REVISION 0

ST. LOUIS DOWNTOWN SITE ANNUAL ENVIRONMENTAL MONITORING DATA AND ANALYSIS REPORT FOR CALENDAR YEAR 2015

ST. LOUIS, MISSOURI

JUNE 21, 2016

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

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prepared by:

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

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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 (e.g., depths are given in feet and meters, and areas are given in square feet and square meters). Acres are given for areas when applicable.

°C	degree(s) Celsius
µCi/mL	microcurie(s) per milliliter
µg/L	microgram(s) per liter
µS/cm	microSiemen(s) per centimeter
AEC	U.S. Atomic Energy Commission
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
ATD	alpha track detector
BTOC	below top of casing
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
Ci	curie(s)
COC	contaminant of concern
CY	calendar year
DL	detection limit
DO	dissolved oxygen
DOD	U.S. Department of Defense
DQO	data quality objective
EDE	effective dose equivalent
ELAP	Environmental Laboratory Accreditation Program
EM	Engineer Manual
EMDAR	Environmental Monitoring Data and Analysis Report
EMG	*Environmental Monitoring Guide for the St. Louis Sites*
EMICY	Environmental Monitoring Implementation for Calendar Year
EMICY15	*Environmental Monitoring Implementation Plan for the St. Louis Downtown Site for Calendar Year 2015*
EMP	Environmental Monitoring Program
ER	Engineer Regulation
FUSRAP	Formerly Utilized Sites Remedial Action Program
GRAAA	ground-water remedial action alternative assessment
HU	hydrostratigraphic unit
ICP	inductively coupled plasma
IL	investigative limit
K	potassium
KPA	kinetic phosphorescence analysis
Mallinckrodt	Mallinckrodt LLC
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MDNR	Missouri Department of Natural Resources
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDL	method detection limit
MED	Manhattan Engineer District

ACRONYMS AND ABBREVIATIONS (Continued)

mg/L	milligram(s) per liter
mL	milliliter(s)
mrem	millirem
MSD	Metropolitan St. Louis Sewer District
mV	millivolt(s)
NAD	normalized absolute difference
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NRC	U.S. Nuclear Regulatory Commission
NTU	nephelometric turbidity unit
ORP	oxidation reduction potential
pCi/L	picocuries per liter
PDI	pre-design investigation
QA	quality assurance
QAPP	quality assurance program plan
QC	quality control
QSM	*Department of Defense (DoD)/Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*
Ra	radium
RA	remedial action
RL	reporting limit
RME	reasonably maximally exposed
Rn	radon
ROD	*Record of Decision for the St. Louis Downtown Site*
RPD	relative percent difference
SAG	*Sampling and Analysis Guide for the St. Louis Sites*
SLDS	St. Louis Downtown Site
SLS	St. Louis Sites
SOP	standard operating procedure
SOR	sum of ratios
SU	survey unit
TEDE	total effective dose equivalent
Th	thorium
TLD	thermoluminescent dosimeter
TSS	total suspended solid(s)
U	uranium
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
VP	vicinity property
VQ	validation qualifier
WL	working level
WRS	Wilcoxon Rank Sum
yd^3	cubic yard(s)

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EXECUTIVE SUMMARY

This annual Environmental Monitoring Data and Analysis Report (EMDAR) for calendar year (CY) 2015 applies to the St. Louis Downtown Site (SLDS), which is within the St. Louis Sites (SLS) (Figure 1-1) and under the scope of the Formerly Utilized Sites Remedial Action Program (FUSRAP). This EMDAR provides an evaluation of the data collected as part of the implementation of the Environmental Monitoring Program (EMP) for the SLDS. The SLDS consists of the Mallinckrodt LLC (Mallinckrodt) plant and surrounding vicinity properties (VPs) (Figure 1-2). Environmental monitoring of various media at the SLDS is required in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the commitments in the *Record of Decision for the St. Louis Downtown Site* (ROD) (USACE 1998a).

The purpose of this EMDAR is:

1) to document the environmental monitoring activities, and
2) to assess whether remedial actions (RAs) had a measurable environmental impact by:
    a) reporting the current condition of the SLDS,
    b) summarizing the data collection effort for CY 2015, and
    c) providing an analysis of the environmental monitoring data to date.

The U.S. Army Corps of Engineers (USACE) St. Louis District collects comprehensive environmental data for decision-making and planning purposes. Environmental monitoring, performed as a Best Management Practice or as a component of RA, serves as a critical component in the evaluation of the current status and potential future migration of residual contaminants.

All environmental monitoring required through implementation of the *Environmental Monitoring Implementation Plan for the St. Louis Downtown Site for Calendar Year 2015* (EMICY15) (USACE 2014) was conducted as planned during CY 2015. Evaluation of the environmental monitoring data for all SLDS properties demonstrates compliance with applicable or relevant and appropriate requirements (ARARs).

RADIOLOGICAL AIR MONITORING

Radiological air data were collected and evaluated at the SLDS through airborne radioactive particulate, radon (indoor and outdoor), and gamma radiation monitoring, as required in the EMICY15. In addition, for environmental monitoring purposes, radiological air data were also used as inputs to calculate total effective dose equivalent (TEDE) to the hypothetical maximally exposed individual at the SLDS.

The TEDE calculated for the hypothetical maximally exposed individual at the SLDS was less than 0.1 millirem (mrem) per year. The results of the radiological air monitoring conducted at the SLDS demonstrate compliance with ARARs for the SLDS.

EXCAVATION-WATER DISCHARGE MONITORING AT THE ST. LOUIS DOWNTOWN SITE

CY 2015 was the 17th year excavation-water discharge from the SLDS was monitored and reported. Excavation water from the SLDS was discharged to the St. Louis sanitary sewer system in compliance with the requirements stated in the July 23, 2001, Metropolitan St. Louis Sewer District (MSD) authorization letter (MSD 2001) and amended in the October 13, 2004, MSD letter (MSD 2004). This authorization was extended through the issuance of letters dated

June 19, 2006; May 22, 2008; May 10, 2010; May 24, 2012; and June 23, 2014 (MSD 2006, 2008, 2010, 2012, 2014). This authorization expires July 23, 2016 (MSD 2014). During CY 2015, no exceedances of the MSD limits occurred at the SLDS.

GROUND-WATER MONITORING

Ground water was sampled during CY 2015 at the SLDS following a protocol for individual wells and analytes. Samples were analyzed for various radiological constituents and inorganic parameters. Static ground-water elevations for all SLDS wells were measured quarterly.

The environmental sampling requirements and ground-water criteria for each analyte are consistent with the EMICY15. The ground-water criteria are used for comparison and discussion purposes. The criteria for assessing ground-water sampling data at the SLDS include the investigative limits (ILs) identified in the ROD (USACE 1998a) and the combined radium (Ra)-226/Ra-228 concentration limit from 40 *Code of Federal Regulations* (*CFR*) 192.02 (Table 1 of Subpart A). The ground-water criteria are presented in Table 2-6 of the EMICY15 and in Section 4.0 of this EMDAR. For those stations where an analyte exceeded the ground-water criteria at least once during CY 2015 and sufficient data were available to evaluate trends, Mann-Kendall statistical trend analyses were completed to assess whether analyte concentrations were increasing or decreasing through time.

During CY 2015, two hydrostratigraphic unit (HU)-A monitoring wells (B16W06S and B16W12S) were sampled (Figure 4-3). B16W06S was sampled for arsenic and cadmium during the second quarter. B16W06S and B16W12S were sampled for arsenic, cadmium, Ra-226, Ra-228, thorium (Th)-228, Th-230, Th-232, uranium (U)-234, U-235, and U-238 during the fourth quarter. Trend analysis was conducted for arsenic in B16W06S and for total U in B16W12S. Based on the graph and a quantitative evaluation of the trend using the Mann-Kendall Trend Test (Section 4.2.3), there is a downward trend in arsenic concentrations in B16W06S. There is no trend for total U in B16W12S. Because total U values are calculated using the U-234, U-235, and U-238 values, the trends in their values should be the same as the total U trend results. Therefore, it was unnecessary to perform a separate trend analysis for each of the isotopes. Because the majority of their historical results were near or below their detection limits (DLs), a trend analysis was not performed for arsenic, cadmium or Th-230 in B16W12S; Ra-226 in B16W06S; or total U in B16W06S. The remaining SLDS contaminants of concern (COCs) (Ra-228, Th-228, Th-232, and U-235) were not detected in HU-A ground water during CY 2015.

During CY 2015, six SLDS wells completed in the Mississippi Alluvial Aquifer (HU-B) were sampled. Mann-Kendall Trend Tests were conducted for two of the three COCs that exceeded the ILs in HU-B wells during CY 2015: arsenic in DW14, DW16, and DW18, and total U in DW19. A trend analysis was not conducted for cadmium in DW15 or DW19, because historical results were generally within the range of measurement error of their DLs. The results of the Mann-Kendall Trend Tests for arsenic indicate a statistically significant downward trend in DW14 and a statistically significant upward trend in DW16 and DW18. The Mann-Kendall Trend Test results also indicate a statistically significant downward trend for total U in DW19.

Potentiometric surface maps were created from ground-water elevations measured in May and November to illustrate ground-water flow conditions in wet and dry seasons. The ground-water surface in HU-A under the eastern portion of the Mallinckrodt plant is generally sloping northeastward toward the Mississippi River (Figures 4-7 and 4-9). In HU-B, ground-water flow and direction are strongly influenced by river stage, which indicates a hydraulic connection to the Mississippi River. The flow direction at the site is generally northeast toward the Mississippi River.

1.0 HISTORICAL SITE BACKGROUND AND CURRENT SITE STATUS

1.1 INTRODUCTION

This annual Environmental Monitoring Data and Analysis Report (EMDAR) for calendar year (CY) 2015 applies to the St. Louis Downtown Site (SLDS) which is within the St. Louis Sites (SLS) (Figure 1-1) and under the scope of the Formerly Utilized Sites Remedial Action Program (FUSRAP). This EMDAR provides an evaluation of the data collected as part of the implementation of the Environmental Monitoring Program (EMP) for the SLDS. The SLDS consists of the Mallinckrodt LLC (Mallinckrodt) plant and surrounding vicinity properties (VPs) (Figure 1-2). Environmental monitoring of various media at the SLDS is required in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the commitments in the *Record of Decision for the St. Louis Downtown Site* (ROD) (USACE 1998a).

1.2 PURPOSE

The purpose of this EMDAR is to document the environmental monitoring activities and to assess whether remedial actions (RAs) at the SLDS had a measurable environmental impact. In addition, this EMDAR serves to enhance the reader's awareness of the current condition of the SLDS, summarize the data collection efforts for CY 2015, and provide analysis of the CY 2015 environmental monitoring data results. This EMDAR presents the following information:

- Sample collection data for various media at the SLDS and interpretation of CY 2015 EMP results;
- The compliance status of the SLDS with federal and state applicable or relevant and appropriate requirements (ARARs) or other benchmarks (e.g., *Environmental Monitoring Implementation Plan for the St. Louis Downtown Site for CY 2015* [EMICY15] [USACE 2014]);
- Dose assessments for radiological contaminants as appropriate at the SLDS;
- A summary of trends based on changes in contaminant concentrations to support RAs, ensure public safety, and maintain surveillance monitoring requirements at the SLDS; and
- The identification of data gaps and future EMP needs.

1.3 ST. LOUIS SITE PROGRAM AND SITE BACKGROUND

The FUSRAP was executed by the U.S. Atomic Energy Commission (AEC) in 1974 to identify, remediate, or otherwise control sites where residual radioactivity remains from operations conducted for the Manhattan Engineer District (MED) and AEC during the early years of the nation's atomic energy program. The FUSRAP was continued by the follow-on agencies to the AEC until 1997, when the U.S. Congress transferred responsibility for FUSRAP to the U.S. Army Corps of Engineers (USACE).

The SLDS properties were involved with: refinement of uranium ores, production of uranium metal and compounds, uranium recovery from residues and scrap, and the storage and disposal of associated process byproducts. The processing activities were conducted in portions of the SLDS under contract to the MED/AEC between the early 1940s and the 1950s.

A detailed descriptions and history of the SLDS can be found in the *Remedial Investigation Report for the St. Louis Site* (DOE 1994); the *Remedial Investigation Addendum for the St. Louis Site* (DOE 1995); the ROD (USACE 1998a); and the *Environmental Monitoring Guide for the St. Louis Sites* (EMG) (USACE 1999a).

During CY 2015, the following USACE documents were finalized for the SLDS:

- *CY2014 Fourth Quarter Laboratory QA/QC Report for the FUSRAP St. Louis Radioanalytical Laboratory & Associated Satellite Laboratories, St. Louis, Missouri* (February);
- *Post-Remedial Action Report and Final Status Survey Evaluation for the Accessible Soils within the St. Louis Downtown Site Vicinity Property Terminal Railroad Association (DT-9), St. Louis, Missouri* (March 3);
- *CY2015 First Quarter Radiation Protection Program Review, St. Louis, Missouri* (April 24);
- *Destrehan Street - East/Plant 7 West - North Remedial Action Work Area-Specific Description and Design Package, FUSRAP St. Louis Downtown Site, St. Louis, Missouri* (April 28);
- *CY2015 First Quarter Laboratory QA/QC Report for the FUSRAP St. Louis Radioanalytical Laboratory & Associated Satellite Laboratories, St. Louis, Missouri* (May);
- *St. Louis Downtown Site Annual Environmental Monitoring Data and Analysis Report For Calendar Year 2014, St. Louis, Missouri* (June 30);
- *Post-Remedial Action Report and Final Status Survey Evaluation for the Accessible Soils within the Kiesel Hall Street Properties, St. Louis, Missouri* (August 27);
- *CY2015 Second Quarter Laboratory QA/QC Report for the FUSRAP St. Louis Radioanalytical Laboratory & Associated Satellite Laboratories, St. Louis, Missouri* (September);
- *CY2015 Third Quarter Laboratory QA/QC Report for the FUSRAP St. Louis Radioanalytical Laboratory & Associated Satellite Laboratories, St. Louis, Missouri* (November); and
- *Final Status Survey Plan for Soils, Structures, and Sediments at the St. Louis FUSRAP Sites, St. Louis, Missouri* (December 28).

1.3.1 St. Louis Downtown Site Calendar Year 2015 Remedial Actions

During CY 2015, RAs were performed at the following SLDS properties throughout the year (Figure 1-2): Plant 6 West Half Building 101 and Plant 6 East Half. A total of 28,729 cubic yards (yd^3) of contaminated material were shipped from the SLDS via railcar to US Ecology in Idaho for proper disposal.

Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (DOD 2000) Class 1 verifications were performed at Plant 6 West Half (SU-15) and Plant 6 East Half (SU-10) during CY 2015.

MARSSIM Class 2 verifications were performed at Plant 7, City Property (DT-2), Keisel Gunther Salt (DT-4), Destrehan Street, and Mallinckrodt Street during CY 2015. No MARSSIM Class 3 verifications were performed during CY 2015. Verifications at the SLDS were performed to confirm that the remediation goals of the ROD were achieved. The SLDS is shown on Figure 1-2.

A characterization/pre-design investigation (PDI) was performed at City Property (DT-2) during CY 2015.

No monitoring wells were decommissioned in CY 2015.

In accordance with the Metropolitan St. Louis Sewer District (MSD) authorization letter for the SLDS, 2,964,362 gallons of excavation water were discharged in CY 2015. Since the beginning of the project, 21,163,248 gallons have been treated and released to MSD at the SLDS.

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2.0 EVALUATION OF RADIOLOGICAL AIR MONITORING DATA

This section documents environmental monitoring activities related to radiological air data. The radiological air monitoring conducted at the SLDS is conducted as part of the EMP. Radiological air data are collected to evaluate the compliance status of each site with respect to ARARs, to evaluate trends, and to perform dose assessments for radiological contaminants, as appropriate, at each site. Section 2.1 includes a description of the types of radiological air monitoring conducted at the SLDS, potential sources of the contaminants to be measured (including natural background), and measurement techniques employed during CY 2015.

All radiological air monitoring required through implementation of the EMICY15 (USACE 2014) was conducted as planned during CY 2015. The evaluations of radiological air monitoring data for all SLDS properties demonstrate compliance with ARARs.

A total effective dose equivalent (TEDE) for the reasonably maximally exposed (RME) member of the public was calculated for the SLDS by summing the dose due to gamma radiation, radiological air particulates, and radon. The TEDE calculated for the RME individual at the SLDS was less than 0.1 millirem (mrem) per year. The TEDE for the SLDS was below the 10 *Code of Federal Regulations* (*CFR)* 20.1301 limit for members of the public, which is 100 mrem per year. Details of the radiological dose assessment (TEDE calculation) are presented in Section 6.0.

2.1 RADIOLOGICAL AIR MEASUREMENTS

The three types of radiological air monitoring conducted at the SLS during CY 2015 are gamma radiation, airborne radioactive particulates, and airborne radon. Section 2.2 provides details of the air monitoring conducted at the SLDS.

2.1.1 Gamma Radiation

Gamma radiation is emitted from natural, cosmic, and manmade sources. The earth naturally contains gamma radiation-emitting substances, such as the uranium decay series, the thorium decay series, and potassium (K)-40. Cosmic radiation originates in outer space and filters through the atmosphere to the earth. Together, these two sources comprise the majority of natural gamma background radiation. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) estimates that the total naturally occurring background radiation dose equivalent due to gamma exposure is 65 mrem per year, 35 mrem per year of which originates from sources on earth and 30 mrem per year of which originates from cosmic sources (UNSCEAR 1982). The background monitoring locations for the SLS (Figure 2-1) are reasonably representative of background gamma radiation for the St. Louis metropolitan area.

Gamma radiation was measured at the SLDS during CY 2015 using thermoluminescent dosimeters (TLDs). TLDs were placed at locations representative of areas accessible to the public (Figure 2-2) in order to provide input for calculation of the TEDE.

The TLDs were placed at the monitoring location approximately 3 ft above the ground surface inside a housing shelter. The TLDs were collected quarterly and sent to a properly certified, off-site laboratory for analysis.

2.1.2 Airborne Radioactive Particulates

2.1.2.1 Air Sampling

Airborne radioactive particulates result from radionuclides in soils that become suspended in the air. The radionuclides in soil normally become airborne as a result of wind erosion of the surface soil or as a result of soil disturbance (e.g., excavation). This airborne radioactive material includes naturally occurring background concentrations as well as above-background concentrations of radioactive materials present at the SLDS.

Airborne radioactive particulates were measured at the SLDS by drawing air through a filter membrane with an air sampling pump placed approximately 3 ft above the ground, and then analyzing the material contained on the filter. The results of the analysis, when compared to the amount of air drawn through the filter, were reported as radioactive contaminant concentrations (i.e., microcuries per milliliter [µCi/mL]). Particulate air monitors were located in predominant wind directions at excavation and loadout area perimeter locations, as appropriate, to provide input for the National Emissions Standard for Hazardous Air Pollutants (NESHAP) Report and calculation of TEDE to the critical receptor. Air particulate samples were typically collected weekly or more frequently.

2.1.2.2 Estimation of Emissions in Accordance with the National Emissions Standard for Hazardous Air Pollutants

The SLDS CY 2015 NESHAP report (Appendix A) presents calculation of the effective dose equivalent (EDE) from radionuclide emissions to critical receptors in accordance with the NESHAP. The report is prepared in accordance with the requirements and procedures contained in 40 *CFR* 61, Subpart I.

Emission rates calculated using air sampling data, activity fractions, and other site-specific information were used for the SLDS as inputs to the U.S. Environmental Protection Agency (USEPA) CAP88-PC Version 4.0 modeling code (USEPA 2014) to demonstrate compliance with the 10 mrem per year ARAR in 40 *CFR* 61, Subpart I.

CY 2015 monitoring results for the SLDS demonstrate compliance with the 10 mrem per year ARAR prescribed in 40 *CFR* 61, Subpart I. See Section 2.2.1 for further details.

2.1.3 Airborne Radon

Uranium (U)-238 is a naturally occurring radionuclide commonly found in soil and rock. Radon (Rn)-222 is a naturally occurring radioactive gas found in the uranium decay series. A fraction of the radon produced from the radioactive decay of naturally occurring U-238 diffuses from soil and rock into the atmosphere, accounting for natural background airborne radon concentrations. In addition to this natural source, radon is produced from the above-background concentrations of radioactive materials present at the SLDS.

Outdoor airborne radon concentration is governed by the emission rate and dilution factors, both of which are strongly affected by meteorological conditions. Surface soil is the largest source of radon. Secondary contributors include oceans, natural gas, geothermal fluids, volcanic gases, ventilation from caves and mines, and coal combustion. Radon levels in the atmosphere have been observed to vary with elevation, season, time of day, or location. The chief meteorological parameter governing airborne radon concentration is atmospheric stability; however, the largest variations in atmospheric radon occur spatially (USEPA 1987).

Radon alpha track detectors (ATDs) were used at the SLDS to measure alpha particles emitted from radon and its associated decay products. Radon ATDs were co-located with environmental TLDs 3 ft above the ground surface in housing shelters at locations representative of areas accessible to the public (Figure 2-2). Outdoor ATDs were collected approximately every 6 months and sent to an off-site laboratory for analysis. Recorded radon concentrations are listed in picocuries per liter (pCi/L) and are compared to the value of 0.5 pCi/L average annual concentration above background as listed in 40 *CFR* 192.02(b).

CY 2015 monitoring results for the SLDS demonstrate compliance with the 0.5 pCi/L ARAR prescribed in 40 *CFR* 192.02(b). See Section 2.2.3 for further details.

At the SLDS, ATDs were also placed in locations within applicable structures (Building 26 at Plant 1 and the South Storage Building at DT-4 North) to monitor for indoor radon exposure. The ATDs were placed in areas that represent the highest likely exposure from indoor radon. ATD locations were selected with consideration given to known radium (Ra)-226 concentrations under applicable buildings and occupancy times at any one location within each building. Annual average indoor radon data in each applicable building were compared to the 40 *CFR* 192.12(b) ARAR value of 0.02 working levels (WL). In accordance with 40 *CFR* 192.12(b), reasonable effort shall be made to achieve, in each habitable or occupied building, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. In any case, the radon decay product concentration shall not exceed 0.03 WL. Background indoor radon monitors were not necessary, because the regulatory standard of 0.02 WL includes background. Indoor ATDs were also collected approximately every 6 months and sent to an off-site laboratory for analysis.

CY 2015 monitoring results for the SLDS demonstrate compliance with the 0.02 WL ARAR prescribed by 40 *CFR* 192.12(b). See Section 2.2.4 for further details.

2.2 EVALUATION OF RADIOLOGICAL AIR MONITORING DATA

2.2.1 Evaluation of Gamma Radiation Data

Gamma radiation monitoring was performed at the SLDS during CY 2015 at four locations representative of areas accessible to the public (Figure 2-2) and at the background location (Figure 2-1) to compare on-site/off-site exposure and to provide input for calculation of TEDE to the critical receptor. The EMP uses two TLDs at Monitoring Station DA-1 (for each monitoring period) to provide additional quality control (QC) of monitoring data (Figure 2-2). A summary of TLD monitoring results for CY 2015 at the SLDS is shown in Table 2-1. TLD data are located in Appendix B, Table B-1, of this EMDAR.

Table 2-1. Summary of SLDS Gamma Radiation Data for CY 2015

Monitoring Location	Monitoring Station	First Quarter TLD Data		Second Quarter TLD Data		Third Quarter TLD Data		Fourth Quarter TLD Data		CY 2015 Net TLD Data (mrem/year)
		(mrem/quarter)								
		Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	
SLDS Perimeter	DA-1	16.4	0	17.1	0	17.9	0.9	18.2	0	1
	DA-1[c]	16	0	15.8	0	17.1	0	18.6	0	0
	DA-2	18	0.2	18.3	0	18.4	1.4	20.6	0	2
	DA-3	16.3	0	18	0	17.3	0.2	18.1	0	0
	DA-6	18	0	16.4	0	18.5	1.5	18.9	0	2

Table 2-1. Summary of SLDS Gamma Radiation Data for CY 2015 (Continued)

Monitoring Location	Monitoring Station	First Quarter TLD Data		Second Quarter TLD Data		Third Quarter TLD Data		Fourth Quarter TLD Data		CY 2015 Net TLD Data (mrem/year)
		(mrem/quarter)								
		Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	
Background	BA-1	17.8	---	19	---	17.1	---	21.2	---	18.8

[a] All quarterly data reported from the vendor have been normalized to exactly one quarter's exposure above background.
[b] CY 2015 net TLD data are corrected for background, shelter absorption (s/a = 1.075), and fade.
[c] A QC duplicate is collected at the same time and location, and is analyzed by the same method for evaluating precision in sampling and analysis. Duplicate sample results were not included in calculations.
--- Result calculation is not required.
Cor. – corrected
Rpt. – reported

2.2.2 Evaluation of Airborne Radioactive Particulate Data

Air sampling for radiological particulates during CY 2015 was conducted by the RA contractor at the perimeter of each active excavation and loadout area within the SLDS. Air particulate data were used as inputs to the NESHAP report (Appendix A) and calculation of TEDE to the critical receptor (Section 6.0). Air sampling for radiological particulates was not conducted at the SLDS perimeter locations during CY 2015 due to the insignificant potential for material to become airborne at the site. The ground surface at the SLDS is generally covered with asphalt or concrete, which limits the potential for material to become airborne. A summary of air particulate monitoring data from excavation perimeters is shown in Table 2-2. Airborne radioactive particulate data are contained in Appendix B, Table B-2, of this EMDAR.

Table 2-2. Summary of SLDS Airborne Radioactive Particulate Data for CY 2015

Monitoring Location	Average Concentration (μCi/mL)	
	Gross Alpha	Gross Beta
Plant 6	3.78E-15	2.49E-14
Plant 6 Loadout	3.92E-15	2.39E-14
Background Concentration[a] (BA-1)	3.66E-15	1.86E-14

[a] These concentrations are only provided for informational purposes.

2.2.3 Evaluation of Outdoor Airborne Radon Data

Outdoor airborne radon monitoring was performed at the SLDS using ATDs to measure radon emissions. Four detectors were co-located with the TLDs at locations shown on Figure 2-2. One additional detector was located at Monitoring Station DA-1 as a QC duplicate. A background ATD, co-located with the background TLD (Section 2.2.1), was used to compare on-site exposure and off-site background exposure. In accordance with 40 *CFR* 192.02(b)(2), control of residual radioactive materials from a uranium mill tailings pile must be designed to provide reasonable assurance that releases of radon to the atmosphere will not increase the annual average concentration of radon outside the disposal site by more than 0.5 pCi/L. Although a uranium mill tailings pile is not associated with any of the SLS, these standards are used for comparative purposes. Outdoor airborne radon data were used as an input for calculation of the TEDE to the critical receptor (Section 6.0) and compared to the 0.5 pCi/L average annual concentration above background value listed in 40 *CFR* 192.02(b)(2). The average annual radon concentration above background at the SLDS monitoring stations was 0.0 pCi/L, meeting the 40 *CFR* 192.02(b)(2) limit of 0.5 pCi/L. A summary of outdoor airborne radon data is shown in Table 2-3. Outdoor ATD data are contained in Appendix B, Table B-3, of this EMDAR.

Table 2-3. Summary of SLDS Outdoor Airborne Radon (Rn-222) Data for CY 2015

Monitoring Location	Monitoring Station	Average Annual Concentration (pCi/L)		
		01/08/15 to 07/02/15[a] (uncorrected)	07/02/15 to 01/04/16[a] (uncorrected)	Average Annual Concentration[b]
SLDS	DA-1	0.2	0.2	0.0
	DA-1[c]	0.2	0.2	0.0
	DA-2	0.2	0.2	0.0
	DA-3	0.2	0.2	0.0
	DA-6	0.2	0.2	0.0
Background	BA-1	0.2	0.2	---

[a] Detectors were installed and removed on the dates listed. Data are as reported from the vendor (gross data including background).
[b] Results reported from vendor for two periods are time-weighted and averaged to estimate an annual average radon concentration (pCi/L) above background.
[c] A QC duplicate is collected at the same time and location, and is analyzed by the same method for evaluating precision in sampling and analysis.
--- Result calculation is not required.

2.2.4 Evaluation of Indoor Airborne Radon Data

Indoor radon monitoring was performed at two SLDS buildings (Building 26 at Plant 1 and the South Storage Building at DT-4 North) using one ATD placed in each building at a height of 4 ft (to approximate breathing zone conditions) to measure radon concentrations (Figure 2-2). The ATDs were installed in January of CY 2015 at each monitoring location, collected for analysis after approximately 6 months of exposure, and replaced with another set that would represent radon exposure for the remainder of the year. Recorded radon concentrations (listed in pCi/L) were converted to radon WL, and an indoor radon equilibrium factor of 0.4 (NCRP 1988) was applied.

The results (including background) were evaluated based on the criteria contained in 40 *CFR* 192.12(b). The average annual radon concentration was determined to be less than the 40 *CFR* 192.12(b) criterion of 0.02 WL in each building (Leidos 2016). Additional details of the data and calculation methodology used to determine indoor radon WL in SLDS buildings are contained in Table 2-4. Indoor ATD data are contained in Appendix B, Table B-3, of this EMDAR.

Table 2-4. Summary of SLDS Indoor Airborne Radon (Rn-222) Data for CY 2015

Monitoring Location	Monitoring Station	Average Annual Concentration (pCi/L)			WL[c]
		01/08/15 to 07/02/15[a]	07/02/15 to 01/04/16[a]	Annual Average[b]	
Plant 1 Building 26	DI-1	0.2	0.2	0.2	0.001
DT-4 North South Storage Building	DI-2	0.7	1	0.85	0.003

[a] Detectors were installed and removed on the dates listed. Data are as reported from the vendor.
[b] Results reported from vendor for two periods are averaged to estimate an annual average radon concentration (pCi/L).
[c] The average annual WL is calculated by dividing the average pCi/L by 100 pCi/L per WL and multiplying by 0.4. The average annual WL must be less than 0.02 (40 *CFR* 192.12(b)).

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3.0 EXCAVATION-WATER MONITORING DATA

This section provides a description of the excavation-water discharge monitoring activities conducted at the SLDS during CY 2015. Excavation water is storm water and ground water that accumulates in excavations present at the SLDS as a result of RAs. Excavation-water effluent from the SLDS is discharged to a combined (sanitary and storm) MSD sewer inlet located at the SLDS. It then flows to the Bissell Point Sewage Treatment Plant under a special discharge authorization. This excavation water was collected, treated, and tested before being discharged to MSD manhole 17D4-353C. This MSD manhole is depicted on Figure 3-1.

The purpose of excavation-water discharge monitoring at the SLDS is to maintain compliance with specific discharge limits to ensure protection of human health and the environment. The MSD is the regulatory authority for water discharges and has issued authorization letters for the SLDS allowing discharges of excavation water that meets discharge-limit-based criteria (MSD 1998, 2001, 2004, 2006, 2008, 2010, 2012, 2014). On October 30, 1998, the USACE received an MSD conditional authorization letter to discharge the excavation water collected at the SLDS resulting from USACE RAs (MSD 1998). On July 23, 2001, the MSD issued a separate conditional discharge authorization letter for discharges of excavation water resulting from USACE RAs (MSD 2001). The MSD issued a change to the self-monitoring and special discharge authorization for the SLDS on October 13, 2004, and issued a 2-year extension to that authorization dated June 19, 2006 (MSD 2004, 2006). On May 22, 2008; May 10, 2010; and May 24, 2012, the MSD issued extensions to the special discharge authorization for the SLDS that remained in effect until July 23, 2010; July 23, 2012; and July 23, 2014, respectively (MSD 2008, 2010, 2012). On June 23, 2014, the MSD issued an extension to the special discharge authorization for the SLDS that remains in effect until July 23, 2016 (MSD 2014). The results obtained from these monitoring activities are presented and evaluated with respect to the discharge limits described in the EMICY15 (USACE 2014).

Section 2.2.2 of the EMICY15 outlines the parameters and annual average discharge limits for the excavation-water discharges at the SLDS (USACE 2014). For cases in which the local regulatory authorities have not provided discharge limits for the SLDS radiological contaminants of concern (COCs), parameters from 10 *CFR* 20, Appendix B, water effluent values are used to calculate the sum of ratios (SOR) value for each discharge. Additionally, the SOR aids in the establishment of water management protocols.

3.1 EVALUATION OF EXCAVATION-WATER DISCHARGE MONITORING RESULTS AT THE ST. LOUIS DOWNTOWN SITE

During CY 2015, 2,964,362 gallons of excavation water from 12 batches were discharged to MSD manhole 17D4-353C. The analytical results for all measured parameters by batch, along with the total activity discharged for each parameter, are included in Appendix C, Table C-1. A summary of the number of discharges, gallons of water discharged, and total radiological activity for the CY 2015 excavation-water discharges is provided in Table 3-1. All excavation-water discharge monitoring required through implementation of the EMICY15 was conducted as planned during CY 2015. The evaluation of monitoring data demonstrates compliance with all MSD criteria.

Table 3-1. Excavation Water Discharged at the SLDS in CY 2015

Quarter	Number of Discharges	Number of Gallons Discharged[a]	Total Activity (Curies [Ci])		
			Thorium[b]	Uranium (KPA)[c]	Radium[d]
1	3	112,950	9.3E-07	6.8E-05	7.1E-07
2	3	899,980	1.5E-05	1.4E-03	8.7E-06
3	3	1,509,162	1.4E-05	2.1E-03	8.8E-06
4	3	442,270	3.5E-06	4.5E-04	2.3E-06
Annual Totals	12	2,964,362	3.4E-05	4.1E-03	2.0E-05

[a] Quantities based on actual quarterly discharges from the SLDS.
[b] Calculated value based on the addition of isotopic analyses: thorium (Th)-228, Th-230, and Th-232.
[c] Activity based on total U results (kinetic phosphorescence analysis [KPA]).
[d] Calculated value based on the addition of isotopic analyses: Ra-226 and Ra-228.

4.0 GROUND-WATER MONITORING DATA

Eight (8) ground-water monitoring wells were sampled at the SLDS during CY 2015. Ground water was sampled following a protocol for individual wells and analytes, and was analyzed for various radiological constituents and inorganic analytes. With the exception of DW19 and DW22R, static water levels were measured quarterly at the SLDS. In addition, field parameters were measured continuously during purging of the wells prior to sampling. The ground-water field parameter results for CY 2015 sampling at the SLDS are presented in Appendix D, Table D-1. The SLDS ground-water analytical sampling results for CY 2015 are contained in Appendix D, Table D-2.

Stratigraphy at the St. Louis Downtown Site

Ground water at the SLDS is found within three hydrostratigraphic units (HUs). These units are, in order of increasing depth, the Upper HU (HU-A), which consists of fill overlying clay and silt; the Lower HU (HU-B), also referred to as the Mississippi Alluvial Aquifer, consisting of sandy silts and silty sands; and the Limestone Bedrock Unit, referred to as HU-C (Figures 4-1 and 4-2). The upper unit, HU-A, is not an aquifer and is not considered a potential source of drinking water, because it has insufficient yield and poor natural water quality. HU-B is one of the principal aquifers in the St. Louis area, but expected future use as drinking water at the SLDS is minimal, because the Mississippi and Missouri Rivers provide a readily available source and the water from the aquifer is of poor quality due to elevated concentrations of iron and manganese. HU-C would be an unlikely water supply source, as it is a deeper and less productive HU. There are no known drinking-water wells in the vicinity of the SLDS. St. Louis City Ordinance 66777 explicitly forbids the installation of wells into the subsurface for the purposes of using ground water as a potable water supply (City of St. Louis 2005). The expected future use of SLDS ground water is not anticipated to change from its current use.

As shown in the geologic cross-section of the SLDS (Figure 4-2), the erosional surface of the bedrock dips eastward toward the Mississippi River. HU-A overlies HU-B on the eastern side of the SLDS and bedrock on the western side of the SLDS. HU-B thins westerly along the bedrock surface until it becomes absent beneath the SLDS. HU-C underlies the unconsolidated sediments at depths ranging from 19 ft on the western side of the SLDS to 80 ft near the Mississippi River.

Ground-Water Criteria

The CY 2015 monitoring data for HU-B ground water at the SLDS are compared to the following ground-water criteria established in the ROD: 50 micrograms per liter (µg/L) arsenic, 5 µg/L cadmium, 20 µg/L total U, and 5 pCi/L combined Ra-226 and Ra-228 (USACE 1998a). The ROD did not establish ground-water criteria for HU-A ground water. An evaluation of concentration trends is conducted for COCs detected in HU-A.

Summary of Calendar Year 2015 Ground-Water Monitoring Results for the St. Louis Downtown Site

Trend analysis of the COCs detected in HU-A ground water indicates continued improvement in HU-A ground-water quality, as reflected in the decreasing trend in arsenic concentrations observed in HU-A well B16W06S. No other significant changes in the concentrations of the COCs occurred in shallow ground water during CY 2015.

Three COCs (arsenic, cadmium, and total U) were detected at concentrations above the ROD ground-water criteria in HU-B ground water during CY 2015. The arsenic concentration exceeded the investigative limit (IL) (50 µg/L) in HU-B wells DW14 (100 µg/L in the second quarter), DW16

(130 µg/L in the second quarter and 88 µg/L in the fourth quarter) and DW18 (68 µg/L in the fourth quarter). The cadmium concentration exceeded the IL (5 µg/L) in the fourth quarter sample from DW15 (14 µg/L) and the third quarter sample from DW19 (15 µg/L). The total U concentration exceeded the IL (20 µg/L) in the third quarter sample from DW19 (54.8 µg/L).

The Mann-Kendall Trend Test results for the HU-B wells indicate a statistically significant upward trend in arsenic concentrations in DW16 and DW18, and a statistically significant downward trend in the arsenic concentration in DW14. In addition, a downward trend in total U concentrations was observed in the HU-B well DW19. No other significant changes in the concentrations of the COCs occurred in deep ground water during CY 2015.

4.1 GROUND-WATER MONITORING AT THE ST. LOUIS DOWNTOWN SITE

The selected remedy presented in the ROD involves excavation and disposal of radiologically contaminated accessible soil and ground-water monitoring. The goal of the ground-water portion of the SLDS remedy is to maintain protection of HU-B and to establish the effectiveness of the source removal action. This goal is achieved by monitoring perimeter wells on a routine basis to ensure there are no significant impacts from COCs on HU-B. The HU-B ground-water results for the SLDS COCs are compared to the following ROD ground-water criteria (USACE 1998a):

1) the ILs: 50 µg/L arsenic, 5 µg/L cadmium, and 20 µg/L total U; and
2) the concentration limits from the Uranium Mill Tailings Radiation Control Act regulations listed in 40 *CFR* 192.02, Table 1 to Subpart A: 5 pCi/L combined Ra-226 and Ra-228.

The concentration limits for other SLDS COCs listed in 40 *CFR* 192.02, Table 1 to Subpart A (50 µg/L arsenic, 10 µg/L cadmium, and 30 pCi/L combined U-234 and U-238), are not relevant or appropriate because these limits are equal to or less stringent than the ILs.

If monitoring of HU-B indicates that the concentrations of SLDS COCs significantly exceed the above criteria, the ROD requires that a ground-water remedial action alternative assessment (GRAAA) be initiated to further assess the fate and transport of the COCs in HU-B and to determine if additional RAs are necessary. Total U concentrations were above the IL in HU-B well DW19 over an extended period, initiating Phase 1 of the GRAAA. The first phase of the GRAAA was completed in CY 2003 (USACE 2003). Phase 1 summarized the sampling data available for each of the monitoring wells completed in HU-B and provided recommendations for further investigation of HU-B. This EMDAR carefully reviews the HU-B data to provide additional information for future phases of the GRAAA. The ROD also specifies that a ground-water monitoring plan will be developed to assess the fate and transport of MED/AEC residual contaminants through and following the RA.

Because HU-A is not considered a potential source of drinking water, the ROD did not establish criteria for HU-A ground water. An evaluation of concentration trends is conducted for select COCs detected in HU-A ground water to support assessment of the effectiveness of the RA in the CERCLA 5-year reviews. The results of the trend analysis are presented in Section 4.2.3.

4.2 EVALUATION OF GROUND-WATER MONITORING DATA

St. Louis Downtown Site Monitoring Well Network

The EMP monitoring well network for the SLDS is shown on Figure 4-3. The screened HUs for the SLDS ground-water monitoring wells are identified in Table 4-1. Prior to initiating long-term monitoring of HU-B, as specified by the ROD (USACE 1998a), there was no EMP sampling performed at the SLDS. In CY 2015, eight monitoring wells (two HU-A and six HU-B) were sampled for radionuclides and inorganic COCs at the SLDS. No new ground-water monitoring wells were installed or transferred at the SLDS in CY 2015. Ground-water sampling at the SLDS was conducted on May 21 (second quarter); August 13 (third quarter); and November 19 (fourth quarter) of CY 2015. No ground-water sampling was conducted at the SLDS during the first quarter of CY 2015. The CY 2015 analytical results for the SLDS are presented in Appendix D, Table D-2. For discussion purposes, the ground-water analytical data acquired from the CY 2015 sampling events at the SLDS are presented separately for HU-A and HU-B. Appendix E provides the well maintenance checklists for the annual inspection of the SLDS ground-water monitoring wells conducted in February 2015.

Table 4-1. Screened HUs for SLDS Ground-Water Monitoring Wells in CY 2015

Well ID	Screened HU
B16W06D	HU-B
B16W06S[a]	HU-A
B16W07D[a]	HU-B
B16W08D	HU-B
B16W08S	HU-A
B16W09D	HU-B
B16W12S[a]	HU-A
DW14[a]	HU-B
DW15[a]	HU-B
DW16[a]	HU-B
DW17	HU-B
DW18[a]	HU-B
DW19[a]	HU-B
DW21	HU-A
DW22R[b]	HU-B

[a] Wells sampled in CY 2015.
[b] DW22R was damaged in CY 2014. Decommissioning is planned for CY 2016.

4.2.1 Evaluation of HU-A Ground-Water Monitoring Data

The results of the CY 2015 ground-water sampling of HU-A ground water at the SLDS are summarized in Table 4-2. During CY 2015, two HU-A monitoring wells (B16W06S and B16W12S) were sampled. B16W06S was sampled in the second quarter for arsenic and cadmium. B16W06S and B16W12S were sampled in the fourth quarter for the following analytes: arsenic, cadmium, Ra-226, Ra-228, thorium (Th)-228, Th-230, Th-232, U-234, U-235, and U-238.

Table 4-2. Analytes Detected in HU-A Ground Water at the SLDS in CY 2015

Analyte	Units	Station[a]	Minimum Detected	Maximum Detected	Mean Detected	Frequency of Detection
Arsenic	µg/L	B16W06S	130	230	180	2/2
		B16W12S	1.7	1.7	1.7	1/1
Cadmium	µg/L	B16W12S	0.98	0.98	0.98	1/1
Ra-226	pCi/L	B53W06S	1.09 J	1.09 J	1.09 J	1/1
Th-230	pCi/L	B16W12S	0.37 J	0.37 J	0.37 J	1/1
U-234	pCi/L	B16W06S	0.39 J	0.39 J	0.39 J	1/1
		B16W12S	1.63	1.63	1.63	1/1

Table 4-2. Analytes Detected in HU-A Ground Water at the SLDS in CY 2015 (Continued)

Analyte	Units	Station[a]	Minimum Detected	Maximum Detected	Mean Detected	Frequency of Detection
U-238	pCi/L	B16W06S	0.50 J	0.50 J	0.50 J	1/1
		B16W12S	2.09	2.09	2.09	1/1
Total U[b]	µg/L	B16W06S	1.5	1.5	1.5	1/1
		B16W12S	6.2	6.2	6.2	1/1

[a] Table lists only those stations at which the analyte was detected in HU-A ground water.
[b] Total U values were calculated from isotopic concentrations in pCi/L and converted to µg/L using radionuclide-specific activities and assuming secular equilibrium.
Validation qualifier (VQ) symbol indicates: "J" analyte was identified as estimated quantity.

The analytes detected in HU-A ground water in CY 2015 are listed in Table 4-2. The remaining SLDS COCs (Ra-228, Th-228, Th-232, and U-235) were not detected in the two HU-A ground-water wells monitored during CY 2015. Because the majority of their historical results were near or below their detection limits (DLs), a trend analysis was not performed for arsenic, cadmium or Th-230 in B16W12S; Ra-226 in B16W06S; or total U in B16W06S. Because total U values are calculated using the U-234 and U-238 values, the trends in their values should be the same as the total U trend results. Therefore, it was unnecessary to perform a separate trend analysis for each of these isotopes. Trend analysis was conducted for arsenic in B16W06S and total U in B16W12S. Based on the graphs and quantitative evaluation of trends using the Mann-Kendall Trend Test (Section 4.2.3), there is a statistically significant downward trend in arsenic concentrations in B16W06S (Figure 4-4). No trend for total U in B16W12S was identified (Figure 4-5). Figure 4-6 provides an expanded version of the time-versus-concentration plots for arsenic in B16W06S.

4.2.2 Evaluation of HU-B Ground-Water Monitoring Data

During CY 2015, six SLDS wells completed in the HU-B were monitored for various parameters, including the COCs arsenic, cadmium, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, and U-238. Detected concentrations were compared to the respective ROD ground-water criteria. Table 4-3 lists the analytes detected in HU-B ground water during CY 2015 and compares the results with the ROD ground-water criteria.

Table 4-3. Analytes Detected in HU-B Ground Water at the SLDS in CY 2015

Analyte	ROD Ground-Water Criteria		Units	Station[b]	Minimum Detected	Maximum Detected	Mean Detected	Number of Detects > ROD Ground-Water Criteria	Frequency of Detection
	IL[a]	40 *CFR* 192.02, Table 1, Subpart A							
Arsenic	50	NA	µg/L	B16W07D	37	37	37	0	1/1
				DW14	100	100	100	1	1/1
				DW15	19	19	19	0	1/1
				DW16	24	130	80.7	2	3/3
				DW18	68	68	68	1	1/1
				DW19	18	18	18	0	1/1
Cadmium	5	NA	µg/L	B16W07D	0.82	0.82	0.82	0	1/1
				DW14	0.46	0.46	0.46	0	1/1
				DW15	14	14	14	1	1/1
				DW16	0.19	1.8	1.03	0	3/3
				DW18	0.57	0.57	0.57	0	1/1
				DW19	15	15	15	1	1/1

Table 4-3. Analytes Detected in HU-B Ground Water at the SLDS in CY 2015 (Continued)

Analyte	ROD Ground-Water Criteria		Units	Station[b]	Minimum Detected	Maximum Detected	Mean Detected	Number of Detects > ROD Ground-Water Criteria	Frequency of Detection
	IL[a]	40 *CFR* 192.02, Table 1, Subpart A							
Ra-226	NA[c]	5[d]	pCi/L	DW15	1.49 J	1.49 J	1.49 J	0	1/1
Th-228	NA	NA	pCi/L	DW19	0.40 J	0.40 J	0.40 J	NA	1/1
Th-230	NA	NA	pCi/L	DW16	0.46 J	0.46 J	0.46 J	NA	1/1
U-234	NA	NA	pCi/L	DW15	0.43 J	0.43 J	0.43 J	NA	1/1
				DW16	1.5 J	1.5 J	1.5 J	NA	1/1
				DW19	18.7	18.7	18.7	NA	1/1
U-235	NA	NA	pCi/L	DW19	2.23	2.23	2.23	NA	1/1
U-238	NA	NA	pCi/L	DW15	0.48 J	0.48 J	0.48 J	NA	1/1
				DW16	1.23 J	1.23 J	1.23 J	NA	1/1
				DW19	18	18	18	NA	1/1
Total U[e]	20	NA	µg/L	DW15	1.5	1.5	1.5	0	1/1
				DW16	3.9	3.9	3.9	0	1/1
				DW19	54.8	54.8	54.8	1	1/1

[a] USACE 1998a.
[b] Table lists only those stations at which the analyte was detected in HU-B ground water.
[c] Although the ROD does not reference an IL for Ra-226, it does reference the maximum constituent concentration listed in Table 1 of 40 *CFR* 192.02, Subpart A.
[d] Concentration limit for combined Ra-226 and Ra-228.
[e] Total U values were calculated from isotopic concentrations in pCi/L and converted to µg/L using radionuclide-specific activities and assuming secular equilibrium.
NA – not appropriate (No IL is specified or the concentration limits specified in Table 1 of 40 *CFR* 192.02, Subpart A, are the same or less stringent than the IL and thus not relevant or appropriate.)
VQ symbol indicates: “J” analyte was identified as estimated quantity.

Two inorganic SLDS COCs (arsenic and cadmium) were detected at concentrations above their ROD ground-water criteria in HU-B ground water during CY 2015. The concentration of arsenic exceeded the IL (50 µg/L) in the May 2015 samples from DW14 (100 µg/L) and DW16 (130 µg/L). The concentration of arsenic also exceeded the IL in the November 2015 samples from DW16 (88 µg/L) and DW18 (68 µg/L). Figure 4-6 provides the time-versus-concentration plots for arsenic in DW14, DW16, and DW18. The concentration of cadmium in the November 2015 sample from DW15 (14 µg/L) and the August 2015 sample from DW19 (15 µg/L) exceeded the IL (5 µg/L).

One radiological COC, total U, exceeded the ROD ground-water criteria in HU-B ground water during CY 2015. The concentration of total U exceeded the IL (20 µg/L) in the August 2015 sample from DW19 (54.8 µg/L). Figure 4-5 shows the total U concentration trends in unfiltered ground water at the SLDS. It includes the time-versus-concentration plot for total U in DW19 at the SLDS. Figures 4-4 and 4-5 show the concentrations trends for arsenic and total U, respectively, at the SLDS. Based on the time-versus-concentrations graphs and quantitative evaluation of trends using the Mann-Kendall Trend Test (Section 4.2.3), four statistically significant trends were identified in HU-B ground water. There are statistically significant downward trends in arsenic concentrations in DW14 and total U concentrations in DW19. There are also statistically significant upward trends in arsenic concentrations in DW16 and DW18.

4.2.3 Comparison of Historical Ground-Water Data at the St. Louis Downtown Site

A quantitative evaluation of COC concentration trends in SLDS ground water was conducted based on available sampling data for the period from January 1999 through December 2015. The Mann-Kendall Trend Test was used to evaluate possible trends for those COCs detected in HU-A and for those COCs that exceeded ROD ground-water criteria in HU-B during CY 2015. The

Mann-Kendall Trend Test was not conducted for those COCs with insufficient sampling data (fewer than six sampling results for the period from January 1999 to December 2015), a detection frequency less than 50 percent, or historical results generally within the range of measurement error of their DLs. For HU-A, a trend analysis was conducted for arsenic in B16W06S and for total U in B16W12S. A trend analysis was not conducted for arsenic, cadmium, or Th-230 in B16W12S; for Ra-226 or total U in B16W06S; or for total U in B16W06S, because their historical results were generally below or only slightly above their DLs. The Mann-Kendall Trend Test was conducted for two COCs that exceeded the ILs in HU-B wells during CY 2015: arsenic in DW14, DW16, and DW18, and total U in DW19. Trend analysis was not conducted for cadmium in DW15 or DW19, because the historical results were generally within the range of measurement error of their DLs.

Statistical Method and Trend Analysis

Several statistical methods are available to evaluate contaminant trends in ground water. These include the Mann-Kendall Trend Test, the Wilcoxon Rank Sum (WRS) Test, and the Seasonal Kendall Test (USEPA 2000). The latter two tests are applicable to data that may or may not exhibit seasonal behavior, but generally require larger sample sizes than the Mann-Kendall Trend Test. The Mann-Kendall Trend Test was selected for this project, because this test can be used with small sample sizes (as few as four data points with detect values) and because a seasonal variation in concentrations was not indicated by the time-versus-concentration plots at the SLDS. The Mann-Kendall Trend Test is a non-parametric test and, as such, is not dependent upon assumptions of distribution, missing data, or irregularly-spaced monitoring periods. In addition, data reported as being less than the DL can be used (Gibbons 1994). The test can assess whether a time-ordered dataset exhibits an increasing or decreasing trend, within a predetermined level of significance. While the Mann-Kendall Trend Test can use as few as four data points, often this is not enough data to detect a trend. Therefore, the test was performed only at those monitoring stations where data have been collected for at least six sampling events.

A customized Microsoft Excel spreadsheet was used to perform the Mann-Kendall Trend Test. The test involves listing the sampling results in chronological order and computing all differences that may be formed between current measurements and earlier measurements. The value of the test statistic (S) is the difference between the number of strictly positive differences and the number of strictly negative differences. If S is a large positive value, then there is evidence of an increasing trend in the data. If S is a large negative value, then there is evidence of a decreasing trend in the data. If there is no trend and all observations are independent, then all rank orderings of the annual statistics are equally likely (USEPA 2000). The results of the Mann-Kendall Trend Test are reported in terms of a p value or Z-score, depending on sample size, N. If the sample size is less than or equal to 10, then the p value is computed. If the p value is less than or equal to 0.05, the test concludes that the trend is statistically significant. If the p value is greater than 0.05, the test concludes there is no evidence of a significant trend. For dataset sizes larger than 10, the Z-score is compared to ±1.64, which is the comparison level at a 95 percent confidence level. If the Z-score is greater than +1.64, the test concludes that a significant upward trend exists. If the Z-score is less than –1.64, the test concludes that a significant downward trend exists. For Z-scores between –1.64 and +1.64, there is no evidence of a significant trend.

The results of the Mann-Kendall Trend Test are less reliable for datasets containing high numbers of non-detects, particularly if the DL changes over time. Thus, for datasets for which more than 50 percent of the time-series data are non-detect, the Mann-Kendall Trend Test was not conducted. There is no general consensus regarding the percentage of non-detects that can be handled by the Mann-Kendall Trend Test. However, because the Mann-Kendall Trend Test is a nonparametric test that uses relative magnitudes, not actual values, it is generally valid even in cases in which there are large numbers of non-detects.

Only unfiltered data were used, and split sample and QC sample results were not included in the database for the Mann-Kendall Trend Test. The Mann-Kendall Trend Test is used to evaluate the data and determine trends without regard to isotopic analysis. In addition, for monitoring wells for which the Mann-Kendall Trend Test has indicated a trend (either upward or downward), another analysis is performed to determine if the trend is due to inherent error associated with the analytical test method for each sample analysis. For this analysis, graphs are generated to depict the trends, if present, and the associated error bars.

Results of Trend Analysis for Ground Water at the St. Louis Downtown Site

The Mann-Kendall Trend Test results are provided in Table 4-4. Time-versus-concentration plots for those wells and analytes exhibiting a statistically significant trend based on the Mann-Kendall Trend Test results (i.e., arsenic in B16W06S, DW14, DW16, DW18; and total U in DW19) are provided on Figure 4-6.

Table 4-4. Results of Mann-Kendall Trend Test[a] for SLDS Ground Water in CY 2015

Analyte	Station	HU	N[b]	Test Statistics[c]		Trend[d]
				S	Z	
Arsenic	B16W06S	HU-A	20	-85	-2.73	Downward Trend
	DW14	HU-B	21	-105	-3.15	Downward Trend
	DW16	HU-B	18	80	3.0	Upward Trend
	DW18	HU-B	26	161	3.53	Upward Trend
Total U	B16W12S	HU-A	18	15	0.53	No Trend
	DW19	HU-B	28	-94	-1.84	Downward Trend

[a] One-tailed Mann-Kendall Trend Tests were performed at a 95 percent level of confidence. For non-radiological data, non-detected results were replaced with one half of the lowest DL.
[b] N is the number of unfiltered ground-water sample results for a particular analyte at the well for the period between January 1999 and December 2015.
[c] Test Statistics: S – S-statistic, Z – Z-score, or normalized test statistic (used if N>10).
[d] Trend: The Z-score is compared to ±1.64 to determine trend significance.

Inorganics

Based on the results of the Mann-Kendall Trend Test, two wells exhibit downward trends for arsenic (one HU-A well, B16W06S, and one HU-B well, DW14), and two wells exhibit upward trends for arsenic (HU-B wells DW16 and DW18). Because the Mann-Kendall Trend Test does not consider the effects of measurement error and does not provide any information concerning the magnitude of the trend, time-versus-concentration plots of arsenic in B16W06S, DW14, DW16, and DW18 were used to evaluate these factors (Figure 4-6). The plots also show the best-fit trend lines based on the data scatter. No other significant changes in the concentrations of the inorganic COCs occurred in shallow or deep ground water during CY 2015.

Radionuclides

The Mann-Kendall Trend Test results indicate there is a statistically significant downward trend for total U in HU-B well DW19. As shown in the time-versus-concentration plot for DW19 on Figure 4-5, concentrations of total U have decreased since reaching the maximum concentration of 201 µg/L in CY 2007; however, concentrations have remained above the IL (20 µg/L) since 1999. The Mann-Kendall Trend Test results indicate there is no trend for total U in HU-A well B16W12S.

4.2.4 Evaluation of Potentiometric Surface at the St. Louis Downtown Site

Ground-water elevations were measured in monitoring wells at the SLDS in February, May, August, and November of CY 2015. Potentiometric surface maps were created from the May and November measurements to illustrate ground-water flow conditions in wet and dry seasons. The potentiometric maps for both HU-A and HU-B are presented on Figures 4-7 through 4-10.

The ground-water surface in HU-A under the eastern portion of the Mallinckrodt plant is generally sloping northeastward toward the Mississippi River (Figures 4-7 and 4-9). The ground water may be present in separate lenses or subunits of the heterogeneous HU-A. Comparison of Figure 4-7 (May) with Figure 4-9 (November) indicates ground-water flow direction patterns in HU-A are similar for the wet and dry season conditions, but the hydraulic gradient is much higher (steeper) during the dry season. During CY 2015, the HU-A potentiometric surface elevations showed some seasonal fluctuation in ground-water elevations, with elevations averaging approximately 3.7 ft higher during the wet season (May) than during the dry season (November).

As shown on Figures 4-8 and 4-10, the ground-water flow direction and gradient in HU-B are strongly influenced by river stage. This indicates that ground water in HU-B is hydraulically connected to the Mississippi River. The water levels measured at the SLDS indicate that HU-B ground-water elevations averaged approximately 9.5 ft higher on May 21 than on November 19; this generally corresponds to the difference in the daily river stage, which was 9.6 ft higher on May 21 (403.3 ft above mean sea level [amsl]) than on November 19 (393.7 ft amsl). The flow direction at the SLDS is generally northeast toward the Mississippi River.

5.0 ENVIRONMENTAL QUALITY ASSURANCE PROGRAM

5.1 PROGRAM OVERVIEW

The environmental quality assurance (QA) program includes management of the QA and QC programs, plans, and procedures governing environmental monitoring activities at all SLS and at subcontracted vendor laboratories. This section describes the environmental monitoring standards of the FUSRAP and the goals for these programs, plans, and procedures.

The environmental QA program provides the FUSRAP with reliable, accurate, and precise monitoring data. The program furnishes guidance and directives to detect and prevent problems from the time a sample is collected until the associated data are evaluated. The Missouri Department of Natural Resources (MDNR) conducted site visits on March 4, 2015, March 31, 2015, October to 21, 2015, and November 18, 2015, to observe and participate in the environmental monitoring activities. USEPA and MDNR regulatory oversight of sampling activities provided an additional level of QA/QC.

Key elements in achieving the goals of this program are maintaining compliance with the QA program; personnel training; compliance assessments; use of QC samples; documentation of field activities and laboratory analyses; and a review of data documents for precision, accuracy, and completeness.

General objectives are:

- To provide data of sufficient quality and quantity to support ongoing remedial efforts, to aid in defining potential COCs, to meet the requirements of the EMG (USACE 1999a) and the *Sampling and Analysis Guide for the St. Louis Sites* (SAG) (USACE 2000), and to support the ROD (USACE 1998a).
- To provide data of sufficient quality to meet applicable State of Missouri and federal concerns (e.g., reporting requirements).
- To ensure samples were collected using approved techniques and are representative of existing site conditions.

5.2 QUALITY ASSURANCE PROGRAM PLAN

The quality assurance program plan (QAPP) for activities performed at the SLDS is described within Section 3.0 of the SAG. The QAPP provides the organization, objectives, functional activities, and specific QA/QC activities associated with investigations and sampling activities at the SLDS.

QA/QC procedures are performed in accordance with applicable professional technical standards, USEPA requirements, government regulations and guidelines, and specific project goals and requirements. The QAPP was prepared in accordance with USEPA and USACE guidance documents, including *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (USEPA 1991), *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (USEPA 1994), and *Requirements for the Preparation of Sampling and Analysis Plans* (USACE 2001).

5.3 SAMPLING AND ANALYSIS GUIDE

The SAG summarizes standard operating procedures (SOPs) and data quality requirements for collecting and analyzing environmental data. The SAG integrates protocols and methodologies identified under various USACE and regulatory guidance. It describes administrative procedures for managing environmental data and governs sampling plan preparation, data review, evaluation and validation, database administration, and data archiving. The identified sampling and monitoring structures are delineated in programmatic documents such as the EMG (USACE 1999a), which is an upper tier companion document to the SAG (USACE 2000). The EMICY15 outlines the analyses to be performed at each site for various media (USACE 2014).

Flexibility to address non-periodic environmental sampling (e.g., specific studies regarding environmental impacts, well installations, and/or in-situ waste characterizations) was accomplished by the issuance of work descriptions. Environmental monitoring data obtained during these sampling activities were reported to USEPA Region 7 on a quarterly basis.

5.4 FIELD SAMPLE COLLECTION AND MEASUREMENT

Prior to beginning field sampling, field personnel were trained, as necessary, and participated in a project-specific readiness review. These activities ensured that standard procedures were followed in sample collection and completion of field logbooks, chain-of-custody forms, labels, and custody seals. Documentation of training and readiness was submitted to the project file.

The master field investigation documents are the site field logbooks. The primary purpose of these documents is to record each day’s field activities; personnel on each sampling team; and any administrative occurrences, conditions, or activities that may have affected the fieldwork or data quality of any environmental samples for any given day. Guidance for documenting specific types of field sampling activities in field logbooks or log sheets is provided in Appendix C of Engineer Manual (EM)-200-1-3 (USACE 2001).

At any point in the process of sample collection or data and document review, a non-conformance report may be initiated if non-conformances are identified (Leidos 2015a). Data entered into the St. Louis FUSRAP database may be flagged accordingly.

5.5 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits of both field and laboratory activities were conducted to verify that sampling and analysis activities were performed in accordance with the procedures established in the SAG and activity-specific work description or the EMICY15 (USACE 2014).

5.5.1 Field Assessments

Internal assessments (audit or surveillance) of field activities (sampling and measurements) were conducted by the QA/QC Officer (or designee). Assessments included an examination of field sampling records; field instrument operating records; sample collection, handling, and packaging procedures; and maintenance of QA procedures and chain-of-custody forms. These assessments occurred at the onset of the project to verify that all established procedures were followed (systems audit).

Performance assessments followed the systems audit to ensure that deficiencies had been corrected and to verify that QA practices/procedures were being maintained throughout the duration of the project. These assessments involved reviewing field measurement records, instrumentation calibration records, and sample documentation.

External assessments may be conducted at the discretion of the USACE, USEPA Region 7, or the State of Missouri.

5.5.2 Laboratory Audits

The on-site USACE St. Louis District FUSRAP Radioanalytical Laboratory locations are subject to periodic review(s) by the local USACE Chemist to demonstrate compliance with the *Department of Defense (DoD)/Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories* (QSM) (DOD and DOE 2013). In conjunction, the on-site laboratories participate in blind, third-party performance evaluation studies (performance audits) at least twice per year, with results reported to the local USACE point(s) of contact. In addition, contract laboratories are required to be accredited under the U.S. Department of Defense (DOD) Environmental Laboratory Accreditation Program (ELAP). The DOD ELAP requires an annual audit and re-accreditation every 3 years.

These system audits include examining laboratory documentation of sample receipt, sample log-in, sample storage, chain-of-custody procedures, sample preparation and analysis, and instrument operating records. Performance audits consist of USACE laboratories receiving performance evaluation samples from an outside vendor for an ongoing assessment of laboratory precision and accuracy. The analytical results of the analysis of performance evaluation samples are evaluated by USACE Hazardous, Toxic and Radioactive Waste – Center of Expertise and/or the local oversight chemist to ensure that laboratories maintain acceptable performance.

Internal performance and system audits of laboratories were conducted by the Laboratory QA Manager as directed in the *Laboratory Quality Assurance Plan for the FUSRAP St. Louis Radioanalytical Laboratory* (USACE 2013). System audits included an examination of laboratory documentation of sample receipt, sample log-in, sample storage, chain-of-custody procedures, sample preparation and analysis, and instrument operating records against the requirements of the laboratory's SOPs. Internal performance audits were also conducted on a regular basis. Single-blind performance samples were prepared and submitted along with project samples to the laboratory for analysis. The Laboratory QA Manager evaluated the analytical results of these single-blind performance samples to ensure that the laboratory maintained acceptable performance. Quarterly QA/QC reports were generated and provided to the local USACE authority – the reports document the ongoing QC elements and provide for further monitoring of quality processes/status. Also, QA plans and methodology follow the guidance presented in the QSM (DOD and DOE 2013).

5.6 SUBCONTRACTED LABORATORY PROGRAMS

All samples collected during environmental monitoring activities were analyzed by USACE-approved subcontractor laboratories. QA samples were collected for ground water and soil, and samples were analyzed by the designated USACE QA laboratory. Each laboratory supporting this work maintained statements of qualifications, including organizational structure, QA Manual, and SOPs. Additionally, subcontracted laboratories are also required to be an accredited laboratory under the DOD ELAP.

Samples collected during these investigations were analyzed by the USEPA methods contained in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846*, (USEPA 1993) and by other documented USEPA or nationally recognized methods. Laboratory SOPs are based on the QSM (DOD and DOE 2013).

5.7 QUALITY ASSURANCE AND QUALITY CONTROL SAMPLES

QA/QC samples were collected and analyzed for the purpose of assessing the quality of the sampling effort and the reported analytical data. QA/QC samples include duplicate samples (–1) and split samples (–2). The equation utilized for accuracy and precision can be found in Section 5.9.

5.7.1 Duplicate Samples

Duplicate samples measure precision and were collected by the sampling teams. Samples were submitted for analysis to the on-site USACE St. Louis FUSRAP laboratory or contract laboratories. The identity of duplicate samples is held blind to the analysts, and the purpose of these samples is to provide activity-specific, field-originated information regarding the homogeneity of the sampled matrix and the consistency of the sampling effort. These samples were collected concurrently with the primary environmental samples and equally represent the medium at a given time and location. Duplicate samples were collected from each medium addressed by this project and were submitted to the contracted laboratories for analysis. Approximately one duplicate sample was collected for every 20 field samples of each matrix and analyte across the SLS. Precision is measured by the relative percent difference (RPD) for radiological and non-radiological analyses or by the normalized absolute difference (NAD) for radiological analyses.

The RPDs for non-radiological analyses are presented in Table 5-1. The RPDs and NADs for radiological analyses are presented in Table 5-2. The overall precision for the CY 2015 environmental monitoring sampling activities was acceptable. See Section 5.9 for the evaluation process.

Table 5-1. Non-radiological Duplicate Sample Analysis for CY 2015[a]

Ground-Water Sample Name[b]	Arsenic	Cadmium
	RPD	RPD
SLD182121 / SLD182121-1	**31.58**	**31.11**
SLD184165 / SLD184165-1	26.67	NC

[a] RPD criterion for liquid samples is less than or equal to 30 percent.
[b] Soil samples ending in “-1” are duplicate soil samples.
Bold values exceed the control limits. Values not in bold are within control limits.
NC – not calculated (due to one or both concentrations being below DLs)

Table 5-2. Radiological Duplicate Sample Analysis for CY 2015[a]

Ground-Water Sample Name[b]	Ra-226		Ra-228		Th-228		Th-230	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
SLD182121 / SLD182121-1	NC	NA	*	*	NC	NA	9.98	NA
SLD184165 / SLD184165-1	NC	NA	*	*	NC	NA	NC	NA
Ground-Water Sample Name[b]	**Th-232**		**U-234**		**U-235**		**U-238**	
	RPD	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**
SLD182121 / SLD182121-1	NC	NA	25.56	NA	NC	NA	35.07	0.41
SLD184165 / SLD184165-1	NC	NA	NC	NA	NC	NA	NC	NA

[a] RPD criterion for liquid samples is less than or equal to 30 percent. If the RPD is greater than 30 percent, then the NAD shall be less than or equal to 1.96 to remain within the control limits.
[b] Soil samples ending in “-1” are duplicate soil samples.
* Not calculated, because either the parent or split sample was not analyzed.
NA – not applicable (see RPD)
NC – not calculated (due to one or both concentrations being below minimum detectable concentrations [MDCs])

5.7.2 Split Samples

Split samples measure accuracy and were collected by the sampling team and sent to a USACE QA laboratory for analysis to provide an independent assessment of contractor and subcontractor laboratory performance. Approximately one split sample was collected for every 20 field samples of each matrix for non-radiological and radiological analytes across the SLS. The RPDs for non-radiological analyses are presented in Table 5-3. The RPDs and NADs for radiological analyses are presented in Table 5-4. The overall accuracy for CY 2015 environmental monitoring sampling activities was acceptable. See Section 5.9 for the evaluation process.

Table 5-3. Non-radiological Split Sample Analysis for CY 2015[a]

Ground-Water Sample Name[b]	Arsenic	Cadmium
	RPD	RPD
SLD182121 / SLD182121-2	*	*
SLD184165 / SLD184165-2	10.91	NC

[a] RPD criterion for liquid samples is less than or equal to 30 percent.
[b] Soil samples ending in "-2" are split soil samples.
* Not calculated, because either the parent or split sample was not analyzed.
NC – not calculated (due to one or both concentrations being below DLs)

Table 5-4. Radiological Split Sample Analysis for CY 2015[a]

Ground-Water Sample Name[b]	Ra-226		Ra-228		Th-228		Th-230	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
SLD182121 / SLD182121-2	NC	NA	*	*	NC	NA	NC	NA
SLD184165 / SLD184165-2	128.56	1.09	*	*	NC	NA	NC	NA
Ground-Water Sample Name[b]	**Th-232**		**U-234**		**U-235**		**U-238**	
	RPD	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**
SLD182121 / SLD182121-2	NC	NA	58.62	0.78	NC	NA	79.70	0.90
SLD184165 / SLD184165-2	NC	NA	134.41	1.02	NC	NA	NC	NA

[a] RPD criterion for liquid samples is less than or equal to 30 percent. If the RPD is greater than 30 percent, then the NAD shall be less than or equal to 1.96 to remain within the control limits.
[b] Soil samples ending in "-2" are split soil samples.
* Not calculated, because either the parent or split sample was not analyzed.
NA – not applicable (see RPD)
NC – not calculated (due to one or both concentrations being below MDCs)

5.7.3 Equipment Rinsate Blanks

Equipment rinsate blank samples are typically taken from the rinsate water collected from equipment decontamination activities. These samples consist of analyte-free water that has been rinsed over sampling equipment for the purposes of evaluating the effectiveness of equipment decontamination. All of the monitoring wells have dedicated sampling equipment, rendering decontamination unnecessary. Because decontamination does not apply, equipment rinsate blanks were not employed.

5.8 DATA REVIEW, EVALUATION, AND VALIDATION

All data packages received from the analytical laboratory were reviewed and either evaluated or validated by data management personnel. Data validation is the systematic process of ensuring that the precision and accuracy of the analytical data are adequate for their intended use. Validation was performed in accordance with *Data Verification and Validation* (Leidos 2015b), and/or with project-specific guidelines. General chemical data quality management guidance found in Engineer Regulation (ER)-1110-1-263 (USACE 1998b) was also used when planning for chemical data management and evaluation. Additional details of data review, evaluation, and validation are provided in the *FUSRAP Laboratory Data Management Process for the St. Louis Site* (USACE 1999b). Data assessment guidance to determine the usability of data from hazardous, toxic and radioactive waste projects is provided in EM-200-1-6 (USACE 1997).

One hundred (100) percent of the data generated from all analytical laboratories was independently reviewed and either evaluated or validated. The data review process documents the possible effects on the data from various QC failures; it does not determine data usability, nor does it include assignment of data validation qualifier (VQ) flags. The data evaluation process uses the results of the data review to determine the usability of the data. The process of data evaluation summarizes the potential effects of QA/QC failures on the data, and the USACE District Chemist or District Health Physicist assesses their impact on the attainment of the project-specific data quality objectives (DQOs). Consistent with the data quality requirements, as defined in the DQOs, approximately 10 percent of all project data were validated.

5.9 PRECISION, ACCURACY, REPRESENTATIVENESS, COMPARABILITY, COMPLETENESS, AND SENSITIVITY

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

Accuracy and precision can be measured by the RPD or the NAD using the following equations:

$$RPD = \left(\frac{|S - D|}{\frac{S + D}{2}} \right) \times 100$$

$$NAD = \frac{|S - D|}{\sqrt{U_S^2 + U_D^2}}$$

where:

- S = parent sample result
- D = duplicate/split sample result
- U_S = parent sample uncertainty
- U_D = duplicate/split sample uncertainty

The RPD is calculated for all samples 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 30 percent, the NAD is used to determine the accuracy or precision of the method. NAD accounts for uncertainty in the results, RPD does not. The NAD should be less than or equal to 1.96. Neither equation is used when the analyte in one or both of the samples is not detected. In cases in which neither equation can be used, the comparison is counted as acceptable in the overall number of comparisons.

Precision is a measure of mutual agreement among individual measurements performed under the same laboratory controls. To evaluate for precision, a field duplicate is submitted to the same laboratory as the original sample to be analyzed under the same laboratory conditions. The RPD and NAD between the two results was calculated and used as an indication of the precision of the analyses performed (Tables 5-1 and 5-2). Sample collection precision was measured in the laboratory by the analyses of duplicates. The overall precision for the CY 2015 environmental monitoring sampling activities was acceptable.

Accuracy provides a gauge or measure of the agreement between an observed result and the true value for an analysis. The RPD and NAD between the two results was calculated and used as an indication of the accuracy of the analyses performed (Tables 5-3 and 5-4). For this EMDAR, 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. The overall accuracy for CY 2015 environmental monitoring sampling activities was acceptable.

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is a qualitative parameter that depends upon the proper design of the sampling program and proper laboratory protocols. Representativeness is satisfied through proper design of the sampling network, use of proper sampling techniques, following proper analytical procedures, and not exceeding holding times of the samples. Representativeness was determined by assessing the combined aspects of the QA program, QC measures, and data evaluations. The network design was developed from the EMICY15, the sampling protocols from the SAG have been followed, and analytical procedures were conducted within the bounds of the QAPP. The overall representativeness of the CY 2015 environmental monitoring sampling activities was acceptable.

Comparability expresses the confidence with which one dataset can be compared to another. The extent to which analytical data will be comparable depends upon the similarity of sampling and analytical methods, as well as sample-to-sample and historical comparability. Standardized and consistent procedures used to obtain analytical data are expected to provide comparable results. For example, post-CY 1997 analytical data may not be directly comparable to data collected before CY 1997, because of differences in DQOs. Additionally, some sample media (e.g., storm-water and radiological monitoring) have values that are primarily useful in the present, thus the comparison to historic data is not as relevant. However, the overall comparability of the applicable environmental monitoring sampling data met the project DQOs.

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under normal conditions. It is expected that laboratories will provide data meeting QC acceptance criteria for all samples tested. For the CY 2015 environmental monitoring sampling activities, the data completeness was 100 percent (St. Louis FUSRAP DQO for completeness is 90 percent).

Sensitivity is the determination of minimum detectable concentration (MDC) values that allows the investigation to assess the relative confidence that can be placed in an analytical result in comparison to the magnitude or level of analyte concentration observed. For this EMDAR, MDC is a term generically used to represent both the method detection limit (MDL) for non-radiological analytes and the minimum detectable activity (MDA) for radiological analytes. The closer a measured value to the MDC, the less confidence and more variation the measurement will have. Project sensitivity goals were expressed as quantitation level goals in the SAG. 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, and inductively coupled plasma (ICP) for metals. 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. Variations in MDLs for the same non-radiological analyte reflect variability in calibrations between laboratories, dilutions, and analytical methods. In order to complete the data evaluation (i.e., precision, accuracy, representativeness, and comparability), analytical results that exceed the MDC of the analyte are desired.

5.10 DATA QUALITY ASSESSMENT SUMMARY

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

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 less than desired but adequate for interpretation.

These data can withstand scientific scrutiny, are appropriate for their intended purpose, are technically defensible, and are of known and acceptable 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.

5.11 RESULTS FOR PARENT SAMPLES AND THE ASSOCIATED DUPLICATE AND SPLIT SAMPLES

Summaries of the QA parent sample results and associated duplicate and/or split sample results are presented in Tables 5-5 and 5-6.

Table 5-5. Non-Radiological Parent Samples and Associated Duplicate and Split Samples for CY 2015

Ground-Water Sample Name[b]	Arsenic[a]			Cadmium[a]		
	Result	DL	VQ	Result	DL	VQ
SLD182121	24.00	1.20	=	0.19	0.10	=
SLD182121-1	33.00	1.20	=	0.26	0.10	=
SLD182121-2	*	*	*	*	*	*
SLD184165	130.00	1.20	=	0.10	0.10	U
SLD184165-1	170.00	1.20	=	0.10	0.10	U
SLD184165-2	145.00	10.00	=	2.00	2.00	U

[a] Results are expressed in ug/L.
[b] Samples ending in "-1" are duplicate samples. Samples ending in "-2" are split samples.
* Not available because sample was not analyzed.
VQ symbols indicate: "=" for positively identified results, "U" for not detected.

Table 5-6. Radiological Parent Samples and Associated Duplicate and Split Samples for CY 2015

Ground-Water Sample Name[b]	Ra-226[a]				Ra-228[a]			
	Result	Error	MDC	VQ	Result	Error	MDC	VQ
SLD182121	1.34	1.03	1.38	U	*	*	*	*
SLD182121-1	0.62	0.63	0.82	UJ	*	*	*	*
SLD182121-2	0.43	0.11	0.09	=	*	*	*	*
SLD184165	1.09	0.78	0.91	J	*	*	*	*
SLD184165-1	0.91	0.75	0.96	U	*	*	*	*
SLD184165-2	0.24	0.09	0.10	=	*	*	*	*

Table 5-6. Radiological Parent Samples and Associated Duplicate and Split Samples for CY 2015 (Continued)

Ground-Water Sample Name[b]	Th-228[a]				Th-230[a]			
	Result	Error	MDC	VQ	Result	Error	MDC	VQ
SLD182121	0.15	0.22	0.37	UJ	0.46	0.36	0.37	J
SLD182121-1	0.39	0.40	0.57	UJ	0.51	0.43	0.47	J
SLD182121-2	0.25	0.17	0.20	J	0.12	0.12	0.18	UJ
SLD184165	0.13	0.23	0.46	UJ	0.34	0.32	0.38	U
SLD184165-1	0.32	0.33	0.47	UJ	0.38	0.32	0.17	J
SLD184165-2	0.07	0.08	0.13	UJ	0.13	0.08	0.08	J
Ground-Water Sample Name[b]	**Th-232[a]**				**U-234[a]**			
	Result	**Error**	**MDC**	**VQ**	**Result**	**Error**	**MDC**	**VQ**
SLD182121	0.18	0.21	0.17	UJ	1.50	0.84	0.73	J
SLD182121-1	0.08	0.16	0.21	UJ	1.16	0.61	0.43	J
SLD182121-2	0.01	0.08	0.19	UJ	0.82	0.26	0.12	=
SLD184165	0.06	0.13	0.17	UJ	0.39	0.30	0.15	J
SLD184165-1	0.06	0.13	0.17	UJ	0.17	0.20	0.15	UJ
SLD184165-2	0.01	0.03	0.08	UJ	0.08	0.06	0.07	J
Ground-Water Sample Name[b]	**U-235[a]**				**U-238[a]**			
	Result	**Error**	**MDC**	**VQ**	**Result**	**Error**	**MDC**	**VQ**
SLD182121	0.44	0.45	0.30	UJ	1.23	0.75	0.73	J
SLD182121-1	0.19	0.31	0.54	UJ	0.86	0.50	0.18	J
SLD182121-2	0.02	0.07	0.15	UJ	0.53	0.20	0.13	=
SLD184165	-0.05	0.09	0.45	UJ	0.50	0.34	0.15	J
SLD184165-1	0.02	0.17	0.45	UJ	0.02	0.13	0.36	UJ
SLD184165-2	0.01	0.03	0.04	UJ	0.03	0.04	0.06	UJ

[a] Results are expressed in pCi/L. Negative results are less than the laboratory system's background level.
[b] Samples ending in "-1" are duplicate samples. Samples ending in "-2" are split samples.
* Data for analyte not available from laboratory analysis. Ra-228 assumed to be in equilibrium with Th-228.
VQ symbols indicate: "=" for positively identified results, "J" analyte was identified as estimated quantity, and "UJ" analyte was not detected and had QC deficiencies.

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6.0 RADIOLOGICAL DOSE ASSESSMENT

This section evaluates the cumulative dose to a hypothetically impacted individual from exposure to radiological contaminants at the SLDS and documents dose trends. The regulatory dose limit for members of the public is 100 mrem per year, as stated in 10 *CFR* 20.1301. Although 10 *CFR* 20.1301 is not an ARAR for the SLDS, the USACE has provided this evaluation to evaluate public exposures from St. Louis FUSRAP cleanup operations. Compliance with the dose limit in §20.1301 can be demonstrated in one of the two following methods (§20.1302(b)(1) and (2)):

1) Demonstrating by measurement or calculation that the TEDE to the individual likely to receive the highest dose from SLDS operations does not exceed the annual dose limit (i.e., 100 mrem per year); or
2) Demonstrating that: (*i*) the annual average concentration of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area does not exceed the values specified in Table 1 of Appendix B of 10 *CFR* 20; and (*ii*) if an individual were continuously present in an unrestricted area, the dose from external sources would not exceed 2 mrem per hour.

The USACE has elected to demonstrate compliance by calculation of the TEDE to a hypothetical individual likely to receive the highest dose from the SLDS operations (method 1). This section describes the methodology employed for this evaluation.

Dose calculations are presented for a hypothetical maximally exposed individual at the SLDS. The monitoring data used in the dose calculations are reported in the respective environmental monitoring sections of this EMDAR.

Dose calculations related to airborne emissions, as required by 40 *CFR* 61, Subpart I (*National Emission Standards for Emissions of Radionuclides Other Than Radon From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered By Subpart H*), are presented in Appendix A (the “St. Louis Downtown Site 2015 Radionuclide Emissions NESHAP Report Submitted in Accordance with Requirements of 40 *CFR* 61, Subpart I”).

6.1 SUMMARY OF ASSESSMENT RESULTS

The TEDE from the SLDS to the receptor from all complete/applicable pathways combined was less than 0.1 mrem per year, estimated for an individual who works full-time at Thomas & Proetz Lumber Company (DT-10).

Figure 6-1 documents annual dose trends from CY 2000 to CY 2015 at the SLDS. Figure 6-2 provides a comparison of the maximum annual dose from CY 2000 to CY 2015 at the SLDS to the annual average natural background dose of approximately 300 mrem per year.

6.2 PATHWAY ANALYSIS

Table 6-1 lists the four complete pathways for exposure from SLDS radiological contaminants evaluated by the St. Louis FUSRAP EMP. These pathways are used to identify data gaps in the EMP and to estimate potential radiological exposures from the SLDS. Of the four complete pathways, three were applicable in CY 2015 and were thus incorporated into radiological dose estimates.

Table 6-1. Complete Radiological Exposure Pathways for the SLDS

Exposure Pathway	Pathway Description	Applicable to CY 2015 Dose Estimate
Liquid A	Ingestion of ground water from local wells downgradient from the site.	NA
Airborne A	Inhalation of particulates dispersed through wind erosion and RAs.	Y
Airborne B	Inhalation of Rn-222 and decay products emitted from contaminated soils/wastes.	Y
External	Direct gamma radiation from contaminated soils/wastes.	Y

Data from the SLDS storm-water discharges and MSD discharges are not applicable to the hypothesized recreational receptor; therefore, those data are not evaluated in this section.
NA – not applicable for the site
Y – applicable for the site

In developing specific elements of the St. Louis FUSRAP EMP, potential exposure pathways of the radioactive materials present on-site are reviewed to determine which pathways are complete. Evaluation of each exposure pathway is based on hypothesized sources, release mechanisms, types, probable environmental fates of contaminants, and the locations and activities of potential receptors. Pathways are then reviewed to determine whether a link exists between one or more radiological contaminant sources, or between one or more environmental transport processes, to an exposure point where human receptors are present. If it is determined that a link exists, the pathway is termed complete. Each complete pathway is reviewed to determine if a potential for exposure was present during CY 2015. If potential for exposure was present, the pathway is termed applicable. Only applicable pathways are considered in estimates of dose.

Table 6-1 shows the pathways applicable to the CY 2015 dose estimates for the SLDS. The Liquid A exposure pathway was not applicable in CY 2015, because the aquifer is of naturally low quality and it is not known to be used for any domestic purpose in the vicinity of the SLDS (DOE 1994).

6.3 EXPOSURE SCENARIOS

Dose calculations were performed for a maximally exposed individual at a critical receptor location for applicable exposure pathways (Table 6-1) to assess dose due to radiological releases from the SLDS. A second set of dose equivalent calculations were performed to meet NESHAP requirements (Appendix A), which were also used for purposes of TEDE calculation.

The scenarios and models used to evaluate these radiological exposures are conservative, but appropriate. Although radiation doses can be calculated or measured for individuals, it is not appropriate to predict the health risk to a single individual using the methods prescribed herein. Dose equivalents to a single individual are estimated by hypothesizing a maximally exposed individual and placing this individual in a reasonable, but conservative scenario. This method is acceptable when the magnitude of the dose to a hypothetical maximally exposed individual is small, as is the case for the SLDS. This methodology provides for reasonable estimates of potential exposure to the public and maintains a conservative approach. The scenarios and resulting estimated doses are outlined in Section 6.4.

6.4 DETERMINATION OF TOTAL EFFECTIVE DOSE EQUIVALENT FOR EXPOSURE SCENARIOS

The TEDE for the exposure scenario was calculated using CY 2015 monitoring data. Calculations for dose scenarios are provided in Appendix F. Dose equivalent estimates are well below the standards set by the U.S. Nuclear Regulatory Commission (NRC) for annual public exposure and USEPA NESHAP limits.

The CY 2015 TEDE for a hypothetical maximally exposed individual near the SLDS is less than 0.1 mrem per year.

This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent the perimeter of the SLDS and receive a radiation dose by the exposure pathways identified in Section 6.2. No private residences are adjacent to the site areas where uranium processing activities occurred. Therefore, all calculations of dose equivalent due to the applicable pathway assume a realistic residence time that is less than 100 percent. A full-time employee business receptor was considered to be the maximally exposed individual from the SLDS.

The exposure scenario assumptions include:

- Exposure to radiation from all SLDS sources occurs to the maximally exposed individual while working full-time outside at the receptor location facility located approximately 50 m from the assumed line source. Exposure time is 2,000 hours per year (Leidos 2016).
- Exposure from external gamma radiation was calculated using environmental TLD monitoring data at the site locations representative of areas accessible to the public between the source and the receptor. The site is assumed to represent a line-source to the receptor.
- Exposure from airborne radioactive particulates was estimated using soil concentration data and air particulate monitoring data to determine a source term, and then running the CAP-88 PC modeling code to estimate dose to the receptor (Leidos 2016).
- Exposure from Rn-222 (and progeny) was calculated using a dispersion factor and Rn-222 (ATD) monitoring data at the site locations representative of areas accessible to the public between the source and receptor (Leidos 2016).

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor location facility received less than 0.1 mrem per year from external gamma, less than 0.1 mrem per year from airborne radioactive particulates, and 0.0 mrem per year from Rn-222, for a TEDE of less than 0.1 mrem per year (Leidos 2016). In comparison, the average exposure to natural background radiation in the United States results in a TEDE of approximately 300 mrem per year (NCRP 2009).

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FIGURES

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APPENDIX A

ST. LOUIS DOWNTOWN SITE
2015 RADIONUCLIDE EMISSIONS NESHAP REPORT
SUBMITTED IN ACCORDANCE WITH REQUIREMENTS OF 40 *CFR* 61, SUBPART I

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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 (e.g., depths are given in feet and meters, and areas are given in square feet and square meters). Acres are given for areas when applicable.

$\mu Ci/cm^3$	microcurie(s) per cubic centimeter
µCi/mL	microcurie(s) per milliliter
Ac	actinium
AEC	U.S. Atomic Energy Commission
°C	degree(s) Celsius (centigrade)
CFR	*Code of Federal Regulations*
Ci	curie(s)
CY	calendar year
EDE	effective dose equivalent
FUSRAP	Formerly Utilized Sites Remedial Action Program
GIS	geographic information system
Mallinckrodt	Mallinckrodt LLC
MED	Manhattan Engineer District
mL	milliliter(s)
mrem	millirem
NESHAP	National Emission Standard for Hazardous Air Pollutants
Pa	protactinium
pCi/g	picocurie(s) per gram
Ra	radium
RA	remedial action
SLDS	St. Louis Downtown Site
SU	survey unit
Th	thorium
U	uranium
USEPA	U.S. Environmental Protection Agency
VP	vicinity property

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EXECUTIVE SUMMARY AND DECLARATION STATEMENT

This report presents the results of National Emission Standard for Hazardous Air Pollutants (NESHAP) calculations for the St. Louis Formerly Utilized Sites Remedial Action Program (FUSRAP) St. Louis Downtown Site (SLDS) for calendar year (CY) 2015. NESHAP requires the calculation of the effective dose equivalent (EDE) from radionuclide emissions to critical receptors. The report follows the requirements and procedures contained in 40 *Code of Federal Regulations* (*CFR*) 61, Subpart I, *National Emission Standards for Radionuclide Emissions from Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H.*

This NESHAP report evaluates SLDS properties where there was a reasonable potential for radionuclide emissions due to St. Louis FUSRAP activities. These sites include: Plant 6 and Plant 6 Loadout.

Emissions from the SLDS were evaluated for the entire CY 2015 to provide a conservative estimate of total emissions.

The NESHAP standard of EDE to a critical receptor from radionuclide emissions is 10 millirem (mrem) per year. The SLDS did not exceed this standard. The EDE from radionuclide emissions at the SLDS was calculated using soil characterization data, air particulate monitoring data, and the U.S. Environmental Protection Agency (USEPA) CAP88-PC modeling code, which resulted in an EDE at the SLDS of less than 0.1 mrem per year.

The evaluation for the SLDS resulted in less than 10 percent of the dose standard prescribed in 40 *CFR* 61.102. This site is exempt from the reporting requirements of 40 *CFR* 61.104(a).

DECLARATION STATEMENT – 40 *CFR* 61.104(a)(xvi)

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment. See 18 *U.S. Code* 1001.

____________________________________ _______________

Signature Date

Office: U.S. Army Corps of Engineers, St. Louis District Office
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Berkeley, MO 63134
Contact: Jon Rankins

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1.0 PURPOSE

This NESHAP report contains the EDE calculations from radionuclide emissions (exclusive of radon) to critical receptors from the SLDS properties at which a reasonable potential existed for radionuclide emissions due to St. Louis FUSRAP activities. These sites include: Plant 6 and Plant 6 Loadout. The air emissions from the SLDS are ground releases of particulate radionuclides in soil as a result of windblown action and remedial activity in the form of excavation and off-site disposal of soil.

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2.0 METHOD

Emission rates for the SLDS were modeled using guidance documents (i.e., *A Guide for Determining Compliance with the Clean Air Act Standards for Radionuclide Emissions from NRC-Licensed and Non-DOE Federal Facilities* [USEPA 1989]) referenced in 40 *CFR* 61, Appendix E, *Compliance Procedures Methods for Determining Compliance with Subpart I*, and were measured by collection of environmental air samples. Emission rates, along with appropriate meteorological data and distances to critical receptors[1], were input into the USEPA computer code CAP88-PC to obtain the EDE from the air emissions.

Although 40 *CFR* 61.103 requires the use of the USEPA computer code COMPLY, USEPA no longer supplies technical support for COMPLY. However, the USEPA lists both COMPLY and CAP88-PC as atmospheric models for assessing dose and risk from radioactive air emissions (USEPA 2014). The USEPA continues to maintain and update the CAP88-PC modeling program, and has updated it as recently as September, 2014. In previous FUSRAP NESHAP reports, both COMPLY and CAP88-PC results have been compared. This comparison indicated that CAP88-PC is a comparable and conservative method of demonstrating compliance with 40 *CFR* 61, Subpart I. For these reasons, CAP88-PC was used in this NESHAP report to demonstrate compliance with the NESHAP standard.

2.1 EMISSION RATE

The method used to determine particulate radionuclide emission rates from the SLDS was 40 *CFR* 61, Appendix D, *Methods for Estimating Radionuclide Emissions*. Emissions during excavations were evaluated using air sampling data at the excavation and loadout perimeters.

2.2 EFFECTIVE DOSE EQUIVALENT

The EDE to critical receptors[1] is obtained using USEPA computer code CAP88-PC, Version 4.0 (USEPA 2014). CAP88-PC uses a Gaussian plume equation to estimate the dispersion of radionuclides and is referenced by the USEPA to demonstrate compliance with the NESHAP emissions criterion in 40 *CFR* 61. An area ground release at a height of 1 m is modeled for the SLDS.

The EDE is calculated by combining doses from ingestion, inhalation, air immersion, and external ground surface. CAP88-PC contains historical weather data libraries for major airports across the country, and the results can be modeled for receptors at multiple distances from the emissions source.

[1] "Critical receptors," as used in this report, are the locations for the nearest residence, school, business, and farm.

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3.0 METEOROLOGICAL DATA

Meteorological data were obtained from the CAP88-PC code for the Lambert – St. Louis International Airport (wind file 13994.WND). Data in the file were accumulated from 1988 through 1992.

- Average Annual Wind Velocity: 4.446 m per second
- Average Annual Precipitation Rate: 111 cm per year
- Average Annual Air Temperature: 14.18 degrees Celsius (ºC)

Wind speed frequency data were obtained from Lambert – St. Louis International Airport (Table A-1).

Table A-1. St. Louis Wind Speed Frequency

Wind Speed Group (Knots)	Frequency
0 – 3	0.10
4 – 7	0.29
8 – 12	0.36
13 – 18	0.21
19 – 24	0.03
25 – 31	0.01

Knot = 1.151 miles per hour

Wind direction frequency data were obtained from the CAP88-PC wind file, 13994.WND (Table A-2).

Table A-2. St. Louis Wind Rose Frequency

Wind Direction		Wind Frequency	Wind Direction		Wind Frequency
Wind Toward	Wind From		Wind Toward	Wind From	
N	S	0.131	S	N	0.056
NNW	SSE	0.074	SSE	NNW	0.043
NW	SE	0.068	SE	NW	0.061
WNW	ESE	0.069	ESE	WNW	0.087
W	E	0.055	E	W	0.090
WSW	ENE	0.028	ENE	WSW	0.068
SW	NE	0.031	NE	SW	0.054
SSW	NNE	0.037	NNE	SSW	0.050

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4.0 ST. LOUIS DOWNTOWN SITE PROPERTIES UNDER ACTIVE REMEDIATION

4.1 SITE HISTORY

From 1942 until 1957, Mallinckrodt LLC (Mallinckrodt) was contracted by the Manhattan Engineer District (MED) and the U.S. Atomic Energy Commission (AEC) to process uranium ore for the production of uranium metal. Residuals of the process, including spent pitchblende ore, and radium, thorium, uranium, and their radioactive decay products, were inadvertently released from the Mallinckrodt property into the environment. Residuals from the uranium process had elevated levels of radioactive radium, thorium, and uranium. From 1942 to 1945, Plants 1, 2, 6, 7, and 4 (now Plant 10) were involved in the development of uranium-processing techniques, uranium compounds and metal production, and uranium metal recovery from residues and scrap. Mallinckrodt decontaminated Plants 1 and 2 from 1948 through 1950 to meet the AEC criteria then in effect, and the AEC released these plants for use without radiological restrictions in 1951.

4.2 MATERIAL HANDLING AND PROCESSING FOR CALENDAR YEAR 2015

Excavation activities were performed at the SLDS areas of Plant 6. Additionally, loadout activities were performed at Plant 6. Excavated soils placed in the loadout area remained covered for most of the year, except during normal working hours. The excavated soils were removed from the site by rail. General area air samples were collected around excavation and loadout perimeters during CY 2015, with the results used to determine the excavation emissions. In situ emissions from inactive areas of the SLDS were not calculated, because the ground surface soil at the SLDS is generally covered with asphalt or concrete that limits the potential for material to become airborne.

4.3 SOURCE DESCRIPTION – RADIONUCLIDE SOIL CONCENTRATIONS

For the SLDS excavation areas, the activity fraction for each radionuclide was determined from radionuclide concentrations listed in the *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual* (USACE 2000) or in property-specific pre-design investigation reports. Attachment A-1 contains summary tables of the radionuclide concentrations for each area or plant and vicinity properties (VPs). The averaged total alpha and total beta air particulate concentrations at each SLDS property and the activity fraction for each corresponding property were used to calculate the emission rate for each area.

4.4 LIST OF ASSUMED AIR RELEASES FOR CALENDAR YEAR 2015

Wind erosion during periods of remedial action (RA) excavations and periods in which the loadout pile was uncovered is assumed for the particulate radionuclide emission determinations from the SLDS. Unexcavated plants and VPs do not contribute to the emission determinations for periods of inactivity due to the low activity and cover.

4.5 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown on Figure A-1 and listed in Table A-3. Distances and directions to critical receptors are determined by using tools in a geographic information system (GIS).

Table A-3. SLDS Critical Receptors for CY 2015

Sources	Nearest Residence		School		Business		Farm	
	Distance (m)	Direction	Distance (m)	Direction	Distance (m)	Direction	Distance (m)	Direction
Plant 6	495	SW	750	W	160	SSE	2,915	NE
Plant 6 Loadout	495	SW	750	W	160	SSE	2,915	NE

4.6 EMISSIONS DETERMINATION

4.6.1 Measured Airborne Radioactive Particulate Emissions

Particulate air samples were collected from several locations around the perimeter of the SLDS excavations and loadout area to measure the radionuclide emissions from remedial activities. The sample locations were established at the start of each remedial activity and provide the basis for determining the radionuclide emission rates during CY 2015. The average gross alpha and beta concentrations (in microcuries per milliliter [μCi/mL]) are determined for each area or plant location for CY 2015. The area or plant average concentrations are presented in Table A-4.

Table A-4. SLDS Average Gross Alpha and Beta Airborne Particulate Emissions for CY 2015

Sampler Location	Average Concentration (μCi/mL)	
	Gross Alpha	Gross Beta
Plant 6	3.78E-15	2.49E-14
Plant 6 Loadout	3.92E-15	2.39E-14
Background Concentration[a]	3.66E-15	1.86E-14

[a] These concentrations are provided for informational purposes only. However, as a conservative approach, they were not subtracted from the gross average concentration during the determination of the EDE.

The activity fractions for all radionuclides at each SLDS property were determined as discussed in Section 4.3 of this NESHAP report. The product of the radionuclide activity fraction and the gross concentration for each property provides the radionuclide emission concentration (in microcuries per cubic centimeter [$\mu Ci/cm^3$]) for that area. The gross average concentration ($\mu Ci/cm^3$) is converted to a release (emission) rate, measured in curies per year using Equations 1 and 2.

A Guide for Determining Compliance with the Clean Air Act Standards for Radionuclide Emissions from NRC-Licensed and Non-DOE Federal Facilities (USEPA 1989) (page 3-21, [2]) provides Equation 1 for determination of the effective diameter of a non-circular stack or vent.

$$D = (1.3\ A)^{1/2} \qquad \textit{Equation 1}$$

where:

D = effective diameter of the release in m

A = area of the stack, vent, or release point (in m^2)

Table A-5 provides the effective surface area available for release of airborne radionuclides normalized to one year and the effective diameter for each area or plant of the SLDS where excavation or loadout was conducted in CY 2015. Calculation of the effective surface area is contained in Attachment A-1.

Table A-5. SLDS Excavation Effective Areas and Effective Diameters for CY 2015

SLDS Location	Effective Area (m^2)	Effective Diameter (m)
Plant 6	3,916	71
Plant 6 Loadout	460	24

The average annual wind speed for the Lambert – St. Louis International Airport is provided in CAP88-PC as 4.446 m per second. Conversion of this wind speed to a flow rate through stacks with the listed effective diameters for each area is completed using Equation 2.

$$F = V \pi (D)^2 / 4 \qquad \textit{Equation 2}$$

where:

V = wind velocity (in m per minute) = 266.76 m per minute
F = flow rate (in m^3 per minute)
π = mathematical constant
D = effective diameter of the release (in m) determined using Equation 1

Converting the velocity of emissions from the sites to an effective flow rate results in the following site release flow rates for the SLDS areas, as listed in Table A-6. The product of the flow rate, the activity fraction associated with each radionuclide, and the appropriate conversion factors provide the site emission rate for each radionuclide, as listed in Table A-7. Flow rate and average radionuclide concentration data are contained in Attachment A-1.

Table A-6. SLDS Site Release Flow Rates for CY 2015

SLDS Location	Site Release Flow Rate (m^3/minute)
Plant 6	1.1E+06
Plant 6 Loadout	1.3E+05

4.6.2 St. Louis Downtown Site Total Airborne Radioactive Particulate Emission Rates

The CY 2015 emission rates for each excavated SLDS area are presented in Table A-7 and are based on the air samples collected from the perimeter of the excavated areas.

Table A-7. SLDS Area Airborne Radioactive Particulate Emission Rates Based on Excavation Perimeter Air Samples for CY 2015

Radionuclide	Emission (curies [Ci]/year)[a]	
	Plant 6	Plant 6 Loadout
Uranium (U)-238	3.6E-04	9.3E-05
U-235	1.8E-05	4.7E-06
U-234	3.6E-04	9.3E-05
Radium (Ra)-226	6.9E-05	1.8E-05
Thorium (Th)-232	1.8E-05	4.7E-06
Th-230	1.3E-04	3.5E-05
Th-228	1.8E-05	4.7E-06
Ra-224	1.8E-05	4.7E-06
Th-234	3.2E-03	7.6E-04
Protactinium (Pa)-234m	3.2E-03	7.6E-04
Th-231	1.6E-04	3.8E-05
Ra-228	1.6E-04	3.8E-05

Table A-7. SLDS Area Airborne Radioactive Particulate Emission Rates Based on Excavation Perimeter Air Samples for CY 2015 (Continued)

Radionuclide	Emission (curies [Ci]/year)[a]	
	Plant 6	Plant 6 Loadout
Actinium (Ac)-228	1.6E-04	3.8E-05
Pa-231	1.8E-05	4.7E-06
Ac-227	1.8E-05	4.7E-06

[a] Release rate based on 365-day period at a respective flow rate (as presented in Table A-6) as determined from the average annual wind speed (4.446 m per second) and the effective site area (as presented in Table A-5) for each location.

4.7 CAP88-PC RESULTS

The CAP88-PC report is contained in Attachment A-2. The effective area factor input was taken from Table A-5. This evaluation demonstrates that all SLDS critical receptors receive less than 10 percent of the dose standard prescribed in 40 *CFR* 61.102; therefore, the SLDS is exempt from the reporting requirements of 40 *CFR* 61.104(a). The results are summarized in Table A-8.

Table A-8. SLDS CAP88-PC Results for Critical Receptors for CY 2015

Source	Dose (mrem/year)			
	Nearest Residence[a]	School[b]	Business[b]	Farm[a]
Plant 6	<0.1	<0.1	<0.1	<0.1
Plant 6 Loadout	<0.1	<0.1	<0.1	<0.1
SLDS Total Dose[c]	<0.1	<0.1	<0.1	<0.1

[a] 100 percent occupancy factor.
[b] Corrected for the 23 percent occupancy factor (40 hours per week for 50 weeks per year).
[c] Combined dose from all sources at the SLDS.

5.0 REFERENCES

USACE 2000. U.S. Army Corps of Engineers, St. Louis District Office. *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual*. September.

USEPA 1989. U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, D.C. *A Guide for Determining Compliance with the Clean Air Act Standards for Radionuclide Emissions from NRC-Licensed and Non-DOE Federal Facilities*. EPA 520/1-89-002. October.

USEPA 2014. U.S. Environmental Protection Agency. CAP88-PC Version 4.0 Computer Code, U.S. Environmental Protection Agency. September.

40 *CFR* 61, Subpart I. *National Emission Standards for Radionuclide Emissions from Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H*.

40 *CFR* 61, Appendix D. *Methods for Estimating Radionuclide Emissions.*

40 *CFR* 61, Appendix E. *Compliance Procedures Methods for Determining Compliance with Subpart I*.

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APPENDIX A

FIGURE

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ATTACHMENT A-1

CALCULATED EMISSION RATES FROM ST. LOUIS DOWNTOWN SITE PROPERTIES

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Table A-1-1. SLDS Excavation/Loadout Area Soil Radionuclide Concentrations for CY 2015

Property	Plant 6[a]	Plant 6 Loadout[b]	Average[b]
Radionuclide	Average Concentration (picocuries per gram [pCi/g])		
U-238	140	140	140
U-235	7	7	7
U-234	140	140	140
Ra-226	27	27	27
Ra-228	7	7	7
Th-232	7	7	7
Th-230	52	52	52
Th-228	7	7	7

[a] Radionuclides and concentrations from *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual* (USACE 1999) or in property-specific pre-design investigation reports.
[b] Average concentration from the SLDS CY 2015 excavated property and loadout area.

Table A-1-2. SLDS Average Gross Alpha and Beta Airborne Particulate Concentrations for CY 2015

Location	Average Concentration (μCi/mL) for Location[a]	
	Gross Alpha	Gross Beta
Plant 6	3.78E-15	2.49E-14
Plant 6 Loadout	3.92E-15	2.39E-14
Background Concentration[b]	3.66E-15	1.86E-14

[a] Average concentration values for the sampling period by location.
[b] These concentrations are provided for informational purposes only. However, as a conservative approach, they were not subtracted from the gross average concentration during the determination of EDE.

Table A-1-3. SLDS Excavation Data for CY 2015

Excavation Location Name	Surface Area (m^2)	Start Date[a]	Backfill Date[a]
Plant 6WH, Building 101, Remaining survey units (SUs)	3,530	01/12/15	12/31/15
Plant 6WH, Building 101, SU-15B	770	01/01/15	01/29/15
Plant 6EH, SU-10 (Building 101, SU-14A East Slope)	431	01/01/15	12/31/15
Plant 6 Loadout	2,000	01/01/15	12/31/15

[a] Open/close dates set to start or stop at the CY boundary.

Table A-1-4. SLDS Average Surface Area and Flow Rate Per Location at the SLDS for CY 2015

Location	Total Days	Surface Area × Total Days	Average Surface Area/year[a] (m^2)	Diameter of Stack $D = (1.3\ A)^{1/2}$ (m)	Flow Rate $F = V \pi (D)^2 / 4$ (m^3/minute)
Plant 6					
Building 101, Remaining SUs	354	1,249,620			
Building 101, SU-15B	29	22,330			
Building 101, SU-14A East Slope	365	157,315			
Total		696,600	3,916	71	**1.1E+06**
Plant 6 Loadout					
Plant 6 Loadout	365	167,900			
Total		167,900	460	24	**1.3E+05**[b]

[a] Average surface area/year = [Σ(surface area x total days)]/365.
[b] This value has been multiplied by a factor of 0.23 to account for the loadout pile being uncovered for 2,000 hours per year.

Table A-1-5. SLDS Airborne Radioactive Particulate Emissions Based on Excavation Perimeter Air Samples for CY 2015

Property	Plant 6			Plant 6 Loadout		
Radionuclide	Activity Fraction[a]	Emission Conc. (μCi/cm³)[b]	Release Rate (Ci/year)[c]	Activity Fraction[a]	Emission Conc. (μCi/cm³)[b]	Release Rate (Ci/year)[c]
U-238	0.35	1.3E-15	3.6E-04	0.35	1.4E-15	9.3E-05
U-235	0.02	6.6E-17	1.8E-05	0.02	6.8E-17	4.7E-06
U-234[d]	0.35	1.3E-15	3.6E-04	0.35	1.4E-15	9.3E-05
Ra-226	0.07	2.5E-16	6.9E-05	0.07	2.6E-16	1.8E-05
Th-232	0.02	6.6E-17	1.8E-05	0.02	6.8E-17	4.7E-06
Th-230	0.13	4.9E-16	1.3E-04	0.13	5.1E-16	3.5E-05
Th-228[d]	0.02	6.6E-17	1.8E-05	0.02	6.8E-17	4.7E-06
Ra-224[d]	0.02	6.6E-17	1.8E-05	0.02	6.8E-17	4.7E-06
Th-234[d]	0.47	1.2E-14	3.2E-03	0.47	1.1E-14	7.6E-04
Pa-234m[d]	0.47	1.2E-14	3.2E-03	0.47	1.1E-14	7.6E-04
Th-231[d]	0.02	5.8E-16	1.6E-04	0.02	5.5E-16	3.8E-05
Ra-228[d]	0.02	5.8E-16	1.6E-04	0.02	5.5E-16	3.8E-05
Ac-228[d]	0.02	5.8E-16	1.6E-04	0.02	5.5E-16	3.8E-05
Pa-231[d]	0.02	6.6E-17	1.8E-05	0.02	6.8E-17	4.7E-06
Ac-227[d]	0.02	6.6E-17	1.8E-05	0.02	6.8E-17	4.7E-06

[a] Derived from the average soil radionuclide concentrations for the SLDS, as presented in Table A-1-1.

[b] Emission concentration is equal to the activity fraction * the gross alpha or gross beta airborne particulate concentrations listed in Table A-1-2.

[c] Release rate based on 365-day period at measured flow rate (Table A-1-4) for each site, as determined from the average annual wind speed (4.446 m per second) and calculated site area (Table A-1-4). (Note: 1 milliliter [mL] = 1 cm³).

[d] When data were not available, the radionuclide was assumed to be in secular equilibrium with parent.

ATTACHMENT A-2

CAP88-PC OUTPUT REPORT FOR ST. LOUIS DOWNTOWN SITE PROPERTIES

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CAP88 OUTPUT RESULTS

Plant 6

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                    C A P 8 8 - P C

                      Version 4.0

          Clean Air Act Assessment Package – 1988

           D O S E   A N D   R I S K   S U M M A R I E S

              Non-Radon Individual Assessment
                  Mon Mar 14 14:12:59 2016


      Facility:  Plant 6
       Address:  Destrehan
          City:  Saint Louis
         State:  MO          Zip:  63147


  Source Category:  Area
      Source Type:  Area
    Emission Year:  2015
   DOSE Age Group:  Adult

         Comments:  Air
                  Air


     Dataset Name:  Plant6 2015.
     Dataset Date:  Mar 14, 2016 02:12 PM
        Wind File:  C:\Users\hansenra\Documents\CAP88\Wind Files\13994.WND
```

Mon Mar 14 14:12:59 2016 SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem)
Adrenal	1.08E-01
UB_Wall	1.17E-01
Bone_Sur	9.73E+00
Brain	1.13E-01
Breasts	1.22E-01
St_Wall	1.14E-01
SI_Wall	1.14E-01
ULI_Wall	1.21E-01
LLI_Wall	1.37E-01
Kidneys	2.79E-01
Liver	6.47E-01
Muscle	1.25E-01
Ovaries	1.84E-01
Pancreas	1.09E-01
R_Marrow	5.33E-01
Skin	2.02E+00
Spleen	1.15E-01
Testes	1.99E-01
Thymus	1.13E-01
Thyroid	1.17E-01
GB_Wall	1.10E-01
Ht_Wall	1.13E-01
Uterus	1.12E-01
ET_Reg	6.51E-01
Lung_66	1.99E+00
Effectiv	5.51E-01

PATHWAY COMMITTED EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem)
INGESTION	2.15E-02
INHALATION	4.23E-01
AIR IMMERSION	3.82E-06
GROUND SURFACE	1.06E-01
INTERNAL	4.45E-01
EXTERNAL	1.06E-01
TOTAL	5.51E-01

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Page 2

NUCLIDE COMMITTED EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem)
U-238	4.33E-02
Th-234	2.65E-03
Pa-234m	1.63E-02
Pa-234	3.22E-04
U-234	5.23E-02
Th-230	9.15E-02
Ra-226	1.35E-02
Rn-222	1.04E-05
Po-218	1.85E-10
Pb-214	6.77E-03
At-218	6.96E-10
Bi-214	3.95E-02
Rn-218	4.03E-12
Po-214	2.19E-06
Tl-210	1.54E-05
Pb-210	3.32E-05
Bi-210	5.37E-04
Hg-206	4.34E-11
Po-210	1.39E-07
Tl-206	1.25E-09
U-235	3.39E-03
Th-231	1.11E-04
Pa-231	8.65E-02
Ac-227	6.55E-02
Th-227	8.12E-04
Fr-223	7.66E-06
Ra-223	9.09E-04
Rn-219	3.93E-04
At-219	0.00E+00
Bi-215	1.77E-09
Po-215	1.20E-06
Pb-211	7.73E-04
Bi-211	3.18E-04
Tl-207	4.00E-04
Po-211	1.53E-07
Th-232	2.33E-02
Ra-228	3.24E-02
Ac-228	1.39E-02
Th-228	3.14E-02
Ra-224	2.16E-03
Rn-220	9.62E-06
Po-216	2.32E-07
Pb-212	2.11E-03
Bi-212	2.46E-03
Po-212	0.00E+00
Tl-208	1.70E-02
TOTAL	5.51E-01

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Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	5.13E-09
INHALATION	8.94E-08
AIR IMMERSION	1.83E-12
GROUND SURFACE	4.96E-08
INTERNAL	9.45E-08
EXTERNAL	4.96E-08
TOTAL	1.44E-07

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NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.45E-08
Th-234	1.09E-09
Pa-234m	2.86E-09
Pa-234	1.75E-10
U-234	1.80E-08
Th-230	2.02E-08
Ra-226	7.09E-09
Rn-222	5.65E-12
Po-218	8.27E-17
Pb-214	3.62E-09
At-218	8.58E-17
Bi-214	2.09E-08
Rn-218	2.21E-18
Po-214	1.20E-12
Tl-210	8.25E-12
Pb-210	1.49E-11
Bi-210	5.96E-11
Hg-206	1.92E-17
Po-210	7.64E-14
Tl-206	1.41E-16
U-235	1.36E-09
Th-231	5.05E-11
Pa-231	3.74E-09
Ac-227	8.19E-09
Th-227	4.40E-10
Fr-223	2.85E-12
Ra-223	4.91E-10
Rn-219	2.15E-10
At-219	0.00E+00
Bi-215	7.89E-16
Po-215	6.59E-13
Pb-211	2.76E-10
Bi-211	1.74E-10
Tl-207	5.14E-11
Po-211	8.39E-14
Th-232	5.10E-09
Ra-228	4.70E-09
Ac-228	7.38E-09
Th-228	1.13E-08
Ra-224	8.12E-10
Rn-220	5.27E-12
Po-216	1.28E-13
Pb-212	1.15E-09
Bi-212	9.51E-10
Po-212	0.00E+00
Tl-208	9.26E-09
TOTAL	1.44E-07

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SUMMARY
Page 5

INDIVIDUAL COMMITTED EFFECTIVE DOSE EQUIVALENT (mrem)
(All Radionuclides and Pathways)

Direction	Distance (m) 160	495	750	2915	
N	5.5E-01	8.1E-02	4.6E-02	1.8E-02	
NNW	2.9E-01	4.9E-02	3.1E-02	1.7E-02	
NW	3.4E-01	5.5E-02	3.3E-02	1.7E-02	
WNW	4.1E-01	6.4E-02	3.7E-02	1.8E-02	
W	3.1E-01	5.2E-02	3.2E-02	1.7E-02	School
WSW	1.6E-01	3.3E-02	2.3E-02	1.6E-02	
SW	2.2E-01	4.0E-02	2.7E-02	1.6E-02	Residence
SSW	2.7E-01	4.6E-02	2.9E-02	1.7E-02	
S	2.3E-01	4.2E-02	2.8E-02	1.7E-02	
SSE	1.7E-01	3.4E-02	2.4E-02	1.6E-02	Business
SSE	2.4E-01	4.3E-02	2.8E-02	1.7E-02	
ESE	4.0E-01	6.2E-02	3.7E-02	1.7E-02	
E	5.2E-01	7.6E-02	4.3E-02	1.8E-02	
ENE	4.3E-01	6.6E-02	3.8E-02	1.8E-02	
NE	2.7E-01	4.6E-02	3.0E-02	1.7E-02	Farm
NNE	2.3E-01	4.1E-02	2.7E-02	1.7E-02	

Mon Mar 14 14:12:59 2016 SUMMARY
Page 6

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

Direction	Distance (m) 160	495	750	2915
N	1.4E-07	2.1E-08	1.2E-08	4.5E-09
NNW	7.5E-08	1.3E-08	7.8E-09	4.1E-09
NW	8.9E-08	1.4E-08	8.5E-09	4.1E-09
WNW	1.1E-07	1.6E-08	9.5E-09	4.2E-09
W	8.2E-08	1.3E-08	8.1E-09	4.1E-09
WSW	4.1E-08	8.3E-09	5.8E-09	3.9E-09
SW	5.7E-08	1.0E-08	6.6E-09	4.0E-09
SSW	7.0E-08	1.2E-08	7.3E-09	4.0E-09
S	6.1E-08	1.1E-08	7.0E-09	4.0E-09
SSE	4.4E-08	8.7E-09	6.0E-09	3.9E-09
SSE	6.2E-08	1.1E-08	7.0E-09	4.0E-09
ESE	1.0E-07	1.6E-08	9.4E-09	4.2E-09
E	1.4E-07	2.0E-08	1.1E-08	4.4E-09
ENE	1.1E-07	1.7E-08	9.8E-09	4.3E-09
NE	7.0E-08	1.2E-08	7.4E-09	4.0E-09
NNE	6.0E-08	1.1E-08	6.8E-09	4.0E-09

CAP88 OUTPUT RESULTS

Plant 6 Loadout

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                              C A P 8 8 - P C

                               Version 4.0

                  Clean Air Act Assessment Package – 1988

            D O S E   A N D   R I S K   S U M M A R I E S

                      Non-Radon Individual Assessment
                           Mon Mar 14 14:27:15 2016


           Facility:  Plant 6 Loadout
            Address:  Destrehan
               City:  Saint Louis
              State:  MO          Zip:  63147


      Source Category:  Area
          Source Type:  Area
        Emission Year:  2015
       DOSE Age Group:  Adult

             Comments:  Air
                       Air


         Dataset Name:  Plant6 Loadout 2
         Dataset Date:  Mar 14, 2016 02:27 PM
            Wind File:  C:\Users\hansenra\Documents\CAP88\Wind Files\13994.WND
```

Mon Mar 14 14:27:15 2016 SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem)
Adrenal	2.76E-02
UB_Wall	2.98E-02
Bone_Sur	2.52E+00
Brain	2.87E-02
Breasts	3.11E-02
St_Wall	2.91E-02
SI_Wall	2.89E-02
ULI_Wall	3.08E-02
LLI_Wall	3.49E-02
Kidneys	7.15E-02
Liver	1.67E-01
Muscle	3.18E-02
Ovaries	4.72E-02
Pancreas	2.77E-02
R_Marrow	1.37E-01
Skin	5.16E-01
Spleen	2.92E-02
Testes	5.10E-02
Thymus	2.89E-02
Thyroid	2.99E-02
GB_Wall	2.79E-02
Ht_Wall	2.87E-02
Uterus	2.85E-02
ET_Reg	1.69E-01
Lung_66	5.15E-01
Effectiv	1.42E-01

PATHWAY COMMITTED EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem)
INGESTION	5.33E-03
INHALATION	1.10E-01
AIR IMMERSION	9.03E-07
GROUND SURFACE	2.69E-02
INTERNAL	1.15E-01
EXTERNAL	2.69E-02
TOTAL	1.42E-01

Mon Mar 14 14:27:15 2016 SUMMARY
Page 2

NUCLIDE COMMITTED EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem)
U-238	1.11E-02
Th-234	6.50E-04
Pa-234m	4.19E-03
Pa-234	8.26E-05
U-234	1.34E-02
Th-230	2.45E-02
Ra-226	3.51E-03
Rn-222	2.69E-06
Po-218	4.81E-11
Pb-214	1.76E-03
At-218	1.81E-10
Bi-214	1.03E-02
Rn-218	1.05E-12
Po-214	5.69E-07
Tl-210	4.01E-06
Pb-210	8.63E-06
Bi-210	1.40E-04
Hg-206	1.13E-11
Po-210	3.61E-08
Tl-206	3.26E-10
U-235	8.81E-04
Th-231	2.88E-05
Pa-231	2.24E-02
Ac-227	1.70E-02
Th-227	2.11E-04
Fr-223	1.99E-06
Ra-223	2.36E-04
Rn-219	1.02E-04
At-219	0.00E+00
Bi-215	4.59E-10
Po-215	3.12E-07
Pb-211	2.01E-04
Bi-211	8.26E-05
Tl-207	1.04E-04
Po-211	3.98E-08
Th-232	6.05E-03
Ra-228	7.66E-03
Ac-228	3.41E-03
Th-228	8.16E-03
Ra-224	5.59E-04
Rn-220	2.36E-06
Po-216	5.69E-08
Pb-212	5.18E-04
Bi-212	6.04E-04
Po-212	0.00E+00
Tl-208	4.17E-03
TOTAL	1.42E-01

Mon Mar 14 14:27:15 2016

SUMMARY
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	1.31E-09
INHALATION	2.32E-08
AIR IMMERSION	4.33E-13
GROUND SURFACE	1.26E-08
INTERNAL	2.45E-08
EXTERNAL	1.26E-08
TOTAL	3.71E-08

Mon Mar 14 14:27:15 2016 SUMMARY
Page 4

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	3.72E-09
Th-234	2.70E-10
Pa-234m	7.34E-10
Pa-234	4.49E-11
U-234	4.61E-09
Th-230	5.42E-09
Ra-226	1.84E-09
Rn-222	1.47E-12
Po-218	2.15E-17
Pb-214	9.40E-10
At-218	2.23E-17
Bi-214	5.42E-09
Rn-218	5.73E-19
Po-214	3.12E-13
Tl-210	2.14E-12
Pb-210	3.87E-12
Bi-210	1.55E-11
Hg-206	4.99E-18
Po-210	1.98E-14
Tl-206	3.66E-17
U-235	3.52E-10
Th-231	1.31E-11
Pa-231	9.71E-10
Ac-227	2.13E-09
Th-227	1.14E-10
Fr-223	7.40E-13
Ra-223	1.27E-10
Rn-219	5.59E-11
At-219	0.00E+00
Bi-215	2.05E-16
Po-215	1.71E-13
Pb-211	7.17E-11
Bi-211	4.51E-11
Tl-207	1.34E-11
Po-211	2.18E-14
Th-232	1.33E-09
Ra-228	1.11E-09
Ac-228	1.81E-09
Th-228	2.93E-09
Ra-224	2.10E-10
Rn-220	1.29E-12
Po-216	3.13E-14
Pb-212	2.82E-10
Bi-212	2.33E-10
Po-212	0.00E+00
Tl-208	2.27E-09
TOTAL	3.71E-08

Mon Mar 14 14:27:15 2016

SUMMARY
Page 5

INDIVIDUAL COMMITTED EFFECTIVE DOSE EQUIVALENT (mrem)
(All Radionuclides and Pathways)

	Distance (m)				
Direction	160	495	750	2915	
N	1.4E-01	2.1E-02	1.2E-02	4.6E-03	
NNW	7.4E-02	1.3E-02	7.8E-03	4.2E-03	
NW	8.7E-02	1.4E-02	8.5E-03	4.3E-03	
WNW	1.1E-01	1.6E-02	9.5E-03	4.4E-03	
W	8.1E-02	1.3E-02	8.1E-03	4.2E-03	School
WSW	4.1E-02	8.3E-03	5.9E-03	4.0E-03	
SW	5.7E-02	1.0E-02	6.7E-03	4.1E-03	Residence
SSW	6.9E-02	1.2E-02	7.4E-03	4.1E-03	
S	6.0E-02	1.1E-02	7.0E-03	4.1E-03	
SSE	4.3E-02	8.7E-03	6.1E-03	4.0E-03	
SSE	6.1E-02	1.1E-02	7.1E-03	4.1E-03	Business
ESE	1.0E-01	1.6E-02	9.4E-03	4.3E-03	
E	1.4E-01	2.0E-02	1.1E-02	4.5E-03	
ENE	1.1E-01	1.7E-02	9.8E-03	4.4E-03	
NE	6.9E-02	1.2E-02	7.5E-03	4.2E-03	Farm
NNE	5.9E-02	1.1E-02	6.9E-03	4.1E-03	

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INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)			
Direction	160	495	750	2915
N	3.7E-08	5.4E-09	3.0E-09	1.2E-09
NNW	1.9E-08	3.3E-09	2.0E-09	1.0E-09
NW	2.3E-08	3.6E-09	2.2E-09	1.1E-09
WNW	2.8E-08	4.2E-09	2.5E-09	1.1E-09
W	2.1E-08	3.4E-09	2.1E-09	1.1E-09
WSW	1.1E-08	2.1E-09	1.5E-09	9.9E-10
SW	1.5E-08	2.6E-09	1.7E-09	1.0E-09
SSW	1.8E-08	3.0E-09	1.9E-09	1.0E-09
S	1.6E-08	2.8E-09	1.8E-09	1.0E-09
SSE	1.1E-08	2.2E-09	1.5E-09	1.0E-09
SSE	1.6E-08	2.8E-09	1.8E-09	1.0E-09
ESE	2.7E-08	4.1E-09	2.4E-09	1.1E-09
E	3.5E-08	5.1E-09	2.8E-09	1.1E-09
ENE	2.9E-08	4.4E-09	2.5E-09	1.1E-09
NE	1.8E-08	3.1E-09	1.9E-09	1.0E-09
NNE	1.5E-08	2.7E-09	1.8E-09	1.0E-09

APPENDIX B

ENVIRONMENTAL THERMOLUMINESCENT DOSIMETER, ALPHA TRACK DETECTOR, AND PERIMETER AIR DATA

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

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APPENDIX C

STORM-WATER, WASTE-WATER, AND EXCAVATION-WATER DATA

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

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Table C-1. First Quarter Self-Monitoring Report for Excavation-Water Discharge at the SLDS During CY 2015

Parameter	Batch Number	Date of Discharge	Batch Results[a]		Amount Discharged (Gallons)	Total Activity per Discharge[b] (Ci)	MSD Discharge Limit		SOR
Gross Alpha (raw water)	SLDS-BK532	01/05/15 (Plant 6WH)	347	pCi/L	17,760	2.3E-05	3,000	pCi/L	0.11
Gross Beta			120	pCi/L		8.1E-06	N/A		
Th-228			<0.3	pCi/L		1.0E-08	2,000	pCi/L	
Th-230			<0.3	pCi/L		1.0E-08	1,000	pCi/L	
Th-232			<0.1	pCi/L		4.4E-09	300	pCi/L	
Uranium (KPA)			328	pCi/L		2.2E-05	3,000	pCi/L	
Ra-226[c]			1	pCi/L		4.7E-08	10	pCi/L	
Ra-228[d,e]			<0.3	pCi/L		1.0E-08	30	pCi/L	
TSS			10	mg/L		-	-		
Gross Alpha (raw water)	SLDS-BK533	02/24/15 (Plant 6WH)	174	pCi/L	15,040	9.9E-06	3,000	pCi/L	0.08
Gross Beta			106	pCi/L		6.0E-06	N/A		
Th-228			<1	pCi/L		2.8E-08	2,000	pCi/L	
Th-230			<1.1	pCi/L		3.2E-08	1,000	pCi/L	
Th-232			<0.8	pCi/L		2.3E-08	300	pCi/L	
Uranium (KPA)			230	pCi/L		1.3E-05	3,000	pCi/L	
Ra-226[c]			<1.3	pCi/L		3.8E-08	10	pCi/L	
Ra-228[d,e]			<1	pCi/L		2.8E-08	30	pCi/L	
TSS			11	mg/L		-	-		
Gross Alpha (raw water)	SLDS-BK534	03/10/15 - 03/30/15 (Plant 6WH)	95	pCi/L	80,150	2.9E-05	3,000	pCi/L	0.04
Gross Beta			47	pCi/L		1.4E-05	N/A		
Th-228			<0.6	pCi/L		9.7E-08	2,000	pCi/L	
Th-230			2	pCi/L		6.4E-07	1,000	pCi/L	
Th-232			<0.6	pCi/L		9.0E-08	300	pCi/L	
Uranium (KPA)			107	pCi/L		3.3E-05	3,000	pCi/L	
Ra-226[c]			2	pCi/L		4.9E-07	10	pCi/L	
Ra-228[d,e]			<0.6	pCi/L		9.7E-08	30	pCi/L	
TSS			30	mg/L		-	-		

Total Activity Discharged in First Quarter of CY 2015 (Ci)

Th-228	1.4E-07
Th-230	6.8E-07
Th-232	1.2E-07
Uranium (KPA)	6.8E-05
Ra-226	5.7E-07
Ra-228[d]	1.4E-07

Total Activity Discharged through 03/31/15 (Ci)

Th-228	1.4E-07
Th-230	6.8E-07
Th-232	1.2E-07
Uranium (KPA)	6.8E-05
Ra-226	5.7E-07
Ra-228[d]	1.4E-07

Total Volume Discharged in First Quarter of CY 2015 (gallons)

Gallons 112,950

Total Volume Discharged through 03/31/15 (gallons)

Gallons 112,950

[a] Non-detect sample results are converted to half the DL.
[b] The weighted average was used to calculate the total activity.
[c] 10 *CFR* 20 limit is 600 pCi/L for Ra-226.
[d] Ra-228 assumed to be in equilibrium with Th-228.
[e] 10 *CFR* 20 limit is 600 pCi/L for Ra-228.

Notes:
- No data/No limit
Ci - curie(s)
mg/L - milligram(s) per liter
N/A - Not applicable
pCi/L - picocurie(s) per liter
SOR - sum of ratios
TSS - total suspended solid(s)

Table C-1. Second Quarter Self-Monitoring Report for Excavation-Water Discharge at the SLDS During CY 2015

Parameter	Batch Number	Date of Discharge	Batch Results[a]		Amount Discharged (Gallons)	Total Activity per Discharge[b] (Ci)	MSD Discharge Limit		SOR
Gross Alpha (raw water)	SLDS-BK535	04/06/15 - 04/29/15 (Plant 6WH)	227	pCi/L	133,710	1.2E-04	3,000	pCi/L	0.10
Gross Beta			136	pCi/L		6.9E-05	N/A		
Th-228			<0.5	pCi/L		1.3E-07	2,000	pCi/L	
Th-230			9	pCi/L		4.6E-06	1,000	pCi/L	
Th-232			<0.5	pCi/L		1.2E-07	300	pCi/L	
Uranium (KPA)			282	pCi/L		1.4E-04	3,000	pCi/L	
Ra-226[c]			4	pCi/L		1.8E-06	10	pCi/L	
Ra-228[d,e]			<0.5	pCi/L		1.3E-07	30	pCi/L	
TSS			83	mg/L		-	-		
Gross Alpha (raw water)	SLDS-BK536	05/11/15 - 05/19/15 (Plant 6WH)	480	pCi/L	96,630	1.8E-04	3,000	pCi/L	0.20
Gross Beta			226	pCi/L		8.3E-05	N/A		
Th-228			<0.5	pCi/L		9.9E-08	2,000	pCi/L	
Th-230			3	pCi/L		9.4E-07	1,000	pCi/L	
Th-232			<0.5	pCi/L		9.0E-08	300	pCi/L	
Uranium (KPA)			577	pCi/L		2.1E-04	3,000	pCi/L	
Ra-226[c]			<1.7	pCi/L		3.1E-07	10	pCi/L	
Ra-228[d,e]			<0.5	pCi/L		9.9E-08	30	pCi/L	
TSS			49	mg/L		-	-		
Gross Alpha (raw water)	SLDS-BK537	06/02/15 - 06/30/15 (Plant 6WH)	315	pCi/L	669,640	8.0E-04	3,000	pCi/L	0.15
Gross Beta			163	pCi/L		4.1E-04	N/A		
Th-228			<0.5	pCi/L		6.9E-07	2,000	pCi/L	
Th-230			3	pCi/L		7.6E-06	1,000	pCi/L	
Th-232			<0.7	pCi/L		8.5E-07	300	pCi/L	
Uranium (KPA)			425	pCi/L		1.1E-03	3,000	pCi/L	
Ra-226[c]			2	pCi/L		5.7E-06	10	pCi/L	
Ra-228[d,e]			<0.5	pCi/L		6.9E-07	30	pCi/L	
TSS			45	mg/L		-	-		

Total Activity Discharged in Second Quarter of CY 2015 (Ci)		Total Activity Discharged through 06/30/15 (Ci)	
Th-228	9.2E-07	**Th-228**	1.1E-06
Th-230	1.3E-05	**Th-230**	1.4E-05
Th-232	1.1E-06	**Th-232**	1.2E-06
Uranium (KPA)	1.4E-03	**Uranium (KPA)**	1.5E-03
Ra-226	7.8E-06	**Ra-226**	8.4E-06
Ra-228[d]	9.2E-07	**Ra-228[d]**	1.1E-06

Total Volume Discharged in Second Quarter of CY 2015 (gallons)		Total Volume Discharged through 06/30/15 (gallons)	
Gallons	899,980	**Gallons**	1,012,930

[a] Non-detect sample results are converted to half the DL.
[b] The weighted average was used to calculate the total activity.
[c] 10 *CFR* 20 limit is 600 pCi/L for Ra-226.
[d] Ra-228 assumed to be in equilibrium with Th-228.
[e] 10 *CFR* 20 limit is 600 pCi/L for Ra-228.

Notes:
- No data/No limit
Ci - curie(s)
mg/L - milligram(s) per liter
N/A - Not applicable
pCi/L - picocurie(s) per liter
SOR - sum of ratios
TSS - total suspended solid(s)

Table C-1. Third Quarter Self-Monitoring Report for Excavation-Water Discharge at the SLDS During CY 2015

Parameter	Batch Number	Date of Discharge	Batch Results[a]		Amount Discharged (Gallons)	Total Activity per Discharge[b] (Ci)	MSD Discharge Limit		SOR
Gross Alpha (raw water)	SLDS-BK538	07/01/15 - 07/29/15 (Plant 6WH)	410	pCi/L	886,700	1.4E-03	3,000	pCi/L	0.17
Gross Beta			183	pCi/L		6.1E-04	N/A		
Th-228			<1.2	pCi/L		2.0E-06	2,000	pCi/L	
Th-230			2	pCi/L		5.0E-06	1,000	pCi/L	
Th-232			<0.6	pCi/L		1.0E-06	300	pCi/L	
Uranium (KPA)			490	pCi/L		1.6E-03	3,000	pCi/L	
Ra-226[c]			<2.1	pCi/L		3.6E-06	10	pCi/L	
Ra-228[d,e]			<1.2	pCi/L		2.0E-06	30	pCi/L	
TSS			29	mg/L		-	-		
Gross Alpha (raw water)	SLDS-BK539	08/05/15 - 08/31/15 (Plant 6WH)	164	pCi/L	501,026	3.1E-04	3,000	pCi/L	0.08
Gross Beta			75	pCi/L		1.4E-04	N/A		
Th-228			<0.7	pCi/L		7.0E-07	2,000	pCi/L	
Th-230			2	pCi/L		4.2E-06	1,000	pCi/L	
Th-232			<0.6	pCi/L		5.5E-07	300	pCi/L	
Uranium (KPA)			211	pCi/L		4.0E-04	3,000	pCi/L	
Ra-226[c]			<2.1	pCi/L		2.0E-06	10	pCi/L	
Ra-228[d,e]			<0.7	pCi/L		7.0E-07	30	pCi/L	
TSS			42	mg/L		-	-		
Gross Alpha (raw water)	SLDS-BK540	09/01/15 - 09/14/15 (Plant 6WH)	171	pCi/L	121,436	7.9E-05	3,000	pCi/L	0.07
Gross Beta			87	pCi/L		4.0E-05	N/A		
Th-228			<0.5	pCi/L		1.1E-07	2,000	pCi/L	
Th-230			1	pCi/L		6.0E-07	1,000	pCi/L	
Th-232			<0.3	pCi/L		7.4E-08	300	pCi/L	
Uranium (KPA)			185	pCi/L		8.5E-05	3,000	pCi/L	
Ra-226[c]			<1.9	pCi/L		4.3E-07	10	pCi/L	
Ra-228[d,e]			<0.5	pCi/L		1.1E-07	30	pCi/L	
TSS			71	mg/L		-	-		

Total Activity Discharged in Third Quarter of CY 2015 (Ci)

Th-228	2.8E-06
Th-230	9.8E-06
Th-232	1.6E-06
Uranium (KPA)	2.1E-03
Ra-226	6.0E-06
Ra-228[d]	2.8E-06

Total Activity Discharged through 09/30/15 (Ci)

Th-228	3.9E-06
Th-230	2.4E-05
Th-232	2.8E-06
Uranium (KPA)	3.6E-03
Ra-226	1.4E-05
Ra-228[d]	3.9E-06

Total Volume Discharged in Third Quarter of CY 2015 (gallons)

Gallons 1,509,162

Total Volume Discharged through 09/30/15 (gallons)

Gallons 2,522,092

[a] Non-detect sample results are converted to half the DL.

[b] The weighted average was used to calculate the total activity.

[c] 10 *CFR* 20 limit is 600 pCi/L for Ra-226.

[d] Ra-228 assumed to be in equilibrium with Th-228.

[e] 10 *CFR* 20 limit is 600 pCi/L for Ra-228.

Notes:

- No data/No limit

Ci - curie(s)

mg/L - milligram(s) per liter

N/A - Not applicable

pCi/L - picocurie(s) per liter

SOR - sum of ratios

TSS - total suspended solid(s)

Table C-1. Fourth Quarter Self-Monitoring Report for Excavation-Water Discharge at the SLDS During CY 2015

Parameter	Batch Number	Date of Discharge	Batch Results[a]		Amount Discharged (Gallons)	Total Activity per Discharge[b] (Ci)	MSD Discharge Limit		SOR
Gross Alpha (raw water)	SLDS-BK541	10/07/15 - 10/28/15 (Plant 6 WH)	346	pCi/L	31,500	4.1E-05	3,000	pCi/L	0.13
Gross Beta			182	pCi/L		2.2E-05	N/A		
Th-228			<0.7	pCi/L		4.2E-08	2,000	pCi/L	
Th-230			<0.7	pCi/L		4.2E-08	1,000	pCi/L	
Th-232			<0.6	pCi/L		3.5E-08	300	pCi/L	
Uranium (KPA)			378	pCi/L		4.5E-05	3,000	pCi/L	
Ra-226[c]			<1.5	pCi/L		9.1E-08	10	pCi/L	
Ra-228[d,e]			<0.7	pCi/L		4.2E-08	30	pCi/L	
TSS			24	mg/L		-	-		
Gross Alpha (raw water)	SLDS-BK542	11/10/15 - 11/30/15 (Plant 6WH)	154	pCi/L	309,180	1.8E-04	3,000	pCi/L	0.07
Gross Beta			107	pCi/L		1.2E-04	N/A		
Th-228			0.7	pCi/L		7.6E-07	2,000	pCi/L	
Th-230			1	pCi/L		1.6E-06	1,000	pCi/L	
Th-232			<0.6	pCi/L		3.4E-07	300	pCi/L	
Uranium (KPA)			206	pCi/L		2.4E-04	3,000	pCi/L	
Ra-226[c]			<1.7	pCi/L		9.8E-07	10	pCi/L	
Ra-228[d,e]			0.7	pCi/L		7.6E-07	30	pCi/L	
TSS			243	mg/L		-	-		
Gross Alpha (raw water)	SLDS-BK543	12/08/15 - 12/22/15 (Plant 6WH)	341	pCi/L	101,590	1.3E-04	3,000	pCi/L	0.14
Gross Beta			188	pCi/L		7.2E-05	N/A		
Th-228			<0.5	pCi/L		1.0E-07	2,000	pCi/L	
Th-230			1	pCi/L		4.6E-07	1,000	pCi/L	
Th-232			0.2	pCi/L		8.1E-08	300	pCi/L	
Uranium (KPA)			420	pCi/L		1.6E-04	3,000	pCi/L	
Ra-226[c]			<1.5	pCi/L		2.8E-07	10	pCi/L	
Ra-228[d,e]			<0.5	pCi/L		1.0E-07	30	pCi/L	
TSS			97	mg/L		-	-		

Total Activity Discharged in Fourth Quarter of CY 2015 (Ci)

Th-228	9.1E-07
Th-230	2.1E-06
Th-232	4.5E-07
Uranium (KPA)	4.5E-04
Ra-226	1.4E-06
Ra-228[d]	9.1E-07

Total Activity Discharged through 12/31/15 (Ci)

Th-228	4.8E-06
Th-230	2.6E-05
Th-232	3.3E-06
Uranium (KPA)	4.1E-03
Ra-226	1.6E-05
Ra-228[d]	4.8E-06

Total Volume Discharged in Fourth Quarter of CY 2015 (gallons)

Gallons 442,270

Total Volume Discharged through 12/31/15 (gallons)

Gallons 2,964,362

[a] Non-detect sample results are converted to half the DL.

[b] The weighted average was used to calculate the total activity.

[c] 10 *CFR* 20 limit is 600 pCi/L for Ra-226.

[d] Ra-228 assumed to be in equilibrium with Th-228.

[e] 10 *CFR* 20 limit is 600 pCi/L for Ra-228.

Notes:

- No data/No limit

Ci - curie(s)

mg/L - milligram(s) per liter

N/A - Not applicable

pCi/L - picocurie(s) per liter

SOR - sum of ratios

TSS - total suspended solid(s)

APPENDIX D

GROUND-WATER FIELD PARAMETER DATA FOR CY 2015 AND ANALYTICAL DATA RESULTS FOR CY 2015

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Table D-1. Ground-Water Monitoring First Quarter 2015 - Field Parameters for the SLDS

Station ID	Date Sampled	Purge Rate (mL/minute)	Volume Removed (mL)	pH	Conductivity (µS/cm)	Turbidity (NTU)	DO (mg/L)	Temp (°C)	ORP (mV)	Depth to Water (ft) at Sampling Time	Depth to Water (ft) (BTOC) 02/25/15
B16W06D	---	---	---	---	---	---	---	---	---	---	38.75
B16W06S	---	---	---	---	---	---	---	---	---	---	37.66
B16W07D	---	---	---	---	---	---	---	---	---	---	40.45
B16W08D	---	---	---	---	---	---	---	---	---	---	41.09
B16W08S	---	---	---	---	---	---	---	---	---	---	33.53
B16W09D	---	---	---	---	---	---	---	---	---	---	36.00
B16W12S	---	---	---	---	---	---	---	---	---	---	18.40
DW14	---	---	---	---	---	---	---	---	---	---	31.10
DW15	---	---	---	---	---	---	---	---	---	---	41.42
DW16	---	---	---	---	---	---	---	---	---	---	29.50
DW17	---	---	---	---	---	---	---	---	---	---	36.28
DW18	---	---	---	---	---	---	---	---	---	---	42.23
DW19	---	---	---	---	---	---	---	---	---	---	*
DW21	---	---	---	---	---	---	---	---	---	---	11.86
DW22R	---	---	---	---	---	---	---	---	---	---	**

Table D-1. Ground-Water Monitoring Second Quarter 2015 - Field Parameters for the SLDS

Station ID	Date Sampled	Purge Rate (mL/minute)	Volume Removed (mL)	pH	Conductivity (μS/cm)	Turbidity (NTU)	DO (mg/L)	Temp (°C)	ORP (mV)	Depth to Water (ft) at Sampling Time	Depth to Water (ft) (BTOC) 05/21/15
B16W06D	---	---	---	---	---	---	---	---	---	---	20.82
B16W06S	05/21/15	100	1,500	6.73	3.15	13.9	3.19	16.9	145	25.39	25.22
B16W07D	---	---	---	---	---	---	---	---	---	---	23.73
B16W08D	---	---	---	---	---	---	---	---	---	---	23.62
B16W08S	---	---	---	---	---	---	---	---	---	---	25.15
B16W09D	---	---	---	---	---	---	---	---	---	---	20.24
B16W12S	---	---	---	---	---	---	---	---	---	---	17.12
DW14	05/21/15	150	1,800	6.73	0.554	146	2.43	20.7	-168	19.15	17.98
DW15	---	---	---	---	---	---	---	---	---	---	25.92
DW16	05/21/15	290	4,350	6.57	0.162	140	0.8	18.6	-24	21.2	21.2
DW17	---	---	---	---	---	---	---	---	---	---	19.33
DW18	---	---	---	---	---	---	---	---	---	---	24.98
DW19	---	---	---	---	---	---	---	---	---	---	22.02
DW21	---	---	---	---	---	---	---	---	---	---	10.70
DW22R	---	---	---	---	---	---	---	---	---	---	**

Table D-1. Ground-Water Monitoring Third Quarter 2015 - Field Parameters for the SLDS

Station ID	Date Sampled	Purge Rate (mL/minute)	Volume Removed (mL)	pH	Conductivity (μS/cm)	Turbidity (NTU)	DO (mg/L)	Temp (°C)	ORP (mV)	Depth to Water (ft) at Sampling Time	Depth to Water (ft) (BTOC) 08/13/15
B16W06D	---	---	---	---	---	---	---	---	---	---	25.50
B16W06S	---	---	---	---	---	---	---	---	---	---	25.98
B16W07D	8/13/15	270	4,050	6.53	0.328	160	0.9	19.5	-171	27.81	27.81
B16W08D	---	---	---	---	---	---	---	---	---	---	28
B16W08S	---	---	---	---	---	---	---	---	---	---	22.65
B16W09D	---	---	---	---	---	---	---	---	---	---	23.48
B16W12S	---	---	---	---	---	---	---	---	---	---	12.61
DW14	---	---	---	---	---	---	---	---	---	---	17.78
DW15	---	---	---	---	---	---	---	---	---	---	29.25
DW16	8/13/15	290	5,220	6.53	0.161	178	0.81	18.9	-72	24.83	24.83
DW17	---	---	---	---	---	---	---	---	---	---	23.45
DW18	---	---	---	---	---	---	---	---	---	---	29.30
DW19	8/13/15	NA	3,500	6.71	0.15	600	4.05	22.1	9	25.55	25.55
DW21	---	---	---	---	---	---	---	---	---	---	7.51
DW22R	---	---	---	---	---	---	---	---	---	---	**

Table D-1. Ground-Water Monitoring Fourth Quarter 2015 - Field Parameters for the SLDS

Station ID	Date Sampled	Purge Rate (mL/minute)	Volume Removed (mL)	pH	Conductivity (µS/cm)	Turbidity (NTU)	DO (mg/L)	Temp (°C)	ORP (mV)	Depth to Water (ft) at Sampling Time	Depth to Water (ft) (BTOC) 11/19/15
B16W06D	---	---	---	---	---	---	---	---	---	---	28.92
B16W06S	11/19/15	100	1,500	6.54	0.163	303	1.57	16.7	-145	33.11	32.68
B16W07D	---	---	---	---	---	---	---	---	---	---	33.59
B16W08D	---	---	---	---	---	---	---	---	---	---	32.64
B16W08S	---	---	---	---	---	---	---	---	---	---	32.22
B16W09D	---	---	---	---	---	---	---	---	---	---	30.45
B16W12S	11/19/15	85	765	6.36	0.179	0	2.04	17.8	113	17.74	17.45
DW14	---	---	---	---	---	---	---	---	---	---	26.76
DW15	11/19/15	250	2,000	6.89	0.263	263	6.29	17.7	109	36.47	36.47
DW16	11/19/15	300	2,700	6.53	0.155	406	1.31	18.3	69	31.64	31.64
DW17	---	---	---	---	---	---	---	---	---	---	29.04
DW18	11/19/15	300	4,500	6.67	0.177	70.9	0.94	17.4	-174	33.85	33.85
DW19	---	---	---	---	---	---	---	---	---	---	*
DW21	---	---	---	---	---	---	---	---	---	---	10.58
DW22R	---	---	---	---	---	---	---	---	---	---	**

No ground-water samples were collected at the SLDS during the first quarter of 2015.

* Measurement could not be taken at DW19 due to well problem (frozen vault in the first quarter of 2015, silting in the fourth quarter of 2015).

** Measurement could not be taken at DW22R because well was not accessible.

--- monitoring well was not sampled during this event.

°C - degrees Celsius

µS/cm - microSiemen(s) per centimeter

BTOC - below top of casing

DO - dissolved oxygen

mg/L - milligram(s) per liter

mL - milliliter(s)

mV - millivolt(s)

NTU - nephelometric turbidity unit

ORP - oxidation reduction potential

Table D-2. CY 2015 Ground-Water Sampling Data for the SLDS

Site: SLDS											
Sample Name	Station Name	Sample Collect Date	Analytical Method	Analyte	Analytical Result	Measurement Error	DL	Units	VQ	Validation Reason Code	Filtered
SLD180857	B16W06S	05/21/15	SW846 6020	Arsenic	230		1.2	µg/L	=		No
SLD180857	B16W06S	05/21/15	SW846 6020	Cadmium	0.1		0.1	µg/L	U		No
SLD184165	B16W06S	11/19/15	SW846 6020	Arsenic	130		1.2	µg/L	=		No
SLD184165	B16W06S	11/19/15	SW846 6020	Cadmium	0.1		0.1	µg/L	U		No
SLD184165	B16W06S	11/19/15	ML-006	Ra-226	1.09	0.777	0.907	pCi/L	J	T04	No
SLD184165	B16W06S	11/19/15	ML-005	Th-228	0.125	0.234	0.459	pCi/L	UJ	T06	No
SLD184165	B16W06S	11/19/15	ML-005	Th-230	0.343	0.317	0.375	pCi/L	U	T04, T05	No
SLD184165	B16W06S	11/19/15	ML-005	Th-232	0.0623	0.125	0.169	pCi/L	UJ	T06	No
SLD184165	B16W06S	11/19/15	ML-015	U-234	0.389	0.301	0.15	pCi/L	J	T04	No
SLD184165	B16W06S	11/19/15	ML-015	U-235	-0.0457	0.0916	0.446	pCi/L	UJ	T06	No
SLD184165	B16W06S	11/19/15	ML-015	U-238	0.497	0.341	0.15	pCi/L	J	T04	No
SLD182123	B16W07D	08/13/15	SW846 6020	Arsenic	37		1.2	µg/L	=		No
SLD182123	B16W07D	08/13/15	SW846 6020	Cadmium	0.82		0.1	µg/L	=		No
SLD184166	B16W12S	11/19/15	SW846 6020	Arsenic	2		1.2	µg/L	=		No
SLD184166	B16W12S	11/19/15	SW846 6020	Cadmium	1		0.1	µg/L	=		No
SLD184166	B16W12S	11/19/15	ML-006	Ra-226	0.63	0.625	0.897	pCi/L	U	T04, T05	No
SLD184166	B16W12S	11/19/15	ML-005	Th-228	0.216	0.297	0.518	pCi/L	UJ	T06	No
SLD184166	B16W12S	11/19/15	ML-005	Th-230	0.37	0.307	0.167	pCi/L	J	F01, T04	No
SLD184166	B16W12S	11/19/15	ML-005	Th-232	0.123	0.175	0.167	pCi/L	UJ	T06	No
SLD184166	B16W12S	11/19/15	ML-015	U-234	1.63	0.732	0.435	pCi/L	=		No
SLD184166	B16W12S	11/19/15	ML-015	U-235	-0.0275	0.227	0.666	pCi/L	UJ	T06	No
SLD184166	B16W12S	11/19/15	ML-015	U-238	2.09	0.841	0.433	pCi/L	=		No
SLD180858	DW14	05/21/15	SW846 6020	Arsenic	100		1.2	µg/L	=		No
SLD180858	DW14	05/21/15	SW846 6020	Cadmium	0.46		0.1	µg/L	=		No
SLD184167	DW15	11/19/15	SW846 6020	Arsenic	19		1.2	µg/L	=		No
SLD184167	DW15	11/19/15	SW846 6020	Cadmium	14		0.1	µg/L	=		No
SLD184167	DW15	11/19/15	ML-006	Ra-226	1.49	1.01	1.31	pCi/L	J	T04	No
SLD184167	DW15	11/19/15	ML-005	Th-228	0.322	0.332	0.429	pCi/L	UJ	T06	No
SLD184167	DW15	11/19/15	ML-005	Th-230	0.322	0.375	0.602	pCi/L	UJ	T06	No
SLD184167	DW15	11/19/15	ML-005	Th-232	-0.0715	0.102	0.526	pCi/L	UJ	T06	No
SLD184167	DW15	11/19/15	ML-015	U-234	0.428	0.31	0.145	pCi/L	J	T04	No
SLD184167	DW15	11/19/15	ML-015	U-235	0.132	0.188	0.179	pCi/L	UJ	T06	No
SLD184167	DW15	11/19/15	ML-015	U-238	0.479	0.329	0.144	pCi/L	J	T04	No
SLD180859	DW16	05/21/15	SW846 6020	Arsenic	130		1.2	µg/L	=		No
SLD180859	DW16	05/21/15	SW846 6020	Cadmium	1.1		0.1	µg/L	=		No

Table D-2. CY 2015 Ground-Water Sampling Data for the SLDS

Site: SLDS											
Sample Name	Station Name	Sample Collect Date	Analytical Method	Analyte	Analytical Result	Measurement Error	DL	Units	VQ	Validation Reason Code	Filtered
SLD182121	DW16	08/13/15	SW846 6020	Arsenic	24.00		1.2	µg/L	=		No
SLD182121	DW16	08/13/15	SW846 6020	Cadmium	0.19		0.1	µg/L	=		No
SLD182121	DW16	08/13/15	ML-006	Ra-226	1.34	1.03	1.38	pCi/L	U	T04, T05	No
SLD182121	DW16	08/13/15	ML-005	Th-228	0.152	0.221	0.365	pCi/L	UJ	T06	No
SLD182121	DW16	08/13/15	ML-005	Th-230	0.457	0.357	0.365	pCi/L	J	F01, T04	No
SLD182121	DW16	08/13/15	ML-005	Th-232	0.182	0.212	0.165	pCi/L	UJ	T02	No
SLD182121	DW16	08/13/15	ML-015	U-234	1.5	0.836	0.728	pCi/L	J	T04	No
SLD182121	DW16	08/13/15	ML-015	U-235	0.444	0.453	0.301	pCi/L	UJ	T02	No
SLD182121	DW16	08/13/15	ML-015	U-238	1.23	0.754	0.725	pCi/L	J	F01, T04	No
SLD184168	DW16	11/19/15	SW846 6020	Arsenic	88		1.2	µg/L	=		No
SLD184168	DW16	11/19/15	SW846 6020	Cadmium	1.8		0.1	µg/L	=		No
SLD184169	DW18	11/19/15	SW846 6020	Arsenic	68		1.2	µg/L	=		No
SLD184169	DW18	11/19/15	SW846 6020	Cadmium	0.57		0.1	µg/L	=		No
SLD182122	DW19	08/13/15	SW846 6020	Arsenic	18		1.2	µg/L	=		No
SLD182122	DW19	08/13/15	SW846 6020	Cadmium	15		0.1	µg/L	=		No
SLD182122	DW19	08/13/15	ML-006	Ra-226	0.562	0.77	1.35	pCi/L	UJ	T06	No
SLD182122	DW19	08/13/15	ML-005	Th-228	0.399	0.332	0.18	pCi/L	J	T04	No
SLD182122	DW19	08/13/15	ML-005	Th-230	0.1	0.201	0.4	pCi/L	UJ	T06	No
SLD182122	DW19	08/13/15	ML-005	Th-232	-0.0665	0.0946	0.49	pCi/L	UJ	T06	No
SLD182122	DW19	08/13/15	ML-015	U-234	18.7	4.07	0.47	pCi/L	=		No
SLD182122	DW19	08/13/15	ML-015	U-235	2.23	0.977	0.242	pCi/L	=		No
SLD182122	DW19	08/13/15	ML-015	U-238	18	3.94	0.195	pCi/L	=		No

VQs:

= Indicates that the data met all QA/QC requirements, and that the parameter has been positively identified and the associated concentration value is accurate.
J Indicates that the parameter was positively identified; the associated numerical value is the approximate concentration of the parameter in the sample.
U Indicates that the data met all QA/QC requirements, and that the parameter was analyzed for but was not detected above the reported sample quantitation limit.
UJ Indicates that the parameter was not detected above the reported sample quantitation limit and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. However, the reported quantitation limit is approximate.

Validation Reason Codes:

F01 Blanks: Sample data were qualified as a result of the method blank.
T02 Radionuclide Quantitation: Analytical uncertainties were not met and/or not reported.
T04 Radionuclide Quantitation: Professional judgment was used to qualify the data.
T05 Radionuclide Quantitation: Analytical result is less than the associated MDA, but greater than the counting uncertainty.
T06 Radionuclide Quantitation: Analytical result is less than both the associated counting uncertainty and MDA.

APPENDIX E

WELL MAINTENANCE CHECKLISTS FOR THE ANNUAL GROUND-WATER MONITORING WELL INSPECTIONS CONDUCTED AT THE SLDS IN CY 2015

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

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Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 0930

Monitoring Well Station Identification: B16W06D ☐SLAPS* ☒SLDS ☐HISS

		Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☐	☐	☒
2.	Is well identification visible on top of well casing for flush mount well?	☒	☐	☐
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☐	☐	☒
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☒	☐	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☒	☐	☐
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☒	☐	☐
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☐	☒	☐

Comments / Observations regarding this well.

WL – 38.75, TD -82.60 (Estimated TD – 81.9)

Soft bottom

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 0940

Monitoring Well Station Identification: B16W06S ☐SLAPS* ☒SLDS ☐HISS

	Question	Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☒	☐	☐
2.	Is well identification visible on top of well casing for flush mount well?	☐	☐	☒
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☒	☐	☐
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☒	☐	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☒	☐	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☒	☐	☐
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☒	☐	☐

Comments / Observations regarding this well.

WL – 37.66, TD – 46.75 (Estimated TD – 42.9; formerly a flush mount well, stick up well retrofit added)

Needs paint and new ID tag or label

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 1040

Monitoring Well Station Identification: B16W07D ☐SLAPS* ☒SLDS ☐HISS

	Question	Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☒	☐	☐
2.	Is well identification visible on top of well casing for flush mount well?	☐	☐	☒
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☒	☐	☐
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☒	☐	☐
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☐	☒	☐

Comments / Observations regarding this well.

WL – 40.45, TD – 82.55 (Estimated TD – 78.5; formerly a flush mount well, stick up retrofit added)

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 0955

Monitoring Well Station Identification: B16W08D ☐SLAPS* ☒SLDS ☐HISS

#	Question	Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☒	☐	☐
2.	Is well identification visible on top of well casing for flush mount well?	☐	☐	☒
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☒	☐	☐
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☒	☐	☐
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☐	☒	☐

Comments / Observations regarding this well.

WL – 41.09, TD – 75.75 (Estimated TD – 70.8; formerly a flush mount well, stick up retrofit added)

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 0950

Monitoring Well Station Identification: B16W08S ☐SLAPS* ☒SLDS ☐HISS

		Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☒	☐	☐
2.	Is well identification visible on top of well casing for flush mount well?	☐	☐	☒
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☒	☐	☐
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☒	☐	☐
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☐	☒	☐

Comments / Observations regarding this well.

WL – 33.53, TD – 41.90 (Estimated TD – 38.20; formerly a flush mount well, stick up retrofit added)

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 1200

Monitoring Well Station Identification: B16W09D ☐SLAPS* ☒SLDS ☐HISS

	Question	Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☐	☐	☒
2.	Is well identification visible on top of well casing for flush mount well?	☐	☒	☐
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☐	☐	☒
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☒	☐	☐

Comments / Observations regarding this well.

WL – 36.00, TD – 55.9 (Estimated TD – 55.5)

Semi-soft bottom

Remark well ID or add label

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 1240

Monitoring Well Station Identification: B16W12S ☐SLAPS* ☒SLDS ☐HISS

	Question	Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☐	☐	☒
2.	Is well identification visible on top of well casing for flush mount well?	☒	☐	☐
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☐	☐	☒
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☐	☒	☐

Comments / Observations regarding this well.

WL – 18.4, TD – 19.90 (Estimated TD – 20.1)

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 1310

Monitoring Well Station Identification: DW14 ☐SLAPS* ☒SLDS ☐HISS

		Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☐	☐	☒
2.	Is well identification visible on top of well casing for flush mount well?	☐	☒	☐
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☐	☐	☒
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☒	☐	☐

Comments / Observations regarding this well.

WL – 31.10, TD – 38.0 (Estimated TD – 40.0)

Semisoft bottom

Add label or remark well ID

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 1235

Monitoring Well Station Identification: DW15 ☐ SLAPS* ☒ SLDS ☐ HISS

		Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☐	☐	☒
2.	Is well identification visible on top of well casing for flush mount well?	☒	☐	☐
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☐	☐	☒
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☐	☒	☐

Comments / Observations regarding this well.

WL – 41.42, TD – 63.5 (Estimated TD – 64.5)

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 1210

Monitoring Well Station Identification: DW16 ☐SLAPS* ☒SLDS ☐HISS

		Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☐	☐	☒
2.	Is well identification visible on top of well casing for flush mount well?	☒	☐	☐
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☐	☐	☒
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☐	☒	☐

Comments / Observations regarding this well.

WL – 29.50, TD – 49.50 (Estimated TD – 50.0)

Mud/Sediment on pump but solid bottom

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 1020

Monitoring Well Station Identification: DW17 ☐SLAPS* ☒SLDS ☐HISS

		Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☒	☐	☐
2.	Is well identification visible on top of well casing for flush mount well?	☐	☐	☒
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☒	☐	☐
6.	Is the weep hole open? If not, clear blockage.	☐	☐	☒
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☒	☐	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☐	☒	☐
10.	Does the pad move or is it unstable?	☐	☐	☒
11.	Are there gaps between pad and well casing?	☐	☐	☒
12.	Are there signs of erosion around the well or pad?	☒	☐	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☒	☐	☐
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☐	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☒	☐	☐

Comments / Observations regarding this well.

WL – 36.28, TD – 42.60 (Estimated TD – 44.5)

Soft bottom

Retrofit to stick up well and redevelop well before taking samples.

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 1010

Monitoring Well Station Identification: DW18 ☐SLAPS* ☒SLDS ☐HISS

		Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☒	☐	☐
2.	Is well identification visible on top of well casing for flush mount well?	☐	☐	☒
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☒	☐	☐
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☒	☐	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☒	☐	☐
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☒	☐	☐

Comments / Observations regarding this well.

WL – 42.23, TD – 58.0 (Estimated TD – 55.0; formerly flush mount well, stick up retrofit added)

Needs primer and paint

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 1100

Monitoring Well Station Identification: DW19 ☐SLAPS* ☒SLDS ☐HISS

#	Question	Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☐	☐	☒
2.	Is well identification visible on top of well casing for flush mount well?	☐	☒	☐
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☒	☐	☐
6.	Is the weep hole open? If not, clear blockage.	☐	☐	☒
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☐	☒	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☒	☐	☐

Comments / Observations regarding this well.

WL – unable to take, frozen water in flush mount well casing

TD – see note above for WL (Estimated TD – 64.5)

Needs grading or retrofit to stick up well.

Recommend developing well before taking samples

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: 1220

Monitoring Well Station Identification: DW21 ☐SLAPS* ☒SLDS ☐HISS

		Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☐	☐	☒
2.	Is well identification visible on top of well casing for flush mount well?	☒	☐	☐
3.	Is well accessible?	☒	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☒	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☒	☐
6.	Is the weep hole open? If not, clear blockage.	☐	☐	☒
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☒	☐
8.	Is the riser casing dented or damaged?	☐	☒	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☒	☐	☐
10.	Does the pad move or is it unstable?	☐	☒	☐
11.	Are there gaps between pad and well casing?	☐	☒	☐
12.	Are there signs of erosion around the well or pad?	☐	☒	☐
13.	Is riser cap present?	☒	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☒
16.	Is the well secure (shut properly or locked, if applicable)?	☒	☐	☐
17.	Do the locks work properly?	☒	☐	☐
18.	Are the locks rusted?	☐	☒	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☒	☐	☐
20.	Is TOC elevation mark clearly visible?	☒	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☒	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☐	☒	☐

Comments / Observations regarding this well.
WL – 11.86, TD – 22.15 (Estimated TD – 22.7)

* - SLAPS and SLAPS Vicinity Properties (VPs)

Well Maintenance Checklist

Name of Observer(s): L. Hoover, N. Gross Date: 02/25/15 Time: ____________

Monitoring Well Station Identification: DW22R ☐SLAPS* ☒SLDS ☐HISS

	Question	Yes	No	N/A
1.	Is well identification number visible on outer casing for a stick up well?	☐	☐	☐
2.	Is well identification visible on top of well casing for flush mount well?	☐	☐	☐
3.	Is well accessible?	☐	☐	☐
4.	Is well covered/surrounded by vegetation?	☐	☐	☐
5.	Is there standing water or debris inside well casing? If so, remove water.	☐	☐	☐
6.	Is the weep hole open? If not, clear blockage.	☐	☐	☐
7.	Is the protective casing dented, damaged, rusted, or covered in other matter (i.e., bird droppings)?	☐	☐	☐
8.	Is the riser casing dented or damaged?	☐	☐	☐
9.	Is the concrete pad intact (free of cracks, chips, etc.)?	☐	☐	☐
10.	Does the pad move or is it unstable?	☐	☐	☐
11.	Are there gaps between pad and well casing?	☐	☐	☐
12.	Are there signs of erosion around the well or pad?	☐	☐	☐
13.	Is riser cap present?	☐	☐	☐
14.	Do the wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☐
15.	Do the flush mount wells in the Mississippi River and Coldwater Creek floodplain have a properly working pressure cap?	☐	☐	☐
16.	Is the well secure (shut properly or locked, if applicable)?	☐	☐	☐
17.	Do the locks work properly?	☐	☐	☐
18.	Are the locks rusted?	☐	☐	☐
19.	Does surface water flow away from well casing (i.e., no ponding)?	☐	☐	☐
20.	Is TOC elevation mark clearly visible?	☐	☐	☐
21.	Has there been a change in land use that impacts the well? If yes, describe in comment section.	☐	☐	☐
22.	Will the well need any type of attention before the next groundwater surface measurement? If yes, describe in comment section.	☐	☐	☐

Comments / Observations regarding this well.

Damaged, to be decommissioned.

* - SLAPS and SLAPS Vicinity Properties (VPs)

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APPENDIX F

DOSE ASSESSMENT ASSUMPTIONS

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DOSE ASSESSMENT ASSUMPTIONS

DOSE FROM THE ST. LOUIS DOWNTOWN SITE TO A MAXIMALLY EXPOSED INDIVIDUAL

An off-site, worker-based receptor is the most realistic choice to represent the hypothetical maximally exposed individual, because of the proximity of the receptor, approximately 50 m southeast of the Mallinckrodt fenceline (DT-10), and because of the time the individual will spend at this location. Thus, a realistic assessment of dose can be performed using conservative assumptions of occupancy rate and distance from the source.

The following dose assessment is for a maximally exposed individual who works full-time (2,000 hours per year) at a location approximately 50 m southeast of the external gamma and radon monitoring location and 160 m from the SLDS excavation areas.

Airborne Radioactive Particulates

An EDE of less than 0.1 mrem per year to the receptor was calculated by using activity fractions to determine a source term, and then combining the dose results for Plant 6 and Plant 6 Loadout. The USEPA CAP88-PC modeling code was used to calculate dose to the receptor at 160 m from the SLDS excavation areas and loadout (Leidos 2015a). Figure A-1 of Appendix A presents the distances and directions of the maximally exposed receptor from the excavated areas. Details related to calculation of EDE for the maximally exposed receptor are contained in Appendix A.

External Gamma Pathway

Because station DA-2 was the closest TLD to the receptor, the TLD results from this location were used for the dose calculations. The station DA-2 TLD measured an annual exposure, above background, of 0 mrem per year, based on 8,760 hours of continuous detector exposure. The EDE due to gamma exposure for the maximally exposed individual is estimated by assuming that the site approximates a line source with a source strength (H_1) that is the average of the TLD measurements between the source and the receptor (Cember 1996).

$$H_1 = \frac{(2)\text{ mrem/year}}{1} = 2 \text{ mrem/year}$$

Based on 100 percent occupancy rate, the exposure rate (H_2) to the receptor was calculated as follows:

$$H_2 = H_1 \times \frac{h_1}{h_2} \times \frac{\tan^{-1}(L/h_2)}{\tan^{-1}(L/h_1)}$$

$$H_2 = 0.05 \text{ mrem/year}$$

where:

H_2 = exposure rate to the receptor
H_1 = exposure rate to the TLDs
h_2 = distance from the source to the receptor = 50 m
h_1 = distance from the source to the TLDs = 1.6 m
L = average distance from centerline of the line source (H_1) to the end of the line source = 150 m

The actual dose to the maximally exposed individual, who is only present during a normal work year, is calculated as follows:

$$H_{MEI} = H_2 \times \frac{2{,}000 \text{ hours/work year}}{8{,}760 \text{ hours/total year}}$$

$$H_{MEI} = 1.2\text{E-02 mrem/year}$$

Airborne Radon Pathway

Like external gamma calculations, only the radon data from station DA-2 were used to determine dose due to radon and progeny. Appendix B presents the radon results at all stations. Station DA-2 ATDs measured annual exposures above background of 0 pCi/L based on 8,760 hours of continuous exposure. Exposure to the receptor from radon (and progeny) was estimated using a dispersion factor (C_2) and the average ATD monitoring data at the site perimeter between the source and the receptor.

In order to calculate the dispersion factor, the EDEs were determined to a receptor located at 1 m and 50 m, southeast of the SLDS by inputting a radon release rate of 1 Ci per year, the St. Louis – Lambert International Airport wind file, and a surface area of 4,376 m^2 into the CAP-88 model. Effective surface area was determined by summing the time-weighted average annual open surface areas for all SLDS excavation areas and loadout. The CAP88 input data and the result of the CAP88 run are highlighted and presented in Appendix A. The radon dispersion factor (C_2) for the site was calculated as follows:

$$C_2 = \left[\frac{0.00960 \; pCi/L}{0.0331 \; pCi/L} \right] = 0.29$$

The average of ATD monitoring data (S_1) at the site perimeter (Plant 7/DT-10 fenceline) was calculated as follows:

$$S_1 = \left[\frac{(0) \text{ pCi/L}}{1} \right] = 0 \text{ pCi/L}$$

The actual radon exposure dose to the hypothetical maximally exposed individual was calculated as follows:

$$S_{MEI} = S_1 \times F \times DCF \times T \times C_1 \times C_2$$

$$S_{MEI} = 0 \text{ pCi/L} \times 0.0005 \frac{\text{WL}}{\text{pCi/L}} \times 1{,}250 \frac{\text{mrem}}{\text{WLM}} \times \frac{2{,}000 \, hours}{year} \times \frac{1 \text{ month}}{170 \text{ hours}} \times 0.29 = 0 \text{ mrem/year}$$

where:

S_1	=	fenceline average of ATD measurements between source and receptor
S_{MEI}	=	radon exposure to the hypothetical maximally exposed individual
F	=	equilibrium fraction of 0.05 WL per 100 pCi/L (DOE 1998)
DCF	=	dose conversion factor (USEPA 1989) = 1,250 mrem per WLM
T	=	exposure time for the hypothetical maximally exposed receptor = 2,000 hours per year
C_1	=	occupancy factor constant = 1 month per 170 hours
C_2	=	dispersion factor
WL	=	working level (concentration unit)
WLM	=	working level month (exposure unit)

Total Effective Dose Equivalent

TEDE = CEDE (airborne particulates) + H_{MEI} (external gamma) + S_{MEI} (airborne radon)

TEDE = <0.1 mrem/year + <0.1 mrem/year + 0 mrem/year = <0.1 mrem/year

where:

CEDE = committed effective dose equivalent

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