REVISION 0

NORTH ST. LOUIS COUNTY SITES ANNUAL ENVIRONMENTAL MONITORING DATA AND ANALYSIS REPORT FOR CALENDAR YEAR 2011

ST. LOUIS, MISSOURI

JULY 13, 2012

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

REVISION 0

NORTH ST. LOUIS COUNTY SITES ANNUAL ENVIRONMENTAL MONITORING DATA AND ANALYSIS REPORT FOR CALENDAR YEAR 2011

ST. LOUIS, MISSOURI

JULY 13, 2012

prepared by:

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

with assistance from:

Science Applications International Corporation
under Contract No. W912P9-12-D-0506, Delivery Order 0001

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

SECTION **PAGE**

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

SECTION **PAGE**

LIST OF TABLES

NUMBER **PAGE**

LIST OF TABLES (Continued)

NUMBER **PAGE**

LIST OF FIGURES

NUMBER

LIST OF FIGURES (Continued)

NUMBER

LIST OF APPENDICES
(Appendices B, C, D, and E are on a CD-ROM at the end of this document)

LIST OF ACRONYMS AND ABBREVIATIONS

μCi/mL	microcurie per milliliter
μg/L	microgram per liter
μS/cm	micro-Semens per centimeter
Ac	actinium
AEC	Atomic Energy Commission
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
ATD	alpha track detector
BOD	biological oxygen demand
BTOC	below top of casing
°C	degrees Celsius (centigrade)
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
Ci	curies
COC	contaminant of concern
COD	chemical oxygen demand
CSR	*Code of State Regulations*
CY	calendar year
DCF	dose conversion factor
DHSS	Department of Health and Senior Services
DL	detection limit
DO	dissolved oxygen
DOD	U.S. Department of Defense
DOD QSM	*Department of Defense Quality Systems Manual*
DOE	U.S. Department of Energy
DQO	data quality objective
EDE	effective dose equivalent
EE/CA	engineering evaluation/cost analysis
EMDAR	Environmental Monitoring Data and Analysis Report
EMG	Environmental Monitoring Guide
EMICY	Environmental Monitoring Implementation for Calendar Year
EMICY11	*Environmental Monitoring Implementation Plan for the North St. Louis County Sites for CY 2011*
EMP	Environmental Monitoring Program
FWV	Field Work Variance
ft	foot/feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
Futura	Futura Coatings Company
g	gram(s)
HISS	Hazelwood Interim Storage Site
HZ	hydrostratigraphic zone
IA	investigation area
ICP	inductively coupled plasma
KPA	kinetic phosphorescence analysis
LCL_{95}	95 percent lower confidence limit

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

m	meter(s)
m^2	square meter(s)
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MDC	minimum detectable concentration
MDL	method detection limit
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineer District
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MGD	million gallons per day
mSv/yr	milliseivert per year
mL	milliliter
mL/L/hr	milliliter per liter per hour
mL/min	milliliter per minute
mrem	millirem
mrem/pCi	millirem per picocurie
mrem/qtr	millirem per quarter
mrem/yr	millirem per year
MSD	Metropolitan St. Louis Sewer District
mV	millivolt(s)
NAD	normalized absolute difference
NC	North St. Louis County
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NTU	nephelometric turbidity unit
ORP	oxidation reduction potential
Pa	protactinium
pCi/g	picocurie per gram
pCi/L	picocurie per liter
PDI	pre-design investigation
QA	quality assurance
QAPP	Quality Assurance Program Plan
QC	quality control
RA	remedial action
Ra	radium
RCRA	Resource Conservation Recovery Act
RG	remediation goal
Rn	radon
ROD	*Record of Decision for the North St. Louis County Sites*
ROW	right of way
RPD	relative percent difference
S	test statistic
SAG	*Sampling and Analysis Guide for the St. Louis Sites*
SAIC	Science Application International Corporation

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

SLAPS	St. Louis Airport Site
SOP	standard operating procedure
SOR	sum of ratios
SS	settleable solid
SU	survey unit
TEDE	total effective dose equivalent
Th	thorium
TLD	thermoluminescent dosimeter
TPH	total petroleum hydrocarbon
TRPH	total recoverable petroleum hydrocarbon
TSS	total suspended solid(s)
U	uranium
UCL	upper confidence limit
UCL_{95}	95 percent upper confidence limit
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VP	vicinity property
WL	working level
WRS	Wilcoxon rank sum
yd^3	cubic yard(s)

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

This Annual Environmental Monitoring Data and Analysis Report (EMDAR) for calendar year (CY) 2011 applies to the North St. Louis County (NC) Sites within 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 NC Sites within the FUSRAP. Environmental monitoring of various media at the Latty Avenue Properties (Futura Coatings Company [Futura], the Hazelwood Interim Storage Site [HISS], and other Vicinity Properties [VPs]), the St. Louis Airport Site (SLAPS), and SLAPS VPs is required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and a commitment outlined in the St. Louis FUSRAP Federal Facility Agreement.

The purpose of this report is:

1) to document the environmental monitoring activities, and
2) to assess whether the remedial actions had a measurable environmental impact by:
    a) summarizing the data collection effort for CY 2011,
    b) reporting the current condition of the NC Sites, 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 remedial actions, serves as a critical component in the evaluation of the current status of residual contaminants and assessment of the potential future migration of residual contaminants.

All environmental monitoring required through implementation of the *Environmental Monitoring Implementation Plan for the North St. Louis County Sites for CY 2011* (EMICY11) (USACE 2011) was conducted as planned during CY 2011. The evaluation of environmental monitoring data for all NC Sites demonstrates compliance with *Record of Decision for the North St. Louis County Sites* (ROD) goals and applicable or relevant and appropriate requirements (ARARs).

RADIOLOGICAL AIR MONITORING

Radiological air data was collected and evaluated at the NC Sites through airborne radioactive particulate, radon (Ra) (indoor and outdoor), and gamma radiation monitoring as required in the EMICY11 (USACE 2011). In addition to environmental monitoring purposes, radiological air data was also used as inputs to calculate total effective dose equivalent (TEDE) to the reasonably maximally exposed member of the public for the NC Sites.

The TEDE calculated for the reasonably maximally exposed individual at the Latty Avenue Properties and the SLAPS and SLAPS VPs were both less than 0.1 millirem per year (mrem/yr) (0.001 milliseivert per year [mSv/yr]). These calculated TEDEs are compliant with the 100 mrem/yr (1 milliseivert per year) limit provided in 10 *Code of Federal Regulations (CFR)* 20.1301.

The radiological air monitoring results conducted at the NC Sites demonstrated compliance with all of the ARARs for the NC Sites as described in Tables 2-1 through 2-4 of the EMICY11 (USACE 2011).

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM MONITORING

Discharge requirements for the NC Sites are currently set by the Missouri Department of Natural Resources (MDNR) National Pollutant Discharge Elimination System (NPDES) ARARs (permit-equivalent) document dated October 2, 1998 (MDNR 1998), and amended in a letter from the MDNR dated February 19, 2002 (MDNR 2002).

The storm-water sampling results for the NC Sites demonstrate compliance with the discharge limits described in Section 2.2.2 of the EMICY11 (USACE 2011).

EXCAVATION-WATER DISCHARGE MONITORING AT THE NORTH ST. LOUIS COUNTY SITES

CY 2011 was the tenth year that excavation water was treated and discharged from the NC Sites. Excavation water from the NC Sites discharged to the sanitary sewer system is subject to the requirements stated in the July 23, 2001, Metropolitan St. Louis Sewer District (MSD) authorization letter (MSD 2001) and the selenium discharge variance letter for the SLAPS dated February 10, 2005 (MSD 2005). This authorization was extended for two years through the issuance of a letter dated May 10, 2010, from Mr. Steve Grace to Ms. Sharon Cotner. This authorization expires on July 23, 2012 (MSD 2010a). The selenium discharge variance for the SLAPS was utilized in the first quarter of CY 2011 (MSD 2005 and 2010a). The selenium variance was utilized for Batches 257 and 258.

HISS laboratory waste water is discharged in accordance with the MSD discharge authorization letter dated February 1, 2010 (MSD 2010b). The special discharge authorization was extended to February 7, 2012. The data collected at each site were compared to discharge limits described in Section 2.2.2 of the EMICY11 (USACE 2011). During CY 2011, no exceedances of the discharge limits occurred at the HISS laboratory or the NC Sites.

COLDWATER CREEK MONITORING

The CY 2011 Coldwater Creek surface-water and sediment sampling events completed in March and October of 2011 evaluated the physical, radiological, and chemical conditions in the creek. Samples were collected at each of the six surface-water and sediment sampling locations (C002 through C007). The data collected were compared to the monitoring guidelines and/or remediation goals as described in Section 2.2.3 of the EMICY11 (USACE 2011).

The results of the surface water and sediment sampling conducted in Coldwater Creek demonstrated compliance with ARARs for the NC Sites.

GROUND-WATER MONITORING

Ground water was sampled during CY 2011 at the NC Sites. Ground water was sampled following a protocol for individual wells and analytes and was analyzed for various radiological constituents, organic compounds, and inorganic parameters. Static ground-water elevations for all NC Site wells were measured quarterly.

The environmental sampling requirements and ground-water monitoring guidelines for each analyte are consistent with the EMICY11 (USACE 2011) and were used for comparison and discussion purposes. The ROD ground-water monitoring guidelines (i.e., ROD guidelines) for assessing ground-water sampling data at the NC Sites (Latty Avenue Properties and the SLAPS and SLAPS VPs) are presented in Section 2.2.4 of the EMICY11 (USACE 2011) and in Section 4.0 and Appendix F of this report. For those wells where an analyte exceeded the ROD guidelines at least once during CY 2011 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.

LATTY AVENUE PROPERTIES

Ground-water sampling was conducted at nine Hydrostratigraphic Zone A (HZ-A) ground-water monitoring wells at the Latty Avenue Properties during CY 2011. The data indicate localized impacts to the HZ-A ground water from site-related constituents. Selenium in HISS-06A and arsenic and molybdenum in HW22 were the inorganic contaminants of concern (COCs) detected at concentrations above the ROD guidelines for the shallow ground water (HZ-A). Three radiological COCs (uranium [U]-234, U-238, and total U) were detected in HISS-01 exceeding the ROD guidelines during CY 2011. One of the inorganic soil COCs, arsenic in HW22, has been detected above the ROD guideline for more than 12 months. In addition, the three radiological COCs (U-234, U-238, and total U) have been detected above the ROD guidelines for more than 12 months in HZ-A ground water at HISS-01. Because a significant degrading of Coldwater Creek surface water has not occurred, there is currently no finding of significantly degraded ground-water conditions in HZ-A ground water.

Ground-water samples were collected from one deep HZ-C well (HW23) during CY 2011. It was sampled for radionuclides in third quarter of CY 2011. Radiological results from CY 2011 samples obtained from HW23 indicated concentrations of U-234 above the ROD ground-water guideline. However, when measurement error is taken into account, the result was not above the ROD ground-water guideline. The total U concentration in HW23 (calculated from the isotopic concentrations) did not exceed the total U monitoring guideline of 30 µg/L. In addition, a significant degrading of Coldwater Creek surface water has not occurred. Therefore, there is currently no finding of significantly degraded ground-water conditions in HZ-C ground water. Therefore, an evaluation of potential response actions is not required.

The Mann-Kendall trend test was performed for analytes in two HZ-A wells (total U in HISS-01 and arsenic and molybdenum in HW22) during CY 2011. There were less than six samples in the dataset for selenium at HISS-06A. Therefore, a trend analysis was not conducted for selenium in HISS-06A. The Mann-Kendall trend test resulted in a statistically significant increasing trend for arsenic and molybdenum in HW22. A statistically significant increasing trend in total U concentrations was also identified for HISS-01. However, total U concentrations in HISS-01 have declined from a high of 337 µg/L on May 29, 2009, to 46.6 µg/L on August 29, 2011. No trend analysis was performed for HZ-C ground water because the frequency of non-detected results exceeds 50 percent for the ground-water criteria in the HZ-C wells during CY 2011.

The potentiometric surface of the HZ-A ground water indicates that some mounding is occurring near the center of the HISS. At the western edge of the site, ground water in HZ-A flows to the west, toward CWC. The local gradient for HZ-A groundwater at the HISS and Futura ranged from 0.0029 ft/ft (June) to 0.0016 ft/ft (November) in CY 2011.

The potentiometric surface of the HZ-C ground water at the Latty Avenue Properties is not well defined due to the limited data available for the deeper HZs. Based on measured ground-water elevations in the HZ-C monitoring well HW23 at the Latty Avenue Properties and several HZ-C wells located to the southwest at the SLAPS and SLAPS VPs, the flow direction in the HZ-C ground water is generally toward the east or northeast. The local horizontal gradient for HZ-C ranged from 0.0034 ft/ft (June) to 0.0036 ft/ft (November) in CY 2011. This is similar to the gradient in CY 2010, which ranged from 0.0031 ft/ft (May) to 0.0036 ft/ft (December).

ST. LOUIS AIRPORT SITE AND ST. LOUIS AIRPORT SITE VICINITY PROPERTIES

At the SLAPS and SLAPS VPs, 10 ground-water wells were sampled for various parameters during CY 2011. Eight wells, screened in HZ-A, were sampled at the SLAPS and the adjacent ballfields. Three inorganic analytes (chromium, molybdenum, and nickel) and one radiological contaminant (total U) were detected in HZ-A ground water at concentrations above the ROD guidelines. A comparison of the data indicates that the nickel concentrations in B53W13S and the total U concentrations in PW46 have been above the ROD guideline for a period of at least 12 months. Because a significant degrading of Coldwater Creek surface water has not occurred, there is currently no finding of significantly degraded ground-water conditions in HZ-A ground water at the SLAPS and SLAPS VPs in CY 2011. However, because nickel and total U levels have been above the ROD ground-water monitoring guidelines for a period of at least 12 months, monitoring will continue subject to subsequent five-year reviews.

During CY 2011, two wells screened across the deeper HZs (HZ-C through HZ-E) were sampled at the SLAPS and SLAPS VPs. Comparison of the data to the ROD ground-water guideline indicate that no COCs were detected at levels above the ROD ground-water guideline in HZ-C through HZ-E ground water. Therefore, the CY 2011 HZ-C through HZ-E ground-water data from the SLAPS and SLAPS VPs indicate that significant degradation of lower ground water is not occurring.

The Mann-Kendall trend test was performed for chromium (B53W09S and B53W13S), nickel (B53W13S), and total U (PW46). Statistically significant increasing trends were observed for nickel in B53W13S and for chromium in B53W09S and B53W13S. No trend was observed for total U in PW46. Due to the high percentage of nondetect values for nickel in PW43, the Mann-Kendall trend test could not be performed for this analyte.

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, respectively. The potentiometric data indicated ground-water flow to the northwest toward Coldwater Creek in the HZ-A at the SLAPS. The potentiometric surface of the HZ-C ground water at the SLAPS is generally east to northeast.

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) 2011 applies to the North St. Louis County (NC) Sites (Figure 1-1) within 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 NC Sites within the FUSRAP. The NC Sites consists of the St. Louis Airport Site (SLAPS), its associated vicinity properties (VPs) (SLAPS VPs) (Figure 1-2), and the Latty Avenue Properties (Figure 1-3). The Latty Avenue Properties include Futura Coatings Company (Futura), the Hazelwood Interim Storage Site (HISS), and the Latty Avenue VPs. Additional environmental data were collected along Coldwater Creek, which flows adjacent to the SLAPS and near the HISS. Environmental monitoring of various media at each of the NC Sites is required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and a commitment outlined in the Federal Facility Agreement.

1.2 PURPOSE

The purpose of this report is to document the environmental monitoring activities and to assess whether the remedial actions (RAs) being performed at the NC Sites could be having a measurable environmental impact. In addition, this report serves to enhance the reader's awareness of the current condition of the NC Sites, summarize the data collection efforts for CY 2011, and provide analysis of the CY 2011 environmental monitoring data results. This document presents the following information:

- Sample collection data for various media at each site and interpretation of CY 2011 EMP results;
- The compliance status of each site with federal and state applicable or relevant and appropriate requirements (ARARs) or other benchmarks (*Environmental Monitoring Implementation Plan for the North St. Louis County Sites for CY 2011* [EMICY11] [USACE 2011]);
- Dose assessments for radiological contaminants as appropriate at each site;
- A summary of trends based on changes in contaminant concentrations to support RAs, ensure public safety, and maintain surveillance monitoring requirements at each site; and
- The identification of data gaps and future EMP needs.

1.3 ST. LOUIS SITE PROGRAM AND SITE BACKGROUND

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. 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).

On October 4, 1989, the SLAPS, the HISS, and Futura were placed on the National Priorities List (NPL) (USEPA 1989a). The three NPL sites have been involved with some of the following:

refining of uranium (U) ores, production of U metal and compounds, U recovery from residues and scrap, and the storage and disposal of associated process byproducts.

Detailed descriptions and histories for each site can be found in the *Remedial Investigation Report for the St. Louis Site*, St. Louis, Missouri (DOE 1994); *Remedial Investigation Addendum for the St. Louis Site,* St. Louis, Missouri (DOE 1995); *SLAPS Interim Action Engineering Evaluation/Cost Analysis* (EE/CA), St. Louis, Missouri (DOE 1997); *EE/CA and Responsiveness Summary for the SLAPS* (USACE 1998a); *EE/CA for HISS,* St. Louis, Missouri (USACE 1998b); the *Environmental Monitoring Guide for the St. Louis Sites* (EMG) (USACE 1999a); and the *Record of Decision for the North County Sites* (ROD) (USACE 2005).

During CY 2011, the following documents were finalized for the NC Sites:

- *Remedial Action Site Work Plan for the North St. Louis County Vicinity Properties*, St. Louis, Missouri (January);
- *Remedial Action Site Work Plan, Addendum 5 for Vicinity Property 31A, North St. Louis FUSRAP Vicinity Properties,* St. Louis, Missouri (January);
- *Environmental Protection Plan, North St. Louis FUSRAP Vicinity Properties,* St. Louis, Missouri (January);
- Field Work Variance (FWV) 198: Changes made to reflect conditions, personnel, and field situations to *McDonnell Boulevard: East Section (b) Right-Of-Way, Remedial Design/Remedial Action Work Description, Supplement No. 6 to the FUSRAP Remedial Action Work Plan for the North St. Louis County Sites,* St. Louis, Missouri (January);
- *Environmental Monitoring Implementation Plan for the North St. Louis County Sites for Calendar Year 2011,* St. Louis, Missouri (January 11);
- *Radiological Survey Plan for Latty Avenue Vicinity Property 02(L) Building Structures,* St. Louis, Missouri (January 26);
- *Pre-Design Investigation Work Plan, Eva Road Vicinity Property, FUSRAP North St. Louis County Sites,* St. Louis, Missouri (January 27);
- FWV 200: Addition of new information regarding excavation limits and updated property lines to *HISS Load-Out Facility and VP-06(L) – Tract 1 Remedial Design/Remedial Action Work Description, Supplement No. 12 to the FUSRAP Remedial Action Work Plan for the North St. Louis County Sites,* St. Louis, Missouri (February 15);
- FWV 006: Modification of the haul route between VP-31A and the SLAPS because of temporary closure of Eva Avenue to the *Remedial Action Site Work Plan, Addendum 5 for Vicinity Property 31A, North St. Louis FUSRAP Vicinity Properties,* St. Louis, Missouri (March 2);
- FWV 201: Addition of new information to reflect current field conditions to *McDonnell Boulevard: East Section (b) Right-Of-Way, Remedial Design/Remedial Action Work Description, Supplement No. 6 to the FUSRAP Remedial Action Work Plan for the North St. Louis County Sites,* St. Louis, Missouri (March 7);
- *Pre-Design Investigation Summary Report for the Latty Avenue Vicinity Property 06(L),* St. Louis, Missouri (April 5);
- *Sampling Plan for Investigation of the Soils on the Latty Avenue Vicinity Property 40A,* St. Louis, Missouri (April 25);

- *Vicinity Property 02(L) Building Sewer Cleaning Plan, Addendum 1 of the Vicinity Property (VP) 02(L) Remedial Design/Remedial Action Work Description (RD/RAWD), Supplement No. 7 to the FUSRAP Remedial Action Work Plan for the North St. Louis County Sites,* St. Louis, Missouri (June 15);
- *Vicinity Property 02(L) Structure Decontamination Plan, Addendum 2 of the Vicinity Property (VP) 02(L) Remedial Design/Remedial Action Work Description (RD/RAWD), Supplement No. 7 to the FUSRAP Remedial Action Work Plan for the North St. Louis County Sites,* St. Louis, Missouri (June 22);
- *Pre-Design Investigation Summary Report and Final Status Survey Evaluation for St. Louis Airport Site Vicinity Properties 03 and 04,* St. Louis, Missouri (June 24);
- *North St. Louis County Sites Annual Environmental Monitoring Data and Analysis Report for Calendar Year 2010,* St. Louis, Missouri (July 8);
- *Pre-Design Investigation Work Plan for the St. Louis Airport Site Vicinity Property 16 and the Eva Loadout Facility,* St. Louis, Missouri (July 26);
- *Sampling Plan for Investigation of Soils on the St. Louis Airport Site and Latty Avenue Vicinity Property 40A,* St. Louis, Missouri (August 1);
- *Post-Remedial Action Report and Final Status Survey Evaluation for the St. Louis Airport Site Vicinity Properties 05 and 06,* St. Louis, Missouri (August 3);
- *Post-Remedial Action Report and Final Status Survey Evaluation for the St. Louis Airport Site Vicinity Properties 08 and 09,* St. Louis, Missouri (August 3);
- *Post-Remedial Action Report and Final Status Survey Evaluation for the St. Louis Airport Site Vicinity Property 53,* St. Louis, Missouri (August 15);
- *Post-Remedial Action Report and Final Status Survey Evaluation for the St. Louis Airport Site Vicinity Property 63,* St. Louis, Missouri (September 8);
- *Supplemental Pre-Design Work Description, Vicinity Properties Ballfields – Phase 2, FUSRAP North St. Louis County Sites,* St. Louis, Missouri (November 22);
- *Pre-Design Investigation Summary Data Report, Eva Road Vicinity Property, FUSRAP North St. Louis County Sites,* St. Louis, Missouri (November 23);
- *Post-Remedial Action Report and Final Status Survey Evaluation for the St. Louis Airport Site Vicinity Property 54,* St. Louis, Missouri (December 12);
- *Post-Remedial Action Report and Final Status Survey Evaluation for the St. Louis Airport Site Vicinity Property 55,* St. Louis, Missouri (December 12);
- *Frost Avenue Right-of-Way Site Work Plan, FUSRAP North St. Louis County Sites,* St. Louis, Missouri (December 14);
- FWV-202: Reduced estimated extent of contamination and initial excavation limits and updated the planned haul routes (modified the *Vicinity Properties Futura, HISS, and 40A: East - Tract 3 Remedial Design/Remedial Action Work Description, Supplement No. 5 to the FUSRAP Remedial Action Work Plan for the North St. Louis County Sites,* St. Louis, Missouri). (December 15); and
- *Environmental Monitoring Implementation Plan for the North St. Louis County Sites for Calendar Year 2012,* St. Louis, Missouri. (December 30).

1.3.1 Latty Avenue Properties CY 2011 Remedial Actions

During CY 2011, RAs were performed at the following Latty Avenue Properties (Figure 1-3): the HISS, Futura, and VP-02(L). Excavation activities continued throughout the first and second quarter and were completed in the third quarter at the HISS. Excavation activities continued throughout the year at Futura, with excavation activities being completed in the fourth quarter. Restoration activities continued throughout the year at the HISS and Futura. Restoration activities on the outside of the VP-02(L) building continued throughout the first, second, and third quarters and were completed in the fourth quarter. Remedial activities began on the inside of the VP-02(L) building in the second quarter and were completed in the third quarter. The contaminated materials excavated as a result of the RA at the Latty Avenue Properties site during CY 2011 totaled 24,815 cubic yards (yd^3). All of the contaminated materials were shipped via railcar to U.S. Ecology in Idaho for proper disposal.

During CY 2011, *Multi-Agency Radiation Survey and Site Investigation (MARSSIM)* Class 1 verifications were performed at VP-02(L) (Areas 9 and 12) and HISS/Futura (survey units [SU]-14 through SU-20). Verifications at the Latty Avenue Properties were performed to confirm the remediation goals (RGs) were achieved. No MARSSIM Class 2 and 3 verifications were performed.

Characterizations/Pre-Design Investigations were performed at the following Latty Avenue Properties during CY 2011: VP-40A, the VP-02(L) building and the Futura buildings.

During the first quarter of CY 2011, one container stored in a satellite accumulation area for the HISS Laboratory was determined to be hazardous in accordance with Resource Conservation Recovery Act (RCRA). The lead-containing waste water was generated from analytical testing for radium. The container was properly manifested and shipped to US Ecology, Inc. for disposal.

Additionally, seven monitoring wells (HISS-05D, HISS-06, HISS-09, HISS-14, HISS-15, HISS-18S, and HW21) were decommissioned and two monitoring wells (HISS-06A and HISS-11A) were installed in CY2011.

During CY 2011, the perimeter particulate air monitoring was discontinued at the HISS.

1.3.2 St. Louis Airport Site and St. Louis Airport Site Vicinity Properties CY 2011 Remedial Actions

During CY 2011, RAs were performed at the following SLAPS-related investigation areas (IAs) and VPs (Figure 1-2): VPs 12, 31A, the McDonnell Boulevard East Section B, Coldwater Creek, and Ballfields Phase 1. Excavation and restoration activities continued in the first quarter and were completed during the second quarter at VPs 12, 31A, the McDonnell Boulevard East Section B and CWC. Excavation activities began at the Ballfields Phase 1 in the fourth quarter. Approximately 4,130 yd^3 of contaminated materials were removed from the SLAPS IAs and VPs and were shipped via railcar to U.S. Ecology in Idaho.

During CY 2011, MARSSIM Class 1 verifications were performed at VPs 12 (SUs 1H, 1I and 1J), 31A (SU-1), the McDonnell Boulevard East Section B (SUs 1F, 1G, 1H, 1I, 1J, 1K and 1L), and CWC (SU-2C) to confirm that ROD RGs were achieved. No MARSSIM Class 2 and 3 verifications were performed.

Characterizations/Pre-Design Investigations (PDIs) were performed at the following SLAPS VPs during CY 2011: Eva Avenue, Eva Loadout, and VP-16.

In accordance with the Metropolitan St. Louis Sewer District (MSD) authorization letter, 2,225,366 gallons of excavation water were discharged from the NC Sites in CY 2011. Since the beginning of the project, 23,784,793 gallons have been treated and released to MSD from the NC Sites.

THIS PAGE INTENTIONALLY LEFT BLANK

2.0 EVALUATION OF RADIOLOGICAL AIR MONITORING DATA

This section documents environmental monitoring activities related to radiological air data. The radiological air measurements conducted at the NC Sites are part of the EMP. Radiological air data is collected to evaluate the compliance status of each site with 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 measurements conducted at the NC Sites, potential sources of the contaminants to be measured (including natural background), and measurement techniques employed during CY 2011.

All radiological air monitoring required through implementation of the EMICY11 (USACE 2011) was conducted as planned during CY 2011. The evaluations of radiological air monitoring data for all NC Sites demonstrate compliance with ARARs.

A total effective dose equivalent (TEDE) for the reasonably maximally exposed member of the public was calculated for the Latty Avenue Properties, the SLAPS, and the SLAPS VPs by summing the dose due to gamma radiation, radiological air particulates, and radon (Rn). The TEDE calculated for the reasonably maximally exposed individual at the Latty Avenue Properties, the SLAPS, and the SLAPS VPs were both less than 0.1 millirem per year (mrem/yr) (0.001 milliseivert per year [mSv/yr]). These calculated TEDEs are compliant with the 100 mrem/yr (1 milliseivert per year) limit provided in 10 *Code of Federal Regulations (CFR)* 20.1301. 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 that were conducted at the NC Sites during CY 2011 are gamma radiation, airborne radioactive particulates, and airborne radon. Sections 2.2 and 2.3 provide details of the air monitoring conducted at the Latty Avenue Properties and the SLAPS and SLAPS VPs, respectively.

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 uranium decay series, thorium (Th) decay series, and potassium-40. Cosmic radiation originates in outer space and filters through the atmosphere to the earth. Together, these two sources make up 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/yr (0.65 mSv/yr), 35 mrem/yr (0.35 mSv/yr) of which originates from sources on earth and 30 mrem/yr (0.3 mSv/yr) of which originates from cosmic sources (UNSCEAR 1982). The background monitoring locations for the NC Sites (Figure 2-1) are reasonably representative of background gamma radiation for the St. Louis Metropolitan Area.

Gamma radiation was measured at the NC Sites during CY 2011 using thermoluminescent dosimeters (TLDs). TLDs were located at site boundaries in order to provide input for calculation of TEDE.

The TLDs were placed at the monitoring location approximately 3 feet (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 soil 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 the soil being disturbed (e.g., excavation). This airborne radioactive material includes naturally occurring background concentrations, as well as above background concentrations of radioactive materials present at the NC Sites.

Airborne radioactive particulates were measured at the NC Sites 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., microcurie per milliliter [µCi/mL]). Particulate air monitors were located at excavation and loadout area perimeter locations, as appropriate to provide input for the National Emissions Standards for Hazardous Air Pollutants (NESHAP) Report and calculation of TEDE to the critical receptor. Air particulate samples were typically collected weekly or at more frequent intervals.

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

The NC Sites CY 2011 NESHAP Report (provided as Appendix A) presents the 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 NC Sites as inputs to the U.S. Environmental Protection Agency (USEPA) CAP88-PC Version 3.0 modeling code (USEPA 2007) to demonstrate compliance with the 10 mrem/yr ARAR in 40 *CFR* 61, Subpart I.

2.1.3 Airborne Radon

U-238 is a naturally occurring radionuclide that is commonly found in soil and rock. Rn-222 is a naturally occurring radioactive gas found in the U 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 NC Sites.

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 height above the ground, season, time of day, and 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 NC Sites to measure alpha particles emitted from radon and its associated decay products. Radon ATDs were co-located with environmental

TLDs three feet above the ground surface in housing shelters at the site boundaries or at locations representative of areas accessible to the public. Outdoor ATDs were collected approximately every six months and sent to an off-site laboratory for analysis. Recorded radon concentrations are listed in picocurie per liter (pCi/L), and are used to provide input for calculation of TEDE.

In the NC Sites, ATDs were also placed in locations within applicable structures to monitor for indoor radon exposure. The ATDs were located in areas that represent the highest likely exposure from indoor radon. ATD locations were chosen with consideration given to known radium (Ra)-226 concentrations under applicable buildings and occupancy time 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 six months and sent to an off-site laboratory for analysis.

2.2 LATTY AVENUE PROPERTIES

For CY 2011, radiological air monitoring was conducted at the following Latty Avenue Properties: the HISS, Futura, VP-02(L), and VP-40A.

2.2.1 Evaluation of Gamma Radiation Data

External gamma radiation exposure from Latty Avenue Properties other than the HISS is considered negligible; therefore, environmental TLD monitoring was not conducted at Latty Avenue Properties other than the HISS. Gamma radiation monitoring was performed at five locations around the perimeter of the HISS (see Figure 2-2) and at the background location to compare on-site/off-site exposure and to provide input for calculation of TEDE to the critical receptor (Section 6.0) in CY 2011. The EMP uses two TLDs at monitoring Station HA-5 (for each monitoring period) to provide additional quality control (QC) of the monitoring data. A summary of TLD monitoring data for CY 2011 at the HISS is shown in Table 2-1. TLD data is located in Appendix B of this report.

Table 2-1. Summary of HISS Gamma Radiation Data for CY 2011

Monitoring Location	Monitoring Station	First Quarter TLD Data (mrem/qtr) Reported/ Corrected		Second Quarter TLD Data (mrem/qtr) Reported/ Corrected		Third Quarter TLD Data (mrem/qtr) Reported/ Corrected		Fourth Quarter TLD Data (mrem/qtr) Reported/ Corrected		CY 2011 Net TLD Data (mrem/yr)
		Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	
HISS Perimeter	HA-1	16.9	0.0	17.1	0.0	15.9	0.0	17.8	0.0	0
	HA-2	18.1	0.3	16.3	0.0	16.5	0.0	16.7	0.0	0
	HA-3	21.8	4.3	22.3	2.9	22.4	4.8	25.0	4.1	16
	HA-4	16.7	0.0	17.2	0.0	16.6	0.0	17.2	0.0	0
	HA-5	16.9	0.0	18.5	0.0	18.36	0.2	21.3	0.3	1

Table 2-1. Summary of HISS Gamma Radiation Data for CY 2011 (Continued)

Monitoring Location	Monitoring Station	First Quarter TLD Data (mrem/qtr) Reported/ Corrected		Second Quarter TLD Data (mrem/qtr) Reported/ Corrected		Third Quarter TLD Data (mrem/qtr) Reported/ Corrected		Fourth Quarter TLD Data (mrem/qtr) Reported/ Corrected		CY 2011 Net TLD Data (mrem/yr)
		Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	
HISS Perimeter	HA-5[c]	17.2	0.0	17.6	0.0	17.8	0.0	19.0	0.0	---
Background	BA-1	17.8	---	19.6	---	18.1	---	21.0	---	---

[a] All quarterly data reported from the vendor have been normalized to exactly one quarter's exposure above background.
[b] CY 2011 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 not required.
mrem/qtr - millirem per quarter

2.2.2 Evaluation of Airborne Radioactive Particulate Data

For the Latty Avenue Properties, air sampling for particulate radionuclides was conducted at the perimeter of each active excavation and loadout area throughout the year. Air particulate data was used as inputs to the NESHAP Report (Appendix A) and calculation of TEDE to the critical receptor (Section 6.0). A summary of air particulate monitoring data for Latty Avenue Properties is shown in Table 2-2. Airborne radioactive particulate data is located in Appendix B of this report.

Table 2-2. Summary of Latty Avenue Properties Airborne Radioactive Particulate Data for CY 2011

Monitoring Stations	Average Concentration[a] (µCi/mL)	
	Gross Alpha	Gross Beta
HISS	2.22E-15	2.18E-14
Futura	2.19E-15	3.01E-14
VP-02(L)	4.55E-15	2.01E-14
VP-40A[b]	0.00E+00	2.68E-14
Background Concentration[b]	3.37E-15	1.97E-14

[a] Average concentration values for the sampling period by location.
[b] These concentrations are only provided for informational purpose.

2.2.3 Evaluation of Outdoor Airborne Radon Data

Outdoor exposure from Rn-222 from Latty Avenue Properties other than the HISS is considered negligible. Therefore, outdoor environmental Rn-222 monitoring was not conducted at Latty Avenue Properties other than the HISS. For the Latty Avenue Properties, outdoor airborne radon monitoring was performed at the HISS using ATDs placed around the site perimeter to measure radon emissions from the site. Five detectors were co-located with TLDs, as identified in Figure 2-2, and one duplicate detector was placed at Station HA-5 for QC purposes. Background ATDs were used to compare on-site exposure and off-site background exposure. Outdoor airborne radon data was used as an input for calculation of TEDE to the critical receptor (Section 6).

A summary of CY 2011 outdoor radon data at the HISS is shown in Table 2-3. Outdoor ATD data is located in Appendix B of this report.

Table 2-3. Summary of HISS Outdoor Airborne Radon (Rn-222) Data for CY 2011

Monitoring Location	Monitoring Station	Average Annual Concentration (pCi/L)		
		01/04/11 to 07/06/11 [a] (uncorrected)	07/06/11 to 01/10/12[a] (uncorrected)	Average Annual Concentration[b]
HISS Perimeter	HA-1	0.2	0.2	0.0
	HA-2	0.2	0.2	0.0
	HA-3	0.2	0.3	0.0
	HA-4	0.2	0.2	0.0
	HA-5	0.2	0.2	0.0
	HA-5[c]	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 not required.

2.2.4 Evaluation of Indoor Airborne Radon Data

Indoor radon monitoring was performed at Futura buildings adjacent to the HISS using ATDs placed at several locations in each Futura building at a height of 4 ft (to approximate breathing zone conditions) to measure radon concentrations. The detectors were located as shown on Figure 2-2. The ATDs were installed in January CY 2011 at each monitoring location, collected for analysis after approximately six months of exposure, and replaced with another set that would represent radon exposure for the rest of the year. Recorded radon concentrations, listed in pCi/L, were converted to radon WLs 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 (SAIC 2012a). Additional details of the data and calculation methodology used to determine indoor radon WLs in the Futura buildings are located in Table 2-4. Indoor ATD data is located in Appendix B of this report.

Table 2-4. Summary of Futura Indoor Airborne Radon (Rn-222) Data for CY 2011

Monitoring Location	Monitoring Station	Average Annual Concentration				
		01/04/11 to 07/06/11 [a] (pCi/L)	07/06/11 to 01/10/12[a] (pCi/L)	Annual Average (pCi/L)[b]	Building Average (pCi/L)[c]	WL[d]
Futura Building #1	HF-1	1.5	1.6	1.55	**1.82**	**0.007**
	HF-2	3.1	3.7	3.4		
	HF-3	0.5	0.5	0.5		
Futura Building #2/3	HF-4	0.2	0.2[e]	0.2	**0.49**	**0.002**
	HF-5	0.5	0.7	0.6		
	HF-6	0.2	0.4	0.3		
	HF-7	0.6	1.1	0.85		
Futura Building #4	HF-8	0.2	0.3	0.25	**0.25**	**0.001**
	HF-9	0.2	0.3	0.25		
	HF-10	0.3	0.2	0.25		

[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) above background.
[c] In each building, the average annual result for each monitoring station within the building was used to calculate a building average.
[d] The average annual WL is calculated by dividing the average pCi/L by 100 pCi/L per WL and multiplying by 0.4.
[e] The second semi-annual ATD at station HF-4 was lost and could not be collected. First semi-annual results were assumed for second semi-annual monitoring period for both monitoring periods.

2.3 SLAPS AND SLAPS VICINITY PROPERTIES

For CY 2011, radiological air monitoring was conducted at McDonnell Boulevard, IA-09, VP-12, VP-31A, and the SLAPS.

2.3.1 Evaluation of Gamma Radiation Data

External gamma radiation exposure from the SLAPS VPs is considered negligible. Environmental TLD monitoring was not conducted at the SLAPS VPs. Gamma radiation monitoring was performed at the SLAPS during CY 2011 at four site locations surrounding the loadout area (Figure 2-3) and at the background location to compare on-site/off-site exposure and to provide input for calculation of TEDE to the critical receptor (Section 6.0). The EMP uses two TLDs at Monitoring Station PA-4 (for each monitoring period) to provide additional QC of the monitoring data.

A summary of TLD monitoring results for CY 2011 at the SLAPS is shown in Table 2-5. TLD data is located in Appendix B of this report.

Table 2-5. Summary of SLAPS Gamma Radiation Data for CY 2011

Monitoring Location	Monitoring Station	First Quarter TLD Data (mrem/qtr) Reported/ Corrected		Second Quarter TLD Data (mrem/qtr) Reported/ Corrected		Third Quarter TLD Data (mrem/qtr) Reported/ Corrected		Fourth Quarter TLD Data (mrem/qtr) Reported/ Corrected		CY 2011 Net TLD Data (mrem/yr)
		Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	Rpt.	Cor.[a,b]	
SLAPS Perimeter	PA-1	19	1.3	21.3	1.8	20.2	2.3	20.7	0.0	5
	PA-2	20.1	2.5	20.9	1.4	23.0	5.4	24.3	3.4	13
	PA-2[c]	21.6	4.1	25.0	5.8	23.4	5.9	23.5	2.5	---
	PA-3	18.1	0.3	18.	0.0	19.7	1.8	19.9	0.0	2
	PA-4	17.5	0.0	21.8	2.4	17.4	0.0	21.6	0.6	3
Background	BA-1	17.8	---	19.6	---	18.1	---	21.0	---	---

[a] All quarterly data reported from the vendor have been normalized to exactly one quarter's exposure above background.
[b] CY 2011 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 calculations not required.

2.3.2 Evaluation of Airborne Radioactive Particulate Data

For the SLAPS and SLAPS VPs, air sampling for particulate radionuclides was conducted at the perimeter of each active excavation and loadout area throughout the year. Air particulate data was used as inputs to the NESHAP Report (Appendix A) and calculation of TEDE to the critical receptor (Section 6.0).

A summary of air particulate monitoring data for the SLAPS and SLAPS VPs is shown in Table 2-6. Airborne radioactive particulate data is located in Appendix B of this report.

Table 2-6. Summary of SLAPS Airborne Radioactive Particulate Data for CY 2011

Monitoring Station	Average Concentration (μCi/mL)[a]	
	Gross Alpha	Gross Beta
McDonnell Blvd	3.29E-15	2.62E-14
IA-09	5.14E-15	3.08E-14
VP-12	2.22E-15	1.28E-14
VP-31A	2.07E-15	7.49E-15
SLAPS Load Out	3.43E-15	2.54E-14
Background Concentration[b]	3.37E-15	1.97E-14

[a] Average concentration values for the sampling period by location.
[b] These concentrations are only provided for informational purposes.

2.3.3 Evaluation of Outdoor Airborne Radon Data

Exposure from Rn-222 from the SLAPS VPs is considered negligible. Therefore, outdoor environmental Rn-222 monitoring was not conducted at the SLAPS VPs. Outdoor airborne radon monitoring was performed at the SLAPS using ATDs placed around the loadout area to measure radon emissions from the site. Four detectors were co-located with TLDs, as identified in Figure 2-3. One additional detector was located at Monitoring Station PA-2 as a QC duplicate. A background ATD was used to compare on-site exposure and off-site background exposure. Outdoor airborne radon data was used as an input for calculation of TEDE to the critical receptor (Section 6).

A summary of CY 2011 outdoor radon data at the HISS is shown in Table 2-7. Outdoor ATD data is located in Appendix B of this report.

Table 2-7. Summary of SLAPS Outdoor Airborne Radon (Rn-222) Data for CY 2011

Monitoring Location	Monitoring Station	Average Annual Concentration (pCi/L)		
		01/04/11 to 07/06/11 [a] (uncorrected)	07/06/11 to 01/10/12[a] (uncorrected)	Average Annual Concentration[b]
SLAPS Perimeter	PA-1	0.2	0.2	0
	PA-2	0.2	0.2	0
	PA-2[c]	0.2	0.2	0
	PA-3	0.2	0.2	0
	PA-4	0.2	0.2	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 not required.

THIS PAGE INTENTIONALLY LEFT BLANK

3.0 EVALUATION OF EXCAVATION-WATER, STORM-WATER, SURFACE-WATER, AND SEDIMENT MONITORING DATA

This section provides a description of the excavation-water, storm-water, surface-water, and sediment monitoring activities conducted at the NC Sites, including the monitoring of Coldwater Creek during CY 2011. The results obtained from these monitoring activities are presented and evaluated with respect to historical data and the appropriate discharge limits as described in the EMICY11 (USACE 2011).

Section 2.2.2 of the EMICY11 for the NC Sites outlines the discharge limits for the storm-water and excavation-water discharged at each site (USACE 2011). The MSD has issued discharge authorization letters for the NC Sites that establish discharge-limit-based criteria (MSD 1998, 2001, 2006, 2008, and 2010a). The pollutants addressed for all NC Sites are identified in Table 2-5 of the EMICY11 (USACE 2011). The pollutants addressed in the National Pollutant Discharge Elimination System (NPDES) permit equivalent for the SLAPS will be applied at all NC Sites and are identified in Table 2-6 of the EMICY11 (USACE 2011). For cases in which the regulatory authorities have not provided radiological contaminant of concern (COC) discharge limits, the 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. The Missouri Department of Natural Resources (MDNR) has also issued an ARAR document outlining limits for the storm-water outfalls at the SLAPS (MDNR 1998).

3.1 EXCAVATION-WATER AND STORM-WATER DISCHARGE MONITORING

This section provides a description of the excavation-water and storm-water monitoring activities conducted at the NC Sites during CY 2011. The monitoring results obtained from these activities are presented and compared with the various authorization letters or permit-equivalent limits as presented in the EMICY11 (USACE 2011). The purpose of storm-water and excavation-water discharge sampling at the NC Sites is to maintain compliance with the specific discharge requirements for each respective site.

3.1.1 Metropolitan St. Louis Sewer District Special Discharge Approval for the Hazelwood Interim Storage Site On-Site Radioanalytical Laboratory

The USACE owns the HISS on-site laboratory located at 8945 Latty Avenue in Hazelwood, Missouri. The laboratory operates in accordance with an MSD special discharge approval. The laboratory waste-water is discharged to the MSD sewer system at Manhole 10K2-075S, which is shown on Figure 3-1. The MSD special discharge approval requires compliance with applicable discharge regulations (Ordinance 8472) (MSD 1991). The current special discharge approval extension was renewed on February 1, 2010, and expires February 7, 2012 (MSD 2010b).

3.1.2 Evaluation of Storm-Water Discharge Monitoring Results

During CY 2011, storm-water sampling at the SLAPS was conducted to verify compliance with NPDES permit-equivalent requirements. There is one NPDES outfall located at the SLAPS. This outfall has been assigned the station identification PN02 for Outfall 002. PN02 is located at the termination of a drainage feature that conveys storm water along the north side of McDonnell Boulevard to Coldwater Creek (Figure 3-2).

In conjunction with the construction of a sedimentation basin during CY 1998, the MDNR issued discharge sampling requirements for three outfalls (PN01 [now terminated], PN02, and PN03 [now terminated]). The ARAR permit-equivalent document requires monthly monitoring for flow, oil and grease, total petroleum hydrocarbons, pH, settleable solids, and polychlorinated biphenyls, as well as total recoverable arsenic, chromium, and cadmium. In addition, effluent monitoring for gross alpha, gross beta, protactinium (Pa)-231, actinium (Ac)-227, total Ra, total Th, and total U is required for each discharge event. Effluent monitoring for radon is required twice per year. As outlined in a letter from the USACE to the MDNR dated November 18, 2003, chemical oxygen demand monitoring has been modified from quarterly to annually (USACE 2003).

On February 19, 2002, the MDNR issued a letter to the USACE conditionally agreeing with a request to reduce the sampling frequency at PN02 to once per year, effective February 2002 until the drainage area becomes affected by soil disturbance such as excavation (MDNR 2002). The condition of the agreement is that the MDNR be notified prior to the soil in the area being disturbed.

During 2011, un-named moving pumping outfalls were utilized during excavation activities at HISS/Futura, VP-02(L), and McDonnell Boulevard for the management of storm water with regard to sediment control and pumped excavation water. The moving outfalls were necessary to pump excess excavation water, which could not be contained due to geographic conditions, to Coldwater Creek. The un-named excess excavation water was pumped to Coldwater Creek in accordance with agreements made during a March 12, 2007, meeting with Mr. Tom Siegel (MDNR), and as described in a subsequent letter from the USACE dated April 20, 2007, letter from the USACE (USACE 2007). The excavation water sampling is conducted to verify compliance with the NPDES permit-equivalent requirements. The discharge parameters for the un-named outfalls follow the same NPDES parameters as Outfall PN02.

Analytical results for the NC Sites are presented in Appendix C, Table C-1. Quarterly summaries of the CY 2011 storm-water monitoring events for the NC Sites are presented in the following subsections. Quarterly NC Sites storm-water monitoring results for CY 2011 are presented in Tables 3-1 through 3-3.

During CY 2011, rainfall data was obtained from the National Weather Service Station at Lambert – St. Louis International Airport, which is adjacent to the NC Sites. Daily flow and rainfall data are included in Appendix C, Table C-2.

First Quarter

During the first quarter (January, February, and March) of CY 2011, all NPDES sample results were in compliance with permit-equivalent requirements (Table 3-1). Samples were collected when flow permitted. Eleven sampling events were conducted at Un-named Outfall VP-02(L) during the first quarter. Four sampling events were conducted at Un-named Outfall McDonnell Boulevard during the first quarter. In accordance with a letter from the MDNR, dated February 19, 2002, sampling at PN02 was reduced to one event per year (MDNR 2002). Outfall PN02 was not sampled during the first quarter.

Second Quarter

During the second quarter (April, May, and June) of CY 2011, all NPDES sample results were in compliance with permit-equivalent requirements (Table 3-2). Samples were collected when flow permitted. One sampling event was conducted at Outfall PN02 during the second quarter.

Thirteen sampling events were conducted at Un-named Outfall VP-02(L) during the second quarter. One sampling event was conducted at Un-named Outfall HISS/Futura.

Third Quarter

During the third quarter (July, August, and September) of CY 2011, all NPDES sample results were in compliance with permit-equivalent requirements (Table 3-3). Samples were collected when flow permitted. Outfall PN02 was not sampled during the third quarter. Six sampling events were conducted at Un-named Outfall VP-02(L) during the third quarter. One sampling event was conducted at Un-named Outfall HISS/Futura during the third quarter.

Fourth Quarter

During the fourth quarter (October, November, and December) of CY 2011, no Outfalls were sampled.

THIS PAGE INTENTIONALLY LEFT BLANK

Table 3-1. First Quarter CY 2011 NPDES Sampling Events[a]

MONITORING PARAMETER	FINAL EFFLUENT LIMITATIONS			ANALYTICAL RESULTS											
	Daily Maximum	Monthly Average	Units	Un-named Outfall 02(L) Results						Un-named Outfall McDonnell Blvd Results					
				Chemical Parameters						Chemical Parameters					
				January		February		March		January		February		March	
Flow	Monitor	Monitor	MGD	0.031		0.021		0.011		[b]		[n]		[n]	
Oil and Grease	15	10	mg/L	non-detect		non-detect		non-detect							
Total Petroleum Hydrocarbons	10	10	mg/L	non-detect		non-detect		non-detect							
pH-Units	6.0-9.0	NA	SU	7.66		7.83		7.60							
Chemical Oxygen Demand[d]	120	90	mg/L	[l]		[l]		[l]							
Settleable Solids[j]	1.5	1	mL/L/hr	<0.2[m]		<0.2[m]		<0.2[m]							
Arsenic, Total Recoverable	100	100	mg/L	16		<15		<15							
Lead, Total Recoverable	190	190	mg/L	[c]		[c]		[c]							
Chromium, Total Recoverable	280	280	mg/L	<2		<2		<2							
Copper, Total Recoverable	84	84	mg/L	[c]		[c]		[c]							
Cadmium, Total Recoverable	94	94	mg/L	<2		<2		<2							
Polychlorinated Biphenyls[k]	No release	No release	µg/L	non-detect		non-detect		non-detect							
EVENT SAMPLING DATE				Radiological Parameters[e,f]						Radiological Parameters[e,f]					
				Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
				01/04/11	01/18/11	02/14/11 - 02/15/11, 02/17/11	02/21/11, 02/23/11 - 02/24/11	[b]	02/28/11	[b]	[b]	02/17/11	02/21/11	02/25/11	[b]
Uranium, Total[g,h]	Monitor	Monitor	mg/L	2.E+01	1.E+01	4.E+00	1.E+01		1.E+01			0.E+00	0.E+00	2.E+00	
Radium, Total[f,g,h]	Monitor	Monitor	mg/L	1.E-09	2.E-07	1.E-06	9.E-07		2.E-07			8.E-07	9.E-10	1.E-06	
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L	6.E-01	4.E-01	7.E-05	2.E-05		3.E-05			7.E+00	1.E+00	3.E+00	
Gross Alpha[g]	Monitor	Monitor	pCi/L	8.E+00	2.E+01	1.E+01	2.E+01		1.E+01			7.E+00	4.E+00	1.E+01	
Gross Beta[g]	Monitor	Monitor	pCi/L	4.E+00	3.E+00	4.E+00	2.E+00		3.E+00			9.E+00	5.E+00	3.E+00	
Protactinium-231[g]	Monitor	Monitor	pCi/L	0.E+00	4.E+00	2.E+00	4.E+00		1.E+01			2.E+01	5.E+00	0.E+00	
Actinium-227[g]	Monitor	Monitor	pCi/L	0.E+00	6.E-01	1.E+00	2.E+00		4.E+00			5.E+00	0.E+00	0.E+00	
Radon[i]	Monitor	Monitor	pCi/L	NS[i]	NS[i]	non-detect	NS[i]		NS[i]			NS[i]	NS[i]	NS[i]	
EVENT SAMPLING DATE				Event 7	Event 8	Event 9	Event 10	Event 11	Event 12	Event 7	Event 8	Event 9	Event 10	Event 11	Event 12
				03/01/11 - 03/03/11	03/07/11 - 03/09/11	03/14/11, 03/16/11	03/21/11	03/23/11	03/28/11	[b]	[b]	03/16/11	[b]	[b]	[b]
Uranium, Total[g,h]	Monitor	Monitor	mg/L	1.E+01	7.E+00	1.E+01	2.E+01	2.E+01	2.E+01			0.E+00			
Radium, Total[f,g,h]	Monitor	Monitor	mg/L	5.E-07	6.E-08	6.E-07	5.E-07	1.E-09	7.E-07			1.E-09			
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L	1.E+00	6.E-01	5.E-01	2.E-05	6.E-01	7.E-01			4.E-01			
Gross Alpha[g]	Monitor	Monitor	pCi/L	2.E+01	6.E+00	1.E+01	3.E+01	1.E+01	2.E+01			3.E+00			
Gross Beta[g]	Monitor	Monitor	pCi/L	5.E+00	0.E+00	1.E+00	3.E+00	0.E+00	7.E+00			3.E+00			
Protactinium-231[g]	Monitor	Monitor	pCi/L	4.E+00	1.E+00	0.E+00	5.E+00	6.E+00	0.E+00			6.E+00			
Actinium-227[g]	Monitor	Monitor	pCi/L	0.E+00	2.E+00	2.E+00	0.E+00	0.E+00	0.E+00			2.E+00			
Radon[i]	Monitor	Monitor	pCi/L	NS[i]	NS[i]	NS[i]	NS[i]	NS[i]	NS[i]			NS[i]			

MGD – million gallons per day
mg/L – milligrams per liter
mL/L/hr – milliliter per liter per hour
NS – not sampled

[a] A rainfall event is defined as a measurable increase in discharge rate from precipitation producing 0.1 inch or more of liquid in a 24-hour period which may also exceed the duration of 24 hours, and two events experienced within 48 hours may be reported together.
[b] No sample is required since it doesn't meet the definition of an event.
[c] Lead and copper sampling no longer necessary per the ROD.
[d] Sampled annually.
[e] Value reported is based on a volume-weighted average of analyte activity concentrations for samples collected during the defined event. Corresponding radiological samples were collected on the same date as chemical samples; however, the radiological results are incorporated into the volume-weighted average for the specified event.
[f] It is assumed that Ra-228 and Th-228 are in secular equilibrium with Th-232; therefore, Th-232 results are used to estimate Ra-228 and Th-228 values.
[g] As specified in the permit-equivalent, radionuclides require monitoring only, and limits are not permit specified.
[h] Total nuclide values in µg/L units were calculated using the activity concentration values reported by the laboratory and values for specific activity listed in Table 8.4.1 of *The Health Physics and Radiological Health Handbook* (Shleien 1992).
[i] Semi-annual reporting requirement only.
[j] Detection Limit (DL) = 0.1 mL/L/hr
[k] DL = 0.5 µg/L
[l] As per USACE letter dated 11/18/03, chemical oxygen demand sampling requirement has been reduced from quarterly to annual sampling.
[m] The settleable solid values ranged from 0 to 0.1 mL/L/hr with the weighted average of <0.2 mL/L/hr.
[n] Un-named Outfall only requires monthly chemical sampling if pumping is conducted during that month.

Table 3-2. Second Quarter CY 2011 NPDES Sampling Events[a,m]

MONITORING PARAMETER	FINAL EFFLUENT LIMITATIONS			ANALYTICAL RESULTS								
	Daily Maximum	Monthly Average	Units	PN02 (Outfall 002)[d] Chemical Parameters			Un-named Outfall 02(L) Results Chemical Parameters			Un-named Outfall HISS/Futura Results Chemical Parameters		
				April	May	June	April	May	June	April	May	June
Flow	Monitor	Monitor	MGD	0.268	m	m	0.006	0.005	0.007	b	b	0.009
Oil and Grease	15	10	mg/L	non-detect			non-detect	non-detect	non-detect			non-detect
Total Petroleum Hydrocarbons	10	10	mg/L	non-detect			non-detect	non-detect	non-detect			non-detect
pH-Units	6.0-9.0	NA	SU	7.29			7.73	7.51	7.38			7.76
Chemical Oxygen Demand[d]	120	90	mg/L	48			l	l	l			l
Settleable Solids[j]	1.5	1	mL/L/hr	<0.2			<0.2[n]	<0.2[n]	<0.2[n]			<0.2
Arsenic, Total Recoverable	100	100	mg/L	<15			<15	<15	<15			<15
Lead, Total Recoverable	190	190	mg/L	c			c	c	c			c
Chromium, Total Recoverable	280	280	mg/L	<2			<2	<2	<2			3.1
Copper, Total Recoverable	84	84	mg/L	c			c	c	c			c
Cadmium, Total Recoverable	94	94	mg/L	<2			<2	<2	<2			<2
Polychlorinated Biphenyls[k]	No release	No release	µg/L	non-detect			non-detect	non-detect	non-detect			non-detect

PN02 (Outfall 002)[d] — Radiological Parameters[e,f]

MONITORING PARAMETER	Daily Maximum	Monthly Average	Units	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
EVENT SAMPLING DATE				m	m	04/20/11	m	m	m
Uranium, Total[g,h]	Monitor	Monitor	mg/L			3.E+00			
Radium, Total[f,g,h]	Monitor	Monitor	mg/L			4.E-07			
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L			3.E-06			
Gross Alpha[g]	Monitor	Monitor	pCi/L			0.E+00			
Gross Beta[g]	Monitor	Monitor	pCi/L			0.E+00			
Protactinium-231[g]	Monitor	Monitor	pCi/L			0.E+00			
Actinium-227[g]	Monitor	Monitor	pCi/L			5.E-01			
Radon[i]	Monitor	Monitor	pCi/L			non-detect			
				Event 7	**Event 8**	**Event 9**	**Event 10**	**Event 11**	**Event 12**
EVENT SAMPLING DATE				m	m	m	m	m	m
Uranium, Total[g,h]	Monitor	Monitor	mg/L						
Radium, Total[f,g,h]	Monitor	Monitor	mg/L						
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L						
Gross Alpha[g]	Monitor	Monitor	pCi/L						
Gross Beta[g]	Monitor	Monitor	pCi/L						
Protactinium-231[g]	Monitor	Monitor	pCi/L						
Actinium-227[g]	Monitor	Monitor	pCi/L						
Radon[i]	Monitor	Monitor	pCi/L						

Un-named Outfall 02(L) Results — Radiological Parameters[e,f]

MONITORING PARAMETER	Daily Maximum	Monthly Average	Units	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
EVENT SAMPLING DATE				04/04/11 - 04/06/11	04/11/11 - 04/13/11	04/18/11 - 04/20/11	04/25/11 - 04/28/11	05/02/11	05/11/11
Uranium, Total[g,h]	Monitor	Monitor	mg/L	2.E+01	2.E+01	2.E+00	3.E+00	2.E+01	2.E+01
Radium, Total[f,g,h]	Monitor	Monitor	mg/L	6.E-07	2.E-09	4.E-07	6.E-07	9.E-07	2.E-09
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L	2.E-01	2.E-05	7.E-02	1.E-01	3.E-05	3.E-05
Gross Alpha[g]	Monitor	Monitor	pCi/L	2.E+01	1.E+01	8.E-01	3.E+00	1.E+01	2.E+01
Gross Beta[g]	Monitor	Monitor	pCi/L	6.E+00	1.E+00	7.E+00	4.E+00	6.E+00	7.E+00
Protactinium-231[g]	Monitor	Monitor	pCi/L	6.E+00	5.E+00	1.E+01	5.E-01	0.E+00	0.E+00
Actinium-227[g]	Monitor	Monitor	pCi/L	2.E+00	2.E+00	1.E+00	2.E+00	0.E+00	0.E+00
Radon[i]	Monitor	Monitor	pCi/L	NS[i]	NS[i]	NS[i]	NS[i]	NS[i]	NS[i]
				Event 7	**Event 8**	**Event 9**	**Event 10**	**Event 11**	**Event 12**
EVENT SAMPLING DATE				05/16/11	05/24/11 - 05/26/11	06/01/11	06/13/11 - 06/15/11	06/20/11	06/23/11
Uranium, Total[g,h]	Monitor	Monitor	mg/L	2.E+01	9.E+00	1.E+01	2.E-01	1.E+00	1.E+01
Radium, Total[f,g,h]	Monitor	Monitor	mg/L	2.E-07	4.E-08	6.E-07	4.E-07	4.E-07	3.E-10
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L	2.E+00	1.E+00	1.E+00	7.E-01	2.E-05	2.E-05
Gross Alpha[g]	Monitor	Monitor	pCi/L	2.E+01	4.E+00	2.E+01	4.E+00	4.E+00	9.E+00
Gross Beta[g]	Monitor	Monitor	pCi/L	2.E+00	1.E+00	0.E+00	4.E-01	0.E+00	0.E+00
Protactinium-231[g]	Monitor	Monitor	pCi/L	2.E+01	7.E+00	6.E+00	1.E+00	8.E+00	8.E+00
Actinium-227[g]	Monitor	Monitor	pCi/L	0.E+00	2.E+00	2.E-01	7.E-01	0.E+00	5.E+00
Radon[i]	Monitor	Monitor	pCi/L	NS[i]	NS[i]	NS[i]	NS[i]	NS[i]	NS[i]

Un-named Outfall HISS/Futura Results — Radiological Parameters[e,f]

MONITORING PARAMETER	Daily Maximum	Monthly Average	Units	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
EVENT SAMPLING DATE				b	b	b	b	b	b
Uranium, Total[g,h]	Monitor	Monitor	mg/L						
Radium, Total[f,g,h]	Monitor	Monitor	mg/L						
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L						
Gross Alpha[g]	Monitor	Monitor	pCi/L						
Gross Beta[g]	Monitor	Monitor	pCi/L						
Protactinium-231[g]	Monitor	Monitor	pCi/L						
Actinium-227[g]	Monitor	Monitor	pCi/L						
Radon[i]	Monitor	Monitor	pCi/L						
				Event 7	**Event 8**	**Event 9**	**Event 10**	**Event 11**	**Event 12**
EVENT SAMPLING DATE				b	b	b	b	b	b
Uranium, Total[g,h]	Monitor	Monitor	mg/L						
Radium, Total[f,g,h]	Monitor	Monitor	mg/L						
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L						
Gross Alpha[g]	Monitor	Monitor	pCi/L						
Gross Beta[g]	Monitor	Monitor	pCi/L						
Protactinium-231[g]	Monitor	Monitor	pCi/L						
Actinium-227[g]	Monitor	Monitor	pCi/L						
Radon[i]	Monitor	Monitor	pCi/L						

Table 3-2. Second Quarter CY 2011 NPDES Sampling Events[a,m] (Continued)

MONITORING PARAMETER	FINAL EFFLUENT LIMITATIONS			ANALYTICAL RESULTS					
	Daily Maximum	Monthly Average	Units	PN02 (Outfall 002)[d]		Un-named Outfall 02(L) Results		Un-named Outfall HISS/Futura Results	
				Radiological Parameters[e,f]		Radiological Parameters[e,f]		Radiological Parameters[e,f]	
EVENT SAMPLING DATE				Event 13		Event 13		Event 13	
				m		06/27/11 - 06/30/11		06/28/11	
Uranium, Total[g,h]	Monitor	Monitor	mg/L			4.E+00		6.E+00	
Radium, Total[f,g,h]	Monitor	Monitor	mg/L			3.E-07		4.E-07	
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L			2.E-02		1.E+00	
Gross Alpha[g]	Monitor	Monitor	pCi/L			5.E+00		2.E+01	
Gross Beta[g]	Monitor	Monitor	pCi/L			4.E-02		1.E+01	
Protactinium-231[g]	Monitor	Monitor	pCi/L			5.E-01		1.E+01	
Actinium-227[g]	Monitor	Monitor	pCi/L			4.E-01		4.E+00	
Radon[i]	Monitor	Monitor	pCi/L			NS[i]		NS[i]	

NS – not sampled
[a] A rainfall event is defined as a measurable increase in discharge rate from precipitation producing 0.1 inch or more of liquid in a 24-hour period which may also exceed the duration of 24 hours, and two events experienced within 48 hours may be reported together. Events may also be defined as "pumping events" where monitoring of excavation water is conducted at an outfall on an as-needed basis.
[b] No sample is required since it doesn't meet the definition of an event.
[c] Lead and copper sampling no longer necessary per the ROD.
[d] Sampled annually.
[e] Value reported is based on a volume-weighted average of analyte activity concentrations for samples collected during the defined event. Corresponding radiological samples were collected on the same date as chemical samples, however, the radiological results are incorporated into the volume-weighted average for the specified event.
[f] It is assumed that Ra-228 and Th-228 are in secular equilibrium with Th-232; therefore, Th-232 results are used to estimate Ra-228 and Th-228 values.
[g] As specified in the permit-equivalent, radionuclides require monitoring only, and limits are not permit specified.
[h] Total nuclide values in micrograms per liter (μg/L) units were calculated using the activity concentration values reported by the laboratory and values for specific activity listed in Table 8.4.1 of *The Health Physics and Radiological Health Handbook* (Shleien 1992).
[i] Semi-annual reporting requirement only.
[j] DL = 0.1 mL/L/hr
[k] DL = 0.5 μg/L
[l] As per USACE letter dated 11/18/03, chemical oxygen demand sampling requirement has been reduced from quarterly to annual sampling.
[m] As per MDNR letter dated 02/19/02, sampling at Outfall 002 has been reduced to once a year.
[n] The settleable solid values ranged from 0 to 0.1 mL/L/hr with the weighted average of <0.2 mL/L/hr.

Table 3-3. Third Quarter CY 2011 NPDES Sampling Events[a,m]

MONITORING PARAMETER	FINAL EFFLUENT LIMITATIONS			Analytical Results					
				Un-named Outfall 02(L) Results			Un-named Outfall HISS/Futura Results		
				Chemical Parameters			Chemical Parameters		
	Daily Maximum	Monthly Average	Units	July	August	September	July	August	September
Flow	Monitor	Monitor	MGD	0.011	0.002	0.005	[b]	[b]	[b]
Oil and Grease	15	10	mg/L	non-detect	non-detect	non-detect			
Total Petroleum Hydrocarbons	10	10	mg/L	non-detect	non-detect	non-detect			
pH-Units	6.0-9.0	NA	SU	7.17	7.54	7.92			
Chemical Oxygen Demand[d]	120	90	mg/L	[l]	[l]	[l]			
Settleable Solids[j]	1.5	1	mL/L/hr	<0.2[o]	0.4[p]	<0.2			
Arsenic, Total Recoverable	100	100	mg/L	<15	<15	<15			
Lead, Total Recoverable	190	190	mg/L	[c]	[c]	[c]			
Chromium, Total Recoverable	280	280	mg/L	<2	<2	9			
Copper, Total Recoverable	84	84	mg/L	[c]	[c]	[c]			
Cadmium, Total Recoverable	94	94	mg/L	<2	<2	<2			
Polychlorinated Biphenyls[k]	No release	No release	µg/L	non-detect	non-detect	non-detect			
EVENT SAMPLING DATE				Radiological Parameters[e,f]			Radiological Parameters[e,f]		
				Event 1	Event 2	Event 3	Event 1	Event 2	Event 3
				07/05/11 - 07/07/11	07/11/11	08/01/11	[b]	[b]	[b]
Uranium, Total[g,h]	Monitor	Monitor	mg/L	1.E+01	4.E+00	2.E+01			
Radium, Total[f,g,h]	Monitor	Monitor	mg/L	5.E-07	2.E-07	1.E-06			
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L	1.E+00	8.E-01	1.E+00			
Gross Alpha[g]	Monitor	Monitor	pCi/L	1.E+01	8.E+00	1.E+01			
Gross Beta[g]	Monitor	Monitor	pCi/L	2.E+00	0.E+00	6.E+00			
Protactinium-231[g]	Monitor	Monitor	pCi/L	0.E+00	0.E+00	0.E+00			
Actinium-227[g]	Monitor	Monitor	pCi/L	6.E-02	4.E+00	0.E+00			
Radon[i]	Monitor	Monitor	pCi/L	NS[i]	NS[i]	NS[i]			
EVENT SAMPLING DATE				Event 4	Event 5	Event 6	Event 4	Event 5	Event 6
				08/08/11	09/15/11	09/19/11	[b]	09/15/11	[b]
Uranium, Total[g,h]	Monitor	Monitor	mg/L	2.E+01	6.E+00	1.E+00		2.E+00	
Radium, Total[f,g,h]	Monitor	Monitor	mg/L	1.E-07	6.E-07	5.E-07		4.E-09	
Thorium, Total[f,g,h]	Monitor	Monitor	mg/L	4.E-01	3.E-05	1.E+00		6.E+00	
Gross Alpha[g]	Monitor	Monitor	pCi/L	1.E+01	5.E+00	4.E+00		7.E+00	
Gross Beta[g]	Monitor	Monitor	pCi/L	8.E+00	0.E+00	6.E+00		7.E-01	
Protactinium-231[g]	Monitor	Monitor	pCi/L	0.E+00	2.E+00	0.E+00		0.E+00	
Actinium-227[g]	Monitor	Monitor	pCi/L	1.E+00	1.E+00	6.E+00		0.E+00	
Radon[i]	Monitor	Monitor	pCi/L	NS[i]	NS[i]	NS[i]		NS[i]	

NS – not sampled

[a] A rainfall event is defined as a measurable increase in discharge rate from precipitation producing 0.1 inch or more of liquid in a 24-hour period which may also exceed the duration of 24 hours, and two events experienced within 48 hours may be reported together. Events may also be defined as "pumping events" where monitoring of excavation water is conducted at an outfall on an as-needed basis.

[b] No sample is required since it doesn't meet the definition of an event.

[c] Lead and copper sampling no longer necessary per the ROD.

[d] Sampled annually.

[e] Value reported is based on a volume-weighted average of analyte activity concentrations for samples collected during the defined event. Corresponding radiological samples were collected on the same date as chemical samples, however, the radiological results are incorporated into the volume-weighted average for the specified event.

[f] It is assumed that Ra-228 and Th-228 are in secular equilibrium with Th-232; therefore, Th-232 results are used to estimate Ra-228 and Th-228 values.

[g] As specified in the permit-equivalent, radionuclides require monitoring only, and limits are not permit specified.

[h] Total nuclide values in µg/L units were calculated using the activity concentration values reported by the laboratory and values for specific activity listed in Table 8.4.1 of *The Health Physics and Radiological Health Handbook* (Shleien 1992).

[i] Semi-annual reporting requirement only.

[j] DL = 0.1 mL/L/hr

[k] DL = 0.5 µg/L

[l] As per USACE letter dated 11/18/03, chemical oxygen demand sampling requirement has been reduced from quarterly to annual sampling.

[m] PN02 (Outfall 002) sampled annually in the second quarter and not displayed.

[n] Un-named Outfalls only require monthly chemical sampling if pumping is conducted during that month.

[o] The settleable solid value for July at VP-02L un-named Outfall was 0.10 mL/L/hr with the weighted average of <0.2 mL/L/hr.

[p] The settleable solid values for August at VP-02L un-named Outfall ranged from 0.30 to 0.50 mL/L/hr with the weighted average of 0.4 mL/L/hr.

3.1.3 Evaluation of Excavation-Water Monitoring Results at the North St. Louis County Sites

On July 23, 2001, the MSD conditionally approved the discharge of treated excavation-water to an MSD sanitary sewer inlet located at the SLAPS (MSD 2001). The current extension to the special discharge approval expires on July 23, 2012 (MSD 2010a). The primary condition of the approval requires a treatment system be installed, maintained, and operated to produce an effluent meeting the following standards: MSD ordinances 8472, 10177, and 10082 (MSD 1991, 1994, 1997); the Nuclear Regulatory Commission (NRC) requirements in 10 *CFR* 20, Appendix B; and the Missouri Department of Health and Senior Services (DHSS) requirements in 19 *Code of State Regulations (CSR)* 20-10. In addition, the MSD limits the annual allocation for radioactivity from the NC Sites to the MSD Coldwater Creek treatment plant. The MSD establishes the maximum volume of excavation-water allowed to be discharged in a 24-hour period and requires that the analytical results of the treated excavation-water comply with applicable standards and limits prior to discharge. The evaluation of monitoring data results demonstrate that all ARARs have been met. Additionally, the selenium discharge variance for the SLAPS was utilized in the first quarter of CY 2011 (MSD 2005, 2008, 2010a). The selenium variance was utilized for Batches 257 and 258. The selenium variance calculations are presented in Appendix C, Table C-3. Analytical results of the treated water are presented in Appendix C, Table C-4.

During CY 2011, approximately 2,225,366 gallons of treated excavation-water from 17 treatment batches were released to one of three discharge points: 10K1-017S, 10K1-070S, and 10L3-043S (Table 3-4). The discharge locations are illustrated on Figures 3-2 and 3-3. Batches of treated excavation-water were sampled and analyzed for MSD effluent criteria (Appendix C, Table C-4).

Table 3-4. Excavation Water Discharged at the NC Sites During CY 2011

Quarter	Number of Discharges	Number of Gallons Discharged[a]	Total Activity (Curies [Ci])		
			Th[b]	U (KPA)[c]	Ra[d]
1	7	594,116	3.74E-06	1.65E-05	2.77E-06
2	4	567,342	2.06E-06	3.09E-06	2.54E-06
3	3	710,642	2.92E-06	6.24E-06	3.11E-06
4	3	353,266	1.33E-06	2.07E-05	1.59E-06
Total	17	2,225,366	1.00E-05	4.65E-05	1.00E-05

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

3.2 COLDWATER CREEK MONITORING

RA monitoring of surface water and sediment in Coldwater Creek is required until the creek has been remediated. The purpose of the monitoring is to document that RAs are having a positive effect on the creek and to provide additional data to assess whether Coldwater Creek is being measurably affected by COC migration from hydrostratigraphic zone (HZ)-A.

The EMP for Coldwater Creek evaluates the water quality and the radiological and chemical parameters present in the surface water and sediment. Surface water and sediment are monitored for the radiological and chemical parameters in List 2 of Table 3-3 of the EMICY11 (USACE 2011). The water quality parameters are measured only for surface water.

The water quality parameters measured include pH, temperature, dissolved oxygen (DO), specific conductivity, oxidation reduction potential (ORP), and turbidity. The objectives of the EMP are:

- to assess the quality of surface water and sediment in Coldwater Creek;
- to compare the results with monitoring guidelines and/or RGs as established for these media in the EMICY11 (USACE 2011); and,
- to evaluate/determine whether runoff from the SLAPS, the HISS, the SLAPS VPs, and the Latty Avenue Properties affect the quality of surface water and sediment in Coldwater Creek.

MDNR has designated Coldwater Creek as a metropolitan no-discharge stream. Therefore, discharges are prohibited, except as specifically permitted under the water quality standard, 10 *CSR* 20-7.031 and non-contaminated storm-water flows (10 *CSR* 20-7.015.1.A.4). Coldwater Creek, from its mouth at the Missouri River to its crossing with U.S. Highway 67 (Lindbergh Boulevard) (a distance of roughly 5.5 miles), is a Class C stream. Class C streams may cease flow during dry periods but maintain permanent pools that support aquatic life (10 *CSR* 20-7.031.1.F.6). The upper reach of Coldwater Creek south of U.S. Highway 67, which includes the SLAPS/HISS reach, is an unclassified water of the state.

Surface water and sediment samples are collected from Coldwater Creek on a semi-annual basis as part of the EMP (USACE 2011). The sampling events are conducted at six Coldwater Creek monitoring stations (C002 through C007). Locations of the six monitoring stations are shown on Figure 3-4. Monitoring station C004, located between the SLAPS and the HISS, is used to monitor the potential water quality impacts from the SLAPS to Coldwater Creek. Monitoring Station C005 is used to monitor water quality downstream from the HISS and those VPs located around Latty Avenue. Monitoring station C007, located approximately 3,700 ft downstream of the HISS, is the farthest downstream monitoring station on Coldwater Creek.

It should be noted that other non-FUSRAP industrial discharges are relatively common along the sampled reaches of Coldwater Creek, and therefore, sample parameters could be influenced by existing industrial sources other than former MED/AEC operations.

3.2.1 Coldwater Creek Surface-Water Monitoring Results

Sampling of surface water at Coldwater Creek was conducted at or below base flow elevation during the months of March and October in 2011. The base flow elevation for Coldwater Creek at the McDonnell Boulevard Bridge is 508.2 ft above mean sea level (amsl). The base flow also may be approximated by a depth measurement of 3.2 ft or less at an "average cross-section." The monitoring of Coldwater Creek surface water included determining water quality parameters, as well as obtaining samples for metals and radionuclides as listed in Table 3-3 of EMICY11 (USACE 2011). Grab samples were collected and analyzed according to the protocol defined in the *Sampling and Analysis Guide for the St. Louis Sites* (SAG) (USACE 2000). In addition, isotopic U results were used to evaluate total U concentrations in surface water for comparison to the 30 micrograms per liter (µg/L) monitoring guide described in the ROD.

All surface water monitoring required through implementation of the EMICY11 was conducted as planned during CY 2011. The evaluation of monitoring data demonstrates that all applicable ARARs have been met. The sample results are presented in Table D-1 of Appendix D (USACE 2011).

Water Quality Parameters

Water quality data is collected as part of the routine performance of surface water sampling and is used as part of the overall evaluation of water quality. The water quality results for each surface-water monitoring station are summarized in Table 3-5. The average surface-water temperatures during the March and October sampling events were 8.88 and 19.43 degrees Celsius (°C), respectively. The average surface-water pH values were 6.95 and 7.09, respectively. The pH values for both sampling events were within the acceptance range (6.0 to 9.0), and thus provide suitable conditions for aquatic life.

Table 3-5. Water Quality Results for CY 2011 Coldwater Creek Surface-Water Sampling

Monitoring Parameter	Unit	Monitoring Station						Average
		C002	C003	C004	C005	C006	C007	
First Sampling Event (March 31, 2011)								
Temperature	°C	9.6	9.4	9.3	8.6	8.2	8.2	8.88
pH	standard unit	6.87	7.01	7.15	6.96	6.98	6.72	6.95
DO	mg/L	5.91	6.36	7.63	8.01	6.09	4.31	6.39
Specific Conductivity	micro-Semens per centimeter (µS/cm)	0.193	0.196	0.197	0.201	0.204	0.208	0.199
ORP	millivolt (mV)	151	167	163	195	204	221	183.5
Turbidity	nephelometric turbidity units (NTU)	8.0	10.3	9.8	8.2	8.8	9.7	9.13
Second Sampling Event (October 11, 2011)								
Temperature	°C	19.2	21.4	19.2	20.2	18.3	18.3	19.43
pH	standard unit	7.62	7.56	7.19	6.99	6.82	6.35	7.09
DO	mg/L	10.05	13.15	7.06	6.31	5.84	4.06	7.75
Specific Conductivity	µS/cm	0.125	0.131	0.135	0.120	0.133	0.140	0.131
ORP	mV	201	188	202	211	195	173	195
Turbidity	NTU	46.9	17.1	119.0	243.0	36.4	32.0	82.4

Average DO levels were 6.39 milligrams per liter (mg/L) in March and 7.75 mg/L in October. Specific conductivity values were higher for the March event compared to the October event. The average specific conductivity for the March sampling event was 0.199 micro-Semens per centimeter (µS/cm), and the average specific conductivity for the October sampling event was 0.131 µS/cm. The average turbidity value during the March sampling event (9.13 nephelometric turbidity units [NTUs]) was less than the October sampling event (82.4 NTUs).

Radiological Parameters

The radiological monitoring results for the CY 2011 Coldwater Creek surface-water sampling events are summarized in Table 3-6. Historically, FUSRAP surface-water analysis has included unfiltered water samples for the following radiological parameters: Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, and U-238. Unfiltered surface-water samples from Coldwater Creek were not analyzed for Ra-228 during CY 2011, because Ra-228 rapidly achieves equilibrium with Th-228 such that their concentrations are equal.

Surface water data for U-234, U-235, and U-238 (reported in pCi/L) were converted to µg/L and compared to the 30 µg/L criterion for total U described in the ROD. The total U concentrations in surface water were less than the 30 µg/L ROD criterion. A summary of the surface-water radiological data collected from Coldwater Creek since 2001 is presented in Table 3-7.

Table 3-6. Radiological Results for CY 2011 Coldwater Creek Surface-Water Sampling

Monitoring Parameter	Monitoring Stations					
	C002	C003	C004	C005	C006	C007
Radionuclide Concentration (pCi/L)						
First Sampling Event (March 31, 2011)						
Ra-226	<2.14[a]	<1.30[a]	<1.84[a]	<1.80[a]	<1.82[a]	<1.22[a]
Th-228[b]	<0.52[a]	<0.53[a]	<0.52[a]	<0.39[a]	<0.44[a]	<0.43[a]
Th-230	<0.52[a]	0.52	0.43	<0.39[a]	0.45	0.59
Th-232	<0.17[a]	<0.43[a]	<0.20[a]	<0.18[a]	<0.21[a]	<0.20[a]
U-234	0.75	2.52	1.02	0.81	0.94	0.88
U-235	<0.23[a]	<0.60[a]	<0.54[a]	0.25	<0.30[a]	<0.65[a]
U-238	0.75	1.38	0.94	0.59	0.94	0.70
Second Sampling Event (October 11, 2011)						
Ra-226	0.87	<1.28[a]	0.64	0.68	<1.26[a]	<1.37[a]
Th-228[b]	<0.55[a]	<0.50[a]	<0.49[a]	0.32	<0.57[a]	<0.40[a]
Th-230	0.37	0.48	<0.49[a]	<0.64[a]	0.38	0.40
Th-232	<0.20[a]	<0.18[a]	0.25	<0.29[a]	<0.26[a]	<0.18[a]
U-234	0.96	1.39	0.63	0.68	0.94	0.72
U-235	<0.25[a]	<0.22[a]	<0.26[a]	<0.23[a]	<0.25[a]	<0.24[a]
U-238	1.48	0.89	0.82	1.01	0.37	0.36

[a] Reported result is less than the minimum detectable concentration (MDC) and is therefore set equal to the MDC.
[b] Ra-228 rapidly achieves equilibrium with Th-228 such that their concentrations are equal.

Table 3-7. Comparison of Historical Radiological Surface-Water Results for Coldwater Creek

Stations	Radionuclide	Units	03/01	10/01	03/02	08/02	04/03	10/03	03/04	10/04	03/05	10/05	03/06	09/06	03/07	10/07	04/08	11/08	04/09	10/09	03/10	10/10	3/11	10/11
C002	Total U[b]	µg/L	<3.0[a]	<4.0[a]	4.2	5.8	5.1	2.8	1.0	2.1	3.0	1.3	0.72	2.2	2.3	2.2	3.2	2.2	1.6	3.3	2.4	2.3	2.3	3.8
	Ra-226	pCi/L	<4.1[a]	<1.6[a]	0.32	0.0	<1.8[a]	<2.8[a]	<4.7[a]	<2.4[a]	<0.42[a]	<0.39[a]	<0.44[a]	<0.46[a]	0.52	<0.67[a]	0.81	0.34	<0.39[a]	<0.48[a]	<0.17[a]	<1.51[a]	<2.14[a]	0.87
	Th-228[c]	pCi/L	<1.8[a]	<1.6[a]	<0.43[a]	<0.72[a]	<1.6[a]	<1.0[a]	1.8	<1.5[a]	<0.97[a]	<0.45[a]	0.64	<0.38[a]	0.25	<0.53[a]	<0.20[a]	<0.40[a]	<0.59[a]	0.21	0.46	<0.78[a]	<0.52[a]	<0.55[a]
	Th-230	pCi/L	<0.73[a]	<1.2[a]	1.2	1.8	<1.8[a]	2.2	2.0	<1.2[a]	<0.97[a]	0.60	<0.55[a]	0.64	0.38	1.3	0.59	<0.40[a]	0.69	0.41	0.28	<0.68[a]	<0.52[a]	0.37
	Th-232	pCi/L	<0.72[a]	<1.4[a]	0.0	0.0	0.65	<1.0[a]	<1.5[a]	<1.2[a]	<0.36[a]	<0.45[a]	<0.77[a]	<0.38[a]	<0.17[a]	<0.38[a]	<0.20[a]	<0.18[a]	<0.59[a]	<0.41[a]	<0.19[a]	<0.68[a]	<0.17[a]	<0.20[a]
C003	Total U[b]	µg/L	<5.5[a]	<5.2[a]	3.0	2.4	4.8	3.6	3.5	2.7	4.5	2.8	2.1	1.2	3.1	2.1	4.4	3.6	3.9	3.4	5.4	2.3	6.0	3.4
	Ra-226	pCi/L	<1.2[a]	<0.60[a]	<3.8[a]	0.30	<1.7[a]	<1.4[a]	<1.3[a]	<2.0[a]	<0.41[a]	<0.45[a]	<0.41[a]	1.5	0.20	<0.54[a]	1.32	<0.49[a]	0.29	<.0.65	<0.54[a]	<1.8[a]	<1.3[a]	<1.3[a]
	Th-228[c]	pCi/L	<1.5[a]	<2.4[a]	<0.52[a]	<0.20[a]	<1.3[a]	<2.3[a]	<1.2[a]	<1.9[a]	1.4	0.70	<0.54[a]	<0.50[a]	<0.54[a]	<0.42[a]	<0.44[a]	<0.33[a]	<0.50[a]	<0.48	<0.63[a]	<0.60[a]	<0.53[a]	<0.50[a]
	Th-230	pCi/L	<0.67[a]	<0.77[a]	1.5	1.7	2.2	2.5	<1.1[a]	2.0	1.6	0.63	0.55	0.67	0.44	1.3	1.32	0.58	<0.41[a]	<0.67[a]	0.60	<0.61[a]	0.52	0.48
	Th-232	pCi/L	<0.67[a]	<0.80[a]	0.0	<0.14[a]	<0.60[a]	<1.9[a]	<1.2[a]	<0.59[a]	<0.92[a]	<0.40[a]	<0.20[a]	<0.41	<0.16[a]	<0.19[a]	<0.20[a]	<0.15[a]	0.20	<0.48[a]	<0.23[a]	<0.22[a]	<0.43[a]	<0.18[a]
C004	Total U[b]	µg/L	<4.5[a]	<2.7[a]	5.0	0.80	6.4	5.5	2.8	4.0	6.4	4.4	4.3	1.9	2.7	2.1	2.4	2.6	3.4	2.1	6.4	3.0	3.0	2.3
	Ra-226	pCi/L	<1.4[a]	<1.6[a]	0.11	0.70	<2.2[a]	<2.6[a]	<3.8[a]	1.2	<0.58[a]	<0.54[a]	<0.50[a]	<0.67[a]	0.41	<0.61[a]	<0.63[a]	<0.71[a]	0.64	<0.52[a]	<0.49[a]	<1.5[a]	<1.9[a]	0.64
	Th-228[c]	pCi/L	<1.2[a]	<1.4[a]	<0.30[a]	<1.3[a]	<2.6[a]	<2.7[a]	<1.7[a]	<1.6[a]	<0.93[a]	0.31	0.45	<0.44[a]	<0.53[a]	<0.17[a]	0.31	<0.50[a]	<0.51[a]	0.32	0.52	<0.65[a]	<0.52[a]	<0.49[a]
	Th-230	pCi/L	1.4	<1.2[a]	0.59	0.65	4.2	3.1	1.6	2.2	1.3	0.47	0.55	0.71	<0.38[a]	<0.45[a]	0.79	<0.50[a]	<0.51[a]	0.83	0.55	0.58	0.43	<0.49[a]
	Th-232	pCi/L	<1.2[a]	<1.2[a]	0.0	<0.11[a]	<0.59[a]	<1.1[a]	<0.56[a]	<1.6[a]	<0.34[a]	<0.47[a]	<0.19[a]	<0.20[a]	0.19	<0.19[a]	<0.21[a]	<0.18[a]	<0.51[a]	<0.38[a]	<0.20[a]	<0.24[a]	<0.20[a]	0.25
C005	Total U[b]	µg/L	<5.0[a]	<4.6[a]	5.7	1.7	5.0	6.8	2.2	2.8	3.8	4.9	2.1	3.0	4.8	1.4	4.0	3.2	1.8	3.9	3.1	3.0	2.1	2.6
	Ra-226	pCi/L	<1.2[a]	<2.8[a]	0.40	1.5	<1.5[a]	<1.9[a]	<2.4[a]	2.8	0.83	0.68	0.57	<0.36[a]	<0.51[a]	<0.64[a]	<0.74[a]	<0.20[a]	<0.42[a]	<0.40[a]	0.26	<0.64[a]	<1.8[a]	0.68
	Th-228[c]	pCi/L	<1.3[a]	<2.4[a]	<0.37[a]	<0.91[a]	<1.1[a]	<2.7[a]	0.82	<1.3[a]	0.88	<0.41[a]	<0.56[a]	0.26	<0.39[a]	0.23	<0.46[a]	<0.68[a]	0.21	<0.72[a]	0.33	<0.19[a]	<0.39[a]	0.32
	Th-230	pCi/L	<0.67[a]	<1.6[a]	2.6	0.98	1.8	3.4	2.6	1.5	1.5	0.52	0.87	0.46	<0.39[a]	0.99	1.7	0.32	0.41	<0.23[a]	0.27	0.42	<0.39[a]	<0.64[a]
	Th-232	pCi/L	<0.67[a]	<1.6[a]	<0.24[a]	0.0	<0.51[a]	<2.4[a]	<1.2[a]	<0.59[a]	<0.32[a]	<0.41[a]	<0.45[a]	<0.39[a]	<0.39[a]	<0.56[a]	<0.21[a]	<0.17[a]	0.34	<0.23[a]	<0.18[a]	<0.51[a]	<0.18[a]	<0.3[a]
C006	Total U[b]	µg/L	<5.0[a]	<3.1[a]	5.4	2.5	5.0	7.3	15	1.4	1.3	2.1	2.0	1.9	3.5	2.2	2.9	3.2	3.2	2.5	2.8	2.6	2.8	1.9
	Ra-226	pCi/L	<3.1[a]	<1.7[a]	0.36	<2.2[a]	<2.4[a]	<0.67[a]	<2.9[a]	<1.9[a]	<0.41[a]	<0.55[a]	<0.57[a]	<0.55[a]	0.51	<0.46[a]	<0.66[a]	0.91	5.26	<0.56[a]	<0.42[a]	<0.64[a]	<1.82[a]	<1.26[a]
	Th-228[c]	pCi/L	<2.1[a]	<1.8[a]	0.02	<0.88[a]	<2.2[a]	<2.4[a]	<1.9[a]	<1.3[a]	0.54	0.73	<0.56[a]	<0.59[a]	<0.43[a]	<0.36[a]	<0.56[a]	<0.39[a]	0.56	<0.42[a]	<0.42[a]	<0.19[a]	<0.44[a]	<0.57[a]
	Th-230	pCi/L	<2.2[a]	<1.6[a]	0.88	0.96	4.6	2.0	1.5	2.4	1.9	1.2	0.83	<0.52[a]	<0.16[a]	0.36	0.60	0.53	<0.48[a]	0.50	0.35	0.42	0.45	0.38
	Th-232	pCi/L	<1.5[a]	<0.72[a]	0.0	<0.11[a]	<1.2[a]	<1.1[a]	<1.5[a]	<0.60[a]	0.18	<0.20[a]	<0.18[a]	<0.19[a]	<0.16[a]	<0.16[a]	<0.20[a]	<0.39[a]	<0.22[a]	<0.19[a]	<0.42[a]	<0.51[a]	<0.21[a]	<0.26[a]
C007	Total U[b]	µg/L	<3.7[a]	<4.5[a]	7.9	3.1	4.1	4.7	1.2	2.1	1.9	2.1	1.9	1.7	3.1	1.7	2.7	1.8	2.3	3.0	2.5	2.8	2.6	1.6
	Ra-226	pCi/L	<2.7[a]	<2.3[a]	0.84	0.48	<1.5[a]	<1.9[a]	<2.2[a]	<1.7[a]	<0.79[a]	<0.43[a]	<0.58[a]	<0.40[a]	0.55	<0.46[a]	<0.81[a]	<0.18[a]	<0.51[a]	0.22	<0.19[a]	<2.24[a]	<1.2[a]	<1.4[a]
	Th-228[c]	pCi/L	<1.2[a]	1.7	1.2	1.9	<1.7[a]	<2.0[a]	1.8	<1.2[a]	0.78	0.42	<0.41[a]	<0.38[a]	<0.17[a]	<0.47[a]	0.51	0.18	<0.23[a]	<0.46[a]	<0.47[a]	0.53	<0.43[a]	<0.40[a]
	Th-230	pCi/L	<0.67[a]	<1.9[a]	2.4	3.1	2.4	2.3	2.5	2.2	<0.44[a]	1.3	0.62	0.45	<0.17[a]	0.99	1.03	0.47	0.25	<0.46[a]	0.51	<0.49[a]	0.59	0.40
	Th-232	pCi/L	<1.2[a]	<1.4[a]	<0.11[a]	<0.20[a]	<0.55[a]	<1.1[a]	0.86	<0.52[a]	<0.36[a]	<0.36[a]	<0.19[a]	<0.18[a]	<0.17[a]	<0.38[a]	<0.41[a]	<0.16[a]	<0.23[a]	<0.21[a]	<0.21[a]	<0.40[a]	<0.20[a]	<0.18[a]

[a] Reported result is less than the MDC and is therefore set equal to the MDC.
[b] Total U is equal to the sum of the concentrations of U isotopes in pCi/L divided by 0.677, where 0.677 microgram per picocurie is the specific activity for Total U, assuming secular equilibrium.
[c] Ra-228 rapidly achieves equilibrium with Th-228 such that their concentrations are equal.

Chemical Parameters

The chemical monitoring results for the CY 2011 Coldwater Creek surface-water sampling events are presented in Table 3-8.

Table 3-8. Chemical Results for CY 2011 Coldwater Creek Surface-Water Sampling

Monitoring Parameter	Monitoring Stations					
	C002	C003	C004	C005	C006	C007
Target Analyte List Metals Concentration (µg/L)						
First Sampling Event (March 31, 2011)						
Antimony	<1.7[a]	<1.7[a]	<1.7[a]	<1.7[a]	<1.7[a]	<1.7[a]
Arsenic	3.2	2.4	2.2	2.3	2.2	1.6
Barium	165	164	170	164	164	157
Cadmium	0.32	<0. 1[a]	<0. 1[a]	<0. 1[a]	0. 12	<0. 1[a]
Chromium	<3.3[a]	<3.3[a]	<3.3[a]	<3.3[a]	<3.3[a]	<3.3[a]
Molybdenum	13.5	13.6	12.2	10.7	10.3	10.2
Nickel	2.7	2.4	2.8	3.1	3.1	2.6
Selenium	2.5	2.9	1.4	2.4	2.7	2.6
Thallium	1.6	0.83	<0.55[a]	<0.55[a]	<0.55[a]	<055[a]
Vanadium	<2.4[a]	<2.4[a]	<2.4[a]	<2.4[a]	<2.4[a]	<2.4[a]
Second Sampling Event (October 11, 2011)						
Antimony	2.1	3.5	2.3	2.6	2.0	<1.7[a]
Arsenic	4.1	4.3	2.9	2.9	2.6	2.6
Barium	128	117	139	135	136	150
Cadmium	0.36	<0. 1[a]	<0. 1[a]	<0. 1[a]	<0. 1[a]	<0. 1[a]
Chromium	<3.3[a]	<3.3[a]	<3.3[a]	<3.3[a]	<3.3[a]	<3.3[a]
Molybdenum	8.5	11	8.7	8.3	7.6	8.9
Nickel	2.4	2.5	3.1	3.1	3.2	3.7
Selenium	2.5	3.8	2.6	2.7	1.7	<1.6[a]
Thallium	1.2	0.84	<0.55[a]	0.56	<0.55[a]	<0.55[a]
Vanadium	<2.4[a]	<2.4[a]	<2.4[a]	<2.4[a]	2.6	3.3

[a] Reported result is less than the DL and is therefore set equal to the DL.

3.2.2 Coldwater Creek Sediment Monitoring Results

During CY 2011, sediment sampling at Coldwater Creek was conducted during the months of March and October as part of the EMP. Sediment samples were collected in depositional environments near each of the six previously described surface-water locations (C002 through C007) (Figure 3-4) and analyzed according to the methods described in the SAG. Sediment samples, collected for the EMP, were evaluated for the radiological and metal constituents listed in Table 3-3 of the EMICY11 (USACE 2011).

All sediment monitoring required through implementation of the EMICY11 was conducted as planned during CY 2011 (USACE 2011). The evaluation of monitoring data demonstrates that all applicable ARARs have been met. Appendix D, Table D-2, presents the analytical results from these monitoring activities.

Radiological Parameters

The radiological results for CY 2011 Coldwater Creek sediment sampling events are presented in Table 3-9. The ROD (USACE 2005) established sediment RGs for Ra-226, Th-230, and U-238 at the NC Sites. Therefore, sediment sampling results for those radionuclides were compared against their corresponding RGs. Sediment samples from Coldwater Creek were not analyzed for U-234 during CY 2011, because U-234 is assumed to be in equilibrium with U-238.

Table 3-9. Radiological Results for CY 2011 Coldwater Creek Sediment Sampling

Monitoring Parameter	RGs[b]	Monitoring Stations					
		C002	C003	C004	C005	C006	C007
Radionuclide Concentration (picocuries per gram [pCi/g])							
First Sampling Event (March 31, 2011)							
Ac-227	No RG	<0.098[a]	<0.102[a]	<0.185[a]	<0.137[a]	<0.193[a]	<0.192[a]
Pa-231	No RG	<0.27[a]	<0.30[a]	<0.45[a]	<0.36[a]	<0.54[a]	<0.51[a]
Ra-226	15	0.866	0.733	1.11	1.16	1.31	1.27
Ra-228	No RG	0.27	0.39	0.85	0.56	0.86	0.87
Th-228[c]	No RG	0.26	0.55	1.37	0.61	1.92	1.39
Th-230[c]	43	1.49	0.89	2.65	3.94	9.72	3.30
Th-232[c]	No RG	<0.29[a]	0.64	0.85	0.63	1.63	0.93
U-235	No RG	<0.14[a]	<0.14[a]	<0.22[a]	<0.18[a]	<0.23[a]	<0.25[a]
U-238[d]	150	0.69	0.64	0.81	0.91	1.02	0.91
Second Sampling Event (October 11, 2011)							
Ac-227	No RG	<0.175[a]	<0.235[a]	<0.275[a]	<0.294[a]	<0.185[a]	<0.282[a]
Pa-231	No RG	<0.52[a]	<0.70[a]	<0.81[a]	<0.88[a]	<0.53[a]	<0.82[a]
Ra-226	15	0.847	1.15	1.31	1.46	0.902	1.35
Ra-228	No RG	0.28	0.79	0.96	0.94	0.48	0.81
Th-228[c]	No RG	0.37	1.79	1.33	0.61	0.54	1.32
Th-230[c]	43	1.13	1.93	3.76	3.42	1.23	2.84
Th-232[c]	No RG	0.39	1.22	1.10	0.87	0.82	0.95
U-235	No RG	<0.21[a]	<0.29[a]	<0.34[a]	<0.35[a]	<0.23[a]	<0.36[a]
U-238[d]	150	0.56	0.74	1.02	1.25	0.52	1.12

[a] Reported result is less than the MDC and is therefore set equal to the MDC.
[b] RGs presented in the ROD (USACE 2005).
[c] Both gamma-spec and alpha spec results produced; alpha-spec results reported.
[d] U-238 and U-234 assumed to be in equilibrium.

All sediment data results were below the RGs established by the ROD. The historical radiological sediment sampling information for all monitoring stations since 2001 is summarized in Table 3-10.

<u>Chemical Parameters</u>

Chemical monitoring results for CY 2011 Coldwater Creek sediment sampling events are presented in Table 3-11.

3.2.3 Impact of FUSRAP Coldwater Creek Remedial Action on Total Uranium Concentrations in Coldwater Creek Surface Water and Sediment

As part of the FUSRAP RA at the SLAPS, sediment and soil were removed from the bed and banks of Coldwater Creek near monitoring stations C002 and C003 during August 2004. An evaluation was conducted to determine if the SLAPS RA resulted in increased levels of uranium in Coldwater Creek. The concentrations of radionuclides in sediment and surface-water samples from various stations along Coldwater Creek were assessed. Radionuclide data from surface-water and sediment samples collected from March 2000 to March 2004 were used to create a baseline for comparison with sample results collected after the RA.

Table 3-10. Comparison of Historical Radiological Sediment Results for Coldwater Creek

Stations	Radionuclide	Units	03/01	10/01	03/02	08/02	04/03	10/03	03/04	10/04	03/05	10/05	03/06	09/06	03/07	10/07	04/08	11/08	03/09	10/09	03/10	10/10	03/11	10/11
C002	Total U[b]	pCi/g	<1.5[a]	<1.1[a]	0.48	0.42	1.5	3.9	1.8	1.1	0.91	0.93	1.2	1.7	0.97	1.1[c]	1.7	0.73	0.80	0.89	1.3	1.3	1.4	1.1
	Ra-226	pCi/g	0.50	0.06	0.86	1.0	0.88	0.93	0.99	0.89	0.92	0.69	0.74	0.72	0.97	<0.37[a,c]	1.0	0.85	0.75	1.07	0.71	0.95	0.87	0.85
	Ra-228	pCi/g	0.18	0.15	0.22	0.19	0.21	0.24	0.28	0.16	0.26	0.26	0.22	0.29	0.20	0.18	0.20	0.17	0.20	0.24	0.30	0.33	0.27	0.28
	Th-228	pCi/g	0.41	0.37	0.33	0.92	0.58	0.38	0.49	0.40	0.51	0.61	0.75	0.67	0.26	0.24[c]	0.53	0.41	0.50	0.35	0.46	0.44	0.26	0.37
	Th-230	pCi/g	0.48	0.83	1.52	<0.71[a]	0.67	0.81	1.0	1.0	0.78	0.98	1.1	1.3	1.2	0.84[c]	0.92	1.1	0.51	1.2	0.67	1.2	1.5	1.1
	Th-232	pCi/g	0.26	0.15	0.31	0.45	0.19	0.17	0.12	<0.27[a]	<0.26[a]	0.41	0.30	0.22	0.46	<0.24[a,c]	0.24	<0.26[a]	0.28	0.31	0.53	0.21	<0.29[a]	0.39
C003	Total U[b]	pCi/g	<2.0[a]	<1.9[a]	0.63	0.98	1.4	3.3	1.8	0.85	1.6	2.0	1.4	1.4	1.2	2.0[c]	1.9	2.3	1.2	2.9	0.72	1.7	1.4	1.5
	Ra-226	pCi/g	0.68	0.84	0.78	1.4	0.72	0.96	0.81	0.92	1.0	1.5	1.1	1.3	1.5	1.7[c]	1.1	1.1	0.79	1.4	0.98	1.1	0.73	1.2
	Ra-228	pCi/g	0.41	0.82	0.32	0.73	0.30	0.25	0.38	0.33	0.59	0.86	0.45	0.38	0.68	0.49	0.49	0.57	0.40	1.0	0.44	0.36	0.39	0.79
	Th-228	pCi/g	0.98	0.96	0.45	1.1	1.3	0.47	0.74	0.57	1.1	0.92	1.2	0.34	0.97	0.53[c]	0.70	0.66	0.64	1.1	0.85	0.42	0.55	1.79
	Th-230	pCi/g	3.6	1.9	1.3	2.3	1.4	0.81	2.4	3.3	3.5	1.5	2.6	3.8	1.2	1.5[c]	2.1	2.3	1.2	1.5	1.0	1.1	0.89	1.9
	Th-232	pCi/g	0.67	0.93	<0.31[a]	0.7	0.35	0.14	0.35	0.41	0.75	0.71	0.69	0.43	0.38	0.46[c]	0.51	0.57	0.34	0.73	0.43	0.17	0.64	1.22
C004	Total U[b]	pCi/g	<2.5[a]	<1.1[a]	0.62	0.71	2.1	5.2	2.9	1.6	2.1	2.1	1.6	1.9	2.7	7.3[c,d]	2.0	2.3	2.0	3.3	1.8	2.6	1.8	2.0
	Ra-226	pCi/g	0.85	0.99	0.9	1.4	1.0	1.1	0.93	1.1	1.0	1.3	1.2	1.2	1.3	1.6[c]	1.0	1.0	0.97	1.3	1.3	1.5	1.1	1.3
	Ra-228	pCi/g	1.0	0.96	0.32	0.83	0.82	0.90	0.83	0.72	0.85	0.87	0.83	0.74	0.80	0.81	0.70	1.0	0.73	0.85	0.62	0.81	0.85	0.96
	Th-228	pCi/g	1.8	1.3	0.42	0.96	0.94	1.4	1.7	1.6	0.99	1.1	0.9	0.93	1.7	1.3[c]	1.2	1.4	0.83	1.1	0.90	1.2	1.4	1.3
	Th-230	pCi/g	2.6	1.6	3.0	1.3	1.7	1.6	2.4	1.4	2.0	2.2	2.2	2.1	2.6	2.2[c]	2.0	1.0	1.7	2.0	2.2	1.6	2.7	3.8
	Th-232	pCi/g	1.5	0.96	1.0	0.81	0.99	0.84	1.0	0.92	0.82	0.86	1.0	0.85	0.79	0.97[c]	1.3	0.80	0.82	1.0	0.77	1.0	0.85	1.1
C005	Total U[b]	pCi/g	<3.2[a]	<1.4[a]	0.71	1.1	2.4	5.4	2.2	1.8	3.3	2.0	2.3	2.0	0.94	2.0[c]	2.0	3.6	1.6	2.8	1.6	3.6	1.8	2.5
	Ra-226	pCi/g	1.4	0.73	1.2	1.9	1.7	2.2	1.3	1.9	1.6	1.8	1.4	1.4	1.7	1.6[c]	1.1	5.4	1.0	1.4	1.5	2.5	1.2	1.5
	Ra-228	pCi/g	0.98	0.23	0.4	0.55	0.66	0.74	0.53	0.53	0.85	0.73	0.78	0.53	0.98	0.58	0.78	1.1	0.31	0.86	0.73	0.88	0.56	0.94
	Th-228	pCi/g	1.1	0.38	0.73	1.2	1.2	1.3	0.98	0.79	0.99	0.95	1.5	1.0	1.5	0.68[c]	0.98	1.7	0.50	1.3	0.92	0.96	0.61	0.61
	Th-230	pCi/g	19	3.2	3.6	14	8.7	23	3.8	3.5	8.4	4.5	11	11	4.7	3.7[c]	6.6	82.6	4.2	9.6	2.2	19.6	3.9	3.4
	Th-232	pCi/g	0.98	0.29	0.21	0.86	1.0	0.69	0.57	0.20	0.43	0.57	1.3	0.77	1.6	0.45[c]	0.98	1.4	0.50	0.87	0.65	1.1	0.63	0.87
C006	Total U[b]	pCi/g	<2.7[a]	<1.6[a]	0.91	0.69	1.8	4.8	1.0	1.9	2.6	1.8	2.7	2.3	2.9	2.3[c]	1.7	1.8	2.1	0.75	1.9	2.2	2.0	1.0
	Ra-226	pCi/g	0.93	0.90	1.2	1.3	1.3	1.1	1.1	1.1	1.2	1.3	1.3	1.3	1.4	0.94[c]	1.0	1.4	1.0	1.1	1.7	1.7	1.3	0.90
	Ra-228	pCi/g	0.79	0.95	0.85	0.86	0.87	0.86	0.94	0.74	0.94	1.0	0.74	0.92	0.97	0.93	0.88	0.98	0.82	0.99	0.88	0.88	0.86	0.48
	Th-228	pCi/g	1.1	1.3	1.5	1.2	1.2	1.7	1.6	2.0	1.4	1.2	0.92	2.0	0.99	1.6[c]	1.7	0.94	1.5	1.6	1.0	0.82	1.9	0.54
	Th-230	pCi/g	4.0	2.8	2.9	1.4	1.7	3.7	3.2	3.1	2.2	2.1	2.8	3.2	1.8	2.7[c]	3.4	2.2	2.2	2.6	2.0	4.1	9.7	1.2
	Th-232	pCi/g	1.2	1.5	0.91	0.84	1.0	1.2	0.79	0.64	1.3	0.98	1.3	0.85	1.1	1.4[c]	1.1	1.2	1.1	0.97	0.80	0.71	1.6	0.82
C007	Total U[b]	pCi/g	<2.6[a]	<2.0[a]	1.3	1.2	2.4	6.0	0.90	0.99	2.8	1.6	2.1	1.9	2.0	2.3[c]	1.4	2.3	1.9	2.6	2.2	1.7	1.9	2.4
	Ra-226	pCi/g	1.1	0.99	1.2	1.6	1.1	1.3	1.4	1.5	1.1	1.5	1.3	1.5	1.9	1.1[c]	1.1	1.4	1.1	1.3	1.4	1.4	1.3	1.4
	Ra-228	pCi/g	0.95	0.73	0.85	0.74	0.85	0.95	1.1	0.90	0.87	0.90	0.99	0.87	0.79	0.84	0.69	0.89	0.77	0.77	0.82	0.73	0.87	0.81
	Th-228	pCi/g	1.9	1.5	1.6	1.1	1.4	1.5	2.1	1.4	0.79	1.2	1.2	1.0	1.2	1.5[c]	0.73	0.67	1.1	0.66	1.0	0.78	1.4	1.3
	Th-230	pCi/g	5.8	9.3	2.8	4.7	2.8	4.2	2.0	3.5	5.6	2.9	3.8	2.8	19	4.6[c]	3.8	3.6	3.6	2.3	2.6	4.4	3.3	2.8
	Th-232	pCi/g	0.95	1.1	1.1	0.74	0.79	0.66	1.4	0.94	0.98	1.4	1.1	0.84	1.2	0.83[c]	0.55	0.72	1.00	0.57	1.04	0.72	0.93	0.95

[a] Reported result is less than the MDC and is therefore set equal to the MDC.
[b] Total U is equal to the sum of the concentrations of U isotopes (Office of the Federal Register, NARA 1998).
[c] Both gamma-spec and alpha-spec results produced, for Table 3-11 gamma-spec results reported.
[d] The 7.3 pCi/g value for total U obtained on 10/07 from C004 was a typographical error and the result should be reported as 1.3.

Table 3-11. Chemical Results for CY 2011 Coldwater Creek Sediment Sampling

Monitoring Parameter	Monitoring Stations					
	C002	C003	C004	C005	C006	C007
Target Analyte List Metals Concentration (milligrams per kilogram [mg/kg])						
First Sampling Event (March 31, 2011)						
Antimony	<1.6[a]	2.2	3.3	2.1	<2.9[a]	2.6
Arsenic	5.3	3.8	6.7	5.8	4.5	5.5
Barium	22.1	123	194	113	149	160
Cadmium	0.28	0.79	0.9	1.4	1.1	0.98
Chromium	4.1	50.8	32.8	55.9	26.0	23.9
Molybdenum	<2.5[a]	<2.9[a]	<3.3[a]	<2.7[a]	<4.6[a]	<3.4[a]
Nickel	3.3	12.8	20.0	14.1	18.1	20.7
Selenium	<1.3[a]	1.5	2.2	1.4	<2.3[a]	2.3
Thallium	<3.8[a]	<4.3[a]	<5.0[a]	<4.1[a]	<6.9[a]	<5.1[a]
Vanadium	4.9	14.8	30.1	17.5	26.2	26.0
Second Sampling Event (October 11, 2011)						
Antimony	3.3	<1.8[a]	2.1	3.3	<1.5[a]	<2.7[a]
Arsenic	7.5	3.2	8.0	7.9	3.5	6.7
Barium	441	67.5	183	193	63.7	158
Cadmium	<0.65[a]	<0.14[a]	0.40	0.71	0.67	0.43
Chromium	92.1	13.5	29.6	25.7	10.2	20.0
Molybdenum	3.1	<2.8[a]	<3.1[a]	<3.6[a]	<2.3[a]	<4.2[a]
Nickel	14.5	14.7	20.0	23.9	11.5	21.4
Selenium	<6.5[a]	<1.4[a]	<1.5[a]	<1.8[a]	<1.2[a]	<2.1[a]
Thallium	<19.5[a]	<4.2[a]	<4.6[a]	<5.5[a]	<3.5[a]	<6.4[a]
Vanadium	16.0	19.0	26.0	28.1	15.1	24.1

[a] Reported result is less than the DL and is therefore set equal to the DL.

Methodology

Total U results from surface-water and sediment samples from the six monitoring stations (C002 through C007) for 2011 were compared to the 2000 to 2004 dataset for this evaluation. Total U was selected for this evaluation because it is among the most mobile of all the radionuclide COCs present at the SLAPS.

Figure 3-5 presents qualitative trend line graphs of total U results from surface-water samples collected at monitoring stations C002 through C007 from March 2000 to October 2011. This figure also shows the mean, 95 percent upper confidence limit (UCL_{95}), and 95 percent lower confidence limit (LCL_{95}) concentrations of total U calculated from the March 2000 to March 2004 dataset.

Figure 3-6 presents qualitative trend line graphs of total U results from sediment samples collected at monitoring stations C002 through C007 from March 2000 to October 2011. This figure also shows the mean, UCL_{95}, and LCL_{95} concentrations of total U calculated from the March 2000 to March 2004 dataset.

The total U concentration statistics for surface water and sediment in Coldwater Creek for 2000 through 2004 are presented in Table 3-12.

Table 3-12. Total U Concentration Statistics for Coldwater Creek (2000-2004)

Stations	Statistics for Total U in Surface Water March 2000 to March 2004 data (pCi/L)			Statistics for Total U in Sediment March 2000 to March 2004 data (pCi/g)		
	UCL_{95}	Mean	LCL_{95}	UCL_{95}	Mean	LCL_{95}
C002	4.2	3.1	1.9	1.7	1.4	1.1
C003	3.8	3.3	2.7	1.9	1.5	1.0
C004	4.5	3.4	2.3	2.3	1.7	1.2
C005	4.1	3.0	1.9	2.8	2.4	2.0
C006	8.2[a]	5.0	[b]	3.0	2.4	1.8
C007	4.7	3.4	0.75	2.5	1.9	1.3

[a] March 2000 to March 2004 data are gamma distributed. Therefore, approximate gamma upper confidence limit (UCL) used.
[b] LCL_{95} not calculated due to gamma distributed data.

Conclusion

The data could suggest two hypotheses. First, the post-RA sampling results were not significantly below the pre-RA sampling results for downstream stations at the SLAPS (C003 through C007), so it is unlikely that total U on the SLAPS was causing a significant contribution to Coldwater Creek. The RA over time should markedly reduce the total U load in Coldwater Creek if the SLAPS were a significant contributor. While a time lag in the fate downstream could occur, the current total U concentrations are already low. Second, the RA within Coldwater Creek did not adversely impact concentrations of total U in Coldwater Creek surface water or sediment. Had the RA contributed adversely, an excessive short-term increase in total U concentrations could have been observed.

4.0 EVALUATION OF GROUND-WATER MONITORING DATA

Nineteen ground-water monitoring wells were sampled at the NC Sites during CY 2011. Ground water was sampled following protocol for individual wells and analytes and was analyzed for various radiological constituents and inorganic analytes. Static water levels were measured quarterly at the retained monitoring wells. In addition, field parameters were measured continuously during purging of the wells before sampling. The static water levels and other ground-water field parameter results for CY 2011 sampling are presented in Appendix E, Tables E-1 and E-2. Summary tables providing the NC Sites ground-water analytical sampling results for CY 2011 are found in Appendix E, Tables E-3 and E-4.

Ground-Water Guidelines

The CY 2011 ground-water monitoring data for the NC Sites are compared to the ROD ground-water monitoring guidelines listed in Tables F-1 and F-2 in Appendix F of this EMDAR. The ROD ground-water monitoring guidelines (i.e., ROD guidelines) for the NC Sites are based on requirements specified in the ROD (USACE 2005) and are further explained in Sections 4.1.1 and 4.2.1.

Stratigraphy at the North St. Louis County Sites

The stratigraphic units present at the NC sites are shown in the stratigraphic column presented in Figure 4-1. Fill and topsoil (Unit 1) overlie Pleistocene loess (Unit 2) and glaciolacustrine deposits. The glaciolacustrine sediments consist of Subunit 3T (silty clay), Subunit 3M (moderately to highly plastic clay), Subunit 3B (silty clay), and Unit 4 (clayey and sandy gravel). Beneath these unconsolidated deposits, the bedrock is composed of Mississippian limestone (Unit 6). Stratigraphic Unit 5, Pennsylvanian shale bedrock, is not present at the HISS or Futura but is found directly overlying Unit 6 under portions of the SLAPS.

4.1 LATTY AVENUE PROPERTIES

The Latty Avenue Properties include the HISS, Futura, and eight Latty Avenue VPs (VPs 01L through 06L, 40A, and Parcel 10K530087). The ground-water monitoring wells at the Latty Avenue Properties are located on or immediately adjacent to the HISS and Futura.

Stratigraphy at the Latty Avenue Properties

Four HZs (HZ-A through HZ-C, and HZ-E) have been identified at the Latty Avenue Properties. The shallow ground-water zone, HZ-A, consists of the fine-grained silts and clays of Unit 1, Unit 2, and Subunit 3T. Underlying HZ-A is HZ-B, which consists of a highly impermeable clay (Subunit 3M). HZ-C consists of silty clay, clayey silt, and clayey gravel deposits that make up the stratigraphic Subunit 3B and Unit 4. The Mississippian limestone bedrock is defined as HZ-E. HZ-E is the protected aquifer for the site. As a result of their very low permeability, Subunits 3M and 3B limit vertical ground-water movement between HZ-A and the deep ground-water zones (HZ-C and HZ-E) at the Latty Avenue Properties.

Summary of CY 2011 Ground-Water Monitoring Results at the Latty Avenue Properties

Based on an evaluation of the ground-water data at the Latty Avenue Properties, three inorganic soil COCs (arsenic, molybdenum, and selenium) and three radiological analytes (U-234, U-238, and total U) were detected at concentrations above the ROD guidelines in HZ-A ground water at the Latty Avenue Properties in CY 2011. However, molybdenum does not exceed its ROD guideline when measurement error is taken into account. The concentration of one of the inorganic soil COCs, arsenic in HW22, has been above the ROD guideline for more than 12 months. The concentration of selenium at HISS-06A was above the ROD ground-water guideline during the first two CY 2011 sampling events but fell below the guideline during the third quarter of CY 2011; therefore selenium at HISS-06A has not been above the ROD ground-water guideline for more than 12 months. In addition, the three radiological COCs (U-234, U-238, and total U) have been above the ROD guidelines for more than a 12-month period in HZ-A ground water at HISS-01, based on previous sampling results. Because a significant degrading of Coldwater Creek surface water has not occurred, there is currently no finding of significantly degraded ground-water conditions in HZ-A ground water.

Based on the CY 2011 results and associated measurement errors, one well (HW23) had concentrations of U-234 (4.81 pCi/L) exceeding the ROD ground-water guideline (3.8 pCi/L) in HZ-C ground water during CY 2011. It has exceeded the ROD guideline for more than 12-months, based on the previous sampling results (5.5 pCi/L in September 2010). However, U-234 does not exceed its ROD guideline when measurement error is taken into account, and the total U concentration is not above the monitoring guideline of 30 μg/L. In addition, a significant degrading of Coldwater Creek surface water has not occurred. Therefore, there is currently no finding of significantly degraded ground-water conditions in HZ-C ground water. An evaluation of potential response actions is not required.

4.1.1 Evaluation of Ground-Water Monitoring Data at the Latty Avenue Properties

The ground-water monitoring data for the Latty Avenue Properties are evaluated against the requirements for ground-water monitoring identified in the ROD (USACE 2005). The ROD specifies two types of ground-water monitoring guidelines: 1) response-action monitoring guidelines and 2) a total U monitoring guideline (which is used for both response-action and long-term monitoring). Response-action monitoring of HZ-A and HZ-C is being conducted to assure that the RA does not degrade current ground-water conditions. Another purpose of the response-action ground-water monitoring of HZ-C is to document the protection of the limestone aquifer (HZ-E) during the RA.

The response-action monitoring guideline is two times the UCL_{95}, based on historical concentrations of the analyte in a particular well before RAs were initiated under the ROD. The response-action monitoring guidelines have been developed for the ROD soil COCs for each of the wells at the Latty Avenue Properties. The methodology for the development of the response-action monitoring guidelines is detailed in Appendix F of this document. The total U guideline is defined in the ROD to be equal to the total U maximum contaminant level of 30 μg/L (USACE 2005). If total U levels exceed 30 μg/L, monitoring would continue subject to a five-year review.

In addition to the above, an evaluation of concentration trends over time is conducted for the COCs detected above the ROD guidelines in ground water to support assessment of the effectiveness of the RA in the CERCLA five-year reviews.

Monitoring Well Network at the Latty Avenue Properties

The CY 2011 EMP well network for the Latty Avenue Properties is shown in Figure 4-2. Seven ground-water monitoring wells were decommissioned at HISS/Futura in CY 2011. Two wells, HISS-06 and HISS-05D, were decommissioned because they had become damaged during remediation activities conducted at the HISS in early CY 2010. A replacement well for HISS-06 (HISS-06A) was installed in February 2011. Five additional wells (HISS-09, HISS-14, HISS-15, HISS-18S, and HW21) were decommissioned in CY 2011 because they were no longer needed for response-action monitoring. In addition, a new monitoring well, HISS-11A, was installed to allow for interim monitoring immediately downgradient of Futura Building Number 4. HISS-11A was installed near the former location of HISS-11 and is screened across the same interval (HZ-A). With the exception of monitoring well HW23, which is screened in HZ-C, the monitoring wells are screened in HZ-A. The screened HZs for the ground-water monitoring wells at the Latty Avenue Properties are identified in Table 4-1.

Ground-water sampling was conducted at nine ground-water monitoring wells at the Latty Avenue Properties during CY 2011. First quarter sampling was conducted on January 28 and March 28; second quarter sampling was conducted on June 7; third quarter sampling was conducted on August 25 and 29; and fourth quarter sampling was conducted on November 15.

Table 4-1. Screened HZs for Ground-Water Monitoring Wells at the Latty Avenue Properties During CY 2011

Well ID	Screened HZs
HISS-01	HZ-A
HISS-05D[a]	HZ-C
HISS-06[a]	HZ-A
HISS-06A[b]	HZ-A
HISS-09[a]	HZ-A
HISS-10	HZ-A
HISS-11A[b]	HZ-A
HISS-14[a]	HZ-A
HISS-15[a]	HZ-A
HISS-17S	HZ-A
HISS-18S[a]	HZ-A
HISS-19S	HZ-A
HW21[a]	HZ-A
HW22	HZ-A
HW23	HZ-C

[a] HISS-05D, HISS-06, HISS-09, HISS-14, HISS-15, HISS-18S, and HW21 were decommissioned in CY 2011.

[b] HISS-06A and HISS-11A were installed in CY 2011.

<u>HZ-A Ground Water</u>

Ground-water samples were collected from eight HZ-A wells during CY 2011. Summary tables presenting the analytical data for all analytes are included in Appendix E.

For response-action monitoring, the CY 2011 ground-water data were evaluated to determine if ground-water conditions have significantly degraded. Continued monitoring of HZ-A could be required long term if significantly degraded ground-water conditions are found. Based on the ROD, a significantly degraded ground-water condition requires all of the following:

1) that soil COC concentrations have statistically increased in ground water (relative to the well's historic data and accounting for uncertainty) for more than a 12-month period. Significantly increased concentrations are defined as doubling of an individual COC concentration above the upper confidence limit (UCL) of the mean (based on the historical concentration before RA) for a period of 12 months;

2) that the degraded well is close enough to impact Coldwater Creek; and

3) that a significant degrading of Coldwater Creek surface water is anticipated.

The CY 2011 results were compared to the ROD ground-water guidelines for the soil COCs identified in the ROD (i.e., antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, total U, vanadium, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, and U-238). Table 4-2 lists those soil COCs with concentrations above the ROD ground-water guidelines in HZ-A ground-water samples at the Latty Avenue Properties during CY 2011. Because no ground-water sampling data is available for HISS-06A and HISS-11A prior to CY 2011, the ROD ground-water guidelines for HISS-06A and HISS-11A were developed using the pre-2006 data from the wells previously at these locations (HISS-06 and HISS-11, respectively).

Table 4-2. Analytes Exceeding ROD Ground-Water Criteria in HZ-A Ground Water at the Latty Avenue Properties During CY 2011

Analyte	Units	Station	ROD Ground-Water Guidelines[a]	Minimum Detected	Maximum Detected	Mean Detected	# Detects > ROD Ground-Water Guidelines[a]
Arsenic	µg/L	HW22	2.4	112	139	126	2
Molybdenum	µg/L	HW22	3.4	6.4[b]	7.5[b]	7.0[b]	2
Selenium	µg/L	HISS-06A	770	618	951	802	2
U-234	pCi/L	HISS-01	12	15.7	15.7	15.7	1
U-235[c]	pCi/L	HISS-01	---	0.7	0.7	0.7	0
U-238	pCi/L	HISS-01	13	15.5	15.5	15.5	1
Total U[d]	µg/L	HISS-01	30	46.6	46.6	46.6	1

[a] ROD ground-water guidelines include the response-action monitoring guidelines and the total U monitoring guideline of 30 µg/L. Response-Action Monitoring Guideline = 2 x UCL_{95}, based on historical concentrations before RAs were initiated (USACE 2005).
Results are reported to two significant digits.
[b] The concentrations of molybdenum in HW22 are not above the ROD guideline when the measurement error (5 µg/L) is taken into account.
[c] The results for U-235 do not exceed the ROD ground-water criteria. The U-235 results are provided because they were used in the Total U calculation.
[d] Total U values were calculated from isotopic concentrations in pCi/L and converted to µg/L using radionuclide specific activities using the following formula: Total U (µg/L) = U-234(pCi/L)/6240 + U-235 (pCi/L)/2.16 + U-238 (pCi/L)/0.335.
Shaded cells represent results that do not exceed ROD ground-water criteria.
--- No monitoring guideline due to lack of detected results in historical dataset.

Three inorganic soil COCs were detected at concentrations above the ROD guidelines in HZ-A ground water at the Latty Avenue Properties: arsenic (HW22), molybdenum (HW22), and selenium (HISS-06A). The concentrations of molybdenum in HW22 are not above the ROD guidelines when measurement error is taken into account. The concentration of selenium at HISS-06A was above the ROD ground-water guideline during the first and second quarter CY 2011 sampling events but was below the guideline during the third quarter of CY 2011. Therefore, concentrations of selenium at HISS-06A have not been above the ROD ground-water guideline for more than 12 months. The concentrations of arsenic at HW22 were above the ROD ground-water guidelines during the two sampling events conducted at HW22 in CY 2011, as well as in the previous two CY 2010 and two CY 2009 sampling events. Therefore, concentrations of arsenic at HW22 have been above the ROD ground-water guidelines for more than 12 months. Because a significant degrading of Coldwater Creek surface water has not occurred, there is currently no finding of significantly degraded ground-water conditions in HZ-A ground water.

Concentrations of the radiological COCs U-234 and U-238 were above the ROD ground-water guidelines in HZ-A ground water at the Latty Avenue Properties in CY 2011. The concentrations of U-234 and U-238 were above the ROD ground-water guidelines in HISS-01 during the third quarter sampling event conducted at HISS-01 in CY 2011, as well as in the previous CY 2010 and CY 2009 sampling events. Therefore, U-234 and U-238 have exceeded the ROD ground-water guidelines for more than 12 months at HISS-01.

The ROD ground-water guideline for total U (30 µg/L) is used for both response-action and long-term monitoring of ground water at the Latty Avenue Properties. Total U concentrations were compared to the 30 µg/L monitoring guideline. Total U concentrations (in µg/L) were calculated as follows from the isotopic results (in pCi/L) and the specific activities (in pCi/µg) for each radionuclide.

$$TotalU\left(\mu g/L\right) = \left[\frac{U^{234}\left(pCi/L\right)}{6240\left(pCi/\mu g\right)}\right] + \left[\frac{U^{235}\left(pCi/L\right)}{2.16\left(pCi/\mu g\right)}\right] + \left[\frac{U^{238}\left(pCi/L\right)}{0.335\left(pCi/\mu g\right)}\right]$$

Total U concentrations in samples collected from HISS-01 again exceeded the 30 µg/L monitoring guideline creating an exceedance period of more than 12 months. Based on trend analysis, total U concentrations have shown a statistically significant increase at HISS-01 from CY 1999 to CY 2011. However, Coldwater Creek surface-water sampling results for CY 2011, presented in Section 3.2, indicate there has not been an increase in total U concentrations. Therefore, there is currently no finding of significantly degraded ground-water conditions in HZ-A ground water at the Latty Avenue Properties.

In summary, comparison of the data to the ROD ground-water guidelines indicate that one inorganic soil COC (arsenic) and three radiological COCs (U-234, U-238, and total U) exceeded the ROD ground-water guidelines for a period of at least 12 months. However, because a significant degrading of Coldwater Creek surface water has not occurred, there is currently no finding of significantly degraded ground-water conditions in HZ-A ground water.

<u>HZ-C Ground Water</u>

Ground-water samples were collected from one HZ-C well, HW23, during CY 2011. It was sampled once for radionuclides (third quarter) during CY 2011. Table 4-3 lists those radiological soil COCs with concentrations above the ROD ground-water guidelines in HZ-C ground-water samples at the Latty Avenue Properties during CY 2011.

One radiological COC, U-234, was detected above its ROD ground-water guideline in CY 2011 in ground-water samples from HW23. However, when measurement error is taken into account, the result is not above the ROD ground-water guideline. The total U concentration in HW23 (9.3 µg/L, calculated from the isotopic concentrations) did not exceed the total U monitoring guideline of 30 µg/L. Therefore, because COCs are not present at significantly increased concentrations and total-U concentrations are not above 30 µg/L in HZ-C, there is no finding of significantly degraded ground-water conditions in HZ-C.

Table 4-3. Analytes Exceeding ROD Ground-Water Criteria in HZ-C Ground Water at the Latty Avenue Properties During CY 2011

Analyte	Units	Station	ROD Ground-Water Criteria[a]	Minimum Detected	Maximum Detected	Mean Detected	# Detects > ROD Ground-Water Criteria[a]
U-234	pCi/L	HW23	3.8	4.8[b]	4.8[b]	4.8[b]	1
U-235[c]	pCi/L	HW23	---	0.06	0.06	0.06	0
U-238[c]	pCi/L	HW23	3.2	3.1	3.1	3.1	0
Total U[d]	µg/L	HW23	30	9.3	9.3	9.3	0

[a] ROD ground-water guidelines include the response-action monitoring guidelines and the total U monitoring guideline of 30 µg/L. Response-action monitoring guideline = 2 x UCL_{95}, based on historical concentrations before RAs were initiated (USACE 2005). Results are reported to two significant digits.
[b] The concentration of U-234 in HW23 is not above the ROD guideline when the measurement error (1.6 pCi/L) is taken into account.
[c] The results for U-235, U-238, and Total U do not exceed the ROD ground-water criteria. The results are provided because they were used in the Total U calculation.
[d] Total U values were calculated from isotopic concentrations in pCi/L and converted to µg/L using radionuclide specific activities using the following formula: Total U (µg/L) = U-234(pCi/L)/6240 + U-235 (pCi/L)/2.16 + U-238 (pCi/L)/0.335.
--- No monitoring guideline due to lack of detected results in historical dataset.
Shaded cells represent results that do not exceed ROD ground-water criteria.

In summary, the CY 2011 HZ-C ground-water data from the Latty Avenue Properties indicate that one analyte, U-234, was detected at concentrations above its ROD ground-water guideline in HZ-C ground water. However, because the U-234 does not exceed its ROD guideline when measurement error is taken into account and the total U concentration is not above the monitoring guideline of 30 µg/L, there is currently no finding of significantly degraded ground-water conditions in HZ-C ground water. An evaluation of potential response actions is therefore not required.

4.1.2 Comparison of Historical Ground-Water Data at the Latty Avenue Properties

Ground-water sampling has been conducted at the Latty Avenue Properties from CY 1984 to the present. The most comprehensive ground-water monitoring program, involving sampling from 18 monitoring wells, was conducted at the site in the summer of CY 1997. Results from subsequent sampling events were used to evaluate contaminant trends at the Latty Avenue Properties during the period from the first quarter of CY 1999 to the fourth quarter of CY 2011. Statistical analysis was used to assist with identifying trends for those contaminants that exceeded the ROD ground-water guidelines during CY 2011.

<u>Statistical Method and Trend Analysis</u>

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) and because a seasonal variation in concentrations was not indicated by the time-versus-concentration plots at the NC Sites. 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 detection limit (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 at the NC Sites 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 ≤ 10, then the p-value is computed. If the p value ≤ 0.05, the test concludes that the trend is statistically significant. If the p value is > 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 ± 1.65, which is the comparison level at a 95 percent confidence level. If the Z-score is greater than +1.65, the test concludes that a significant upward trend exists. If the Z-score is less than -1.65, the test concludes that a significant downward trend exists. For Z-scores between -1.65 and 1.65, there is no evidence of a significant trend.

The results of the Mann-Kendall trend test are less reliable for datasets containing a high number of nondetects, particularly if the DL changes over time. For that reason, for datasets where more than 50 percent of the time-series data is 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 a large number of nondetects.

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 radiological 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 whether the trend is due to inherent error associated with the analytical test method for each sample analysis. This methodology graphs the data and the associated error-bar for the specific constituent. Time-concentration plots for total U in HISS-01 and arsenic and molybdenum in HW22 are provided in Figures 4-3 and 4-4, respectively.

<u>Results of Trend Analysis for Ground Water at the Latty Avenue Properties</u>

For those stations at which an analyte exceeded the ROD ground-water monitoring guideline at least once during the year and for which sufficient historical data were available to evaluate trends (i.e., at least six samples), statistical trend analysis was conducted to assess whether concentrations of the analyte are increasing (upward trending) or decreasing (downward trending) over time. For the purposes of this trend analysis, a statistically significant trend in concentration is defined as a trend with a confidence level greater than 95 percent. The confidence level denotes the probability that the indicated trend is an actual trend in the data, rather than a result of the random nature of environmental data.

HZ-A Ground Water

The Mann-Kendall trend test was performed for those wells in which analytes exceeded the ROD ground-water monitoring guidelines at least once during CY 2011, for which sufficient data was available (i.e., at least six samples were collected during the period from the first quarter of CY 1999 to the fourth quarter of CY 2011), and at which the percentage of non-detect results is ≤ 50 percent. However, for HW22, the time period was limited to CY 2003 through CY 2011 in order to obtain a dataset for which less than 50 percent of the results were non-detect. Six analytes, (arsenic and molybdenum in HW22, selenium in HISS-06A, and U-234, U-238, and total U in HISS-01) were above the ROD ground-water guidelines in HZ-A ground water at the Latty Avenue Properties during CY 2011.

Inorganics

Statistical trend analysis using the Mann-Kendall trend test was conducted to confirm whether concentrations of arsenic and molybdenum are increasing or decreasing over time in HW22. The arsenic concentrations for the first quarter (139 µg/L) and third quarter (112 µg/L) CY 2011 samples from HW22 are above the ROD ground-water guideline for arsenic (2.4 µg/L). As shown in Table 4-4, an increasing trend in arsenic concentrations was observed for HW22 for the period between January 2003 and December 2011. Figure 4-4 provides the time-versus-concentration plot for arsenic in HW22. The molybdenum concentrations for the first quarter (7.5 µg/L) and third quarter (6.4 µg/L) CY 2011 samples from HW22 are above the ROD ground-water guideline for molybdenum (3.4 µg/L). An increasing trend in molybdenum concentrations was observed for HW22 for the period between January 2003 and December 2011. 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, a time-versus-concentration plot for molybdenum in HW22 (Figure 4-4) was used to evaluate these factors. The graph also shows the best-fit trend line based on the data scatter. When measurement error is taken into account, there is no trend in molybdenum concentrations at HW22. The graph also indicates that the molybdenum concentrations at HW22 during CY 2011 were not above the ROD guideline when associated measurement errors were taken into account. There were less than six samples in the dataset for selenium at HISS-06A. Therefore, a trend analysis was not conducted for selenium in HISS-06A.

Table 4-4. Results of Mann-Kendall Trend Test[a] for Analytes With Concentrations Above the ROD Ground-Water Criteria in Ground Water at the Latty Avenue Properties During CY 2011

Analyte	Station	N[b]	Test Statistics[c]		Trend[d]
			S	Z	
Arsenic	HW22	11	35	2.79	Upward Trend
Molybdenum	HW22	11	28	2.22	Upward Trend
Total U	HISS-01	27	93	1.92	Upward Trend

[a] One-tailed Mann-Kendall trend tests were performed at a 95-percent level of confidence.
[b] N is the number of unfiltered ground-water sample results for a particular analyte at a well within a specified time period. With the exception of HW22, the time period is between January 1999 and December 2011. For HW22, the dataset was restricted to the period between January 2003 and December 2011 in order to meet the Mann-Kendall trend test requirement that the dataset have a detection frequency greater than 50 percent.
[c] Test Statistics: S – the S-Statistic; Z – Z-score, or normalized test statistic (for datasets having N>10).
[d] Trend: If N>10, the Z-score is compared to ±1.65 to determine trend significance.

Radionuclides

The time-versus-concentration plots shown in Figure 4-3 provide an overview of the temporal and spatial variability in the concentrations of total U in ground water at the Latty Avenue Properties. Total U concentrations were calculated using the isotopic U results in pCi/L and were converted to µg/L using radionuclide-specific activities. The reported values were used for detected and non-detected isotopic values, except in instances when the value was negative. If the reported value was negative, a value equal to zero was substituted for the result prior to calculating the total U concentration. Three radiological analytes, (U-234, U-238, and total U) were detected at concentrations above the ROD ground-water guidelines in HZ-A well HISS-01 at the Latty Avenue Properties during CY 2011. A trend analysis was performed for the total U concentrations for HISS-01. Because the 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. As shown in Table 4-4, a statistically significant increasing trend in total U concentrations was identified for HISS-01. Based on the time-versus-concentration plot for HISS-01 in Figure 4-3, the concentrations were relatively stable prior to 2009, and increased abruptly in February 2009, possibly as a result of the remedial action conducted in adjacent areas during this period. Concentrations have since declined from a high of 337 µg/L on May 29, 2009, to 46.6 µg/L on August 29, 2011.

HZ-C Ground Water

A sample from one HZ-C well, HW23, was above the ROD ground-water guideline for U-234 during CY 2011. However, total U concentrations did not exceed the 30 µg/L monitoring guideline in this well. A trend analysis was not conducted for U-234, because the frequency of non-detected results exceeds 50 percent. Based on the time-versus-concentration plot for total U shown in Figure 4-3, there is no trend in total U concentrations at HW23. Therefore, based on the historical data and the time-versus-concentration plots, there were no significant changes in total U concentrations in HZ-C ground water during CY 2011.

4.1.3 Evaluation of the Potentiometric Surface at the Latty Avenue Properties

Ground-water surface elevations were measured at the Latty Avenue Properties in March, June, August, and November of CY 2011. The potentiometric surface maps for HZ-A and HZ-C created from the June 1 and November 14, 2011, ground-water elevation measurements are provided in Figures 4-5, 4-6, 4-7, and 4-8. The ground-water surface elevations at the Latty Avenue Properties and the SLAPS and SLAPS VPs were mapped on the same figures because these areas are in the same ground-water flow regime.

The top of the saturated zone occurs in the low hydraulic conductivity silts and clays of stratigraphic Units 2 and 3T at the Latty Avenue Properties. The potentiometric data indicate near-radial potentiometric surface contour patterns for the HZ-A ground water at the HISS and Futura. Wells HISS-01, HISS-10, and HISS-17S, located near the center of the site, have the highest potentiometric surface elevations, with lower ground-water elevations measured in the surrounding wells. At the western edge of the site, ground water in the HZ-A zone flows to the west toward Coldwater Creek. The local horizontal gradient for HZ-A ground water at the HISS and Futura ranged from 0.0029 ft/ft (June) to 0.0016 ft/ft (November) in CY 2011.

The potentiometric surface of the HZ-C ground water at the Latty Avenue Properties is not well defined due to the limited data available for the deeper HZs. Based on measured ground-water elevations in the HZ-C monitoring well HW23 at the Latty Avenue Properties and several HZ-C wells located to the southwest at the SLAPS and SLAPS VPs, the flow direction in the HZ-C ground water is generally toward the east or northeast. The local horizontal gradient for HZ-C ranged from 0.0034 ft/ft (June) to 0.0036 ft/ft (November) in CY 2011. This is similar to the gradient in CY 2010, which ranged from 0.0031 ft/ft (May) to 0.0036 ft/ft (December).

4.2 ST. LOUIS AIRPORT SITE AND ST. LOUIS AIRPORT SITE VICINITY PROPERTIES

Summary of CY 2011 Ground-Water Monitoring Results at the St. Louis Airport Site and St. Louis Airport Site Vicinity Properties

Four soil COCs (chromium at B53W09S and B53W13S; molybdenum at B53W13S; nickel at B53W13S, PW43, and PW46; and total U at PW46) were above the ROD ground-water guidelines in HZ-A ground water at the SLAPS and SLAPS VPs in CY 2011. However, chromium at B53W09S; molybdenum at B53W13S; and nickel at PW46 did not exceed their ROD guidelines if the associated measurement errors are taken into account. Nickel concentrations at B53W13S were above the ROD ground-water guideline during all three sampling events conducted at B53W13S in CY 2011 and also were above the guideline in the previous sampling events conducted in CY 2010; therefore, nickel concentrations at B53W13S have been above the ROD ground-water monitoring guideline for more than 12 months. The nickel concentration at PW43 was above the ROD ground-water monitoring guideline in CY 2011 but not in CY 2010 if the associated measurement error is taken into account. None of the remaining inorganic soil COCs have been above the ROD guidelines for more than 12 months. Total U concentrations were above the total U guideline of 30 µg/L in one HZ-A well (PW46) located at the SLAPS and have been above the guideline for a period of at least 12 months. However, based on trend analysis, concentrations of total U have not statistically increased in PW46.

Because a significant degrading of Coldwater Creek surface water has not occurred, there is currently no finding of significantly degraded ground-water conditions in HZ-A ground water at the SLAPS and SLAPS VPs in CY 2011. However, because nickel and total U levels have been above the ROD ground-water monitoring guidelines for a period of at least 12 months, monitoring will continue subject to subsequent five-year reviews.

No contaminants exceeded the ROD criteria in HZ-C through HZ-E ground water. Because no soil COCs have statistically increased in ground water (relative to the well's historic data and accounting for uncertainty) for more than a 12-month period, there is currently no finding of significantly degraded ground-water conditions in HZ-C through HZ-E ground water at the SLAPS and SLAPS VPs.

Stratigraphy at the St. Louis Airport Site and St. Louis Airport Site Vicinity Properties

Ground-water monitoring wells have been installed at the SLAPS and SLAPS VPs to characterize the site stratigraphy, ground-water chemistry, and ground-water migration pathways. In the vicinity of the SLAPS and the adjacent ballfields, surficial deposits (Unit 1) include topsoil and anthropogenic fill (rubble, scrap metal, gravel, glass, slag, and concrete) generally less than 14 ft thick (Figures 4-1, 4-9, and 4-10). Unit 2 is comprised of loess and has a thickness of 11 to 30 ft. Unit 3, which is subdivided into Subunits 3T, 3M, and 3B, consists primarily of clay and silt lakebed deposits. Each of these clayey subunits has a thickness of up to 30 ft. Unit 4 consists of clayey gravel with fine to very-fine sand and sandy gravel. This unit is interpreted to be approximately 5 to 15 ft thick and thins eastward and westward of the SLAPS. This unit is absent beneath the eastern part of the SLAPS, where the 3T, 3M, and 3B drape, or onlap, onto shale bedrock. Below Units 3 and 4 are Units 5 and 6, which consist of Pennsylvanian shale/siltstone and Mississippian limestone, respectively. Depth to bedrock ranges from approximately 55 ft on the eastern part of the SLAPS to a maximum of 90 ft toward Coldwater Creek to the west. The hydrogeologic and geologic setting at the SLAPS and SLAPS VPs is similar to that at the HISS, with one exception. The Pennsylvanian shale bedrock unit (Unit 5) present beneath portions of the SLAPS and SLAPS VPs is absent beneath the HISS.

Five HZs (HZ-A through HZ-E) are recognized beneath the SLAPS and SLAPS VPs. HZ-A consists of fill (Unit 1) and the Pleistocene, glacially related sediments of stratigraphic Unit 2, and Subunit 3T. Underlying HZ-A is HZ-B, which consists of highly impermeable clay (Subunit 3M). HZ-C consists of the stratigraphic Subunit 3B and Unit 4. The shale (Unit 5) and limestone (Unit 6) bedrock are recognized as HZ-D and HZ-E, respectively. HZ-E is the protected aquifer for the site.

The shallow (HZ-A) ground-water flow is toward Coldwater Creek under normal flow conditions. Average depths to the ground-water surface at the site range from near the ground surface during the spring months to approximately 10 ft below ground surface during the fall months. The dominant flow in HZ-A is through the more permeable Unit 2. Each of the subunits in Unit 3 has lower hydraulic conductivity than Units 1, 2, and 4. Units HZ-B and the Pennsylvanian shale, HZ-D, limit the passage of ground water vertically beneath the SLAPS and SLAPS VPs. Subunit 3M of HZ-B acts as a vertical barrier to ground-water movement under the western portion of the site. Subunit 3M is a clayey aquitard (unit resisting water passage) that effectively separates the HZ-A ground-water system from the underlying HZ-C and HZ-E. The dominant unit to obtain water in the lower horizon is the sandy, clayey gravel of Unit 4. Unit 4 of HZ-C is used as a surrogate for HZ-E, as water movement within the Mississippian limestone is dependent upon the limestone's joint and solutioned system. In addition, the limestone has exhibited massive characteristics and is very slow to recharge.

4.2.1 Evaluation of Ground-Water Monitoring Data at the St. Louis Airport Site and St. Louis Airport Site Vicinity Properties

The purpose of the ground-water monitoring conducted at the SLAPS and SLAPS VPs is specified in the ROD (USACE 2005). Response-action monitoring is currently being conducted in HZ-A and HZ-C to assess the improvement of water quality due to source removals and to document the protection of the limestone aquifer (HZ-E) during the RA.

As noted in Section 4.1.1, the ground-water monitoring data at the SLAPS and SLAPS VPs are evaluated against the requirements for ground-water monitoring identified in the ROD (USACE 2005).

In addition to the above, an evaluation of concentration trends is conducted for the COCs detected above ROD ground-water guidelines in ground water to support assessment of the effectiveness of the RA in the CERCLA five-year reviews.

Monitoring Well Network at the St. Louis Airport Site and St. Louis Airport Site Vicinity Properties

The current EMP well network for the SLAPS and SLAPS VPs is shown in Figure 4-11. A summary of the HZ information for the ground-water monitoring wells located at the SLAPS and

SLAPS VPs is provided in Table 4-5. HZ-A is considered the upper (or shallow) zone, while HZ-C, HZ-D, and HZ-E have been considered the lower (or deep) zone. This designation of upper and lower zones is separated at Subunit 3M of HZ-B. Fourteen wells are screened exclusively across the shallow zone (HZ-A). Four wells are screened exclusively in the lower zone across HZ-C, HZ-D, and/or HZ-E. The remaining well (PW36) is screened across both HZ-B and HZ-C.

Table 4-5. Ground-Water Monitoring Well Network at the SLAPS and SLAPS VPs During CY 2011

Well ID	Screened HZs			
	HZ-A	**HZ-B**	**HZ-C**	**HZ-E**
B53W01D			X	
B53W01S	X			
B53W06S	X			
B53W07D			X	
B53W07S	X			
B53W09S	X			
B53W13S	X			
B53W17S	X			
B53W18S	X			
B53W19S	X			
MW31-98	X			
MW32-98	X			
PW35				X
PW36		X	X	
PW42			X	
PW43	X			
PW44	X			
PW45	X			
PW46	X			

During CY 2011, 10 ground-water wells were sampled for various parameters at the SLAPS and SLAPS VPs. Ground-water samples collected from these wells were analyzed for both radiological and inorganic constituents. Historically, radiological parameters (Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, and U-238) and inorganic constituents have been the main focus of the ground-water sampling. In CY 2011, ground-water sampling was conducted on March 21 and 22 (first quarter); June 1 and 2 (second quarter); August 23 and 24 (third quarter); and November 14, 15, and 16 (fourth quarter).

HZ-A Ground Water

Eight HZ-A wells were sampled at the SLAPS and the adjacent ballfields during CY 2011 (B53W06S, B53W07S, B53W09S, B53W13S, B53W17S, MW31-98, PW43, and PW46). The analytical data for the CY 2011 ground-water sampling at the SLAPS and SLAPS VPs are provided in Table E-4 in Appendix E.

The CY 2011 results were compared to ROD ground-water guidelines for the soil COCs identified in the ROD (i.e., antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, total U, vanadium, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, and U-238). Table 4-6 lists those soil COCs exceeding the ROD ground-water guidelines in CY 2011 ground-water samples from HZ-A wells at the SLAPS and SLAPS VPs.

Table 4-6. Analytes Exceeding ROD Ground-Water Criteria in HZ-A Ground Water at the SLAPS and SLAPS VPs During CY 2011

Analyte	Units	Station	ROD Ground-Water Guidelines[a]	Minimum Detected	Maximum Detected	Mean Detected	# Detects > ROD Ground-Water Guidelines[a]
Chromium	µg/L	B53W09S	9.6	17.5[b]	17.5[b]	17.5[b]	1
		B53W13S	9.1	8	116	69	2
Molybdenum	µg/L	B53W13S	3.2	2[b]	5.1 [b]	3.6[b]	2
Nickel	µg/L	B53W13S	38	127	339	227	3
		PW43	3.6	16	16	16	1
		PW46	3.4	4.4[c]	4.4[c]	4.4[c]	1
U-234[d]	pCi/L	PW46	5,500	1,261	1,261	1,261	0
U-235[d]	pCi/L	PW46	290	73.5	73.5	73.5	0
U-238[d]	pCi/L	PW46	5,600	1,211	1,211	1,211	0
Total U[e]	µg/L	PW46	30	3,649	3,649	3,649	1

[a] ROD Ground-Water Guidelines = Response-Action Monitoring Guideline and Total U Monitoring Guideline. Response-Action Monitoring Guideline = 2 x UCL_{95} (based on historical concentrations before RAs were initiated). Total U Monitoring Guideline = 30 µg/L (USACE 2005).

[b] Chromium at B53W09S and molybdenum at B53W13S did not exceed their ROD guidelines if their associated measurement errors (10 µg/L chromium and 5 µg/L molybdenum) are taken into account.

[c] Nickel at PW46 did not exceed its ROD guidelines if the associated measurement error (5 µg/L) is taken into account.

[d] The results for U-234, U-235, and U-238 do not exceed the ROD ground-water criteria. The results are provided because they were used in the Total U calculation.

[e] Total U values were calculated from isotopic concentrations in pCi/L and converted to µg/L using radionuclide specific activities using the following formula: Total U (µg/L) = U-234(pCi/L)/6240 + U-235 (pCi/L)/2.16 + U-238 (pCi/L)/0.335.

Shaded cells represent results that do not exceed ROD ground-water criteria.

Three inorganic analytes (chromium, molybdenum, and nickel) were detected in HZ-A ground water at concentrations above the ROD guidelines at the SLAPS and SLAPS VPs. Chromium was detected in B53W09S in the third quarter but not above the ROD guideline if the associated measurement error is taken into account. Additionally, chromium was not detected in the B53W09S sample taken in the first quarter of CY 2010. Therefore, chromium concentrations in B53W09S did not exceed the guideline for more than 12 months. Chromium was also detected in B53W13S at concentrations above the ROD guideline of 9.1 µg/L in the first and second quarter samples (83.7 µg/L and 116 µg/L, respectively). The chromium concentration in B53W13S was not above the ROD guideline in the fourth quarter sampling event and thus did not exceed the guideline for more than 12 months. Molybdenum was detected in B53W13S at levels above the ROD guideline of 3.2 µg/L in the first and second quarter samples (5.1 µg/L and 3.8 µg/L, respectively). However, molybdenum concentrations are not above the ROD guideline in B53W13S if the associated measurement error is taken into account. The molybdenum concentration was not above the ROD guideline in the fourth quarter sampling event and thus did not exceed the guideline for more than 12 months. Nickel was detected in B53W13S, PW43, and PW46 at concentrations above the ROD guidelines during CY 2011. However, the nickel concentration is not above the ROD guideline in PW46 if the associated measurement error is taken into account. The nickel concentration at PW46 was below the ROD guideline in the CY 2010 sampling event and thus did not exceed the ROD guideline for a period of at least 12 months. At PW43, the nickel concentration was not above the ROD ground-water monitoring guideline in CY 2010 if the associated measurement error is taken into account and thus did not exceed the ROD guideline for a period of at least 12 months. Nickel concentrations were above the ROD guideline in all samples collected from B53W13S in CY 2010 and CY 2011. Therefore, the nickel concentration at B53W13S has been above the ROD guideline for a period of at least 12 months. In summary, comparison of the data to the ROD ground-water guidelines indicate that one inorganic soil COC, nickel, had concentrations greater than its ROD ground-water guideline for a period of at least 12 months. However, because a significant degrading of Coldwater Creek surface water has not occurred, there is currently no finding of significantly degraded ground-water conditions in HZ-A ground water.

One radiological contaminant (total U) exceeded the ROD guideline in HZ-A ground water at the SLAPS and SLAPS VPs. The total U concentration in PW46 (converted from pCi/L to µg/L using the isotopic concentrations and radionuclide-specific activities) exceeded the 30 µg/L guideline during the first quarter CY 2011 sampling event. The total U concentration in PW46 was 3,649 µg/L on March 21, 2011. PW46 is an RA evaluation well that was installed at the western edge of the SLAPS in April 2006. Although no ground-water sampling data is available for PW46 prior to May 18, 2006, data is available for the well previously at this location, PW38. The ROD ground-water guidelines for PW46 were developed using pre-2004 data from PW38. Based on the total U data collected in PW38 prior to its decommissioning in November 2003, the CY 2011 total U concentration at PW46 is lower than the historical concentrations reported at PW38. Based on the statistical evaluation of trends presented in Section 4.2.2, no increases in the concentrations of total U have occurred in PW46 during CY 2011. However, because the total U concentrations in PW46 have exceeded the total U guideline, monitoring will continue subject to the subsequent five-year reviews.

In summary, two inorganic contaminants, chromium and nickel (at B53W13S), were above the ROD ground-water guidelines in HZ-A ground water at the SLAPS and SLAPS VPs in CY 2011 if the associated measurement errors are taken into account. Only one of these inorganic contaminants, nickel at B53W13S, has been above the ROD guidelines for a period of at least 12 months. Total U concentrations were above the total U guideline of 30 µg/L in one HZ-A well (PW46) located at the SLAPS and have been above the guideline for a period of at least 12 months. However, comparison of their CY 2011 concentrations with historical well data did not indicate that significant degradation of HZ-A ground water is occurring. Because a significant degrading of Coldwater Creek surface water has not occurred, there is currently no finding of significantly degraded ground-water conditions in HZ-A ground water at the SLAPS and SLAPS VPs in CY 2011. However, because nickel and total U levels have been above the ROD ground-water monitoring guidelines for a period of at least 12 months, monitoring will continue subject to subsequent five-year reviews.

Lower, HZ-C Through HZ-E, Ground Water

Two wells (B53W07D and PW42) screened across lower ground water (HZ-C through HZ-E) were sampled at the SLAPS and SLAPS VPs during CY 2011. Comparison of the data to the ROD ground-water criteria indicate that no COCs were detected at levels above the ROD ground-water criteria in HZ-C through HZ-E ground water. Therefore, the CY 2011 HZ-C through HZ-E ground-water data from the SLAPS and SLAPS VPs does not indicate that significant degradation of lower ground water is occurring.

4.2.2 Comparison of Historical Ground-Water Data at the St. Louis Airport Site and St. Louis Airport Site Vicinity Properties

Results of ground-water sampling conducted between CY 1998 though CY 2011 indicated that various inorganics and radionuclides have been detected above their ROD ground-water guidelines in HZ-A ground water at the SLAPS and SLAPS VPs. Statistical analysis was used to identify trends for those contaminants that exceeded these criteria during CY 2011. The statistical method used to evaluate the trends, the Mann-Kendall trend test, is described in Section 4.1.2. Filtered data, split samples, and field duplicates were not included in the analysis. For datasets in which 50 percent or more of the time-series data are nondetect, the Mann-Kendall trend test was not performed.

Results of Trend Analysis at the St. Louis Airport Site and St. Louis Airport Site Vicinity Properties

The evaluation of historical trends for ground water at the SLAPS and SLAPS VPs focuses on those contaminants that exceeded the ROD ground-water guidelines in samples collected during CY 2011. For those monitoring wells where an analyte exceeded these guidelines in one or more samples during CY 2011 and the historical dataset had a detection frequency greater than 50 percent and a sample size of at least six, a statistical trend analysis was conducted to assess whether concentrations of the analyte are increasing (upward trending) or decreasing (downward trending) over time. For the purposes of this report, a statistically significant trend in concentration is defined as a trend with a confidence level greater than 95 percent. Because the Mann-Kendall trend test does not consider the effects of measurement error and does not provide any information concerning the magnitude of trends, time-concentration plots were used to evaluate these factors.

Based on the CY 2011 ground-water monitoring data for the SLAPS and SLAPS VPs, three soil COCs (chromium, nickel, and total U) exceeded their ROD ground-water guidelines in HZ-A ground water in CY 2011, if associated measurement errors are taken into account. To aid in the evaluation of trends, time-versus-concentration plots for chromium, nickel, and total U are provided in Figures 4-12 through 4-15. Due to the high percentage of nondetect values for nickel in PW43, the Mann-Kendall trend test could not be performed for this analyte. The Mann-Kendall trend test was performed for chromium in B53W09S and B53W13S, nickel in B53W13S, and total U in PW46.

Trend analysis was not performed for deep (HZ-C through HZ-E) ground water because no COCs exceeded the ROD ground-water criteria in deep ground water during CY 2011.

Inorganics

The Mann-Kendall trend test was performed for chromium (B53W09S and B53W13S) and nickel (B53W13S). The results of the Mann-Kendall trend tests are provided in Table 4-7. As shown in Table 4-7, a statistically significant increasing trend in chromium concentrations (i.e., a trend with a confidence level greater than 95 percent) was observed for B53W09S and B53W13S. In addition, a statistically significant increasing trend in nickel concentrations was observed for B53W13S. 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 chromium and nickel in B53W13S (Figure 4-13) and chromium in B53W09S (Figure 4-14) were used to evaluate these factors. The graphs also show the best-fit trend lines based on the data scatter. Figure 4-13 indicates that the chromium concentrations at B53W13S during the fourth quarter CY 2011 sampling event decreased from higher concentrations reported in the first and second quarters sampling events and were not above the ROD guideline. Figure 4-14 indicates that when the measurement error is taken into account, there does not appear to be a significant upward trend in the chromium concentrations in B53W09S.

Table 4-7. Results of Mann-Kendall Trend Test[a] for Analytes with Concentrations Above ROD Criteria in Ground Water at the SLAPS and SLAPS VPs During CY 2011

Analyte	Station	N[b]	Test Statistics[c]		Trend[d]
			S	Z	
Chromium	B53W09S	14	39	2.13	Upward Trend
	B53W13S	18	111	4.19	Upward Trend
Nickel	B53W13S	18	87	3.28	Upward Trend
Total U	PW46	12	2	0.07	No Trend

[a] One-tailed Mann-Kendall trend tests were performed at a 95-percent level of confidence.
[b] N is the number of unfiltered ground-water sample results for a particular analyte for the period between January 1999 and December 2011 for B53W09S and B53W13S and between May 2006 and December 2011 for PW46.
[c] Test Statistics: S – the S-Statistic; Z – Z-score, or normalized test statistic (used if N>10).
[d] Trend: If N>10, the Z-score is compared to ±1.64 to determine trend significance.

Radionuclides

A statistical evaluation of historical U concentrations has been conducted using total U concentrations. Total U values were calculated from isotopic concentrations in pCi/L and converted to µg/L using radionuclide specific activities. Figure 4-12 provides time-versus-concentration graphs for total U for some of the wells sampled in CY 2011 at the SLAPS and SLAPS VPs. The Mann-Kendall trend test was performed for total U in the one HZ-A well, PW46, having levels above the 30 µg/L ROD guideline in CY 2011. The results of the Mann-Kendall trend test are provided in Table 4-7. The Mann-Kendall trend test results indicate that there is no trend for total U in PW46. Figure 4-15 shows a graph of time versus total U concentrations for PW46. PW46 was installed in April 2006 near the former location of PW38 and is screened across the same interval. For comparison purposes, the graph of PW46 data on Figure 4-15 also shows the PW38 data collected between March 2000 and November 2003. The graph indicates that total U concentrations in PW46 have decreased from the levels reported at PW38 prior to installation of PW46.

4.2.3 Evaluation of Potentiometric Surface at the St. Louis Airport Site and St. Louis Airport Site Vicinity Properties

Ground-water surface elevations were measured from wells at the SLAPS and SLAPS VPs in March, June, August, and November of CY 2011. Ground-water elevation contours were drawn using the June 1, 2011, and November 14, 2011, measurements to provide a comparison of the ground-water flow conditions during periods of high and low ground-water elevations, respectively. The potentiometric surface maps, shown in Figures 4-5 through 4-8, were developed for both HZ-A and HZ-C ground-water zones. The ground-water flow direction is interpreted to be perpendicular to the ground-water equipotential contours.

The ground-water flow direction at the SLAPS and adjacent SLAPS VP IA-09 in June and November CY 2011 in the HZ-A ground water is northwesterly toward Coldwater Creek (Figures 4-5 and 4-7). In the eastern portion of the SLAPS, the average horizontal hydraulic gradient ranges from 0.008 ft/ft (June 1, 2011) to 0.012 ft/ft (November 14, 2011). The hydraulic gradient increases near Coldwater Creek, where the average horizontal gradient ranges from 0.034 ft/ft (June 1, 2011) to 0.021 ft/ft (November 14, 2011). The unconfined HZ-A ground water is interpreted to discharge into Coldwater Creek, which divides the HZ-A ground-water system south and east of the creek from areas north and west of Coldwater Creek. Ground-water recharge comes from three primary sources: precipitation, off-site inflow of ground water, and creek bed infiltration during high creek stage. Ground-water discharge could occur by seepage into Coldwater Creek during low creek stage (DOE 1994). The vertical gradient varies beneath the site and is influenced by stratigraphic heterogeneity and seasonal fluctuations in recharge and evapotranspiration. Based on the June and November 2011 water-level measurements, the position of the HZ-A ground-water surface averages approximately three feet higher in the corresponding shallow wells at the SLAPS and SLAPS VPs in the wet season (June) than in the dry season (November).

A review of the screened intervals in the deep wells indicates that many wells are screened across multiple lithologic units and HZs. Based on this review, the HZ-C (Units 3B and 4) potentiometric surface was determined to be a proper representation of the lower ground-water system. This review reduces the number of data points used to develop the potentiometric surface contours but results in a higher level of confidence in contouring the HZ-C potentiometric surface.

The potentiometric surface contours for the HZ-C ground water in CY 2011 are illustrated in Figures 4-6 and 4-8. The flow in HZ-C is generally east to northeast, at an average horizontal gradient of 0.003 ft/ft in June 2011 and 0.004 ft/ft in November 2011. A comparison of the ground-water elevations from monitoring well pairs indicates that the wells completed in HZ-A exhibit different hydraulic heads from the wells completed in HZ-C. Near Coldwater Creek, the potentiometric surface of the “confined” aquifer HZ-C (ranging in elevation between approximately 515 and 516 ft amsl) is higher than the potentiometric surface of the unconfined HZ-A zone, indicating an upward vertical gradient. In the southwestern portion of the SLAPS, the potentiometric maps indicate a downward hydraulic gradient. The large difference in hydraulic head demonstrates that the HZ-A and HZ-C ground-water zones are distinct ground-water systems with limited hydraulic connection. This is supported by the lithologic data, which indicate that a highly impermeable clay (Subunit 3M of HZ-B) and silty clay (Subunit 3B of HZ-C) separates the HZ-A ground-water system from the underlying ground-water zones. The HZ-C potentiometric surfaces do not appear to be influenced by Coldwater Creek (the creek’s thalweg is about 500 ft amsl) or by seasonal changes. These features are likely a result of the overlying clay layers limiting vertical ground-water movement.

THIS PAGE INTENTIONALLY LEFT BLANK

5.0 ENVIRONMENTAL QUALITY ASSURANCE PROGRAM

5.1 PROGRAM OVERVIEW

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

The environmental QA program provides 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. MDNR conducted site visits to observe 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 as follows:

- To provide data of sufficient quality and quantity to support ongoing remedial efforts, aid in defining potential COCs, meet the requirements of the EMG and the SAG, and support the ROD (USACE 1999a, 2000, 2005).
- 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 NC Sites 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 NC Sites.

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 structure for identified sampling/monitoring was delineated through programmatic documents such as the EMG for the NC Sites, which is an upper tier companion document to the SAG (USACE 2000). The EMICY11 document outlines the analyses to be performed at the NC Sites for various media (USACE 2011).

Flexibility to address non-periodic environmental sampling, such as 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 VII on a quarterly basis per the requirements of the Federal Facility Agreement.

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 in completing field logbooks, chain-of-custody forms, labels, and custody seals. Documentation of training and readiness were 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 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 (SAIC 2002). Data entered into the database may be flagged accordingly.

5.5 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits of both field and laboratory activities are 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 EMICY documents.

5.5.1 Field Assessments

Internal assessments (audit or surveillance) of field activities (sampling and measurements) are conducted by the QA/QC Officer (or designee). Assessments include an examination of field sampling records, field instrument operating records, sample collection, handling and packaging procedures, 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 system audits 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 VII, or the State of Missouri.

5.5.2 Laboratory Audits

The onsite laboratories are subject to USACE periodic review(s) by the local USACE Chemist to demonstrate compliance with the *Department of Defense Quality Systems Manual (DOD QSM)* Version 4.2 (DOD 2010). In conjunction, blind third-party performance evaluation studies (performance audits) are participated in at least twice per year, and results are reported to the local USACE point(s) of contact. In addition, contract laboratories are required to be an accredited laboratory under the Department of Defense (DOD) Environmental Laboratory Accreditation Program (ELAP). The DOD ELAP requires an annual audit and re-accrediation every three 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 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 QA Plan. These 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 are generated and provided to the local USACE authority – these reports document the ongoing QC elements and to allow further monitoring of quality processes/status. Also, QA Plans and methodology are to follow the guidance as presented in the *DOD QSM* (DOD 2010).

5.6 SUBCONTRACTED LABORATORY PROGRAMS

All samples collected during environmental monitoring activities were analyzed by USACE-approved laboratories. QA samples were collected for ground water and sediment, which 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 were also required to be an accredited laboratory under the DOD ELAP.

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

5.7 QUALITY ASSURANCE AND QUALITY CONTROL SAMPLES

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

5.7.1 Duplicate Samples

These samples, which measure precision, were collected by the sampling teams and were submitted for analysis to the on-site laboratory or contract laboratories. The identity of duplicate samples is held blind to the analysts. 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. Precision is measured by the relative percent difference (RPD) for radiological and non-radiological analyses or the normalized absolute difference (NAD) for radiological analyses.

The non-radiological analyses RPDs are presented in Tables 5-1 and 5-2. The radiological analyses RPDs and NADs are presented in Tables 5-3 through 5-5. See Section 5.9 for the evaluation process.

Table 5-1. Non-Radiological Duplicate Sample Analysis for CY 2011 – Ground Water

Sample Name	Antimony	Arsenic	Barium	Cadmium	Chromium
	RPD	RPD	RPD	RPD	RPD
CWC139130 / CWC139130-1	4.44	3.51	2.92	NC	NC
HIS138646 / HIS138646-1	NC	NC	1.68	NC	NC
SLA135305 / SLA135305-1	NC	8.00	0.33	**43.90**	22.61
SLA137283 / SLA137283-1	NC	NC	1.93	6.90	NC
	Molybdenum	**Nickel**	**Selenium**	**Thallium**	**Vanadium**
	RPD	**RPD**	**RPD**	**RPD**	**RPD**
CWC139130 / CWC139130-1	2.33	3.28	NC	NC	NC
HIS138646 / HIS138646-1	3.64	5.88	3.65	**46.45**	NC
SLA135305 / SLA135305-1	21.74	10.89	2.66	NC	NC
SLA137283 / SLA137283-1	**33.01**	4.26	3.41	NC	NC

NC Not calculated due to one or both concentrations being below DLs.
-1 Sample Duplicate
Boldface Values exceed the control limits. Values not in boldface are within control limits.

Table 5-2. Non-Radiological Duplicate Sample Analysis for CY 2011 – Sediment

Sample Name	Antimony	Arsenic	Barium	Cadmium	Chromium
	RPD	RPD	RPD	RPD	RPD
CWC139131 / CWC139131-1	NC	22.22	4.47	**57.14**	12.19
	Molybdenum	**Nickel**	**Selenium**	**Thallium**	**Vanadium**
	RPD	**RPD**	**RPD**	**RPD**	**RPD**
CWC139131 / CWC139131-1	NC	13.08	NC	NC	2.28

NC Not calculated due to one or both concentrations being below DLs.
-1 Sample Duplicate
Boldface Values exceed the control limits. Values not in boldface are within control limits.

Table 5-3. Radiological Duplicate Sample Analysis for CY 2011 – Ground Water

Sample Name	Radium-226		Radium-228		Thorium-228		Thorium-230	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
CWC139130 / CWC139130-1	NC	NA	*	*	NC	NA	NC	NA
HIS138646 / HIS138646-1	NC	NA	*	*	NC	NA	57.74	0.52
SLA137283 / SLA137283-1	NC	NA	*	*	83.66	0.64	NC	NA
SLA135305 / SLA135305-2	*	*	*	*	*	*	*	*
	Thorium-232		Uranium-234		Uranium-235		Uranium-238	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
CWC139130 / CWC139130-1	NC	NA	0.16	NA	NC	NA	81.03	0.75
HIS138646 / HIS138646-1	NC	NA	30.96	0.72	NC	NA	4.76	NA
SLA137283 / SLA137283-1	NC	NA	1.25	NA	NC	NA	1.20	NA
SLA135305 / SLA135305-2	*	*	*	*	*	*	*	*

NC Not calculated due to one or both concentrations being below DLs.
NA Not applicable; see RPD.
* Not calculated because either parent or split sample was not analyzed.
-1 Sample Duplicate

Table 5-4. Radiological Duplicate Sample Analysis for CY 2011 – Sediment

Sample Name	Thorium-228[a]		Thorium-230[a]		Thorium-232[a]	
	RPD	NAD	RPD	NAD	RPD	NAD
CWC139131 / CWC139131-1	24.47	NA	58.86	1.25	10.22	NA

NA Not applicable; see RPD.
-1 Sample Duplicate
[a] Results from alpha spectroscopy.

Table 5-5. Radiological Duplicate Sample Gamma Analysis for CY 2011 – Sediment

Sample Name	Actinium-227		Americium-241		Cesium-137		Potassium-40	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
CWC139131 / CWC139131-1	NC	NA	NC	NA	NC	NA	15.85	NA
	Protactinium-231		Radium-226		Radium-228		Thorium-228	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
CWC139131 / CWC139131-1	NC	NA	11.29	NA	**30.26**	**2.14**	**30.26**	**2.14**
	Thorium-230		Thorium-232		Uranium-235		Uranium-238	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
CWC139131 / CWC139131-1	NC	NA	**30.26**	**2.14**	NC	NA	0.99	NA

NC Not calculated due to one or both concentrations being below DLs
NA Not applicable; see RPD.
-1 Sample Duplicate
Boldface Values exceed the control limits. Values not in boldface are within control limits

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 radiological analytes.

The radiological analyses RPDs and NADs are presented in Tables 5-6 through 5-8. The non-radiological analysis RPDs are presented in Tables 5-9 and 5-10. The overall precision for the CY 2011 environmental monitoring sampling activities was acceptable. See Section 5.9 for the evaluation process.

Table 5-6. Non-Radiological Split Sample Analysis for CY 2011 – Ground Water

Sample Name	Antimony	Arsenic	Barium	Cadmium	Chromium
	RPD	RPD	RPD	RPD	RPD
CWC139130 / CWC139130-2	**48.65**	15.87	0.72	NC	NC
HIS138646 / HIS138646-2	NC	NC	13.80	NC	NC
SLA135305 / SLA135305-2	NC	**101.89**	7.56	22.22	16.42
SLA137283 / SLA137283-2	NC	NC	8.57	NC	NC
	Molybdenum	**Nickel**	**Selenium**	**Thallium**	**Vanadium**
	RPD	**RPD**	**RPD**	**RPD**	**RPD**
CWC139130 / CWC139130-2	23.35	**54.12**	**66.67**	NC	NC
HIS138646 / HIS138646-2	**32.84**	**96.30**	12.44	NC	NC
SLA135305 / SLA135305-2	14.74	5.77	15.05	**154.84**	NC
SLA137283 / SLA137283-2	8.00	**143.56**	**32.56**	NC	NC

NC Not calculated due to one or both concentrations being below DLs.
Boldface Values exceed the control limits. Values not in boldface are within control limits.
-2 Sample Split

Table 5-7. Non-Radiological Split Sample Analysis for CY 2011 – Sediment

Sample Name	Antimony	Arsenic	Barium	Cadmium	Chromium
	RPD	RPD	RPD	RPD	RPD
CWC139131 / CWC139131-2	**78.15**	**40.00**	**30.95**	**93.33**	**43.62**
	Molybdenum	**Nickel**	**Selenium**	**Thallium**	**Vanadium**
	RPD	**RPD**	**RPD**	**RPD**	**RPD**
CWC139131 / CWC139131-2	NC	5.13	NC	NC	7.41

NC Not calculated due to one or both concentrations being below DLs.
Boldface Values exceed the control limits. Values not in boldface are within control limits.
-2 Sample Split

Table 5-8. Radiological Split Sample Analysis for CY 2011 – Ground Water

Sample Name	Radium-226		Radium-228		Thorium-228		Thorium-230	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
CWC139130 / CWC139130-2	94.25	0.54	*	*	NC	NA	NC	NA
HIS138646 / HIS138646-2	NC	NA	*	*	NC	NA	127.94	0.91
SLA137283 / SLA137283-2	NC	NA	*	*	NC	NA	NC	NA
	Thorium-232		**Uranium-234**		**Uranium-235**		**Uranium-238**	
	RPD	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**
CWC139130 / CWC139130-2	NC	NA	33.27	0.46	NC	NA	48.71	0.55
HIS138646 / HIS138646-2	NC	NA	8.48	NA	21.43	NA	12.11	NA
SLA137283 / SLA137283-2	NC	NA	16.52	NA	NC	NA	35.21	0.55

NA Not applicable; see RPD.
* Not calculated because either parent or split sample was not analyzed.
-2 Sample Split

Table 5-9. Radiological Split Sample Alpha Analysis for CY 2011 – Sediment

Sample Name	Thorium-228		Thorium-230		Thorium-232	
	RPD	NAD	RPD	NAD	RPD	NAD
CWC139131 / CWC139131-2	42.92	0.77	70.02	1.69	39.13	0.66

NC Not calculated due to one or both concentrations being below DLs.
NA Not applicable; see RPD.
-2 Sample Split

Table 5-10. Radiological Split Sample Gamma Analysis for CY 2011 – Sediment

Sample Name	Actinium-227		Americium-241		Cesium-137		Potassium-40	
	RPD	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**
CWC139131 / CWC139131-2	NC	NA	NC	NA	NC	NA	0.70	NA
	Protactinium-231		**Radium-226**		**Radium-228**		**Thorium-228**	
	RPD	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**
CWC139131 / CWC139131-2	NC	NA	9.60	NA	11.36	NA	*	*
	Thorium-230		**Thorium-232**		**Uranium-235**		**Uranium-238**	
	RPD	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**
CWC139131 / CWC139131-2	*	*	11.36	NA	NC	NA	NC	NA

NC Not calculated due to one or both concentrations being below DLs.
NA Not applicable; see RPD.
* Not calculated because either parent or split sample was not analyzed.
-2 Sample Split

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. Because all of the monitoring wells have dedicated sampling equipment, equipment rinsate blanks were not employed to assess the effectiveness of the decontamination process, because it does not apply.

Sediment samples from Coldwater Creek are collected from each station using a clean sampling spoon. These spoons are segregated after use and decontaminated at the SLAPS field trailer according to Field Technical Procedure 405 *Cleaning and Decontaminating Sample Containers and Sampling Equipment* (SAIC 2000). Because the process of collecting sediment is below the surface of the water, a rinsate blank would not represent the wetted surface of the sampling spoon at the time of sample collection and, therefore, would not apply. The Coldwater Creek surface water samples are collected using new nitrile gloves and new laboratory sample containers. Therefore, equipment rinsate blanks for these samples are also not required.

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 USEPA regional or National Functional Guidelines or project-specific guidelines. General chemical data quality management guidance found in Engineer Regulation 1110-1-263 (USACE 1998c) 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 FUSRAP Site* (USACE 1999b). Data assessment guidance, to determine the usability of data from hazardous, toxic, and radioactive waste projects, was provided in Engineer Manual 200-1-6 (USACE 1997).

One hundred 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 that result from various QC failures; it does not determine data usability, nor does it include assignment of data qualifier 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 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 was validated.

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

The data evaluation process considers precision, accuracy, representativeness, completeness, comparability, and sensitivity. The following sub-sections will provide detail to the particular parameters and how the data was 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:

$$RPD = \left(\frac{[S - D]}{\frac{S+D}{2}} \right) x\ 100$$

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

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 for which 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 equal to or less than a value of 1.96. Neither equation is used when the analyte in one or both of the samples is not detected. In cases 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 5-3, 5-4, 5-5, 5-8, 5-9, and 5-10). Sample collection precision was measured in the laboratory by the analyses of duplicates. With the exception of a few outliers, which were qualified accordingly, the overall precision for the CY 2011 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 5-6 through 5-10). For this report, accuracy is measured through the use of the field split samples through a comparison of the prime laboratory results versus the results of an independent laboratory.

Representativeness expresses the degree to which data accurately and precisely represents 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 EMICY11; the sampling protocol from the SAG has been followed; and, analytical procedures were conducted within the bounds of the QAPP. The overall representativeness of the CY 2011 environmental monitoring sampling activities was acceptable for the media and the media's sampling previously listed in this document.

Comparability expresses the confidence with which one data set can be compared with 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. These most recent (post CY 1997) analytical data, however, may not be directly comparable to data collected before CY 1997 because of differences in DQOs. Some media, such as storm-water, and radiological monitoring have values that are primarily useful in the present and the comparison to historic data is not as relevant.

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 2011 environmental monitoring sampling activities, the data completeness was 100 percent (FUSRAP DQO for completeness is 90 percent).

Sensitivity is the determination of MDC values that allows the investigation to assess the relative confidence that can be placed in a value in comparison to the magnitude or level of analyte concentration observed. For this report, MDC is a term generically used to represent both the method detection limit (MDL) for non-radiologicals and the minimum detectable activity (MDA) for radiological analytes. The closer a measured value comes to the MDC, the less confidence and more variation the measurement will have. Project sensitivity goals were expressed as quantitation level goals in the 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 spec, 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 are desired that exceed the MDC of the analyte.

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 being less than desired but adequate for interpretation.

This data can withstand scientific scrutiny, is appropriate for its intended purpose, and is technically defensible. 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 5-11 through 5-14.

Table 5-11. Non-Radiological Parent Samples and Associated Duplicate and Split Samples (Ground Water) for CY 2011[a]

Sample Name[b]	Antimony			Arsenic			Barium			Cadmium			Chromium		
	Result	DL	VQ	Result	DL	VQ	Result	DL	VQ	Result	DL	VQ	Result	DL	VQ
CWC139130	2.30	1.70	=	2.90	0.95	=	139.00	0.20	=	0.10	0.10	U	3.30	3.30	U
CWC139130-1	2.20	1.70	=	2.80	0.95	=	135.00	0.20	=	0.10	0.10	U	3.30	3.30	U
CWC139130-2	1.40	0.72	=	3.40	0.61	=	140.00	0.22	=	0.27	0.27	U	0.94	0.32	=
HIS138646	1.70	1.70	U	0.95	0.95	U	95.80	0.20	=	0.10	0.10	U	3.30	3.30	U
HIS138646-1	1.70	1.70	U	0.95	0.95	U	94.20	0.20	=	0.10	0.10	U	3.30	3.30	U
HIS138646-2	0.72	0.72	U	0.85	0.61	=	110.00	0.22	=	0.27	0.27	U	0.32	0.32	U
SLA135305	1.70	1.70	U	1.30	0.95	=	302.00	0.20	=	0.50	0.10	=	83.70	3.30	=
SLA135305-1	1.70	1.70	U	1.20	0.95	=	303.00	0.20	=	0.32	0.10	=	66.70	3.30	=
SLA135305-2	0.96	0.72	J	4.00	0.24	=	280.00	0.43	J	0.40	0.11	=	71.00	0.13	J
SLA137283	1.70	1.70	U	0.95	0.95	U	257.00	0.20	J	0.14	0.10	=	3.30	3.30	U
SLA137283-1	1.70	1.70	U	0.95	0.95	U	262.00	0.20	J	0.15	0.10	=	3.30	3.30	U
SLA137283-2	0.72	0.72	U	1.30	0.61	=	280.00	0.22	=	0.27	0.27	U	0.70	0.32	=
	Molybdenum			**Nickel**			**Selenium**			**Thallium**			**Vanadium**		
	Result	**DL**	**VQ**	**Result**	**DL**	**VQ**	**Result**	**DL**	**VQ**	**Result**	**DL**	**VQ**	**Result**	**DL**	**VQ**
CWC139130	8.70	1.00	=	3.10	0.40	=	2.60	1.60	=	0.55	0.55	U	2.40	2.40	U
CWC139130-1	8.50	1.00	=	3.00	0.40	=	1.60	1.60	U	0.55	0.55	U	2.40	2.40	U
CWC139130-2	11.00	0.72	=	5.40	0.20	=	5.20	1.50	=	0.20	0.16	=	1.40	0.49	=
HIS138646	2.80	1.00	=	3.50	0.40	=	618.00	1.60	=	1.30	0.55	=	2.40	2.40	U
HIS138646-1	2.70	1.00	=	3.30	0.40	=	641.00	1.60	=	0.81	0.55	=	2.40	2.40	U
HIS138646-2	3.90	0.72	=	10.00	0.20	=	700.00	1.50	=	0.16	0.16	U	1.80	0.49	=
SLA135305	5.10	0.41	=	339.00	0.40	=	81.70	1.30	=	1.10	0.55	=	2.40	2.40	U
SLA135305-1	4.10	0.41	=	304.00	0.40	=	83.90	1.30	=	0.55	0.55	U	2.40	2.40	U
SLA135305-2	4.40	0.29	=	320.00	0.41	J	95.00	0.58	J	0.14	0.07	J	0.20	0.20	U
SLA137283	1.20	0.41	=	2.30	0.40	J	86.40	1.60	J	0.95	0.55	=	2.40	2.40	U
SLA137283-1	0.86	0.41	=	2.40	0.40	J	89.40	1.60	J	0.55	0.55	U	2.40	2.40	U
SLA137283-2	1.30	0.72	=	14.00	0.20	=	120.00	1.50	=	0.16	0.16	U	0.79	0.49	=

[a] Results are expressed in µg/L.
[b] Samples ending in "-1" are duplicate samples. Samples ending in "-2" are split samples.
Validation Qualifier (VQ) symbols indicate: "=" for positively identified results, "U" for not detected, and "J" analyte was identified as estimated quantity.

Table 5-12. Non-Radiological Parent Samples and Associated Duplicate and Split Samples (Sediment) for CY 2011[a]

Sample Name[b]	Antimony			Arsenic			Barium			Cadmium			Chromium		
	Result	DL	VQ	Result	DL	VQ	Result	DL	VQ	Result	DL	VQ	Result	DL	VQ
CWC139131	2.10	2.00	=	8.00	0.97	=	183.00	0.76	J	0.40	0.15	=	29.60	0.94	J
CWC139131-1	2.00	2.00	U	6.40	1.00	=	175.00	0.79	J	0.72	0.16	=	26.20	0.97	J
CWC139131-2	0.92	0.13	=	12.00	0.09	=	250.00	0.10	J	1.10	0.08	=	19.00	0.17	J
	Molybdenum			Nickel			Selenium			Thallium			Vanadium		
	Result	DL	VQ	Result	DL	VQ	Result	DL	VQ	Result	DL	VQ	Result	DL	VQ
CWC139131	3.10	3.10	U	20.00	0.69	=	1.50	1.50	U	4.60	4.60	U	26.00	3.80	=
CWC139131-1	3.20	3.20	U	22.80	0.71	=	1.60	1.60	U	4.80	4.80	U	26.60	4.00	=
CWC139131-2	1.10	0.56	=	19.00	0.30	=	1.40	0.33	=	0.18	0.11	=	28.00	0.11	=

[a] Results are expressed in µg/L.
[b] Samples ending in "-1" are duplicate samples. Samples ending in "-2" are split samples.
Validation Qualifier (VQ) symbols indicate: "=" for positively identified results, "U" for not detected, and "J" analyte was identified as estimated quantity.

Table 5-13. Radiological Parent Samples and Associated Duplicate and Split Samples (Ground Water) for CY 2011[a]

Sample Name[b]	Radium-226				Radium-228				Thorium-228				Thorium-230			
	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
CWC139130	0.64	0.74	0.58	J	*	*	*	*	0.21	0.30	0.49	UJ	0.45	0.42	0.49	U
CWC139130-1	-0.12	0.25	1.49	UJ	*	*	*	*	0.25	0.35	0.61	UJ	0.58	0.42	0.20	J
CWC139130-2	0.23	0.16	0.23	=	*	*	*	*	0.06	0.14	0.26	UJ	0.05	0.09	0.14	UJ
HIS138646	0.47	0.93	1.86	UJ	*	*	*	*	0.45	0.41	0.55	U	0.45	0.37	0.20	J
HIS138646-1	0.31	0.62	1.23	UJ	*	*	*	*	0.33	0.40	0.57	UJ	0.81	0.59	0.57	J
HIS138646-2	0.22	0.12	0.14	J	*	*	*	*	0.02	0.04	0.09	UJ	0.10	0.09	0.09	J
SLA137283	0.00	0.00	1.61	U	*	*	*	*	0.51	0.40	0.41	J	0.27	0.28	0.19	J
SLA137283-1	0.15	0.98	2.48	UJ	*	*	*	*	0.21	0.24	0.19	J	0.25	0.29	0.42	UJ
SLA137283-2	0.41	0.17	0.17	=	*	*	*	*	-0.01	0.18	0.41	UJ	0.03	0.18	0.38	UJ
SLA135305	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SLA135305-1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SLA135305-2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

	Thorium-232				Uranium-234				Uranium-235				Uranium-238			
	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
CWC139130	0.25	0.29	0.22	J	0.63	0.46	0.21	J	0.10	0.20	0.26	UJ	0.82	0.55	0.47	J
CWC139130-1	0.07	0.15	0.20	UJ	0.63	0.43	0.19	J	0.00	0.00	0.23	U	0.35	0.32	0.19	J
CWC139130-2	0.03	0.07	0.14	UJ	0.88	0.29	0.13	=	0.05	0.08	0.07	UJ	0.50	0.21	0.09	J
HIS138646	0.04	0.17	0.45	UJ	4.55	1.36	0.41	=	0.25	0.29	0.23	J	3.49	1.14	0.18	=
HIS138646-1	-0.05	0.10	0.57	UJ	3.33	1.03	0.16	=	0.00	0.00	0.20	U	3.66	1.10	0.16	=
HIS138646-2	0.00	0.01	0.09	UJ	4.18	0.69	0.12	=	0.31	0.18	0.11	J	3.94	0.66	0.09	=
SLA137283	0.10	0.21	0.41	UJ	1.61	0.74	0.43	=	-0.09	0.13	0.65	UJ	1.67	0.76	0.43	=
SLA137283-1	0.07	0.14	0.19	UJ	1.59	0.73	0.42	=	0.04	0.20	0.52	UJ	1.65	0.75	0.42	=
SLA137283-2	0.05	0.12	0.24	UJ	1.90	0.63	0.43	=	0.08	0.16	0.30	UJ	1.17	0.49	0.34	=
SLA135305	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SLA135305-1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SLA135305-2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

[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.

Validation Qualifier (VQ) symbols indicate: "=" for positively identified results, "U" for not detected, "J" analyte was identified as estimated quantity, and "UJ" analyte was not detected and had QC deficiencies.

* Not available because sample was not analyzed.

Table 5-14. Radiological Parent Samples and Associated Duplicate and Split Samples (Sediment) for CY 2011[a]

Sample Name[b]	Thorium-228[c]				Thorium-230[c]				Thorium-232[c]			
	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
CWC139131	1.33	0.58	0.30	=	3.76	1.11	0.14	=	1.10	0.51	0.14	=
CWC139131-1	1.04	0.54	0.29	J	2.05	0.80	0.16	J	0.99	0.52	0.16	J
CWC139131-2	0.86	0.20	0.08	=	1.81	0.31	0.05	=	0.74	0.18	0.04	=
	Actinium-227				Americium-241				Cesium-137			
	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
CWC139131	-0.02	0.18	0.28	UJ	0.03	0.04	0.05	UJ	0.02	0.02	0.04	UJ
CWC139131-1	-0.04	0.15	0.23	UJ	0.00	0.03	0.04	UJ	0.03	0.02	0.03	UJ
CWC139131-2	-0.05	0.14	0.65	UJ	0.13	0.14	0.23	UJ	0.02	0.05	0.09	UJ
	Potassium-40				Protactinium-231				Radium-226			
	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
CWC139131	14.30	1.19	0.27	=	0.34	0.52	0.81	UJ	1.31	0.36	0.07	=
CWC139131-1	12.20	1.00	0.21	=	0.14	0.44	0.66	UJ	1.17	0.32	0.06	=
CWC139131-2	14.40	2.00	0.80	=	1.00	1.10	2.50	UJ	1.19	0.23	0.18	=
	Radium-228				Thorium-228				Thorium-230			
	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
CWC139131	0.96	0.09	0.11	=	0.96	0.09	0.11	=	-0.13	3.54	5.19	UJ
CWC139131-1	0.70	0.07	0.09	=	0.70	0.07	0.09	=	-0.23	3.67	4.25	UJ
CWC139131-2	1.07	0.26	0.24	=	*	*	*	*	*	*	*	*
	Thorium-232				Uranium-235				Uranium-238			
	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
CWC139131	0.96	0.09	0.11	=	-0.12	0.21	0.34	UJ	1.02	0.45	0.51	=
CWC139131-1	0.70	0.07	0.09	=	-0.02	0.19	0.30	UJ	1.01	0.52	0.42	J
CWC139131-2	1.07	0.26	0.24	=	-0.25	0.53	0.63	UJ	0.79	0.62	1.80	U

[a] Results are expressed in pCi/g. 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.
[c] Results from alpha spectroscopy.
Validation Qualifier (VQ) symbols indicate: "=" for positively identified results, "U" for not detected, "J" analyte was identified as estimated quantity, and "UJ" analyte was not detected and had QC deficiencies.
* Not available because sample was not analyzed.

6.0 RADIOLOGICAL DOSE ASSESSMENT

This section evaluates the cumulative dose to a hypothetically impacted individual from exposure to radiological contaminants at the NC Sites and documents dose trends. The regulatory dose limit for members of the public is 100 mrem/yr as stated in 10 *CFR* 20.1301. Although 10 *CFR* 20.1301 is not an ARAR for the NC Sites, USACE has provided this evaluation to assess public exposures from FUSRAP cleanup operations. Compliance with the dose limit in §20.1301 can be demonstrated in one of the two following ways [§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 NC Sites FUSRAP cleanup operations does not exceed the annual dose limit (i.e., 100 mrem/yr); 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 2 of Appendix B to Part 20; and (*ii*) if an individual were continuously present in an unrestricted area, the dose from external sources would not exceed 2 millirem per hour.

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

Dose calculations are presented for hypothetical maximally exposed individuals at Latty Avenue Properties, the SLAPS and SLAPS VPs, and Coldwater Creek. The monitoring data used in the dose calculations are reported in the respective environmental monitoring sections of this report.

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 NC Sites FUSRAP CY 2011 Radionuclide Emissions NESHAP Report.

6.1 SUMMARY OF ASSESSMENT RESULTS AND DOSE TRENDS

- The TEDE from Latty Avenue Properties and SLAPS VP-31A to a hypothetical maximally exposed individual from all complete/applicable pathways combined was <0.1 mrem/yr, estimated for an individual who works full time at a location approximately 50 meters west of the HISS perimeter.
- The TEDE from the SLAPS and SLAPS VPs to a hypothetical, maximally exposed individual from all complete/applicable pathways combined was <0.1 mrem/yr, estimated for an individual who works full time at a location approximately 500 meters west-southwest from the center of the SLAPS loadout area.
- The TEDE from Coldwater Creek to a hypothetical, maximally exposed individual from all complete/applicable pathways combined was 0.2 mrem/yr, estimated for a youth spending time as a recreational user of Coldwater Creek.

Figure 6-1 documents annual dose trends from CY 2000 to CY 2011 at the NC Sites. Figure 6-2 provides a comparison of the maximum annual dose from CY 2000 to CY 2011 at each of the NC Sites to the annual average background dose of 300 mrem/yr.

6.2 PATHWAY ANALYSIS

Table 6-1 lists the six complete pathways for exposure from 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 site. Of the six complete pathways, four were applicable in CY 2011 and were thus incorporated into radiological dose estimates.

Table 6-1. Complete Radiological Exposure Pathways for the NC Sites

Exposure Pathway	Pathway Description	Applicable to CY 2011 Dose Estimate		
		SLAPS	HISS	Coldwater Creek
Liquid A	Ingestion of ground water from local wells down-gradient from the site.	N	N	N
Liquid B	Ingestion of fish inhabiting Coldwater Creek.	NC	NC	N
Liquid C	Ingestion of surface water[a] and sediments.	NC	NC	Y[b]
Airborne A	Inhalation of particulates dispersed through wind erosion and RAs.	Y	Y	NC
Airborne B	Inhalation of Rn-222 and decay products emitted from contaminated soils/wastes.	Y	Y	NC
External	Direct gamma radiation from contaminated soils/wastes.	Y	Y	N

a Surface water includes storm-water run-off from NC Sites, MSD discharges, and the water in Coldwater Creek.
b The pathway is only applicable to a recreational receptor (youth) exposed to contaminants present in Coldwater Creek water and sediments. Data from NC Sites storm-water discharges and MSD discharges are not applicable to the hypothesized recreational receptor; therefore, that data is not evaluated in this section.
NC Not a complete pathway for the respective site.
N 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 whether a potential for exposure was present during CY 2011. If a potential exposure was determined to be possible, the pathway is termed applicable. Only applicable pathways are considered in estimates of dose.

Table 6-1 shows the pathways that are applicable to the CY 2011 dose estimates for NC Sites including Coldwater Creek. The pathways that are not complete were not considered in the dose assessment and are only listed in Table 6-1 because they were complete for at least one receptor location. The pathways listed as not applicable were listed as such in CY 2011 for the following reasons:

- Liquid A is not applicable 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 NC Sites (DOE 1994).
- Liquid B is not applicable at Coldwater Creek or for the SLAPS transient receptor, because it is unlikely that a game fish would be caught and eaten by the receptor. A

survey was conducted, and 97 percent of the fish collected at Coldwater Creek during the survey (Parker and Szlemp 1987) were fathead minnows.

- The dose equivalent from Coldwater Creek to the receptor from contaminants in the water/sediment was estimated by using the Microshield Version 5.03 computer-modeling program. The scenario used was a youth playing in the creek bed (1 ft of water shielding and dry) for 52 hours per year. The highest estimated whole body dose to the youth was 0.3 microrem per year. Therefore, the external gamma pathway (from contaminants in the creek water/sediment) is not applicable for the Coldwater Creek receptor, because the gamma dose rate emitted from the contaminants is indistinguishable from background gamma radiation.

6.3 EXPOSURE SCENARIOS

Dose calculations were performed for maximally exposed individuals at critical receptor locations for applicable exposure pathways (see Table 6-1) to assess dose due to radiological releases from the NC Sites. First, conditions were set to determine the TEDE to a maximally exposed individual at each of the main site locations (Latty Avenue Properties and the SLAPS and SLAPS VPs). Because excavation occurred on SLAPS VP-31A located near the HISS, a single maximally exposed individual was selected for determination of TEDE from Latty Avenue Properties and that SLAPS VP. A second dose equivalent for Coldwater Creek was calculated. A third set of dose equivalent calculations was performed to meet NESHAP requirements (Appendix A). These 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 here. 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 NC Sites. 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.

All ingestion calculations were performed using the methodology described in International Commission on Radiation Protection Reports 26 and 30 for a 50-year committed effective dose equivalent (CEDE). Fifty-year CEDE conversion factors were obtained from the USEPA *Federal Guidance Report,* No. 11 (USEPA 1989b).

6.4 DETERMINATION OF TOTAL EFFECTIVE DOSE EQUIVALENT FOR EXPOSURE SCENARIOS

TEDE for the exposure scenarios were calculated using CY 2011 monitoring data. Calculations for dose scenarios are provided in Appendix G. Dose equivalent estimates are well below the standards set by the NRC for annual public exposure and USEPA NESHAP limits.

The CY 2011 TEDEs for hypothetical maximally exposed individuals near the Latty Avenue Properties, the SLAPS and SLAPS VPs, and Coldwater Creek are <0.1 mrem/yr, <0.1 mrem/yr, and 0.2 mrem/yr, respectively. In comparison, the annual average exposure to natural background radiation in the United States results in a TEDE of approximately 300 mrem/yr (Beir 1990). Assumptions are detailed in the following sections.

6.4.1 Radiation Dose Equivalent from Latty Avenue Properties and St. Louis Airport Site Vicinity Property 31A to a Maximally Exposed Individual

The Latty Avenue Properties contributing to dose (i.e., those properties where remedial action occurred in CY 2011) include: the HISS, Futura, VP-02(L), and VP-40A. Additionally, SLAPS VP-31A is included in this dose calculation, because it is located closer to the Latty Avenue receptors than the SLAPS receptors. This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent the Latty Avenue Properties and SLAPS VP-31A and receive a radiation dose by the exposure pathways identified above. A full-time-employee business receptor was considered to be the maximally exposed individual from Latty Avenue Properties and SLAPS VP-31A. Therefore, all calculations of dose equivalent due to the applicable pathway assume a realistic residence time that is less than 100 percent.

The exposure scenario assumptions are as follows:

- Exposure to radiation from all Latty Avenue Properties and SLAPS VP-31A sources occurs to the maximally exposed individual while working full-time outside at the receptor location facility located approximately 50 meters west of the HISS perimeter. Exposure time is 2,000 hours per year (SAIC 2012b).
- Exposure from external gamma radiation was calculated using environmental TLD monitoring data at the site perimeter between the source and the receptor. The site is assumed to represent a line-source to the receptor.
- Exposure from airborne radioactive particulates was calculated using soil concentration data and air particulate monitoring data to determine a source term and then running the CAP-88 PC modeling code to calculate dose to the receptor (SAIC 2012b).
- Exposure from Rn-222 (and progeny) was calculated using a dispersion factor and Rn-222 (alpha track) monitoring data at the site perimeter between the source and the receptor (SAIC 2012b).

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor location facility 50 meters west from the HISS perimeter received less than 0.1 mrem/yr from external gamma, less than 0.1 mrem/yr from airborne radioactive particulates, and 0 mrem/yr from Rn-222 for a TEDE of less than 0.1 mrem/yr (SAIC 2012b).

6.4.2 Radiation Dose Equivalent from St. Louis Airport Site/St. Louis Airport Site Vicinity Properties to a Maximally Exposed Individual

The SLAPS and SLAPS VPs contributing to dose (i.e., those properties where remedial action occurred in CY 2011) include: McDonnell Boulevard, VP-12, VP-31A, IA-09, and the SLAPS loadout. VP-31A is closer in proximity to the Latty Avenue Properties receptors than to the SLAPS receptors. Therefore, the dose due to air particulate emissions from VP-31A is included in the Latty Avenue Properties does evaluation. This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent the perimeter of the SLAPS and SLAPS VPs and receive a radiation dose by the exposure pathways identified above. No private residences are adjacent to the site. 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 SLAPS and SLAPS VPs.

The exposure scenario assumptions are as follows:

- Exposure to radiation from all SLAPS sources occurs to the maximally exposed individual while working full time outside at the receptor location facility located approximately 500 meters west-southwest from the center of the SLAPS loadout area. Exposure time is 2,000 hours per year (SAIC 2012c).
- Exposure from external gamma radiation was calculated using environmental TLD monitoring data at the perimeter between the source and the receptor. The site is assumed to represent a line-source to the receptor.
- Exposure from airborne radioactive particulates was calculated using soil concentration data and air particulate monitoring data to determine a source term and then running the CAP-88 PC modeling code to calculate dose to the receptor (SAIC 2012c).
- Exposure from Rn-222 (and progeny) was calculated using a dispersion factor and Rn-222 (alpha track) monitoring data at the site perimeter between the source and the receptor (SAIC 2012c).

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor facility 500 meters west-southwest of the center of the SLAPS loadout area received less than 0.1 mrem/yr from external gamma, less than 0.1 mrem/yr from airborne radioactive particulates, and 0 mrem/yr from Rn-222 for a TEDE of less than 0.1 mrem/yr (SAIC 2012c).

6.4.3 Radiation Dose Equivalent from Coldwater Creek to a Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent Coldwater Creek and receive a radiation dose by the exposure pathways identified above. The assumed scenario is for a recreational user. Therefore, all calculations of dose equivalent due to the applicable pathway assume a realistic residence time that is less than 100 percent. A youth spending time as a recreational user of Coldwater Creek is considered to be the maximally exposed individual from Coldwater Creek.

The exposure scenario assumptions are as follows:

- The youth spends two hours at Coldwater Creek during each visit, and visits once every two weeks. It is likely that this activity would be greater in summer and less in winter, but the yearly average is 26 visits.
- The soil/sediment ingestion rate is 50 milligrams per day, and water ingestion rate is two liters per day (USEPA 1989c).
- The UCL_{95} of the mean radionuclide concentrations in Coldwater Creek surface water/sediment samples taken in CY 2011 were assumed to be present in the water/sediment ingested by the maximally exposed individual (SAIC 2012d).
- Dose equivalent conversion factors for ingestion are: Total U, 2.50E-5 millirem per picocurie (mrem/pCi); Ra-226, 1.33E-3 mrem/pCi; Ra-228, 1.44E-3 mrem/pCi; Th-228,

3.96E-4 mrem/pCi; Th-230, 5.48E-4 mrem/pCi; and Th-232, 2.73E-3 mrem/pCi (USEPA 1989b).

Based on the exposure scenario and assumptions described above, a maximally exposed individual using Coldwater Creek for recreational purposes received less than 0.011 mrem/yr from soil/sediment ingestion, and 0.18 mrem/yr from water ingestion for a TEDE of 0.2 mrem/yr (SAIC 2012d).

7.0 REFERENCES

Beir V. 1990. *Health Effects of Exposure to Low Levels of Ionizing Radiation*, National Academy Press, Washington, D.C.

DOD 2010. *Department of Defense Quality Systems Manual for Environmental Laboratories,* Version 4.2, October 25.

DOE 1994. *Remedial Investigation Report for the St. Louis Site,* St. Louis, Missouri, DOE/OR/21949-280, January.

DOE 1995. *Remedial Investigation Addendum for the St. Louis Site,* St. Louis, Missouri, DOE/OR/21950-132, September.

DOE 1997. *St. Louis Airport Site (SLAPS) Interim Action Engineering Evaluation/Cost Analysis (EE/CA),* St. Louis, Missouri, DOE/OR/21950-12026, September.

Gibbons, Robert D. 1994. *Statistical Methods for Groundwater Monitoring*, John Wiley and Sons, Inc., New York.

MDNR 1998. Letter dated October 2, 1998. From Philip A. Schroeder, Permit Section Chief, to Sharon Cotner, USACE FUSRAP Project Manager. Subject: St. Louis Airport Site (SLAPS), St. Louis, Missouri.

MDNR 2002. Letter dated February 19, 2002 from Matthew Sikes to Sharon Cotner, USACE FUSRAP Project Manager. Subject: Reduce Sampling at SLAPS Outfall 002.

MSD 1991. Ordinance No. 8472. Adopted August 14, 1991.

MSD 1994. Ordinance No. 10177. Adopted November 9, 1994.

MSD 1997. Ordinance No. 10082. Adopted May 8, 1997.

MSD 1998. Letter dated October 30, 1998. From Bruce H. Litzsinger, Civil Engineer, to Ken Axetel, International Technology Corporation.

MSD 2001. Letter dated July 23, 2001. From Bruce H. Litzsinger, Civil Engineer, to Sharon Cotner, USACE FUSRAP Project Manager. Subject: St. Louis Airport Site, File: SD – St. Louis Airport FUSRAP Site, 110 McDonnell.

MSD 2006. Letter dated June 19, 2006 from Roland A. Biehl, Environmental Assistant Engineer, to Sharon Cotner, USACE FUSRAP Project Manager. Subject: FUSRAP St. Louis Airport Site, File: SD, St. Louis Airport FUSRAP Site, 9012138501, SP801.

MSD 2008. Letter dated May 22, 2008. From Steve Grace, Environmental Assistant Engineer, to Sharon Cotner, USACE FUSRAP Project Manager. Subject: FUSRAP St. Louis Airport Site, File: SD, St. Louis Airport FUSRAP Site, 9012138501, SP801.

MSD 2010a. Letter dated May 10, 2010. From Steve Grace, Environmental Assistant Engineer, to Sharon Cotner, USACE FUSRAP Project Manager. Subject: FUSRAP St. Louis Airport Site, File: SD, St. Louis Airport FUSRAP Site, 9012138501, SP801.

MSD 2010b. Letter dated February 1, 2010 from Steve Grace, Environmental Assistant Engineer, to Sharon Cotner, USACE FUSRAP Project Manager. Subject: SD, Hazelwood Interim Storage Site, 8945 Latty Avenue, Berkeley, Missouri.

NCRP 1988. National Council on Radiation Protection and Measurements. *Measurement of Radon and Radon Daughters in Air*, NCRP Report No. 97, November.

Office of the Federal Register, NARA 1998. National Archives and Records Administration. "National Primary Drinking Water Regulations: Disinfectants and Disinfection Byproducts; Final Rule." *Federal Register*. Volume 63, No. 241, 40 *CFR* 9, 141, and 142. December 16.

Parker, M. A., and R. Szlemp 1987. Final Fish and Wildlife Coordination Act Report, Coldwater Creek Flood Control Project, St. Louis County, Missouri, May, published as Appendix D of Coldwater Creek Missouri Feasibility Report and Environmental Impact Statement, St. Louis District, Lower Mississippi Valley Division. St. Louis, Missouri, May.

SAIC 2000. Science Applications International Corporation. *Cleaning and Decontaminating Sample Containers and Sampling Equipment,* Field Technical Procedure 405, August 15.

SAIC 2002. *Control on Nonconforming Items and Services*, QAAP 15.1 Rev. 7, March 13.

SAIC 2012a. *Radon Working Levels (WL) at FUTURA,* March.

SAIC 2012b. *Total Effective Dose Equivalent (TEDE) to the Hypothetically Maximally Exposed Individual at Latty Avenue Properties*, March.

SAIC 2012c. *Total Effective Dose Equivalent (TEDE) to the Hypothetically Maximally Exposed Individual at SLAPS/SLAPS VPs*, March.

SAIC 2012d. *Total Effective Dose Equivalent (TEDE) to the Hypothetically Maximally Exposed Individual at Coldwater Creek*, March.

Shleien, Bernard, ed. 1992. *The Health Physics and Radiological Health Handbook.* Silver Spring, MD: Scinta Inc.

UNSCEAR 1982. *United Nations Scientific Committee on the Effects of Radiation, 37th Session, Supplement No. 45 (A/37/45).* United Nations, New York, NY.

USACE 1997. *Engineering and Design – Chemical Data Quality Management for Hazardous, Toxic, and Radioactive Waste (HTRW) Projects,* Engineer Manual, EM-200-1-6, October.

USACE 1998a. *Engineering Evaluation/Cost Analysis (EE/CA) and Responsiveness Summary for the St. Louis Airport Site (SLAPS)*, St. Louis, Missouri, May.

USACE 1998b. *Engineering Evaluation/Cost Analysis (EE/CA) for the Hazelwood Interim Storage Site (HISS),* St. Louis, Missouri, October.

USACE 1998c. *Engineering and Design – Chemical Data Quality Management for Hazardous, Toxic, and Radioactive Waste Activities,* Engineer Regulation ER-1110-1-263, April.

USACE 1999a. *Environmental Monitoring Guide for the St. Louis Sites,* Final, December.

USACE 1999b. *FUSRAP Laboratory Data Management Process for the St. Louis Site,* St. Louis, Missouri, June.

USACE 2000. *Sampling and Analysis Guide for the St. Louis Site,* Final, October.

USACE 2001. *Requirements for the Preparation of Sampling and Analysis Plans,* Engineer Manual, EM 200-1-3, February 1.

USACE 2003. Letter dated November 18, 2003. From Sharon Cotner, USACE FUSRAP Project Manager, to Phillip A. Schroeder, Permit Section Chief, MDNR.

USACE 2005. *Record of Decision for the North St. Louis County Sites,* St. Louis, Missouri, Final, September 2.

USACE 2007. Letter dated April 20, 2007. From Sharon Cotner, USACE FUSRAP Project Manager, to Thomas Siegel, Permit and Engineering Chief, MDNR. Subject: Sediment Control and Pumped Excavation Water Outfall Vicinity Properties 08(c) and 40A.

USACE 2011. *Environmental Monitoring Implementation Plan for the North St. Louis County Sites for Calendar Year 2011,* St. Louis, Missouri, Revision 0, January 11.

USEPA 1987. U.S. Environmental Protection Agency. *Environmental Radon; Volume 35,* New York.

USEPA 1989a. *National Priorities List, St. Louis Airport/Hazelwood Interim Storage/FUTURA Coatings Co.,* St. Louis County, Missouri, NIL-U8-2-6-10/89, October.

USEPA 1989b. *"Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion," Federal Guidance Report* No. 11, September.

USEPA 1989c. *Exposure Factor Handbook EPA/600/8-89/043,* Office of Health and Environmental Assessment, Washington D.C., July.

USEPA 1991. *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans,* QAMS-005/80.

USEPA 1992. *Supplemental Guidance to RAGS: Calculating the Concentration Term.*Office of Solid Waste and Emergency Response, Washington, DC. OSWER Directive 9285.7-081, May.

USEPA 1993. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846*, Third Edition, Revision 1, Updates 1, 2, and 3.

USEPA 1994. *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations,* EPA QA/R-5, January.

USEPA 2000. *Guidance for Data Quality Assessment - Practical Methods for Data Analysis*, EPA QA/G-9, QA00 Update, July.

USEPA 2007. CAP88-PC Version 3.0 Computer Code, U.S. Environmental Protection Agency, December 9.

10 *CFR* 20, *Standards for Protection Against Radiation.*

10 *CFR* 20.1301, *Dose Limits For Individual Members Of The Public*.

10 *CFR* 20.1302, *Compliance With Dose Limits For Individual Members Of The Public*.

10 *CSR* 20-7.015, *Effluent Regulations.*

10 *CSR* 20-7.031, *Water Quality Standards.*

19 *CSR* 20-10, *Protection Against Ionizing Radiation.*

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

40 *CFR* 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings.*

FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A

NORTH ST. LOUIS COUNTY FUSRAP SITES
2011 RADIONUCLIDE EMISSIONS NESHAP REPORT

SUBMITTED IN ACCORDANCE WITH REQUIREMENTS OF 40 *CFR* 61 SUBPART I

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

SECTION **PAGE**

LIST OF ATTACHMENTS

LIST OF FIGURES

NUMBER

LIST OF TABLES

NUMBER **PAGE**

LIST OF TABLES (Continued)

NUMBER **PAGE**

ACRONYMS AND ABBREVIATIONS

$\mu Ci/cm^3$	microcurie per cubic centimeter
µCi/mL	microcurie per milliliter
Ac	actinium
AEC	Atomic Energy Commission
°C	degrees Celsius (centigrade)
CFR	*Code of Federal Regulations*
Ci/yr	curie per year
CY	calendar year
DOE	U.S. Department of Energy
EDE	effective dose equivalent
FUSRAP	Formerly Utilized Sites Remedial Action Program
Futura	Futura Coatings Company
GIS	Geographic Information System
HEPA	high efficiency particulate air
HISS	Hazelwood Interim Storage Site
IA	investigation area
IAAAP	Iowa Army Ammunition Plant
m	meter(s)
m^2	square meter
m/min	meters per minute
m/sec	meter per sec
m^3/min	cubic meter(s) per minute
MED	Manhattan Engineer District
mrem/yr	millirem per year
mSv/yr	milliSievert(s) per year
NC	North St. Louis County
NESHAP	National Emission Standard for Hazardous Air Pollutants
Pa	protactinium
Ra	radium
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
Th	thorium
U	uranium
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VP	vicinity property
yd^3	cubic yards

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) North St. Louis County (NC) Sites for calendar year 2011 (CY 2011). 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 Regulation* (*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* (USEPA 1989).

This report evaluates sites where there was a reasonable potential for radionuclide emissions due to St. Louis FUSRAP activities. These sites include: the Latty Avenue Properties (consisting of the Hazelwood Interim Storage Sites [HISS], Futura Coatings Company [Futura], Vicinity Property [VP]-02[L], and VP-40A), the St. Louis Airport Site (SLAPS) VP-12, VP-31A, Investigation Area (IA)-09, McDonnell Boulevard, and SLAPS loadout. This report also evaluates radionuclide emissions from the United States Army Corps of Engineers (USACE) Radioanalytical Laboratory operations. Emissions from the sites and lab were evaluated for the entire CY 2011 to provide a conservative estimate of total emissions.

The NESHAP standard of EDE to a critical receptor from radionuclide emissions is 10 millirem per year (mrem/yr) (0.1 milliseivert per year [mSv/yr]). None of the sites exceeded this standard. The EDE from radionuclide emissions at the sites were 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 of less than 0.1 mrem/yr (<0.001 mSv/yr) and less than 0.1 mrem/yr (<0.001 mSv/yr) from the Latty Avenue Properties and the SLAPS and SLAPS VPs, respectively. The EDE from the laboratory emissions was calculated using the methodology in Appendix D of 40 *CFR* 61, *Methods for Estimating Radionuclide Emissions*, soil characterization data, and the USEPA CAP88-PC modeling code, which resulted in less than 0.1 mrem/yr (<0.001 mSv/yr).

Evaluations for the Latty Avenue Properties, the SLAPS VPs, and the USACE Radioanalytical Laboratory resulted in less than 10 percent of the dose standard in 40 *CFR* 61.102. These sites are 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 that 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
Address:	8945 Latty Ave.
	Berkeley, MO 63134
Contact:	Jon Rankins

1.0 PURPOSE

This report calculates the EDE from radionuclide emissions (exclusive of radon) to critical receptors from the USACE Radioanalytical Laboratory and the NC FUSRAP Sites where there was a reasonable potential for radionuclide emissions due to St. Louis FUSRAP activities. These sites include: the Latty Avenue Properties (consisting of the HISS, Futura, VP-02[L], and VP-40A), and the SLAPS VP-12, VP-31A, IA-09, McDonnell Boulevard, and SLAPS loadout. The air emissions from the laboratory include fume hood stack releases of particulate radionuclides from sample preparation and separation activities. The air emissions from the other sites 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.

THIS PAGE INTENTIONALLY LEFT BLANK

2.0 METHOD

Emission rates for the sites were modeled using guidance documents referenced in 40 *CFR* 61, Appendix E, *Compliance Procedures Methods for Determining Compliance with Subpart I*, (USEPA 1989) and measured by collection of environmental air samples. Emission rates for the laboratory were modeled using guidance in 40 *CFR* 61 Appendix D, *Methods for Estimating Radionuclide Emissions.* Emission rates were input into the USEPA computer code CAP88-PC, along with appropriate meteorological data and distances to critical receptors[1], 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 transport models for assessing dose and risk from radioactive air emissions." The USEPA continues to maintain and update the CAP88-PC modeling program and has updated it as recently as December 9, 2007. 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 report to demonstrate compliance with the NESHAP standard.

2.1 EMISSION RATE

Two methods were used to determine particulate radionuclide emission rates from the sites: (1) 40 *CFR* 61 Appendix D, *Methods for Estimating Radionuclide Emissions*, and (2) environmental air samples collected from the perimeter of a site. Emissions during excavations and waste loadout were evaluated using air sampling data at the excavation and waste loadout perimeters when site perimeter air particulate data was not available.

2.2 EFFECTIVE DOSE EQUIVALENT

The EDE to critical receptors[1] is obtained using USEPA computer code CAP88-PC, Version 3.0 (USEPA 2007). 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 one meter (m) is modeled for the sites, and a stack release was modeled for the laboratory.

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.

THIS PAGE INTENTIONALLY LEFT BLANK

3.0 METEOROLOGICAL DATA

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

Average Annual Wind Velocity	4.446 meters/second (m/sec)
Average Annual Precipitation Rate	111 centimeters per year
Average Annual Air Temperature	14.18 degrees Celsius (centigrade) (°C)

Wind speed frequency data was obtained from St. Louis Lambert International Airport (see Table A.3-1).

Table A.3-1. St. Louis Wind Speed Frequency

Wind Speed Group, Knots[a]	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

[a] knot = 1.151 miles/hour

Wind direction frequency was obtained from the CAP88-PC wind file, 13994.WND (see Table A.3-2).

Table A.3-2. St. Louis Wind Rose Frequency

Wind Direction (wind toward)	Wind From	Wind Frequency	Wind Direction (wind toward)	Wind From	Wind Frequency
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

THIS PAGE INTENTIONALLY LEFT BLANK

4.0 LATTY AVENUE PROPERTIES UNDER ACTIVE REMEDIATION

4.1 SITE HISTORY

In 1966, Continental Mining and Milling Company of Chicago, Illinois, purchased the wastes stored at the SLAPS and began moving them to a property at 9200 Latty Avenue for storage. In 1967, the Commercial Discount Corporation of Chicago, Illinois, purchased the residues, dried the materials, and shipped much of the material to Canon City, Colorado. Cotter Corporation purchased the remaining residues in 1969 and dried and shipped more material to Canon City during 1970. In 1973, the remaining undried material was shipped to Canon City and leached barium sulfate was mixed with soil and transported to a St. Louis County landfill. During these activities, improper storage, handling, and transportation of materials caused the spread of materials along haul routes and to the adjacent VPs.

In 1979, the owner of the 9200 Latty Avenue property excavated approximately 13,000 cubic yards (yd^3) from the western half of the property prior to constructing a manufacturing facility. The material excavated at this time was stockpiled on the eastern half of the property, which now constitutes the HISS. In 1984, Bechtel National, Inc. performed removal actions, including clearing, cleanup, and excavation of the property at 9200 Latty Avenue and the surrounding VPs. This action created approximately 14,000 yd^3 of additional contaminated soil, which was stockpiled on the HISS.

In 1986, the U.S. Department of Energy (DOE) provided radiological support to the cities of Hazelwood and Berkeley for a drainage and road improvement project. Soil with constituents in excess of DOE remedial action guidelines was excavated and stored at the HISS. This action resulted in an additional 4,600 yd^3 of material being placed at the HISS in a supplemental storage pile.

In 1996, the owner of the property to the east of the HISS, General Investment Funds Real Estate Holding Company, in consultation with DOE, made commercial parking and drainage improvements on the property. This action resulted in the stockpiling of approximately 8,000 yd^3 of soil and debris in two interim storage piles located in the southwestern portion of the Latty Avenue VP-02(L). These piles were referred to as the Eastern Piles.

In 2000 and 2001, the USACE removed the main, supplemental, and Eastern piles and shipped the material by rail to properly permitted disposal facilities. The ground surface where the piles were previously located was covered by a layer of plastic and approximately six inches of gravel.

4.2 MATERIAL HANDLING AND PROCESSING FOR CALENDAR YEAR 2011

During CY 2011, excavations were conducted on the following Latty Avenue Properties: the HISS, Futura, VP-02(L), and VP-40A. Air particulate samples were collected around excavation and loadout area perimeters during active excavation and loadout on other Latty Avenue Properties throughout CY 2011. Analytical results of air particulate samples were used to determine windblown *in situ* emissions.

4.3 SOURCE DESCRIPTION – RADIONUCLIDE SOIL CONCENTRATIONS

The radionuclide concentrations for each site were obtained from data contained in Table D-5 of the *Feasibility Study for the St. Louis North County Site* (USACE 2003). Attachment 1 contains a summary table of the radionuclide concentrations used to calculate the emission rate from the site.

4.4 LIST OF ASSUMED AIR RELEASES FOR CALENDAR YEAR 2011

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 are assumed for the particulate radionuclide emission determinations from the Latty Avenue Properties at which excavation and/or loadout occurred in CY 2011. Other Latty Avenue Properties do not contribute to the emission determinations for periods of inactivity due to the low activity and vegetative cover.

4.5 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown on Figure A-1 and presented in Table A.4-1. Distances and directions to critical receptors are determined by using tools in a Geographic Information System (GIS). SLAPS VP-31A where remedial action occurred in CY 2011 was in closer proximity to Latty Avenue Properties receptors than to the SLAPS receptors. Therefore, the dose due to air particulate emissions from VP-31A was included in the Latty Avenue Properties does evaluation.

Table A.4-1. Latty Avenue Properties Critical Receptors for CY 2011

Sources	Resident		Farm		Business		School	
	Dist.[a]	Dir.[a]	Dist.[a]	Dir.[a]	Dist.[a,b]	Dir.[a]	Dist.[a]	Dir.[a]
HISS	480	SSE	740	NE	130	NW	2,220	ESE
Futura	470	SSE	820	NE	150	NW	2,270	ESE
VP-02(L)	350	SSE	775	NE	230	NW	2,045	ESE
VP-31A[c]	780	W	935	NNW	1,120	NW	1,175	ESE
VP-40A	960	S	530	E	475	SSW	2,360	SE

[a] Dist. = Distance in m; Dir. = Direction.
[b] Distance from business receptor to fenceline is 50 m. Distance from business receptor to center of source from the HISS is 110 m for emissions determination.
[c] The SLAPS VP was in closer proximity to the Latty Avenue receptors than the SLAPS receptors, and, therefore, will be included in the Latty Avenue receptor dose evaluation.

4.6 EMISSIONS DETERMINATIONS

4.6.1 Measured Airborne Radioactive Particulate Emissions

Particulates in air were continuously sampled around the perimeter of excavations during active excavation at the Latty Avenue Properties and the SLAPS VPs. The air sample results provide the basis for determining the radionuclide emission rates during CY 2011. The average site gross alpha and gross beta concentrations in microcuries per milliliter (μCi/mL) are determined for each site. The average site concentrations are presented in Table A.4-2.

Table A.4-2. Latty Avenue Properties and SLAPS VPs Average Gross Alpha and Beta Airborne Particulate Emissions for CY 2011

Site	Average Concentration (μCi/mL)	
	Gross Alpha	Gross Beta
HISS	2.22E-15	2.18E-14
Futura	2.19E-15	3.01E-14
VP-02(L)	4.55E-15	2.01E-14
VP-40A	0.00E+00	2.68E-14
VP-31A	2.07E-15	7.49E-15
Background Concentration[a]	3.37E-15	1.97E-14

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

Radionuclide activity fractions are determined for alpha and beta from the average radionuclide concentration data contained in Table D-5 of the *Feasibility Study for the St. Louis North County Site* (USACE 2003). The product of each radionuclide activity fraction and the gross concentration provides the radionuclide emission concentration in microcuries per cubic centimeter ($\mu Ci/cm^3$). The gross average concentration ($\mu Ci/cm^3$) is converted to a release (emission) rate as measured in curies per year (Ci/yr) using Equations (1) and (2). The emission rates are summarized in Table A.4-5.

USEPA 1989 (page 3-21, [2]) provides Equation (1) for determination of the effective diameter of a non-circular stack or vent.

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

where:

D is the effective diameter in m of the release, and
A is the area of the stack, vent, or release point in square meter (m^2).

Table A.4-3 provides the effective surface area available for release of airborne radionuclides normalized to one year and the effective diameter for the HISS and the other Latty Avenue and the SLAPS VPs that were excavated in CY 2011. Calculation of the effective surface area can be referenced in Attachment 1.

Table A.4-3. Latty Avenue Properties Excavation Effective Areas and Effective Diameters for CY 2011

Location	Effective Area (m^2)	Effective Diameters (m)
HISS	671	30
Futura	67	9
VP-02(L)	88	11
VP-40A	41	7
VP-31A	9	3

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

$$V = (4)\ F / \pi\ (D)^2$$ **Equation (2)**

where:

V is the wind velocity (meters per minute [m/min]) = 266.76 m/min,
F is the flow rate (cubic meters per minute [m^3/min]),
π is a mathematical constant, and
D is the effective diameter of the release determined using Equation (1) above (m).

Converting the velocity of emissions from the sites to an effective flow rate results in the following site release flow rates for the Latty Avenue Properties and the SLAPS VP areas as listed in Table A.4-4. 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 illustrated in Table A.4-5. Attachment 1 can be referenced for flow rate and average radionuclide concentration data.

Table A.4-4. Latty Avenue Properties Site Release Flow Rates for CY 2011

Location	Site Release Flow Rate (m^3/min.)
HISS	1.8E+05
Futura	1.8E+04
VP-02(L)	2.4E+04
VP-40A	1.1E+04
VP-31A	2.5E+03

4.6.2 Latty Avenue Properties Total Airborne Radioactive Particulate Emission Rates

The Latty Avenue Properties and the SLAPS VP areas' total CY 2011 emission/release rates that were input into the USEPA codes are shown in Table A.4-5 and are based on the measured emission rates from the air samples collected from the perimeter of the site or excavations as appropriate.

Table A.4-5. Latty Avenue Properties Total Airborne Radioactive Particulate Emission Rates for CY 2011

Radionuclide	Emission (Ci/yr)[a]				
	HISS	Futura	VP-02(L)	VP-31A	VP-40A
Uranium (U)-238	3.4E-05	3.0E-06	3.9E-06	2.4E-08	0.0E+00
U-235	3.2E-06	1.4E-07	1.8E-07	1.0E-09	0.0E+00
U-234	3.4E-05	3.0E-06	3.9E-06	2.4E-08	0.0E+00
Radium (Ra)-226	1.9E-05	2.5E-06	1.0E-06	2.5E-07	0.0E+00
Thorium (Th)-232	3.6E-06	1.3E-07	7.3E-07	3.6E-07	0.0E+00
Th-230	1.0E-04	5.6E-06	4.5E-05	2.0E-06	0.0E+00
Th-228	2.0E-06	1.3E-07	4.0E-07	2.0E-09	0.0E+00
Ra-224	2.0E-06	1.3E-07	4.0E-07	2.0E-09	0.0E+00
Th-234	9.3E-04	1.4E-04	1.1E-04	4.7E-06	7.1E-05
Protactinium (Pa)-234m	9.3E-04	1.4E-04	1.1E-04	4.7E-06	7.1E-05
Th-231	8.7E-05	6.4E-06	5.2E-06	2.0E-07	1.3E-06
Ra-228	5.4E-05	4.8E-07	1.2E-05	1.4E-07	6.0E-06
Actinium (Ac)-228	5.4E-05	4.8E-07	1.2E-05	1.4E-07	6.0E-06
Pa-231	3.4E-06	3.3E-06	1.3E-06	1.6E-08	0.0E+00
Ac-227	3.4E-06	2.8E-06	1.1E-06	1.4E-08	0.0E+00

[a] Release rate based on 365-day period at a respective flow rate (as presented in Table A.4-4) as determined from the average annual wind speed (4.446 m/sec) and the effective site area (as presented in Table A.4-3) for each location.

4.7 CAP88-PC RESULTS

The CAP88-PC report is contained in Attachment 2. The effective area factor input was taken from Table A.4-3. Results show compliance with the 10 mrem/yr (0.1 mSv/yr) criterion for all critical receptors. Table A.4-6 summarizes the results.

Table A.4-6. Latty Avenue Properties CAP88-PC Results for Critical Receptors for CY 2011

Source	Dose (mrem/yr)			
	Resident[a]	**School[b]**	**Business[b]**	**Farm[a]**
HISS[c]	<0.1	<0.1	<0.1	<0.1
Futura	<0.1	<0.1	<0.1	<0.1
VP-02(L)	<0.1	<0.1	<0.1	<0.1
VP-31A	<0.1	<0.1	<0.1	<0.1
VP-40A	<0.1	<0.1	<0.1	<0.1
Latty Avenue Properties Total Dose	**<0.1**	**<0.1**	**<0.1**	**<0.1**

[a] Occupancy factor is 100 percent for resident and farm.
[b] Corrected for the 23 percent occupancy factor (50 weeks/year 40 hours/week).
[c] Distance from business receptor to fenceline is 50 m. Distance from business receptor to center of source from the HISS is 110 m for emissions determination.

THIS PAGE INTENTIONALLY LEFT BLANK

5.0 ST. LOUIS AIRPORT SITE AND ST. LOUIS AIRPORT SITE VICINITY PROPERTIES UNDER ACTIVE REMEDIATION

5.1 SITE HISTORY

The Manhattan Engineer District (MED) acquired the SLAPS in 1946 to store uranium (U)-bearing residuals generated at the St. Louis Downtown Site (SLDS) from 1946 until 1966. In 1966, these residuals were purchased by Continental Mining and Milling Company of Chicago, removed from the SLAPS, and placed in storage at the Latty Avenue HISS under an Atomic Energy Commission (AEC) license. After most of the residuals were removed, site structures were demolished and buried on the property along with approximately 60 truckloads of scrap metal and a vehicle that had become contaminated. In 1973, the U.S. Government and the City of St. Louis agreed to transfer ownership from AEC to the St. Louis Airport Authority. The USACE conducted cleanup operations on the SLAPS from 1998 to 2007. Although excavations have concluded at the SLAPS, a small portion of the site is still used to conduct waste storage and loadout activities.

5.2 MATERIAL HANDLING AND PROCESSING FOR CALENDAR YEAR 2011

During CY 2011, excavations were conducted on McDonnell Boulevard, VP-12, VP-31A, and IA-09 and waste loadout activities were conducted at the SLAPS loadout facility. Air particulate samples were collected around excavation perimeters during active excavation on the SLAPS VPs and around the SLAPS loadout area throughout CY 2011. Analytical results of air particulate samples were used to determine windblown *in situ* emissions.

SLAPS VP-31A where remedial action occurred in CY 2011 was in closer proximity to the Latty Avenue Properties receptors than the SLAPS receptors. Therefore, the dose due to air particulate emissions from VP-31A was included in the Latty Avenue Properties dose evaluation (Section 4.0).

5.3 SOURCE DESCRIPTION – RADIONUCLIDE SOIL CONCENTRATIONS

The radionuclide concentrations for each site were obtained from data contained in Table D-5 of the *Feasibility Study for the St. Louis North County Site* (USACE 2003). Attachment 1 contains a summary table of the radionuclide concentrations used to calculate the emission rate from the site.

5.4 LIST OF ASSUMED AIR RELEASES FOR CALENDAR YEAR 2011

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, are assumed for the particulate radionuclide emission determinations from the SLAPS VPs where excavations occurred in CY 2011. Other SLAPS VPs do not contribute to the emission determinations for periods of inactivity due to the low activity and vegetative cover.

5.5 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown on Figure A-2 and presented in Table A.5-1. Distances and directions to critical receptors are determined by using tools in a GIS.

Table A.5-1. SLAPS Critical Receptors for CY 2011

Sources	Resident		Farm		Business		School	
	Dist.[a]	Dir.[a]	Dist.[a]	Dir.[a]	Dist.[a,b]	Dir.[a]	Dist.[a]	Dir.[a]
McDonnell Blvd	680	NNE	1,670	NNE	950	W	2,050	ENE
IA-09	490	E	1,485	NE	775	WSW	2,265	E
VP-12	1,290	ENE	2,095	NE	345	SE	3,105	E
SLAPS Loadout	770	NE	1,710	NE	500	WSW	2,580	E

[a] Dist. = Distance in m; Dir. = Direction.
[b] Distance from business receptor to fenceline is 160 m. Distance from business receptor to center of source from the SLAPS loadout is 500 m for emissions determination.

5.6 EMISSIONS DETERMINATION

5.6.1 Measured Airborne Radioactive Particulate Emissions

Particulate air samples were collected from four locations around the perimeter of the SLAPS loadout to measure the radionuclide emissions. The samples provide the basis for determining the radionuclide emission rates during all of CY 2011. The average gross alpha and beta concentrations in μCi/mL are determined for each sample location for CY 2011. The site average concentrations are presented in Table A.5-2.

Table A.5-2. SLAPS Average Gross Alpha and Beta Airborne Particulate Emissions for CY 2011

Monitoring Location	Average Concentration (μCi/mL)	
	Gross Alpha	Gross Beta
McDonnell Blvd	3.29E-15	2.62E-14
IA-09	5.14E-15	3.08E-14
VP-12	2.22E-15	1.28E-14
SLAPS Loadout	3.43E-15	2.54E-14
Background Concentration[a]	3.37E-15	1.97E-14

[a] These concentrations are provided only for informational purpose. As a conservative approach, background values were not subtracted from the gross average concentration during the determination of EDE.

Radionuclide activity fractions are determined for alpha and beta from the average radionuclide concentration data contained in Table D-5 of the *Feasibility Study for the St. Louis North County Site* (USACE 2003). The product of each radionuclide activity fraction and the gross concentration provides the radionuclide emission concentration as measured in $\mu Ci/cm^3$. The gross average concentration ($\mu Ci/cm^3$) is converted to a release (emission) rate (Ci/yr) using Equations (1) and (2). The emission rates are summarized in Table A.5-5.

USEPA 1989 (page 3-21, [2]) provides Equation (1) for determination of the effective diameter of a non-circular stack or vent.

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

where:

D is the effective diameter of the release (m), and
A is the area of the stack, vent, or release point (m^2).

Table A.5-3 provides the effective surface area available for release of airborne radionuclides normalized to one year and the effective diameter for the SLAPS and SLAPS VPs that were excavated in CY 2011. Calculation of the effective surface area can be referenced in Attachment 1.

Table A.5-3. SLAPS/SLAPS VPs Excavation Effective Areas and Effective Diameters for CY 2011

Location	Effective Area (m^2)	Effective Diameters (m)
McDonnell Blvd	11	4
IA-09	125	13
VP-12	789	32
SLAPS Loadout	1,311	41

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

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

where:

V is the wind velocity (m/min) = 266.76 m/min,
F is the flow rate (m^3/min),
π is a mathematical constant, and
D is the effective diameter of the release determined using Equation (1) above (m).

Converting the velocity of emissions from the sites to an effective flow rate results in the following site release flow rates for the SLAPS and SLAPS VPs areas as listed in Table A.5-4. 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 illustrated in Table A.5-5. Attachment 1 can be referenced for flow rate and average radionuclide concentration data.

Table A.5-4. SLAPS/SLAPS VPs Site Release Flow Rates for CY 2011

Location	Site Release Flow Rate (m^3/min)
McDonnell Blvd	3.1E+03
IA-09	3.4E+04
VP-12	2.1E+05
SLAPS Loadout	3.6E+05

5.6.2 St. Louis Airport Site and St. Louis Airport Site Vicinity Properties Total Airborne Radioactive Particulate Emission Rates

The SLAPS and SLAPS VPs' total CY 2011 emission/release rates that were input into the USEPA codes are shown in Table A.5-5 and are based on the measured emission rates from the air samples collected from the perimeter of the site or excavations as appropriate.

Table A.5-5. SLAPS/SLAPS VPs Total Airborne Radioactive Particulate Emission Rates for CY 2011

Radionuclide	Emission (Ci/yr)[a]			
	McDonnell Blvd	IA-09	VP-12	SLAPS Loadout
U-238	6.6E-07	1.0E-05	5.5E-05	1.2E-04
U-235	3.2E-08	5.3E-07	8.6E-08	1.1E-06
U-234	6.6E-07	1.1E-05	2.0E-06	2.3E-05
Ra-226	2.6E-07	3.4E-06	1.0E-05	2.7E-05
Th-232	2.5E-07	2.8E-06	9.6E-06	2.5E-05
Th-230	2.9E-06	5.9E-05	1.6E-04	4.3E-04
Th-228	2.0E-07	2.3E-06	1.6E-07	6.1E-06

Table A.5-5. SLAPS/SLAPS VPs Total Airborne Radioactive Particulate Emission Rates (Continued)

Radionuclide	Emission (Ci/yr)[a]			
	McDonnell Blvd	IA-09	VP-12	SLAPS Loadout
Ra-224	2.0E-07	2.3E-06	1.6E-07	6.1E-06
Th-234	1.7E-05	2.3E-04	7.0E-04	2.3E-03
Pa-234m	1.7E-05	2.3E-04	7.0E-04	2.3E-03
Th-231	8.3E-07	1.2E-05	1.1E-06	2.1E-05
Ra-228	3.8E-06	4.0E-05	7.5E-07	8.6E-05
Ac-228	3.8E-06	4.0E-05	7.5E-07	8.6E-05
Pa-231	8.7E-08	5.3E-07	1.3E-06	5.3E-06
Ac-227	6.5E-08	5.3E-07	1.2E-06	4.3E-06

[a] Release rate based on 365-day period at a respective flow rate (as presented in Table A.5-4) as determined from the average annual wind speed (4.446 m/sec) and the effective site area (as presented in Table A.5-3) for each location.

5.7 CAP88-PC RESULTS

The CAP88-PC report is contained in Attachment 2. The effective area factor input was taken from Table A.5-3. Results show compliance with the 10 mrem/yr (0.1 mSv/yr) criterion for all critical receptors. Table A.5-6 summarizes the results.

Table A.5-6. SLAPS/SLAPS VPs CAP88-PC Results for Critical Receptors for CY 2011

Source	Dose (mrem/yr)			
	Resident[a]	School[b]	Business[b]	Farm[a]
McDonnell Blvd	<0.1	<0.1	0.1	<0.1
IA-09	<0.1	<0.1	<0.1	<0.1
VP-12	<0.1	<0.1	<0.1	<0.1
SLAPS Loadout[c]	<0.1	<0.1	<0.1	<0.1
SLAPS/SLAPS VPs	**<0.1**	**<0.1**	**<0.1**	**<0.1**

[a] Occupancy factor is 100 percent for resident and farm.
[b] Corrected for the 23 percent occupancy factor (50 weeks/year, 40 hours/week).
[c] Distance from business receptor to fenceline is 160 m. Distance from business receptor to center of source is 500 m for emissions determination.

6.0 U.S. ARMY CORPS OF ENGINEERS RADIOANALYTICAL LABORATORY

6.1 SITE DESCRIPTION

The USACE radioanalytical laboratory is located on VP-38. VP-38 is a SLAPS VP, owned by SuperValue, Inc. The USACE radioanalytical laboratory is bounded on the north, east, and west by SuperValue, Inc. property and on the south by Latty Avenue. The laboratory site covers approximately one acre of VP-38.

6.2 LIST OF ASSUMED AIR RELEASES FOR CALENDAR YEAR 2011

Emissions from USACE Radioanalytical Laboratory operations are assumed for the particulate radionuclide emission determinations from the Laboratory Site. There were no active excavations on VP-38 during CY 2011.

6.3 EFFLUENT CONTROLS

The effluent controls at the USACE laboratory during operations include performing all radioanalytical activities in fume hoods that exhaust to the outside air after passing through a high efficiency particulate air (HEPA) filter.

6.4 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown on Figure A-2 and listed in Table A.6-1. Distances and directions to critical receptors are determined by using tools in a GIS.

Table A.6-1. Laboratory Critical Receptors for CY 2011

Receptor	Distance (m)	Direction from Site
Nearest Resident	330	NE
School	1,830	SE
Business	110	S
Farm	310	NE

6.5 EMISSIONS DETERMINATIONS

6.5.1 Stack Emissions from U.S. Army Corps of Engineers Laboratory Operations

There are two potential sources of emissions from laboratory operations:

1. The drying and grinding operations for soil samples, and
2. The dissolution of soil and water samples.

To obtain an estimate of the emissions that these operations can cause, the methodology in Appendix D of 40 *CFR* 61, *Methods for Estimating Radionuclide Emissions*, was utilized. For the drying and grinding operations, a factor of 0.001 (applicable to liquids and powders) was applied to the entire annual laboratory inventory to determine the emissions for the year. For the dissolution operation; however, only five grams of any sample are used. Because the dissolution involved heating samples to near boiling temperatures, no adjustment was made to the dissolution inventory to determine the emissions (a factor of 1.0 as specified in Appendix D). To account for the small aliquot utilized, the annual inventory was adjusted by a factor of 0.005 (the ratio of the five-gram aliquot to the one-kilogram sample mass) to estimate emissions. The two emission sources were then summed to determine the total laboratory source term.

Note that no credit is taken for emission controls serving the drying and grinding operations, even though Appendix D of 40 *CFR* 61 allows for credit to be taken for the HEPA filters installed on the grinder equipment. The calculated source term therefore provides a conservative basis on which to determine compliance with USEPA guidance in 40 *CFR* 61.

To determine whether the laboratory complies with the 10 mrem/yr (0.1 mSv/yr) limit specified in 40 *CFR* 61, Subpart I, the annual inventory handled by the laboratory had to be determined. The actual number of samples handled by the laboratory was reported as shown in Table A.6-2. With this data, the following equation was used to calculate laboratory emissions from the operations conducted in CY 2011.

$$Emission\ Rate\ (Ci/yr) = C * \left[N_1 * F_1 + N_2 * F_2\right] * 1{,}000\ grams/sample\ *\ 1E-12\ (curies\ per\ picocuries)$$

where:

- C = the concentration of a radionuclide of concern in a sample type (picocuries per gram)
- N_1 = the number of samples involved in drying/grinding operation
- N_2 = the number of samples involved in separations operation
- F = the appropriate correction factor (i.e., 0.001 for drying/grinding [F_1] or 0.005 for dissolution [F_2])

Table A.6-2. Laboratory Annual Sample Inventory for CY 2011

Site	Type	Gamma	IsoRa[c]	IsoTh[c]	IsoU[c]	Total Drying and Grinding[a]	Total Separations[b]
HISS	soil	60	0	60	0	60	60
HISS	water	0	17	17	17	0	51
Latty Avenue Properties	soil	580	0	701	0	580	701
Latty Avenue Properties	water	0	39	39	0	0	78
IAAAP	soil	44	0	0	44	44	44
IAAAP	water	0	0	0	0	0	0
SLAPS	soil	0	0	0	0	0	0
SLAPS	water	53	73	73	15	53	161
SLAPS VPs	soil	1,839	0	1,645	0	1,839	1,645
SLAPS VPs	water	0	7	7	0	0	14
Coldwater Creek	sediment (soil)	20	0	13	0	20	13
Coldwater Creek	water	0	13	13	13	0	39
SLDS	soil	923	0	894	0	923	894
SLDS	water	0	83	82	16	0	181
		HISS and Latty Avenue Properties			**Total**	**640**	**890**
		IAAAP			**Total**	**44**	**44**
		SLAPS, SLAPS VPs, and Coldwater Creek			**Total**	**1,859**	**1,872**
		SLDS			**Total**	**923**	**1,075**

[a] Assumes all soil samples went through a drying/grinding process.
[b] Assumes all soil and water samples for isotopic radium, thorium, and uranium went through a separations process.
[c] Assumes isotopic radium, thorium, and uranium occur in separate and distinct processes.

Notes:

Sample data from the lab did not separate Latty Avenue Properties from SLAPS VPs samples. Based on a property-specific summary, 40 percent of NC Sites samples were assumed to be from Latty Avenue Properties; the remainder was assumed to be from SLAPS VPs.

Coldwater Creek samples use SLAPS characterization data to determine release rates.

Gamma = Gamma Spectroscopy; IAAAP = Iowa Army Ammunition Plant; IsoRa = Isotopic Radium; IsoTh = Isotopic Thorium; IsoU = Isotopic Uranium.

6.5.2 Laboratory Total Airborne Radioactive Particulate Emission Rates

The laboratory total CY 2011 emission rate was input into the USEPA CAP88-PC code. The total emission rates are shown in Table A.6-3 as the calculated emissions from laboratory operations. The result was then used to calculate total dose to the hypothetical maximally exposed receptor. Calculation of emission rates can be referenced in Attachment 1.

Table A.6-3. Laboratory Total Airborne Radioactive Particulate Emission Rates for CY 2011

Radionuclide	Emission (Ci/yr)[a]
U-238	5.6E-07
U-235	2.5E-08
U-234	4.9E-07
Ra-226	1.8E-07
Th-232	4.9E-08
Th-230	8.6E-07
Th-228	3.5E-08
Ra-224	3.5E-08
Th-234	5.6E-07
Pa-234m	5.6E-07
Th-231	2.5E-08
Ra-228	1.1E-07
Ac-228	1.1E-07
Pa-231	8.8E-08
Ac-227	7.8E-08

[a] Total emission rate is the sum of individual emission rates that were determined by using the calculation in Section 6.5.1.

6.6 CAP88-PC RESULTS

The CAP88-PC report is contained in Attachment 2. The stack factor input was 3 m high and 0.3 m in diameter. This evaluation demonstrates that all USACE Radioanalytical Laboratory critical receptors receive less than 10 percent of the dose standard in 40 *CFR* 61.102, and therefore, the laboratory is exempt from the reporting requirement of 40 *CFR* 61.104(a). Table A.6-4 summarizes the results.

Table A.6-4. Laboratory CAP88-PC Results for Critical Receptors for CY 2011

Receptor	Distance (m)	Direction from Site	Dose (mrem/yr)
Nearest Resident[a]	330	NE	<0.1
School[b]	1,830	SE	<0.1
Business[b]	110	S	<0.1
Farm[a]	310	NE	<0.1

[a] Occupancy factor is 100 percent for resident and farm.
[b] Corrected for the 23 percent occupancy factor (50 weeks/year; 40 hours/week).

THIS PAGE INTENTIONALLY LEFT BLANK

7.0 REFERENCES

USACE 2003. *Feasibility Study for the St. Louis North County Site*, U.S. Army Corps of Engineers, St. Louis District Office, FUSRAP. Final, May.

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

USEPA 2007. CAP88-PC Version 3.0 Computer Code, U.S. Environmental Protection Agency, December.

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* Subpart D. *Method for Estimating Radionuclide Emissions.*

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

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A

FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

ATTACHMENT 1

CALCULATED EMISSION RATES FROM NORTH ST. LOUIS COUNTY SITES PROPERTIES

THIS PAGE INTENTIONALLY LEFT BLANK

Table A1-1. Latty Avenue Properties Soil Radionuclide Concentrations for CY 2011

Property	HISS	Futura	VP-02L	VP-31A	VP-40A
Radionuclide	Average Concentration (pCi/g)[a]				
U-238	17.1	54.2	10.3	0.13	10.6
U-235	1.59	2.49	0.4738	0.01	0.19
U-234	17.1	54.2	10.3	0.13	2.17
Ra-226	9.6	46	2.72	1.4	7.66
Ra-228	0.99	0.19	1.06	0.01	0.89
Th-232	1.79	2.33	1.95	2.0	1.94
Th-230	51.9	102	119	11	181
Th-228	0.99	2.33	1.06	0.01	0.89
Pa-231	1.67	59.8	3.54	0.09	0.0
Ac-227	1.68	50.6	3.0	0.08	0.33

[a] Radionuclides and concentrations from the *Feasibility Study for the St. Louis North County Site* Appendix D, Attachment 5 (USACE 2003).

Table A1-2. Latty Avenue Properties Average Gross Alpha and Beta Airborne Particulate Emissions for CY 2011

Location	Average Concentration (uCi/ml) for Location[a]	
	Gross Alpha	Gross Beta
HISS	2.22E-15	2.18E-14
Futura	2.19E-15	3.01E-14
VP-02(L)	4.55E-15	2.01E-14
VP 40A[b]	0.00E+00	2.68E-14
VP-31A	2.07E-15	7.49E-15
Background Concentration[c]	3.37E-15	1.97E-14

[a] Average concentration values for the sampling period by location.
[b] Negative gross alpha values were less than the laboratory instrument background value, and were reported as zero.
[c] These concentrations are only provided for informational purpose. However, as a conservative approach, they were not subtracted from the gross average concentration during the determination of EDE.

Table A1-3. Latty Avenue Properties Excavation Data for CY 2011

Location	Area (m^2)	Start Date	Backfill Date
Futura/HISS - SU-12G	12	09/13/11	09/21/11
Futura/HISS - SU-13E[a]	642	01/01/11	01/25/11
Futura/HISS - SU-13F	183	01/04/11	02/09/11
Futura/HISS - SU-13G	95	02/21/11	03/09/11
Futura/HISS - SU-15D[a]	890	01/01/11	01/04/11
Futura/HISS - SU-16A	875	01/19/11	02/28/11
Futura/HISS - SU-16B	554	01/19/11	03/03/11
Futura/HISS - SU-16C	633	03/17/11	04/06/11
Futura/HISS - SU-17A	533	03/07/11	04/19/11
Futura/HISS - SU-17B	720	03/24/11	05/10/11
Futura/HISS - SU-17C	921	03/28/11	05/18/11
Futura/HISS - SU-17D	71	03/28/11	08/24/11
Futura/HISS - SU-18A	391	04/14/11	06/29/11
Futura/HISS - SU-18B	25	04/14/11	06/29/11
Futura/HISS - SU-19A	225	07/12/11	08/15/11
Futura/HISS - SU-19B	32	07/21/11	08/15/11
Futura/HISS - SU-19C	132	08/17/11	08/31/11
Futura/HISS - SU-19D	86	09/01/11	09/14/11
Futura/HISS - SU-20A	194	07/25/11	08/15/11
Futura/HISS - SU-20B	50	08/05/11	08/15/11
Futura/HISS - SU-20C	197	08/10/11	08/19/11
Futura/HISS - SU-20D	68	08/17/11	08/23/11
VP-02(L) - Excavation Area-12C	7	07/21/11	08/18/11
VP-02(L) - Excavation Area-9K	37	03/28/11	06/07/11
VP-02(L) - Excavation Area-9L	335	04/14/11	06/21/11
VP-02(L) - Excavation Area-9M	79	04/14/11	06/28/11
VP-31A	115	02/10/11	03/10/11
VP-40A: EAST - TRACT 3 - SU-17	448	06/06/11	07/06/11
VP-40A: EAST - TRACT 3 - SU-18	19	09/17/11	11/02/11

Note:
Open/close dates set to start or stop at the calendar year boundary.

Table A1-4. Latty Avenue Properties Average Surface Area and Flow Rate per Location for CY 2011

Location	Total Days	Surface Area * Total Days	Average Surface Area/yr (m^2)	Diameter of Stack $D=(1.3*A)^{1/2}$(m)	Flow Rate $F=V*Pi*(D)^2/4$ (m^3/min.)
VP-31A					
VP-31A	29	3,341			
	Total	**3,341**	9	3	**2.5E+03**
HISS					
HISS/Futura - SU-12G	9	104			
HISS/Futura - SU-15D	4	3,558			
HISS/Futura - SU-16A	41	35,891			
HISS/Futura - SU-16B	44	24,362			
HISS/Futura - SU-16C	21	13,293			
HISS/Futura - SU-17A	44	23,462			
HISS/Futura - SU-17B	48	34,571			
HISS/Futura - SU-17C	52	47,872			
HISS/Futura - SU-17D	150	10,715			
HISS/Futura - SU-18A	77	30,092			
HISS/Futura - SU-18B	77	1,909			
HISS/Futura - SU-19A	35	7,865			
HISS/Futura - SU-19B	26	832			
HISS/Futura - SU-19C	15	1,985			
HISS/Futura - SU-19D	14	1,201			
HISS/Futura - SU-20A	22	4,266			
HISS/Futura - SU-20B	11	549			
HISS/Futura - SU-20C	10	1,970			
HISS/Futura - SU-20D	7	473			
	Total	**244,970**	671	30	**1.8E+05**
Futura					
HISS/Futura - SU-13E	25	16,050			
HISS/Futura - SU-13F	37	6,784			
HISS/Futura - SU-13G	17	1,613			
	Total	**24,447**	67	9	**1.8E+04**
VP-02(L)					
VP-02(L) - Excavation Area 9K	72	2,631			
VP-02(L) - Excavation Area 9L	69	23,138			
VP-02(L) - Excavation Area 9M	76	6,021			
VP-02(L) - Excavation Area 12C	29	205			
	Total	**31,996**	88	11	**2.4E+04**
VP-40A					
VP-40A East Tract 3 - SU-17	31	13,880			
VP-40A East Tract 3 - SU-18	47	914			
	Total	**14,795**	41	7	**1.1E+04**

Table A1-5. Latty Avenue Properties Airborne Radioactive Particulate Emissions Based on Site Perimeter Air Samples for CY 2011[a]

Property	HISS			Futura			VP-02L			VP-31A		
Radionuclide	Activity Fraction[a]	Emission Conc. (uCi/cm³)[b]	Release Rate (Ci/y)[c]	Activity Fraction[a]	Emission Conc. (uCi/cm³)[b]	Release Rate (Ci/y)[c]	Activity Fraction[a]	Emission Conc. (uCi/cm³)[b]	Release Rate (Ci/y)[c]	Activity Fraction[a]	Emission Conc. (uCi/cm³)[b]	Release Rate (Ci/y)[c]
U-238	0.16	3.6E-16	3.4E-05	0.14	3.2E-16	3.0E-06	0.07	3.1E-16	3.9E-06	0.01	1.8E-17	2.4E-08
U-235	0.02	3.4E-17	3.2E-06	0.01	1.4E-17	1.4E-07	0.00	1.4E-17	1.8E-07	0.00	8.0E-19	1.0E-09
U-234	0.16	3.6E-16	3.4E-05	0.14	3.2E-16	3.0E-06	0.07	3.1E-16	3.9E-06	0.01	1.8E-17	2.4E-08
Ra-226	0.09	2.0E-16	1.9E-05	0.12	2.7E-16	2.5E-06	0.02	8.1E-17	1.0E-06	0.09	1.9E-16	2.5E-07
Th-232	0.02	3.8E-17	3.6E-06	0.01	1.4E-17	1.3E-07	0.01	5.8E-17	7.3E-07	0.13	2.8E-16	3.6E-07
Th-230	0.50	1.1E-15	1.0E-04	0.27	5.9E-16	5.6E-06	0.78	3.5E-15	4.5E-05	0.74	1.5E-15	2.0E-06
Th-228	0.01	2.1E-17	2.0E-06	0.01	1.4E-17	1.3E-07	0.01	3.1E-17	4.0E-07	0.00	1.5E-18	2.0E-09
Ra-224[d]	0.01	2.1E-17	2.0E-06	0.01	1.4E-17	1.3E-07	0.01	3.1E-17	4.0E-07	0.00	1.5E-18	2.0E-09
Th-234[d]	0.45	9.9E-15	9.3E-04	0.49	1.5E-14	1.4E-04	0.44	8.9E-15	1.1E-04	0.48	3.6E-15	4.7E-06
Pa-234m[d]	0.45	9.9E-15	9.3E-04	0.49	1.5E-14	1.4E-04	0.44	8.9E-15	1.1E-04	0.48	3.6E-15	4.7E-06
Th-231[d]	0.04	9.2E-16	8.7E-05	0.02	6.8E-16	6.4E-06	0.02	4.1E-16	5.2E-06	0.02	1.5E-16	2.0E-07
Ra-228	0.03	5.7E-16	5.4E-05	0.00	5.0E-17	4.8E-07	0.05	9.2E-16	1.2E-05	0.01	1.1E-16	1.4E-07
Ac-228[d]	0.03	5.7E-16	5.4E-05	0.00	5.0E-17	4.8E-07	0.05	9.2E-16	1.2E-05	0.01	1.1E-16	1.4E-07
Pa-231	0.02	3.5E-17	3.4E-06	0.16	3.5E-16	3.3E-06	0.02	1.0E-16	1.3E-06	0.01	1.2E-17	1.6E-08
Ac-227	0.02	3.6E-17	3.4E-06	0.13	2.9E-16	2.8E-06	0.02	8.9E-17	1.1E-06	0.01	1.1E-17	1.4E-08

Table A1-5. Latty Avenue Properties Airborne Radioactive Particulate Emissions Based on Site Perimeter Air Samples for CY 2011[a] (Continued)

Property	VP-40A		
Radionuclide	Activity Fraction[a]	Emission Conc. (uCi/cm^3)[b]	Release Rate (Ci/y)[c]
U-238	0.05	0.0E+00	0.0E+00
U-235	0.00	0.0E+00	0.0E+00
U-234	0.01	0.0E+00	0.0E+00
Ra-226	0.04	0.0E+00	0.0E+00
Th-232	0.01	0.0E+00	0.0E+00
Th-230	0.88	0.0E+00	0.0E+00
Th-228	0.00	0.0E+00	0.0E+00
Ra-224[d]	0.00	0.0E+00	0.0E+00
Th-234[d]	0.46	1.2E-14	7.1E-05
Pa-234m[d]	0.46	1.2E-14	7.1E-05
Th-231[d]	0.01	2.2E-16	1.3E-06
Ra-228	0.04	1.0E-15	6.0E-06
Ac-228[d]	0.04	1.0E-15	6.0E-06
Pa-231	0.00	0.0E+00	0.0E+00
Ac-227	0.00	0.0E+00	0.0E+00

[a] Derived from the average soil radionuclide concentrations from the *Feasibility Study for the St. Louis North County Site* Table D-5 (USACE 2003). Average soil radionuclide concentrations are presented in Table A1-1. Activity fractions have been rounded; non-rounded values were used in calculations.

[b] Emission concentration is equal to the activity fraction * the gross alpha or gross beta airborne particulate concentrations listed in Table A1-2.

[c] Release rate based on 365-day period at measured flow rate (Table A1-4) for each site as determined from the average annual wind speed (4.446 meters/second) and calculated site area (Table A1-4). (Note: 1 mL = 1 cm^3).

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

Table A1-6. SLAPS/SLAPS VPs Soil Radionuclide Concentrations for CY 2011

Property	McDonnell Boulevard	IA-09	VP-12	SLAPS Loadout
Radionuclide	**Average Concentration (pCi/g)[a]**			
Uranium-238	2.0	5.7	11	3
Uranium-235	0.1	0.3	0.02	0.03
Uranium-234	2	5.9	0.4	0.6
Radium-226	0.8	1.9	2.0	0.7
Radium-228	0.5	1	0.01	0.1
Thorium-232	0.8	1.6	2	0.6
Thorium-230	9	33	31	11
Thorium-228	0.6	1.3	0.03	0.2
Protactinium-231	0.3	0.3	0.3	0.1
Actinium-227	0.2	0.3	0.2	0.1

[a] Radionuclides and concentrations from the *Feasibility Study for the St. Louis North County Site* Table D-5 (USACE 2003).

Table A1-7. SLAPS/SLAPS VPs Average Gross Alpha and Beta Airborne Particulate Emissions for CY 2011

Location	Average Concentration (uCi/ml) for Location[a]	
	Gross Alpha	**Gross Beta**
McDonnell Blvd	3.29E-15	2.62E-14
IA-09	5.14E-15	3.08E-14
VP-12	2.22E-15	1.28E-14
SLAPS Loadout	3.43E-15	2.54E-14
Background Concentration[b]	3.37E-15	1.97E-14

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

Table A1-8. SLAPS/SLAPS VPs Excavation Data for CY 2011

USACE Location Name	Surface Area (m^2)	Start Date	Backfill Date
IA-09 - Phase 1 – SU-1A	297	11/17/11	12/05/11
IA-09 - Phase 1 – SU-1B	63	11/21/11	12/05/11
IA-09 - Phase 1 – SU-1C	153	11/10/11	12/19/11
IA-09 - Phase 1 – SU-1D	306	11/14/11	12/31/11
IA-09 - Phase 1 – SU-1E	262	11/17/11	12/31/11
IA-09 - Phase 1 – SU-1F	370	12/15/11	12/31/11
McDonnell Blvd - East Section(b) - SU-1F	228	02/20/11	02/26/11
McDonnell Blvd - East Section(b) - SU-1G	95	02/20/11	02/26/11
McDonnell Blvd - East Section(b) - SU-1H	7	02/20/11	03/01/11
McDonnell Blvd - East Section(b) - SU-1I	4	02/21/11	03/01/11
McDonnell Blvd - East Section(b) - SU-1J	56	02/26/11	03/04/11
McDonnell Blvd - East Section(b) - SU-1K	54	03/05/11	03/15/11
McDonnell Blvd - East Section(b) - SU-1L	118	03/12/11	03/18/11
SLAPS Loadout	1,311	01/01/11	12/31/11
VP-12 A1	561	01/01/11	04/13/11
VP-12 A2	96	01/01/11	04/13/11
VP-12 A3	898	01/01/11	04/13/11
VP-12 A4	241	01/01/11	04/13/11
VP-12 A5	495	01/01/11	04/13/11
VP-12 A6	251	01/01/11	04/13/11
VP-12 A7	18	01/01/11	04/13/11
VP-12 B	60	01/01/11	08/24/11
VP-12 C/E	1,086	01/01/11	01/06/11
VP-12 D	223	01/01/11	01/13/11
VP-12 H	23	01/01/11	01/13/11

Note:
Open/close dates set to start or stop at the calendar year boundary.

Table A1-9. SLAPS/SLAPS VPs Average Surface Area and Flow Rate Per Location for CY 2011

Location	Total Days	Surface Area * Total Days	Average Surface Area/yr (m^2)	Diameter of stack $D=(1.3*A)^{1/2}$ (m)	Flow Rate $F=V*Pi*(D)^2/4$ (m^3/min)
McDonnell Boulevard					
McDonnell Blvd - East Section(b) - SU-1F	7	1,594			
McDonnell Blvd - East Section(b) - SU-1G	7	666			
McDonnell Blvd - East Section(b) - SU-1H	10	67			
McDonnell Blvd - East Section(b) - SU-1I	9	40			
McDonnell Blvd - East Section(b) - SU-1J	7	389			
McDonnell Blvd - East Section(b) - SU-1K	11	596			
McDonnell Blvd - East Section(b) - SU-1L	7	829			
	Total	**4,181**	11	4	**3.1E+03**
IA-09 (Ballfields)					
IA-09 Phase 1 SU-1A	19	5,648			
IA-09 Phase 1 SU-1B	15	942			
IA-09 Phase 1 SU-1C	40	6,111			
IA-09 Phase 1 SU-1D	48	14,696			
IA-09 Phase 1 SU-1E	45	11,794			
IA-09 Phase 1 SU-1F	17	6,287			
	Total	**45,479**	125	13	**3.3E+04**
VP-12					
VP-12 Excavation Area A-1	103	57,844			
VP-12 Excavation Area A-2	103	9,953			
VP-12 Excavation Area A-3	103	92,516			
VP-12 Excavation Area A-4	103	24,835			
VP-12 Excavation Area A-5	103	51,084			
VP-12 Excavation Area A-6	103	25,876			
VP-12 Excavation Area A-7	103	1,865			
VP-12 Excavation Area B	236	14,351			
VP-12 Excavation Area C/E	6	6,518			
VP-12 Excavation Area D	13	2,899			
VP-12 Excavation Area H	13	308			
	Total	**288,050**	778	32	**2.1E+05**
SLAPS Loadout					
SLAPS Loadout	365	478,515			
	Total	**478,515**	1,311	41	**3.6E+05**

Table A1-10. SLAPS/SLAPS VPs Airborne Radioactive Particulate Emissions Based on Site Perimeter Air Samples for CY 2011

Property	McDonnell Boulevard			IA-09			VP-12			SLAPS Loadout		
Radionuclide	Activity Fraction[a]	Emission Conc. (uCi/cm^3)[b]	Release Rate (Ci/y)[c]	Activity Fraction[a]	Emission Conc. (uCi/cm^3)[b]	Release Rate (Ci/y)c	Activity Fraction[a]	Emission Conc. (uCi/cm^3)[b]	Release Rate (Ci/y)[c]	Activity Fraction[a]	Emission Conc. (uCi/cm^3)[b]	Release Rate (Ci/y)[c]
U-238	0.12	4.1E-16	6.6E-07	0.23	5.0E-16	1.0E-05	0.23	1.7E-15	5.5E-05	0.18	6.3E-16	1.2E-04
U-235	0.01	2.0E-17	3.2E-08	0.00	7.8E-19	5.3E-07	0.00	2.7E-18	8.6E-08	0.00	5.9E-18	1.1E-06
U-234	0.12	4.1E-16	6.6E-07	0.01	1.8E-17	1.1E-05	0.01	6.1E-17	2.0E-06	0.04	1.2E-16	2.3E-05
Ra-226	0.05	1.6E-16	2.6E-07	0.04	9.4E-17	3.4E-06	0.04	3.2E-16	1.0E-05	0.04	1.4E-16	2.7E-05
Th-232	0.05	1.5E-16	2.5E-07	0.04	8.7E-17	2.8E-06	0.04	3.0E-16	9.6E-06	0.04	1.3E-16	2.5E-05
Th-230	0.55	1.8E-15	2.9E-06	0.67	1.5E-15	5.9E-05	0.67	5.1E-15	1.6E-04	0.67	2.3E-15	4.3E-04
Th-228	0.04	1.2E-16	2.0E-07	0.00	1.5E-18	2.3E-06	0.00	5.1E-18	1.6E-07	0.01	3.2E-17	6.1E-06
Ra-224[d]	0.04	1.2E-16	2.0E-07	0.00	1.5E-18	2.3E-06	0.00	5.1E-18	1.6E-07	0.01	3.2E-17	6.1E-06
Th-234[d]	0.40	1.0E-14	1.7E-05	0.50	6.4E-15	2.3E-04	0.50	2.8E-14	7.0E-04	0.48	1.2E-14	2.3E-03
Pa-234m[d]	0.40	1.0E-14	1.7E-05	0.50	6.4E-15	2.3E-04	0.50	2.8E-14	7.0E-04	0.48	1.2E-14	2.3E-03
Th-231[d]	0.02	5.1E-16	8.3E-07	0.00	9.9E-18	1.2E-05	0.00	4.3E-17	1.1E-06	0.00	1.1E-16	2.1E-05
Ra-228	0.09	2.4E-15	3.8E-06	0.00	6.8E-18	4.0E-05	0.00	3.0E-17	7.5E-07	0.02	4.5E-16	8.6E-05
Ac-228[d]	0.09	2.4E-15	3.8E-06	0.00	6.8E-18	4.0E-05	0.00	3.0E-17	7.5E-07	0.02	4.5E-16	8.6E-05
Pa-231	0.02	5.4E-17	8.7E-08	0.01	1.2E-17	5.3E-07	0.01	4.1E-17	1.3E-06	0.01	2.8E-17	5.3E-06
Ac-227	0.01	4.0E-17	6.5E-08	0.00	1.0E-17	5.3E-07	0.00	3.6E-17	1.2E-06	0.01	2.3E-17	4.3E-06

[a] Derived from the average soil radionuclide concentrations from the *Feasibility Study for the St. Louis North County Site* Table D-5 (USACE 2003). Average soil radionuclide concentrations are presented in Table A1-6. Activity fractions have been rounded; non-rounded values were used in calculations.
[b] Emission concentration is equal to the activity fraction * the gross alpha or gross beta airborne particulate concentrations listed in Table A1-7.
[c] Release rate based on 365-day period at measured flow rate (Table A1-9) for each site as determined from the average annual wind speed (4.446 meters/second) and calculated site area (Table A1-9). (Note: 1 mL = 1 cm^3).
[d] Note: When data was not available, the radionuclide was assumed to be in secular equilibrium with parent.

Table A1-11. FUSRAP Laboratory Lab Analyses for CY 2011[a]

Site	Type	Gamma	IsoRa	IsoTh	IsoU	Total Drying and Grinding	Total Separations
HISS	soil	60	0	60	0	60	60
HISS	water	0	17	17	17	0	51
Latty Avenue Properties	soil	580	0	701	0	580	701
Latty Avenue Properties	water	0	39	39	0	0	78
IAAAP	soil	44	0	0	44	44	44
IAAAP	water	0	0	0	0	0	0
SLAPS	soil	0	0	0	0	0	0
SLAPS	water	53	73	73	15	53	161
SLAPS VPs	soil	1,839	0	1,645	0	1,839	1,645
SLAPS VPs	water	0	7	7	0	0	14
Coldwater Creek	sediment (soil)	20	0	13	0	20	13
Coldwater Creek	water	0	13	13	13	0	39
SLDS	soil	923	0	894	0	923	894
SLDS	water	0	83	82	16	0	181

HISS and Latty Avenue Properties	**Total**	640	890
IAAAP	**Total**	44	44
SLAPS, SLAPS VPs, and Coldwater Creek	**Total**	1,859	1,872
SLDS	**Total**	923	1,075

Assumptions:
[a] Data provided by the USACE laboratory for CY 2011.
All soil samples went through a drying/grinding process.
All soil and water samples for IsoRa, IsoTh, and IsoU went through a separations process.
IsoRa, IsoTh, and IsoU are distinctly separate processes occurring at different times.
Sample data from the lab did not separate Latty Avenue Properties from SLAPS VPs samples. Based on a property-specific summary, 40 percent of NC Sites samples were assumed to be from Latty Avenue Properties; the remainder was assumed to be from SLAPS VPs.
Gamma = Gamma Spectroscopy; IAAAP = Iowa Army Ammunition Plant; IsoRa = Isotopic Radium; IsoTh = Isotopic Thorium; IsoU = Isotopic Uranium.

Table A1-12. SLDS Property Laboratory Samples for CY 2011

Radionuclide	Avg. (pCi/g)[a]	No. Samples[b]	No. Samples[c]	Emission Rate[d] (Ci/y)
U-238	60	923	1,075	3.8E-07
U-235	3	923	1,075	1.8E-08
U-234	60	923	1,075	3.8E-07
Ra-226	16	923	1,075	9.8E-08
Th-232	4	923	1,075	2.4E-08
Th-230	22	923	1,075	1.4E-07
Th-228	4	923	1,075	2.4E-08
Ra-224	4	923	1,075	2.4E-08
Th-234	60	923	1,075	3.8E-07
Pa-234m	60	923	1,075	3.8E-07
Th-231	3	923	1,075	1.8E-08
Ra-228	16	923	1,075	9.8E-08
Ac-228	16	923	1,075	9.8E-08
Pa-231	3	923	1,075	1.8E-08
Ac-227	60	923	1,075	3.8E-07

[a] Average soil concentration from Table A1-1 of SLDS CY 2011 EMDAR Appendix A, Attachment 1.
[b] Number of samples involved in drying/grinding operations.
[c] Number of samples involved in separations operations.
[d] Emission Rate = (0.001*Avg * No. Samples [drying & grinding]+ 0.005*Avg * No. Samples [separations])*(1000g * 1E-12Ci/pCi).

Table A1-13. SLAPS/SLAPS VPs Laboratory Samples for CY 2011

Radionuclide	Avg. (pCi/g)[a]	No. Samples[b]	No. Samples[c]	Emission Rate[d] (Ci/y)
U-238	5.34	1,859	1,872	6.0E-08
U-235	0.11	1,859	1,872	1.2E-09
U-234	2.23	1,859	1,872	2.5E-08
Ra-226	1.34	1,859	1,872	1.5E-08
Th-232	1.21	1,859	1,872	1.4E-08
Th-230	21.17	1,859	1,872	2.4E-07
Th-228	0.52	1,859	1,872	5.9E-09
Ra-224	0.52	1,859	1,872	5.9E-09
Th-234	5.34	1,859	1,872	6.0E-08
Pa-234m	5.34	1,859	1,872	6.0E-08
Th-231	0.11	1,859	1,872	1.2E-09
Ra-228	0.40	1,859	1,872	4.4E-09
Ac-228	0.40	1,859	1,872	4.4E-09
Pa-231	0.24	1,859	1,872	2.7E-09
Ac-227	0.21	1,859	1,872	2.3E-09

[a] Average soil concentration from Table A1-6.
[b] Number of samples involved in drying/grinding operations.
[c] Number of samples involved in separations operations.
[d] Emission Rate = (0.001*Avg * No. Samples [drying &grinding]+ 0.005*Avg * No. Samples [separations])*(1000g * 1E-12Ci/pCi).

Table A1-14. IAAAP Site Laboratory Samples for CY 2011

Radionuclide	Avg. (pCi/g)[a]	No. Samples[b]	No. Samples[c]	Emission Rate[d] (Ci/y)
U-238	95	44	44	2.5E-08
U-235	1	44	44	3.8E-10
U-234	8	44	44	2.2E-09
Ra-226	1	44	44	1.9E-10
Th-232	7	44	44	1.8E-09
Th-230	18	44	44	4.8E-09
Th-228	0.4	44	44	1.1E-10
Ra-224	0.4	44	44	1.1E-10
Th-234	95	44	44	2.5E-08
Pa-234m	95	44	44	2.5E-08
Th-231	1	44	44	3.8E-10
Ra-228	0.4	44	44	9.8E-11
Ac-228	0.4	44	44	9.8E-11
Pa-231	1	44	44	3.8E-10
Ac-227	95	44	44	2.5E-08

[a] Average soil concentration from Table A1-1.
[b] Number of samples involved in drying/grinding operations.
[c] Number of samples involved in separations operations.
[d] Emission Rate = (0.001*Avg * No. Samples [drying & grinding]+ 0.005*Avg * No. Samples [separations])*(1000g * 1E-12Ci/pCi).
IAAAP = Iowa Army Ammunition Plant

Table A1-15. Latty Avenue Property Laboratory Samples for CY 2011

Radionuclide	Avg. (pCi/g)[a]	No. Samples[b]	No. Samples[c]	Emission Rate[d] (Ci/y)
U-238	18	640	890	9.4E-08
U-235	1	640	890	4.8E-09
U-234	17	640	890	8.5E-08
Ra-226	13	640	890	6.9E-08
Th-232	2	640	890	1.0E-08
Th-230	93	640	890	4.7E-07
Th-228	1	640	890	5.4E-09
Ra-224	1	640	890	5.4E-09
Th-234	18	640	890	9.4E-08
Pa-234m	18	640	890	9.4E-08
Th-231	1	640	890	4.8E-09
Ra-228	0.6	640	890	3.2E-09
Ac-228	0.6	640	890	3.2E-09
Pa-231	13	640	890	6.6E-08
Ac-227	11	640	890	5.7E-08

[a] Average soil concentration from Table A1-1.
[b] Number of samples involved in drying/grinding operations.
[c] Number of samples involved in separations operations.
[d] Emission Rate = (0.001*Avg * No. Samples [drying & grinding]+ 0.005*Avg * No. Samples [separations])*(1000g * 1E-12Ci/pCi).

Table A1-16. Total Laboratory Airborne Radioactive Particulate Emission Rate for CY 2011

Radionuclides	Emission Rate (Ci/y)				
	SLDS	IAAAP	SLAPS/ SLAPS VPs	Latty Avenue Properties	Total Across Lab[1]
U-238	3.8E-07	2.5E-08	6.0E-08	9.4E-08	5.6E-07
U-235	1.8E-08	3.8E-10	1.2E-09	4.8E-09	2.5E-08
U-234	3.8E-07	2.2E-09	2.5E-08	8.6E-08	4.9E-07
Ra-226	9.8E-08	1.9E-10	1.5E-08	6.9E-08	1.8E-07
Th-232	2.4E-08	1.8E-09	1.4E-08	1.0E-08	4.9E-08
Th-230	1.4E-07	4.8E-09	2.4E-07	4.7E-07	8.6E-07
Th-228	2.4E-08	1.1E-10	5.9E-09	5.4E-09	3.5E-08
Ra-224	2.4E-08	1.1E-10	5.9E-09	5.4E-09	3.5E-08
Th-234	3.8E-07	2.5E-08	6.0E-08	9.4E-08	5.6E-07
Pa-234m	3.8E-07	2.5E-08	6.0E-08	9.4E-08	5.6E-07
Th-231	1.8E-08	3.8E-10	1.2E-09	4.8E-09	2.5E-08
Ra-228	9.8E-08	9.8E-11	4.4E-09	3.2E-09	1.1E-07
Ac-228	9.8E-08	9.8E-11	4.4E-09	3.2E-09	1.1E-07
Pa-231	1.8E-08	3.8E-10	2.7E-09	6.6E-08	8.8E-08
Ac-227	1.8E-08	3.8E-10	2.3E-09	5.7E-08	7.8E-08

[a] Total emission rate is sum of SLDS, IAAAP, SLAPS/SLAPS VPs, and Latty Avenue Properties emission rates.
IAAAP = Iowa Army Ammunition Plant

THIS PAGE INTENTIONALLY LEFT BLANK

ATTACHMENT 2

CAP88-PC RUNS FOR NORTH ST. LOUIS COUNTY SITES PROPERTIES

THIS PAGE INTENTIONALLY LEFT BLANK

CAP88-PC RUNS FOR LATTY AVENUE PROPERTIES

THIS PAGE INTENTIONALLY LEFT BLANK

CAP88 OUTPUT RESULTS

HISS

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

D O S E   A N D   R I S K   E Q U I V A L E N T   S U M M A R I E S

Non-Radon Individual Assessment
Mar 28, 2012 01:11 pm

```
Facility:  HISS
 Address:  HISS/Latty Ave
    City:  Berkely
   State:  MO          Zip:    63134

Source Category:  Area
    Source Type:  Area
  Emission Year:  2011

Comments:  Air
           Air

   Dataset Name:  HISS 2011
   Dataset Date:  3/28/2012 1:10:00 PM
      Wind File:      C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 28, 2012 01:11 pm

SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
Adrenals	1.04E-03
B Surfac	2.85E-01
Breasts	1.11E-03
St Wall	1.07E-03
ULI Wall	1.15E-03
Kidneys	5.14E-03
Lungs	6.11E-02
Ovaries	3.12E-03
R Marrow	1.29E-02
Spleen	1.07E-03
Thymus	1.06E-03
Uterus	1.05E-03
Bld Wall	1.07E-03
Brain	1.06E-03
Esophagu	2.46E-02
SI Wall	1.06E-03
LLI Wall	1.32E-03
Liver	1.19E-02
Muscle	1.12E-03
Pancreas	1.04E-03
Skin	1.54E-02
Testes	3.22E-03
Thyroid	1.09E-03
EFFEC	2.64E-01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	1.01E-02
INHALATION	2.53E-01
AIR IMMERSION	1.47E-06
GROUND SURFACE	5.56E-04
INTERNAL	2.63E-01
EXTERNAL	5.57E-04
TOTAL	2.64E-01

Mar 28, 2012 01:11 pm

SUMMARY
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	9.65E-03
Th-234	7.35E-04
Pa-234m	1.44E-04
Pa-234	3.53E-06
U-234	1.17E-02
Th-230	1.41E-01
Ra-226	7.38E-03
Rn-222	1.39E-13
Po-218	7.22E-10
Pb-214	2.00E-05
Bi-214	1.20E-04
Po-214	6.60E-09
Pb-210	6.78E-06
Bi-210	2.19E-08
Po-210	5.63E-07
At-218	0.00E+00
U-235	9.72E-04
Th-231	2.99E-06
Pa-231	3.02E-02
Ac-227	2.35E-02
Th-227	1.72E-06
Ra-223	1.34E-05
Rn-219	0.00E+00
Po-215	1.47E-09
Pb-211	8.30E-07
Bi-211	3.85E-07
Tl-207	4.85E-07
Po-211	0.00E+00
Fr-223	2.65E-08
Th-232	8.61E-03
Ra-228	2.05E-02
Ac-228	2.79E-04
Th-228	7.78E-03
Ra-224	5.84E-04
Rn-220	1.36E-11
Po-216	3.83E-10
Pb-212	3.44E-06
Bi-212	5.32E-06
Po-212	0.00E+00
Tl-208	2.52E-05
TOTAL	2.64E-01

Mar 28, 2012 01:11 pm

SUMMARY
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
Esophagu	1.17E-10
Stomach	3.46E-10
Colon	1.26E-09
Liver	2.85E-09
LUNG	1.15E-07
Bone	3.76E-09
Skin	2.31E-11
Breast	2.01E-10
Ovary	5.32E-10
Bladder	2.72E-10
Kidneys	4.06E-10
Thyroid	2.60E-11
Leukemia	7.29E-10
Residual	1.32E-09
Total	1.27E-07
TOTAL	2.54E-07

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.41E-09
INHALATION	1.23E-07
AIR IMMERSION	7.10E-13
GROUND SURFACE	2.41E-10
INTERNAL	1.27E-07
EXTERNAL	2.42E-10
TOTAL	1.27E-07

Mar 28, 2012 01:11 pm

SUMMARY
Page 4

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	7.97E-09
Th-234	6.95E-10
Pa-234m	2.31E-11
Pa-234	1.92E-12
U-234	9.71E-09
Th-230	7.25E-08
Ra-226	5.74E-09
Rn-222	7.54E-20
Po-218	3.96E-16
Pb-214	1.07E-11
Bi-214	6.39E-11
Po-214	3.62E-15
Pb-210	2.25E-12
Bi-210	1.02E-14
Po-210	2.16E-13
At-218	0.00E+00
U-235	8.03E-10
Th-231	2.77E-12
Pa-231	2.86E-09
Ac-227	6.19E-09
Th-227	1.32E-12
Ra-223	7.29E-12
Rn-219	0.00E+00
Po-215	8.06E-16
Pb-211	2.75E-13
Bi-211	2.11E-13
Tl-207	6.19E-14
Po-211	0.00E+00
Fr-223	1.51E-14
Th-232	3.80E-09
Ra-228	9.22E-09
Ac-228	1.55E-10
Th-228	6.65E-09
Ra-224	5.02E-10
Rn-220	7.42E-18
Po-216	2.10E-16
Pb-212	1.96E-12
Bi-212	2.39E-12
Po-212	0.00E+00
Tl-208	1.37E-11
TOTAL	1.27E-07

Mar 28, 2012 01:11 pm **SUMMARY**
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)				
Direction	130	480	740	2200	
N	2.6E-01	3.0E-02	1.7E-02	8.3E-03	
NNW	1.4E-01	1.9E-02	1.2E-02	7.6E-03	
NW	1.6E-01	2.1E-02	1.3E-02	7.7E-03	Business
WNW	2.0E-01	2.4E-02	1.4E-02	7.9E-03	
W	1.5E-01	1.9E-02	1.2E-02	7.7E-03	
WSW	7.6E-02	1.3E-02	9.5E-03	7.2E-03	
SW	1.0E-01	1.5E-02	1.1E-02	7.4E-03	
SSW	1.3E-01	1.7E-02	1.1E-02	7.5E-03	
S	1.1E-01	1.6E-02	1.1E-02	7.5E-03	
SSE	8.0E-02	1.3E-02	9.7E-03	7.3E-03	Residence
SE	1.1E-01	1.6E-02	1.1E-02	7.5E-03	
ESE	1.9E-01	2.3E-02	1.4E-02	7.9E-03	School
E	2.5E-01	2.8E-02	1.6E-02	8.2E-03	
ENE	2.1E-01	2.4E-02	1.5E-02	8.0E-03	
NE	1.3E-01	1.8E-02	1.2E-02	7.5E-03	Farm
NNE	1.1E-01	1.6E-02	1.1E-02	7.4E-03	

Mar 28, 2012 01:11 pm

SUMMARY
Page 6

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

	Distance (m)			
Direction	130	480	740	2200
N	1.3E-07	1.3E-08	7.2E-09	3.0E-09
NNW	6.6E-08	8.0E-09	4.8E-09	2.7E-09
NW	7.8E-08	9.0E-09	5.3E-09	2.8E-09
WNW	9.5E-08	1.0E-08	5.9E-09	2.8E-09
W	7.2E-08	8.4E-09	5.0E-09	2.7E-09
WSW	3.6E-08	5.3E-09	3.6E-09	2.5E-09
SW	5.0E-08	6.5E-09	4.1E-09	2.6E-09
SSW	6.1E-08	7.5E-09	4.6E-09	2.6E-09
S	5.3E-08	6.8E-09	4.3E-09	2.6E-09
SSE	3.8E-08	5.5E-09	3.7E-09	2.5E-09
SE	5.4E-08	6.9E-09	4.4E-09	2.6E-09
ESE	9.2E-08	1.0E-08	5.8E-09	2.8E-09
E	1.2E-07	1.3E-08	6.8E-09	3.0E-09
ENE	1.0E-07	1.1E-08	6.1E-09	2.9E-09
NE	6.1E-08	7.5E-09	4.6E-09	2.7E-09
NNE	5.2E-08	6.7E-09	4.2E-09	2.6E-09

CAP88 OUTPUT RESULTS

FUTURA

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

D O S E   A N D   R I S K   E Q U I V A L E N T   S U M M A R I E S

Non-Radon Individual Assessment
Mar 28, 2012 01:14 pm

```
 Facility:  Futura
  Address:  HISS/Latty Avenue
     City:  Berkely
    State:  MO          Zip:    63134

 Source Category:  Area
     Source Type:  Area
   Emission Year:  2011

 Comments:  Air
            Air

    Dataset Name:  Futura 2011
    Dataset Date:  3/28/2012 1:14:00 PM
       Wind File:      C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 28, 2012 01:14 pm

SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
Adrenals	9.06E-02
B Surfac	2.99E+01
Breasts	9.21E-02
St Wall	9.12E-02
ULI Wall	1.02E-01
Kidneys	3.92E-01
Lungs	1.56E+00
Ovaries	3.37E-01
R Marrow	1.22E+00
Spleen	9.17E-02
Thymus	9.11E-02
Uterus	9.09E-02
Bld Wall	9.15E-02
Brain	9.10E-02
Esophagu	5.77E-01
SI Wall	9.11E-02
LLI Wall	1.23E-01
Liver	2.00E+00
Muscle	9.22E-02
Pancreas	9.06E-02
Skin	6.44E-01
Testes	3.40E-01
Thyroid	9.15E-02
EFFEC	1.69E+01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	1.51E-01
INHALATION	1.67E+01
AIR IMMERSION	2.52E-05
GROUND SURFACE	1.34E-02
INTERNAL	1.69E+01
EXTERNAL	1.34E-02
TOTAL	1.69E+01

Mar 28, 2012 01:14 pm **SUMMARY**
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	2.29E-01
Th-234	3.05E-02
Pa-234m	5.81E-03
Pa-234	1.36E-04
U-234	2.78E-01
Th-230	2.14E+00
Ra-226	2.72E-01
Rn-222	5.12E-12
Po-218	2.66E-08
Pb-214	7.39E-04
Bi-214	4.43E-03
Po-214	2.43E-07
Pb-210	2.55E-04
Bi-210	8.10E-07
Po-210	2.16E-05
At-218	2.25E-09
U-235	1.14E-02
Th-231	5.91E-05
Pa-231	8.26E+00
Ac-227	5.39E+00
Th-227	5.60E-04
Ra-223	3.15E-03
Rn-219	0.00E+00
Po-215	3.39E-07
Pb-211	1.91E-04
Bi-211	8.86E-05
Tl-207	1.12E-04
Po-211	4.18E-08
Fr-223	6.09E-06
Th-232	8.43E-02
Ra-228	4.99E-02
Ac-228	6.76E-04
Th-228	1.34E-01
Ra-224	1.01E-02
Rn-220	2.36E-10
Po-216	2.94E-09
Pb-212	2.89E-05
Bi-212	4.09E-05
Po-212	0.00E+00
Tl-208	1.94E-04
TOTAL	1.69E+01

Mar 28, 2012 01:14 pm

SUMMARY
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
Esophagu	1.10E-08
Stomach	2.38E-08
Colon	6.78E-08
Liver	4.47E-07
LUNG	3.02E-06
Bone	3.22E-07
Skin	1.25E-09
Breast	1.35E-08
Ovary	5.72E-08
Bladder	2.64E-08
Kidneys	2.70E-08
Thyroid	1.94E-09
Leukemia	5.38E-08
Residual	8.49E-08
Total	4.15E-06
TOTAL	8.30E-06

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.52E-08
INHALATION	4.11E-06
AIR IMMERSION	1.00E-11
GROUND SURFACE	4.88E-09
INTERNAL	4.15E-06
EXTERNAL	4.89E-09
TOTAL	4.15E-06

Mar 28, 2012 01:14 pm SUMMARY
Page 4

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.89E-07
Th-234	2.89E-08
Pa-234m	9.34E-10
Pa-234	7.41E-11
U-234	2.30E-07
Th-230	1.09E-06
Ra-226	2.11E-07
Rn-222	2.78E-18
Po-218	1.46E-14
Pb-214	3.94E-10
Bi-214	2.35E-09
Po-214	1.34E-13
Pb-210	8.47E-11
Bi-210	3.82E-13
Po-210	8.27E-12
At-218	1.06E-15
U-235	9.42E-09
Th-231	5.56E-11
Pa-231	7.80E-07
Ac-227	1.42E-06
Th-227	4.49E-10
Ra-223	1.71E-09
Rn-219	0.00E+00
Po-215	1.86E-13
Pb-211	6.34E-11
Bi-211	4.85E-11
Tl-207	1.43E-11
Po-211	2.29E-14
Fr-223	3.46E-12
Th-232	3.72E-08
Ra-228	2.24E-08
Ac-228	3.75E-10
Th-228	1.15E-07
Ra-224	8.66E-09
Rn-220	1.29E-16
Po-216	1.61E-15
Pb-212	1.71E-11
Bi-212	1.84E-11
Po-212	0.00E+00
Tl-208	1.06E-10
TOTAL	4.15E-06

Mar 28, 2012 01:14 pm

SUMMARY
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)				
Direction	150	470	820	2270	
N	1.7E+01	2.1E+00	8.0E-01	2.2E-01	
NNW	8.7E+00	1.1E+00	4.6E-01	1.6E-01	
NW	1.0E+01	1.3E+00	5.2E-01	1.7E-01	Business
WNW	1.3E+01	1.6E+00	6.1E-01	1.9E-01	
W	9.5E+00	1.2E+00	4.9E-01	1.7E-01	
WSW	4.6E+00	6.3E-01	2.9E-01	1.3E-01	
SW	6.5E+00	8.5E-01	3.6E-01	1.4E-01	
SSW	8.0E+00	1.0E+00	4.2E-01	1.5E-01	
S	7.0E+00	9.2E-01	3.9E-01	1.5E-01	
SSE	4.9E+00	6.7E-01	3.0E-01	1.4E-01	Residence
SE	7.1E+00	9.4E-01	3.9E-01	1.5E-01	
ESE	1.2E+01	1.5E+00	6.0E-01	1.9E-01	School
E	1.6E+01	2.0E+00	7.5E-01	2.1E-01	
ENE	1.3E+01	1.7E+00	6.4E-01	1.9E-01	
NE	8.1E+00	1.0E+00	4.3E-01	1.6E-01	Farm
NNE	6.8E+00	8.9E-01	3.8E-01	1.5E-01	

Mar 28, 2012 01:14 pm

SUMMARY
Page 6

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

	Distance (m)			
Direction	150	470	820	2270
N	4.2E-06	5.2E-07	2.0E-07	5.3E-08
NNW	2.1E-06	2.8E-07	1.1E-07	3.9E-08
NW	2.5E-06	3.2E-07	1.3E-07	4.1E-08
WNW	3.1E-06	3.9E-07	1.5E-07	4.5E-08
W	2.3E-06	3.0E-07	1.2E-07	4.0E-08
WSW	1.1E-06	1.5E-07	6.9E-08	3.1E-08
SW	1.6E-06	2.1E-07	8.8E-08	3.4E-08
SSW	2.0E-06	2.5E-07	1.0E-07	3.7E-08
S	1.7E-06	2.3E-07	9.4E-08	3.6E-08
SSE	1.2E-06	1.6E-07	7.3E-08	3.2E-08
SE	1.7E-06	2.3E-07	9.6E-08	3.6E-08
ESE	3.0E-06	3.8E-07	1.5E-07	4.5E-08
E	3.9E-06	4.9E-07	1.8E-07	5.0E-08
ENE	3.3E-06	4.1E-07	1.6E-07	4.6E-08
NE	2.0E-06	2.6E-07	1.0E-07	3.7E-08
NNE	1.7E-06	2.2E-07	9.2E-08	3.5E-08

CAP88 OUTPUT RESULTS

VP-02(L)

```
                              C A P 8 8 - P C

                                Version 3.0

                   Clean Air Act Assessment Package - 1988


     D O S E   A N D   R I S K   E Q U I V A L E N T   S U M M A R I E S

                       Non-Radon Individual Assessment
                           Mar  28, 2012  01:23 pm


         Facility:  VP 02L
          Address:  HISS/Latty Avenue
             City:  Berkely
            State:  MO          Zip:    63134


         Source Category:  Area
             Source Type:  Area
           Emission Year:  2011


         Comments:  Air
                    Air


            Dataset Name:  VP 02L 2011
            Dataset Date:  3/28/2012 1:22:00 PM
               Wind File:      C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 28, 2012 01:23 pm **SUMMARY**
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
Adrenals	2.90E-03
B Surfac	1.13E+00
Breasts	3.00E-03
St Wall	2.94E-03
ULI Wall	3.20E-03
Kidneys	1.80E-02
Lungs	2.10E-01
Ovaries	1.12E-02
R Marrow	4.72E-02
Spleen	2.95E-03
Thymus	2.92E-03
Uterus	2.92E-03
Bld Wall	2.95E-03
Brain	2.93E-03
Esophagu	9.19E-02
SI Wall	2.94E-03
LLI Wall	3.72E-03
Liver	4.15E-02
Muscle	3.02E-03
Pancreas	2.89E-03
Skin	2.15E-02
Testes	1.15E-02
Thyroid	2.97E-03
EFFEC	9.50E-01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	3.11E-02
INHALATION	9.19E-01
AIR IMMERSION	2.67E-06
GROUND SURFACE	8.52E-04
INTERNAL	9.50E-01
EXTERNAL	8.54E-04
TOTAL	9.50E-01

Mar 28, 2012 01:23 pm **SUMMARY Page 2**

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	1.10E-02
Th-234	9.10E-04
Pa-234m	1.78E-04
Pa-234	4.34E-06
U-234	1.33E-02
Th-230	6.33E-01
Ra-226	4.24E-03
Rn-222	7.80E-14
Po-218	4.07E-10
Pb-214	1.13E-05
Bi-214	6.79E-05
Po-214	3.73E-09
Pb-210	4.84E-06
Bi-210	1.32E-08
Po-210	4.08E-07
At-218	2.04E-11
U-235	5.48E-04
Th-231	1.89E-06
Pa-231	1.22E-01
Ac-227	8.01E-02
Th-227	8.93E-06
Ra-223	5.77E-05
Rn-219	0.00E+00
Po-215	5.11E-09
Pb-211	2.88E-06
Bi-211	1.34E-06
Tl-207	1.68E-06
Po-211	6.18E-10
Fr-223	9.14E-08
Th-232	1.83E-02
Ra-228	4.95E-02
Ac-228	6.23E-04
Th-228	1.55E-02
Ra-224	1.17E-03
Rn-220	2.75E-11
Po-216	8.30E-10
Pb-212	7.42E-06
Bi-212	1.15E-05
Po-212	0.00E+00
Tl-208	5.46E-05
TOTAL	9.50E-01

Mar 28, 2012 01:23 pm **SUMMARY**
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
Esophagu	3.70E-10
Stomach	1.02E-09
Colon	3.39E-09
Liver	9.63E-09
LUNG	3.86E-07
Bone	1.37E-08
Skin	4.54E-11
Breast	5.78E-10
Ovary	1.96E-09
Bladder	8.64E-10
Kidneys	1.35E-09
Thyroid	7.79E-11
Leukemia	2.42E-09
Residual	3.66E-09
Total	4.26E-07
TOTAL	8.51E-07

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	9.26E-09
INHALATION	4.16E-07
AIR IMMERSION	1.35E-12
GROUND SURFACE	3.85E-10
INTERNAL	4.25E-07
EXTERNAL	3.87E-10
TOTAL	4.26E-07

Mar 28, 2012 01:23 pm **SUMMARY**
Page 4

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	9.04E-09
Th-234	8.66E-10
Pa-234m	2.87E-11
Pa-234	2.36E-12
U-234	1.10E-08
Th-230	3.24E-07
Ra-226	3.22E-09
Rn-222	4.24E-20
Po-218	2.23E-16
Pb-214	6.03E-12
Bi-214	3.61E-11
Po-214	2.05E-15
Pb-210	1.61E-12
Bi-210	6.98E-15
Po-210	1.56E-13
At-218	9.66E-18
U-235	4.52E-10
Th-231	1.76E-12
Pa-231	1.15E-08
Ac-227	2.11E-08
Th-227	7.34E-12
Ra-223	3.14E-11
Rn-219	0.00E+00
Po-215	2.80E-15
Pb-211	9.57E-13
Bi-211	7.32E-13
Tl-207	2.15E-13
Po-211	3.39E-16
Fr-223	5.17E-14
Th-232	8.05E-09
Ra-228	2.20E-08
Ac-228	3.46E-10
Th-228	1.33E-08
Ra-224	1.00E-09
Rn-220	1.50E-17
Po-216	4.55E-16
Pb-212	4.20E-12
Bi-212	5.17E-12
Po-212	0.00E+00
Tl-208	2.98E-11
TOTAL	4.26E-07

Mar 28, 2012 01:23 pm

SUMMARY
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)				
Direction	230	350	775	2045	
N	9.5E-01	4.5E-01	1.2E-01	4.0E-02	
NNW	5.0E-01	2.4E-01	7.2E-02	3.2E-02	
NW	5.8E-01	2.8E-01	8.0E-02	3.3E-02	Business
WNW	7.1E-01	3.4E-01	9.2E-02	3.5E-02	
W	5.4E-01	2.6E-01	7.5E-02	3.2E-02	
WSW	2.7E-01	1.4E-01	4.8E-02	2.7E-02	
SW	3.8E-01	1.8E-01	5.8E-02	2.9E-02	
SSW	4.6E-01	2.2E-01	6.6E-02	3.1E-02	
S	4.0E-01	2.0E-01	6.2E-02	3.0E-02	
SSE	2.9E-01	1.4E-01	5.0E-02	2.8E-02	Residence
SE	4.1E-01	2.0E-01	6.2E-02	3.0E-02	
ESE	6.9E-01	3.3E-01	9.0E-02	3.5E-02	School
E	9.0E-01	4.2E-01	1.1E-01	3.9E-02	
ENE	7.5E-01	3.5E-01	9.5E-02	3.6E-02	
NE	4.6E-01	2.2E-01	6.7E-02	3.1E-02	Farm
NNE	3.9E-01	1.9E-01	6.0E-02	3.0E-02	

Mar 28, 2012 01:23 pm

SUMMARY
Page 6

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

	Distance (m)			
Direction	230	350	775	2045
N	4.3E-07	2.0E-07	5.0E-08	1.5E-08
NNW	2.2E-07	1.0E-07	2.9E-08	1.1E-08
NW	2.6E-07	1.2E-07	3.2E-08	1.2E-08
WNW	3.2E-07	1.5E-07	3.8E-08	1.3E-08
W	2.4E-07	1.1E-07	3.0E-08	1.1E-08
WSW	1.2E-07	5.8E-08	1.8E-08	8.9E-09
SW	1.7E-07	7.9E-08	2.3E-08	9.7E-09
SSW	2.0E-07	9.6E-08	2.6E-08	1.0E-08
S	1.8E-07	8.5E-08	2.4E-08	1.0E-08
SSE	1.3E-07	6.1E-08	1.9E-08	9.1E-09
SE	1.8E-07	8.6E-08	2.5E-08	1.0E-08
ESE	3.1E-07	1.4E-07	3.7E-08	1.2E-08
E	4.0E-07	1.9E-07	4.6E-08	1.4E-08
ENE	3.4E-07	1.6E-07	3.9E-08	1.3E-08
NE	2.1E-07	9.7E-08	2.7E-08	1.1E-08
NNE	1.7E-07	8.3E-08	2.4E-08	1.0E-08

CAP88 OUTPUT RESULTS

VP-31A

```
                        C A P 8 8 - P C

                          Version 3.0


              Clean Air Act Assessment Package - 1988


   D O S E   A N D   R I S K   E Q U I V A L E N T   S U M M A R I E S

                   Non-Radon Individual Assessment
                        Mar  29, 2012  08:25 am


      Facility:  VP-31a
       Address:  Latty/HISS
          City:  Berkely
         State:  MO          Zip:    63134


      Source Category:  Area
          Source Type:  Area
        Emission Year:  2011


      Comments:  Air
                 Air


         Dataset Name:  VP 31A 2011
         Dataset Date:  3/29/2012 8:24:00 AM
            Wind File:      C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 29, 2012 08:25 am

SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
Adrenals	8.63E-07
B Surfac	3.71E-04
Breasts	9.06E-07
St Wall	8.84E-07
ULI Wall	9.55E-07
Kidneys	5.95E-06
Lungs	9.83E-05
Ovaries	3.42E-06
R Marrow	1.49E-05
Spleen	8.91E-07
Thymus	8.78E-07
Uterus	8.74E-07
Bld Wall	8.88E-07
Brain	8.78E-07
Esophagu	4.10E-05
SI Wall	8.84E-07
LLI Wall	1.12E-06
Liver	8.31E-06
Muscle	9.15E-07
Pancreas	8.65E-07
Skin	8.04E-06
Testes	3.52E-06
Thyroid	8.92E-07
EFFEC	3.73E-04

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	1.37E-05
INHALATION	3.59E-04
AIR IMMERSION	4.63E-10
GROUND SURFACE	3.36E-07
INTERNAL	3.73E-04
EXTERNAL	3.37E-07
TOTAL	3.73E-04

Mar 29, 2012 08:25 am

SUMMARY
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	6.22E-07
Th-234	3.49E-07
Pa-234m	6.83E-08
Pa-234	1.44E-09
U-234	7.55E-07
Th-230	2.51E-04
Ra-226	1.04E-05
Rn-222	0.00E+00
Po-218	9.86E-13
Pb-214	2.74E-08
Bi-214	1.64E-07
Po-214	9.02E-12
Pb-210	0.00E+00
Bi-210	0.00E+00
Po-210	0.00E+00
At-218	0.00E+00
U-235	2.89E-08
Th-231	6.00E-10
Pa-231	1.35E-05
Ac-227	8.96E-06
Th-227	9.70E-10
Ra-223	1.02E-08
Rn-219	0.00E+00
Po-215	6.12E-13
Pb-211	3.46E-10
Bi-211	1.60E-10
Tl-207	2.02E-10
Po-211	0.00E+00
Fr-223	0.00E+00
Th-232	7.99E-05
Ra-228	6.98E-06
Ac-228	7.58E-08
Th-228	7.07E-07
Ra-224	5.34E-08
Rn-220	1.30E-15
Po-216	8.34E-14
Pb-212	6.94E-10
Bi-212	1.16E-09
Po-212	0.00E+00
Tl-208	4.17E-09
TOTAL	3.73E-04

Mar 29, 2012 08:25 am

SUMMARY
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
Esophagu	9.75E-14
Stomach	2.60E-13
Colon	1.07E-12
Liver	1.80E-12
LUNG	1.68E-10
Bone	4.32E-12
Skin	1.41E-14
Breast	1.50E-13
Ovary	5.58E-13
Bladder	2.29E-13
Kidneys	4.07E-13
Thyroid	2.00E-14
Leukemia	7.22E-13
Residual	1.15E-12
Total	1.79E-10
TOTAL	3.58E-10

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.20E-12
INHALATION	1.75E-10
AIR IMMERSION	2.12E-16
GROUND SURFACE	1.53E-13
INTERNAL	1.79E-10
EXTERNAL	1.53E-13
TOTAL	1.79E-10

Mar 29, 2012 08:25 am **SUMMARY Page 4**

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	5.10E-13
Th-234	3.39E-13
Pa-234m	1.10E-14
Pa-234	7.85E-16
U-234	6.21E-13
Th-230	1.27E-10
Ra-226	7.48E-12
Rn-222	0.00E+00
Po-218	5.41E-19
Pb-214	1.46E-14
Bi-214	8.73E-14
Po-214	4.95E-18
Pb-210	0.00E+00
Bi-210	0.00E+00
Po-210	0.00E+00
At-218	0.00E+00
U-235	2.41E-14
Th-231	5.78E-16
Pa-231	1.27E-12
Ac-227	2.36E-12
Th-227	8.42E-16
Ra-223	5.55E-15
Rn-219	0.00E+00
Po-215	3.36E-19
Pb-211	1.15E-16
Bi-211	8.78E-17
Tl-207	2.58E-17
Po-211	0.00E+00
Fr-223	0.00E+00
Th-232	3.51E-11
Ra-228	3.02E-12
Ac-228	4.19E-14
Th-228	6.00E-13
Ra-224	4.56E-14
Rn-220	7.08E-22
Po-216	4.57E-20
Pb-212	3.78E-16
Bi-212	5.19E-16
Po-212	0.00E+00
Tl-208	2.27E-15
TOTAL	1.79E-10

Mar 29, 2012 08:25 am

SUMMARY
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)				
Direction	780	935	1120	1175	
N	3.7E-04	2.7E-04	2.0E-04	1.8E-04	
NNW	2.0E-04	1.4E-04	1.1E-04	1.0E-04	Farm
NW	2.3E-04	1.6E-04	1.2E-04	1.1E-04	Business
WNW	2.8E-04	2.0E-04	1.5E-04	1.4E-04	
W	2.1E-04	1.5E-04	1.1E-04	1.1E-04	Residence
WSW	1.1E-04	7.9E-05	6.0E-05	5.6E-05	
SW	1.5E-04	1.1E-04	8.0E-05	7.4E-05	
SSW	1.8E-04	1.3E-04	9.6E-05	8.9E-05	
S	1.6E-04	1.2E-04	8.7E-05	8.1E-05	
SSE	1.2E-04	8.5E-05	6.5E-05	6.1E-05	
SE	1.6E-04	1.2E-04	8.9E-05	8.3E-05	
ESE	2.7E-04	1.9E-04	1.4E-04	1.3E-04	School
E	3.4E-04	2.5E-04	1.8E-04	1.7E-04	
ENE	2.9E-04	2.1E-04	1.5E-04	1.4E-04	
NE	1.8E-04	1.3E-04	9.8E-05	9.1E-05	
NNE	1.5E-04	1.1E-04	8.4E-05	7.9E-05	

Mar 29, 2012 08:25 am

SUMMARY
Page 6

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

	Distance (m)			
Direction	780	935	1120	1175
N	1.8E-10	1.3E-10	9.3E-11	8.6E-11
NNW	9.3E-11	6.7E-11	4.9E-11	4.6E-11
NW	1.1E-10	7.7E-11	5.7E-11	5.3E-11
WNW	1.3E-10	9.4E-11	6.8E-11	6.3E-11
W	9.9E-11	7.1E-11	5.2E-11	4.8E-11
WSW	4.9E-11	3.5E-11	2.6E-11	2.4E-11
SW	6.8E-11	4.9E-11	3.6E-11	3.3E-11
SSW	8.4E-11	6.0E-11	4.4E-11	4.1E-11
S	7.5E-11	5.4E-11	4.0E-11	3.7E-11
SSE	5.3E-11	3.8E-11	2.9E-11	2.7E-11
SE	7.6E-11	5.5E-11	4.1E-11	3.8E-11
ESE	1.3E-10	9.1E-11	6.7E-11	6.2E-11
E	1.6E-10	1.2E-10	8.5E-11	7.9E-11
ENE	1.4E-10	9.7E-11	7.1E-11	6.6E-11
NE	8.5E-11	6.1E-11	4.5E-11	4.2E-11
NNE	7.2E-11	5.2E-11	3.8E-11	3.5E-11

CAP88 OUTPUT RESULTS

VP-40A

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

D O S E   A N D   R I S K   E Q U I V A L E N T   S U M M A R I E S

Non-Radon Individual Assessment
Mar 29, 2012 08:18 am

```
     Facility:  VP 40a
      Address:  HISS/Latty Avenue
         City:  Berkely
        State:  MO         Zip:    63134

     Source Category:  Area
         Source Type:  Area
       Emission Year:  2011

     Comments:  Air
                Air

        Dataset Name:  VP 40A 2011
        Dataset Date:  3/29/2012 8:17:00 AM
           Wind File:      C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 29, 2012 08:18 am

SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
Adrenals	7.27E-06
B Surfac	5.95E-04
Breasts	7.99E-06
St Wall	7.54E-06
ULI Wall	7.95E-06
Kidneys	1.74E-05
Lungs	5.06E-05
Ovaries	9.63E-06
R Marrow	5.98E-05
Spleen	7.59E-06
Thymus	7.43E-06
Uterus	7.41E-06
Bld Wall	7.60E-06
Brain	7.49E-06
Esophagu	2.61E-05
SI Wall	7.46E-06
LLI Wall	8.87E-06
Liver	3.07E-05
Muscle	8.14E-06
Pancreas	7.23E-06
Skin	1.69E-04
Testes	1.05E-05
Thyroid	7.81E-06
EFFEC	4.61E-04

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	2.07E-04
INHALATION	2.48E-04
AIR IMMERSION	2.21E-08
GROUND SURFACE	6.23E-06
INTERNAL	4.55E-04
EXTERNAL	6.26E-06
TOTAL	4.61E-04

Mar 29, 2012 08:18 am SUMMARY
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	0.00E+00
Th-234	8.75E-06
Pa-234m	1.64E-06
Pa-234	3.49E-08
U-234	0.00E+00
Th-230	0.00E+00
Ra-226	0.00E+00
Rn-222	0.00E+00
Po-218	0.00E+00
Pb-214	0.00E+00
Bi-214	0.00E+00
Po-214	0.00E+00
Pb-210	0.00E+00
Bi-210	0.00E+00
Po-210	0.00E+00
At-218	0.00E+00
U-235	0.00E+00
Th-231	6.27E-11
Pa-231	0.00E+00
Ac-227	0.00E+00
Th-227	0.00E+00
Ra-223	0.00E+00
Rn-219	0.00E+00
Po-215	0.00E+00
Pb-211	0.00E+00
Bi-211	0.00E+00
Tl-207	0.00E+00
Po-211	0.00E+00
Fr-223	0.00E+00
Th-232	0.00E+00
Ra-228	4.44E-04
Ac-228	5.13E-06
Th-228	5.45E-07
Ra-224	6.28E-08
Rn-220	0.00E+00
Po-216	4.64E-12
Pb-212	3.85E-08
Bi-212	6.42E-08
Po-212	0.00E+00
Tl-208	3.04E-07
TOTAL	4.61E-04

Mar 29, 2012 08:18 am SUMMARY
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
Esophagu	1.10E-12
Stomach	4.66E-12
Colon	1.73E-11
Liver	1.43E-11
LUNG	1.09E-10
Bone	2.51E-11
Skin	2.64E-13
Breast	2.61E-12
Ovary	2.70E-12
Bladder	2.41E-12
Kidneys	2.69E-12
Thyroid	3.25E-13
Leukemia	7.17E-12
Residual	1.69E-11
Total	2.07E-10
TOTAL	4.14E-10

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	8.20E-11
INHALATION	1.22E-10
AIR IMMERSION	1.10E-14
GROUND SURFACE	2.71E-12
INTERNAL	2.04E-10
EXTERNAL	2.72E-12
TOTAL	2.07E-10

Mar 29, 2012 08:18 am **SUMMARY**
Page 4

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	0.00E+00
Th-234	8.39E-12
Pa-234m	2.64E-13
Pa-234	1.90E-14
U-234	0.00E+00
Th-230	0.00E+00
Ra-226	0.00E+00
Rn-222	0.00E+00
Po-218	0.00E+00
Pb-214	0.00E+00
Bi-214	0.00E+00
Po-214	0.00E+00
Pb-210	0.00E+00
Bi-210	0.00E+00
Po-210	0.00E+00
At-218	0.00E+00
U-235	0.00E+00
Th-231	6.05E-17
Pa-231	0.00E+00
Ac-227	0.00E+00
Th-227	0.00E+00
Ra-223	0.00E+00
Rn-219	0.00E+00
Po-215	0.00E+00
Pb-211	0.00E+00
Bi-211	0.00E+00
Tl-207	0.00E+00
Po-211	0.00E+00
Fr-223	0.00E+00
Th-232	0.00E+00
Ra-228	1.95E-10
Ac-228	2.85E-12
Th-228	1.86E-13
Ra-224	3.76E-14
Rn-220	0.00E+00
Po-216	2.54E-18
Pb-212	2.10E-14
Bi-212	2.88E-14
Po-212	0.00E+00
Tl-208	1.66E-13
TOTAL	2.07E-10

Mar 29, 2012 08:18 am

SUMMARY
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)				
Direction	475	530	960	2360	
N	4.6E-04	4.1E-04	2.4E-04	1.8E-04	
NNW	3.2E-04	2.9E-04	2.1E-04	1.7E-04	
NW	3.4E-04	3.1E-04	2.1E-04	1.8E-04	
WNW	3.8E-04	3.4E-04	2.2E-04	1.8E-04	
W	3.3E-04	3.0E-04	2.1E-04	1.8E-04	
WSW	2.4E-04	2.3E-04	1.9E-04	1.7E-04	
SW	2.8E-04	2.6E-04	1.9E-04	1.7E-04	
SSW	3.0E-04	2.8E-04	2.0E-04	1.7E-04	Business
S	2.9E-04	2.6E-04	2.0E-04	1.7E-04	Residence
SSE	2.5E-04	2.3E-04	1.9E-04	1.7E-04	
SE	2.9E-04	2.7E-04	2.0E-04	1.7E-04	School
ESE	3.8E-04	3.4E-04	2.2E-04	1.8E-04	
E	4.4E-04	3.9E-04	2.4E-04	1.8E-04	Farm
ENE	3.9E-04	3.5E-04	2.3E-04	1.8E-04	
NE	3.0E-04	2.8E-04	2.0E-04	1.7E-04	
NNE	2.8E-04	2.6E-04	2.0E-04	1.7E-04	

Mar 29, 2012 08:18 am

SUMMARY
Page 6

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

	Distance (m)			
Direction	475	530	960	2360
N	2.1E-10	1.8E-10	1.0E-10	7.4E-11
NNW	1.4E-10	1.2E-10	8.5E-11	7.0E-11
NW	1.5E-10	1.3E-10	8.8E-11	7.1E-11
WNW	1.7E-10	1.5E-10	9.3E-11	7.2E-11
W	1.4E-10	1.3E-10	8.6E-11	7.0E-11
WSW	1.0E-10	9.6E-11	7.6E-11	6.8E-11
SW	1.2E-10	1.1E-10	8.0E-11	6.9E-11
SSW	1.3E-10	1.2E-10	8.3E-11	6.9E-11
S	1.2E-10	1.1E-10	8.1E-11	6.9E-11
SSE	1.1E-10	9.9E-11	7.7E-11	6.8E-11
SE	1.2E-10	1.1E-10	8.2E-11	6.9E-11
ESE	1.7E-10	1.5E-10	9.2E-11	7.2E-11
E	2.0E-10	1.7E-10	1.0E-10	7.3E-11
ENE	1.7E-10	1.5E-10	9.4E-11	7.2E-11
NE	1.3E-10	1.2E-10	8.3E-11	7.0E-11
NNE	1.2E-10	1.1E-10	8.1E-11	6.9E-11

CAP88 OUTPUT RESULTS

HISS Radon Diffusion Constant

```
                              C A P 8 8 - P C

                                Version 3.0

                   Clean Air Act Assessment Package - 1988


    D O S E   A N D   R I S K   E Q U I V A L E N T   S U M M A R I E S

                        Radon Individual Assessment
                          Mar  28, 2012  01:49 pm


        Facility:  HISS Radon Diffusion Constant
         Address:  HISS/Latty Avenue
            City:  Berkely
           State:  MO          Zip:    63134


        Source Category:  Area
            Source Type:  Area
          Emission Year:  2011


        Comments:  Air
                   Air


           Dataset Name:  HISS Radon 2011
           Dataset Date:  3/28/2012 1:49:00 PM
              Wind File:  .   C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 28, 2012 01:49 pm **SUMMARY**
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
EFFEC	3.57E-01

Radon Decay Product Concentration (working level)

4.46E-05

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	0.00E+00
INHALATION	3.57E-01
AIR IMMERSION	3.22E-05
GROUND SURFACE	0.00E+00
INTERNAL	3.57E-01
EXTERNAL	3.22E-05
TOTAL	3.57E-01

Radon Decay Product Concentration (working level)

4.46E-05

No Ground Surface Concentration or Ingestion Rate Exposures for RN-222

Mar 28, 2012 01:49 pm **SUMMARY**
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Nuclide	Selected Individual (mrem/y)
Rn-222	3.57E-01
TOTAL	3.57E-01

Radon Decay Product Concentration (working level)

4.46E-05

Mar 28, 2012 01:49 pm

SUMMARY
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	5.86E-05
Total Fatal Risk All Exposures	6.27E-05

Mar 28, 2012 01:49 pm **SUMMARY**
Page 4

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	0.00E+00
INHALATION	4.04E-06
AIR IMMERSION	7.70E-10
GROUND SURFACE	0.00E+00
INTERNAL	4.04E-06
EXTERNAL	7.70E-10
TOTAL	4.04E-06

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	5.86E-05
Total Fatal Risk All Exposures	6.27E-05

Mar 28, 2012 01:49 pm SUMMARY
Page 5

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
Rn-222	4.04E-06
TOTAL	4.04E-06

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	5.86E-05
Total Fatal Risk All Exposures	6.27E-05

Mar 28, 2012 01:49 pm

SUMMARY
Page 6

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	1	50	
N	3.6E-01	3.3E-01	
NNW	3.6E-01	3.1E-01	
NW	3.6E-01	2.9E-01	(0.29 ÷ 0.36) = 0.81
WNW	3.6E-01	2.8E-01	
W	3.6E-01	2.7E-01	
WSW	3.6E-01	2.6E-01	
SW	3.6E-01	2.5E-01	
SSW	3.6E-01	2.6E-01	
S	3.6E-01	2.7E-01	
SSE	3.6E-01	2.6E-01	
SE	3.6E-01	2.6E-01	
ESE	3.6E-01	2.9E-01	
E	3.6E-01	3.0E-01	
ENE	3.6E-01	3.1E-01	
NE	3.6E-01	3.2E-01	
NNE	3.6E-01	3.3E-01	

Mar 28, 2012 01:49 pm

SUMMARY
Page 7

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

	Distance (m)	
Direction	1	50
N	5.9E-05	5.4E-05
NNW	5.9E-05	5.0E-05
NW	5.9E-05	4.7E-05
WNW	5.9E-05	4.5E-05
W	5.9E-05	4.4E-05
WSW	5.9E-05	4.3E-05
SW	5.9E-05	4.1E-05
SSW	5.9E-05	4.3E-05
S	5.9E-05	4.4E-05
SSE	5.9E-05	4.3E-05
SE	5.9E-05	4.3E-05
ESE	5.9E-05	4.7E-05
E	5.9E-05	4.9E-05
ENE	5.9E-05	5.1E-05
NE	5.9E-05	5.3E-05
NNE	5.9E-05	5.5E-05

THIS PAGE INTENTIONALLY LEFT BLANK

CAP88-PC RUNS FOR SLAPS PROPERTIES

THIS PAGE INTENTIONALLY LEFT BLANK

CAP88 OUTPUT RESULTS

McDONNELL BLVD

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 29, 2012 09:28 am

```
Facility:  McDonnell Blvd
 Address:  SLAPS
    City:  Berkely
   State:  MO          Zip:    63134


Source Category:
    Source Type:  Area
  Emission Year:  2011


Comments:  Air
           Air


   Dataset Name:  McDonnell Bvd 11
   Dataset Date:  3/29/2012 9:24:00 AM
      Wind File:      C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 29, 2012 09:28 am

SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
Adrenals	1.31E-05
B Surfac	2.70E-03
Breasts	1.41E-05
St Wall	1.35E-05
ULI Wall	1.45E-05
Kidneys	5.28E-05
Lungs	5.81E-04
Ovaries	3.07E-05
R Marrow	1.47E-04
Spleen	1.36E-05
Thymus	1.34E-05
Uterus	1.33E-05
Bld Wall	1.36E-05
Brain	1.34E-05
Esophagu	2.35E-04
SI Wall	1.34E-05
LLI Wall	1.65E-05
Liver	1.04E-04
Muscle	1.43E-05
Pancreas	1.31E-05
Skin	1.14E-04
Testes	3.21E-05
Thyroid	1.38E-05
EFFEC	2.55E-03

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	2.60E-04
INHALATION	2.28E-03
AIR IMMERSION	2.14E-08
GROUND SURFACE	7.30E-06
INTERNAL	2.54E-03
EXTERNAL	7.32E-06
TOTAL	2.55E-03

Mar 29, 2012 09:28 am **SUMMARY**
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	5.24E-05
Th-234	3.92E-06
Pa-234m	8.26E-07
Pa-234	1.88E-08
U-234	6.37E-05
Th-230	1.13E-03
Ra-226	3.22E-05
Rn-222	5.91E-16
Po-218	3.21E-12
Pb-214	8.90E-08
Bi-214	5.34E-07
Po-214	2.93E-11
Pb-210	3.65E-08
Bi-210	9.51E-11
Po-210	0.00E+00
At-218	0.00E+00
U-235	2.83E-06
Th-231	8.31E-09
Pa-231	2.24E-04
Ac-227	1.31E-04
Th-227	1.23E-08
Ra-223	1.16E-07
Rn-219	0.00E+00
Po-215	9.08E-12
Pb-211	5.12E-09
Bi-211	2.38E-09
Tl-207	2.96E-09
Po-211	0.00E+00
Fr-223	1.18E-10
Th-232	1.72E-04
Ra-228	5.05E-04
Ac-228	6.16E-06
Th-228	2.11E-04
Ra-224	1.58E-05
Rn-220	3.89E-13
Po-216	9.62E-12
Pb-212	8.70E-08
Bi-212	1.34E-07
Po-212	0.00E+00
Tl-208	6.33E-07
TOTAL	2.55E-03

Mar 29, 2012 09:28 am

SUMMARY
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
Esophagu	1.76E-12
Stomach	6.35E-12
Colon	2.20E-11
Liver	3.05E-11
LUNG	1.09E-09
Bone	4.95E-11
Skin	2.49E-13
Breast	3.60E-12
Ovary	6.18E-12
Bladder	3.96E-12
Kidneys	5.26E-12
Thyroid	4.58E-13
Leukemia	1.14E-11
Residual	2.35E-11
Total	1.25E-09
TOTAL	2.50E-09

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	9.52E-11
INHALATION	1.15E-09
AIR IMMERSION	1.12E-14
GROUND SURFACE	3.57E-12
INTERNAL	1.25E-09
EXTERNAL	3.58E-12
TOTAL	1.25E-09

Mar 29, 2012 09:28 am SUMMARY
Page 4

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	4.31E-11
Th-234	3.76E-12
Pa-234m	1.33E-13
Pa-234	1.02E-14
U-234	5.25E-11
Th-230	5.75E-10
Ra-226	2.39E-11
Rn-222	3.21E-22
Po-218	1.76E-18
Pb-214	4.75E-14
Bi-214	2.84E-13
Po-214	1.61E-17
Pb-210	1.21E-14
Bi-210	5.42E-17
Po-210	0.00E+00
At-218	0.00E+00
U-235	2.33E-12
Th-231	7.65E-15
Pa-231	2.11E-11
Ac-227	3.46E-11
Th-227	1.01E-14
Ra-223	6.31E-14
Rn-219	0.00E+00
Po-215	4.98E-18
Pb-211	1.70E-15
Bi-211	1.30E-15
Tl-207	3.78E-16
Po-211	0.00E+00
Fr-223	7.28E-17
Th-232	7.57E-11
Ra-228	2.22E-10
Ac-228	3.41E-12
Th-228	1.80E-10
Ra-224	1.36E-11
Rn-220	2.12E-19
Po-216	5.27E-18
Pb-212	4.96E-14
Bi-212	5.99E-14
Po-212	0.00E+00
Tl-208	3.45E-13
TOTAL	1.25E-09

Mar 29, 2012 09:28 am

SUMMARY
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)				
Direction	680	950	1670	2050	
N	2.5E-03	1.4E-03	6.8E-04	5.4E-04	
NNW	1.4E-03	8.5E-04	4.5E-04	3.8E-04	
NW	1.6E-03	9.5E-04	4.8E-04	4.0E-04	
WNW	1.9E-03	1.1E-03	5.5E-04	4.4E-04	
W	1.5E-03	8.9E-04	4.6E-04	3.8E-04	Business
WSW	8.2E-04	5.3E-04	3.3E-04	2.9E-04	
SW	1.1E-03	6.6E-04	3.7E-04	3.2E-04	
SSW	1.3E-03	7.7E-04	4.2E-04	3.5E-04	
S	1.2E-03	7.1E-04	4.0E-04	3.4E-04	
SSE	8.7E-04	5.6E-04	3.4E-04	3.0E-04	
SE	1.2E-03	7.2E-04	4.0E-04	3.4E-04	
ESE	1.9E-03	1.1E-03	5.4E-04	4.4E-04	
E	2.4E-03	1.3E-03	6.3E-04	5.0E-04	
ENE	2.0E-03	1.1E-03	5.6E-04	4.5E-04	School
NE	1.3E-03	7.8E-04	4.2E-04	3.6E-04	
NNE	1.1E-03	6.9E-04	3.9E-04	3.3E-04	Residence / Farm

Mar 29, 2012 09:28 am

SUMMARY
Page 6

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

	Distance (m)			
Direction	680	950	1670	2050
N	1.3E-09	7.0E-10	3.1E-10	2.4E-10
NNW	6.8E-10	4.0E-10	2.0E-10	1.6E-10
NW	7.8E-10	4.5E-10	2.2E-10	1.7E-10
WNW	9.4E-10	5.3E-10	2.5E-10	2.0E-10
W	7.2E-10	4.2E-10	2.0E-10	1.6E-10
WSW	3.8E-10	2.4E-10	1.4E-10	1.2E-10
SW	5.1E-10	3.0E-10	1.6E-10	1.3E-10
SSW	6.2E-10	3.6E-10	1.8E-10	1.5E-10
S	5.6E-10	3.3E-10	1.7E-10	1.4E-10
SSE	4.1E-10	2.5E-10	1.4E-10	1.2E-10
SE	5.7E-10	3.4E-10	1.7E-10	1.4E-10
ESE	9.1E-10	5.2E-10	2.4E-10	1.9E-10
E	1.2E-09	6.5E-10	2.9E-10	2.2E-10
ENE	9.8E-10	5.5E-10	2.5E-10	2.0E-10
NE	6.3E-10	3.7E-10	1.8E-10	1.5E-10
NNE	5.4E-10	3.2E-10	1.7E-10	1.4E-10

CAP88 OUTPUT RESULTS

IA-09 Ballfields

```
                         C A P 8 8 - P C

                          Version 3.0

             Clean Air Act Assessment Package - 1988


 D O S E   A N D   R I S K   E Q U I V A L E N T   S U M M A R I E S

                Non-Radon Individual Assessment
                     Mar  29, 2012  09:37 am


     Facility:  IA-09 Ballfields
      Address:  SLAPS
         City:  Berkely
        State:  MO         Zip:    63134


     Source Category:  Area
         Source Type:  Area
       Emission Year:  2011


     Comments:  Air
                Air


        Dataset Name:  IA09 2011
        Dataset Date:  3/29/2012 9:37:00 AM
           Wind File:  .   C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 29, 2012 09:37 am

SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
Adrenals	9.08E-07
B Surfac	2.40E-04
Breasts	9.73E-07
St Wall	9.34E-07
ULI Wall	9.96E-07
Kidneys	4.59E-06
Lungs	6.27E-05
Ovaries	2.51E-06
R Marrow	1.17E-05
Spleen	9.38E-07
Thymus	9.25E-07
Uterus	9.22E-07
Bld Wall	9.41E-07
Brain	9.29E-07
Esophagu	2.61E-05
SI Wall	9.30E-07
LLI Wall	1.13E-06
Liver	6.98E-06
Muscle	9.87E-07
Pancreas	9.06E-07
Skin	8.91E-06
Testes	2.61E-06
Thyroid	9.55E-07
EFFEC	2.46E-04

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	1.63E-05
INHALATION	2.30E-04
AIR IMMERSION	1.49E-09
GROUND SURFACE	5.02E-07
INTERNAL	2.46E-04
EXTERNAL	5.03E-07
TOTAL	2.46E-04

Mar 29, 2012 09:37 am

SUMMARY
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	5.14E-06
Th-234	3.36E-07
Pa-234m	7.01E-08
Pa-234	0.00E+00
U-234	6.59E-06
Th-230	1.53E-04
Ra-226	2.53E-06
Rn-222	0.00E+00
Po-218	2.52E-13
Pb-214	6.99E-09
Bi-214	4.19E-08
Po-214	2.30E-12
Pb-210	0.00E+00
Bi-210	0.00E+00
Po-210	0.00E+00
At-218	0.00E+00
U-235	2.96E-07
Th-231	7.87E-10
Pa-231	8.86E-06
Ac-227	6.89E-06
Th-227	5.14E-10
Ra-223	2.58E-09
Rn-219	0.00E+00
Po-215	2.24E-13
Pb-211	1.26E-10
Bi-211	5.86E-11
Tl-207	7.38E-11
Po-211	0.00E+00
Fr-223	0.00E+00
Th-232	1.25E-05
Ra-228	3.17E-05
Ac-228	4.02E-07
Th-228	1.64E-05
Ra-224	1.23E-06
Rn-220	3.00E-14
Po-216	6.67E-13
Pb-212	5.56E-09
Bi-212	9.26E-09
Po-212	0.00E+00
Tl-208	4.39E-08
TOTAL	2.46E-04

Mar 29, 2012 09:37 am

SUMMARY
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
Esophagu	1.16E-13
Stomach	4.05E-13
Colon	1.43E-12
Liver	1.95E-12
LUNG	1.17E-10
Bone	3.76E-12
Skin	1.76E-14
Breast	2.30E-13
Ovary	4.71E-13
Bladder	2.64E-13
Kidneys	4.08E-13
Thyroid	2.94E-14
Leukemia	7.96E-13
Residual	1.50E-12
Total	1.28E-10
TOTAL	2.56E-10

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	5.68E-12
INHALATION	1.22E-10
AIR IMMERSION	7.73E-16
GROUND SURFACE	2.41E-13
INTERNAL	1.28E-10
EXTERNAL	2.41E-13
TOTAL	1.28E-10

Mar 29, 2012 09:37 am **SUMMARY**
Page 4

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	4.24E-12
Th-234	3.21E-13
Pa-234m	1.13E-14
Pa-234	0.00E+00
U-234	5.44E-12
Th-230	7.83E-11
Ra-226	1.91E-12
Rn-222	0.00E+00
Po-218	1.38E-19
Pb-214	3.73E-15
Bi-214	2.23E-14
Po-214	1.26E-18
Pb-210	0.00E+00
Bi-210	0.00E+00
Po-210	0.00E+00
At-218	0.00E+00
U-235	2.44E-13
Th-231	7.26E-16
Pa-231	8.37E-13
Ac-227	1.81E-12
Th-227	4.15E-16
Ra-223	1.40E-15
Rn-219	0.00E+00
Po-215	1.23E-19
Pb-211	4.19E-17
Bi-211	3.21E-17
Tl-207	9.42E-18
Po-211	0.00E+00
Fr-223	0.00E+00
Th-232	5.52E-12
Ra-228	1.40E-11
Ac-228	2.23E-13
Th-228	1.40E-11
Ra-224	1.06E-12
Rn-220	1.64E-20
Po-216	3.66E-19
Pb-212	3.03E-15
Bi-212	4.16E-15
Po-212	0.00E+00
Tl-208	2.40E-14
TOTAL	1.28E-10

Mar 29, 2012 09:37 am

SUMMARY
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)				
Direction	490	775	1485	2265	
N	2.5E-04	1.1E-04	4.3E-05	2.7E-05	
NNW	1.3E-04	6.3E-05	2.8E-05	2.0E-05	
NW	1.5E-04	7.1E-05	3.1E-05	2.1E-05	
WNW	1.8E-04	8.4E-05	3.5E-05	2.3E-05	
W	1.4E-04	6.6E-05	2.9E-05	2.0E-05	
WSW	7.4E-05	3.8E-05	2.0E-05	1.6E-05	Business
SW	1.0E-04	4.9E-05	2.4E-05	1.8E-05	
SSW	1.2E-04	5.8E-05	2.6E-05	1.9E-05	
S	1.1E-04	5.3E-05	2.5E-05	1.8E-05	
SSE	7.9E-05	4.1E-05	2.1E-05	1.7E-05	
SE	1.1E-04	5.3E-05	2.5E-05	1.9E-05	
ESE	1.8E-04	8.2E-05	3.4E-05	2.3E-05	
E	2.3E-04	1.0E-04	4.0E-05	2.6E-05	School
ENE	1.9E-04	8.7E-05	3.6E-05	2.4E-05	
NE	1.2E-04	5.8E-05	2.7E-05	1.9E-05	Residence / Farm
NNE	1.0E-04	5.1E-05	2.4E-05	1.8E-05	

Mar 29, 2012 09:37 am

SUMMARY
Page 6

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

	Distance (m)			
Direction	490	775	1485	2265
N	1.3E-10	5.6E-11	2.1E-11	1.2E-11
NNW	6.8E-11	3.1E-11	1.3E-11	8.4E-12
NW	7.9E-11	3.5E-11	1.4E-11	9.0E-12
WNW	9.5E-11	4.2E-11	1.6E-11	1.0E-11
W	7.3E-11	3.3E-11	1.3E-11	8.6E-12
WSW	3.7E-11	1.8E-11	8.6E-12	6.4E-12
SW	5.1E-11	2.4E-11	1.0E-11	7.2E-12
SSW	6.2E-11	2.8E-11	1.2E-11	7.9E-12
S	5.5E-11	2.6E-11	1.1E-11	7.5E-12
SSE	4.0E-11	1.9E-11	9.0E-12	6.6E-12
SE	5.6E-11	2.6E-11	1.1E-11	7.6E-12
ESE	9.3E-11	4.1E-11	1.6E-11	9.9E-12
E	1.2E-10	5.2E-11	1.9E-11	1.1E-11
ENE	1.0E-10	4.4E-11	1.7E-11	1.0E-11
NE	6.2E-11	2.9E-11	1.2E-11	8.0E-12
NNE	5.3E-11	2.5E-11	1.1E-11	7.4E-12

CAP88 OUTPUT RESULTS

VP-12

```
                         C A P 8 8 - P C

                           Version 3.0

              Clean Air Act Assessment Package - 1988


    D O S E   A N D   R I S K   E Q U I V A L E N T   S U M M A R I E S

                  Non-Radon Individual Assessment
                       Mar  29, 2012  09:42 am


        Facility:  VP-12
         Address:  SLAPS
            City:  Berkely
           State:  MO          Zip:    63134


        Source Category:  Area
            Source Type:  Area
          Emission Year:  2011


        Comments:  Air
                   Air


           Dataset Name:  VP 12 2011
           Dataset Date:  3/29/2012 9:42:00 AM
              Wind File:  .   C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 29, 2012 09:42 am SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
Adrenals	8.69E-05
B Surfac	4.49E-02
Breasts	9.04E-05
St Wall	8.84E-05
ULI Wall	9.44E-05
Kidneys	7.58E-04
Lungs	1.21E-02
Ovaries	4.08E-04
R Marrow	1.70E-03
Spleen	8.88E-05
Thymus	8.81E-05
Uterus	8.76E-05
Bld Wall	8.87E-05
Brain	8.79E-05
Esophagu	5.13E-03
SI Wall	8.84E-05
LLI Wall	1.07E-04
Liver	1.02E-03
Muscle	9.07E-05
Pancreas	8.70E-05
Skin	1.88E-03
Testes	4.17E-04
Thyroid	8.90E-05
EFFEC	4.54E-02

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	6.03E-04
INHALATION	4.48E-02
AIR IMMERSION	6.65E-08
GROUND SURFACE	3.57E-05
INTERNAL	4.54E-02
EXTERNAL	3.57E-05
TOTAL	4.54E-02

Mar 29, 2012 09:42 am SUMMARY
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	2.48E-03
Th-234	8.96E-05
Pa-234m	1.98E-05
Pa-234	5.34E-07
U-234	1.07E-04
Th-230	3.50E-02
Ra-226	6.46E-04
Rn-222	1.25E-14
Po-218	6.54E-11
Pb-214	1.82E-06
Bi-214	1.09E-05
Po-214	5.99E-10
Pb-210	6.21E-07
Bi-210	1.99E-09
Po-210	5.16E-08
At-218	0.00E+00
U-235	4.11E-06
Th-231	6.58E-09
Pa-231	1.96E-03
Ac-227	1.29E-03
Th-227	9.89E-08
Ra-223	7.76E-07
Rn-219	0.00E+00
Po-215	8.43E-11
Pb-211	4.76E-08
Bi-211	2.21E-08
Tl-207	2.78E-08
Po-211	0.00E+00
Fr-223	1.48E-09
Th-232	3.70E-03
Ra-228	5.21E-05
Ac-228	8.10E-07
Th-228	9.83E-05
Ra-224	7.37E-06
Rn-220	1.77E-13
Po-216	2.54E-12
Pb-212	2.12E-08
Bi-212	3.53E-08
Po-212	0.00E+00
Tl-208	1.67E-07
TOTAL	4.54E-02

Mar 29, 2012 09:42 am SUMMARY
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
Esophagu	9.56E-12
Stomach	2.15E-11
Colon	8.85E-11
Liver	2.06E-10
LUNG	2.18E-08
Bone	4.69E-10
Skin	2.40E-12
Breast	1.23E-11
Ovary	6.45E-11
Bladder	2.29E-11
Kidneys	5.09E-11
Thyroid	1.71E-12
Leukemia	7.13E-11
Residual	8.18E-11
Total	2.29E-08
TOTAL	4.59E-08

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	1.05E-10
INHALATION	2.28E-08
AIR IMMERSION	2.55E-14
GROUND SURFACE	1.16E-11
INTERNAL	2.29E-08
EXTERNAL	1.16E-11
TOTAL	2.29E-08

Mar 29, 2012 09:42 am **SUMMARY Page 4**

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	2.05E-09
Th-234	8.50E-11
Pa-234m	3.18E-12
Pa-234	2.91E-13
U-234	8.87E-11
Th-230	1.79E-08
Ra-226	5.00E-10
Rn-222	6.77E-21
Po-218	3.59E-17
Pb-214	9.69E-13
Bi-214	5.79E-12
Po-214	3.28E-16
Pb-210	2.06E-13
Bi-210	9.30E-16
Po-210	1.97E-14
At-218	0.00E+00
U-235	3.40E-12
Th-231	5.84E-15
Pa-231	1.86E-10
Ac-227	3.40E-10
Th-227	7.64E-14
Ra-223	4.22E-13
Rn-219	0.00E+00
Po-215	4.62E-17
Pb-211	1.58E-14
Bi-211	1.21E-14
Tl-207	3.55E-15
Po-211	0.00E+00
Fr-223	8.37E-16
Th-232	1.63E-09
Ra-228	2.31E-11
Ac-228	4.46E-13
Th-228	8.41E-11
Ra-224	6.34E-12
Rn-220	9.69E-20
Po-216	1.39E-18
Pb-212	1.15E-14
Bi-212	1.58E-14
Po-212	0.00E+00
Tl-208	9.12E-14
TOTAL	2.29E-08

Mar 29, 2012 09:42 am

SUMMARY
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)				
Direction	345	1290	2095	3105	
N	4.5E-02	4.3E-03	2.1E-03	1.3E-03	
NNW	2.3E-02	2.4E-03	1.3E-03	8.6E-04	
NW	2.8E-02	2.7E-03	1.4E-03	9.2E-04	
WNW	3.4E-02	3.2E-03	1.6E-03	1.0E-03	
W	2.5E-02	2.5E-03	1.3E-03	8.7E-04	
WSW	1.2E-02	1.4E-03	8.4E-04	6.3E-04	
SW	1.7E-02	1.8E-03	1.0E-03	7.2E-04	
SSW	2.2E-02	2.2E-03	1.2E-03	7.9E-04	
S	1.9E-02	2.0E-03	1.1E-03	7.6E-04	
SSE	1.3E-02	1.5E-03	8.9E-04	6.5E-04	
SE	1.9E-02	2.0E-03	1.1E-03	7.7E-04	Business
ESE	3.3E-02	3.2E-03	1.6E-03	1.0E-03	
E	4.3E-02	4.0E-03	1.9E-03	1.2E-03	School
ENE	3.5E-02	3.3E-03	1.7E-03	1.1E-03	Residence
NE	2.2E-02	2.2E-03	1.2E-03	8.1E-04	Farm
NNE	1.8E-02	1.9E-03	1.1E-03	7.4E-04	

Mar 29, 2012 09:42 am

SUMMARY
Page 6

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

	Distance (m)			
Direction	345	1290	2095	3105
N	2.3E-08	2.1E-09	9.4E-10	5.2E-10
NNW	1.2E-08	1.1E-09	5.2E-10	3.0E-10
NW	1.4E-08	1.3E-09	5.9E-10	3.4E-10
WNW	1.7E-08	1.5E-09	7.0E-10	3.9E-10
W	1.3E-08	1.2E-09	5.4E-10	3.1E-10
WSW	6.2E-09	5.9E-10	2.9E-10	1.9E-10
SW	8.7E-09	8.0E-10	3.8E-10	2.3E-10
SSW	1.1E-08	9.7E-10	4.6E-10	2.7E-10
S	9.4E-09	8.8E-10	4.2E-10	2.5E-10
SSE	6.6E-09	6.4E-10	3.2E-10	2.0E-10
SE	9.6E-09	9.0E-10	4.3E-10	2.6E-10
ESE	1.6E-08	1.5E-09	6.8E-10	3.9E-10
E	2.2E-08	1.9E-09	8.5E-10	4.7E-10
ENE	1.8E-08	1.6E-09	7.2E-10	4.0E-10
NE	1.1E-08	9.9E-10	4.7E-10	2.8E-10
NNE	9.1E-09	8.5E-10	4.1E-10	2.4E-10

CAP88 OUTPUT RESULTS

SLAPS Loadout

```
                              C A P 8 8 - P C

                                Version 3.0

                    Clean Air Act Assessment Package - 1988


      D O S E   A N D   R I S K   E Q U I V A L E N T   S U M M A R I E S

                        Non-Radon Individual Assessment
                             Mar  29, 2012  10:14 am


          Facility:  SLAPS Loadout
           Address:  SLAPS
              City:  Berkely
             State:  MO          Zip:    63134


          Source Category:  Area
              Source Type:  Area
            Emission Year:  2011


          Comments:  Air
                     Air


             Dataset Name:  SLAPS LDT 2011
             Dataset Date:  3/29/2012 10:13:00 AM
                Wind File:      C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 29, 2012 10:14 am SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
Adrenals	1.83E-04
B Surfac	7.02E-02
Breasts	1.93E-04
St Wall	1.87E-04
ULI Wall	2.01E-04
Kidneys	1.22E-03
Lungs	1.77E-02
Ovaries	6.76E-04
R Marrow	2.92E-03
Spleen	1.88E-04
Thymus	1.86E-04
Uterus	1.85E-04
Bld Wall	1.88E-04
Brain	1.86E-04
Esophagu	7.48E-03
SI Wall	1.86E-04
LLI Wall	2.30E-04
Liver	1.89E-03
Muscle	1.94E-04
Pancreas	1.83E-04
Skin	3.21E-03
Testes	6.95E-04
Thyroid	1.90E-04
EFFEC	6.93E-02

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	2.31E-03
INHALATION	6.69E-02
AIR IMMERSION	2.27E-07
GROUND SURFACE	8.96E-05
INTERNAL	6.92E-02
EXTERNAL	8.99E-05
TOTAL	6.93E-02

Mar 29, 2012 10:14 am **SUMMARY**
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	2.75E-03
Th-234	1.50E-04
Pa-234m	3.19E-05
Pa-234	8.13E-07
U-234	6.68E-04
Th-230	4.83E-02
Ra-226	8.78E-04
Rn-222	1.64E-14
Po-218	8.75E-11
Pb-214	2.43E-06
Bi-214	1.46E-05
Po-214	8.01E-10
Pb-210	1.06E-06
Bi-210	2.84E-09
Po-210	8.90E-08
At-218	4.38E-12
U-235	2.76E-05
Th-231	6.36E-08
Pa-231	3.91E-03
Ac-227	2.49E-03
Th-227	2.14E-07
Ra-223	1.91E-06
Rn-219	0.00E+00
Po-215	1.67E-10
Pb-211	9.41E-08
Bi-211	4.36E-08
Tl-207	5.50E-08
Po-211	1.00E-11
Fr-223	2.92E-09
Th-232	4.96E-03
Ra-228	3.05E-03
Ac-228	3.89E-05
Th-228	1.92E-03
Ra-224	1.44E-04
Rn-220	3.50E-12
Po-216	7.08E-11
Pb-212	6.53E-07
Bi-212	9.83E-07
Po-212	0.00E+00
Tl-208	4.66E-06
TOTAL	6.93E-02

Mar 29, 2012 10:14 am SUMMARY
Page 3

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
Esophagu	2.17E-11
Stomach	6.24E-11
Colon	2.43E-10
Liver	4.36E-10
LUNG	3.24E-08
Bone	8.54E-10
Skin	4.62E-12
Breast	3.56E-11
Ovary	1.14E-10
Bladder	5.05E-11
Kidneys	9.13E-11
Thyroid	4.70E-12
Leukemia	1.52E-10
Residual	2.34E-10
Total	3.47E-08
TOTAL	6.94E-08

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	6.71E-10
INHALATION	3.40E-08
AIR IMMERSION	1.06E-13
GROUND SURFACE	3.57E-11
INTERNAL	3.46E-08
EXTERNAL	3.59E-11
TOTAL	3.47E-08

Mar 29, 2012 10:14 am SUMMARY
Page 4

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	2.27E-09
Th-234	1.44E-10
Pa-234m	5.13E-12
Pa-234	4.43E-13
U-234	5.52E-10
Th-230	2.47E-08
Ra-226	6.63E-10
Rn-222	8.93E-21
Po-218	4.80E-17
Pb-214	1.30E-12
Bi-214	7.75E-12
Po-214	4.39E-16
Pb-210	3.51E-13
Bi-210	1.52E-15
Po-210	3.41E-14
At-218	2.08E-18
U-235	2.28E-11
Th-231	5.79E-14
Pa-231	3.69E-10
Ac-227	6.55E-10
Th-227	1.73E-13
Ra-223	1.04E-12
Rn-219	0.00E+00
Po-215	9.14E-17
Pb-211	3.12E-14
Bi-211	2.39E-14
Tl-207	7.02E-15
Po-211	5.48E-18
Fr-223	1.64E-15
Th-232	2.19E-09
Ra-228	1.35E-09
Ac-228	2.16E-11
Th-228	1.64E-09
Ra-224	1.24E-10
Rn-220	1.92E-18
Po-216	3.88E-17
Pb-212	3.75E-13
Bi-212	4.42E-13
Po-212	0.00E+00
Tl-208	2.54E-12
TOTAL	3.47E-08

Mar 29, 2012 10:14 am

SUMMARY
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)				
Direction	500	770	1710	2580	
N	6.9E-02	3.2E-02	9.0E-03	5.3E-03	
NNW	3.6E-02	1.7E-02	5.5E-03	3.6E-03	
NW	4.2E-02	2.0E-02	6.1E-03	3.9E-03	
WNW	5.1E-02	2.4E-02	7.0E-03	4.3E-03	
W	3.9E-02	1.8E-02	5.7E-03	3.7E-03	
WSW	2.0E-02	9.6E-03	3.6E-03	2.7E-03	Business
SW	2.7E-02	1.3E-02	4.4E-03	3.0E-03	
SSW	3.3E-02	1.5E-02	5.0E-03	3.3E-03	
S	2.9E-02	1.4E-02	4.7E-03	3.2E-03	
SSE	2.1E-02	1.0E-02	3.8E-03	2.8E-03	
SE	3.0E-02	1.4E-02	4.8E-03	3.2E-03	
ESE	5.0E-02	2.3E-02	6.9E-03	4.3E-03	
E	6.5E-02	2.9E-02	8.3E-03	5.0E-03	School
ENE	5.4E-02	2.5E-02	7.2E-03	4.4E-03	
NE	3.4E-02	1.6E-02	5.1E-03	3.4E-03	Residence / Farm
NNE	2.8E-02	1.3E-02	4.6E-03	3.1E-03	

Mar 29, 2012 10:14 am

SUMMARY
Page 6

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

	Distance (m)			
Direction	500	770	1710	2580
N	3.5E-08	1.6E-08	4.2E-09	2.3E-09
NNW	1.8E-08	8.3E-09	2.4E-09	1.4E-09
NW	2.1E-08	9.6E-09	2.7E-09	1.6E-09
WNW	2.6E-08	1.2E-08	3.2E-09	1.8E-09
W	1.9E-08	8.8E-09	2.5E-09	1.5E-09
WSW	9.6E-09	4.5E-09	1.5E-09	9.8E-10
SW	1.3E-08	6.1E-09	1.8E-09	1.2E-09
SSW	1.6E-08	7.4E-09	2.2E-09	1.3E-09
S	1.4E-08	6.7E-09	2.0E-09	1.2E-09
SSE	1.0E-08	4.8E-09	1.6E-09	1.0E-09
SE	1.5E-08	6.8E-09	2.0E-09	1.3E-09
ESE	2.5E-08	1.1E-08	3.1E-09	1.8E-09
E	3.2E-08	1.4E-08	3.8E-09	2.1E-09
ENE	2.7E-08	1.2E-08	3.3E-09	1.9E-09
NE	1.7E-08	7.6E-09	2.2E-09	1.3E-09
NNE	1.4E-08	6.5E-09	1.9E-09	1.2E-09

CAP88 OUTPUT RESULTS

SLAPS Radon Diffusion Constant

```
                    C A P 8 8 - P C

                     Version 3.0

          Clean Air Act Assessment Package - 1988


D O S E   A N D   R I S K   E Q U I V A L E N T   S U M M A R I E S

                Radon Individual Assessment
                   Mar  29, 2012  10:22 am


    Facility:  SLAPS
     Address:  McDonnell Blvd
        City:  St. Louis
       State:  MO          Zip:    63134


    Source Category:  Area
        Source Type:  Area
      Emission Year:  2011


    Comments:  Air
               Air


       Dataset Name:  SLAPS Radon 2011
       Dataset Date:  3/29/2012 10:22:00 AM
          Wind File:  .   C:\Program Files\CAP88-PC30\WindLib\13994.WND
```

Mar 29, 2012 10:22 am

SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
EFFEC	9.93E-01

Radon Decay Product Concentration (working level)

1.24E-04

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	0.00E+00
INHALATION	9.93E-01
AIR IMMERSION	8.96E-05
GROUND SURFACE	0.00E+00
INTERNAL	9.93E-01
EXTERNAL	8.96E-05
TOTAL	9.93E-01

Radon Decay Product Concentration (working level)

1.24E-04

No Ground Surface Concentration or Ingestion Rate Exposures for RN-222

Mar 29, 2012 10:22 am **SUMMARY**
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Nuclide	Selected Individual (mrem/y)
Rn-222	9.93E-01
TOTAL	9.93E-01

Radon Decay Product Concentration (working level)

1.24E-04

Mar 29, 2012 10:22 am **SUMMARY Page 3**

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	1.63E-04
Total Fatal Risk All Exposures	1.74E-04

Mar 29, 2012 10:22 am **SUMMARY**
Page 4

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	0.00E+00
INHALATION	1.12E-05
AIR IMMERSION	2.14E-09
GROUND SURFACE	0.00E+00
INTERNAL	1.12E-05
EXTERNAL	2.14E-09
TOTAL	1.12E-05

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	1.63E-04
Total Fatal Risk All Exposures	1.74E-04

Mar 29, 2012 10:22 am

SUMMARY
Page 5

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
Rn-222	1.12E-05
TOTAL	1.12E-05

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	1.63E-04
Total Fatal Risk All Exposures	1.74E-04

Mar 29, 2012 10:22 am SUMMARY
Page 6

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)	
Direction	1	400
N	9.9E-01	1.1E-02
NNW	9.9E-01	5.6E-03
NW	9.9E-01	6.8E-03
WNW	9.9E-01	8.3E-03
W	9.9E-01	6.2E-03
WSW	9.9E-01	3.0E-03
SW	9.9E-01	4.3E-03 (0.0043 ÷ 0.99) = 0.0043
SSW	9.9E-01	5.3E-03
S	9.9E-01	4.5E-03
SSE	9.9E-01	3.1E-03
SE	9.9E-01	4.6E-03
ESE	9.9E-01	8.0E-03
E	9.9E-01	1.1E-02
ENE	9.9E-01	8.8E-03
NE	9.9E-01	5.3E-03
NNE	9.9E-01	4.4E-03

Mar 29, 2012 10:22 am

SUMMARY
Page 7

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

	Distance (m)	
Direction	1	400
N	1.6E-04	1.9E-06
NNW	1.6E-04	9.9E-07
NW	1.6E-04	1.2E-06
WNW	1.6E-04	1.5E-06
W	1.6E-04	1.1E-06
WSW	1.6E-04	5.2E-07
SW	1.6E-04	7.5E-07
SSW	1.6E-04	9.3E-07
S	1.6E-04	7.9E-07
SSE	1.6E-04	5.5E-07
SE	1.6E-04	8.0E-07
ESE	1.6E-04	1.4E-06
E	1.6E-04	1.9E-06
ENE	1.6E-04	1.5E-06
NE	1.6E-04	9.2E-07
NNE	1.6E-04	7.7E-07

APPENDIX B

ENVIRONMENTAL TLD, ALPHA TRACK AND PERIMETER AIR DATA
(On CD-ROM at the end of this document)

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX C

STORM-WATER, WASTE-WATER AND EXCAVATION-WATER DATA
(On CD-ROM at the end of this document)

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX D

COLDWATER CREEK SURFACE-WATER AND SEDIMENT DATA
(On CD-ROM at the end of this document)

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX E

GROUND-WATER FIELD PARAMETER DATA FOR CY 2011, ANALYTICAL DATA FOR CY 2011, AND LOGS FOR GROUND-WATER MONITORING WELL PW46
(On CD-ROM at the end of this document)

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX F

CALCULATION OF THE ROD GROUND-WATER EVALUATION CRITERIA

THIS PAGE INTENTIONALLY LEFT BLANK

CALCULATION OF THE ROD GROUND-WATER MONITORING GUIDELINES

This appendix briefly outlines the methodology used to develop the ground-water monitoring guidelines for select wells and analytes at the NC Sites. The development of these guidelines was necessary to meet the requirements of response-action monitoring and long-term monitoring specified in the ROD (USACE 2005). These requirements are also identified in the EMICY11 (USACE 2011). The results of these calculations are used in the EMDAR to evaluate ground-water monitoring data at the Latty Avenue Properties and the SLAPS and SLAPS VPs for CY 2011.

Introduction

Response-action monitoring is conducted for HZ-A and HZ-C ground water at the NC Sites to assess if water quality has improved due to source removals or if ground-water conditions have significantly degraded. Based on the ROD, a significantly degraded ground-water condition requires all of the following:

1) that soil COC concentrations have statistically increased in ground water (relative to the well's historic data and accounting for uncertainty) for more than a 12-month period. Significantly increased concentrations are defined as doubling of an individual COC concentration above the UCL of the mean (based on the historical concentration before remedial activity) for a period of 12 months;
2) that the degraded well is close enough to impact Coldwater Creek; and
3) that a significant degrading of Coldwater Creek surface water is anticipated.

In addition to the above requirements, the ROD specifies that the maximum contaminant level for total U of 30 µg/L be used as a monitoring guideline for both the response-action and long-term monitoring of ground water. If ground-water monitoring indicates the presence of COCs at significantly increased concentrations and total U significantly above 30 µg/L, then an evaluation of potential response actions would be conducted.

Methodology

In order to evaluate ground water for significant degradation, the UCL must be calculated using the historical ground water data (i.e., data collected before remedial activity). The UCL is used to represent a historical average concentration for an analyte in a particular well. USEPA's *Supplemental Guidance to RAGS: Calculating the Concentration Term* (USEPA 1992) states that, "because of the uncertainty associated with estimating the true average concentration at a site, the UCL_{95} of the arithmetic mean should be used for this variable." Based on the above guidance, a 95 percent confidence interval was used in the UCL calculations.

Consistent with the ROD, UCL_{95} values for the soil COCs are used in the CY 2011 EMDAR to evaluate if concentrations have statistically increased in ground water for more than a 12-month period. The soil COCs defined in the ROD include antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, total U, vanadium, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, and U-238. Because the SLAPS well PW46 is a replacement well, pre-2006 data from PW38 was used to develop the ground-water monitoring guideline to compare with the PW46 results. PW46 was installed in April 2006 near the former location of PW38 and is screened across the same interval. Similarly, pre-2006 data from HISS-06 and HISS-11 was used to develop the ground-water monitoring guidelines for the two replacement wells (HISS-06A and HISS-11A) installed in CY 2011 at the HISS. For wells located in areas where a response action has been taken, significant degradation is defined as occurring if the concentration of any COC in a recent sample from that well is double its UCL_{95}, and the total U is significantly above 30 µg/L. The ROD ground-water monitoring guideline for the soil COC for a particular well is defined as equivalent to two times the UCL_{95} value.

The dataset used for this evaluation was reduced prior to performing the statistical analysis. Filtered data, results qualified with an "R" designation, and QC samples were removed from each of the data sets. The analytical result was used where the data qualifier was assigned an "=" or a "J". For nondetect chemical data (i.e., the data qualifier was assigned a "U" or "UJ"), the value used in the UCL_{95} calculation was half the DL. For nondetect radiological data, the reported value was used except in cases in which the value reported was negative. In those cases, a value of zero was substituted for the negative value.

Results

The USEPA software package ProUCL (Version 4.0) was used to calculate the UCL_{95} value. ProUCL computes parametric UCLs (for normal, lognormal, and gamma distributions) and nonparametric UCLs using several nonparametric methods (USEPA 2004). Based upon the data distribution and the associated skewness, ProUCL performs and recommends the appropriate UCL.

The UCL_{95} values are those recommended by ProUCL with the following exceptions:

- If the calculated UCL_{95} exceeded the maximum detected value, then the maximum detected value was used, as recommended in USEPA's *Risk Assessment Guidance for Superfund Volume 1 Human Health Evaluation Manual (Part A)* (USEPA 1989d).
- If there were no detected values for the COC in the historical database for that well, then the UCL_{95} was not determined. If there were only one detected value of the COC, then the detected value was used.

The ground-water monitoring guidelines based on these UCL_{95} values are listed in Tables F-1 and F-2 for the Latty Avenue Properties and the SLAPS and SLAPS VPs, respectively.

Table F-1. ROD Monitoring Guidelines for Ground Water at the Latty Avenue Properties

Analyte Type	Soil COCs	HISS-01	HISS-06A[a]	HISS-09	HISS-10	HISS-11A[a]	HISS-14
Inorganics (ug/L)	**Antimony**	12	---	---	---	---	---
	Arsenic	---	---	---	---	5.2	---
	Barium	250	240	420	270	370	1,080
	Cadmium	---	---	---	1.4	---	---
	Chromium	13	2.2	---	2.4	7.0	---
	Molybdenum	23	40	22	5.6	4.8	---
	Nickel	20	34	21	3.8	20	11
	Selenium	570	770	19	7.6	---	610
	Thallium	4.6	---	---	---	---	5.8
	Total Uranium	30	30	30	30	30	30
	Vanadium	37	31	17	16	---	250
Radionuclides (pCi/L)	**Ra-226**	5.3	---	---	---	16	4.2
	Th-228	1.9	2.4	3.2	3.4	3.4	2.0
	Th-230	4.2	7.0	7.4	6.0	5.0	21
	Th-232	---	1.8	---	0.2	---	---
	U-234	12	32	1.8	6.6	4.8	14
	U-235	---	4.2	---	---	---	---
	U-238	13	31	1.4	5.2	3.0	11

Table F-1. ROD Monitoring Guidelines for Ground Water at the Latty Avenue Properties

Analyte Type	Soil COCs	HISS-17S	HISS-18S	HISS-19S	HW21	HW22	HW23
Inorganics (ug/L)	**Antimony**	---	---	7.4	---	---	4.6
	Arsenic	---	6.6	510	6.8	2.4	320
	Barium	500	410	1,200	3,700	460	810
	Cadmium	---	---	---	2.8	1.6	3.4
	Chromium	12	---	3.0	7.0	9.0	8.1
	Molybdenum	16	---	10	5.6	3.4	26
	Nickel	30	39	7.0	44	7.0	12
	Selenium	250	---	---	110	17	---
	Thallium	---	---	8.0	6.2	---	5.4
	Total Uranium	30	30	30	30	30	30
	Vanadium	18	16	4.4	12	4.0	6.4
Radionuclides (pCi/L)	**Ra-226**	5.7	5.5	2.5	8.4	11	2.4
	Th-228	2.4	3.2	10	4.2	1.8	2.6
	Th-230	3.8	5.8	12	5.2	3.8	5.2
	Th-232	---	1.9	---	---	---	1.0
	U-234	8.2	8.2	---	24	6.4	3.8
	U-235	---	---	---	2.0	---	---
	U-238	5.6	3.7	---	16	5.4	3.2

Notes:

[a] The ROD Evaluation Criteria for HISS-06A and HISS-11A were calculated using historical data from wells previously at this location (HISS-06 and HISS-11).

Ground-Water Monitoring Guideline = 2 x UCL_{95}

Total U monitoring guide = 30 ug/L.

--- The analyte was not detected in the historical database so a monitoring guideline was not developed.

Table F-2. ROD Monitoring Guidelines for Ground Water at the SLAPS and SLAPS VPs

Analyte Type	Soil COCs	B53W01D	B53W01S	B53W06S	B53W07D	B53W07S	B53W09S	B53W13S	B53W17S	B53W18S
Inorganics (ug/L)	**Antimony**	---	---	105	5.0	---	---	---	---	---
	Arsenic	170	---	---	150	140	---	---	---	3.6
	Barium	840	390	190	730	530	630	510	450	1,200
	Cadmium	---	---	---	---	---	---	---	8.8	---
	Chromium	7.2	15	47	5.6	11	9.6	9.1	7.0	51
	Molybdenum	---	---	22	4.0	4.4	14	3.2	21	28
	Nickel	---	30	16	12	5.2	83	38	5.2	910
	Selenium	---	---	---	4.0	5.2	700	790	140	---
	Thallium	---	8.0	---	7.4	---	---	7.0	---	---
	Total Uranium	30	30	30	30	30	30	30	30	30
	Vanadium	19	44	48	12	17	24	---	83	54
Radionuclides (pCi/L)	**Ra-226**	4.4	---	3.8	3.4	7.2	2.5	---	---	7.2
	Th-228	1.6	1.0	1.5	---	2.2	3.0	4.4	3.8	7.0
	Th-230	5.8	2.9	3.9	4.4	4.0	5.0	6.0	5.6	8.0
	Th-232	---	---	---	---	---	---	---	---	1.4
	U-234	3.4	8.2	66	3.6	11	18	13	5.4	4.5
	U-235	---	---	2.9	---	---	6.1	---	4.4	---
	U-238	2.7	2.7	57	4.6	8.2	13	10	4.2	3.4

Table F-2. ROD Monitoring Guidelines for Ground Water at the SLAPS and SLAPS VPs

Analyte Type	Soil COCs	B53W19S	MW31-98	MW32-98	PW35	PW36	PW42	PW43	PW44	PW45	PW46[a]
Inorganics (ug/L)	**Antimony**	---	---	---	---	---	---	---	---	---	---
	Arsenic	36	---	5.8	90	220	280	53	13	---	7.0
	Barium	510	1,300	700	3,300	1,500	670	260	260	610	250
	Cadmium	0.7	3.8	3.8	0.6	---	0.8	---	---	---	1.2
	Chromium	290	4.6	5.6	16	3.2	52	3.5	---	---	37
	Molybdenum	130	35	3.0	32	8.0	6.0	6.4	12	1,500	2.2
	Nickel	1,100	7.8	4.0	35	13	28	3.6	---	67	3.4
	Selenium	4.2	390	740	2.8	3.8	---	---	---	7,200	710
	Thallium	7.7	---	9.8	7.4	14	7.6	---	---	---	---
	Total Uranium	30	30	30	30	30	30	30	30	30	30
	Vanadium	36	110	54	35	13	12	3.1	---	---	67
Radionuclides (pCi/L)	**Ra-226**	1.4	3.4	1.6	8.0	2.0	4.0	6.1	1.8	2.4	22
	Th-228	5.2	4.6	1.4	2.6	2.6	1.6	2.4	3.4	2.5	2.1
	Th-230	6.0	4.0	4.0	4.1	3.6	3.4	2.6	12	5.8	60
	Th-232	2.2	---	0.4	2.3	---	---	---	---	---	7.0
	U-234	2.4	7.0	21	4.3	3.2	9.0	29	4.7	79	5,500
	U-235	---	5.9	9.4	---	---	---	2.2	---	3.0	290
	U-238	1.8	5.7	19	4.7	4.9	6.6	26	3.4	64	5,600

Notes:

[a] The ROD Evaluation Criteria for PW46 were calculated using historical data from a well previously at this location (PW38).

Ground-Water Monitoring Guideline = 2 x UCL_{95}

Total U monitoring guide = 30 ug/L.

--- The analyte was not detected in the historical database so a monitoring guideline was not developed.

APPENDIX G

DOSE ASSESSMENT ASSUMPTIONS

THIS PAGE INTENTIONALLY LEFT BLANK

DOSE ASSESSMENT ASSUMPTIONS

A. Dose from the Latty Avenue Properties to a Maximally Exposed Individual

A full-time employee business receptor was evaluated to determine the maximally exposed individual from Latty Avenue Properties since the remedial action work conducted on Latty Avenue Properties occurred in the vicinity of the receptor. The business receptor worked full-time outside of the facility, located approximately 50 meters (m) west of the HISS perimeter and 110 m from the center of the HISS. Exposure time was 2,000 hours per year (250 days per year).

Gamma radiation and radon exposure measured at the HISS perimeter fenceline assumes that a hypothetical member of the public would be at the same location 24 hours per day, 365 days per year. Off-site dose to the nearest member of the public is dependent upon the member's proximity to the gamma source and amount of time spent at the affected site. A more realistic approach to project dose is to evaluate members of the public as either residence-based or off-site-worker-based receptors. A residence-based off-site exposure assumes a 100 percent occupancy rate at a given location. There are no public areas or residences near the HISS; therefore, exposure to a residence-based receptor is greatly reduced due to the distance relative to the site. An off-site-worker exposure assumes that a worker's occupancy rate is 23 percent, based on 8 hours per day, 5 days per week, and 50 weeks per year. The off-site-worker-based receptor is a more realistic choice to represent the hypothetical maximally exposed individual because of the proximity of the receptor. 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 one exposed individual who works full-time (2,000 hours per year) at a location approximately 50 m west of the HISS perimeter and 110 m from the center of the HISS.

1. <u>Airborne Radioactive Particulates</u>

EDE of <0.1 mrem/yr to the receptor was calculated by using activity fraction and air particulate monitoring data to determine a source term, and then using the USEPA CAP88-PC modeling code to calculate dose to the receptor at 50 m west of the HISS (SAIC 2012a). Details related to calculation of EDEs for the exposed receptors are presented in Appendix A.

2. <u>External Gamma Pathway</u>

Data collected from stations HA-1 through HA-5 were used to calculate external gamma dose to the respective receptor. Appendix C presents the TLD results at all stations and background for the HISS.

Station HA-1, HA-2, HA-3, HA-4, and HA-5 TLDs measured annual exposures above background of 1 mrem/yr, 0 mrem/yr, 16 mrem/yr, 1 mrem/yr, and 0 mrem/yr, respectively, based on 8,760 hours of continuous 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).

$$H_1 = \frac{(0 + 0 + 16 + 0 + 1)\ \text{mrem/yr}}{5} = 3\ \text{mrem/yr}$$

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

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

$$H_2 = 0.07 \text{ mrem/yr}$$

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 = 70 m

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

$$H_{MEI} = H_2 \times \frac{2{,}000 \text{ hours per work year}}{8{,}760 \text{ hours per total year}} = 0.02 \text{ mrem/yr}$$

$$H_{MEI} = <0.1 \text{ mrem/yr}$$

3. Airborne Radon Pathway

Data collected from stations HA-1 through HA-5 were used to determine dose due to radon and progeny. Appendix B presents the radon results at all stations.

Station HA-1, HA-2, HA-3, HA-4 and HA-5 ATDs measured above background annual exposures of 0 pCi/L, 0 pCi/L, 0 pCi/L, 0 pCi/L, and 0 pCi/L, respectively, 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 (S_1) at the site perimeter between the source and the receptor (SAIC 2012a).

The average of ATD measurement at the site perimeter (S_1) was calculated as follows:

$$S_1 = \left[\frac{(0+0+0+0+0) \text{ pCi/L}}{5} \right] = 0 \text{ pCi/L}$$

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

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

$$S_{MEI} = 0 \text{ pCi/L} \times 0.0005 \frac{\text{WL}}{\text{pCi/L}} \times 1{,}250 \frac{\text{mrem}}{\text{WLM}} \times \frac{2{,}000 \text{ hours}}{\text{year}} \, x \, \frac{1 \text{ month}}{170 \text{ hours}} \times 0.81 = 0 \text{ mrem/yr}$$

where:

S_{MEI} = Radon exposure to the hypothetical maximally exposed individual.

S_1 = Fenceline average of ATD measurements between source and receptor

F = Equilibrium fraction of 0.05 WL per 100 pCi/L (DOE 1998)

DCF = Dose Conversion Factor (USEPA 1989b) = 1250 mrem/WLM

T = Exposure time for the hypothetical maximally exposed receptor

C_1 = Occupancy factor constant = 1 month per 170 hours

C_2 = Constant derived using CAP-88PC Version 2, the Lambert Airport wind file (assuming a distance of 50 m), and an impacted surface area of 22,000 square meters (m^2). Calculation assumes a 1 Ci/yr radon release rate and then ratios the concentrations at 1 m and 50 m to determine the constant.

WL = working level (concentration unit)

WLM = working level month (exposure unit)

4. Total Effective Dose Equivalent (TEDE)

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

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

B. Dose from the St. Louis Airport Site/St. Louis Airport Site Vicinity Properties to a Maximally Exposed Individual

As at the Latty Avenue Properties, the off-site-worker-based receptor is a more realistic choice to represent the hypothetically maximally exposed individual because of the proximity of the receptor, approximately 500 m west-southwest of the center of the SLAPS loadout area, and the time the individual will spend at this location. Thus, a more 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 500 m west-southwest of the center of the SLAPS loadout area.

1. Airborne Radioactive Particulates

EDE of <0.1 mrem/yr to the receptor was calculated by using activity fraction and air particulate monitoring data to determine a source term, and then using the USEPA CAP88-PC modeling code to calculate dose to the receptor at 500 m west-southwest of the center of the SLAPS loadout area (SAIC 2012b). Details related to calculation of EDEs for the exposed receptors are presented in Appendix A.

2. External Gamma Pathway

Because station PA-1 was the closest to the receptor, the TLD results from this station were used for the dose calculations. Station PA-1 TLDs measured an annual exposure, above background, of 5 mrem/yr based on 8,760 hours of continuous exposure. The dose equivalent 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).

$$H_1 = 5 \text{ mrem/yr}$$

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

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

$$H_2 = 0.001 \text{ mrem/yr}$$

where:

H_2 = exposure rate to the receptor (continuous exposure)

H_1 = exposure rate to TLDs

h_2 = distance from source to receptor = 500 m

h_1 = distance from source to TLDs = 1.6 m

L = average distance from centerline of the line source (H_1) to the end of the line source = 50 m

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

$$H_{MEI} = H_2 \times \frac{2{,}000 \text{ hours per work year}}{8{,}760 \text{ hours per total year}} = 0.0002 \text{ mrem/yr}$$

$$H_{MEI} = <0.1 \text{ mrem/yr}$$

3. Airborne Radon Pathway

Station PA-1 ATDs measured an above background annual exposure 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 (S_1) at the site perimeter between the source and the receptor (SAIC 2012b).

$$S_1 = 0 \text{ pCi/L}$$

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

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

$$S_{MEI} = 0 \text{ pCi/L} \times 0.0005 \frac{\text{WL}}{\text{pCi/L}} \times 1250 \frac{\text{mrem}}{\text{WLM}} \times \frac{2000 \text{ hours}}{\text{year}} \times \frac{1 \text{ month}}{170 \text{ hours}} \times 0.00436 = 0 \text{ mrem/yr}$$

where:

S_{MEI} = Radon exposure to the hypothetical maximally exposed individual.

S_1 = Fenceline average of ATD measurements between source and receptor

F = Equilibrium fraction of 0.05 WL per 100 pCi/L (DOE 1998)

DCF = Dose Conversion Factor (USEPA 1989b) = 1,250 mrem/WLM

T = Exposure time = 2,000 hours/year

C_1 = Occupancy factor constant = 1 month per 170 hours

C_2 = Constant derived using CAP-88PC Version 2.0, the Lambert Airport wind file (assuming a distance of 160 m), and an impacted surface area of 1,800 m^2. Calculation assumes a 1 Ci/yr radon release rate and then ratios the concentrations at 1 m and 160 m to determine the constant.

WL = working level (concentration unit)

WLM = working level month (exposure unit)

4. Total Effective Dose Equivalent (TEDE)

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

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

C. Dose from Coldwater Creek to a Maximally Exposed Individual

The following dose assessment is for a maximally exposed individual who is assumed to be a youth that spends time at Coldwater Creek for recreational purposes.

1. Contaminated Water Ingestion (SAIC 2012c)

The UCL-95 values of the average contamination values measured in Coldwater Creek in 2011 at each monitoring station (Table G-2) were used to calculate the EDE to the receptor from an intake of contaminated water. Assumptions are as follows:

The receptor visits Coldwater Creek as a recreational user once every two weeks (26 visits per year) and the receptor drinks 2 liters per day of contaminated water from the creek during each visit (USEPA 1989a).

The TEDE due to ingestion of surface water ($TEDE_w$) was calculated as follows:

$$TEDE_W = \Sigma\ (TEDE_{Tot\text{-}U}, TEDE_{Th\text{-}228}, TEDE_{Th\text{-}230}, TEDE_{Th\text{-}232}, TEDE_{Ra\text{-}226}, TEDE_{Ra\text{-}228})$$

$$TEDE_i = \text{(UCL-95) pCi/L} \times 2.0 \text{ Liters per day} \times 26 \text{ days per year} \times \text{DCF mrem/pCi}$$

DCFs (USEPA 1989b) for radionuclides present in Coldwater Creek surface water are presented in Table G-1.

Table G-1. Radionuclide DCF for CY 2011

Radionuclides	DCF	Unit
Ra-226	1.33E-03	mrem/pCi
Th-228	3.96E-04	mrem/pCi
Th-230	5.48E-04	mrem/pCi
Th-232	2.73E-03	mrem/pCi
Total U	2.50E-05	mrem/pCi

USEPA's software ProUCL version 3.0 was used to determine the UCL-95 values for radiological contaminants present in Coldwater Creek (SAIC 2012c). The UCL-95 values are presented in Table G-2.

Table G-2. UCL-95 Values for Radionuclides for CY 2011

Radionuclides	UCL-95 Concentration	Unit
Ra-226	1.60	pCi/L
Th-228	0.51	pCi/L
Th-230	0.52	pCi/L
Th-232	0.27	pCi/L
Total U	2.79	pCi/L

Therefore:

$$TEDE_{Ra\text{-}226} = 1.60 \text{ pCi/L} \times 2.0 \text{ Liters per day} \times 26 \text{ days per year} \times 1.33E\text{-}03 \text{ mrem/pCi} = 1.11E\text{-}01 \text{ mrem/yr}$$

$$TEDE_{Th\text{-}228} = 0.51 \text{ pCi/L} \times 2.0 \text{ Liters per day} \times 26 \text{ days per year} \times 3.96E\text{-}04 \text{ mrem/pCi} = 1.05E\text{-}02 \text{ mrem/yr}$$

$$TEDE_{Th\text{-}230} = 0.52 \text{ pCi/L} \times 2.0 \text{ Liters per day} \times 26 \text{ days per year} \times 5.48E\text{-}04\text{mrem/pCi} = 1.47E\text{-}02 \text{ mrem/yr}$$

$$TEDE_{Th\text{-}232} = 0.27 \text{ pCi/L} \times 2.0 \text{ Liters per day} \times 26 \text{ days per year} \times 2.73E\text{-}3 \text{ mrem/pCi} = 3.79E\text{-}02\text{mrem/yr}$$

$$TEDE_{Tot\text{-}U} = 2.79 \text{ pCi/L} \times 2.0 \text{ Liters per day} \times 26 \text{ days per year} \times 2.50E\text{-}05 \text{ mrem/pCi} = 3.63E\text{-}03 \text{ mrem/yr}$$

$$TEDE_W = 1.78E\text{-}01 \text{ mrem}$$

2. <u>Contaminated Sediment Ingestion (SAIC 2012c)</u>

The UCL-95 values of the average contamination values measured in Coldwater Creek in 2011 at each monitoring station (Table G-4) were used to calculate the EDE to the receptor from an intake of contaminated sediment. Assumptions are as follows:

The receptor visits Coldwater Creek as a recreational user once every two weeks (26 visits per year). The receptor ingests 50 mg/day of contaminated sediment from the creek during each visit (USEPA 1989a).

The TEDE due to ingestion of contaminated sediment ($TEDE_S$) was calculated as follows:

$$TEDE_S = \Sigma\,(TEDE_{Tot\text{-}U}, TEDE_{Th\text{-}228}, TEDE_{Th\text{-}230}, TEDE_{Th\text{-}232}, TEDE_{Ra\text{-}226}, TEDE_{Ra\text{-}228})$$

$$TEDE_i = (\text{UCL-95}) \text{ pCi/g} \times 0.05 \text{ g/day} \times 26 \text{ days per year} \times \text{DCF mrem/pCi}$$

DCFs (USEPA 1989b) for radionuclides present in Coldwater Creek sediment are presented in Table G-3.

Table G-3. Radionuclide DCFs for CY 2011

Radionuclides	DCF	Unit
Ra-226	1.33E-3	mrem/pCi
Ra-228	1.44E-3	mrem/pCi
Th-228	3.96E-4	mrem/pCi
Th-230	5.48E-4	mrem/pCi
Th-232	2.73E-3	mrem/pCi
Total U	2.50E-5	mrem/pCi

USEPA's software ProUCL version 3.0 was used to determine UCL-95 values for radiological contaminants present in Coldwater Creek sediment (SAIC 2012c). The UCL-95 values are presented in Table G-4.

Table G-4. UCL-95 Values for Radionuclide for CY 2011

Radionuclides	UCL-95 Concentration	Unit
Ra-226	1.24	pCi/g
Ra-228	0.81	pCi/g
Th-228	1.30	pCi/g
Th-230	4.43	pCi/g
Th-232	1.05	pCi/g
Total U	2.21	pCi/g

Therefore:

$$TEDE_{Ra\text{-}226} = 1.24 \text{ pCi/g} \times 0.05 \text{ g/day} \times 26 \text{ days per year} \times 1.33E\text{-}3 \text{ mrem/pCi} = 2.14E\text{-}3 \text{ mrem/yr}$$

$$TEDE_{Ra\text{-}228} = 0.81 \text{ pCi/g} \times 0.05 \text{ g/day} \times 26 \text{ days per year} \times 1.44E\text{-}3 \text{ mrem/pCi} = 1.52\ E\text{-}3 \text{ mrem/yr}$$

$$TEDE_{Th\text{-}228} = 1.30 \text{ pCi/g} \times 0.05 \text{ g/day} \times 26 \text{ days per year} \times 3.96E\text{-}4 \text{ mrem/pCi} = 6.69E\text{-}4 \text{ mrem/yr}$$

$$TEDE_{Th\text{-}230} = 4.43 \text{ pCi/g} \times 0.05 \text{ g/day} \times 26 \text{ days per year} \times 5.48E\text{-}4 \text{ mrem/pCi} = 3.16E\text{-}3 \text{ mrem/yr}$$

$$TEDE_{Th\text{-}232} = 1.05 \text{ pCi/g} \times 0.05 \text{ g/day} \times 26 \text{ days per year} \times 2.73E\text{-}3 \text{ mrem/pCi} = 3.73E\text{-}3 \text{ mrem/yr}$$

$$TEDE_{Tot\text{-}U} = 2.21 \text{ pCi/g} \times 0.05 \text{ g/day} \times 26 \text{ days per year} \times 2.50E\text{-}5 \text{ mrem/pCi} = 7.18E\text{-}5 \text{ mrem/yr}$$

$$TEDE_S = 1.13E\text{-}02 \text{ mrem/yr}$$

3. <u>Total Effective Dose Equivalent</u>

$$TEDE = TEDE_W + TEDE_S$$

$$TEDE = 1.78E\text{-}01 \text{ mrem/yr} + 1.13E\text{-}2 \text{ mrem/yr} = 0.2 \text{ mrem/yr}$$

REFERENCES

Cember, H., 1996. *Introduction to Health Physics,* Mcgraw-Hill, New York, NY.

DOE 1998. *Internal Dosimetry Program Technical Basis Manual*, DOE/OR/21548-241, Oak Ridge Operations Office, Rev. 5, November.

SAIC 2012a. *Total Effective Dose Equivalent (TEDE) to the Hypothetically Maximally Exposed Individual at HISS*, March.

SAIC 2012b. *Total Effective Dose Equivalent (TEDE) to the Hypothetically Maximally Exposed Individual at SLAPS*, March.

SAIC 2012c. *Total Effective Dose Equivalent (TEDE) to the Hypothetically Maximally Exposed Individual at Coldwater Creek*, March.

USEPA 1989a. *Exposure Factor Handbook EPA/600/8-89/043,* Office of Health and Environmental Assessment, Washington D.C., July.

USEPA 1989b. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, Federal Guidance Report No. 11, September.