches. Some sections of the trenches were also used as burn pits for combustible waste disposal. This Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA) identifies the objectives of the removal action (RA) for ECODS B-3 and B-5, evaluates alternatives that address the potential threats from release of contaminants to the environment, and provides a vehicle for public comment per the National Oil and Hazardous Substances Pollution Contingency Plan, 40 Code of Federal Regulations 300.415.

ECODS B-3 and B-5 were sampled under the Site Evaluation Program to determine the nature and extent of construction waste/impacted soil and to aid in the selection of the RA. Both ECODS contain various waste materials, including: metal, glass, and rubber. Soil sampling analytical results demonstrated that these ECODS contain metals, organic chemicals, pesticides, polychlorinated biphenyls, and minor amounts of other contaminants, predominantly in subsurface soils. Based upon evaluations of other ECODS, friable asbestos may also be present. No Principal Threat Source Material (PTSM) refined constituents of concern (RCOCs) or contaminant migration RCOCs were identified in either ECODS. The Human Health Risk Assessment (HHRA) for ECODS B-3 identified one semi-volatile organic compound (hexachlorobenzene) and seven pesticides (alpha-chlordane, gamma-chlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT, heptachlor, and heptachlor epoxide) as human health RCOCs for both residential and industrial worker scenarios. Arsenic is a human health RCOC at ECODS B-5 for both residential and industrial worker scenarios.

The volume of construction waste/impacted soil within ECODS B-3 and B-5 is approximately 6,600 yd^3 (5,046 m^3) and the preferred RA is Alternative 2, Removal and Offsite Disposal. Under this alternative, the construction waste/impacted soil will be removed from both ECODS and transported to a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Off-Site Rule Approved Landfill (e.g., Three Rivers Landfill) for disposal. Alternative 2 will: 1) meet the remedial action objectives, 2) be protective of human health and the environment in the short- and long-terms, and 3) remove potential ecological risks. Removal of construction waste/impacted soil from ECODS B-3 and B-5 will reduce the environmental footprint at SRS and place the waste in a facility designed for long-term disposal. Furthermore, the proposed RA will meet residential goals and result in the release of the Operable Unit. A Sampling and Analysis Plan that contains the details of confirmatory sampling will be submitted for approval prior to the RA, and the results will be described in the Removal Action Report (RAR).

1.0 INTRODUCTION

The U.S. Department of Energy (USDOE) is proposing to perform a non-time critical removal (NTCR) action at the Early Construction and Operational Disposal Sites (ECODS) B-3 and B-5 located at the Savannah River Site (SRS), in Aiken, South Carolina. The ECODS were initially listed in Appendix G.1 of the SRS Federal Facility Agreement (FFA; FFA 1993). However, they have been subsequently transferred to Appendix C as a Resource Conservation and Recovery Act (RCRA)/Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) operable unit (OU).

This Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA) identifies the objectives of the removal action (RA) for ECODS B-3 and B-5, evaluates alternatives that address potential threats from release of contaminants to the environment, and provides a vehicle for public comment per the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) 300.415.

SRS encompasses 310 mi^2 (803 km^2) of land adjacent to the Savannah River, principally in Aiken and Barnwell counties of South Carolina. SRS is located approximately 25 mi (40 km) southeast of Augusta, Georgia, and 20 mi (32 km) south of Aiken, South Carolina (Figure 1). SRS is owned by USDOE, while Savannah River Nuclear Solutions (SRNS), LLC 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 the nuclear material production processes. Hazardous substances, as defined by 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.

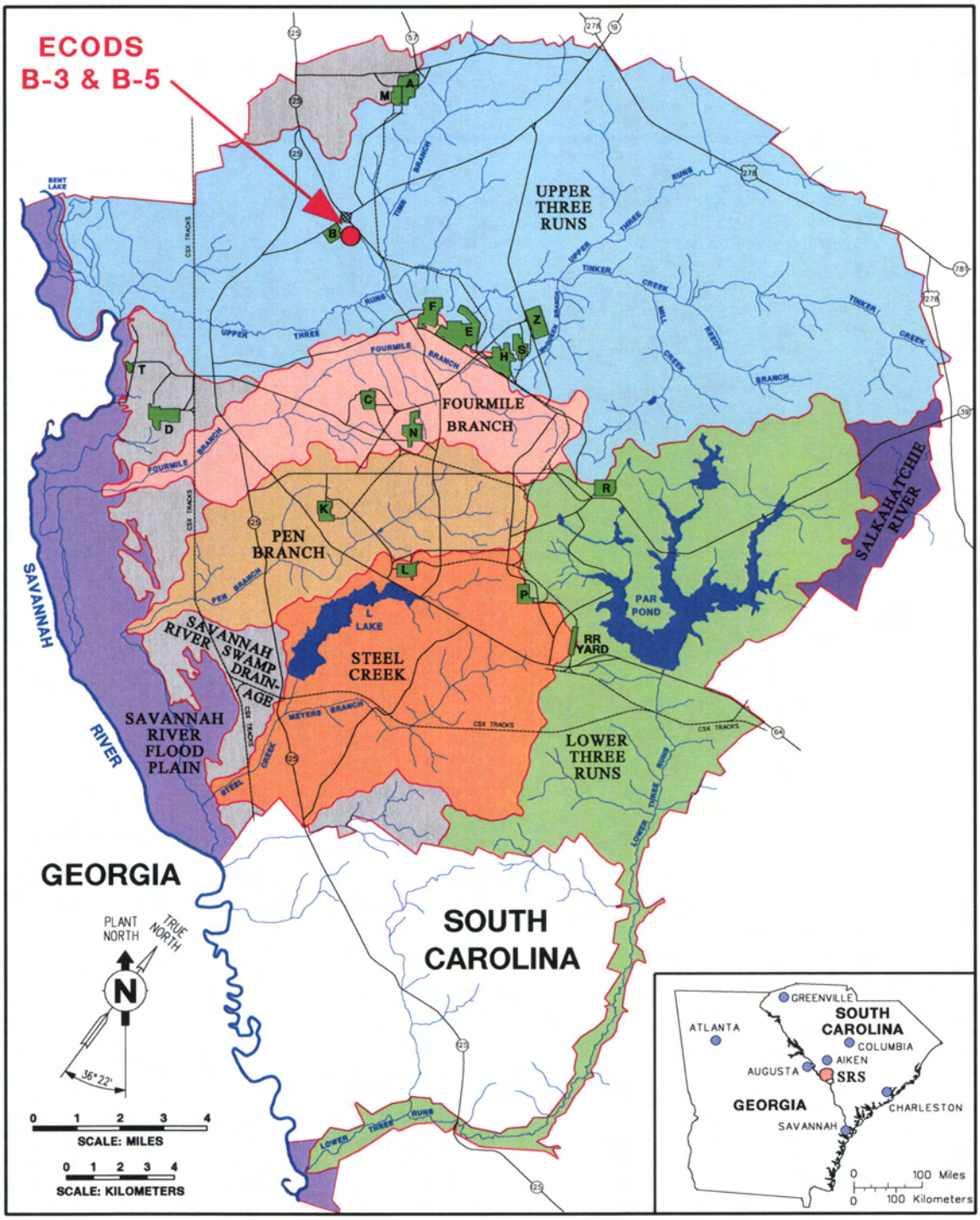

Figure 1. Map of the Savannah River Site

All responses to the public comments will be included in the Responsiveness Summary of the 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, SC 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:

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2.0 SITE CHARACTERIZATION

2.1 Site Description and Background

Construction activities at the SRS were initiated in 1951, with the majority of production facilities and related support facilities completed by 1955. During that period, an abundance of construction waste was generated, which required disposal.

Several years ago historical and recent aerial photographs of SRS were utilized to search for potential environmental hazards related to historical waste disposal practices. Early aerial photographs revealed that, prior to SRS construction, land around B-Area was used as farmland. However, in aerial photographs taken after SRS construction began, several anomalies (i.e., disturbed soil) were observed within this area. These anomalies were subsequently identified as land burial tracts where construction waste had been placed. Upon identification, these areas were denoted as ECODS and were added to Appendix G.1 (areas to be investigated) of the FFA. ECODS B-3 and B-5 have subsequently been transferred to Appendix C as a RCRA/CERCLA OU.

ECODS B-3 and B-5 were two of 25 ECODS identified that were used to dispose of waste material associated with the construction of SRS facilities; ECODS B-3 and B-5 were associated with the construction of B-Area. Construction waste was buried in shallow, elongated trenches, with several also used as burn pits for combustible waste disposal. Figure 2 shows the location of ECODS B-3 and B-5. Current photographs of ECODS B-3 and B-5 are shown in Figures 3 and 4.

ECODS B-3 and B-5 were sampled in 2001 and 2002 under the Site Evaluation (SE) Program to determine the nature and extent of construction waste/impacted soil. The analytical results from this sampling are being used to aid in the evaluation of the RA (WSRC 2002, 2003). Under the SE Program, the maximum detected contaminant concentrations in both surface and subsurface soil intervals were compared to U.S. Environmental Protection Agency (USEPA) residential and industrial Preliminary Remediation Goal (PRG) values current at the time,

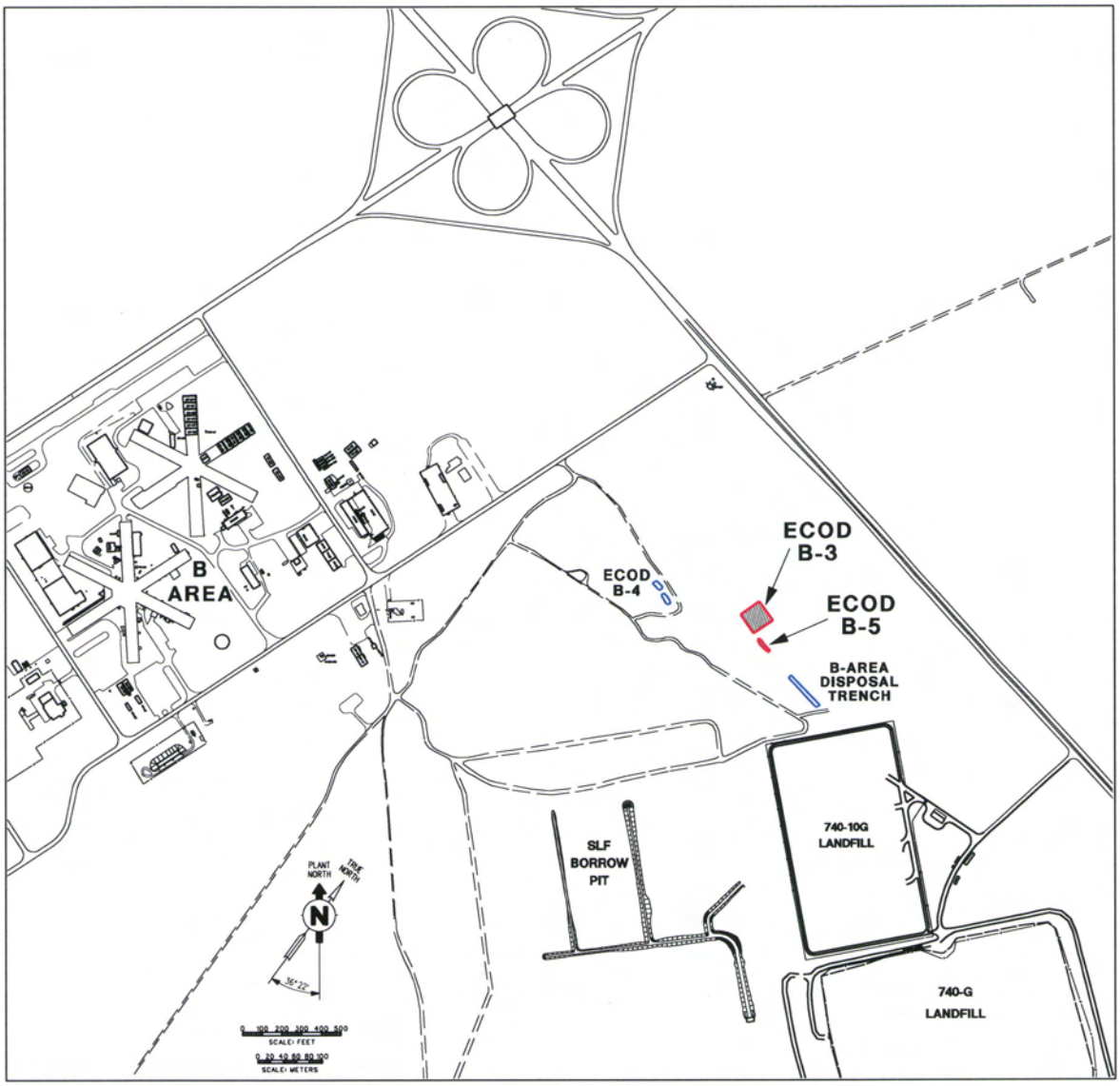

Figure 2. Location of ECODS B-3 and B-5 at the Savannah River Site

Figure 3. Photograph of ECODS B-3

Figure 4. Photograph of ECODS B-5

followed by weight-of-evidence discussion to determine the final disposition. The soil sampling analytical results demonstrated that these ECODS contain metals, organic chemicals, pesticides, polychlorinated biphenyls (PCBs), and minor amounts of other contaminants, predominantly in the subsurface soils. Based on evaluations of other ECODS, friable asbestos may also be present at ECODS B-3 and B-5.

2.2 Previous Action

Sampling activities conducted at ECODS B-3 consisted of a radiological survey and soil sampling (Figure 5). Initially, a ground penetrating radar (GPR) survey could not be conducted due to the ECODS inaccessibility for the GPR equipment. However, a GPR survey was completed in 2009 when the site was cleared; this GPR survey resulted in the expansion of the defined boundary of ECODS B-3 (Figure 5a) as subsurface disturbances were detected both north and south of previous boundaries. In February 2001, a radiological survey was performed, which consisted of measuring background radiation levels, probing the surface for possible contamination, and collecting random soil samples (0-6 inches [15.2 cm] below the ground surface) for analysis in a radiological counting facility. The area was designated as a 'Clean Area' in accordance with WSRC Procedure 5Q 1.2 (WSRC 2009). In March 2001, composite soil sampling was performed at 16 locations within or near ECODS B-3. Note that with the exception of EB3-14 and EB3-16, the soil sampling locations are within the expanded ECODS B-3 boundary shown in Figure 5a.

Sampling activities conducted at ECODS B-5 consisted of a radiological survey, a GPR survey, and soil sampling (Figure 6). In January 2002, a radiological survey was performed, which consisted of measuring background radiation levels, probing the surface for possible contamination, and collecting random soil samples (0-6 inches [15.2 cm] below the ground surface) for analysis in a radiological counting facility. A second survey was conducted in March 2002, after GPR results more clearly defined the boundaries of the subunit. Based on the results, the area was designated as a 'Clean Area' in accordance

with WSRC Procedure 5Q 1.2 (WSRC 2009). In March 2002, composite soil sampling was performed at 22 locations within or near ECODS B-5.

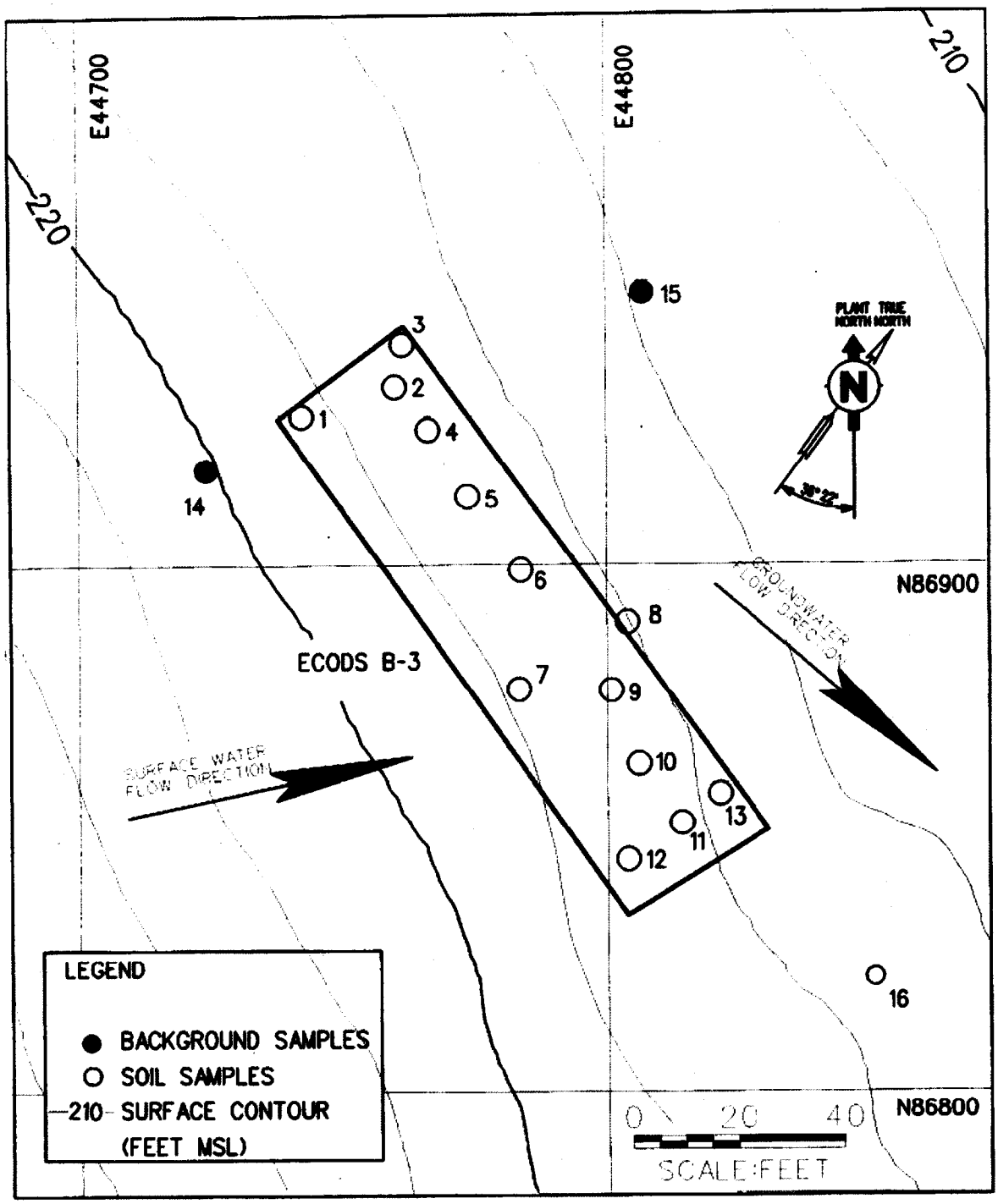

Figure 5. 2001 Soil Sampling Locations at ECODS B-3

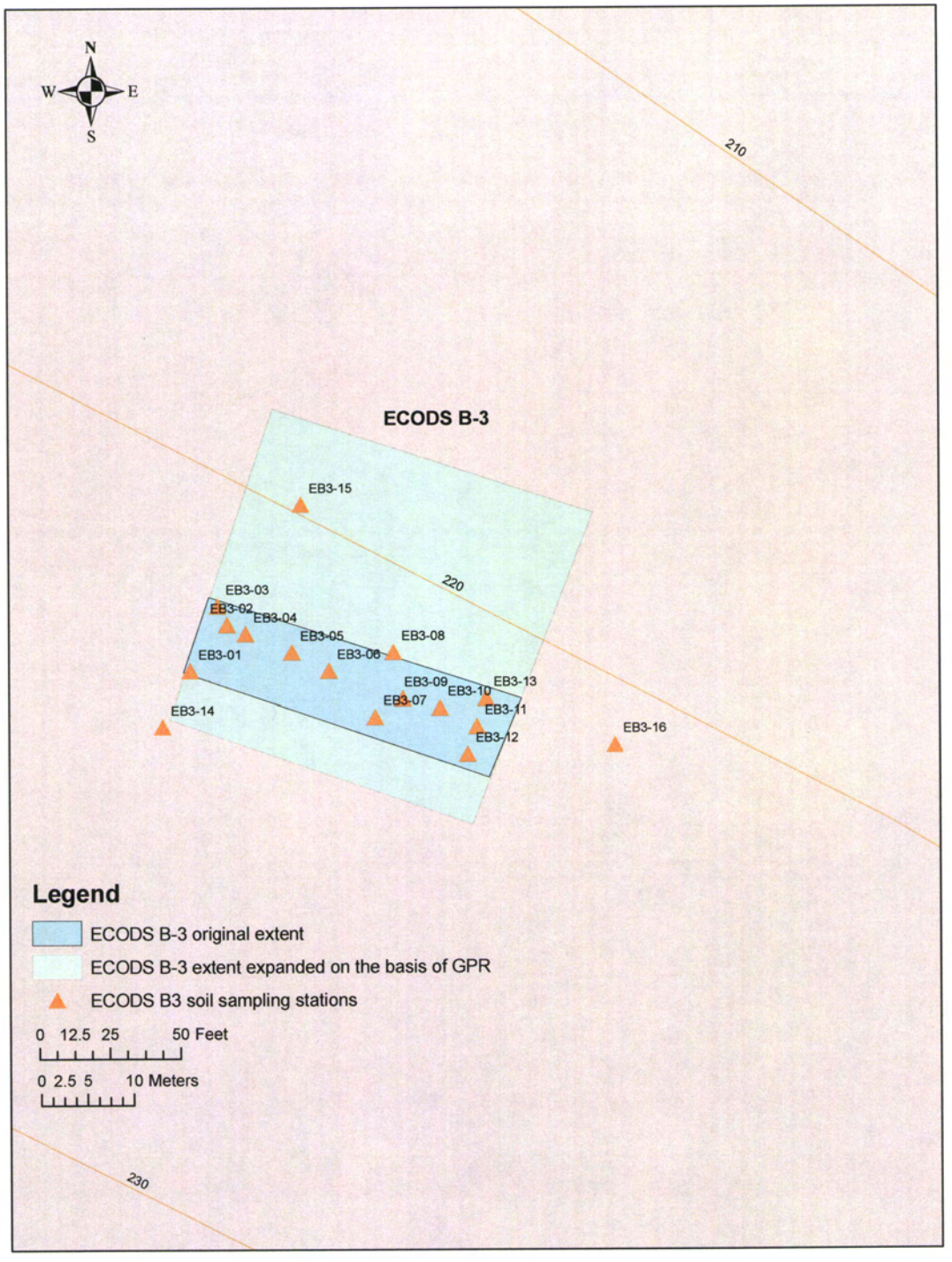

Figure 5a. Original and Expanded Boundaries for ECODS B-3

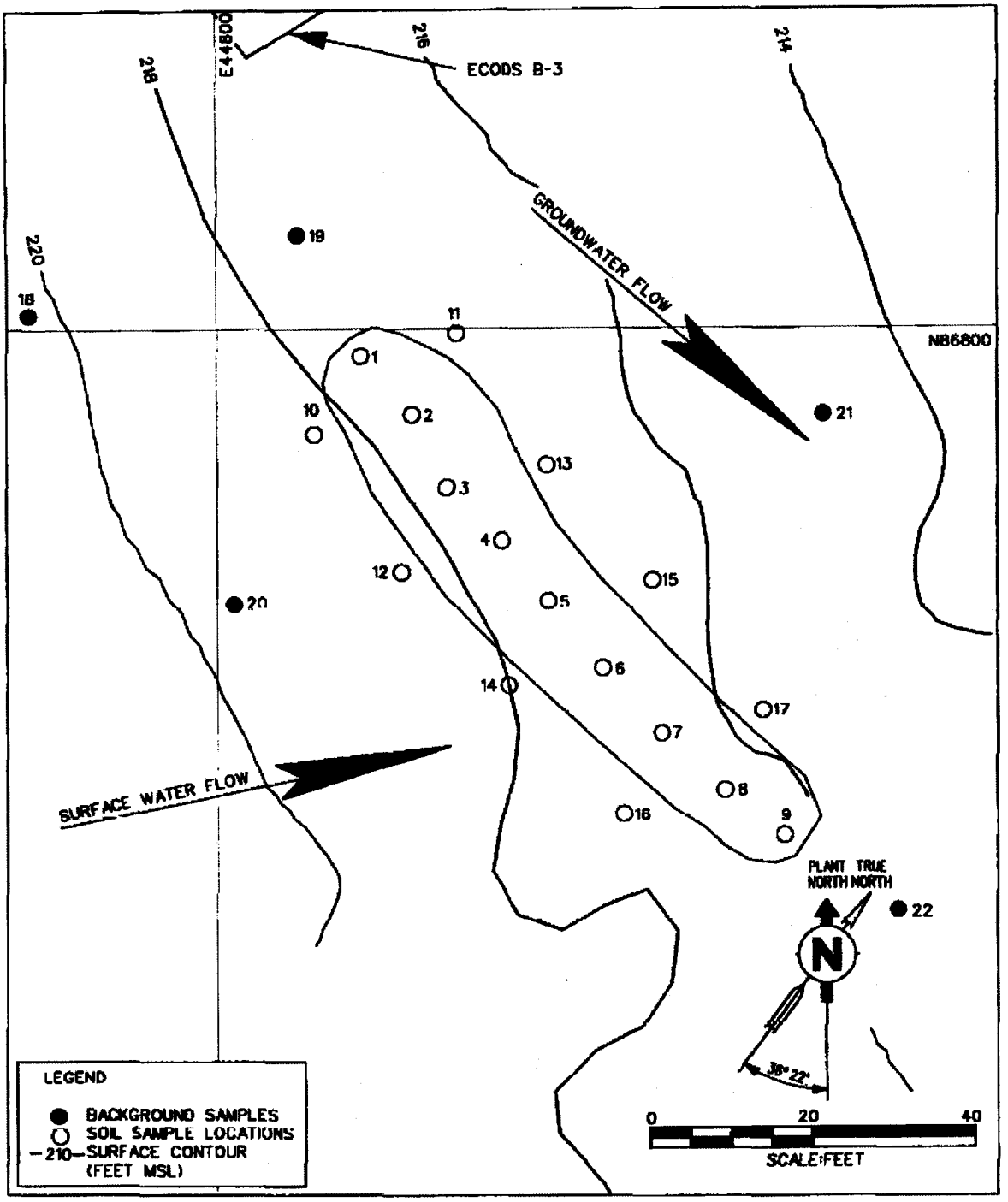

Figure 6. ECODS B-5 Soil Sampling Locations

2.3 Land Use

ECODS B-3 and B-5 are located in an area currently designated for industrial use, with no current or projected future development planned; there is no current or projected future use of groundwater as a drinking water source. Future land use at SRS will be controlled in accordance with the *SRS Land Use Control Assurance Plan* (LUCAP; WSRC 1999). In order to support risk management decision-making, both residential and industrial land use scenarios were evaluated for ECODS B-3 and B-5.

2.4 Environmental Setting

ECODS B-3 and B-5 are located east of B-Area and approximately 600 ft (183 m) north of the northeast corner of the SRS Sanitary Landfill. Prior to the construction of the SRS, the land was used mainly for farming. Surrounding areas are relatively flat with a gradual east-northeastern slope.

ECODS B-3 and B-5 are within the Upper Three Runs Watershed. This includes 0.6 mi (0.9 km) of wetlands along a tributary of Upper Three Runs Creek, as well as 0.7 mi (1.1 km) of wetlands along Upper Three Runs Creek itself. This is an area of approximately 70 acres (28.3 ha) of forested wetlands. The aquifer beneath both subunits is approximately 50 ft (15.2 m) below ground surface.

The only threatened or endangered species habitat within a 4-mile (6.4 km) radius of ECODS B-3 and B-5 consists of a smooth purple coneflower habitat approximately 2.5 mi (4.0 km) to the south along the edge of SRS Road 3.

2.5 Nature and Extent of Contamination

ECODS B-3

In March 2001, composite soil sampling was performed at 16 locations within or near ECODS B-3 (Figure 5). A total of 52 samples were collected by hand auger at depths of 0-1 ft (0-0.3 m) and 1-4 ft (0.3-1.2 m). Additional samples were collected at depths

of 8-10 ft (2.4-3.0 m) (two ft [0.6 m] below the estimated depth of the ECODS B-3 trench). During sampling activities, field personnel noted various waste materials, including: metal, glass, and rubber. At sample locations 5 and 6, construction waste was identified at 9.5 ft (2.9 m) and 10 ft (3.0 m) below grade, respectively. However, no additional soil confirmation samples were collected below the waste.

All samples were analyzed for USEPA Target Analyte List (TAL) inorganics, and Target Compound List (TCL) organics, pesticides, and PCBs. The analytical results are provided on a data compact disk placed in the front pocket of the report binder. Table 1 presents a summary of the maximum contaminant concentrations detected in soil at ECODS B-3 and B-5.

During the Site Evaluation investigation, the analytical results were compared to USEPA Region 9 residential and industrial PRG values (USEPA Region 9 PRG Tables, November 22, 2000). Hexachlorobenzene, seven pesticides (heptachlor, heptachlor epoxide, alpha-chlordane, gamma-chlordane, p,p'-DDD [dichlorodiphenyldichloroethane], p,p'-DDE [dichlorodiphenyldichloroethylene], p,p'-DDT [dichlordiphenyltrichloroethane], arsenic, and iron were measured at ECODS B-3 in concentrations exceeding residential PRGs, with arsenic concentrations also exceeding the industrial PRG for many samples. It is believed that the hexachlorobenzene and pesticide exceedances are the result of construction waste buried in this subunit. There is also the potential for this subunit to contain buried friable asbestos.

Based on field characterization methods, GPR, and sampling results, the areal extent of ECODS B-3 is 13,680 ft^2 (1,270 m^2). The construction waste was encountered in ECODS B-3 down to a depth of 10 ft (3.0 m). Accordingly, the estimated volume of construction waste/impacted soil present at ECODS B-3 is 164,160 ft^3 (4,648 m^3).

ECODS B-5

In March 2002, composite soil sampling was performed at 22 locations within ECODS B-5 (Figure 6). A total of 72 samples were collected by hand auger at depths of 0-1 ft (0-0.3

Table 1. Soil Sampling Results Summary for ECODS B-3 and B-5 - All Depths

Analyte	ECODS B-3 Detected Maximum Concentration	ECODS B-5 Detected Maximum Concentration
***Inorganics** (mg/kg)*		
Aluminum	1.95E+04	5.47E+04
Arsenic	1.34E+01	3.60E+01
Barium	1.42E+02	2.98E+02
Beryllium	4.65E+00	<SQL
Cadmium	<SQL[1]	9.74E+00
Calcium	1.37E+03	1.19E+04
Chromium	4.36E+01	8.68E+01
Cobalt	1.79E+00	1.09E+01
Copper	7.48E+01	5.78E+02
Cyanide	7.08E-01	2.01E+01
Iron	4.11E+04	1.32E+05
Lead	1.74E+01	3.60E+03
Magnesium	2.66E+02	8.83E+02
Manganese	1.59E+02	3.13E+04
Mercury	1.04E-01	5.13E+00
Nickel	1.01E+01	4.72E+01
Potassium	1.75E+02	4.26E+02
Selenium	2.15E+00	9.39E+00
Silver	<SQL	1.37E+00
Sodium	<SQL	6.97E+03
Thallium	<SQL	3.08E+00
Vanadium	9.04E+01	1.74E+02
Zinc	3.07E+02	1.93E+04
***Volatile Organics** (mg/kg)*		
1,1-Dichloroethylene	<SQL	2.42E-02
1,2-Dichlorobenzene	7.26E-02	<SQL
1,3-Dichlorobenzene	2.25E-01	<SQL
1,4-Dichlorobenzene	1.34E+00	<SQL
1,2,4-Trichlorobenzene	4.08E-02	<SQL
Acetone	1.03E-01	1.23E-03
Benzene	<SQL	5.55E-03
Carbon disulfide	4.18E-03	<SQL
Chlorobenzene	6.26E-02	<SQL

Analyte	ECODS B-3 Detected Maximum Concentration	ECODS B-5 Detected Maximum Concentration
Ethyl benzene	<SQL	7.69E-04
Methylene chloride	1.35E-03	<SQL
Methyl ethyl ketone	1.05E-02	<SQL
Toluene	<SQL	3.41E-03
Trichloroethylene	<SQL	1.73E-04
Xylenes	1.54E-03	7.47E-04
Semi-Volatile Organics *(mg/kg)*		
Benzo(g,h,i)perylene	<SQL	8.86E-01
Benzo[a]anthracene	<SQL	2.69E-01
Benzo[a]pyrene	<SQL	6.98E-01
Benzo[b]fluoranthene	<SQL	1.45E+00
Benzo[k]fluoranthene	<SQL	6.56E-01
Bis(2-ethylhexyl)phthalate	<SQL	6.94E-01
Chrysene	<SQL	3.38E-01
Dibenzo[ah]anthracene	<SQL	8.91E-02
Di-n-butyl phthalate	<SQL	4.73E-02
Fluoranthene	<SQL	1.58E-01
2-Methylnaphthalene	2.78E-02	<SQL
Hexachlorobenzene	1.98E+00	<SQL
Indeno[1,2,3-cd]pyrene	<SQL	8.09E-01
Naphthalene	1.90E+00	<SQL
Phenanthrene	9.55E-01	<SQL
Pyrene	<SQL	1.59E-01
Pesticides/PCBs *(mg/kg)*		
alpha-Chlordane	3.58E+01	1.25E-02
Aroclor 1254	<SQL	2.56E-02
p,p'-DDD	4.24E+01	2.84E-03
p,p'-DDE	9.91E+00	2.18E-02
p,p'-DDT	1.62E+01	8.33E-03
Dieldrin	5.32E-04	<SQL
gamma-Chlordane	3.96E+01	1.52E-02
Heptachlor	2.04E+00	6.72E-04
Heptachlor epoxide	2.19E-01	2.40E-03

[1] - The analytical result reported is less than the sample quantitation limit (SQL)

m) and 1-4 ft (0.3-1.2 m). Additional samples were collected at depths of 9-11 ft (2.7-3.3 m) (two ft [0.6 m] below the depth indicated by the GPR survey of the trench). During sampling activities, field personnel noted various waste materials, including metal, glass, and rubber in the samples.

During the Site Evaluation investigation, the analytical results were compared to the USEPA Region 9 residential and industrial PRG values (USEPA Region 9 PRG Tables, November 22, 2000). Benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, arsenic, iron, lead, and manganese exceeded PRGs. A review of the analytical results for these constituents indicated that soil had groupings of polycyclic aromatic hydrocarbons (PAHs), arsenic, iron, lead, and manganese that suggests the presence of buried waste at a depth of 1-4 ft (0.3-1.2 m). The iron is considered naturally occurring. There is also the potential for this subunit to contain buried friable asbestos although it was not detected, since ECODs with similar disposal histories in other SRS areas contain friable asbestos.

Based on field characterization methods, GPR, and sampling results, the areal extent of ECODS B-5 is 1,242 ft^2 (115 m^2). Construction waste was encountered in B-5 down to a depth of 9 ft (2.7 m). Accordingly, the estimated volume of construction waste/impacted soil present in ECODS B-5 is 13,662 ft^3 (387 m^3).

2.6 Data Evaluation

The PTSM, HHRA, and Contaminant Migration Analysis for ECODS B-3 and B-5 presented in this document used the maximum concentration detected for the exposure point concentration. This is a conservative approach and the data include the background soil sampling locations. The most current USEPA Regional Screening Levels (RSLs) were used to develop the PTSM and HHRA threshold criteria and risk estimates for chemical carcinogens and noncarcinogens.

The PTSM evaluation and HHRA calculations are provided in Appendix A. The Contaminant Migration Analysis is in Appendix B, and the discussion of remedial goal options (RGOs) is in Appendix C.

2.6.1 Principal Threat Source Material Evaluation

Based on the 2001-2002 soil sampling results, no PTSM refined constituents of concern (RCOCs) were identified for ECODS B-3 and B-5.

2.6.2 Human Health Risk Assessment

ECODS B-3 HHRA Conclusion

For the future resident scenario the following HH RCOCs are identified: hexachlorobenzene (risk = 6.6E-06), alpha-chlordane (risk = 2.2E-05), gamma-chlordane (risk = 2.5E-05), p,p'-DDD (risk = 2.1E-05), p,p'-DDE (risk = 7.1E-06), p,p'-DDT (risk = 9.5E-06), heptachlor (1.9E-05), and heptachlor epoxide (4.1E-06). The total cumulative risk is 1.1E-04.

For the future industrial worker scenario, the following HH RCOCs are identified: hexachlorobenzene (risk = 1.8E-06), alpha-chlordane (risk = 5.5E-06), gamma-chlordane (risk = 6.1E-06), p,p'-DDD (risk = 5.9E-06), p,p'-DDE (risk = 1.9E-06), p,p'-DDT (risk = 2.3E-06), heptachlor (5.4E-06), and heptachlor epoxide (1.2E-06). The total cumulative risk is 3.0E-05.

ECODS B-5 HHRA Conclusion

Arsenic is identified as an HH RCOC for surface soil at the ECODS B-5 for the future resident scenario (risk = 4.9E-05) and the future industrial worker scenario (risk = 1.2E-05).

2.6.3 Contaminant Migration Analysis

In the Contaminant Migration Analysis, 43 constituents are identified as having detectable

concentrations from the ECODS B-3 soil data set and 50 constituents at ECODS B-5. Fourteen of the constituents are classified as Tier 1 Contaminant Migration Analysis constituents of potential concern (COPCs) at ECODS B-3 [where the maximum soil concentrations exceed the USEPA default soil screening levels (dSSLs) or default mass-limited SSLs (dMLSSLs)], and 14 constituents also at ECODS B-5 (see Appendix B). Cobalt exceeds the Tier 2 SRS site-specific SSLs for ECODS B-3, and cobalt and cyanide exceed Tier 2 SSLs for ECODS B-5. For both ECODS, the calculated mean travel time for cyanide to reach the water table is 715 years and the mean travel time for cobalt is 722 years.

The five cobalt detections at ECODS B-3 are J-qualified data and all of the estimated concentrations are less than 2 mg/kg (the 95th percentile for SRS cobalt background in SRS soil is 2.2 mg/kg; WSRC 2006b). At ECODS B-5, cobalt is detected in 40 samples at slightly higher concentrations in soil (max = 10.9 mg/kg), of which one quarter (10 detections) are unqualified and 13 are higher than the SRS 95th percentile background concentration in soil. As a result, cobalt is not retained as a refined Contaminant Migration Analysis COC for ECODS B-3 and B-5.

Further analysis shows that cyanide is immobile in SRS soil. Cyanide tends to bind and form complexes in soil, especially with iron oxide, clay and organic materials. Since iron is abundant (maximum iron detected in soil at ECODS B-5 is 132 g/kg and iron exists in oxidized form) and clay is present (normally kaolinite, gibbsite and vermiculite), it is expected that cyanide is immobile at ECODS B-5. For this reason, cyanide is not retained as a refined Contaminant Migration Analysis COC for ECODS B-5.

Three constituents that are components of pesticides (alpha-chlordane, gamma-chlordane, and p,p'-DDD) exceeded solubilty limits and are considered saturated sources for ECODS B-3, while the PAH indeno-1,2,3-cd)pyrene is a saturated source for ECODS B-5. These constituents are identified as preliminary Contaminant Migration Analysis COCs. Constituents are considered saturated sources when the maximum concentration in soil exceeds the solubility of the compound in water and it may exist in a solid or free phase in

the vadose zone. The calculated mean travel time through the vadose zone (to the water table) exceeds 1,000 years for all four of these compounds. Additional vadose zone modeling of these constituents was not performed.

It is not known if there has been a historical release of contaminants to groundwater at ECODS B-3 and B-5. This uncertainty impacts the nature and scope of the problem warranting action. This uncertainty will be managed by investigating whether data can be obtained from groundwater wells located downgradient of the OU or by installing a temporary well(s) downgradient of the OU. Groundwater and soil sampling will be described in a Sampling and Analysis Plan (SAP) submitted before the RA, and the results will be reported in the Removal Action Report (RAR) submitted after the RA is completed.

2.6.4 Ecological Risk

An ecological risk assessment was not performed for ECODS B-3 and B-5. However, because of the limited areal extent (0.3 acre [1387 m^2]), the OU is considered an insignificant contaminant source for wildlife receptors and, therefore, is unlikely to cause ecological impacts at the community level. There are no threatened, endangered, or sensitive species habitats within two miles downstream of the two ECODS. Any uncertainty related to potential ecological risk would be managed by implementing removal and offsite disposal as the preferred action.

3.0 REMOVAL ACTION SCOPE AND OBJECTIVES

The scope of the RA is to address approximately 6,600 yd^3 (5,046 m^3) of construction waste/impacted soil that exceeds human health risk (1.0E-06) under both the residential and industrial worker scenarios.

3.1 Remedial Action Objectives

The remedial action objectives (RAOs) protect human health and the environment and include the following:

- Prevent human exposure to contaminants present in the surface soils that present a risk to a future resident or future industrial worker greater than 1E-06.
- Prevent human exposure to potential friable asbestos buried in subsurface soils.

3.2 Justification for Action

USDOE, as 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 RA to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release. This determination should be based on the factors identified in 40 CFR Section 300.415(b) (2).

In July 2009, a scoping meeting between USEPA, the South Carolina Department of Health and Environmental Control (SCDHEC), and USDOE identified ECODS B-3 and B-5 as a candidate for an early action to reduce risk to human health and the environment (SRNS 2009). The elevated levels of hexachlorobenzene, p,p'-DDD, p,p'-DDT, p,p'-DDE, alpha-chlordane, gamma-chlordane, heptachlor, and heptachlor epoxide at ECODS B-3 and arsenic at ECODS B-5 meet the criteria in 40 CFR Section 300.415(b) (2) (iv.); high levels of hazardous substances or pollutants or contaminants in soils, largely at or near the surface, may migrate. Also, friable asbestos may be buried in subsurface soils. Because of the threat of an asbestos release, the USDOE is exercising the option to proceed directly to a removal action without sampling/analyzing for asbestos per the *Framework for Investigating Asbestos-Contaminated Superfund Sites* (USEPA 2008).

3.3 Remedial Goal Options

A range of RGOs have been developed (Appendix C) in order to provide a basis for selecting final remedial levels. ECODS B-3 and B-5 are in an area currently designated for industrial use. No current or future development is planned. However, it is USDOE's desire that any proposed RAs at ECODS B-3 and B-5 would meet residential goals (i.e., unrestricted release with no land use controls) once the RA is completed. Therefore, risk-based RGOs based on the residential scenario are considered the most likely remedial goals (RGs).

Because of the inherently conservative nature of the risk assessment and RGO calculations, it is possible for the risk-based RGO to be less than what occurs naturally in unimpacted background soils. Accordingly, in this case, the RG defaults to the background concentration in order to be technically practical to achieve. The 95th percentile for unimpacted SRS-wide soils (WSRC 2006) is proposed as the appropriate background level to establish RGs.

Table 2 provides the most likely RGs for ECODS B-3 and B-5.

Table 2. Most Likely RGs for ECODS B-3 and B-5

Subunit	RCOC	Units	Risk-Based RGO		SRS Background[2]			Most Likely RG[3]
			HH RGO (Resident)[1]	HH RGO[1] (Industrial Worker)	Max	95th %tile	2X Mean	
ECODS B-3	Hexachlorobenzene	mg/kg	3.00E-01	1.10E+00	NA	NA	NA	3.00E-01
	alpha-Chlordane	mg/kg	1.60E+00	6.50E+00	NA	NA	NA	1.60E+00
	gamma-Chlordane	mg/kg	1.60E+00	6.50E+00	NA	NA	NA	1.60E+00
	p,p'-DDD	mg/kg	2.00E+00	7.2E+00	NA	NA	NA	2.00E+00
	p,p'-DDE	mg/kg	1.40E+00	5.10E+00	NA	NA	NA	1.40E+00
	p,p'-DDT	mg/kg	1.70E+00	7.00E+00	NA	NA	NA	1.70E+00
	Heptachlor	mg/kg	1.10E-01	3.80E-01	NA	NA	NA	1.10E-01
	Heptachlor epoxide	mg/kg	5.30E-02	1.90E-01	NA	NA	NA	5.30E-02
ECODS B-5	Arsenic	mg/kg	3.90E-01	1.60E+00	2.29E+01	8.20E+00	4.50E+00	8..20E+00

[1] – Human health RGOs for the residential and industrial worker scenarios are based on a risk level of 1E-06.
[2] – SRS background information for naturally occurring constituents from Appendix B-2 of the *Background Soils Statistical Summary Report for the Savannah River Site* (WSRC 2006).
[3] – Most likely RG is the most restrictive risk-based RGO concentration if it is greater than background concentrations. If the risk-based RGO is less than SRS background, then the most likely RG defaults to the background concentration.

4.0 IDENTIFICATION OF REMOVAL ACTION ALTERNATIVES

The alternatives evaluated as part of this RSER/EE/CA are identified below:

4.1 Alternative 1 – No Action

Under this alternative, the construction waste/impacted soil at ECODS B-3 and B-5 will remain in place. Thus, the potential exists for contaminants to be directly contacted and/or to migrate to soil, groundwater, and/or surface water.

4.2 Alternative 2 – Removal and Offsite Disposal

Under this alternative, approximately 6,600 yd^3 (5,046 m^3) of construction waste/impacted soil would be removed and transported to a CERCLA Off-Site Rule Approved Landfill (e.g., Three Rivers Landfill) for disposal. The excavations will extend a minimum of two feet beyond the waste (horizontally and vertically). SRS will conduct confirmation sampling of the soil underlying ECODS B-3 and B-5. A SAP will be submitted for approval by USEPA and SCDHEC prior to the RA. The results of the sampling will be included in the RAR, which will be submitted to USEPA and SCDHEC following completion of the RA. The established cleanup goals would attempt to meet residential goals (i.e., unlimited land use with no land use controls). Upon completion of confirmation sampling, backfilling with clean fill, final contouring/grading and establishment of vegetative cover will be performed to stabilize the affected areas.

5.0 ANALYSIS AND COMPARISON OF REMOVAL ACTION ALTERNATIVES

Two alternatives are presented in this RSER/EE/CA for evaluation. According to the NCP, the No Action alternative, Alternative 1, must be evaluated as a baseline. Alternative 2 proposes to remove all construction waste/impacted soil from ECODS B-3 and B-5 and properly dispose of it at an approved landfill.

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 on other related documents. 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 ECODS B-3 and B-5 in place does not reduce the risk to the future industrial worker and does not provide overall protection to human health or the environment. This alternative does not contribute to a reduction of toxicity, mobility, or volume through treatment. The short-term and long-term effectiveness are not applicable since no action is being implemented. This alternative does not provide overall protection. If the native surface soil/vegetation cover erodes, this alternative does not provide 100% protection from directly contacting construction waste/impacted soil. In addition, if construction waste/impacted soil remains, there is potential for future releases to soil, groundwater, and surface water. Thus, this alternative does not comply with applicable or relevant and appropriate requirements (ARARs).

Alternative 2, Removal and Offsite Disposal, meets the effectiveness criteria. The removal of the estimated 6,600 yd^3 (5,046 m^3) of construction waste/impacted soil and transport to and disposal at a CERCLA Off-Site Rule Approved Landfill (e.g., Three Rivers Landfill) provides overall protection to human health and the environment. The excavations will extend a minimum of two feet beyond the waste (horizontally and vertically). This alternative provides short-term and long-term effectiveness because it removes all construction waste/impacted soil from ECODS B-3 and B-5, thereby eliminating the direct contact risk and potential ongoing contaminant source. Alternative 2 complies with the ARARs.

5.2 Identification of ARARs

In accordance with the NCP [40 CFR 300.415(j)] and USDOE guidance, onsite RAs conducted under CERCLA are required to meet 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 ECODS B-3 and B-5 in Table 3. This RSER/EE/CA does not propose to waive any ARARs. The final disposition of the entire ECODS B-3 and B-5 will be addressed as part of the RA. Completion activities are identified in the FFA, a legally binding and enforceable tri-party agreement between USDOE and the two regulatory agencies, USEPA and SCDHEC.

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. A streamlined human health risk evaluation, PTSM evaluation, and Contaminant Migration Analysis have been conducted for ECODS B-3 and B-5 and are

included as appendices to this document (Appendix A, Appendix B). CERCLA risk assessments and the associated remedial clean up goals are protective of hypothetical future workers at the site, and thus are necessarily protective of offsite receptors.

An HHRA has been performed as prescribed by USEPA risk assessment guidance and SRS protocols. CERCLA risk assessments and the associated remedial clean up goals will be protective of hypothetical future residents and offsite receptors. Any potential environmental releases resulting from implementation of the preferred alternative would be minimal. Impacts beyond the SRS boundary would be negligible, ensuring that no environmental justice concerns are associated with the proposed RA.

ECODS B-3 and B-5 represents no cultural or historical significance. It has not been identified as a structure which qualifies as historically significant as documented in the SRS's Cold War Built Environmental Cultural Resource Management Plan (CRMP) (USDOE 2005). The site of the proposed RA is located within an established industrial landscape. Any previously existing archaeological, cultural, or historical resource(s) in the project area would have been destroyed by land alterations and modern construction-related activities associated with development of ECODS B-3 and B-5. Implementation of the proposed RA would have a negligible impact on SRS archaeological, cultural, or historical resources.

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, Removal and Offsite Disposal, could be implemented without major technical or administrative concerns. Personnel are readily available and technologies for removal and disposal are well defined. The solid waste landfill proposed for disposal of the construction waste/impacted soil from ECODS B-3 and B-5 is not owned or operated by USDOE, but is on USDOE property and transportation would not be a significant issue. Excavation of the construction waste/impacted soil material uses standard construction equipment readily available in most areas.

5.4 Cost

The costs for these alternaitives are $0 for Alternative 1 (No Action), while Alternative 2 (Removal and Offsite Disposal) is expected to cost approximately $320,252.

The cost categories considered for each alternative were; capital, operational, and maintenance, as appropriate. The summary costs presented are based on the anticipated scope associated with the alternatives discussed. The cost elements may change as a result of new information and changing site conditions during implementation. The costs presented are in Fiscal Year (FY) 2010 dollars.

5.5 Comparison of Removal Action Alternatives

A comparative analysis of the alternatives is presented in Table 4.

Table 3. Potential ARARs and TBC Criteria for the Removal Action Alternatives

Citation(s)	Status	Requirement Summary	Reason for Inclusion
SCR.61-62.6 Fugitive Dust	Applicable	Fugitive particulate material shall be controlled.	Construction/RA may require dust suppression.
SC R.61-9 NPDES Permit SCR 10000	Applicable	Requirement for control of stormwater discharges.	Any stormwater discharges from construction activities must meet these standards.
SC R.72-300 Standards for Stormwater Management and Sediment Reduction	Applicable	Stormwater management and sediment control plan for land disturbances.	Construction activities may require an erosion control plan.
SC R. 61 -107 Solid Waste Management	Applicable	Regulations governing disposal of non-hazardous solid waste.	Implementation of certain alternatives will generate solid waste requiring disposal.
40 CFR 261, Identification and Listing of Hazardous Waste, 40 CFR 268, Land Disposal Restrictions (LDR) Hazardous Waste Managements System SC R.61-79.261 and SC R.61-79.268	Applicable	Defines criteria for determining whether a waste is a solid waste and is RCRA hazardous waste. If a waste is RCRA hazardous, identifies storage, treatment, and disposal requirements, recordkeeping, and training of workers. RCRA hazardous wastes are prohibited from being land disposed without meeting the treatment stands identified in 40 CFR 268.	Would be applicable if any hazardous waste is generated during demolition activities. Workers would be required to meet health and safety training requirements. Waste would have to be evaluated to determine if it is hazardous waste per RCRA. If a hazardous waste is generated and moved from the area of contamination it would need to be stored in a permitted RCRA storage facility. On site storage would need to comply with substantive labeling, packaging (containers), and training requirements. Debris and hazardous waste sent offsite for disposal would have to meet any LDRs prior to disposal.
SC R.61-86 Standards of Performance for Asbestos Projects	Applicable	Regulations governing handling and disposal of asbestos containing material.	Implementation of certain alternatives may require handling/disposal of asbestos containing material.

Table 3. Potential ARARs and TBC Criteria for Removal Action Alternatives (Cont.)

Citation(s)	Status	Requirement Summary	Reason for Inclusion
SC R.61-79.273 Standards for Universal Waste Management	Applicable	Regulations governing handling and disposal of universal wastes.	Implementation of certain alternatives may require handling/disposal of universal wastes.
OSHA/29 CFR 1910	Applicable	Safety Standards for general industry.	Implementation of certain alternatives requires general field activity.
OSHA/29 CFR 1926	Applicable	Safety Standards for construction.	Implementation of certain alternatives requires construction activity.

ARAR = Applicable and Relevant or Appropriate Standards
NPDES = National Pollutant Discharge Elimination System
TBC = To Be Considered

Table 4. Comparative Analysis of Alternatives

Criteria	Alternative 1 No Action	Alternative 2 Removal and Offsite Disposal
Effectiveness	**Very Low** • Does not comply with ARARs • No implementation risk • Greater potential for contaminant migration via surface water intrusion and subsequent hypothetical groundwater impacts • Contact hazards remain for industrial workers • No unrestricted use.	**High** • Achieves RAO by preventing future resident/industrial worker exposure. • Complies with ARARs • Direct contact hazard is removed • Complete removal provides long-term protectiveness. • Future long-term potential for impact to groundwater is removed. • All construction waste/impacted soil could be removed and land restored to unrestricted residential use
Implementability	High	High
Cost (FY10 Dollars)	$0	$320,252

6.0 PREFERRED REMOVAL ACTION ALTERNATIVE

The preferred RA for ECODS B-3 and B-5 is Alternative 2 - Removal and Offsite Disposal. This alternative provides good short-term and long-term effectiveness because it removes all construction waste/impacted soil, thereby eliminating a direct exposure risk and future contaminant source for soil and groundwater. The exposure pathway model for ECODS B-3 and B-5 with the preferred RA is presented in Figure 7. In addition, the action removes the potential for being an ecological risk. Once confirmation soil samples verify that all RCOCs have been removed, no future investigation or RA(s) would be necessary. Figure 8 presents the proposed approximate excavation boundary for ECODS B-3 and B-5, which will extend a minimum of two feet beyond the waste. The proposed excavation boundary shown in Figure 8 is the same as the expanded ECODS B-3 boundary defined by GPR in 2009 (Figure 5a).

On July 7, 2009, the Core Team agreed to perform the NTCR action. The RA will attempt to meet residential cleanup goals (i.e., unrestricted use with no land use controls) for the land. This will allow a No Further Action final Record of Decision for the OU, since there will be no remaining problem warranting response action after the RA has been completed. Note that a SAP that contains the details of confirmatory sampling will be submitted for approval prior to the RA, and the results will be described in the RAR upon completion.

7.0 IMPLEMENTATION SCHEDULE

This RSER/EE/CA will be submitted to USEPA and SCDHEC for review and comment. Following this review, the document will be available for public comment. The RA schedule is presented in Table 5 below:

Table 5. Implementation Schedule

Submit RSER/EE/CA for Regulatory Comment	December 30, 2009
Submit RSER/EE/CA for Public Comment	March 16, 2010
Submit final Action Memorandum	April 28, 2010
Anticipated Start of Removal Action Activity	July 10, 2010
Anticipated Completion of Removal Action Activity	December 2, 2010

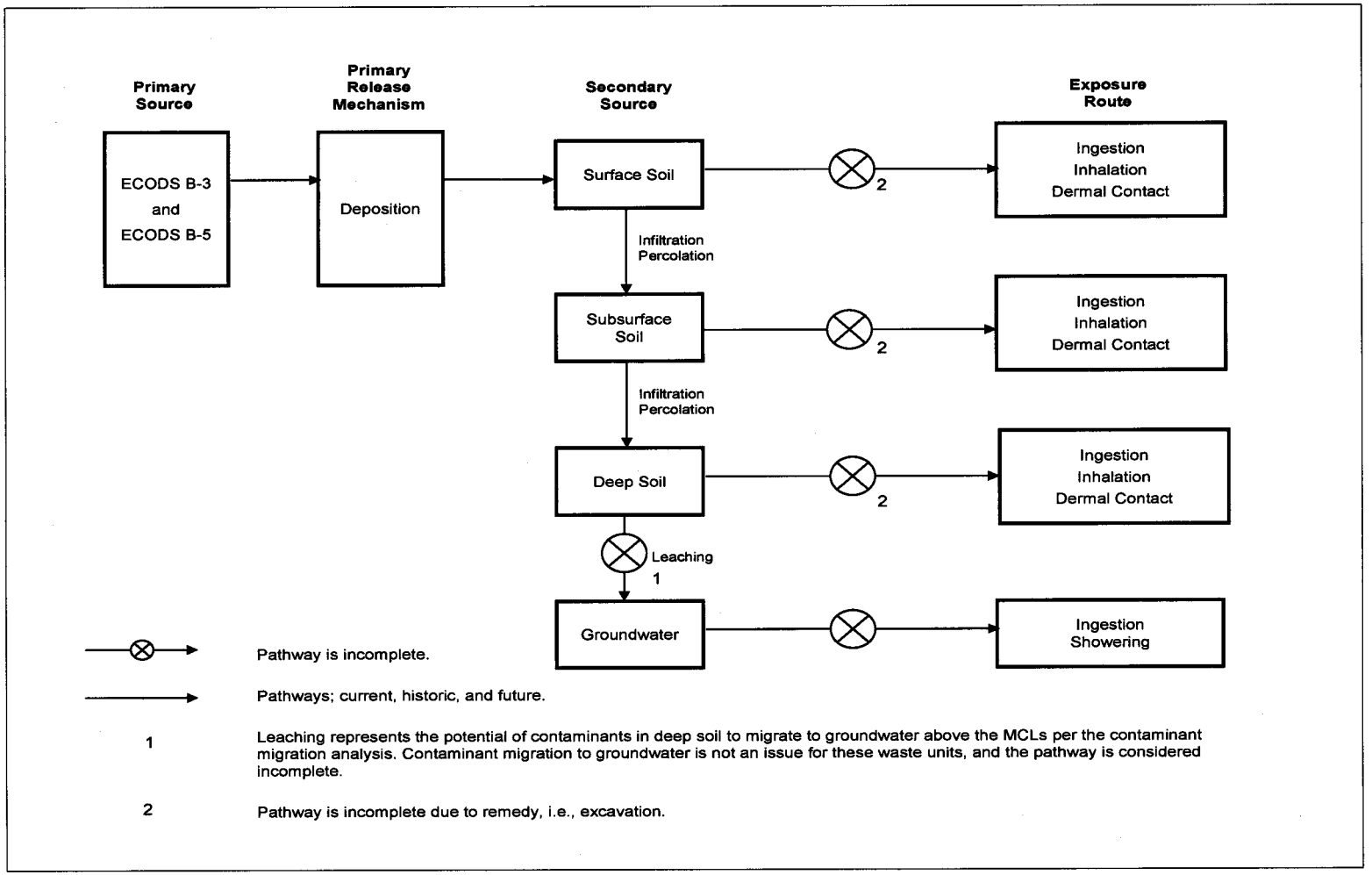

Figure 7. Exposure Pathway Model for ECODS B-3 and B-5

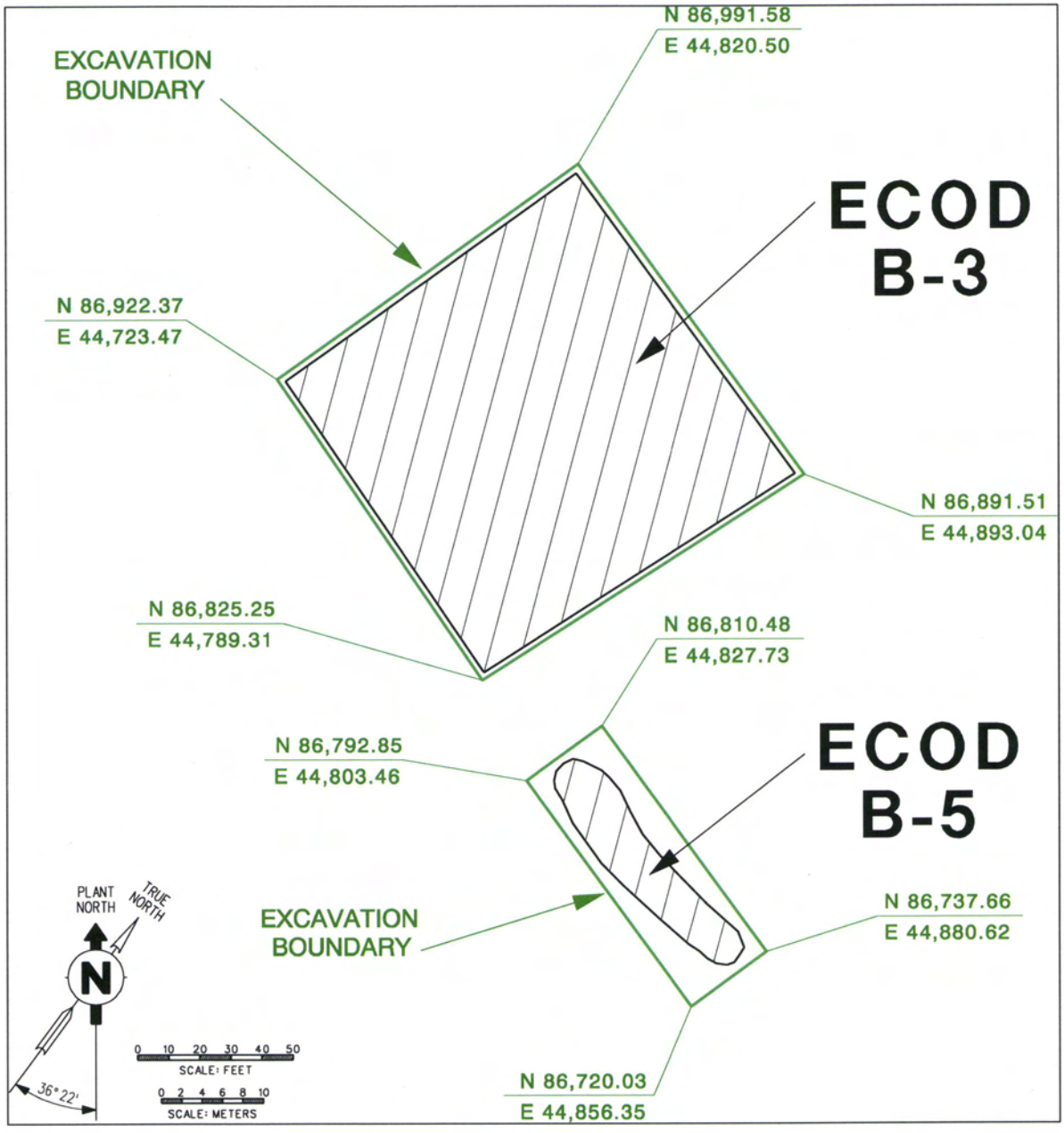

Figure 8. Excavation Boundaries for ECODS B-3 and B-5

8.0 REFERENCES

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WSRC, 2003. *Site Evaluation Report for Early Construction and Operational Disposal Site (ECODS) B-5 (NBN) (U)*, Revision 0, WSRC-RP-2003-4012, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC (June).

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WSRC*, 2009. Manual 5Q1.2, *Radiation Monitoring Procedures,* http://shrine01.srs.gov/eshqa/dps/rco/5q1.2/toc.htm, Environment, Safety, Health and Quality, Savannah River Site, Aiken, SC.

* WSRC procedures have been accepted by SRNS, but have not yet received an SRNS or SRS procedure number.

9.0 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.

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 RA 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.

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 RA authority to implement an appropriate response to the risks posed. Activities that may be taken under CERCLA RA 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. RAs 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.

Appendix A

Potential Threat Source Material Evaluation

and

Human Health Risk Assessment

A.1 Introduction

The Potential Threat Source Material (PTSM) evaluation and Human Health Risk Assessment (HHRA) for Early Construction and Operational Disposal Sites (ECODS) B-3 and B-5 are presented in this appendix. The purpose is to assess the potential for adverse effects associated with exposure to constituents present at this facility and to provide a basis for determining the need for a RA from a human health risk perspective.

The soil data used for the PTSM evaluation and HHRA were collected in March 2001 (ECODS B-3) and March 2002 (ECODS B-5) and reported in Savannah Rive Site (SRS) Site Evaluation Reports (WSRC 2002, 2003). The data collected under the SRS Site Evaluation Program were used to determine the nature and extent of contamination and selection of the remedial action.

A.2 Sources of Risk Threshold Values

U.S. Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs) are risk-based concentrations used to evaluate and clean up contaminated sites. The USEPA generic Regional Screening Levels Table, dated April 2009, is the source of RSLs for nonradiological constituents (USEPA 2009); it combines current USEPA toxicity values with standard exposure factors to estimate contaminant concentrations in soil that USEPA considers protective of humans over a lifetime. The April 2009 RSL table used for this analysis is provided on the CD in the front pocket of the report binder. RSL concentrations are based on direct exposure pathways for which generally accepted methods, models, and assumptions have been developed (i.e., ingestion, dermal contact, and inhalation) for specific land use conditions. More detailed information can be found at the USEPA RSLs website: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm. Note that prior to April 2009, SRS used USEPA Region 9 PRGs in place of RSLs for evaluating and screening contaminated sites. The PRGs were used for evaluating the Site Evaulation data collected at ECODS B-3 and B-5 as discussed in Section 2.5 on pages 12-16 of this document.

A.3 Receptors

ECODS B-3 and B-5 are located in an area currently designated for industrial use, with no current or projected future development planned. Future industrial land use will be controlled in accordance with the SRS Land Use Control Assurance Plan (LUCAP; WSRC 1999). In order to support risk management decision making, both unrestricted (i.e., residential) and industrial land use scenarios will be evaluated in this appendix.

The future resident exposure scenario evaluates long term risks to individuals expected to have unrestricted use of the unit as described in the protocol for *Human Health Receptors and Scenarios* (WSRC 2006a). It assumes that residents hypothetically live on the unit and are exposed chronically, both indoors and outdoors, to unit contaminants. The standard exposure assumptions are 30 years, 350 days per year, and 24 hours per day. The protocol for *Human Health Exposure Parameters* (WSRC 2006a) and the RSL website (USEPA 2009) describe the exposure assumptions and detailed input parameters used to derive the RSLs for a reasonable maximum exposure (RME) scenario.

The future industrial worker exposure scenario is a standard USEPA scenario that 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 2006a). The future industrial worker is an adult who hypothetically works on-unit in an outdoor setting for the majority of time. The standard exposure assumptions are 25 years, 250 days per year, 8 hours per day. The protocol for *Human Health Exposure Parameters* (WSRC 2006a) and the RSL website (USEPA 2009) describe the exposure assumptions and detailed input parameters used to derive the RSLs for an RME scenario.

The primary exposure pathway for evaluation relative to the future resident and future industrial worker in the HHRA (Section A.5) is exposure to surface (0 - 1 ft [0 - 0.3 m]) soil via the incidental ingestion, dermal contact, inhalation of windblown dust, and inhalation of volatile constituents pathways.

Based on field characterization methods, GPR, and sampling results, the areal extent of ECODS B-3 is 13,680 ft^2 (1,270 m^2). Construction waste was encountered in B-5 down to a depth of 12 ft (3.7 m). Thus, the estimated volume of construction waste/impacted soil present at ECODS B-3 is 164,160 ft^3 (4,648 m^3).

Based on field characterization methods, GPR, and sampling results, the areal extent of ECODS B-5 is 1,242 ft^2 (115 m^2). Construction waste was encountered in B-5 down to a depth of 11 ft (3.3 m). Thus, the estimated volume of construction waste/impacted soil present in ECODS B-5 is 13,662 ft^3 (387 m^3).

Exposure to potential contamination in subsurface soil is documented in the PTSM evaluation in Section A.4.

A.4 Principal Threat Source Material Evaluation

The concept of principal threat waste and low level threat waste as developed by USEPA in the National Contingency Plan (NCP) (40 CFR 300.430(a)(1)(iii)) is to be applied on a site-specific basis when characterizing source material. Source materials are those materials that include or contain hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or that act as a source for direct exposure (USEPA 1991).

The protocol *Evaluation of Source Materials at SRS Waste Units* reflects the U.S. Department of Energy (USDOE), South Carolina Department of Health and Environmental Control (SCDHEC), and USEPA expectations with respect to defining and managing PTSM at SRS (WSRC 2006a). The determination of whether the source materials present at a waste unit would be classified as PTSM is based principally on *A Guide to Principal Threat and Low Level Threat Wastes* (USEPA 1991). In this guidance, USEPA defines principal threat wastes as "those source materials considered highly toxic or mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur." Included are liquids and other highly mobile materials (e.g., materials that are released from surface

soil due to volatilization, leaching, or surface runoff) or materials having high concentrations of toxic compounds. No "threshold level" of toxicity/risk has been established to equate to "principal threat." However, the guidance does state that treatment alternatives for source materials should generally be evaluated where the combined toxicity and mobility pose a potential risk of 10^{-3} or greater. The principle threat waste concept and the NCP expectations were established to help streamline and focus the remedy selection process.

USEPA, SCDHEC, and USDOE evaluated the USEPA guidance with respect to toxicity and contaminant migration analyses performed at SRS. In practice, the SRS risk assessment and contaminant migration evaluations identify constituents of concern (COCs) associated with source material or impacted media and determine the associated risk or potential impact to groundwater. If threshold risk levels are exceeded or groundwater protection standards are predicted to be contravened in less than 1,000 years, these problems are identified and an evaluation of remedial alternatives is conducted. Since the risk assessment conducted for the ECODS B-3 and B-5 RSER/EE/CA evaluates human receptor exposure to surface soils only (0-1 ft), further evaluation is needed to account for highly toxic source material or contaminated soils at depth that would result in unacceptable risk should exposure occur. However, since this RSER/EE/CA determines Contaminant Migration (CM) COCs for the entire soil column (vadose zone) in the CM Analysis (Appendix B), and these COCs are addressed in the evaluation of the removal alternatives, the mobility aspect of PTSM is being addressed. Therefore, a separate quantitative determination of PTSM based on mobility is not required.

A.4.1 Determination of Principal Threat Source Material

Initially, a qualitative assessment of the source material(s) can be used to determine if the source material should be considered PTSM. These source materials would include containerized liquid wastes (e.g. drums) or non-aqueous phase liquids (NAPLs) (e.g.,

perched dense NAPLs in the vadose zone), and highly toxic solid wastes such as polycyclic chlorinated biphenyls (PCB) transformers or lead batteries.

In order to determine whether contaminated source material/soils/sediment should be preliminarily considered PTSM, a simple quantitative assessment evaluating the toxicity of the source was used for the ECODS B-3 and B-5, as described in the following paragraphs.

In determining whether the source should be preliminarily considered PTSM, the evaluation considers the cumulative effects of both the potential risk from carcinogenic constituents and the adverse health effects from noncarcinogens to human receptors. Because the most likely future land use scenario for most SRS OUs being evaluated is industrial, the toxicity assessment of the source material is based on the potential exposure of a future on-unit industrial worker. The most current USEPA RSLs (USEPA 2009) for an industrial scenario exposure to soil were used to develop the PTSM threshold criteria for chemical carcinogens and noncarcinogens.

The source material is preliminarily considered to be PTSM if the cumulative risk exceeds one of the following toxicity threshold criteria:

- Carcinogens - greater than 1E-03 industrial worker risk
- Noncarcinogens – industrial worker hazard index (HI) greater than 10

For carcinogens, the individual risk is calculated by multiplying the ratio of the exposure point concentration (EPC) over the RSL by 1E-06. In the preliminary screen, the unit maximum concentration for every detected constituent is used as the EPC. Each of these risks is summed to calculate the cumulative carcinogenic risk of the source. For noncarcinogens, an individual hazard quotient (HQ) is equal to the ratio of the EPC over the RSL. These HQs are summed to derive the cumulative HI. If the threshold criteria for PTSM are not exceeded based on a maximum concentration, then PTSM is not present and further evaluation is not necessary.

A.4.1.1 ECODS B-3

No constituents were identified at ECODS B-3 as PTSM for soil media (Table A-1: HI = 0.1; cumulative risk = 5.5E-05).

A.4.1.2 ECODS B-5

No constituents were identified at ECODS B-5 as PTSM for soil media (Table A-2: HI = 5.0 cumulative risk = 2.8E-05).

A.4.2 Principal Threat Source Material Evaluation Summary

The PTSM evaluation indicated no PTSM refined constituents of concern (RCOCs) for soil media at ECODS B-3 and B-5.

A.5 Human Health Risk Assessment

A.5.1 Constituents of Potential Concern Screening

The process described in the protocol for *Human Health Constituents of Potential Concern* (WSRC 2006a) was used to identify human health (HH) constituents of potential concern (COPCs) for each of the waste units and is summarized below:

- Compare unit maximum concentration to residential soil RSLs for carcinogenic constituents.
- Compare unit maximum concentration to 0.1 times the residential soil RSL for noncarcinogenic constituents.
- Compare unit maximum concentration of the naturally-occurring (nonanthropogenic) constituents to 2 times the average SRS background soil concentration (WSRC 2006b).
- Constituents exceeding the residential soil RSL and background screen are identified as HH COPCs and are carried forward to Step A.5.2, *Risk/Hazard Calculation.*

A.5.2 Risk / Hazard Calculation

The process described in the protocol for *Human Health Constituents of Concern* (WSRC 2006a) was used to identify HH COCs for each of the waste units and is summarized below:

- Segregate carcinogenic (risk) and non-carcinogenic (hazard) constituents. Typically risk and hazard estimates are based on the RME EPC, which is defined as the lesser of the maximum concentration and the 95% upper confidence limit on the mean concentration. For the evaluation of these waste units, the maximum detected concentration was used as the EPC. This is a conservative approach.
- For carcinogens, the risk estimate = ([EPC] / [RSL]) x 1E-06: calculate the total chemical risk, total radiological risk, and total media risk. Constituents with an individual cancer risk $\geq$ 1E-06 are identified as HH COCs.
- For noncarcinogens, the hazard estimate = ([EPC / [RSL]); calculate the total media hazard index (HI). If the total media HI < 1, then no HH COCs are identified. If the total media HI $\geq$ 1, then the constituents are segregated based on relevant target organs. Hazard Quotients (HQs) are summed according to target organs. Constituents are identified as HH COCs if the total organ HQ $\geq$ 0.1 and the total organ HI $\geq$ 1.
- Constituents identified as HH COCs are further evaluated in Step A.5.3, *Refinement of Constituents of Concern.*

A.5.3 Refinement of Constituents of Concern

A recommendation of whether or not a HH COC should be carried forward as an HH RCOC for further remedial evaluation is based on a thorough analysis of each constituent. The uncertainty discussion is provided per the *Constituents of Concern Refinement Process Protocol* (WSRC 2006a). SRS soil background concentrations used in this section were obtained from Appendix B-2 of the *Background Soils Statistical Summary Report* (WSRC 2006b).

Results of the HH COPC screening (Step A.5.1), risk/hazard calculations to determine HH COCs (Step A.5.2), and the refinement of HH COC analysis (Step A.5.3) are provided below for each waste unit.

ECODS B-3

Table A-3 identifies the following constituents as HH COPCs for surface soil; aluminum, arsenic, iron, vanadium, hexachlorobenzene, alpha-chlordane, gamma-chlordane, p,p'-DDD, p,p'- DDE, p,p'- DDT, heptachlor, and heptachlor epoxide.

Table A-4 identifies arsenic, hexachlorobenzene, alpha-chlordane, gamma-chlordane, p,p'- DDD, p,p'- DDE, p,p'- DDT, heptachlor, and heptachlor epoxide as HH COCs based on the future resident scenario. Table A-5 identifies these same constituents as HH COCs based on the future industrial worker scenario.

Uncertainty Analysis: Arsenic

Arsenic is identified as a HH COC for the future resident scenario (risk = 1.2E-05) and the future industrial worker scenario (risk = 3.0E-06). It was detected in 16 of 16 surface soil samples, with 13 of the 16 detects being estimated (i.e., "J" qualified) values. Concentrations ranged from 0.761 mg/kg to 4.76 mg/kg, with an average concentration of 2.51 mg/kg. The RSL for the future resident is 0.39 mg/kg, and the RSL for the future industrial worker is 1.6 mg/kg (Tables A-4, A-5). All 16 surface samples are above the residential RSL; 10 results are above the industrial RSL.

Arsenic is a naturally-occurring constituent that is common in soils at the SRS. The maximum concentration in SRS soils (WSRC 2006b) is 22.9 mg/kg and the mean concentration is 2.23 mg/kg.

Arsenic is not recommended for further remedial evaluation as an HH RCOC in surface soil for either the future resident or the future industrial worker scenarios based on the following lines-of-evidence:

- Arsenic is a naturally occurring constituent that is common in SRS soils.

- Unit concentrations are within soil background concentrations at SRS.

Uncertainty Analysis: Hexachlorobenzene, alpha-Chlordane, gamma-Chlordane, p,p'-DDD, p,p'- DDE, p,p'- DDT, Heptachlor, and Heptachlor epoxide

An uncertainty analysis was not conducted for these constituents. All are considered RCOCs for both the future resident and the future industrial worker scenarios.

ECODS B-3 Conclusion

For the future residential scenario, hexachlorobenzene (risk = 6.6E-06), alpha-chlordane (risk = 2.2E-05), gamma-chlordane (risk = 2.5E-05), p,p'- DDD (risk = 2.1E-05), p,p'-DDE (risk = 7.1E-06), p,p'- DDT (risk = 9.5E-06), heptachlor (1.9E-05), and heptachlor epoxide (4.1E-06) are identified as HH RCOCs; the total cumulative risk is 1.1E-04.

For the future industrial worker scenario, the following constituents are identified as HH RCOCs; hexachlorobenzene (risk = 1.8E-06), alpha-chlordane (risk = 5.5E-06), gamma-chlordane (risk = 6.1E-06), p,p'- DDD (risk = 5.9E-06), p,p'- DDE (risk = 1.9E-06), p,p'-DDT (risk = 2.3E-06), heptachlor (5.4E-06), and heptachlor epoxide (1.2E-06). The total cumulative risk is 3.0E-05.

ECODS B-5

Table A-6 identifies the following constituents as HH COPCs for surface soil; aluminum, arsenic, and cobalt.

Tables A-7 and A-8 identify arsenic as an HH COC based on the future resident and future industrial worker scenarios, respectively.

Uncertainty Analysis: Arsenic

An uncertainty analysis for arsenic was not conducted - this constituent is considered an HH RCOC for both the future resident and the future industrial worker scenarios.

ECODS B-5 Conclusion

Arsenic is identified as an HH RCOC in surface soil at the ECODS B-5 for the future resident scenario (risk = 4.9E-05) and the future industrial worker scenario (risk = 1.2E-05).

A.5.4 Health Risk Assessment Summary

Results of the HHRA, including identification of RCOCs and corresponding risk estimates for the media of concern are provided below.

Waste Unit	HH RCOCs	Risk Estimate	Total Cumulative Risk	Media
ECODS B-3	Resident		1.1E-04	surface soil
	Hexachlorobenzene	6.6E-06		
	Alpha-Chlordane	2.2E-05		
	Gamma-Chlordane	2.5E-05		
	p,p'- DDD	2.1E-05		
	p,p'- DDE	7.1E-06		
	p,p'- DDT	9.5E-06		
	Heptachlor	1.9E-05		
	Heptachlor epoxide	4.1E-06		
	Industrial Worker		3.0E-05	surface soil
	Hexachlorobenzene	1.8E-06		
	Alpha-Chlordane	5.5E-06		
	Gamma-Chlordane	6.1E-06		
	p,p'- DDD	5.9E-06		
	p,p'- DDE	1.9E-06		
	p,p'- DDT	2.3E-06		
	Heptachlor	5.4E-06		
	Heptachlor epoxide	1.2E-06		
ECODS B-5	Resident		4.9E-05	surface soil
	Arsenic	4.9E-05		
	Industrial Worker		1.2E-05	surface soil
	Arsenic	1.2E-05		

A.6 References

USEPA, 1991. *A Guide to Principal Threat and Low Level Threat Wastes*, U.S. Environmental Protection Agency OSWER Superfund Publication 9380.3-06FS. (November)

USEPA, 2009. *EPA Regional Screening Levels Table*, United States Environmental Protection Agency, dated April 2009 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)

WSRC, 2002, *Site Evaluation Report for the Early Construction and Operational Disposal Site (ECODS) B-3 (NBN) (U),* WSRC-RP-2001-4274, Rev. 0, Westinghouse Savannah River Company, Aiken, SC.

WSRC, 2003, *Site Evaluation Report for the Early Construction and Operational Disposal Site (ECODS) B-5 (NBN) (U),* WSRC-RP-2003-4012, Rev. 0, Westinghouse Savannah River Company, Aiken, SC.

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

WSRC, 2006b. *Background Soils Statistical Summary Report for Savannah River Site,* ERD-EN-2005-0223, Rev. 1, Washington Savannah River Company, Savannah River Site, Aiken, SC (October).

Table A-1. PTSM Evaluation for Soil Media (All Depths) - ECODS B-3

Constituent	Exposure Point Concentration[1]	Noncarcinogenic Hazard Estimate		Carcinogenic Risk Estimate	
		Industrial RSL[2]	Industrial Hazard Quotient (HQ) Estimate[3]	Industrial RSL[2]	Industrial Risk Estimate[4]
Inorganics (mg/kg)					
Aluminum	1.95E+04	9.9E+05	1.97E-02	----	----
Arsenic	1.34E+01	----	----	1.6E+00	8.38E-06
Barium	1.42E+02	1.9E+05	7.47E-04	----	----
Beryllium	4.65E+00	2.0E+03	2.33E-03	----	----
Calcium	1.37E+03	EN	NA	----	----
Chromium	4.36E+01	----	----	1.4E+03	3.11E-08
Cobalt	1.79E+00	3.0E+02	5.97E-03	----	----
Copper	7.48E+01	4.1E+04	1.82E-03	----	----
Cyanide	7.08E-01	2.0E+04	3.54E-05	----	----
Iron	4.11E+04	7.2E+05	5.71E-02	----	----
Lead	1.74E+01	8.0E+02	2.18E-02	----	----
Magnesium	2.66E+02	EN	NA	----	----
Manganese[5]	1.59E+02	na	NA	----	----
Mercury	1.04E-01	3.1E+02	3.35E-04	----	----
Nickel	1.01E+01	2.0E+04	5.05E-04	----	----
Potassium	1.75E+02	EN	NA	----	----
Selenium	2.15E+00	5.1E+03	4.22E-04	----	----
Vanadium	9.04E+01	5.2E+03	1.74E-02	----	----
Zinc	3.07E+02	3.1E+05	9.90E-04	----	----
Volatile Organics (mg/kg)					
1,2,4-Trichlorobenze	3.24E-01	4.0E+02	8.10E-04	----	----
1,2-Dichlorobenzene	7.26E-02	1.0E+04	7.26E-06	----	----
1,3-Dichlorobenzene[5]	2.25E-01	na	NA	----	----
1,4-Dichlorobenzene	1.34E+00	----	----	1.3E+01	1.03E-07
Acetone	1.03E-01	6.1E+05	1.69E-07	----	----
Carbon disulfide	4.18E-03	3.0E+03	1.39E-06	----	----
Chlorobenzene	6.26E-02	1.5E+03	4.17E-05	----	----
Methylene chloride	1.35E-03	----	----	5.4E+01	2.50E-11
Methyl ethyl ketone	1.05E-02	1.9E+05	5.53E-08	----	----
Toluene	5.09E-04	4.6E+04	1.11E-08	----	----
Xylenes	1.54E-03	2.6E+03	5.92E-07	----	----

Table A-1. PTSM Evaluation for Soil Media (All Depths) - ECODS B-3 (Cont.)

Constituent	Exposure Point Concentration[1]	Noncarcinogenic Hazard Estimate		Carcinogenic Risk Estimate	
		Industrial RSL[2]	Industrial Hazard Quotient (HQ) Estimate[3]	Industrial RSL[2]	Industrial Risk Estimate[4]
Semi-Volatile Organics *(mg/kg)*					
2-Methylnaphthalene	1.08E+01	4.1E+03	2.63E-03	----	----
Bis(2-Ethylhexyl)phthalate	1.57E+00	----	----	1.2E+02	1.31E-08
Hexachlorobenzene	1.98E+00	----	----	1.1E+00	1.80E-06
Naphthalene	1.90E+00	----	----	2.0E+01	9.50E-08
Phenanthrene[5]	9.55E-01	na	NA	----	----
Pesticides/PCBs *(mg/kg)*					
alpha-Chlordane	3.58E+01	----	----	6.5E+00	5.51E-06
p,p'- DDD	1.47E+02	----	----	7.2E+00	2.04E-05
p,p'- DDE	9.91E+00	----	----	5.1E+00	1.94E-06
p,p'- DDT	2.04E+01	----	----	7.0E+00	2.91E-06
Dieldrin	5.32E-04	----	----	1.1E-01	4.84E-09
gamma-Chlordane	3.96E+01	----	----	6.5E+00	6.09E-06
Heptachlor	2.40E+00	----	----	3.8E-01	6.32E-06
Heptachlor epoxide	2.19E-01	----	----	1.9E-01	1.15E-06
		Hazard Index	**1.33E-01**	**Cumulative Risk**	**5.48E-05**
		PTSM?[6]	**no**	**PTSM?[7]**	**no**

[1] - EPC = maximum detected concentration from all depth intervals.

[2] - Nonradiological RSLs are industrial worker soil values from the EPA Regional Screening Levels Table, dated April, 2009.

[3] - Hazard Estimate = exposure point concentration / RSL concentration

[4] - Risk Estimate = (exposure point concentration / RSL concentration) x 1E-06

[5] - RSL for this constituent is not available.

[6] - Subunit potentially has PTSM if HI $\geq$ 10 for noncarcinogenic constituents.

[7] - Subunit potentially has PTSM if cumulative risk $\geq$ 1E-03 for carcinogenic constituents.

EN = essential nutrient

NA = not applicable

na = not available

Table A-2. PTSM Evaluation for Soil Media (All Depths) - ECODS B-5

Constituent	Exposure Point Concentration[1]	Noncarcinogenic Hazard Estimate		Carcinogenic Risk Estimate	
		Industrial RSL[2]	Industrial Hazard Quotient (HQ) Estimate[3]	Industrial RSL[2]	Industrial Risk Estimate[4]
Inorganics (mg/kg)					
Aluminum	5.47E+04	9.9E+05	5.53E-02	----	----
Antimony	8.80E+00	4.1E+02	2.15E-02	----	----
Arsenic	3.60E+01	----	----	1.6E+00	2.25E-05
Barium	2.98E+02	1.9E+05	1.57E-03	----	----
Cadmium	9.74E+00	8.0E+02	1.22E-02	----	----
Calcium	1.19E+04	EN	NA	----	----
Chromium	8.68E+01	----	----	1.4E+03	6.20E-08
Cobalt	1.09E+01	3.0E+02	3.63E-02	----	----
Copper	5.78E+02	4.1E+04	1.41E-02	----	----
Cyanide	2.01E+01	2.0E+04	1.01E-03	----	----
Iron	1.32E+05	7.2E+05	1.83E-01	----	----
Lead	3.60E+03	8.0E+02	4.50E+00	----	----
Magnesium	8.83E+02	EN	NA	----	----
Manganese[5]	3.13E+04	na	NA	----	----
Mercury	5.13E+00	3.1E+02	1.65E-02	----	----
Nickel	4.72E+01	2.0E+04	2.36E-03	----	----
Potassium	4.26E+02	EN	NA	----	----
Selenium	9.39E+00	5.1E+03	1.84E-03	----	----
Silver	1.37E+00	5.1E+03	2.69E-04	----	----
Sodium	6.97E+03	EN	NA	----	----
Thallium	3.08E+00	6.6E+01	4.67E-02	----	----
Vanadium	1.74E+02	5.2E+03	3.35E-02	----	----
Zinc	1.93E+04	3.1E+05	6.23E-02	----	----
Volatile Organics (mg/kg)					
1,1-Dichloroethylene	2.42E-02	1.1E+03	2.20E-05	----	----
Acetone	1.23E-03	6.1E+05	2.02E-09	----	----
Benzene	5.55E-03	----	----	5.6E+00	9.91E-10
Ethybenzene	7.69E-04	----	----	2.9E+01	2.65E-11
Toluene	3.41E-03	4.6E+04	7.41E-08	----	----
Trichloroethylene (TCE)	1.73E-04	----	----	1.4E+01	1.24E-11
Xylenes	7.47E-04	2.6E+03	2.87E-07	----	----

Table A-2. PTSM Evaluation for Soil Media (All Depths) - ECODS B-5 (Cont.)

Constituent	Exposure Point Concentration[1]	Noncarcinogenic Hazard Estimate		Carcinogenic Risk Estimate	
		Industrial RSL[2]	Industrial Hazard Quotient (HQ) Estimate[3]	Industrial RSL[2]	Industrial Risk Estimate[4]
Semi-Volatile Organics (mg/kg)					
Benzo(g,h,i)perylene[5]	8.86E-01	na	NA	----	----
Benzo[a]anthracene	2.69E-01	----	----	2.1E+00	1.28E-07
Benzo[a]pyrene	6.98E-01	----	----	2.1E-01	3.32E-06
Benzo[b]fluoranthene	1.45E+00	----	----	2.1E+00	6.90E-07
Benzo[k]fluoranthene	6.56E-01	----	----	2.1E+01	3.12E-08
Bis(2-ethylhexyl)phthalate	2.17E+00	----	----	1.2E+02	1.81E-08
Chrysene	3.38E-01	----	----	2.1E+02	1.61E-09
Dibenz[ah]anthracene	8.91E-02	----	----	2.1E-01	4.24E-07
Di-N-Butyl phthalate	4.73E-02	6.2E+04	7.63E-07	----	----
Fluoranthene	1.58E-01	2.2E+04	7.18E-06	----	----
Indeno[1,2,3-cd]pyrene	8.09E-01	----	----	2.1E+00	3.85E-07
Pyrene	1.59E-01	1.7E+04	9.35E-06	----	----
Pesticides/PCBs (mg/kg)					
alpha-Chlordane	1.25E-02	----	----	6.5E+00	1.92E-09
Aroclor 1254	2.56E-02	----	----	7.4E-01	3.46E-08
p,,p'- DDD	2.84E-03	----	----	7.2E+00	3.94E-10
p,,p'- DDE	2.18E-02	----	----	5.1E+00	4.27E-09
p,,p'- DDT	8.33E-03	----	----	7.0E+00	1.19E-09
gamma-Chlordane	1.52E-02	----	----	6.5E+00	2.34E-09
Heptachlor	6.72E-04	----	----	3.8E-01	1.77E-09
Heptachlor epoxide	2.40E-03	----	----	1.9E-01	1.26E-08
		Hazard Index	**4.99E-+00**	**Cumulative Risk**	**2.76E-05**
		PTSM?[6]	**no**	**PTSM?[7]**	**no**

[1] - EPC = maximum detected concentration from all depth intervals.

[2] - Nonradiological RSLs are industrial worker soil values from the EPA Regional Screening Levels Table, dated April, 2009.

[3] - Hazard Estimate = exposure point concentration / RSL concentration.

[4] - Risk Estimate = (exposure point concentration / RSL concentration) x 1E-06.

[5] - RSL for this constituent is not available.

[6] - Subunit potentially has PTSM if HI $\geq$ 10 for noncarcinogenic constituents.

[7] - Subunit potentially has PTSM if cumulative risk $\geq$ 1E-03 for carcinogenic constituents.

EN = essential nutrient

NA = not applicable

na = not available

Table A-3. Human Health COPC Screening - ECODS B-3 OU Surface Soil (0-1 ft)

Analyte	Detected Maximum Concentration[1]	Human Health Screening Value	Human Health Screening Value Source[2]	Exceeds Human Health Screening Value?	2X Average Background Concentration[3]	Exceeds 2X Average Background?[4]	COPC?[5]
Inorganics (mg/kg)							
Aluminum	1.06E+04	7.7E+03	0.1xRSL	Yes	1.05E+04	Yes	Yes
Arsenic	4.76E+00	3.9E-01	RSL	Yes	4.28E+00	Yes	Yes
Barium	4.08E+01	1.5E+03	0.1xRSL	no	3.91E+01	Yes	no
Calcium	1.37E+03	EN[6]	Nutrient	no	4.76E+02	Yes	no
Chromium	2.59E+01	2.8E+02	RSL	no	1.54E+01	Yes	no
Cobalt	1.79E+00	2.3E+00	0.1xRSL	no	1.55E+00	Yes	no
Copper	9.48E+00	3.1E+02	0.1xRSL	no	4.34E+00	Yes	no
Cyanide	7.08E-01	1.6E+02	0.1xRSL	no	ND	Yes	no
Iron	1.92E+04	5.5E+03	0.1xRSL	Yes	1.27E+04	Yes	Yes
Lead	1.08E+01	4.0E+01	0.1xRSL	no	1.03E+01	Yes	no
Magnesium	2.19E+02	EN[6]	Nutrient	no	2.75E+02	no	no
Manganese[7]	1.59E+02	na	NA	no	1.53E+02	Yes	no
Mercury	7.47E-02	2.3E+00	0.1xRSL	no	7.10E-02	Yes	no
Nickel	2.83E+00	1.5E+02	0.1xRSL	no	3.48E+00	no	no
Potassium	1.60E+02	EN[6]	Nutrient	no	2.16E+02	no	no
Vanadium	4.57E+01	3.9E+01	0.1xRSL	Yes	3.91E+01	Yes	Yes
Zinc	3.07E+02	2.3E+03	0.1xRSL	no	9.47E+00	Yes	no
Volatile Organics (mg/kg)							
1,2,4-Trichlorobenzene	4.08E-02	8.7E+00	0.1xRSL	no	ND	NA	no
Acetone	1.03E-01	6.1E+03	0.1xRSL	no	ND	NA	no
Methylene chloride	1.24E-03	1.1E+01	RSL	no	ND	NA	no
Methyl ethyl ketone	1.05E-02	2.8E+03	0.1xRSL	no	ND	NA	no

Table A-3. Human Health COPC Screening - ECODS B-3 OU Surface Soil (0-1 ft) (Cont.)

Analyte	Detected Maximum Concentration[1]	Human Health Screening Value	Human Health Screening Value Source[2]	Exceeds Human Health Screening Value?	2X Average Background Concentration[3]	Exceeds 2X Average Background?[4]	COPC?[5]
Semi-Volatile Organics (mg/kg)							
2-Methylnaphthalene	2.78E-02	3.1E+01	0.1xRSL	no	ND	NA	no
Bis(2-ethylhexyl)phthalate	1.51E-01	3.5E+01	RSL	no	ND	NA	no
Hexachlorobenzene	1.98E+00	3.0E-01	RSL	Yes	ND	NA	Yes
Pesticides/PCBs (mg/kg)							
alpha-chlordane	3.58E+01	1.6E+00	RSL	Yes	ND	NA	Yes
p,,p'- DDD	4.24E+01	2.0E+00	RSL	Yes	ND	NA	Yes
p,,p'- DDE	9.91E+00	1.4E+00	RSL	Yes	ND	NA	Yes
p,,p'- DDT	1.62E+01	1.7E+00	RSL	Yes	ND	NA	Yes
gamma-chlordane	3.96E+01	1.6E+00	RSL	Yes	ND	NA	Yes
Heptachlor	2.04E+00	1.1E-01	RSL	Yes	ND	NA	Yes
Heptachlor epoxide	2.19E-01	5.3E-02	RSL	Yes	ND	NA	Yes

[1] - Maximum detected concentration from 0-1 ft soil interval.

[2] - Nonradiological RSLs are residential soil values from the EPA Regional Screening Levels Table, dated April, 2009.

[3] - SRS Background values (WSRC 2006, Appendix B-1).

[4] - For screening purposes, maximum concentration of only the naturally-occurring (nonanthropogenic) constituents are compared to 2X average background concentration. Background concentration of anthropogenic constituents are presented for information purposes.

[5]- Constituents are identified as COPCs if the maximum detected concentration exceeds the human health screening value and the 2X average background concentration.

[6] - Essential nutrients are not identified as COPCs.

[7] - RSL for this constituent is not available.

EN = essential nutrient

NA = not applicable

na = not available

ND = not detected

Table A-4. Human Health Risk/Hazard Calculation – Residential Scenario, ECODS B-3 OU Surface Soil

Analyte[1]	Maximum Concentration	Residential RSL[2]	Residential Hazard Estimate[3]	Residential Risk Estimate[4]	COC?[5]
Noncarcinogenic Hazard Estimate					
Inorganics (mg/kg)					
Aluminum	1.06E+04	7.7E+04	1.38E-01	----	no
Iron	1.92E+04	5.5E+04	3.49E-01	----	no
Vanadium	4.57E+01	3.9E+02	1.17E-01	----	no
Total Media Hazard Index (HI) = 6.04E-01					
Carcinogenic Risk Estimate					
Inorganics (mg/kg)					
Arsenic	4.76E+00	3.9E-01	----	1.22E-05	Yes
Semi-Volatile Organics (mg/kg)					
Hexachlorobenzene	1.98E+00	3.0E-01	----	6.60E-06	Yes
Pesticides/PCBs (mg/kg)					
alpha-Chlordane	3.58E+01	1.6E+00	----	2.24E-05	Yes
p,,p'- DDD	4.24E+01	2.0E+00	----	2.12E-05	Yes
p,,p'- DDE	9.91E+00	1.4E+00	----	7.08E-06	Yes
p,,p'- DDT	1.62E+01	1.7E+00	----	9.53E-06	Yes
gamma-Chlordane	3.96E+01	1.6E+00	----	2.48E-05	Yes
Heptachlor	2.04E+00	1.1E-01	----	1.85E-05	Yes
Heptachlor epoxide	2.19E-01	5.3E-02	----	4.13E-06	Yes
Total Chemical Risk =				**1.26E-04**	
Total Media Risk =				**1.26E-04**	

[1] - Analytes from Table A-3 that were identified as COPCs.
[2] - Nonradiological RSLs are residential worker soil values from the EPA Regional Screening Levels Table, dated April, 2009.
[3] - Residential Hazard Estimate = EPC / RSL
[4] - Residential Risk Estimate = (EPC / RSL) x 1E-06.
[5] - For noncarcinogens, constituents are identified as COCs if the total media hazard index ≥1. For carcinogens, constituents are identified as COCs if the individual cancer risk ≥1E-06.

Table A-5. Human Health Risk/Hazard Calculation – Industrial Worker Scenario, ECODS B-3 OU Surface Soil

Analyte[1]	Maximum Concentration	Residential RSL[2]	Residential Hazard Estimate[3]	Residential Risk Estimate[4]	COC?[5]
Noncarcinogenic Hazard Estimate					
Inorganics (mg/kg)					
Aluminum	1.06E+04	9.9E+05	1.07E-02	----	no
Iron	1.92E+04	7.2E+05	2.67E-02	----	no
Vanadium	4.57E+01	5.2E+03	8.79E-03	----	no
Total Media Hazard Index (HI) = 4.62E-02					
Carcinogenic Risk Estimate					
Inorganics (mg/kg)					
Arsenic	4.76E+00	1.6E+00	----	2.98E-06	Yes
Semi-Volatile Organics (mg/kg)					
Hexachlorobenzene	1.98E+00	1.1E+00	----	1.80E-06	Yes
Pesticides/PCBs (mg/kg)					
alpha-Chlordane	3.58E+01	6.5E+00	----	5.51E-06	Yes
p,,p'- DDD	4.24E+01	7.2E+00	----	5.89E-06	Yes
p,,p'- DDE	9.91E+00	5.1E+00	----	1.94E-06	Yes
p,,p'- DDT	1.62E+01	7.0E+00	----	2.31E-06	Yes
gamma-Chlordane	3.96E+01	6.5E+00	----	6.09E-06	Yes
Heptachlor	2.04E+00	3.8E-01	----	5.37E-06	Yes
Heptachlor epoxide	2.19E-01	1.9E-01	----	1.15E-06	Yes
Total Chemical Risk =				**3.30E-05**	
Total Media Risk =				**3.30E-05**	

[1] - Analytes from Table A-3 that were identified as COPCs.
[2] - Nonradiological RSLs are industrial worker soil values from the EPA Regional Screening Levels Table, dated April, 2009.
[3] – Industrial Worker Hazard Estimate = EPC / RSL .
[4] - Industrial Worker Risk Estimate = (EPC / RSL) x 1E-06.
[5] - For noncarcinogens, constituents are identified as COCs if the total media hazard index ≥1. For carcinogens, constituents are identified as COCs if the individual cancer risk ≥1E-06.

Table A-6. Human Health COPC Screening - ECODS B-5 OU Surface Soil (0-1 ft)

Analyte	Detected Maximum Concentration[1]	Human Health Screening Value	Human Health Screening Value Source[2]	Exceeds Human Health Screening Value?	2X Average Background Concentration[3]	Exceeds 2X Average Background?[4]	COPC?[5]
Inorganics (mg/kg)							
Aluminum	1.18E+04	7.7E+03	0.1xRSL	Yes	1.05E+04	Yes	Yes
Arsenic	1.91E+01	3.9E-01	RSL	Yes	4.28E+00	Yes	Yes
Barium	4.44E+01	1.5E+03	0.1xRSL	no	3.91E+01	Yes	no
Cadmium	5.05E-01	7.0E+00	0.1xRSL	no	4.83E-01	Yes	no
Calcium	1.64E+03	EN[6]	Nutrient	no	4.76E+02	Yes	no
Chromium	9.71E+00	2.8E+02	RSL	no	1.54E+01	no	no
Cobalt	2.35E+00	2.3E+00	0.1xRSL	Yes	1.55E+00	Yes	Yes
Copper	4.23E+00	3.1E+02	0.1xRSL	no	4.34E+00	no	no
Cyanide	5.65E+00	1.6E+02	0.1xRSL	no	ND	Yes	no
Iron	8.10E+03	5.5E+03	0.1xRSL	Yes	1.27E+04	no	no
Lead	2.35E+01	4.0E+01	0.1xRSL	no	1.03E+01	Yes	no
Magnesium	2.00E+02	EN[6]	Nutrient	no	2.75E+02	no	no
Manganese[7]	2.01E+02	na	NA	no	1.53E+02	Yes	no
Mercury	4.51E-02	2.3E+00	0.1xRSL	no	7.10E-02	no	no
Nickel	4.23E+00	1.5E+02	0.1xRSL	no	3.49E+00	Yes	no
Potassium	1.74E+02	EN[6]	Nutrient	no	2.16E+02	no	no
Sodium	1.40E+02	EN[6]	Nutrient	no	4.02E+01	Yes	no
Vanadium	1.76E+01	3.9E+01	0.1xRSL	no	3.91E+01	no	no
Zinc	2.67E+02	2.3E+03	0.1xRSL	no	9.47E+00	Yes	no
Volatile Organics (mg/kg)							
1,1-Dichloroethylene	6.60E-03	2.5E+01	0.1xRSL	no	ND	NA	no
Toluene	2.68E-04	5.0E+02	0.1xRSL	no	ND	NA	no

Table A-6. Human Health COPC Screening - ECODS B-5 OU Surface Soil (0-1 ft) (Cont.)

Analyte	Detected Maximum Concentration[1]	Human Health Screening Value	Human Health Screening Value Source[2]	Exceeds Human Health Screening Value?	2X Average Background Concentration[3]	Exceeds 2X Average Background?[4]	COPC?[5]
Pesticides/PCBs (mg/kg)							
alpha-Chlordane	5.92E-03	1.6E+00	RSL	no	ND	NA	no
p,p'- DDE	1.14E-02	1.4E+00	RSL	no	ND	NA	no
p,p'- DDT	5.97E-03	1.7E+00	RSL	no	ND	NA	no
gamma-Chlordane	8.31E-03	1.6E+00	RSL	no	ND	NA	no
Heptachlor	6.72E-04	1.1E-01	RSL	no	ND	NA	no
Heptachlor epoxide	8.03E-04	5.3E-02	RSL	no	ND	NA	no

[1] - Maximum detected concentration from 0-1 ft soil interval.
[2] - Nonradiological RSLs are residential soil values from the EPA Regional Screening Levels Table, dated April, 2009.
[3] - SRS Background values (WSRC 2006, Appendix B-1).
[4] - For screening purposes, maximum concentration of naturally-occurring (nonanthropogenic) constituents are compared to 2X average background concentration. Background concentrations of anthropogenic constituents are presented for information purposes.
[5]- Constituents are identified as COPCs if the maximum detected concentration exceeds the human health screening value and the 2X average background concentration.
[6] - Essential nutrients are not identified as COPCs.
[7] - RSL for this constituent is not available.
EN = essential nutrient
NA = not applicable
na = not available
ND = not detected

Table A-7. Human Health Risk/Hazard Calculation – Residential Scenario, ECODS B-5 OU Surface Soil

Analyte[1]	Maximum Concentration	Residential RSL[2]	Residential Hazard Estimate[3]	Residential Risk Estimate[4]	COC?[5]
Noncarcinogenic Hazard Estimate					
		Inorganics (mg/kg)			
Aluminum	1.18E+04	7.7E+04	1.53E-01	----	no
Cobalt	2.35E+00	2.3E+01	1.02E-01	----	no
				Total Media Hazard Index (HI) =2.55E-01	
Carcinogenic Risk Estimate					
		Inorganics (mg/kg)			
Arsenic	1.91E+01	3.9E-01	----	4.90E-05	Yes
			Total Chemical Risk =	**4.90E-05**	
			Total Media Risk =	**4.90E-05**	

[1] - Analytes from Table A-6 that were identified as COPCs.
[2] - Nonradiological RSLs are residential worker soil values from the EPA Regional Screening Levels Table, dated April, 2009.
[3] - Residential Hazard Estimate = EPC / RSL.
[4] - Residential Risk Estimate = (EPC / RSL) x 1E-06.
[5] - For noncarcinogens, constituents are identified as COCs if the total media hazard index ≥1.
For carcinogens, constituents are identified as COCs if the individual cancer risk ≥1E-06.

Table A-8. Human Health Risk/Hazard Calculation – Industrial Worker Scenario, ECODS B-5 OU Surface Soil

Analyte[1]	Maximum Concentration	Industrial RSL[2]	Industrial Hazard Estimate[3]	Industrial Risk Estimate[4]	COC?[5]
Noncarcinogenic Hazard Estimate					
Inorganics (mg/kg)					
Aluminum	1.18E+04	9.9E+05	1.19E-02	----	no
Cobalt	2.35E+00	3.0E+02	7.83E-03	----	no
Total Media Hazard Index (HI) =1.98E-02					
Carcinogenic Risk Estimate					
Inorganics (mg/kg)					
Arsenic	1.91E+01	1.6E+00	----	1.19E-05	Yes
Total Chemical Risk =				**1.19E-05**	
Total Media Risk =				**1.19E-05**	

[1] - Analytes from Table A-6 that were identified as COPCs.
[2] - Nonradiological RSLs are industrial worker soil values from the EPA Regional Screening Levels Table, dated April, 2009.
[3] – Industrial Worker Hazard Estimate = EPC / RSL .
[4] - Industrial Worker Risk Estimate = (EPC / RSL) x 1E-06.
[5] - For noncarcinogens, constituents are identified as COCs if the total media hazard index ≥1.
For carcinogens, constituents are identified as COCs if the individual cancer risk >1E-06.

Appendix B

Contaminant Migration Analysis

B.1 Introduction and Screening Methods

This appendix describes the determination of Contaminant Migration Analysis constituents of potential concern (COPCs) and Contaminant Migration Analysis constituents of concern (COCs) for unit-specific soil concentrations (USCs) of constituents from soil data collected at ECODS B-3 and B-5 at the Savannah River Site (SRS). The soil data used for this Contaminant Migration Analysis were collected in March 2001 (ECODS B-3) and March 2002 (ECODS B-5) and reported in SRS Site Evaluation Reports (WSRC 2002, 2003). The data collected under the Site Evaluation Program were used to determine the nature and extent of contamination and selection of the remedial action. The identification of CM COPCs and Contaminant Migration Analysis COCs is based on a comparison of USCs to the calculated soil screening levels (SSLs) following the method described by Rucker (2007). The method incorporates the U.S. Environmental Protection Agency (USEPA) Soil Screening Guidance (USEPA 1996) as described below.

SRS uses Federal Facility Agreement (FFA) Contaminant Migration Analysis Protocols that follow USEPA Soil Screening Guidance that includes calculation of USEPA 'default' SSLs (dSSLs) for a 'Tier 1' screen, and SRS site-specific SSLs (srsSSLs) for a 'Tier 2' screen (WSRC 1998, WSRC 2000a, WSRC 2000b). The srsSSLs (Tier 2 screen) include terms for chemical/radiological decay and biodegradation. SSLs for Contaminant Migration Analysis are back-calculated soil concentrations that are site-specific for contaminants in soil that may be used to identify areas of waste units that require further characterization or remediation or, conversely, do not need further study or remediation. To calculate SSLs, the equations are run in reverse from a drinking water standard to calculate an acceptable concentration of a contaminant in soil that will not exceed the drinking water standard.

Both the Tier 1 and Tier 2 screens include infinite source mass and source mass-limited calculations. In reality, the consideration of an infinite source is not reasonable, so the

mass-limited calculations [default mass-limited SSLs (dMLSSLs) and SRS site-specific mass-limited SSLs (srsMLSSLs)] consider the entire release of the source mass within 70-year exposure duration. This prevents a mass balance error in the calculations. The equations used to calculate dSSLs, dMLSSLs, srsSSLs, srsMLSSLs, and other parameters needed for soil data screening are provided in this appendix.

A spreadsheet-based tool named *CMScreen* was developed at SRS to facilitate SSL calculations and Tier 1/Tier 2 soil data screens (WSRC 1999, WSRC 2006a). *CMScreen* calculates all of the SSLs for the inorganic constituents on the target analyte list, organic target compound list, and radionuclide list (a total of 196 constituents). *CMScreen* compares the user-entered soil concentrations to SSLs and identifies constituents that are Tier 1 Contaminant Migration Analysis COPCs and Tier 2 Contaminant Migration Analysis COCs.

For this RSER/EE/CA, the recently developed Regional Screening Levels (RSLs) developed by USEPA for Regions 3, 6, and 9 were substituted for Preliminary Remediation Goals (PRGs) for contaminants where PRGs are used in the *CMScreen* and the RSLs are less than the PRGs (USEPA 2004, 2009). The RSLs will be substituted for PRGs in future Contaminant Migration Analyses.

If Tier 2 Contaminant Migration Analysis COCs are identified it is up to the user to evaluate the results and apply professional judgment and other modeling approaches and/or knowledge of site conditions and geochemistry to further refine the list of Contaminant Migration Analysis COCs. The refined Contaminant Migration Analysis COCs include those constituents that are mobile at that site and can leach to the aquifer in 1,000 years and exceed drinking water standards at a receptor well on the edge of the waste unit. If Tier 2 Contaminant Migration Analysis COCs or detected concentrations in excess of solubility limits (i.e., saturated concentrations) are indicated, SRS uses the one-dimensional (1-D) vadose zone model *SE*asonal *SOIL* Compartment Model (*SESOIL*) to predict soil leachate and groundwater concentrations during a refinement step. Since the recommended response action is 'removal and offsite disposal', additional modeling was

not performed as the vadose zone contaminants will no longer exist at ECODS B-3 and B-5 at the conclusion of this RA.

B.2 Equations

The equations used for the Contaminant Migration Analysis performed by *CMScreen* are consistent with USEPA Soil Screening Guidance and FFA Contaminant Migration Analysis Protocols. A conceptual model diagram that illustrates the vadose zone and physical processes and parameters used by *CMScreen* is provided in Figure B-1. This figure represents a generic vadose zone profile that can be modified based on site-specific and constituent-specific conditions. The source layer is the zone of contamination detected in the vadose zone and the depth and thickness of the source layer is based on the extent of contamination.

For each constituent, the source concentration used is the maximum concentration detected in soil (from all sample depths). The *CMScreen* layers 2, 3, and 4 are clean zones in the vadose zone that are optional for any particular site and can accommodate different soil properties and thicknesses. Note that the conceptual model applies to all detected constituents and the aquifer layer represents the water table aquifer. Following is a discussion of the parameters and equations used by *CMScreen* in the Contaminant Migration Analysis process.

Dilution Attenuation Factor

The dilution attenuation factor (DAF) is used by *CMScreen* to determine the leachate dilution in the aquifer to calculate the soil concentration (or SSL) back-calculated from an acceptable groundwater concentration, i.e., Maximum Contaminant Level (MCL) or RSL. The DAF calculation assumes that the aquifer is unconfined, unconsolidated and has isotropic and homogeneous properties. The DAF is calculated from site specific values as follows:

$$DAF = 1 + \frac{K \cdot 365 \cdot i \cdot d}{I/12 \cdot L} \quad \text{(E-1)}$$

where;

DAF = dilution attenuation factor (dimensionless),

K = saturated zone horizontal hydraulic conductivity (ft/d),

i = saturated zone hydraulic gradient (ft/ft),

I = infiltration rate through vadose zone (in/yr),

L = length of the source parallel to the groundwater flow direction (ft),

d_a = saturated zone thickness (ft),

d_i = mixing zone thickness in the aquifer (ft), and

d = mixing zone depth in the aquifer (minimum of d_i and d_a) (ft).

If the input infiltration rate through the vadose zone is greater than any of the individual vadose zone layer saturated hydraulic conductivities, then the infiltration rate is adjusted to the maximum of the individual vadose zone layer saturated hydraulic conductivities.

The mixing zone depth in the aquifer (d) is calculated as follows:

$$d_i = \left(0.0112 \cdot L^2\right)^{0.5} + d_a\left(1 - e^{\left(-L \cdot I/12/(K \cdot 365 \cdot i \cdot d_a)\right)}\right) \quad \text{(E-2)}$$

Note that the calculated d_i value cannot exceed the actual aquifer thickness.

The DAF will not calculate to a value less than 1, as this value indicates that dilution does not occur in the aquifer (i.e., the leachate concentration equals the groundwater concentration). The USEPA recommends a DAF value of 20 as a default for sites up to 0.5 acre whenever site-specific data are not available for DAF calculation (USEPA 1996). A DAF value of 3.85 was calculated by *CMScreen* for ECODS B-3 and B-5.

Soil Partitioning

As mentioned above, the target soil concentration is back-calculated in two ways: (1) SSL (infinite source) and, (2) MLSSL (finite source). The Tier 1 SSL (dSSL) assumes an infinite source and uses equilibrium soil partitioning equations to calculate the total soil concentration (mg/kg) as follows:

$$dSSL = C_{std} \cdot \frac{DAF}{1000} \cdot (K_d + \frac{\theta_w + \theta_a \cdot H}{\rho_b}) \quad \text{(E-3)}$$

where;

C_{std} = water-phase concentration limit standard (i.e., MCL or RSL) (µg/L),

K_d = soil-water partitioning coefficient (L/kg),

θ_w = water-filled soil porosity (%),

θ_a = air-filled soil porosity (%),

H = Henry's Law constant (dimensionless), and

ρ_b = dry soil bulk density (kg/L).

The water-filled porosity value (θ_w) is a weighted average for all of the vadose zone layers and calculated as follows:

$$\theta_w = \frac{\sum_i h_i \cdot \theta_{wi}}{\sum_i h_i} \quad \text{(E-4)}$$

where;

h_i = vadose zone layer *i* thickness (ft),

θ_{wi} = vadose zone layer *i* water-filled soil porosity (percent).

Similarly, the effective porosity (n_{ei}, %) is a weighted average for all of the vadose zone layers and calculated as follows:

$$n_e = \frac{\sum_i h_i \cdot n_{ei}}{\sum_i h_i} \quad \text{(E-5)}$$

and the air-filled soil porosity (θ_a, %) is calculated by:

$$\theta_a = n_e - \theta_w \quad \text{(E-6)}$$

The soil texture is determined for the different layers or soil types observed in the vadose zone, and the soil layer parameters are used to calculate the volumetric water content as follows:

$$\theta_{wi} = n_{ei}\left(\frac{I}{K_i}\right)^{(1/(2b_i+3))} \quad \text{(E-7)}$$

where;

b_i = vadose zone layer *i* Clapp and Hornberger "b" parameter (dimensionless), and

K_i = vadose zone layer *i* Clapp and Hornberger "K" parameter (dimensionless).

For organic constituents, the soil-water partitioning coefficient (K_d) (L/kg) is defined by:

$$K_d = (f_{oc}) \cdot (K_{oc}) \quad \text{(E-8)}$$

where;

f_{oc} = soil organic carbon content as mass fraction (%), and

K_{oc} = organic carbon partitioning coefficient (L/kg).

For metals or metalloids, the K_d is taken from literature and is dependent on the chemical form that exists and the geochemical environment at each site. Normally, the K_d is derived from laboratory column studies.

To solve the mass-balance violations inherent in the infinite source equation (E-3), the USEPA developed a Tier 1 MLSSL (mg/kg) as follows:

$$dMLSSL = C_{std} \cdot \frac{DAF}{1000} \cdot \frac{I \cdot (1/12) \cdot ED}{\rho_b \cdot d_s} \quad \text{(E-9)}$$

where;

ED = exposure duration in years (USEPA default value of 70 years), and

d_s = average source thickness (ft).

Mean Travel Time

The mean travel time (T) (years) through the vadose zone layers below the source is calculated in *CMScreen* as follows:

$$T = \frac{d_v \cdot R}{V_{mnr}} \quad \text{(E-10)}$$

where the retardation coefficient (R) (dimensionless) is calculated as:

$$R = 1 + K_d \cdot \rho_b / \theta_w \quad \text{(E-11)}$$

The mean non-retarded total vadose zone velocity (V_{mnr}) (ft/year) is calculated as:

$$V_{mnr} = \sum_j T_j \Big/ d_v \quad \text{(E-12)}$$

where;

d_v = thickness of vadose zone below source (ft), and

T_j = individual layer (j) mean travel time (years).

T_j (years) is calculated as:

$$T_j = h_j \cdot \theta_{wi} / (I/12) \quad \text{(E-13)}$$

where;

h_j = vadose zone layer *j* thickness (ft), and

θ_{wi} = vadose zone layer *i* water-filled soil porosity (%).

Incorporating Decay

To account for the radioactive decay, chemical degradation, or biodegradation of constituents, Tier 1 dSSLs and dMLSSLs are adjusted to calculate the Tier 2 srsSSL and srsMLSSL (mg/kg) as follows:

$$srsSSL = \frac{dSSL}{e^{(-0.693 \cdot T / t_{1/2})}} \quad \text{(E-14)}$$

$$srsMLSSL = \frac{dMLSSL}{e^{(-0.693 \cdot ED / t_{1/2})}} \quad \text{(E-15)}$$

where;

$t_{1/2}$ = radiological, chemical or biological half-life for the constituent (years).

Saturation Concentration

For organic (non-radioactive) constituents, the saturation concentration (C_{sat}) (mg/kg) is calculated from the solubility constant in water (C_{sol}) (mg/L) as follows:

$$C_{sat} = C_{sol} \cdot (K_d + \frac{\theta_w + \theta_a \cdot H}{\rho_b}) \quad \text{(E-16)}$$

The C_{sat} is a theoretical concentration that represents a pure solid phase or non-aqueous phase liquid (NAPL) threshold concentration. The C_{sat} is compared to the maximum detected concentration to predict if a NAPL liquid phase or 'pure' solid phase may be present in soil.

B.3 Input Data and Conceptual Model

Soil samples were collected at depths of 0-1 ft (0-0.3 m), 1-4 ft (0.3-1.2m), and 8-10 ft (2.4-3.0 m) at ECODS B-3 and 0-1 ft (0-0.3 m), 1-4 ft (0.3-1.2m), and 9-11 ft (2.7-3.3 m) at ECODS B-5. The soil was analyzed and the maximum concentrations were compiled for the detected contaminants. In accordance with the protocol for identifying Contaminant Migration Analysis COPCs (WSRC 1998), the essential elements calcium, magnesium, potassium, and sodium were excluded from further evaluation.

These data were used to formulate a conceptual model for Tier 1/Tier 2 analysis using *CMScreen* (Figure B-1). The physical parameters used for Tier 1/Tier 2 evaluations are provided in Table B-1. Since these ECODS units are close together, the same parameters were used for both. The general sediment textures and parameters used for numerical modeling of the Sanitary Landfill (the Sanitary Landfill is approximately 400 ft [122 m] south of ECODS B-5) were used for these ECODS B-3 and B-5 calculations. The vadose zone parameters are based on general knowledge of soil and sediments in B-Area or representative SRS values.

The maximum contaminant concentrations detected in soil and chemical parameters used for analysis by *CMScreen* are provided in Tables B-2 and B-3. The maximum concentrations at ECODS B-3 are distributed evenly in the shallow, intermediate and deeper sample intervals, while they are present in the shallow zones at ECODS B-5. Also, polyaromatic hydrocarbons (PAHs) are detected at ECODS B-5 which is indicative of burning. Since most of the constituents are detected in either the 0-1 ft (0-0.3 m) or 1-4 ft (0.3-1.2 m) interval at ECODS B-5 and lower concentrations (or no detections) are observed at depth, this practice of using the maximum concentration has the effect of overestimating the mass of the source term (i.e., provides conservative results). SRS default values were used for the f_{oc} (0.003), soil bulk density (1.77 g/cm^3), and rainfall infiltration rate (12 in/yr [30.5 cm/yr]). The overall thickness of the vadose zone (50 ft [15.2 m]) is interpreted from the water table (i.e., piezometric) surface to the south at the Sanitary Landfill.

B.4 Results

Forty-three (43) constituents were identified as having detectable concentrations from the ECODS B-3 soil data set and fifty (50) at ECODS B-5 (see Tables B-2 and B-3 for maximum or total soil concentrations that were used for this analysis). Using *CMScreen*, fourteen (14) of the constituents were classified as Tier 1 Contaminant Migration Analysis COPCs at ECODS B-3 (where the maximum soil concentration exceeds the dSSL or dMLSSL), and fourteen (14) as well at ECODS B-5. The Contaminant Migration Analysis results are provided in Tables B-4 and B-5. Cobalt exceeds the Tier 2 SRS site-specific SSLs for ECODS B-3, and cobalt and cyanide exceed Tier 2 SSLs for ECODS B-5. The calculated mean travel time for cyanide to reach the water table is 715 years, and the mean travel time for cobalt is 722 years (for both ECODS).

The five cobalt detections at ECODS B-3 are J-qualified data, and all of the estimated concentrations are less than 2 mg/kg (95th percentile for SRS cobalt background is 2.2 mg/kg; WSRC 2006b). As a result, cobalt was not retained as a refined Contaminant Migration Analysis COC for ECODS B-3. At ECODS B-5, cobalt was detected in 40 samples at higher concentrations in soil (max = 10.9 mg/kg), of which one quarter (10 detections) are unqualified and 13 are higher than the SRS 95th percentile background concentration in soil. However, the soil will be removed from the site during the subsequent RA. As a result, cobalt was not retained as a refined Contaminant Migration Analysis COC for ECODS B-5.

Further analysis shows that cyanide is present at ECODS B-5 at low levels and has limited mobility in SRS soil. Cyanide tends to bind and form complexes in soil, especially with iron oxide, clay and organic materials. Since iron is abundant (maximum iron detected in soil at ECODS B-5 is 132 g/kg and iron exists in oxidized form) and clay is present (normally kaolinite, gibbsite and vermiculite), it is expected that cyanide is immobile at ECODS B-5. For this reason, cyanide is not retained as a Tier 2 Contaminant Migration Analysis COC at ECODS B-5.

Three constituents that are components of pesticides (alpha-chlordane, gamma-chlordane, and p,p'-DDD) exceeded saturation limits and are considered saturated sources for ECODS B-3, while the polycyclic aromatic hydrocarbon (PAH) indeno-1,2,3-cd)pyrene is a saturated source for ECODS B-5 (Tables B-4 and B-5). The mean travel time through the vadose zone (to the water table) exceeds 1,000 years for all four of these compounds. These constituents are identified as preliminary Contaminant Migration Analysis COCs. Since the recommended response action in this RSER/EE/CA is 'offsite disposal' (the soil that contains these compounds will be removed), additional vadose zone modeling was not performed. No contaminant migration RCOCs were identified for ECODS B-3 and B-5.

It is not known if there has been a historical release of contaminants to groundwater at ECODS B-3 and B-5. This uncertainty impacts the nature and scope of the problem warranting action. This uncertainty will be managed by investigating whether data can be obtained from groundwater wells located downgradient of the unit or by installing a temporary well downgradient of the waste unit. Also, confirmatory soil samples will be collected. A Sampling and Analysis Plan (SAP) will be submitted for approval prior to the RA, and groundwater and soil sampling results will be reported in the Removal Action Report (RAR) for the action.

B.5 References

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Table B-1. Summary of ECODS B-3 and B-5 Physical Parameters used for Contamination Migration Model Analysis

Parameter	Value used in *CMScreen*
Water Table Gradient (i)	0.0080
Source Length Parallel to Groundwater Flow (L)	10 ft
Aquifer Hydraulic Conductivity (K_h)	6 ft/day
Bulk Density (ρ_b)	1.7 g/cm^3
Fraction Organic Carbon (f_{oc})	0.0030
Source Layer Texture	Sandy Clay Loam
Source Layer Thickness	10 ft
Layer 2 Texture	Silty Clay Loam
Layer 2 Thickness	20 ft
layer 3 Texture	Silty Clay Loam
Layer 3 Thickness	20 ft
Vadose Zone Thickness (Source + all Layers)	50 ft
[1]Dilution Attenuation Factor	3.85

[1]Calculated using *CMScreen*

Table B-2. Maximum (Total Soil) Concentrations of Detected Contaminants at ECODS B-3, Chemical Parameters, and Regulatory Standards

Constituent	Total Soil Concentration C_t (mg/kg)	K_{oc} (L/kg)	Half-life (year)	H (-)	Free Air Diffusion (m^2/d)	Solubility (mg/L)	Regulatory Standard (µg/L)		K_d (L/Kg)
1,2,4-Trichlorobenzene	0.324	1,660	0.5	0.0582	0.7	300	70	MCL	4.9
1,2-Dichlorobenzene	0.0726	379	0.5	0.0779	0.7	156	600	MCL	1.1
1,3-Dichlorobenzene	0.225	1,700	0.5	0.1476	0.7	133	5.5	PRG	5.1
1,4-Dichlorobenzene	1.34	616	0.5	0.0656	0.7	73.8	75	MCL	1.8
2-Methylnaphthalene	10.8	7,940	0.132	0.013571	0.7	25.4	6.2	PRG	23.8
Acetone	0.103	2.2	0.019	0.00159	0.7	1,000,000	610	PRG	---
alpha-Chlordane	35.8	51,300	3.8	0.00199	0.7	0.056	---	---	153
Aluminum	19,500	---	---	---	0.7	---	36,000	PRG	1,500
Arsenic	13.4	---	---	---	0.7	---	10	MCL	39
Barium	142	---	---	---	0.7	---	2,000	MCL	41
Beryllium	4.65	---	---	---	0.7	---	4	MCL	790
Bis(2-ethylhexyl) phthalate	1.57	111,000	0.063	0.00000418	0.7	0.34	6	MCL	333
Calcium[1]	1,370	---	---	---	0.7	---	---	---	5
Carbon disulfide	0.0048	54	0.00934	1.24	0.7	1,190	1,000	PRG	0.1
Chlorobenzene	0.0626	224	0.411	0.152	0.7	472	100	MCL	0.6
Chromium	43.6	---	---	---	0.7	---	100	MCL	1,800,000
Cobalt	1.79	---	---	---	0.7	---	11	RSL	10
Copper	74.8	---	---	---	0.7	---	1,400	PRG	25
Cyanide	0.708	---	---	---	0.7	---	200	MCL	9.9
Methylene chloride	0.00135	10	0.3068	0.0898	0.7	13,000	5	MCL	---
Dieldrin	0.000532	25,500	3	0.000619	0.7	0.19	0.0042	PRG	76.5
gamma-Chlordane	39.6	51,300	3.8	0.000322	0.7	0.05	2	MCL	153
Heptachlor	2.4	9,530	0.015	60.7	0.7	0.18	0.4	MCL	28.5
Heptachlor epoxide	0.219	83,200	1.51	0.00039	0.7	0.2	0.2	MCL	249
Hexachlorobenzene	1.98	80,000	5.7	0.0541	0.7	6.2	1	MCL	240
Iron	41,100	---	---	---	0.7	---	11,000	PRG	220
Lead	17.4	---	---	---	0.7	---	50	MCL	270
Magnesium[1]	266	---	---	---	0.7	---	---	---	---
Manganese	159	---	---	---	0.7	---	880	PRG	50
Mercury	0.104	---	---	0.467	0.7	---	2	MCL	52

Table B-2. Maximum (Total Soil) Concentrations of Detected Contaminants at ECODS B-3, Chemical Parameters, and Regulatory Standards (Continued)

Constituent	Total Soil Concentration C_t (mg/kg)	K_{oc} (L/kg)	Half-life (year)	H (-)	Free Air Diffusion (m^2/d)	Solubility (mg/L)	Regulatory Standard (µg/L)		K_d (L/Kg)
Methyl ethyl ketone	0.0105	4.51	0.019	0.0021	0.7	268,000	1,900	PRG	---
Naphthalene	1.9	1,190	0.132	0.0198	0.7	31	0.14	RSL	3.5
Nickel	10.1	---	---	---	0.7	---	730	PRG	65
p,p'-DDD	147	45,800	15.6	0.000164	0.7	0.09	0.28	PRG	137
p,p'-DDE	9.91	86,400	15.6	0.000861	0.7	0.12	0.2	PRG	259
p,p'-DDT	20.4	678,000	15.6	0.000332	0.7	0.02	0.2	PRG	2,034
Phenanthrene	0.955	14,000	0.548	0.001599	0.7	1.29	180	PRG	42
Potassium[1]	175	---	---	---	0.7	---	---	---	---
Selenium	2.15	---	---	---	0.7	---	50	MCL	55
Toluene	0.000509	140	0.06	0.272	0.7	526	1,000	MCL	0.4
Vanadium	90.4	---	---	---	0.7	---	260	PRG	1,000
Xylenes	0.00154	238	0.077	0.213	0.7	161	10,000	MCL	0.714
Zinc	307	---	---	---	0.7	---	11,000	PRG	62

[1]Essential nutrient excluded from further evaluation

Table B-3. Maximum (Total Soil) Concentrations of Detected Contaminants at ECODS B-5, Chemical Parameters, and Regulatory Standards

Constituent	Total Soil Concentration C_t (mg/kg)	K_{oc} (L/kg)	Half-life (year)	H (-)	Free Air Diffusion (m^2/d)	Solubility (mg/L)	Regulatory Standard (µg/L)		K_d (L/Kg)
1,1-Dichloroethylene	0.0242	65	0.5	1.07	0.7	2,250	7	MCL	0.195
Acetone	0.00123	2.2	0.019	0.00159	0.7	1,000,000	610	PRG	0.006
alpha-Chlordane	0.0125	51,300	3.8	0.00199	0.7	0.05	---	---	153
Aluminum	54,700	---	---	---	0.7	----	36,000	PRG	1,500
Antimony	8.8	---			0.7	---	6	MCL	4,000
Aroclor 1254	0.0256	309,000	34,200	0.0082	0.7	0.04	0.5	MCL	927
Arsenic	36	---	---	---	0.7	---	10	MCL	39
Barium	298	---	---	---	0.7	---	2,000	MCL	41
Benzene	0.00555	61.7	0.044	0.228	0.7	1,750	5	MCL	0.18
Benzo[a]anthracene	0.269						0.029	RSL	
Benzo[a]pyrene	0.698	969,000	1.45	0.0000463	0.7	0.001	0.2	MCL	2,907
Benzo[b]fluoranthene	1.45	1,230,000	1.67	0.00455	0.7	0.001	0.029	RSL	3,690
Benzo[g,h,i]perylene	0.886	1,600,000	1.78	0.00000512	0.7	0.0003	180	PRG	4,800
Benzo[k]fluoranthene	0.656	1,230,000	5.86	0.000034	0.7	0.0008	0.29	RSL	3,690
Bis(2-ethylhexyl) phthalate	2.17	111,000	0.063	0.00000418	0.7	0.34	6	MCL	333
Cadmium	9.74	---	---	---	0.7	---	5	MCL	75
Calcium[1]	11,900	---	---	---	0.7	---	---	---	5
Chromium	86.8	---	---	---	0.7	---	100	MCL	1,800,000
Chrysene	0.338	398,000	2.72	0.00388	0.7	0.001	2.9	RSL	1,194
Cobalt	10.9	---	---	---	0.7	---	11	RSL	10
Copper	578	---	---	---	0.7	---	1,400	PRG	25
Cyanide	20.1	---	---	---	0.7	---	200	MCL	9.9
Dibenz[a,h]anthracene	0.0891	1,790,000	2.58	0.00000060	0.7	0.002	0.0029	RSL	5,370
Di-n-butyl phthalate	0.0473	1,570	0.063	3.85E-08	0.7	11.2	3,600	PRG	4.7
Ethylbenzene	0.000769	204	0.027	0.323	0.7	169	700	MCL	0.61
Fluoranthene	0.158	49,000	1.21	0.00066	0.7	0.20	1,500	PRG	147
gamma-Chlordane	0.0152	51,300	3.8	0.000322	0.7	0.05	2	MCL	153
Heptachlor	0.000672	9,530	0.015	60.7	0.7	0.18	0.4	MCL	28.5
Heptachlor epoxide	0.0024	83,200	1.51	0.00039	0.7	0.2	0.2	MCL	249
Indeno[1,2,3-cd]pyrene	0.809	3,740,000	2	0.0000656	0.7	0.00002	0.029	RSL	11,220

Table B-3. Maximum (Total Soil) Concentrations of Detected Contaminants at ECODS B-5, Chemical Parameters, and Regulatory Standards (Continued)

Constituent	Total Soil Concentration C_t (mg/kg)	K_{oc} (L/kg)	Half-life (year)	H (-)	Free Air Diffusion (m^2/d)	Solubility (mg/L)	Regulatory Standard (µg/L)		K_d (L/Kg)
Iron	132,000	---	---	---	0.7	---	11,000	PRG	220
Lead	3,600	---	---	---	0.7	---	50	MCL	270
Magnesium[1]	883	---	---	---	0.7	---	---	---	---
Manganese	31,300	---	---	---	0.7	---	880	PRG	50
Mercury	5.13	---	---	0.467	0.7	---	2	MCL	52
Nickel	47.2	---	---	---	0.7	---	730	PRG	65
p,p'-DDD	0.00284						0.28	PRG	
p,p'-DDE	0.0218	86,400	15.6	0.000861	0.7	0.12	0.2	PRG	259
p,p'-DDT	0.00833	678,000	15.6	0.000332	0.7	0.02	0.2	PRG	2,034
Potassium[1]	426	---	---	---	0.7	---	---	---	---
Pyrene	0.159	68,000	5.2	0.000451	0.7	0.13	180	PRG	204
Selenium	9.39	---	---	---	0.7	---	50	MCL	55
Silver	1.37	---	---	---	0.7	---	180	PRG	90
Sodium[1]	69,700	---	---	---	0.7	---	---	---	---
Thallium	3.08	---	---	---	0.7	---	2	MCL	71
Toluene	0.00341	140	0.06	0.272	0.7	526	1,000	MCL	0.4
Trichloroethylene	0.000173	265	10	0.422	0.7	1,100	5	MCL	0.795
Vanadium	174	---	---	---	0.7	---	260	PRG	1,000
Xylenes	0.000747	238	0.077	0.213	0.7	161	10,000	MCL	0.71
Zinc	19,300	---	---	---	0.7	---	11,000	PRG	62

[1]Essential nutrient excluded from further evaluation

Table B-4. Results of Contaminant Migration Model Analysis for ECODS B-3

Constituent	Tier 1 CM COPC?	Tier 2 CM COPC ?	Satur-ated Source?	C_t (mg/kg)	C_{sat} (mg/kg)	Tier 1 dSSL (mg/kg)	Tier 1 dMLSSL (mg/kg)	Mean Travel Time (yr)	Tier 2 srsSSL (mg/kg)	Tier 2 srsMLSSL (mg/kg)
1,2,4-Trichlorobenzene	No	No	No	0.324	1.542E+03	1.3855E+00	1.1101E+00	3.65E+02	∞[2]	∞
1,2-Dichlorobenzene	No	No	No	0.0726	2.023E+02	2.9969E+00	9.5150E+00	9.20E+01	∞	∞
1,3-Dichlorobenzene	Yes	No	No	0.225	6.999E+02	1.1147E-01	8.7220E-02	3.74E+02	∞	∞
1,4-Dichlorobenzene	Yes	No	No	1.34	1.481E+02	5.7985E-01	1.1894E+00	1.43E+02	∞	∞
2-Methylnaphthalene	Yes	No	No	10.8	6.090E+02	5.7253E-01	9.8321E-02	1.71E+03	∞	∞
Acetone	No	No	No	0.103	1.636E+05	3.8439E-01	9.6735E+00	1.16E+01	∞	∞
alpha-Chlordane	na	na	Yes	35.8	8.627E+00	na	na	1.10E+04	na	na
Aluminum	No	No	na	19,500	na	2.0799E+05	5.7090E+02	1.07E+05	2.0799E+05	5.7090E+02
Arsenic	Yes	No	na	13.4	na	1.5080E+00	1.5858E-01	2.78E+03	1.5080E+00	1.5858E-01
Barium	No	No	na	142	na	3.1702E+02	3.1717E+01	2.93E+03	3.1702E+02	3.1717E+01
Beryllium	No	No	na	4.65	na	1.2173E+01	6.3433E-02	5.62E+04	1.2173E+01	6.3433E-02
Bis(2-ethylhexyl)phthalate	No	No	No	1.57	1.133E+02	7.6985E+00	9.5150E-02	2.37E+04	∞	∞
Carbon disulfide	No	No	No	0.0048	4.356E+02	1.4098E+00	1.5858E+01	2.27E+01	∞	∞
Chlorobenzene	No	No	No	0.0626	3.940E+02	3.2148E-01	1.5858E+00	5.90E+01	∞	∞
Chromium	No	No	na	43.6	na	6.9323E+05	1.5858E+00	1.28E+08	6.9323E+05	1.5858E+00
Cobalt	No	No	na	1.79	na	4.303E-01	1.744E-01	7.22E+02	4.303E-01	1.744E-01
Copper	No	No	na	74.8	na	1.3564E+02	2.2202E+01	1.79E+03	1.3564E+02	2.2202E+01
Cyanide	No	No	na	0.708	na	7.7465E+00	3.1717E+00	7.15E+02	7.7465E+00	3.1717E+00
Dichloromethane	No	No	No	0.00135	2.475E+03	3.6658E-03	7.9291E-02	1.33E+01	∞	∞
Dieldrin	No	No	No	0.000532	1.495E+01	1.2400E-03	6.6605E-05	5.45E+03	∞	7.0153E+02
gamma-Chlordane	Yes	No	Yes	39.6	8.627E+00	1.1866E+00	3.1717E-02	1.10E+04	∞	1.1102E+04
Heptachlor	Yes	No	No	2.4	5.589E+00	4.7837E-02	6.3433E-03	2.04E+03	∞	∞
Heptachlor epoxide	Yes	No	No	0.219	4.995E+01	1.9238E-01	3.1717E-03	1.78E+04	∞	∞
Hexachlorobenzene	Yes	No	No	1.98	1.489E+03	9.2492E-01	1.5858E-02	1.71E+04	∞	7.8764E+01
Iron	Yes	No	na	41,100	na	9.3268E+03	1.7444E+02	1.57E+04	9.3268E+03	1.7444E+02
Lead	No	No	na	17.4	na	5.2023E+01	7.9291E-01	1.92E+04	5.2023E+01	7.9291E-01
Manganese	No	No	na	159	na	1.6999E+02	1.3955E+01	3.57E+03	1.6999E+02	1.3955E+01
Mercury	No	No	na	0.104	na	4.0188E-01	3.1717E-02	3.71E+03	4.0188E-01	3.1717E-02

Table B-4. Results of Contaminant Migration Model Analysis for ECODS B-3 (Continued)

Constituent	Tier 1 CM COPC?	Tier 2 CM COC?	Saturated Source?	C_t (mg/kg)	C_{sat} (mg/kg)	dSSL (mg/kg)	dMLSSL (mg/kg)	Mean Travel Time (year)	srsSSL (mg/kg)	srsMLSSL (mg/kg)
Methyl ethyl ketone	No	No	No	0.0105	4.571E+04	1.2481E+00	3.0131E+01	1.21E+01	∞	∞
Naphthalene	Yes	No	No	1.9	1.156E+02	2.010E-03	2.220E-03	2.65E+02	∞	∞
Nickel	No	No	na	10.1	na	1.8319E+02	1.1577E+01	4.63E+03	1.8319E+02	1.1577E+01
p,p'-DDD	Yes	No	Yes	147	1.238E+01	1.4834E-01	4.4403E-03	9.78E+03	∞	9.9518E-02
p,p'-DDE	Yes	No	No	9.91	3.112E+01	1.9977E-01	3.1717E-03	1.84E+04	∞	7.1084E-02
p,p'-DDT	Yes	No	No	20.4	5.085E+01	1.5668E+00	3.1717E-03	1.45E+05	∞	7.1084E-02
Phenanthrene	No	No	No	0.955	5.438E+01	2.9225E+01	2.8545E+00	3.00E+03	∞	∞
Selenium	No	No	na	2.15	na	1.0621E+01	7.9291E-01	3.92E+03	1.0621E+01	7.9291E-01
Toluene	No	No	No	0.000509	3.089E+02	2.2618E+00	1.5858E+01	4.10E+01	∞	∞
Vanadium	No	No	na	90.4	na	1.0015E+03	4.1232E+00	7.11E+04	1.0015E+03	4.1232E+00
Xylenes	No	No	No	0.00154	1.415E+02	3.3855E+01	1.5858E+02	6.19E+01	∞	∞
Zinc	No	No	na	334	na	2.6332E+03	1.7444E+02	4.42E+03	2.6332E+03	1.7444E+02

[1]na = not applicable
[2]The infinity symbol denotes that the calculated SSL has exceeded unity (i.e., $>1x10^6$ mg/kg, or $>1x10^{12}$ pCi/g)

Table B-5. Results of Contaminant Migration Model Analysis for ECODS B-5

Constituent	Tier 1 CM COPC?	Tier 2 CM COC?	Saturated Source?	C_t (mg/kg)	C_{sat} (mg/kg)	dSSL (mg/kg)	dMLSSL (mg/kg)	Mean Travel Time (year)	srsSSL (mg/kg)	srsMLSSL (mg/kg)
1,1-Dichloroethylene	No	No	No	0.0242	8.834E+02	1.0584E-02	1.1101E-01	2.50E+01	∞	∞
Acetone	No	No	No	0.00123	1.636E+05	3.8439E-01	9.6735E+00	1.16E+01	∞	∞
alpha-Chlordane	na	na	No	0.0125	8.627E+00	na	na	1.10E+04	na	na
Aluminum	No	No	na	54,700	na	2.0799E+05	5.7090E+02	1.07E+05	2.0799E+05	5.7090E+02
Antimony	Yes	No	na	132	na	9.2435E+01	9.5150E-02	2.85E+05	9.2435E+01	9.5150E-02
Aroclor 1254	No	No	No	0.0256	3.801E+01	1.7854E+00	7.9291E-03	6.59E+04	6.7925E+00	7.9404E-03
Arsenic	Yes	No	na	10.2	na	1.5080E+00	1.5858E-01	2.78E+03	1.5080E+00	1.5858E-01
Barium	No	No	na	298	na	3.1702E+02	3.1717E+01	2.93E+03	3.1702E+02	3.1717E+01
Benzene	No	No	No	0.00555	6.138E+02	6.7536E-03	7.9291E-02	2.43E+01	∞	∞
Benzo[a]anthracene	Yes	No	No	2.690E-01	1.010E+01	1.241E-02	4.757E-05	7.640E+04	∞	∞
Benzo[a]pyrene	No	No	No	0.698	4.710E+00	2.2393E+00	3.1717E-03	2.07E+05	∞	∞
Benzo[b]fluoranthene	Yes	No	No	1.45	5.535E+00	4.121E-01	4.599E-04	2.62E+05	∞	∞
Benzo[g,h,i]perylene	No	No	No	0.886	1.440E+00	3.3276E+03	2.8545E+00	3.41E+05	∞	∞
Benzo[k]fluoranthene	No	No	No	0.656	2.952E+00	4.121E+00	4.599EE-03	2.62E+05	∞	1.811E+01
Bis(2-ethylhexyl)phthalate	No	No	No	2.17	1.133E+02	7.6985E+00	9.5150E-02	2.37E+04	∞	∞
Cadmium	No	No	na	0.777	na	1.4473E+00	7.9291E-02	5.35E+03	1.4473E+00	7.9291E-02
Chromium	No	No	na	86.8	na	6.9323E+05	1.5858E+00	1.28E+08	6.9323E+05	1.5858E+00
Chrysene	No	No	No	0.338	1.911E+00	1.334E+01	4.599E-02	8.49E+04	∞	∞
Cobalt	No	No	na	10.9	na	4.303E-01	1.744E-01	7.22E+02	4.303E-01	1.744E-01
Copper	No	No	na	53.5	na	1.3564E+02	2.2202E+01	1.79E+03	1.3564E+02	2.2202E+01
Cyanide	Yes	Yes	na	20.1	na	7.7465E+00	3.1717E+00	7.15E+02	7.7465E+00	3.1717E+00
Dibenz[a,h]anthracene	No	No	No	0.0891	1.337E+01	6.205E-02	4.757E-05	3.82E+05	∞	6.968E+03
Di-n-butyl phthalate	No	No	No	0.0473	5.451E+01	6.7479E+01	5.7090E+01	3.46E+02	∞	∞
Ethylbenzene	No	No	No	0.000769	1.320E+02	2.1061E+00	1.1101E+01	5.47E+01	∞	∞
Fluoranthene	No	No	No	0.158	3.031E+01	8.5012E+02	2.3787E+01	1.05E+04	∞	∞
gamma-Chlordane	No	No	No	0.0152	8.627E+00	1.1866E+00	3.1717E-02	1.10E+04	∞	1.1102E+04
Heptachlor	No	No	No	0.000672	5.589E+00	4.7837E-02	6.3433E-03	2.04E+03	∞	∞
Heptachlor epoxide	No	No	No	0.0024	4.995E+01	1.9238E-01	3.1717E-03	1.78E+04	∞	∞
Indeno[1,2,3-cd]pyrene	No	No	Yes	0.809	2.468E-01	1.253E+00	4.599E-04	7.98E+05	∞	∞
Iron	Yes	No	na	132,000	na	9.3268E+03	1.7444E+02	1.57E+04	9.3268E+03	1.7444E+02
Lead	Yes	No	na	169	na	5.2023E+01	7.9291E-01	1.92E+04	5.2023E+01	7.9291E-01

Table B-5. Results of Contaminant Migration Model Analysis for ECODS B-5 (Continued)

Constituent	Tier 1 CM COPC?	Tier 2 CM COC?	Saturated Source?	C_t (mg/kg)	C_{sat} (mg/kg)	dSSL (mg/kg)	dMLSSL (mg/kg)	Mean Travel Time (year)	srsSSL (mg/kg)	srsMLSSL (mg/kg)
Manganese	Yes	No	na	31,300	na	1.6999E+02	1.3955E+01	3.57E+03	1.6999E+02	1.3955E+01
Mercury	No	No	na	0.354	na	4.0188E-01	3.1717E-02	3.71E+03	4.0188E-01	3.1717E-02
Nickel	No	No	na	47.2	na	1.8319E+02	1.1577E+01	4.63E+03	1.8319E+02	1.1577E+01
p,p'-DDE	No	No	No	0.0218	3.112E+01	1.9977E-01	3.1717E-03	1.84E+04	∞	7.1084E-02
p,p'-DDT	No	No	No	0.12	5.085E+01	1.5668E+00	3.1717E-03	1.45E+05	∞	7.1084E-02
Pyrene	No	No	No	0.159	2.756E+01	1.4153E+02	2.8545E+00	1.45E+04	∞	3.2136E+04
Selenium	No	No	na	9.39	na	1.0621E+01	7.9291E-01	3.92E+03	1.0621E+01	7.9291E-01
Silver	No	No	na	1.37	na	6.2500E+01	2.8545E+00	6.41E+03	6.2500E+01	2.8545E+00
Thallium	Yes	No	na	3.08	na	5.4809E-01	3.1717E-02	5.06E+03	5.4809E-01	3.1717E-02
Toluene	No	No	No	0.00341	3.089E+02	2.2618E+00	1.5858E+01	4.10E+01	∞	∞
Trichloroethylene	No	No	No	0.000173	1.065E+03	1.8640E-02	7.9291E-02	6.77E+01	2.0331E+00	1.0139E+01
Vanadium	No	No	na	174	na	1.0015E+03	4.1232E+00	7.11E+04	1.0015E+03	4.1232E+00
Xylenes	No	No	No	0.000747	1.415E+02	3.3855E+01	1.5858E+02	6.19E+01	∞	∞
Zinc	No	No	na	334	na	2.6332E+03	1.7444E+02	4.42E+03	2.6332E+03	1.7444E+02

[1]na = not applicable

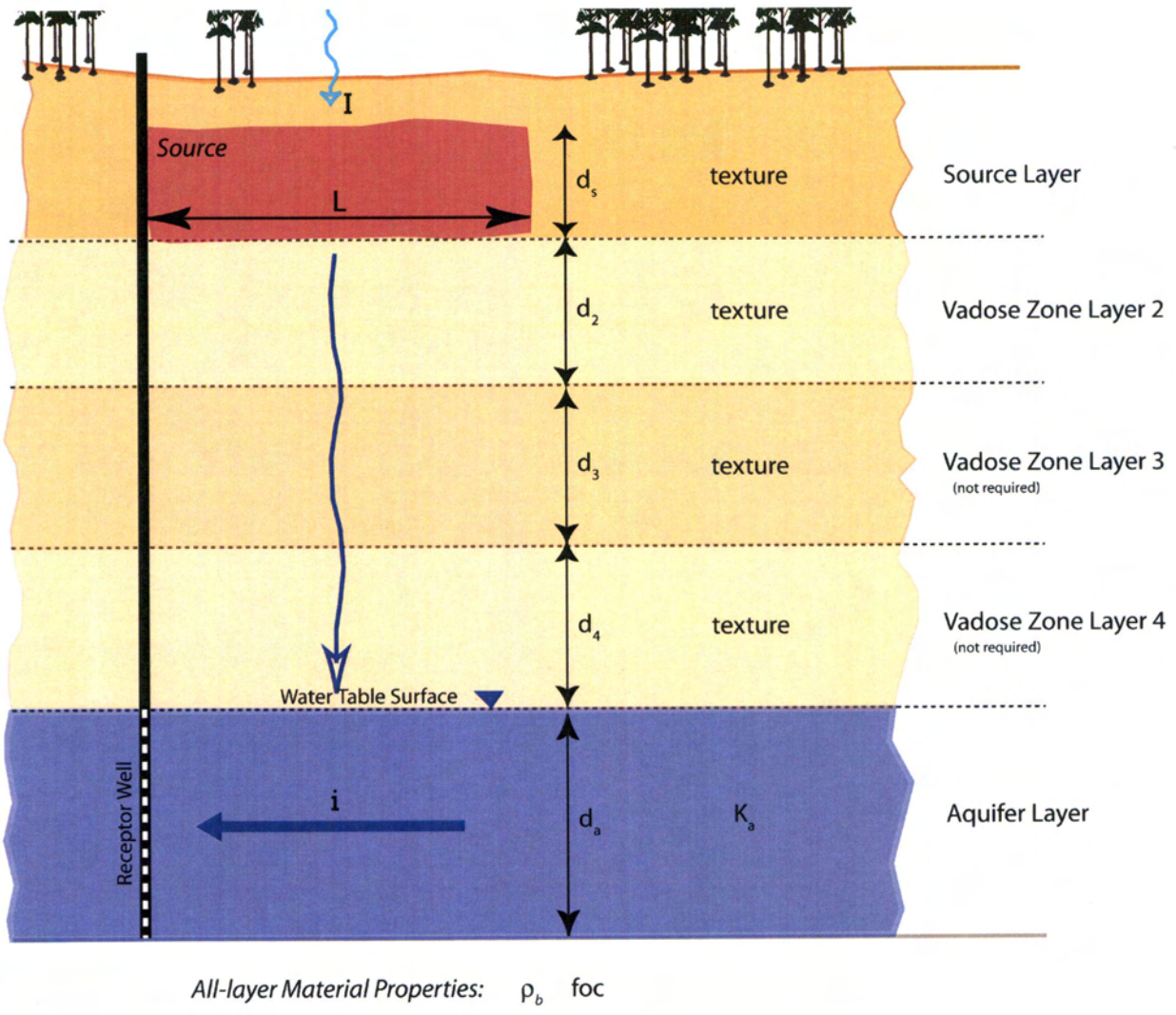

Figure B-1. Diagram of Conceptual Model and Vadose Zone Parameters used for Contaminant Migration Model Analysis

Appendix C

Calculation of Remedial Goal Options

C.1 Introduction

The Remedial Goal Option (RGO) calculations for ECODS B-3 and B-5 are presented in this appendix.

C.2 Human Health Risk-Based Remedial Goal Options

The Human Health Risk Assessment (HHRA) is presented in Appendix A of this document. RGOs are provided for the refined constituents of concern (RCOCs) identified in that appendix. Human health risk-based RGOs are developed in accordance with the protocol for *Human Health Remedial Goal Options* (WSRC 2006a). Risk-based RGOs are calculated for the future resident and the future industrial worker for soil media at various target risk levels (i.e., 1E-06, 1E-05, 1E-04). The human health risk-based RGOs for both of these scenarios are listed in Table C-1.

Table C-1. Human Health Risk-Based RGOs

RCOC	Units	Future Resident- Carcinogens (soil media)			Future Worker- Carcinogens (soil media)		
		1E-06	1E-05	1E-04	1E-06	1E-05	1E-04
Arsenic	mg/kg	0.39	3.9	39	1.6	16	160
Hexachlorobenzene	mg/kg	0.30	3.0	30	1.1	11	110
alpha-Chlordane	mg/kg	1.6	16	160	6.5	65	650
gamma-Chlordane	mg/kg	1.6	16	160	6.5	65	650
p,p'- DDD	mg/kg	2.0	20	200	7.2	72	720
p,p'- DDE	mg/kg	1.4	14	140	5.1	51	510
p,p'- DDT	mg/kg	1.7	17	170	7.0	70	700
Heptachlor	mg/kg	0.11	1.1	11	0.38	3.8	38
Heptachlor epoxide	mg/kg	0.053	0.53	5.3	0.19	1.9	19

Table C-1 identifies a range of RGOs in order to provide a basis for selecting final remedial levels. The selection of the RCOCs and final RGOs is subject to approval of the risk managers for the Savannah River Site (SRS). The risk managers are the key decision makers and include representatives of the U.S. Department of Energy (USDOE), South

Carolina Department of Health and Environmental Control (SCDHEC), and U.S. Environmental Protection Agency (USEPA). In addition, the Citizens Advisory Board and the SRS Natural Resource Trustees will serve the risk managers in an advisory role.

ECODS B-3 and B-5 are in an area currently designated for industrial use. No current or projected future development is planned. However, it is USDOE's desire to pursue a remedial action to meet residential goals for the land (i.e., unrestricted release with no land use controls) of ECODs B-3 and B-5 once the action is completed. Therefore, risk-based RGOs based on the residential scenario are considered the most likely RGs.

Because of the inherently conservative nature of the risk assessment and RGO calculations, it is possible for the risk-based RGO to be less than what occurs naturally in unimpacted background soils. In this case, the RG defaults to the background concentration in order to be technically practical to achieve. The 95th percentile for unimpacted SRS-wide soils (WSRC 2006b) is proposed as the appropriate background level to establish RGs. Table C-2 identifies the most likely RGs for ECODS B-3 and B-5.

Table C-2. Most Likely RGs

Subunit	RCOC	Units	Risk-Based RGO		SRS Background[2]			Most Likely RG[3]
			HH RGO (Resident)[1]	HH RGO[1] (Industrial Worker)	Max	95th %tile	2X Mean	
ECODS B-3	Hexachlorobenzene	mg/kg	3.00E-01	1.10E+00	NA	NA	NA	3.00E-01
	alpha-Chlordane	mg/kg	1.60E+00	6.50E+00	NA	NA	NA	1.60E+00
	gamma-Chlordane	mg/kg	1.60E+00	6.50E+00	NA	NA	NA	1.60E+00
	p,p'-DDD	mg/kg	2.00E+00	7.2E+00	NA	NA	NA	2.00E+00
	p,p'-DDE	mg/kg	1.40E+00	5.10E+00	NA	NA	NA	1.40E+00
	p,p'-DDT	mg/kg	1.70E+00	7.00E+00	NA	NA	NA	1.70E+00
	Heptachlor	mg/kg	1.10E-01	3.80E-01	NA	NA	NA	1.10E-01
	Heptachlor epoxide	mg/kg	5.30E-02	1.90E-01	NA	NA	NA	5.30E-02
ECODS B-5	Arsenic	mg/kg	3.90E-01	1.60E+00	2.29E+01	8.20E+00	4.50E+00	8..20E+00

[1] – Human health RGOs for the residential and industrial worker scenarios are based on a risk level of 1E-06.
[2] – SRS background information for naturally occurring constituents from Appendix B-2 of the *Background Soils Statistical Summary Report for the Savannah River Site* (WSRC 2006b).
[3] – Most likely RG is the most restrictive risk-based RGO concentration if it is greater than background concentrations. If the risk-based RGO is less than SRS background, then the most likely RG defaults to the background concentration.

C.3 References

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

WSRC, 2006b. *Background Soils Statistical Summary Report for Savannah River Site,* ERD-EN-2005-0223, Rev. 1, Washington Savannah River Company, Savannah River Site, Aiken, SC (October).