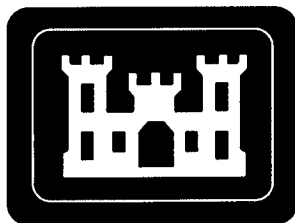

REVISION 0

**PRE-DESIGN INVESTIGATION SUMMARY
REPORT AND FINAL STATUS SURVEY
EVALUATION FOR THE ACCESSIBLE SOILS
WITHIN THE ST. LOUIS DOWNTOWN SITE
VICINITY PROPERTY METROPOLITAN
ST. LOUIS SEWER DISTRICT LIFT STATION
(DT-15)**

ST. LOUIS, MISSOURI

AUGUST 27, 2012



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

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BACK COVER

*CD-ROM	Appendices F, H and J; and Attachment I-1, EPC Calculations (Pro-UCL Output Files)
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ACRONYMS AND ABBREVIATIONS

Both English and metric units are used in this report. The units used in a specific situation are based on common unit usage or regulatory language.

Δ/σ	relative shift
σ	standard deviation
σ_{eff}	effective standard deviation
Ac	actinium
AEC	U.S. Atomic Energy Commission
ARAR	applicable or relevant and appropriate requirement
bcm	below cover material
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	<i>Code of Federal Regulations</i>
cm	centimeter(s)
COC	contaminant of concern
cpm	counts per minute
DCGL	derived concentration guideline level
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
DT-15	vicinity property Metropolitan St. Louis Sewer District Lift Station
ELAP	Environmental Laboratory Accreditation Program
EPC	exposure point concentration
FS	<i>Feasibility Study for the St. Louis Downtown Site</i>
FSS	final status survey
FSSE	final status survey evaluation
FSSP	<i>Final Status Survey Plan for Accessible Soil within Mallinckrodt Property and the Vicinity Properties, Excluding Plants 1, 2, and the City Property at the St. Louis Downtown Site</i>
ft	foot/feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
g/cm^3	gram(s) per cubic centimeter
g/m^3	gram(s) per cubic meter
GRAAA	Ground-Water Remedial Action Alternative Assessment
g/yr	gram(s) per year
GWS	gamma walkover survey
HISS	Hazelwood Interim Storage Site
HTZ	hot zone
kg/yr	kilogram(s) per year
LBGR	lower bound of the gray region
LCS	laboratory control sample
m	meter(s)

ACRONYMS AND ABBREVIATIONS (Continued)

m/yr	meter(s) per year
m ²	square meter(s)
m ³ /yr	cubic meter(s) per year
Mallinckrodt	Mallinckrodt Chemical Works
MARSSIM	<i>Multi-Agency Radiation Survey and Site Investigation Manual</i>
MDC	minimum detectable concentration
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineer District (U.S. Army Corps of Engineers)
mrem/yr	millirem per year
MSD	Metropolitan St. Louis Sewer District
NAD	normalized absolute difference
NCP	National Oil and Hazardous Substances Contingency Plan
NRC	U.S. Nuclear Regulatory Commission
NUREG	U.S. Nuclear Regulatory Commission Regulation
OU	operable unit
Pa	protactinium
Pb	lead
pCi/g	picocurie per gram
pCi/L	picocurie per Liter
pCi/m ²	picocurie per square meter(s)
PDI	pre-design investigation
PP	Proposed Plan
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QCSR	Quality Control Summary Report
Ra	radium
RA	remedial action
RAO	remedial action objective
RESRAD	RESidual RADioactivity (computer model)
RG	remediation goal
RI	remedial investigation
ROD	<i>Record of Decision for the St. Louis Downtown Site</i>
RPD	relative percent difference
SAG	<i>Sampling and Analysis Guide for the St. Louis Sites</i>
SAIC	Science Applications International Corporation
SLDS	St. Louis Downtown Site
SOR _G	gross sum of ratios
SOR _N	net sum of ratios
SU	survey unit
Th	thorium
U	uranium
UCL ₉₅	95 percent upper confidence limit

ACRONYMS AND ABBREVIATIONS (Continued)

USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VP	vicinity property
VQ	validation qualifier
WRS	Wilcoxon Rank Sum
yr	year

ABSTRACT

Site Name	St. Louis Downtown Site Vicinity Property: Metropolitan St. Louis Sewer District Lift Station (DT-15)
Operable Unit	Accessible soil and ground water
Location	St. Louis, Missouri
Regulatory Oversight	U.S. Environmental Protection Agency, Region 7 Missouri Department of Natural Resources
Contract Oversight	U.S. Army Corps of Engineers (USACE), St. Louis District
Verification Contractor	Science Applications International Corporation
Waste Source	Manhattan Engineer District and the U.S. Atomic Energy Commission uranium ore processing and uranium metal production in the 1940s and 1950s.
Contaminants	Radionuclides from the uranium-238, thorium-232, and uranium-235 decay series. Non-radiological contaminants are not applicable to the property addressed in this report per the <i>Record of Decision for the St. Louis Downtown Sites</i> (ROD) (USACE 1998a).
Remediation Method, Quantity, and Date	Accessible Soils: None required.
Regulatory Requirements/ Remediation Goals	See Section 2.1.3 for ROD requirements.
Results	The accessible soil on DT-15 is releasable for unrestricted use based on a comparison of the analytical data, radiological surveys, and a risk and dose assessment to the ROD remediation goals. The highest residual risk ¹ calculated for this property is zero, which met the target risk range 10^{-6} to 10^{-4} . The highest residual radiological dose calculated for this property is 0 millirem per year (mrem/yr), which is compliant with the dose criterion of 25 mrem/yr. The potential risk and dose was the highest resulting risk and dose while evaluating each year over the next 1,000 years based on a residential use scenario and does not account for cover material.
Description	This report addresses a property near the intersection of the levee and McKinley Bridge in downtown St. Louis that is owned by the City of St. Louis and has been designated as DT-15. DT-15 is located east of the Burlington Northern Santa Fe Railroad (DT-12), west of City Property (DT-2), north of the City of Venice, Illinois, property (DT-11), and south of the Terminal Railroad Association property (DT-9). The DT-15 pumping station consists of a two story brick structure and inlet chamber. Adjacent to the pumping station, to the south, is a paved equipment yard. Remaining property area is covered with vegetation. Current elevations on the property vary from about 440 feet above mean sea level near the top of the levee to about 423 feet above mean sea level adjacent to the pumping station building.

¹ When estimating cancer risk, a lifetime risk level for an exposed individual and how many additional cancer cases might occur in a population of exposed people (i.e., 1×10^{-6} is equal to one additional case in a population of one million) are predicted. These are cancers that may or may not occur, but if they were to occur, they would be in addition to cancers from other causes, such as smoking tobacco. For non-cancer toxicity, a daily exposure level that is likely to be of little risk to people is estimated.

1.0 INTRODUCTION

The *Record of Decision for the St. Louis Downtown Site* (ROD) (USACE 1998a) provides the final remedial action (RA) for the accessible soil and ground water contaminated as a result of Manhattan Engineer District (MED) and U.S. Atomic Energy Commission (AEC) uranium manufacturing and processing activities at the St. Louis Downtown Site (SLDS).

The response actions described in this report were performed by the St. Louis District U.S. Army Corps of Engineers (USACE) as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was initiated by the AEC in 1974 to identify, remediate, or otherwise control sites where residual radioactivity remains from operations conducted for the MED and was continued by the successor agencies to the AEC until 1997 when the U.S. Congress transferred responsibility for the execution aspect of FUSRAP from the U.S. Department of Energy (DOE) to the USACE. The DOE will assume a stewardship responsibility beginning two years after completion of the response action at the SLDS.

The USACE was authorized by Congress as the lead agency for implementation of the Selected Remedy. The remedy was selected by the USACE in consultation with the U.S. Environmental Protection Agency (USEPA) and with the concurrence of the Missouri Department of Natural Resources (MDNR).

The work within the scope of this report was managed by the USACE St. Louis District FUSRAP Project Office, and was accomplished in accordance with the National Oil and Hazardous Substances Contingency Plan (NCP) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

This report specifically documents the pre-design investigation (PDI) and final status survey evaluation (FSSE) conducted at the property described in Section 1.1 (SLDS vicinity property [VP] Metropolitan St. Louis Sewer District [MSD] Lift Station [DT-15]) and shown on Figure 1. The PDI was conducted at this property because it was potentially impacted by the inadvertent release of materials from uranium processing at Mallinckrodt Chemical Works (Mallinckrodt). Mallinckrodt is currently owned by Mallinckrodt LLC.

When it was determined that RA was not necessary at this property, a FSSE was conducted using procedures compatible with the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (DOD 2000) to ensure that any residual radioactivity complied with the criteria specified in the ROD (USACE 1998a). Non-radiological contaminants are not applicable to this property. Inaccessible soils that contain MED/AEC contamination and the surfaces of buildings and other permanent structures are excluded from the scope of the ROD and will be addressed in a subsequent CERCLA action. Inaccessible soils on this property are shown on Figure 2.

1.1 PROPERTY DESCRIPTION

This report addresses a property in downtown St. Louis that is currently owned by the City of St. Louis and has been designated as DT-15. The property is located near the intersection of the levee and McKinley Bridge.

This property is being addressed in this report because it was potentially impacted by the inadvertent release of residual radioactivity from uranium metal production processes. DT-15 was not specifically identified as part of the SLDS in the ROD. However, the SLDS boundaries were later clarified to include this and other properties, in accordance with the *Memorandum*:

Non-Significant Change to the Record of Decision for the St. Louis Downtown Site (USACE 2005c).

Table 1 contains the addresses of the property being addressed in this report, the parcel designation established by St. Louis City (STLCITY 2012), and whether the ROW was included. The area within the scope of this report is shown on Figure 1.

Table 1. Addresses, Parcels, and Designations

Address	Parcel	Designation for this Project	Right of Way Included
1 East Salisbury Street	25260000200	DT-15	No ^a
3525 North Wharf Street	25360000200		

^a There is no ROW adjacent to DT-15.

As shown on Figure 1, DT-15 is located east of the Burlington Northern Santa Fe Railroad (DT-12), west of City Property (DT-2), north of the City of Venice, Illinois, property (DT-11), and south of the Terminal Realty Company property (DT-9). The DT-15 pumping station consists of a two-story, brick structure and inlet chamber. Adjacent to the pumping station, to the south, is a paved equipment yard. Remaining property area is covered with vegetation.

Since DT-15 is situated within the original floodplain of the Mississippi River, this area is 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. Part of the levee is present on the DT-15 property. As shown on Figure 2, the soils beneath the levee and the pumping station building are inaccessible. Current elevations on the property vary from about 440 feet above mean sea level near the top of the levee to about 423 feet above mean sea level adjacent to the pumping station building. The surrounding properties are a mixture of industrial and commercial facilities.

Historical information indicates that DT-15 was mostly undeveloped prior to 1961, with only a minor roadway and a small out-building noted on aerial photos taken prior to the construction of the Mississippi River Flood Protection Levee. Currently, over 60 percent of the DT-15 property is covered by the levee, which was constructed with select embankment fill material in 1961. The MSD Pumping Station was subsequently installed in 1963.

1.2 GEOPHYSICAL FEATURES

The regional geological setting of the subsurface soils at the SLDS is generally characterized by a fill layer which extends from the surface down to a layer of alluvial sediments (i.e., silty sediments deposited by flowing water). The alluvial sediments overlay the bedrock. The fill, discernible as multiple horizons at most locations, has an average thickness of 13 ft and may contain concrete, brick, glass, coal cinders, slag material, and/or other miscellaneous material that was placed on top of the original flood plain sediments in the late 1800s and early 1900s. The alluvial flood plain deposits underlying the fill material consist of stratified clays, silts, sands, and gravels that range in thickness from 5 to 30 ft. The alluvial deposits generally become coarser grained with depth. Earthquake faults are not evident (USACE 1998a).

Under the fill and alluvial deposits, the uppermost bedrock unit underlying the SLDS is the Mississippian age Ste. Genevieve Formation. The formation is composed of limestone with some dolomite. The depth to bedrock at the SLDS ranges from approximately 10 ft below ground

surface (bgs) on the western side of the property to 80 ft bgs near the Mississippi River (USACE 1998a). On DT-15, sand and gravel fill with some clay was encountered in all of the sampling locations.

Surface water runoff east of the levee on DT-15 follows the surface topography, which slopes gently from west to east towards the Mississippi River. The surface water runoff west of the levee on DT-15 follows the surface topography, which slopes gently from east to west towards DT-12. The surface water runoff is collected in various inlets to the St. Louis Municipal storm water underground drainage system, which conveys the water to the Mississippi River.

1.3 GROUND WATER

Ground water at the SLDS is found within three horizons (or hydrostratigraphic units): the upper, nonlithified (soil) unit, referred to as the "A Unit"; the lower, nonlithified unit, referred to as either the Mississippi Alluvial Aquifer or the "B Unit"; and the bedrock (the lithified water-bearing unit), referred to as the "C Unit". The Mississippi Alluvial Aquifer is the principal aquifer in the St. Louis area, including the SLDS area. Aquifers in this region also exist in the bedrock formations underlying the alluvial deposits (USACE 1998a).

The upper ground-water unit at the SLDS (the A Unit) consists of fill overlying naturally deposited clays and silts. The shallow ground-water system is not considered to be a potential source of drinking water because of its poor quality resulting from the natural occurring dissolved solid and metal content and very low yields. The A Unit is underlain by the sandy silts and silty sands of the Mississippi Alluvial Aquifer (the B Unit). Ground waters of the St. Louis area are generally of poor quality and do not meet drinking water standards without treatment. Expected future use of ground water at the SLDS is minimal, since the higher quality and large quantity of Mississippi and Missouri Rivers is readily available (USACE 1998a). There are no ground-water monitoring wells on DT-15. Ground-water monitoring is performed on and in the vicinity of the SLDS. The ground-water monitoring data is contained in annual environmental monitoring reports. The need for ground-water remediation will be investigated as part of Phase II of the Ground-Water Remedial Action Alternative Assessment (GRAAA). In addition, there is a memorandum of understanding between the MDNR and the City of St. Louis (MDNR and City of St. Louis 2006) that prohibits the installation and use of potable water supply wells by public and private entities.

1.4 NATURE AND EXTENT OF CONTAMINATION

From 1942 to 1957, Mallinckrodt processed uranium ore and other feed materials to produce various forms of uranium compounds and uranium metal for U.S. military purposes under contract to the MED/AEC. Mallinckrodt performed this processing at its facilities in downtown St. Louis, Missouri. Materials from uranium processing were inadvertently released into the environment. The primary contaminants of concern (COCs) for this property are the radioactive metals radium (Ra), thorium (Th), and uranium (U) and their decay products. Soil on various parts of Mallinckrodt property and some VPs has been determined to have COCs above background levels. VPs may have been impacted by contaminant migration in air, water, waste handling, or a combination thereof. Non-radiological COCs do not apply to DT-15 per the ROD (USACE 1998a).

1.5 ENVIRONMENTAL MONITORING

Environmental monitoring was conducted to determine if the public and/or the environment (i.e., water and air) was being impacted by conditions at the site or RAs on the site. Environmental monitoring for the FUSRAP in St. Louis has confirmed that radiation safety regulations for the public, workers, and the environment have been met during the conduct of this project.

There are no ground-water monitoring wells on DT-15; however, at the SLDS, ground-water monitoring is accomplished site-wide rather than on a property-specific basis. In calendar year (CY) 2007 (the year the sampling was performed on DT-15), 10 monitoring wells (2 in HU-A and 8 in HU-B) were sampled for radionuclides and inorganic COCs at the SLDS. The ground-water monitoring data are contained in the *St. Louis Downtown Site Annual Environmental Monitoring Data and Analysis Report for Calendar Year 2007* (SLDS EMDAR CY 2007) (USACE 2008).

1.6 CURRENT AND REASONABLY ANTICIPATED FUTURE USE

The current land uses of DT-15 are predominantly commercial/industrial. The SLDS is generally commercial/industrial with some residences and a recreational bike trail adjacent to the Mississippi River. The closest residential dwelling is located approximately 200 ft southwest of the southwestern corner of the SLDS. Zoning regulations prohibit new residences from being established in the area as industrial. No significant changes in land use are expected.

1.7 SUMMARY OF COMMUNITY INVOLVEMENT ACTIVITIES

The community has been provided with multiple opportunities to be involved with the decision process at the St. Louis sites. The St. Louis Sites Remediation Task Force actively investigated the St. Louis Sites from 1994 to 1996 and published a report, *St. Louis Sites Remediation Task Force Report* (STLOC 1996), which included specific recommendations and hundreds of pages of analysis. The St. Louis Sites Remediation Task Force became the St. Louis Oversight Committee after publishing its report.

The St. Louis Oversight Committee, formed in 1997, is a group of community leaders who serve in a consultative and participatory role in the cleanup of the St. Louis FUSRAP sites. As a consultant, the committee provides comments, recommendations, and constructive criticism for USACE in its efforts to address the FUSRAP sites. Members of the committee are actively involved in their neighborhoods, businesses, and governmental units. They assist USACE by clarifying community concerns and conveying information to other members of the community to ensure that residents are fully informed about response actions. The Committee ensures that residents' questions are answered to the fullest extent possible. The USACE has provided regular briefings at the St. Louis Oversight Committee meetings, which have been open to the public. The USACE has maintained a web site with current information about the status of the St. Louis FUSRAP Sites and historical documentation. Newsletters and fact sheets have been distributed throughout the community on an as-needed basis.

A public meeting was held at the Henry Clay Elementary School near the SLDS on April 21, 1998, to present the *Feasibility Study for the St. Louis Downtown Site* (FS) (USACE 1998b) and Proposed Plan (PP) to interested members of the community and to solicit comments on the FS/PP. A notice announcing the availability of the FS/PP and the intent to hold a public meeting to discuss the documents was published in the Federal Register and in the St. Louis Post-

Dispatch. The meeting included an open-house session allowing one-on-one discussions with agency representatives, an informal presentation, and an open microphone question and answer period. A complete transcript of the meeting was kept and provided to individuals upon request. In addition, the transcript of the public meeting and comment period was made available to the public on the USACE's St. Louis District FUSRAP website <http://www.mvs.usace.army.mil/eng-con/expertise/fusrap.html> and was included as part of the Administrative Record. A 30-day comment period for the FS/PP began on April 8, 1998, and ended on May 8, 1998. Responses to the comments received from the public, and local, state, and federal agencies were provided in the Responsiveness Summary. The detailed responsiveness summary on the FS/PP, including responses to comments received during the public meeting was included in the final ROD, Appendix A. USACE accepted and complied with the public's recommendation for remediation work to follow Alternative 6, "Selective Excavation and Disposal" rather than USACE's preferred Alternative 4, "Partial Excavation and Disposal".

In August 1998, USEPA signed the final ROD developed by USACE in accordance with Alternative 6. Program documents, including the ROD, have been made available to the public through the Administrative Record maintained at the USACE FUSRAP Project Office, 8945 Latty Avenue, Berkeley, Missouri; at the St. Louis Public Library, Government Information Section, 1302 Olive Street, St. Louis, Missouri; or at Henry Clay Elementary School, 3820 North 14th Street, St. Louis, Missouri.

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2.0 BACKGROUND ON THE REMEDIATION PROCESS AND PRE-DESIGN INVESTIGATION

The purpose of a PDI is to obtain data to address historical data gaps, further define the nature and extent of contamination, and provide data needed to support remedial design (if required) and/or the FSSE. The PDI was executed on DT-15 to collect additional data to be used in the design or to confirm that the property met the remediation goals (RGs) as presented in the ROD. This section describes the PDI conducted in 2007 and the associated conclusions. Although no remediation was required at DT-15, this section also summarizes the remedial action objectives (RAOs), the selected remedy, and the RGs that are specified in the ROD.

2.1 REMEDIAL ACTION

The CERCLA process began with gathering existing information about the SLDS and determining if there was a threat to human health and the environment. In 1986, the DOE began gathering this information. A remedial investigation was performed to characterize the extent and type of release, and to evaluate the baseline risk to human health and the environment. The results of the investigation were documented in the *Remedial Investigation Report for the St. Louis Site* (DOE 1994). The *Feasibility Study for the St. Louis Downtown Site* (FS) (USACE 1998b) was developed to evaluate remedial alternatives.

While DT-15 was not specifically addressed during the remedial investigation activities, the nearby Mallinckrodt plants were included. The Mallinckrodt plants generated the types of potential radiological contamination that could be expected at the SLDS.

2.1.1 Remedial Action Objectives

RAOs were established early in the CERCLA process for the SLDS. The RAOs served as a basis for developing RA alternatives for the ROD. The RAOs describe what the RA needed to accomplish in order to be protective of human health and the environment. Table 2 identifies the following RAOs for the SLDS (USACE 1998a).

Table 2. SLDS Remedial Action Objectives

Medium	Remedial Action Objective
Accessible Soil	Prevent exposures from surface residual contamination in soils greater than the criteria prescribed in 40 <i>Code of Federal Regulations (CFR)</i> Part 192. Eliminate or minimize the potential for humans or biota to contact, ingest, or inhale soil containing COCs. Eliminate or minimize volume, toxicity, and mobility of impacted soil. Eliminate or minimize the potential for migration of radioactive materials off-site. Comply with applicable or relevant and appropriate requirements (ARARs). Eliminate or minimize potential exposure to external gamma radiation.
Ground water	Remove sources of COCs in the A Unit. Continue to maintain low concentrations of operable unit COCs in the B Unit.

2.1.2 Selected Remedy

The selected remedy for the SLDS was Alternative 6 from the FS, “Selective Excavation and Disposal”. The selected remedy addressed accessible soil and ground water contaminated as a result of MED/AEC uranium ore processing activities. Contaminants from other sources that are commingled with the MED/AEC COCs are addressed at the same time.

The main components of the Selected Remedy for the SLDS, pertinent to DT-15, consist of the following:

- Excavation of all accessible contaminated soils to RGs that support release and dispose off-site at a permitted facility, and
- No remedial action is required for ground water beneath the site. Perimeter monitoring of the ground water in the B Unit will be performed, and the need for ground-water remediation will be evaluated as part of the periodic reviews performed for the site. Ground-water monitoring is currently being conducted at the SLDS. The need for ground-water remediation will be investigated as part of Phase II of the Ground-Water Remedial Action Alternative Assessment.

The following points were identified in the ROD in selecting this remedy.

- The current land use is generally commercial/industrial with some residences and a recreational bike trail adjacent to the Mississippi River. The closest residential dwelling is located approximately 200 ft southwest of the southwestern corner of the SLDS. Zoning regulations prohibit new residences from being established in the area. No significant changes in land use are expected (USACE 1998a).
- Ground water is not currently used as a water-supply source. The contaminated shallow ground-water system (A-unit) is not considered to be a potential source of drinking water because of its poor quality resulting from the natural occurring dissolved solid and metal content and very low yields.
- The Mississippi Alluvial Aquifer (the B Unit) is considered to be a potential source of drinking water. However, its use for a drinking water resource is highly unlikely for several reasons, including the industrial setting of the SLDS, the site’s proximity to both the Mississippi River and the city’s drinking water supply, and its poor water quality (i.e., naturally-occurring high dissolved solids and metal content).
- Approved borrow obtained from an offsite location will be used to backfill excavations above 1.2 or 1.8 m (4 or 6 ft) to grade.
- The final status survey (FSS) will be compatible with the MARSSIM (DOD 2000).

2.1.3 Remediation Goals

Achievement of RGs demonstrates that residual concentrations of COCs within accessible soil on the property are protective and can be released in accordance with the Selected Remedy. Table 3 lists the RGs, their applicability to DT-15, and the method for confirming that the applicable RGs have been achieved.

The media to be evaluated at DT-15 is limited to accessible soil. DT-15 does not have any ground-water monitoring wells. Ground-water monitoring results associated with the SLDS

are documented in annual environmental monitoring reports. There is no surface water or sediment on this property.

Table 3. Remediation Goals and Assessment Methods

Type	Specification		Methods
Soil Radionuclide (Results from a 0.5 ft soil interval can be averaged over 100 square meters [m ²].)	Ra-226 Th-230	<5 picocuries per gram (pCi/g) above background for soil less than 0.5 ft below cover material (bcm). <15 pCi/g above background for soil deeper than 0.5 ft bcm.	Use analytical results to calculate the net sum of the ratio (SOR _N) and gross sum of the ratio (SOR _G). Calculate area-weighted averages as necessary. Use MARSSIM to determine the required number of systematic or random samples.
	Ra-228 Th-232	<5 pCi/g above background for soil less than 0.5 ft bcm <15 pCi/g above background for soil deeper than 0.5 ft bcm.	
	U-238	<50 pCi/g above background for soil.	
	SOR _N ^{a,b}	$SOR_N^{depth \leq 0.5ft} = \frac{(greater \ of \ Th-230_N \ or \ Ra-226_N)}{5 \ pCi/g} + \frac{(greater \ of \ Th-232_N \ or \ Ra-228_N)}{5 \ pCi/g} + \frac{U-238_N}{50 \ pCi/g}$ $SOR_N^{depth > 0.5ft} = \frac{(greater \ of \ Th-230_N \ or \ Ra-226_N)}{15 \ pCi/g} + \frac{(greater \ of \ Th-232_N \ or \ Ra-228_N)}{15 \ pCi/g} + \frac{U-238_N}{50 \ pCi/g}$ <p>SOR_N < 1 over 100 m² using area-weighted average SOR_N < 1 when systematic sample results averaged over survey unit (SU)</p>	
	SOR _G	Pass MARSSIM Wilcoxon Rank Sum (WRS) test	Use WRS test to demonstrate that the SU achieves RGs (if required).
Soil Non-Radionuclide	Not applicable (N/A)		
Consolidated Material Surfaces	N/A		
Health Risk	10 ⁻⁶ to 10 ⁻⁴		Use the RESidual RADioactivity (RESRAD) computer model to estimate health risk.
Dose	Total Effective Dose Equivalent < 25 millirem/year (mrem/yr)		Use soil sample results as inputs to the RESRAD to estimate dose.
Toxicity	N/A		
Ground Water	No action required at DT-15.		

^a In the SOR_N equations, the radioactivity (e.g., Ra-226) is measured as a concentration (i.e., pCi/g). The radioactivity concentration is divided by the RG for that specific radionuclide (e.g., 5 pCi/g for Ra-226). The subscript "N" represents net concentration above background. Background values were determined using 32 samples collected from non-impacted areas near the SLDS. The background reference sample data is summarized in Appendix A.

^b A soil concentration of 5 pCi/g of Th-230 would result in the in-growth of < 5 pCi/g Ra-226 (approximately 2 pCi/g) at the end of the 1,000-year time period stated in 40 CFR 192.02(a). Therefore, constraining the concentration to 5 pCi/g for the higher of Ra-226 or Th-230 in surface soil along with the use of the unity rule assures that the concentration of Ra-226 does not exceed 5 pCi/g during the 1000-year time period. These RGs achieve doses that are less than typically < 15 mrem/yr in practice. In addition, risk assessments performed to date have determined that soils that meet the RGs achieve protectiveness to levels within the CERCLA risk range.

Notes:

The ROD lists RG components addressing ground-water monitoring of the Mississippi Alluvial Aquifer (B unit). This aquifer is addressed separately from this report on accessible soil.

The ROD lists an RG component addressing sewer and drain sediments. The sewer systems used for MED/AEC processing operations are not located within the boundary of DT-15; therefore, soils on DT-4 would not have been impacted by flow from areas within MED/AEC operations. Sewers (i.e., structures and interior sediment) will be addressed in a subsequent CERCLA action.

Inaccessible soils and structures are not within the scope of the ROD or the FSSE. Inaccessible soils include the footprint of a building, the supporting soils beneath the footprint, and the soils adjacent to the building necessary for structural stability and safety of the building. Similarly,

inaccessible soils may be associated with other structures, such as roadways, rail lines, and flood control levees.

Using this concept of inaccessible soils, there are inaccessible soils associated with the flood control levee, underground sewers, and the building on DT-15, as shown on Figure 2. The structures and the inaccessible soils associated with the structures on DT-15 will be evaluated in subsequent CERCLA actions.

2.1.4 Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and (NCP) §300.430(f)(1)(ii)(B) require that RAs at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations, which are collectively referred to as “ARARs,” unless such ARARs are waived under CERCLA section 121(d)(4).

Relevant and appropriate requirements are cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility citing laws that, while not “applicable” to a hazardous substance, pollutant, contaminant, RA, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that are well-suited to the particular site. Only those State standards that are identified in a timely manner, and are more stringent than Federal requirements may be relevant and appropriate. The key ARARs, as presented in the ROD, for the selected remedy are listed in the following paragraphs.

40 Code Of Federal Regulations (CFR) Part 192, Subpart A, Section 192.12(a) is relevant and appropriate: Residual radioactive material concentration of Ra-226 and Ra-228 in land averaged over any 100 square meter (m²) area shall not exceed the background level by > 5 picocuries per gram (pCi/g) averaged over the first 15 centimeters (cm) of soil (6 inches) and 15 pCi/g averaged over 15 cm thick layers of soil > 15 cm below the surface (USEPA 2002).

40 CFR Part 192, Subpart A, Section 192.02(b)(1-2) is relevant and appropriate: Radon-222 releases will not exceed an average rate of 20 picocurie per square meter (pCi/m²) per second or increase the average annual concentration by more than 0.5 picocurie per Liter (pCi/L) in air outside the site (USEPA 2002).

40 CFR Part 192, Sections 192.40 and 192.41 are relevant and appropriate: This regulation was used in developing the thorium cleanup criteria for sites where thorium ores were processed (USEPA 2002).

40 CFR Parts 257-272 are relevant and appropriate: The selected remedy will comply with 40 CFR Parts 257-272, which establish accountability in handling hazardous waste from generation to disposal.

10 CFR 20, Subpart E is applicable: This rule provides consistent standards to U.S. Nuclear Regulatory Commission (NRC) licensees for determining the extent to which lands must be remediated before decommissioning of a site can be considered complete and the license terminated.

2.2 PRE-DESIGN INVESTIGATION INFORMATION

The purpose of a PDI is to obtain data to address historical data gaps, further define the nature and extent of contamination, and provide data needed to support remedial design (if required) and/or the FSSE.

2.2.1 Historical Information Review

A review of available historical information sources and documents was performed as part of the PDI in order to gain insight as to when land development activities and/or related physical changes may have occurred at DT-15 and surrounding properties. These land development activities/changes included the placement of fill material, earth movement activities that may have altered the topography, and the addition, removal, or modification of man-made structural elements. Historical drainage/erosional features were also identified. Consideration was given to the identification of the changes to the topographic surface at the DT-15 before, during, and following MED/AEC operations in order to identify buried or topographically elevated soil horizons that may contain SLDS COCs.

The historical information sources and documents used to help identify features at DT-15 included the following:

- Historical topographic maps (USGS 1933, 1935, 1937, 1940, 1950, 1954, 1968, 1993);
- 86 aerial photographs covering approximately 36 dates provided by the USACE, Geospatial Engineering Branch (USACE 2001); and
- Mississippi River Flood Protection - St. Louis, Missouri, Reach 3, Sverdrup & Parcel, Inc., Engineers-Architects, USACE, St. Louis District (USACE 1960).

In addition, radiological and geological data from the remedial investigation (RI), previous USACE characterization, and PDI activities at DT-15 and adjacent VPs were also utilized to help develop insight as to the nature and extent of potential soil COCs at DT-15. Data from previous DOE and USACE investigations that are not included in the FSS data set are presented in Appendix B, and the sample locations are shown on Figure 3.

The historical information review also included an evaluation of the investigation activities and sampling results described in the *Radiological, Chemical, and Hydrogeological Characterization Report for the St. Louis Downtown Site in St. Louis, Missouri* (DOE 1990), the *Remedial Investigation Report for the St. Louis Site* (DOE 1994), and the *Remedial Investigation Addendum for the St. Louis Site* (DOE 1995) as pertaining to DT-15.

Potential contaminant migration scenarios were identified through the review of historical documentation and include:

- Airborne transport via dust from former processing operations and/or wind erosion from stockpiles.
- Direct loss of materials from hauling trucks and railcars. Given the configuration of roads and railroads and the proximity of DT-15 to the former Mallinckrodt processing operations, this migration scenario could not be ruled out.
- Transport via storm water causing erosion of residues from stockpiles or from the beds of railcars and trucks.

- Transport of materials via flood water from the Mississippi River. The highest flood water elevation in the SLDS area between 1941 and 1955 was determined to be 420 ft above mean sea level. DT-15 was noted to be significantly affected by floodwaters along with many other properties to the south of DT-15. After 1955, the SLDS was protected from flooding by the construction of a levee and floodwall, further reducing the potential for flood water impacting areas west of the levee on DT-15.

While the 1993 flood did not overtop the floodwall for downtown St. Louis, ponding due to storm water backup on the west side of the levee occurred in the areas of DT-15. This storm water backup is another potential migration scenario.

These potential contaminant migration scenarios were investigated through the PDI and FSS processes.

2.2.2 Pre-Design Investigation Survey

After review and evaluation of existing sample results, the USACE determined that the Class 2 samples collected in 2000 were not sufficient for FSS at DT-15 and that additional investigation (i.e., PDI) was necessary to evaluate the property (Class 2 samples will be further defined in section 3.2.1). The previous Class 2 samples collected in 2000 were from shallow borings in the levee embankment material placed in 1962 after the period of MED/AFC operations; therefore, they were not representative of soil below cover materials (bcm). These sample locations are depicted on Figure 3.

The available data leading up to the PDI survey in 2007 indicated that existing conditions on DT-15 could meet the RGs. Accordingly, the PDI survey was designed to meet MARSSIM in the event that the results could also serve as the FSS. MARSSIM states, "In some cases when no remediation is anticipated, results of the characterization survey may indicate compliance with derived concentration guideline levels (DCGLs) established by the regulatory agency. When planning for the potential use of characterization survey data as part of the final status survey, the characterization analytical data must be of sufficient quality and quantity for that use." The PDI for DT-15 included collection of soil samples from 21 locations, which included 15 potential Class 2 sample locations designed to meet MARSSIM. In addition, samples were collected from 6 PDI locations. The USACE PDI sample results not included in the FSS sample set are presented in Appendix B, and the sample locations are shown on Figure 3. The Class 2 sample results from the 2007 PDI that were used for the FSS are presented in Appendix C and the FSS sample locations are shown on Figure 4. The FSS design and methodology is discussed in Sections 3.2.1 through 3.2.3.

2.3 CONCLUSIONS FROM EXISTING DATA

PDI analytical data indicated no residual radioactivity above the RGs was present on DT-15 and the property was ready for an FSS. The PDI analytical data was of sufficient quality and quantity to be included in the FSS. No additional surveying or sampling on DT-15 was conducted during the FSS. The FSS analytical data indicated that remediation on DT-15 was not required.

3.0 FINAL STATUS SURVEY PROCESS

3.1 DATA QUALITY OBJECTIVES

The data quality objective (DQO) process is a strategic planning approach for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including where to collect samples, how many samples to collect, and the tolerable level of decision errors for the study. The DQO process includes the following seven steps from the USEPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA 2006a):

- State the problem. Inadvertent release of contaminants into the environment.
- Identify the decision. Determine if the accessible soil on DT-15 can be released for unrestricted use in accordance with the ROD.
- Identify inputs to the decision. Radiological soil analytical data for accessible soil.
- Define the study boundaries. Accessible soil on DT-15.
- Develop a decision rule. See Table 3.
- Specify tolerable limits on decision errors. The desired tolerable limits included minimum detectable concentrations (MDCs) for soil samples equating to less than 50 percent of the RG, with a goal of 10 percent of the RG. Sample error is reported with the sample result. The MARSSIM evaluation was based on decision errors of less than 5 percent false negatives and less than 20 percent false positives. This means that the decision is more likely to conclude contamination is present when it is not, than to conclude that contamination is not present when it is.
- Optimize the design for obtaining data. For the PDI sampling, the sample grid and systematic sample locations were developed in anticipation that the sample results could be used for the FSS.

The FSS analytical data were examined using data quality assessment (DQA) guidance to ensure two things: (1) that the data met the quality requirements of the *Final Status Survey Plan for Accessible Soil within Mallinckrodt Property and the Vicinity Properties, Excluding Plants 1, 2, and the City Property at the St. Louis Downtown Site* (FSSP) (USACE 2002a) and the *Sampling and Analysis Guide for the St. Louis Sites* (SAG) (USACE 2000), and (2) that the data provided the necessary basis for determining whether the property can be released for unrestricted use. The DQA involves scientific and statistical evaluations to determine if data are of the right type, quality, and quantity to support the intended use. The DQA process is based on guidance from Chapter 8 and Appendix E in MARSSIM and follows USEPA's *Data Quality Assessment: A Reviewer's Guide* (USEPA 2006b). The five steps in the DQA process are listed below and are addressed by the subsequent report sections and appendices.

- Review the FSS design, including DQOs.
- Conduct a preliminary data review.
- Select a statistical test.
- Verify the assumptions of the statistical test.
- Draw conclusions from the data.

3.2 FINAL STATUS SURVEY PROCESS FOR SOIL

3.2.1 Final Status Survey Design for Soil

In accordance with MARSSIM, land areas receiving an FSS should be classified into Class 1, Class 2, or Class 3 soil survey units (SUs). The classification is based on their potential for radioactive contamination in soils. Class 1 areas have the greatest potential for contamination, while Class 3 areas have the lowest potential. Per the FSSP, Class 1 SUs are typically limited in size to 2,000 m² plus 10 percent, Class 2 SUs are typically limited in size to 10,000 m² plus 10 percent, and Class 3 SUs are unlimited in size. MARSSIM states that Class 1 and 2 areas are to be sampled using a systematic grid, and that Class 3 areas are to be sampled using random locations.

Based on a review of site information and analytical data, the accessible soil making up DT-15 was classified into one Class 2 area (SU-1). There were no areas designated as Class 1 or Class 3 areas. SU-1 consists of approximately 3,835 m².

For DT-15, the location of systematic sample stations was based on a triangular grid pattern, extended from a random starting point. Per MARSSIM, triangular grids are generally more efficient for locating small areas of elevated radioactivity. The random-start point for the systematic grid ensures that the sample results are representative of the SU.

For DT-15, the grid was originally laid out without recognition of the inaccessible area of the levee. The sampling team in the field relocated the sample stations from these original grid locations to the edge of the inaccessible area. In one case, this field relocation resulted in moving a sample station to just outside the unmarked property boundary. This sample station is considered valid for assessing DT-15 since there is no difference in the nature of the soils a few feet outside of the property boundary.

The number of soil samples for the SU was determined based on experience with other properties. Appendix D contains the detailed process for determining the minimum number of systematic samples.

3.2.2 Final Status Survey Methodology for Soil

FSS sampling of soil involves collecting soil samples at the locations identified in the FSS design. Figure 4 depicts the sampling locations on DT-15. These soil samples were collected from the top 0.5 ft bgs or within the top 0.5 ft of soil bcm (e.g., gravel).

Per the FSSP, subsurface soils were sampled to confirm that no unexpected subsurface radioactive contamination was present. These soil samples are generally taken at the same locations as the FSS surface soil samples. For Class 2 areas, the process for collecting subsurface samples for laboratory analysis starts with removing a soil column that is 1.5 to 2.0 ft long, with approximately one-third (30 percent) of the locations reaching a depth of 6 ft bgs.

In the first soil column, two (2) soil samples will be collected. The first soil sample will be from the first 0.5 ft of the uppermost soil layer below any cover material (i.e., asphalt and associated gravel). The second soil sample with a span of 0.5 ft will be collected from the remaining column in the area exhibiting the greatest radioactivity determined by using appropriate radiological survey instrumentation. If the remaining soil column has a relatively uniform count rate, the second soil sample should be the deepest 0.5 ft portion of the column. One (1) soil sample will be collected from each subsequent soil column below the first column. A soil sample

with a span of 15 cm (0.5 ft) will be collected from each soil column in the area exhibiting the greatest radioactivity. If the soil column has a relatively uniform count rate, the soil sample interval should be the deepest 15 cm (0.5 ft) portion of the column. In the deepest soil column removed, one-third of the soil samples will be subject to laboratory analysis with two-thirds subject to field screening. The results of the radiological screening will provide qualitative data regarding the potential for elevated radiological COCs in soil cores.

MARSSIM also recommends performing radiological scans of the ground surface (with any cover material). The size of the area surveyed for Class 2 areas should be 10 to 100 percent (proportional to the potential for finding areas of elevated radioactivity). These radiological scans are gamma walkover surveys (GWSs). The GWSs are used to select biased sample locations as an additional effort to locate areas requiring further investigation and ensure that the systematic samples are representative of the SU. There are no RGs specifying an unacceptable GWS result.

The GWS did not indicate any areas of elevated radiological readings above background for accessible soil; therefore, the GWS did not result in any biased samples of accessible soil being collected on DT-15. Additional information on the GWS, including a figure illustrating the evaluation of GWS data, is in Appendix E. The GWS files have been included in Appendix F (on CD-ROM attached to the back cover of this report).

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4.0 ASSESSMENT OF FINAL STATUS SURVEY RESULTS

4.1 ASSESSMENT OF SOIL SAMPLE RESULTS

The background reference soil data set used in the evaluation of the FSS soil samples is summarized in Appendix A. The radiological soil sample analytical data are reported in Appendix C. A copy of the boring logs and field logbook entries for these samples are provided in Appendix J (on the CD-ROM attached to the back cover of this report). The surface and subsurface RGs were applied as follows to calculate the net sum of the ratio (SOR_N).

- SOR_N using surface RGs: If no cover material was present, the soil sample was collected from the upper 0.5 ft of the soil. If cover material was less than 0.5 ft, the soil sample was taken from the first 0.5 ft of soil bcm.
- SOR_N using subsurface RGs: The soil sample was collected from below 0.5 ft of the ground surface.

All of the soil sample analytical data for SU-1 was evaluated to ensure the average SOR_N over the entire SU did not exceed one. All of the surface soil sample analytical data had SOR_N values equal to zero. Since the mean SOR_N value was less than one, the radionuclide RGs were met for the SU. The data are summarized in Appendix G.

In addition to a direct comparison to the RGs, MARSSIM recommends that an investigation level be established to investigate the results that pass the statistical test, but potentially represent the edge of more significant contamination. MARSSIM identifies the DCGL, which is an SOR_N of one for this report, as the investigation level for Class 2 areas. The maximum sample SOR_N values for DT-15 are 0.0 (surface samples) and 0.3 (subsurface samples). Therefore, since the maximum sample SOR_N values for DT-15 were below the DCGL SOR_N value of one, no samples required additional investigation.

Soil samples collected at three (SLD98539, SLD98549, and SLD98553) out of nine systematic stations were from the 4 to 6 ft bcm soil column interval, meeting the one-third FSSP requirement. Samples collected at two systematic stations (SLD98537 and SLD98543) only included subsurface samples. The soil above the uppermost sample collected appeared to be recent fill and was not sampled.

4.1.1 Statistical Test for Radiological Soil Sample Results

Because soil contains natural background levels of the radionuclide COCs, the Wilcoxon Rank Sum (WRS) statistical test is used for soil sample results per MARSSIM. Data from biased and subsurface soil samples were not included in the statistical tests per MARSSIM guidance: "judgment measurements are not included in the statistical evaluation of the SU because they violate the assumption of randomly selected, independent measurements. Instead, these judgmental measurements are individually compared to the DCGL."

MARSSIM also states that "if the difference between the largest SU measurement and the smallest reference area measurement is less than or equal to the DCGL [i.e., $SOR_G^{max \text{ systematic or random}} - SOR_G^{min \text{ reference}} < 1.0$], the WRS statistical test will always show the SU meets the release criterion." From the SLDS background reference data, the minimum surface gross sum of the ratios (SOR_G) is 0.53 and the largest SU measurement SOR_G is 0.40. (Background values are not subtracted in the SOR_G calculation.)

For SU-1, the difference between the maximum SU measurement and the smallest reference area measurement was less than one (e.g., for SU-1, $0.40 - 0.53 = -0.13$). Therefore, a WRS test is not necessary.

4.1.2 Review of Final Status Survey Design for Soil

An important factor in MARSSIM is determining an appropriate number of samples for the statistical test. Collecting too few samples can result in an inaccurate conclusion. Collecting an excessive number of samples diverts resources that could be better used elsewhere. MARSSIM establishes a method for determining the minimum number of samples. Appendix D contains the detailed process for determining the minimum number of systematic or random samples. The calculated minimum number of systematic or random samples for SU-1 was six samples. The actual number of FSS samples collected for SU-1 was seven samples.

4.2 DATA QUALITY

Quality control (QC) and quality assurance (QA) measures for FSS analytical data are summarized in the FSSP and are presented in the QA/QC sections of the SAG. The Quality Control Summary Report (QCSR) in Appendix H discusses these measures in detail for DT-15. The FSS analytical data met QA/QC requirements.

4.2.1 Minimum Detectable Concentration for Soil Samples

Soil samples were analyzed in the USACE FUSRAP laboratory in order to measure the radioactivity at very low levels. The USACE FUSRAP laboratory is certified through the U.S. Department of Defense (DOD) Environmental Laboratory Accreditation Program (ELAP). In general, the MDC represents the lowest amount of activity that the laboratory could detect for laboratory given sample. Variables, including detection efficiencies and conversion factors due to influences such as individual sample aliquot and sample density and variations in analyte background radioactivity at the laboratory are taken into account when determining the MDC. The MDC was reported with each sample result in Appendix C.

MARSSIM recommends that analytical methods should be capable of measuring levels of activity (i.e., the MDCs) between 10 and 50 percent of the established RGs. These MDC limits for surface soils are listed in Table 4.

Table 4. Minimum Detectable Concentration Limits

Radionuclide	Maximum MDC		Preferred MDC	
	Surface Soil (pCi/g)	Subsurface Soil (pCi/g)	Surface Soil (pCi/g)	Subsurface Soil (pCi/g)
Ra-226	2.5	7.5	0.5	1.5
Ra-228	2.5	7.5	0.5	1.5
Th-230	2.5	7.5	0.5	1.5
Th-232	2.5	7.5	0.5	1.5
U-238	25	25	5.0	5.0

The MDCs for all soil samples included in the FSS are less than 10 percent of the established RGs for the radionuclides listed in Table 4. As discussed in MARSSIM, the reported radionuclide concentrations from the laboratory were used in this FSSE even if those results were below the MDCs. These data were used to complete the MARSSIM evaluation and assess the risk and dose for the SU.

5.0 RESIDUAL RISK AND DOSE ASSESSMENT

A property-specific residual risk and dose assessment was performed for the subject property, in accordance with the ROD, to confirm that conditions are protective of human health and the environment. The ROD established the CERCLA target risk range as the risk RG, and the 10 *CFR* 20 Subpart E dose limit of 25 millirem per year (mrem/yr) as the dose RG. The USEPA defines the CERCLA target risk range as 10^{-6} to 10^{-4} where “the upper boundary of the risk range is not a discrete line at 10^{-4} . A specific risk estimate around 10^{-4} may be considered acceptable if justified based on site-specific conditions” per Memorandum OSWER 9200.4-18 “*Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*” (USEPA 1997a).

The risk and dose scenario for the ROD is based on the industrial worker and utility worker exposure scenarios defined in the FS. The assessment for DT-15 was performed for each of these scenarios, and an additional on-site residential scenario was considered at the request of the regulators.

CERCLA recommends a lifetime exposure assessment period of 30 years for individuals under a residential exposure scenario. Subpart A of 40 *CFR* 192 requires a 1,000-year exposure assessment scenario that takes into account the risk posed by residual levels of long-lived radionuclides and the in-growth of their decay daughter products. This is the period of time over which achievement of the cleanup standard must be reasonably assured.

Section C.2.1.3 of the FS states: “To estimate a dose or risk, the appropriate exposure parameters, the source term (concentrations of radionuclides), and other variables such as depth of contamination and distribution of coefficients are selected to provide conservative yet realistic estimates of exposure.” This means that the actual risk and dose received by an individual from residual MED/AEC material on this property will be lower than the estimates in this assessment. Additionally, the protection provided by clean material covering the property is not accounted for in the estimates. This is another example of how the actual MED/AEC-related risk and dose will be lower than the estimates provided in this assessment.

The radiological results of systematic, random, and subsurface samples were used in the residual risk and dose assessment. The risk and dose estimates are provided in Table 5.

Based on the results of the risk and dose assessments, it can be concluded that residual risk and dose for soil at DT-15 are protective for all of the receptor scenarios (including on-site resident), are protective of public health and the environment, and the accessible soils on the property can be released for unrestricted use. More information on how these values were calculated is provided in Appendix I.

Table 5. Risk and Dose Estimate

Scenario	Period Assessed (years)	Maximum Risk	Maximum Dose (mrem/yr)
Utility Worker	0 to 1,000	0.0	0.0
Industrial Worker	0 to 1,000	0.0	0.0
On-Site Resident	0 to 1,000	0.0	0.0
On-Site Resident with 6 inches of cover	0 to 1,000	0.0	0.0

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6.0 CONCLUSIONS

The conditions established in the ROD for protecting human health and the environment has been met for the accessible soils on DT-15. This conclusion is the result of a comparison of the ROD requirements and the current conditions, as presented in Table 6. The survey results and the risk and dose assessment demonstrate that the accessible soils on DT-15 can be released for unrestricted use in accordance with the ROD.

Table 6. Comparison of Results to Remediation Goals

RG Type	Specification	Results*
Soil Radionuclide (Note: 40 CFR 192 allows area-weighted averaging over a 0.5 ft layer of soil.)	Sample $SOR_N < 1$ when averaged over 100 m ² $SOR_N < 1$ when systematic sample results averaged over SU. Pass MARSSIM WRS test (if required)	The highest systematic sample SOR_N was 0.00. SU-1: Mean systematic $SOR_N = 0.00$ (Appendix G, Table G-1) WRS test not required (see Section 4.1.1).
Health Risk	10^{-6} to 10^{-4}	0
Dose	Total Effective Dose Equivalent < 25 mrem/yr	0 mrem/yr

* Results can be found in Appendix G.

The main components of the ROD Selected Remedy are repeated below (i.e., bulleted/italicized items) along with a brief summary of conclusions drawn from this report.

- Excavation of accessible soils according to the ARAR-based composite cleanup criteria (i.e., RG) of 5/15 pCi/g above background for Ra-226, Ra-228, Th-232, and Th-230, and 50 pCi/g above background for U-238 in the uppermost 1.8 m (6 ft) (USACE 1998a).*

FSS analytical data has confirmed that no accessible soils have been left in place at DT-15 with contamination exceeding the RGs. Excavation was not required.

- On the portion of the Mallinckrodt property addressed in the operable unit, site-specific target removal levels of 50 pCi/g above background for Ra-226, 100 pCi/g above background for Th-230, and 150 pCi/g above background for U-238 (50/100/150 RGs) will be used as the deep-soil cleanup guidelines (RG) below 1.8 m (6 ft) as described in Section 7.3.6 of the ROD (USACE 1998a).*

Not applicable. Deep-soil RGs do not apply to DT-15 because RA was not required.

- For arsenic and cadmium:*
 - within the upper 1.2 or 1.8 m (4 or 6 ft) of grade, soil concentrations of arsenic greater than 60 mg/kg and/or cadmium concentrations greater than 17 mg/kg will be removed, or*
 - below 1.2 or 1.8 m (4 or 6 ft) of grade, soil concentrations of arsenic greater than 2500 mg/kg and/or cadmium are greater than 400 mg/kg will be removed (USACE 1998a).*

Non-radiological requirements are not applicable to the areas addressed by this report.

- *Remediation goals for radiological contaminants are applied to soil concentrations above background consistent with the ARAR (40 CFR 192), from which they derive. However, addition of background concentrations to these goals would not alter any judgments regarding protectiveness. Remediation goals for non-radiological RGs are applied to soil concentrations including background consistent with the NCP (USACE 1998a).*

FSS analytical data has confirmed that no accessible soils have been left in place at DT-15 that exceed the RGs. This statement in the ROD is true for SU-1 on DT-15. The SOR_G (the raw data including background) are also less than 1.0 when averaged across the SU. Non-radiological requirements are not applicable to DT-15.

- *Compliance with soil contamination criteria (RGs) will be verified by methods that are compatible with MARSSIM for soils being cleaned up in the operable unit (OU) effective with MARSSIM publication. (A representative number of samples obtained in the bottom of excavations will also be subjected to chemical analysis and comparison to chemical RGs.) (USACE 1998a).*

The FSSP was designed in accordance with MARSSIM methodology and applied to DT-15. Chemical (non-radiological) analysis is not applicable to the area addressed by this report.

- *A post-remedial action risk assessment will be performed to describe the level of risk remaining from MED/AEC contaminants following completion of remedial activities (USACE 1998a).*

A post-remedial action risk and dose assessment was performed for the modeled scenarios stated in the ROD. In addition, regulators requested that the USACE develop an on-site residential scenario to document protectiveness if land use changed from industrial to residential. The residual risk and dose calculated for DT-15 meets the criteria stated in the ROD.

- *Final determinations as to whether institutional controls and use restrictions are necessary will be based on calculations of post remedial action risk derived from actual residual conditions. Five-year reviews will be conducted per the NCP for residual conditions that are unsuitable for release without restrictions (USACE 1998a).*

The risk and dose from actual residual conditions (without regard to cover materials) are acceptable to release DT-15 accessible areas without restrictions. There are no accessible areas on the SU where it is necessary to apply use restrictions or institutional controls.

- *Institutional controls may include land use restrictions for those areas having residual concentrations of contaminants unsuitable for unrestricted use. This determination will be made based on risk analysis of the actual post-remedial action conditions. Until a decision is developed to address the ultimate disposition of inaccessible soils, steps will be taken to control uses inconsistent with current uses and to learn of anticipated changes in conditions that might make these soils accessible or increase the potential for exposure. Periodic reviews with affected property owners will be conducted throughout the duration of active site remediation. For residual conditions requiring use restrictions after the period of active remediation, coordination with property owners and local land use planning authorities will be necessary to implement deed restrictions or other mechanisms to maintain industrial/commercial land use (USACE 1998a).*

The risk and dose from actual residual conditions (without regard to cover materials) are acceptable to release DT-15 accessible areas without use restrictions. There are no accessible areas at DT-15 that necessitate application of use restrictions or institutional controls.

- *A long-term ground-water monitoring strategy will be implemented to confirm expectations that significant impacts to the Mississippi Alluvial Aquifer (B unit) will not occur. Although ground water use in this area is not anticipated, agreements will be proposed to state and local water authorities to prevent well drilling, which may be impacted by the surficially-contaminated A unit (USACE 1998a).*

The areas covered by this report have no ground-water monitoring wells; however, a long-term ground-water monitoring strategy for the SLDS has been implemented to confirm expectations that significant impacts to the Mississippi Alluvial Aquifer (B unit) will not occur.

- *Perimeter wells in the Mississippi Alluvial Aquifer will be monitored to determine if further action will be required with respect to ground water (USACE 1998a).*

The areas covered by this report have no ground-water monitoring wells; however, ground-water monitoring wells in the Mississippi Alluvial Aquifer are being monitored at the SLDS.

- *Protactinium (Pa)-231 and actinium (Ac)-227 will be included in the analyses for the post-remedial action residual site risk (USACE 1998a).*

Pa-231 and Ac-227 were included in residual risk and dose assessments.

- *Contaminated sediments in sewers and drains considered to be accessible will be remediated along with the soils (USACE 1998a).*

Potentially impacted sewers are limited to those that provided service to MED/AEC areas of Mallinckrodt property. There was no remediation required on DT-15; therefore, there were no sewers that were made accessible as a result of remediation on DT-15. Potentially impacted sewers and associated inaccessible soils on DT-15 will be addressed under a separate CERLCA action.

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7.0 CONTACT INFORMATION

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8.0 REFERENCES

- DOD 2000. U.S. Department of Defense, U. S. Department of Energy, U.S. Environmental Protection Agency, and U. S. Nuclear Regulatory Commission. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*. NUREG 1575. EPA 402-R-97-016. August 2000.
- DOD 2006. U.S. Department of Defense. *Department of Defense Quality Systems Manual for Environmental Laboratories*. Version 3 Final. January 2006.
- DOE 1990. U.S. Department of Energy, Oak Ridge Operations Office. *Radiological, Chemical, and Hydrogeological Characterization Report for the St. Louis Downtown Site in St. Louis, Missouri*. DOE/OR/20722-258. September 1990.
- DOE 1993. U.S. Department of Energy, Oak Ridge National Laboratory. *Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site*. DOE/OR/23701-41.1. November 1993.
- DOE 1994. U.S. Department of Energy, Oak Ridge National Laboratory. *Remedial Investigation Report for the St. Louis Site*. DOE/OR/21949-280. January 1994.
- DOE 1995. U.S. Department of Energy, Oak Ridge Operations Office. *Remedial Investigation Addendum for the St. Louis Site*. DOE/OR/21950-132. September 1995.
- MDNR and City of St. Louis 2006. Memorandum of Understanding. *Use of Local Groundwater Ordinance as Environmental Institutional Control when Using Missouri's Risk-Based Corrective Action Process on Contaminated Sites* (Attachment A: Ordinance #66777, dated July 13, 2005). <http://www.dnr.mo.gov/env/hwp/docs/StLouisGroundwaterMOU.pdf>. October 20, 2006.
- NRC 1998. U.S. Nuclear Regulatory Commission. *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*. NUREG-1507. June 1998.
- SAIC 2006. Science Applications International Corporation. *Data Validation*. TP-DM-300-7. Revision 6. February 2006.
- STLCITY 2012. *City of St. Louis Assessor's Office*. <http://stlouis-mo.gov/data/address-search/index.cfm>. July 2012.
- STLOC 1996. St. Louis Oversight Committee. *St. Louis Sites Remediation Task Force Report*. September 1996.
- USACE 1960. U.S. Army Corps of Engineers, St. Louis District. *Mississippi River Flood Protection – St. Louis, Missouri, Reach 3*, prepared by Sverdrup & Parcel, Inc., Engineers-Architects, St. Louis, Missouri. 1960.
- USACE 1998a. U.S. Army Corps of Engineers, St. Louis District. *Record of Decision for the St. Louis Downtown Site*. Final. October 1998.
- USACE 1998b. U.S. Army Corps of Engineers, St. Louis District. *Feasibility Study for the St. Louis Downtown Site*. U.S. Army Corps of Engineers. Final. April 1998.
- USACE 1999. U.S. Army Corps of Engineers, St. Louis District. *Background Soils Characterization Report for the St. Louis Downtown Site*. March 1999.

- USACE 2000. U.S. Army Corps of Engineers, St. Louis District. *Sampling and Analysis Guide for the St. Louis Sites*. September 2000.
- USACE 2001. U.S. Army Corps of Engineers, St. Louis District. Collection of 86 Aerial Photographs of the Downtown St. Louis, Missouri Area: 1941, 1945, 1947, 1949, 1951-1955, 1958, 1962, 1968, 1971, 1973, 1974, 1976, 1979, 1980, 1983, 1986, 1988-1990, 1992, 1994-1996, 1998, and undated, provided to IT Corporation by Mr. Dave Kreigbaum, USACE Geospatial Engineering Branch, St. Louis, Missouri. November, 2001.
- USACE 2002a. U.S. Army Corps of Engineers, St. Louis District. *Final Status Survey Plan for Accessible Soil within Mallinckrodt Property and the Vicinity Properties, Excluding Plants 1, 2, and the City Property at the St. Louis Downtown Site*. Revision 2. February, 2002.
- USACE 2002b. U.S. Army Corps of Engineers. *USACE Kansas City and St. Louis District Radionuclide Data Quality Evaluation Guidance for Alpha and Gamma Spectroscopy*. Final. December 2002.
- USACE 2002c. U.S. Army Corps of Engineers, St. Louis District. *Post-Remedial Action Report for the Accessible Soils within the St. Louis Downtown Site Plant 2 Property*. Revision 0. January 2002.
- USACE 2005a. U.S. Army Corps of Engineers, St. Louis District. Memorandum for the Record. *SAG Implementation Guidance for Interpretation of QA Split Program*, by Sharon R. Cotner. November 23, 2005.
- USACE 2005b. U.S. Army Corps of Engineers, St. Louis District. *Record of Decision for the North St. Louis County Sites*. Final. September 2, 2005.
- USACE 2005c. U.S. Army Corps of Engineers, St. Louis District. *Memorandum: Non-Significant Change to the Record of Decision for the St. Louis Downtown Site*, Final. March 2005.
- USACE 2008. U.S. Army Corps of Engineers, St. Louis District. *St. Louis Downtown Site Annual Environmental Monitoring Data and Analysis Report for Calendar Year 2007*. Revision 0. June 27, 2008.
- USEPA 1989. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual*, (Part A). EPA/540/1-89/002. Interim Final. December 1989.
- USEPA 1997a. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*. Memorandum OSWER 9200.4-18. August 22, 1997.
- USEPA 1997b. U.S. Environmental Protection Agency, Office of Research and Development. *Exposure Factors Handbook, Volumes I, II, and III*. EPA/600/P-95/002Fa-c. August, 1997.
- USEPA 2002. U.S. Environmental Protection Agency, Office of Superfund Remediation Technology Innovation *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*. CFR Title 40 Chapter 1 Section 192. July 2002.

- USEPA 2006a. U.S. Environmental Protection Agency, Office of Environmental Information. *Guidance on Systematic Planning Using the Data Quality Objectives Process*. EPA QA/G-4. EPA/240/B-06/001. February 2006.
- USEPA 2006b. U.S. Environmental Protection Agency, Office of Environmental Information. *Data Quality Assessment: A Reviewer's Guide*. EPA QA/G-9R. EPA/240/B-06/002. February 2006.
- USGS 1933. U.S. Geological Survey, 1933, Granite City, Missouri Quadrangle Map, Scale 1:24,000, National Cartographic Information Center, Reston, Virginia. 1933.
- USGS 1935. U.S. Geological Survey, 1935, Illinois-Missouri Granite City Quadrangle Map, Scale 1:24,000, Reston, Virginia. 1935.
- USGS 1937. U.S. Geological Survey, 1937, Missouri-Illinois St. Louis Quadrangle Map, Edition of April 50 1904, Reprinted 1937, Scale 1:62,500, Reston, Virginia. 1937.
- USGS 1940. U.S. Geological Survey, 1940, Illinois-Missouri Granite City Quadrangle Map, Scale 1:24,000, Reston, Virginia. 1940.
- USGS 1950. U.S. Geological Survey, 1950, Illinois-Missouri Granite City Quadrangle Map, Edition of 1940, Reprinted 1950 with Corrections, Scale 1:24,000, Reston, Virginia. 1950.
- USGS 1954. U.S. Geological Survey, 1954, Granite City Quadrangle, Illinois-Missouri, 7.5-Minute Series (Topographic) Map, Scale 1:24,000, Reston, Virginia. 1954.
- USGS 1968. U.S. Geological Survey, 1968, Granite City Quadrangle, Illinois-Missouri, 7.5-Minute Series (Topographic) Map, 1954 Map Photo-revised 1968, Scale 1:24,000, Reston, Virginia. 1968.
- USGS 1993. U.S. Geological Survey, 1993, Granite City Quadrangle, Illinois-Missouri, 7.5-Minute Series (Topographic) Map, Scale 1:24,000, Reston, Virginia. 1993.

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FIGURES

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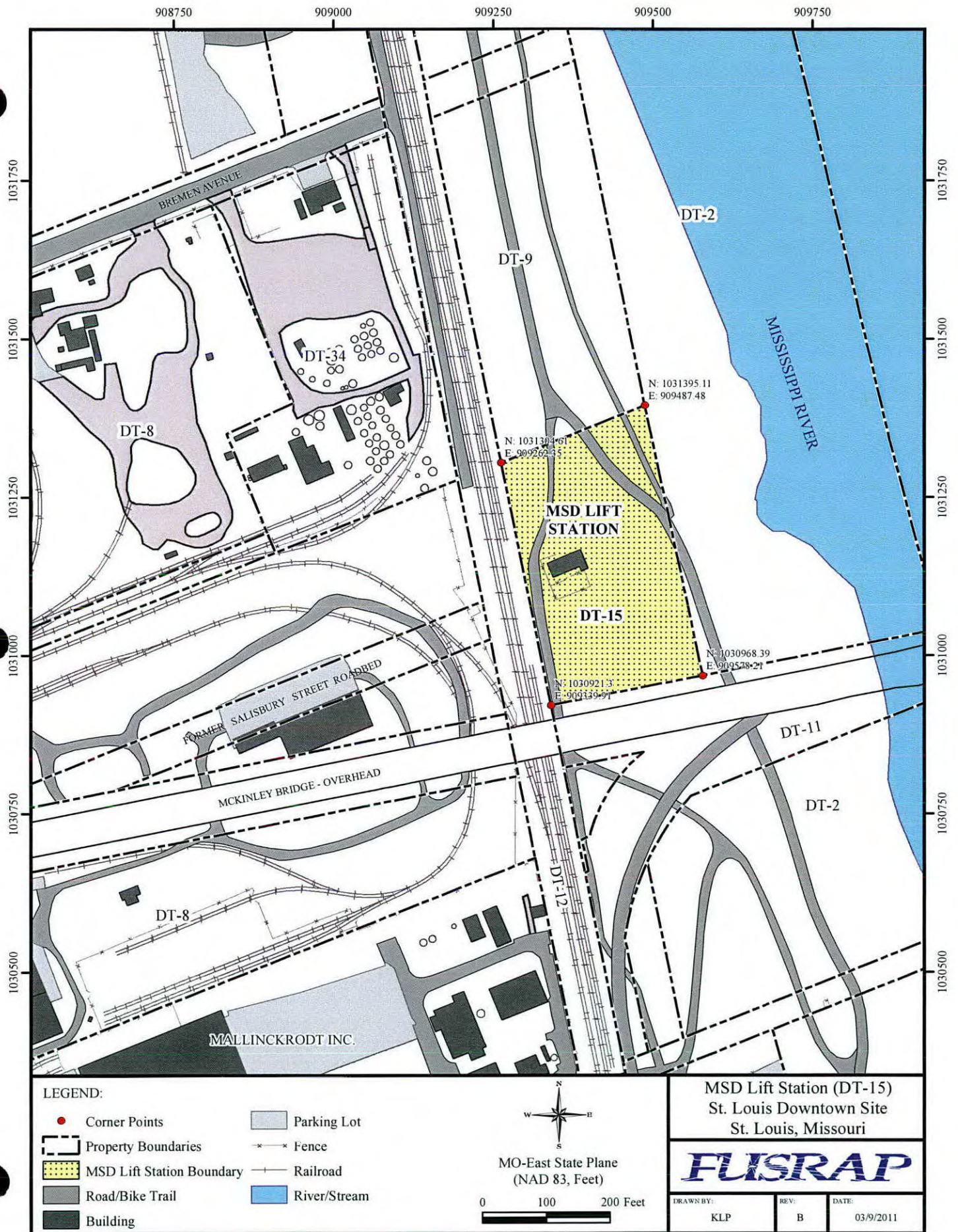


Figure 1. MSD Lift Station (DT-15) Property Location

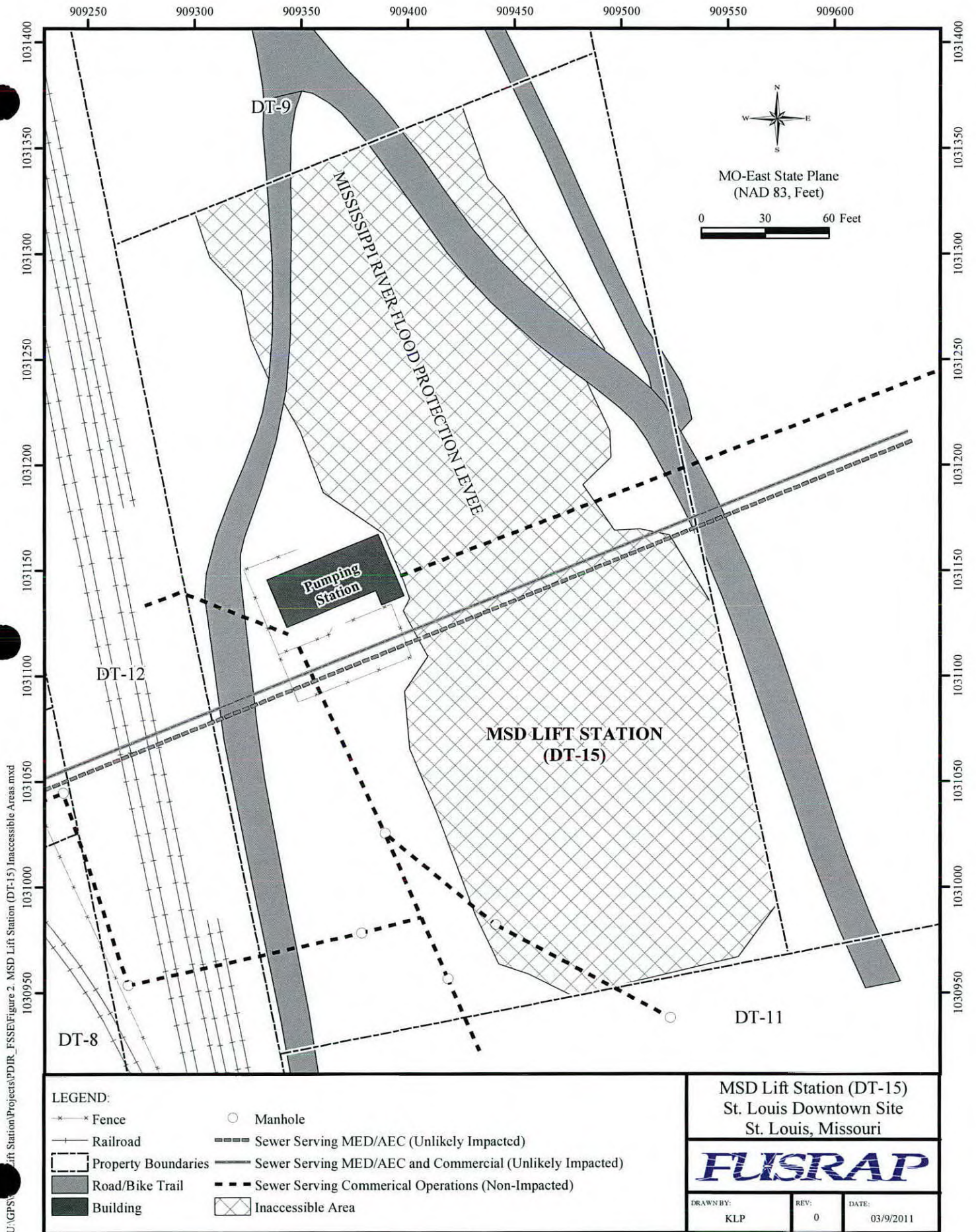


Figure 2. MSD Lift Station (DT-15) Inaccessible Areas

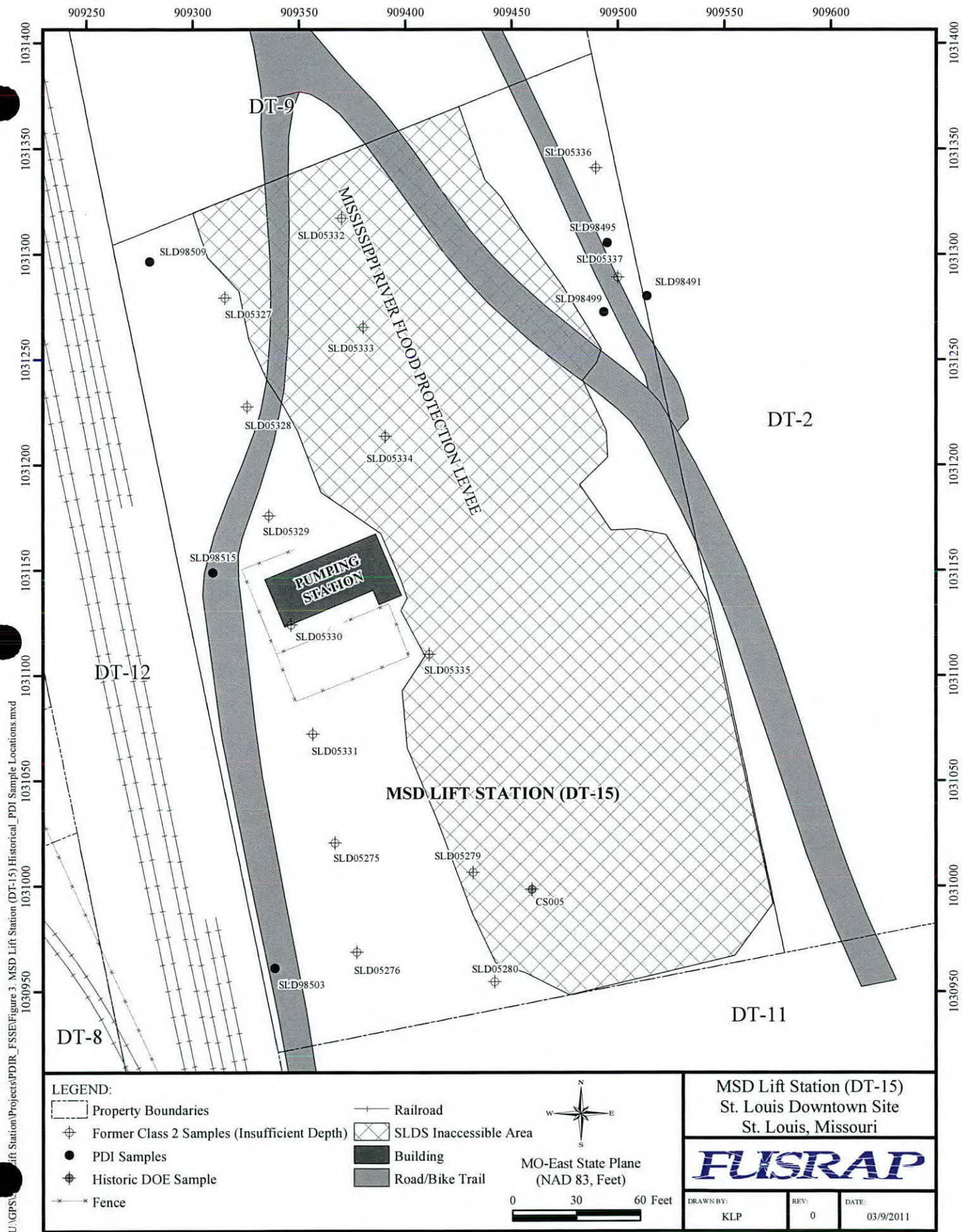


Figure 3. MSD Lift Station (DT-15) Historical/PDI Sample Locations

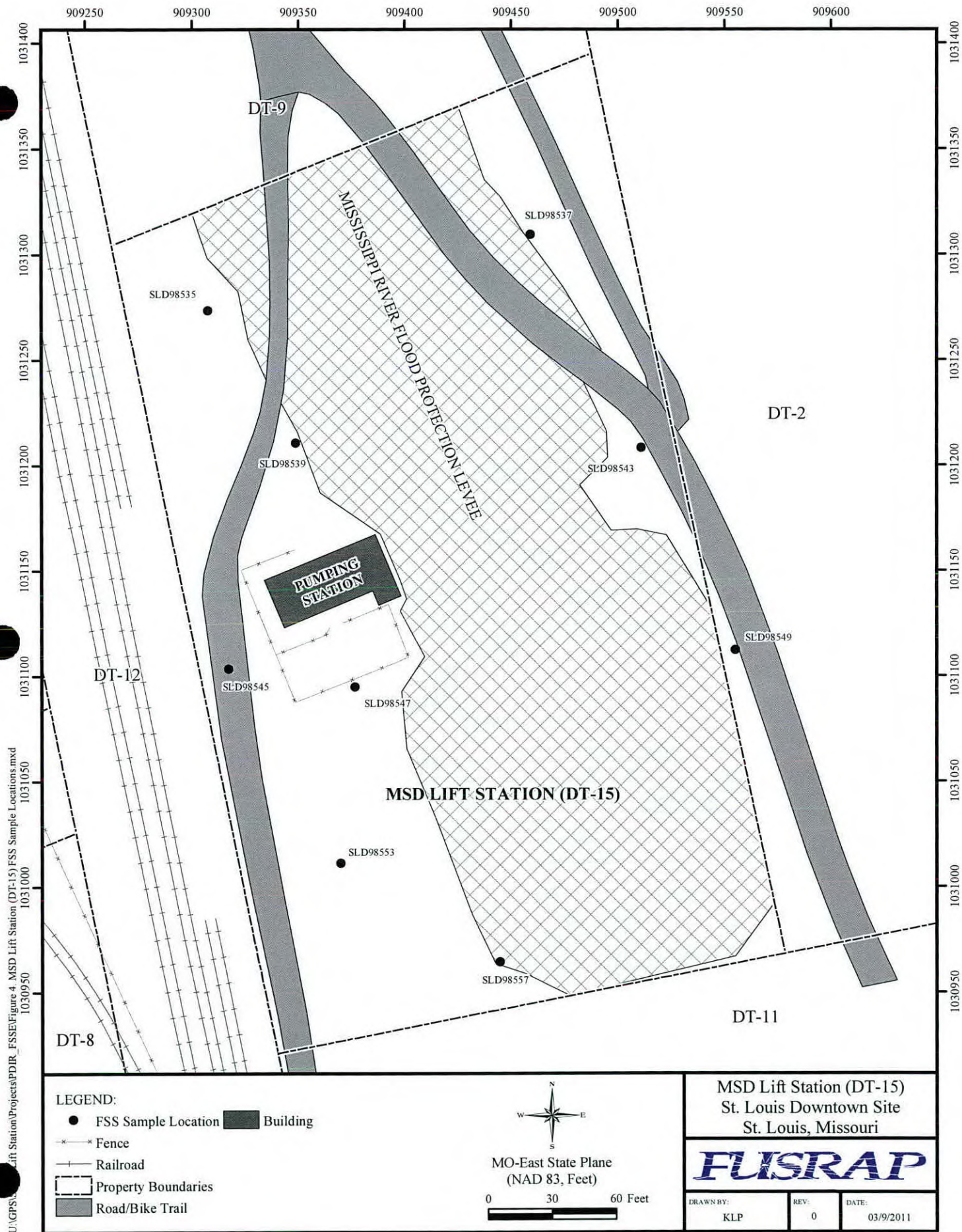


Figure 4. MSD Lift Station (DT-15) FSS Sample Locations

APPENDIX A
BACKGROUND REFERENCE SOIL SAMPLE DATA

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Table A-1. Background Reference Soil Data

Background Reference Soil Data Summary (32 Samples)											
Statistic	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	Surf. SOR _G	Sub. SOR _G
Mean	0.14	0.90	2.78	0.95	1.16	1.94	1.09	0.08	1.44	0.82	0.29
Median	0.11	0.98	2.53	0.97	1.10	1.66	1.07	0.09	1.16	0.76	0.27
Std. Dev.	0.14	0.76	0.89	0.17	0.35	0.76	0.29	0.08	0.75	0.21	0.08
Maximum	0.70	2.34	5.46	1.28	2.10	4.15	1.68	0.31	3.78	1.48	0.54
Minimum	-0.10	-0.21	1.53	0.46	0.51	0.96	0.43	-0.02	0.59	0.53	0.19
Range	0.80	2.55	3.93	0.82	1.59	3.19	1.25	0.33	3.19	0.95	0.35

Background Reference Soil Sample Results											
Sample	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	Surf. SOR _G	Sub. SOR _G
SLD00001	0.18	0.62	1.94	0.97	1.29	2.07	1.11	0.25	1.66	0.67	0.25
SLD00002	-0.03	2.34	2.39	1.03	1.08	1.67	1.12	0.00	0.61	0.71	0.25
SLD00022	0.36	1.33	2.56	1.17	1	1.83	1.49	0.24	1.38	0.84	0.30
SLD00023	0.29	0.95	2.26	0.76	0.51	2.80	1.23	0.00	1.17	0.83	0.29
SLD00041	0.16	-0.09	2.48	0.84	0.77	1.98	1.13	0.17	1.57	0.75	0.27
SLD00042	0.70	-0.02	3.02	1.07	1.14	2.24	1.05	0.00	1.80	0.85	0.31
SLD00043	0.28	2.07	2.59	0.99	1.24	2.69	1.68	0.11	1.15	0.90	0.31
SLD00044	0.13	1.65	3.46	1.03	1.06	1.16	1.33	0.00	0.90	0.98	0.34
SLD00061	0.10	1.23	3.11	1.08	1.02	2.67	1.43	-0.01	1.47	0.94	0.33
SLD00062	0.12	1.36	2.59	1.28	1.29	1.91	1.59	0.11	0.94	0.85	0.30
SLD00063	0.15	2.12	2.11	1.03	1.01	1.61	0.70	-0.02	0.74	0.64	0.22
SLD00081	0.24	0.98	2.44	0.96	1.46	1.47	1.30	0.12	1.05	0.77	0.27
SLD00082	0.06	1.19	2.89	1.28	2.1	1.97	1.17	0.18	1.28	0.86	0.30
SLD00083	0.20	0.98	2.33	0.88	1.6	1.94	0.69	0.11	0.59	0.65	0.23
SLD00101	0.15	1.01	4.24	0.79	1.12	3.05	0.90	0.22	3.12	1.09	0.41
SLD00102	0.06	1.42	3.53	0.86	1	3.11	1.41	0.08	2.53	1.04	0.38
SLD00103	0.08	1.30	3.08	0.81	0.54	1.46	0.92	0.05	1.69	0.83	0.30
SLD00121	0.17	-0.10	3.31	0.87	1.27	2.25	1.34	0.31	1.84	0.97	0.35
SLD00122	0.09	0.42	2.68	0.85	1.69	1.46	0.94	0.06	1.13	0.75	0.26
SLD00123	0.23	0.25	3.51	1.02	1.23	1.33	0.94	0.06	1.17	0.93	0.33
SLD00141	0.16	-0.21	5.46	1.04	1.4	4.15	1.56	0.07	3.78	1.48	0.54
SLD00142	0.08	0.33	5.30	1.12	1.74	3.61	1.04	0.16	3.15	1.35	0.49
SLD00143	0.19	0.02	2.33	0.96	1.5	1.45	1.02	0.05	0.93	0.69	0.24
SLD00144	0.10	0.01	2.04	1.10	1.51	1.48	1.25	0.17	1.61	0.69	0.25
SLD00161	0.10	0.11	1.53	0.86	1.38	1.56	1.01	0.10	1.11	0.54	0.19
SLD00162	0.04	2.01	2.07	1.04	0.73	1.35	0.86	0.12	1.00	0.64	0.23
SLD00181	0.03	1.13	2.24	0.73	0.94	1.34	0.78	0.00	0.91	0.62	0.22
SLD00201	0.06	1.74	2.40	0.86	1.07	1.64	1.08	0.10	1.15	0.72	0.26
SLD00202	-0.10	1.73	2.67	0.97	0.88	1.62	0.78	0.05	1.11	0.75	0.26
SLD00241	0.01	-0.04	2.04	0.46	0.87	1.28	0.43	0.11	1.70	0.53	0.20
SLD00242	0.07	0.42	2.50	0.89	0.8	1.05	0.80	0.00	0.92	0.70	0.24
SLD00243	0.03	0.37	1.97	0.65	0.84	0.96	0.90	0.08	0.86	0.59	0.21

Notes:

Results are expressed in pCi/g.

SOR values are unitless.

Negative results are less than the laboratory system's background level.

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APPENDIX B

HISTORICAL DOE AND PRE-DESIGN INVESTIGATION SOIL SAMPLE DATA

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APPENDIX C
FINAL STATUS SURVEY SOIL SAMPLE DATA

Table B-1. Historical DOE and Pre-Design Investigation Soil Sample Data

						Ac-227				Pa-231				Ra-226				Ra-228				Th-228				Th-230				Th-232				U-235				U-238			
Station Name	Sample Name	Easting	Northing	Start Depth (ft)	End Depth (ft)	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ				
CS005	S00501 ^a	909460	1030998	0.0	0.5	-	-	-	-	-	-	-	-	0.80	0.00	0.00	=	-	-	-	-	-	-	-	-	1.80	0.70	0.00	=	1.30	0.40	0.00	U	-	-	-	-	14.50	0.00	0.00	U
SLD05275	SLD05275 ^b	909367	1031020	1.0	1.5	0.05	0.07	0.11	U	0.19	0.28	0.46	U	0.68	0.05	0.03	J	0.12	0.03	0.04	J	0.27	0.25	0.33	U	1.25	0.52	0.27	=	-0.01	0.02	0.23	U	0.05	0.07	0.11	U	0.77	0.31	2.67	U
	SLD05299 ^b	909367	1031020	2.5	3.0	0.03	0.07	0.11	U	-0.03	0.32	0.53	U	0.63	0.04	0.03	J	0.07	0.04	0.05	J	0.19	0.25	0.45	U	1.51	0.63	0.36	=	0.21	0.22	0.14	R	0.04	0.07	0.11	U	0.69	0.51	2.20	U
SLD05276	SLD05276 ^b	909377	1030969	0.5	1.0	0.04	0.08	0.13	U	0.08	0.36	0.55	U	0.92	0.06	0.04	J	0.36	0.06	0.05	J	0.67	0.40	0.26	J	1.97	0.73	0.26	=	0.99	0.48	0.14	=	0.19	0.09	0.13	J	1.60	1.06	2.41	U
	SLD05300 ^b	909377	1030969	2.0	2.5	0.10	0.13	0.19	U	0.60	0.59	0.93	U	1.35	0.10	0.06	J	0.81	0.10	0.08	J	0.85	0.44	0.25	J	2.34	0.79	0.25	=	1.15	0.52	0.14	=	0.10	0.14	0.19	U	2.59	1.77	4.43	U
SLD05279	SLD05279 ^b	909432	1031006	0.2	0.8	0.14	0.12	0.19	U	0.33	0.50	0.78	U	0.85	0.06	0.05	J	0.67	0.08	0.08	J	1.45	0.57	0.33	=	1.30	0.53	0.12	J	0.79	0.40	0.23	J	0.13	0.15	0.19	U	1.11	0.75	3.32	J
	SLD05303 ^b	909432	1031006	1.7	2.2	0.16	0.13	0.21	U	0.31	0.56	0.87	U	1.25	0.08	0.06	J	0.92	0.10	0.09	J	1.13	0.53	0.31	=	1.87	0.70	0.14	J	0.36	0.30	0.38	U	0.15	0.17	0.22	U	1.40	0.99	4.19	U
SLD05280	SLD05280 ^b	909442	1030955	0.2	0.8	0.21	0.27	0.46	U	-0.37	1.40	2.34	U	0.65	0.12	0.15	J	0.57	0.17	0.20	J	1.07	0.49	0.28	=	1.39	0.56	0.24	=	0.46	0.31	0.24	J	0.10	0.30	0.45	U	0.58	6.09	11.70	U
	SLD05280-1	909442	1030955	0.2	0.8	-0.01	0.10	0.14	U	-0.06	0.48	0.70	U	0.69	0.06	0.04	J	0.49	0.07	0.06	J	0.93	0.45	0.35	=	1.29	0.52	0.12	=	0.87	0.42	0.22	=	0.10	0.12	0.16	U	1.46	1.54	3.16	U
	SLD05280-2	909442	1030955	0.2	0.8	0.00	0.34	0.53	U	-0.90	1.70	2.40	U	0.91	0.24	0.17	=	0.45	0.43	0.72	U	0.65	0.26	0.12	=	1.11	0.37	0.18	=	0.65	0.25	0.15	=	-0.33	0.25	0.15	U	-0.90	1.10	1.50	U
	SLD05304 ^b	909442	1030955	1.7	2.2	0.16	0.32	0.52	U	-1.63	1.56	2.35	U	1.13	0.15	0.14	J	1.09	0.22	0.24	J	1.54	0.61	0.29	=	1.70	0.64	0.13	=	1.35	0.56	0.13	=	-0.07	0.30	0.51	U	-1.84	7.27	13.50	U
SLD05327	SLD05327 ^b	909278	1031267	0.2	0.8	0.01	0.13	0.20	U	0.48	0.59	0.96	U	0.78	0.07	0.05	J	0.41	0.09	0.09	J	1.37	0.64	0.36	=	1.97	0.78	0.30	J	0.89	0.49	0.30	J	0.07	0.12	0.21	U	0.91	0.97	3.81	U
	SLD05353 ^b	909278	1031267	1.7	2.2	0.17	0.10	0.18	U	0.09	0.50	0.76	U	0.73	0.06	0.05	J	0.42	0.08	0.08	J	0.70	0.37	0.25	J	3.64	0.97	0.11	=	1.09	0.46	0.11	=	0.09	0.15	0.18	U	0.21	0.71	3.55	U
SLD05328	SLD05328 ^b	909289	1031216	0.2	0.8	0.07	0.08	0.18	U	0.55	0.57	0.91	U	0.83	0.07	0.05	J	0.57	0.08	0.07	J	0.73	0.42	0.26	J	0.99	0.49	0.14	=	0.57	0.36	0.14	J	0.01	0.10	0.17	U	1.17	0.40	4.48	U
	SLD05354 ^b	909289	1031216	1.7	2.2	0.07	0.09	0.14	U	0.00	0.43	0.64	U	0.71	0.05	0.04	J	0.37	0.05	0.05	J	0.77	0.43	0.26	J	1.32	0.57	0.31	J	0.72	0.40	0.14	J	0.10	0.12	0.15	U	0.94	0.74	3.51	U
SLD05329	SLD05329 ^b	909300	1031163	0.2	0.8	0.05	0.08	0.12	U	-0.16	0.36	0.59	U	0.53	0.05	0.03	J	0.25	0.05	0.05	J	0.24	0.25	0.39	U	1.03	0.48	0.13	J	0.33	0.27	0.25	J	0.10	0.09	0.13	U	0.45	0.52	2.73	U
	SLD05329-1	909300	1031163	0.2	0.8	0.07	0.08	0.13	U	0.05	0.38	0.58	U	0.63	0.05	0.03	J	0.29	0.05	0.06	J	0.45	0.33	0.32	J	1.42	0.60	0.27	=	0.46	0.33	0.27	J	0.10	0.10	0.11	U	0.49	0.32	2.55	U
	SLD05355 ^b	909300	1031163	1.7	2.2	0.01	0.09	0.13	U	0.17	0.40	0.62	U	0.77	0.06	0.04	J	0.33	0.05	0.06	J	0.44	0.33	0.28	J	1.17	0.55	0.15	J	0.32	0.28	0.28	J	0.02	0.08	0.14	U	0.99	0.59	3.20	U
SLD05330	SLD05330 ^b	909310	1031112	1.0	1.5	0.06	0.07	0.11	U	-0.09	0.32	0.46	U	0.58	0.04	0.03	J	0.17	0.04	0.04	J	0.51	0.33	0.30	J	1.25	0.52	0.23	=	0.45	0.29	0.12	J	0.05	0.06	0.11	U	0.74	0.62	2.59	U
	SLD05356 ^b	909310	1031112	2.5	3.0	0.03	0.08	0.12	U	-0.12	0.35	0.50	U	0.65	0.05	0.04	J	0.20	0.05	0.05	J	1.17	0.55	0.32	=	1.03	0.50	0.15	=	0.43	0.31	0.15	J	0.08	0.09	0.12	U	0.75	0.59	2.91	U
SLD05331	SLD05331 ^b	909319	1031060	0.5	1.0	0.05	0.08	0.13	U	0.30	0.41	0.58	U	0.66	0.05	0.04	J	0.25	0.04	0.06	J	0.72	0.42	0.32	J	1.27	0.56	0.14	=	0.58	0.36	0.14	J	0.00	0.07	0.12	U	0.68	0.57	3.27	U
	SLD05357 ^b	909319	1031060	2.0	2.5	0.10	0.07	0.13	U	-0.08	0.43	0.63	U	0.75	0.05	0.04	J	0.31	0.06	0.06	J	1.07	0.51	0.14	=	1.63	0.66	0.27	=	0.85	0.45	0.14	J	0.14	0.09	0.14	J	1.27	0.70	2.94	U
SLD05332	SLD05332 ^b	909304	1031333	0.2	0.8	0.13	0.13	0.20	U	0.49	0.54	0.87	U	0.79	0.06	0.06	J	1.03	0.10	0.08	J	1.55																			

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APPENDIX C
FINAL STATUS SURVEY SOIL SAMPLE DATA

Table C-1. DT-15 Final Status Survey Soil Data

SU	Station Name	Sample Name	Easting	Northing	Ac-227				Pa-231				Ra-226				Ra-228				Th-228				Th-230				Th-232				U-235				U-238			
					Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
SU-1	SLD98535	SLD98535	909307	1031274	-0.04	0.33	0.51	UJ	-0.36	1.07	1.52	UJ	1.14	0.35	0.15	=	0.52	0.11	0.19	=	0.48	0.34	0.30	J	1.3	0.58	0.26	J	0.56	0.35	0.14	J	-0.04	0.41	0.66	UJ	1.21	1.01	1.0	J
SU-1		SLD98536	909307	1031274	0.10	0.10	0.17	U	0.02	0.29	0.43	UJ	0.88	0.23	0.04	=	0.07	0.07	0.08	UJ	0.19	0.24	0.40	UJ	0.71	0.43	0.16	J	0.00	0.0	0.16	U	-0.02	0.12	0.20	UJ	0.49	0.32	0.29	J
SU-1	SLD98537	SLD98537	909459	1031310	-0.03	0.15	0.24	UJ	0.31	0.42	0.66	UJ	1.61	0.40	0.06	=	0.70	0.07	0.09	=	0.58	0.34	0.26	J	1.37	0.55	0.22	J	0.82	0.41	0.12	=	0.17	0.20	0.34	UJ	1.32	0.56	0.50	=
SU-1		SLD98538	909459	1031310	-0.08	0.17	0.26	UJ	0.08	0.48	0.73	UJ	1.72	0.43	0.07	=	0.71	0.07	0.10	=	0.62	0.34	0.24	J	1.36	0.53	0.11	J	0.80	0.39	0.11	=	-0.13	0.21	0.34	UJ	1.73	0.49	0.52	=
SU-1	SLD98539	SLD98539	909349	1031211	0.04	0.13	0.19	UJ	-0.56	0.38	0.48	UJ	1.00	0.26	0.05	=	0.21	0.04	0.06	J	0.28	0.23	0.12	J	0.83	0.42	0.13	J	0.32	0.25	0.12	J	-0.02	0.14	0.23	UJ	0.58	0.30	0.32	J
SU-1		SLD98540	909349	1031211	-0.01	0.13	0.21	UJ	0.14	0.39	0.60	UJ	1.01	0.27	0.06	=	0.67	0.06	0.08	=	1.10	0.52	0.14	=	1.81	0.70	0.14	J	0.60	0.37	0.14	J	0.09	0.18	0.29	UJ	0.95	0.51	0.43	J
SU-1		SLD98541	909349	1031211	0.04	0.15	0.24	UJ	-0.16	0.44	0.63	UJ	1.43	0.36	0.06	=	0.80	0.06	0.08	=	0.94	0.49	0.27	J	1.41	0.62	0.32	J	1.22	0.56	0.14	=	-0.07	0.18	0.29	UJ	0.87	0.41	0.45	=
SU-1		SLD98542	909349	1031211	-0.28	0.56	0.86	UJ	-0.25	1.50	2.19	UJ	5.93	1.50	0.23	=	1.26	0.21	0.35	=	1.16	0.55	0.27	=	5.44	1.52	0.15	=	0.91	0.47	0.14	J	0.06	0.66	1.08	UJ	3.89	1.89	1.63	=
SU-1	SLD98543	SLD98543	909511	1031208	0.03	0.15	0.24	UJ	0.21	0.30	0.60	UJ	1.19	0.31	0.06	=	0.62	0.06	0.08	=	0.89	0.45	0.24	J	1.11	0.51	0.28	J	0.61	0.36	0.13	J	0.09	0.18	0.30	UJ	0.95	0.50	0.45	J
SU-1		SLD98544	909511	1031208	0.02	0.18	0.29	UJ	0.18	0.55	0.84	UJ	1.34	0.36	0.08	=	0.95	0.08	0.11	=	1.27	0.54	0.12	=	1.28	0.54	0.12	J	0.81	0.42	0.23	J	-0.12	0.23	0.37	UJ	1.44	0.74	0.58	J
SU-1	SLD98545	SLD98545	909317	1031103	-0.02	0.12	0.18	UJ	0.01	0.33	0.50	UJ	0.89	0.24	0.04	=	0.31	0.04	0.06	=	0.40	0.30	0.26	J	1.12	0.53	0.14	J	0.19	0.21	0.26	UJ	0.05	0.14	0.23	UJ	1.18	0.39	0.32	=
SU-1		SLD98545-1	909317	1031103	-0.10	0.10	0.16	UJ	-0.03	0.26	0.42	UJ	1.20	0.31	0.04	=	0.48	0.04	0.04	=	0.70	0.40	0.29	J	1.30	0.56	0.13	=	0.58	0.35	0.13	J	0.04	0.15	0.24	UJ	1.07	0.39	0.41	J
SU-1		SLD98546	909317	1031103	0.02	0.11	0.18	UJ	0.10	0.33	0.50	UJ	0.91	0.24	0.04	=	0.09	0.03	0.06	J	0.07	0.17	0.38	UJ	1.13	0.56	0.15	J	-0.01	0.03	0.29	UJ	0.16	0.16	0.23	U	0.86	0.34	0.31	=
SU-1	SLD98547	SLD98547	909376	1031095	0.02	0.09	0.14	UJ	-0.17	0.24	0.38	UJ	1.08	0.27	0.03	=	0.10	0.03	0.04	J	0.33	0.27	0.24	J	1.65	0.65	0.13	J	0.19	0.20	0.13	J	0.01	0.10	0.17	UJ	0.74	0.28	0.24	=
SU-1		SLD98547-1	909376	1031095	0.02	0.09	0.14	UJ	-0.01	0.23	0.39	UJ	1.11	0.27	0.04	=	0.10	0.03	0.04	J	0.26	0.23	0.23	J	1.21	0.52	0.12	J	0.04	0.09	0.12	UJ	0.10	0.11	0.19	UJ	0.72	0.26	0.24	=
SU-1		SLD98547-2	909376	1031095	0.06	0.17	0.30	UJ	0.00	65.00	1.00	UJ	0.69	0.13	0.12	=	0.07	0.13	0.22	UJ	0.12	0.08	0.05	J	1.23	0.30	0.03	=	0.10	0.08	0.03	J	0.09	0.18	0.31	UJ	1.09	0.52	1.00	=
SU-1		SLD98548	909376	1031095	-0.04	0.12	0.18	UJ	0.15	0.35	0.53	UJ	1.30	0.32	0.05	=	0.83	0.05	0.07	=	1.10	0.48	0.22	J	1.33	0.54	0.12	J	0.60	0.34	0.12	J	-0.02	0.15	0.24	UJ	0.85	0.37	0.36	=
SU-1	SLD98549	SLD98549	909555	1031112	-0.03	0.13	0.18	UJ	0.50	0.55	0.56	UJ	0.91	0.24	0.05	=	0.20	0.04	0.07	J	0.38	0.28	0.13	J	0.61	0.37	0.24	J	0.23	0.22	0.24	U	-0.03	0.14	0.23	UJ	0.60	0.35	0.32	J
SU-1		SLD98550	909555	1031112	0.00	0.16	0.26	UJ	0.45	0.46	0.74	UJ	1.39	0.36	0.06	=	0.61	0.06	0.09	=	1.08	0.51	0.13	=	1.26	0.56	0.25	J	0.83	0.44	0.13	J	-0.03	0.21	0.33	UJ	0.87	0.54	0.49	J
SU-1		SLD98551	909555	1031112	-0.09	0.16	0.25	UJ	0.54	0.52	0.69	U	1.32	0.34	0.07	=	0.94	0.07	0.09	=	1.29	0.54	0.13	=	1.75	0.66	0.13	J	0.95	0.46	0.23	=	0.00	0.22	0.32	UJ	0.90	0.51	0.52	J
SU-1		SLD98552	909555	1031112	-0.05	0.17	0.27	UJ	-0.02	0.49	0.72	UJ	1.61	0.41	0.07	=	0.95	0.08	0.10	=	1.53	0.61	0.13	=	2.82	0.91	0.13	=	0.86	0.44	0.13	J	-0.28	0.22	0.33	UJ	1.06	0.55	0.55	J
SU-1	SLD98553	SLD98553	909370	1031011	0.11	0.10	0.15	U	-0.13	0.25	0.40	UJ	0.90	0.23	0.04	=	0.08	0.03	0.05	=	0.09	0.13	0.13	UJ	1.10	0.50	0.23	J	0.14	0.16	0.13	J	0.01	0.11	0.19	UJ	0.72	0.27	0.25	=
SU-1		SLD98554	909370	1031011	-0.15	0.17	0.25	UJ	0.19	0.43	0.74	UJ	1.63	0.41	0.07	=	0.76	0.07	0.09	=	0.83	0.42	0.13	J	1.84	0.68	0.23	J	0.69	0.38	0.13	J	0.06	0.21	0.35	UJ	2.17	0.61	0.53	=
SU-1		SLD98555	909370	1031011	-0.08	0.16	0.25	UJ	0.13	0.47	0.71	UJ	1.66	0.42	0.06	=	0.98	0.07	0.09	=	1.07	0.47	0.25	J	1.84	0.65	0.21	J	1.13	0.48	0.11	=	-0.03	0.20	0.32	UJ	1.24	0.56	0.48	=
SU-1		SLD98556	909370	1031011	0.00	0.16	0.25	UJ	0.50	0.44	0.69	U	1.45	0.36	0.07	=	0.97	0.07	0.09	=	1.18	0.53	0.29	J	1.35	0.57	0.13	J	1.30	0.56	0.13	=	0.11	0.18	0.31	UJ	1.16	0.38	0.44	=
SU-1	SLD98557	SLD98557	909444	1030964	-0.06	0.12	0.17	UJ	0.07	0.31	0.53	UJ	0.80	0.22	0.05	=	0.15	0.04	0.07	J	0.08	0.12	0.11	UJ	0.59	0.33	0.11	J	0.12	0.15	0.21	UJ	-0.02	0.16	0.25	UJ	0.65	0.31	0.32	=
SU-1		SLD98558	909444	1030964	0.02	0.16	0.22	UJ	0.54	0.41	0.65	U	1.51	0.37	0.06	=	0.68	0.05	0.07	=	1.14	0.53	0.13	J	1.82	0.70	0.25	J	1.13	0.53	0.25	=	-0.07	0.17	0.27	UJ	1.28	0.43	0.40	=

Notes:

Results are expressed in pCi/g.

Values reported to two decimal places regardless of the number of significant digits.

Negative values indicate results that are less than the laboratory system’s background level.

Validation Qualifiers (VQs) are defined as follows:

 "=" - Positive result.

 "U" - When the material was analyzed for, but not detected above the level of the associated value.

 "J" - When the associated value is an estimated quantity, indicating there is cause to question accuracy or precision of the reported value.

 "UJ" - When the analyte was analyzed for but not detected above the associated value, however, the reported value is an estimate and demonstrates a decreased knowledge of its accuracy or precision.

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APPENDIX D

DETERMINATION OF THE MINIMUM NUMBER OF SYSTEMATIC SAMPLES

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DETERMINATION OF THE MINIMUM NUMBER OF SYSTEMATIC OR RANDOM SAMPLES

The number of systematic or random soil samples for the subject property was based on experience with other properties. The following retrospective analysis confirmed that an adequate number of systematic or random samples were collected.

To meet the minimum statistical requirements (i.e., WRS test) for a soil SU, MARSSIM provides guidance on determining the minimum number of samples. The necessary parameters for calculating the minimum number of samples and their values are:

- Type I error probability (probability of a false decision that the radionuclide RGs are met when they are actually not met)—set at 0.05 per the FSSP.
- Type II error probability (probability of a false decision that the radionuclide RGs are not met when they actually are met)—typically set at 0.20. FSSP-allowed values are 0.05 to 0.25.
- DCGL—set at $SOR_N = 1.0$ per the ROD.
- Variability of the contaminant concentration (i.e., standard deviation [σ])—set based upon engineering estimates for the SU per MARSSIM. Examples include calculating the effective standard deviation (σ_{eff}) for multiple radionuclides using characterization or screening sample results from the SU, and using a historical σ_{eff} based on samples taken previously from other SUs within the SLDS.
- Lower bound of the gray region (LBGR)—set based upon engineering estimates for the SU per MARSSIM. Examples include using the mean SOR_N calculated from characterization or screening samples in the SU, and using half of the DCGL as an arbitrary, but reasonable, starting point per MARSSIM. The LBGR is the SOR_N value at which the Type II error is specified, and is adjustable to achieve the desired relative shift (Δ/σ) between 1 and 3, with up to 4 being acceptable.

Initially, for this FSSE, the calculation was performed using an assumed LBGR of 0.5 and a calculated effective standard deviation using characterization data. The effective standard deviation represents the variability of the contaminant concentration. This resulted in a minimum number of 8 soil samples for SU-1. Because the number of characterization soil samples in the SU that were potentially usable for MARSSIM statistics was more than 8 soil samples, valid characterization data could also be used as FSS data. As an additional check to ensure sufficient soil samples were collected, the calculation of the minimum number of soil samples was repeated for the SU with the LBGR set at the mean SOR_N . This calculation, using SU-1 FSS data, is presented below.

The first step in determining the number of soil samples to support the WRS test was to determine the effective standard deviation. The specific standard deviation values for SU-1 are: Ra-226 = 0.89; Th-230 = 0.76; Th-232 = 0.29; and U-238 = 0.75. Using these values, the a conservative effective standard deviation was calculated using surface RGs even though some soil samples were taken below 15 cm (0.5 ft) bcm.

$$\sigma_{eff} = \sqrt{\left(\frac{\sigma_{Ra-226}}{DCGL_{Ra-226}}\right)^2 + \left(\frac{\sigma_{Th-230}}{DCGL_{Th-230}}\right)^2 + \left(\frac{\sigma_{Th-232}}{DCGL_{Th-232}}\right)^2 + \left(\frac{\sigma_{U-238}}{DCGL_{U-238}}\right)^2} = \sqrt{\left(\frac{0.89}{5}\right)^2 + \left(\frac{0.76}{5}\right)^2 + \left(\frac{0.29}{5}\right)^2 + \left(\frac{0.75}{50}\right)^2} = 0.21$$

The next step was to calculate the relative shift, Δ/σ . Although the mean SOR_N value is 0.00, the LBGR was set to 0.5 (which would yield a higher number of samples than if the actual mean were used).

$$\frac{\Delta}{\sigma} = \frac{DCGL - LBGR}{\sigma_{eff}} = \frac{DCGL - SOR_N^{mean}}{\sigma_{eff}} \frac{1.0 - 0.5}{0.21} = 4.5$$

The calculated value for relative shift can be used to obtain the minimum number of samples/measurements necessary to satisfy requirements using the MARSSIM equation presented below:

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$$

The calculated value, N, is the combined number of samples/measurements from the reference area and each SU. $Z_{1-\alpha}$ and $Z_{1-\beta}$ are critical values that can be found in MARSSIM Table 5.2, and P_r is a measure of probability available from MARSSIM Table 5.1. Since the calculated value for relative shift is greater than 4.0, $P_r = 1.0$ will be used to calculate N, per MARSSIM.

Normally, N/2 samples/measurements are conducted in each SU and in the reference area. That is, N/2 samples/measurements are conducted in *each* SU and N/2 samples/measurements are conducted in the reference (background) area. However, the statistical methods are still valid if there are an unequal number of samples/measurements in the SUs and reference areas. A 20 percent increase in this number is recommended to account for lost or unusable samples/measurements.

The number of data points, N, for the WRS test of each combination of reference area and SU is calculated using Equation 5-1 and Table 5.1 in MARSSIM, given 5 percent Type I error and 20 percent Type II error.

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$$

$$N = \frac{(1.645 + 0.842)^2}{3(1.0 - 0.5)^2} = 8.2 = 9 \text{ Samples}$$

The uncertainty associated with the calculation, N, should be accounted for during survey planning, thus the number of data points is increased by 20 percent and rounded up. This is in order to ensure there are sufficient data points to allow for any possible lost or unusable data.

$$N = 9 + .2(9) = 11 \text{ Samples}$$

The 11 samples include the combined samples/measurements from the reference area and one SU. Therefore six samples/measurements are required in the reference area and six in each SU. The actual number of systematic samples collected in SU-1 was greater than six.

Table D-1 lists the actual number of FSS surface soil samples collected and the minimum number of FSS soil samples for each SU. A sufficient number of soil samples were collected from the SU.

Table D-1. Number of FSS Samples

SU	Class	Minimum Number of Samples per MARSSIM	Number of Random Samples Collected
SU-1	2	6	7

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APPENDIX E
GAMMA RADIATION WALKOVER SURVEY

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GAMMA RADIATION WALKOVER SURVEY

Many radioactive contaminants can be identified through field detection methods such as surface gamma radiation scans. (Field detection methods are generally not available for detection of non-radioactive contaminants, which solely rely on laboratory analysis of field samples.) While radioactive contaminants that emit gamma radiation can be detected through radiation scans, the contaminants are not the only radioactivity that may be detected. The gamma scans detect radiation from both naturally-occurring sources and environmental contamination, and both are present in the GWS results.

GWS is a qualitative tool that can help locate radioactive contamination. However, elevated GWS readings do not, in and of themselves, provide a definitive indication that the RGs are exceeded. There are no RGs specifying an unacceptable GWS result. Where there are higher levels of naturally-occurring radioactivity, higher GWS readings will occur even though the RGs are met. Such readings can be thought of as false positive results. Representative biased samples are collected and analyzed in a radioanalytical laboratory to investigate areas identified during the GWS. These areas are investigated to ensure the RGs are met in those areas. Unlike the GWS, the analytical laboratory can quantitatively identify the COC for comparison to the RGs.

Before starting the GWS, the professional health physics technicians established the relative background radiation level in counts per minute (cpm) for the specific survey area with the survey instrument being used. During the GWS, the technicians assessed the count rates displayed on the instrument and the associated audible click rates to identify locations (by paint or flag) from which representative biased soil samples should be obtained. The identified locations had radiation readings that typically exceeded the relative background radiation levels by 2,000 cpm or higher. Then, professional health physicists reviewed the results of the GWSs and defined locations from which any additional representative biased soil samples were collected.

This review considered count rates, mathematical analysis of the count rates, existing sample information in the area(s) of interest, increased radiation from materials with higher concentrations of natural-occurring radioactivity (such as granite, brick, some concrete, coal or coal ash, and road salt), increased radiation from soil located perpendicular to the surveyed surface (such as the side wall to an excavation or a hill or mound), attempts to duplicate higher count rates, and experience with variations in the radiation readings of soil. As an example of the wide variation of naturally-occurring radioactivity in soil, the laboratory results for soil samples collected to establish background levels for the SLDS identified some samples with isotopic concentrations that were nearly twice the average.

With consideration of the above factors, health physicists assessed the results of the GWSs performed in 2000 and determined that the data did not indicate any area above the investigation level established in the FSSP.

The GWS did not indicate any areas of elevated radiological readings above background for accessible soil; therefore the GWS did not result in any biased samples of accessible soil being collected on DT-15.

The GWS figure (Figure E-1) was developed by using a geographic information system. The GWS results (in count rates) and the location coordinates were translated into maps of colored data points. The range for the colors was calculated using the mean and standard deviation of the count rate from each GWS. The calculation also factors at what count rate a surveyor can

distinguish an overall increase in fluctuating readings from the general level of fluctuating readings. The factor is calculated using equations from the *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, U.S. Nuclear Regulatory Commission Regulation (NUREG) 1507 (NRC 1998).

Because MARSSIM identifies that environmental data does not generally fit a normal distribution and uses non-parametric tests, Chebyshev's Inequality was used for setting the ranges of the colors for the GWS data. The 85th and 95th percentile of the data were chosen to focus on areas of interest with higher cpm. The 85th percentile means that 85 percent of the data have values less than the 85th percentile value; the 95th percentile is similarly defined. To achieve the 85th percentile of the data, a 1.83 factor for the standard deviation was calculated for each GWS file using Chebyshev's Inequality. To achieve the 95th percentile of the data, a 3.15 factor for the standard deviation was calculated using Chebyshev's Inequality. The NUREG 1507 factor for fluctuating readings was added to these percentile values to determine the color set points for each GWS file.

An area represented by red on the GWS figure indicates an area of interest. However, not every red data point is sampled. In some cases, a sampled location (soil) is representative of multiple areas of interest based on a professional health physicist review, as previously described.

The global positioning system used for the GWSs has inherent variability in identifying location coordinates. Some of the GWSs and soil samples may be, or may appear to be, outside the subject property or SU boundary due to structural interferences, and/or variance in the global positioning system and the geographical information system. Some sample station coordinates were obtained at a time other than the time the GWS was performed and the sample locations were painted or flagged. Thus, samples and their corresponding elevated GWS readings may have different coordinates and may be separated by several feet on the figure when in reality they are in the same location.

The GWS instruments and their detection sensitivities are listed in Table E-1 below. Detection sensitivities were determined following the guidance of NUREG 1507 and are derived in the FSSP. The sensitivities presented were derived using typical instrument parameters and are well below the RGs for soil, with the exception of Th-230. Since Ra-226 and Th-230 are commingled, Ra-226 was used as a surrogate for Th-230. For each SU, the ratio of Ra-226 and Th-230 was confirmed to be high enough for Ra-226 to be a surrogate for Th-230 so Th-230 would be identified at levels below its RG.

Field instrumentation was calibrated annually and source checked daily during use. In addition, daily field performance checks were conducted in accordance with instrument use procedures. The performance checks were conducted prior to initiating daily field activities, upon completion of daily field activities, and if the instrument response appeared questionable.

Table E-1. Radiological Field Instrument Detection Sensitivity

Description	Application	Detection Sensitivity	
Ludlum Model 2221 with a Ludlum Model 44-10 (2" x 2" sodium iodide gamma scintillation detector)	Gamma scans of ground surface and cover material	Ra-226	1.2 pCi/g
		Th-230	1,120 pCi/g
		U-natural	40 pCi/g

APPENDIX E

FIGURE

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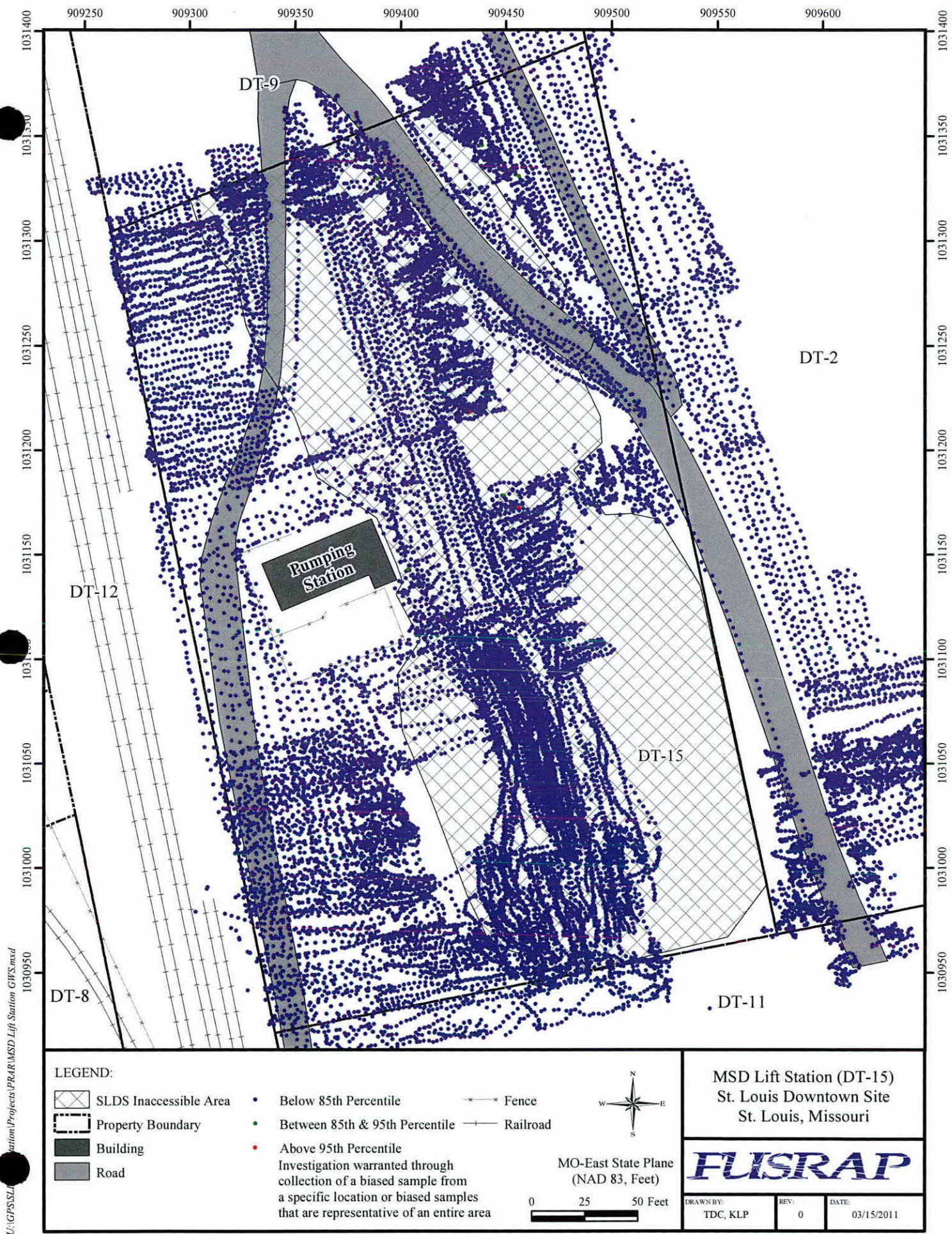


Figure E-1. Gamma Walkover Survey

APPENDIX F

GAMMA RADIATION SURVEY FILES

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APPENDIX G

EVALUATION OF FINAL STATUS SURVEY SOIL SAMPLE DATA

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Table G-1. Class 2 SU-1 Systematic Soil Data Summary

Number of Systematic Samples:		7		Number of Biased Samples:				0		Area:	3,835 m ²	
Statistic	Type	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR _G	SOR _N
Mean	Systematic	0.00	-0.09	0.96	0.23	0.29	1.03	0.25	-0.01	0.81	0.30	0.00
Median	Systematic	-0.02	-0.13	0.91	0.20	0.33	1.10	0.19	-0.02	0.72	0.28	0.00
Standard Deviation	Systematic	0.06	0.34	0.12	0.15	0.15	0.38	0.15	0.03	0.27	0.07	0.00
Maximum	All	0.11	0.50	1.14	0.52	0.48	1.65	0.56	0.05	1.21	0.40	0.00
Range	All	0.11	0.50	0.34	0.44	0.40	1.06	0.44	0.05	0.63	0.19	0.00

Sample/ Station Name	GWS- Biased Area (m ²)	Type	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR _G	SOR _N
SLD98535	--	Systematic	-0.04	-0.36	1.14	0.52	0.48	1.31	0.56	-0.04	1.21	0.40	0.00
SLD98539	--	Systematic	0.04	-0.56	1.00	0.21	0.28	0.8	0.32	-0.02	0.58	0.28	0.00
SLD98545	--	Systematic	-0.02	0.01	0.89	0.31	0.40	1.12	0.19	0.05	1.18	0.31	0.00
SLD98547	--	Systematic	0.02	-0.17	1.08	0.10	0.33	1.65	0.19	0.01	0.74	0.38	0.00
SLD98549	--	Systematic	-0.03	0.50	0.91	0.20	0.38	0.61	0.23	-0.03	0.60	0.24	0.00
SLD98553	--	Systematic	0.11	-0.13	0.90	0.08	0.09	1.10	0.14	0.01	0.72	0.26	0.00
SLD98557	--	Systematic	-0.06	0.07	0.80	0.15	0.08	0.59	0.12	-0.02	0.65	0.20	0.00

Notes:

Results are expressed in pCi/g.

SOR values are unitless.

Negative results are less than the laboratory system's background level.

Surface samples were collected in the top 0.5 ft of soil.

Table G-2. SU-1 Subsurface Soil Data Summary

Number of Subsurface Samples: 17														
Statistic				Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR _G	SOR _N
Mean				-0.03	0.18	1.64	0.74	0.94	1.74	0.78	0.00	1.30	0.21	0.02
Median				-0.01	0.15	1.43	0.76	1.08	1.37	0.82	-0.02	1.06	0.19	0.00
Standard Deviation				0.09	0.23	1.13	0.30	0.39	1.06	0.36	0.12	0.77	0.10	0.07
Maximum				0.10	0.54	5.93	1.26	1.53	5.44	1.30	0.17	3.89	0.56	0.30
Range				0.10	0.54	5.05	1.19	1.46	4.73	1.30	0.17	3.40	0.48	0.30
Sample Name	Station Name	Start Depth (ft)	End Depth (ft)	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR _G	SOR _N
SLD98536	SLD98535	1.25	1.75	0.10	0.02	0.88	0.07	0.19	0.71	0.00	-0.02	0.49	0.07	0.00
SLD98537	SLD98537	2.5	3.0	-0.03	0.31	1.61	0.70	0.58	1.37	0.82	0.17	1.32	0.19	0.00
SLD98538	SLD98537	3.0	3.5	-0.08	0.08	1.72	0.71	0.62	1.36	0.80	-0.13	1.73	0.20	0.01
SLD98540	SLD98539	1.25	1.75	-0.01	0.14	1.01	0.67	1.10	1.81	0.60	0.09	0.95	0.18	0.00
SLD98541	SLD98539	2.0	2.5	0.04	-0.16	1.43	0.80	0.94	1.41	1.22	-0.07	0.87	0.19	0.01
SLD98542	SLD98539	5.25	5.75	-0.28	-0.25	5.93	1.26	1.16	5.44	0.91	0.06	3.89	0.56	0.30
SLD98543	SLD98543	2.0	2.5	0.03	0.21	1.19	0.62	0.89	1.11	0.61	0.09	0.95	0.14	0.00
SLD98544	SLD98543	3.5	4.0	0.02	0.18	1.34	0.95	1.27	1.28	0.81	-0.12	1.44	0.18	0.00
SLD98546	SLD98545	1.5	2.0	0.02	0.10	0.91	0.09	0.07	1.13	-0.01	0.16	0.86	0.10	0.00
SLD98548	SLD98547	1.5	2.0	-0.04	0.15	1.30	0.83	1.10	1.33	0.60	-0.02	0.85	0.16	0.00
SLD98550	SLD98549	1.2	1.7	0.00	0.45	1.39	0.61	1.08	1.26	0.83	-0.03	0.87	0.17	0.00
SLD98551	SLD98549	3.0	3.5	-0.09	0.54	1.32	0.94	1.29	1.75	0.95	0.00	0.90	0.20	0.00
SLD98552	SLD98549	5.5	6.0	-0.05	-0.02	1.61	0.95	1.53	2.82	0.86	-0.28	1.06	0.27	0.06
SLD98554	SLD98553	1.5	2.0	-0.15	0.19	1.63	0.76	0.83	1.84	0.69	0.06	2.17	0.22	0.01
SLD98555	SLD98553	2.9	3.4	-0.08	0.13	1.66	0.98	1.07	1.84	1.13	-0.03	1.24	0.22	0.00
SLD98556	SLD98553	4.75	5.25	0.00	0.50	1.45	0.97	1.18	1.35	1.30	0.11	1.16	0.21	0.01
SLD98558	SLD98557	0.9	1.4	0.02	0.54	1.51	0.68	1.14	1.82	1.13	-0.07	1.28	0.22	0.00

Notes:

Depths are in feet.

Results are expressed in pCi/g.

SOR values are unitless.

Negative results are less than the laboratory system's background level.

APPENDIX H

QUALITY CONTROL SUMMARY REPORT

(On the CD-ROM on the Back Cover of this Report)

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

This QCSR was performed on the soil samples taken for the FSSE on the Accessible Soils within DT-15.

1.2 PROJECT OBJECTIVES

The intent of the QCSR is to document the usability of the data based on project DQOs, precision, accuracy, representativeness, comparability, completeness, and sensitivity.

1.3 PROJECT IMPLEMENTATION

The sampling was conducted from January 2007 until February 2007. Radiological analyses were conducted by the onsite FUSRAP laboratory at the Hazelwood Interim Storage Site (HISS) with QA split samples being analyzed by Test America (formerly Severn-Trent Laboratories).

1.4 PROJECT PURPOSE

The primary intent of this assessment is to evaluate whether data generated from these samples can withstand scientific scrutiny, are appropriate for their intended purpose, are technically defensible, and are of known and acceptable sensitivity, precision, and accuracy.

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2.0 QUALITY ASSURANCE PROGRAM

A Quality Assurance Project Plan (QAPP) was developed for this project and is part of the SAG. The QAPP established requirements for both field and laboratory QC procedures. An analytical laboratory QC duplicate sample, laboratory control sample (LCS), and a method blank were required for approximately every 20 field samples of each matrix.

A primary goal of the QA program is to ensure that the quality of measurements is appropriate for the intended use of the results. To this end, a QAPP and standardized field procedures were compiled to guide the investigation. Through the process of readiness review, training, equipment calibration, QC implementation, and detailed documentation, the project has successfully accomplished the goals set by the QA program.

The resulting “definitive” data, as defined by USEPA, has been reported including the following basic information:

- Laboratory case narratives
- Sample analytical results
- Laboratory method blank results
- Laboratory control standard results
- Laboratory duplicate sample results
- Tracer recoveries
- Sample extraction dates
- Sample analysis dates

This information provides the basis for an independent data evaluation relative to accuracy, precision, sensitivity, representativeness, comparability, and completeness, as discussed in the following sections.

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3.0 DATA VALIDATION

This project implemented the use of data validation checklists to facilitate laboratory data validation. These checklists were completed by the project-designated validation staff and were reviewed by the project laboratory coordinator. Data validation checklists or verification summaries for each laboratory sample delivery group have been retained with laboratory data deliverables by SAIC.

3.1 LABORATORY DATA VALIDATION

Analytical data generated for this project have been subjected to a process of data verification, validation, and review. The SAG and the following documents establish the criteria against which the data are compared and from which a judgment is rendered regarding the acceptance and qualification of the data:

- *Department of Defense Quality Systems Manual for Environmental Laboratories* (DOD 2006).
- *USACE Kansas City and St. Louis District Radionuclide Data Quality Evaluation Guidance for Alpha and Gamma Spectroscopy* (USACE 2002b).
- *Data Validation* (SAIC 2006).

Upon receipt of field and analytical data, verification staff performed a systematic examination of the reports to ensure the content, presentation, and administrative validity of the data. In conjunction with data package verification, laboratory electronic data deliverables were available. These data deliverables were subjected to review and verification against the hardcopy deliverable. Both a structural and technical assessment of the laboratory-delivered electronic reports were performed. The structural evaluation verified that required data had been reported and contract specified requirements were met (i.e., analytical holding times, contractual turnaround times, etc.).

During the validation phase of the review and evaluation process, data were subjected to a systematic technical review by examining the field results, analytical QC results, and laboratory documentation following appropriate guidelines provided in the above referenced documents. These data validation guidelines define the technical review criteria, methods for evaluation of the criteria, and actions to be taken resulting from the review of these criteria. The primary objective of this phase was to assess and summarize the quality and reliability of the data for the intended use and to document factors that may affect the usability of the data. Data verification/validation included but was not necessarily limited to the following parameters for radiological methods, as appropriate:

- Holding time information and methods requested
- Discussion of laboratory analysis, including any laboratory problems
- Sample results
- Initial calibration
- Efficiency check
- Background determinations
- Spike recovery results
- Internal standard results (tracers or carriers)
- Duplicate sample analytical results

- Self-absorption factor (for alpha and beta radioactivity)
- Cross-talk factor (during simultaneous detection of alpha and beta radioactivity)
- LCSs
- Run log

As an end result of this phase of the review, the data were qualified based on the technical assessment of the validation criteria. Validation qualifiers (VQs) were applied to each analytical result to indicate the usability of the data for its intended purpose with a reason code to explain the retention or the qualifier.

3.2 DEFINITIONS OF DATA QUALIFIERS

During the data validation process, all laboratory data were assigned appropriate data VQs and reason codes, as follows:

- “=” Positive result was obtained.
- “U” The material was analyzed for a COC, but it was not detected above the level of the associated value.
- “J” The associated value is an estimated quantity, indicating a decreased knowledge of the accuracy or precision of the reported value.
- “UJ” The analyte was analyzed for, but it was not detected above the minimum detectable value, and the reported value is an estimate, indicating a decreased knowledge of the accuracy or precision of the reported value.
- “R” The analyte value reported is unusable. The integrity of the analyte's identification, accuracy, precision, or sensitivity has raised significant question as to the reliability of the information presented.

A positive result is flagged with a “J” qualifier, and a non-detect result is flagged “UJ” when data quality is suspect due to QC issues, either blank contamination or analytical interference. None of the laboratory data were assigned an “R” code. SAIC VQs, reason codes, copies of validation checklists and qualified data forms are filed with the analytical hard copy deliverable.

4.0 DATA EVALUATION

The data evaluation process considers precision, accuracy, representativeness, completeness, comparability, and sensitivity. The following subsections will provide detail to the particular parameters and how the data were evaluated for each with discussion and tables to present the associated data.

Accuracy and precision can be measured by the relative percent difference (RPD) for radiological analyses or the normalized absolute difference (NAD) for radiological analyses using the following equations:

$$RPD = \left(\frac{\frac{|S - D|}{S + D}}{2} \right) * 100$$
$$NAD = \frac{|S - D|}{\sqrt{U_S^2 + U_D^2}}$$

Where: S = Parent Sample Result
 D = Field Split/Duplicate Parent Sample Result
 U_S = Parent Sample Uncertainty
 U_D = Field Split/Duplicate Parent Sample Uncertainty

The RPD is calculated for all radiological sample-duplicate/split pairs, if a detectable result is reported for both the parent and the QA field split or field duplicate. For radiological samples, when the RPD is greater than 50 percent, the NAD is used to determine the precision of the method. NAD accounts for uncertainty in the results, RPD does not. The NAD should be equal to or less than a value of 1.96. Neither equation is used when the analyte in one or both of the samples is not detected. In cases where neither equation can be used, the comparison is counted as acceptable in the overall number of comparisons.

The USACE memorandum entitled *SAG Implementation Guidance for Interpretation of QA Split Program* (USACE 2005a), states that a QA split sample should be collected and analyzed at a frequency of approximately 1 every 20 samples (5 percent). For radiological analyses, one split sample and one field duplicate sample were analyzed using both gamma and alpha spectrometry. These represent approximately 5 percent (4.2 percent) of the 24 systematic, biased, and their associated subsurface samples.

4.1 ACCURACY

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 samples through a comparison of the prime laboratory results versus the results of an independent laboratory.

4.1.1 Radiological Parameters

Individual sample chemical yields and LCS recoveries were within the 25 percent criterion for the verification samples, as stated in the SAG. Therefore, the data can be used for its intended purpose.

4.1.2 Inter-Laboratory Accuracy

As previously discussed, RPD and NAD were used to measure the analytical accuracy of split sample pairs for two radiological analytical groups (i.e., alpha spectroscopy and gamma spectroscopy). The split sample pairs were analyzed by the FUSRAP laboratory at the HISS and an independent contract laboratory, Test America (formerly Severn Trent Laboratory). The ability to compare the results from the laboratories is subject to several factors, such as sample homogeneity, analytical methods, volume of sample, and, for radiological samples, the size of the uncertainty (reported as error) relative to the result (e.g., a low result near the detection limit may have an uncertainty close to or even higher than the result itself). Accuracy is affected by the size of the relative uncertainty in the result. Typically, as the result gets closer to the MDC, the relative uncertainty gets larger. Many of the sample results discussed in this report are close to the MDC.

The analytical accuracy between laboratories met the FSS goal of ensuring that 90 percent of the verification samples met the DQOs. For radiological analyses, the sample results comparison must be less than the 50 percent criteria for RPD, or be less than or equal to 1.96 for NAD, to meet the DQOs. For radiological analyses, 1 sample pair was compared for 12 analytes for a total of 12 comparisons. All comparisons were within the criteria as demonstrated in Tables H-1 and H-2, yielding 100 percent acceptance. This meets the SAG goal of 90 percent acceptance. The data are acceptable.

Table H-1. Split Sample Accuracy Among Alpha Spectroscopy Analyses

Sample Name	Thorium-228		Thorium-230		Thorium-232	
	RPD	NAD	RPD	NAD	RPD	NAD
SLD98547 / SLD98547-2	91.31	0.74	29.17	NA	64.85	0.45

Notes:

NAD — Calculated for additional information when RPD greater than 50 percent.

Boldface — Values for RPD/NAD pairs exceed the control limits. Values not in boldface — pair meets the acceptance criteria.

NA — Not applicable; see other calculated value.

Table H-2. Split Sample Accuracy Among Gamma Spectroscopy Analyses

Sample Name	Actinium-227		Americium-241		Cesium-137		Potassium-40		Protactinium-231		Radium-226		Radium-228		Uranium-235		Uranium-238	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
SLD98547 / SLD98547-2	NC	NC	NC	NC	NC	NC	32.97	NA	NC	NC	44.07	NA	NC	NC	NC	NC	38.38	NA

Notes:
NAD — Calculated for additional information when RPD greater than 50 percent.
Boldface – Values for RPD/NAD pairs exceed the control limits. Values not in boldface – pair meets the acceptance criteria.
NC — Value cannot be calculated since the radionuclide was not detected in one or both of the samples.
NA — Not applicable; see other calculated value.

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4.2 PRECISION

4.2.1 Analytical Precision

Precision is a measure of mutual agreement among individual measurements performed under the same laboratory controls. To evaluate precision, a field duplicate sample is submitted to the HISS laboratory along with the original sample. Both samples are analyzed under the same laboratory conditions. If any bias was introduced at the laboratory, that bias would affect both samples equally.

Field duplicate samples were employed at a frequency of approximately 1 duplicate sample per 20 samples. As a measure of analytical precision, the RPDs for these field duplicate sample pairs for the two radiological analytical groups (i.e., alpha spectroscopy and gamma spectroscopy) were calculated at the time of verification and validation. RPD (and/or NAD) values for all analytes were within the 50 percent window (or less than or equal to 1.96) of acceptance for the verification samples, except where noted.

4.2.2 System Precision

Field duplicate samples were collected to ascertain the contribution to variability (i.e., precision) due to the combination of environmental media, sampling consistency, and analytical precision that contribute to the precision for the entire system of collecting and analyzing samples. The field duplicate samples were collected from the same spatial and temporal conditions as the primary environmental sample. Soil samples were collected from the same sampling device, after homogenization for all analytes.

For the one duplicate sample taken for the verification activities, the NAD and RPD values indicated acceptable precision for the data. For radiological analyses, 12 analytes were compared for 1 duplicate pair for a total of 12 comparisons. All comparisons were within the criteria, as demonstrated in Tables H-3 and H-4. This meets the SAG goal of 90 percent acceptance. The data are acceptable.

Table H-3. Duplicate Precision Among Alpha Spectroscopy Analyses

Sample Name	Thorium-228		Thorium-230		Thorium-232	
	RPD	NAD	RPD	NAD	RPD	NAD
SLD98547 / SI.D98547-1	23.97	NA	30.77	NA	NC	NC

Notes:

NAD calculated for additional information when RPD greater than 50 percent.

Boldface – Values for RPD/NAD pairs exceed the control limits. Values not in boldface – pair meets the acceptance criteria.

NC – Value not calculated since the radionuclide was not detected in one or both of the samples.

NA — Not applicable; see other calculated value.

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Table H-4. Duplicate Precision Among Gamma Spectroscopy Analyses

Sample Name	Actinium-227		Americium-241		Cesium-137		Potassium-40		Protactinium-231		Radium-226		Radium-228		Uranium-235		Uranium-238	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
SLD98547 / SLD98547-1	NC	NC	NC	NC	NC	NC	7.71	NA	NC	NC	2.74	NA	4.42	NA	NC	NC	3.30	NA

Notes:
NAD calculated for additional information when RPD greater than 50 percent.
Boldface – Values for RPD/NAD pairs exceed the control limits. Values not in boldface – pair meets the acceptance criteria.
NC – Value not calculated since the radionuclide was not detected in one or both of the samples.
NA — Not applicable; see other calculated value.

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4.3 SENSITIVITY

Determination of MDC values allows the investigation to assess the relative confidence that can be placed in a value in comparison to the magnitude or level of analyte concentration observed. The closer a measured value comes to the MDC, the less confidence and more variation the measurement will have. Project sensitivity goals were expressed as quantitation level goals in the FSSP. These levels were achieved or exceeded throughout the analytical process.

The MDC is reported for each result obtained by laboratory analysis. These very low MDCs are achieved through the use of gamma spectroscopy for all radionuclides of concern, with additional analyses from alpha spectroscopy for thorium. Variations in MDCs for the same radiological analyte reflects variability in the detection efficiencies and conversion factors due to factors such as individual sample aliquot, sample density, and variations in analyte background radioactivity for gamma and alpha spectroscopy, at the laboratory. In order to complete the Data Evaluation (i.e. precision, accuracy, representativeness, and comparability), analytical results are desired that exceed the MDC of the analyte.

4.4 REPRESENTATIVENESS AND COMPARABILITY

Representativeness expresses the degree to which data accurately reflect the analyte or parameter of interest for an environmental site and is the qualitative term most concerned with the proper design of a sampling program. Factors that affect the representativeness of analytical data include proper preservation, holding times, use of standard sampling and analytical methods, and determination of matrix or analyte interferences. Sample preservation, analytical methodologies, and soil sampling methodologies were documented to be adequate and consistently applied.

Comparability, like representativeness, is a qualitative term relative to a project data set as an individual. These investigations employed appropriate sampling methodologies, site surveillance, use of standard sampling devices, uniform training, documentation of sampling, standard analytical protocols/procedures, QC checks with standard control limits, and universally accepted data reporting units to ensure comparability to other data sets. Through the proper implementation and documentation of these standard practices, the project has established the confidence that the data will be comparable to other project and programmatic information.

Tables H-5 and H-6 present the duplicate and split results used in comparison with associated parent sample results for alpha spectroscopy and gamma spectroscopy, respectively. In Table H-6, the Ra-226 results reported by the FUSRAP laboratory automatically include an upward adjustment factor of 1.5 for all samples analyzed after February 20, 2002. The adjustment is necessary to conservatively account for Ra-226 in-growth and to provide proper comparability with the independent laboratory.

4.5 COMPLETENESS

Acceptable results are defined as those data which pass individual scrutiny during the verification and validation process and are accepted for unrestricted use. The DQO of achieving 90 percent completeness, as defined in the FSSP, was satisfied with the project producing valid results for 100 percent of the sample analyses performed and successfully collected.

A total of 7 systematic and 17 subsurface soil samples, were collected with approximately 288 discrete analyses being obtained, reviewed, and integrated into the assessment. The project produced acceptable results for 100 percent of the sample analyses performed.

Table H-5. Alpha Spectroscopy Results for Parent Samples and Associated Split and Duplicate Samples

Sample Name	Thorium-228				Thorium-230				Thorium-232			
	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
SLD98547	0.33	0.27	0.24	J	1.65	0.65	0.13	J	0.19	0.20	0.13	J
SLD98547-1	0.26	0.23	0.23	J	1.21	0.52	0.12	J	0.04	0.09	0.12	UJ
SLD98547-2	0.12	0.08	0.05	J	1.23	0.30	0.03	=	0.10	0.08	0.03	J

Notes:

Results are expressed in pCi/g.

Samples ending in "-1" are duplicate samples.

Samples ending in "-2" are split samples.

Table H-6. Gamma Spectroscopy Results for Parent Samples and Associated Split and Duplicate Samples

Sample Name	Actinium-227				Americium-241				Cesium-137				Potassium-40				Protactinium-231				Radium-226				Radium-228				Uranium-235				Uranium-238			
	Result	Error	MDC	Qual	Result	Error	MDC	Qual	Result	Error	MDC	Qual	Result	Error	MDC	Qual	Result	Error	MDC	Qual	Result	Error	MDC	Qual	Result	Error	MDC	Qual	Result	Error	MDC	Qual	Result	Error	MDC	Qual
SLD98547	0.02	0.09	0.14	UJ	0.01	0.02	0.02	UJ	0.00	0.01	0.01	UJ	2.12	0.26	0.13	=	-0.17	0.24	0.38	UJ	1.08	0.27	0.03	=	0.10	0.03	0.04	J	0.01	0.10	0.17	UJ	0.74	0.28	0.24	=
SLD98547-1	0.02	0.09	0.14	UJ	0.02	0.02	0.03	U	0.00	0.01	0.01	UJ	2.29	0.28	0.13	=	-0.01	0.23	0.39	UJ	1.11	0.27	0.04	=	0.10	0.03	0.04	J	0.10	0.11	0.19	UJ	0.72	0.26	0.24	=
SLD98547-2	0.06	0.17	0.30	UJ	0.04	0.07	0.12	UJ	-0.02	0.04	0.07	UJ	1.52	0.57	0.71	=	0.00	65.00	1.00	UJ	0.69	0.13	0.12	=	0.07	0.13	0.22	UJ	0.09	0.18	0.31	UJ	1.09	0.52	1.00	=

Notes:
Results are expressed in pCi/g.
Negative results are less than the laboratory system’s background level.
Samples ending in “-1” are duplicate samples.
Samples ending in “-2” are split samples.

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5.0 DATA QUALITY ASSESSMENT SUMMARY

The overall quality of this data meets or exceeds the established project objectives. Through proper implementation of the project data verification, validation, and assessment process, project information has been determined to be acceptable for use.

Sample data, as presented, have been qualified as usable, but estimated when necessary. Data that have been estimated have concentrations/activities that are below the quantitation limit or are indicative of accuracy, precision, or sensitivity being less than desired but adequate for interpretation. Comparisons that have exceeded the requirements have bolded type in associated tables. There are numerous possibilities for these anomalies:

- Dilution of a sample due to high analyte concentration(s) that exceed analytical calibration(s);
- Excessive dilution for sample turbidity or other matrix issues that was deemed necessary for a laboratory analysis;
- Incomplete sample homogenization, either at the laboratory or during the field sampling;
- Matrix interferences within the sample itself that caused inadequate analytical quantitation;
- Different preparation methods for associated split samples at different laboratories;
- Different analytical methods for associated split samples at different laboratories; and
- Concentration of an analyte being below the calibration range, or near the method detection limit for that analyte; etc.

Further analysis of the data can display trends or even randomness within the data set that could be explained with one or more of the above mentioned contributors to anomalies. For instance, a single split sample pair analyzed at two different laboratories for which the RPD was not met for any analyte, could be an indicator of incomplete homogenization in the field, matrix effects in the sample, use of different preparation methods, dilutions that were required to overcome sample concentration, or analyte concentrations approaching the method detection limit. Precision and/or accuracy anomalies occurring for some analytes, but not for others, could be the results of a simple matrix effect causing poor quantitation of a sample, or perhaps low concentrations of those analytes. When considering split sample data, if a laboratory has numerous "out of specification" data for a certain analyte(s) versus the corresponding data produced by another laboratory, differences in sample preparation by the laboratories in question, or perhaps differences in instrument calibrations could be considered as potential causes for differences in data quality for the specific analyte(s) in question. Exceedance by one laboratory of the RPD acceptance criterion for an analyte measured in a duplicate sample pair, for which the same duplicate analysis at another laboratory produced results for which the RPD was within the same acceptance limit, could be attributed to randomness of quantitation within the analysis.

The *Department of Defense Quality Systems Manual for Environmental Laboratories* (DOD 2006) defines allowable marginal exceedances as 10 percent of the total analysis for random anomalies that occur during regular laboratory analysis. As presented in this report, there are 24 total comparisons with no exceedances, resulting in a marginal exceedance rate of zero percent. This is well within the *Department of Defense Quality Systems Manual for Environmental*

Laboratories 10 percent allowance for marginal exceedances. The allowable marginal exceedance requirements for the project have been met, with over 90 percent of the data being within acceptance limits, while allowing for some noticeable trends and randomness of anomalous exceedances between laboratories.

Data evaluated by this QCSR demonstrates that it can withstand scientific scrutiny, are appropriate for its intended purpose, are technically defensible, and are of known and acceptable sensitivity, precision, and accuracy. Data integrity has been documented through proper implementation of QA/QC measures. The environmental information presented has an established confidence, which allows utilization for the project objectives and provides data for future needs.

APPENDIX I
RISK AND DOSE ASSESSMENT

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RISK AND DOSE ASSESSMENT

RISK AND DOSE ASSESSMENT MODEL

RESRAD (RESidual RADioactivity) is a computer model developed by the Argonne National Laboratory for the DOE. RESRAD calculates site-specific risk and dose to various future hypothetical on-site receptors at sites that are contaminated with residual radioactive materials. The use of RESRAD codes for modeling risk and dose has become an acceptable industry practice among prominent federal agencies. For example:

- The USEPA used RESRAD in its “Reassessment of Radium and Thorium Soil Concentrations and Annual Dose Rates” that demonstrated the protectiveness of the Uranium Mill Tailing Radiation Control Act soil criteria and in its rulemaking for cleanup of sites contaminated with radioactivity.
- Seven U.S. Cabinet-level agencies including the USEPA, DOE, NRC, and DOD, functioning as the Interagency Steering Committee on Radiation Standards, formally accepted RESRAD-BIOTA.
- The USEPA was also a signatory to both the ROD and the *Record of Decision for the North St. Louis County Sites* (USACE 2005b), both of which used RESRAD in their development. The USEPA has participated in many other CERCLA actions involving RESRAD.

RESRAD was not ultimately required to calculate a risk and dose for DT-15 based on the data results for the property. For all radionuclide COCs, the residual MED/AEC material is less than or equal to average background values, which means the associated risk and dose (above background) for DT-15 is zero and calculations are not required.

RECEPTOR SCENARIO

The input parameters selected for the utility and industrial worker scenarios are those defined in the FS. The exposure parameters selected for the on-site residential receptor scenario are those defined for the on-site residential receptor in the *Post-Remedial Action Report for the Accessible Soils within the St. Louis Downtown Site Plant 2 Property* (USACE 2002c). Input parameters for the hydrological data (site soil and water properties) for all scenarios were selected or determined from the *Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site* (DOE 1993), FS, and RESRAD guidance.

Each receptor scenario is summarized as follows:

- **Industrial Worker:** The industrial worker is modeled as a typical site worker who spends most of their time indoors. The worker is at the property for 250 days per year for 25 years. During a standard year, the industrial worker is assumed to spend 1600 hours indoors and 400 hours outdoors plus 125 hours (0.5 hours per day) indoors to account for the possibility of eating lunch on-site, early daily arrival, and late daily departure.
- **Utility Worker:** The utility worker may participate in utility work or other intrusive outdoor activities at the property. It is assumed that the utility worker is exposed in a single event that takes place over an 80-hour period.
- **On-Site Residential Receptor:** The on-site residential receptor is modeled as a potential future receptor in case the current land use areas being assessed changes to residential.

From the *Risk Assessment Guidance for Superfund: Volume 1—Human Health Evaluation Manual* (USEPA 1989), the residential receptor is assumed to live on site for 350 days per year for 30 years. The resident is assumed to spend 16.4 hours indoors and 2.0 hours outdoors each day per the *Exposure Factors Handbook, Volumes I, II, and III* (USEPA 1997b). Among outdoor activities, the resident is assumed to spend 0.2 hours each day for gardening.

The exposure pathways applicable to the radiological risk and dose assessment are external gamma, inhalation, and soil ingestion for the three scenarios, with plant ingestion added for the on-site resident scenario. Since ground water is not a potential source of drinking water for the SLDS, the drinking water pathway is not considered a potential pathway for the property (USACE 1998a). The non-default RESRAD input parameters for the receptor scenarios are presented in Table I-1.

Table I-1. RESRAD Non-Default Input Parameters

Category	Parameter	Values		
Physical Parameters	Area of Contaminated Zone (m ²)	Non-HTZ Area	3,835	
		HTZ Area	Not Applicable	
		Combined Area	3,835	
	Thickness of the Contaminated Zone (meter [m])	Not Applicable		
Cover Parameters	Cover Depth (m)	0		
	Density of the Cover Material (g/cm ³)	Not Applicable		
	Cover Erosion Rate (meter(s) per year [m/yr])	Not Applicable		
Hydrological Data for Contaminated Zone	Density of Contaminated Zone (g/cm ³)	1.28 (Clay Loam)		
	Contaminated Zone Total Porosity (unitless)	0.42 (Clay Soil)		
	Contaminated Zone Field Capacity (unitless)	0.36		
	Contaminated Zone Hydraulic Conductivity (m/yr)	3.048		
	Contaminated Zone b parameter (unitless)	10.4		
	Wind Speed (m per second)	4.17		
	Precipitation (m/yr)	0.92		
	Irrigation (m/yr)	0		
	Run-off Coefficient (unitless)	0.8 (Built-Up Area)		
	Contaminated zone Erosion Rate (m/yr)	0.00006		
Exposure Parameters		On-Site Resident	Utility Worker	Industrial Worker
	Inhalation Rate (cubic meter(s) per year [m ³ /yr])	8,400	10,550	10,550
	Mass Loading for Inhalation (g/m ³)	5.9×10 ⁻⁶	0.0002	0.0002
	Exposure Duration (year [yr])	30	1	25
	Indoor Dust Filtration Factor (unitless)	0.5	0.5	0.5
	External Gamma Shielding Factor	0.7	0.7	0.7
	Indoor Time Fraction ^a (unitless)	0.655	0	0.1969
	Outdoor Time Fraction ^b (unitless)	0.0799	0.0091	0.04566
	Fruit, Vegetable, and Grain Consumption (kg/yr)	42.7	Not Applicable	Not Applicable
	Leafy Vegetable Consumption (kg/yr)	4.66	Not Applicable	Not Applicable
	Soil Ingestion (gram(s) per year [g/yr])	43.8	175.2	49.64

^a Fraction of Time Indoor per year (On-Site Resident) = (16.4 hrs/day * 350 days/yr) / (24 hrs/day * 365 hrs/day) = 0.655

^b Fraction of Time Outdoor per year (On-Site Resident) = (2 hrs/day * 350 days/yr) / (24 hrs/day * 365 hrs/day) = 0.0799

g/m³ – gram(s) per cubic meter, g/cm³ – gram(s) per cubic centimeter, kg/yr – kilogram(s) per year

DETERMINATION OF EXPOSURE POINT CONCENTRATIONS

Risk and dose for this property is determined by developing a source term and applying that source term to the three receptor scenarios using RESRAD. For this property, the source terms

are based upon exposure point concentrations (EPCs). EPCs for applicable COCs were independently calculated for both hot zone ('HTZ') soil samples and 'non-HTZ' soil samples (surface and subsurface soils are combined for each type of soil sample). For this analysis, 'HTZ' soil samples are those samples taken based on increased readings identified during GWSs that may be due to environmental contamination in the soil or due to higher amounts of naturally-occurring radioactivity in the soil. 'HTZ' soil samples are assigned areas, in square meters, based on the estimated area exhibiting increased readings. (Biased soil samples for bounding purposes may have 'HTZ' in the sample identification, but no area is assigned since they are not associated with the GWS; these samples are treated as 'non-HTZ' soil samples.) Area-weighting of the sample analytical data was conducted to ensure that 'HTZ' sampling did not cause the true average concentration term to be misrepresented (USEPA 1989). The following discussion summarizes the process for calculating each COC's EPC.

- The 'non-HTZ' soil sample results for each radionuclide COC were inserted into the USEPA-designed software ProUCL (Version 4.0) to calculate the 95 percent upper confidence limit (UCL₉₅) of the arithmetic mean.
- The 'HTZ' soil sample results for each radionuclide COC were inserted into ProUCL to calculate the UCL₉₅.
- The areas represented by the 'HTZ' soil sample results were summed. The total area represented by the 'non-HTZ' soil samples was calculated by subtracting the total biased soil sample area from the total area of all the SUs. Next, these areas are used to provide a weighted average of the two UCL₉₅ values.

The EPCs for each radionuclide COC were calculated by subtracting the average background concentration from the smaller of its UCL₉₅ result or its maximum detection concentration. Since the soil sample results did not include lead (Pb)-210 and U-234, which are COCs having negligible contributions, the EPCs for these radionuclides were estimated from established ratios to other radionuclides for which an EPC was calculated. From Table 2.15 of the *Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site* (DOE 1993), the ratio of Pb-210 to Ra-226 is 1.3 and the ratio of U-234 to U-238 is 1.0.

Table I-2 presents the summary statistics and EPC results for non-HTZ soil samples. There were no HTZ (biased) soil samples required based on the GWS; therefore, it was not necessary to calculate EPCs for HTZ soil samples. All statistics are based upon the representative area concentration values used to determine UCL₉₅ values for the SU.

Table I-2. Exposure Point Concentrations

Sample Group	Area (m ²)	Statistic	Ac-227	Pa-231	Pb-210 ^a	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-234 ^a	U-235	U-238
			(pCi/g)										
Non-HTZ Soil Samples	3512	Background ^b	0.14	0.90	-	2.78	0.95	1.16	1.94	1.09	-	0.08	1.44
		Maximum	0.11	0.54	-	5.93	1.26	1.53	5.44	1.30	-	0.17	3.89
		Distribution	X	N	-	X	N	N	L	N	-	N	G
		UCL ₉₅	0.05	0.20	-	1.82	0.72	0.91	1.84	0.76	-	0.03	1.38
		EPC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

^a EPC was determined based on Table 2.15 of the *Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site* (DOE 1993).

^b Background values were taken from Table 3-2 of the *Background Soils Characterization Report for the St. Louis Downtown Site* (USACE 1999).

Note: G = Gamma, L = Lognormal, N = Normal, X = Non Parametric

RISK AND DOSE ASSESSMENT RESULTS

For all radionuclide COCs, the EPC values were zero (i.e., residual MED/AEC material is indistinguishable from background) which means the associated risk and dose for DT-15 is zero. The use of RESRAD software was not required to calculate risk and dose since the EPC values were zero. EPC calculations (including Pro-UCL output files) are included with this report as Attachment I-1.

ATTACHMENT I-1

EPC CALCULATIONS (PRO-UCL OUTPUT FILES)

(On the CD-ROM on the Back Cover of this Report)

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Table 1: Determination of Exposure Point Concentration for MSD Lift Station-Systematic samples

Statistic	Ac-227 (pCi/g)	Pa-231 (pCi/g)	Pb-210 ² (pCi/g)	Ra-226 (pCi/g)	Ra-228 (pCi/g)	Th-228 ² (pCi/g)	Th-230 (pCi/g)	Th-232 (pCi/g)	U-234 ² (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
Background	0.14	0.89	NA	2.78	0.95	1.16	1.94	1.09	NA	0.09	1.44
Maximum	0.11	0.54	NA	5.93	1.26	1.53	5.44	1.30	NA	0.17	3.89
Distribution	G	N	NA	X	N	N	L	N	NA	N	G
UCL-95 ¹	0.01	0.21	NA	1.82	0.72	0.91	1.84	0.77	NA	0.03	1.38
EPC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1 Table 2 presents the ProUCL output results for each radionuclide.

2 EPC was determined based upon table 2.15 of the Baseline Risk Assessment

NA - No Data Available or Not Applicable

General UCL Statistics for Full Data Sets

User Selected Options
 From File C:\Documents and Settings\hansenra\Desktop\Dose & Risk Assessment\FUSRAP\SLDS\MSD Lift Station\ProUCL Input.wst
 Full Precision OFF
 Confidence Coefficient 95%
 Number of Bootstrap Operations 2000

Ac-227m

General Statistics

Number of Valid Samples 24 Number of Unique Samples 24

Raw Statistics

Minimum 1 Minimum of Log Data 0
 Maximum 1.389 Maximum of Log Data 0.329
 Mean 1.259 Mean of log Data 0.229
 Median 1.267 SD of log Data 0.0664
 SD 0.0795
 Coefficient of Variation 0.0631
 Skewness -1.411

Log-transformed Statistics

Relevant UCL Statistics

Normal Distribution Test Lognormal Distribution Test
 Shapiro Wilk Test Statistic 0.892 Shapiro Wilk Test Statistic 0.858
 Shapiro Wilk Critical Value 0.916 Shapiro Wilk Critical Value 0.916
 Data not Normal at 5% Significance Level Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 1.287 95% H-UCL N/A
 95% UCLs (Adjusted for Skewness) 95% Chebyshev (MVUE) UCL 1.334
 95% Adjusted-CLT UCL 1.281 97.5% Chebyshev (MVUE) UCL 1.366
 95% Modified-t UCL 1.287 99% Chebyshev (MVUE) UCL 1.429

Assuming Lognormal Distribution

Gamma Distribution Test

k star (bias corrected) 214.9 Data Follow Appr. Gamma Distribution at 5% Significance Level
 Theta Star 0.00586
 nu star 10314
 Approximate Chi Square Value (.05) 10079 Nonparametric Statistics
 Adjusted Level of Significance 0.0392 95% CLT UCL 1.286
 Adjusted Chi Square Value 10063 95% Jackknife UCL 1.287
 95% Standard Bootstrap UCL 1.286

Data Distribution

Anderson-Darling Test Statistic 0.829 95% Bootstrap-t UCL 1.284
 Anderson-Darling 5% Critical Value 0.742 95% Hall's Bootstrap UCL 1.204
 Kolmogorov-Smirnov Test Statistic 0.146 95% Percentile Bootstrap UCL 1.284
 Kolmogorov-Smirnov 5% Critical Value 0.177 95% BCA Bootstrap UCL 1.282
 Data follow Appr. Gamma Distribution at 5% Significance Level 95% Chebyshev(Mean, Sd) UCL 1.33
 97.5% Chebyshev(Mean, Sd) UCL 1.361
 99% Chebyshev(Mean, Sd) UCL 1.421

Assuming Gamma Distribution

95% Approximate Gamma UCL 1.289
 95% Adjusted Gamma UCL 1.291

Potential UCL to Use

Use 95% Approximate Gamma UCL 1.289 1.29-1.28 **G**
0.01

Pa-231m

General Statistics

Number of Valid Samples

24 Number of Unique Samples

24

Raw Statistics

Minimum

Log-transformed Statistics

1 Minimum of Log Data

0

Maximum

2.105 Maximum of Log Data

0.744

Mean

1.665 Mean of log Data

0.494

Median

1.674 SD of log Data

0.184

SD

0.289

Coefficient of Variation

0.173

Skewness

-0.287

Relevant UCL Statistics

Normal Distribution Test

Lognormal Distribution Test

Shapiro Wilk Test Statistic

0.961 Shapiro Wilk Test Statistic

0.939

Shapiro Wilk Critical Value

0.916 Shapiro Wilk Critical Value

0.916

Data appear Normal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

Assuming Lognormal Distribution

95% Student's-t UCL

1.766

95% H-UCL

1.784

95% UCLs (Adjusted for Skewness)

95% Chebyshev (MVUE) UCL

1.941

95% Adjusted-CLT UCL

1.759

97.5% Chebyshev (MVUE) UCL

2.06

95% Modified-t UCL

1.766

99% Chebyshev (MVUE) UCL

2.293

Gamma Distribution Test

Data Distribution

k star (bias corrected)

28.37

Data appear Normal at 5% Significance Level

Theta Star

0.0587

nu star

1362

Approximate Chi Square Value (.05)

1277

Nonparametric Statistics

Adjusted Level of Significance

0.0392

95% CLT UCL

1.762

Adjusted Chi Square Value

1271

95% Jackknife UCL

1.766

95% Standard Bootstrap UCL

1.759

Anderson-Darling Test Statistic

0.364

95% Bootstrap-t UCL

1.76

Anderson-Darling 5% Critical Value

0.742

95% Hall's Bootstrap UCL

1.758

Kolmogorov-Smirnov Test Statistic

0.107

95% Percentile Bootstrap UCL

1.755

Kolmogorov-Smirnov 5% Critical Value

0.177

95% BCA Bootstrap UCL

1.754

Data appear Gamma Distributed at 5% Significance Level

95% Chebyshev(Mean, Sd) UCL

1.922

97.5% Chebyshev(Mean, Sd) UCL

2.033

99% Chebyshev(Mean, Sd) UCL

2.252

Assuming Gamma Distribution

95% Approximate Gamma UCL

1.776

95% Adjusted Gamma UCL

1.784

Potential UCL to Use

Use 95% Student's-t UCL

1.766

1.77-1.56

N
0.21

Ra_226G

General Statistics

Number of Valid Samples	24 Number of Unique Samples	23
-------------------------	-----------------------------	----

Raw Statistics

Minimum	0.803	Minimum of Log Data	-0.219
Maximum	5.93	Maximum of Log Data	1.78
Mean	1.443	Mean of log Data	0.259
Median	1.31	SD of log Data	0.403
SD	0.999		
Coefficient of Variation	0.692		
Skewness	4.237		

Log-transformed Statistics

Relevant UCL Statistics

Normal Distribution Test	Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.474 Shapiro Wilk Test Statistic	0.777
Shapiro Wilk Critical Value	0.916 Shapiro Wilk Critical Value	0.916
Data not Normal at 5% Significance Level	Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution

95% Student's-t UCL	1.792	95% H-UCL	1.648
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	1.916
95% Adjusted-CLT UCL	1.967	97.5% Chebyshev (MVUE) UCL	2.139
95% Modified-t UCL	1.822	99% Chebyshev (MVUE) UCL	2.577

Assuming Lognormal Distribution

Gamma Distribution Test

k star (bias corrected)	4.245	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.34		
nu star	203.8		
Approximate Chi Square Value (.05)	171.7	Nonparametric Statistics	
Adjusted Level of Significance	0.0392	95% CLT UCL	1.778
Adjusted Chi Square Value	169.7	95% Jackknife UCL	1.792
		95% Standard Bootstrap UCL	1.766

Data Distribution

Anderson-Darling Test Statistic	1.971	95% Bootstrap-t UCL	2.381
Anderson-Darling 5% Critical Value	0.747	95% Hall's Bootstrap UCL	3.115
Kolmogorov-Smimov Test Statistic	0.25	95% Percentile Bootstrap UCL	1.841
Kolmogorov-Smimov 5% Critical Value	0.178	95% BCA Bootstrap UCL	2.053
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	2.332
		97.5% Chebyshev(Mean, Sd) UCL	2.716
		99% Chebyshev(Mean, Sd) UCL	3.472
Assuming Gamma Distribution			
95% Approximate Gamma UCL	1.712		
95% Adjusted Gamma UCL	1.733		

Potential UCL to Use

Use 95% Student's-t UCL	1.792
or 95% Modified-t UCL	1.822

X
1.82

Ra_228G

General Statistics

Number of Valid Samples

24 Number of Unique Samples

24

Raw Statistics

Minimum

0.0744

Log-transformed Statistics

-2.598

Maximum

1.26

Maximum of Log Data

0.231

Mean

0.591

Mean of log Data

-0.824

Median

0.676

SD of log Data

0.917

SD

0.354

Coefficient of Variation

0.6

Skewness

-0.163

Relevant UCL Statistics

Normal Distribution Test

Lognormal Distribution Test

Shapiro Wilk Test Statistic

0.917

Shapiro Wilk Test Statistic

0.828

Shapiro Wilk Critical Value

0.916

Shapiro Wilk Critical Value

0.916

Data appear Normal at 5% Significance Level

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

Assuming Lognormal Distribution

95% Student's-t UCL

0.715

95% H-UCL

1.059

95% UCLs (Adjusted for Skewness)

95% Chebyshev (MVUE) UCL

1.245

95% Adjusted-CLT UCL

0.707

97.5% Chebyshev (MVUE) UCL

1.502

95% Modified-t UCL

0.714

99% Chebyshev (MVUE) UCL

2.006

Gamma Distribution Test

Data Distribution

k star (bias corrected)

1.626

Data appear Normal at 5% Significance Level

Theta Star

0.363

nu star

78.04

Approximate Chi Square Value (.05)

58.69

Nonparametric Statistics

Adjusted Level of Significance

0.0392

95% CLT UCL

0.71

Adjusted Chi Square Value

57.51

95% Jackknife UCL

0.715

Anderson-Darling Test Statistic

1.427

95% Bootstrap-t UCL

0.711

Anderson-Darling 5% Critical Value

0.757

95% Hall's Bootstrap UCL

0.705

Kolmogorov-Smimov Test Statistic

0.243

95% Percentile Bootstrap UCL

0.709

Kolmogorov-Smimov 5% Critical Value

0.181

95% BCA Bootstrap UCL

0.716

Data not Gamma Distributed at 5% Significance Level

95% Chebyshev(Mean, Sd) UCL

0.906

97.5% Chebyshev(Mean, Sd) UCL

1.042

99% Chebyshev(Mean, Sd) UCL

1.31

Assuming Gamma Distribution

95% Approximate Gamma UCL

0.786

95% Adjusted Gamma UCL

0.802

Potential UCL to Use

Use 95% Student's-t UCL

0.715

N
0.72

Th-228

General Statistics

Number of Valid Samples

24 Number of Unique Samples

23

Raw Statistics

Minimum

0.0707 Minimum of Log Data

-2.649

Maximum

1.53 Maximum of Log Data

0.425

Mean

0.753 Mean of log Data

-0.578

Median

0.86 SD of log Data

0.926

SD

0.448

Coefficient of Variation

0.595

Skewness

-0.143

Relevant UCL Statistics

Normal Distribution Test

Lognormal Distribution Test

Shapiro Wilk Test Statistic

0.924 Shapiro Wilk Test Statistic

0.843

Shapiro Wilk Critical Value

0.916 Shapiro Wilk Critical Value

0.916

Data appear Normal at 5% Significance Level

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL

0.91

Assuming Lognormal Distribution

95% H-UCL

1.376

95% UCLs (Adjusted for Skewness)

95% Chebyshev (MVUE) UCL

1.615

95% Adjusted-CLT UCL

0.901 97.5% Chebyshev (MVUE) UCL

1.95

95% Modified-t UCL

0.91

99% Chebyshev (MVUE) UCL

2.609

Gamma Distribution Test

k star (bias corrected)

Data Distribution

1.643 Data appear Normal at 5% Significance Level

Theta Star

0.459

nu star

78.85

Approximate Chi Square Value (.05)

59.39 Nonparametric Statistics

Adjusted Level of Significance

0.0392 95% CLT UCL

0.904

Adjusted Chi Square Value

58.21 95% Jackknife UCL

0.91

Anderson-Darling Test Statistic

1.063 95% Bootstrap-t UCL

0.897

Anderson-Darling 5% Critical Value

0.757 95% Hall's Bootstrap UCL

0.908

Kolmogorov-Smirnov Test Statistic

0.191 95% Percentile Bootstrap UCL

0.899

Kolmogorov-Smirnov 5% Critical Value

0.181 95% BCA Bootstrap UCL

0.897

Data not Gamma Distributed at 5% Significance Level

95% Chebyshev(Mean, Sd) UCL

1.152

97.5% Chebyshev(Mean, Sd) UCL

1.325

99% Chebyshev(Mean, Sd) UCL

1.664

Assuming Gamma Distribution

95% Approximate Gamma UCL

1

95% Adjusted Gamma UCL

1.021

Potential UCL to Use

Use 95% Student's-t UCL

0.91

N
0.91

Th_230G

General Statistics

Number of Valid Samples

24 Number of Unique Samples

23

Raw Statistics

Minimum

0.591 Minimum of Log Data

-0.526

Maximum

5.44 Maximum of Log Data

1.694

Mean

1.535 Mean of log Data

0.308

Median

1.34 SD of log Data

0.47

SD

0.962

Coefficient of Variation

0.627

Skewness

3.137

Log-transformed Statistics

Relevant UCL Statistics

Normal Distribution Test

Lognormal Distribution Test

Shapiro Wilk Test Statistic

0.662 Shapiro Wilk Test Statistic

0.916

Shapiro Wilk Critical Value

0.916 Shapiro Wilk Critical Value

0.916

Data not Normal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

Assuming Lognormal Distribution

95% Student's-t UCL

1.871 95% H-UCL

1.838

95% UCLs (Adjusted for Skewness)

95% Chebyshev (MVUE) UCL

2.167

95% Adjusted-CLT UCL

1.992 97.5% Chebyshev (MVUE) UCL

2.45

95% Modified-t UCL

1.892 99% Chebyshev (MVUE) UCL

3.007

Gamma Distribution Test

Data Distribution

k star (bias corrected)

3.787 Data appear Lognormal at 5% Significance Level

Theta Star

0.405

nu star

181.8

Approximate Chi Square Value (.05)

151.6 Nonparametric Statistics

Adjusted Level of Significance

0.0392 95% CLT UCL

1.858

Adjusted Chi Square Value

149.7 95% Jackknife UCL

1.871

Anderson-Darling Test Statistic

1.039 95% Standard Bootstrap UCL

1.849

Anderson-Darling 5% Critical Value

0.748 95% Bootstrap-t UCL

2.175

Kolmogorov-Smimov Test Statistic

0.209 95% Hall's Bootstrap UCL

3.422

Kolmogorov-Smimov 5% Critical Value

0.209 95% Percentile Bootstrap UCL

1.887

Data not Gamma Distributed at 5% Significance Level

0.179 95% BCA Bootstrap UCL

2.036

95% Chebyshev(Mean, Sd) UCL

2.391

97.5% Chebyshev(Mean, Sd) UCL

2.761

99% Chebyshev(Mean, Sd) UCL

3.489

Assuming Gamma Distribution

95% Approximate Gamma UCL

1.84

95% Adjusted Gamma UCL

1.864

Potential UCL to Use

Use 95% Student's-t UCL

1.871

or 95% Modified-t UCL

1.892

or 95% H-UCL

1.838

L
1.84

Th-232m

General Statistics

Number of Valid Samples

24 Number of Unique Samples

23

Raw Statistics

Minimum

Log-transformed Statistics

1 Minimum of Log Data

0

Maximum

2.314 Maximum of Log Data

0.839

Mean

1.639 Mean of log Data

0.464

Median

1.668 SD of log Data

0.256

SD

0.397

Coefficient of Variation

0.243

Skewness

-0.0968

Relevant UCL Statistics

Normal Distribution Test

Lognormal Distribution Test

Shapiro Wilk Test Statistic

0.945 Shapiro Wilk Test Statistic

0.928

Shapiro Wilk Critical Value

0.916 Shapiro Wilk Critical Value

0.916

Data appear Normal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

Assuming Lognormal Distribution

95% Student's-t UCL

1.778 95% H-UCL

1.808

95% UCLs (Adjusted for Skewness)

95% Chebyshev (MVUE) UCL

2.019

95% Adjusted-CLT UCL

1.77 97.5% Chebyshev (MVUE) UCL

2.182

95% Modified-t UCL

1.778 99% Chebyshev (MVUE) UCL

2.503

Gamma Distribution Test

Data Distribution

k star (bias corrected)

14.64 Data appear Normal at 5% Significance Level

Theta Star

0.112

nu star

702.8

Approximate Chi Square Value (.05)

642.3 Nonparametric Statistics

Adjusted Level of Significance

0.0392 95% CLT UCL

1.772

Adjusted Chi Square Value

638.2 95% Jackknife UCL

1.778

95% Standard Bootstrap UCL

1.767

Anderson-Darling Test Statistic

0.619 95% Bootstrap-t UCL

1.774

Anderson-Darling 5% Critical Value

0.743 95% Hall's Bootstrap UCL

1.768

Kolmogorov-Smimov Test Statistic

0.149 95% Percentile Bootstrap UCL

1.773

Kolmogorov-Smimov 5% Critical Value

0.178 95% BCA Bootstrap UCL

1.766

Data appear Gamma Distributed at 5% Significance Level

95% Chebyshev(Mean, Sd) UCL

1.992

97.5% Chebyshev(Mean, Sd) UCL

2.145

99% Chebyshev(Mean, Sd) UCL

2.446

Assuming Gamma Distribution

95% Approximate Gamma UCL

1.793

95% Adjusted Gamma UCL

1.805

Potential UCL to Use

Use 95% Student's-t UCL

1.778

1.78-1.01

N
0.77

U-235m

General Statistics

Number of Valid Samples

24 Number of Unique Samples

24

Raw Statistics

Minimum

Log-transformed Statistics

1 Minimum of Log Data

0

Maximum

1.449 Maximum of Log Data

0.371

Mean

1.278 Mean of log Data

0.242

Median

1.264 SD of log Data

0.0791

SD

0.0978

Coefficient of Variation

0.0766

Skewness

-0.622

Relevant UCL Statistics

Normal Distribution Test

Lognormal Distribution Test

Shapiro Wilk Test Statistic

0.949 Shapiro Wilk Test Statistic

0.926

Shapiro Wilk Critical Value

0.916 Shapiro Wilk Critical Value

0.916

Data appear Normal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

Assuming Lognormal Distribution

95% Student's-t UCL

1.312 95% H-UCL

N/A

95% UCLs (Adjusted for Skewness)

95% Chebyshev (MVUE) UCL

1.368

95% Adjusted-CLT UCL

1.308 97.5% Chebyshev (MVUE) UCL

1.407

95% Modified-t UCL

1.311 99% Chebyshev (MVUE) UCL

1.483

Gamma Distribution Test

Data Distribution

k star (bias corrected)

149.6 Data appear Normal at 5% Significance Level

Theta Star

0.00854

nu star

7181

Approximate Chi Square Value (.05)

6985 Nonparametric Statistics

Adjusted Level of Significance

0.0392 95% CLT UCL

1.31

Adjusted Chi Square Value

6971 95% Jackknife UCL

1.312

Anderson-Darling Test Statistic

0.453 95% Bootstrap-t UCL

1.31

Anderson-Darling 5% Critical Value

0.742 95% Hall's Bootstrap UCL

1.31

Kolmogorov-Smimov Test Statistic

0.133 95% Percentile Bootstrap UCL

1.308

Kolmogorov-Smimov 5% Critical Value

0.177 95% BCA Bootstrap UCL

1.307

Data appear Gamma Distributed at 5% Significance Level

95% Chebyshev(Mean, Sd) UCL

1.365

97.5% Chebyshev(Mean, Sd) UCL

1.402

99% Chebyshev(Mean, Sd) UCL

1.476

Assuming Gamma Distribution

95% Approximate Gamma UCL

1.313

95% Adjusted Gamma UCL

1.316

Potential UCL to Use

Use 95% Student's-t UCL

1.312

1.31-1.28

N
0.03

U_238G

General Statistics

Number of Valid Samples	24 Number of Unique Samples	23
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Raw Statistics

Minimum	0.491	Minimum of Log Data	-0.711
Maximum	3.89	Maximum of Log Data	1.358
Mean	1.155	Mean of log Data	0.0301
Median	0.949	SD of log Data	0.451
SD	0.697		
Coefficient of Variation	0.604		
Skewness	2.896		

Log-transformed Statistics

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.7	Shapiro Wilk Test Statistic	0.939
Shapiro Wilk Critical Value	0.916	Shapiro Wilk Critical Value	0.916
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution

95% Student's-t UCL	1.398	95% H-UCL	1.368
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	1.606
95% Adjusted-CLT UCL	1.478	97.5% Chebyshev (MVUE) UCL	1.81
95% Modified-t UCL	1.412	99% Chebyshev (MVUE) UCL	2.21

Assuming Lognormal Distribution

Gamma Distribution Test

k star (bias corrected)	4.017	Data Follow Appr. Gamma Distribution at 5% Significance Level	
Theta Star	0.287		
nu star	192.8		
Approximate Chi Square Value (.05)	161.7	Nonparametric Statistics	
Adjusted Level of Significance	0.0392	95% CLT UCL	1.389
Adjusted Chi Square Value	159.7	95% Jackknife UCL	1.398
		95% Standard Bootstrap UCL	1.383

Data Distribution

Anderson-Darling Test Statistic	0.807	95% Bootstrap-t UCL	1.62
Anderson-Darling 5% Critical Value	0.747	95% Hall's Bootstrap UCL	2.529
Kolmogorov-Smimov Test Statistic	0.161	95% Percentile Bootstrap UCL	1.411
Kolmogorov-Smimov 5% Critical Value	0.178	95% BCA Bootstrap UCL	1.483
Data follow Appr. Gamma Distribution at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	1.775
		97.5% Chebyshev(Mean, Sd) UCL	2.043
		99% Chebyshev(Mean, Sd) UCL	2.57
Assuming Gamma Distribution			
95% Approximate Gamma UCL	1.377		
95% Adjusted Gamma UCL	1.394		

Potential UCL to Use

Use 95% Approximate Gamma UCL	1.377
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G
1.38

APPENDIX J

BORING LOGS AND FIELD LOGBOOK ENTRIES FOR SAMPLES

(On the CD-ROM on the Back Cover of this Report)

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HTRW DRILLING LOG			DISTRICT ST. LOUIS		HOLE NUMBER SLD 98535	
1. COMPANY NAME SHAW ENVIRONMENTAL			2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 of 2	
3. PROJECT FUSRAP/SLDS			4. LOCATION MSD L.H. Stahen VP(OT-5)			
5. NAME OF DRILLER Dan Gotto			6. MANUFACTURER'S DESIGNATION OF DRILL CNE 75			
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT CNE 75 using 3.25" HSA and 1" x 2" split spoon			8. HOLE LOCATION See location sketch			
9. SURFACE ELEVATION						
10. DATE STARTED 1/31/07			11. DATE COMPLETED 1/31/07			
12. OVERBURDEN THICKNESS N/A			13. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A			
14. TOTAL DEPTH OF HOLE 4 C' BGS			15. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A			
16. GEOTECHNICAL SAMPLES <input type="checkbox"/> DISTURBED <input type="checkbox"/> UNDISTURBED			17. TOTAL NUMBER OF CORE BOXES <input type="checkbox"/>			
18. SAMPLES FOR CHEMICAL ANALYSIS <input type="checkbox"/> VOC <input type="checkbox"/> METALS <input type="checkbox"/> OTHER (SPECIFY) <input type="checkbox"/>			19. TOTAL CORE RECOVERY <input type="checkbox"/>			
20. DISPOSITION OF HOLE <input checked="" type="checkbox"/> ABANDONED <input type="checkbox"/> MONITORING WELL <input type="checkbox"/> OTHER (SPECIFY) <input type="checkbox"/>			21. SIGNATURE OF INSPECTOR James L. Adams			
LOCATION SKETCH/COMMENTS Witnessed by: James L. Adams SCALE: Not to Scale						
PROJECT FUSRAP/SLDS			HOLE NO. SLD 98535			

HTRW DRILLING LOG (CONTINUATION SHEET)						HOLE NUMBER 510 98535	
PROJECT FUSRAP/SLDS			INSPECTOR Susan Adams			SHEET 2 of 2	
DEPTH (ft)	DESCRIPTION OF MATERIALS (1)	RECOVERY (%)	REMARKS (2)	REMARKS (3)	REMARKS (4)	REMARKS (5)	REMARKS (6)
CL	dark brown silty clay, medium stiff, medium plastic, trace brick frag, trace cinders	200 0.0	RECOVERY	SLD 98535 1548	20		
GP	coarse to medium size gravel, possibly rounded	100 0.0	1.8/2.0		30		
	fine to coarse gravel, some cobble size, possibly graded, trace cinders	200 0.0		SLD 98536 1550	20		
		400 0.0			17		
2	no recovery		no recovery				
3	(see SLD 98535A)						
4	med brown silty clay, medium sh A, medium plastic, trace brick frag, trace cinders	100 0.0	1.8/2.0		4		
5		300 0.0			5		
		400 0.0		SLD 98535 1554	8		
		200 0.0	no recovery		12		
6							
7	EOB 1600 TD: 6.0' BGS						Backfilled w/ Bentonite chips
8							
9							
10							

HTRW DRILLING LOG				DISTRICT ST. LOUIS		HOLE NUMBER SLD 98535A	
1. COMPANY NAME SHAW ENVIRONMENTAL			2. DRILLING SUBCONTRACTOR Shaw			SHEET 1 of 2	
3. PROJECT FUSRAP/SLDS			4. LOCATION MSD LIT Station VP(UT-15)				
5. NAME OF DRILLER Dan Gotto			6. MANUFACTURER'S DESIGNATION OF DRILL CME 75				
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT CME 75 using 3.25" HSA and 2" x 2" split spoon			8. HOLE LOCATION See location sketch				
9. SURFACE ELEVATION			10. DATE STARTED 11/31/07				
11. DATE COMPLETED 11/31/07			12. OVERBURDEN THICKNESS N/A				
13. DEPTH DRILLED INTO ROCK N/A			14. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A				
15. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A			16. TOTAL DEPTH OF HOLE 4.0' BGS				
17. GEOTECHNICAL SAMPLES 0			18. DISTURBED 0		19. UNDISTURBED 0		20. TOTAL NUMBER OF COPE BOXES 0
21. SAMPLES FOR CHEMICAL ANALYSIS 0			22. VOC 0		23. METALS 0		24. OTHER (SPECIFY) 0
25. DEPOSITION OF HOLE 0			26. BACKFILLED 0		27. MONITORING WELL 0		28. OTHER (SPECIFY) 0
29. SIGNATURE OF INSPECTOR Susan L. Adams			30. SCALE: Not to Scale				
<p>LOCATION SKETCH/COMMENTS Witnessed by: Susan L. Adams</p> <p>Trace <5% Few 5-10% Little 15-25% Some 20-35% Mostly 50-100%</p>							
PROJECT FUSRAP/SLDS						HOLE NO. SLD 98535A	

HTRW DRILLING LOG (CONTINUATION SHEET)							HOLE NUMBER SLD 98535A
PROJECT FUSRAP/SLDS		INSPECTOR Susan Adams					SHEET 2 of 2
DEPTH (ft)	DESCRIPTION OF PLUG SAMPLES (1)	RECOVERY (2)	GRAIN SIZE (3)	BLD'W CORREL (4)	REMARKS (5)		
1	See SLD 98535						
2							
3	Dark to light gray fine to cobble size gravel, poorly graded	-300 0.0	1.3/2.0	SLD 98535 1614	7 11 16 28 ← Archive		
4		100 0.0					
5	EOB 1616 TD= 4.0' BGS	-400 0.0					
6		NA NA					
7							
8							
9							
10							

HTRW DRILLING LOG		DISTRICT ST. LOUIS		HOLE NUMBER SLD 98537	
1. COMPANY NAME SHAW ENVIRONMENTAL		2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 of 2	
3. PROJECT FUSRAP/SLDS			4. LOCATION MSD 1st Station VPCOT-15		
5. NAME OF DRILLER Dan Gotto			6. MANUFACTURER'S DESIGNATION OF DRILL CME 75		
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT CME 75 using 1.25" HSA and 1" x 2" split screen			8. HOLE LOCATION See location sketch		
9. DATE 4/13/07			10. DATE STARTED 2/1/07		
11. DATE COMPLETED 2/1/07			12. OTHER HOLE INFORMATION NA		
13. DEPTH DRILLED INTO ROCK NA			14. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED NA		
15. TOTAL DEPTH OF HOLE 80'			16. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) NA		
17. GEOTECHNICAL SAMPLES		18. UNDISTURBED		19. TOTAL NUMBER OF CORE BOXES	
<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
20. SAMPLES FOR CHEMICAL ANALYSIS		21. TOTAL CORE RECOVERY		<input type="checkbox"/>	
<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
22. DISPOSITION OF HOLE		23. SIGNATURE OF INSPECTOR		Susan L. Adams	
<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
LOCATION SKETCH/COMMENTS Witnessed by: Susan L. Adams SCALE: Not to Scale					
PROJECT FUSRAP/SLDS		HOLE NO. SLD 98537			

HTRW DRILLING LOG (CONTINUATION SHEET)						HOLE NUMBER SLD 98537
PROJECT FUSRAP/SLDS		INSPECTOR Susan Adams		SHEET 2 of 2 SHEETS		
DEPTH (ft)	DESCRIPTION OF LOG INTERVALS (ft)	REMARKS (ft)	REMARKS (ft)	REMARKS (ft)	REMARKS (ft)	
1	medium brown, silty clay, medium stiff to stiff, medium plastic, dry	0.0	RECOVERY	25	clean backfill	
2		300 0.0	1.8/2.0	6		
3		300 0.0		7		
4		400 0.0		12		
5	turning dark brown, some coarse sand, few cinders very stiff	500 0.0		8		
6		700 0.0	2.0/2.0	17		
7		600 0.0		24		
8	trace slag, some brown paint chips (clay)	100 0.0		16		
9	medium brown, silty clay, soft, medium plastic, some coarse sand, some cinders, few slag	100 0.0		2		
10		900 0.0	1.8/2.0	2	Archive	
11		500 0.0		7		
12	turning soft	300 0.0		2		
13		600 0.0	no recovery	3		
14		700 0.0		4		
15	piece of slag, cobbles, etc	300 0.0	2.0/2.0	3		
16	piece of glass, mostly coarse sand	100 0.0		6		
17	EOB 1627				Backfilled w/ Bentonite chips	
18	TD = 8.0' BGS					

HTRW DRILLING LOG		DISTRICT ST. LOUIS		HOLE NUMBER SLD 98539	
1. COMPANY NAME SHAW ENVIRONMENTAL		2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 OF 2	
3. PROJECT FUSRAP/SLDS			4. LOCATION MSO Lift Station		
5. NAME OF DRILLER Dan Gotto			6. MANUFACTURER'S DESIGNATION OF DRILL CME 75		
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT CME 75 using 3.25" HSA and 1" x 2" split spoon			8. HOLE LOCATION See location sketch		
9. SURFACE ELEVATION Driven with a 140# hammer over 35' drop			10. DATE STARTED 1/31/07		
11. DATE COMPLETED 1/31/07			12. OVERBURDEN THICKNESS N/A		
13. DEPTH DRILLED INTO ROCK N/A			14. TOTAL DEPTH OF HOLE 6.0' BGS		
15. DEPTH TO GROUNDWATER ENCOUNTERED N/A			16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A		
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A			18. GEOTECHNICAL SAMPLES		
19. TOTAL NUMBER OF CORE BOXES 0			20. SAMPLES FOR CHEMICAL ANALYSIS		
21. TOTAL CORE RECOVERY 0%			22. DISPOSITION OF HOLE		
23. SIGNATURE OF INSPECTOR Steven A. Adams			24. LOCATION SKETCH/COMMENTS		
25. SCALE: Not to Scale			26. WITNESSED BY: Steven A. Adams		
27. LOCATION SKETCH/COMMENTS			28. LOCATION SKETCH/COMMENTS		
29. LOCATION SKETCH/COMMENTS			30. LOCATION SKETCH/COMMENTS		
31. LOCATION SKETCH/COMMENTS			32. LOCATION SKETCH/COMMENTS		
33. LOCATION SKETCH/COMMENTS			34. LOCATION SKETCH/COMMENTS		
35. LOCATION SKETCH/COMMENTS			36. LOCATION SKETCH/COMMENTS		
37. LOCATION SKETCH/COMMENTS			38. LOCATION SKETCH/COMMENTS		
39. LOCATION SKETCH/COMMENTS			40. LOCATION SKETCH/COMMENTS		
41. LOCATION SKETCH/COMMENTS			42. LOCATION SKETCH/COMMENTS		
43. LOCATION SKETCH/COMMENTS			44. LOCATION SKETCH/COMMENTS		
45. LOCATION SKETCH/COMMENTS			46. LOCATION SKETCH/COMMENTS		
47. LOCATION SKETCH/COMMENTS			48. LOCATION SKETCH/COMMENTS		
49. LOCATION SKETCH/COMMENTS			50. LOCATION SKETCH/COMMENTS		
51. LOCATION SKETCH/COMMENTS			52. LOCATION SKETCH/COMMENTS		
53. LOCATION SKETCH/COMMENTS			54. LOCATION SKETCH/COMMENTS		
55. LOCATION SKETCH/COMMENTS			56. LOCATION SKETCH/COMMENTS		
57. LOCATION SKETCH/COMMENTS			58. LOCATION SKETCH/COMMENTS		
59. LOCATION SKETCH/COMMENTS			60. LOCATION SKETCH/COMMENTS		
61. LOCATION SKETCH/COMMENTS			62. LOCATION SKETCH/COMMENTS		
63. LOCATION SKETCH/COMMENTS			64. LOCATION SKETCH/COMMENTS		
65. LOCATION SKETCH/COMMENTS			66. LOCATION SKETCH/COMMENTS		
67. LOCATION SKETCH/COMMENTS			68. LOCATION SKETCH/COMMENTS		
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171. LOCATION SKETCH/COMMENTS			172. LOCATION SKETCH/COMMENTS		

NOI DIVISION
50 98539

INSPECTION Susan Adams

2 2

ENG FORM 5036A-R, AUG 94

HTRW DRILLING LOG				DISTRICT ST. LOUIS		HOLE NUMBER SLD 98543	
1. COMPANY NAME SHAW ENVIRONMENTAL				2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 OF 2 SHEETS	
3. PROJECT FUSRAP/SLDS				4. LOCATION MSO Lift Station VP(DT-15)			
5. NAME OF DRILLER Dan Gotto				6. MANUFACTURER'S DESIGNATION OF DRILL CME 75			
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT CME 75 using 1.25" HSA and 1" x 2" split screen				8. HOLE LOCATION See location sketch			
9. SURFACE ELEVATION Driven with a 140# hammer over 30" drop				10. DATE STARTED 2/7/07			
11. DATE COMPLETED 2/7/07				12. OVERBURDEN THICKNESS N/A			
13. DEPTH DRILLED INTO ROCK N/A				14. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A			
15. TOTAL DEPTH OF HOLE 8.0' BGS				16. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A			
18. GEOTECHNICAL SAMPLES 0		DISTURBED 0		UNDISTURBED 1		19. TOTAL NUMBER OF CORE BORES 1	
20. SAMPLES FOR CHEMICAL ANALYSIS 0		METALS 0		OTHER (SPECIFY) RAI		21. TOTAL CORE RECOVERY 0%	
22. DISPOSITION OF HOLE 0		RACKED 0		MONITORING WELL N/A		23. SIGNATURE OF INSPECTOR Susan L. Adams	
<div style="display: flex; justify-content: space-between;"> <div> <p>LOCATION SKETCH/COMMENTS</p> </div> <div> <p>Witnessed by: Susan L. Adams</p> <p>SCALE: Not to Scale</p> <p>Trace <5% Few 5-10% Little 15-25% Some 20-35% Mostly 50-100%</p> </div> </div>							
PROJECT FUSRAP/SLDS						HOLE NO. SLD 98543	

HTRW DRILLING LOG (CONTINUATION SHEET)						HOLE NUMBER 310 98543
PROJECT FUSRAP/SLDS		INSPECTOR Susan Adams		SHEET 2 of 2		
DEPTH (ft)	DESCRIPTION OF HOLE DRILLS (1)	LOG (2)	RECOVERY (3)	LOG (4)	REMARKS (5)	
1	dark brown s. lty clay, medium stiff, med. un plastic, clay, some coarse to cobble sized gravel (limestone)	300 0.0	RECOVERY	50	clean backfill to depth,	
2		100 0.0	1.8/2.0	5	see	
3		400 0.0		6	SLD 98543A	
4		300 0.0	no recovery	9	for sample information.	
5		600 0.0		9		
6		700 0.0	1.9/2.0	8		
7		300 0.0		10		
8		300 0.0		13		
9		600 0.0	no recovery	3		
10		700 0.0		6		
11		600 0.0	2.0/2.0	8		
12		200 0.0		15		
13						
14			2.0/2.0			
15						
16						
17						
18						
19	EOB 1500				Backfilled	
20	TD=80' BGS				w/ Bentonite	
21					Chips	
22						
23						
24						
25						
26						
27						
28						
29						
30						

HTRW DRILLING LOG		DISTRICT ST. LOUIS		HOLE NUMBER SLD 98543A	
1. COMPANY NAME SHAW ENVIRONMENTAL		2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 OF 2 SHEETS	
3. PROJECT FUSRAP/SLDS		4. LOCATION MSO Lift Station VPCOT-15			
5. NAME OF DRILLER Dan Gotto		6. MANUFACTURER'S DESIGNATION OF DRILL CNIE 75			
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT CNIE 75 using 1.25" (USA) and 1.5" x 2" (OH) rods		8. HOLE LOCATION See location sketch			
9. SURFACE ELEVATION		10. DATE STARTED 2/7/07			
11. DATE COMPLETED 2/7/07		12. OVERBURDEN THICKNESS N/A			
13. DEPTH DRILLED INTO ROCK N/A		14. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A			
15. TOTAL DEPTH OF HOLE 8.0' BGS		16. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A			
17. GEOTECHNICAL SAMPLES <input type="checkbox"/> DISTURBED <input type="checkbox"/> UNDISTURBED		18. TOTAL NUMBER OF CORE BOXES <input type="checkbox"/>			
19. SAMPLES FOR CHEMICAL ANALYSIS <input type="checkbox"/> YES <input type="checkbox"/> NO		20. METALS <input type="checkbox"/>		21. OTHER (SPECIFY) <input type="checkbox"/>	
22. DEPOSITION OF HOLE <input type="checkbox"/> BACTERIALIZED <input type="checkbox"/> MONITORING WELL <input type="checkbox"/>		23. OTHER (SPECIFY) <input type="checkbox"/>		24. SIGNATURE OF INSPECTOR Susan L. Adams	
LOCATION SKETCH/COMMENTS Witnessed by: Susan L. Adams SCALE: Not to Scale					
PROJECT FUSRAP/SLDS				HOLE NO. SLD 98543A	

HTRW DRILLING LOG (CONTINUATION SHEET)						HOLE NUMBER SLD 98543A	
PROJECT FUSRAP/SLDS		INSPECTOR Susan Adams		SHEET 2 of 2		SHEET 1	
DEPTH (ft)	DESCRIPTION OF HOLE BRIMS (ft)	TIME (min)	RECOVERY (%)	TEST (ft)	BLOW COUNT (ft)	REMARKS (ft)	
SM	black to gray silty fine sand, mostly coarse to cobble size gravel, poorly graded	200 0.0	RECOVERY		50	Clean backfill	
		500 0.0	2.0/2.0		20		
		500 0.0			5		
CL	medium brown s. to clay, medium stiff, med. plast. dry	400 0.0			12		
		400 0.0			9		
	medium to dark brown silty clay, stiff, medium plast, few coarse grains, trace cinders	800 0.0		SLD 98543 1522	8		
		100 0.0	2.0/2.0		9		
		100 0.0			11		
	turning soft	0 0.0		SLD 98544 1524	3		
		800 0.0		Archive 98543A 1523	3		
		600 0.0			8		
	turning stiff	300 0.0			14		
		600 0.0			6		
		800 0.0		Archive 98543A 1525	9		
	few cinders, trace brick frag	600 0.0	2.0/2.0		11		
		400 0.0			14		
	turning olive gray piece of wood	400 0.0					
	EOB 1555 TD = 8.0' BGS						
10							

HTRW DRILLING LOG		DISTRICT ST. LOUIS		HOLE NUMBER SLD 98545	
1. COMPANY NAME SHAW ENVIRONMENTAL		2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 OF 2	
3. PROJECT FUSRAP/SLDS		4. LOCATION MSD LIFT STATION VP (DT-15)			
5. NAME OF DRILLER Dan Gotto		6. MANUFACTURER'S DESIGNATION OF DRILL CME 75			
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT CME 75 utilizes 1.25" HSA and 1" x 2" split spoon		8. HOLE LOCATION See location sketch			
Driven with a 140# hammer over 30" drop End Date: 6/13/07		9. SURFACE ELEVATION			
PID: 562307 NL: 172051 LUD: 172012 RYG: C.O Cal Due: 4/1/07 Drilling cost 4800		10. DATE STARTED 1/31/07		11. DATE COMPLETED 1/31/07	
12. OVERBURDEN THICKNESS N/A		15. DEPTH GROUNDWATER ENCOUNTERED N/A			
13. DEPTH DRILLED INTO ROCK N/A		16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A			
14. TOTAL DEPTH OF HOLE 60' BGS		17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A			
18. GEOTECHNICAL SAMPLES <input type="checkbox"/> DISTURBED <input type="checkbox"/> UNDISTURBED		19. TOTAL NUMBER OF CORE BOXES <input type="checkbox"/>			
20. SAMPLES FOR CHEMICAL ANALYSIS <input type="checkbox"/> VOC <input type="checkbox"/> METALS <input type="checkbox"/> OTHER (SPECIFY) <input type="checkbox"/> RAD <input type="checkbox"/> OTHER (SPECIFY) <input type="checkbox"/> OTHER (SPECIFY)		21. TOTAL CORE RECOVERY 0%			
22. DISPOSITION OF HOLE <input type="checkbox"/> BACKFILLED <input type="checkbox"/> MONITORING WELL <input type="checkbox"/> OTHER (SPECIFY)		23. SIGNATURE OF INSPECTOR Susan R. Adams			
<div style="display: flex; justify-content: space-between;"> <div> <p>LOCATION SKETCH/COMMENTS Witnessed by: Susan R. Adams</p> </div> <div> <p>SCALE: Not to Scale</p> <ul style="list-style-type: none"> Trace <5% Few 5-10% Little 15-25% Some 20-35% Mostly 50-100% </div> </div>					
PROJECT FUSRAP/SLDS				HOLE NO. SLD 98545	

HTRW DRILLING LOG (CONTINUATION SHEET)						HOLE NUMBER S.D. 98545
PROJECT FUSRAP/SLDS		INSPECTOR Susan Adams		SHEET 2 of 2		
DEPTH (ft)	DESCRIPTION OF HOLE WALLS (1)	REMARKS (2)	RECOVERY (3)	BLOW COUNT (4)	REMARKS (5)	
SM	dark brown silty fine sand poorly graded few coarse to cobb size gravel	200 0.0	RECOVERY	S.D. 98545 1404	62	
1	mostly dark brown silty clay silty med plastic clay, trace brick frag	200 0.0	2.0/ 2.0		50	
	Fine to cobb size gravel (limestone), poorly graded, gray	200 0.0			60	
2	turning brown	200 0.0		S.D. 98546 1407	61	
		600 0.0			17	
3	turning light brown to gray, some silt	300 0.0	1.7/ 2.0		20	
		200 0.0		Archive 98545 1437	15	
4		0 0.0	no recovery		13	
	piece of cobb size gravel	200 0.0			7	
5		0 0.0	1.8/ 2.0		12	
	mostly brown silty clay	300 0.0		Archive 98545 1414	17	
	some med brown silty clay	1100 0.0	no recovery		15	
6	EOB 1430				Backfilled w/ Bentonite chips	
7	TD = 6.0' BGS					
8						
9						
10						

HTRW DRILLING LOG			DISTRICT ST. LOUIS	HOLE NUMBER SLD 98547
1. COMPANY NAME SHAW ENVIRONMENTAL		2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 OF 2 SHEETS
3. PROJECT FUSRAP/SLDS			4. LOCATION MSD Lift Station VP (DT-15)	
5. NAME OF DRILLER NA			6. MANUFACTURER'S DESIGNATION OF DRILL NA	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 2.5" Hand Auger w/ Extensions			8. HOLE LOCATION See location sketch	
9. SURFACE ELEVATION			10. DATE STARTED 2/20/07	
11. DATE COMPLETED 2/20/07			12. OVERBURDEN THICKNESS N/A	
13. DEPTH DRILLED INTO ROCK N/A			14. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED NA	
15. TOTAL DEPTH OF HOLE			16. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A	
17. GEOTECHNICAL SAMPLES		DISTURBED <input type="checkbox"/>	UNDISTURBED <input type="checkbox"/>	18. TOTAL NUMBER OF CORE BOXES <input type="checkbox"/>
19. SAMPLES FOR CHEMICAL ANALYSIS		VOC <input type="checkbox"/>	METALS <input type="checkbox"/>	OTHER (SPECIFY) <input type="checkbox"/>
20. DISPOSITION OF HOLE		BACTERIALIZED <input type="checkbox"/>	MONITORING WELL <input type="checkbox"/>	OTHER (SPECIFY) <input type="checkbox"/>
21. SIGNATURE OF INSPECTOR Shawn L Adams		22. TOTAL CORE RECOVERED <input type="checkbox"/> %		
<div style="display: flex; justify-content: space-between;"> <div> <p>LOCATION SKETCH/COMMENTS</p> </div> <div> <p>Witnessed by: Shawn L Adams</p> <p>SCALE: Not to Scale</p> <p>Trace <5% Few 5-10% Little 15-25% Some 20-35% Mostly 50-100%</p> </div> </div>				
PROJECT FUSRAP/SLDS				HOLE NO. SLD 98547

HTRW DRILLING LOG (CONTINUATION SHEET)							HOLE NUMBER SLO 98547
PROJECT FUSRAP/SLDS		INSPECTOR Susan Adams		SHEET 2 of 2		SHEET 1	
DEPTH ft	DESCRIPTION OF MATERIALS	LOG ft	RECOVERY %	LOG ft	BLOW COUNT 10	REMARKS	
GP	dark gray fine to cobble size gravel, poorly graded some dark brown silt	500 0.0	RECOVERY	SLO 98547 1506	NA	SLO 98547-1, -2	
1	medium brown silty clay, soft, medium plast, moist, trace cinders, trace coarse gravel	600 0.0	NA		NA		
2	piece of concrete trace slag	700 0.0	NA		NA		
CL	turning medium stiff	800 0.0	NA	SLO 98548 1516	NA		
3	mostly coarse to cobble size gravel, some well-rounded, some medium sand	900 0.0	NA		NA		
		1000 0.0					
		1100 0.0		SLO 98548 1555	NA	SLO 98547 Archive Hit refusal	
4	EOB 1530 TD = 3.8' BGS					Backfilled w/ Bentonite chips	
5							
6							
7							
8							
9							
10							

HTRW DRILLING LOG		DISTRICT ST. LOUIS		HOLE NUMBER SLD 98547A	
1. COMPANY NAME SHAW ENVIRONMENTAL		2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 of 2 SHEETS	
3. PROJECT FUSRAP/SLDS		4. LOCATION MSD Lift Station VP(DT-15)			
5. NAME OF DRILLER NA		6. MANUFACTURER'S DESIGNATION OF DRILL NA			
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 2.5" Hand Auger w/ Extensions		8. HOLE LOCATION See location sketch			
9. SURFACE ELEVATION		10. DATE STARTED 2/20/07			
11. DATE COMPLETED 2/20/07		12. OVERBURDEN THICKNESS N/A			
13. DEPTH DRILLED INTO ROCK N/A		14. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A			
15. TOTAL DEPTH OF HOLE 6.0' BGS		16. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A			
17. GEOLOGICAL SAMPLES DISTURBED UNDISTURBED		18. TOTAL NUMBER OF CORE BOXES 0			
19. SAMPLES FOR CHEMICAL ANALYSIS VOC METALS OTHER (SPECIFY) RAI OTHER (SPECIFY)		20. TOTAL CORE RECOVERY 0%			
21. DISPOSITION OF HOLE BACKFILLED MONITORING WELL OTHER (SPECIFY)		22. SIGNATURE OF INSPECTOR Susan L. Adams			
LOCATION SKETCH/COMMENTS Witnessed by: Susan L. Adams SCALE: Not to Scale					
PROJECT FUSRAP/SLDS		HOLE NO. SLD 98547A			

HOLD NUMBER
 560 985471
 S-SHEET 2 2 S-SHEET 1

INSPECTOR Susan Arlams

24 2

DEPTH FT	DESCRIPTION OF HOLE LOGS (1)	TEST NO. PID	TEST TYPE (2)	TEST NO. (3)	TEST DATE (4)	TEST TIME (5)
1	See SLD 98547 for Sample information		RECOVERY			
2						
3						
4	medium brown silty clay, soft, medium plastic, dry, low coarse sand, few coarse to cobble size gravel	700 0.0	NA			NA
5		700 0.0	NA			NA
6		900 0.0	NA			NA
7		1000 0.0				NA
8		1000 0.0				NA
9	EOB 1610 TD = 6.0' BGS					Archive
10						Backfilled w/ Bentonite Chips

HTRW DRILLING LOG		DISTRICT ST. LOUIS		HOLE NUMBER SLD 98549	
1. COMPANY NAME SHAW ENVIRONMENTAL		2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 OF 2	
3. PROJECT FUSRAP/SLDS			4. LOCATION MSD Lift Station VP (DT-15)		
5. NAME OF DRILLER Dan Gatto			6. MANUFACTURER'S DESIGNATION OF DRILL CME 75		
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT CME 75 using 1.25" HSA and 3" x 2" split spear			8. HOLE LOCATION See location sketch		
9. SURFACE ELEVATION Driven with a 140# hammer over 30" drop			10. DATE STARTED 2/1/01		
11. DATE COMPLETED 2/7/01			12. OTHER BOREHOLE INFORMATION N/A		
13. DEPTH DRILLED INTO ROCK N/A			14. TOTAL DEPTH OF HOLE 60' BGS		
15. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A			16. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A		
17. GEOTECHNICAL SAMPLES 0		18. DISTURBED 0		19. TOTAL NUMBER OF CORE BOIES 0	
20. SAMPLES FOR CHEMICAL ANALYSIS 0		21. METALS 0		22. OTHER (SPECIFY) 0	
23. DEPOSITION OF HOLE 0		24. BACKFILLED 0		25. MONITORING WELL 0	
26. SIGNATURE OF INSPECTOR Robert J. Adams		27. SIGNATURE OF DRILLER Dan Gatto		28. TOTAL CORE RECOVERY 0	
LOCATION SKETCH/COMMENTS Witnessed by: Robert J. Adams SCALE: Not to Scale					
PROJECT FUSRAP/SLDS					HOLE NO. SLD 98549

HTRW DRILLING LOG (CONTINUATION SHEET)						HOLE NUMBER SLD 93549
PROJECT FUSRAP/SLDS	INSPECTOR Susan Adams	HOLE DEPTH 202		SHEET 2 of 2		
DEPTH (ft)	DESCRIPTION OF HOLE WALLS	TIME (min)	RECOVERY (%)	FLOW (gpm)	REMARKS	
GP	fine to coarse size gravel lime sand, pebbly gravel, dry	400 0.0	RECOVERY	50		
1		800 0.0	1.7/ 2.0	70		
		0 0.0		30		
	medium to fine silty clay stiff, mod plastic, arg. black in tip	200 0.0	no recovery	40		
2	turning med stiff, few brick frags, trace cinders	500 0.0		7		
	piece of cinder size gravel	500 0.0	1.8/ 2.0	7		
3		900 0.0		9		
		800 0.0	no recovery	11		
4	few cinder frag, turning soft	400 0.0		2		
		0 0.0	2.0/ 2.0	3		
5		200 0.0		4		
	large brick frag, trace w/ri frag, trace fine sand, black	200 0.0		6		
6						
	EOB 1025				Backfilled w/ Bentonite chips	
7	TD = 6.0' BGS					
8						
9						
10						

HTRW DRILLING LOG		DISTRICT ST. LOUIS		HOLE NUMBER SLD 98553	
1. COMPANY NAME SHAW ENVIRONMENTAL		2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 OF 2 SHEETS	
3. PROJECT FUSRAP/SLDS			4. LOCATION MSD Lift Station VP (DT-15)		
5. NAME OF DRILLER Dan Gotto			6. MANUFACTURER'S DESIGNATION OF DRILL CME 75		
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT CME 75 using 3.25" USA and 2" split spoon			8. HOLE LOCATION See location sketch		
Driven with a 140# hammer over 30" drop			9. SURFACE ELEVATION		
CME 75 7/3/07			10. DATE STARTED 2/12/07		
PID SD2339 S# 170251 LUD 173019			11. DATE COMPLETED 2/12/07		
RVE: 0.0 C/DW: 4/12/07 Background 470			12. OVERBURDEN THICKNESS N/A		
13. DEPTH DRILLED INTO ROCK N/A			15. DEPTH GROUNDWATER ENCOUNTERED N/A		
14. TOTAL DEPTH OF HOLE 6.0' RGS			16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A		
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A			18. GEOTECHNICAL SAMPLES		
18. GEOTECHNICAL SAMPLES <input type="checkbox"/> DISTURBED <input type="checkbox"/> UNDISTURBED <input type="checkbox"/>			19. TOTAL NUMBER OF CORE BOLES <input type="checkbox"/>		
20. SAMPLES FOR CHEMICAL ANALYSIS		VOC		METALS	
<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
22. DEPOSITION OF HOLE		BAC/ALLO		MONITORING WELL	
<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
21. TOTAL CORE RECOVERY		OTHER (SPECIFY)		OTHER (SPECIFY)	
<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
23. SIGNATURE OF INSPECTOR		OTHER (SPECIFY)		OTHER (SPECIFY)	
Susan L. Adams		<input type="checkbox"/>		<input type="checkbox"/>	
LOCATION SKETCH/COMMENTS Witnessed by: Susan L. Adams SCALE: Not to Scale 					
PROJECT FUSRAP/SLDS				HOLE NO. SLD 98553	

HTRW DRILLING LOG (CONTINUATION SHEET)						HOLE NUMBER SD 98553
PROJECT FUSRAP/SLDS		INSPECTION Susan Adams		HOLE DEPTH A-2		
DEPTH (ft)	DESCRIPTION OF HOLE WALLS (ft)	LOG TIME (min)	RECOVERY (ft)	LOG TIME (min)	LOG TIME (min)	
SM	dark brown, silty fine sand, poorly graded, dry	100 0.0	RECOVERY	SD 98553 0939	30	
	mostly fine to coarse gravel	100 0.0	2.0		20	
1	medium brown silty clay, stiff, few coarse gravel, med. plast	700 0.0	2.0		17	
	mostly fine to coarse size gravel	600 0.0		SD 98554 0930	15	
2	turning dark brown, few cinders, few coarse to coarse gravel, trace brick frag, trace slag	200 0.0			7	
	piece of cobble size gravel (limestone)	600 0.0	1.4 1.3		7	
3		700 0.0	2.0	SD 98555 1002	6	
		NA NA	no recovery		7	
4		600 0.0			3	
	turning medium brown, medium stiff, medium plast, trace brick frag, trace cinders, trace fine gravel	500 0.0	1.8		4	
5		1100 0.0	2.0	SD 98556 0945	5	
	turning dark brown, some cinders	800 0.0		SD 98553 0941	6	
6			no recovery			
	EOB 1005				Backfilled w/ Bentonite Chips	
7	TD = 6.0' BGS					
8						
9						
10						

HTRW DRILLING LOG		DISTRICT ST. LOUIS		HOLE NUMBER SLD 98557	
1. COMPANY NAME SHAW ENVIRONMENTAL		2. DRILLING SUBCONTRACTOR Shaw		SHEET 1 of 2 SHEETS	
3. PROJECT FUSRAP/SLDS		4. LOCATION MSD Lift Station VP (DT-15)			
5. NAME OF DRILLER Dan Gotto		6. MANUFACTURER'S DESIGNATION OF DRILL CME 75			
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT CME 75 using 3.25" HSA and 1" x 2" split pipe		8. HOLE LOCATION See location sketch			
9. SURFACE ELEVATION		10. DATE STARTED 2/12/07			
11. DATE COMPLETED 2/12/07		12. OVERBURDEN THICKNESS N/A			
13. DEPTH DRILLED INTO ROCK N/A		14. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A			
15. TOTAL DEPTH OF HOLE 6.0' BGS		16. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A			
17. GEOTECHNICAL SAMPLES 0		18. DISTURBED 0		19. TOTAL NUMBER OF CORE BOIES 0	
20. SAMPLES FOR CHEMICAL ANALYSIS 0		21. VOC 0		22. METALS 0	
23. OTHER (SPECIFY) 0		24. OTHER (SPECIFY) 0		25. OTHER (SPECIFY) 0	
26. DISPOSITION OF HOLE 0		27. BACKFILLED 0		28. MONITORING WELL 0	
29. SIGNATURE OF INSPECTOR Susan L. Adams		30. TOTAL CORE RECOVERY 0 %			
LOCATION SKETCH/COMMENTS Witnessed by: Susan L. Adams SCALE: Not to Scale					
PROJECT FUSRAP/SLDS				HOLE NO. SLD 98557	

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