FINAL

REMEDIAL INVESTIGATION AND BASELINE RISK ASSESSMENT REPORT FOR THE INACCESSIBLE SOIL OPERABLE UNIT AT THE ST. LOUIS DOWNTOWN SITE

ST. LOUIS, MISSOURI

SEPTEMBER 20, 2012

U.S. Army Corps of Engineers
St. Louis District Office
Formerly Utilized Sites Remedial Action Program

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prepared by:
U.S. Army Corps of Engineers, St. Louis District Office
Formerly Utilized Sites Remedial Action Program

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LIST OF ACRONYMS AND ABBREVIATIONS

ε_i	instrument efficiency
ε_s	surface efficiency
µg	microgram(s)
µg Pb/dL	micrograms lead per deciliter
µg/dL	micrograms per deciliter
µg/kg-day	microgram(s) of chemical per kilogram body weight per day
µg/L	microgram(s) per Liter
µg/m^3	microgram(s) per cubic meter
95/95 UTL	95 percent UCL at 95 percent sample coverage
1993 BRA	*Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site*
1998 FS	*Feasibility Study for the St. Louis Downtown Site*
1998 ROD	*Record of Decision for the St. Louis Downtown Site*
Ac	actinium
AEC	Atomic Energy Commission
ALM	Adult Lead Model
amsl	above mean sea level
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
ARAR	applicable or relevant and appropriate requirement
As^{+3}	arsenite
As^{+5}	arsenate
AsS	arsenic sulfide
ATD	alpha track detector
bgs	below ground surface
BNSF	Burlington-Northern Santa Fe
BRA	baseline risk assessment
BV	background value
C-T	Columbium-Tantalum
Cd^{2+}	cadmium ion
CdS	cadmium sulfide
CDC	Centers for Disease Control and Prevention
CDI	chronic daily intake
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
cm	centimeter
cm^2	square centimeter(s)
cm^2-event	square centimeter(s) per event
COC	contaminant of concern
COPC	contaminant of potential concern
cpm	counts per minute
cpm/dpm	counts per minute per disintegrations per minute
CR	cancer risk
CSF	cancer slope factor
CSM	conceptual site model
CSR	*Code of State Regulations*

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

DAD	dermally absorbed dose
DCGL	derived concentration guideline level
dL	deciliter
DOD	U.S. Department of Defense
DOD QSM	*Department of Defense Quality Systems Manual for Environmental Laboratories*
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
dpm	disintegrations per minute
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
DQO	data quality objective
DSR	dose-to-source ratio
EC	exposure concentration
ERAGS	*Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*
EPC	exposure point concentration
FeS	iron sulfide
FFA	Federal Facility Agreement
FGR	Federal Guidance Report
FOD	frequency of detection
FS	feasibility study
FSS	final status survey
FSSE	final status survey evaluation
FSSP	final status survey plan
FSSP for Structures	*Final Status Survey Plan for Structures and Other Consolidated Material Left in Place at the St. Louis Site*
ft	foot/feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
g	gram(s)
GI	gastrointestinal
GIABS	gastrointestinal absorption fractions
GIS	geographic information system
GOF	goodness of fit
GPS	global positioning system
GSD_i	geometric standard deviation of blood level
GWS	gamma walkover survey
HHRA	human health risk assessment
HI	hazard index
HISS	Hazelwood Interim Storage Site
HQ	hazard quotient
hr	hour
HU	hydrostratigraphic unit
ICP	Inductively Coupled Plasma
IDOT	Illinois Department of Transportation
IDW	investigation-derived waste
IRIS	Integrated Risk Information System
ISOU	Inaccessible Soil Operable Unit

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

IUR	inhalation unit risk
K	Henry's Law constant
K_d	soil-water partitioning coefficient
K_{oc}	organic carbon partitioning coefficient
K_{ow}	octanol-water partitioning coefficient
keV	kiloelectron Volt(s)
kg	kilogram(s)
kg/m^3	kilogram(s) per cubic meter
kg/mg	kilogram(s) per milligram
L	Liter(s)
L/kg	Liter(s) per kilogram
LCS	laboratory control sample
LLC	Limited Liability Company
LOAEL	lowest observed adverse effects level
m	meter
m^2	square meter(s)
m^3	cubic meter(s)
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MDL	method detection limit
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineer District
meq	milliequivalent(s)
mg	milligram(s)
mg/cm^2-event	milligram(s) per square centimeters per event
mg/kg	milligram(s) per kilogram
mg/kg-day	milligram(s) per kilogram body weight per day
mg/L	milligram(s) per liter
mg/m^3	milligram(s) per cubic meter
mL	milliliter(s)
mL/g	milliliter(s) per gram
MoDOT	Missouri Department of Transportation
MoECA	Missouri Environmental Covenants Act
MoRBCA	Missouri Risk Based Corrective Action
mrem/yr	millirem per year
MSD	Metropolitan St. Louis Sewer District
NAD	normalized absolute difference
NaI	sodium-iodide
NAPL	non-aqueous phase liquid
NC	North St. Louis County
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NHANES III	Third National Health and Nutrition Examination Survey
NOAEL	no observed adverse effects level
NORM	naturally occurring radioactive material
NRC	U.S. Nuclear Regulatory Commission

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

NRHP	National Register of Historic Places
NUREG	U.S. Nuclear Regulatory Commission Regulation
ORP	oxidation-reduction potential
ORNL	Oak Ridge National Laboratory
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
Pa	protactinium
PAH	polycyclic aromatic hydrocarbons
Pb	lead
Pb^{2+}	lead ion
PbB	blood lead concentration
pCi	picocurie(s)
pCi/g	picocuries per gram
pCi/L	picocuries per liter
pCi/m^2	picocuries per square meter
PCOC	potential contaminant of concern
PDI	pre-design investigation
PE	Performance Evaluation
PID	photoionization detector
PP	Proposed Plan
PRAR	post-remedial action report
PRG	preliminary remediation goal
QA	quality assurance
QAPP	*Quality Assurance Project Plan for the St. Louis Airport and Downtown Sites*
QC	quality control
QCSR	Quality Control Summary Report
Ra	radium
Ra(II)	radium in the +2 valence state
Ra^{2+}	radium ion
RAGS	*Risk Assessment Guidance for Superfund*
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RESRAD	Residual Radioactivity (model)
RfC	reference concentration
RfD	reference dose
RG	remediation goal
RI	remedial investigation
RI WP	*Remedial Investigation Work Plan for the Inaccessible Soil Operable Unit at the St. Louis Downtown Site*
Rn	radon
ROD	record of decision
ROW	right-of-way
RPD	relative percent difference
RR	railroad
RSR	risk-to-source ratio
RSL	regional screening level

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

SAG	*Sampling and Analysis Guide for the St. Louis Site*
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act
SF	slope factor
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
SLERA	Screening Level Ecological Risk Assessment
SLS	St. Louis Sites
SQL	sample quantitation limit
SQL/2	one-half the reported sample quantitation limit
SVOC	semivolatile organic compound
T&E	threatened and endangered
TEDE	total effective dose equivalent
Th	thorium
Th(IV)	thorium in the +4 valence state
U	uranium
U(IV)	uranium in the +4 valence state
U(VI)	uranium in the +6 valence state
UCL	upper confidence limit
UF_4	uranium tetrafluoride (green salt)
UMTRCA	Uranium Mill Tailings Radiation Control Act
UNH	uranyl nitrate hexahydrate
UO_2	uranium oxide
UO_3	uranium trioxide
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTL	upper tolerance limit
VCP	vitrified clay pipe
VOC	volatile organic compound
VP	vicinity property
VQ	validation qualifier
WP	work plan

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EXECUTIVE SUMMARY

This Remedial Investigation (RI) and Baseline Risk Assessment (BRA) Report for the Inaccessible Soil Operable Unit (ISOU) at the St. Louis Downtown Site (SLDS) was developed in support of the Formerly Utilized Sites Remedial Action Program (FUSRAP). The SLDS is located in an industrial area in the eastern portion of the City of St. Louis, just west of the Mississippi River. The SLDS is comprised of approximately 210 acres of land, which includes the former Mallinckrodt property and 38 surrounding vicinity properties (VPs). The former Mallinckrodt property comprises approximately 44.5 acres of land, where uranium was processed for the nation's early atomic weapons development program conducted under the Manhattan Engineer District (MED) and the U.S. Atomic Energy Commission (AEC). The 38 surrounding VPs comprise more than 165 acres of land. The former Mallinckrodt property and the surrounding VPs have the potential for radiological and chemical contamination as a result of the historical MED/AEC operations and/or subsequent transportation, storage, or migration of MED/AEC-related residues. The RI areas for the ISOU include:

- Former Mallinckrodt Plants 1, 2, 3, 6, 7, 8, 9, and 11; and
- 38 VPs (i.e., DT-1 through DT-37 and the Terminal Railroad [RR] Soil Spoils Area).

The RI activities generated data, which when combined with applicable existing data, provided sufficient information to assess risks to various receptors within the ISOU. RI activities included a review of the available history and usage of the sites, determination of potential contaminants of concern (PCOCs), inaccessible soil sampling, gamma walkover surveys (GWSs), radiological surveys of structures, sewer investigations, determination of contaminants of potential concern (COPCs), contaminant dose and risk evaluation, and development of this RI/BRA report.

PURPOSE AND SCOPE

The purpose of this RI/BRA is to define the nature and extent of MED/AEC soil contamination present in the ISOU and assess the associated risk to human health and the environment under the current and reasonably anticipated future land use (industrial/commercial in an urban setting) for the SLDS. The results of this RI/BRA will be used to determine if MED/AEC-related contaminants are present at concentrations sufficiently low to be fully protective of human health and the environment.

The *Record of Decision for the St. Louis Downtown Site* (USACE 1998a) (hereafter referred to as the 1998 ROD) addressed accessible soil contamination and ground-water contamination. The scope of the ISOU includes all media not covered by the 1998 ROD that may have become contaminated as a result of the deposition or migration of MED/AEC-related contaminated media. Specifically, these media include the following:

- Soil that is inaccessible due to the presence of buildings and other permanent structures, including the supporting subsoil within the footprint of a structure of which remediation would reasonably be expected to affect the stability of the structure.
- Soil located under active RRs, including the supporting soil in the associated right-of-way (ROW).
- Soil located under roadways, including the supporting soil in the associated ROW. Roadways are defined as the public and private streets. Inaccessible soil does not include soil beneath driveways, parking lots, or other paved surfaces that were addressed as accessible soil areas.

- Soil on the exteriors and interiors of buildings and permanent structures (e.g., tanks, bridges, sheds, loading docks, utility poles, traffic signals, piping, rail tracks, and equipment boxes).
- Sewers (e.g., structures and interior sediment) not directly encountered within an excavation area during the remedial action conducted under the 1998 ROD.
- Soil adjacent to sewers located beneath buildings, permanent structures, RRs, and/or roads.

During preparation of the *Remedial Investigation Work Plan for the Inaccessible Soil Operable Unit at the St. Louis Downtown Site* (USACE 2009a) (hereafter referred to as the RI Work Plan [WP]), detailed reviews of historical usage of the SLDS areas within the scope of this RI were conducted to determine appropriate PCOCs. In addition, several characterization studies of various media (i.e., soil, sediment, ground water, sewers, and buildings) have been conducted at the SLDS since 1977. The characterization data that resulted from these studies and the results of the *Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site* (DOE 1993) were used during development of the RI WP to streamline the data needs for this RI.

Data collected from pre-design investigations (PDIs) and final status surveys (FSSs) conducted as part of the remediation activities for accessible soil was also useful in determining potentially contaminated inaccessible soil areas or structures. In addition, data resulting from ongoing investigations in support of the remediation of accessible soil have been used to supplement, modify, or amend RI sampling, as appropriate.

The PCOCs determined for the ISOU were identified based on the results of previous investigations. The radioactive contaminants in soil and sediment are: actinium (Ac)-227 and protactinium (Pa)-231, radium (Ra)-226, Ra-228, thorium (Th)-228, Th-230, Th-232, uranium (U)-235, and U-238 (USACE 1998a). Uranium-bearing ores that were processed for MED/AEC may have contained elevated levels of some metals. For the inaccessible soil within the uranium-ore processing area, the metal PCOCs are those that were identified as contaminants of concern (COCs) for accessible soil in the 1998 ROD (i.e., arsenic, cadmium, and uranium metal) (USACE 1998a). Because sediment present in the drains, manholes, and sewers used for MED/AEC operations had not been analyzed for metals during past investigations, metals associated with formerly used pitchblende and domestic ores (i.e., arsenic, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, vanadium, zinc, and uranium metal) were identified as PCOCs for sampling and analysis of sewer sediment and soil adjacent to sewers.

The scope of response actions authorized under FUSRAP at SLDS is limited to responding to contamination resulting from MED/AEC-related activities in support of the nations' early atomic energy program. Due to the history and diverse nature of industries located at and surrounding SLDS, there are many possible sources of chemical and radioactive contamination. The sources of metals contamination throughout SLDS, in particular, have not been established. For the purpose of providing a comprehensive assessment, the RI/BRA investigated and analyzed radiological and metal PCOCs regardless of source. The purpose of this risk analysis was only to establish site risk and should not be taken as an admission by USACE that such contamination is the result of MED/AEC-related activities. Additional information may be considered during the development of alternatives regarding site-specific sources of contamination. Response actions to address contamination not resulting from MED/AEC-related activities and not co-located with MED/AEC-related contamination are outside FUSRAP response authority.

FIELD ACTIVITIES AND FINDINGS OF THE REMEDIAL INVESTIGATION

As described in Section 2.0 of this report, a variety of field investigation methods were utilized to evaluate the presence of PCOCs for areas within the scope of this RI/BRA. Primary investigation methods consisted of:

Inaccessible Surface and Subsurface Soil Sampling: GWSs were conducted in indoor and outdoor areas that had the potential for MED/AEC-related radiological soil contamination. GWSs were conducted using a sodium-iodide (NaI) gamma scintillation detector coupled with a global positioning system (GPS) unit when possible in order to record both gamma radiation readings and geographic position data. At locations where GPS had limited effectiveness, GWSs were recorded manually. Surveys were focused on inaccessible soil areas beneath buildings, permanent structures, RRs, and roadways, and the results were used to identify biased soil sample locations.

Soil sampling was conducted in the inaccessible soil areas to determine the extent of radiological and metal PCOC contamination. Soil investigations were conducted at random, biased, and/or systematic soil sampling locations in inaccessible areas. Soil investigations consisted of surface (typically below ground cover) and subsurface soil sampling for radiological and metal PCOCs. All soil samples were analyzed for radionuclides, and only soil samples collected from some locations within the boundary of the former uranium-ore processing area were also analyzed for metals.

Radiological Structure Surveys: Structures with the potential for MED/AEC-related radiological soil contamination were surveyed. Radiological surveys included scanning for total alpha and beta surface activity and obtaining fixed-point measurements for total alpha and beta surface activity using portable radiological survey equipment. Building and structure surfaces that were surveyed included roofs, exposed exterior and interior surfaces, air vents, vertical and horizontal piping, and piping supports. The scoping surveys were biased, focusing on areas that are prone to accumulate contamination, such as horizontal surfaces, depressions, cracked surfaces, rusted or unpainted surfaces, intake and exhaust vents, etc.

Sewer Investigation: Soil and sediment samples associated with sewers were collected and analyzed to obtain sufficient and representative data to determine the extent of radiological and metals contamination associated with sewers. Specifically, two types of samples were collected:

- sediment samples from manholes and surface drains (grate inlets), and
- soil samples from areas adjacent to sewer lines.

The investigation included sewers that were used for MED/AEC operations, as well as sewers that could contain MED/AEC contamination due to receiving runoff from contaminated areas. Sediment sampling was conducted in manholes located upstream (west) of the Mallinckrodt facility to provide a background dataset for determining site-specific sewer sediment background values. Sediment and soil samples were analyzed for the metal and radionuclide PCOCs.

Section 4.0 of this report presents the findings of the RI field activities. Gross analytical results (i.e., results from which background concentrations have not been subtracted) generated for each PCOC in each media during the RI field activities were compared to appropriate USEPA risk-based preliminary remediation goals (PRGs). Concentrations below PRGs are unlikely to cause any health risks following exposure. PCOCs with concentrations exceeding their PRGs were subsequently defined as COPCs for quantitative evaluation in the BRA.

Table ES-1 summarizes the constituents that exhibited analytical results above the PRGs in each media. These COPCs were carried forward for quantitative evaluation in the BRA to determine human health carcinogenic and non-carcinogenic risks.

Table ES-1. Contaminants of Potential Concern

Media	Radiological	Metals
Inaccessible Soil	Ac-227, Pa-231, Ra-226, Ra-228, Th-230, Th-232, U-235, U-238	Arsenic
Sewer Sediment	Ra-226, Ra-228, U-238	Arsenic
Soil Adjacent to Sewers	Ac-227, Pa-231, Ra-226, Ra-228, Th-230, U-238	Arsenic, Cadmium, Lead
Structural Surfaces	Ac-227, Pa-231, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, U-238	NA

NA = Not Applicable.

FATE AND TRANSPORT

A conceptual site model (CSM) was developed based on analysis of contaminant fate and transport, along with information regarding the nature and extent of contamination and the physical features of the ISOU. The CSM identifies the potentially complete human or environmental exposure pathways that form the basis of evaluations for the BRA.

The CSM assumes that current and reasonably anticipated future land use for the SLDS is industrial/commercial in an urban setting. Under current land use, exposure pathways are evaluated assuming the current physical configurations that exist relative to the ISOU media (i.e., ground cover in the forms of buildings, RR, roadways, and other permanent structures being present). Under future land use, exposure pathways are evaluated assuming scenarios in which the inaccessible soil areas become accessible due to removal or gross degradation of ground cover. The ISOU CSM identifies the following types of potential exposure pathways assumed for both the current and reasonably anticipated future land use scenarios: (1) complete and potentially significant, (2) potentially complete but insignificant, and (3) incomplete. Complete and potentially significant exposure pathways identified by the CSM are retained for further quantitative evaluations in the BRA. Generally, a complete exposure pathway is comprised of the following elements:

- a contaminant source,
- a release/transport mechanism,
- an exposure medium (or point) where humans could contact the contaminated medium, and
- an exposure route (i.e., ingestion, dermal contact, inhalation, or external radiation).

The CSM identifies three main categories of potential sources of contamination and exposure within the ISOU: (1) contaminated inaccessible soil, (2) radiologically contaminated particles (i.e., soil) on structural surfaces, and (3) contaminated sewer media. Source media identified for the sewers include sewer sediment and soil adjacent to sewer lines.

The CSM considers release/transport mechanisms associated with ISOU source media and areas, under both current and assumed future land use scenarios. Release and transport of COPCs can result in direct and indirect contact exposures. Direct contact exposures occur at the source, whereas indirect contact exposures occur away from the source. Indirect contact exposures to COPCs identified in all ISOU source media require COPC release from those media and the availability of transport mechanisms that make it possible for the migration of the COPCs from the source to some downgradient/downwind receptor location or medium. Once released from a source, transport mechanisms provide a pathway by which COPCs can migrate in or through an environmental medium (i.e., "transport medium"). The potentially significant transport pathways are Air Transport Pathways, Subsurface Water Transport Pathways, and Surface Runoff Transport Pathways.

Based on an evaluation of COPC-specific and site-specific characteristics, all radiological and metal COPCs are expected to persist in ISOU media. An examination of the ranges of K_d values estimated for the COPCs indicate that cadmium, lead, radium, thorium, and uranium are expected to be relatively immobile in ISOU media. On the other hand, the soil-water partitioning coefficient (K_d) values estimated for arsenic indicate a higher potential for mobility. However, the presence of ground cover over most of the inaccessible soil areas minimizes the potential for environmental release and transport of arsenic, as well as all COPCs identified in inaccessible soil and soil adjacent to sewers.

BASELINE RISK ASSESSMENT

A human health risk assessment (HHRA) was completed based on the identification of radiological and metal COPCs. The purpose of the HHRA is to provide risk and dose estimates and hazard index (HI) values for ISOU media and properties. The following nine receptor scenarios and the associated data sets were evaluated:

- current industrial worker exposures to inaccessible soil and combined inaccessible/ accessible soil;
- future industrial worker exposures to inaccessible soil and combined inaccessible/ accessible soil;
- current/future recreational user exposures to inaccessible soil and combined inaccessible/ accessible soil in the levee areas associated with the St. Louis Riverfront Trail;
- current/future construction worker exposures to inaccessible soil;
- current/future utility worker exposures to inaccessible soil;
- current/future industrial worker exposures to interior building surfaces;
- current/future maintenance worker exposures to exterior building surfaces;
- current/future sewer maintenance worker exposures to sewer sediment; and
- current/future sewer utility worker exposures to soil adjacent to sewer lines.

The above scenarios assume (1) current land use configurations in which ground cover is present over most inaccessible soil areas, but is absent from accessible soil areas and (2) future land use configurations in which ground cover is absent from both inaccessible and accessible soil areas. Except for building/structural surfaces, each of the above scenarios, were evaluated for sitewide dose and risk and property-specific evaluations for inaccessible soil and combined inaccessible/accessible soil. Building-specific evaluations were conducted for soil on interior and exterior building/structural surfaces, and sampling location-specific dose and risk evaluations were conducted for sewer sediment and soil adjacent to sewers.

Dose and risk characterization summaries for inaccessible soil and combined inaccessible/ accessible soil exposures to radiological and metal COPCs are presented in Tables ES-2 and ES-3, respectively. Radiological dose and risk characterization summaries for soil on interior and exterior building/structural surfaces are presented in Table ES-4. The radiological dose and risk characterization summary for soil adjacent to sewers is presented in Table ES-5. The doses and

Table ES-2. Radiological Doses and Risks Above Background for Inaccessible and Accessible Soil

Property	Soil Operable Unit	Current Industrial Worker [a]		Future Industrial Worker [b]		Current/Future Recreational User [c]		Current/Future Construction Worker [d]		Current/Future Utility Worker [d]	
		Dose (mrem/yr)	CR (unitless)	Dose (mrem/yr)	CR (unitless)	Dose (mrem/yr)	CR (unitless)	Dose (mrem/yr)	CR (unitless)	Dose (mrem/yr)	CR (unitless)
SLDS (Sitewide)	Inaccessible	---	3.1E-06	---	4.3E-05	NA	NA	---	---	---	---
	Accessible	---	---	---	---	NA	NA	NA	NA	NA	NA
	Sitewide	---	2.1E-05	---	4.4E-06	NA	NA	NA	NA	NA	NA
Mallinckrodt Properties											
Plant 1	Inaccessible	---	2.0E-05	29	5.2E-04	NA	NA	---	9.6E-06	---	1.1E-06
	Accessible	---	8.9E-06	---	8.9E-06	NA	NA	NA	NA	NA	NA
	Property-Wide	---	1.9E-05	---	2.5E-04	NA	NA	NA	NA	NA	NA
Plant 2	Inaccessible	---	---	---	---	NA	NA	---	---	---	---
	Accessible	---	---	---	---	NA	NA	NA	NA	NA	NA
	Property-Wide	---	5.1E-05	---	---	NA	NA	NA	NA	NA	NA
Plant 6	Inaccessible	---	7.4E-06	---	3.0E-04	NA	NA	---	6.3E-06	---	---
	Accessible	---	7.7E-06	---	7.7E-06	NA	NA	NA	NA	NA	NA
	Property-Wide	---	8.1E-05	---	2.9E-05	NA	NA	NA	NA	NA	NA
Mallinckrodt Security Gate 49	Inaccessible	---	---	---	---	NA	NA	---	---	---	---
	Accessible	---	---	---	---	NA	NA	NA	NA	NA	NA
	Property-Wide	---	5.8E-05	---	---	NA	NA	NA	NA	NA	NA
Industrial/Commercial Vicinity Properties											
DT-2	Inaccessible	---	---	---	---	---	---	---	---	---	---
	Accessible	---	---	---	---	---	---	NA	NA	NA	NA
	Property-Wide	---	5.4E-05	---	---	---	---	NA	NA	NA	NA
DT-4 North	Inaccessible	---	4.4E-05	45	7.9E-04	NA	NA	---	1.5E-05	---	1.6E-06
	Accessible	---	3.4E-06	---	3.4E-06	NA	NA	NA	NA	NA	NA
	Property-Wide	---	1.5E-05	25	4.4E-04	NA	NA	NA	NA	NA	NA
DT-6	Inaccessible	---	1.5E-05	---	2.5E-04	NA	NA	---	4.6E-06	---	---
	Accessible	---	---	---	---	NA	NA	NA	NA	NA	NA
	Property-Wide	---	2.5E-05	---	7.9E-05	NA	NA	NA	NA	NA	NA
DT-8	Inaccessible	---	---	---	---	NA	NA	---	---	---	---
	Accessible	---	---	---	---	NA	NA	NA	NA	NA	NA
	Property-Wide	---	5.3E-05	---	---	NA	NA	NA	NA	NA	NA
DT-10	Inaccessible	---	1.6E-06	---	3.2E-05	NA	NA	---	---	---	---
	Accessible	---	---	---	---	NA	NA	NA	NA	NA	NA
	Property-Wide	---	7.5E-05	---	2.0E-06	NA	NA	NA	NA	NA	NA

Table ES-2. Radiological Doses and Risks Above Background for Inaccessible and Accessible Soil (Continued)

Property	Soil Operable Unit	Current Industrial Worker [a]		Future Industrial Worker [b]		Current/Future Recreational User [c]		Current/Future Construction Worker [d]		Current/Future Utility Worker [d]	
		Dose (mrem/yr)	CR (unitless)	Dose (mrem/yr)	CR (unitless)	Dose (mrem/yr)	CR (unitless)	Dose (mrem/yr)	CR (unitless)	Dose (mrem/yr)	CR (unitless)
DT-29	Inaccessible	---	---	---	---	NA	NA	---	---	---	---
	Accessible	---	3.3E-06	---	3.3E-06	NA	NA	NA	NA	NA	NA
	Property-Wide	---	3.9E-05	---	---	NA	NA	NA	NA	NA	NA
South of Angelrodt Property Group	Inaccessible	---	---	---	---	NA	NA	---	---	---	---
	Accessible	---	---	---	---	NA	NA	NA	NA	---	NA
	Combined Properties	---	3.3E-05	---	---	NA	NA	NA	NA	NA	NA
Railroad Vicinity Properties											
DT-3	Inaccessible	---	1.4E-06	---	9.0E-06	NA	NA	---	---	---	---
	Accessible	---	---	---	---	NA	NA	NA	NA	NA	NA
	Property-Wide	---	3.1E-05	---	2.8E-06	NA	NA	NA	NA	NA	NA
DT-9 Levee	Inaccessible	---	---	---	---	---	---	---	---	---	---
	Accessible	---	---	---	---	---	---	NA	NA	NA	NA
	Property-Wide	---	2.1E-05	---	---	---	---	NA	NA	NA	NA
DT-9 Main Tracks	Inaccessible	---	1.7E-06	---	6.0E-06	NA	NA	---	---	---	---
	Accessible	---	---	---	---	NA	NA	NA	NA	NA	NA
	Property-Wide	---	---	---	---	NA	NA	NA	NA	NA	NA
DT-9 Rail Yard	Inaccessible	---	1.2E-05	---	3.1E-04	NA	NA	---	5.9E-06	---	---
	Accessible	---	6.4E-06	---	6.4E-06	NA	NA	NA	NA	NA	NA
	Property-Wide	---	6.6E-05	---	5.4E-05	NA	NA	NA	NA	NA	NA
Terminal RR Soil Spoils Area	Inaccessible	---	1.6E-05	---	2.6E-04	NA	NA	---	4.9E-06	---	---
	Accessible	---	---	---	---	NA	NA	NA	NA	NA	NA
	Property-Wide	---	5.1E-05	---	2.2E-05	NA	NA	NA	NA	NA	NA
Roadways [e]											
Bremen Avenue	Inaccessible	---	3.2E-06	---	4.2E-05	NA	NA	---	---	---	---
Buchanan Street	Inaccessible	---	3.6E-06	---	4.8E-05	NA	NA	---	1.0E-06	---	---
Destrehan Street	Inaccessible	---	5.3E-06	---	4.7E-05	NA	NA	---	---	---	---
Hall Street	Inaccessible	---	2.7E-06	---	5.5E-05	NA	NA	---	1.0E-06	---	---
North Second Street	Inaccessible	---	1.2E-06	---	---	NA	NA	---	---	---	---

[a] Current industrial worker scenario assumes a soil cover in inaccessible soil areas that is 0.3048 meters thick and no ground cover in accessible soil areas.

[b] Future industrial worker scenario assumes no ground cover in inaccessible or accessible soil areas.

[c] Current/future recreational user scenario assumes the levee is present as ground cover in inaccessible soil areas at a minimum thickness of 1 meter and that there is no ground cover in accessible soil areas.

[d] Current/future construction and utility worker scenarios assume no ground cover in inaccessible soil areas. Accessible soil areas are not evaluated for these receptor scenarios as they are evaluated under the more limiting industrial worker scenarios and the the recreational user scenarios.

[e] No accessible soil areas exist at roadways.

--- Indicates that dose or risk is within the range of background and/or less than the target dose of 25 mrem/yr and/or less than the CERCLA risk range.

NA - Calculation of dose or risk is not applicable.

Table ES-3. Cancer Risks for Metals Above Background for Inaccessible and Accessible Soil

Property	Soil Operable Unit	Future Industrial Worker [a]	Current/Future Construction Worker	Current/Future Utility Worker
		CR [a] (unitless)	CR [a] (unitless)	CR [a] (unitless)
SLDS (Sitewide)	Inaccessible	1.7E-05	3.6E-06	---
	Accessible	2.6E-06	NA	NA
	Sitewide	7.2E-06	NA	NA
Plant 2	Inaccessible	---	---	---
	Accessible	2.9E-06	NA	NA
	Property-Wide	2.7E-06	NA	NA
Plant 6	Inaccessible	---	---	---
	Accessible	2.7E-06	NA	NA
	Property-Wide	2.6E-06	NA	NA
DT-10	Inaccessible	2.9E-05	6.2E-06	---
	Accessible	8.3E-06	NA	NA
	Property-Wide	1.2E-05	NA	NA
DT-12 [b]	Inaccessible	2.9E-05	6.3E-06	---
Mallinckrodt Street [b]	Inaccessible	2.6E-06	---	---
Destrehan Street [b]	Inaccessible	3.0E-06	---	---

[a] Incidental ingestion of arsenic was the predominant contributor to all total CRs. All HIs for all receptor scenarios are less than 1.0.
[b] Accessible soil metals data are not available for calculating CRs for the property indicated.
--- Indicates that CR is within the range of background and/or less than the CERCLA target risk range.
CRs – cancer risks; NA – Calculation of dose or risk is not applicable.

Table ES-4. Radiological Dose and Risk Characterization for Building Surfaces

Property	Building	Interior Surfaces [a]		Exterior Surfaces [b]	
		Dose (mrem/yr)	CR (unitless)	Dose (mrem/yr)	CR (unitless)
Plant 1	Building 7	---	1.2E-06	NA	NA
	Building 26	---	1.3E-06	NA	NA
Plant 2	Building 41	---	1.2E-06	NA	NA
	Building 508	---	1.1E-06	NA	NA
DT-10	Metal Storage Building	---	1.0E-06	NA	NA
	Wood Storage Building	---	---	---	1.2E-06

[a] An industrial worker was evaluated for interior surface exposures.
[b] A maintenance worker was evaluated for exterior surface exposures.
--- Indicates that dose or risk is less than the target does of 25 mrem/yr or the CERCLA risk range.
mrem/yr – millirem per year; NA – Calculation not applicable due to no PRG exceedances.

Table ES-5. Radiological Doses and Risks Above Background for Soil Adjacent to Sewer Lines

Property	Soil Locations Adjacent to Sewers	Current/Future Sewer Utility Worker	
		Dose (mrem/yr)	CR (unitless)
SLDS (Sitewide)	All SLDS Locations	---	8.3E-06
Plant 6	HTZ88929	---	1.1E-05
	HTZ88930	---	1.1E-06
Plant 7/DT-12	SLD93275	259	1.9E-04
	SLD93276	75	5.5E-05
	SLD93277	115	8.5E-05
DT-2 Levee	SLD120945	29	2.1E-05
	SLD120946	---	1.4E-05
	SLD120947	30	2.2E-05

--- Indicates that dose or risk is within the range of background and/or less than the target dose of 25 mrem/yr and/or less than the CERCLA risk range.

cancer risks (CRs) presented in the aforementioned tables are those doses greater than 25 millirem per year (mrem/yr) and CRs above background that are within or exceed the USEPA's target CR range. HIs estimated for metals are not summarized in the tables because all HIs were below the target value of 1.0 for all evaluated scenarios. Also, the summary tables do not include a radiological dose and CR summary for sewer sediment, nor do they include a metals CR and HI summary for sewer sediment because all doses, CRs and HIs are less than target criteria.

Based on the findings from a site visit that occurred during the RI, as documented in the USEPA's Ecological Checklist, along with the findings of the Screening Level Ecological Risk Assessment (SLERA), potential impacts to ecological receptors from ISOU media at the SLDS are likely to be insignificant.

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1.0 INTRODUCTION

This Remedial Investigation (RI) and Baseline Risk Assessment (BRA) Report for the Inaccessible Soil Operable Unit (ISOU) at the St. Louis Downtown Site (SLDS) was developed in support of the Formerly Utilized Sites Remedial Action Program (FUSRAP). In 1974, the U.S. Atomic Energy Commission (AEC) (later to become the U.S. Department of Energy [DOE] and the U.S. Nuclear Regulatory Commission [NRC]) established the FUSRAP to address sites, such as the SLDS, that were contaminated as a result of the nation's early atomic weapons development program.

The SLDS is one of two separate geographical areas collectively referred to as the St. Louis Sites (SLS). These two areas are comprised of multiple properties and are located in two distinct areas: downtown St. Louis City and North St. Louis County (NC) (Figure 1-1). These two areas are designated as the SLDS and the NC sites, respectively. The SLDS is divided into two operable units (OUs), one for accessible soil and ground water and another for inaccessible soil. This RI/BRA applies only to the SLDS ISOU.

The SLDS is located in an industrial area in the eastern portion of the City of St. Louis, just west of the Mississippi River. The SLDS consists of an active chemical processing facility and additional tracts of land called vicinity properties (VPs) (Figure 1-2). The chemical processing facility was formerly used to process uranium for the Manhattan Engineer District (MED) and the AEC and was previously owned and operated by Mallinckrodt Chemical Works, Inc., and Mallinckrodt, Inc., but is now owned and operated by Covidien. For the purpose of this RI/BRA report, the chemical plant property will be referred to by its historical designation as the "Mallinckrodt" plant area or property. The SLDS VPs consist of 37 numbered properties and one unnumbered property that surround the Mallinckrodt property and have potential radiological and metals contamination as a result of the historic MED/AEC operations and/or subsequent transportation, storage, or migration of MED/AEC-related residues.

1.1 PURPOSE

In 1980, Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Public Law 96-510), also known as "Superfund," which was created to remedy threats to human health and the environment from releases of hazardous wastes from various industries. In 1986, CERCLA was reauthorized and amended by the Superfund Amendments and Reauthorization Act (SARA) requiring federal facilities to abide by the same CERCLA requirements. Response actions at FUSRAP sites are subject to the administrative, procedural, and regulatory provisions of CERCLA.

The CERCLA process includes the investigation, evaluation, and documentation of the contaminants present at a site or portions of a site (the RI); an assessment of the potential risks to human health and the environment posed by those contaminants (the BRA); and, if necessary, assessment screening and detailed evaluation of potential remedial alternatives for reducing unacceptable risk (a Feasibility Study [FS]). Based upon the results of the RI/BRA/FS process, a Proposed Plan (PP) is developed, and a remedial decision is documented in a Record of Decision (ROD).

In accordance with 40 *Code of Federal Regulations (CFR)* 300.430(a)(ii)(A), the CERCLA process may be completed in OUs when phased analysis and response is necessary or appropriate given the size or complexity of the site or to expedite site cleanup. The *Record of Decision for the St. Louis Downtown Site* (USACE 1998a) (hereafter referred to as the 1998 ROD), addressed accessible soil and ground-water contamination as one OU. The other OU (i.e., the ISOU), which this RI/BRA covers, includes soil and sediment at SLDS not addressed by the 1998 ROD that have the potential for MED/AEC contamination, as further described in Section 1.1.2.

The purpose of this RI/BRA is to define the nature and extent of MED/AEC soil contamination present in the ISOU and assess the associated risk to human health and the environment under the current and reasonably anticipated future land use (industrial/commercial in an urban setting) for the SLDS. The results of this RI/BRA will be used to determine if MED/AEC-related contaminants are present at concentrations sufficiently low to be fully protective of human health and the environment.

The scope of response actions authorized under FUSRAP at SLDS is limited to responding to contamination resulting from MED/AEC-related activities in support of the nations' early atomic energy program. Due to the history and diverse nature of industries located at and surrounding SLDS, there are many possible sources of chemical and radioactive contamination. The sources of metals contamination throughout SLDS, in particular, have not been established. For the purpose of providing a comprehensive assessment, the RI/BRA investigated and analyzed radiological and metal potential contaminants of concern (PCOCs) regardless of source. The purpose of this risk analysis was only to establish site risk and should not be taken as an admission by USACE that such contamination is the result of MED/AEC-related activities. Additional information may be considered during the development of alternatives regarding site-specific sources of contamination. Response actions to address contamination not resulting from MED/AEC-related activities and not co-located with MED/AEC-related contamination are outside FUSRAP response authority.

1.1.1 Regulatory Overview

In 1974, AEC established FUSRAP for the cleanup of sites contaminated from past activities involving radioactive materials. Because contamination related to MED/AEC activities was present at the SLDS at levels that required a response, the SLDS was designated for inclusion under the FUSRAP. At that time, one OU was established for the SLS.

In June 1990, a Federal Facility Agreement (FFA) for the SLS was established between the DOE and U.S. Environmental Protection Agency (USEPA) Region VII (DOE 1990). This agreement, pursuant to CERCLA Section 120, Federal Facilities, defined implementation and oversight roles for the respective agencies involved in the CERCLA process. The FFA stated that the DOE would conduct response actions at the SLS for the following materials:

- All wastes, including but not limited to radiologically contaminated wastes, resulting from or associated with MED/AEC uranium manufacturing or processing activities conducted at the SLDS; and
- Other chemical or non-radiological wastes that have been mixed or commingled with wastes resulting from or associated with MED/AEC uranium manufacturing or processing activities conducted at the SLDS (DOE 1990).

The DOE managed the FUSRAP until October 1997, when responsibility for the execution of the program was transferred to the U.S. Army Corps of Engineers (USACE) under the Fiscal Year 1998 Energy and Water Appropriations Act. Consistent with the transfer of authority, the USACE is the lead agency responsible for response actions at the SLDS. The DOE will assume a stewardship responsibility beginning two years after completion of the response actions at the SLDS.

Between 1989 and 1993, an RI/BRA for the SLS was conducted and included the sampling of accessible and inaccessible soil, buildings, sewers, surface water, sediment, and ground water at both the NC site and the SLDS. The *Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site* (DOE 1993) (hereafter referred to as the 1993 BRA) concluded that radiologically contaminated soil at the SLDS was the source of cancer risks (CRs) in excess of USEPA's CERCLA target CR range of 1 in 1,000,000 to 1 in 10,000 (i.e., 1.0E-06 to 1.0E-04) under current industrial and future land use scenarios. Based on these results, remedial action was judged to be warranted at the SLDS.

In 1991, the *Engineering Evaluation/Cost Analysis for Decontamination at the St. Louis Downtown Site* (DOE 1991) evaluated potential removal actions at the SLDS. In 1992, the *Action Memorandum for the Removal of Contaminated Materials at the St. Louis Downtown Site*, *St. Louis, Missouri* (DOE 1992) was issued to address four removal actions involving the demolition of several buildings at the Mallinckrodt Plant area remaining from MED/AEC operations. When the *Feasibility Study for the St. Louis Downtown Site* (USACE 1998b) (hereafter referred to as the 1998 FS) was published in 1998, it stated that the inaccessible soil beneath buildings and other permanent structures would be addressed as a subsequent CERCLA action, because the inaccessible soil did not present a significant threat in its current configuration and "remediation of these soils at this time would result in severe economic dislocations and community disruptions" (USACE 1998b).

The 1998 ROD was published by the USACE in consultation with the USEPA and with concurrence from the Missouri Department of Natural Resources (MDNR). It defined remedial actions for accessible soil at the Mallinckrodt property and VPs, plus ground water beneath the SLDS for MED/AEC-related hazardous substances. The selected remedy for accessible soil was Alternative 6, Selective Excavation and Disposal. Accessible soil is defined in the 1998 ROD as soil that is not beneath buildings or other permanent structures. Long-term monitoring was required for ground water beneath the site. The 1998 ROD also stated that contaminated sediment in sewers and drains considered accessible would also be remediated (USACE 1998a).

The principal risk identified in the 1998 ROD was exposure to radioactivity remaining from past MED/AEC operations. The radiological contaminants of concern (COCs) (i.e., one or more contaminants found on, in, or under a property at a concentration that exceeds the applicable site condition standards for the property) defined by the 1998 ROD were actinium (Ac)-227, protactinium (Pa)-231, radium (Ra)-226, Ra-228, thorium (Th)-228, Th-230, Th-232, uranium (U)-235, and U-238. The metal COCs applicable for soil inside the uranium-ore processing area of the SLDS were identified as arsenic, cadmium, and uranium metal. Soil remediation goals (RGs) for the radiological COCs identified in the 1998 ROD were consistent with applicable or relevant and appropriate requirements (ARARs) identified in accordance with CERCLA. RGs for metal COCs were developed based on site-specific risk-based values in accordance with CERCLA.

In March 2005, the *Memorandum for Record: Non-Significant Change to the Record of Decision for the St. Louis Downtown Site* was published, which provided specific clarifications regarding the delineation of the SLDS boundary (USACE 2005a). Additional VPs were determined to be impacted (i.e., potentially contaminated) by MED/AEC wastes from the SLDS. In addition, certain property boundaries and, in some cases, the associated property owners, differed from those originally identified in the 1998 ROD. The following specific revisions were stated in the Memorandum for Record:

- Designating VPs by assigning property-specific alphanumeric identification numbers to clearly identify each property and to minimize confusion resulting from changing property ownership (e.g., DT-2) (Table 1-1).
- Modifying some VP boundaries due to changes in property boundaries after issuance of the 1998 ROD.
- Clarifying that contaminated soil under active rail lines on the three "Railroad (RR) Properties" is inaccessible and will be addressed as part of the ISOU.
- Clarifying that the 1998 ROD "specifically includes the Remediated Levee Property east of the levee but excludes contamination present beneath the existing levee, which will be addressed as part of the future ISOU" (USACE 2005a).
- Amending the SLDS boundaries "to increase the geographical area/scope of the SLDS site to include additional areas to the north, south, and west of the site" (USACE 2005a).
- Adding the Terminal RR Soil Spoils Area, located south of the SLDS, to the amended geographical area of the SLDS.

Table 1-1. St. Louis Downtown Site Vicinity Properties

Current Property Name	VP Number
Kiesel (formerly Archer Daniels Midland and PVO Foods) [a]	DT-1
St. Louis City Property	DT-2
Norfolk Southern RR (formerly Norfolk and Western RR)	DT-3
Gunther Salt (North and South)	DT-4
AmerenUE	DT-5
Heintz Steel and Manufacturing	DT-6
Midwest Waste [a]	DT-7
PSC Metals, Inc. (formerly McKinley Iron Works)	DT-8
Terminal RR Association	DT-9
Thomas and Proetz Lumber Company	DT-10
Illinois Department of Transportation (IDOT) and the Missouri Department of Transportation (MoDOT) (also known as McKinley Bridge) (formerly the City of Venice, Illinois)	DT-11
Burlington-Northern Santa Fe (BNSF) RR (formerly Chicago, Burlington, and Quincy RR)	DT-12
Cash's Scrap Metal	DT-13
Cotto-Waxo Company	DT-14
Metropolitan St. Louis Sewer District (MSD) Lift Station	DT-15
Star Bedding Company	DT-16
Christiana Court, Limited Liability Company (LLC)	DT-17
Curley Collins Recycling (currently owned by the City of St. Louis)	DT-18
City of St. Louis Streets	DT-19
Richey	DT-20
Favre	DT-21
Tobin Electric	DT-22
InterChem	DT-23
Bremen Bank	DT-24
Eirten's Parlors	DT-25
United Auto Workers Local 1887	DT-26
Dillon	DT-27
Challenge Enterprise	DT-28
Midtown Garage (currently owned by Cash's Scrap Metal)	DT-29
ZamZow Manufacturing	DT-30
Porter Poultry	DT-31
Westerheide Tobacco [a, b]	DT-32

Table 1-1. St. Louis Downtown Site Vicinity Properties (Continued)

Current Property Name	VP Number
MoDOT Roads	DT-33
Hjersted	DT-34
Factory Tire Outlet	DT-35
OJM, Inc.	DT-36
Lange-Stegmann	DT-37
Terminal RR Soil Spoils Area	NA

[a] These VPs are not included in the scope of this OU because no inaccessible soil areas or buildings and structures remain at the property.

[b] Property was purchased by Mallinckrodt, building was demolished, and area is now a parking lot at Plant 8.

NA = Not applicable.

The *Remedial Investigation Work Plan for the Inaccessible Soil Operable Unit at the St. Louis Downtown Site* (USACE 2009a) (hereafter referred to as the RI Work Plan [WP]) was finalized in November 2009 after regulatory review by the USEPA and MDNR. The RI WP presented the sampling protocol for the ISOU based on an evaluation of data from characterization studies of various media (e.g., soil, sediment, sewers, and buildings) conducted at the SLDS since 1977. These studies provided a detailed understanding of the environmental setting and the nature of contamination at the SLDS. In addition, the data collected from 1977 to 1993 were used as part of the 1993 BRA to evaluate the human health and ecological risks associated with the impacted media at the SLDS, including both inaccessible and accessible soil. The existing characterization data and the results of the 1993 BRA were used to streamline the data needs for the ISOU RI.

Sampling for the ISOU RI began in June 2009 and ended in August 2010 with the majority of work being completed between October 2009 and May 2010. The results of the RI are detailed in this report.

1.1.2 Operable Unit Scope

The scope of the ISOU includes all media at the SLDS not covered by the 1998 ROD that may have become contaminated as a result of the deposition or migration of MED/AEC-related contaminated media. A conceptual view of the inaccessible areas is shown on Figure 1-2.

Media within the scope of the ISOU include:

- Soil that is inaccessible due to the presence of buildings and other permanent structures, including the subsoil within the footprint of a structure of which remediation would reasonably be expected to affect the stability of the structure.
- Soil located under active RRs, including the supporting soil in the associated right-of-way (ROW).
- Soil located under roadways, including the supporting soil in the associated ROW. Roadways are defined as the public and private streets. Inaccessible soil does not include soil beneath driveways, parking lots, or other paved surfaces located at plant or VP areas that were addressed as accessible soil areas.
- Soil on the exteriors and interiors of buildings and permanent structures (e.g., tanks, bridges, sheds, loading docks, utility poles, traffic signals, piping, rail tracks, and equipment boxes).
- Sewers (e.g., structures and interior sediment) not directly encountered within an excavation area during the remedial action conducted under the 1998 ROD.

- Soil adjacent to sewers located beneath buildings, permanent structures, RRs, and/or roads.

The following properties are excluded from the scope of the ISOU:

- Plant 7E and three VPs (DT-1, DT-7, and DT-32) are excluded because they do not contain inaccessible soil areas and there are no sewers, buildings, or structures impacted by MED/AEC operations present at these properties. Accessible soil contamination has been remediated at Plant 7E and DT-7 to standards specified in the 1998 ROD. DT-1 and DT-32 did not require remediation.
- The inaccessible soil and structures at Plant 10 have been excluded because Plant 10 was remediated by the DOE. The sewers used for MED/AEC operations at Plant 10 were included and evaluated in the RI WP and were determined to be non-impacted.
- Plant 5 is excluded because residual contamination is reasonably attributable to the Columbium-Tantalum (C-T) processing activities that were conducted at these areas by Mallinckrodt. C-T ores were processed by Mallinckrodt at Plant 5 under a separate NRC Source-Material License and, therefore, remediation of this radiologically contaminated soil is not within the scope of the FUSRAP. These ores contain natural uranium, thorium, and actinium decay series radionuclides.
- Plant 7W was previously used by MED/AEC for processing radioactive feed materials and by Mallinckrodt to store containerized tin slag feed material and the operation of the concrete-lined, waste-water neutralization ponds. Plant 7W is currently excluded from the ISOU, because historic sources of contamination have not been determined. If historic sources of contamination are determined to be from MED/AEC activities, inaccessible data will be added as an appendix to the current CERCLA document (i.e., RI or FS), and the results of the evaluation will be incorporated into that document (RI or FS). If the determination is made after the ROD is signed, a standalone document will be written to cover Plant 7W.

The status of the following properties has changed since the publication of the RI WP and, therefore, the inclusion of the specific property areas within the scope of the ISOU has also changed. These areas are now being addressed under the 1998 ROD.

- A sewer line at the northern edge of the 50-series excavation area in Plant 2 was characterized during the RI. Results of the soil sampling indicated subsurface soil adjacent to the sewer line was radiologically contaminated. In calendar year 2011, this area was made available for remediation by the owner and the sewer line and associated contaminated soil were removed. Therefore, the soil and sewer line at the northern edge of the 50-series excavation area are no longer included in the scope of the ISOU.
- Plant 6 Building 101 is planned for demolition by the USACE. Soil remaining within the footprint of Building 101 is considered accessible soil and is outside the scope of the ISOU.
- Soil at the northeastern corner of Plant 7N was defined in the RI WP as an "inaccessible area of detected contamination" and was proposed for sampling as part of the ISOU. The subsurface soil beneath this area was found to be radiologically contaminated. Because of the proposed remediation of Destrehan Street, this area at Plant 7N is proposed for accessible soil remediation under the 1998 ROD. Following the remediation, any inaccessible soil remaining will be evaluated as part of the ISOU. If any inaccessible soil remains, the inaccessible data will be added as an appendix to the current CERCLA

document (i.e., RI or FS), and the results of the evaluation will be incorporated into that document (RI or FS). If the determination is made after the ROD is signed, a standalone document will be written.

- The Hazardous Waste Storage Area at Plant 7N was razed in 2010, and the associated soil and sewer lines were remediated. Therefore, soil and sewer lines beneath this building are no longer defined as inaccessible and are outside the scope of the ISOU.
- ROW soil along the DT-12, was characterized during the RI, found to be radiologically contaminated, and then made available for remediation by the owner. Following the remediation, any inaccessible soil remaining will be evaluated as part of the ISOU.
- Soil beneath Destrehan Street, between Hall Street and DT-12, was characterized during the RI, found to be radiologically contaminated, and then made available for remediation by the owner. Following the remediation, any inaccessible soil remaining will be addressed as part of the ISOU.

1.2 SITE BACKGROUND

1.2.1 Location and General Site Description

The SLDS is located in an industrialized area on the eastern border of the City of St. Louis, just west of the Mississippi River (Figure 1-1). The SLDS consists of approximately 44.5 acres of the Mallinckrodt property, where MED/AEC activities were formerly conducted, and approximately 165 acres of surrounding VPs (Figure 1-2).

Mallinckrodt, Inc., became part of Covidien in 2007 and currently utilizes a number of plants (Plants 1 through 3 and 5 through 11) at the former Mallinckrodt facility. To maintain historic references, any actions taken prior to 2007 by the former Mallinckrodt, Inc., will be identified within this document as actions taken by Mallinckrodt. Similarly, any actions completed during and after 2007 will be identified as Covidien actions.

The Mallinckrodt property encompasses an area of approximately 12 city blocks roughly bounded by the McKinley Bridge on the north, Angelrodt Street on the south, North Broadway on the west, and DT-12 on the east (Figure 1-2).

Thirty-seven numbered VPs and one unnumbered VP surrounding the Mallinckrodt property, which are identified in Table 1-1 and shown on Figure 1-2, are part of the SLDS. The VPs are identified using the prefix of DT to represent the "downtown" site and are followed by a number for consistent identification regardless of changing property ownership. Most of the VPs are small parcels of land owned by individuals conducting industrial, commercial, manufacturing, or retail businesses, including a lumber distributor (DT-10), a steel manufacturing facility (DT-6), scrap metal recyclers (DT-8 and DT-13), a bedding manufacturer (DT-16), a salt packaging and storage facility (DT-4), a bank (DT-24), and a fertilizer company (DT-37). DT-37 has handled various materials, including potash, fertilizer, and bauxite, that are known to contain naturally occurring radioactive material (NORM) and exhibit radiation levels above background soil levels (NCRP 1995, USEPA 1999d).

Some VPs are roadways owned either by the City of St. Louis or Illinois Department of Transportation (IDOT) and Missouri Department of Transportation (MoDOT). The McKinley Bridge, which provides a vehicle transportation route over the Mississippi River between Illinois and Missouri, is owned by IDOT and MoDOT (State of Illinois 2002).

There are three RR main lines or lead tracks traversing the SLDS in a north-south direction, each having an associated network of spur tracks and sidings (Figure 1-2). These RR lines are defined as VPs and include the Norfolk Southern RR (DT-3), the Terminal RR Association (DT-9), and the BNSF RR (DT-12). The materials making up a section of railroad track consist of several components, including the rail and rail fasteners, the ties, and the rail bed materials (i.e., subgrade, sub-ballast, and ballast). The ballast consists of crushed stone, including materials such as granite that contain NORM. The constituents of this NORM are similar to the radiological PCOCs at the SLDS, so railroads can contain radioactive materials irrespective of historical MED/AEC activities (NCRP 1995). Portions of the RRs having RR ties constructed of lumber treated with arsenic could act as a potential source of arsenic contamination (MassDEP 2003).

Portions of the SLDS lie within the original floodplain of the Mississippi River. Such areas are now separated from the river by a levee and floodwall system identified as the St. Louis Flood Protection system. This system includes the Mississippi River levee, an earthen levee, and concrete floodwall that protect St. Louis from Mississippi River floodwaters. The levee is present on VPs DT-2, DT-9, and DT-15. The St. Louis Riverfront Trail, a recreational bike trail, runs parallel to the Mississippi River along the Mississippi levee area (Figure 1-2). This recreational bike trail was constructed in 1997.

The Terminal RR Soil Spoils Area is the one unnumbered VP and is located approximately 650 feet (ft) south of the contiguous portion of the SLDS (Figure 1-2). This 16.7-acre property is located south of Dock Street and is bounded by Branch Street on the north, North Market Street on the south, Produce Row and a RR line continuing to the north to Branch Street on the west, and Grossman Iron and Steel Company on the east.

Many of the buildings on the Mallinckrodt property were constructed in the early 1900s, prior to MED/AEC operations The buildings at the SLDS are constructed of a variety of materials, including wood, concrete, brick, granite, and other types of building stone. Portions of some of the buildings were constructed with materials such as granite, brick, ceramics, and some types of concrete, which exhibit naturally occurring elevated radioactivity (NCRP 1995).

An extensive network of utility services exists at the SLDS, including sewers, sprinklers, city water lines, natural gas lines, overhead electricity and telephone lines, and overhead plant process pipes. Some of the sewers and subsurface utilities (e.g., electricity) are owned by municipal or public utility companies. Runoff from the SLDS is directed to a sewer system that discharges to a publicly owned treatment facility, which then discharges to the Mississippi River.

1.2.2 Operating History

Chemical production operations at the Mallinckrodt property began in 1867 when the original chemical plant was constructed, continued during MED/AEC operations, and are ongoing by Covidien today. Historically, Mallinckrodt used, blended, and/or manufactured various chemicals at the site, including organic and inorganic compounds. Covidien currently manufactures pharmaceuticals, specialty chemicals, and other imaging products. Additionally, heavy industry and commercial processes have been performed throughout the SLDS and surrounding area for more than 100 years.

From 1942 to 1957, under contract to MED and AEC, Mallinckrodt processed uranium feed materials in support of the nation's early nuclear program. The contractual work from 1942 to 1947 was performed under MED. In 1947, the contract was transferred to the newly formed AEC and remained under AEC until operations ceased at the SLDS in 1957 (ORNL 1981).

The MED/AEC work conducted by Mallinckrodt included the development of uranium-processing techniques and the production of uranium metal. Processing of uranium ore was completed by digesting the ore in nitric acid to form uranyl nitrate, which was extracted with ether and water and denitrated by heating to produce uranium oxide (UO_2). Hydrofluoric acid was used to fluorinate the UO_2 to create uranium tetrafluoride (UF_4) (also referred to as "green salt"), which then was reduced with magnesium to produce uranium metal (DOE 1993). The main uranium ore processed for MED/AEC was African Congo pitchblende, though some domestic ores were also processed (DOE 1993). Early feed materials were relatively pure "black oxides," which had been extracted from uranium ores by other companies. Once stocks of "black oxides" were depleted, the plant began extracting uranium directly from uranium ores rather than merely purifying uranium from feed materials. In addition, some facilities were used for metallurgical processing of uranium and uranium recovery from metal slag (BNI 1990a). Process residuals, including radium, thorium, uranium, and their decay products, were inadvertently released into the environment. Uranium-bearing ores that were processed for MED/AEC may have contained elevated levels of some metals (e.g., arsenic, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, vanadium, or zinc) (USACE 1998a).

The MED/AEC work was conducted at Plants 1, 2, 6, 7, and 10 (formerly Plant 4) of the former Mallinckrodt Chemical Works. The historic layout of the MED/AEC and Mallinckrodt plant facility from 1958 is shown in Figure 1-3. Between 1942 and 1945, Plant 1 was used by MED/AEC for developmental work in refining triuranium octoxide feed and experimental processing of radium-containing pitchblende ores. The MED/AEC work at Plant 1 was performed in four pre-existing Mallinckrodt structures; Buildings 25, A, K, and X. Developmental work at the laboratory level to support Plant 2 and Plant 10 operations took place in the second floor laboratory of Building 25 and in the alley between Buildings 25 and K. Experimental processing of radium-containing pitchblende ores, which began in the 1944 to 1945 timeframe, was conducted in the second floor laboratory of Building 25. The pilot plant to test radium-extraction methods was located in Building K and in the alley between Buildings 25 and K. Building 25 also contained the project offices. Building A was used for general plant maintenance, Building X housed locker rooms, and Buildings P and Z contained the engineering and other offices. Plant 1 was not used after 1945 and the MED/AEC offices and laboratories moved to Plant 6.

Uranium refining operations began at Plant 2 in April 1942, producing approximately 4,400 tons of UO_2. Facilities for batch production were installed in Buildings 50, 51, 51A, 52, and 52A (the 50-series buildings) to produce uranium trioxide (UO_3) from ore concentrates. The concentrates were digested in nitric acid in Building 51 to produce uranyl nitrate, which was then transferred to Building 52 to be purified by ether extraction to uranyl nitrate hexahydrate (UNH). The UNH was converted in Building 51A first to UO_3 and then to UO_2. Building 50 was used as a warehouse to store incoming feed materials, outgoing product material, and tanks of process liquids. Building 55 contained the laboratory that tested samples. In the spring of 1945, Building 52A was added to serve as a pilot plant for a continuous ether extraction process to replace the existing batch process. Work at Plant 2 ended in 1946 when the plant was closed, and the work moved to the newly built Plant 6.

Late in 1942, Plant 10, a former sash and door works, was converted for uranium refining and dubbed "the metal plant." In 1943, production of green salts (UF_4) began at Plant 10. The metal production took place in Buildings 400 and 401B, and the UF_4 production took place in Building 400 (Figure 1-3). Production of uranium metal was moved from Plant 10 to Plant 6E (now known as Plant 6EH) in 1946, and the UO_2 to UF_4 process was moved to Plant 7 in the 1951 to 1952 timeframe. Plant 10 was refitted as an experimental development and metallurgical pilot plant processing uranium metal; consequently, Plant 10 was thereafter referred to as the "pilot plant." The ingot metal production process was developed and conducted at Plant 10 in the mid-1950s, along with sporadic ordinary metal derby production on a developmental basis. Plant 10 was used by AEC until 1956.

In 1944, the government decided to build a new refinery to extract uranium from pitchblende ore. The new facility, called the Destrehan Street Facility (Plants 6, 6E, and 7), began operations in 1946. Plant 6 was built in 1945 and 1946 on a site fronting Destrehan Street and was then referred to as "the refinery." Most of the administrative offices, laboratories, and support facilities for the uranium refining operations were located at Plant 6. The second new plant at the Destrehan Street site was Plant 7, the green salt plant. Construction included the 700-series buildings (703 to 708), which went into operation sometime during 1951 and 1952, when the UO_2 to UF_4 process was moved from Plant 10 to Plant 7.

The pitchblende ore-to-UO_2 part of the refining process was moved to Plant 6 in early 1946 from Plant 2, along with the laboratory work from Plant 1. At that time, UO_2 production in the 50-series buildings at Plant 2 ceased (NPS 1997). The UO_2-to-metal production remained at Plant 10. The incoming ore arrived by rail and was stored in Plant 6 Building 110 (Figure 1-3); however, in late 1950, an outdoor storage area was added for pitchblende ore. Building 104 processed mostly pitchblende ore and housed the continuous process equipment, which replaced the batch process equipment that had been used in Plant 2. In 1949, a second digest line was added in the building to process uranium ore concentrates. Most of the UO_2 produced at Plant 6 was trucked to Plant 10, with the rest going by rail to the Harshaw Chemical Company in Cleveland, Ohio, and the Linde Ceramics Plant in Tonawanda, New York. When equipment was added to Plant 7 to allow continuous UO_3 to UF_4 conversion, Plant 6 began to produce only UO_3. Milling of UO_3 and pre-digestion ore grinding, both conducted at Plant 6, were discontinued in 1950 and 1955, respectively. Pitchblende ore continued to be used as feed until early 1955.

Plant 6E (now known as Plant 6EH), located in the eastern portion of Plant 6 (Figure 1-3), was built as the new metal plant, which went into operation in late 1950. Metal production (UF_4-to-U-metal) operations at Plant 10 moved to Plant 6E, which was then referred to as "the metal plant." Metal production took place in Building 116. Building 116C was built in 1954 to recycle magnesium fluoride slag.

At Plant 7, a continuous process replaced the batch-type process used at Plant 10, and equipment was added later to allow for continuous production of UF_4 from UO_3 directly. Uranium metal recovery and some storage operations were moved to Plant 7 in 1952. Some reversion of UF_4 to UO_2 or UO_3 was done in 1954 and perhaps later. A new wet slag (interim residue) recovery operation was added in late 1955 in Building 701 as UF_4 was processed at Plant 7. Plant 7 Building 700 was built in 1955 as a warehouse, with a portion of Building 700 used for machining of reactor cores (Mason 1977). Plant 7E (Figure 1-3), regarded administratively as part of Plant 7, was used from 1955 to 1957 to process pitchblende raffinate (solids removed during the uranium refining by wet filtration). Pitchblende raffinate was used to produce a concentrated Th-230 solution by an acid digestion process similar to the uranium ore digestion. The concentrate was sent to the Mound Site in Ohio for further processing. Some Plant 7 operations continued up to 1957, when they were transferred to the Weldon Spring Chemical Plant, located in St. Charles County, Missouri.

When uranium processing operations began at the Mallinckrodt property, most of the streets and RRs now in existence at the SLDS had already been constructed. The raw material for the processing operations was transported to Mallinckrodt along the existing RRs. According to a

February 15, 1945, memorandum titled *Shipment Security Survey at Mallinckrodt Chemical Works,* the raw materials were sent to the plant in sealed, individual containers such as metal containers, wood barrels and boxes, or fiber drums via sealed RR cars (Mallinckrodt 1945).

During MED/AEC operations, most process, storm, and sanitary effluents for Mallinckrodt were collected in a combined sewer system. Effluent entered the combined system from the MED/AEC areas and passed through the system, ultimately discharging to the Mississippi River (prior to December 1970). Currently, sewer flow from the SLDS discharges to the Metropolitan St. Louis Sewer District (MSD) Bissell Point Treatment Plant. Sewers at the Mallinckrodt property were predominantly constructed from vitrified clay pipe (VCP) and vitrified brick sealed with bituminous tar or cementitious materials, but portions of the plumbing system (i.e., smaller diameter pipes within buildings that drain to the sewer) could have had lead as a component. Lead pipes and/or lead-based solder at piping connections are often found in older buildings (MDNR 2010). The bedding material commonly used during this era was granulated rock material, but some sewers may have been constructed without any bedding material (BNI 1990b).

From 1948 to 1950, decontamination activities were conducted at Plants 1 and 2. The decontamination efforts were conducted to meet criteria in effect at that time, and the plants were released in 1951 for use without radiological restrictions. Operations at Plant 10 were terminated during 1955 and 1956 (ORNL 1981). Operations in Plants 6 and 7 ceased in 1957. Shutdown of all remaining MED/AEC operations at Mallinckrodt began in 1958. During 1961 and 1962, AEC managed the decontamination efforts at Plants 6 and 10, removing radiologically contaminated buildings, equipment, and soil. AEC also returned Plants 6 and 10 to Mallinckrodt for use without radiological restrictions (ORNL 1981). Plant 7 was decontaminated to meet criteria and was released for use with no radiological restrictions in 1962 (DOE 1993). When MED/AEC operations at Mallinckrodt were completed in 1962, buildings owned by the government had either been demolished or transferred to Mallinckrodt. Since then, a number of buildings that existed in 1962 have been razed, and a number of new buildings have been constructed at Plants 6 and 10; some of these buildings are being used for the commercial production of chemicals by Covidien. Additionally, since 1962, much of the superstructure used for MED/AEC operations has been demolished, and some underground utilities have been abandoned in place.

Non-MED/AEC radiological work was also completed by Mallinckrodt. C-T ores were processed under a separate NRC Source-Material License. While a majority of the work was performed at Plant 5, C-T activities also took place at Plant 1, Plant 3, Plant 6, Plant 7, and Plant 8 areas. C-T activities began in 1961 and continued through 1985, and again briefly in 1987. Some C-T waste was buried at Plant 6 beneath Building 101 (Figure 1-3). In 1971, Mallinckrodt constructed waste-water neutralization ponds at the western edge of Plant 7 (Plant 7W) (Figure 1-2).

1.2.3 Previous Site Characterization Studies

Several characterization studies of various media (i.e., soil, sediment, ground water, sewers, and buildings) have been conducted at the SLDS since 1977. Table 1-2 provides an overview of some of the characterization studies that were conducted and the types of sampling activities that were completed. The RI WP provides a detailed discussion of the major characterization studies conducted at the SLDS and an overview of characterization studies on a property-by-property basis (USACE 2009a). The existing characterization data and the results of the 1993 BRA were used to predict the extent of contamination in the ISOU and to streamline the data needs for this RI. The 1998 ROD defined the nature of contamination at the SLDS based on the results of the previous RI and characterization studies at the SLDS.

Table 1-2. Historic Characterization Studies Supporting the Inaccessible Soil Operable Unit

Location	Characterization Study	Reference Document
Plants 1, 2, 6, 6E, 7, and 10	Oak Ridge National Laboratory (ORNL), July through September 1977 **Radiological survey and sampling at locations of MED/AEC processing activities** • Performed direct alpha and beta-gamma measurements and removable alpha and beta measurements on 21 buildings, including indoor walls, floors, ledges, drains, outdoor pads, loading docks, buildings, and roofs • Performed surface and subsurface soil sampling in areas of suspected contamination (e.g., below some buildings and parking lots and near RR spurs) • Collected ground-water samples from 31 auger holes • Collected sediment from indoor and outdoor building drains • Performed surface-water sampling along the Mississippi River at four locations where runoff from the site drains into the river	*Radiological Survey of Mallinckrodt Chemical Works* (ORNL 1981)
Plants 1, 2, 6, 7, and 10; DT-2; and Background Location	RI for the SLS: Site Characterization Phase 1 and Phase 2 • Performed walkover gamma scan of soil in specific areas with suspected contamination • Performed biased and systematic sampling of surface and subsurface soil for radiological and chemical analyses of metals, volatile organic compounds (VOCs), Resource Conservation and Recovery Act (RCRA) characteristics, and base/neutral and acid extractables • Installed nine ground-water monitoring wells and conducted ground-water sampling • Conducted a radiological survey and collected sediment samples from drains, manholes, sumps, and sewers • Performed direct alpha and beta-gamma measurements, and performed removable alpha and beta measurements on interior surfaces (e.g., floors, walls, ceilings, and roofs) of 20 buildings associated with processing operations • Collected biased soil samples of surfaces in building interiors for radiological analysis • Conducted additional surface and subsurface soil sampling for radiological and chemical analyses for metals and RCRA hazardous waste characteristics • Conducted soil testing (particle-size analysis, soil permeability, uranium partitioning coefficient) • Performed direct alpha and beta-gamma measurements and removable alpha and beta measurements on additional surfaces of former processing buildings	*Remedial Investigation Report for the St. Louis Site, St. Louis, Missouri* (BNI 1994) *Remedial Investigation Addendum Report for the St. Louis Site, St. Louis, Missouri,* (DOE 1995) *Radiological, Chemical, and Hydrogeological Characterization Report for the St. Louis Downtown Site* (BNI 1990a)

Table 1-2. Historic Characterization Studies Supporting the Inaccessible Soil Operable Unit (Continued)

Location	Characterization Study	Reference Document
Plant Areas, DT-1, DT-3, DT-8, DT-9, DT-10, and DT-12	RI Addendum: 1992 to 1993 • Performed supplemental soil sampling for radiological analysis to refine the boundaries of soil contamination at the plant areas as well as six VPs • Collected 10 background soil samples at Hyde Park to establish background for chemicals • Sampled sediment from manholes, sumps, and drain lines • Collected radon measurements in 19 buildings • Collected sediment samples from the Mississippi River • Installed an additional ground-water monitoring well • Performed beta-gamma survey on the interior of Building 101	*Remedial Investigation Report for the St. Louis Site, St. Louis, Missouri* (BNI 1994) *Remedial Investigation Addendum Report for the St. Louis Site, St. Louis, Missouri* (DOE 1995) *Preliminary Radiological Survey Report for the Chicago, Burlington, and Quincy Railroad Property in St. Louis, Missouri* (BNI 1989e) *Report on the Limited Radiological Survey of the PVO Foods, Inc. Property in St. Louis, Missouri* (BNI 1989f) *Preliminary Radiological Survey Report for the Norfolk and Western Railroad Property in St. Louis, Missouri* (BNI 1989d) *Preliminary Radiological Survey Report for the St. Louis Terminal Railroad Property in St. Louis, Missouri* (BNI 1989c) *Report on the Limited Radiological Survey of the Thomas and Proetz Lumber Company Property in St. Louis, Missouri* (BNI 1989b) *Report on the Limited Radiological Survey of the McKinley Iron Company Property in St. Louis, Missouri* (BNI 1989a)
City-owned Property Located North and South of the SLDS	Background Soil: 1998 • Sampled boreholes to provide background soil concentrations of chemicals and radionuclides	*Background Soils Characterization Report for the St. Louis Downtown Site* (USACE 1999a)
Plant Areas and VPs	PDI and FSSE: 1998 to 2010 • Characterized accessible soil • Characterized properties included in the boundary enlargement of the 2005 Memorandum for Record (USACE 2005a) • Conducted gamma walkover surveys (GWSs) to identify areas of elevated radiological contamination above background • Conducted systematic, random, and biased soil sampling • Conducted verification sampling at remediation areas • Identified inaccessible soil areas of detected contamination	Various titles including *Pre-Design Investigation Data Summary Report Gunther Salt North Vicinity Property (DT-4), FUSRAP St. Louis Downtown Site, St. Louis, Missouri* (IT 2001) *Post-Remedial Action Report for the Accessible Soils within the St. Louis Downtown Site Plant 2 Property* (USACE 2002a) *Post-Remedial Action Report for the Accessible Soils within the St. Louis Downtown Site, Heintz Steel and Manufacturing Vicinity Property (DT-6), and Midwest Waste Vicinity Property (DT-7), St. Louis, Missouri* (USACE 2005b) *Final Status Survey Evaluation for the Accessible Soils within the St. Louis Downtown Site Vicinity Properties West of Broadway, Mallinckrodt Plants 3, 8, 9, 11 and Parking Lots* (USACE 2006) *Pre-Design Investigation and Final Status Survey Evaluation for the Accessible Soils within the St. Louis Downtown Site Vicinity Properties DT-35 and DT-36* (USACE 2009b) *Post-Remedial Action Report and Final Status Survey Evaluation for the Accessible Soils within the St. Louis Downtown Site Vicinity Property Thomas and Proetz Lumber Company (DT-10)* (USACE 2010a)

Data collected from pre-design investigations (PDIs) and final status surveys (FSSs) conducted as part of the remediation activities for accessible soil also yielded characterization data useful in determining potentially contaminated inaccessible soil areas or structures. Ongoing work at the accessible portions of the SLDS under the authority of the 1998 ROD continues to yield new data that is relevant to the ISOU. Ongoing investigations have been used to supplement and/or modify RI sampling, as appropriate. This report captures the data collected up to June 15, 2011, and considers all areas in the typical inaccessible profile to be part of the ISOU unless specifically excluded or addressed under the 1998 ROD. Some completed PDI and final status survey evaluation (FSSE) reports are identified in Table 1-2.

1.3 REPORT ORGANIZATION

This RI was conducted in accordance with the USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA 1988a). Data collected as part of this RI are detailed in this report and provide a basis for defining the nature and extent of contamination. The RI data were used to perform a BRA to evaluate human health impacts from inaccessible soil, sewer sediment, soil adjacent to sewers, and buildings and other permanent structures in the ISOU. The report is organized as follows:

Section 1.0: Introduction describes the purpose of this report, as well the site background and previous characterization studies of the SLDS.

Section 2.0: Study Area Investigation includes a summary of the determination of the PCOCs originally identified in the RI WP, the completed sampling activities, descriptions of field methods used, and an evaluation of data usability.

Section 3.0: Physical Characteristics of Study Area describes the physical characteristics of the site, including geologic and hydrogeologic conditions, surface-water hydrology, ecological resources, demographics, and land use.

Section 4.0: Nature and Extent of Contamination describes the preliminary remediation goals (PRGs) used for comparisons with data; contaminant source areas; PCOCs; and the nature and extent of contamination in inaccessible soil areas, sewer sediment, soil adjacent to the sewers, and soil on buildings and other permanent structures.

Section 5.0: Contaminant Fate and Transport introduces the conceptual site model (CSM) as it pertains to source release mechanisms and environmental transport pathways under current ISOU conditions. This section also describes PCOC-specific contaminant mobility and persistence characteristics.

Section 6.0: Baseline Risk Assessment summarizes the human health risk assessment (HHRA) and Screening Level Ecological Risk Assessment (SLERA). The detailed BRA is presented in Appendix K.

Section 7.0: Summary and Conclusions includes a summary of site conditions for the ISOU, including identification of contaminants of potential concern (COPCs) (i.e., one or more contaminants found on, in or under a property that exceeds the initial site condition standards for the property) and the estimation of the nature and extent of the COPCs. This section also summarizes the HHRA and SLERA, describes data limitations, and defines potential remedial action objectives (RAOs) for the ISOU.

Section 8.0: References

2.0 STUDY AREA INVESTIGATION

This section summarizes the RI field investigation activities conducted to fill data needs identified in the RI WP. The RI methodology presented in the RI WP was developed using the USEPA's seven-step data quality objective (DQO) process as outlined in the *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA 2006) to ensure defensible data was obtained to evaluate the risk associated with the ISOU media.

2.1 POTENTIAL CONTAMINANTS OF CONCERN

The purpose of the RI is to define the nature and extent of MED/AEC soil contamination present in the ISOU media. Due to the history and diverse nature of the industries located at and surrounding the SLDS, many of the organic and non-radioactive inorganic chemicals detected during the previous characterization activities cannot be attributed to one source, industry, or event. A review of the past uranium processing activities at the SLDS indicated that chemical contamination consists primarily of elemental metals (USACE 1998b). The constituents that were evaluated in the 1993 BRA are those that the DOE is responsible for addressing during the remedial process. The 1993 BRA states: "*Such responsibilities are limited to all radioactive and nonradioactive contamination at the SLDS, [St. Louis Airport Site] SLAPS, and Latty Avenue Properties and their related vicinity properties that is associated with the original processes conducted at the SLDS under the MED/AEC programs. In addition, DOE is responsible for any other chemical (nonradioactive) contamination, not related to the process, that is commingled with identified radioactive wastes*." The source of metals contamination has not been established and any analysis of the risk of those metals is only to establish site risk and should not be taken as an admission by the USACE that such metal contamination was caused by the DOE or the U.S. Government.

The 1993 BRA used the concentrations and distribution of potential radiological and chemical contaminants identified as being within the scope of MED/AEC to characterize the risks associated with the SLS, including the SLDS. The 1993 BRA concluded that the radionuclides of concern are those found in the U-238, Th-232, and U-235 decay series – primarily U-238, Ra-226, Th-230, lead (Pb)-210, Ac-227 and Pa-231. The 1993 BRA estimated that CRs to receptors from exposures to radioactive contaminants at the SLDS exceeded the USEPA's target CR range for most current industrial land use and all future land use scenarios evaluated (DOE 1993).

Chemical constituents in soil, sediment, and ground water evaluated for carcinogenic and non-carcinogenic risk in the 1993 BRA (DOE 1993) included volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, and inorganic anions. Risk characterization tables in the 1993 BRA show that carcinogenic risks and/or non-carcinogenic hazard quotients (HQs) exceeded the USEPA's *de minimus* criteria of 1.0E-06 and 1.0, respectively, for each of the following contaminants: antimony, arsenic, beryllium, nickel, thallium, and polycyclic aromatic hydrocarbons (PAHs). During the 1998 FS, further evaluation of COCs for the SLDS was conducted. The 1998 FS evaluation concluded that, although thallium and PAHs were previously identified as PCOCs, these substances are not attributable to MED/AEC operations (USACE 1998b). The list of metals for soil was further refined to include only arsenic, cadmium, and uranium metal. Copper and nickel were eliminated during additional evaluations due to the low concentrations, distribution, and toxicity (USACE 1998a).

2.1.1 Inaccessible Soil Potential Contaminants of Concern

The inaccessible soil PCOCs selected as the starting point for the ISOU RI were those radionuclides and metals identified as COCs in the 1998 ROD (i.e., the primary radioactive contaminants in soil and sediment at the SLDS including Ac-227, Pa-231, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, and U-238, and the metal contaminants including arsenic, cadmium, and uranium metal) (USACE 1998a).

The derivation of chemical contaminants potentially attributable to MED/AEC operations indicated that chemical contamination consists primarily of elemental metal compounds resulting from uranium-ore processing operations in specific areas of the SLDS (USACE 1998b). The plant properties within the boundary where the uranium-ore processing was conducted by MED/AEC are Plant 2, Plant 6, and Plants 7N and 7S (Figure 1-2). Some VPs that are adjacent to these plant areas were also included in the MED/AEC uranium-ore processing area due to potential migration of contaminants. These VPs include DT-10, portions of DT-9 between Plants 2 and 6, portions of DT-12 adjacent to Plants 6 and 7, portions of Destrehan Street adjacent to Plants 2 and 6 and Plants 7N and 7S, Hall Street between Plants 2 and 6, and portions of Mallinckrodt Street adjacent to Plant 2 (Figure 1-2). All other plant properties and VPs are outside of the uranium-ore processing area and, therefore, only have radiological PCOCs.

The same radiological PCOCs for soils are being evaluated for the building and structural surfaces. The 1993 BRA stated that chemical contaminants were not applicable to building surfaces; therefore, there are no metals PCOCs for building and structural surfaces (DOE 1993).

The list of PCOCs for the ISOU soil was defined as those radiological and chemical contaminants identified as being attributable to MED/AEC contamination, as shown in Table 2-1.

Table 2-1. Potential Contaminants of Concern for Soil in the Inaccessible Soil Operable Unit

Chemical Constituents [a]	Radiological Constituents
Arsenic	Ac-227
Cadmium	Pa-231
Uranium metal	Ra-226
	Ra-228
	Th-228
	Th-230
	Th-232
	U-235
	U-238

[a] Applicable to soil in the uranium-ore processing area: Plants 2, 6, and 7; DT-10; and portions of DT-9, DT-12, Hall Street, Mallinckrodt Street, and Destrehan Street (USACE 1998a).

2.1.2 Sewer Sediment and Soil Adjacent to Sewers Potential Contaminants of Concern

The same radiological PCOCs for soils are being evaluated for sediment in sewers used for MED/AEC operations, as well as the soil adjacent to those sewers. Additionally, sewer sediment and soil adjacent to sewers used for MED/AEC operations were not analyzed for metals during past investigations; therefore, all metals associated with formerly used pitchblende and domestic ores were identified as PCOCs for sampling and analysis of sediment and soil adjacent to sewers (See Table 2-2). These metals include arsenic, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, thorium-metal, uranium-metal, vanadium, and zinc. However, manganese, molybdenum, and vanadium do not meet the USEPA's National Oil and Hazardous

Substances Pollution Contingency Plan (NCP) (USEPA 1990) definition of a pollutant or contaminant.

The list of PCOCs for the ISOU sewer sediment and soil adjacent to sewers was defined as those radiological and chemical contaminants identified as being attributable to MED/AEC contamination, as shown in Table 2-2.

Table 2-2. Potential Contaminants of Concern for Sewer Sediment and Soil Adjacent to Sewers in the Inaccessible Soil Operable Unit

Chemical Constituents	Radiological Constituents
Arsenic	Ac-227
Cadmium	Pa-231
Cobalt	Ra-226
Copper	Ra-228
Lead	Th-228
Manganese	Th-230
Molybdenum	Th-232
Nickel	U-235
Selenium	U-238
Thorium metal	
Uranium metal	
Vanadium	
Zinc	

Note: Sewer sediment and soil adjacent to sewers had not been characterized for metals; therefore, all metals associated with pitchblende and domestic ores used in the former MED/AEC uranium-ore processing operations (DOE 1993) were identified as PCOCs in sewer sediment and soil adjacent to sewers.

2.2 SUMMARY OF REMEDIAL INVESTIGATION ACTIVITIES

RI sampling began in June 2009 and ended in August 2010 with the majority of work being completed between October 2009 and May 2010. The data collected, as well as data from previous characterizations and ongoing actions under the 1998 ROD, were used to evaluate the nature and extent of MED/AEC contamination in ISOU media of concern (Section 4.0), to identify contaminant ISOU-specific fate and transport mechanisms (Section 5.0), and to determine COPCs for the BRA (Section 6.0 and Appendix K).

The specific survey and sampling activities conducted and methods used during the RI are as listed below and discussed in this section:

- inaccessible soil investigations beneath buildings, structures, RRs, and roads (Section 2.2.1);
- building and structure radiological surveys (Section 2.2.2);
- sewer sediment and soil adjacent to sewers investigations (Section 2.2.3);
- quality assurance (QA)/quality control (QC) sampling and analysis (Section 2.2.4);
- equipment decontamination (Section 2.2.5);
- management of investigation-derived waste (IDW) (Section 2.2.6); and
- data validation and quality assessment (Section 2.2.7).

2.2.1 Inaccessible Soil Investigations

Soil sampling was conducted in the inaccessible soil areas to determine the extent of contamination of the PCOCs. Field soil sampling activities were conducted in accordance with the methods and procedures specified in the RI WP (USACE 2009a) and described below.

The horizontal boundaries for an inaccessible soil area associated with a structure are defined by the footprint of the structure. The footprint typically includes the area directly beneath the structure as well as an area surrounding the structure extending a minimum of 5 ft outward from the foundation (USACE 1999b) (Figure 2-1). Inaccessible areas associated with structures also include additional supporting soil extending outward beyond this 5-ft buffer zone at a slope that is determined based on soil properties and on site-specific engineering and safety concerns. The areas beyond the 5-ft buffer zone were investigated under the 1998 ROD. Therefore, for the purposes of this investigation, the initial boundaries for inaccessible soil areas associated with a structure were limited to the areas directly beneath the structure and the 5-ft buffer zone extending outward from the foundation.

The typical horizontal boundary for inaccessible soil beneath or adjacent to a roadway is defined as the roadway and its associated ROW extending 5 ft from the edge of the pavement (USACE 1999b) (Figure 2-2). Any additional inaccessible soil extending outward beyond the 5-ft buffer zone was not included in the investigation because it was characterized under the 1998 ROD. Therefore, for the purposes of this investigation, the initial boundaries for inaccessible soil areas associated with roadways were limited to the areas directly beneath the roadway and the 5-ft buffer zone.

The typical horizontal boundary for inaccessible soil beneath or adjacent to a RR track is defined as the area that includes the track and the associated RR ROW extending a distance of 10 ft from the outermost rail of the track (USACE 1999b) (Figure 2-3). Any additional inaccessible soil extending outward beyond the 10-ft buffer zone was not included in the investigation because it was characterized under the 1998 ROD. Therefore, for the purposes of this investigation, the initial boundaries for inaccessible soil areas associated with the RRs were limited to the areas directly beneath the RR tracks and the 10-ft buffer zone.

Gamma walkover surveys (GWSs) were conducted to identify elevated gamma radioactivity in soil beneath or associated with buildings, structures, roads, and RRs for potential biased soil sampling locations. GWSs were performed using a Ludlum Model 44-10 2 × 2 sodium-iodide (NaI) detector coupled with a global positioning system (GPS) when possible. GPS units have limited effectiveness inside or around structures due to satellite signal interference. In these situations, the GWS readings were recorded manually on paper survey forms.

GWS coverage was approximately 50 to 100 percent of the footprint of buildings or other permanent structures (e.g., roadway and RR). Typically, 100 percent coverage of the ground floor was attempted within buildings. However, coverage was sometimes affected by interferences (i.e., equipment, piping, materials, walls, etc.). Granite, brick, ceramics, and some concrete exhibit naturally occurring elevated radioactivity; therefore, the nature of the construction materials was considered when interpreting GWS results. The ambient background for each survey area was determined at the start of the survey, and locations exhibiting activity 1.5 times or higher above background were further investigated and, if appropriate, sampled.

GWSs have limitations due to gamma ray attenuation in areas covered by concrete floor slabs, roadway materials, and gravel. The effectiveness of the GWSs to detect gamma activity under consolidated material depends on the type of consolidated material, the thickness of the material, the radionuclides present, and radionuclide concentrations. Despite these limitations, GWSs are still useful in detecting elevated gamma activity underlying concrete, roadway materials, and gravel.

Soil investigations consisted of surface (typically within the first 0.5 ft below ground cover) and subsurface soil sampling for radiological and chemical PCOCs. All soil samples were analyzed for radionuclides (Ac-227, Pa-231, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, and U-238), and soil samples from some locations inside the uranium-ore processing area were analyzed for metals (arsenic, cadmium, and uranium metal).

Soil investigations for radiological assessment were conducted at random, biased, and systematic soil sampling locations. Biased samples were collected at specific areas determined to have a greater likelihood of exceeding the PRG or at areas adjacent to remediated soil areas. Biased samples were also collected at locations where GWS measurements or scans were shown to be elevated above background. The soil sampling locations for metal PCOCs (arsenic, cadmium, and uranium metal) were selected from the biased radiological soil sampling locations.

Systematic samples for radiological PCOCs were collected at potentially contaminated inaccessible soil areas using uniform grid spacing. Random sampling for radiological PCOCs was conducted at inaccessible soil areas unlikely to be contaminated to provide reasonable assurance that an area has been sufficiently characterized. Systematic or random sampling for metal PCOCs was not completed, because it was expected that areas slated for biased sampling would best characterize any metal contaminants, because metals have predominantly been found commingled with higher concentrations of radiological PCOCs in the accessible portions of the SLDS.

Northing and easting coordinates for the sampling locations were determined using geographic information system (GIS) software and then located in the field using hand-held GPS units when possible. Sample locations inside structures were located by measuring from features (e.g., corners, doorways, etc.). Proposed sample locations were modified, if necessary, based on field conditions that would prevent effective sampling in the proposed locations (e.g., areas with access constraints).

Utility clearance was necessary prior to soil sampling. Prior to initiating soil sampling, available utility maps and historical data were reviewed to help identify utility lines. In the field, the proposed sampling locations were inspected for potential utility impacts. Determination of utility locations in public utility easements was performed through the Missouri "One-Call" system. The locations of overhead and underground utilities were identified, and the locations of the underground utilities were marked on the ground surface. If necessary, the proposed RI WP sample locations were moved a minimal distance to avoid utilities. Once the soil boring locations were determined to be clear of utilities, sampling activities began. In addition, modifications to the proposed sampling locations were necessary when auger refusal occurred prior to reaching the proposed sampling depth. Sampling locations where auger refusal occurred were relocated a minimal distance to ensure that relocation did not impact the intended sampling purpose.

Soil samples were primarily collected utilizing a drill rig with hollow stem augers and a split-spoon soil sampler. In areas that the drill rig could not access (e.g., inside buildings, areas with low overhead clearance), an electric coring machine was utilized to remove cover material (e.g., concrete, asphalt) and hand augers were used to collect soil samples. Surface soil sampling was initiated in the uppermost soil layer below any gravel material located beneath consolidated material (i.e., asphalt or concrete). Sampling began by removing a soil column of approximately 1.5 to 2.0 ft below original grade at the sampling location, with two samples collected from this initial soil column. The first sample (i.e., surface soil sample) was taken within the first 0.5 ft of the uppermost soil layer below any consolidated material and associated gravel. The second sample (i.e., subsurface soil sample) was collected from a 0.5-ft interval of the remaining column at the depth that exhibited the greatest radioactivity determined by using a NaI gamma radiation detector or instrument of equal or greater sensitivity. If the soil column exhibited a relatively uniform count rate, the subsurface sample was collected from the deepest 0.5-ft interval of the column. Subsurface sampling continued by removing subsequent soil columns of approximately 2 ft in length until a total minimum depth of 6 ft below original grade was obtained and radioactivity readings were at or near background. A subsurface soil sample was collected from the 0.5-ft interval that exhibited the greatest radioactivity within each 2-ft soil column as determined by using a NaI gamma radiation detector or instrument of equal or greater sensitivity. As noted above for the initial soil column, any subsequent subsurface sample was collected from the deepest 0.5-ft interval of a soil column if the soil column exhibited a relatively uniform gamma radiation count rate. Greater depths were sampled for specific VPs or plant areas as defined in the RI WP or if elevated readings were obtained at the deepest planned sampling depth. Samples for metals analysis were collected from the same 0.5-ft interval of soil from which a radiological sample was collected.

Samples were placed in a stainless steel bowl and were homogenized using a stainless steel spoon, spatula, or trowel prior to filling the sample container(s). Excess sample material was disposed of as IDW. Samples were logged and described in accordance with the Unified Soil Classification System (USCS) by a geologist, geotechnical engineer, or soil scientist. Sample containers were sealed and labeled and placed into coolers or other containers until delivered to the laboratory. Proper chain-of-custody documentation was kept with the samples. Copies of the soil boring logs for each sampling location are provided in Appendix A.

Industry-standard surveying equipment then was used to measure the as-built coordinates and the corresponding ground surface elevations for each sampling location.

The base reference for surveying coordinates for each sample location was a local, USACE-established, SLDS benchmark. The coordinate and elevation data for the SLDS benchmark and each sample location are referenced to the Missouri State Plane Coordinate System, the North American Datum of 1983, and the North American Vertical Datum of 1988.

Table 2-3 summarizes the number of locations and type of samples collected for evaluation of inaccessible soil by plant area or VP. Soil sampling results are discussed in Section 4.2.

2.2.2 Buildings and Structures Investigations

In accordance with the RI WP (USACE 2009a), building and structure surfaces (i.e., interior, exterior, and roof) were designated for a scoping survey based on a preliminary assessment that included evaluating previous data collected on the structure, the construction date, use of the structure, the proximity of the structure to MED/AEC processing operations, and the proximity to remediated accessible soil areas. Radiological surveys included scanning for total alpha and beta surface activity and fixed-point measurements for total alpha and beta surface activity using portable radiological survey equipment. Building surveys began in September 2009 and were completed in August 2010.

Table 2-3 summarizes the number of buildings and surfaces surveyed by plant area or VP. Results of the radiological investigation of buildings/structures are discussed in Section 4.3.

Building and structure surfaces that were surveyed included, but were not limited to, roofs, exposed exterior and interior surfaces, air vents, vertical and horizontal piping, and piping supports. The scoping surveys were biased, focusing on areas that are prone to accumulate contamination such as horizontal surfaces, depressions, cracked surfaces, rusted or unpainted surfaces, intake and exhaust vents, etc. While in the field, professional judgment also was used to select biased survey locations. The surfaces scanned were defined by the dimensions of each individual building or structure. Generally, 10 to 20 percent of each building or structure surface was scanned. The scoping surveys were conducted in accordance with the *Final Status Survey Plan for Structures and Other Consolidated Material Left in Place at the St. Louis Site* (USACE 2003) (hereafter referred to as the Final Status Survey Plan [FSSP] for Structures).

Table 2-3. Remedial Investigation Characterization Activities by Sample Media and Number of Sampling Locations

Property Area	Number of Inaccessible Soil Sampling Locations			Number of Building Surfaces Surveyed			Number of Sewer Sampling Locations	
	Systematic or Random Sampling	**Biased Soil Sampling**	**GWS at Building, Roadway, or RR**	**Interior**	**Exterior**	**Rooftop**	**Sediment Sampling**	**Adjacent Soil Sampling**
Plant 1	16	30	12	17	20	15	11	17
Plant 2	13	14	6	6	6	2	10	5
Plant 6	0	7	0	1	1	0	3	2 [c]
Plant 7N and 7S	0	1	0	No buildings [a]			1	1 [c]
Plant 10	Out of scope; previously remediated						Non-impacted [b]	
Mallinckrodt West Properties (Plants 3, 8, 9, and 11 and parking lots)	0	2	0	0	7	4	Non-impacted [b]	
Mallinckrodt Security Gate 49 Area	0	2	1	Non-impacted [b]			No sewers present	
DT-2	10	7	0	No buildings			0	0 [c]
DT-4 North	15	23	4	3	5	3	No sewers present	
DT-4 South	Non-impacted [b]			Non-impacted [b]			Non-impacted [b]	
DT-6	14	10	2	2	2	1	No sewers present	
DT-8	41	8	9	5	6	1	0	3
DT-10	8	4	2	6	7	2	No sewers present	
DT-11	Included in roadways			No buildings; structures non-impacted [b]			1	0
DT-15	4	0	1	Non-impacted			Location identified with DT-8	
DT-29	Non-impacted [b]			Non-impacted [b]			Non-impacted [b]	
DT-34	Non-impacted [b]			Non-impacted [b]			Non-impacted [b]	
South of Angelrodt Property Group	Non-impacted [b]			0	1	1	Non-impacted [b]	
West of Broadway Property Group	Non-impacted [b]			0	5	5	Non-impacted [b]	
DT-3	70	10	1	No buildings; sewers addressed with property areas				
DT-9	127	17	3	No buildings; sewers addressed with property areas				
Terminal RR Soil Spoils Area	7	0	1	No buildings			Non-impacted [b]	
DT-12	165	7	1	No buildings; sewers addressed with property areas				
Roadways	83	45	8	No buildings; sewers addressed with property areas				
Background Locations (sewers)	NA			NA			11	0
Total Sample Locations	**573**	**187**	**51**	**40**	**60**	**34**	**37**	**28**

[a] The Hazardous Waste Storage Area at Plant 7N was dismantled in 2010.
[b] The specific media (inaccessible soil, sewers, or buildings) at the property were previously determined to be non-impacted as documented in the RI WP; therefore, no RI sampling was conducted.
[c] Excavation sidewall samples adjacent to sewers were collected for this area during remediation activities conducted under the 1998 ROD.
NA = Not applicable.

A Ludlum Model 2360 coupled with a Ludlum 43-89 (zinc sulfide plastic scintillator) or equivalent was used to perform the alpha and beta scans. Prior to performing field measurements, the detection sensitivity of the equipment was calculated to ensure that levels were below the RI WP screening level. Methods for evaluating this detection sensitivity are provided in the FSSP for Structures (USACE 2003). A minimum of 10 fixed data points were collected on structures identified as impacted by MED/AEC-related contaminants. The scan speed with these detectors was approximately 1 to 2 inches per second. Distance from the detector probe to the scanned surface was approximately 0.25 inches. Instrument response was monitored continuously during scanning through use of the audible instrument signal.

Scoping surveys were conducted from the ground level to the roof line to get representative data on exterior building surfaces. A manlift, capable of reaching 60 ft in height, was utilized for exterior building and roof surveys. Reasonable efforts were made to scan locations where safety considerations or other restrictions prevented access. These areas included those obstructed by overhead piping or utilities and those areas/surfaces (i.e., roofs) that would not safely support access. These areas were minimal and did not jeopardize the objective of the scoping survey.

Total alpha and beta surface activity (fixed-point) measurements were obtained from areas exhibiting elevated count rates. Fixed-point gross alpha and beta activity measurements were made with a 1-minute static count. The surface activity measurements for both alpha and beta were recorded in counts per minute (cpm), which, along with the appropriate instrument geometry, instrument background, instrument efficiency (ε_i), and surface efficiency (ε_s), was used to convert the data to disintegrations per minute per 100 square centimeters (dpm/100 cm^2), in accordance with the FSSP for Structures (USACE 2003), for comparison to the screening levels. The following equation was used to convert the data recorded in cpm to dpm/100 cm^2.

$$Result\ \left(\frac{dpm}{100\ cm^2}\right) = \frac{R_g - R_b}{(\varepsilon_i)(\varepsilon_s)(Probe\ \ Area/100)}$$

where: R_g is the static data point gross count rate (cpm)
R_b is the field background count rate (cpm)
ε_i is the instrument efficiency (cpm/dpm)
ε_s is the surface efficiency
Probe Area is the open area of the detector face (square centimeters [cm^2])

Building materials, such as granite, brick, ceramics, and some concrete, exhibit alpha and beta activity above area background levels due to naturally occurring radioactivity. Portions of many of the buildings were constructed with materials that contain NORM. The construction material exhibiting the greatest alpha and beta activity from NORM was brown clay/ceramic brick-caps, due to the glaze used on such caps (NCRP 1995, NIST 2000). The average alpha activity detected on clay/ceramic brick-caps from three properties (DT-21, DT-22, and DT-25) west of North Broadway is approximately 1,900 dpm/100 cm^2. As a conservative assumption, 50 percent of this value (i.e., 950 dpm/100 cm^2) was attributed to naturally occurring radioactivity for the clay/ceramic brick-caps surveyed during the RI. Except for the clay/ceramic brick-caps measurements, the scoping survey results do not take into account the naturally occurring radioactivity of the various building materials.

2.2.3 Sewer Investigations

The objectives of sewer sampling were to obtain sufficient and representative data to determine the extent of MED/AEC contamination associated with sewers (i.e., interior sediment and surrounding soil) and to evaluate potential contaminant migration pathways associated with sewers.

During MED/AEC operations, most process, storm, and sanitary effluents for Mallinckrodt were collected in a combined sewer system. The sewer system consists of the following types of structures, listed in the direction of flow: (1) individual building drains (usually with diameters of 2 to 4 inches) that discharge into (2) building sewers (typically with diameters of 4 to 6 inches) that empty into (3) lateral sewers that feed into (4) mains, and then discharge to (5) trunk lines and interceptor sewers. Effluent entered the combined system from the MED/AEC areas and passed through the system, ultimately discharging to the Mississippi River (prior to December 1970). Currently, sewer flow from the SLDS discharges to the MSD Bissell Point Treatment Plant. Additional components of the sewer system include manholes, curb drains, surface drains, and sumps. Sewers at the Mallinckrodt property were predominantly constructed from VCP and vitrified brick sealed with bituminous tar or cementitious materials, but portions of the plumbing system (i.e., smaller diameter pipes within buildings that drain to the sewer) could have had lead as a component. Lead pipes and/or lead-based solder at piping connections are often found in older buildings (MDNR 2010). The bedding material commonly used during this era was granulated rock material, but some sewers may have been constructed without any bedding material (BNI 1990b).

Table 2-3 summarizes the number of samples of sewer sediment and of soil adjacent to sewers collected by plant area or VP. These areas include sewers that were used for MED/AEC operations or that were located downstream of areas where MED/AEC operations were conducted, based on available data concerning sewer flow directions. In addition to the sampling locations at the plant areas and VPs, sediment sampling was conducted in manholes located upstream (west) of the Mallinckrodt facility to provide background data for comparison. In general, the samples of sewer sediment and soil adjacent to sewers collected during the RI were analyzed for 9 radionuclide PCOCs and 12 metal PCOCs identified in Section 2.1. However, at those sampling locations where insufficient sediment was found to conduct both analyses, only the radionuclide analysis was conducted. RI field tasks for the sewers were initiated in December 2009 and completed in August 2010. The results of the sewer sampling are summarized in Section 4.4.

2.2.3.1 Manhole Sediment Sampling

Sediment sampling activities for the sewers began in December 2009, and were completed in January 2010. Sediment sampling was conducted in manholes and surface drains. All sewer field activities were completed from the ground surface (i.e., no sewers were entered due to confined space safety concerns). Before sampling activities began, manhole covers and grates were removed to inspect their integrity. Each manhole cover or surface drain grate was removed and photographs were then taken. Photographs were taken inside and outside the manhole to document the condition of the manhole and any visible portions of adjoining sewer lines. When visible, the depths to the flowlines of adjoining pipes were measured. If standing water was present, that depth to water in the sewer was also measured.

The thickness of sediment was measured to determine if sufficient volume was present for collection and analysis. If sufficient volume was not present, an attempt was made to collect samples from the nearest alternate location along the same sewer line. If the sample was within reach, a stainless steel scoop, spoon, or trowel was used to collect the sample. If the sample was not within reach, a sampling device (scoop or similar device) was mounted to an extendable handle to collect loose sediment, or a stainless steel hand auger with extensions was used to collect consolidated sediment. All samples were field-screened for organics using a photoionization detector (PID) or similar device and for external radiation using a NaI gamma radiation detector or instrument of equal or greater sensitivity.

Sediment samples were placed in a stainless steel bowl and free-standing water was drained. Each sample was homogenized by mixing it with a stainless steel spoon, spatula, or trowel prior to filling the sample container(s). Excess sample material was returned to the point of origin from which it was collected. Sediment samples were described in accordance with the USCS. Samples were labeled and kept chilled in coolers until delivered to the laboratory. Proper chain-of-custody documentation was kept with the samples.

Field activities were conducted in accordance with the methods and procedures specified in the RI WP (USACE 2009a) as described above. However, some field changes and/or additions to the proposed sampling locations originally identified in the RI WP were necessary based on information obtained during the field investigation. Some of the proposed manhole sampling locations were not sampled due to access problems (e.g., manhole cover or grate was covered or sealed closed), the lack of adequate volume of sediment required for analysis, or other site conditions (e.g., the presence of sanitary effluent). In these cases, the closest accessible manhole or surface drain was sampled to minimize any impact to the intended sampling purpose. The number of background sewer sediment sampling locations also was increased to provide a more statistically robust background dataset.

Other related field tasks, including surveying soil boring locations, decontaminating equipment, and managing IDW, were completed as discussed in Sections 2.2.1, 2.2.5, and 2.2.6, respectively. Sediment lithologic descriptions, field measurements, and other relevant information were recorded on sewer sediment manhole logs provided in Appendix A.

2.2.3.2 Soil Boring Sampling Adjacent to Sewers

The soil boring sampling approach for sewers was based on available information concerning the operational history of the sewers and the surrounding areas, available sewer maps, and historical analytical manhole sediment data for the SLDS. The borings were located adjacent to representative sections of sewer pipe, as well as adjacent to areas of the pipe where leakage was suspected based on historical maps. Consistent with the RI WP, the soil borings were drilled within a horizontal distance of approximately 2 ft of the sewer lines to get sufficiently close to sample the surrounding soil while also maintaining an adequate distance from the sewer lines to ensure the sewer line was not punctured.

Prior to soil sampling adjacent to the sewers, determination of utility locations was performed in the same manner as for soil borings. Drilling activities for the soil borings located adjacent to sewers began in February 2010 and were completed in July 2010.

Some modifications were made to the soil sampling approach outlined in the RI WP based on field conditions that would prevent effective sampling in the proposed locations (e.g., access constraints and the presence of utilities). The RI WP specified that a minimum of two soil samples would be collected from each boring at depth intervals of 0 to 2 ft and 2 to 4 ft beneath the base of the sewer line. Based on site conditions, three, rather than two, soil samples were collected from each boring to compensate for uncertainties concerning the depths of the sewer pipes. The additional soil sample was collected at an estimated depth interval from 2 ft above the base of the pipe to the base of the pipe. When the results of field screening indicated the presence of significant concentrations of radionuclides in the deepest sample, additional samples were collected from the underlying soil to bound the vertical extent of contamination.

Samples were placed in a stainless steel bowl and were homogenized by mixing with a stainless steel spoon, spatula, or trowel prior to filling the sample container(s). Excess sample material was disposed of as IDW. Samples were logged and described in accordance with the USCS by a geologist, geotechnical engineer, or soil scientist. Sample containers were sealed and labeled and placed in coolers or other containers until delivered to the laboratory. Proper chain-of-custody documentation was kept with the samples. Copies of the soil adjacent to sewers boring logs for each sampling location are provided in Appendix A.

2.2.4 Quality Assurance/Quality Control Sampling and Analysis

During RI characterization, QA/QC sampling and laboratory analysis activities were conducted in accordance with the performance criteria and QA objectives that were established in the RI WP (USACE 2009a), and that are presented in the bulleted items below. The QA/QC sample results are documented in the Quality Control Summary Report (QCSR) contained in Appendix B.

- Duplicate and split samples were each collected at a rate of approximately 5 percent for field and laboratory QC purposes.
- Precision is the degree to which the analytical result for a sample can be reproduced during separate measurements. Precision was determined by the collection of a parent sample along with a split sample and a duplicate sample. The acceptable relative percent difference (RPD) between a parent and duplicate samples or parent and split samples was 50 percent or less. The objective applied for the RPD when reported results are greater than five times their minimum detectable concentrations was 50 percent. If radiological sample results are less than five times their respective minimum detectable concentrations, then the normalized absolute difference (NAD) was used with the objective being an NAD less than 1.96.
- Accuracy provides a gauge or measure of the agreement between an observed result and the true value for an analysis. For this report, accuracy is measured through the use of the field split soil samples through a comparison of the prime laboratory results versus the results of an independent laboratory.
- Representativeness and comparability were used to ensure that the samples represent a characteristic of the location sampled and are assured through the selection and proper implementation of systematic sampling and measurement techniques, as well as compliance with analytical methods and sample hold times.
- Completeness refers to the portion of the data that meets acceptance criteria and is, therefore, usable for statistical testing and risk assessment. The objective applied for this RI was 90 percent.

The QA/QC samples included field duplicate samples and split samples collected and analyzed at a targeted frequency of 5 percent of the number of prime samples analyzed per environmental medium. Soil and sediment samples collected for radiological analyses were submitted to the USACE FUSRAP laboratory located in St. Louis, Missouri. Prime radiological samples analyzed by the USACE FUSRAP laboratory were split with TestAmerica in St. Louis, Missouri. Soil and sediment samples submitted for chemical analyses were sent to TestAmerica in St. Louis, Missouri. Prime chemical samples analyzed by TestAmerica were split with RTI Laboratories.

Laboratory analyses were conducted in accordance with the *Quality Assurance Project Plan for the St. Louis Airport and Downtown Sites* (USACE 1998c) (hereafter referred to as the QAPP).

2.2.5 Equipment Decontamination

Decontamination procedures were completed based on whether the type of sampling performed was for chemical or radiological laboratory analyses. For the purposes of this report, chemical sampling refers to the sampling of soil or sediment for chemical analysis (i.e., laboratory analysis for the metal PCOCs identified for inaccessible soil, soil adjacent to sewers, and sewer sediment). Radiological sampling refers to the sampling of soil or sediment for radiological analysis (i.e., laboratory analysis for the radiological PCOCs identified for inaccessible soil, soil adjacent to sewers, and sewer sediment). Small, reusable sampling equipment used for sampling media for chemical analysis was washed with phosphate-free detergent and tap water to remove visible contamination. The equipment was then rinsed with tap water, then alcohol, followed by a de-ionized water rinse. Equipment was air dried and wrapped in aluminum foil until additional sampling occurred.

Small, reusable equipment used for sampling media for radiological analysis was washed with phosphate-free detergent and water to remove visible soil from equipment. The equipment was then rinsed with tap water and allowed to air dry.

Following decontamination, all equipment was surveyed for radiological contaminants prior to release for unrestricted use. Equipment leaving the site for unrestricted use had alpha contamination levels at or below 100 dpm/100 cm^2 total average activity and 20 dpm/100 cm^2 removable activity.

Larger pieces of equipment, such as drill rigs, were decontaminated with pressurized hot water/steam as necessary. Steps were taken to assure that contamination did not spread to previously uncontaminated areas during the transport of sampling and other equipment. Any equipment deemed to be heavily contaminated was decontaminated in the immediate area of the sample collection or was wrapped in plastic prior to transit to a decontamination area.

2.2.6 Management of Investigation-Derived Waste

IDW included surplus soil from subsurface investigations, decontamination fluids, disposable sampling equipment, and personal protective equipment. During the RI sampling, efforts were made to minimize the volume of waste derived from sampling and decontamination procedures and to dispose of IDW in bulk, along with other wastes that may be generated during accessible soil remedial actions. Waste generated during field activities was drummed in 55-gallon containers at the site for disposal by the USACE. The drums of IDW were properly labeled with information including the waste generator, contact information, date of generation, contents, and potential health and safety hazards.

IDW generated during RI activities was taken to a USACE-approved location for staging and/or treatment prior to waste characterization and disposition. IDW was managed, stored, transported, and disposed in accordance with the *Sampling and Analysis Guide for the St. Louis Site, St. Louis, Missouri* (USACE 2000) (hereafter referred to as the Sampling and Analysis Guide [SAG]) and MDNR, USEPA, and U.S. Department of Transportation (DOT) regulations. In addition, the IDW disposal complied with the federal and/or state regulations applicable to the disposal facility.

2.2.7 Data Validation and Quality Assessment

Radiological data generated by the USACE FUSRAP laboratory and chemical data generated by TestAmerica in St. Louis, Missouri, were validated at a rate of 5 percent in accordance with the SAG and the RI WP. Data verification was performed on the remainder of all data from each laboratory that was not validated. Split sample data generated by the USACE's QA laboratory were verified before inclusion in the QCSR (Appendix B). Validations and verifications were performed electronically using the FUSRAP St. Louis Data and Environmental Information Management System, in which analytical qualifiers denoting data usability were applied based on comparisons to acceptance criteria established for checklist items presented in the QAPP. Reason codes also were generated with each analytical qualifier.

Data validation reports were written for the validated radiological data from the USACE FUSRAP laboratory, and data validation checklists were completed for the validated chemical data. Additionally, data validation checklists or verification summaries for each sample delivery group have been retained with the respective laboratory data. The validation/verification checklists, data qualifiers and reason codes, radiological data validation reports, and QCSR, all provide adequate documentation of the evaluations performed for determining quality and usability of the FUSRAP data for meeting project DQOs. Appendix B of this report presents the QCSR and radiological data validation reports.

As discussed in the Data Quality Assessment Summary of the QCSR, all validated/verified data were determined to be usable, with data qualifications and reason codes being applied due to minor issues. Minor data issues resulted in the qualification of some detect and non-detect results as being estimated with appropriate USEPA qualification flags.

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3.0 PHYSICAL CHARACTERISTICS OF STUDY AREA

3.1 LAND USE AND DEMOGRAPHY

The SLDS is located in the City of St. Louis, Missouri, which is bordered by the Mississippi River on the east and by St. Louis County on the north, south, and west (Figure 1-1).

Land use within a 1-mile radius of the SLDS includes a mixture of commercial, industrial, and residential uses. The largest property found within the SLDS is the 45-acre former Mallinckrodt property that is currently owned by Covidien. The Mallinckrodt property currently includes a chemical manufacturing plant, support facilities, and administrative buildings that cover a large portion of the SLDS. The remainder of the complex is covered, mostly with asphalt or concrete pavement. The Mallinckrodt property is enclosed by a maintained and patrolled security fence. The closest resident is located on North Broadway approximately 200 ft southwest of the Mallinckrodt Plant 10 property (USACE 1998a).

The VPs encompass over 165 acres of land surrounding the Mallinckrodt property with similar topography, geology, hydrogeology, and surface-water features.

According to the City of St. Louis Zoning District Map, the SLDS properties are currently zoned as either “J Industrial District” or “K Unrestricted District” (City of St. Louis 2012a). Regardless of which of these two zoning classifications the SLDS properties fall under, it appears that based on the current configuration of SLDS properties buildings, no buildings may be erected or altered for residential dwelling purposes.

According to the City of St. Louis Strategic Land Use Map, which was adopted by the City of St. Louis’ Planning Commission on January 5, 2005, all SLDS properties are listed as “Business and Industrial Preservation and Development Area” or “Business and Industrial Development Area” (City of St. Louis 2012b). The long-term plans by the City of St. Louis for the SLDS area are to retain the industrial uses, encourage the wholesale produce district, and phase out the remaining, marginal residential uses.

3.2 TOPOGRAPHY, DRAINAGE, AND SURFACE WATER

St. Louis is located in an area of gently rolling uplands that feature low hills and broad, shallow valleys that gradually flatten out to the north and east in Illinois. The hilly terrain is cut by several broad river valleys (up to 10 miles wide) with steep bluffs. The Illinois and Mississippi Rivers converge northwest of St. Louis and are joined downstream by the Missouri River from the west. Both the Mississippi and the Missouri Rivers have cut large valleys with wide floodplains. St. Louis is built on bluffs that rise above the western banks of the Mississippi River, 13 miles downstream of the Missouri River – Mississippi River confluence.

At the SLDS, surface elevations range from approximately 430 ft above mean sea level (amsl) in the southwestern part of the site to 420 ft amsl near the Mississippi River. The SLDS ground surface slopes at an average of 0.4 percent eastward toward the Mississippi River. An extensive levee system parallel to the Mississippi River has been constructed near the riverbank to protect the city from flooding. The top of the Mississippi River levee is approximately 438 ft amsl and is designed to protect against a 500-year flood event. Surface drainage is directed through ditches and catchment basins into an extensive storm drainage system that discharges to a nearby MSD sewage treatment plant (i.e., the Bissell Plant). The surface water is treated at the plant prior to discharge to the Mississippi River. Much of the SLDS area is covered with concrete or asphalt, which interferes with natural surface-water runoff and ground-water recharge mechanisms (DOE 1993). No permanent surface-water bodies exist within the boundaries of the SLDS.

The Mississippi and Missouri Rivers are the major water supply sources for the St. Louis area. All of the St. Louis area municipal water intakes are located upstream of the SLDS except for the Illinois-American Water Plant, which supplies a small percentage of the water required by the City of East St. Louis, Illinois. The Illinois-American Water Plant intake is located approximately 8 miles downstream of the SLDS on the opposite (east) bank of the Mississippi River.

3.3 SITE GEOLOGY AND HYDROGEOLOGY

A generalized stratigraphic column for the SLDS is shown on Figure 3-1. Surficial fill is present over most of the property with an average thickness of 13 ft (BNI 1994). The fill consists of brick, concrete, organic material, and coal slag with minor sand, coal ash, coal cinders, and silt. Underlying the fill, there are two depositional units that are identified based on differences in their geologic properties: an upper unit, consisting of clay and silty clay with interbedded clay, silt, and sandy silt, ranging in thickness from 10 to 17 ft; and a lower unit comprised of sandy silt, silty sand, and gravelly sand deposits ranging in thickness from 0 to 60 ft.

The uppermost bedrock unit at the SLDS is the Mississippian-age Ste. Genevieve Formation, which consists of moderately fractured limestone with some dolomite. The erosional surface of the bedrock dips eastward from a depth of approximately 19 ft below ground surface (bgs) at the western edge of the SLDS to a depth of approximately 80 ft bgs near the Mississippi River.

Ground water at the SLDS is found within the following three hydrostratigraphic units (HUs), in order of increasing depth (Figure 3-1):

- HU-A, which consists of fill and underlying fine-grained deposits (primarily silty clay, clay, and silt);
- HU-B, also referred to as the Mississippi Alluvial Aquifer, which predominantly consists of somewhat coarser-grained deposits (sandy silt, silty sand, sand, and gravelly sand); and
- HU-C, the limestone bedrock.

HU-A overlies the Mississippi Alluvial Aquifer (HU-B) on the east side of the SLDS and overlies bedrock on the western side of the SLDS. HU-A is not an aquifer and is not considered a potential source of drinking water, because it has insufficient yield and poor natural water quality. Soil boring logs and results of particle-size analysis of soil samples from various borehole locations across the SLDS indicate that HU-A contains varying amounts of clay. Clays retard the movement of radionuclides and metals by a variety of processes, including adsorption, coprecipitation, and cation exchange. As part of the characterization activities conducted between 1989 and 1993 to support the RI/BRA for the SLS, the cation exchange capacity (CEC) was measured in the upper unit. The effective CEC for the HU-A was determined to be 200 milliequivalents per 100 grams (meq/100 g) of soil (BNI 1994). Results of one variable-head permeability test conducted within HU-A provided an estimated hydraulic conductivity value of 9.9E-6 cm per second (BNI 1990a). In addition, as part of the characterization activities conducted between 1989 and 1993 to support the RI/BRA for the SLS, one silty soil sample from HU-A was analyzed to determine the soil-water partitioning coefficient (K_d) for uranium, reported at 146 milliliters per gram (mL/g).

HU-B thins westward on the bedrock surface until it becomes absent beneath the SLDS, being truncated by the rising bedrock and the overlying HU-A. HU-B is one of the principal aquifers in the St. Louis area. It qualifies as a potential source of drinking water under the *Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy* (USEPA 1988b). However, expected future use of HU-B as a drinking water source at the SLDS is highly unlikely for several reasons: the industrial setting, the site's proximity to the Mississippi and Missouri Rivers (i.e., major water supply sources), and the poor natural water quality of HU-B. Because ground water in HU-B is hydraulically connected to the Mississippi River, ground-water flow direction and gradient are strongly influenced by river stage. The predominant ground-water flow direction is to the east, toward the Mississippi River.

Aquifers in this region also exist in the limestone bedrock (HU-C) underlying the alluvial deposits. HU-C would be an unlikely water supply source because it is deeper and less productive.

There are no known drinking water wells in the vicinity of the SLDS. The City of St. Louis has Ordinance 66777, which explicitly forbids the installation of wells into the subsurface for the purposes of using the ground water as a potable water supply (City of St. Louis 2005). The expected future use of SLDS ground water is not anticipated to change from its current use. USACE continues to evaluate ground-water impacts beneath the SLDS under the 1998 ROD.

3.4 ECOLOGICAL AND CULTURAL RESOURCES

The SLDS is located in the Oak-Hickory-Bluestem Parkland section of the Prairie Parkland Province. Pre-settlement vegetation is characterized by deciduous woodlands intermixed with open prairie. Today, the ecological resources at the SLDS are limited because of the site's location within an urban area of concentrated industrial and commercial developments (DOE 1993). Site vegetation consists of a mixture of prairie species, disturbance-related aggressive species, and species typical to old fields, including wild carrot, aster, clover, dandelion, milkweed, ragweed, and various grasses (DOE 1993).

Vertebrate fauna of the St. Louis area consist of species that have adapted to urban encroachment, including mammals (e.g., mice, opossum, eastern cottontail rabbit, gray squirrel, and eastern mole) (DOE 1993). Birds that inhabit the urban environment include the Canada goose, rock dove, mourning dove, American crow, American robin, and Northern cardinal (DOE 1993).

No wetlands occur within the SLDS boundaries, although according to the U.S. Fish and Wildlife Service's (USFWS) National Wetlands Inventory (USFWS 2008), a portion of the area directly north of the McKinley Bridge and east of the Mississippi River levee is classified as palustrine wetlands (i.e., non-tidal wetlands that are substantially covered with emergent vegetation), which are commonly found along the Mississippi River. Based on the "Environmental Assessment for Biota" presented in the 1993 BRA, and the conclusions of the SLERA conducted as part of this RI/BRA report (Sections 6.2 and Appendix K Section 3.0), no potentially sensitive habitats for biota occur either on site or adjacent to the SLDS (DOE 1993).

Available data indicate that no archaeological sites or historic buildings lie within the SLDS boundaries and no archeological survey has been conducted at the site. Due to the intensive industrial use of the site, it is unlikely that any significant archeological sites exist at the SLDS (USACE 1998b). Two sites listed in the March 1992 edition of the National Register of Historic Places (NRHP) for the state of Missouri exist within 1 mile of the SLDS. The first site is the Bissell Street Water Tower, located northwest of the SLDS, and the second is the Murphy-Blair Historic District, located 0.5 mile southwest from the SLDS. Additionally, an official historic district (Hyde Park) is located west and northwest of the SLDS.

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4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents the results of the RI sampling, additional characterization data from previous investigations and relevant data collected as part of ongoing activities for soil addressed by the 1998 ROD to define the nature and extent of contamination in ISOU media. A detailed overview of each plant or property, including a property description, history of MED/AEC use, summary of previous investigations, and a review of the previously existing characterization data, is provided in the RI WP (USACE 2009a). RI sampling was conducted between June 2009 and August 2010. The data collected as part of this RI were evaluated for the PCOCs as discussed in Section 4.2. The results of the RI for inaccessible soil are presented in Section 4.2; the results of building surveys are presented in Section 4.3; and the results of the sewer investigation are presented in Section 4.4. A summary of the nature and extent of contamination is provided in Section 4.5.

4.1 DATA EVALUATION PROCESS FOR THE POTENTIAL CONTAMINANTS OF CONCERN

Inaccessible soil evaluated for nature and extent of contamination in ISOU media included data collected from the RI sampling activities, inaccessible soil data collected from previous characterization activities, and relevant data collected as part of ongoing activities for soil addressed by the 1998 ROD at the SLDS. Previous characterization activities included soil sampling at locations within the typical inaccessible soil area boundary (e.g., the building foundation and extending out 5 ft). However, data collected during pre-1990 investigations (BNI 1989c; BNI 1989e; BNI 1990a) were not included for the ISOU RI evaluation. Although the RI WP used the pre-1990 data to identify potential areas for investigation, the sampling locations were not defined according to the Missouri State Plane Coordinate System, and sampling locations could not be replicated. Therefore, for this RI report, only samples collected at locations identified to the Missouri State Plane Coordinate System were used to define nature and extent. Additionally, although historic sewer sediment data were used to define some locations for sampling in the RI WP, the data were not included in the RI evaluation of nature and extent because of the changing conditions of the sewer system under continued operational use since the historical data were collected. Historical building radiological survey data were only available for Plant 1 Building 25 and some rooftops at Plants 1 and 2 and, likewise, these data were only used for planning potential sampling locations. Only building radiological survey data collected during the RI were used to define the nature and extent of contamination on buildings.

To evaluate the nature and extent of contamination at each plant area or VP, USEPA risk-based PRGs were adopted for each PCOC in inaccessible soil, sewer sediment, and soil adjacent to sewers, while site-specific, risk-based PRGs were derived for building and structure surfaces. Risk-based PRGs provide a tool to be used by risk assessors, remedial project managers, and others involved with risk assessment and decision making at CERCLA sites. The USEPA initially provided guidance on developing and using PRGs in the *Risk Assessment Guidance for Superfund* [RAGS]*: Volume I, Human Health Evaluation Manual: Part B, Development of Risk-based Preliminary Remediation Goals* (USEPA 1991a).

Soil PRGs were obtained for the ISOU from the most recent USEPA databases available and are more health conservative than the screening levels initially proposed in the RI WP. Soil PRGs were used for evaluating sewer sediment because no established, risk based PRGs are available for sediment. As discussed in Section 4.1.2, site-specific PRGs were derived and used for evaluating interior and exterior structural surfaces. All ISOU PRGs are presented in Table 4-1. All risk-based PRGs used for evaluations of the ISOU are concentration limits that were derived using carcinogenic and non-carcinogenic toxicity values, under assumed sets of exposure conditions deemed as being most applicable to the industrial land use, receptors, exposure pathways, and environmental conditions typically encountered at the SLDS. Concentrations below PRGs are not expected to cause any health risks following exposure, assuming exposures occur in a manner consistent with the exposure assumptions used to derive the PRGs. The PRGs for the RI/BRA were used in a conservative manner, because they were applied to individual sampling results and/or locations collected during the RI rather than to upper-bound average concentrations derived for an area per USEPA methodology (e.g., the 95 percent upper confidence limit [UCL] of the arithmetic mean concentration). PCOCs detected in an ISOU medium with at least one concentration exceeding the corresponding PRGs are being retained for further quantitative evaluations in the BRA as COPCs. One set of sitewide COPCs is being identified for each ISOU medium that will be applied to all sitewide and property-specific evaluations being conducted in the BRA except for metals COPCs in inaccessible soil. The metals COPCs in inaccessible soil will be applied to the uranium-ore processing area and the individual properties in the uranium-ore processing area.

In addition to risk-based PRGs, SLDS background values (BVs) were used in the characterization of inaccessible soil, sewer sediment, and soil adjacent to sewer lines to provide a reference point for evaluating if concentrations of PCOCs are a result of historical MED/AEC releases. The BVs are also presented in Table 4-1. Sections 4.1.1, 4.1.2, and 4.1.3 discuss the basis of the BVs, radiological PRGs, and metal PRGs.

Table 4-1. Preliminary Remediation Goals and Background Values for Potential Contaminants of Concern Identified for the Inaccessible Soil Operable Unit

Media [a]	PCOC	Soil Background Value [b]	Sewer Sediment Background Value [b]	Risk-Based PRG [c]
Inaccessible Soil	Ac-227 (picocuries per gram [pCi/g])	0.18	NA	11.4
	Pa-231 (pCi/g)	1.12	NA	1.25
	Ra-226 +D (pCi/g)	3.04	NA	0.0248
	Ra-228 +D (pCi/g)	1.00	NA	0.0538
	Th-228 (pCi/g)	1.26	NA	121
	Th-230 (pCi/g)	2.18	NA	20
	Th-232 (pCi/g)	1.18	NA	18.9
	U-235 +D (pCi/g)	0.1	NA	34.3
	U-238 +D (pCi/g)	1.67	NA	1.65
	Arsenic (milligrams per kilogram [mg/kg])	10.6	NA	1.6
	Cadmium (mg/kg)	1.03	NA	800
	Uranium metal (mg/kg)	NA	NA	3,100

Table 4-1. Preliminary Remediation Goals and Background Values for Potential Contaminants of Concern Identified for the Inaccessible Soil Operable Unit (Continued)

Media [a]	PCOC	Soil Background Value [b]	Sewer Sediment Background Value [b]	Risk-Based PRG [c]
Sewer Sediment and Soil Adjacent to Sewer Lines	Ac-227 (pCi/g)	0.18	0.0916	11.4
	Pa-231 (pCi/g)	1.12	0.265	1.25
	Ra-226 +D (pCi/g)	3.04	1.007	0.0248
	Ra-228 +D (pCi/g)	1.00	0.466	0.0538
	Th-228 (pCi/g)	1.26	0.527	121
	Th-230 (pCi/g)	2.18	1.127	20
	Th-232 (pCi/g)	1.18	0.51	18.9
	U-235 +D (pCi/g)	0.1	0.0848	34.3
	U-238 +D (pCi/g)	1.67	1.05	1.65
	Arsenic (mg/kg)	10.6	11.84	1.6
	Cadmium (mg/kg)	1.03	6.165	800
	Cobalt (mg/kg)	8.51	8.856	300
	Copper (mg/kg)	184	157.1	41,000
	Lead (mg/kg)	381	601.5	800
	Manganese (mg/kg)	576	626.2	23,000
	Molybdenum (mg/kg)	2.77	7.156	5,100
	Nickel (mg/kg)	24.7	34.01	20,000
	Selenium (mg/kg)	0.37	2.937	5,100
	Thorium Metal (mg/kg)	NA	NA	NA [d]
	Uranium Metal (mg/kg)	NA	17.86	3,100
	Vanadium (mg/kg)	39.1	19.36	5,200
	Zinc (mg/kg)	324	659.4	310,000
Interior Structural Surfaces [e,f]	Gross Alpha Activity (dpm/100 cm^2)	NA	NA	130
Exterior Structural Surfaces [e,f]	Gross Alpha Activity (dpm/100 cm^2)	NA	NA	3,200

[a] All depth intervals apply.

[b] All site-specific soil BVs presented for radionuclides and metals were obtained by USACE (1999a) and are not being used for data screening. Data comparisons to BVs are being done only for the purpose of characterization. Site-specific sewer sediment BVs for radionuclides and metals were estimated from data collected during the RI (see Tables I-3-1 and I-3-2 in Attachment I-3 of Appendix I for statistical summary). All soil and sediment BVs for radionuclides and metals were selected as the lower value of the 95 percent UCL and the maximum detected background concentration. All soil and sediment BVs equate to the 95 percent UCL.

[c] Radiological PRGs were obtained from USEPA's (August 2010) online Generic Preliminary Remediation Goals table for the outdoor worker (http://epa-prgs.ornl.gov/radionuclides/download.html) (USEPA 2010c). USEPA PRGs for Ra-226, Ra-228, and U-238 incorporate the ingrowth of daughter products out to 100 years and are, therefore, designated as "+D." PRGs used for evaluating metal PCOCs are USEPA's (April 2012) industrial soil Regional Screening Levels (RSLs) (USEPA 2012a). All PRGs were established for soil and target a CR of 1.0E-06 or a non-carcinogenic hazard index of 1.0. No published sediment PRGs are available for human health.

[d] A PRG is not available for elemental thorium; however, it is the carcinogenic effects from radiological exposures to thorium isotopes that will drive risk evaluations of this PCOC.

[e] PRGs for interior and exterior structural surfaces were derived using the Residual Radioactivity (RESRAD)-BUILD computer model. No metal PRGs are needed for structural surfaces. No BV is available for structural surfaces.

[f] No structural surface PRGs were derived for gross beta activity because Ra-228 and Pb-210 were not determined to be significant dose contributors; therefore, all beta-emitting PCOCs are accounted for in the gross alpha PRG, as detailed in Appendix S.

NA = Not applicable.

The PRGs used in this RI/BRA report should not be confused with numerical RGs that will be determined later in the CERCLA process for the ISOU. Generally, the USEPA's recommended approach for developing RGs is to identify PRGs at scoping, modify them as needed at the end of the RI or during the FS based on site-specific information from the BRA, and ultimately select remediation levels in the ROD (USEPA 2010a). ARARs are also used to select the remediation levels in the ROD. The State of Missouri has provided an initial list of potential ARARs as follows:

- Uranium Mill Tailings Radiation Control Act (UMTRCA) (40 *CFR* 192.12(a), (b); 192.21; 192.22; 192.02(a); 192.40; 192.41);
- Office of Solid Waste and Emergency Response (OSWER) 9200.4-18;
- OSWER 9200.4-23;
- OSWER 9200.4-25;
- Missouri Clean Water Act;
- Missouri Water Well Driller's Law (RSMo 256.600 and 256.670) and Regulations (10 *Code of State Regulations* [*CSR*] 23);
- Missouri Risk Based Corrective Action (MoRBCA) guidance of long term stewardship; and
- Missouri Environmental Covenants Act (MoECA).

The inclusion of these potential ARARs does not constitute applicability or USACE acceptance. The potential ARARs will be evaluated during subsequent CERCLA documents in accordance with the time frames established in the NCP.

4.1.1 Background Values

SLDS soil and sediment BVs are being used to facilitate characterization efforts by providing a reference point for evaluating if concentrations at the SLDS are a result of historical MED/AEC releases or if they are due to releases from other anthropogenic activities not related to historical uranium-ore processing at the SLDS. The BVs are not being subtracted from site concentrations or added to PRGs in order to reflect concentrations above SLDS background. All soil and sediment BVs were selected as the lesser of the 95 percent UCL or the maximum detected concentrations calculated from SLDS background datasets. The soil background data were obtained from the *Background Soils Characterization Report for the St. Louis Downtown Site* (USACE 1999a).

No background data set was available for sewer sediment; therefore, background sediment samples were collected from manholes in areas upstream of the SLDS during the RI. A total of 11 background sediment samples were collected from manholes located in the industrial area located upstream (west) of the Mallinckrodt facility (Figure I-3-1). The RI WP identified 8 background sediment sample locations, but three manhole locations (SLD123754, SLD123755, and SLD123756) located further upstream of the plant were also sampled to provide a more statistically robust background dataset. Additional field changes to some of the proposed manhole sampling locations were made due to access restrictions and safety issues encountered in the field. The background sediment samples are generally described as consisting predominantly of fine to medium sand with varying amounts of silt and traces of fine gravel.

The data from the 11 upstream sewer sediment sampling locations provide an appropriate dataset for establishing background sediment concentrations for metals and radionuclides. Prior to determination of background values, statistical outlier evaluations were conducted. Results identified as outliers were removed from the background data set prior to calculations of summary statistics, goodness of fit (GOF), and BVs. Table I-4 of Appendix I summarizes the sewer sediment background statistics that were calculated for each PCOC, including the frequency of detection (FOD), mean, minimum, and maximum detected concentration; standard deviation; 95 percent UCL on the mean; and 95 percent upper tolerance limit (UTL) of the 95th percentile. Because all 95 percent UTL values are greater than the maximum detection, the sediment background value for each metal was set equal to the lower of the 95 percent UCL and the maximum detected background concentration. The use of the lower of the two concentrations is consistent with the method outlined in the *Guidance for Conducting Risk Assessments and Related Risk Activities for the DOE-ORO Environmental Management Program* (DOE 1999). A detailed description of the methodology used to develop the background statistics is presented in Appendix I. Results were used to develop a statistical background concentration for each of the PCOCs identified in Table 4-1.

Because representative building materials not impacted by site operations are unavailable for establishing site specific and medium-specific (e.g., metal, wood, and concrete) background levels, only instrument backgrounds were utilized.

The analytical results for the inaccessible soil samples, sewer sediment samples, and soil adjacent to sewers samples collected in MED/AEC areas were compared to the background values, as well as to the PRGs, to support evaluation of the nature and extent of the radionuclide and metal PCOCs in the ISOU.

Comparisons of site data versus BVs can result in some data being less than background. This is because the BV, as previously described, is an upper confidence limit calculated from a range of background concentrations following a particular distribution, which varies among COPCs. Therefore, it becomes possible for site data to be less than BVs, and also, for site doses and/or risk to be less than the corresponding background doses and/or risks.

4.1.2 Radiological Preliminary Remediation Goals

The USEPA's radiological risk-based PRGs for soil were obtained from the online generic PRGs table for the outdoor worker (USEPA 2010c). All radiological PRGs established for soil target a CR of 1.0E-06. Generally, the USEPA's outdoor worker is a long-term receptor exposed during the work day and is assumed to be a full-time employee, who works on site and spends most of the workday conducting maintenance activities outdoors. The activities for this receptor (e.g., moderate digging, landscaping) typically involve on-site exposures to surface soils, although the PRGs established by the USEPA for this receptor are applied to all inaccessible soils. The outdoor worker is expected to have an elevated soil ingestion rate (100 milligrams [mg] per day) and is assumed to be exposed to contaminants via the following pathways: incidental ingestion of soil, external radiation from contaminants in soil, and inhalation of fugitive dust. Relative to other worker receptors for which the USEPA has derived generic PRGs, the outdoor worker is expected to be the most highly exposed receptor in the outdoor environment under commercial/industrial conditions (USEPA 2010c). The USEPA's generic soil PRGs for the outdoor worker are purely risk-based and do not include background concentrations.

Each generic radiological PRG was derived by the USEPA to target a CR of 1.0E-06. Cancer slope factors used by the USEPA to derive generic soil PRGs for Ra-226, Ra-228, and U-238 incorporate the ingrowth of daughter products out to 100 years. PRGs in Table 4-1 that incorporate these slope factors with in-growth are designated as "+D."

The soil PRGs were used for evaluating sewer sediment because no established, risk based PRGs are available for sediment.

For soil on interior and exterior structural surfaces, industrial worker PRGs were determined by the USACE for gross alpha, as presented in Table 4-1. No structural surface PRGs were derived for gross beta activity, because Ra-228 and Pb-210 contributed less than 10 percent of the dose criteria and were considered to be insignificant dose contributors; therefore, all beta-emitting PCOCs are accounted for in the gross alpha PRG. The gross alpha PRG is based on radionuclide-specific derived concentration guideline levels (DCGLs) calculated using average soil concentrations from the 1993 BRA (DOE 1993) based on methods prescribed in *Derivation of Site-Specific DCGLs for North County Structures* (USACE 2004a). The building and structure radiological survey results are gross measurements that do not take into account the naturally occurring radioactivity of the various building materials. A detailed description of the calculation process for determining PRGs for structure surfaces, along with Residual Radioactivity (model) (RESRAD)-BUILD outputs, is presented in Appendix S.

4.1.3 Metal Preliminary Remediation Goals

PRGs used for evaluating metal PCOCs are the most current USEPA (April 2012) industrial soil Regional Screening Levels (RSLs) (USEPA 2012a). All metal PRGs established for soil target a CR of 1.0E-06 or a non-carcinogenic hazard index (HI) of 1.0. PRGs for characterizing metals contamination of inaccessible soil and soil adjacent to sewer lines are shown in Table 4-1. The metals PRGs are based on the current and expected future land use of the SLDS, which has been identified as heavily industrial within an urbanized setting (DOE 1993). Because published sediment PRGs are generally not available for human health protection from metals exposures, the soil PRGs for metals are also being used to evaluate metals concentrations in sewer sediment. Soil on structural surfaces was not investigated for metals contamination; therefore, no PRGs are presented. Similar to the USEPA's generic radiological PRGs, the metal PRGs represented by the USEPA's industrial soil RSLs are purely risk-based and do not include background.

4.2 NATURE AND EXTENT OF CONTAMINATION IN INACCESSIBLE SOIL

RI sampling activities for inaccessible soil were determined on a property-by-property basis using various information, including the MED/AEC historical activities conducted at the property, the results of previous sampling data, and the construction date of the structure (i.e., building, levee, RR, or roadway). Also evaluated were the locations where MED/AEC activities were conducted at the property, or the locations where accessible soil may have been excavated under the 1998 ROD, or structures that were constructed after MED/AEC operations were identified for inaccessible soil sampling. The evaluation of each property indicated that RI sampling was necessary at several Mallinckrodt plant areas, VPs, levee areas, RRs, and roadways.

Inaccessible soil was considered non-impacted in the RI WP and not subjected to additional sampling if previous data indicated contamination levels were below background or the 1998 ROD RGs and if the structure causing the soil to be inaccessible was constructed prior to MED/AEC processing operations. As such, no additional sampling for inaccessible soil was required at DT-4 South, DT-29, DT-24, the South of Angelrodt Property Group (DT-5, DT-13, DT-14, DT-16, and DT-18) or the West of Broadway Property Group (Plants 3, 8, 9, and 11 and DT-20, DT-23, DT-27, DT-35, and DT-36), and the Mallinckrodt Parking Lots (Figure 1-2) (USACE 2009a).

RI sampling was conducted in accordance with the RI WP (USACE 2009a) as described in section 2.1.1, with very few modifications to the sampling locations. The primary reason the locations were moved was the presence of utilities at the proposed location or auger refusal. The change in locations was typically minor (<10 ft).

The results of the RI sampling for inaccessible soil are discussed sitewide on a PCOC basis. The distribution of samples exceeding the PRG by PCOC is presented in Appendix C. The GWS data collected for each inaccessible soil area are presented in Appendix D. The analytical results for soil samples are presented in Appendix E, along with figures identifying sample locations on a property-by-property basis.

A summary of the radiological concentrations in inaccessible soil at the SLDS is shown in Table 4-2 on a property-by-property basis. A summary of the metals concentrations in inaccessible soil at the SLDS is shown in Table 4-3 on a property-by-property basis. The analytical results for each sample used in this RI are presented in Appendix E.

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Table 4-2. Summary of Radiological Concentrations in Inaccessible Soil [a,b]

Location	Ac-227 ISOU PRG = 11.4						Pa-231 ISOU PRG = 1.25						Ra-226 ISOU PRG = 0.0248						Ra-228 ISOU PRG = 0.0538						Th-228 ISOU PRG = 121					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	0.64	-0.47	22.10	275	46	4	0.57	-1.72	27.70	275	14	24	6.58	0.39	623.00	279	275	279	0.82	0.00	2.15	279	273	276	1.12	0.00	3.96	275	261	0
Plant 2	0.06	-0.30	1.55	166	1	0	0.07	-1.45	1.30	166	0	1	1.72	0.28	12.20	166	166	166	0.78	0.05	13.10	166	164	165	1.14	-0.01	16.30	166	160	0
Plant 6	0.32	-0.27	13.50	63	2	1	0.24	-1.13	14.80	63	2	2	3.59	0.31	57.30	63	63	63	0.74	0.15	1.34	63	61	63	0.99	0.15	1.74	63	59	0
Plant 7	0.05	-0.05	0.11	5	0	0	0.11	-0.31	0.26	5	0	0	1.91	1.29	2.93	5	5	5	0.83	0.47	0.99	5	5	5	1.26	0.70	1.73	5	5	0
Mallinckrodt Security Gate 49	0.12	-0.28	0.53	18	1	0	-0.15	-1.56	0.51	18	0	0	4.13	1.30	10.30	18	18	18	0.83	0.28	1.35	18	18	18	1.13	0.38	2.16	18	18	0
DT-4 North	4.68	-0.35	186.00	254	83	21	4.77	-1.79	192.00	254	41	57	6.27	0.50	137.00	254	254	254	0.96	0.05	2.35	254	250	253	1.33	0.11	3.06	254	250	0
DT-6	1.90	-1.62	151.00	135	21	5	1.96	-2.15	160.00	136	6	18	3.90	0.60	31.50	136	121	136	0.84	0.17	2.32	136	121	136	1.22	0.22	3.34	136	119	0
DT-8	0.08	-0.29	1.21	322	5	0	0.02	-1.84	3.11	322	1	7	2.28	0.50	12.70	322	322	322	0.73	-0.02	2.44	322	312	321	0.93	-0.02	3.22	322	310	0
DT-10	0.11	-0.27	1.15	47	6	0	0.03	-1.13	1.30	47	1	1	3.91	0.96	9.70	47	47	47	0.77	0.12	1.36	47	46	47	0.99	0.09	1.89	47	43	0
DT-29	-0.04	-0.09	0.01	2	0	0	0.17	0.09	0.25	2	0	0	1.11	1.08	1.13	2	2	2	0.59	0.37	0.81	2	2	2	1.09	0.49	1.68	2	2	0
DT-34	0.07	0.07	0.07	1	0	0	0.16	0.16	0.16	1	0	0	2.37	2.37	2.37	1	1	1	0.93	0.93	0.93	1	1	1	0.71	0.71	0.71	1	1	0
West of Broadway Property Group [c]	0.05	-0.18	0.36	40	0	0	0.12	-0.40	1.45	40	0	1	1.92	0.91	4.70	40	40	40	0.73	0.31	1.25	40	40	40	1.02	0.34	1.96	40	40	0
South of Angelrodt Property Group [d]	0.08	-0.17	0.57	14	0	0	0.13	-0.32	0.65	14	0	0	2.06	0.67	5.84	14	13	14	0.70	0.13	1.35	14	14	14	0.96	0.26	1.84	14	14	0
DT-2 Levee	0.03	-0.56	1.87	257	2	0	0.01	-1.78	1.85	257	0	3	3.04	0.74	66.40	257	257	257	0.93	0.07	1.79	257	251	257	1.19	0.18	2.64	257	254	0
DT-15 Levee	0.02	-0.25	0.41	44	0	0	0.07	-0.95	2.50	44	0	1	1.90	1.02	7.21	44	44	44	0.88	0.33	1.96	44	44	44	1.13	0.45	2.02	44	44	0
DT-3	0.06	-0.63	4.16	351	6	0	0.01	-1.97	6.30	351	0	10	2.53	0.50	12.80	351	351	351	1.04	0.07	28.10	351	346	351	1.25	0.12	27.70	351	345	0
DT-9 Rail Yard	0.18	-0.58	13.80	214	6	1	0.20	-2.43	17.90	214	3	16	5.69	0.45	191.00	214	214	214	0.92	0.04	2.55	214	211	213	1.13	0.05	2.84	214	206	0
DT-9 Levee	0.00	-0.37	0.41	131	1	0	0.02	-0.96	0.97	131	0	0	1.40	0.65	3.48	131	131	131	0.88	0.06	1.58	131	130	131	1.09	0.02	1.97	131	130	0
DT-9 Main Line	0.05	-0.37	1.10	454	6	0	0.05	-1.67	4.23	454	1	14	2.37	0.61	28.20	454	454	454	0.85	0.01	64.80	454	447	453	1.11	0.06	64.80	454	443	0
Terminal RR Spoils Area	0.26	-0.31	9.32	56	3	0	0.32	-0.77	12.30	56	1	3	2.76	0.67	16.90	56	56	56	0.70	0.11	2.60	56	54	56	0.93	0.04	2.60	56	51	0
DT-12	0.05	-0.65	1.42	483	16	0	0.01	-1.23	2.42	483	0	6	2.02	0.32	8.95	483	482	483	0.65	0.03	1.80	483	474	482	0.85	-0.02	2.86	483	456	0
North Second Street	0.17	-0.37	12.70	189	14	1	0.20	-1.30	13.70	189	5	9	2.48	0.78	10.30	189	189	189	0.75	0.03	2.10	189	187	188	1.01	-0.04	4.87	189	181	0
Hall Street	0.37	-0.40	14.60	264	34	1	0.37	-0.88	15.00	264	13	21	2.93	0.47	85.20	264	264	264	0.79	0.13	2.09	264	264	264	1.04	0.14	2.37	264	261	0
Bremen Avenue	0.59	-0.38	14.60	67	6	2	0.67	-0.83	15.80	67	3	3	1.35	0.45	4.24	67	67	67	0.85	0.10	1.47	67	66	67	1.09	0.10	1.95	67	64	0
Salisbury Street	0.06	-0.15	0.26	21	0	0	0.00	-0.56	0.40	21	0	0	1.23	0.36	3.18	21	21	21	0.59	0.12	1.39	21	20	21	0.87	0.18	1.98	21	19	0
Mallinckrodt Street	0.10	-0.44	2.29	81	4	0	0.19	-1.01	3.71	81	3	6	1.46	0.50	3.93	81	81	81	0.71	0.12	1.70	81	81	81	1.06	0.25	3.95	81	81	0
Destrehan Street	0.05	-0.82	2.26	288	8	0	0.02	-1.46	4.23	288	0	7	2.48	0.60	25.10	288	288	288	0.80	0.07	7.35	288	284	288	1.12	0.24	8.03	288	284	0
Angelrodt Street	0.07	-0.44	1.07	122	2	0	0.16	-1.16	4.03	122	0	5	2.86	0.75	14.30	122	122	122	0.75	0.17	1.38	122	121	122	1.01	0.16	2.32	122	120	0
Buchanan Street	0.89	-0.55	37.40	172	38	4	0.92	-2.38	38.60	172	14	17	3.24	0.50	8.70	172	172	172	0.83	0.12	1.73	172	169	172	1.14	0.11	3.28	172	166	0

Table 4-2. Summary of Radiological Concentrations in Inaccessible Soil [a,b] (Continued)

Location	Th-230 ISOU PRG = 20						Th-232 ISOU PRG = 18.9						U-235 ISOU PRG = 34.3						U-238 ISOU PRG = 1.65					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	8.48	-95.80	**505.00**	279	273	16	0.95	0.00	3.38	279	261	0	0.72	-0.60	17.40	275	62	0	**13.05**	-31.20	**316.00**	279	200	189
Plant 2	1.64	-55.50	11.00	166	165	0	0.95	0.00	12.30	166	154	0	0.51	-0.15	19.80	166	27	0	**9.83**	-0.77	**394.00**	166	90	87
Plant 6	2.57	-11.30	**44.80**	63	62	1	0.88	0.07	1.80	63	61	0	1.85	-0.19	**95.40**	63	9	1	**36.80**	-1.19	**1949.00**	63	39	38
Plant 7	2.47	0.93	3.84	5	5	0	0.96	0.56	1.22	5	5	0	0.11	0.04	0.16	5	0	0	**3.34**	0.91	**6.26**	5	5	3
Mallinckrodt Security Gate 49	3.82	1.26	9.01	18	18	0	0.96	0.30	1.73	18	18	0	0.20	-0.05	0.68	18	2	0	**4.85**	-0.87	**10.90**	18	15	17
DT-4 North	**30.63**	-0.06	**1462.00**	254	249	35	1.10	0.04	2.50	254	249	0	2.63	-0.22	**81.30**	254	98	2	**46.67**	0.16	**1626.00**	254	237	232
DT-6	3.86	-221.38	**569.00**	136	121	4	0.98	0.25	2.78	136	120	0	0.80	-0.10	13.77	136	22	0	**13.75**	0.55	**244.74**	136	113	120
DT-8	1.57	-16.00	10.90	322	198	0	0.78	-0.02	2.44	322	311	0	0.14	-0.36	1.19	322	23	0	**2.58**	-0.82	**21.40**	322	242	163
DT-10	3.65	0.78	9.53	47	47	0	0.87	0.17	1.73	47	45	0	0.38	-0.09	1.98	47	9	0	**6.08**	0.83	**34.70**	47	46	38
DT-29	1.18	0.91	1.45	2	2	0	0.78	0.50	1.05	2	2	0	0.22	0.18	0.26	2	0	0	1.36	0.96	**1.76**	2	2	1
DT-34	2.86	2.86	2.86	1	1	0	1.46	1.46	1.46	1	1	0	0.06	0.06	0.06	1	0	0	**1.87**	**1.87**	**1.87**	1	1	1
West of Broadway Property Group [c]	2.09	0.97	7.13	40	40	0	0.82	0.37	1.43	40	40	0	0.09	-0.36	0.47	40	2	0	**2.09**	0.75	**8.24**	40	39	21
South of Angelrodt Property Group [d]	2.15	-0.06	4.99	14	13	0	0.75	0.18	1.39	14	13	0	0.14	-0.11	0.49	14	1	0	**2.50**	0.56	**7.03**	14	8	9
DT-2 Levee	2.38	-1.57	11.00	257	252	0	1.03	0.00	2.51	257	249	0	0.15	-0.49	1.56	257	6	0	**2.32**	-0.39	**12.50**	257	175	122
DT-15 Levee	1.97	0.95	7.80	44	44	0	0.99	0.24	2.32	44	44	0	0.09	-0.16	0.75	44	0	0	1.51	0.13	**4.99**	44	36	12
DT-3	2.70	0.36	**29.80**	351	351	1	1.07	0.03	**24.00**	351	340	1	0.20	-0.64	2.12	351	19	0	**3.29**	-2.71	**42.70**	351	258	205
DT-9 Rail Yard	5.83	0.62	**272.00**	214	214	6	0.98	-0.01	2.73	214	206	0	0.35	-0.38	12.30	214	15	0	**5.50**	0.37	**177.00**	214	192	170
DT-9 Levee	1.45	0.50	4.76	131	131	0	0.98	0.09	1.81	131	127	0	0.05	-0.34	0.46	131	0	0	1.28	-2.30	**3.88**	131	89	33
DT-9 Main Line	2.42	0.54	**71.50**	454	454	2	0.97	0.05	**64.80**	454	438	1	0.13	-0.49	1.41	454	10	0	**2.09**	-1.43	**14.30**	454	333	233
Terminal RR Spoils Area	9.26	0.58	**260.00**	56	56	4	0.76	0.05	2.60	56	52	0	0.33	-0.20	8.60	56	3	0	**6.45**	-0.85	**179.00**	56	39	26
DT-12	3.45	0.26	**53.90**	483	483	11	0.73	-0.03	1.74	483	439	0	0.16	-0.33	1.82	483	43	0	**2.82**	0.14	**33.50**	483	435	266
North Second Street	3.58	-0.58	**57.70**	189	186	2	0.90	-0.01	3.56	189	183	0	0.26	-0.19	1.99	189	38	0	**4.40**	-1.70	**32.10**	189	157	131
Hall Street	4.03	-6.24	**54.40**	264	258	9	0.91	0.00	1.90	264	259	0	0.28	-0.31	9.48	264	34	0	**4.65**	-0.66	**190.00**	264	206	143
Bremen Avenue	-1.67	-123.00	15.60	67	65	0	0.94	0.10	1.65	67	64	0	1.81	-0.40	**43.10**	67	19	2	**35.70**	-0.07	**856.00**	67	43	29
Salisbury Street	1.30	0.30	2.67	21	20	0	0.71	-0.02	1.84	21	19	0	0.05	-0.19	0.25	21	0	0	0.99	0.09	**3.37**	21	12	3
Mallinckrodt Street	2.23	-1.96	13.90	81	79	0	0.97	0.09	3.39	81	77	0	0.18	-0.27	2.38	81	9	0	**3.16**	-1.24	**50.30**	81	36	46
Destrehan Street	4.54	0.35	**411.00**	288	285	5	0.99	0.09	8.61	288	281	0	0.22	-0.53	4.48	288	39	0	**4.33**	-2.65	**75.90**	288	187	169
Angelrodt Street	3.14	0.34	**46.40**	122	115	1	0.87	0.14	1.74	122	120	0	0.15	-0.28	0.79	122	6	0	**2.57**	-0.43	**9.33**	122	99	81
Buchanan Street	5.16	0.64	**76.40**	172	171	8	0.93	0.03	1.92	172	166	0	1.10	-0.22	17.60	172	57	0	**19.59**	0.05	**326.00**	172	155	135

[a] This table does not include data for inaccessible soil adjacent to sewer lines.
[b] Appendix E provides the analytical results for each location at the property including summary statistics for each PCOC. Statistics include number of samples, minimum, maximum, average, median, and mode of the parameter concentration.
[c] West of Broadway Property Group consists of Plant 3, Plant 8, Plant 9, Plant 11, DT-20, DT-23, DT-27, DT-35, and DT-36.
[d] South of Angelrodt Property Group consists of DT-13, DT-14, DT-16, and DT-17.
Units are pCi/g.
Bold values and gray shading indicate samples collected at the property that exceeded the PRG.

Table 4-3. Summary of Metal Concentrations in Inaccessible Soil for Properties Within the Uranium-Ore Processing Area [a,b,c]

Location	Arsenic						Cadmium						Uranium					
	ISOU PRG = 1.6						ISOU PRG = 800						ISOU PRG = 3,100					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 2	**6.19**	**2.7**	**10.5**	7	3	7	1.14	0.12	3.6	7	2	0	10.5	5.6	14.9	7	5	0
Plant 6	**7.19**	**3.5**	**15.1**	8	3	8	0.55	0.03	0.8	8	8	0	24	5.7	62.1	7	1	0
DT-10	**49.2**	0.74	**178**	8	5	7	1.88	0.76	3.3	8	2	0	53.6	12	104	8	8	0
DT-9	**6.87**	**2.8**	**14.6**	18	0	18	5.61	0.6	69.3	18	7	0	41.5	5.9	68.2	18	18	0
DT-12	**108**	1.5	**543**	34	15	33	2.35	0.48	6.7	34	17	0	12.9	12.1	13.5	12	3	0
Hall Street	**7.2**	**3.6**	**10**	6	5	6	1.86	0.83	2.4	6	1	0	42.33	7.5	84.9	6	1	0
Mallinckrodt Street	**12.35**	**9.9**	**14.8**	2	0	2	0.42	0.34	0.5	2	2	0	[c]	[c]	[c]	[c]	[c]	[c]
Destrehan Street	**13.47**	**6.1**	**25**	9	6	9	0.77	0.02	2.4	9	6	0	58.5	13.4	146	6	5	0

[a] Summary data do not include inaccessible soil associated with sewers (see Tables 4-12 and 4-13).

[b] Appendix E provides the analytical results for each location at the property including summary statistics for each PCOC. Statistics include number of samples, minimum, maximum, average, median, and mode of the parameter concentration.

[c] Uranium metal was not analyzed in samples collected at Mallinckrodt Street.

Units are mg/kg.

Samples were not collected at Plant 7N.

Bold values and gray shading indicate samples collected at the property that exceeded the PRG.

4.2.1 Comparison to Background

Inaccessible soil sample results were compared to BVs. As shown in Table 4-4, sample results exceeded the corresponding BV for each PCOC in the inaccessible soil.

Table 4-4. Number of Inaccessible Soil Samples Exceeding Background Values

PCOC	Number of Samples	Number of Samples Exceeding Background	Percentage of Samples Exceeding Background
Radiological			
Ac-227	4,536	917	20%
Pa-231	4,537	244	5%
Ra-226	4,541	1,233	27%
Ra-228	4,541	1,012	22%
Th-228	4,537	1,353	30%
Th-230	4,541	2,070	46%
Th-232	4,541	1,035	23%
U-235	4,537	2,518	55%
U-238	4,541	2,703	60%
Metals			
Arsenic	92	39	42%
Cadmium	92	49	53%
Uranium metal	64	[a]	[a]

[a] Uranium metal has no BV.

4.2.2 Comparison to Preliminary Remediation Goals

Inaccessible soil sample results were compared to the PRGs to determine which of the PCOCs would be carried forward for evaluation in the BRA and to identify those areas where concentrations of the PCOCs are high enough to warrant further evaluation. The data used for the RI showed that the PRGs are exceeded throughout the SLDS. A large percentage of the sample results exceeded the PRG for Ra-226, Ra-228, and arsenic as the PRG is less than background. A similar percentage of U-238 sample results exceeded the PRG as exceeded background as the values are almost equal (1.65 picocuries per gram [pCi/g] and 1.67 pCi/g, respectively). As shown in Table 4-5, at least one sample result exceeded the corresponding PRG for each of the radiological PCOCs except Th-228, and thus, all radiological PCOCs except Th-228 will be evaluated in the BRA. Only arsenic results exceeded the metals PRGs; therefore, arsenic is the only inaccessible soil metal that will be carried forward into BRA. The figures in Appendix C show the distribution of samples exceeding the PRG by PCOC.

Table 4-5. Number of Inaccessible Soil Samples Exceeding the Preliminary Remediation Goal

PCOC	PRG	Number of Samples	Number of Samples Exceeding the PRG	Percentage of Samples Exceeding the PRG
Radiological				
Ac-227	11.4 pCi/g	4,536	40	<1%
Pa-231	1.25 pCi/g	4,537	232	5%
Ra-226	0.0248 pCi/g	4,541	4,541	100%
Ra-228	0.0538 pCi/g	4,541	4,531	99%
Th-228	121 pCi/g	4,537	0	0%
Th-230	20 pCi/g	4,541	105	2%
Th-232	18.9 pCi/g	4,541	2	<1%
U-235	34.3 pCi/g	4,537	5	<1%
U-238	1.65 pCi/g	4,541	2,723	60%

Table 4-5. Number of Inaccessible Soil Samples Exceeding the Preliminary Remediation Goal (Continued)

PCOC	PRG	Number of Samples	Number of Samples Exceeding the PRG	Percentage of Samples Exceeding the PRG
Metals				
Arsenic	1.6 mg/kg	92	90	98%
Cadmium	800 mg/kg	92	0	0%
Uranium metal	3,100 mg/kg	64	0	0%

4.3 NATURE AND EXTENT OF CONTAMINATION ON BUILDINGS AND STRUCTURES

The RI survey activities for buildings were determined on a property-by-property basis using various information, including prior radiological survey data, construction date of the structure, use of the structure by MED/AEC, proximity to accessible soil remediation activities, and distance from MED/AEC operational areas (USACE 2009a). A building surface was considered impacted (i.e., building surface has the potential to be contaminated) in the RI WP and subjected to additional sampling if

- previous data indicate contamination levels are above background or the RI WP screening level criteria;
- the structure was used for MED/AEC processing activities;
- the structure was constructed prior to or during MED/AEC processing operations and is located on, or adjacent to, MED/AEC processing areas; or
- if accessible soil remediation occurred adjacent to, or within 6 meters (m) (20 ft) of, the structure.

Based on the evaluation conducted in the RI WP, the buildings at the following properties were determined to be non-impacted: Plant 7, Mallinckrodt Security Gate 49, DT-4 South, DT-11, DT-15, DT-29, and DT-34 (USACE 2009a). Buildings determined to be non-impacted were not surveyed in the RI. Additionally, no buildings are present at DT-2, the three RR properties (DT-3, DT-9, and DT-12), the Terminal RR Soil Spoils Area, or at any SLDS roadways.

The RI scoping surveys consisted of scanning for alpha and beta surface activity and fixed-point measurements for total alpha and beta activity in accordance with the RI WP as described in Section 2.2.2. There were more than 4,600 fixed-point measurements obtained during the RI.

The results of the building and structure surveys for the ISOU are discussed on a building-by-building basis. The buildings surveyed are shown on figures provided in Appendix E. The individual scoping survey results are presented in Appendix F. Pictures of the exterior of the structures exceeding the PRG and drawings of the interiors exceeding the PRG are presented in Appendix G.

Table 4-6 presents the summary of gross alpha survey results based upon the individual scoping survey results presented in Appendix F.

Table 4-6. Building Scoping Survey Summary

Property Area	Associated Structure/Building	Appendix Figure	Gross Alpha Results (dpm/100 cm^2)								
			Interior			Exterior			Rooftop		
			Number	Range	Average	Number	Range	Average	Number	Range	Average
Plant 1	Building 3	E-1	18	0-66	37	82	0-1,186	105	25	0-2,195	275
	Building 4	E-1	4	0-49	12	28	0-310	67	6	15-218	92
	Building 5	E-1	3	0-33	16	14	0-39	6	[a]	[a]	[a]
	Building 6	E-1	3	16-16	16	37	0-940	97	24	9-1,136	346
	Building 7	E-1	5	**0-163**	39	35	0-731	184	10	27-1,614	546
	Building 8	E-1	4	0-33	16	61	0-1,254	165	8	91-1,345	519
	Building 10	E-1	10	0-37	12	48	0-1,966	193	14	0-2,009	538
	Building 10A	E-1	6	0-64	20	23	0-646	83	5	29-287	126
	Building 17	E-1	7	0-49	16	52	0-282	35	45	26-2,390	307
	Building 25	E-1	30	0-51	9	101	**0-18,232** [b]	498	45	92-3,056	1,086
	Building 26	E-1	8	**0-236**	111	10	39-117	83	--	--	--
	Building B	E-1	22	0-57	18	25	0-414	51	33	25-1,377	518
	Building C	E-1	20	0-70	26	150	0-1,675	155	33	0-1,292	227
	Building P	E-1	12	0-70	41	42	0-1,205	193	12	221-1,254	656
	Building X	E-1	7	0-66	22	128	0-928	94	43	**0-4,279** [c]	626
	Building Z	E-1	21	0-51	13	336	0-2,833	256	20	24-1,828	578
	Building L	E-1	10	0-57	22	96	0-2,878	118	71	5-2,375	755
	Utility Measurements [d]	E-1	NA	NA	NA	28	15-872	146	NA	NA	NA
	Area between Buildings L and Z	E-1	NA	NA	NA	20	0-152	35	--	--	--
	Tanks and Loading Dock	E-1	NA	NA	NA	22	0-571	145	NA	NA	NA
	Old Retaining Wall Salisbury	E-1	NA	NA	NA	49	18-605	130	NA	NA	NA
Plant 2	Building 40	E-2	6	0-127	58	10	19-91	64	--	--	--
	Building 41	E-2	9	**0-164**	57	28	0-465	56	5	291-1,353	719
	Building 501	E-2	22	0-18	1	94	0-446	60	73	13-1,280	195
	Building 506	E-2	[a]	[a]	[a]	20	27-219	75	--	--	--
	Building 508	E-2	8	**0-164**	57	15	0-220	69	--	--	--
	Building 510	E-2	14	0-53	15	40	0-197	44	--	--	--
	Utility Measurements [d]	E-2	NA	NA	NA	27	0-351	120	NA	NA	NA
Plant 6	Building 100	E-3	10	0-58	16	20	4-597	143	--	--	--
	Building 123	E-3	--	--	--	10	0-171	57	--	--	--
	Utility Measurements [d]	E-3	NA	NA	NA	4	18-163	74	NA	NA	NA
Plant 3	Building 63	E-12	--	--	--	30	0-849	150	22	104-2,599	706
	Building 66	E-12	--	--	--	56	0-263	60	22	5-3,018	880
	Building 62	E-12	--	--	--	30	0-1,016	137	20	26-836	232
	Utility Measurements [d]	E-12	NA	NA	NA	1	75-75	75	NA	NA	NA
Plant 8	Building 90	E-12	--	--	--	70	0-1,636	367	--	--	--
	Building 91	E-12	--	--	--	54	0-1,492	343	--	--	--
	Utility Measurements [d]	E-12	NA	NA	NA	3	22-61	44	NA	NA	NA
Plant 9	Building 96	E-12	--	--	--	146	0-1,052	149	34	0-887	237
	Northeast Corner Building	E-12	--	--	--	5	24-67	44	--	--	--
	Building 90	E-12	--	--	--	70	0-1,636	367	--	--	--

Table 4-6. Building Scoping Survey Summary (Continued)

Property Area	Associated Structure/Building	Appendix Figure	Gross Alpha Results (dpm/100 cm^2)								
			Interior			Exterior			Rooftop		
			Number	Range	Average	Number	Range	Average	Number	Range	Average
Plant 9	Building 96	E-12	--	--	--	146	0-1,052	149	34	0-887	237
	Northeast Corner Building	E-12	--	--	--	5	24-67	44	--	--	--
	Building 90	E-12	--	--	--	70	0-1,636	367	--	--	--
DT-4	Administration/ Warehouse	E-6	30	0-51	17	155	0-372	35	110	10-4,055 [c]	224
	South Storage Building	E-6	4	13-97	48	110	0-125	30	19	18-125	52
	North Storage Building	E-6	[f]	[f]	[f]	40	0-618	91	15	18-178	91
	South Salt Dome	E-6	[e]	[e]	[e]	12	5-130	78	--	--	--
	North Salt Dome	E-6	[e]	[e]	[e]	10	5-130	66	--	--	--
	Utility Measurements [d]	E-6	NA	NA	NA	20	0-909	102	NA	NA	NA
DT-6	Storage Building	E-7	11	**0-138**	31	65	0-317	82	13	41-248	116
	Fabrication Building	E-7	10	0-75	18	10	27-74	43	--	--	--
DT-8	Warehouse	E-8	11	0-55	19	15	23-231	87	[f]	[f]	[f]
	Administration Building	E-8	[e]	[e]	[e]	66	0-743	133	16	106-2,128	1,194
	Building A	E-8	[e, f]	[e, f]	[e, f]	11	162-813	589	--	--	--
	Building B	E-8	10	0-51	8	10	0-137	66	--	--	--
	Building C	E-8	17	0-51	25	10	51-203	135	--	--	--
	Building D	E-8	7	0-40	26	12	10-981	497	--	--	--
DT-10	Dry Kiln	E-9	5	0-46	18	7	0-257	142	--	--	--
	Metal Storage Building	E-9	14	**0-330**	39	22	0-686	123	--	--	--
	Planer Building	E-9	5	0-43	17	19	0-614	111	--	--	--
	Saw Building	E-9	24	0-72	26	11	0-429	109	--	--	--
	Storage Structure	E-9	--	--	--	14	5-366	85	--	--	--
	Wood Storage Structure	E-9	29	**0-172**	33	115	**0-22,476** [b]	2,100	32	**68-7,335** [b]	2,172
	Office Building	E-9	16	0-122	33	41	5-965	252	14	62-2,636	519
DT-14	L-Shaped Building	E-13	--	--	--	99	**4-4,760** [b]	378	15	30-3,969 [c]	784
DT-21	Building	E-12	--	--	--	10	0-1,271	345	10	0-125	56
	Building	E-12	--	--	--	41	9-1,665	347	22	40-3,427	1,102
DT-22	Buildings	E-12	--	--	--	69	0-1,218	151	21	0-1,339	398
DT-24	Building	E-12	--	--	--	92	0-1,378	144	20	124-3895	1,525
DT-25	Building	E-12	--	--	--	31	9-1,037	141	5	102-3,302	761

[a] Survey not conducted because field evidence indicates building is new construction.

[b] Locations of measurement results that are greater than the screening level are shown in Appendix G.

[c] The natural occurring radioactivity from clay/ceramic brick caps, as discussed in Section 2.2.2, has not been subtracted from the reported results.

[d] Utility measurements included power poles, street signs, fire hydrants, overhead pipe supports, etc.

[e] Interior inaccessible for survey.

[f] Modified from the RI WP based on field conditions.

-- Sampling not proposed in the RI WP (USACE 2009a).

NA = Not applicable, because structure does not have an interior or rooftop.

Values in bold exceed the PRGs (i.e., 130 dpm/100 cm^2 for interior structural surfaces and 3,200 dpm/100 cm^2 for exterior structural surfaces).

Data Summarized from Scoping Screening Measurements Presented in Appendix F.

4.3.1 Comparison to Background Values

No BVs were calculated for structural surfaces; therefore, there is no comparison of the survey results to BVs.

4.3.2 Comparison to Preliminary Remediation Goals

The RI sampling results indicate that 7 buildings exceed the interior PRG and 4 buildings exceed the exterior PRG (includes exterior surfaces and roofs). These 10 buildings will be carried forward into the BRA. Table 4-7 presents the buildings and surfaces exceeding the PRGs.

Table 4-7. Buildings Exceeding the Preliminary Remediation Goals

Property Area	Structure/ Building	Surface Exceeding the PRG
Plant 1	Building 7	Interior
	Building 25	Exterior
	Building 26	Interior
	Building X	Roof
Plant 2	Building 41	Interior
	Building 508	Interior
DT-6	Storage Shed	Interior
DT-10	Metal Storage Shed	Interior
	Wood Storage Building	Interior, Exterior, and Roof
DT-14	L-Shaped Building	Exterior

4.4 NATURE AND EXTENT OF CONTAMINATION ASSOCIATED WITH SEWERS

This section summarizes the results of the RI sampling conducted to investigate contamination associated with sewers. Activities conducted as part of the sewer investigation included collecting sediment samples from manholes and surface drains (grate inlets) and collecting soil samples adjacent to sewer lines. The sampling activities focused on the sewers that were used for MED/AEC operations, as well as sewers that could contain MED/AEC contamination due to receiving runoff from contaminated areas. Sediment samples collected within sewer manholes and drains, and soil samples collected adjacent to sewers as part of the RI, are shown on the figures provided in Appendices H and J. The Appendix H figures also identify locations where PCOC PRGs were exceeded for the sediment and soil samples associated with the sewers. The analytical results and sampling locations for sewer sediment and soil adjacent to sewers are presented in Appendix J. Table 4-8 summarizes the results of the screening of the radiological and metal PCOC data against BVs for sewer sediment and soil adjacent to sewers. In addition, the results of background sediment sampling conducted in manholes located along sewer lines upstream of the Mallinckrodt facility are discussed in Appendix I.

Tables 4-8 and 4-9 present summaries of the concentrations of the radiological PCOCs in sewer sediment and soil adjacent to sewers, respectively, by plant or property area. A summary of the metal concentrations on a property-by-property basis is shown in Tables 4-10 (sewer sediment) and 4-11 (soil adjacent to sewers).

The analytical results for each sewer sample evaluated in this RI are presented in Appendix J.

Table 4-8. Summary of Radiological Concentrations in Sewer Sediment [a,b]

Location	Ac-227 ISOU PRG = 11.4						Pa-231 ISOU PRG = 1.25						Ra-226 ISOU PRG = 0.0248						Ra-228 ISOU PRG = 0.0538						Th-228 ISOU PRG = 121					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	0.02	-0.12	0.14	11	0	0	0.13	-0.17	0.97	11	0	0	**1.08**	**0.67**	**2.14**	11	11	11	**0.33**	**0.14**	**0.81**	11	11	11	0.46	0.20	0.86	11	10	0
Plant 2	-0.02	-0.22	0.11	10	0	0	0.02	-0.51	0.95	10	0	0	**0.82**	**0.43**	**1.14**	10	10	10	**0.26**	**0.17**	**0.56**	10	10	10	0.33	0.15	0.54	10	7	0
Plant 6	0.00	-0.05	0.03	3	0	0	0.15	-0.04	0.38	3	0	0	**0.98**	**0.83**	**1.22**	3	3	3	**0.30**	**0.20**	**0.42**	3	3	3	0.40	0.10	0.67	3	2	0
Plant 7	0.06	0.06	0.06	1	0	0	-0.01	-0.01	-0.01	1	0	0	**0.89**	**0.89**	**0.89**	1	1	1	**0.48**	**0.48**	**0.48**	1	1	1	0.59	0.59	0.59	1	1	0
DT-11	-0.02	-0.02	-0.02	1	0	0	0.06	0.06	0.06	1	0	0	**0.61**	**0.61**	**0.61**	1	1	1	**0.27**	**0.27**	**0.27**	1	1	1	0.54	0.54	0.54	1	1	0

Location	Th-230 ISOU PRG = 20						Th-232 ISOU PRG = 18.9						U-235 ISOU PRG = 34.3						U-238 ISOU PRG = 1.65					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	0.92	0.40	1.41	11	11	0	0.33	0.03	0.78	11	9	0	0.14	0.03	0.49	11	1	0	**2.41**	0.35	**13.60**	11	7	3
Plant 2	0.92	0.27	2.01	10	10	0	0.33	0.05	0.76	10	8	0	0.06	-0.07	0.20	10	0	0	0.55	-1.46	**2.10**	10	6	1
Plant 6	0.84	0.37	1.08	3	3	0	0.33	0.07	0.50	3	2	0	0.14	-0.02	0.38	3	1	0	**2.62**	0.90	**6.04**	3	2	1
Plant 7	0.78	0.78	0.78	1	1	0	0.26	0.26	0.26	1	1	0	0.19	0.19	0.19	1	0	0	1.02	1.02	1.02	1	1	0
DT-11	0.87	0.87	0.87	1	1	0	0.40	0.40	0.40	1	1	0	0.27	0.27	0.27	1	0	0	0.70	0.70	0.70	1	1	0

[a] This table does not include data for inaccessible soil or soil adjacent to sewer lines.

[b] Appendix J provides the analytical results for each location at the property including summary statistics for each PCOC. Statistics include number of samples, minimum, maximum, average, median, and mode of the parameter concentration.

Units are pCi/g.

Bold values and gray shading indicate samples collected at the property that exceeded the PRG.

Table 4-9. Summary of Radiological Concentrations in Soil Adjacent to Sewers [a,b]

Location	Ac-227						Pa-231						Ra-226						Ra-228						Th-228					
	ISOU PRG = 11.4						ISOU PRG = 1.25						ISOU PRG = 0.0248						ISOU PRG = 0.0538						ISOU PRG = 121					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	0.11	-0.31	2.11	59	4	0	-0.01	-1.01	**1.51**	59	1	3	**1.91**	**1.11**	**5.49**	59	59	59	**0.88**	**0.29**	**1.26**	59	59	59	1.11	0.24	2.12	59	59	0
Plant 2	0.05	-0.47	0.32	23	0	0	0.01	-1.20	**1.26**	23	0	1	**1.64**	**1.05**	**2.26**	23	23	23	**0.86**	**0.21**	**1.41**	23	23	23	1.15	0.06	1.72	23	22	0
Plant 6	2.74	-0.19	**44.80**	18	2	1	**3.06**	-1.12	**56.30**	18	2	2	**6.35**	**1.32**	**58.30**	18	18	18	**0.88**	**0.57**	**1.16**	18	18	18	1.10	0.42	1.64	18	17	0
Plant 7/DT-12	5.49	-0.24	**153.00**	46	3	3	**6.45**	-1.97	**170.00**	46	3	4	**6.06**	**0.86**	**117.00**	46	46	46	**0.85**	**0.10**	**2.56**	46	46	46	1.05	0.10	2.56	46	42	0
DT-2 Levee	6.20	0.57	**11.60**	4	3	1	**7.25**	0.70	**14.10**	4	1	3	**29.44**	**4.35**	**45.20**	4	4	4	**1.18**	**0.89**	**1.55**	4	4	4	1.18	0.89	1.55	4	4	0
DT-8	-0.02	-0.35	0.25	10	0	0	0.11	-0.41	0.92	10	0	0	**1.44**	**0.94**	**2.19**	10	10	10	**0.89**	**0.44**	**1.20**	10	10	10	1.02	0.49	1.82	10	10	0

Location	Th-230						Th-232						U-235						U-238					
	ISOU PRG = 20						ISOU PRG = 18.9						ISOU PRG = 34.3						ISOU PRG = 1.65					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	2.46	0.85	**24.00**	59	59	2	1.02	0.20	1.72	59	59	0	0.17	-0.44	3.69	59	4	0	**3.49**	-2.15	**78.60**	59	30	19
Plant 2	1.48	0.59	2.23	23	23	0	0.93	0.22	1.74	23	22	0	1.41	-0.19	15.00	23	5	0	**25.23**	0.28	**287.00**	23	18	158
Plant 6	**32.79**	1.15	**489.00**	18	18	2	1.07	0.65	1.60	18	18	0	0.28	-0.13	0.93	18	2	0	**3.54**	-0.37	**14.50**	18	11	10
Plant 7/DT-12	**386.61**	0.47	**10180.00**	46	46	4	0.94	-0.03	2.56	46	42	0	0.17	-0.27	1.68	46	2	0	**4.10**	-0.54	**48.70**	46	42	18
DT-2 Levee	**765.58**	**47.30**	**1180.00**	4	4	4	1.18	0.89	1.55	4	4	0	0.79	-0.02	1.31	4	1	0	**20.11**	**3.82**	**35.30**	4	4	4
DT-8	1.27	1.00	1.86	10	10	0	0.84	0.62	1.03	10	10	0	0.06	-0.18	0.28	10	0	0	0.01	-4.71	1.65	10	3	0

[a] This table does not include data for inaccessible soil or sewer sediment.

[b] Appendix J provides the analytical results for each location at the property including summary statistics for each PCOC. Statistics include number of samples, minimum, maximum, average, median, and mode of the parameter concentration.

Units are pCi/g.

Bold values and gray shading indicate samples collected at the property that exceeded the PRG.

Table 4-10. Summary of Metal Concentrations in Sewer Sediment [a,b]

Location	Arsenic ISOU PRG = 1.6						Cadmium ISOU PRG = 800						Cobalt ISOU PRG = 300						Copper ISOU PRG = 41,000					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	**5.72**	1.30	**17.10**	10	1	9	5.09	0.47	17.60	10	0	0	9.61	1.50	38.50	10	6	0	1182.21	11.10	7930.00	10	10	0
Plant 2	**3.09**	**1.70**	**4.30**	8	4	8	2.22	0.96	3.80	8	0	0	3.81	2.30	5.80	8	0	0	271.95	21.60	1640.00	8	8	0
Plant 6	**1.80**	1.00	**2.60**	3	0	2	0.81	0.37	1.30	3	0	0	2.00	1.10	2.80	3	1	0	46.57	3.30	79.50	3	3	0
Plant 7	**4.60**	**4.60**	**4.60**	1	1	1	2.80	2.80	2.80	1	0	0	3.20	3.20	3.20	1	0	0	60.70	60.70	60.70	1	1	0
DT-11	**3.90**	**3.90**	**3.90**	1	0	1	1.00	1.00	1.00	1	0	0	7.10	7.10	7.10	1	0	0	17.60	17.60	17.60	1	1	0

Location	Lead ISOU PRG = 800						Manganese ISOU PRG = 23,000						Molybdenum ISOU PRG = 5,100						Nickel ISOU PRG = 20,000					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	126.15	4.10	438.00	10	9	0	283.03	34.30	772.00	10	10	0	6.11	1.80	16.10	10	1	0	69.23	3.70	344.00	10	9	0
Plant 2	45.45	14.10	96.60	8	1	0	207.50	112.00	308.00	8	8	0	6.04	2.00	12.20	8	0	0	50.05	12.20	152.00	8	0	0
Plant 6	30.10	5.90	72.70	3	0	0	171.07	57.20	308.00	3	3	0	2.00	1.60	2.30	3	0	0	7.60	2.70	12.40	3	1	0
Plant 7	80.70	80.70	80.70	1	0	0	495.00	495.00	495.00	1	1	0	1.70	1.70	1.70	1	0	0	17.70	17.70	17.70	1	0	0
DT-11	59.10	59.10	59.10	1	1	0	152.00	152.00	152.00	1	1	0	2.10	2.10	2.10	1	1	0	20.40	20.40	20.40	1	1	0

Location	Selenium ISOU PRG = 5,100						Uranium ISOU PRG = 3,100						Vanadium ISOU PRG = 5,200						Zinc ISOU PRG = 310,000					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	3.10	0.32	9.00	10	8	0	37.31	5.80	78.00	10	3	0	13.75	8.80	27.90	10	2	0	562.78	50.20	1950.00	10	9	0
Plant 2	2.04	0.31	3.90	8	7	0	12.75	5.60	35.90	8	5	0	12.44	5.40	18.40	8	0	0	550.88	293.00	802.00	8	1	0
Plant 6	0.39	0.34	0.45	3	3	0	6.63	6.20	6.90	3	2	0	8.63	3.70	14.50	3	0	0	153.70	56.10	229.00	3	0	0
Plant 7	4.20	4.20	4.20	1	1	0	7.90	7.90	7.90	1	0	0	15.80	15.80	15.80	1	0	0	551.00	551.00	551.00	1	0	0
DT-11	1.90	1.90	1.90	1	1	0	34.60	34.60	34.60	1	0	0	10.80	10.80	10.80	1	0	0	206.00	206.00	206.00	1	1	0

[a] This table does not include data for inaccessible soil or soil adjacent to sewer lines.

[b] Appendix J provides the analytical results for each location at the property including summary statistics for each PCOC. Statistics include number of samples, minimum, maximum, average, median, and mode of the parameter concentration.

Units are mg/kg.

Bold values and gray shading indicate samples collected at the property that exceeded the PRG.

Table 4-11. Summary of Metal Concentrations in Soil Adjacent to Sewers [a,b]

Location	Arsenic						Cadmium						Cobalt						Copper					
	ISOU PRG = 1.6						ISOU PRG = 800						ISOU PRG = 300						ISOU PRG = 41,000					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	**13.60**	**2.40**	**94.80**	48	8	48	43.70	0.12	**1730.00**	48	10	1	8.69	4.20	19.70	48	0	0	53.85	9.20	537.00	48	9	0
Plant 2	**10.82**	0.38	**67.50**	17	4	13	1.99	0.27	11.10	17	9	0	10.70	1.50	17.60	17	0	0	31.46	3.50	92.90	17	1	0
Plant 6	**5.45**	**2.80**	**11.00**	6	1	6	0.47	0.31	0.63	6	6	0	7.03	6.20	8.30	6	1	0	25.93	10.40	57.80	6	0	0
Plant 7 and DT-12	**5.10**	**3.90**	**7.20**	3	2	3	8.64	0.62	17.20	3	1	0	8.80	6.70	10.30	3	0	0	531.30	16.90	1460.00	3	3	0
DT-8 and DT-11	**4.61**	**3.00**	**9.20**	7	2	7	0.56	0.06	0.84	7	3	0	6.60	4.30	8.70	7	0	0	12.59	3.50	17.60	7	3	0

Location	Lead						Manganese						Molybdenum						Nickel					
	ISOU PRG = 800						ISOU PRG = 23,000						ISOU PRG = 5,100						ISOU PRG = 20,000					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	147.66	8.90	**1260.00**	48	12	3	561.33	136.00	3250.00	48	30	0	1.74	0.39	10.00	48	19	0	34.53	8.70	282.00	48	0	0
Plant 2	619.19	1.50	**9930.00**	17	9	1	611.39	79.60	1410.00	17	10	0	3.00	0.34	14.90	17	7	0	37.44	9.10	150.00	17	1	0
Plant 6	595.48	8.40	**3370.00**	6	1	1	353.83	133.00	557.00	6	3	0	2.48	0.60	6.60	6	3	0	18.02	15.20	20.90	6	0	0
Plant 7 and DT-12	148.47	51.40	264.00	3	3	0	801.00	380.00	1600.00	3	0	0	1.70	0.74	3.40	3	0	0	37.93	18.80	65.50	3	0	0
DT-8 and DT-11	9.86	4.90	13.10	7	3	0	443.57	295.00	675.00	7	3	0	0.43	0.39	0.54	7	6	0	16.11	9.50	20.30	7	2	0

Location	Selenium						Uranium						Vanadium						Zinc					
	ISOU PRG = 5,100						ISOU PRG = 3,100						ISOU PRG = 5,200						ISOU PRG = 310,000					
	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG	Average	Minimum	Maximum	Total # of Samples	# of Detects	# of Samples Exceeding the PRG
Plant 1	1.91	0.36	4.10	48	42	0	15.33	0.60	105.00	48	26	0	26.84	13.10	35.70	48	3	0	1004.83	40.10	8930.00	48	9	0
Plant 2	1.35	0.31	6.90	17	11	0	201.91	5.60	1070.00	17	4	0	46.56	7.10	104.00	17	0	0	131.58	37.80	890.00	17	11	0
Plant 6	1.60	0.36	3.40	6	6	0	29.23	7.90	48.60	6	3	0	28.93	20.30	47.30	6	0	0	89.95	41.50	161.00	6	0	0
Plant 7 and DT-12	1.58	0.36	4.00	3	3	0	13.10	6.50	25.90	3	2	0	30.47	29.60	31.10	3	0	0	1065.20	73.60	2620.00	3	3	0
DT-8 and DT-11	1.71	0.36	6.00	7	4	0	6.73	6.50	7.10	7	7	0	19.51	10.90	25.20	7	0	0	52.30	29.50	66.90	7	0	0

[a] This table does not include data for inaccessible soil or sewer sediment.

[b] Appendix J provides the analytical results for each location at the property including summary statistics for each PCOC. Statistics include number of samples, minimum, maximum, average, median, and mode of the parameter concentration.

Units are mg/kg.

Bold values and gray shading indicate samples collected at the property that exceeded the PRG.

4.4.1 Comparison to Background

Sample results for each PCOC were compared to BVs. As shown in Table 4-12, there were exceedances of BVs for each of the radiological PCOCs in sewer sediment and soil adjacent to sewers. With the exception of lead in sewer sediment and uranium metal in soil adjacent to sewers, all of the metal PCOCs had at least one exceedance of BVs in the sewer sediment samples and soil samples collected adjacent to sewers.

Table 4-12. Number of Samples Associated with Sewers Exceeding Background

PCOC	Number of Samples	Number of Samples Exceeding Background	Percentage of Samples Exceeding Background
Sewer Sediment			
Radiological			
Ac-227	26	3	12%
Pa-231	26	4	15%
Ra-226	26	6	23%
Ra-228	26	4	15%
Th-228	26	9	35%
Th-230	26	7	27%
Th-232	26	4	15%
U-235	26	10	38%
U-238	26	9	35%
Metals			
Arsenic	23	1	4%
Cadmium	23	3	13%
Cobalt	23	2	9%
Copper	23	6	26%
Lead	23	0	0%
Manganese	23	1	4%
Molybdenum	23	5	22%
Nickel	23	21	91%
Selenium	23	7	30%
Uranium Metal	23	12	52%
Vanadium	23	1	4%
Zinc	23	5	22%
Soil Adjacent to Sewers			
Radiological			
Ac-227	160	34	21%
Pa-231	160	10	6%
Ra-226	160	17	11%
Ra-228	160	41	26%
Th-228	160	48	30%
Th-230	160	29	18%
Th-232	160	41	26%
U-235	160	77	48%
U-238	160	64	40%

Table 4-12. Number of Samples Associated with Sewers Exceeding Background (Continued)

PCOC	Number of Samples	Number of Samples Exceeding Background	Percentage of Samples Exceeding Background
Soil Adjacent to Sewers			
Metals			
Arsenic	81	20	25%
Cadmium	81	30	37%
Cobalt	81	40	49%
Copper	81	6	7%
Lead	81	7	9%
Manganese	81	20	25%
Molybdenum	81	16	20%
Nickel	81	27	33%
Selenium	81	67	83%
Uranium Metal	81	0 [a]	0%
Vanadium	81	11	14%
Zinc	81	19	23%

[a] There is no BV for uranium metal in soil.

4.4.2 Comparison to Preliminary Remediation Goals

Table 4-13 summarizes the results of the screening of the PCOC data against PRGs in sewer sediment and soil adjacent to sewers. The RI sampling results indicate that three of the radiological PCOCs (Ra-226, Ra-228, and U-238) and one metal PCOC (arsenic) exceed their respective PRGs in sewer sediment. These four sediment PCOCs have been carried forward into the BRA. In soil samples collected adjacent to the sewers, six of the radiological PCOCs (Ac-227, Pa-231, Ra-226, Ra-228, Th-230, and U-238) and three of the metal PCOCs (arsenic, cadmium, and lead) exceed their respective PRGs and have been retained for evaluation in the BRA.

Based on the results presented in Table 4-8, the highest concentrations of the radiological PCOCs exceeding PRGs in sewer sediment (Ra-226, Ra-228, and U-238) are associated with samples collected from manholes at Plant 1. The highest concentrations of Ac-227, Pa-231, Ra-226, Ra-228, and Th-230 in soil collected adjacent to sewers were detected in soil samples collected adjacent to the Destrehan Street sewer that runs beneath DT-12 and the Levee at DT-2. The maximum concentration of U-238 was associated with a soil sample collected adjacent to a sewer line in Plant 2 (at location SLD124580, as shown in Appendix J). Because this Plant 2 sewer line was subsequently remediated in calendar year 2011 under the 1998 ROD, this sampling location has not been carried forward to the BRA.

Based on the results presented in Tables 4-10 and 4-11, the highest concentrations of arsenic associated with sewer sediment and soil adjacent to sewer lines were detected in Plant 1. The highest concentration of lead in soil adjacent to sewer lines was detected in Plant 2. The single cadmium exceedance of PRGs was in a soil sample collected adjacent to a sewer line in Plant 1.

Table 4-13. Number of Samples Associated with Sewers Exceeding the Preliminary Remediation Goals

PCOC	PRG	Number of Samples	Number of Samples Exceeding the PRG	Percentage of Samples Exceeding the PRG
Sewer Sediment				
Radiological				
Ac-227	11.4 pCi/g	26	0	0%
Pa-231	1.25 pCi/g	26	0	0%
Ra-226	0.0248 pCi/g	26	26	100%
Ra-228	0.0538 pCi/g	26	26	100%
Th-228	121 pCi/g	26	0	0%
Th-230	20 pCi/g	26	0	0%
Th-232	18.9 pCi/g	26	0	0%
U-235	34.3 pCi/g	26	0	0%
U-238	1.65 pCi/g	26	5	19%
Metals				
Arsenic	1.6 mg/kg	23	21	91%
Cadmium	800 mg/kg	23	0	0%
Cobalt	300 mg/kg	23	0	0%
Copper	41,000 mg/kg	23	0	0%
Lead	800 mg/kg	23	0	0%
Manganese	23,000 mg/kg	23	0	0%
Molybdenum	5,100 mg/kg	23	0	0%
Nickel	20,000 mg/kg	23	0	0%
Selenium	5,100 mg/kg	23	0	0%
Uranium	3,100 mg/kg	23	0	0%
Vanadium	5,200 mg/kg	23	0	0%
Zinc	310,000 mg/kg	23	0	0%
Soil Adjacent to Sewers				
Radiological				
Ac-227	11.4 pCi/g	160	5	3%
Pa-231	1.25 pCi/g	160	10	6%
Ra-226	0.0248 pCi/g	160	158	99%
Ra-228	0.0538 pCi/g	160	160	100%
Th-228	121 pCi/g	160	0	0%
Th-230	20 pCi/g	160	11	7%
Th-232	18.9 pCi/g	160	0	0%
U-235	34.3 pCi/g	160	0	0%
U-238	1.65 pCi/g	160	66	41%
Metals				
Arsenic	1.6 mg/kg	81	77	95%
Cadmium	800 mg/kg	81	1	1%
Cobalt	300 mg/kg	81	0	0%
Copper	41,000 mg/kg	81	0	0%
Lead	800 mg/kg	81	5	6%
Manganese	23,000 mg/kg	81	0	0%
Molybdenum	5,100 mg/kg	81	0	0%
Nickel	20,000 mg/kg	81	0	0%
Selenium	5,100 mg/kg	81	0	0%
Uranium Metal	3,100 mg/kg	81	0	0%
Vanadium	5,200 mg/kg	81	0	0%
Zinc	310,000 mg/kg	81	0	0%

4.5 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION AND IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

COPCs were conservatively identified based on a single exceedance of their risk-based PRG and are applied on a sitewide basis. These COPCs are carried forward into the BRA. No COPCs were eliminated from being carried into the BRA based on their results being less than BVs. Based on the conservative inclusion of the COPCs to be carried forward in the BRA, potential impacts for defining the nature and extent of contamination due to deviations from the RI WP, including modification of sampling locations and limiting of sampling depth, are minimal. There is no need for additional sampling of inaccessible soil, sewer sediment, soil adjacent to sewers, or building/structure surfaces to define nature and extent of contamination. All site soil and sediment characterization necessary to perform risk assessment and remedial alternatives has been completed. Additional sampling will not impact the remedy decision-making process. The need for additional sampling for remedial design will be evaluated during the remedial design phase after RGs are developed for the COCs.

The COPCs that will be carried forward for evaluation in the BRA are presented in Table 4-14.

Table 4-14. Contaminants of Potential Concern for the Inaccessible Soil Operable Unit

Media	Radiological	Metals
Inaccessible Soil	Ac-227, Pa-231, Ra-226, Ra-228, Th-230, Th-232, U-235, U-238	Arsenic
Sewer Sediment	Ra-226, Ra-228, U-238	Arsenic
Soil Adjacent to Sewers	Ac-227, Pa-231, Ra-226, Ra-228, Th-230, U-238	Arsenic, Cadmium, Lead
Structural Surfaces	Ac-227, Pa-231, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, U-238	NA

NA = Not applicable.