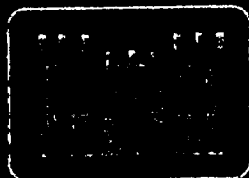


ANALYSIS OF ENVIRONMENTAL
MONITORING DATA AND ANALYSIS
IN THE KILN AREA

ROYAL BINSOFF

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FINAL

ANNUAL ENVIRONMENTAL MONITORING DATA AND ANALYSIS REPORT FOR CY01

ST. LOUIS, MISSOURI

JUNE 2002

prepared by

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

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ACRONYMS AND ABBREVIATIONS

Ac	actinium
AEC	Atomic Energy Commission
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
ATD	alpha track detector
AWQC	ambient water quality criteria
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
CV	coefficient of variation
CY	calendar year
DOE	U.S. Department of Energy
DQO	data quality objective
EDE	effective dose equivalent
EE/CA	Engineering Evaluation/Cost Analysis Report
EMDAR	Environmental Monitoring Data and Analysis Report
EMG	Environmental Monitoring Guide
EMIFY	Environmental Monitoring Implementation for Fiscal Year
FMP	Environmental Monitoring Program
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
FS	Feasibility Study
ft	feet
ft/ft	feet per foot
FUSRAP	Formerly Utilized Sites Remedial Action Program
GRAAA	Ground-water Remedial Action Alternative Assessment
HISS	Hazelwood Interim Storage Site
HTRW CX	Hazardous, Toxic and Radioactive Waste-Center of Expertise
HU	hydrostratigraphic unit
HZ	hydrostratigraphic zone
ICRP	International Commission on Radiation Protection

ACRONYMS AND ABBREVIATIONS (CONT'D)

K	potassium
LCS	laboratory control sample
m	meter(s)
MCL	maximum contaminant level
MDA	minimum detectable activity
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineering District
mg/kg	milligram per kilogram
mg/L	milligrams per liter
mL/L/hr	milliliter per liter per hour
mrem	millirem
mrem/hr	millirem per hour
mrem/pCi	millirem per picocurie
mrem/yr	millirem per year
MSD	Metropolitan Sewer District
NCR	non-conformance report
ND	non-detect
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NTU	nephelometric turbidity unit
Pa	protactinium
Pb	lead
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/m ² /s	picocurie per square meter per second
PCOC	potential contaminant of concern
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
Ra	radium

ACRONYMS AND ABBREVIATIONS (CONT'D)

RA	Remedial/Removal Action
Rn	radon
ROD	Record of Decision
RPD	relative percent difference
SAG	Sampling and Analysis Guide
SDWA	Safe Drinking Water Act
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
SLS	St. Louis Sites
SMCL	secondary maximum contaminant level
SOP	standard operating procedure
SVOC	semivolatile organic compound
TCE	trichloroethene
TDS	total dissolved solids
TEDE	total effective dose equivalent
Th	thorium
TLD	thermoluminescent dosimeter
TOC	total organic compound
TOX	total organic halogen
U	uranium
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USACE	United States Army Corps of Engineers
UST	underground storage tanks
VC	vinyl chloride
VOC	volatile organic compound
VP	vicinity property
WD	work description
WDNR	Wisconsin Department of Natural Resources
yd ³	cubic yard
μCi/mL	microcurie per milliliter
μg/kg	microgram per kilogram
μg/L	microgram per liter
μrem/yr	microrem per year

EXECUTIVE SUMMARY

This annual Environmental Monitoring and Data Analyses Report (EMDAR) for the St. Louis Sites (SLS) for calendar year 2001 (CY01) has been prepared to provide information about the public safety and environmental protection programs at the SLS within the Formerly Utilized Sites Remedial Action Program (FUSRAP). Environmental monitoring of various media at the Hazelwood Interim Storage Site (HISS), St. Louis Airport Site (SLAPS), and the St. Louis Downtown Site (SLDS) is required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and a commitment outlined in the Federal Facilities Agreement (FFA).

The purpose of this report is to summarize the data collection effort for CY01, report the current condition of the SLS, and provide an interpretation of the results of the CY01 environmental monitoring data. The United States Army Corps of Engineers (USACE), St. Louis District collects comprehensive environmental data for decision-making and planning purposes.

AIR MONITORING

HISS

Gamma radiation monitoring was performed at HISS during CY01 at six locations around the perimeter of the site. The average thermoluminescent dosimeter (TLD) measurement at the HISS perimeter was approximately 65 millirem per year (mrem/yr) above background. The gamma radiation results at all HISS perimeter locations indicated dose rates of less than 2 millirem per hour (mrem/hr).

Airborne radon monitoring was performed at HISS during CY01 using alpha track detectors (ATDs) placed around the site perimeter to measure radon emissions from the site. Six detectors were co-located with TLD locations. The average radon concentration at the HISS perimeter was approximately 0.1 picocuries per liter (pCi/L) above background, which is below the 10 CFR 20 regulatory criterion of 0.3 pCi/L.

Air sampling for radiological particulates was conducted at the HISS perimeter at four locations for the entire CY01. The average gross alpha and beta air particulate concentrations at the HISS perimeter were $2.0\text{E-}15$ microcurie per milliliter ($\mu\text{Ci/mL}$) and $2.9\text{E-}14$ $\mu\text{Ci/mL}$, respectively.

SLAPS

Gamma radiation monitoring was performed at SLAPS during CY01 at six locations around the perimeter of the site. The average TLD measurement at the SLAPS perimeter was approximately 69 mrem/yr above background. The gamma radiation results at all SLAPS perimeter locations indicated dose rates of less than 2 mrem/hr.

Airborne radon monitoring was performed at SLAPS during CY01 using ATDs placed around the site perimeter to measure radon emissions from the site. Six detectors were co-located with TLD locations. The average radon concentration measured at the SLAPS perimeter was approximately 0.1 pCi/L above background, which is below the 10 CFR 20 regulatory criterion of 0.3 pCi/L.

Air sampling for radiological particulates was conducted at the SLAPS perimeter at five locations for the entire CY01. The average gross alpha and beta air particulate concentrations at the SLAPS perimeter were $5.6\text{E-}15$ $\mu\text{Ci/mL}$ and $6.3\text{E-}14$ $\mu\text{Ci/mL}$, respectively.

SLDS

Gamma radiation monitoring was performed at SLDS during CY01 at five locations assumed to be representative of areas accessible to the public. The average TLD measurement at the SLDS was approximately 17 mrem/yr above background. The gamma radiation results at all SLDS locations indicated dose rates of less than 2 mrem/hr.

Airborne radon monitoring was performed at SLDS during CY01 using ATDs placed around the site to measure radon emissions from the site. Five detectors were co-located with TLD locations. The average radon concentration measured at the SLDS was less than 0.1 pCi/L above background, which is below the 10 CFR 20 regulatory criterion of 0.3 pCi/L.

Air sampling for radiological particulates was conducted in CY01 by the Remedial Action (RA) contractor at the perimeter of SLDS excavation locations during active excavation. The average gross alpha and beta air particulate concentrations at the SLDS excavation perimeters were $5.2\text{E-}15$ $\mu\text{Ci/mL}$ and $6.0\text{E-}14$ $\mu\text{Ci/mL}$, respectively.

NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAPs) MONITORING

The NESHAP standard of effective dose equivalent (EDE) to a critical receptor from radionuclide emissions is 10 mrem/yr. None of the sites exceeded this standard, however, the EDE at SLAPS and HISS were within a few mrem/yr of the standard. The EDE from radionuclide emissions at the HISS, SLAPS, and SLDS were calculated using soil characterization data, air particulate monitoring data, and the U.S. Environmental Protection Agency (EPA) CAP-88PC modeling code, which resulted in EDEs of 7.8 mrem/yr, 9.4 mrem/yr, and 0.7 mrem/yr, 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 EPA CAP-88PC modeling code, which resulted in less than 0.1 mrem/yr.

Evaluations for the SLDS and the USACE Radioanalytical Laboratory resulted in less than 10% of the dose standard in 40 CFR 61.102. These sites are exempt from the reporting requirements of 40 CFR 61.104(a).

Although evaluations for the SLAPS resulted in an EDE from radionuclide emissions that were less than the regulatory limit, the EDE was approximately fifty percent (50%) higher than the previous year and very close to the limit. In order to ensure that the limit is not exceeded and the applicable or relevant and appropriate requirement (ALARA) requirements of 10 CFR 20.1101(b) and (d) are met in future years, the remedial/removal action (RA) contractor at SLAPS should implement more stringent emission controls to minimize the release of radionuclide air emissions.

The evaluations for the HISS also resulted in an EDE from radionuclide emissions that was less than the regulatory limit, however, the EDE was more than three times higher than the previous year. This is likely due to the complete removal of the Main Pile during CY01. Evaluations for future years are likely to be lower since no excavations at HISS are expected and most of the site has been covered with gravel. When excavations resume at HISS, the RA contractor should implement stringent emission controls to minimize the release of radionuclide air emissions in order to ensure that the limit is not exceeded and the ALARA requirements of 10 CFR 20.1101(b) and (d) are met.

WASTE-WATER DISCHARGE MONITORING AT SLDS

CY01 was the third year that waste-water discharges at SLDS were monitored and reported in accordance with the Metropolitan Sewer District (MSD) authorization letter. The total volume discharged during CY01 is 1,747,170 gallons and total activities discharged for CY00 are 1.15E-05 curies (Ci) for thorium, 6.25E-06 Ci for uranium, and 3.07E-06 Ci for radium. The waste-water discharges from SLDS to the sanitary sewer system complied with the requirements stated in the respective MSD authorization letters.

NPDES MONITORING

Concentration limits are set for water pollutants in the National Pollutant Discharge Elimination System (NPDES) permit at the HISS and the permit-equivalent document at the SLAPS. In CY01, storm-water discharge was monitored from three outfalls at HISS (Permit MO-0111252) HN01, HN02, and HN03. During CY01, storm-water discharges from each outfall were sampled for permit required parameters and no permit limits were exceeded at the HISS. During CY01 storm-water discharges at SLAPS were monitored at PN01a, PN02, and PN03. Chemical sample data results indicated an exceedance of the allowable limit of 1.56 microliter per liter per hour (mL/L/hr) settleable solids. At PN03 in September the results were 4.0 mL/L/hr. The average flow weighted Total Uranium concentration discharged from SLAPS outfalls was 144 pCi/L for CY01.

COLDWATER CREEK SURFACE-WATER MONITORING

For the CY01 surface-water sampling events (March and October) from Coldwater Creek, the maximum activity-based concentration of radiological parameters occurred at sampling location C003 during March CY01. During March CY01, the concentrations of the uranium isotopes (U-234 and U-238) ranged from 1.65 to 2.20 pCi/L for U-234 and 1.87 to

2.92 pCi/L for U-238. During October, the concentrations of uranium isotopes (U-234 and U-238) ranged from 0.78 to 1.85 pCi/L for U-234 and 1.03 to 1.56 pCi/L for U-238.

During the March sampling event, only the concentration of iron exceeded ambient water quality criteria (AWQC) at all stations except for C005. However, the concentrations of iron at those stations are less than its background concentration. No chemical exceeded AWQC during October sampling event.

COLDWATER CREEK SEDIMENT SAMPLING

During CY01 sediment-sampling events, four inorganic and sixteen semi-volatile organic and one volatile organic analytes exceeded the background sediment criteria listed in the Environmental Monitoring Implementation for FY02 (EMIFY02) (USACE, 2001b). The chemicals exceedance are listed in the following table.

Inorganic	Semi-Volatile		Organic
Barium	Anthracene	Benzo(a)anthracene	Methylene Chloride
Calcium	Benzo(b)fluoranthene	Benzo(k)fluoranthene	
Magnesium	Benzo(g,h,i)perylene	Benzo(a)pyrene	
Thallium	Bis(2-ethylhexyl)phthalate	Chrysene	
	Dibenzo(a,h)anthracene	Dibenzofuran	
	Fluoranthene	Fluorine	
	Indeno(1,2,3-cd)pyrene	Naphthalene	
	Phenanthrene	Pyrene	

For most cases, the exceedance of chemical concentrations above background occurred at the furthest downgradient sampling station, C007 and during October sampling event. The concentrations of some chemicals exceeded their background at sampling station C005 and C006. All of these stations are located in a predominantly industrial area. Heavy industrial activities along Coldwater Creek resulted in many potential sources of inflow into the creek. Those industries might contribute to the maximum concentrations of those chemicals at those stations.

GROUND-WATER MONITORING

HISS

The stratigraphy beneath HISS is similar to that found at SLAPS with the exception of a Pennsylvanian shale layer which is found underlying portions of SLAPS. This shale unit (HZ-D) is absent at HISS. Four hydrostratigraphic zones (HZ-A through HZ-C, and HZ-E) are present at HISS. The shallow ground-water zone, HZ-A, consists of the fine-grained silts and clays. Underlying HZ-A are HZ-B, which consists of highly impermeable clay, and HZ-C, which consists of silty clay and clayey silt deposits. The Pennsylvanian limestone bedrock underlying HZ-C is defined as HZ-E and is the protected aquifer for the site.

Sampling was conducted at eighteen ground-water monitoring wells at HISS during CY01. With the exception of monitoring wells HISS-05D and HW23, which are screened in

HZ-C, all of the monitoring wells at HISS are screened in HZ-A. First quarter sampling was conducted from January 17 to March 20; second quarter sampling from May 10 to May 31; third quarter sampling from August 23 to August 29; and fourth quarter sampling from October 25 through October 29. The analytical results were compared to maximum contaminant levels (MCLs), secondary maximum contaminant levels (SMCLs), and background concentrations expected to be established in the future North County Feasibility Study (NCFS).

The CY01 data indicate there are significant localized impacts to the HZ-A ground water from site-related contaminants. The most significant levels of inorganic contaminants were reported for monitoring wells HW21 (for iron, manganese, nitrates, and selenium) and HISS-19S (for arsenic, iron, and manganese). Radiological contaminants are generally present in HZ-A ground water at very low to non-detect levels, with the exception of some slightly elevated levels of radium-226 (Ra-226) and thorium-230 (Th-230) detected in a few samples from wells located near the southern and western edges of the site. In addition, trichloroethene (TCE) was detected at significant levels in two HZ-A ground-water wells located northeast of the Futura building. The source of this contamination is not known but is likely associated with non-FUSRAP-related activities.

Ground-water samples were collected from two deep (HZ-C) wells, HISS-05D and HW23, during CY01. Both wells were sampled twice (in the first and third quarter) during CY01. The sampling results for HZ-C ground water indicate that some metals are present at elevated concentrations. In particular, arsenic, iron, and manganese had average concentrations that exceeded their MCLs or their expected background concentrations for the HZ-C ground-water zone. The source of the elevated arsenic, iron, and manganese concentrations in the HZ-C ground water is not known but is likely the result of natural conditions. The HZ-A ground-water contaminants selenium, nitrate, Ra-226, Th-230, and total uranium were not detected above their background levels or MCLs/SMCLs in HZ-C ground water.

SLAPS

The ground-water zones for SLAPS are: the shallow, hydrostratigraphic zone A (HZ-A, which comprises Unit 1 Fill, Unit 2 Loess, and Subunit 3T Silty Clay); the intermediate depth, hydrostratigraphic zone B (HZ-B, Subunit 3M Clay); the deep soil, hydrostratigraphic zone C (HZ-C, composed of Subunit 3B silty clay and Unit 4 clayey to sandy gravel); hydrostratigraphic zone D (HZ-D, Interbedded Pennsylvanian rock and shale); and the protected, deep hydrostratigraphic zone E (HZ-E, Mississippian Limestone).

A total of forty-six ground-water wells were sampled for various parameters in CY01 at SLAPS. The ground-water sampling at SLAPS was conducted between March 6 and March 21 (first quarter); May 2 to June 6 (second quarter); August 7 to August 27 (third quarter); and October 22 to October 30 (fourth quarter).

The CY01 sampling results indicate that various metals, radionuclides, and organic compounds are present at elevated levels in HZ-A ground water at SLAPS. Based on the CY01 data, the principal inorganic contaminants in shallow, HZ-A ground water at the site include arsenic, chromium, iron, manganese, nitrate, selenium, and thallium. The CY01 ground-water sampling results indicate that the principal radiological contaminants present in the HZ-A ground water are Ra-226, Th-230, U-234, and U-238. In general, the highest concentrations of these

radionuclides were found in the western portion of SLAPS. The organic compounds TCE and 1,2-dichloroethene (1,2-DCE) were also detected at concentrations above their MCLs in several shallow wells. However, these organic contaminants are not Manhattan Engineering District/Atomic Energy Commission (MED/AEC) related.

The CY01 ground-water sampling data indicate that elevated concentrations of arsenic, iron, manganese, and total dissolved solids (TDS) were present above MCLs or SMCLs in samples from the lower, HZ-C, HZ-D, and/or HZ-E ground-water units, but their occurrence is interpreted as due to natural conditions. Total uranium and Ra-226 were not detected above their respective MCLs in any wells screened exclusively across the deep (HZ-C, HZ-D, and/or HZ-E) zones during CY01. Additional radionuclides (Th-228 and Th-230) were detected in wells screened in the HZ-C through HZ-E ground water, but their maximum concentrations were only slightly above expected background levels. The CY01 data supports the determination that HZ-B, Subunit 3M, a relatively impermeable clay layer, is preventing the migration of unacceptable levels of contamination to lower ground-water zones. The localized contamination present in HZ-A ground water is not present in the deeper zones, indicating that mixing between HZ-A and HZ-C, HZ-D, and HZ-E ground-water zones is insignificant.

SLDS

The ground-water zones for SLDS are the shallow, HU-A and the protected, deeper Mississippi Alluvial Aquifer, HU-B. In CY01, a total of twenty-three wells (11 shallow, HU-A and 12 deep, HU-B) were sampled for radionuclides and inorganic (arsenic and cadmium) constituents at SLDS. The concentrations of these contaminants of concern (COCs) were compared against the following site-specific investigative limits specified in the Record of Decision (ROD): 50 micrograms per liter ($\mu\text{g/L}$) for arsenic, 5 $\mu\text{g/L}$ for cadmium, and 20 $\mu\text{g/L}$ for total uranium (USACE, 1998d). For those COCs that do not have established investigative limits, concentrations were compared to MCLs.

The CY01 results indicate that shallow, HU-A ground water at SLDS has been impacted by site contaminants. The two principal COCs that exceed the investigative limits in HU-A ground water during CY01 are arsenic and total uranium. Arsenic concentrations exceeding the investigative limit of 50 $\mu\text{g/L}$ were detected in three HU-A wells (DW21, B15W06S, and B16W05S) at SLDS during CY01. Total uranium concentrations, calculated from the isotopic uranium results, were detected above the investigative limit of 20 $\mu\text{g/L}$ in two HU-A wells, B16W02S and B16W13SR. A sample from B16W11S was also above the investigative limit. It is believed that monitoring well B16W11S may be completed across both HU-A and HU-B; therefore, the elevated uranium in this well is not considered representative of HU-A. Two other COCs identified in the SLDS ROD, Ra-226 and cadmium, were generally detected at low frequencies in HU-A, with their maximum concentrations only slightly exceeding reference levels (MCLs and investigative limits).

During CY01, twelve SLDS wells completed in the Mississippi Alluvial Aquifer (HU-B) were monitored for various parameters, including the COCs arsenic, cadmium, Th-228, Th-230, Th-232, Ra-226, U-234, U-235, and U-238. The CY01 sampling results indicate cadmium was not present above the investigative limit (5 $\mu\text{g/L}$) in samples collected from HU-B ground-water wells. Arsenic was detected above the investigative limit of 50 $\mu\text{g/L}$ in two wells: DW14, and DW15. The arsenic levels ranged from concentrations slightly exceeding the limit in DW15

(ranging from 55.6 $\mu\text{g/L}$ to 71.5 $\mu\text{g/L}$) to over 3 times the limit in DW14 (maximum 189 $\mu\text{g/L}$). Total uranium was present above the investigative level of 30 $\mu\text{g/L}$ in samples collected from DW19. The total uranium concentrations ranged from 58 $\mu\text{g/L}$ to 121 $\mu\text{g/L}$ in this well. Additional COCs were detected in HU-B at SLDS, including Ra-226, Th-228, Th-230, and Th-232, but levels were generally low. Ra-226 was detected at levels slightly exceeding the MCL in three HU-B wells at SLDS: B16W05D (15.5 pCi/L), DW14 (12.1 pCi/L) and DW15 (5.95 pCi/L). Th-228, Th-230, and Th-232 were detected in HU-B ground water at maximum concentration of 2.42 pCi/L, 3.73 pCi/L, and 1.19 pCi/L, respectively.

DOSE ASSESSMENT

The regulatory dose limit for members of the public is 100 mrem/yr as stated in 10 CFR 20.1301. The USACE has shown compliance with this limit at the SLS by demonstrating that the total effective dose equivalent (TEDE) to a maximally exposed individual at each site/location is less than the regulatory limit. The TEDE to maximally exposed individuals from radionuclide sources above background at the HISS, SLAPS, SLDS, and Coldwater Creek were 8.2 mrem/yr, 9.7 mrem/yr, 1.0 mrem/yr, and 0.1 mrem/yr, respectively.

Based on the exposure scenario and assumptions described in Section 6.4.2, a maximally exposed individual working outside at the receptor location facility 50 meters (m) east of the HISS perimeter received 7.8 mrem/yr from airborne radioactive particulates, 0.2 mrem/yr from external gamma, and 0.2 mrem/yr from Rn-222 for a TEDE of 8.2 mrem/yr (SAIC, 2002a).

Based on the exposure scenario and assumptions described in Section 6.4.1, a maximally exposed individual working outside at the receptor facility 160 m south of the SLAPS perimeter received 9.4 mrem/yr from airborne radioactive particulates, 0.1 mrem/yr from external gamma, and 0.2 mrem/yr from radon-222 (Rn-222) for a TEDE of 9.7 mrem/yr (SAIC, 2002b).

Based on the exposure scenario and assumptions described in Section 6.4.3, a maximally exposed individual working outside at the receptor location facility at Thomas and Proetz Lumber Company Vicinity Property received less than 0.7 mrem/yr from airborne radioactive particulates, 0.1 mrem/yr from external gamma, and 0.2 mrem/yr from Rn-222 for a TEDE of 1.0 mrem/yr (SAIC, 2002c).

Based on the exposure scenario and assumptions described in Section 6.4.4, a maximally exposed individual using Coldwater Creek for recreational purposes received 0.0 mrem/yr from soil/sediment ingestion, and 0.1 mrem/yr from water ingestion for a TEDE of 0.1 mrem/yr (SAIC, 2002d).

An additional scenario for a SLAPS transient was evaluated. Based on the exposure scenario and assumptions described in 6.4.5, a maximally exposed receptor passing SLAPS along McDonnell Boulevard 25 m north of the SLAPS perimeter received 3.4 mrem/yr from airborne particulate radionuclides, 0.1 mrem/yr from external gamma, and 0.3 mrem/yr from radon-222 (Rn-222) for a TEDE of 3.8 mrem/yr (SAIC, 2002e).

1.0 HISTORICAL SITE BACKGROUND AND CURRENT SITE STATUS

1.1 INTRODUCTION

The EMDAR for CY01 provides an evaluation of the data collected as part of the implementation of the EMP for the SLS within FUSRAP. Environmental monitoring of various media at each of the SLS locations is required under the CERCLA and a commitment outlined in the FFA. FUSRAP SLS consists of four sites: SLDS with its associated vicinity properties (VPs), SLAPS, SLAPS VPs, and the Latty Avenue Properties. The Latty Avenue Properties includes Futura and the HISS and other VPs. During CY01, data collection activities were conducted at the three primary sites: SLDS, SLAPS, and HISS. Additional environmental data was collected along Coldwater Creek adjacent to SLAPS and near HISS.

1.2 PURPOSE

The purpose of this report is to summarize the data collection effort for CY01, enhance the reader's awareness of the current condition of the four FUSRAP SLS, and provide professional interpretation of the CY01 environmental monitoring data results. This document presents the following information:

- Sample collection data for various media at each site and interpretation of CY01 EMP results;
- The compliance status of each site with federal and state ARARs or other benchmarks;
- Dose assessments for radiological contaminants as appropriate at each site;
- A summary of trends based on changes in contaminant concentrations to support remedial actions, public safety, and maintain surveillance monitoring requirements at each site;
- An evaluation of the adequacy of the monitoring network; and
- The identification of data gaps and future EMP needs.

1.3 SLS PROGRAM AND SITE BACKGROUND

The FUSRAP program was initiated in 1974 by the AEC, the predecessor to the U.S. Department of Energy (DOE). FUSRAP was transferred to the USACE on October 13, 1997. The USACE is responsible for the characterization and remediation of contamination associated with the historical AEC facilities that supported the nation's early nuclear defense-related activities. On October 4, 1989, SLAPS, HISS, and Futura Coatings were placed on the National Priorities List (NPL) (EPA, 1989a).

Figure 1-1 identifies the locations of SLDS, SLAPS, and HISS. The three primary sites were involved in the refining of uranium ores, production of uranium metal and compounds, uranium recovery from residues and scrap, and the storage and disposal of associated process by-products. The processing activities were conducted in parts of SLDS under contract to the MED and AEC between the early 1940s and the mid 1950s.

Detailed descriptions and histories for each site can be found in *Remedial Investigation for the St. Louis Site, St. Louis, Missouri* (DOE, 1994); *Remedial Investigation Addendum for the St. Louis Site, St. Louis, Missouri* (DOE, 1995); *Engineering Evaluation/Cost Analysis for SLAPS* (DOE, 1997 and USACE, 1998b); *Engineering Evaluation/Cost Analysis (EE/CA) for Hazelwood Interim Storage Site* (USACE, 1998c); *Record of Decision for the St. Louis Downtown Site, St. Louis, Missouri* (USACE, 1998d); and the *Environmental Monitoring Guide for the St. Louis Sites* (USACE, 1999a).

1.3.1 Latty Avenue Properties CY01 Remedial Activities

During the first quarter of CY01 at HISS, approximately 5,000 cubic yards (yd³) of contaminated soils were removed from the Supplemental Storage Pile, the north half of the main pile and the utility removal response action at Futura was completed resulting in the removal of 270 yd³ of contaminated soils (Figure 1-2). During the second quarter of CY01, the Phase I excavation of the South half of the main pile was completed and more than 15,800 yd³ of contaminated soils were excavated from this area and shipped via railcar to the Envirocare disposal facility in Utah.

During the fourth quarter of CY01, Phase I of the Stone Container facility roof removal was completed and approximately 560 yd³ of contaminated roofing material was removed and disposed.

1.3.2 SLAPS CY01 Remedial Activities

During CY01, the radium pits at SLAPS were confirmed clean and backfilled (Figure 1-3). The removal action work in the East End Right-of-Way area of SLAPS was completed in the fourth quarter of CY01. All activities resulted in the removal of 138,303 yd³ of contaminated soil. Contaminated soils from SLAPS were shipped for disposal via railcars to disposal facilities in Idaho and Utah. A total of 70,684 yd³ of contaminated soils were shipped to Envirocare/USEcology in Idaho, 67,619 yd³ were shipped to Envirocare in Utah. In addition, removal action within the Phase I excavation area was started in CY01 and 4070 yd³ were removed.

Through the use of an on-site treatment skid, approximately 140,000 gallons of uranium-contaminated water were treated to drinking water quality standards and released from SLAPS during CY01.

1.3.3 SLDS CY01 Remedial Activities

During CY01, 1,747,170 gallons of water were treated to drinking water quality standards in accordance with the Metropolitan Sewer District (MSD) site permit. The total amount of water treated since installation of the on-site treatment system is 4,734,409 gallons. Remedial activities conducted at SLDS during CY01 also included the excavation, transportation, and disposal of 12,930 yd³ of contaminated soil from Plant 6E and 6EH, 1,079 yd³ of contaminated soil from Plant 1, and 785 yd³ of contaminated soil from DT-7 (Figure 1-4). Contaminated soil was transported by railcars to Envirocare in Idaho and Envirocare in Utah for disposal at a licensed facility.

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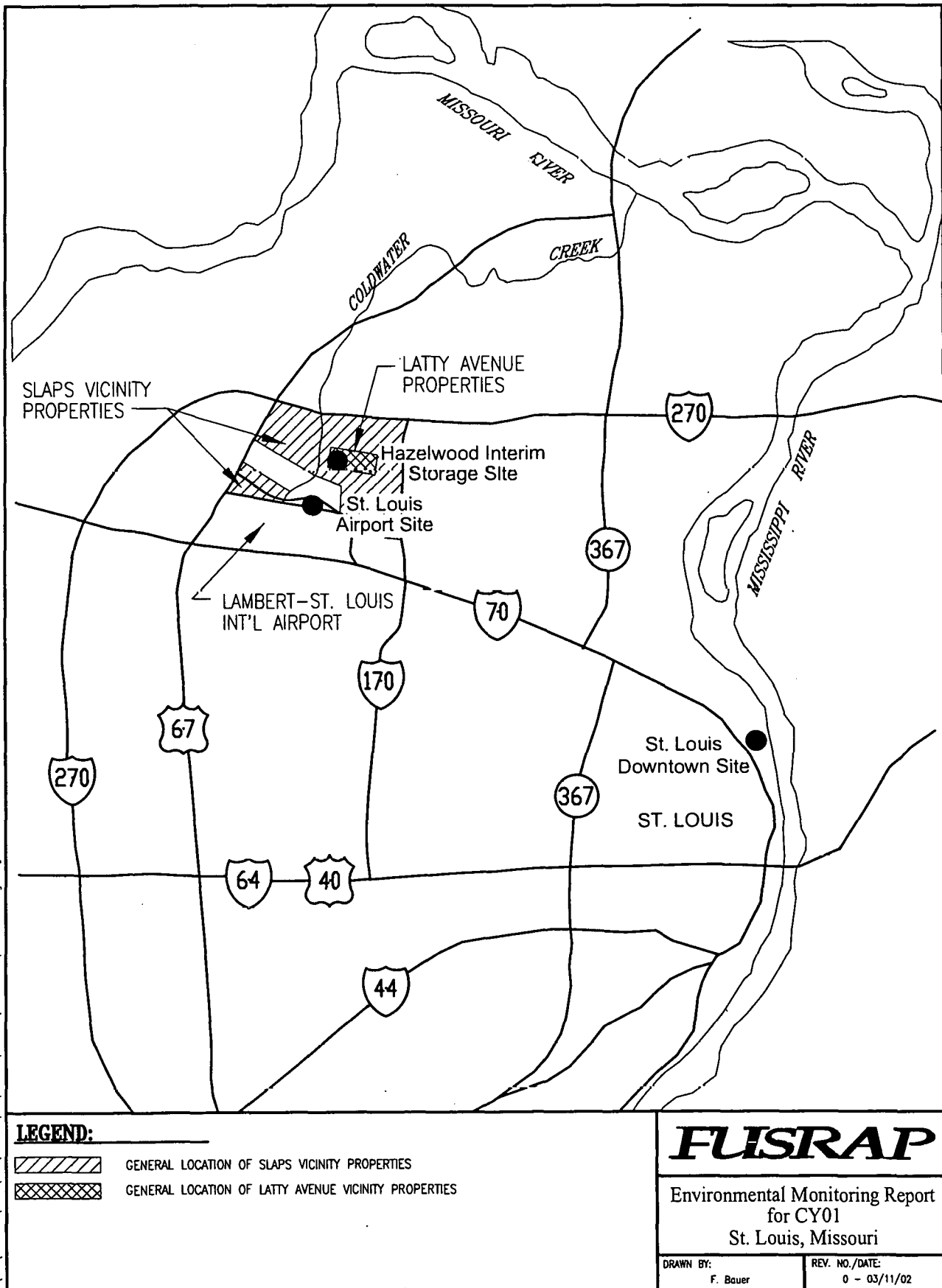


Figure 1-1. Location Map of the St. Louis Sites

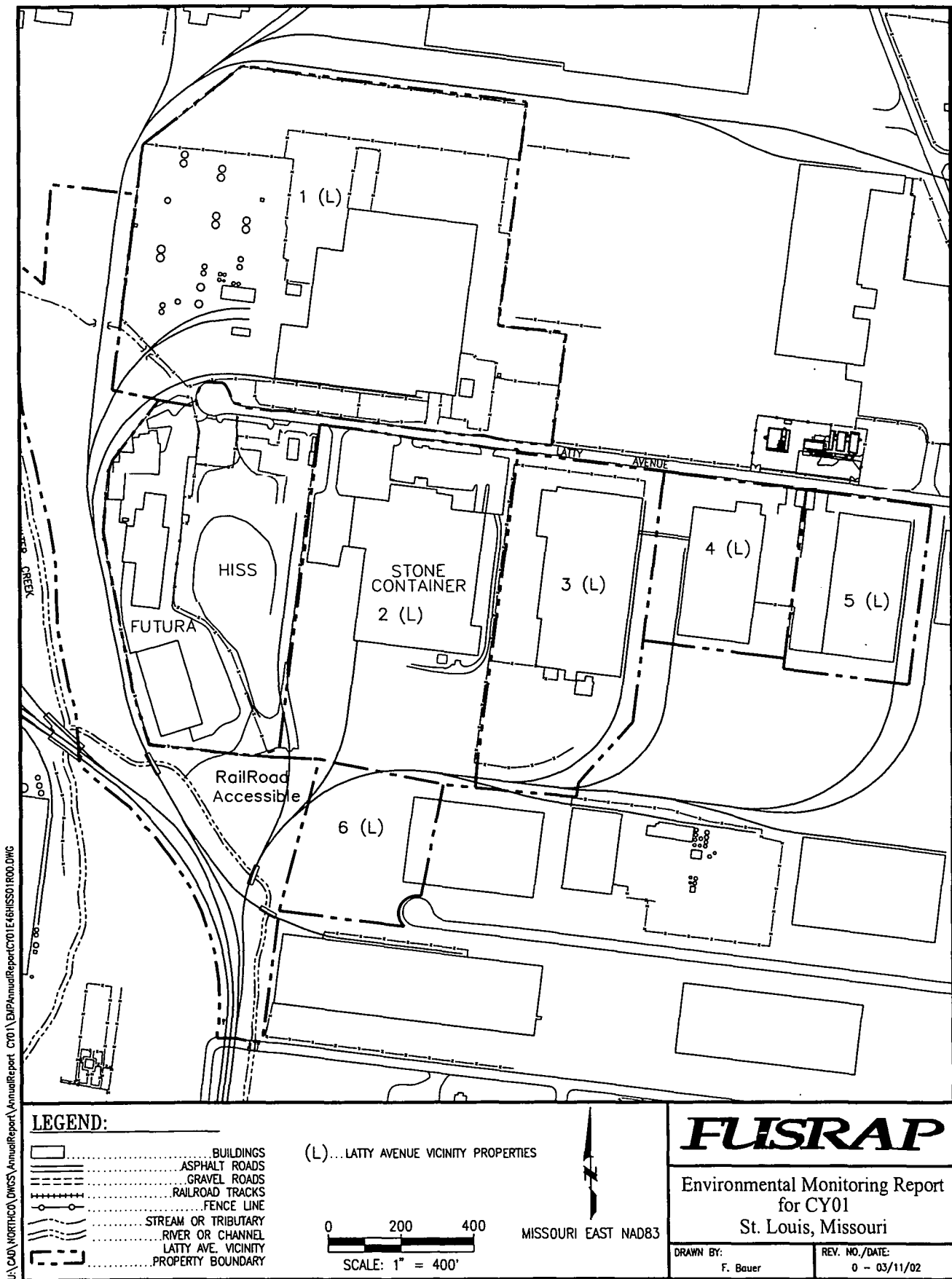


Figure 1-2. Plan View of HISS and Latty Avenue Vicinity Properties

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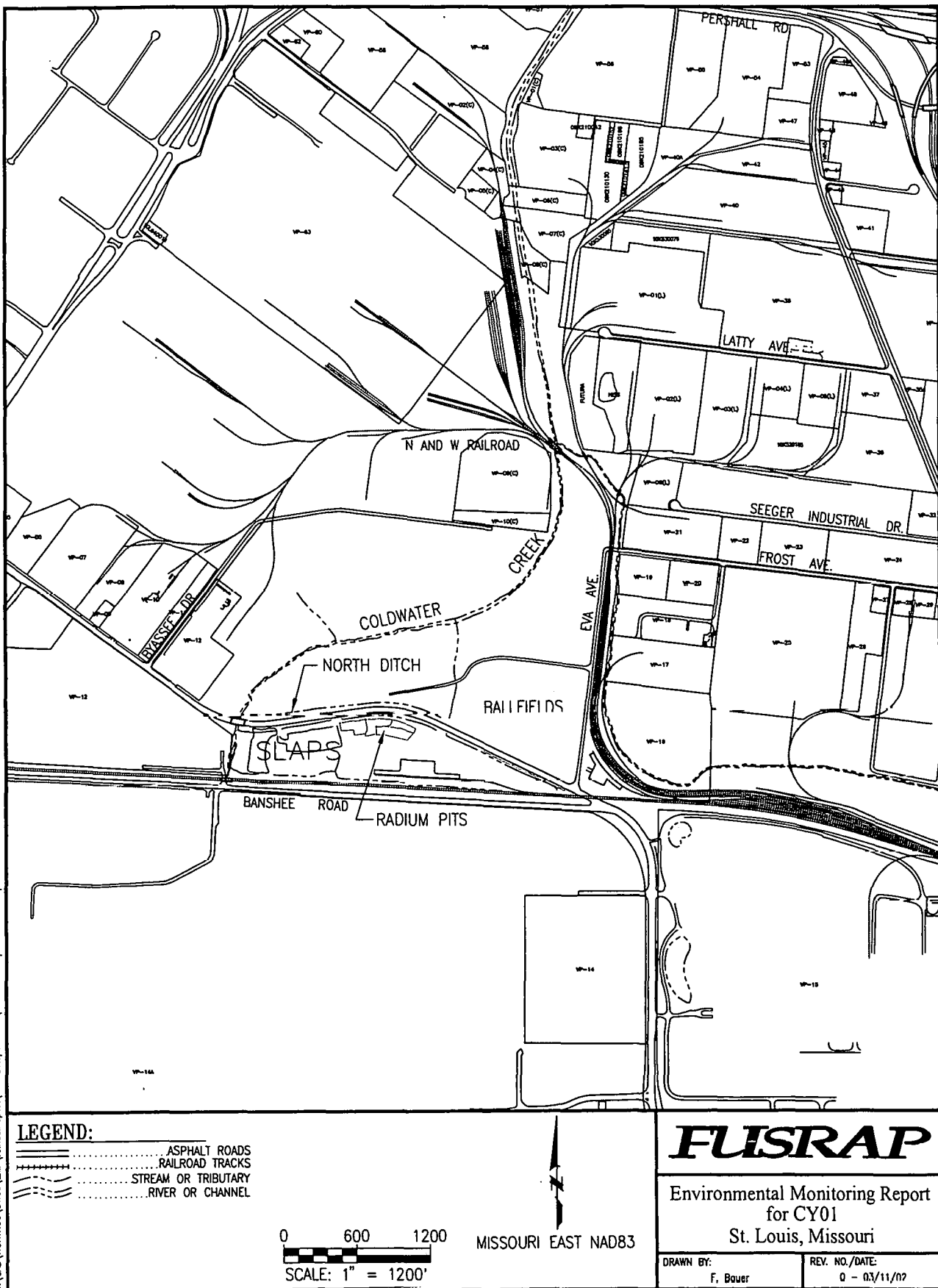
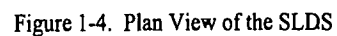


Figure 1-3. Plan View of SLAPS



2.0 SITE PERIMETER RADIOLOGICAL MONITORING

Site perimeter radiological monitoring is separated into two distinct functions: effluent monitoring and environmental surveillance. Effluent monitoring assesses the quantities of radiological contamination in environmental media at the SLS boundaries in contaminant migration pathways, and in pathways subject to regulatory compliance [e.g., National Emission Standards for Hazardous Air Pollutants (NESHAPs)]. Environmental surveillance consists of analyzing environmental conditions within or outside the site boundaries for the presence and concentrations of contaminants. Surveillance data are used to assess the presence and magnitude of radiological exposures and to assess the potential effects to the general public and the environment. The following sections discuss the types of radiological measurements taken at each site boundary, and the results of the data collected during CY01 for various environmental media.

2.1 RADIOLOGICAL MEASUREMENTS

The radiological measurements taken at the SLS facility boundaries are conducted as part of the EMP. Sections 2.1.1 through 2.1.3 describe the types of radiological measurements conducted at SLS, potential sources of the contaminants to be measured (including natural background), and measurement techniques employed during CY01.

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, thorium, and potassium-40 (K-40). Cosmic radiation originates in outer space and filters through the atmosphere to the earth. Together, these two sources comprise the majority of natural gamma background radiation. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) estimates the typical gamma radiation dose is 35 mrem/yr from the earth and 30 mrem/yr from cosmic sources (UNSCEAR, 1982). The total estimated naturally occurring background radiation dose equivalent due to gamma exposure is thus 65 mrem/yr. At the SLS, above background concentrations of radionuclides in the uranium and thorium decay series may be a source of gamma radiation exposure at or outside site boundaries.

Gamma radiation was measured at the SLS (in CY01) using TLDs. TLDs were located at site boundaries at SLAPS and HISS. At SLDS the TLDs were located at areas assumed to be representative of areas accessible to the public. 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 an off-site vendor for analysis.

2.1.2 Airborne Radioactive Particulates

2.1.2.1 Air Sampling

Airborne radioactive particulates result from radioactive material in soil (or other sources) that become suspended in the air. The radioactive material normally becomes airborne as a result of wind erosion of the soil surface or as a result of the soil becoming disturbed (e.g., remediation). This naturally occurring radioactive material, as well as the above background concentrations of radioactive materials present at the SLS, may contribute to emissions of airborne radioactive particulates.

Airborne radioactive particulates are measured at SLS 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, is reported as a radioactive contaminant concentration (i.e., $\mu\text{Ci/mL}$). Particulate air monitors are located at site perimeter locations in predominant wind directions and/or in areas accessible to members of the public. Air particulate samples are collected weekly and analyzed at the on-site radioanalytical laboratory at the HISS.

2.1.2.2 Estimation of Emissions in Accordance with NESHAP

The FUSRAP Sites CY01 NESHAPs Report (provided as Attachment 1) presents results from calculations of the effective dose equivalent from radionuclide emissions to critical receptors in accordance with the NESHAPs. The report follows the requirements and procedures contained in 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*.

Air sampling data, soil characterization data, and other site specific information are used at the SLS as inputs to the CAP88-PC modeling code to demonstrate compliance with the emission standard in 40 CFR 61, Subpart I. The results of calculations performed for SLS are reported in Sections 2.2 through 2.4, as appropriate.

2.1.3 Airborne Radon

Uranium-238 (U-238) is a naturally occurring radionuclide in soil and rock. Radon gas (Rn-222) is a naturally occurring radioactive gas found in the uranium decay series. A fraction of the radon produced from the radioactive decay of naturally occurring U-238 diffuses from soil and rock into the atmosphere, accounting for natural background airborne radon concentrations. Radon is produced at the SLS from this natural source as well as from the contaminated waste materials present at the sites.

Airborne radon concentration is governed by emission rate and dilution factors, both of which are strongly affected by meteorological conditions. The soil surface radiological constituents are 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 (EPA, 1987).

Radon alpha track detectors (ATDs) are used at the SLS to measure alpha particles emitted from radon (primarily Rn-222) and its associated decay products. Radon ATDs are generally co-located with environmental TLDs 3 ft above the ground surface in housing shelters at the site boundaries.

2.2 HISS

2.2.1 Evaluation of Gamma Radiation Data

Gamma radiation monitoring was performed at HISS during CY01 at six locations around the perimeter of the site (see Figure 2-1). In addition to these locations, two background locations in the North County area were utilized to compare on-site exposure and off-site background exposure. In January CY01, one environmental TLD was placed at each monitoring location and replaced quarterly to provide input for annual exposure. The environmental monitoring program utilizes two TLDs at monitoring Station HA-6 (for each monitoring period) to provide additional quality control of monitoring data. In October CY01, Station HA-3 was moved from the southwest perimeter to the south perimeter of the site, Station HA-4 was eliminated due to redundancy of sampling efforts, and Stations HA-5 and HA-6 were renamed Stations HA-4 and HA-5, respectively, in accordance with the EMIFY02 (USACE, 2001b).

TLD monitoring data for CY01 is found in Table 2-1. All quarterly monitoring data reported from the vendor was normalized to exactly one quarter's exposure. Net monitoring results (average normalized location reading minus average normalized background reading) were also corrected for shelter absorption for each monitoring location.

Table 2-1. External Gamma Radiation at HISS

Monitoring Location	Monitoring Station	First Quarter TLD Data ^a (mrem/qtr) Reported/Corrected	Second Quarter TLD Data ^a (mrem/qtr) Reported/Corrected	Third Quarter TLD Data ^a (mrem/qtr) Reported/Corrected	Fourth Quarter TLD Data ^a (mrem/qtr) Reported/Corrected	CY01 Net TLD Data ^b (mrem/yr)
HISS Perimeter	HA-1	50/22	42/29	54/31	46/28	110
	HA-2	41/13	29/14	46/23	35/16	66
	HA-3	45/18	37/23	52/29	25/6	76
	HA-4 ^d	53/26	46/32	58/35	NA ^d /---	94 ^d
	HA-5 ^e	30/1	19/2	28/4	21/2	9
	HA-6 ^e	28/0	16/0	26/2	19/0	2
Duplicate ^c	HA-6 ^e	26/---	16/---	16/---	16/---	---
Background	(Boeing)	30/---	16/---	27/---	20/---	---
Background	(Holtwick)	29/---	16/---	25/---	20/---	---

^a All quarterly data reported from the vendor has been normalized to exactly one quarter's exposure above background.

^b CY01 Net TLD data are corrected for background, shelter absorption (s/a = 1.075), and fade.

^c Duplicate sample results were not included in calculations.

^d Monitoring Station HA-4 was eliminated for fourth quarter CY01 in accordance with the EMIFY02 (USACE, 2001b). CY01 net result normalized to one year.

Monitoring Stations HA-5 and HA-6 were renamed in accordance with the EMIFY02 (USACE, 2001b). However, fourth quarter data is reported for the locations corresponding with the first three quarters.

Result calculation not required.

Gamma radiation exposure measured at the perimeter fenceline assumes that a hypothetical public individual would be at the same locations 24 hours/day, 365 days/year. Off-site dose to the nearest member of the public is significantly affected based on their 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% occupancy rate at a given location. There are no public areas or residences near 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%, based on an 8 hour/day, 5 day/week, 50 week/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, approximately 50 m east of the HISS perimeter, and the time the individual will spend at this location. A realistic assessment of dose can be performed using conservative assumptions of occupancy rate and distance from the source. Based on this methodology, the annual dose from external gamma radiation to the hypothetical maximally exposed individual (the nearest off-site worker, 50 m east of the site) has been calculated at approximately 0.2 mrem/yr (SAIC, 2002a). Additional details of the calculation methodology and data used to determine dose to the receptor are located in Appendix A and E to this report.

2.2.2 Evaluation of Airborne Radioactive Particulate Data

2.2.2.1 Air Sampling

Air sampling for particulate radionuclides was conducted at the HISS perimeter locations beginning in January CY01. Air particulate monitoring data is presented in Table 2-2 below. The monitoring locations are shown on Figure 2-1. Perimeter stations are located in accordance with the EMIFY01 (USACE, 2001a).

Table 2-2. Summary of HISS Air Particulate Data

Monitoring Location	Average Concentration ($\mu\text{Ci/mL}$)	
	Gross Alpha	Gross Beta
HAP-001	1.91E-15	2.56E-14
HAP-002	2.01E-15	3.06E-14
HAP-003	1.91E-15	3.00E-14
HAP-004	2.05E-15	2.96E-14
Average Concentration	1.97E-15	2.90E-14

2.2.2.2 Estimation of Emissions in Accordance with the NESHAP

The St. Louis FUSRAP Sites CY01 NESHAPs Report presents results from calculations of the effective dose equivalent from radionuclide emissions excluding radon to critical receptors in accordance with the NESHAPs. The report follows the requirements and procedures contained in 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*.

The annual dose from radiological particulates to the hypothetical maximally exposed individual (50 m east of the site) has been calculated at approximately 7.8 mrem/yr (SAIC, 2002a and 2002f). Additional details of the calculation methodology and data used to determine dose to the receptor are located in Appendix A and E to this report.

2.2.3 Evaluation of Airborne Radon Data

2.2.3.1 Radon-222 Monitoring

Airborne radon monitoring was performed at the HISS using ATDs placed around the site perimeter to measure radon emissions from the site. Six detectors were co-located with TLD locations as identified in Figure 2-1 and one duplicate detector was placed at Station HA-6 for quality control purposes. Two background detectors located in the North County area were utilized to compare on-site exposure and off-site background exposure. The ATDs were installed in January CY01 at each monitoring location, collected for analysis after approximately six (6) months of exposure, and replaced with another set that would represent radon exposure for the rest of the year. Recorded radon concentrations are listed in picocuries per liter (pCi/L), and are evaluated based on the regulatory criterion listed in 10 CFR 20, Appendix B, of 0.3 pCi/L (at 30% equilibrium) average annual concentration above background at the site perimeter.

The average annual radon concentrations at the HISS perimeter are below the 10 CFR 20 Appendix B regulatory criterion of 0.3 pCi/L (see Table 2-3).

Radon exposure to the receptor outlined in Section 2.2.1 (off-site worker 50 m east of the site perimeter) has been calculated at approximately 0.2 mrem/yr (SAIC, 2002a). Additional details of the calculation methodology and data used to determine dose to the receptor are located in Appendix A and E to this report.

Table 2-3. Radon Gas (Rn-222) Concentrations at HISS

Monitoring Location	Monitoring Station	Average Annual Concentration (pCi/L)		
		01/16/01 to 07/03/01 ^a	07/03/01 to 01/08/02 ^a	Average Annual Concentration ^b
HISS Perimeter	HA-1	0.5	0.3	0.2
	HA-2	0.4	0.2	0.1
	HA-3	0.3	0.2	0.0
	HA-4	0.4	0.2	0.1
	HA-5	0.4	0.2	0.1
	HA-6	0.2	0.2	0.0
Duplicate ^c	HA-6	0.5	0.2	---
Background	(Boeing)	0.4	0.2	---
Background	(Holtwick)	0.3	0.2	---

^a Detectors were installed and removed on the dates listed. Data is as reported from the vendor.

^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 quality control 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.

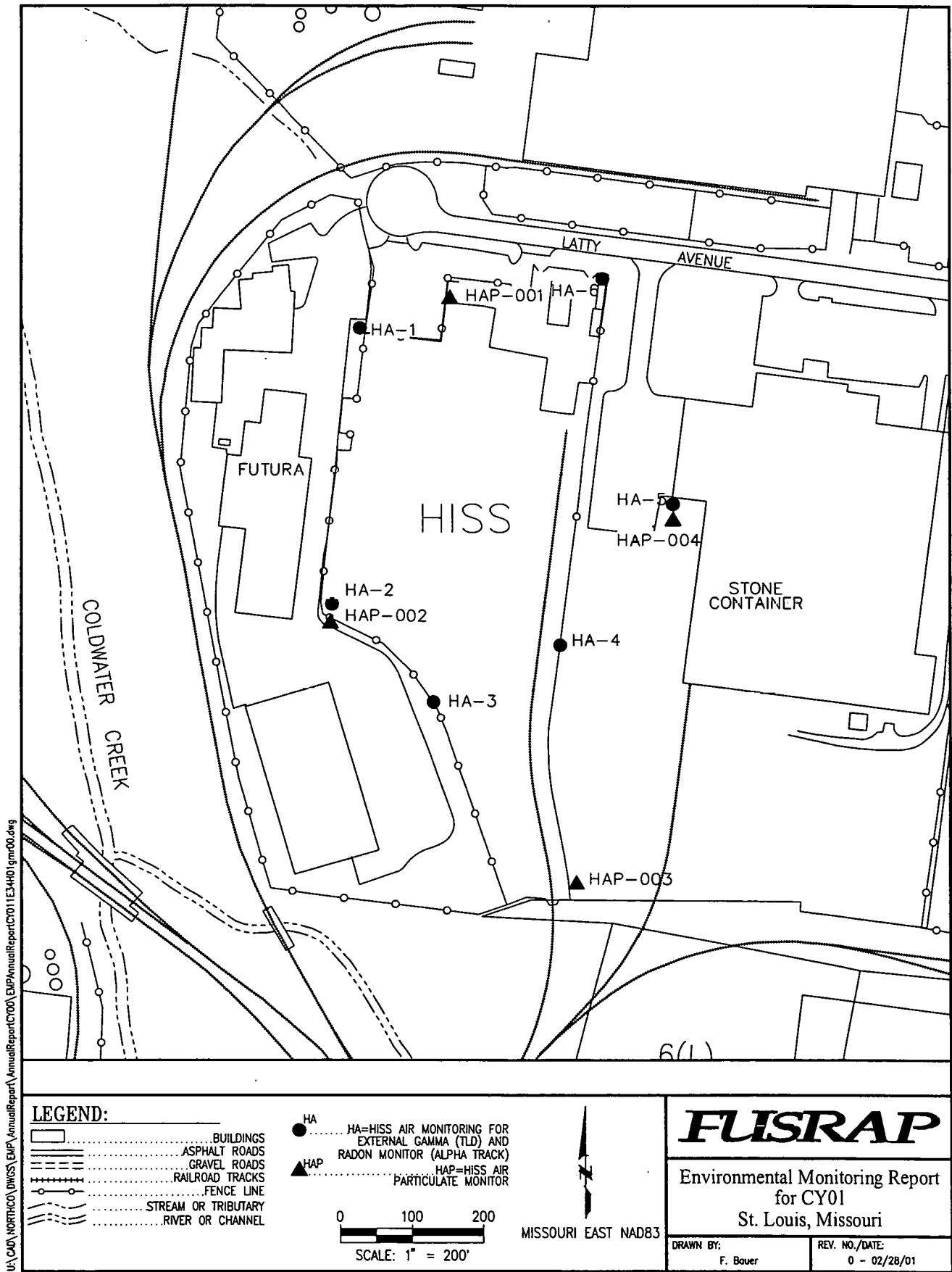


Figure 2-1. Gamma Radiation, Radon-222, and Particulate Air Monitoring Locations at the HISS

2.3 SLAPS

2.3.1 Evaluation of Gamma Radiation Data

Gamma radiation monitoring was performed at SLAPS during CY01 at six locations around the perimeter of the site (Figure 2-2). In addition to these locations two background monitoring stations located in the North County area were utilized to compare on-site exposure and off-site background exposure.

In January CY01, one environmental TLD was placed at each monitoring location and replaced quarterly to provide input for annual exposure. The environmental monitoring program utilizes two TLDs at monitoring Station PA-4 (for each monitoring period) to provide additional quality control of monitoring data.

TLD monitoring results for CY01 are found in Table 2-4. All quarterly monitoring data reported from the vendor was normalized to exactly one quarter's exposure. Net monitoring results (average normalized location reading minus average normalized background reading) were also corrected for shelter absorption for each monitoring location.

As at HISS, 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 160 m south of the SLAPS perimeter, and the time the individual will spend at this location. Thus, a realistic assessment of dose can be performed using conservative assumptions of occupancy rate and distance from the source. Based on this methodology, the annual dose from external gamma radiation to the hypothetical maximally exposed individual (the nearest off-site worker, 160 m south of the site) has been calculated at approximately 0.1 mrem/yr (SAIC, 2002b). Additional details of the calculation methodology and data used to determine dose to the receptor are located in Appendix A and E to this report.

Table 2-4. External Gamma Radiation at SLAPS

Monitoring Location	Monitoring Station	First Quarter TLD Data ^a (mrem/qtr) Reported/Corrected	Second Quarter TLD Data ^a (mrem/qtr) Reported/Corrected	Third Quarter TLD Data ^a (mrem/qtr) Reported/Corrected	Fourth Quarter TLD Data ^a (mrem/qtr) Reported/Corrected	CY01 TLD Data ^b (mrem/yr)
SLAPS Perimeter	PA-1	60/34	51/38	68/46	62/44	162
	PA-2	30/1	21/5	31/6	22/2	14
	PA-3	42/14	31/16	42/18	30/11	60
	PA-4	41/13	28/13	41/18	33/14	58
Duplicate ^c	PA-4	40/---	31/---	40/---	31/---	---
	PA-5	33/4	21/5	26/1	22/3	13
	PA-6	54/27	38/24	52/29	44/26	105
Background	(Boeing)	30/---	16/---	27/---	20/---	---
Background	(Holtwick)	29/---	16/---	25/---	20/---	---

^a All quarterly data reported from the vendor has been normalized to exactly one quarter's exposure above background.

^b CY01 Net TLD data are corrected for background, shelter absorption ($s/a = 1.075$), and fade.

^c Duplicate sample results were not included in calculations.

--- Result calculations not required.

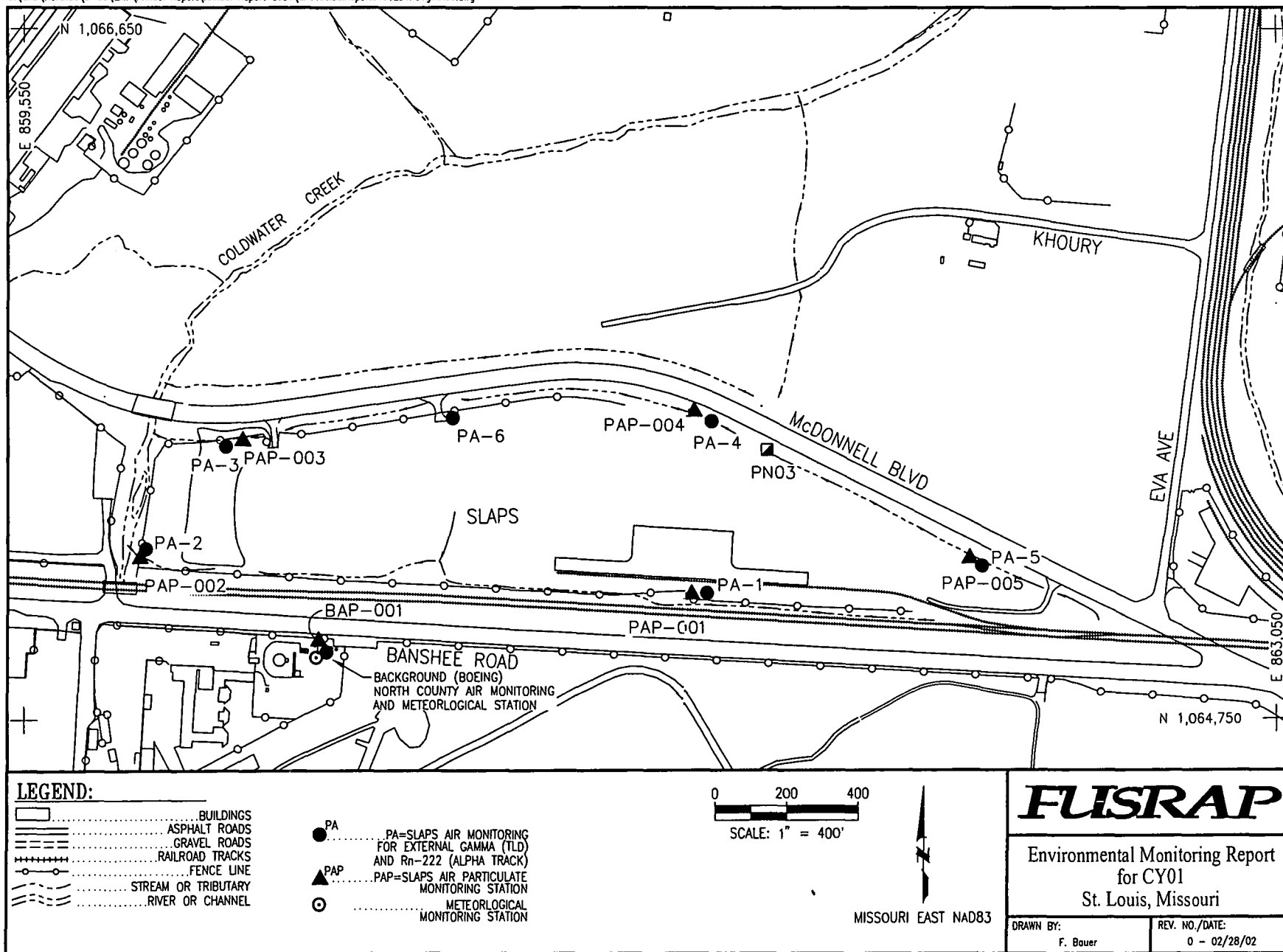


Figure 2-2. Gamma Radiation, Radon-222, and Particulate Air Monitoring Locations at the SLAPS

2.3.2 Evaluation of Airborne Radionuclide Data

2.3.2.1 Air Sampling

Air sampling for radiological particulates was conducted at the SLAPS perimeter locations for the entire CY01. Air particulate monitoring data is presented in Table 2-5. The monitoring locations are shown on Figure 2-2.

Table 2-5. Summary of SLAPS Air Particulate Data

Monitoring Location	Average Concentration ($\mu\text{Ci/mL}$)	
	Alpha	Beta
PAP-001	4.78E-15	5.70E-14
PAP-002	5.57E-15	5.70E-14
PAP-003	5.52E-15	7.39E-14
PAP-004	7.70E-15	6.34E-14
PAP-005	4.27E-15	6.16E-14
Average Concentration	5.57E-15	6.26E-14

2.3.2.2 Estimation of Emissions in Accordance with the NESHAP

The St. Louis FUSRAP Sites CY01 NESHAPs Report presents results from calculations of the effective dose equivalent from radionuclide emissions to critical receptors in accordance with the NESHAPs. The report follows the requirements and procedures contained in 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*.

The annual dose from radiological air particulates to the hypothetical maximally exposed individual (160 m south of the site perimeter) has been calculated at approximately 9.4 mrem/yr (SAIC, 2002b and 2002f). Additional details of the calculation methodology and data used to determine dose to the receptor are located in Appendix A and E to this report.

2.3.3 Evaluation of Airborne Radon Data

Airborne radon monitoring was performed at SLAPS using ATDs placed around the site perimeter to measure radon emissions from the site. Six detectors were co-located with TLD locations as identified in Figure 2-2. One additional detector was located at monitoring Station PA-4 as a quality control duplicate. Two background detectors were located in the North County area to compare on-site exposure and off-site background exposure. The ATDs were placed at all monitoring locations in January CY01. The detectors were collected for analysis after approximately six (6) months of exposure, and replaced with another set that would represent radon exposure for the rest of the year. Recorded radon concentrations are listed in picocuries per liter (pCi/L), and are evaluated based on the regulatory criterion listed in 10 CFR 20, Appendix B, of 0.3 pCi/L (at 30% equilibrium) average annual concentration above background.

Although significant remediation activities occurred at SLAPS during CY01, Rn-222 monitoring results at SLAPS (see Table 2-6) show minimal impact from these activities and are consistent with measured concentrations found in previous environmental monitoring data taken at the site.

Radon exposure to the receptor outlined in Section 2.3.1 (off-site worker 160 m south of the site perimeter) has been calculated at approximately 0.2 mrem/yr (SAIC, 2002b). Additional details of the calculation methodology and data used to determine dose to the receptor are located in Appendix A and E to this report.

Table 2-6. Radon Gas (Rn-222) Concentrations at SLAPS

Monitoring Location	Monitoring Station ID#	Average Annual Concentration (pCi/L)		
		01/16/00 to 07/03/00 ^a (uncorrected)	07/03/00 to 01/08/02 ^a (uncorrected)	Average Annual Concentration ^b
SLAPS perimeter	PA-1	0.6	0.3	0.2
	PA-2	0.4	0.3	0.1
	PA-3	0.3	0.2	0.0
	PA-4	0.4	0.2	0.1
Duplicate ^c	PA-4	0.5	0.2	---
	PA-5	0.3	0.2	0.0
	PA 6	0.6	0.3	0.2
Background	(Boeing)	0.4	0.2	---
Background	(Holtwick)	0.3	0.2	---

^a Detectors were installed and removed on the dates listed. Data is as reported from the vendor.

^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 quality control duplicate is collected at the same time and location and is analyzed by the same method for evaluating precision in sampling and analysis.

2.4 SLDS

2.4.1 Evaluation of Gamma Radiation Data

Gamma radiation monitoring was performed at the SLDS during CY01 at five locations around the perimeter of the Mallinckrodt plant areas (see Figure 2-3). In addition to these locations, two background monitoring stations located in the North County area were utilized to compare on-site exposure and off-site background exposure.

In January CY01, one environmental TLD was placed at each monitoring location and replaced quarterly to provide input for annual exposure. The environmental monitoring program utilizes two TLDs at monitoring Station DA-1 (for each monitoring period) to provide additional quality control of monitoring data. In October CY01, Station 5 was eliminated in accordance with the EMIFY02 (USACE, 2001b).

2-11

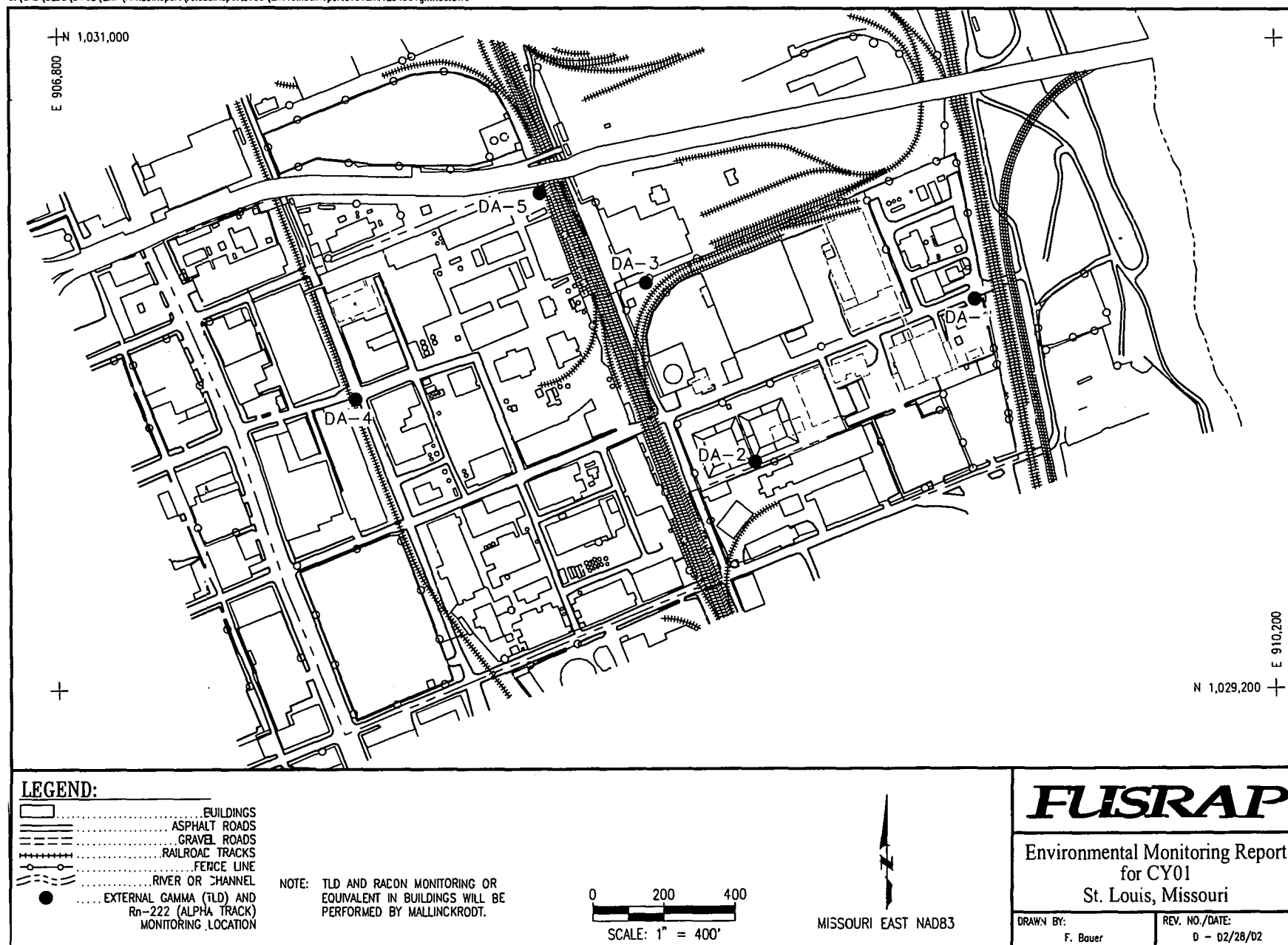


Figure 2-3. Gamma Radiation, Radon-222 Locations at the SLDS

TLD monitoring results for CY01 are presented in Table 2-7. All quarterly monitoring data reported from the vendor has been normalized to exactly one quarter's exposure. Net monitoring results (average normalized location reading minus average normalized background reading) were also corrected for shelter absorption at each monitoring location.

Table 2-7. External Gamma Radiation at SLDS

Monitoring Location	Monitoring Station	First Quarter TLD Data ^a (mrem/qtr) Reported/ Corrected	Second Quarter TLD Data ^a (mrem/qtr) Reported/ Corrected	Third Quarter TLD Data ^a (mrem/qtr) Reported/ Corrected	Fourth Quarter TLD Data ^a (mrem/qtr) Reported/ Corrected	CY01 TLD Data ^b (mrem/yr)
SLDS Perimeter	DA-1	32/3	20/4	29/5	23/3	15
Duplicate ^c	DA-1	32/---	18/---	27/---	20/---	---
	DA-2	30/1	19/3	28/3	22/2	9
	DA-3	38/9	27/12	33/9	29/9	30
	DA-4	32/3	22/6	30/6	23/3	18
	DA-5 ^d	27/0	17/1	27/2	NA ^d /---	4
Background	(Boeing)	30/---	16/---	27/---	20/---	---
Background	(Holtwick)	29/---	16/---	25/---	20/---	---

^a All quarterly data reported from the vendor has been normalized to exactly one quarter's exposure above background.

^b CY01 Net TLD data are corrected for background, shelter absorption ($s/a = 1.075$), and fade.

^c Duplicate sample results were not included in calculations.

^d Monitoring Station DA-5 was eliminated for fourth quarter 2001 in accordance with the EMIFY02 (USACE, 2001b).

--- Result calculation not required.

As at HISS and SLAPS, 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, approximately 50 m from the Mallinckrodt fenceline (Thomas and Proetz Lumber Company VP), and the time the individual will spend at this location. Thus, a realistic assessment of dose can be performed using conservative assumptions of occupancy rate and distance from the source. Based on this methodology, the annual dose from external gamma radiation to the hypothetical maximally exposed individual (the nearest off-site worker, 50 m southeast of the Mallinckrodt fenceline(Thomas and Proetz Lumber Company VP)) has been calculated at 0.1 mrem/yr (SAIC, 2002c). Additional details of the calculation methodology and data used to determine dose to the receptor are located in Appendix A and E to this report.

2.4.2 Evaluation of Airborne Radionuclide Data

2.4.2.1 Air Sampling

Air sampling for radiological particulates was not conducted at SLDS perimeter locations during CY01 due to the insignificant potential for material to become airborne at the site. The ground surface at SLDS is generally covered with asphalt or concrete, which limits the potential for material to become airborne. Air sampling for radiological particulates during CY01 was conducted by the Remedial Action (RA) contractor at the perimeter of each excavation within the SLDS. Air particulate monitoring data from excavation perimeters is presented in Table 2-8.

Table 2-8. Summary of SLDS Air Particulate Data

Monitoring Location	Average Concentration ($\mu\text{Ci/mL}$)	
	Alpha	Beta
Plant 1	6.21E-15	6.39E-14
Plant 6	4.17E-15	6.00E-14
Midwest Waste	5.03E-15	3.82E-14
Average Concentration (excavations)^a	5.18E-15	6.01E-14

^a Average of all excavation perimeter monitoring at Plant 1, Plant 6, and Midwest Waste during CY01.

2.4.2.2 Estimation of Emissions in Accordance with NESHAP

The St. Louis FUSRAP Sites CY01 NESHAPs Report presents results from calculations of the effective dose equivalent from radionuclide emissions to critical receptors in accordance with the NESHAPs. The report follows the requirements and procedures contained in 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*.

The annual dose from radiological air particulates to the hypothetical maximally exposed individual has been calculated at less than 0.7 mrem/yr (SAIC, 2002c and 2002f). Additional details of the calculation methodology and data used to determine dose to the receptor are located in Appendix A and E to this report.

2.4.3 Evaluation of Airborne Radon Data

Airborne radon monitoring was performed at SLDS using ATDs placed around the perimeter of the Mallinckrodt plant areas to measure radon emissions. Five detectors were co-located with TLD locations as identified previously in Figure 2-3. One additional detector was located at monitoring Station DA-1 as a quality control duplicate. Two background detectors were located in the North County area to compare on-site exposure and off-site background exposure. The ATDs were placed at each monitoring location in January CY01 and were collected for analysis after approximately 6 months of exposure, and replaced with another set that would represent radon exposure for the rest of the year. Recorded radon concentrations are listed in picocuries per liter (pCi/L), and are evaluated based on the regulatory criterion listed in 10 CFR 20, Appendix B of 0.3 pCi/L (at 30% equilibrium) average annual concentration above background at the site perimeter.

Although significant remediation activities occurred at SLDS during CY01, radon monitoring results at SLDS (Table 2-9) show minimal impact from these activities and are consistent with measured concentrations found in previous environmental monitoring data collected at the site.

Radon exposure to the receptor outlined in Section 2.4.1 (off-site worker 50 m southeast of the site perimeter) has been calculated at approximately 0.2 mrem/yr (SAIC, 2002c). Additional details of the calculation methodology and data used to determine dose to the receptor are located in Appendix A and E to this report.

Table 2-9. Radon Gas Concentrations at SLDS during CY01

Monitoring Location	Monitoring Station ID#	Average Annual Concentration (pCi/L)		
		01/16/00 to 07/03/00 ^a	07/03/00 to 01/08/02 ^a	Average ^b
SLDS perimeter	DA-1	0.4	0.2	0.1
Duplicate ^c	DA-1	0.5	0.2	---
	DA-2	0.4	0.2	0.1
	DA-3	0.3	0.2	0.0
	DA-4	0.2	0.2	0.0
	DA-5	0.3	0.2	0.0
Background	(Boeing)	0.4	0.2	---
Background	(Holtwick)	0.3	0.2	---

^a Detectors were installed and removed on the dates listed. Data is as reported from the vendor.

^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 quality control 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.

3.0 CY01 WASTEWATER, STORM-WATER, SURFACE-WATER, AND SEDIMENT SAMPLING

This section will provide a description of the storm-water monitoring activities at the SLS, the Coldwater Creek sediment monitoring activities, and the Coldwater Creek surface-water monitoring activities for CY01. The results obtained from these monitoring activities are presented and evaluated with respect to historical data and the appropriate investigative limits.

3.1 WASTE-WATER AND STORM-WATER DISCHARGE MONITORING RESULTS DURING CY01

This section provides a description of the waste-water and storm-water monitoring activities conducted at the SLS during CY01. The monitoring results obtained from these activities are presented and compared with the various permit or permit equivalent limits presented in the EMIFY02 (USACE, 2001b). The purpose of storm-water and waste-water discharge sampling at SLS, is to maintain compliance with the discharge requirements. These requirements are set by the Missouri Department of Natural Resources (MDNR) –NPDES permit number MO-0111252 for the HISS, the MSD discharge authorization letter dated, November 3, 2000 for the HISS Radiological Laboratory, the MDNR-NPDES ARARs (permit equivalent) document dated October 2, 1998, for the SLAPS, and MSD discharge authorization letters, dated October 30, 1998 and modified in July 23, 2001 for SLDS. The storm-water sampling results for HISS and SLAPS demonstrate compliance with 10 CFR 20.1302, 10 CSR 20-7.031, and with permitted requirements and conditions. Wastewater sampling results for the SLDS demonstrate compliance with 10 CFR 20.2003 and requirements listed in the MSD discharge authorization letter for SLDS.

3.1.1 Evaluation of the CY01 Storm-water Discharge Monitoring Results at HISS

In CY01, storm-water discharge was monitored from three outfalls at HISS in accordance with NPDES Permit MO-0111252. For environmental monitoring purposes, these outfalls have been assigned the station identifications HN01 for Outfall 001; HN02 for Outfall 002; and HN03 for Outfall 003, as depicted in Figure 3-1. The permit requires monthly monitoring at the outfalls for total settleable solids. It establishes the daily maximum limit for settleable solids at 1.5 mL/L/hr and a cumulative daily average limit per month of 1.0 mL/L/hr for settleable solids. In addition, it establishes a quarterly composite sampling for pH, specific conductance, settleable solids, total organic compound (TOC), total organic halogen (TOX), gross alpha, gross beta, lead-210 (Pb-210), Ra-226, Ra-228, total uranium, Th-230, and Th-232. A special condition of the permit requires if/when a positive value for TOX is recorded the specific compound shall be identified. As a result, volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) are tested to identify the specific compound. TOX results were positive for all outfalls in all quarters. A summary of CY01 events involving HISS stormwater monitoring follows. Monitoring of storm-water discharges at HISS was conducted to comply with these discharge requirements. All analytical data results for the HISS are in Appendix B, Table B-1.

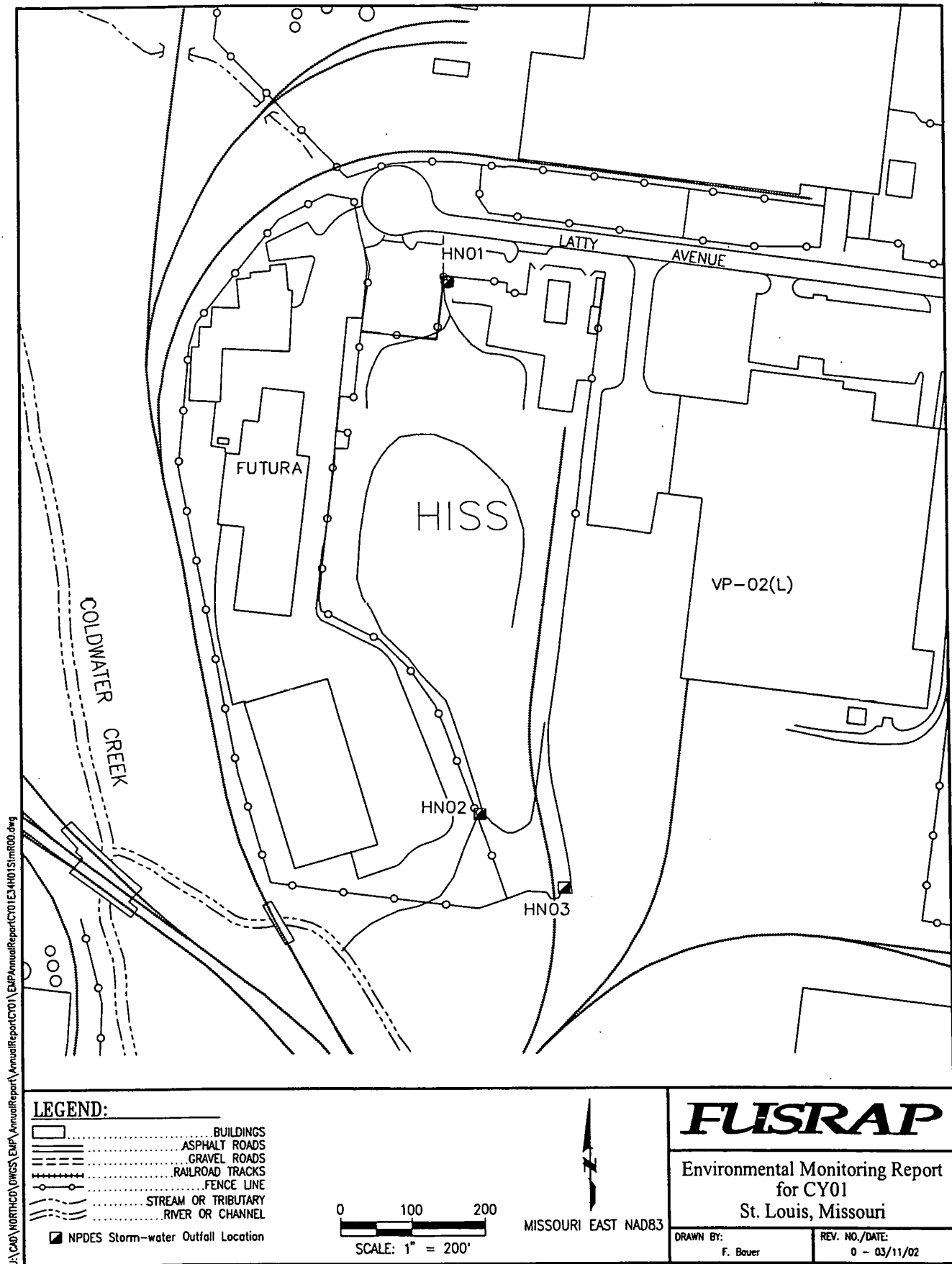


Figure 3-1. Storm-water Outfalls at the HISS

During CY01, storm-water discharges from Outfalls HN01, HN02, and HN03 were sampled for settleable solids each month that flow occurred. The average annual concentration of settleable solids for all outfalls was 0.1 mL/L/hr. In all four quarters for CY01, settleable solids results did not exceed the allowable maximum daily concentration of 1.5 mL/L/hr per outfall. Results for settleable solids storm-water discharge monitoring at HISS during CY01 are presented in Table 3-1.

Table 3-1. Total Settleable Solids Results from CY01 Storm-Water Discharge Monitoring at HISS (mL/L/hr)

Month Collected	HN01	HN02	HN03
January	<0.1	<0.1	<0.1
February	<0.1	<0.1	<0.1
March	<0.1	<0.1	<0.1
April	<0.1	0.1	0.1
May	0.3	<0.1	0.1
June	<0.1	<0.1	<0.1
July	<0.1	0.7	0.2
August	<0.1	<0.1	<0.1
September	0.1	0.2	0.1
October	0.1	0.0	0.0
November	0.1	0.0	0.0
December	0	0.0	0.0

First Quarter

During the first quarter of CY01, the above permit specified parameters were measured in January, February and March (see Table 3-2). Data results indicated that TOX values were positive for all outfalls; therefore VOCs and SVOCs were taken to identify the specific compound. No compounds were detected above reported detection limits.

Second Quarter

The HISS storm-water samples were taken for the second quarter of CY01 in April, May, and June (see Table 3-3). All permit-specified parameters were within permit requirements. Positive values for TOX were detected at all outfalls, therefore, VOC and SVOC analyses were conducted for each of the outfalls to determine specific parameter. One compound, carbon disulfide (8.6 µg/L), was detected above the detection limit, 5.0 milligrams per liter (mg/L) at HN03. Settleable solids, gross alpha, and total uranium results for HN02 are higher than for any other quarter of CY01. Increased excavation activity exposing a larger, uncovered area of subsurface soil, in the watershed for this outfall and the solubility of uranium may be factors.

Third Quarter

For the third quarter of CY01, permit specified parameters were measured during the months of July, August and September (see Table 3-4). TOX values were positive for all Outfalls. Subsequently, VOCs and SVOCs were sampled for as required with positive TOX readings. No compounds were found above reported detection limits.

Fourth Quarter

Samples to measure permit specified parameters were taken in October, November and December for CY01 (Table 3-5). Data results indicated that TOX values were positive for all outfalls. VOC and SVOC data results indicated acetone was present at an estimated quantity below the detection limit in samples at all outfalls. This constituent is often associated with laboratory contamination.

Table 3-2. Results from First Quarter CY01 Storm-water Sampling at HISS

Monitoring Parameter	Units	HN01	HN02	HN03
Thorium-228	pCi/L	1.41	2.30 ¹	1.51 ¹
Thorium-230	pCi/L	8.05	9.14	0.81 ¹
Thorium-232	pCi/L	0.95 ¹	1.72 ¹	1.51 ²
Total Uranium ³	pCi/L	3.06	24.5	6.14
Radium-226	pCi/L	1.70	3.31 ¹	2.17 ²
Radium-228 ⁴	pCi/L	1.41	2.30 ¹	1.51 ¹
Gross Alpha	pCi/L	32.8	20.6	13.4 ¹
Gross Beta	pCi/L	27.5 ²	26.7 ¹	27.0 ¹
pH	SU	7.6	7.7	7.8
Specific Conductance	µmhos/cm	0.95	0.23	0.44
Total Organic Carbon	mg/L	9.2	6.1	5
Total Organic Halogen	mg/L	31.2	8.9	7.4
Lead-210 ⁵	pCi/L	1.70	3.31 ¹	2.17 ²

¹ Result reported is less than the minimum detectable activity (MDA). Value is assumed to be MDA for calculation purposes.

² Result reported is negative. Value is assumed to be the MDA for calculation purposes.

³ Calculated value based on the addition of the isotopic analysis: U-234, U-235, and U-238.

⁴ Assumes secular equilibrium with Th-228.

⁵ Assumes secular equilibrium with Ra-226

SU = Standard Unit

Table 3-3. Results from Second Quarter CY01 Storm-water Sampling at HISS

Monitoring Parameter	Units	HN01	HN02	HN03
Thorium-228	pCi/L	1.42 ¹	3.56	1.35 ¹
Thorium-230	pCi/L	5.21	3.59	12.08
Thorium-232	pCi/L	0.70 ¹	0.82 ¹	2.1 ²
Total Uranium ³	pCi/L	27.85 ¹	175.4	4.64 ¹
Radium-226	pCi/L	3.07	3.56	3.41 ¹
Radium-228 ⁴	pCi/L	1.42 ¹	3.56	1.35 ¹
Gross Alpha	pCi/L	32.44	170	13.08
Gross Beta	pCi/L	26.76 ¹	26.59 ²	26.11 ¹
pH	SU	6.28	6.50	6.48
Specific Conductance	μmhos/cm	0.553	0.607	0.32
Total Organic Carbon	mg/L	9.2	6.1	4.4
Total Organic Halogen	mg/L	20.1	8.8	12.4
Lead-210 ⁵	pCi/L	3.07	3.56	3.41 ¹

¹ Result reported is less than the MDA. Value is assumed to be MDA for calculation purposes.

² Result reported is negative. Value is assumed to be the MDA for calculation purposes.

³ Calculated value based on the addition of the isotopic analyses: U-234, U-235, and U-238.

⁴ Assumes secular equilibrium with Th-228

⁵ Assumes secular equilibrium with Ra-226

SU = Standard Unit

Table 3-4. Results from Third Quarter CY01 Storm-water Sampling at HISS

Monitoring Parameter	Units	HN01	HN02	HN03
Thorium-228	pCi/L	1.13 ¹	1.3 ²	1.37 ¹
Thorium-230	pCi/L	78.39	19.11	11.97
Thorium-232	pCi/L	0.61 ¹	0.59 ¹	0.62 ¹
Total Uranium ³	pCi/L	4.76 ¹	21.17 ¹	3.77 ¹
Radium-226	pCi/L	4.32	3.55	3.54 ¹
Radium-228 ⁴	pCi/L	1.13 ¹	1.3 ²	1.37 ¹
Gross Alpha	pCi/L	104.2	59.07	15.39
Gross Beta	pCi/L	29.75 ¹	26.53 ¹	26.08 ¹
PH	SU	7.7	6.95	6.54
Specific Conductance	μmhos/cm	0.30	0.37	0.37
Total Organic Carbon	mg/L	7.3	8.7	8.7
Total Organic Halogen	mg/L	7.8	<5	<10
Lead-210 ⁵	pCi/L	4.32	3.55	3.54 ¹

¹ Result reported is less than the MDA. Value is assumed to be MDA for calculation purposes.

² Result reported is negative. Value is assumed to be the MDA for calculation purposes.

³ Calculated value based on the addition of isotopic analyses: U-234, U-235, and U-238.

⁴ Assumes secular equilibrium with Th-228.

⁵ Assumes secular equilibrium with Ra-226

SU = Standard Unit

Table 3-5. Results from Fourth Quarter CY01 Storm-water Sampling at HISS

Monitoring Parameter	Units	HN01	HN02	HN03
Thorium-228	pCi/L	0.27	0.44	0.99
Thorium-230	pCi/L	4.04	3.47	1.86
Thorium-232	pCi/L	0	0	0.19
Total Uranium ³	pCi/L	25.06 ¹	80.27 ¹	6.34 ^{1,2}
Radium-226	pCi/L	1.42	0.88	2.92 ²
Radium-228 ⁴	pCi/L	0.27	0.44	0.99
Gross Alpha	pCi/L	26.49	84.94	4.28
Gross Beta	pCi/L	17.45	4.60	5.51
pH	SU	7.05	7.06	7.48
Specific Conductance	µmhos/cm	0.970	0.549	0.309
Total Organic Carbon	mg/L	18.2	13.8	35.2
Total Organic Halogen	mg/L	15.7 ¹	17.3 ¹	11.1 ¹
Lead-210 ⁵	pCi/L	1.42	0.88	2.92 ²

¹ Result reported is less than the MDA. Value is assumed to be MDA for calculation purposes.

² Result reported is negative. Value is assumed to be the MDA for calculation purposes.

³ Calculated value based on the addition of isotopic analyses: U-234, U-235, and U-238.

⁴ Assumes secular equilibrium with Th-228.

⁵ Assumes secular equilibrium with Ra-226

SU = Standard Unit

During CY01 rainfall was measured by the ISCO® rain gauge at HN01. Flow was detected and recorded by flow meter sensors at HN01, HN02, and HN03. Rainfall was measured in inches and flow was recorded as million gallons per day using a continuous recorder. Flow and rainfall data can be referenced in Appendix B, Tables B-2.

3.1.2 MSD Permit Renewal for Radiological Laboratory

The USACE owns the Radiological Laboratory located at 8945 Latty Avenue. The lab operates under a Special Discharge Permit granted by MSD. The MSD special discharge permit requires annual renewal in compliance with discharge regulations (Ordinance 8472, 10177, and 10082). The annual renewal of special permit requires analysis of Group 1 or Group 2 parameters listed on renewal form for the HISS radiological laboratory. The MSD requires analysis of Group 1 constituents and isotopic uranium, thorium, and radium. The Group 1 parameters included: pH, total solids, total suspended solids, chemical oxygen demand (COD), cadmium, chromium, copper, iron, lead, nickel, zinc, the volatile organic priority pollutants. Radionuclide analysis include isotopic radium, thorium, and uranium.

The discharge water from the HISS laboratory tested above detection limits for: cadmium, chromium, copper, iron, lead, nickel, and zinc (Appendix B, Table B-6). Results indicated non-detects for all volatile priority pollutants, with the exception being 2-butanone. This constituent is often associated with lab contamination. There are no discharge limits or criteria regulating these parameters. They are monitored for permit renewal purposes only.

3.1.3 Evaluation of the CY01 Storm-water Discharge Monitoring Results at SLAPS

During CY01, storm-water sampling at SLAPS was conducted to meet the NPDES ARAR discharge limits. Currently, there are three NPDES outfalls at SLAPS: Outfalls 001, 002,

and 003 (Figure 3-2). For environmental monitoring purposes, these outfalls have been assigned the station identifications PN01 for Outfall 001, PN02 for Outfall 002, and PN03 for Outfall 003. In the fall of CY98, the MDNR issued discharge requirements for three outfalls at SLAPS, in conjunction with the proposed construction of a sedimentation basin at the site. The first outfall covers the discharge requirements from the normal discharge conveyance for the sedimentation basin located at the southwest corner of the site and the emergency spillway located in the northwest portion of the site near historical Outfall STW-001. To distinguish discharge points at Outfall PN01, a designation of "a" or "b" is given. Location PN01a designates normal discharge from the sedimentation basin, while PN01b designates discharge from the emergency spillway. PN02 is located at the termination of a drainage way that parallels McDonnell Boulevard along its north side. The third outfall, PN03, addressed by these discharge requirements, drains the eastern end of SLAPS and conveys this run-off to Coldwater Creek in a drainage ditch that travels northward through the ballfields. The monitoring station, for this outfall, is located just before the drainage ditch crosses under McDonnell Boulevard, after leaving the site.

The discharge limits issued by the MDNR-NPDES ARAR permit equivalent document, requires monthly monitoring for oil and grease, total petroleum hydrocarbons, pH, COD, settleable solids, arsenic, lead, chromium, copper, cadmium, polychlorinated biphenyls (PCBs), total uranium, total thorium, gross alpha, gross beta, protactinium-231 (Pa-231), and actinium-227 (Ac-227). In addition, effluent monitoring for gross alpha, gross beta, Pa-231, Ac-227, total radium, total thorium, and total uranium is required for each discharge event. Radon in water monitoring is required twice a year. Due to difficulties with laboratory analysis for total petroleum hydrocarbons (TPH), the actual analysis was modified to total recoverable petroleum hydrocarbons. This issue is described in detail in the third quarter discharge monitoring report for CY99, see letter from USACE to MDNR dated October 23, 1999 (USACE, 1999b). Tables 3-6 through 3-9 present quarterly SLAPS monitoring for CY01. Rainfall and flow data can be found in Appendix B, Table B-4. A summary of CY01 events for SLAPS storm-water monitoring follows.

First Quarter Summary

During the first quarter of CY01, the permit specified parameters were measured in January, February and March. All parameters measured during the first quarter sampling events were within discharge limits. Samples were collected when flow permitted. There were six sampling events in first quarter and occurred in:

Sample Location	Event 1¹	Event 2	Event 3
PN01a	01/14/01 – 01/18/01	01/29/01-02/01/01	02/09/01-02/16/01
PN02	ND	01/30/01	02/09/01
PN03	01/19/01	01/30/01-01/31/01	02/15/01-02/16/01
Sample Location	Event 4	Event 5	Event 6
PN01a	02/27/01-03/05/01	03/13/01-03/18/01	ND
PN02	02/24/01-02/25/01	ND	ND
PN03	02/24/01-02/25/01	03/16/01	03/27/01-03/28/01

¹ An 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, or from pumping operation (such as following treatment). An event may exceed duration of 24 hours, and two events experienced within 48 hours may be reported together.

ND = no or insufficient discharge.

3-8

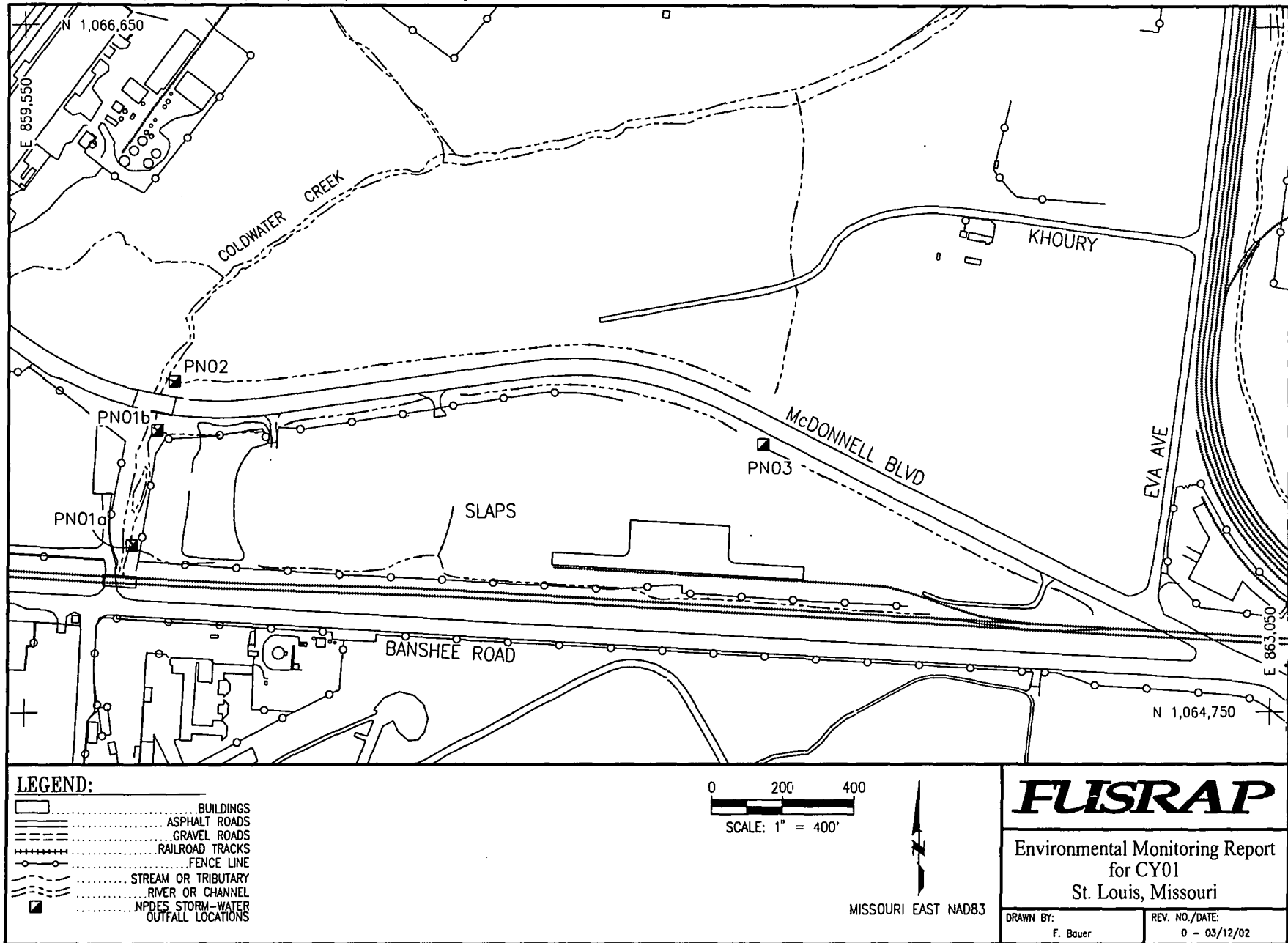


Figure 3-2. Storm-water Outfalls at the SLAPS

Second Quarter Summary

During the second quarter of CY01, the permit specified parameters were measured in April, May and June. Monitoring parameters were all within the permit specified limits. There were ten sampling events during this quarter which occurred as:

Sample Location	Event 1 ¹	Event 2	Event 3	Event 4	Event 5
PN01a	04-03-01-04-05-01	04/11/01	04/15/01-04/16/01	ND	ND
PN02	ND	ND	ND	ND	ND
PN03	04/03/01, 04/05/01	04/11/01-04/12/01	04/16/01-04/17/01	04/25/01	05/07/01
Sample Location	Event 6	Event 7	Event 8	Event 9	Event 10
PN01a	05/19/01, 05/21/01	05/31/01	06/04/01-06/07/01	06/15/01	06/27/01
PN02	ND	05/31/01	06/04/01, 06/06/01	ND	ND
PN03	05/17/01, 05/19/01, 05/21/01	ND	06/04/01-06/06/01	ND	ND

¹ An 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, or from pumping operation (such as following treatment). An event may exceed duration of 24 hours, and two events experienced within 48 hours may be reported together.

ND = no or insufficient discharge.

Third Quarter Summary

During third quarter there were seven rainfall events (see below). There were two exceedences for settleable solids at Outfall 003 on Event 7. The exceedance was the result of intense rainfall that was experienced in a short period of time on September 18, 2001. There was extensive watershed pooling and flowing over the erosion control, silt fences near the outfall. Data received October 17, 2001 revealed that the Outfall 003 sample also exceeded the Copper limit of 84 µg/L with a result of 160 µg/L. (The settleable solids result was reported at 4.0 mL/L/hr exceeding the daily limit of 1.5 mL/L/hr after the rain event. All erosion control measures were inspected to ensure proper installation and function.) All were found to be in working order. MDNR was notified regarding the settleable solids and copper exceedences on September 28 and October 23, 2001, respectively.

Other anomalies were found on further analysis of the sample. The values for Th-228, Th-230, and Th-232 were equivalent. This sample was analyzed twice to verify this result. Additionally, the sample had elevated gross alpha counts that were not accounted for in uranium, thorium, or radium analysis. Both the uranium and gross alpha values were repeated to verify these unusual results. The gross alpha should be considered an estimate due to the high solids content in the sample.

Sample Location	Event 1 ¹	Event 2	Event 3	Event 4	Event 5
PN01a	07/05/01	07/18/01-07/20/01	07/24/01	ND	08/24/01-08/25/01
PN02	ND	ND	ND	ND	ND
PN03	ND	07/19/01-07/23/01	07/24/01-07/26/01	08/06/01	08/27/01-08/30/01
Sample Location	Event 6	Event 7			
PN01a	09/09/01	09/18/01-09/19/01			
PN02	ND	ND			
PN03	ND	09/18/01-09/20/01			

¹ An 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, or from pumping operation (such as following treatment). An event may exceed duration of 24 hours, and two events experienced within 48 hours may be reported together.

ND = no or insufficient discharge.

Fourth Quarter Summary

During the fourth quarter of CY01, permit specific parameters were measured during the months of October, November, and December. In early October, PN03 was plugged to accommodate excavation activities in the area. The water from this watershed was collected in a temporary sedimentation basin and pumped to the basin which flowed to PN01a. There were six rainfall events recorded for this period (Table 3-9). No releases above permit equivalent limits for the fourth quarter were recorded.

Sample Location	Event 1 ¹	Event 2	Event 3
PN01a	10/05/01-10/06/01	10/10/01-10/12/01	10/15/01-10/17/01
PN02	ND	10/10/01-10/12/01	10/16/01
PN03	ND	ND	ND
Sample Location	Event 4	Event 5	Event 6
PN01a	10/23/01-10/25/01	11/24/01-12/02/01	12/12/01-12/20/01
PN02	10/24/01-10/25/01	11/24/01, 11/28/01, 12/01/01	12/13/01-12/14/01, 12/16/01-12/18/01
PN03	ND	ND	ND

¹ An 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, or from pumping operation (such as following treatment). An event may exceed duration of 24 hours, and two events experienced within 48 hours may be reported together.
ND = no or insufficient discharge.

**Table 3-6. First Quarter Storm-water Discharge Monitoring
for Parameters at SLAPS during CY01**

PN01a								
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results					
			Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Uranium, Total ^{1,2,3}	µg/L	Monitor only	4E+02	4E+02	3.3E+02	4E+2	4E+02	*
Radium, Total ^{1,2,3}	µg/L	Monitor only	3E-07	2E-06	1E-09	5E-06	0E+00	*
Thorium, Total ^{1,2,3}	µg/L	Monitor only	2E-04	4E+00	3E-04	2E+00	0E+00	*
Gross Alpha ¹	pCi/L	Monitor only	2E+02	2E+02	9E+01	5E+02	0E+00	*
Gross Beta ¹	pCi/L	Monitor only	5E+01	2E+01	2E+01	6E+01	0E+00	*
Protactinium-231 ¹	pCi/L	Monitor only	6E-02	2E-02	9E-02	2E+00	0E+00	*
Actinium-227 ¹	pCi/L	Monitor only	6E-02	2E-02	9E-02	2E+00	0E+00	*
Radon (semi-annual monitoring) ¹	pCi/L		1E+02					
PN01a								
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results					
			January	February	March			
Oil and Grease	mg/L	10	0.62	0.57	1.9			
Total Petroleum Hydrocarbons	mg/L	10	0.62	Non-detect	Non-detect			
PH	SU	6-9.0	7.4	7.7	7.7			
Chemical Oxygen Demand	mg/L	90	13	29.2	41.2			
Settleable Solids ⁴	mL/L/hr	1.0	0.1	**	Non-detect			
Arsenic, Total Recoverable	µg/L	100	3.0	Non-detect	Non-detect			
Lead, Total Recoverable	µg/L	190	3.0	Non-detect	Non-detect			
Chromium, Total Recoverable	µg/L	280	5.0	Non-detect	7.4			
Copper, Total Recoverable	µg/L	84	10	Non-detect	Non-detect			
Cadmium, Total Recoverable	µg/L	94	2.0	Non-detect	Non-detect			
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	Non-detect	Non-detect	Non-detect			

**Table 3-6. First Quarter Storm-water Discharge Monitoring
for Parameters at SLAPS during CY01 (Cont'd)**

PN02								
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results					
			Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Uranium, Total ^{1,2,3}	µg/L	Monitor only	*	0E+00	0E+00	0E+00	*	*
Radium, Total ^{1,2,3}	µg/L	Monitor only	*	5E-09	7E-07	2E-09	*	*
Thorium, Total ^{1,2,3}	µg/L	Monitor only	*	6E+00	4E+00	1E-04	*	*
Gross Alpha ¹	pCi/L	Monitor only	*	0E+00	0E+00	0E+00	*	*
Gross Beta ¹	pCi/L	Monitor only	*	2E+01	0E+00	0E+00	*	*
Protactinium-231 ¹	pCi/L	Monitor only	*	2E-02	2E-02	4E-02	*	*
Actinium-227 ¹	pCi/L	Monitor only	*	2E-02	2E-02	4E-02	*	*
Radon (semi-annual monitoring) ¹	pCi/L			Non-detect				
PN02								
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results					
			January	February	March			
Oil and Grease	mg/L	10	Non-detect	1	*			
Total Petroleum Hydrocarbons	mg/L	10	Non-detect	0.4	*			
pH	SU	6-9.0	7.7	7.6	*			
Chemical Oxygen Demand	mg/L	90	38.9	51.8	*			
Settleable Solids ⁴	mL/L/hr	1.0	0.0	**	*			
Arsenic, Total Recoverable	µg/L	100	Non-detect	Non-detect	*			
Lead, Total Recoverable	µg/L	190	Non-detect	Non-detect	*			
Chromium, Total Recoverable	µg/L	280	Non-detect	Non-detect	*			
Copper, Total Recoverable	µg/L	84	Non-detect	Non-detect	*			
Cadmium, Total Recoverable	µg/L	94	Non-detect	Non-detect	*			
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	Non-detect	Non-detect	*			
PN03								
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results					
			Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Uranium, Total ^{1,2,3}	µg/L	Monitor only	3E+02	2E+02	9E+01	10E+01	2E+02	3E+02
Radium, Total ^{1,2,3}	µg/L	Monitor only	2E-06	7E-07	4E-07	4E-10	0E+00	0E+00
Thorium, Total ^{1,2,3}	µg/L	Monitor only	2E-04	5E+00	4E-05	2E+00	0E+00	0E+00
Gross Alpha ¹	pCi/L	Monitor only	2E+02	1E+02	1E+01	1E+02	0E+00	0E+00
Gross Beta ¹	pCi/L	Monitor only	2E+01	5E-01	3E+00	0E+00	0E+00	0E+00
Protactinium-231 ¹	pCi/L	Monitor only	6E-02	4E-02	1E-02	2E-02	0E+00	0E+00
Actinium-227 ¹	pCi/L	Monitor only	6E-02	4E-02	1E-02	2E-02	0E+00	0E+00
Radon (semi-annual monitoring) ¹	pCi/L		8E+01					
PN03								
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results					
			January	February	March			
Oil and Grease	mg/L	10	Non-detect	0.45	2.0			
Total Petroleum Hydrocarbons	mg/L	10	Non-detect	Non-detect	Non-detect			
pH	SU	6-9.0	7.4	8	7.3			
Chemical Oxygen Demand	mg/L	90	6.5	6.3	17.7			
Settleable Solids ⁴	mL/L/hr	1.0	0	0	**			
Arsenic, Total Recoverable	µg/L	100	Non-detect	Non-detect	3.2			
Lead, Total Recoverable	µg/L	190	Non-detect	Non-detect	8.6			
Chromium, Total Recoverable	µg/L	280	55	Non-detect	11			
Copper, Total Recoverable	µg/L	84	Non-detect	Non-detect	15			
Cadmium, Total Recoverable	µg/L	94	Non-detect	Non-detect	Non-detect			
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	**	Non-detect	Non-detect			

¹ Discharge requirements per the MDNR-NPDES ARAR permit equivalent document.

² 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 (Schleien, 1992).

³ Calculated estimates based on addition of isotopic analysis and estimated flow.

⁴ Detection Limit = 0.1 mL/L/hr

⁵ Detection Limit = 1.0 µg/L

* No Flow at this outfall for this event.

SU = Standard Unit

** Requested analysis not performed by laboratory.

**Table 3-7. Second Quarter Storm-water Discharge Monitoring
for Parameters at SLAPS During CY01**

PN01a							
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results				
			Event 1	Event 2	Event 3	Event 4	Event 5
Uranium, Total ^{1,2,3}	µg/L	Monitor only	4E+02	2E+02	5E+02	Non-detect	Non-detect
Radium, Total ^{1,2,3}	µg/L	Monitor only	1E-06	6E-06	1E-09	Non-detect	Non-detect
Thorium, Total ^{1,2,3}	µg/L	Monitor only	9E-05	5E-03	3E-04	Non-detect	Non-detect
Gross Alpha ¹	pCi/L	Monitor only	2E+02	3E+02	3E+02	Non-detect	Non-detect
Gross Beta ¹	pCi/L	Monitor only	2E+01	5E+01	2E+01	Non-detect	Non-detect
Protactinium-231 ¹	pCi/L	Monitor only	3E-02	1E+00	1E-01	Non-detect	Non-detect
Actinium-227 ¹	pCi/L	Monitor only	3E-02	1E+00	1E-01	Non-detect	Non-detect

PN01a							
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results				
			Event 6	Event 7	Event 8	Event 9	Event 10
Uranium, Total ^{1,2,3}	µg/L	Monitor only	4E+02	4E+02	4E+02	3E+02	4E+02
Radium, Total ^{1,2,3}	µg/L	Monitor only	5E-06	1E-06	2E-06	*	3E-06
Thorium, Total ^{1,2,3}	µg/L	Monitor only	2E+00	7E-04	1E+01	*	2E+00
Gross Alpha ¹	pCi/L	Monitor only	2E+02	3E+02	3E+02	*	2E+02
Gross Beta ¹	pCi/L	Monitor only	1E+01	0E+00	3E+01	*	5E+01
Protactinium-231 ¹	pCi/L	Monitor only	0E+00	0E+00	4E-02	*	9E-02
Actinium-227 ¹	pCi/L	Monitor only	0E+00	0E+00	4E-02	*	9E-02

PN01a					
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results		
			April	May	June
Oil Grease	mg/L	10	0.36	Non-detect	Non-detect
Total Petroleum Hydrocarbons	mg/L	10	Non-detect	Non-detect	Non-detect
pH	SU	6-9.0	7.7	7.5	8
Chemical Oxygen Demand	mg/L	90	17.6	33.2	20
Settleable Solids ⁴	mL/L/hr	1.0	0	0	0.1
Arsenic, Total Recoverable	µg/L	100	Non-detect	Non-detect	Non-detect
Lead, Total Recoverable	µg/L	190	Non-detect	Non-detect	Non-detect
Chromium, Total Recoverable	µg/L	280	5.7	Non-detect	Non-detect
Copper, Total Recoverable	µg/L	84	Non-detect	Non-detect	Non-detect
Cadmium, Total Recoverable	µg/L	94	Non-detect	Non-detect	Non-detect
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	Non-detect	Non-detect	Non-detect

PN02							
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results				
			Event 1	Event 2	Event 3	Event 4	Event 5
Uranium, Total ^{1,2,3}	µg/L	Monitor only	ND	ND	ND	ND	ND
Radium, Total ^{1,2,3}	µg/L	Monitor only	ND	ND	ND	ND	ND
Thorium, Total ^{1,2,3}	µg/L	Monitor only	ND	ND	ND	ND	ND
Gross Alpha ¹	pCi/L	Monitor only	ND	ND	ND	ND	ND
Gross Beta ¹	pCi/L	Monitor only	ND	ND	ND	ND	ND
Protactinium-231 ¹	pCi/L	Monitor only	ND	ND	ND	ND	ND
Actinium-227 ¹	pCi/L	Monitor only	ND	ND	ND	ND	ND

PN02							
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results				
			Event 6	Event 7	Event 8	Event 9	Event 10
Uranium, Total ^{1,2,3}	µg/L	Monitor only	ND	0E+00	0E+00	ND	ND
Radium, Total ^{1,2,3}	µg/L	Monitor only	ND	5E-07	1E-05	ND	ND
Thorium, Total ^{1,2,3}	µg/L	Monitor only	ND	2E-05	7E-05	ND	ND
Gross Alpha ¹	pCi/L	Monitor only	ND	8E-01	5E+00	ND	ND
Gross Beta ¹	pCi/L	Monitor only	ND	6E+00	1E+01	ND	ND
Protactinium-231 ¹	pCi/L	Monitor only	ND	0E+00	2E-02	ND	ND
Actinium-227 ¹	pCi/L	Monitor only	ND	0E+00	2E-02	ND	ND

**Table 3-7. Second Quarter Storm-water Discharge Monitoring
for Parameters at SLAPS During CY01 (Cont'd)**

PN02							
Monitoring Parameter	Units	Effluent Limitations	Chemical Results				
			April	May	June		
Oil Grease	mg/L	10	*	Non-detect	*		
Total Petroleum Hydrocarbons	mg/L	10	*	Non-detect	*		
pH	SU	6-9.0	*	7.2	7.7		
Chemical Oxygen Demand	mg/L	90	*	26.6	42.7		
Settleable Solids ⁴	mL/L/hr	1.0	*	0.1	0.15		
Arsenic, Total Recoverable	µg/L	100	*	Non-detect	Non-detect		
Lead, Total Recoverable	µg/L	190	*	Non-detect	Non-detect		
Chromium, Total Recoverable	µg/L	280	*	5.1	7		
Copper, Total Recoverable	µg/L	84	*	Non-detect	46		
Cadmium, Total Recoverable	µg/L	94	*	Non-detect	Non-detect		
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	*	Non-detect	Non-detect		
PN03							
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results				
			Event 1	Event 2	Event 3	Event 4	Event 5
Uranium, Total ^{1,2,3}	µg/L	Monitor only	0E+00	2E+02	2E+02	2E+02	2E+02
Radium, Total ^{1,2,3}	µg/L	Monitor only	9E-07	2E-06	0E+00	2E-06	5E-07
Thorium, Total ^{1,2,3}	µg/L	Monitor only	2E-04	4E+00	0E+00	5E-05	6E-05
Gross Alpha ¹	pCi/L	Monitor only	0E+00	9E+01	0E+00	10E+01	8E+01
Gross Beta ¹	pCi/L	Monitor only	3E+00	5E+01	0E+00	2E+01	2E+01
Protactinium-231 ¹	pCi/L	Monitor only	5E-02	7E-02	0E+00	2E-02	0E+00
Actinium-227 ¹	pCi/L	Monitor only	5E-02	7E-02	0E+00	2E-02	0E+00
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results				
			Event 6	Event 7	Event 8	Event 9	Event 10
Uranium, Total ^{1,2,3}	µg/L	Monitor only	0E+00	ND	1E+02	ND	ND
Radium, Total ^{1,2,3}	µg/L	Monitor only	4E-07	ND	1E-06	ND	ND
Thorium, Total ^{1,2,3}	µg/L	Monitor only	1E-04	ND	2E-14	ND	ND
Gross Alpha ¹	pCi/L	Monitor only	4E+00	ND	4E+00	ND	ND
Gross Beta ¹	pCi/L	Monitor only	0E+00	ND	0E+00	ND	ND
Protactinium-231 ¹	pCi/L	Monitor only	0E+00	ND	5E-02	ND	ND
Actinium-227 ¹	pCi/L	Monitor only	0E+00	ND	5E-02	ND	ND
PN03							
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results				
			April	May	June		
Oil Grease	mg/L	10	Non-detect	Non-detect	Non-detect		
Total Petroleum Hydrocarbons	mg/L	10	Non-detect	Non-detect	Non-detect		
pH	SU	6-9.0	7.8	8.0	7.3		
Chemical Oxygen Demand	mg/L	90	11.7	20.2	Non-detect		
Settleable Solids ⁴	mL/L/hr	1.0	0	0	0.1		
Arsenic, Total Recoverable	µg/L	100	Non-detect	Non-detect	Non-detect		
Lead, Total Recoverable	µg/L	190	6.8	Non-detect	Non-detect		
Chromium, Total Recoverable	µg/L	280	11	Non-detect	Non-detect		
Copper, Total Recoverable	µg/L	84	30	Non-detect	Non-detect		
Cadmium, Total Recoverable	µg/L	94	Non-detect	Non-detect	Non-detect		
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	Non-detect	Non-detect	Non-detect		

¹ Discharge requirements per the MDNR-NPDES ARAR permit equivalent document.

² 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 (Schleien, 1992).

³ Calculated estimates based on addition of isotopic analysis and estimated flow.

⁴ Detection Limit = 0.1 mL/L/hr

⁵ Detection Limit = 1.0 µg/L

* No flow at this outfall for this event.

** Sample bottles broken at laboratory.

ND = No or insufficient discharge.

SU = Standard Unit

**Table 3-8. Third Quarter Storm-water Discharge Monitoring for
Parameters at SLAPS during CY01**

PN01a									
Monitoring Parameter	Units	Effluent Limitations ¹							
			Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7
Uranium, Total ^{1,2,3}	µg/L	Monitor only	3E+02	9E+01	2E+02	*	2E+02	1E+02	1E+02
Radium, Total ^{1,2,3}	µg/L	Monitor only	4E-06	2 E-06	3E-07	*	8E-07	7E-07	2E-06
Thorium, Total ^{1,2,3}	µg/L	Monitor only	1E-04	4E+00	3E+00	*	3E+00	1E+00	2E+00
Gross Alpha ¹	pCi/L	Monitor only	2E+02	1E+02	1E+02	*	1E+02	1E+02	1E+02
Gross Beta ¹	pCi/L	Monitor only	3E+01	4E+01	6E+01	*	3E+01	3E+01	2E+01
Protactinium-231 ¹	pCi/L	Monitor only	3E-02	6E-02	1E-01	*	5E-02	5E-02	4E-01
Actinium-227 ¹	pCi/L	Monitor only	3E-02	6E-02	1E-01	*	5E-02	5E-02	4E-01
Radon	pCi/L		Non-detect						
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results						
			July		August		September		
Oil Grease	mg/L	10	Non-detect		Non-detect		Non-detect		
Total Petroleum Hydrocarbons	mg/L	10	Non-detect		Non-detect		Non-detect		
pH	SU	6-9.0	7.7		8.2		7.8		
Chemical Oxygen Demand	mg/L	90	Non-detect		24.4		22.3		
Settleable Solids ⁴	mL/L/hr	1.0	Non-detect		Non-detect		Non-detect		
Arsenic, Total Recoverable	µg/L	100	Non-detect		Non-detect		Non-detect		
Lead, Total Recoverable	µg/L	190	Non-detect		Non-detect		Non-detect		
Chromium, Total Recoverable	µg/L	280	Non-detect		6.7		Non-detect		
Copper, Total Recoverable	µg/L	84	Non-detect		Non-detect		Non-detect		
Cadmium, Total Recoverable	µg/L	94	Non-detect		Non-detect		Non-detect		
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	Non-detect		Non-detect		Non-detect		
PN02									
Monitoring Parameter	Units	Effluent Limitations ¹							
			Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7
Uranium, Total ^{1,2,3}	µg/L	Monitor only	*	*	*	*	*	*	*
Radium, Total ^{1,2,3}	µg/L	Monitor only	*	*	*	*	*	*	*
Thorium, Total ^{1,2,3}	µg/L	Monitor only	*	*	*	*	*	*	*
Gross Alpha ¹	pCi/L	Monitor only	*	*	*	*	*	*	*
Gross Beta ¹	pCi/L	Monitor only	*	*	*	*	*	*	*
Protactinium-231 ¹	pCi/L	Monitor only	*	*	*	*	*	*	*
Actinium-227 ¹	pCi/L	Monitor only	*	*	*	*	*	*	*
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results						
			July		August		September		
Oil Grease	mg/L	10	*		*		*		
Total Petroleum Hydrocarbons	mg/L	10	*		*		*		
pH	SU	6-9.0	*		*		*		
Chemical Oxygen Demand	mg/L	90	*		*		*		
Settleable Solids ⁴	mL/L/hr	1.0	*		*		*		
Arsenic, Total Recoverable	µg/L	100	*		*		*		
Lead, Total Recoverable	µg/L	190	*		*		*		
Chromium, Total Recoverable	µg/L	280	*		*		*		
Copper, Total Recoverable	µg/L	84	*		*		*		
Cadmium, Total Recoverable	µg/L	94	*		*		*		
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	*		*		*		

Table 3-8. Third Quarter Storm-water Discharge Monitoring for Parameters at SLAPS during CY01 (Cont'd)

PN03									
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results						
			Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7
Uranium, Total ^{1,2,3}	µg/L	Monitor only	*	3E+01	2E+01	1E+02	2E+01	*	6E+00
Radium, Total ^{1,2,3}	µg/L	Monitor only	*	7 E-06	8E-07	1E-06	3E-09	*	1E-05
Thorium, Total ^{1,2,3}	µg/L	Monitor only	*	6E+00	2E+00	2E+00	5E-05	*	1E+02
Gross Alpha ¹	pCi/L	Monitor only	*	1E+01	7E-01	1E+02	3E+00	*	4E+02
Gross Beta ¹	pCi/L	Monitor only	*	5E+01	3E+00	4E+01	9E+00	*	4E+02
Protactinium-231 ¹	pCi/L	Monitor only	*	4E-02	4E-02	5E-02	1E-02	*	2E-01
Actinium-227 ¹	pCi/L	Monitor only	*	4E-02	4E-02	5E-02	1E-02	*	2E-01
Radon	pCi/L				Non-detect				
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results						
			July	August	September				
Oil Grease	mg/L	10	Non-detect	Non-detect	Non-detect				
Total Petroleum Hydrocarbons	mg/L	10	Non-detect	Non-detect	Non-detect				
pH	SU	6-9.0	7.9	8.3	8.6				
Chemical Oxygen Demand	mg/L	90	Non-detect	Non-detect	86.4				
Settleable Solids ⁴	mL/L/hr	1.0	0.2	Non-detect	0.25				
Arsenic, Total Recoverable	µg/L	100	Non-detect	Non-detect	Non-detect				
Lead, Total Recoverable	µg/L	190	Non-detect	Non-detect	160				
Chromium, Total Recoverable	µg/L	280	5.4	Non-detect	140				
Copper, Total Recoverable	µg/L	84	Non-detect	Non-detect	160				
Cadmium, Total Recoverable	µg/L	94	Non-detect	Non-detect	Non-detect				
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	Non-detect	Non-detect	Non-detect				

¹ Discharge requirements per the MDNR-NPDES ARAR permit equivalent document.

² 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 (Schleien, 1992).

³ Calculated estimates based on addition of isotopic analysis and estimated flow.

⁴ Detection Limit = 0.1 mL/L/hr

⁵ Detection Limit = 1.0 µg/L

* No flow at this outfall for this event.

SU = Standard Unit

Table 3-9. Fourth Quarter Storm-water Discharge Monitoring at SLAPS During CY01

PN01a								
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results					
			Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Uranium, Total ^{1,2,3}	µg/L	Monitor only	2E+02	1E+02	2E+02	2E+02	2E+02	4E+02
Radium, Total ^{1,2,3}	µg/L	Monitor only	4E-07	4E-06	2E-07	5E-07	1E-07	2E-06
Thorium, Total ^{1,2,3}	µg/L	Monitor only	1E-04	2E+00	2E+00	2E+00	1E-01	2E+00
Gross Alpha ¹	pCi/L	Monitor only	7E+01	1E+02	1E+02	2E+02	1E+02	4E+02
Gross Beta ¹	pCi/L	Monitor only	2E+01	2E+01	2E+01	9E+00	1E+01	8E+01
Protactinium-231 ¹	pCi/L	Monitor only	4E-02	3E-01	2E-01	9E-02	1E-01	2E-01
Actinium-227 ¹	pCi/L	Monitor only	4E-02	3E-01	2E-01	9E-02	1E-01	2E-01
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results					
			October	November	December			
Oil Grease	mg/L	10	Non-detect		Non-detect		Non-detect	
Total Petroleum Hydrocarbons	mg/L	10	Non-detect		Non-detect		Non-detect	
pH	SU	6-9.0	7.8		7.7		7.6	
COD	mg/L	90	27.7		Non-detect		Non-detect	
Settleable Solids ⁴	mL/L/hr	1.0	0.1		0.3		Non-detect	
Arsenic, Total Recoverable	µg/L	100	Non-detect		3.1		Non-detect	
Lead, Total Recoverable	µg/L	190	Non-detect		7.1		Non-detect	
Chromium, Total Recoverable	µg/L	280	Non-detect		9.4		Non-detect	
Copper, Total Recoverable	µg/L	84	Non-detect		Non-detect		Non-detect	
Cadmium, Total Recoverable	µg/L	94	Non-detect		Non-detect		Non-detect	
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	Non-detect		Non-detect		Non-detect	
PN02								
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results					
			Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Uranium, Total ^{1,2,3}	µg/L	Monitor only	*	4E+00	0E+00	0E+00	0E+00	0E+00
Radium, Total ^{1,2,3}	µg/L	Monitor only	*	1E-06	1E-06	2E-09	4E-07	3E-09
Thorium, Total ^{1,2,3}	µg/L	Monitor only	*	4E-05	2E+00	2E+00	6E-02	8E-05
Gross Alpha ¹	pCi/L	Monitor only	*	1E+00	0E+00	0E+00	1E-01	2E+00
Gross Beta ¹	pCi/L	Monitor only	*	5E+00	0E+00	5E+00	5E-02	0E+00
Protactinium-231 ¹	pCi/L	Monitor only	*	1E-02	6E-03	2E-02	2E-02	2E-02
Actinium-227 ¹	pCi/L	Monitor only	*	1E-02	6E-03	2E-02	2E-02	2E-02
Radon ¹	pCi/L	Monitor only	*					
PN02								
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results					
			October	November	December			
Oil Grease	mg/L	10	ND		ND		Non-detect	
Total Petroleum Hydrocarbons	mg/L	10	ND		ND		Non-detect	
pH	SU	6-9.0	7.3		7.2		7.5	
COD	mg/L	90	24.9		23.9		20.4	
Settleable Solids ⁴	mL/L/hr	1.0	ND		Not reported ⁶		Non-detect	
Arsenic, Total Recoverable	µg/L	100	ND		ND		Non-detect	
Lead, Total Recoverable	µg/L	190	ND		ND		Non-detect	
Chromium, Total Recoverable	µg/L	280	ND		ND		Non-detect	
Copper, Total Recoverable	µg/L	84	ND		ND		Non-detect	
Cadmium, Total Recoverable	µg/L	94	ND		ND		Non-detect	
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	ND		ND		Non-detect	

Table 3-9. Fourth Quarter Storm-water Discharge Monitoring at SLAPS During CY01 (Cont'd)

PN03								
Monitoring Parameter	Units	Effluent Limitations ¹	Radiological Results					
			Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
Uranium, Total ^{1,2,3}	µg/L	*	*	*	*	*	**	**
Radium, Total ^{1,2,3}	µg/L	*	*	*	*	*	**	**
Thorium, Total ^{1,2,3}	µg/L	*	*	*	*	*	**	**
Gross Alpha ¹	pCi/L	*	*	*	*	*	**	**
Gross Beta ¹	pCi/L	*	*	*	*	*	**	**
Protactinium-231 ¹	pCi/L	*	*	*	*	*	**	**
Actinium-227 ¹	pCi/L	*	*	*	*	*	**	**
Monitoring Parameter	Units	Effluent Limitations ¹	Chemical Results					
			October	November	December			
Oil Grease	mg/L	10	**	**	**			
Total Petroleum Hydrocarbons	mg/L	10	**	**	**			
pH	SU	6-9.0	**	**	**			
COD	mg/L	90	**	**	**			
Settleable Solids ⁴	mL/L/hr	1.0	**	**	**			
Arsenic, Total Recoverable	µg/L	100	**	**	**			
Lead, Total Recoverable	µg/L	190	**	**	**			
Chromium, Total Recoverable	µg/L	280	**	**	**			
Copper, Total Recoverable	µg/L	84	**	**	**			
Cadmium, Total Recoverable	µg/L	94	**	**	**			
Polychlorinated Biphenyls ⁵	µg/L	<0.5 ppb	**	**	**			

¹ Discharge requirements per the MDNR-NPDES ARAR permit equivalent.

² 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 (Schleien, 1992).

³ Calculated estimates based on addition of isotopic analysis and estimated flow.

⁴ Detection Limit = 0.1 mL/L/hr

⁵ Detection Limit = 1.0 µg/L

⁶ Laboratory unable to analyze sample. This was a weekend sample and hold times were exceeded.

* No flow at this outfall for this event.

** Outfall plugged due to construction activities

ND = No or insufficient flow.

SU = Standard Unit

3.1.4 Evaluation of the CY01 Wastewater Discharge Monitoring Results at SLDS

Storm-water and wastewater effluents at the Mallinckrodt plant are discharged via combined sewers to the Bissell Point Sewage Treatment Plant under a local use permit for a significant industrial user. Monitoring of the combined effluent for compliance with permit limits is the responsibility of Mallinckrodt, Inc. and is not addressed under the EMP. On October 30, 1998 the USACE received a MSD authorization letter to monitor and control the waste water discharges at the SLDS resulting from USACE remedial activities. On July 23, 2001, the St. Louis MSD issued a separate discharges authorization letter for discharges of run-off, ground-water infiltration, or treated water from other accumulated wastewater that result from USACE remedial activities. This authorization letter was modified and another MSD authorization letter. The purpose of the storm-water and wastewater discharge sampling at SLDS is to verify compliance with the MSD discharge authorization letters.

The analytes identified in the local permit include: "pH, settleable solids, COD, and metal parameters (total values), with numeric limits established in Ordinance 8472 Article V, Section Two, B. Also identified in the local permit are VOCs by wastewater Method 624; SVOCs by

Method 625; PCBs by Method 608; gross alpha radioactivity; gross beta radioactivity; U-234; U-235; U-238; Ra-226; Ra-228 and Th-228.”

During CY01, approximately 1,747,170 gallons of waste water were discharged to MSD Base Map Inlet 17D3-022C (see Figure 3-3). All batches were discharged in accordance with the MSD authorization letters, which specifies application of treatment to achieve release standards before discharge to the MSD sewer system. Compliance with the October 30, 1998 and July 23, 2001 MSD authorization letters were met for CY01. (Appendix B. Table B-5).

3.2 CY01 COLDWATER CREEK MONITORING RESULTS

The environmental monitoring of Coldwater Creek continues to focus on the evaluation of radium isotopes, thorium isotopes, uranium isotopes, and certain general water quality parameters such as dissolved oxygen, pH, and turbidity. The monitoring is conducted to ensure compliance with environmental regulations and to assess whether runoff from SLAPS and HISS contribute to contamination of surface water and sediment in the St. Louis area.

Surface water and sediment are collected from Coldwater Creek as part of the environmental monitoring plan. The sampling events are conducted at six Coldwater Creek monitoring stations (C002 through C007). Monitoring station C002 is the historical EMP background location at the northern end of St. Louis International Airport and provides a data result comparison reference for the downgradient stations located in Coldwater Creek. Four downstream monitoring stations (C003, C005, C006, and C007) are utilized to monitor the effect of runoff from the site on Coldwater Creek; and one sampling station (C004) is used to detect the upstream contaminant contribution from SLAPS to Coldwater Creek. Figure 3-4 details the locations of the six monitoring stations along Coldwater Creek.

3.2.1 CY01 Coldwater Creek Surface Water Monitoring Results

The surface water data for Coldwater Creek during CY01 has been evaluated relative to background evaluation guidelines, risk-screening levels, background levels, and guidelines derived from environmental regulatory programs (USACE, 2001b). The background levels for the monitoring parameters are included from the *Environmental Monitoring Implementation for the St. Louis Sites for Fiscal Year 01* (USACE, 2001a). Regulatory guidelines selected for evaluation of the surface-water monitoring data are the AWQC for Class I (Protection of Aquatic Life) and Class V (Livestock, Wildlife Watering) streams as designated in 10 CSR 20-7.031.

In CY01, the sampling of surface water at Coldwater Creek was conducted during the months of March and October as a part of the surface-water monitoring program. The environmental monitoring of Coldwater Creek surface water included AWQC parameters as well as inorganic and organic chemicals, metals, and radionuclides, listed in Table 2-2 of EMIFY02 report (USACE, 2001b). The samples were collected as grab samples and analyzed according to the protocol defined in *Sampling and Analysis Guide for the St. Louis Sites* (USACE, 2000). Table C-1 of Appendix C presents the results of the sampling events at Coldwater Creek.

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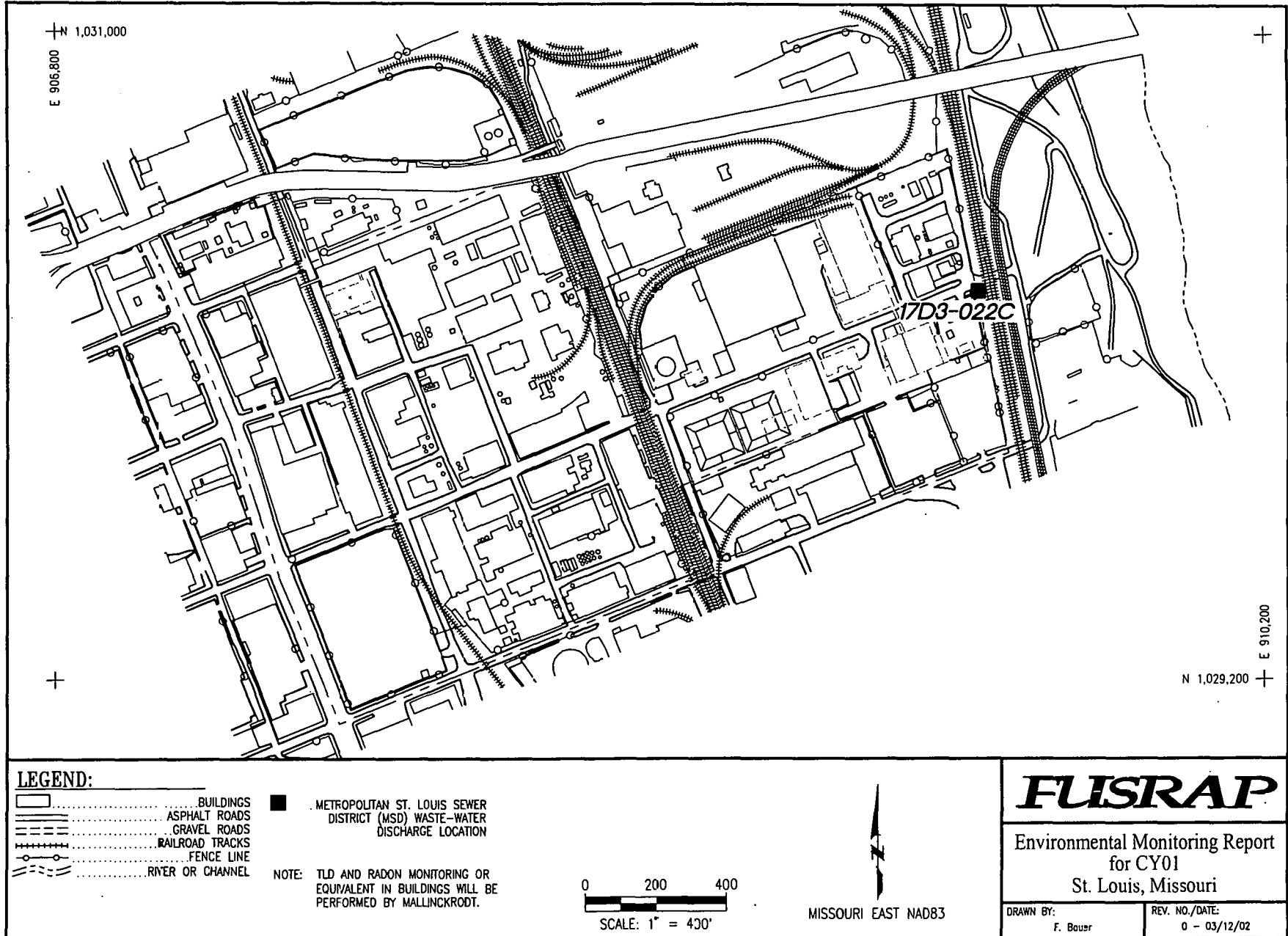


Figure 3-3. Waste-water Discharge Station at the SLDS

Table 3-10 summarizes the radiological and chemical monitoring results for the CY01 Coldwater Creek surface water sampling events. Historically, surface water samples include unfiltered water samples for the radiological parameters Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, and U-238. Ra-228 was not analyzed during CY01 sampling events. Missouri State regulation 10 CSR 60-4.060 requires if the gross alpha activity sample exceeds 5 pCi/L then the same or equivalent sample should be analyzed for Ra-226 only. If the Ra-226 concentration exceeds 3 pCi/L then the same or equivalent sample must be analyzed for Ra-228. During the sampling event, the concentration levels for Ra-226 never exceeded the 3 pCi/L maximum limit at any of the sampling stations therefore, Ra-228 was not included in the surface water analyses.

During March CY01 surface-water sampling events, the concentrations of the uranium isotopes (U-234 and U-238) ranged from 1.65 to 2.20 pCi/L for U-234 and 1.87 to 2.92 pCi/L for U-238 and the maximum concentration of radiological parameters occurred at sampling location C003 (U-238, 2.92 pCi/L). During October CY01 sampling events, the concentrations of uranium isotopes (U-234 and U-238) ranged from 0.78 to 1.85 pCi/L for U-234 and 1.03 to 1.56 pCi/L for U-238 and the maximum concentration occurred at C007. However, during the both sampling events, the maximum concentrations are less than their corresponding background concentrations.

Ra-226 and Th-232 were not detected during either sampling events of CY01. Th-230 was detected only at sampling station C004 (1.39 pCi/L) during March sampling event. Th-228 was detected only at sampling station C007 (1.71 pCi/L) during October sampling event.

The concentrations of iron exceeded AWQC (1 mg/L) at all sampling stations except for C005 during March sampling events. However, the concentrations of iron at those stations are less than its background concentration of 2.15 mg/L. There was no exceedance of the AWQC during October sampling events.

Table 3-11 shows historical radiological parameters results for surface-water sampling of Coldwater Creek at the sampling locations. The March CY01 value for Th-230 at C004 represents the highest level ever detected at this Coldwater Creek station since sampling began in CY92. Th-228 was detected at its highest level in station C007 during the October CY01 sampling event. Th-228 and Th-230 were detected at station C003 in CY99 at their highest concentrations to date. During CY00, the highest concentrations of Th-228 and Th-230 occurred at C006 and C007 Coldwater Creek stations respectively.

Table 3-10. CY01 Coldwater Creek Surface-Water Radiological and Chemical Monitoring Results

First Sample Event (March 2001)									
Monitoring Parameter	Units	Ambient Water Quality Criteria ^a	Background Criteria	C002	C003	C004	C005	C006	C007
U-234	pCi/L	NA-NG	3.9	1.48 ¹	1.65	1.88	2.34 ¹	2.20	1.82
U-235	pCi/L	NA-NG	ND	0.83 ¹	0.96 ¹	0.79 ¹	1.83 ¹	0.82 ¹	1.01 ¹
U-238	pCi/L	NA-NG	5.05	0.67 ¹	2.92	1.87	0.80 ¹	1.95	0.82 ¹
Th-228	pCi/L	NP	NP	1.80 ¹	1.49 ¹	1.22 ¹	1.25 ¹	2.07 ¹	1.24 ¹
Th-230	pCi/L	NA-NG	4.65	0.73 ¹	0.67 ¹	1.39	0.67 ¹	2.18 ¹	0.67 ¹
Th-232	pCi/L	NA-NG	ND	0.72 ¹	0.67 ¹	1.22 ¹	0.67 ¹	1.47 ¹	1.24 ¹
Ra-226	pCi/L	5	0.88	4.13 ¹	1.21 ¹	1.39 ¹	1.20 ¹	3.12 ¹	2.70 ¹
Aluminum	µg/L	750	1130	37.20 ¹	28.10 ¹	59.20	93.40	171	739
Arsenic	µg/L	20	10	0.69 ¹	0.70 ¹	0.69 ¹	0.69 ¹	0.69 ¹	0.69 ¹
Beryllium	µg/L	5	ND	0.20 ¹	0.20 ¹	0.20 ¹	0.20 ¹	0.20 ¹	0.16 ¹
Cadmium	µg/L	94	ND	0.30 ¹	0.30 ¹	0.30 ¹	0.30 ¹	0.30 ¹	0.30 ¹
Chromium	µg/L	84	20	0.75 ¹	0.80 ¹	0.80 ¹	0.80 ¹	0.80 ¹	0.80 ¹
Copper	µg/L	280	50	1.20 ¹	1.20 ¹	3.70	2.09	4.10	4.20
Iron	µg/L	1,000	2,150	1,010	1,040	1,060	857	1,210	1,580
Lead	µg/L	150	10	0.77 ¹	0.80 ¹	0.80 ¹	0.80 ¹	0.77 ¹	0.80 ¹
Mercury	µg/L	2.4	ND	0.20 ¹	0.02 ¹	0.02 ¹	0.02 ¹	0.02 ¹	0.02 ¹
Nickel	µg/L	6,900	10	1 ¹	1.10 ¹	1.10 ¹	1.10 ¹	1 ¹	1 ¹
Selenium	µg/L	5	ND	1.20 ¹	1.20 ¹	1.20 ¹	1.20 ¹	1.20 ¹	1.20 ¹
Silver	µg/L	11	ND	4.20 ¹	4.20 ¹	4.20 ¹	4.20 ¹	4.20 ¹	4.20 ¹
Zinc	µg/L	2073	60	114	40.50	115	31.90	343	164
Chloride	mg/L	860	240	NA	NA	NA	NA	NA	NA
Ethyl Benzene	µg/L	0.32	ND	5 ¹	5 ¹	5 ¹	5 ¹	5 ¹	5 ¹
2,4-Dichlorophenol	µg/L	0.007	ND	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹
2-Chloronaphthalene	µg/L	4.3	ND	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹
Fluoranthene	µg/L	0.3	ND	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹
Hexachlorocyclopentadiene	µg/L	0.0005	ND	50 ¹	50 ¹	50 ¹	50 ¹	50 ¹	50 ¹

^a AWQC is established in 10 CSR 60-4.060 for radionuclides.

¹ Undetected. Value shown is the minimum detection limit.

NA Not Available

ND Never Detected in the background samples

NA-NG Not Applicable, No Guidance is available

NC Not Calculated

NP Not required monitoring parameter

Table 3-10. CY01 Coldwater Creek Surface-Water Radiological and Chemical Monitoring Results (Cont'd)

Second Sample Event (October, 2001)									
Monitoring Parameter	Units	Ambient Water Quality Criteria*	Background Criteria	C002	C003	C004	C005	C006	C007
U-234	pCi/L	NA-NG	3.9	1.65 ¹	1.43	0.78	1.36	0.99	1.85
U-235	pCi/L	NA-NG	ND	1.10 ¹	2.37 ¹	0.87 ¹	1.70 ¹	0.83 ¹	1.08 ¹
U-238	pCi/L	NA-NG	5.05	1.31	1.43 ¹	1.03	1.56	1.24 ¹	1.61 ¹
Th-228	pCi/L	NP	NP	1.61 ¹	2.39 ¹	1.39 ¹	2.40 ¹	1.79 ¹	1.71
Th-230	pCi/L	NA-NG	4.65	1.17 ¹	0.77 ¹	1.17 ¹	1.55 ¹	1.59 ¹	1.89 ¹
Th-232	pCi/L	NA-NG	ND	1.35 ¹	0.80 ¹	1.16 ¹	1.55 ¹	0.72 ¹	1.42 ¹
Ra-226	pCi/L	5	0.88	1.64 ¹	0.60 ¹	1.64 ¹	2.81 ¹	1.72 ¹	2.25 ¹
Aluminum	µg/L	750	1130	94.50	95	195	462	345	572
Arsenic	µg/L	20	10	1.80 ¹	2.40	1.80 ¹	1.80 ¹	1.90	2.40
Beryllium	µg/L	5	ND	0.41 ¹	0.41 ¹	0.41 ¹	0.41 ¹	0.41 ¹	0.41 ¹
Cadmium	µg/L	94	ND	0.53 ¹	0.53 ¹	0.53 ¹	0.53 ¹	0.53 ¹	0.53 ¹
Chromium	µg/L	84	20	1.80	0.41	1.90	2.80	3.80	2.20
Copper	µg/L	280	50	10.50	12.40	6.20	9.40	7.40	10.20
Iron	µg/L	1,000	2,150	292	2.20	348	9.40	492	754
Lead	µg/L	150	10	0.94 ¹	0.94 ¹	0.94 ¹	1	1.10	0.94 ¹
Mercury	µg/L	2.4	ND	0.10 ¹	0.10 ¹	0.10 ¹	0.10 ¹	0.10 ¹	0.10 ¹
Nickel	µg/L	6,900	10	2.70	2.60	2.90	2.30	2	2.90
Selenium	µg/L	5	ND	1.80 ¹	2.60	2.80	1.80 ¹	3.10	1.80 ¹
Silver	µg/L	11	ND	2.90 ¹	2.90 ¹	2.90 ¹	2.90 ¹	2.90 ¹	2.90 ¹
Zinc	µg/L	2073	60	5.60	0.41	3.20	4.70	4.00	9.30
Chloride	mg/L	860	240	137	132	132	74.80	103	106
Ethyl Benzene	µg/L	0.32	ND	5 ¹	5 ¹	5 ¹	5 ¹	5 ¹	5 ¹
2,4-Dichlorophenol	µg/L	0.007	ND	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹
2-Chloronaphthalene	µg/L	4.3	ND	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹
Fluoranthene	µg/L	0.3	ND	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹	10 ¹
Hexachlorocyclopentadiene	µg/L	0.0005	ND	50 ¹	50 ¹	50 ¹	50 ¹	50 ¹	50 ¹
Oil and Grease	mg/L	10	NC	2 ¹	3.80	3.60	3.70	3.40	3.30
Total Suspended Solids	mg/L	NA-NG	NC	39.50	6.60	4	5.80	102	12

* AWQC is established in 10 CSR 60-4.060 for radionuclides.

¹ Undetected. Value shown is the minimum detection limit.

NA Not Available;

NA-NG Not Applicable, No Guidance is available;

NP Not required monitoring parameter

ND

NC

Never Detected in the background samples

Not Calculated

Table 3-11: Comparison of Historical Radiological Parameter Surface-water Results for Coldwater Creek

Historical Location	Radionuclide	Units	03/92	09/92	04/93	10/93	04/94	10/94	04/95	10/95	04/96	10/96	05/97	04/98	06/99	03/00	05/00	03/01 ¹	10/01 ¹
C002	Total Uranium	µg/L	1.63	1.50	1.70	1.47	NS	0.46	1.10	0.69	1.82	0.66	1.36	2.05	<135	<3.41	5.54	<2.98	<4.06
C002	Ra-226	pCi/L	0.35	<0.32	<0.14	0.27	NS	<0.12	<0.3	0.67	0.35	0.28	0.88	<0.2	<0.25	<2.92	<1.21	<4.13	<1.64
C002	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.05	<0.09	0.34	<0.1	NS	NS	NS	NS	NS
C002	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.05	<0.09	0.34	<0.1	3.12	<1.73	<0.60	<1.80	<1.61
C002	Th-230	pCi/L	0.19	<0.26	<-0.01	<0.05	NS	0.15	<0.06	<0.2	<0.18	0.56	0.43	<0.15	4.65	<0.67	<0.60	<0.73	<1.17
C002	Th-232	pCi/L	NS	NS	<0.02	<0	NS	<0.07	<0.02	<0.14	<0.04	<0.22	<0.10	<0.05	<0.62	<1.28	<0.60	<0.72	<1.35
C003	Total Uranium	µg/L	5.35	3.30	9.70	6.01	13.65	0.96	3.70	3.04	9.17	3.03	3.78	16.41	<135	<3.68	<5.05	<5.53	<5.23
C003	Ra-226	pCi/L	1.07	0.34	<0.07	<0.08	0.30	0.30	<0.02	0.50	0.41	0.26	<0.63	<0.21	<0.69	<4.58	<1.12	<1.21	<0.60
C003	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.17	<0.09	<0.09	<0.08	NS	NS	NS	NS	NS
C003	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.17	<0.09	<0.09	<0.08	5.05	<1.71	<1.85	<1.49	<2.39
C003	Th-230	pCi/L	0.51	<0.04	<0.10	<0.02	<0.17	0.33	0.13	0.25	0.68	0.92	0.60	<0.30	6.99	1.44	3.31	<0.67	<0.77
C003	Th-232	pCi/L	NS	NS	<0.14	<-0.01	<0.01	<0.10	<0.07	<0.17	<0.14	<0.09	<0.19	<0.54	1.21	<0.65	<0.60	<0.67	<0.80
C004	Total Uranium	µg/L	6.99	3.90	11.80	9.52	1.52	1.00	4.80	3.74	13.11	3.78	4.71	22.97	NS	<2.27	<5.66	<4.54	<2.68
C004	Ra-226	pCi/L	0.38	0.35	0.38	0.24	<0.06	0.23	0.28	<0.46	0.18	<0.16	0.66	<0.47	NS	<3.46	<2.84	<1.39	<1.64
C004	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.07	0.36	<0.14	<0.31	NS	NS	NS	NS	NS
C004	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.07	0.36	<0.14	<0.31	NS	0.25	<1.31	<1.22	<1.39
C004	Th-230	pCi/L	0.22	<0.27	<-0.04	<0.03	<0.06	<0.16	0.24	0.51	<0.14	0.4	0.42	<0.25	NS	0.49	<0.72	1.39	<1.17
C004	Th-232	pCi/L	NS	NS	<-0.01	<0.03	<0.06	<0.11	<0.02	<0.05	<0.17	<0.13	<0.05	0.25	NS	<0.66	<1.31	<1.22	<1.16
C005	Total Uranium	µg/L	4.77	3.30	1.50	1.73	NS	0.68	1.60	2.48	1.61	1.63	1.43	1.99	NS	<1.97	<4.22	<4.97	<4.62
C005	Ra-226	pCi/L	1.01	0.25	0.21	<-0.01	NS	<0.09	<0.17	0.35	0.52	0.34	<0.18	0.19	NS	<3.47	<3.02	<1.2	<2.81
C005	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	0.33	0.43	<0.09	<0.18	NS	NS	NS	NS	NS
C005	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	0.33	0.43	<0.09	<0.18	NS	0.54	<1.75	<1.25	<2.4
C005	Th-230	pCi/L	0.32	<0.40	0.31	0.19	NS	0.18	5.2	0.39	<0.24	0.42	0.55	<0.35	NS	<0.66	3.65	<0.67	<1.55
C005	Th-232	pCi/L	NS	NS	<-0.1	<0	NS	<0.14	<0.07	<0.14	<0.04	<0.05	<0.18	<0.12	NS	<0.65	<1.75	<0.67	<1.55
C006	Total Uranium	µg/L	3.75	2.70	1.40	1.65	NS	0.68	1.50	2.55	1.84	1.61	1.46	1.58	NS	<3.81	<3.10	<4.97	<3.06
C006	Ra-226	pCi/L	3.01	0.41	<0.09	<0.13	NS	<0.08	<0.10	0.64	0.15	0.3	0.25	<0.07	NS	<2.32	<2.25	<3.12	<1.72
C006	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.11	<0.18	<0.17	<0.05	NS	NS	NS	NS	NS
C006	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.11	<0.18	<0.17	<0.05	NS	2.36	<1.30	<2.08	<1.79
C006	Th-230	pCi/L	0.18	<0.48	<-0.05	<0.06	NS	<0.02	<0.09	0.25	0.32	0.43	0.92	<0.31	NS	3.1	<0.70	<2.18	<1.59
C006	Th-232	pCi/L	NS	NS	<-0.01	<0.02	NS	<0.07	<0.04	<0.10	<0.14	<0.04	<0.12	<0.10	NS	<1.78	<0.70	<1.47	<0.72
C007	Total Uranium	µg/L	5.90	5.00	9.40	5.46	10.28	NS	2.80	3.44	10.45	2.54	4.10	16.02	NS	<5.22	<2.67	<3.65	<4.54
C007	Ra-226	pCi/L	0.87	<0.17	<0.13	<0.15	<0.09	0.16	<0.10	0.42	<0.20	0.54	<0.28	<0.22	NS	<2.57	<2.15	<2.70	<2.25
C007	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.09	<0.31	<0.05	<0.10	NS	NS	NS	NS	NS
C007	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.09	<0.31	<0.05	<0.10	NS	<0.9	<1.34	<1.24	1.71
C007	Th-230	pCi/L	<0.19	1.7	<0.08	<0.10	<0.05	<0.23	<0.08	0.27	<0.09	0.40	0.55	<0.24	NS	4.67	<1.34	<0.67	<1.89
C007	Th-232	pCi/L	NS	NS	<0.03	<0	<0.01	<-0.02	<0.01	<0.04	<0.29	<0.04	<0.20	<0.10	NS	<2.10	<0.72	<1.24	<1.42

Total Uranium is equal to the sum of the concentrations of uranium isotopes. (Source: FR/ Vol. 65, No. 236 : Part II of 40 CFR Part 9, 141 and 142)

NS Not included in sample analysis.

3.2.2 CY01 Coldwater Creek Sediment Monitoring Results

In CY01, the sampling of sediment at Coldwater Creek was conducted during the months of March and October as a part of the environmental monitoring program. Sediment samples were collected in depositional environments from each of the six previously described surface-water locations (C002 through C007) (Figure 3-4) and analyzed in according to the methods described in the *Sampling and Analysis Guide for St. Louis Sites* (USACE, 2000). Sediment samples collected for the EMP were evaluated for radiological, organic chemical, and metal constituents, listed in Table 2-3 of the EMIFY02 (USACE, 2001b). Appendix C, Table C-2 presents the results obtained from these monitoring activities.

Table 3-12 summarized the radiological results for CY01 Coldwater Creek sediment sampling events. For radionuclides, the environmental monitoring data for Coldwater Creek sediments are compared to the results of the concurrent surface water sampling results for each location and with respect to the historical results.

During March CY01 sampling event, the concentrations of Ra-226 and Th-230 ranged from 0.5 pCi/g to 1.44 pCi/g and 0.48 pCi/g to 18.75 pCi/g, respectively during the March sampling event. The maximum concentrations of these two isotopes occurred at EMP Station C005 that is located downstream of surface drainage from HISS. The minimum concentrations occurred at the background station C002 that is located at the southern boundary of the airport. These results indicate that contaminant transport from HISS and certain of its VPs by surface water run-off may be contributing to localized contamination of Coldwater Creek's streambed.

During October CY01 sampling event, the concentrations of Ra-226 and Th-230 ranged from 0.06 pCi/g to 0.99 pCi/g and 0.83 to 9.3 pCi/g, respectively. The minimum concentrations for these two isotopes occurred at station C002. But, the maximum concentrations for Ra-226 occurred at sampling stations C004 and C007, whereas the maximum concentration of Th-230 occurred at C007. These results may indicate a mobile source is being transported in the Coldwater Creek and distributed non-uniformly along the creek bed.

During both March and October CY01 sediment sampling events, the activity-based concentrations of Ra-228, Th-228, and Th-232 remained almost the same at each of the sampling stations. Uranium is the most soluble of the radionuclides monitored, and it was not detected at most of the EMP stations.

Sediment monitoring results from CY01 were compared with historical EMP results. Table 3-13 shows historical results (radiological) for sediment sampling at Coldwater Creek at the EMP sampling locations. According to the results, the maximum concentrations of Ra-226 and Th-230 occurred at stations C005 and C007 (June CY99 and October CY01) and the minimum concentrations occurred at station C002. The concentrations of Ra-228, Th-228 and Th-232 are almost the same for all sampling stations during these periods.

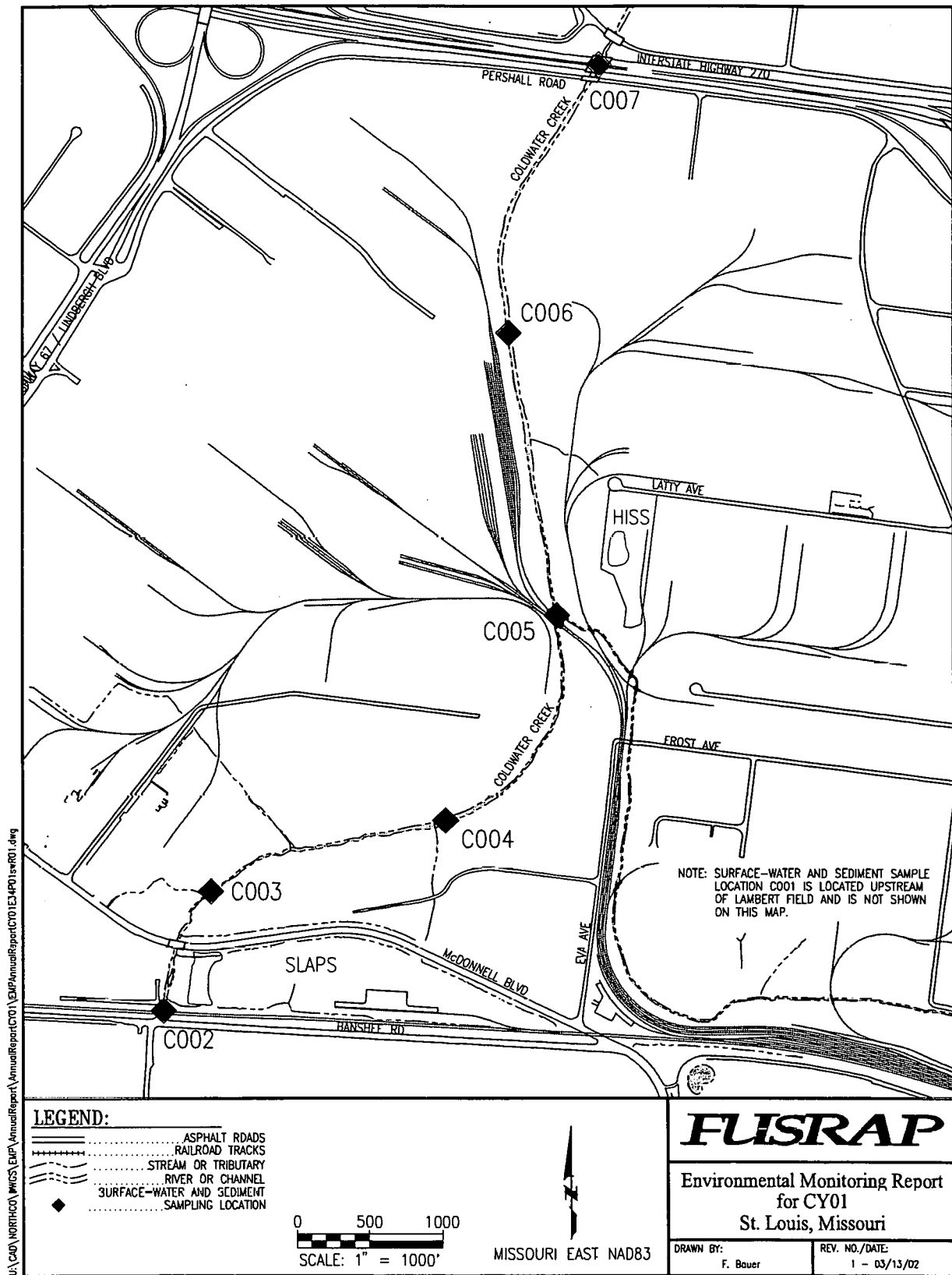


Figure 3-4. Surface-water and Sediment Sampling Locations at Coldwater Creek

Table 3-12. Radiological Results for CY01 Coldwater Creek Sediment Sampling

First Sampling Event (March CY01)								
Radionuclide	Unit	Background ^a	Station/Result					
			EMP C002	EMP C003	EMP C004	EMP C005	EMP C006	EMP C007
Date of Sampling			3/27/01	3/27/01	3/27/01	3/27/01	3/26/01	3/26/01
Americium-241	pCi/g	N/A	0.02 ¹	0.08 ¹	0.02 ¹	0.05 ¹	0.04 ¹	0.04 ¹
Actinium-227	pCi/g	N/A	0.07 ¹	0.07 ¹	0.13 ¹	0.34 ¹	0.15 ¹	0.14 ²
Cesium-137	pCi/g	0	0.02 ¹	0.02 ¹	0.02 ¹	0.06 ²	0.04 ¹	0.02 ¹
Potassium-40	pCi/g	15.60	5.74 ²	9.46 ²	14.44 ²	13.75 ²	13.72 ²	14.43 ²
Protactium-231	pCi/g	N/A	0.30 ¹	0.43 ¹	0.56 ¹	0.74 ¹	0.60 ¹	0.64 ¹
Radium-226	pCi/g	4.70	0.50 ²	0.68 ²	0.85 ²	1.44 ²	0.93 ²	1.08 ²
Radium-228	pCi/g	1.30	0.18 ²	0.41 ²	1.02 ²	0.98 ²	0.79 ²	0.95 ²
Thorium-228	pCi/g	1.30	0.41 ³	0.98 ³	1.75 ³	1.10 ³	1.13 ³	1.93 ³
Thorium-230	pCi/g	2.20	0.48 ³	3.61 ³	2.60 ³	18.75 ²	4.02 ³	5.75 ²
Thorium-232	pCi/g	1.20	0.26 ³	0.67 ³	1.47 ³	0.98 ²	1.19 ³	0.95 ²
Uranium-235	pCi/g	N/A	0.07 ¹	0.09 ²	0.11 ¹	0.16 ¹	0.13 ¹	0.13 ¹
Uranium-238	pCi/g	4.30	1.41 ¹	1.93 ¹	2.40 ¹	3.03 ¹	2.56 ¹	2.50 ¹
Second Sampling Event (October CY01)								
Radionuclide	Unit	Background ^a	Station/Result					
			EMP C002	EMP C003	EMP C004	EMP C005	EMP C006	EMP C007
Date of Sampling			10/2/01	10/2/01	10/2/01	10/2/01	10/2/01	10/2/01
Americium-241	pCi/g	N/A	0.12 ¹	0.21 ¹	0.01 ¹	0.14 ¹	0.19 ¹	0.20 ¹
Actinium-227	pCi/g	N/A	0.09 ¹	0.15 ¹	0.07 ¹	0.11 ¹	0.14 ¹	0.16 ¹
Cesium-137	pCi/g	0	0.02 ¹	0.02 ¹	0.01 ¹	0.02 ²	0.02 ¹	0.02 ¹
Potassium-40	pCi/g	15.60	4.44 ²	13.82 ²	14.62 ²	6.11 ²	13.93 ²	11.96 ²
Protactium-231	pCi/g	N/A	0.47 ¹	0.69 ¹	0.32 ¹	0.52 ¹	0.62 ¹	0.73 ¹
Radium-226	pCi/g	4.70	0.06 ²	0.84 ²	0.99 ²	0.73 ²	0.90 ²	0.99 ²
Radium-228	pCi/g	1.30	0.15 ²	0.82 ²	0.96 ²	0.23 ²	0.95 ²	0.73 ²
Thorium-228	pCi/g	1.30	0.37 ³	0.96 ³	1.28 ³	0.38 ³	1.27 ³	1.45 ³
Thorium-230	pCi/g	2.20	0.83 ³	1.85 ³	1.61 ³	3.23 ³	2.83 ³	9.30 ³
Thorium-232	pCi/g	1.20	0.15 ²	0.93 ³	0.96 ²	0.29 ³	1.50 ³	1.13 ³
Uranium-235	pCi/g	N/A	0.10 ¹	0.16 ¹	0.08 ¹	0.12 ¹	0.15 ²	0.17 ¹
Uranium-238	pCi/g	4.30	1.04 ¹	1.72 ¹	0.99 ²	1.31 ²	1.43 ¹	1.72 ¹

^a Background concentrations derived from Feasibility Study for the North County Site

¹ Not detected. Data results listed as minimum detection limit.

² Data results for Gross Gamma activity.

³ Data results for Gross Alpha activity.

N/A Not Applicable or not determined for respective parameter

Table 3-13. Comparison of Historical Radiological Parameter Sediment Results for Coldwater Creek

Historical Location	Radionuclide	Units	03/92	09/92	04/93	10/93	04/94	10/94	04/95	10/95	04/96	10/96	05/97	04/98	06/99	03/00	05/00	03/01 ⁴	10/01 ⁴
C002	Total Uranium	pCi/g	6.24 ¹	2.60	3.70	1.70	2.70	<2.40	3	<1.73	1.51	2.12	1.63	2.75	<15.70	<2.19	<2.53	<1.48	<1.14
C002	Radium-226	pCi/g	1	1.10	0.85	1.50	0.95	1.80	<1.20	<0.01	1.60	0.83	4.87	0.96	0.51	0.60 ²	0.56 ²	0.50 ²	0.06 ²
C002	Radium-228	pCi/g	NS	NS	NS	NS	<0.76	NS	NS	NS	1.32	0.43	0.78	1.22	0.21	0.23 ²	0.21 ²	0.18 ²	0.15 ²
C002	Thorium-228	pCi/g	NS	NS	NS	NS	NS	NS	NS	0.69	1.32	0.43	0.78	1.22	0.25	0.23 ²	0.21 ²	0.41 ³	0.37 ³
C002	Thorium-230	pCi/g	0.88	0.57	<0.38 ³	0.70	2.04	<1.60	2.20	0.95	2.17	0.92	1.48	1.61	1.11	0.97	0.50	0.48 ³	0.83 ³
C002	Thorium-232	pCi/g	NS	NS	0.38	0.94	1.10	0.64	0.96	0.37	0.86	0.42	0.71	1.19	0.50	0.42	0.21 ²	0.26 ³	0.15 ²
C003	Total Uranium	pCi/g	6.28	3.30	4.70	1.80	2.80	3.40	3.20	<2.81	3.14	3.14	2.67	3.25	<16.4	<3.10	<2.85	<2.02	<1.88
C003	Radium-226	pCi/g	0.56	0.90	0.62	0.63	0.98	2	<1.80	<0.22	0.54	1.06	1.11	1.54	<0.59	2	0.70 ²	0.68 ²	0.84 ²
C003	Radium-228	pCi/g	NS	NS	NS	NS	0.61	NS	NS	NS	0.65	1.12	0.76	1.02	0.32	0.38 ²	0.40 ²	0.41 ²	0.82 ²
C003	Thorium-228	pCi/g	NS	NS	NS	NS	NS	NS	NS	0.42	0.65	1.12	0.76	1.02	1.09	0.78	0.48	0.98 ³	0.96 ³
C003	Thorium-230	pCi/g	2.82	3.30	2.50	0.87	2.43	4.60	6.20	4.61	6.10	5.09	2.15	3.50	5.98	1.81	1.41	3.61 ³	1.85 ³
C003	Thorium-232	pCi/g	NS	NS	<0.41	<0.39	0.59	1.10	0.74	0.40	0.81	1.31	0.62	0.87	0.48	0.32	0.75	0.67 ³	0.93 ³
C004	Total Uranium	pCi/g	7.90	3.30	3.30	1.90	5.10	2.90	3.30	3.95	2.47	2.51	2.32	3.30	<16.2	<2.94	<2.44	<2.51	<1.07
C004	Radium-226	pCi/g	0.72	0.88	0.78	0.95	1.20	2.10	<1.50	1.63	0.64	1.14	1.66	1.57	<0.61	0.81 ²	0.8 ²	0.85 ²	0.99 ²
C004	Radium-228	pCi/g	NS	NS	NS	NS	1.10	NS	NS	NS	0.54	0.68	0.40	0.96	<0.33	0.23 ²	0.21 ²	1.02 ²	0.96 ²
C004	Thorium-228	pCi/g	NS	NS	NS	NS	NS	NS	NS	0.46	0.54	0.68	0.40	0.96	<1.02	1.07	0.98	1.75 ³	1.28 ³
C004	Thorium-230	pCi/g	21.90	4	3	2.50	3.50	3.50	4.40	2.60	3.61	2.59	1.51	3.34	3.02	2.45	1.11	2.60 ³	1.61 ³
C004	Thorium-232	pCi/g	NS	NS	0.72	<0	1.30	0.54	0.81	0.44	0.72	0.49	0.36	0.96	<1.02	0.55	0.21 ²	1.47 ³	0.96 ²
C005	Total Uranium	pCi/g	5.93	3.20	5.20	17.20	2.20	3.10	2.70	<1.98	2.76	11.62	2.33	10.23	<17	<5.72	<3.6	<3.19	<1.43
C005	Radium-226	pCi/g	1.40	0.84	1.90	0.76	1.30	3.70	<1.70	2.77	2.72	5.66	3.29	5.14	0.67	23.47	1.52 ²	1.44 ²	0.73 ²
C005	Radium-228	pCi/g	NS	NS	NS	NS	1.10	NS	NS	NS	1.02	1	1.70	1.17	0.31	0.91 ²	0.78 ²	0.98 ²	0.23 ²
C005	Thorium-228	pCi/g	NS	NS	NS	NS	NS	NS	NS	1.39	1.02	1	1.70	1.17	0.51	1.12	1.07	1.10 ³	0.38 ³
C005	Thorium-230	pCi/g	5.33	2.40	4	14.50	1.76	10.10	12.70	1.34	7.23	229.70	8.12	201.20	<2.32	17.14	12.47	18.75 ²	3.23 ³
C005	Thorium-232	pCi/g	NS	NS	0.92	<0.61	1.10	0.84	1.40	0.93	0.90	1.65	0.75	1.63	<0.69	0.61	1.14	0.98 ²	0.29 ³
C006	Total Uranium	pCi/g	6.56	2.80	4.40	1.70	2.50	3.10	2.70	<2.74	2.54	2.80	1.95	2.18	<17	<4.92	0.19 ²	<2.69	<1.58
C006	Radium-226	pCi/g	1.30	0.81	0.91	0.84	1.40	1.90	<1.40	1.34	0.89	1.50	1.93	1.88	0.35	0.98 ²	0.97 ²	0.93 ²	0.90 ²
C006	Radium-228	pCi/g	NS	NS	NS	NS	1.50	NS	NS	NS	0.89	1.44	1.04	0.96	0.26	1.10	0.96 ²	0.79 ²	0.95 ²
C006	Thorium-228	pCi/g	NS	NS	NS	NS	NS	NS	NS	1.32	0.89	1.44	1.04	0.96	1.09	1.26	1	1.13 ³	1.27 ³
C006	Thorium-230	pCi/g	1.42	0.78	<0	0.49	1.57	2.80	2.70	1.65	1.83	3.48	1.41	2.21	<2.04	1.58	1.46	4.02 ³	2.83 ³
C006	Thorium-232	pCi/g	NS	NS	1.30	0.93	1.50	0.86	1.50	0.96	1.30	1.25	1.34	1.36	0.35	1.16	1.04	1.19 ³	1.50 ³
C007	Total Uranium	pCi/g	7.20	2.90	4.40	5.10	2.30	5.50	3	<3.43	3.23	5.04	2.88	3.84	<19.9	<2.43	<2.09	<2.63	<1.99
C007	Radium-226	pCi/g	1.30	0.62	0.88	1.70	0.95	1.50	<1.60	1.03	1.75	1.43	1.18	2.16	0.96	0.72 ²	0.68 ²	1.08 ²	0.99 ²
C007	Radium-228	pCi/g	NS	NS	NS	NS	0.69	NS	NS	NS	0.81	1.18	0.94	0.94	0.95	0.23 ²	0.25 ²	0.95 ²	0.73 ²
C007	Thorium-228	pCi/g	NS	NS	NS	NS	NS	1.20	NS	<0.78	0.81	1.18	0.94	0.94	1.31	0.62	0.86	1.93 ³	1.45 ³
C007	Thorium-230	pCi/g	11.60	0.85	1.40	44.96	2.68	31.40	2.90	4.53	5.64	32.38	4.52	23.80	8.24	4.82	1.86	5.75 ²	9.30 ³
C007	Thorium-232	pCi/g	<0.00	<0.00	0.56	<0.00	<0.64	1.20	0.86	0.82	0.76	1.12	1.24	1.07	1.70	0.65	0.25 ²	0.95 ²	1.13 ³

¹ Results listed in table are reported as gross alpha activity unless stated otherwise.

² Results are reported for gross gamma activity.

³ Results reported as less than (<) were non-detects and number shown is minimum detection limit or activity.

⁴ Total Uranium is equal to the sum of the concentrations of uranium isotopes. (Source: FR/ Vol. 65, No. 236: Part II of 40 CFR Part 9, 141 and 142)

NS Not included in analysis.

Table 3-14 summarized the chemical results for CY01 Coldwater Creek sediment sampling events. Sediments samples were analyzed for the chemicals listed in Table 2-3 of the EMIFY02 (USACE, 2001a). Chemical concentration data for Coldwater Creek sediments are compared to the sediment sampling results for each location and with respect to North County background concentrations. The background concentrations considered for evaluation of sediment data were collected from the *Feasibility Study for the St. Louis North County Site* and are presented in EMIFY02 (USACE 2001c; USACE 2001b).

During CY01 sampling events, the background sediment criteria were exceeded for four inorganic and sixteen semi volatile organic analytes. Only one volatile organic analyte criterion methylene chloride, a common laboratory contaminant, was exceeded. Table 3-15 summarized the sampling results for those chemicals.

The results of Table 3-14 and Table 3-15 showed that for most cases (13 out of 21), the exceedance of chemical concentrations occurred at sampling station C007, which is the furthest downgradient from the St. Louis Sites (~3700 ft downstream of HISS) and they occurred during the October sampling events during CY01. The concentrations of those chemicals during October sampling event are significantly higher than those for March sampling event and previous sampling stations, respectively. In addition, the concentrations of calcium and magnesium exceeded their background level only at the background sampling station C002. Dibenzofuran and Naphthalene were detected at sampling stations C003. The remaining chemicals were detected at sampling stations 5 and 6.

Attempts have been taken to identify the potential sources for those chemicals. Areas around sampling stations 5, 6 and 7 are predominantly industrial. More than a dozen facilities that are permitted under the NPDES program discharge directly into the streams that flows into Coldwater Creek. Those industries might contribute to the maximum concentrations of those chemicals at those stations.

Attempts were made to co-correlate the concentrations of those chemicals in the surface water with the concentrations of the same in the sediments at the same location. For most cases, the sampling of surface water at those stations could not detect the presence of those chemicals. When they detected the chemicals, the concentrations of the chemicals were below their background levels. Hence, no correlation could be made between surface water results with sediment results even though the samplings were conducted at the same location.

Table 3-14. Chemical Results for CY01 Coldwater Creek Sediment Sampling

Analyte	Background ²	Units	Station/Result											
			EMP C002		EMP C003		EMP C004		EMP C005		EMP C006		EMP C007	
Date of Sampling (CY01)			3/27	10/2	3/27	10/2	3/27	10/2	3/27	10/2	3/26	10/2	3/26	10/2
Aluminum	51,000	mg/kg	738	1,910	3,090	3,040	9,590	7,820	7,680	1,390	7,090	8430	8,980	8,080
Arsenic	13	mg/kg	2.50	4.30	4.60	5.20	9.10	2 ¹	9.40	8.30	7.20	2.40	11.40	12
Barium	890	mg/kg	29	79	116	105	252	37.70	282	2010	170	0.09	275	228
Boron	75.9	mg/kg	16.70	0.60 ¹	1.5 ¹	0.71 ¹	1.70 ¹	0.27 ¹	1.90 ¹	0.67 ¹	2.10 ¹	0.80 ¹	1.60 ¹	0.80 ¹
Calcium	116,000	mg/kg	212,000	145,000	96,300	70,900	12,200	3,780	22,300	85,000	27,000	4,800	16,000	42,600
Chromium	140	mg/kg	5.10	21.80	12.80	24.20	15.30	14	32.30	15.50	56.40	13.70	60.40	47
Cobalt	31	mg/kg	2.50	7.10	4.90	6.20	13.80	6.60	14.90	10	8	6	17.60	15.10
Copper	330	mg/kg	5.80	35.80	16.40	23	19	16.90	45.70	94.90	68.60	13.20	50.20	38.20
Iron	42,000	mg/kg	3550	22,200	10,600	13,200	20,000	11,500	18,400	15,300	16,000	16,700	23,400	20,100
Lead	380	mg/kg	13.50	10.80	28.70	79.50	22	11.60	72.90	48.30	99.30	19.70	59.30	100
Magnesium	2,100	mg/kg	12,400	21,100	11,200	6,760	3,550	3,230	4320	11,000	5,990	3,250	4,590	6,710
Manganese	3,200	mg/kg	375	1,600	868	647	1,470	189	1220	1,790	544	246	1,740	1,370
Potassium	15,000	mg/kg	4,860	404	502	472	1,050	546	934	265	947	604	775	690
Sodium	10,000	mg/kg	395	156	484	226	506	142	654	178	544	123	608	170
Thallium	0	mg/kg	0.30 ¹	0.42	0.18 ¹	0.32 ¹	0.20 ¹	0.32 ¹	0.23 ¹	1.20	0.96	0.75	1.60	0.46
Total Uranium	8.69	mg/kg	2.50 ¹	10.30	3 ¹	6.30 ¹	3.30 ¹	6.40 ¹	21.70 ¹	6 ¹	4.09 ¹	7.10 ¹	3.20 ¹	7.10 ¹
Vanadium	99	mg/kg	6.80	15.90	13.50	13.50	29.70	17.80	26.80	14.30	24.70	18.30	36	29.10
Zinc	1,370	mg/kg	29.10	44.80	63.20	101	57.30	61.60	222	1,080	211	53.30	93.90	171
Anthracene	200	µg/kg	370 ¹	370 ¹	450 ¹	880 ¹	500 ¹	450 ¹	570 ¹	2,100	1,200 ¹	500 ¹	480 ¹	3,000
Benzo(a)anthracene	2,300	µg/kg	81	370 ¹	2,400	880 ¹	110	450 ¹	1,400	4,500	1,300	500 ¹	1,400	9,600
Benzo(b)fluoranthene	1,500	µg/kg	410	560	4,100	880 ¹	370	450 ¹	7,100	4,500	7,100	500 ¹	3,400	11,000
Benzo(k)fluoranthene	1,400	µg/kg	270	680	3000	880 ¹	290	450 ¹	6,900	6,100	6,500	500 ¹	1,400	14,000
Benzo(g,h,i)perylene	1,800	µg/kg	420	370 ¹	4,100	880 ¹	350	450 ¹	6,500	2,500	7,700	500 ¹	350	6,000
Benzo(a)pyrene	1,700	µg/kg	400	400	5,100	880 ¹	390	450 ¹	7,100	4,200	6,900	500 ¹	3,700	9,400
Bis(2-ethylhexyl) phthalate	560	µg/kg	230	370 ¹	490	880 ¹	500 ¹	450 ¹	1,700	620	5,800	500 ¹	510	2,200
Chrysene	2,400	µg/kg	610	530	610	880 ¹	480	450 ¹	9,700	4,900	9,900	500 ¹	4,600	11,000
Dibenzo (a,h) anthracene	0	µg/kg	370 ¹	370 ¹	450 ¹	880 ¹	500 ¹	450 ¹	570 ¹	2,100 ¹	1,200 ¹	500 ¹	580	5,000 ¹
Dibenzofuran	86	µg/kg	370 ¹	370 ¹	610	880 ¹	500 ¹	450 ¹	270	420 ¹	310	500 ¹	270	5,000 ¹
Fluoranthene	7,100	µg/kg	1400	1,100	11,000	880 ¹	1,100	450 ¹	15,000	12,000	17,000	500 ¹	11,000	26,000
Fluorene	200	µg/kg	370 ¹	370 ¹	1200	880 ¹	500 ¹	450 ¹	440	920	510	500 ¹	490	1,200
Indeno (1,2,3-cd) pyrene	1,500	µg/kg	240	370 ¹	2,700	880 ¹	260	450 ¹	6,000	2,100	5,700	500 ¹	1,800	5,400
Naphthalene	40	µg/kg	370 ¹	370 ¹	210	440 ¹	500 ¹	450 ¹	570 ¹	420 ¹	130	500 ¹	98	500 ¹
Phenanthrene	5,700	µg/kg	700	550	11,000	880 ¹	530	450 ¹	9,000	8,700	8,900	500 ¹	710	17,000
Pyrene	4,000	µg/kg	1100	910	13,000	880 ¹	720	450 ¹	17,000	17,000	16,000	500 ¹	5,000	38,000
Methylene Chloride	30	µg/kg	5.70 ¹	5.60 ¹	6.90 ¹	7.60	7.60 ¹	6.80 ¹	8.70 ¹	6.40 ¹	190	7.50 ¹	140	7.50 ¹

¹ Not Detected. Data listed as detection limit

² Background concentrations derived from North County Feasibility Study.

Table 3-15. Chemicals that exceeded Background Concentrations

Type of Chemical	Name of Analyte	Detected Stations	Stations, sample data exceeded background	Maximum Concentration		
				Value	Unit	Station
Inorganic	Barium	All Stations	C005	2,010	mg/kg	C005
	Calcium	All Stations	C002	212,000	mg/kg	C002
	Magnesium	All Stations	All Stations	12,400	mg/kg	C002
	Thallium	C002, C005 - C007	C002, C005 - C007	1.6	mg/kg	C007
Semi Volatile Organics	Anthracene	C005, C007	C005, C007	3,000	µg/kg	C007
	Benzo(a)anthracene	All Stations	C003, C005, C007	9,600	µg/kg	C007
	Benzo(b)fluoranthene	All Stations	C003, C005 - C007	11,000	µg/kg	C007
	Benzo(k)fluoranthene	All Stations	C003, C005 - C007	14,000	µg/kg	C007
	Benzo(g,h,i)perylene	All Stations	C003, C005 - C007	7,700	µg/kg	C006
	Benzo(a)pyrene	All Stations	C003, C005 - C007	9,400	µg/kg	C007
	Bis(2-ethylhexyl)phthalate	All Stations	C005, C006, C007	5,800	µg/kg	C006
	Chrysene	All Stations	C005, C006, C007	11,000	µg/kg	C007
	Dibenzo(a,h)anthracene	C007	C007	580	µg/kg	C007
	Dibenzofuran	C003, C005 - C007	C003, C005 - C007	610	µg/kg	C003
	Fluoranthene	All Stations	C003, C005 - C007	26,000	µg/kg	C007
	Fluorine	C003, C005 - C007	C003, C005 - C007		µg/kg	C007
	Indeno(1,2,3-cd)pyrene	All Stations	C003, C005 - C007	6,000	µg/kg	C005
	Naphthalene	C003, C006, C007	C003, C006, C007	210	µg/kg	C003
	Phenanthrene	All Stations	C003, C005 - C007	17,000	µg/kg	C007
	Pyrene	All Stations	C003, C005 - C007	38,000	µg/kg	C007
Organic	Methylene Chloride	C003, C005, C007	C006, C007	140	µg/kg	C007

4.0 EVALUATION OF ENVIRONMENTAL MONITORING DATA FOR GROUND WATER

The ground-water monitoring activities conducted under the EMP during CY01 are described in this section. The SLS sampled during CY01 are the HISS, SLAPS, and the SLDS. Ground water was sampled following a protocol for individual wells and analytes, and analyzed for various radiological constituents, organic compounds, and inorganics. In addition, field parameters, or indicator parameters, were measured continuously during purging of the wells before sampling. The ground-water field parameter results for CY01 sampling at HISS, SLAPS, and SLDS are presented in Appendix D, Table D-1. Summary tables providing the SLS ground-water analytical sampling results for CY01 are found in Appendix D, Table D-2. Ground-water levels were taken quarterly for all wells.

Guidelines for evaluating ground-water data are derived from various environmental regulatory programs. At SLAPS and HISS the regulatory-based guidelines considered for evaluation of ground-water data are the MCLs and the SMCLs of the Safe Drinking Water Act (SDWA) and ground-water quality criteria promulgated by the MDNR under 10 CSR 20-7 (USACE, 2001b). In addition, ground water background levels expected to be established in the coming North County Feasibility Study (FS) are compared to the sampling results to provide an indication of the nature and extent of contamination in ground water at the SLAPS and HISS. Ground-water sampling results for SLDS are compared to the SDWA MCLs and to the investigative limits established in the SLDS ROD.

4.1 HISS

The stratigraphic units present at HISS are shown in the stratigraphic column for SLAPS and HISS presented in Figure 4-1. Fill and topsoil (Unit 1) overlie Pleistocene loess (Unit 2) and fine-grained glacio-lacustrine deposits. The glacio-lacustrine 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 HISS but found directly overlying Unit 6 under portions of SLAPS.

The stratigraphy beneath HISS is similar to that found at SLAPS with the exception of a Pennsylvanian shale layer which is found underlying portions of SLAPS. The shale zone HZ-D (Unit 5) is absent at HISS. Four hydrostratigraphic zones (HZ-A through HZ-C, and HZ-E) have been identified at HISS. 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 highly impermeable clay (Subunit 3M). HZ-C consists of silty clay and clayey silt deposits that make up the stratigraphic Subunit 3B and Unit 4. The Pennsylvanian limestone bedrock is defined as HZ-E. HZ-E is the protected aquifer for the site. As a result of its very low permeability, Subunit 3M of HZ-B limits vertical ground-water movement between HZ-A and the deep ground-water zones (HZ-C and HZ-E) at HISS.

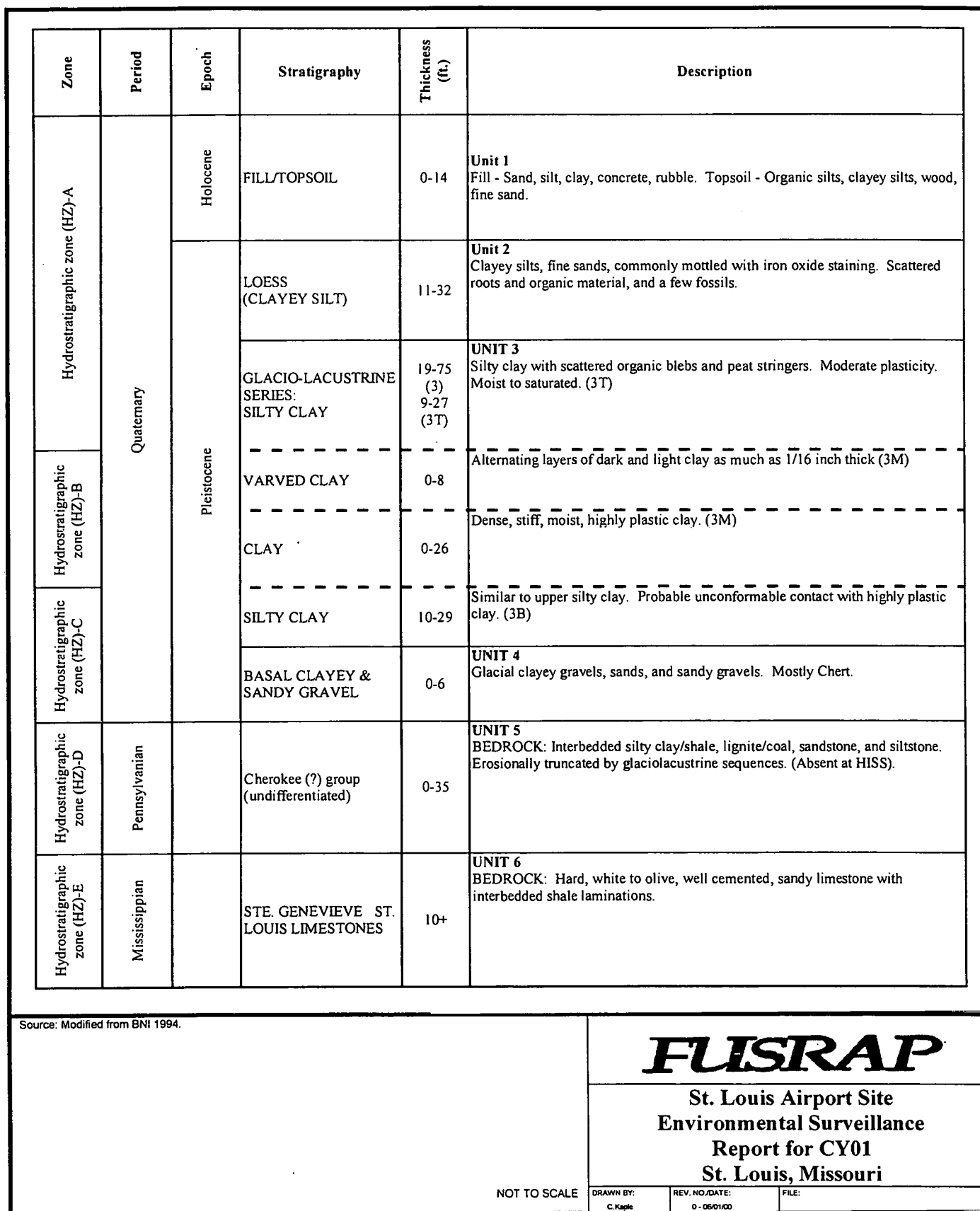


Figure 4-1. Generalized Stratigraphic Column for SLAPS and HISS

The shallow ground-water Unit HZ-A (comprised of Units 1, 2 and 3T) at HISS is of poor quality and low yield. Based on EPA's guidance document "*Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy*", this unit falls under the Class IIIA ground-water designation (EPA, 1988). Class IIIA includes ground water that is not a source of drinking water, is of limited beneficial use, and feeds a surface-water body (e.g., the Missouri River) that could be used for drinking water. The limestone bedrock aquifer (HZ-E) is the aquifer of concern at HISS. Under EPA's ground water classification system, HZ-E meets the requirements for a Class IIB designation. Class IIB denotes that the ground water is a potential source of drinking water but not a current source. Although use of ground water as a drinking water source is not likely at HISS, SDWA MCLs and SMCLs are used here for comparison purposes to determine if there are significant concentrations of site contaminants in ground water.

A total of twenty-four (24) ground-water monitoring wells have been installed at HISS from CY79 to CY01. The EMP well network for HISS is identified in Figure 4-2. With the exception of monitoring wells HISS-05D and HW23, which are screened in HZ-C, all of the monitoring wells at HISS are screened in HZ-A. Table 4-1 provides a summary of the hydrostratigraphic zone (HZ) information for HISS ground-water monitoring wells.

Table 4-1. Screened HZs for HISS Ground-water Monitoring Wells

Well ID	Screened Hydrostratigraphic Zone(s)
HISS-01	HZ-A
HISS-02*	HZ-A
HISS-03*	HZ-A
HISS-04*	HZ-A
HISS-05**	HZ-A
HISS-05D	HZ-C
HISS-06	HZ-A
HISS-07	HZ-A
HISS-08*	HZ-A
HISS-09*	HZ-A
HISS-10	HZ-A
HISS-11	HZ-A
HISS-12*	HZ-A
HISS-13*	HZ-A
HISS-14	HZ-A
HISS-15	HZ-A
HISS-16	HZ-A
HISS-17S	HZ-A
HISS-18S	HZ-A
HISS-19S	HZ-A
HISS-20S	HZ-A
HW21	HZ-A
HW22	HZ-A
HW23	HZ-C

* Decommissioned wells.

** HISS-05 was decommissioned in October CY01.

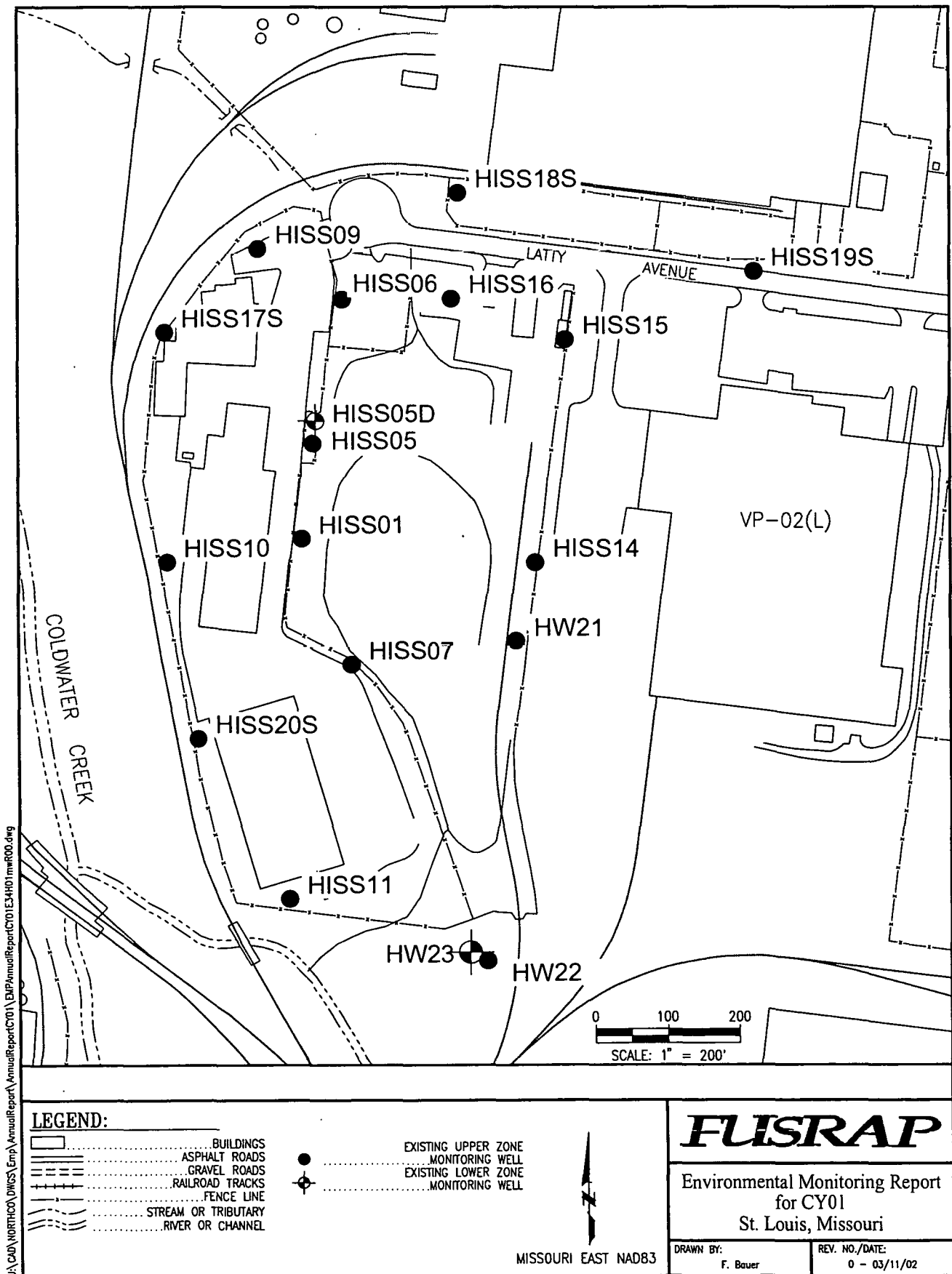


Figure 4-2. Ground-water Monitoring Well Locations at the HISS

4.1.1 Evaluation of the CY01 EMP Ground-Water Sampling at HISS

Ground-water sampling was conducted at eighteen (18) ground-water monitoring wells at HISS during CY01. First quarter sampling was conducted from January 17 to March 20; second quarter sampling from May 10 to May 31; third quarter sampling from August 23 to August 29; and fourth quarter sampling from October 25 through October 29. The analytical results were compared to regulatory limits (MCLs or SMCLs) and to background concentrations expected to be established in the future North County FS. For discussion purposes, the ground-water analytical data acquired in the CY01 sampling events at HISS are presented separately for the upper (HZ-A) and lower (HZ-C) ground-water zones.

HZ-A Ground Water

Table 4-2 summarizes the results of the CY01 ground-water sampling for contaminants exceeding MCLs or SMCLs in HZ-A ground-water at HISS. Summary tables presenting the results for all analytes are included in Appendix D. Seven inorganics (arsenic, iron, manganese, nitrate, selenium, sulfate, and thallium) were detected at concentrations exceeding MCLs or SMCLs in HZ-A ground water. Based on the number of exceedances, the most widely occurring of these inorganics were iron, manganese, nitrate, and selenium. Iron was detected above the MCL of 300 $\mu\text{g/L}$ in four HZ-A wells (HISS-11, HISS-18S, HISS-19S, and HW21). The maximum detected concentration was 13,600 $\mu\text{g/L}$, detected in the third quarter sample from HISS-19S. Manganese exceeded its SMCL of 50 $\mu\text{g/L}$ in nine HZ-A HISS wells during CY01, but only two of these wells (HISS-11 and HISS-19S) had concentrations that exceeded the expected HZ-A background concentration of 1,580 $\mu\text{g/L}$. The highest concentration of manganese (4,330 $\mu\text{g/L}$) was detected in the third quarter sample from HISS-19S. Nitrates were detected above the MCL of 10 mg/L in ten of the sixteen HZ-A wells monitored during CY01. In general, the highest concentrations of nitrates were detected in wells located along the eastern edge of HISS. The maximum nitrate concentration detected was 1,890 mg/L in the third quarter sample from HW21. Selenium was detected above its MCL of 50 $\mu\text{g/L}$ in seven HZ-A wells (HISS-01, HISS-06, HISS-07, HISS-14, HISS-17S, HISS-20S, and HW21). The maximum concentration (502 $\mu\text{g/L}$) was detected in the second quarter sample from HISS-06, located near the northwest corner of HISS.

The remaining three inorganics (arsenic, sulfate, and thallium) were found to exceed MCLs in only a limited number of well samples. Arsenic concentrations were detected once above the MCL (10 $\mu\text{g/L}$) in one HZ-A well, HISS-19S. The maximum arsenic concentration was 183 $\mu\text{g/L}$, detected in the third quarter sample from HISS-19S. HISS-19S is located northeast (downgradient) of HISS, adjacent to Latty Avenue the source of the elevated arsenic in this well is unknown. Arsenic was detected in three other HZ-A wells, HISS-11, HISS-16, and HISS-18S, but the concentrations were well below the MCL. Sulfate slightly exceeded its SMCL of 250 mg/L in one sample (310 mg/L), during the second quarter from monitoring well HISS-20S. The maximum detected concentration was below the expected HZ-A background concentration of 376 mg/L. Thallium was detected at a concentration of 2.3 $\mu\text{g/L}$ in the third quarter sample from monitoring well HISS-01. This level only slightly exceeds the thallium MCL of 2 $\mu\text{g/L}$.

Table 4-2. Analytes Exceeding MCLs or SMCLs in HZ-A Ground Water at HISS in CY01 (Unfiltered Data)

Chemical	Station ¹	MCL or SMCL	Units	Minimum Detected	Maximum Detected	Mean Detected	# Detects > MCL or SMCL	Frequency of Detection
Arsenic	HISS-19S	10	µg/L	183	183	183	1	1/1
Benzene	HISS-11	5	µg/L	251	251	251	1	1/1
Iron	HISS-11	300	µg/L	565	565	565	1	1/1
	HISS-18S	300	µg/L	990	990	990	1	1/1
	HISS-19S	300	µg/L	13,600	13,600	13,600	1	1/1
	HW21	300	µg/L	723	2,510	1,616.5	2	2/2
Manganese	HISS-11	50	µg/L	2,080	2,080	2,080	1	1/1
	HISS-14	50	µg/L	193	193	193	1	1/1
	HISS-15	50	µg/L	125	142	133.5	2	2/2
	HISS-17S	50	µg/L	22.80	320	216	3	4/4
	HISS-18S	50	µg/L	466	466	466	1	1/1
	HISS-19S	50	µg/L	4,330	4,330	4,330	1	1/1
	HISS-20S	50	pCi/L	23.3	178	94.3	2	4/4
	HW21	50	pCi/L	933	1,170	1,051.5	2	2/2
	HW22	50	pCi/L	35.8	117	76.4	1	2/2
Nitrate	HISS-01	10	mg/L	246	384	315	2	2/2
	HISS-06	10	mg/L	221	221	221	1	1/1
	HISS-07	10	mg/L	168	168	168	1	1/1
	HISS-10	10	mg/L	59	59	59	1	1/1
	HISS-11	10	mg/L	35.8	35.8	35.8	1	1/1
	HISS-14	10	mg/L	1,670	1,670	1,670	1	1/1
	HISS-17S	10	mg/L	50.8	59.5	55.2	2	2/2
	HISS-20S	10	mg/L	262	385	323.5	2	2/2
	HW21	10	mg/L	1,890	1,890	1,890	1	1/1
	HW22	10	mg/L	98.2	98.2	98.2	1	1/1
Radium-226	HISS-20S	5	pCi/L	6.94	6.94	6.94	1	1/4
	HW22	5	pCi/L	7.72	7.72	7.72	1	1/2
Selenium	HISS-01	50	µg/L	246	287	259	4	4/4
	HISS-06	50	µg/L	502	502	502	1	1/1
	HISS-07	50	µg/L	391	391	391	1	1/1
	HISS-14	50	µg/L	307	307	307	1	1/1
	HISS-17S	50	µg/L	43.7	52.6	47.4	1	4/4
	HISS-20S	50	µg/L	92.1	137	110	4	4/4
	HW21	50	µg/L	48.5	52.6	50.55	1	2/2
Sulfate	HISS-20S	250	mg/L	238	310	274	1	2/2
Thallium	HISS-01	2	µg/L	2.3	2.3	2.3	1	1/4
TDS	HISS-01	500	mg/L	2,260	2,260	2,260	1	1/1
	HISS-05	500	mg/L	517	517	517	1	1/1
	HISS-06	500	mg/L	1,700	1,700	1,700	1	1/1
	HISS-07	500	mg/L	1,200	1,200	1,200	1	1/1
	HISS-09	500	mg/L	687	687	687	1	1/1
	HISS-10	500	mg/L	688	688	688	1	1/1
	HISS-11	500	mg/L	767	767	767	1	1/1
	HISS-14	500	mg/L	11,100	11,100	11,100	1	1/1
	HISS-15	500	mg/L	551	551	551	1	1/1

**Table 4-2. Analytes Exceeding MCLs or SMCLs in HZ-A Ground Water at HISS
in CY 01(Unfiltered Data) (Cont'd)**

Chemical	Station ¹	MCL or SMCL	Units	Minimum Detected	Maximum Detected	Mean Detected	# Detects > MCL or SMCL	Frequency of Detection
TDS (continued)	HISS-17S	500	mg/L	943	945	944	2	2/2
	HISS-18S	500	mg/L	734	734	734	1	1/1
	HISS-19S	500	mg/L	730	730	730	1	1/1
	HISS-20S	500	mg/L	2,330	2,640	2,485	2	2/2
	HW21	500	mg/L	13,000	13,000	13,000	1	1/1
	HW22	500	mg/L	1,360	1,360	1,360	1	1/1
Trichloroethene	HISS-09	5	µg/L	760	760	760	1	1/1
	HISS-17S	5	µg/L	54	110	87.8	4	4/4
Uranium ²	HISS-05	30	µg/L	262	262	262	1	1/1

¹ Table lists only those stations at which the analyte exceeds the MCL or SMCL.

² Total Uranium values were calculated from isotopic results in pCi/L and converted to µg/L using radionuclide specific activities.

Two organic compounds, benzene and TCE, were detected at concentrations exceeding their MCLs in HZ-A ground water at HISS. TCE was detected in two wells, HISS-17S and HISS-09, above its MCL of 5 µg/L. Ground-water data for HISS has historically shown elevated levels of TCE in these two wells. During CY01, the maximum concentration of 760 µg/L was detected in the second quarter sample from HISS-09. Concentrations in HISS-17S reached a maximum concentration of 110 µg/L in the second quarter CY01 sampling event. 1,2-dichloroethene (1,2-DCE), a TCE degradation product, was detected once in a single well at HISS. The concentration detected was 2.1 µg/L in the second quarter sample from HISS-09. The source of TCE and 1,2-DCE is not known. These contaminants are not related to MED/AEC stockpiled materials and therefore are not designated as COCs at HISS.

Xylene was detected in two wells at HISS (HISS-05 and HISS-11) but the concentrations detected (10 µg/L and 41 µg/L, respectively) are well below the MCL (10,000 µg/L). Activities at Futura may be a potential source of this organic compound. The organic compounds stored in underground storage tanks (USTs) at Futura included xylol (also known as dimethylbenzene), xylene, m-butyl acetate, methyl isobutyl ketone, and toluene. No other organics reportedly stored in USTs at Futura were detected in any HISS wells during CY01. The organic compound benzene (maximum concentration 251 µg/L) was detected in ground-water samples from HISS-11, located at the southern edge of the Futura property.

Total uranium (based on isotopic results) and Ra-226 were detected at levels above their MCLs. Total uranium exceeded the MCL of 30 µg/L in one HISS well, HISS-05, with the maximum concentration of 262 µg/L (calculated from isotopic results and specific activities) reported for the first quarter sample. The radionuclide Ra-226 slightly exceeded the combined Ra-226/Ra-228 MCL of 5 pCi/L as well as the expected HZ-A ground-water background concentration (0.91 pCi/L) in monitoring wells HISS-20S and HW22. The expected background values were established prior to installation of the upgradient well HW22 at HISS. The maximum activity concentration detected was 7.72 pCi/L, reported for the third quarter sample.

from well HW22. No MCL has been established for Th-230, but it was detected in HZ-A ground water above its expected background level of 1.18 pCi/L in 6 wells (HISS-14, HISS-17S, HISS-19S, HISS-20S, HW21, and HW22). The maximum activity concentration, 3.6 pCi/L, was detected in a third quarter sample from HISS-20S.

In summary, the data indicate there are significant localized impacts to the HZ-A ground water from site-related constituents. The most significant levels of inorganic contaminants were reported for monitoring wells HW21 (for iron, manganese, nitrates, and selenium) and HISS-19S (for arsenic, iron, and manganese). Radiological contaminants are generally present in HZ-A ground water at very low to non-detect levels, with the exception of some slightly elevated levels of Ra-226 and Th-230 detected in a few samples from wells located near the southern and western edges of the site. In addition, TCE was detected at significant levels in two HZ-A ground-water wells located northeast of the Futura structures. The source of this contamination is not known but is unlikely associated with FUSRAP related activities.

HZ-C Ground Water

Ground-water samples were collected from two deep (HZ-C) wells, HISS-05D and HW23, during CY01. HW23 is an upgradient well installed to assist in evaluating background conditions. Both wells were sampled twice (during the first and third quarter) during CY01. Concentrations of the analytes were compared to MCLs, SMCLs, and ground-water background concentrations expected to be established in the future North County Feasibility Study. Table 4-3 presents a list of those contaminants detected above MCLs or SMCLs in HZ-C ground-water samples collected at HISS during CY01. Table 4-4 presents a list of the contaminants detected above the expected background concentrations identified for HZ-C ground water at HISS.

Table 4-3. Analytes Exceeding MCLs or SMCLs in HZ-C Ground Water at HISS in CY01 (Unfiltered Data)

Chemical	Station	MCL or SMCL	Units	Minimum Detected	Maximum Detected	Mean Detected	# Detects> MCL or SMCL	Frequency of Detection
Arsenic	HISS-05D	10	µg/L	23.6	33.3	28.4	2	2/2
	HW23	10	µg/L	143	184	163.5	2	1/2
Iron	HISS-05D	300	µg/L	19,000	22,500	20,750	2	2/2
	HW23	300	µg/L	10,500	10,500	10,500	2	2/2
Manganese	HISS-05D	50	µg/L	204	282	243	2	2/2
	HW23	50	µg/L	160	177	168.5	1	1/2
Thallium	HISS-05D	2	µg/L	1.8	2.8	2.3	1	2/2
	HW23	2	µg/L	2.7	2.7	2.7	1	1/2

Table 4-4. Analytes Exceeding Background Concentrations in HZ-C Ground Water at HISS in CY01 (Unfiltered Data)

Chemical	Station ¹	Background (HZ-C)	Units	Minimum Detect	Maximum Detect	Mean Detect	# Detects > Background	Frequency of Detection
Arsenic	HW23	82.7	µg/L	143	184	164	2	2/2
Barium	HISS-05D	424	µg/L	559	582	570.5	2	2/2
Boron	HISS-05D	214	µg/L	256	281	268.5	2	2/2
	HW23	214	µg/L	267	269	268	2	2/2
Chloride	HISS-05D	1.21	mg/L	1.4	1.4	1.4	1	1/1
	HW23	1.21	mg/L	2	2	2	1	1/1
Iron	HISS-05D	15,200	µg/L	19,000	22,500	20,750	2	2/2
Magnesium	HISS-05D	42,600	µg/L	44,100	45,000	44,550	1	2/2
Manganese	HISS-05D	231	µg/L	204	282	243	1	2/2
Molybdenum	HISS-05D	0	µg/L	1.3	2.1	1.7	2	2/2
	HW23	0	µg/L	13.1	13.1	13.1	1	1/2
Nickel	HISS-05D	1.1	µg/L	6.3	8.4	7.4	2	2/2
	HW23	1.1	µg/L	5.4	5.4	5.4	1	1/2
Strontium	HISS-05D	742	µg/L	884	1,010	947	2	2/2
	HW23	742	µg/L	745	845	795	2	2/2
Thallium	HISS-05D	0	µg/L	21.8	2.8	2.3	2	2/2
	HW23	0	µg/L	2.7	2.7	2.7	1	1/2
Zinc	HISS-05D	54.9	µg/L	31.3	660	346	1	2/2
	HW23	54.9	µg/L	25.9	132	79	1	2/2

¹ Table lists only those stations at which the analyte exceeds the expected background concentration for HZ-C ground water.

Analytes exceeding MCLs or SMCLs in samples from both HZ-C wells include arsenic, iron, manganese, and thallium. The maximum concentrations of arsenic and iron also exceeded their expected background levels (82.7 µg/L and 15,200 µg/L, respectively). Arsenic was detected above its proposed MCL of 10 µg/L at a maximum concentration of 184 µg/L in the first quarter sample from HW23. Concentrations of arsenic in the other HZ-C well, HISS-05D, did not exceed expected background levels. Manganese was detected above the SMCL (50 µg/L) at a maximum concentration of 282 µg/L in the first quarter sample from HISS-05D. Manganese was also detected above its SMCL value in HW23, with levels ranging from 160 µg/L, detected in the first quarter sample, to a maximum of 177 µg/L, detected in the third quarter sample. Iron was detected above the SMCL level of 300 µg/L in both wells, with the maximum concentration (22,500 µg/L) detected in the first quarter sample from HISS-05D. Iron was detected at a concentration of 10,500 µg/L in both the first and third quarter sample from HW23, but this value is below the expected iron background level of 15,200 µg/L. Iron was detected above its expected background level in HISS-05D in all four quarterly samples. Thallium was detected at levels only slightly exceeding the MCL of 2 µg/L in both HISS-05D and HW23, with the maximum detected value 2.8 µg/L detected in the third quarter sample from HISS-05D.

Additional inorganics (barium, boron, chloride, magnesium, molybdenum, nickel, strontium, and zinc) were identified as present in HZ-C ground water at levels above the expected background levels. The range of detected concentrations above the expected background are listed in Table 4-4. Although barium exceeded the expected background in

HISS-05D (maximum concentration 582 $\mu\text{g/L}$), it was detected at levels well below the MCL of 2,000 $\mu\text{g/L}$. The levels of boron, chloride, molybdenum, and nickel detected in the deep wells generally only slightly exceeded their expected background levels. Strontium was detected at a maximum concentration of 1,010 $\mu\text{g/L}$ in the third quarter unfiltered sample from HISS-05D. It was detected at concentrations close to expected background levels in the first and third quarter samples from HW23 (745 $\mu\text{g/L}$ and 845 $\mu\text{g/L}$, respectively). Zinc was detected above expected background levels of 54.9 $\mu\text{g/L}$ in the HISS-05D third quarter sample and both the first and third quarter sample from HW23. The maximum concentration, 660 $\mu\text{g/L}$, was detected in the third quarter sample from HISS-05D; however, the split and duplicate samples for this sampling event indicated levels well below the expected background concentration of 54.9 $\mu\text{g/L}$. In addition, the first quarter result from this well, 31.3 $\mu\text{g/L}$, is also below the expected HZ-C background concentration for zinc. The radionuclides U-234, U-235, and U-238 were detected in one unfiltered water sample from a deep HISS well during CY01. The total uranium value (calculated from the isotopic results) for this sample (the first quarter sample from HW23) was 6.9 $\mu\text{g/L}$, which is well below the MCL value of 30 $\mu\text{g/L}$.

In summary, the HZ-C ground-water data from HISS indicate that some metals are present at elevated concentrations. In particular, arsenic, iron, and manganese had average concentrations that exceeded their MCLs or their expected background concentrations for the HZ-C ground-water zone. The source of the elevated arsenic, iron, and manganese concentrations in the HZ-C ground water is not known but is likely the result of natural conditions. The HZ-A ground-water contaminants selenium, nitrate, Ra-226, Th-230, and total uranium were not detected above their expected background levels or MCLs/SMCLs in HZ-C ground water. Additional sampling data will be collected for future evaluations to determine if site contaminants are significantly impacting HZ-C ground water at HISS.

4.1.2 Comparison of Historical Ground-Water Data at HISS

Ground-water sampling has been conducted at HISS from CY84 to the present. The most comprehensive ground-water monitoring program, involving sampling from eighteen monitoring wells, was conducted at the site in the Summer of CY97. The results for this baseline ground-water sampling event and results from subsequent sampling events were used to evaluate contaminant trends at HISS during the period from Summer CY97 to Winter CY01. Statistical analysis was used to assist in identifying trends for those contaminants for which a temporal pattern was suggested by their concentration plots.

4.1.2.1 Statistical Method

There are several statistical methods available to evaluate contaminant trends in ground water. These include the Mann-Kendall test, the Wilcoxon rank sum test, and the Seasonal Kendall test (EPA, 2000). The last two tests are applicable to data that may or may not exhibit seasonal behavior, but generally require larger sample sizes than the Mann-Kendall test. The Mann-Kendall test was selected for the purposes of this study because it can be used with small sample sizes and because a seasonal variation in concentrations was not indicated by the time versus concentration plots at HISS. The Mann-Kendall test is a non-parametric test and, as such, it is not dependent upon assumptions of distribution, missing data, or irregularly-spaced monitoring periods. In addition, data reported as less than the detection limit can be used

(Gibbons, 1994). The test can assess whether a time-ordered data set exhibits an increasing or decreasing trend, within a predetermined level of significance. While the Mann-Kendall test can use as few as four data points, often this is not enough data to detect a trend. Therefore, the test was performed only at those monitoring stations where data has been collected for at least six or more sampling events.

The Mann-Kendall test involves listing the sampling results in chronological order and computing all differences that may be formed between measurements and earlier measurements. 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; this result is used to compute the statistical significance of the test statistic (EPA, 2000).

To avoid biasing the Mann-Kendall test, all non-detect (ND) data values for a given compound were assigned a single value that was less than the detection limit, even when the detection limit varied over time. This was to make sure that any identified trends are data trends and not trends of laboratory detection limits. The value that was entered for ND results is one half of the detection limit from the round with the lowest detection limit for that compound. For data sets where more than 20% of the time-series data is ND, results from the Mann-Kendall trend test were not reported.

The Mann-Kendall test was performed using the Wisconsin Department of Natural Resources (WDNR) Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends. Because the Mann-Kendall test does not take into account the magnitude of scatter in the data, the spreadsheet provides an additional test if the Mann-Kendall test indicates no-trend is present. If no trend is identified, the coefficient of variation (CV) is used to determine if there is a lot of scatter in the data (non-stable condition) or if the amount of scatter is small (stable condition). The CV is equal to the standard deviation divided by the average. If the CV is less than or equal to one, the data is considered stable. If the CV is greater than one, the data is considered non-stable.

4.1.2.2 Results of Trend Analysis at HISS

Time versus concentration plots were prepared for each of the principal contaminants to look for changes in concentration at each monitoring location. Only unfiltered data was used and split samples and field duplicates were not included in the analysis. For those stations where sufficient data was available to evaluate trend, statistical trend analysis was conducted to assess whether concentrations of the principal ground-water contaminants (arsenic, selenium, and total uranium) 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 90%. The confidence level indicates the probability that the trend indicated is an actual trend in the data, rather than a result of the random nature of environmental data.

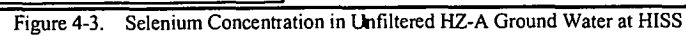
HZ-A Ground-Water

The evaluation of historical trends for the HZ-A ground-water unit focuses on those contaminants that will likely be identified as COCs in the future North County FS that exceeded reference levels (MCLs, SMCLs, and/or expected background levels) in ground-water samples collected during CY01. The soil COCs identified at HISS include antimony, arsenic, barium, cadmium, molybdenum, nickel, selenium, thallium, vanadium, and radionuclides in the uranium, thorium, and actinium series. The COCs detected at significant levels (above MCLs and/or expected background levels) in HZ-A ground water during CY01 include arsenic, selenium, Ra-226, Th-230, and total uranium. The time versus concentration plots shown in Figures 4-3 and 4-4 provide an overview of the temporal and spatial variability in the concentrations of two of the principal contaminants, selenium and total uranium. Statistical analysis was used to assist in identifying trends for those contaminants for which a temporal pattern was suggested by their concentration plots.

Inorganics

As shown in the time versus concentrations plots provided in Figure 4-3, the concentrations of selenium appear relatively constant with respect to the previous year's concentrations. Statistical trend analysis using the Mann-Kendall test was conducted to confirm if concentrations of selenium are increasing or decreasing over time. The test was performed on nine HZ-A wells (HISS-01, HISS-05, HISS-06, HISS-07, HISS-14, HISS-16, HISS-17S, HISS-20S, and HW21) that have exceeded the MCL (50 $\mu\text{g/L}$) at least once in the period from Summer CY97 through Winter CY01. As shown in Table 4-5, a significant trend in selenium concentrations (i.e., a trend with a confidence level greater than 90%) was observed for four of these wells. Two wells located near the western edge of HISS (HISS-17S, and HISS-20S) had decreasing concentrations over time and two wells located near the eastern edge (HISS-14 and HW21) had concentrations that were increasing. The cause of the increasing concentrations in these wells is not known but the increase appears to be of small magnitude. The remaining five wells exhibited no trend in concentrations.

Arsenic has been detected at consistently elevated levels in only a single well, HISS-19S. The arsenic data for Summer CY97 through Winter CY01 indicate that, with the exception of well HISS-19S, arsenic was generally at non-detectable levels in HZ-A ground water. The concentrations in HISS-19S are significantly elevated above the MCL of 10 $\mu\text{g/L}$, with the maximum concentration (183 $\mu\text{g/L}$) detected in the third quarter CY01 sample. Based on the trend analysis, the concentrations are increasing over time in this well (Table 4-6). The cause of the increasing arsenic concentrations in this well is not known.



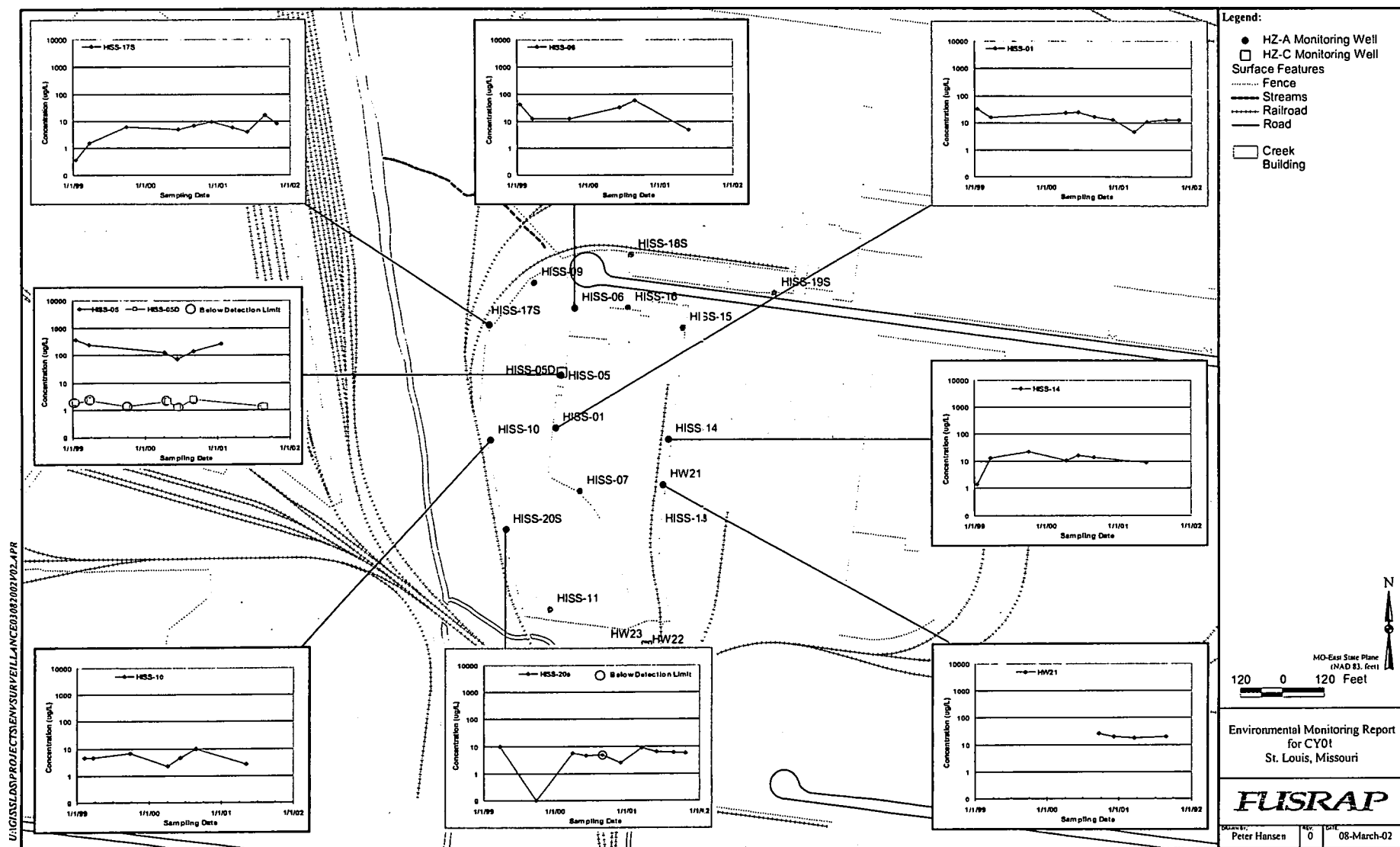


Figure 4-4. Total Uranium Concentration in Unfiltered HZ-A Ground Water at HISS

Table 4-5. Results of Mann-Kendall Trend Test for Selenium in HZ-A Ground Water at HISS

Event Number	Sampling Date (Approximate)	Station ^a								
		HISS-01	HISS-05	HISS-06	HISS-07	HISS-14	HISS-16	HISS-17S	HISS-20S	HW21
1	First Quarter CY99	241	43.5	45.2	415	194	13.8		240	
2	Second Quarter CY99	267	21.8	513	333	236	8.1	72.7	226	
3	Third Quarter CY99						58.8	75.4	151	
4	First Quarter CY00	239	161	520	422	260	0.9	55.6		
5	Second Quarter CY00	238	67.7	2.2	397	264	14.4	65.5	142	
6	Third Quarter CY00	1.2	25.4	96.2	465	273	10.2	62.5	126	45.2
7	Fourth Quarter CY00	215			1.2			38.1	124	45.9
8	First Quarter CY01	247	47.4					43.7	109	48.5
9	Second Quarter CY01	256		502	391	307	7.2	52.6	102	
10	Third Quarter CY01	287						47.5	92	52.6
11	Fourth Quarter CY01	246						46.0	137	
Mann Kendall Statistic (S) =		7.0	1.0	1.0	-3.0	15.0	-5.0	-25.0	-35.0	6
Number of Rounds (n) =		10	6	6	7	6	7	10	10	4
Average =		223.72	61.13	279.77	346.31	255.67	16.20	55.96	144.9	48.05
Standard Deviation =		80.474	51.653	255.835	157.257	37.982	19.324	12.96	49.95	3.349
Coefficient of Variation(CV) =		0.360	0.845	0.914	0.454	0.149	1.193	0.226	0.345	0.070
Trend ≥ 80% Confidence Level		No Trend	No Trend	No Trend	No Trend	Increasing	No Trend	Decreasing	Decreasing	Increasing
Trend ≥ 90% Confidence Level		No Trend	No Trend	No Trend	No Trend	Increasing	No Trend	Decreasing	Decreasing	Increasing
Stability Test, If No Trend Exists at 80% Confidence Level		CV ≤ 1 Stable	CV ≤ 1 Stable	CV ≤ 1 Stable	CV ≤ 1 Stable	NA	CV > 1 Non-stable	NA	NA	NA

^a Monitoring wells are screened in Units 2 and 3B.

The Mann-Kendall test was performed using the WDNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

**Table 4-6. Results of Mann-Kendall Trend Test for Arsenic and Th-230
in HZ-A Ground Water at HISS**

Event Number	Contaminant and Station ^a			
	Sampling Date	Arsenic HISS-19S	Th-230 HISS-10	Th-230 HISS-11
1	Baseline Event (Third Quarter CY97)	31.8	0.05	0.0244
2	First Quarter CY99	94.7	1.05	1.99
3	Second Quarter CY99	136	4.55	1.3
4	Third Quarter CY99	157	2.76	2.13
5	First Quarter CY00	125	4.01	44.29
6	Second Quarter CY00	161	2.32	2.17
7	Third Quarter CY00	158	0.52	1.76
8	Second Quarter CY01		0.93	1.01
9	Third Quarter CY01	183		
Mann Kendall Statistic (S) =		22.0	-2.0	4.0
Number of Rounds (n) =		8	8	8
Average =		130.81	2.02	6.83
Standard Deviation =		48.149	1.659	15.151
Coefficient of Variation(CV) =		0.368	0.820	2.217
Trend \geq 80% Confidence Level		Increasing	No Trend	No Trend
Trend \geq 90% Confidence Level		Increasing	No Trend	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level		NA	CV \leq 1 Stable	CV $>$ 1 Non-Stable

^a Monitoring wells are screened in Units 2 and 3T.

The Mann-Kendall test was performed using the WDNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

Radionuclides

An evaluation of historical uranium concentrations was conducted using total uranium concentrations calculated using the radiological analysis (isotopic uranium results). A value equal to one half of the detection limit was substituted for non-detected isotopic values prior to calculating the total uranium concentration used in the time plots. Three wells (HISS-01, HISS-05, and HISS-06) exceeded the uranium MCL of 30 $\mu\text{g/L}$ during the period from January CY99 through December CY01. HISS-05 had the highest levels at the site, with a maximum level of 368 $\mu\text{g/L}$ (Figure 4-4). The Mann-Kendall test was conducted for HISS-01, HISS-05, and HISS-06 (Table 4-7). The Mann-Kendall test was performed on two additional wells (HISS-14 and HISS-20S) that did not exceed MCLs but had elevated concentrations (greater than 10 $\mu\text{g/L}$) as well as at least six rounds of data. As shown in Table 4-7, a significant trend in total uranium concentrations (decreasing concentrations) was identified for only one well, HISS-01.

Table 4-7. Results of Mann-Kendall Trend Test for Total Uranium in HZ-A Ground Water at HISS

Event Number	Sampling Date	Station ^a				
		HISS-01	HISS-05	HISS-06	HISS-14	HISS-20S
1	First Quarter CY99	32.90	368.44	41.96	1.37	20.54
2	Second Quarter CY99	16.72	242.28	12.8	12.62	9.87
3	Third Quarter CY99			12.6	21.94	0.20
4	First Quarter CY00	24.7	128.17		10.23	
5	Second Quarter CY00	25.14	71.50	33.4	15.61	4.7
6	Third Quarter CY00	17.16	137.31	58.85	13.75	5.9
7	Fourth Quarter CY00	13.23				2.8
8	First Quarter CY01	4.80	262.4			8.7
9	Second Quarter CY01	11.30		4.8	8.8	6.4
10	Third Quarter CY01	13.10				6.1
11	Fourth Quarter CY01	13.00				5.6
Mann Kendall Statistic (S) =		-27.0	-3.0	-3.0	1.0	-7.0
Number of Rounds (n) =		10	6	6	7	10
Average =		17.21	201.68	27.40	12.05	7.08
Standard Deviation =		8.198	109.214	20.881	6.346	5.456
Coefficient of Variation(CV) =		0.476	0.542	0.762	0.527	0.771
Trend ≥ 80% Confidence Level		Decreasing	No Trend	No Trend	No Trend	No Trend
Trend ≥ 90% Confidence Level		Decreasing	No Trend	No Trend	No Trend	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level		NA	CV ≤ 1 Stable	CV ≤ 1 Stable	CV ≤ 1 Stable	CV ≤ 1 Stable

^a Monitoring wells are screened in Units 2 and 3T.

The Mann-Kendall test was performed using the WDNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

During CY01, Ra-226 was detected at levels above the MCL of 5 pCi/L in two HZ-A wells (HISS-20S and HW22). These wells had only a single sample exceeding the MCL, with the remaining samples reported as non-detects. Because the concentrations were generally low and the incidence of non-detection was high, a trend analysis was not performed for Ra-226.

Th-230 was detected in HZ-A ground water above its expected background level of 1.18 pCi/L in sixteen (16) wells during the period from Summer CY97 through Winter CY01. Th-230 levels generally ranged from non-detect to just over expected background in these wells. Due to the high percentage of non-detect values (> 20% ND) in some of these wells, the Mann-Kendall test could only be performed for HISS-10 and HISS-11. The results of the test, provided in Table 4-6, indicate that neither well has statistically significant trends in Th-230 concentrations.

HZ-C Ground-Water

Limited data is available to evaluate contaminant trends in the HZ-C ground-water unit at HISS. Two HZ-C wells (HISS-05D and HW23) are currently sampled at HISS but pre-CY00 data is available only for HISS-05D. Sampling of HW23 was initiated in the third quarter of CY00; therefore only four rounds of data are available for that well. Plots of concentration versus time were constructed for HISS-05D for the contaminants arsenic, iron, and manganese, the

primary contaminants exceeding MCLs or SMCLs based on the CY01 ground-water sampling data (Figure 4-5). Concentrations of these three contaminants in the well pair HISS-05 and HISS-05D were plotted for comparison purposes. The data indicate that concentrations in the HZ-A well do not parallel trends in the HZ-C ground water well. This suggests that the elevated concentrations of arsenic, iron, and manganese in HZ-C ground water are not the result of contaminant migration from the HZ-A ground water and supports the view that the source of these three contaminants is unrelated to FUSRAP-related activities at the site. It also supports the view that the very low permeability subunit 3M aquitard is limiting vertical flow between HZ-A and HZ-C. Additional sampling data will be collected from HZ-C ground water for future evaluations to determine if MED/AEC contaminants are significantly impacting HZ-C ground water at HISS. Concentrations are relatively stable for arsenic, iron, and manganese in HW23 over the four sampling events from third quarter CY00 to third quarter CY01 and the concentrations are at levels similar to those detected in HISS-05D. HW23 will continue to be evaluated in the future when additional data covering a longer time period is available. HW23 is an upgradient well that will provide data that may support re-evaluation of background conditions.

4.1.3 Evaluation of the CY01 Potentiometric Surfaces at HISS

Ground-water surface elevations were measured at HISS in March, April, August, and October of CY01. The potentiometric surface maps for HZ-A and HZ-C created from the April 16-17 and August 6, 2001 ground-water elevation measurements are illustrated in Figures 4-6, 4-7, 4-8, and 4-9. The April 16-17 measurements were conducted within the same 24-hour period during which there were no significant changes in weather conditions. HISS and SLAPS 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 conductivity silts and clays of stratigraphic Units 2 and 3T at HISS. The potentiometric data indicate a near-radial potentiometric surface contour pattern for the HZ-A ground water at HISS. Wells HISS-01, HISS-10, and HISS-07 near the center of the site have the highest potentiometric surface elevations, with decreased ground-water elevations measured in the surrounding wells. At the western edge of the site, ground-water in the HZ-A zone flows toward Coldwater Creek.

The potentiometric surface of the HZ-C ground water at HISS is not well defined due to the limited data available for the deeper HZs. Based on measured ground-water elevations in two HZ-C monitoring wells at HISS (HISS-05D and HW23) and several HZ-C wells located southwest of HISS (at SLAPS and the ballfields), the flow direction in the HZ-C ground water is generally toward the northeast. The regional gradient for HZ-C is low, averaging 0.002 feet per foot (ft/ft), and it is fairly constant, showing little variation from year to year.

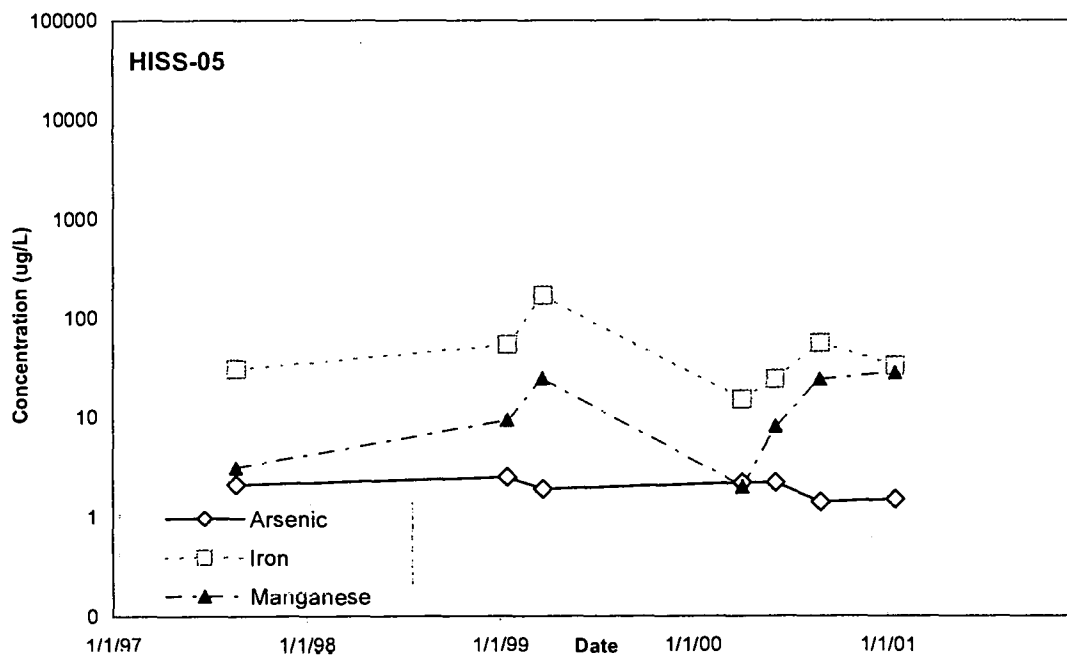
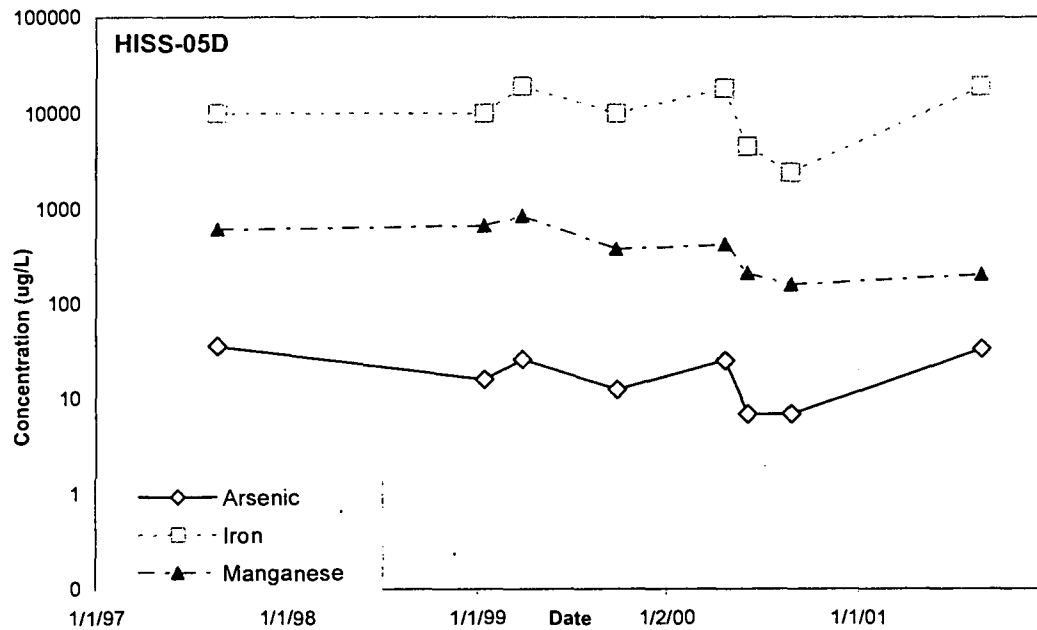


Figure 4-5. Time Versus Concentration Plots for Arsenic, Iron, and Manganese in Wells HISS-05D (HZ-C) and HISS-05 (HZ-A)

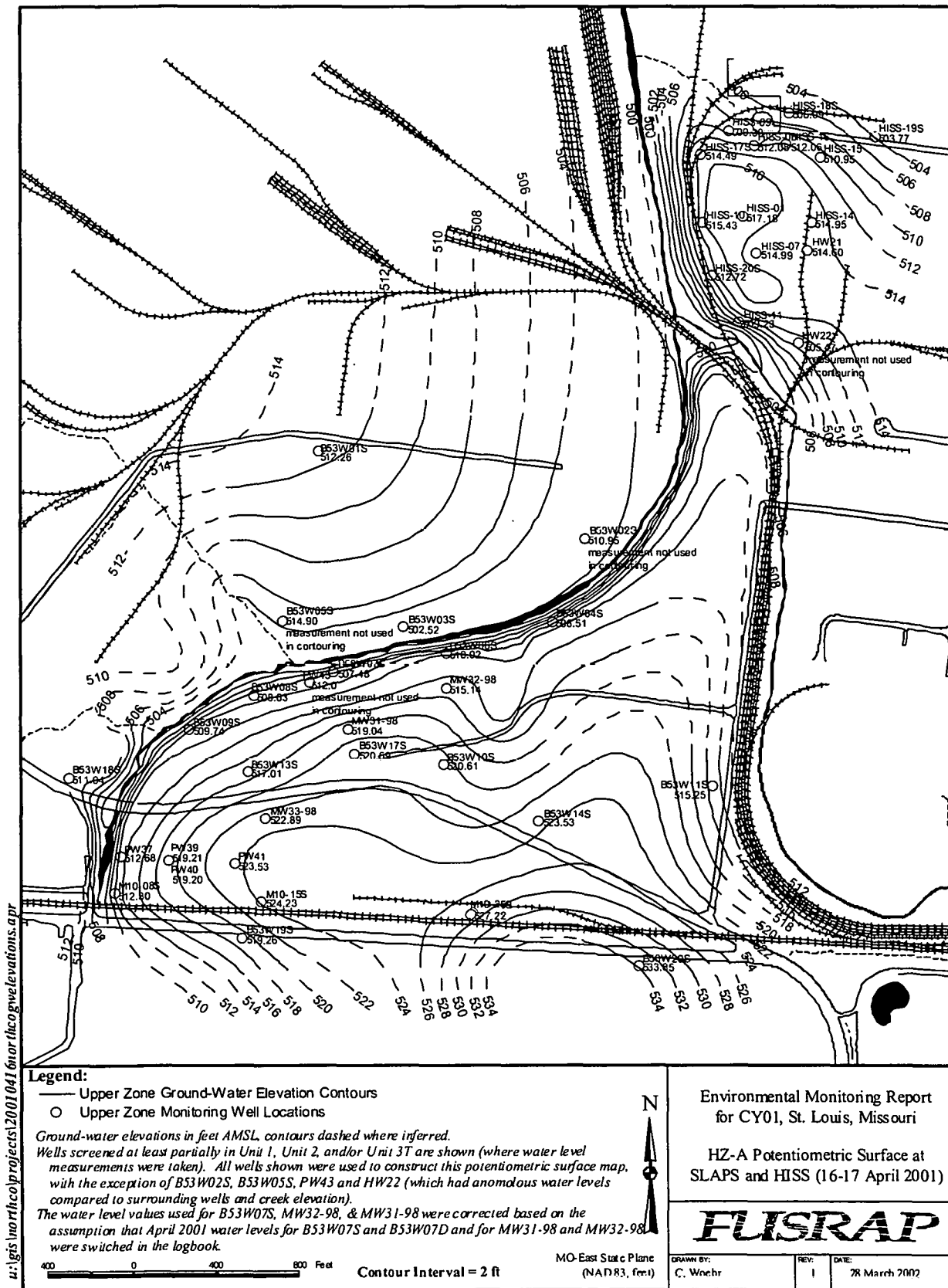


Figure 4-6. HZ-A Potentiometric Surface at SLAPS and HISS (16-17 April 2001)

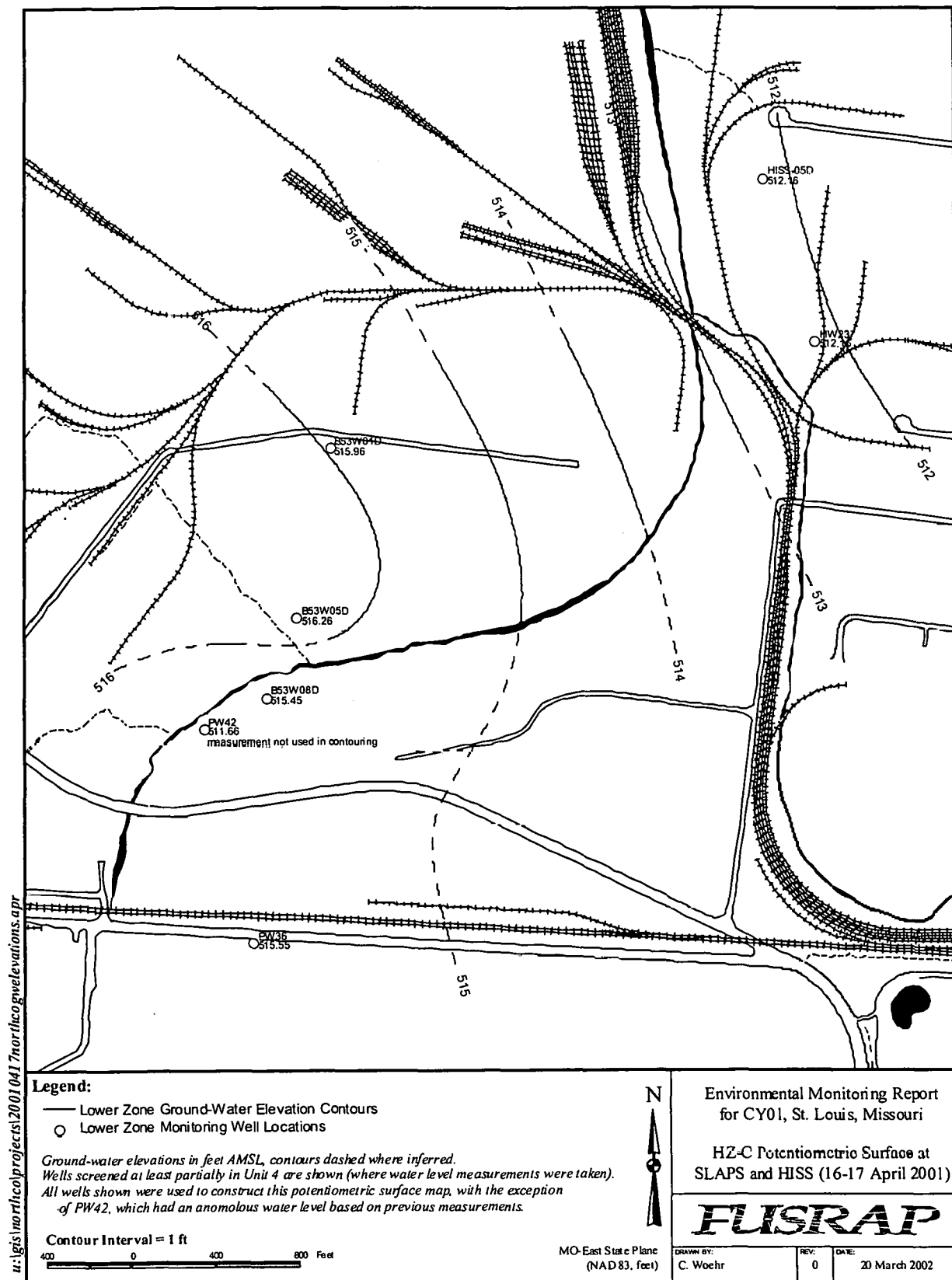


Figure: 4-7. HZ-C Potentiometric Surface at SLAPS and HISS (16-17 April 2001)

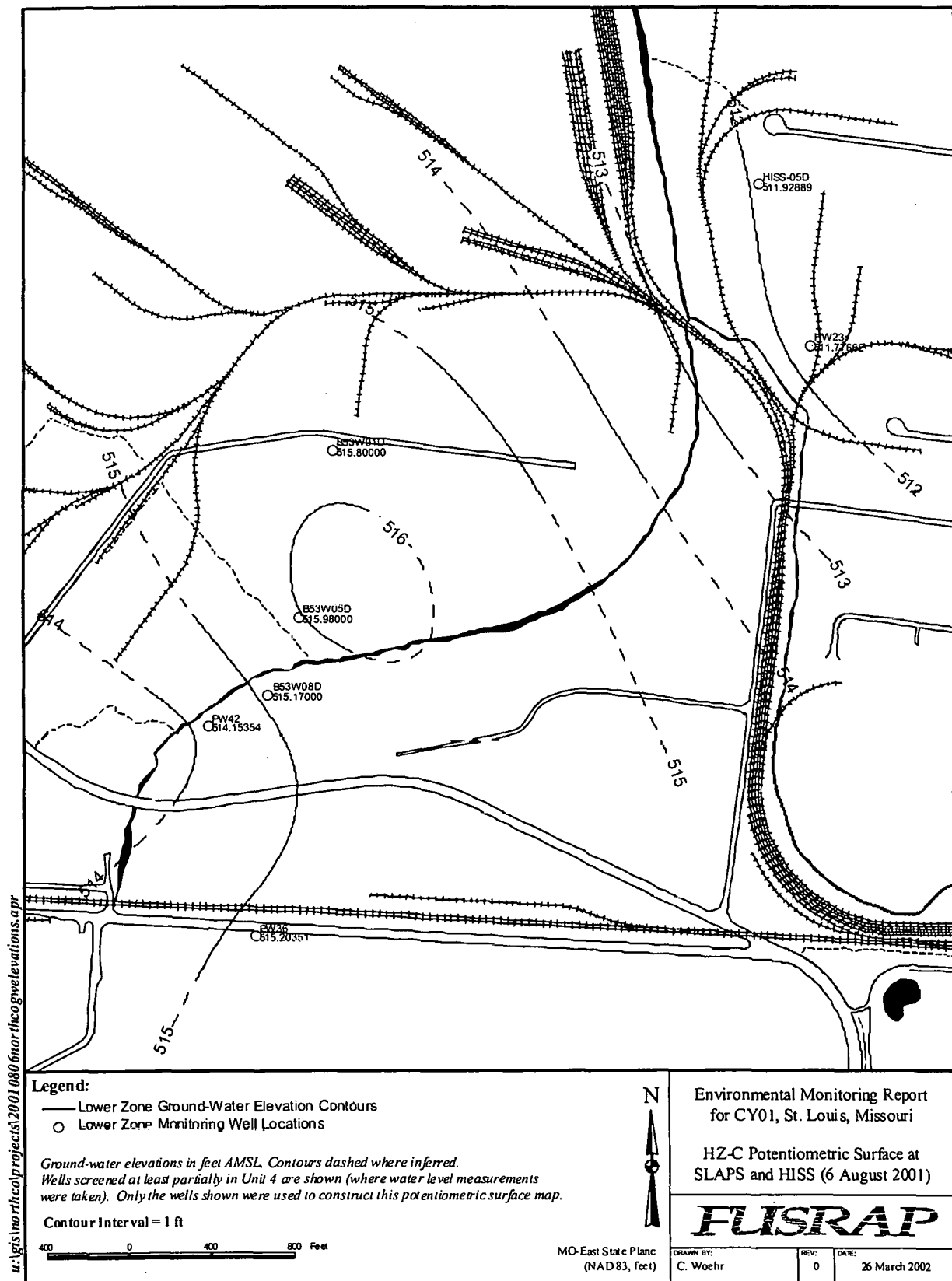


Figure: 4-9. HZ-C Potentiometric Surface at SLAPS and HISS (6 August 2001)

4.2 SLAPS

Ground-water monitoring wells have been installed at SLAPS to characterize the site stratigraphy, ground-water chemistry, and ground-water migration pathways. In the vicinity of SLAPS, surficial deposits (Unit 1) include topsoil and anthropogenic fill (rubble, scrap metal, gravel, glass, slag, and concrete) generally less than 4-m (14-ft) thick (as seen in Figures 4-1, 4-10, and 4-11). Unit 2 corresponds to loess and has a thickness of 3 to 9 m (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 9 m (30 ft). Unit 4 consists of clayey gravel with fine to very-fine sand and sandy gravel. This unit is interpreted to be approximately 2- to 5-m (5- to 15-ft) thick and thins eastward, and is absent beneath the eastern part of SLAPS, where the 3T, 3M, and 3B drape, or onlap, onto shale bedrock. Below Units 3 and 4 are Units 5 and 6, which are comprised of shale/siltstone and limestone, respectively. Depth to bedrock ranges from about 17 m (55 ft) on the east of SLAPS to a maximum of 27 m (90 ft) towards Coldwater Creek on the west. The hydrogeologic and geologic setting at SLAPS is similar to that at HISS, with one exception. The Pennsylvanian shale bedrock unit (Unit 5) present beneath portions of SLAPS is absent at HISS.

Five hydrostratigraphic zones (HZ-A through HZ-E) are recognized beneath SLAPS. HZ-A consists of the 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 and limestone bedrock are recognized as HZ-D and HZ-E, respectively. HZ-E is the protected aquifer for the site.

The HZ-A or shallow ground-water flow is toward Coldwater Creek under normal flow conditions. Average depths to the water table at the site range from near the ground surface during the winter months to about 3 m (10 ft) below ground surface during the summer months. The dominant flow in HZ-A is through the more permeable Unit 2. Each of the subunits in Unit 3 has lower hydraulic conductivities than Units 1, 2 and 4. HZ-B and the Pennsylvanian shale, HZ-D, limit the passage of ground water vertically beneath the entire SLAPS. Subunit 3M of HZ-B acts as a vertical barrier to ground-water movement under the western portion of the site. It is a highly impermeable clay aquitard 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 Unit 4. Unit 4 of HZ-C is taken as a surrogate for HZ-E, as water movement within the limestone is dependent upon the limestone's joint and solution system. In addition, the limestone has exhibited massive characteristics and is very slow to recharge.

Many of the monitoring wells are screened across more than one HZ; therefore, for discussion purposes, HZ-A is considered the upper (or shallow) zone, while HZ-C, HZ-D, and HZ-E are considered the lower (or deep) zone. Twenty-nine wells are screened exclusively across the shallow HZ-A. Ten wells are screened in the lower HZ-C, HZ-D, and/or HZ-E. The remaining seven wells (B53W01D, B53W05D, B53W08D, B53W12D, M10-8D, M10-15D, and M10-25D) are screened across more than one hydrostratigraphic zone.

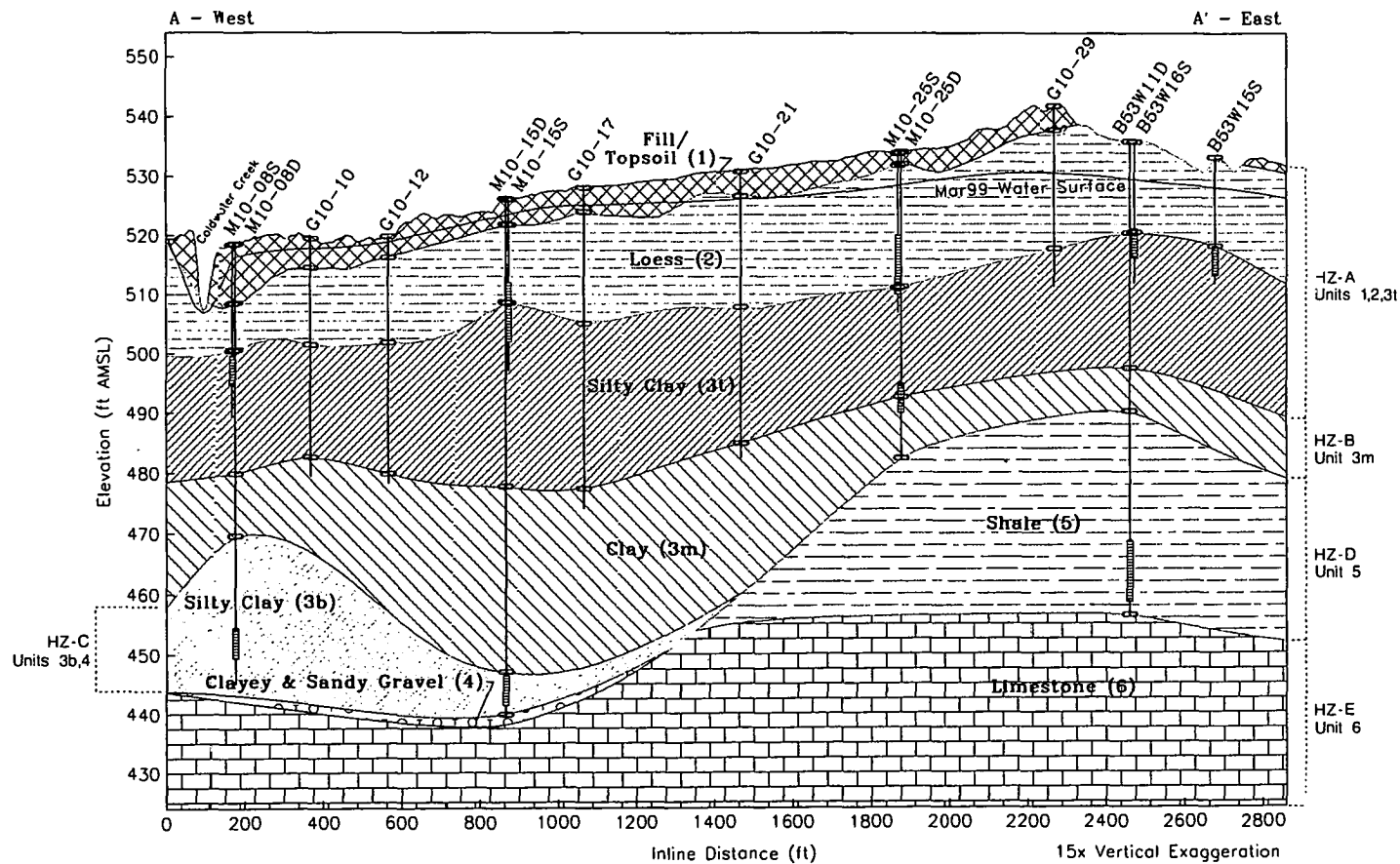


Figure 4-10.
SLAPS Geologic
Cross-Section A-A'

Notes

Geologic data used in the cross section collected through 2000.

Legend



Cross Section Location Map



FUSRAP

St. Louis Airport Site
St. Louis, Missouri

Drawn By: N. Voorhies

Rev. No. / Date: 0 / 29 Aug 00

File: SLAPSGig05ExtendedAAS.sho

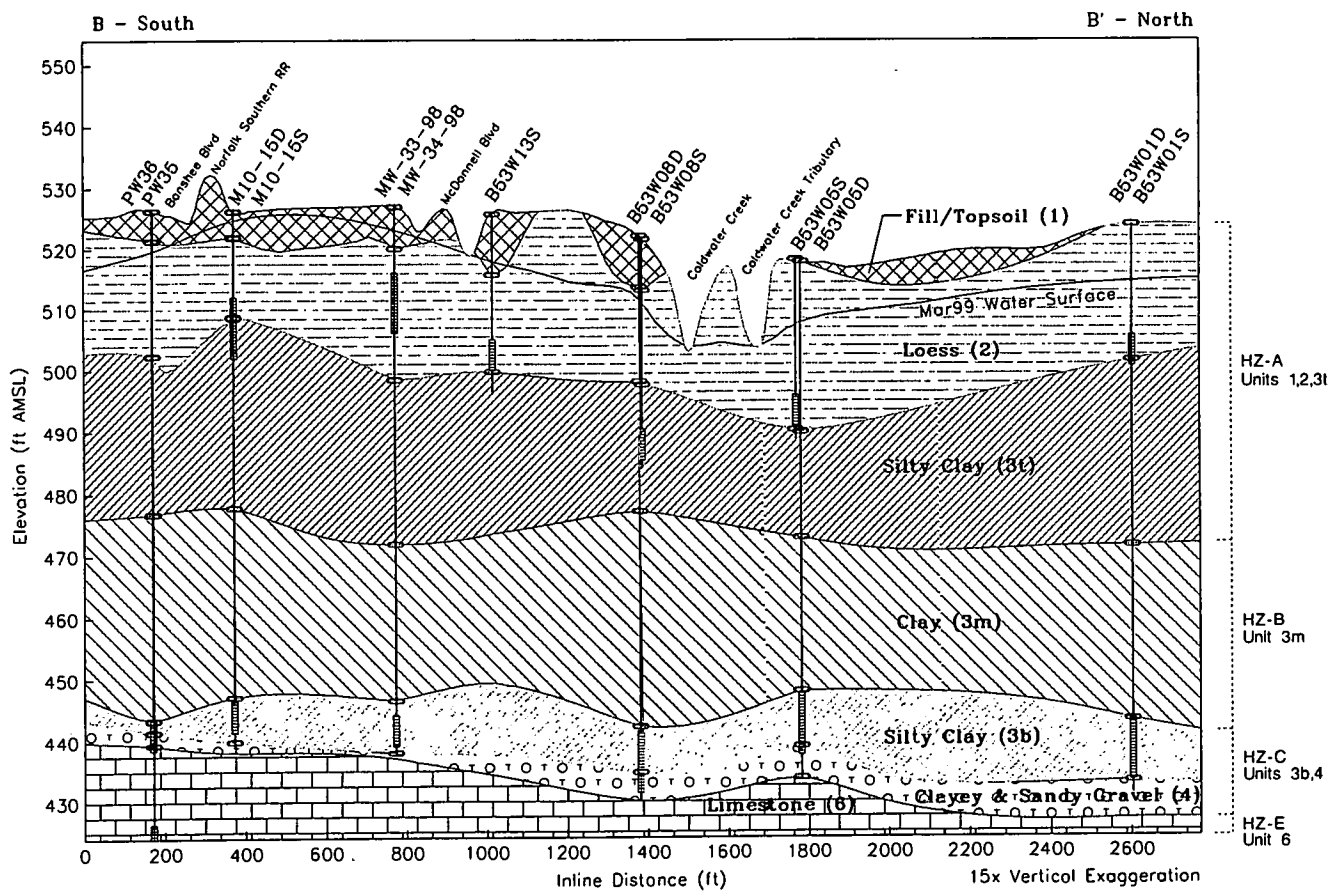
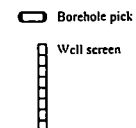


Figure 4-11.
SLAPS Geologic
Cross-Section B-B'

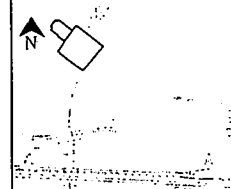
Notes

Geologic data used in the cross section collected through 2000.

Legend



Cross Section Location Map



FUSRAP

St. Louis Airport Site
St. Louis, Missouri

Drawn By: N. Voorhies

Rev. No. / Date: 0 / 29 Aug 00

File: SLAPSGIG05ExtendedBBS.sho

Table 4-8 provides a summary of the HZ information for SLAPS ground-water monitoring wells. This designation of upper and lower HZs is separated at Subunit 3M of HZ-B. The current SLAPS ground-water monitoring well network is shown in Figure 4-12.

**Table 4-8. Screened Hydrostratigraphic Zones for SLAPS
Ground-water Monitoring Wells**

Well ID	Screened Hydrostratigraphic Zone(s)
B53W01D	HZ-C
B53W01S	HZ-A
B53W02D	HZ-C
B53W02S	HZ-A
B53W03D	HZ-C
B53W03S	HZ-A
B53W04D	HZ-C, HZ-B
B53W04S	HZ-A, HZ-B
B53W05D	HZ-C
B53W05S	HZ-A
B53W06D	HZ-C, HZ-B
B53W06S	HZ-A
B53W07D	HZ-C
B53W07S	HZ-A
B53W08D	HZ-C
B53W08S	HZ-A
B53W09D	HZ-D
B53W09S	HZ-A
B53W10S	HZ-A, HZ-B
B53W11S	HZ-A
B53W12D	HZ-B, HZ-D
B53W13S	HZ-A
B53W14S	HZ-A
B53W17S	HZ-A
B53W18S	HZ-A
B53W19S	HZ-A
B53W20S	HZ-A
M10-08D	HZ-B
M10-08S	HZ-A
M10-15D	HZ-B
M10-15S	HZ-A
M10-25D	HZ-A, HZ-B
M10-25S	HZ-A
MW31-98	HZ-A
MW32-98	HZ-A
MW33-98	HZ-A
MW34-98	HZ-B, HZ-C
PW35	HZ-E
PW36	HZ-B, HZ-C
PW37	HZ-A
PW38	HZ-A
PW39	HZ-A
PW40	HZ-A
PW41	HZ-A
PW42	HZ-C
PW43	HZ-A

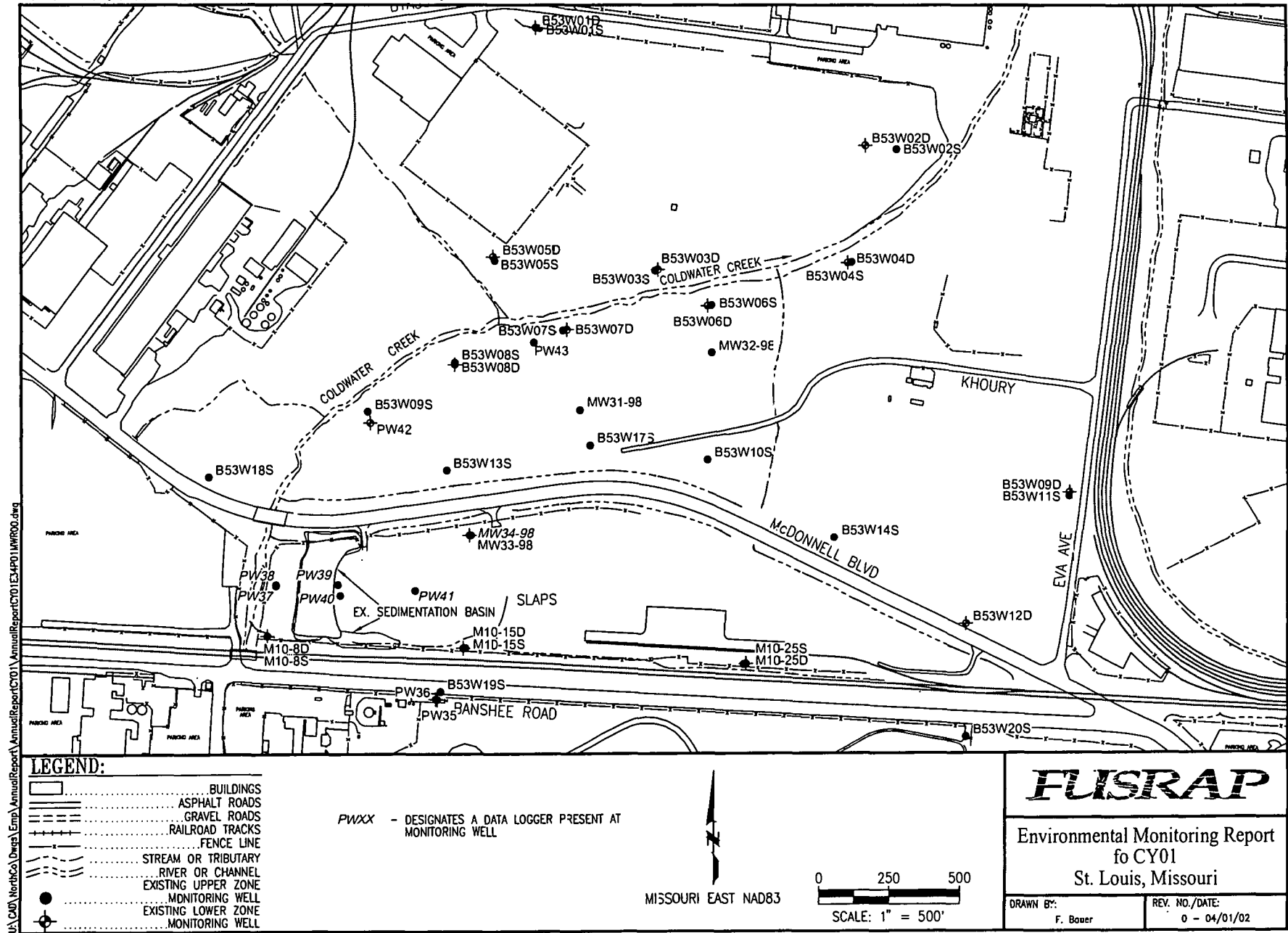


Figure 4-12. Ground-water Monitoring Well Locations at the SLAPS

4.2.1 Evaluation of the CY01 EMP Ground-water Sampling at SLAPS

A total of forty-six (46) ground-water wells were sampled for various parameters in CY01 at SLAPS. Ground-water samples collected from the existing wells have been analyzed for both radiological and nonradiological constituents. However, historically, the main focus of ground-water sampling has been radiological parameters. Ground-water samples were analyzed for total uranium (metals analysis), individual radioisotopes of uranium (U-234, U-235, and U-238), Ra-226, Th-228, Th-230, and Th-232.

In CY01, ground-water sampling at SLAPS was conducted between March 6 and March 21 (first quarter); May 2 to June 6 (second quarter); August 7 to August 27 (third quarter); and October 22 to October 30 (fourth quarter). The results of the ground-water sampling are summarized in Tables 4-9, 4-10, and 4-11. For discussion purposes, the ground-water analytical data acquired in the CY01 sampling events at SLAPS are presented separately for the upper and lower ground-water zones. The sampling results are compared to EPA-designated MCLs and SMCLs. The results are also compared to the ground-water background concentrations expected to be identified in the future North County FS.

HZ-A Ground Water

Results of ground-water sampling conducted during CY01 indicate that various metals, radionuclides, and organic compounds are present above MCLs or SMCLs in HZ-A ground water at SLAPS. The contaminants include the inorganics arsenic, chromium, iron, manganese, nitrate, selenium, and thallium; the organic compounds 1,2-DCE and TCE; and the radionuclides Ra-226 and total uranium. Table 4-9 provides a summary of the results. Additional contaminants, in particular Th-230, were detected in HZ-A ground water but have no designated MCLs or SMCLs. The results of the CY01 ground-water sampling for SLAPS are provided in Table D-2 in Appendix D.

The metals detected above MCLs or SMCLs include arsenic, chromium, iron, manganese, selenium, and thallium. Arsenic was detected in one HZ-A well at SLAPS at concentrations above the proposed MCL (10 $\mu\text{g/L}$). The maximum concentration detected was 24.2 $\mu\text{g/L}$ in the second quarter sample from B53W14S. Chromium (maximum concentration 205 $\mu\text{g/L}$) was detected above the MCL of 100 $\mu\text{g/L}$ in two samples from upgradient well B53W19S, located south of Banshee Road. Iron was detected at concentrations exceeding the SMCL of 300 $\mu\text{g/L}$ in ten wells, with the maximum concentration of 31,900 $\mu\text{g/L}$ detected in M10-08S. Manganese was detected in numerous HZ-A wells at levels exceeding both the MCL (50 $\mu\text{g/L}$) and the expected HZ-A background level (1,580 $\mu\text{g/L}$). The maximum manganese concentration detected was 6,700 $\mu\text{g/L}$ in the third quarter sample from PW40. Selenium was detected in ten HZ-A wells at levels exceeding the MCL of 50 $\mu\text{g/L}$. The maximum detected concentration was 1,380 $\mu\text{g/L}$, detected in the third quarter sample from PW41. Thallium exceeded its MCL of 2 $\mu\text{g/L}$ in two HZ-A wells. The maximum concentration of 6.2 $\mu\text{g/L}$ was detected in B53W19S, located at the southern edge of the site.

Table 4-9. Analytes Exceeding MCLs or SMCLs in HZ-A¹ Ground Water at SLAPS

Chemical	Station ¹	MCL or SMCL	Units	Minimum Detect	Maximum Detect	Mean Detect	Frequency of Detection	# Detects > MCL or SMCL
1,2-DCE (total)	PW38	70 ³	µg/L	100	100	100	1/1	1
Arsenic	B53W14S	10	µg/L	24.2	24.2	24.2	1/2	1
Benzene	B53W13S	5	µg/L	203	203	203	1/1	1
Beryllium	B53W18S	4	µg/L	2,330	2,330	2,330	1/2	1
Chloride	B53W13S	250	mg/L	386	386	386	1/1	1
	B53W18S	250	mg/L	1,200	1,200	1,200	1/1	1
	B53W19S	250	mg/L	757	757	757	1/1	1
Chromium	B53W19S	100	µg/L	128	205	166.5	2/2	2
Iron	B53W05S	300	µg/L	1,400	1,400	1,400	1/1	1
	B53W08S	300	µg/L	10,400	10,400	10,400	1/1	1
	B53W14S	300	µg/L	19,100	22,200	20,650	2/2	2
	B53W18S	300	µg/L	140	403	271.5	2/2	1
	B53W19S	300	µg/L	890	1,340	1,115	2/2	2
	M10-08S	300	µg/L	31,900	31,900	31,900	1/1	1
	M10-25S	300	µg/L	9,680	9,680	9,680	1/1	1
	PW37	300	µg/L	2,320	11,800	7,662.5	4/4	4
	PW41	300	µg/L	477	477	477	1/2	1
	PW43	300	µg/L	5,680	16,800	11,240	2/2	1
Manganese	B53W01S	50	µg/L	72.8	72.8	72.8	1/1	1
	B53W03S	50	µg/L	189	189	189	1/1	1
	B53W04S	50	µg/L	1,460	1,460	1,460	1/1	1
	B53W05S	50	µg/L	478	478	478	1/1	1
	B53W06S	50	µg/L	1,750	1,750	1,750	1/1	1
	B53W08S	50	µg/L	695	695	695	1/1	1
	B53W10S	50	µg/L	1,870	1,870	1,870	1/1	1
	B53W11S	50	µg/L	24.7	103	63.85	2/2	1
	B53W14S	50	µg/L	1,580	1,730	1,655	2/2	1
	B53W18S	50	µg/L	322	514	418	2/2	1
	B53W19S	50	µg/L	529	637	583	2/2	1
	M10-08S	50	µg/L	1,390	1,390	1,390	1/1	1
	M10-25S	50	µg/L	1,140	1,140	1,140	1/1	1
	MW31-98	50	µg/L	764	1,150	982	4/4	4
	PW37	50	µg/L	469	1180	972	4/4	1
	PW38	50	µg/L	291	478	411.8	4/4	1
	PW39	50	µg/L	2,220	2,570	2,395	2/2	1
	PW40	50	µg/L	4,360	6,700	5,530	2/2	1
	PW41	50	µg/L	356	364	360	2/2	1
	PW43	50	µg/L	3,650	4,400	4,025	2/2	1
Methylene Chloride (Dichloromethane)	B53W18S	5	µg/L	11	11	11	1/1	1
	MW31-98	5	µg/L	12	12	12	1/1	1
	PW39	5	µg/L	13	13	13	1/1	1
Nitrate-Nitrite	B53W02S	10	mg/L	199	199	199	1/1	1
	B53W06S	10	mg/L	264	264	264	1/1	1
	B53W07S	10	mg/L	977	977	977	1/1	1
	B53W09S	10	mg/L	555	555	555	1/1	1
	B53W13S	10	mg/L	74.7	74.7	74.7	1/1	1
	B53W17S	10	mg/L	400	504	452	2/2	2

Table 4-9. Analytes Exceeding MCLs or SMCLs in HZ-A¹ Ground Water at SLAPS (Cont'd)

Chemical	Station ¹	MCL or SMCL	Units	Minimum Detect	Maximum Detect	Mean Detect	Frequency of Detection	# Detects > MCL or SMCL
Nitrate-Nitrite (cont)	M10-15S	10	mg/L	204	204	204	1/1	1
	MW31-98	10	mg/L	683	880	782	2/2	2
	MW32-98	10	mg/L	112	170	141	2/2	2
	MW33-98	10	mg/L	439	532	486	2/2	2
	PW38	10	mg/L	190	214	202	2/2	2
	PW39	10	mg/L	856	856	856	1/1	1
	PW40	10	mg/L	537	537	537	1/1	1
	PW41	10	mg/L	771	771	771	1/1	1
Radium-226	PW38	5	pCi/L	7.91	17.53	13.48	3/4	3
	PW39	5	pCi/L	5.23	5.23	5.23	1/2	1
	PW40	5	pCi/L	5.81	13.83	9.82	2/2	2
Selenium	B53W09S	50	µg/L	326	326	326	1/1	1
	B53W13S	50	µg/L	347	347	347	1/1	1
	B53W17S	50	µg/L	48.7	58.8	53.8	4/4	3
	M10-15S	50	µg/L	738	738	738	1/1	1
	MW31-98	50	µg/L	184	193	189	4/4	4
	MW33-98	50	µg/L	231	314	284.5	4/4	4
	PW38	50	µg/L	301	378	330.5	4/4	4
	PW39	50	µg/L	442	473	457.5	2/2	2
	PW40	50	µg/L	226	402	314	2/2	2
	PW41	50	µg/L	1,370	1,380	1,375	2/2	2
Sulfate	B53W06S	250	mg/L	478	478	478	1/1	1
	MW31-98	250	mg/L	278	281	280	2/2	2
	MW33-98	250	mg/L	271	288	280	2/2	2
	PW38	250	mg/L	320	332	326	2/2	1
	PW39	250	mg/L	463	463	463	1/1	1
	PW40	250	mg/L	267	267	267	1/1	1
	PW41	250	mg/L	282	282	282	1/1	1
Tetrachloroethene	B53W18S	5	µg/L	10	10	10	1/2	1
Thallium	B53W14S	2	µg/L	2.8	2.8	2.8	1/2	1
	B53W19S	2	µg/L	6.2	6.2	6.2	1/2	1
Trichloroethene	B53W13S	5	µg/L	9.2	9.2	9.2	1/1	1
	B53W17S	5	µg/L	260	340	302.5	4/4	4
	MW31-98	5	µg/L	33	69	56.5	4/4	4
	PW38	5	µg/L	13	13	13	1/1	1
	PW39	5	µg/L	61	100	80.5	2/2	2
	PW40	5	µg/L	62	110	86	2/2	2
	PW41	5	µg/L	120	140	130	2/2	2
Total Uranium ²	B53W06S	30	µg/L	85.2	85.2	85.2	1/1	1
	M10-25S	30	µg/L	39.5	39.5	39.5	1/1	1
	MW33-98	30	µg/L	116	217	152	4/4	4
	PW38	30	µg/L	6,392	10,169	8,093	4/4	4
	PW39	30	µg/L	414	530	472	2/2	2
	PW40	30	µg/L	2,357	3,198	2,778	2/2	2
	PW41	30	µg/L	33	34	34	2/2	2

¹ Results include those wells screened in the HZ-A and/or HZ-B ground-water units

² Total Uranium values were calculated from isotopic results in pCi/L and converted to µg/L using radionuclide specific activities.

³ This value, 70 µg/L, is the MCL for cis-1,2-DCE. The MCL for trans-1,2-DCE is 100 µg/L

The CY01 ground-water sampling results indicate that the principal radiological contaminants present in the HZ-A ground water at SLAPS are Ra-226, Th 228, Th-230, Th-232, U-238, U-234, and U-235. Ra-226 was detected at levels above the combined Ra-226/Ra-228 MCL of 5 pCi/L in three wells, with the maximum concentration, 17.53 pCi/L, detected in PW38. The HZ-A wells PW39 and PW40 also reported levels of Ra-226 exceeding the MCL (5.23 pCi/L and 13.83 pCi/L, respectively). Th-230 was detected above its expected background concentration of 1.18 pCi/L in twelve HZ-A wells, with the maximum concentration (68.5 pCi/L) detected in PW40 in the western portion of SLAPS. U-238 has been detected at varying levels in HZ-A wells. The U-238 results exceeded the expected HZ-A ground-water background concentration of 2.3 pCi/L in thirteen HZ-A wells. The highest levels of U-238 (up to a maximum of 3,380 pCi/L), U-234 (3,260 pCi/L) and U-235 (171 pCi/L), were detected in PW38. Th-228 (maximum of 2.97 pCi/L in B53W17S) was detected at slightly elevated levels in three HZ-A wells (B53W17S, B53W18S, and PW40). Th-232 was also detected at elevated levels in three wells (B53W19S, PW38 and PW40) with a maximum of 30.9 pCi/L detected in PW40.

Total uranium concentrations were calculated using the isotopic uranium results. These results indicate total uranium concentrations above the MCL of 30 $\mu\text{g/L}$ were present in seven HZ-A wells sampled at SLAPS in CY01. The maximum concentrations were detected in the unfiltered samples from PW38, located near Coldwater Creek at the western edge of SLAPS. Concentrations in this well were elevated well above the MCL in all CY01 samples, increasing from a minimum of 6,392 $\mu\text{g/L}$ in the second quarter sample to 8,954 $\mu\text{g/L}$ in the third quarter and a maximum of 10,169 $\mu\text{g/L}$ in the fourth quarter sample. The remaining seven wells with total uranium concentrations above the MCL (M10-25S, B53W06S, MW33-98, PW39, PW40, and PW41) had maximum concentrations ranging from 34 to 3,198 $\mu\text{g/L}$. In general, the highest total uranium concentrations were found in the western portion of SLAPS. This area is downgradient of the most highly contaminated portions of SLAPS.

The principal organic contaminant detected in the HZ-A ground water is TCE, which was detected in HZ-A ground water at concentrations exceeding the MCL of 5 $\mu\text{g/L}$ in seven wells. The sampling results indicate that TCE is distributed in two distinct areas, one centered around B53W17S west of the end of Khoury Road and the other at the western half of SLAPS centered around PW38, PW39, PW40, and PW41. The highest TCE concentration detected during CY01 (340 $\mu\text{g/L}$) was from B53W17S, located in the ballfields. Concentrations in the area at the western edge of SLAPS ranged from non-detect levels in PW37 to a maximum concentration of 140 $\mu\text{g/L}$ in PW41. The TCE degradation product cis-1,2-DCE has also been detected in the seven wells having elevated TCE levels. The distribution pattern of 1,2-DCE indicates that degradation of TCE to 1,2-DCE is occurring primarily in the western portion of SLAPS. The maximum concentration of 1,2-DCE was 100 $\mu\text{g/L}$, detected in PW38. Vinyl chloride (VC) was not detected in any ground-water samples. The absence of vinyl chloride suggests that biodegradation is incomplete. Two additional VOCs were present at levels slightly exceeding their MCLs in HZ-A ground water at SLAPS: tetrachloroethene (PCE) was detected at a concentration of 10 $\mu\text{g/L}$ in a single sample from well B53W18S, located west of Coldwater Creek, and methylene chloride (or dichloromethane), a common lab contaminant, was detected in three wells (B53W18S, MW31-98, and PW39) at a maximum concentration of 13 $\mu\text{g/L}$ in PW39. The MCL for PCE and methylene chloride is 5 $\mu\text{g/L}$. The source of these VOCs is unknown.

Concentrations of TDS were found to exceed the secondary drinking water standard of 500 mg/L in twenty HZ-A wells, with the maximum concentration, 6,310 mg/L, found in PW39. The elevated TDS concentrations are due at least in part to natural conditions and the industrial activities in the surrounding region. Concentrations of nitrates above the MCL of 10 mg/L were detected in fourteen SLAPS wells sampled in CY01. The nitrate values at SLAPS ranged from 0.11 mg/L at PW37 to 977 mg/L at B53W07S. Sulfate exceeded its expected HZ-A background level of 376 mg/L in 2 wells, B53W06S (478 mg/L) and PW39 (463 mg/L).

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

Seven wells are screened across both the HZ-B and deeper horizons. An additional ten wells are screened exclusively in HZ-C, HZ-D, and/or HZ-E at SLAPS and the adjacent ballfields. The CY01 sampling data indicate that arsenic, iron, manganese, and TDS were present above MCLs or SMCLs in the ground-water samples from these wells. Table 4-10 and Table 4-11 provide a summary of the lower ground-water sampling results for CY01.

Arsenic was detected in thirteen lower ground-water wells at levels exceeding the MCL of 10 $\mu\text{g/L}$. In six of these wells, the maximum detected concentrations also exceeded the expected background concentration for HZ-C ground water, 82.7 $\mu\text{g/L}$. The maximum concentration in unfiltered samples, 201 $\mu\text{g/L}$, was detected in the first quarter sample from MW34-98, which is screened across HZ-B and HZ-C. Iron and manganese were detected above their SMCLs (300 $\mu\text{g/L}$ and 50 $\mu\text{g/L}$, respectively) and expected background concentrations (15,200 $\mu\text{g/L}$ and 231 $\mu\text{g/L}$, respectively) in numerous wells. The maximum concentrations detected were 24,400 $\mu\text{g/L}$ for iron in M10-15D and 4,490 $\mu\text{g/L}$ for manganese in M10-25D. Both M10-15D and M10-25D are screened across both HZ-B and lower ground-water zones (HZ-C and HZ-C/HZ-D, respectively). Elevated concentrations of iron (up to 18,100 $\mu\text{g/L}$) and manganese (up to 2,520 $\mu\text{g/L}$) were also detected in wells screened exclusively across the deep (HZ-C, HZ-D, and/or HZ-E) zones. Total dissolved solids exceeded the SMCL of 500 mg/L, ranging from 528 mg/L to 2,360 mg/L in the deep ground-water samples. Antimony was detected at a concentration of 3.1 $\mu\text{g/L}$ in a single sample from one deep well, B53W12D.

Antimony did not exceed detection limits in any other lower ground-water wells during CY01. Nitrate did not exceed its MCL of 10 mg/L in any of the deep ground-water wells sampled in CY01.

Radium-226 was not detected above the combined Ra-226/Ra-228 MCL of 5 pCi/L in any wells screened exclusively across the deep (HZ-C, HZ-D, and/or HZ-E) zones during CY01. The maximum total uranium concentration detected in the deep zones was 10.2 $\mu\text{g/L}$ in PW35, which is well below the MCL of 30 $\mu\text{g/L}$. The only other significant concentrations of uranium detected in HZ-C ground water were from well B53W09D, screened within the shale (HZ-D). The maximum total uranium concentration calculated for B53W09D was 8.8 $\mu\text{g/L}$. The uranium detected in B53W09D is suspected to be naturally occurring from the shale. Additional radionuclides (Th-228 and Th-230) were detected in wells screened in the HZ-C through HZ-E ground water, but their maximum concentrations were only slightly above expected background levels.

Table 4-10. Analytes Exceeding MCLs or SMCLs in Unfiltered HZ-C¹ Ground Water at SLAPS

Chemical	Station ¹	MCL or SMCL	Units	Minimum Detect	Maximum Detect	Mean Detect	Detection Frequency	# Detects > MCL or SMCL
Arsenic	B53W01D	10	µg/L	85.2	85.2	85.2	1/1	1
	B53W02D	10	µg/L	32.4	32.4	32.4	1/1	1
	B53W03D	10	µg/L	66.8	66.8	66.8	1/1	1
	B53W04D	10	µg/L	19	19	19	1/1	1
	B53W05D	10	µg/L	109	109	109	1/1	1
	B53W06D	10	µg/L	27.8	27.8	27.8	1/1	1
	B53W07D	10	µg/L	69	69	69	1/1	1
	B53W08D	10	µg/L	71.2	71.2	71.2	1/1	1
	M10-08D	10	µg/L	66.5	66.5	66.5	1/1	1
	M10-15D	10	µg/L	105	105	105	1/1	1
	MW34-98	10	µg/L	150	201	174	4/4	4
	PW35	10	µg/L	31.5	33.3	32.4	2/2	2
	PW36	10	µg/L	0.1	93.4	68.25	4/4	3
	PW42	10	µg/L	125	127	126	2/2	2
Iron	B53W01D	300	µg/L	16,800	16,800	16,800	1/1	1
	B53W02D	300	µg/L	12,600	12,600	12,600	1/1	1
	B53W03D	300	µg/L	12,400	12,400	12,400	1/1	1
	B53W04D	300	µg/L	13,700	13,700	13,700	1/1	1
	B53W05D	300	µg/L	14,900	14,900	14,900	1/1	1
	B53W06D	300	µg/L	6,760	6,760	6,760	1/1	1
	B53W07D	300	µg/L	18,100	18,100	18,100	1/1	1
	B53W08D	300	µg/L	19,300	19,300	19,300	1/1	1
	B53W12D	300	µg/L	517	517	517	1/1	1
	M10-08D	300	µg/L	12,200	12,200	12,200	1/1	1
	M10-15D	300	µg/L	24,400	24,400	24,400	1/1	1
	MW34-98	300	µg/L	5,840	8,470	7,018	4/4	4
	PW35	300	µg/L	6,850	9,570	8,210	2/2	2
	PW36	300	µg/L	12,600	13,600	13,125	4/4	4
	PW42	300	µg/L	9,210	11,100	10,155	2/2	2
Manganese	B53W01D	50	µg/L	193	193	193	1/1	1
	B53W02D	50	µg/L	345	345	345	1/1	1
	B53W03D	50	µg/L	148	148	148	1/1	1
	B53W04D	50	µg/L	2,520	2,520	2,520	1/1	1
	B53W05D	50	µg/L	225	225	225	1/1	1
	B53W06D	50	µg/L	440	440	440	1/1	1
	B53W07D	50	µg/L	264	264	264	1/1	1
	B53W08D	50	µg/L	367	367	367	1/1	1
	B53W09D	50	µg/L	936	936	936	1/1	1
	B53W12D	50	µg/L	829	829	829	1/1	1
	M10-08D	50	µg/L	493	493	493	1/1	1
	M10-15D	50	µg/L	1,860	1,860	1,860	1/1	1
	M10-25D	50	µg/L	4,490	4,490	4,490	1/1	1
	MW34-98	50	µg/L	159	195	175	4/4	4
	PW35	50	µg/L	90.8	116	103.4	2/2	2
	PW36	50	µg/L	112	128	119.8	4/4	4
	PW42	50	µg/L	135	169	152	2/2	2
Thallium	PW36	2	µg/L	6.8	6.8	6.8	1/4	1

¹ Results include those wells screened in HZ-C through HZ-E and wells screened across HZ-B and lower ground-water units

**Table 4-11. Analytes Exceeding Background Levels in Unfiltered HZ-C¹
Ground Water at SLAPS**

Chemical	Station ¹	Background	Units	Minimum Detect	Maximum Detect	Mean Detect	Detection Frequency	# Detects > Background
Arsenic	B53W01D	82.7	µg/L	85.2	85.2	85.2	1/1	1
	B53W05D	82.7	µg/L	109	109	109	1/1	1
	M10-15D	82.7	µg/L	105	105	105	1/1	1
	MW34-98	82.7	µg/L	150	201	174	4/4	4
	PW36	82.7	µg/L	0.1	93.4	68.25	4/4	3
	PW42	82.7	µg/L	125	127	126	2/2	2
Barium	B53W01D	424	µg/L	430	430	430	1/1	1
	B53W02D	424	µg/L	460	460	460	1/1	1
	B53W04D	424	µg/L	920	920	920	1/1	1
	B53W06D	424	µg/L	676	676	676	1/1	1
	B53W08D	424	µg/L	534	534	534	1/1	1
	M10-08D	424	µg/L	531	531	531	1/1	1
	M10-15D	424	µg/L	464	464	464	1/1	1
	M10-25D	424	µg/L	427	427	427	1/1	1
	MW34-98	424	µg/L	499	629	567	4/4	4
	PW35	424	µg/L	1,010	1,620	1,315	2/2	2
Iron	PW36	424	µg/L	449	1,700	772.25	4/4	4
	B53W01D	15200	µg/L	16,800	16,800	16,800	1/1	1
	B53W07D	15200	µg/L	18,100	18,100	18,100	1/1	1
	B53W08D	15200	µg/L	19,300	19,300	19,300	1/1	1
Magnesium	M10-15D	15200	µg/L	24,400	24,400	24,400	1/1	1
	B53W01D	42600	µg/L	42,700	42,700	42,700	1/1	1
	B53W04D	42600	µg/L	45,100	45,100	45,100	1/1	1
	B53W08D	42600	µg/L	43,700	43,700	43,700	1/1	1
	M10-25D	42600	µg/L	44,200	44,200	44,200	1/1	1
	PW35	42600	µg/L	32,300	44,300	38,300	2/2	1
Manganese	PW36	42600	µg/L	37,800	48,300	40,575	4/4	1
	B53W02D	231	µg/L	345	345	345	1/1	1
	B53W04D	231	µg/L	2,520	2,520	2,520	1/1	1
	B53W06D	231	µg/L	440	440	440	1/1	1
	B53W07D	231	µg/L	264	264	264	1/1	1
	B53W08D	231	µg/L	367	367	367	1/1	1
	B53W09D	231	µg/L	936	936	936	1/1	1
	B53W12D	231	µg/L	829	829	829	1/1	1
	M10-08D	231	µg/L	493	493	493	1/1	1
	M10-15D	231	µg/L	1,860	1,860	1,860	1/1	1
Moiybdenum	M10-25D	231	µg/L	4,490	4,490	4,490	1/1	1
	B53W07D	0	µg/L	2	2	2	1/1	1
	B53W08D	0	µg/L	5.8	5.8	5.8	1/1	1
	B53W12D	0	µg/L	2.3	2.3	2.3	1/1	1
	M10-08D	0	µg/L	10.2	10.2	10.2	1/1	1
	M10-15D	0	µg/L	12.6	12.6	12.6	1/1	1
	MW34-98	0	µg/L	10.2	13.2	11.5	3/4	3
	PW35	0	µg/L	19.7	19.7	19.7	1/2	1
	PW36	0	µg/L	4	4	4	1/4	1
	PW42	0	µg/L	1.3	1.3	1.3	1/2	1

**Table 4-11. Analytes Exceeding Background Levels in Unfiltered HZ-C¹
Ground Water at SLAPS (Cont'd)**

Chemical	Station ¹	Background	Units	Minimum Detect	Maximum Detect	Mean Detect	Detection Frequency	# Detects > Background
Nickel	B53W07D	1.1	µg/L	2.4	2.4	2.4	1/1	1
	B53W08D	1.1	µg/L	4.4	4.4	4.4	1/1	1
	B53W12D	1.1	µg/L	5	5	5	1/1	1
	MW34-98	1.1	µg/L	1.7	1.9	1.8	2/4	2
	PW36	1.1	µg/L	6.3	6.3	6.3	1/4	1
Radium-226	B53W09D	1.03	pCi/L	2.27	2.27	2.27	1/1	1
	PW35	1.03	pCi/L	3.21	3.21	3.21	1/2	1
Strontium	B53W01D	742	µg/L	864	864	864	1/1	1
	B53W03D	742	µg/L	770	770	770	1/1	1
	B53W05D	742	µg/L	743	743	743	1/1	1
	B53W07D	742	µg/L	795	795	795	1/1	1
	B53W08D	742	µg/L	782	782	782	1/1	1
	MW34-98	742	µg/L	614	767	677	4/4	1
	PW35	742	µg/L	2,880	4,200	3,540	2/2	2
	PW36	742	µg/L	715	4,790	1,759.8	4/4	3
	PW42	742	µg/L	952	952	952	2/2	2
Sulfate	B53W09D	6.93	mg/L	112	112	112	1/1	1
	B53W12D	6.93	mg/L	82.3	82.3	82.3	1/1	1
Thallium	PW36	0	µg/L	6.8	6.8	6.8	1/4	1
Thorium-228	PW36	0.62	pCi/L	0.62	0.75	0.68	2/4	2
Thorium-230	B53W02D	0.63	pCi/L	0.95	0.95	0.95	1/1	1
	B53W06D	0.63	pCi/L	0.75	0.75	0.75	1/1	1
	B53W08D	0.63	pCi/L	0.87	0.87	0.87	1/1	1
	M10-08D	0.63	pCi/L	0.90	0.90	0.90	1/1	1
	M10-15D	0.63	pCi/L	1.2	1.2	1.2	1/1	1
	M10-25D	0.63	pCi/L	2.31	2.31	2.31	1/1	1
	MW34-98	0.63	pCi/L	1.19	1.19	1.19	1/4	1
	PW35	0.63	pCi/L	1.53	1.53	1.53	1/2	1
	PW36	0.63	pCi/L	0.99	1.77	1.38	2/4	2
Uranium-234	B53W04D	0	pCi/L	7.08	7.08	7.08	1/1	1
	B53W06D	0	pCi/L	3.25	3.25	3.25	1/1	1
	B53W07D	0	pCi/L	0.5	0.5	0.5	1/1	1
	B53W09D	0	pCi/L	8.46	8.46	8.46	1/1	1
	B53W12D	0	pCi/L	1.05	1.05	1.05	1/1	1
	M10-25D	0	pCi/L	2.69	2.69	2.69	1/1	1
	PW35	0	pCi/L	2.78	2.78	2.78	1/2	1
	PW36	0	pCi/L	1.6	1.6	1.6	1/4	1
Uranium-238	B53W03D	0.11	pCi/L	0.86	0.86	0.86	1/1	1
	B53W09D	0.11	pCi/L	2.89	2.89	2.89	1/1	1
	B53W12D	0.11	pCi/L	1.05	1.05	1.05	1/1	1
	PW35	0.11	pCi/L	3.33	3.33	3.3	1/2	1
	PW36	0.11	pCi/L	2.47	2.47	2.47	1/4	1
Zinc	B53W07D	54.9	µg/L	66.5	66.5	66.5	1/1	1
	M10-25D	54.9	µg/L	104	104	104	1/1	1
	PW35	54.9	µg/L	53.6	60.2	56.9	2/2	1
	PW36	54.9	µg/L	12.6	91.6	40.7	3/4	1

4.2.2 Comparison of Historical Ground-water Data at SLAPS

The evaluation of historical trends for ground water focuses on those contaminants identified as soil COCs that exceeded ground-water reference levels (MCLs, SMCLs, and/or expected background levels) in a significant number of samples collected during CY01. [The COCs identified for SLAPS soils include antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, vanadium, and various radionuclides.] Based on the CY01 data, arsenic and selenium are the principal inorganic COCs present in ground water at the site. The radionuclides Ra-226, Th-230, U-234, and U-238 were also identified as present at elevated levels in SLAPS ground-water samples during CY01. Where sufficient data was available, statistical trend analysis was conducted to evaluate whether concentrations of the principal contaminants are increasing or decreasing over time.

Results of Trend Analysis at SLAPS

Time versus concentration plots were prepared for each of the principal contaminants to look for changes in concentration at each monitoring location. Only unfiltered data was used and duplicates and split sample results were not included in the analysis. For those stations where sufficient data was available to evaluate trend, statistical trend analysis was conducted to assess whether concentrations of the principal contaminants (selenium, arsenic, and total uranium) are increasing (upward trending) or decreasing (downward trending) over time. Although no organics were identified as COCs for SLAPS, statistical analysis was conducted for TCE because elevated concentrations have been detected in several HZ-A wells. For the purposes of this report, a statistically significant trend in concentration is defined as a trend with a confidence level greater than 90%. The confidence level indicates the probability that the trend indicated is an actual trend in the data, rather than a result of the random nature of environmental data.

Inorganics

HZ-A ground-water data for selenium is available for the period from July CY97 to October CY01. As shown in the time versus concentration plots for selenium presented in Figure 4-13, there are several wells that have consistently shown selenium levels above its MCL of 50 µg/L during this period. All wells with selenium exceedances were screened in the HZ-A ground-water zones. Mann-Kendall tests were performed on six wells having concentrations exceeding the selenium MCL: B53W09S, B53W13S, B53W17S, M10-15S, MW31-98, and MW33-98. Although additional wells (PW37, PW38, PW39, PW40, and PW41) had concentrations above the MCL during this period, insufficient data was available to perform the test. A significant trend in selenium concentrations (i.e., trends with a confidence level greater than 90%) was observed for three wells. Two wells (B53W09S and B53W13S) had concentrations that were decreasing and one well (M10-15S) had concentrations that were increasing during this period. The test indicated no trend for the remaining wells. The well with increasing trend, M10-15S, had the highest selenium concentrations at the site, with a maximum detected concentration of 792 µg/L. The upward trend in M10-15S may reflect a short-term increase resulting from remedial activities being conducted at SLAPS in the vicinity of the well, but continued monitoring will be necessary to determine the cause. Results of the Mann-Kendall test are presented in Table 4-12.

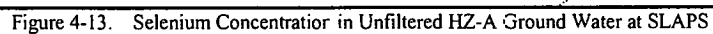


Table 4-12. Results of Mann-Kendall Trend Test for Selenium in HZ-A Ground Water at SLAPS

Event Number	Sampling Date	Station					
		B53W09S (Unit 2 and 3T)	B53W13S (Unit 2)	B53W17S (Unit 2 and 3T)	MW31-98 (Unit 2)	MW33-98 (Unit 2)	M10-15S (Unit 2 and 3T)
1	Third Quarter CY98	344	438	101			634
2	Fourth Quarter CY98	368	435	86.4	178	370	657
3	First Quarter CY99	353	409	86.8	181	387	683
4	Third Quarter CY99	326	401	84.2	181	368	729
5	First Quarter CY00	338	407	71.4	195	429	792
6	Second Quarter CY00	353	392	66.8	185	0.9	712
7	Third Quarter CY00	324	379	58.9	3.3	332	751
8	Fourth Quarter CY00			59.6	171	333	
9	First Quarter CY01			58.8	193	305	
10	Second Quarter CY01	326	347	57.7	193	288	738
11	Third Quarter CY01			48.7	185	314	
12	Fourth Quarter CY01			50.0	184	231	
Mann Kendall Statistic (S) =		-15.0	-19.0	-32.0	-2.0	-9.0	22.0
Number of Rounds (n) =		9	8	13	11	11	9
Average =		353.56	401.00	73.79	168.12	304.99	702.17
Standard Deviation =		39.109	29.534	23.061	55.123	114.005	56.787
Coefficient of Variation(CV)=		0.111	0.074	0.313	0.328	0.374	0.081
Trend \geq 80% Confidence Level		Decreasing	Decreasing	No Trend	No Trend	No Trend	Increasing
Trend \geq 90% Confidence Level		Decreasing	Decreasing	No Trend	No Trend	No Trend	Increasing
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	CV \leq 1 STABLE	CV \leq 1 STABLE	CV \leq 1 STABLE	NA

The Mann-Kendall test was performed using the WDNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends

Arsenic data is available for numerous SLAPS wells for the period since the Summer CY97 baseline ground-water characterization effort. Eleven HZ-C wells have consistently shown arsenic levels above its MCL (10 $\mu\text{g/L}$) during this period. In contrast, with the exception of one well (B53W14S), the concentrations in the HZ-A wells were generally below the MCL. The Mann-Kendall test was conducted for the single HZ-A well (B53W14S) and for the eleven HZ-C wells showing arsenic concentrations consistently exceeding the MCL. The results, presented in Table 4-13, indicate that five of the wells tested (four HZ-C wells and the HZ-A well) have statistically significant increasing trends. The Mann-Kendall test does not provide an indication of the magnitude of the increasing trend. Based on the slopes observed in the time plots, the increasing trends are of low magnitude. One HZ-C well, MW34-98, has a statistically significant decreasing trend. For the remaining HZ-C wells, no significant trend in concentrations was observed. The lack of a correlation between the arsenic concentrations in the HZ-C ground water and the arsenic concentrations reported for nearby HZ-A wells indicate that the increasing trend in HZ-C ground water is not due to FUSRAP-related activities at the site.

Radionuclides

Historical results of radiological analysis for uranium indicate that numerous HZ-A wells have elevated concentrations of uranium isotopes, particularly U-234 and U-238. An evaluation of historical uranium concentrations has been conducted using total uranium concentrations based on radiological analysis. The Mann-Kendall test was performed on thirteen HZ-A wells using the quarterly data collected from Fall CY98 through Winter CY01. PW39 and PW40 had significantly elevated levels of total uranium, but less than six rounds of data are available so a Mann-Kendall test could not be performed for these wells. Total uranium concentrations (in $\mu\text{g/L}$) were calculated for the thirteen wells listed in Table 4-14. A value equal to one half of the detection limit was substituted for non-detect isotopic values prior to calculating the total uranium concentration used in the time plots and Mann-Kendall test. A significant trend in total uranium concentrations (i.e., a trend with a confidence level greater than 90%) was identified for six of the thirteen wells (two decreasing and four increasing trends). The increasing trends were observed in wells B53W06S, B53W09S, B53W18S, and MW33-98. As shown in the time versus concentration plots for total uranium presented in Figure 4-14, with the exception of MW33-98, the increasing trends appear to be of low magnitude. The increasing concentrations of total uranium in MW33-98, located adjacent to the Radium Pits area, may be related to on-going removal activities in areas located immediately upgradient of the well. Total uranium concentrations remain at non-detect levels in MW34-98, located adjacent to MW33-98, indicating that HZ-C is not being impacted. Decreasing trends were identified for HZ-A wells M10-25S and M10-08S located near the southern edge of SLAPS. The decreasing trend may be related to remediation activities that have been conducted at the site. The remaining wells displayed no trend.

Table 4-13. Results of Mann-Kendall Trend Test for Arsenic at SLAPS

Event Number	Sampling Date	Stations					
		B53W01D (Units 3B and 4)	B53W02D (Unit 4)	E53W03D (Unit 4)	B53W04D (Units 3M and 3B)	B53W05D (Units 3B and 4)	B53W06D (Units 3B and 3M)
1	Third Quarter CY98	72					24.5
2	Fourth Quarter CY98	70.4	31.4	67.2	21.5	111	28
3	First Quarter CY99	78.2	29.8	65.6	18.6	99.9	27
4	Third Quarter CY99	73.6		68	16.4	104.3	29.2
5	First Quarter CY00	82.2	28	70.2	17.9	95.5	30.3
6	Second Quarter CY00	83.1	1.1	70.6	19.4	112.7	31.1
7	Third Quarter CY00	83.9	32.7	71.2	20.5	107	27.9
8	Second Quarter CY01	85.2	32.4	66.8		109	
9	Third Quarter CY01				19		27.8
Mann Kendall Statistic (S) =		24.0	1.0	9.0	1.0	3.0	8.0
Number of Rounds (n) =		8	6	7	7	7	8
Average =		78.58	25.90	68.49	19.04	105.63	28.23
Standard Deviation =		5.865	12.275	2.113	1.672	6.182	2.044
Coefficient of Variation(CV)=		0.075	0.474	0.031	0.088	0.059	0.072
Trend ≥ 80% Confidence Level		Increasing	No Trend	Increasing	No Trend	No Trend	Increasing
Trend ≥ 90% Confidence Level		Increasing	No Trend	No Trend	No Trend	No Trend	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level		NA	CV<=1 STABLE	NA	CV <= 1 STABLE	CV <= 1 STABLE	NA

Event Number	Sampling Date	Station					
		B53W07D (Unit 4)	B53W08D (Units 3B and 4)	M10-08D (Unit 3B)	M10-15D (Unit 3B)	MW34-98 (Unit 3B)	B53W14S (Unit 3T)
1	Third Quarter CY98	64		64.2	59	216	
2	Fourth Quarter CY98	5	70.7	71	71.2	236	20.9
3	First Quarter CY99	65.2	70.4	66.2	75	217	21.7
4	Third Quarter CY99	66.2	73.15	69.3	85.4	233	22
5	First Quarter CY00	68.2	74.14	66.1	103		25.3
6	Second Quarter CY00	70.3	78.1	71.3	95.6	213	21.9
7	Third Quarter CY00	69.1	79.8	66	101	227	25.6
8	First Quarter CY01					201	
9	Second Quarter CY01	69		66.5	105	190	24
10	Third Quarter CY01		71.2			154	
11	Fourth Quarter CY01					150	28.5
Mann Kendall Statistic (S) =		20.0	11.0	2.0	24.0	-31.0	20.0
Number of Rounds (n) =		8	7	8	8	10	8
Average =		59.63	73.93	67.58	86.90	203.70	23.74
Standard Deviation =		22.176	3.716	2.610	17.030	30.565	2.598
Coefficient of Variation(CV)=		0.372	0.050	0.039	0.196	0.150	0.109
Trend ≥ 80% Confidence Level		Increasing	Increasing	No Trend	Increasing	Decreasing	Increasing
Trend ≥ 90% Confidence Level		Increasing	Increasing	No Trend	Increasing	Decreasing	Increasing
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	CV <= 1 STABLE	NA	NA	NA

The Mann-Kendall test was performed using the WDNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

Table 4-14. Results of Mann-Kendall Trend Test for Total Uranium in HZ-A Ground Water at SLAPS

Event Number	Sampling Date	Station					
		B53W06S (Units 2 and 3T)	B53W07S (Unit 2)	B53W09S (Units 2 and 3T)	B53W10S (Units 3M and 3T)	B53W13S (Units 3T and 3M)	B53W17S (Units 2 and 3T)
1	Third Quarter 1998	32.6	11.2	7.45	4.5	13.6	
2	Fourth Quarter 1998	64.9	2.2	19.8	0.3	16.8	
3	First Quarter 1999	68.7	12.9	8.6	10.1	11.5	6.4
4	Third Quarter 1999	66.2	7.6	11.2	4.7	14.7	5.4
5	First Quarter 2000	83.5	9.3	11	7.9	13	4.0
6	Second Quarter 2000	75.6	13.2	14	3.6	14	1.1
7	Third Quarter 2000	14.2	9.3	11.2	6.9	13.2	3.0
8	Fourth Quarter 2000						8.1
9	First Quarter 2001						8.2
10	Second Quarter 2001			25.2	3.3	15.7	1.9
11	Third Quarter 2001	85.2	7.1				6.2
12	Fourth Quarter 2001						7.4
Mann Kendall Statistic (S) =		12.0	-1.0	13.0	-2.0	2.0	5.0
Number of Rounds (n) =		8	8	8	8	8	10
Average =		61.36	9.10	13.56	5.16	14.06	5.17
Standard Deviation =		25.078	3.578	6.027	3.050	1.660	2.554
Coefficient of Variation(CV)=		0.409	0.393	0.445	0.591	0.118	0.494
Trend ≥ 80% Confidence Level		Increasing	No Trend	Increasing	No Trend	No Trend	No Trend
Trend ≥ 90% Confidence Level		Increasing	No Trend	Increasing	No Trend	No Trend	No Trend
Stability Test, If No Trend Exists at			CV ≤ 1		CV ≤ 1	CV ≤ 1	CV ≤ 1
80% Confidence Level		NA	STABLE	NA	STABLE	STABLE	STABLE

Table 4-14 Results of Mann-Kendall Trend Test for Total Uranium in HZ-A Ground Water at SLAPS (Cont'd)

Event Number	Sampling Date	Station						
		B53W18S (Unit 2 and 3T)	M10-08S (Unit 3T)	M10-15S (Unit 2 and 3T)	M10-25S (Unit 2 and 3T)	MW32-98 (Unit 2)	MW33-98 (Unit 2)	PW38 (Unit 2)
1	Third Quarter 1998	5.4	66	7.9	114.3	0.7	68.8	
2	Fourth Quarter 1998	2.4	98.3	3.1	120.8	6.5	75.2	
3	First Quarter 1999	2.4	64.1	8.9	74.7	1.4	132.9	
4	Third Quarter 1999	2.9	5.4	8.7	46.6	6.5	46.2	
5	First Quarter 2000	2.9	13.7	6.2	51.7	6.7	65.7	9,168
6	Second Quarter 2000	6.1	7.9	5.0	40.8	6.0	2.5	6,494
7	Third Quarter 2000	6.1	9.7	5.8	65.6			7,091
8	Fourth Quarter 2000							7,874
9	First Quarter 2001	3.7				6.1	116.4	6,858
10	Second Quarter 2001		2.2	5.6	39.5	1.7	118.9	6,392
11	Third Quarter 2001	6.5				6	155.6	8,954
12	Fourth Quarter 2001					21.3	217.4	10,169
Mann Kendall Statistic (S) =		19.0	-18.0	-8.0	-18.0	10.0	15.0	4.0
Number of Rounds (n) =		9	8	8	8	10	10	8
Average =		4.27	33.41	6.40	69.25	6.29	99.93	7875.00
Standard Deviation =		1.733	36.984	1.989	32.172	5.797	61.227	1406.816
Coefficient of Variation(CV)=		0.406	1.107	0.311	0.465	0.922	0.613	0.179
Trend ≥ 80% Confidence Level		Increasing	Decreasing	Decreasing	Decreasing	No Trend	Increasing	No Trend
Trend ≥ 90% Confidence Level		Increasing	Decreasing	No Trend	Decreasing	No Trend	Increasing	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	NA	NA	CV ≤ 1. STABLE	NA	CV ≤ 1 STABLE

The Mann-Kendall test was performed using the WDNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

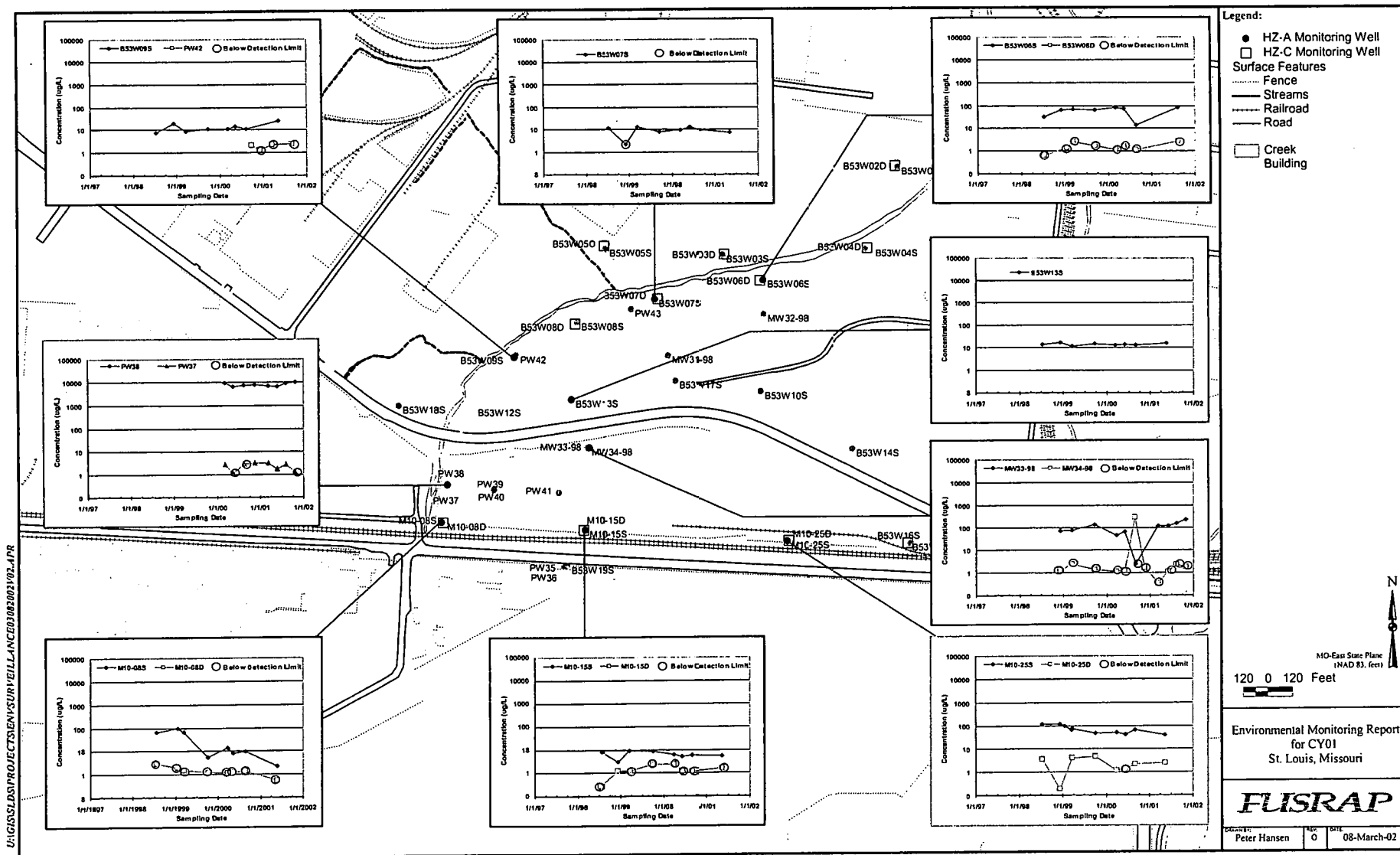


Figure 4-14. Total Uranium Concentration in Unfiltered HZ-A Ground Water at SLAPS

During CY01, Ra-226 was detected at levels above the MCL of 5 pCi/L in three HZ-A wells. Because the concentrations were consistently low and the incidence of non-detection was high, a trend analysis was not performed for Ra-226. Th-230 levels were also consistently low for most wells at the site. Wells PW38, PW39, PW40, and PW41 had multiple detections above the expected Th-230 HZ-A background levels, but insufficient data was available to conduct trend analysis. Future trend analysis is planned, after additional data is collected.

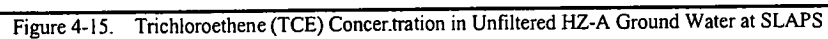
Trichloroethene

Because significant levels of TCE were detected in several HZ-A wells, a trend analysis was also performed for that compound. The historical data indicates that four wells (B53W13S, B53W17S, MW31-98, and MW33-98) have consistently elevated levels of TCE (Figure 4-15). Trend analysis was performed on these four monitoring points using the Mann-Kendall test. Additional wells (in particular, PW38, PW39, PW40, and PW41) have concentrations exceeding the MCL of 5 $\mu\text{g/L}$ but because there is TCE data for only 4 sampling events from these wells, the Mann-Kendall test was not performed. The results of the Mann-Kendall test (Table 4-15) show no change in trends since last year. Two wells (MW31-98 and B53W13S) have concentrations that are increasing and two wells (MW33-98 and B53W17S) have concentrations that are decreasing. The results may indicate that TCE is present due to a discrete release of TCE in the past, in the vicinity of B53W17S. Decreasing concentrations near the source area would indicate there is not a continuing source of TCE contamination in the area. The TCE concentrations in the source area are declining due to advection, dispersion, and natural attenuation. In addition to TCE, the TCE degradation product 1,2-DCE has also been detected in the area. 1,2-DCE was detected in PW38 (maximum concentration of 100 $\mu\text{g/L}$), PW40 (maximum concentration of 45 $\mu\text{g/L}$), and PW39 (maximum concentration of 27 $\mu\text{g/L}$), suggested some degradation of TCE is occurring in this area. The gradually increasing concentrations in downgradient wells MW31-98 and B53W13S may indicate that the dissolved TCE "plume" is continuing to migrate slowly northward and, to a lesser extent westward, from the source area.

Table 4-15. Results of Mann-Kendall Trend Test for TCE at SLAPS

Event Number	Sampling Date	Station			
		B53W17S (Units 2 and 3T)	MW31-98 (Unit 2)	B53W13S (Unit 2)	MW33-98 (Unit 2)
1	Third Quarter CY98			6	
2	Fourth Quarter CY98	970	3	5	24
3	First Quarter CY99	690	2.5	6	14
4	Third Quarter CY99		5	4	13
5	First Quarter CY00	370	7.9	6.4	18
6	Second Quarter CY00	340	14	7.1	14
7	Third Quarter CY00	350	13	7.2	2.5
8	Fourth Quarter CY00	360	21		
9	First Quarter CY01	260	33		
10	Second Quarter CY01	270	55	9.2	
11	Third Quarter CY01	340	69		2.5
12	Fourth Quarter CY01	340	69		
Mann-Kendall Statistic (S) =		-26.0	42.0	19.0	-13.0
Number of Rounds (n) =		10	10	8	7
Average =		429.00	28.94	6.36	12.57
Standard Deviation =		224.324	26.163	1.558	7.823
Coefficient of Variation(CV)=		0.523	0.904	0.245	0.622
Trend \geq 80% Confidence Level		Decreasing	Increasing	Increasing	Decreasing
Trend \geq 90% Confidence Level		Decreasing	Increasing	Increasing	Decreasing
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	NA	NA

The Mann-Kendall test was performed using the WDNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.



4.2.3 Evaluation of the CY01 Potentiometric Surfaces at SLAPS

Ground-water surface elevations were measured from wells at SLAPS in March, April, August, and October of CY01. Ground-water surface elevation contours were drawn using the April 16-17 and August 6, 2001 measurements to provide a comparison of the ground-water flow conditions in periods of high and low precipitation, respectively. The potentiometric surface maps, shown in Figures 4-6 through 4-9, 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 SLAPS in April and August CY01 in the HZ-A ground water is westerly to northwesterly towards Coldwater Creek (Figures 4-6 and 4-8). HZ-A ground water beneath properties located north of the creek also converges to the creek as shown. The hydraulic gradient increases near the southern side of Coldwater Creek. 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. Recharge to the ground water occurs from precipitation, off-site inflow of ground water, and creek bed infiltration during high creek stage. Discharge may occur by seepage into Coldwater Creek during low creek stage (BNI, 1994). The vertical gradient varies beneath the site and is influenced by stratigraphic heterogeneity and seasonal fluctuations in recharge and evapotranspiration. The position of the HZ-A ground-water surface tends to range from 1 to 7 ft lower in the dry season than in the wet season.

A review of the screened intervals in the deep wells indicates many screened intervals crossed several lithologic units and HZs. It was determined that the HZ-C (Unit 4) potentiometric surface was a proper representation of the lower ground-water system. While this reduces the number of data points, it provides a higher confidence in the potentiometric surfaces.

Figures 4-7 and 4-9 illustrate the potentiometric surface contours for the HZ-C ground water in CY01. The flow in HZ-C is generally east to northeast at a gradient of approximately 0.002 ft/ft. A comparison of the ground-water elevation measurements from monitoring well pairs indicates that the wells completed in the upper ground-water zones (HZ-A and HZ-B) exhibit different hydraulic heads from the wells completed in lower zones (HZ-C, HZ-D, and/or HZ-E). Near Coldwater Creek, the potentiometric surface of the "confined" aquifer HZ-C [ranging in elevation between 514 and 516 ft above mean sea level (amsl)] is higher than the potentiometric surface of the unconfined HZ-A zone, indicating an upward vertical gradient. In other areas at SLAPS, the potentiometric measurements indicate a downward hydraulic gradient (as shown in the wells B53W19S/PW36). 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 indicates that a highly impermeable clay (Subunit 3M) and silty clay (Subunit 3B) 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.

4.3 SLDS

Ground water at SLDS is found within three hydrostratigraphic units (HUs). These units are the upper, HU-A unit, which consists of fill overlying clay and silt; the lower, HU-B alluvial unit, referred to as the Mississippi Alluvial Aquifer; and the limestone bedrock, referred to as HU-C (Figure 4-16). HU-A is not an aquifer and is not considered a potential source of drinking water because it has insufficient yield and poor natural water quality. The HU-B, Mississippi Alluvial Aquifer, is one of the principal aquifers in the St. Louis area, but expected future use as drinking water at SLDS is minimal, since the Mississippi and Missouri Rivers provide a readily available source. As shown in Figure 4-17, the erosional surface of the bedrock dips eastward toward the river. HU-A overlies HU-B on the east and overlies bedrock on the western side of SLDS. HU-B thins westerly along the rock surface until it becomes absent beneath the SLDS, being truncated by the rising bedrock and HU-A.

One new ground-water monitoring well, DW22R, was installed at SLDS in November of CY01. This well, located on the PSC Metals Property (DT-8), is intended to serve as upgradient monitoring well for HU-B ground water at SLDS. The location for this new ground-water monitoring well is shown on Figure 4-18. After sufficient data has been collected from DW22R, the results will be used to determine background concentrations for COC's in HU-B ground-water at SLDS.

4.3.1 Evaluation of the CY01 EMP Ground-water Sampling at SLDS

The EMP monitoring well network for SLDS is shown on Figure 4-18. Table 4-16 identifies the screened HUs for the SLDS ground-water monitoring wells. Prior to the long-term monitoring requirements for the HU-B aquifer specified in the SLDS ROD (USACE, 1998d), there was no EMP sampling performed at SLDS. In CY01, a total of twenty-three wells (11 HU-A and 12 HU-B) were sampled for radionuclides and inorganic constituents at SLDS. Three monitoring wells (B16W05S, B16W05D and B16W11S) were decommissioned during the fourth quarter of CY01. Ground-water monitoring well DW20 was transferred to Mallinckrodt in the fourth quarter of CY01 and so is no longer included in the EMP monitoring well network for SLDS. The twelve HU-B wells in the EMP include a new monitoring well, DW22R, which was sampled on December 27, 2001, shortly after it was installed. Ground-water wells at SLDS were not sampled for organics in the CY01 sampling events. Ground water was sampled for the COCs for SLDS as identified in the SLDS ROD: radionuclides, arsenic, and cadmium (USACE, 1998d). The ground-water data for the SLDS COCs are compared to investigative limits as identified in the SLDS ROD and to SDWA MCLs.

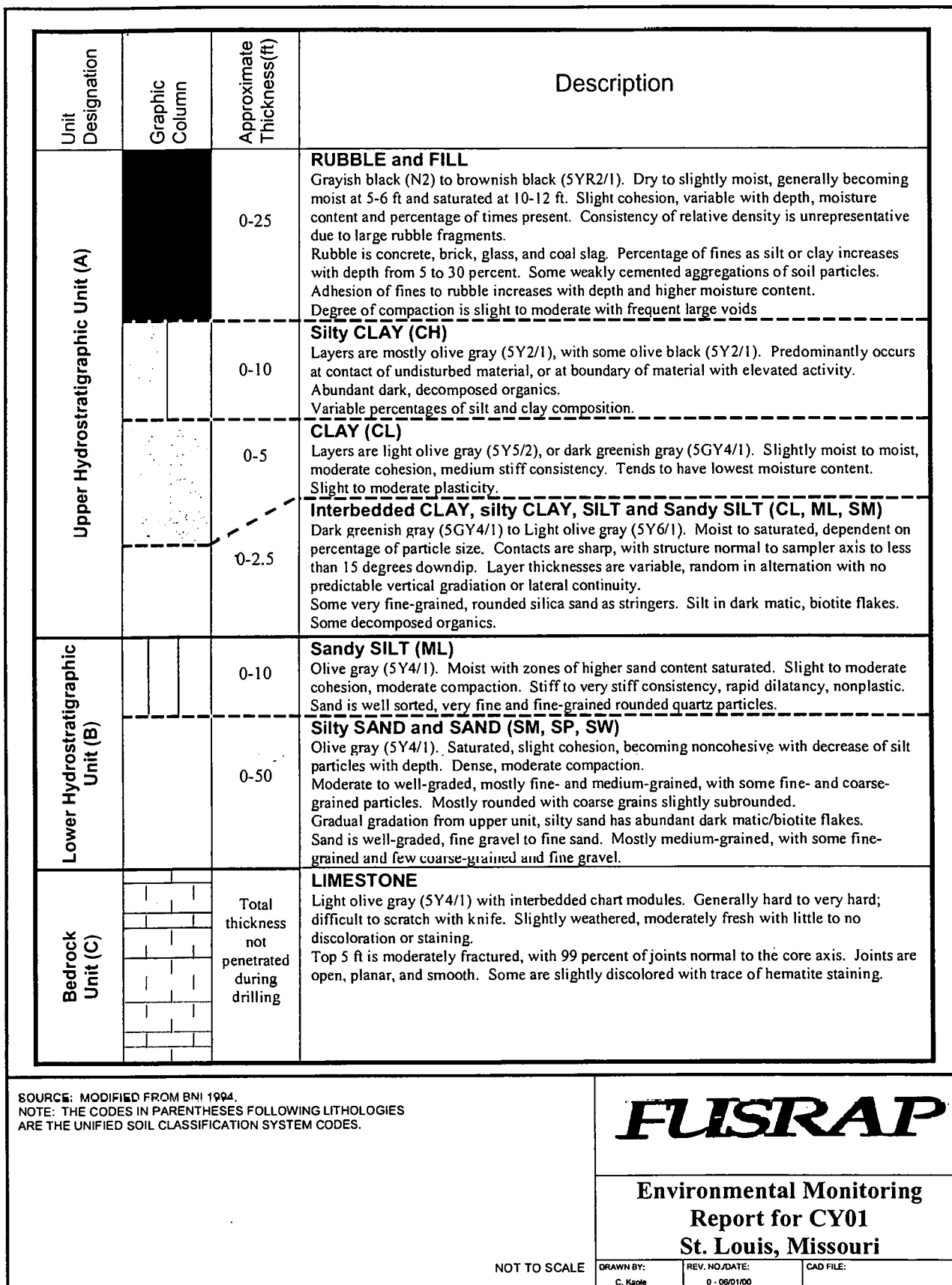


Figure 4-16 Generalized Stratigraphic Column for SLDS

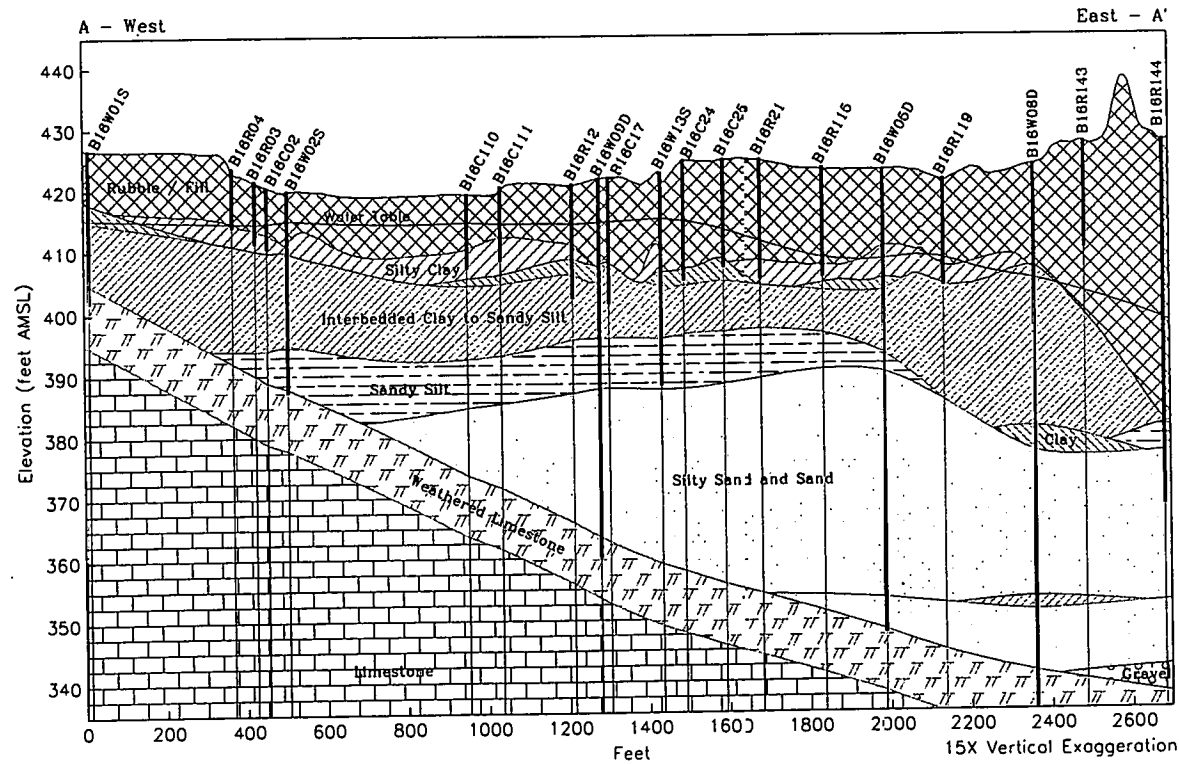


Figure 4-17.
Geologic Cross
Section A - A' at
SLDS

Geologic data used in the cross section
collected prior to 1998.

Cross Section Location Map



FUSRAP

St. Louis Downtown Site
St. Louis, Missouri

Drawn By: R. Smith

Rev. No. / Date: 0 / 24 Mar 99

File: SLDSG1g01XsectA.sho

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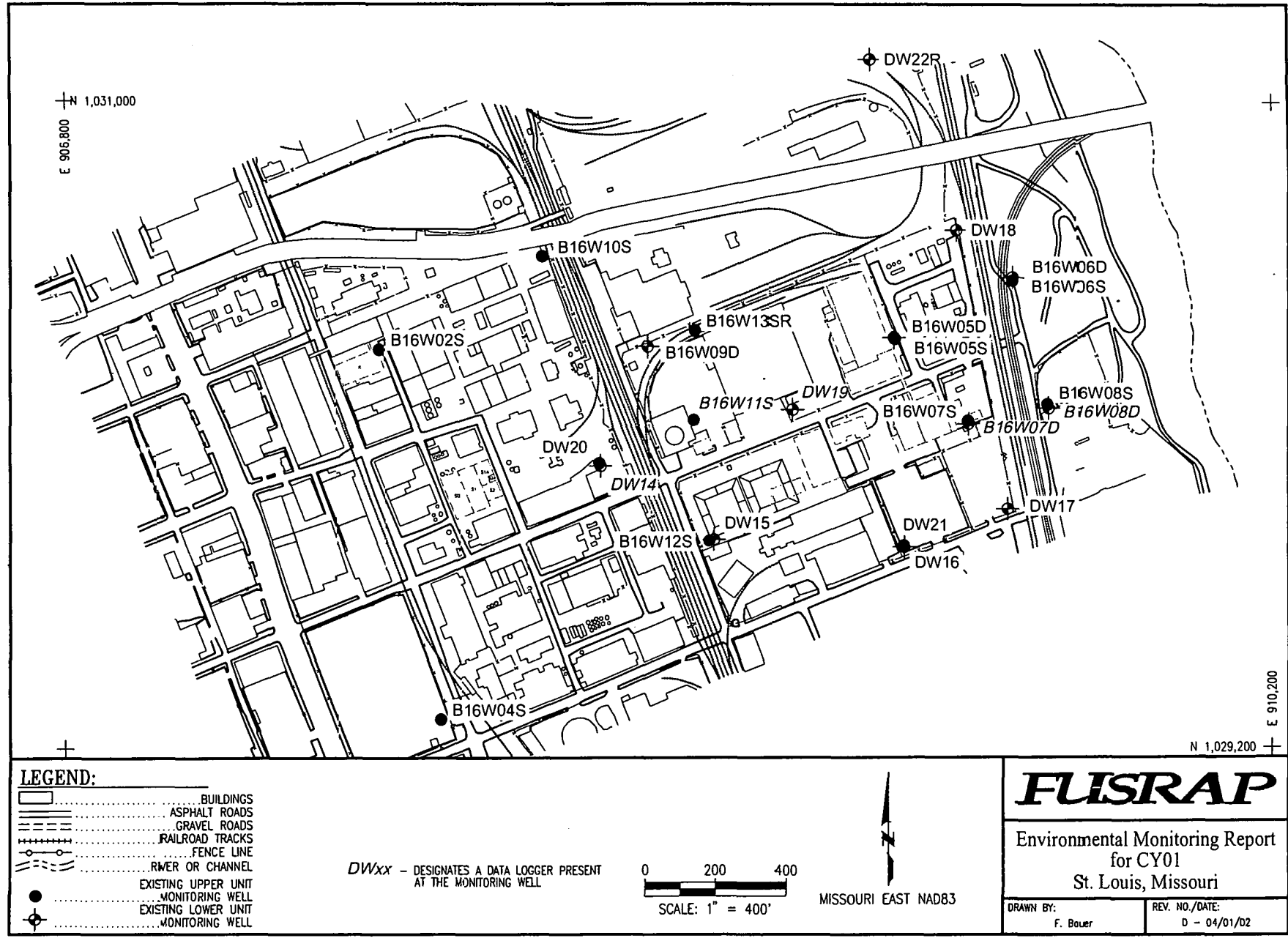


Figure 4-18. Ground-water Monitoring Well Locations at the SLDS

Table 4-16. Screened Hydrostratigraphic Units for SLDS Ground-water Monitoring Wells

Well ID	Screened Hydrostratigraphic Unit
B16W02S	HU-A
B16W04S	HU-A
B16W05D ²	HU-B
B16W05S ²	HU-A
B16W06D	HU-B
B16W06S	HU-A
B16W07D	HU-B
B16W07S	HU-A
B16W08D	HU-B
B16W08S	HU-A
B16W09D	HU-B
B16W10S	HU-A
B16W11S ^{1,2}	HU-A
B16W12S	HU-A
B16W13SR	HU-A
DW14	HU-B
DW15	HU-B
DW16	HU-B
DW17	HU-B
DW18	HU-B
DW19	HU-B
DW21	HU-A
DW22R ³	HU-B

1 Well believed to be communicating with HU-B.

2 Well decommissioned during CY01

3 Well installed in November CY01

In CY01, ground-water sampling at SLDS was conducted between February 21 and February 26 (first quarter); April 18 to April 30 (second quarter); July 11 to September 11 (third quarter); and November 6 to November 7 (fourth quarter). The ground-water sampling results for unfiltered samples are summarized in Tables 4-17 and 4-18. For discussion purposes, the ground-water analytical data acquired in the CY01 sampling events at SLDS are presented separately for the upper (HU-A) and lower (HU-B) ground-water zones.

The results of the CY01 ground-water sampling for SLDS COCs are provided in Tables 4-17 and 4-18. The summary statistics for all analytes in ground water are presented in Table D-2 in Appendix D. The SLDS wells were sampled following a protocol that did not require every analyte to be sampled every quarter for each well.

Table 4-17. Analytes Detected in HU-A Ground Water at SLDS in CY01 (Unfiltered Data)

Chemical	IL ¹	Units	Station ²	Minimum Detected	Maximum Detected	Mean Detected	# Detects > IL	Frequency of Detection
Arsenic	50	µg/L	B16W04S	9.7	9.7	9.7	0	1/1
			B16W05S	50.5	50.5	50.5	1	1/1
			B16W06S	188	188	188	1	1/1
			B16W07S	5.2	5.2	5.2	0	1/1
			B16W11S	3.5	3.5	3.5	0	1/1
			DW21	117	138	127	4	4/4
Cadmium	5	µg/L	B16W11S	14.3	14.3	14.3	1	1/1
Ra-226	---	pCi/L	B16W12S	16	16	16	---	1/2
			B16W13SR	3.5	3.5	3.5	---	1/2
Th-228	---	pCi/L	DW21	0.72	0.72	0.72	---	1/4
Th-230	---	pCi/L	B16W02S	5.21	5.21	5.21	---	1/1
			B16W06S	1.24	1.24	1.24	---	1/1
			B16W07S	1.6	1.6	1.6	---	1/1
			B16W12S	0.94	0.94	0.94	---	1/2
			B16W13SR	0.87	1.45	1.16	---	2/2
			DW21	1.04	1.13	1.09	---	2/4
Total Uranium ³	20	µg/L	B16W02S	89.3	89.3	89.3	1	1/1
			B16W04S	1.2	1.2	1.2	0	1/1
			B16W06S	1.7	1.7	1.7	0	1/1
			B16W08S	0.6	0.6	0.6	0	1/1
			B16W11S	56.5	56.5	56.5	1	1/1
			B16W12S	5.6	5.6	5.6	0	2/2
			B16W13SR	74.6	103.4	89	2	2/2

¹ IL = Investigative Limit

² Table lists only those stations at which the analyte was detected in HU-A ground water.

³ Total Uranium Values were calculated from isotopic concentrations in pCi/L and converted to µg/L using radionuclide specific activities.

--- Not Available

Table 4-18. Analytes Detected in HU-B Ground Water at SLDS in CY01 (Unfiltered Data)

Chemical	IL ¹	Units	Station ²	Minimum Detected	Maximum Detected	Mean Detected	# Detects > IL	Frequency of Detection
Arsenic	50	µg/L	B16W05D	14	14	14	0	1/1
			B16W07D	22.1	22.1	22.1	0	1/1
			B16W08D	31.2	31.2	31.2	0	1/1
			B16W09D	6.8	6.8	6.8	0	1/1
			DW14	169	189	179	2	2/2
			DW15	55.6	71.5	61.8	4	4/4
			DW16	7.7	7.7	7.7	0	1/2
			DW17	7	9.5	8.3	0	2/2
			DW18	31.1	35.9	33.8	0	4/4
			DW19	19.9	21.0	20.4	0	4/4
			DW22R ⁴	36.7	36.7	36.7	0	1/1
Ra-226	---	pCi/L	B16W05D	15.46	15.46	15.46	---	1/1
			DW14	7.62	12.1	9.86	---	2/2
			DW15	0.7	5.95	3.33	---	2/4
Th-228	---	pCi/L	DW14	2.42	2.42	2.42	---	1/2
			DW15	0.49	0.49	0.49	---	1/4
			DW19	0.59	0.59	0.59	---	1/4
Th-230	---	pCi/L	B16W07D	0.83	0.83	0.83	---	1/1
			B16W08D	1.26	1.26	1.26	---	1/1
			DW14	1.83	2.38	2.11	---	2/2
			DW15	1.36	1.83	1.59	---	2/4
			DW17	2.09	2.09	2.09	---	1/2
			DW22R ⁴	3.73	3.73	3.73	---	1/1
Th-232	---	pCi/L	DW14	1.19	1.19	1.19	---	1/2
Total Uranium ³	20	µg/L	B16W05D	1.3	1.3	1.3	0	1/1
			DW14	2.9	5.4	4.2	0	2/2
			DW15	2.1	2.5	2.3	0	2/4
			DW16	1.3	5.5	3.4	0	2/2
			DW17	1.7	5.8	3.8	0	2/2
			DW18	1.1	3.5	2.3	0	3/4
			DW19	58.0	121.0	84.8	4	4/4
			DW22R ⁴	2.1	2.1	2.1	0	1/1

¹ IL = Investigative Limit

² Table lists only those stations at which the analyte was detected in HU-B ground water.

³ Total Uranium Values were calculated from isotopic concentrations in pCi/L and converted to µg/L using radionuclide specific activities.

⁴ DW22R was sampled shortly after development was completed on December 27, 2001

--- Not Available

HU-A Ground Water

HU-A is not considered a potential source of drinking water. For that reason, the federal and state laws and regulations related to drinking water are not considered to be applicable or relevant and appropriate to currently impacted shallow, HU-A ground water beneath SLDS. Instead of MCLs, the investigative limits specified in the SLDS ROD are provided in Tables 4-17 and 4-18 for comparison purposes to assist in identifying the COCs present at

significant concentrations in SLDS ground water (USACE, 1998d). For those COCs that do not have established investigative limits, MCLs are used for comparison purposes only.

The two COCs that exceeded the investigative limits in HU-A ground water during CY01 are arsenic and total uranium. Arsenic concentrations exceeding the investigative limit of 50 $\mu\text{g/L}$ were detected in three HU-A wells at SLDS during CY01. The highest concentrations, 138 $\mu\text{g/L}$ and 188 $\mu\text{g/L}$, were detected in the third quarter samples from DW21 and B16W06S, respectively, located in the eastern portion of SLDS. Arsenic was also detected in a single sample from B15W05S at a concentration (50.5 $\mu\text{g/L}$) slightly exceeded the investigative limit. Total uranium concentrations, calculated from the isotopic uranium results, were detected above the investigative limit of 20 $\mu\text{g/L}$ in two wells screened exclusively in HU-A, B16W02S and B16W13SR. Well B16W02S had a maximum total uranium concentration of 89.3 $\mu\text{g/L}$. B16W13SR had a maximum detected concentration of total uranium of 103.4 $\mu\text{g/L}$. (A single sample from B16W11S was also above the investigative limit; however, there is a high level of uncertainty as to the unit this well is monitoring. It is not considered indicative of HU-A.) All three wells reported their maximum uranium concentration in the third quarter sample. One likely source of the elevated total uranium concentrations in these wells is the past MED/AEC activities conducted at SLDS. An evaluation of the concentration trends over time for arsenic and total uranium in ground water is presented in Section 4.3.2.

Other COCs identified in the SLDS ROD include Ra-226, Th-230, and cadmium. Investigative limits have not been established for Ra-226 so its levels are compared to the MCL. Radium-226 was detected only once above its MCL of 5 pCi/L (combined Ra-226/Ra-228) in the CY01 HU-A ground-water samples. The maximum level detected was 16 pCi/L in a third quarter sample from B16W12S. The only other detection of Ra-226 in HU-A ground water was from B16W13SR. An estimated (J-qualified) concentration of 3.5 pCi/L Ra-226, which is below the MCL of 5 pCi/L, was detected in the third quarter sample from this well. Cadmium was detected above its investigative limit of 5 $\mu\text{g/L}$ at a concentration of 14.3 $\mu\text{g/L}$ in the third quarter sample from B16W11S.

HU-B Ground Water

During CY01, twelve SLDS wells completed in the Mississippi Alluvial Aquifer (HU-B) were monitored for various parameters, including the COCs arsenic, cadmium, Th-228, Th-230, Th-232, Ra-226, U-234, U-235, and U-238. The concentrations of the COCs were compared to the following investigative limits specified in the ROD: 50 $\mu\text{g/L}$ for arsenic, 5 $\mu\text{g/L}$ for cadmium, and 20 $\mu\text{g/L}$ for total uranium (USACE, 1998d). The investigative limits for arsenic and total uranium differ from the current SDWA MCLs. In December CY00, EPA updated its standards for radionuclides in drinking water, increasing the uranium MCL from 20 $\mu\text{g/L}$ to 30 $\mu\text{g/L}$. In October CY01, EPA issued a new standard for arsenic in drinking water that reduced the MCL from 50 $\mu\text{g/L}$ to 10 $\mu\text{g/L}$. The EPA has set the effective date for this rule as January CY06. Although use of the Mississippi River Alluvial Aquifer (Unit B) as a drinking water source is not likely at SLDS, SDWA MCLs are used here for comparison purposes for those COCs for which investigative limits have not been established to determine if significant concentrations of COCs occur in HU-B ground water.

The CY01 sampling results indicate cadmium was not present above the investigative limit (5 $\mu\text{g/L}$) in samples collected from HU-B ground-water wells. Arsenic was detected above the investigative limit of 50 $\mu\text{g/L}$ in two wells: DW14, and DW15. The arsenic levels ranged from concentrations slightly exceeding the limit in DW15 (ranging from 55.6 $\mu\text{g/L}$ to 71.5 $\mu\text{g/L}$) to over 3 times the limit in DW14 (maximum 189 $\mu\text{g/L}$). The maximum concentrations in DW15 and DW14 were reported for the third and first quarter samples, respectively. The arsenic concentrations are likely naturally occurring. Elevated arsenic concentrations are typical for ground water in Mississippi River alluvial deposits (Miller, 1974).

The total uranium concentrations were calculated for each sample from the isotopic uranium results and specific activities. Total uranium was present above the investigative limit of 20 $\mu\text{g/L}$ in all four quarterly samples collected from DW19, located at Plant 6. The total uranium concentrations ranged from 58 $\mu\text{g/L}$ (third quarter) to 121 $\mu\text{g/L}$ (first quarter) in this well. Total uranium concentrations detected in the second quarter and fourth quarter samples from DW19 were similar in value (79.4 $\mu\text{g/L}$ and 80.6 $\mu\text{g/L}$, respectively). The cause of the elevated total uranium concentrations in DW19 is not yet known but will be investigated as part of the Ground-water Remedial Action Alternative Assessment (GRAAA). Seven other HU-B wells (B16W05D, DW14, DW15, DW16, DW17, DW18, and DW22R) indicated detectable levels of total uranium, but their maximum concentrations are well below the investigative limit. Continued ground-water sampling is necessary to determine if the source removal actions being conducted at SLDS will result in a reduction of uranium concentrations in ground-water samples from these wells.

The other COCs detected in HU-B ground-water at SLDS, Ra-226, Th-238, Th-230, and Th-232, do not have established investigative limits. The MCL for combined Ra-226/Ra-228, 5 pCi/L, was compared to the concentration activities of Ra-226 detected in the HU-B wells during CY01. The maximum Ra-226 concentration, 15.5 pCi/L, was reported for the third quarter ground-water sample from B16W05D located near the eastern edge of the site. In addition, Ra-226 was detected at levels slightly exceeding the MCL in two other HU-B wells at SLDS: DW14 (maximum 12.1 pCi/L – third quarter) and DW15 (maximum 5.95 pCi/L – second quarter). There are no established MCLs for Th-228, Th-230, or Th-232. The maximum concentrations of Th-228, Th-230, and Th-232 detected in HU-B ground water were 2.42 pCi/L in DW14 (third quarter), 3.73 pCi/L in DW22R (third quarter), and 1.19 pCi/L in DW14 (third quarter), respectively.

As specified in the SLDS ROD, initiation of a GRAAA would be undertaken if significant exceedances of the investigative limits for arsenic, cadmium, or total uranium are observed in the Mississippi Alluvial Aquifer (HU-B) (USACE, 1998d). Because significant exceedances have occurred, preparation of the GRAAA was initiated in CY01. Phase I of the GRAAA will likely be issued in CY02.

4.3.2 Comparison of Historical Ground-Water Data at SLDS

A qualitative evaluation of COC concentration trends in both HU-A and HU-B was conducted based on available sampling data for the period from January CY99 through November CY01. Table 4-19 summarizes the historical HU-A ground-water sampling data for the principal COCs at SLDS. The results indicate that shallow, HU-A ground water has been impacted by arsenic and uranium. However, the COC concentrations observed in HU-A ground water did not increase in CY01 over the levels observed in CY99 and CY00. Figures 4-19 and 4-20 provide time versus concentration plots for selected SLDS wells for arsenic and uranium, respectively. As shown in Figure 4-19, arsenic concentrations have remained relatively stable, but with some seasonal variation, since January CY99. Decreasing trends in uranium concentrations can be seen in B16W02S located in the western portion of the Mallinckrodt plant (Figure 4-20). Concentrations of total uranium in the remaining HU-A wells have generally remained stable. Historical data indicate that activity concentrations of the radionuclides Ra-226, Th-228, Th-230, and Th-232 have also remained relatively stable at low or nondetectable levels in HU-A ground-water samples.

Ground-water sampling results for SLDS indicate that no significant changes from CY00 COC levels have occurred in HU-B ground water during CY01 (Table 4-20). As shown in the time versus concentration plots in Figures 4-19 and 4-20, concentrations of arsenic and uranium in the HU-B wells have not shown significant increases since January CY99. Total uranium was observed above the investigative limit of 20 $\mu\text{g/L}$ in DW19 (maximum concentration 121 $\mu\text{g/L}$) in CY01, but the concentrations observed were similar to those observed in CY99 and CY00. The concentration of total uranium in monitoring well B16W11S has exceeded the investigative limit, but seems to be declining over time. It is believed that monitoring well B16W11S may be completed across both HU-A and HU-B. The elevated uranium and arsenic levels might not be representative of HU-B concentrations. As with the HU-A ground water samples, arsenic concentrations in HU-B ground-water samples were relatively constant over both CYs. Continued sampling will be necessary to determine if ongoing removal actions will result in a decrease in uranium concentrations in HU-B.

As specified in the ROD, "If long-term monitoring of this unit [HU-B] shows significant exceedances of MCLs or the thresholds established in 40 CFR 192 for the COCs specified in the SLDS ROD, a Ground-Water Remedial Action Alternative Assessment (GRAAA) will be initiated" (USACE, 1998d). The ROD specified the following investigative limits for each of the ground-water COCs: 50 $\mu\text{g/L}$ for arsenic, 5 $\mu\text{g/L}$ for cadmium, and 20 $\mu\text{g/L}$ for total uranium. The ground-water monitoring data indicate that various HU-B monitoring wells have exceeded the investigative limits for the COCs established in the ROD. Monitoring wells DW14 and DW15 have exceeded the investigative limit for arsenic and monitoring well DW19 has exceeded the investigative limit for total uranium. (In addition, samples collected from B16W11S, located west of DW19, have exceeded the investigative limits for total uranium and cadmium. Although B16W11S was originally intended to monitor HU-A, water level data indicate it may be hydraulically connected to HU-B. The concentrations detected in B16W11S may be attenuated by clays in HU-A and so may not reflect actual HU-B concentrations. B16W11S was decommissioned due to concerns regarding the integrity of the well and uncertainty with respect to the monitoring zone.) Because the monitoring data for HU-B

Table 4-19. Historical HU-A Unfiltered Ground-Water Sampling Data for the Contaminants at SLDS

Chemical	Station	Q4 CY98 1/19 - 2/5	Q1 CY99 3/3 - 3/25	Q2 CY99 5/17 - 5/28	Q3 CY99 9/23	Q1 CY00 4/11-4/27	Q2 CY00 5/17- 6/29	Q3 CY00 9/5 - 9/8	Q4 CY00 12/5	Q1 CY01 2/21 - 2/26	Q2 CY01 4/18 - 4/30	Q3 CY01 7/11 - 9/11	Q4 CY01 11/6 - 11/7
Arsenic (µg/L)	B16W02S	2.5 U	2.5 U	2.1		2.5 U	3.2 U	3.6 U				2.6 U	
	B16W04S	24.2	17.1	14.2		15.3	12.2	5.7 U			9.7		
	B16W05S	27.3	25.6	40.8		20	52.3	39.7				50.5	
	B16W06S	242	266	223		155	258	208				188	
	B16W07S	15 U	9.7 J	11.5		13.4	13.6	13.7 U			5.2		
	B16W08S	5.5 J	9.1 J	13		30.6	24.2	8.9 U				4.4 U	
	B16W10S	3.5 J	6.5 J	8.5 U		12.9	20.3	2.3 U				2 U	
	B16W11S	2.5 U	9.7 U	5.6 U		5.3	6.3	71				5.5	
	B16W12S	2.5 U	2.5 U	1.9 U		2.2 U	1.4 U	1.4 U		1.5 U		1.8 U	
	B16W13SR	2.5 U	2.5 U	1.9 U		2.2 U	1.4 U	1.4 U		1.5 U		1.4 U	
	DW20		116	129									
	DW21		125	114	130	173	125	131	134	117	123	138	124
Cadmium (µg/L)	B16W02S	0.59 U	0.5 U	0.3 U		0.8 U	2.8 U	0.3 U				0.71 U	
	B16W04S	4.2 U	4.3 J	0.4 U		0.8 U	0.8 U	7.8 U			0.16 U		
	B16W05S	4.2 U	0.5 U	0.3 U		0.8 U	2.8 U	0.3 U				0.15 U	
	B16W06S	0.5 U	0.5 U	0.3 U		0.8 U	0.8 U	0.64 U				0.15 U	
	B16W07S	0.5 U	0.5 U	0.3 U		2 U	0.3 U	1 U			0.26 U		
	B16W08S	1.9 J	0.8 U	0.77 U		0.8 U	0.8 U	0.71 U				1.8 U	
	B16W10S	0.76 J	1.9 U	8.8		1	0.3 U	0.3 U				0.39 U	
	B16W11S	2 U	0.5 U	0.3 U		0.8 U	2.8 U	5				14.3	
	B16W12S	4.2 U	0.5 U	0.3 U		0.8 U	0.3 U	0.3 U		0.69 U		0.15 U	
	B16W13SR	4.2 U	0.5 U	0.3 U		0.8 U	0.3 U	0.3 U		0.24 U		0.15 U	
	DW20		0.2 U	0.3 U									
	DW21		0.5 U	0.3 U	3 U	0.8 U	0.3 U	0.3 U	0.43 J	0.24 U	0.26 U	0.15 U	5 U
Radium-226 (pCi/L)	B16W02S	0.28 U	0 U	1.39 U		2.13 U	0.53 U	-0.1 U				0.32 U	
	B16W04S	0.3 U	1.06 U	-0.35 U		0.4 U	1.4 U	0.7 U			0.18 U		
	B16W05S	0 U	0.85 U	1.71 U		-0.21 U	0.93 U	0.62 U				0.91 U	
	B16W06S	0 U	0.58 U	-0.14 U		0.81 U	1.34 U	0.32 U				0.19 U	
	B16W07S	-0.09 U	0 U	-0.06 U		-0.11 U	-0.48 U	0.61 U			-0.3 U		
	B16W08S	0 U	-0.1 U	0.17 U		-0.21 U	-0.62 U	-0.23 U				0 U	
	B16W10S	0.31 U	0.41 U	0.43 U		0.49 U	-0.2 U	5.74 J				0.43 U	
	B16W11S	-0.28 U	0 U	1.02 U		1.14 U	1.45 U	0.4 U				0.42 U	
	B16W12S	-0.3 U	1.46 U	0.78 U		0.32 U	0.21 U	1.1 U		0.78 U		16	
	B16W13SR	0.78 U	0.5 U	0.86 U		0.78 U	0.17 U	2.32 J		1.63 U		3.15 J	
	DW20		85.81 J	13.36									
	DW21		0.8 U	0.54 U	0 U	-0.1 U	-0.1 U	0 U	-0.11 U	0.41 U	0.04 U	-0.39 U	0.43 U

Table 4-19. Historical HU-A Ground-Water Sampling Data for the Contaminants at SLDS (Cont'd)

Chemical	Station	Q4 CY98 1/19 - 2/5	Q1 CY99 3/3 - 3/25	Q2 CY99 5/17 - 5/28	Q3 CY99 9/23	Q1 CY00 4/11-4/27	Q2 CY00 5/17- 6/29	Q3 CY00 9/5 - 9/8	Q4 CY00 12/5	Q1 CY01 2/21 - 2/26	Q2 CY01 4/18 - 4/30	Q3 CY01 7/11 - 9/11	Q4 CY01 11/6 - 11/7
Thorium-228 (pCi/L)	B16W02S	0.58 U	0.51 U	0.16 U		0.27 U	0.06 U	0.17 U				0.32 U	
	B16W04S	0.26 U		0.16 U		1.43 U	0.37 U	0.81 U			0.24 U		
	B16W05S	0.72 U	0.51 U	2.43 J		0.45 U	0.13 U	0.3 U				0.69 U	
	B16W06S	0.6 U	4.28 J	0.39 U		0.47 U	0 U	0.46 U				0.51 U	
	B16W07S	0.91 U	0.11 U	0.4 U		0.4 U	-0.18 U	1.08 U			0.53 U		
	B16W08S	0.25 U	1.13 U	0.33 U		0.68 U	-0.12 U	0 U				0.3 U	
	B16W10S	0.39 U	0.34 U	2.96 J		0.91 U	-0.06 U					0.55 U	
	B16W11S	0.37 U	0.1 U	0.83 U		1.9 J	0.67 U	0.24 U				0.42 U	
	B16W12S	0.78 U	0.42 U	1.53 J		0.26 U	0.95 U	1.3 U		0.52 U		-0.32 U	
	B16W13SR	0.07 U	0.22 U	1.14 J		1.05 U	0.41 U	0.5 U		0.87 U		0.17 U	
	DW20		3.08 J	1.39 J									
	DW21		1.32 U	1.02 U	0 U	2.32 J	0.87 J	0.56 U	0.4 U	0.53 U	0.15 U	0.72 J	0.5 U
Thorium-230 (pCi/L)	B16W02S	2.63 J	4.78 J	1.81 J		2.52 J	2.02 J	1.31 J				5.21	
	B16W04S	2.06 J	1.53 J			0.99 U	1.22 J				0.29 U		
	B16W05S	0.51 U	2.17 J	5.12 J		0.48 U	2.02 J	0.47 U				0 U	
	B16W06S	1.74 J	11.96 J	0.83 U		0.7 U	1.68 J	1.29 J				1.24 J	
	B16W07S	2.86 J	1.62 J	0.95 U		0.63 U	0.72 U	0.65 U			1.6 J		
	B16W08S	2.27 J	0.12 U	1.55 J		0.57 U	-0.12 U	1.87 J				0 U	
	B16W10S	3.05 J	2.53 J	5.06 J		0.61 U	1.52 J	0.48 U				1 U	
	B16W11S	1.46 J	1.24 J	1.01 U		0.48 U	1.78 J	-0.06 U				1.14 U	
	B16W12S	1.07 U	0.96 J	6.6 J		0.87 U	0.64 U	1.43 J		0.91 U		0.94 J	
	B16W13SR	2.79 J	1.53 J			1.75 J	2.36 J	1.87 J		1.45 J		0.87 J	
	DW20			0.58 U									
	DW21		0.39 U	1.47 J		2.22 J	1.13 J	0.77 U	0.46 U	0.46 U	1.04 J	0.41 U	1.13 J
Thorium-232 (pCi/L)	B16W02S	0 U	0 U	0 U		0.26 U	0.24 U	0 U				-0.06 U	
	B16W04S	-0.09 U	0.19 U	0.3 U		0 U	0 U	0 U			-0.06 U		
	B16W05S	0.25 U	0.2 U	0 J		0.18 U	-0.06 U	0 U				-0.13 U	
	B16W06S	0 U	0.036 U	-0.08 U		0 U	0.24 U	0 U				0 U	
	B16W07S	0 U	0.18 U	0 U		0 U	0 U	0.24 U			-0.07 U		
	B16W08S	0.32 U	0.5 U	0.15 U		0 U	0.24 U	0 U				-0.06 U	
	B16W10S	0 U	0 U	0 U		0 U	0.25 U	-0.06 U				0 U	
	B16W11S	0 U	0.35 U	-0.07 U		0 U	0.24 U	0.24 U				0 U	
	B16W12S	0 U	0.16 U	0.22 J		-0.12 U	0 U	-0.07 U		-0.11 U		-0.08 U	
	B16W13SR	0 U	0.19 U	0.14 J		0.25 U	0.21 U	-0.05 U		-0.05 U		0.22 U	
	DW20			0 U			U						
	DW21		-0.06 U	0 U	0 U	0.47 U	0 U	0.21 U	0 U	-0.06 U	-0.06 U	0 U	0 U

Table 4-19. Historical HU-A Ground-Water Sampling Data for the Contaminants at SLDS (Cont'd)

Chemical	Station	Q4 CY98 1/19 - 2/5	Q1 CY99 3/3 - 3/25	Q2 CY99 5/17 - 5/28	Q3 CY99 9/23	Q1 CY00 4/11-4/27	Q2 CY00 5/17 - 6/29	Q3 CY00 9/5 - 9/8	Q4 CY00 12/5	Q1 CY01 2/21 - 2/26	Q2 CY01 4/18 - 4/30	Q3 CY01 7/11 - 9/11	Q4 CY01 11/6 - 11/7
Total Uranium ¹ (µg/L)	B16W02S	600.9	305.3	359.3		204.1	115.0	118.3				89.3	
	B16W04S	1.3 U	3.5 U	1.4 U		2.9 U	1.1 U	2.3 U			1.2 U		
	B16W05S	1.0 U	1.2 U	1.2 U		1.2 U	1.2 U	1.2 U				1.3 U	
	B16W06S	1.9 U	91.6 U	2.3 U		1.1 U	1.2 U	1.1 U				1.7	
	B16W07S	1.1 U	1.1 U	2.5 U		1.1 U	1.3 U	1.1 U			0.3 U		
	B16W08S	1.3 U	3.2 U	3.7		2.7 U	1.3 U	2.7 U				0.6	
	B16W10S	2.8 U	2.8	2.7 U		1.2 U	1.5 U	1.9 U				0.7 U	
	B16W11S	106.3	69.9	72.6		59.5	40.8	53.1				56.5	
	B16W12S	11.5	6.9	7.9		9.0	3.9	6.2		5.6		5.6	
	B16W13SR	60.7	60.9	61.2		134.4	62.6	77.3		74.6		103.4	
	DW20		2.3 U	2.0 U									
	DW21		3.2 U	2.7 U	3 U	2.3 U	1.4 U	1.9 U	1.2 U	3.6 U	0 U	1.7 U	1.1 U
Uranium-234 (pCi/L)	B16W02S	189.1	100.1	111.4		76.89	38.84	42.09				30.3	
	B16W04S	0.18 U		-0.06 U		0.52 U	-0.06 U	0 U			0.55 J		
	B16W05S	0 U	0.26 U	0.25 U		0.21 U	2.35 J	0.24 U				0.55 U	
	B16W06S	0 U	0 U	0.45 U		0.23 U	0.25 U	-0.06 U				0.4 U	
	B16W07S	0.42 U	-0.06 U	0.07 U		0.4 U	0.81 U	-0.06 U			0 J		
	B16W08S		0 U	1.12 U		0.26 U	-0.07 U	0 U				0.5 J	
	B16W10S	0.57 U	1.35 J			0.5 U	0.23 U	0 U				-0.15 U	
	B16W11S	32.25	22.25	23.7		19.4	16.41	18.56 J				15.67	
	B16W12S		3.53 J	1.72 J		2.75 J	0.94 U	2.02 J		0.91 U		1.05 J	
	B16W13SR	21.19	17.72	18.63		37.45	19.04	21.87		33.68		35.9	
	DW20		0.94 U	-0.06 U									
	DW21		0.78 U	-0.07 U	0.47 U	0 U	-0.074 U	0 U	-0.06 U	0 U	0.15 U	0.35 U	0.23 U
Uranium-235 (pCi/L)	B16W02S	8.33	3.65 J	8.16		2.29 J	0.79 U					2.11 J	
	B16W04S	-0.07 U	0 U	0.54 U		-0.16 U	0 U	0 U			0 J		
	B16W05S	0 U	0 U	0 U		-0.06 U	0.32 U	0 U				0 U	
	B16W06S	0 U	0 U	-0.08 U		0 U	0 U	0 U				-0.1 U	
	B16W07S	0 U	0 U	-0.25 U		0 U	0 U	0 U			-0.08 U		
	B16W08S	0 U	0.31 U	0.29 U		-0.03 U	0.33 U	0 U				0.15 U	
	B16W10S	0 U	-0.08 U	0 U		0 U	0 U	0 U				0 U	
	B16W11S	1.58 J		0.98 U		0.65 U	1.4 U	0.28 U				0 U	
	B16W12S	0 U	0.4 U	0 U		0 U	0 U	0.28 U		0 U		0 U	
	B16W13SR		0.42 U	1.71 U		2.04 J	0.76 U	0.39 U		0.96 U		1.52 J	
	DW20		-0.15 U	0 U									
	DW21		-0.08 U	-0.08 U	0 U	0 U	0 U	0 U	0 U	-0.4 U	0 J	0 U	0 U
Uranium-238 (pCi/L)	B16W02S	200	101.7	119.1		68.03	38.44	39.46				29.6	
	B16W04S	0.48 U		0.5 U		0 U	0.22 U	0.21 U			0.08 U		
	B16W05S	0 U	0 U	0 U		0 U	0.78 U	0 U				0.27 U	
	B16W06S	0.17 U	0.55 U	-0.06 U		0 U	0 U	0 U				0.48 J	
	B16W07S	0.24 U	0 U	0.2 U		0.23 U	0.54 U	0 U			0 J		
	B16W08S	0.28 U		1.17 J		0.39 U	0.79 U	0.24 U				0.25 U	
	B16W10S		0.94 U	-0.08 U		0.25 U	0.91 U	0 U				0 U	
	B16W11S	35.36	23.29	24.17		19.85	13.58	17.73				18.85	
	B16W12S	3.78 J	2.24 J	2.57 J		2.56 J	1.25 J	2.01 J		1.81 J		1.83 J	
	B16W13SR	20.2	20.21	20.37		44.7	20.88	25.82		24.79		34.4	
	DW20		0.94 U	-0.06 U									
	DW21		-0.26 U	-0.13 U	0.16 U	0.2 U	0.59 U	-0.06 U	0.25 U	-0.16 U	0 J	0 U	0 U

¹ Total Uranium values calculated from isotopic uranium sample results. Values equal to 1/2 of Detection Limit were substituted for non-detect results. Duplicates and Splits not included.

U = Reported concentration below sample quantitation limit based on "laboratory" or "review qualifier".

J = Reported concentration is estimated value

Table 4-20. Historical HU-B Unfiltered Ground-Water Sampling Data for Arsenic, Cadmium, and Total Uranium at SLDS

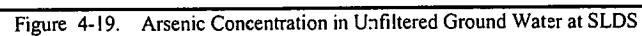
Chemical	Station	Q4 CY98 1/19 - 2/5	Q1 CY99 3/3 - 3/25	Q2 CY99 5/17 - 5/28	Q3 CY99 9/23	Q1 CY00 4/11-4/27	Q2 CY00 5/17- 6/29	Q3 CY00 9/5 - 9/8	Q4 CY00 12/5	Q1 CY01 2/21 - 2/26	Q2 CY01 4/18 - 4/30	Q3 CY01 7/11 - 9/11	Q4 CY01 11/6 - 11/7
Arsenic (µg/L) IL=50	B16W05D	12.3	12.5	11.9		13.8	12.6	11.3				14.0	
	B16W06D	2.5 U	2.5 U	1.9 U		2.2 U	2.2 U	1.4 U				1.4 U	
	B16W07D	17.3	18.3	18.0		24.2	22	27.0		22.1			
	B16W08D	24.9	29.5	22.9		27.5	21.4	26.6				31.2	
	B16W09D	3.6 J	3.6 J	4.6 U		5.4 U	7.1	5.3 U		6.8			
	DW14		188	170.0		176	181	160.0		189.0		169.0	
	DW15		51.2	49.5	51.2	57.1	59.5	55.7	58.4	58.5	55.6	71.5	61.7
	DW16		9.5 J	10.9	6	3.4	9.9	2.1 U		7.7		2.2 U	
	DW17		19.21	25.3		8.4	6.1	15.1		7.0		9.5	
	DW18		34.9	30.3	32.5	32.9	31.2	34.4	28.9	32.4	31.1	35.8	35.9
	DW19		19.3	20.1	19.8	20.9	20.2	19.4	19.4	21.0	20.1	20.5	19.9
	DW22R												36.7
Cadmium (µg/L) IL=5	B16W05D	0.5 U	0.5 U	0.3 U		0.8 U	0.3 U	0.3 U				0.2 U	
	B16W06D	0.5 U	0.5 U	0.3 U		0.8 U	0.8 U	0.3 U				0.2 U	
	B16W07D	0.5 U	0.5 U	0.6 U		0.8 U	2.8 U	0.5 U			0.3 U		
	B16W08D	0.5 U	0.5 U	0.3 U		0.8 U	0.3 U	0.4 U				1.0 U	
	B16W09D	0.5 U	0.5 U	0.3 U		0.8 U	0.3 U	0.3 U			0.3 U		
	DW14		0.2 U	0.3 U		2.0 U	2.8 U	0.3 U		0.2 U		0.2 U	
	DW15		0.2 U	0.3 U	3.75	0.8 U	0.3 U	0.8 U	1.6	0.2 U	0.3 U	0.2 U	1.5 U
	DW16		0.5 U	0.3 U	3 U	0.8 U	0.3 U	0.3 U		0.2 U		0.2 U	
	DW17		0.5 U	0.3 U		2.0 U	0.3 U	0.3 U		0.2 U		0.2 U	
	DW18		0.2 U	0.3 U	3 U	0.8 U	0.3 U	0.3 U	0.4	0.2 U	0.3 U	0.2 U	0.7 U
	DW19		0.2 U	0.3 U	3 U	0.8 U	0.3 U	0.3 U	0.3 U	0.2 U	0.3 U	0.2 U	5.0 U
	DW22R												0.3 U
Total Uranium (µg/L) IL=20	B16W05D	1.3	1.3	1.4		2.0	1.8	1.1				1.3	
	B16W06D	1.2	1.3	1.2		2.2	2.1	1.0				1.5	
	B16W07D	1.2	1.2	1.2		1.2	2.9	1.4			0.6		
	B16W08D	1.3	1.3	1.5		1.2	1.2	1.3				1.6	
	B16W09D	1.1	1.1	1.8		1.0	1.2	1.0			0.7		
	DW14		2.3 U	2.8		1.4 U	1.2 U	1.3		2.9		5.4	
	DW15		1.0 U	1.8 U	1.5 U	1.2 U	16.4	1.2 U	2.6 U	1.3 U	1.0 U	2.5	2.1
	DW16		14.3	12.6	14.3	1.2	19.1	10.9		5.5		1.3 U	
	DW17		2.0 U	2.3 U		1.1	7.6	9.5		5.8		1.7	
	DW18		1.4	2.6 U	1.1 U	1.1 U	2.4	1.5	2.0 U	1.4	3.5	2.1	1.2 U
	DW19		153.3	76.0	175.0	101.1	61.9	90.8	97.2	121.0	79.4	58.0	80.6
	DW22R												2.1

Shaded values exceed the investigative limit (IL).

¹ Total Uranium values calculated from isotopic uranium sample results. Values equal to 1/2 of detection limit were substituted for non-detect results.

U = Reported concentration below sample quantitation limit based on "laboratory" or "review qualifier".

J = Reported concentration is estimated value



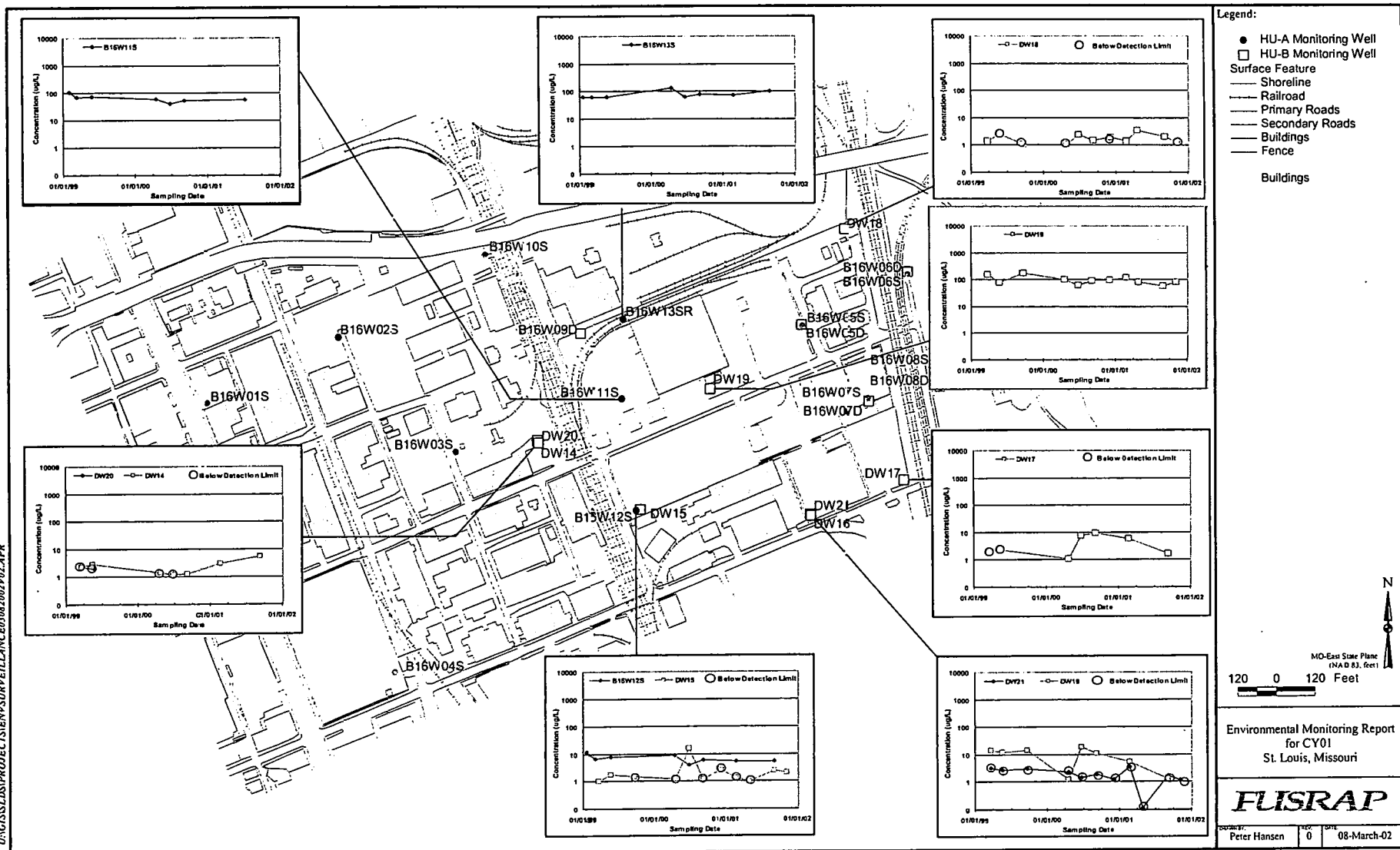


Figure 4-20. Total Uranium Concentration in Unfiltered Ground Water at SLDS

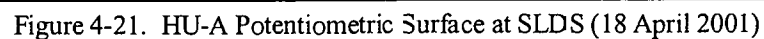
indicates that the total uranium investigative limit is being exceeded in DW19, the USACE has initiated the GRAAA. The USACE has adopted a phased approach to the GRAAA, with the first phase equivalent in process to a Preliminary Assessment. The purpose of the GRAAA, should all process phases require completion, would be to evaluate "MED/AEC COC fate and transport, risk to the public and the environment, practical and efficient technologies to reduce the COCs, the likely concentrations to be removed, the likely concentrations of the COC(s) remaining post-treatment, impact of Mississippi River flooding inflows to the B Unit, and a recommendation for action in the Mississippi Alluvial Aquifer, the B Unit" (USACE, 1998d). The first phase of the GRAAA, to be issued in CY02, will summarize the sampling data available for each of the monitoring wells completed in HU-B and provide recommendations for further investigation of HU-B.

4.3.3 Evaluation of the CY01 Potentiometric Surfaces at SLDS

Ground-water elevations were measured in monitoring wells at SLDS in February, April, August, and November of CY01. Potentiometric surface maps were created from the April and August measurements to illustrate ground-water flow conditions in the wet and dry seasons, respectively. The potentiometric maps for both HU-A and HU-B are presented in Figures 4-21 through 4-24. The top of casing elevations for all of the monitoring wells at the SLDS were resurveyed on December 4, 2000 due to uncertainties concerning the elevations of some of the wells. The resurvey resulted in some minor modifications of the elevations for a few of the monitoring wells.

The ground-water flow direction in HU-A under the eastern portion of the Mallinckrodt plant is generally eastward, toward the Mississippi River (Figures 4-21 and 4-23). A ground-water high is present in Plants 6 and 7 in the eastern portion of SLDS, as illustrated by the radial pattern of the potentiometric surface contours delineated by wells B16W12S, B16W07S, B16W05S, and B16W13SR. A ground-water low, or saddle, is present west of this high in the vicinity of well DW20. The cause of these anomalies is not known, but it is suspected that the presence of thick sections of permeable soils or drainage structures may be impacting ground-water flow patterns in this area. Comparison of Figure 4-21 (wet season) with Figure 4-23 (dry season) indicates ground-water flow directions in HU-A are similar for the April and August conditions. However, flow gradients show some seasonal variation; steeper flow gradients associated with the lower river stage are evident during the dry season (Figure 4-23). The HU-A potentiometric surface elevations show some seasonal fluctuations in ground-water elevations, with elevations ranging from 0.5 to 15 ft higher during the wet season (April) than during the dry season (August). This difference in elevations is most evident in the two HU-A wells located nearest to the Mississippi River (B16W06S and B16W08S); the HZ-A potentiometric surface based on April measurements indicate that ground-water elevations in these two wells are 11 to 15 ft higher than the ground-water elevations measured in these wells during August CY01, demonstrating possible communication with the Mississippi River.

The data indicate that the HU-B potentiometric surface is relatively flat (Figures 4-22 and 4-24). Because ground water in HU-B is hydraulically connected to the Mississippi River, ground-water flow direction and gradient are strongly influenced by river stage. The water levels measured at SLDS indicate that HU-B ground-water elevations were 17 to 19 ft higher on April 18 than on August 30; this corresponds to the difference in the daily river stage, which was approximately 20 ft higher on April 18 than on August 30. Although small contour intervals may



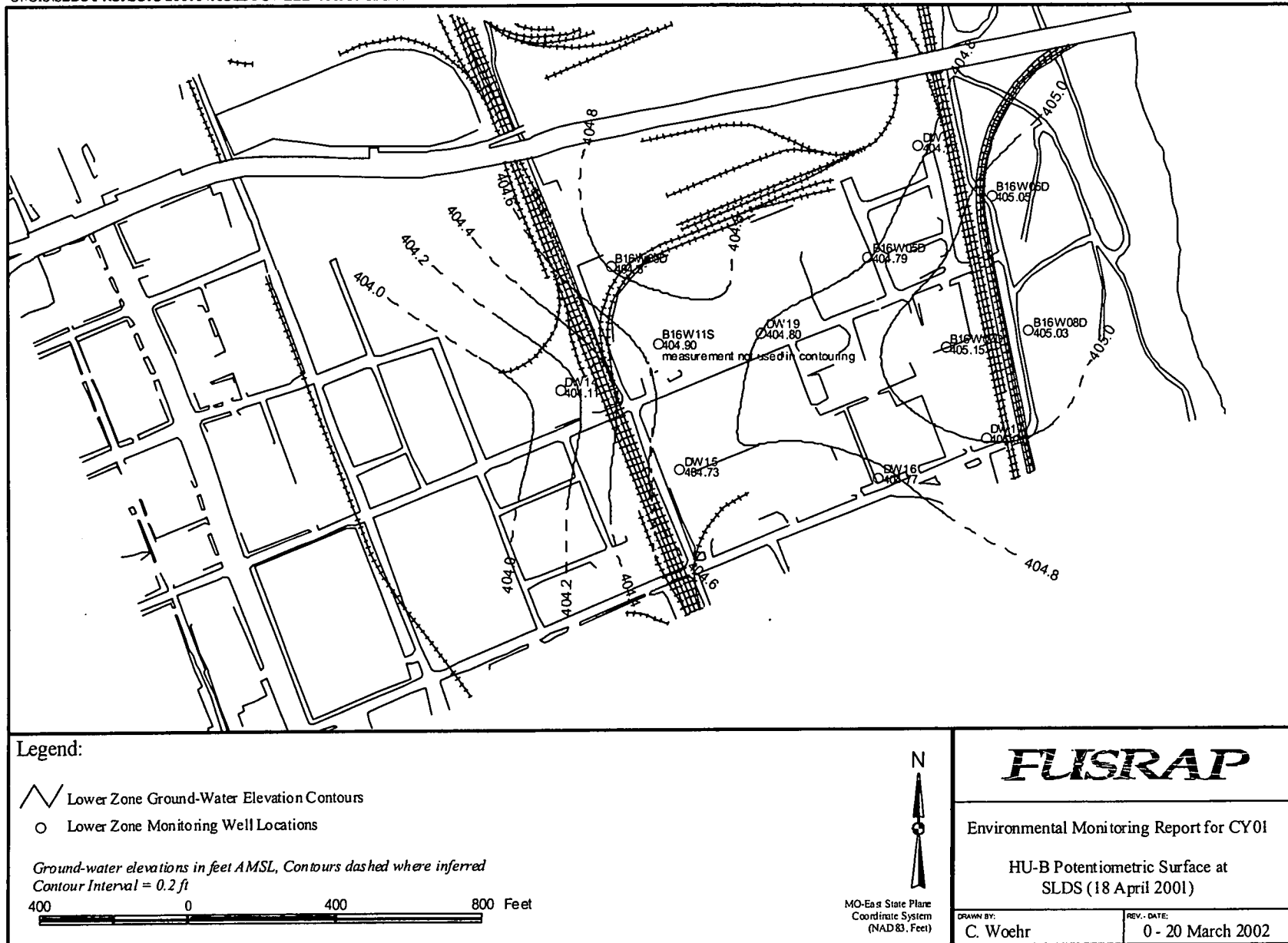


Figure 4-22. HU-B Potentiometric Surface at SLDS (18 April 2001)

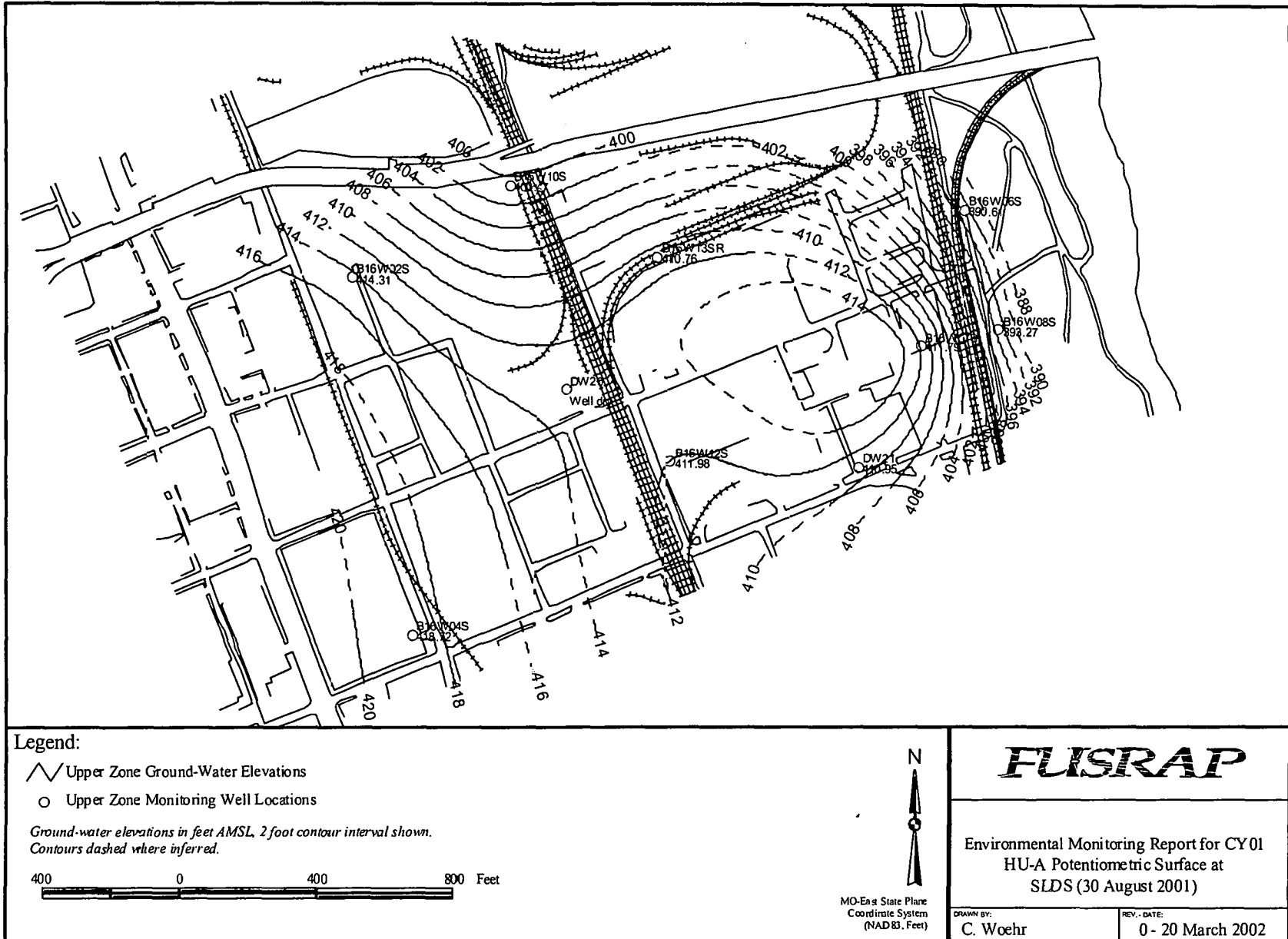


Figure 4-23. HU-A Potentiometric Surface at SLDS (30 August 2001)

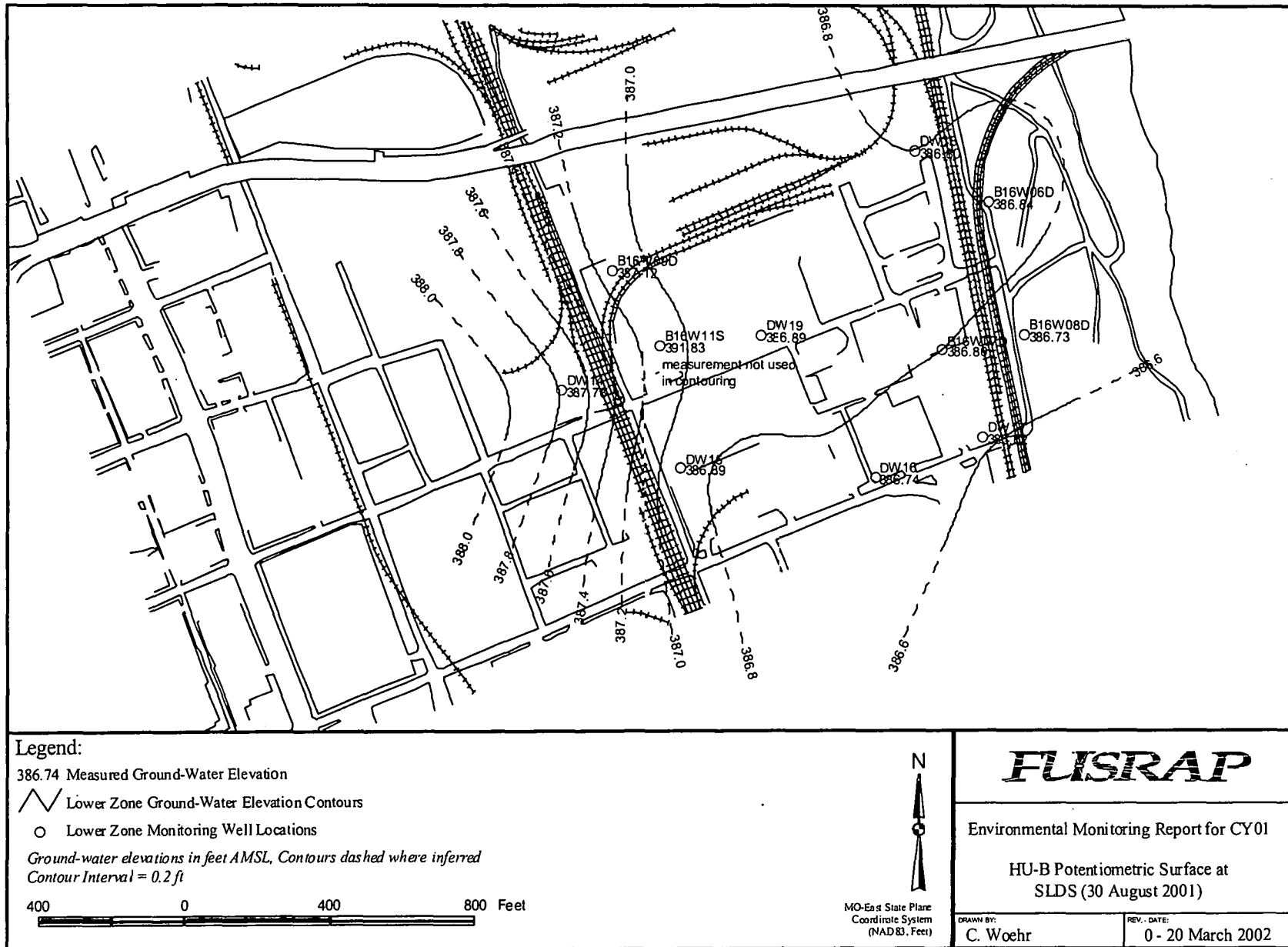


Figure 4-24. HU-B Potentiometric Surface at SLDS (30 August 2001)

tend to exaggerate small differences in ground-water elevations, a contour interval of 0.2 ft was used for HU-B (rather than a contour interval of 2 ft as used for HU-A) in order to more clearly distinguish variations in flow directions at the site. The potentiometric surface maps for HU-B indicate flow direction is generally eastward toward the Mississippi River. A reversal in flow directions (westerly flow) at the eastern edge of the site during April is suggested by the potentiometric map in Figure 4-22, but the magnitude of the reversal is relatively small. This change in direction is interpreted to result from conditions of higher river stage during the wet season, resulting in some surface water discharge into HU-B along the banks of the Mississippi River. Based on the HU-B potentiometric maps, the horizontal gradient is relatively constant in the western portion of the site, ranging between 0.001 and 0.002 ft/ft. The hydraulic gradient is more variable in the eastern portion of the site due to the proximity of the Mississippi River.

Differences in ground-water elevations in five HU-A/HU-B well pairs (B16W06S/06D; B16W07S/07D; B16W08S/08D; B16W12S/DW15; and DW21/DW16) were used to calculate the vertical hydraulic gradient. The vertical gradient was calculated by dividing the difference in measured ground-water elevations in each well pair by the vertical distance between the mid-points of the screened intervals. The April water level measurements indicate downward vertical gradients for three of these HU-A/HU-B well pairs (B16W07S/07D; DW21/DW16; and B16W12S/DW15). The gradient ranges from 0.1 to 0.3 ft/ft, with higher vertical gradients found in wells located farther from the river. The two well pairs in closest proximity to the river, B16W06S/06D and B16W08S/08D, exhibited almost no vertical gradient, indicating most of the flow is lateral in this area. The vertical gradients calculated using the August measurements indicate downward flow gradients for all well pairs. The vertical gradients are generally three times higher (from 0.1 to 1.0 ft/ft) under low river stage conditions than under wet (April) conditions. As with the April results, the August results indicate that downward vertical gradients increase to the west, with increasing distance from the river.

4.4 FILTERED AND NON-FILTERED GROUND-WATER RESULTS FOR SLS CY01

In addition to the ground-water samples that were discussed previously, the CY01 EMP ground-water sampling included the collection of filtered samples at each of the three SLS. Filtered samples were collected when field parameter testing indicated the turbidity of the ground water in a well was greater than 50 nephelometric turbidity units (NTUs) after stabilization. Fifteen wells at SLAPS, three at HISS and thirteen at SLDS required filtered samples in CY01. Table 4-21 summarizes the monitoring wells requiring filtered samples. Tables 4-22 through 4-24 provide statistical comparisons of filtered and unfiltered ground-water sampling results for the three SLS.

Table 4-21. Summary of Monitoring Wells above 50 NTU in CY01

Site	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
SLAPS	B53W19S	B53W01D	B53W06S	MW33-98
	MW34-98	B53W02D	MW34-98	
	PW43	B53W05D	PW36	
		B53W07D	PW37	
		B53W09D	PW41	
		B53W12D		
		B53W14S		
HISS	None	HISS-16	HISS-17S	None
			HW23	
SLDS	DW14	B16W07D	B16W05D	None
	DW17	B16W07S	B16W05S	
	DW19	DW18	DW14	
	DW21	DW19	DW16	
			DW17	
			DW19	

At SLAPS the analytes that illustrate a significant difference in their filtered and unfiltered arithmetic means were aluminum, chromium, and zinc, as shown in Table 4-22. The unfiltered results for aluminum were significantly higher than the filtered results in five wells (B53W05D, B53W06S, B53W19S, PW36, and PW41). Aluminum ranged from 71 µg/L to 336 µg/L in the unfiltered samples but was at non-detect levels in the filtered samples from these wells. Aluminum is highly insoluble but, like iron, is a common constituent of the soil matrix. The higher concentrations of aluminum in the unfiltered samples likely do not represent higher dissolved ground-water concentrations but instead indicate greater amounts of colloid- or sediment-bound aluminum. The unfiltered results for chromium were significantly higher in two monitoring wells, B53W06S and B53W19S. The unfiltered results were 37.7 µg/L and 205 µg/L in B53W06S and B53W19S, respectively, while the filtered results were at non-detect levels in these wells. Although the mean zinc concentrations indicate that the filtered zinc concentrations are higher than the unfiltered, this anomalous result is due to a single high value reported for the filtered sample from PW37. In the majority of samples, the unfiltered results were higher than the filtered results. In wells B53W05D, B53W07D, B53W09D, B53W12D, B53W19S, and MW34-98, the unfiltered zinc concentrations were from 1.5 to 8 times higher than the levels detected in filtered samples. In general, differences in concentrations of most constituents between unfiltered and filtered was not significant. Where concentrations exceeded the MCLs or SMCLs in filtered samples they also exceeded these levels in unfiltered samples.

At the HISS the parameters that were significantly different in the unfiltered and filtered samples based on the arithmetic mean were aluminum and zinc as shown in Table 4-23. The unfiltered results for aluminum in HISS-16 and HW23 were 239 µg/L and 161 µg/L, respectively, whereas aluminum was not detected in the filtered samples. For zinc the unfiltered results ranged from approximately 2.5 times higher in the unfiltered samples compared to the filtered to more than five times higher (HISS-16 at 23.9 µg/L unfiltered and 9.8 µg/L filtered; and HW23 at 132 µg/L unfiltered and 24.6 µg/L filtered). The greater difference in values for the lower ground-water well HW23 may be due to greater amounts of colloid- or sediment-bound metals in the deep ground water zone.

Table 4-22. SLAPS Filtered and Unfiltered Comparison

Chemical	Units	Filtered					Unfiltered					Total Samples
		Detects			Mean Concentration ¹	Number of Detects	Detects			Mean Concentration ¹	Number of Detects	
Minimum	Maximum	Average	Minimum	Maximum			Average					
Aluminum	µg/L	61.1	81.3	71.2	31.2	2	27.5	336	127.6	72.7	7	15
Antimony	µg/L				1.4	0	3.1	3.1	3.1	1.5	1	15
Arsenic	µg/L	6.6	213	78.4	47.2	9	2.3	201	77.1	51.5	10	15
Barium	µg/L	65.7	632	317.5	317.5	15	68.6	629	316.5	316.5	15	15
Beryllium	µg/L	0.1	0.8	0.5	0.2	2	0.2	0.9	0.5	0.2	2	15
Boron	µg/L	50.8	526	228.1	213.5	14	49.5	525	229.6	214.9	14	15
Cadmium	µg/L				0.1	0				0.1	0	15
Calcium	µg/L	76,000	777,000	198,133	19,8133	15	75,700	753,000	193,673	193,673	15	15
Chromium	µg/L	1.2	3.0	2.1	1.0	2	0.8	205	61.3	17	4	15
Cobalt	µg/L	1.2	6.4	3.3	2.2	7	2.5	4.6	3.3	2.0	5	15
Copper	µg/L	4.0	4.0	4.0	1.4	1	15.4	15.4	15.4	2.3	1	15
Iron	µg/L	29.8	19,300	11,006	8,807	12	42.5	19100	9125	8,517	14	15
Lead	µg/L				0.4	0				0.4	0	15
Lithium	µg/L	7.8	34.1	16.6	7.5	3	7.5	63.0	37.9	14	4	15
Magnesium	µg/L	26,600	195,000	70,706.7	70,706.7	15	26,500	194,000	69,360	69,360	15	15
Manganese	µg/L	115	4150	879.8	821.2	14	115	4400	848.9	792.3	14	15
Mercury	µg/L	0.049	0.049	0.049	0.1	1	0.1	0.1	0.1	0.1	1	15
Molybdenum	µg/L	1.5	42	14.2	7.3	7	2.0	57.2	18.3	7.2	5	15
Nickel	µg/L	2.7	830	169.3	62.1	5	1.8	830	170.7	62.6	5	14
Potassium	µg/L	1,430	6,100	2,925.5	2,419	11	1,290	32,600	5,514	3,988.7	10	15
Radium-226	pCi/L	2.2	4.6	3.1	1.5	3	2.3	2.3	2.3	1.2	1	15
Selenium	µg/L	235	1,330	782.5	105	2	231	1380	805.5	108.1	2	15
Silver	µg/L	1.4	1.4	1.4	1.7	1	4.6	4.6	4.6	2.0	1	15
Sodium	µg/L	19,800	1,040,000	129,647	129,647	15	19,400	1,030,000	136,100	127,029	14	15
Strontium	µg/L	302	1530	739	739	15	296	1520	721.1	721.1	15	15
Thallium	µg/L	5.3	5.3	5.3	1.1	1	6.2	6.2	6.2	1.1	1	15
Thorium-228	pCi/L	0	1.6	0.8	0.8	2	0.6	0.6	0.6	0.7	1	15
Thorium-230	pCi/L	0.6	3.4	2.3	1.1	4	0	5.2	1.6	1.0	7	15
Thorium-232	pCi/L	0	1.6	0.4	0.4	4	0.0	0.0	0.0	0.4	2	15
Uranium	µg/L	195	209	202	44	2	210	210	210	39.2	1	15
Uranium-234	pCi/L	0.8	84.1	16	9.8	9	0.5	60.3	15.4	7.5	7	15
Uranium-235	pCi/L	0	3.7	2.6	1.2	4	0	3.8	1.0	0.7	5	15
Uranium-238	pCi/L	1.9	93.7	23.3	9.7	6	0	72.2	16.8	8.7	7	14
Vanadium	µg/L	1.7	45.7	21.5	6.2	4	1.8	46.2	18.1	6.5	5	15
Zinc	µg/L	4.5	904	142.6	68.3	7	5.9	66.5	31.6	20.4	9	15

1. Mean Concentration: Calculated using all data, but values equal to 1/2 of Detection Limit were substituted for non-detect values

Table 4-23. HISS Filtered and Unfiltered Comparison

Chemical	Units	Filtered					Unfiltered					Total Samples
		Detects			Mean Concentration¹	Number of Detects	Detects			Mean Concentration¹	Number of Detects	
		Minimum	Maximum	Average			Minimum	Maximum	Average			
Aluminum	µg/L				20.6	0	161	239	200	141.3	2	3
Antimony	µg/L				1.2	0				1.2	0	3
Arsenic	µg/L	2.70	171	86.85	58.1	2	3.1	143	73.05	48.9	2	3
Barium	µg/L	102	367	245.33	245.3	3	99.50	397	252.17	252.2	3	3
Beryllium	µg/L				0.0	0				0.0	0	3
Boron	µg/L	42.40	268	155.20	105.1	2	41.9	269	155.45	105.2	2	3
Cadmium	µg/L				0.1	0				0.1	0	3
Calcium	µg/L	50,600	125,000	87,533	87533	3	49,800	121,000	88,767	88,767	3	3
Chromium	µg/L	0.70	0.75	0.72	0.6	2	0.81	1.50	1.16	0.9	2	3
Cobalt	µg/L	1.10	1.10	1.10	0.7	1	0.95	0.95	0.95	0.7	1	3
Copper	µg/L	3.20	3.20	3.20	1.5	1	2.00	2.00	2.00	1.1	1	3
Iron	µg/L	56.50	9,480.00	4,768.25	3181	2	57.00	10,500	3580.67	3,581	3	3
Lead	µg/L				0.4	0				0.4	0	3
Lithium	µg/L				3.6	0				3.6	0	3
Magnesium	µg/L	12,900	63,500	38,433	38433	3	12,400	61,800	38,900	38,900	3	3
Manganese	µg/L	146	285	215.50	143.7	2	25.60	315.00	172.53	172.5	3	3
Mercury	µg/L				0.1	0				0.1	0	3
Molybdenum	µg/L	8.90	8.90	8.90	3.2	1	9.30	9.30	9.30	3.4	1	3
Nickel	µg/L				0.5	0	1.60	1.60	1.60	0.9	1	3
Potassium	µg/L	25,200	25,200	25,200	9176.7	1	25,100	25,100	25,100	9143.3	1	3
Radium-226	pCi/L				1.1	0				0.9	0	3
Selenium	µg/L	7.90	48.80	28.35	19.1	2	7.20	47.50	27.35	18.4	2	3
Silver	µg/L				1.1	0				1.1	0	3
Sodium	µg/L	18,600	89,800	50,533	50533	3	18,100	95,200	51,900	51,900	3	3
Strontium	µg/L	333	1230	783	783	3	326	1,170	780	780.3	3	3
Thallium	µg/L				0.7	0				0.7	0	3
Thorium-228	pCi/L				0.7	0				0.8	0	3
Thorium-230	pCi/L	1.19	1.19	1.19	0.8	1	1.50	1.50	1.50	1.0	1	3
Thorium-232	pCi/L				0.3	0				0.5	0	3
Uranium	µg/L				32.7	0				32.7	0	3
Uranium-234	pCi/L	0.72	1.30	1.01	0.9	2	1.89	9.9	5.9	4.2	2	3
Uranium-235	pCi/L				0.7	0				0.5	0	3
Uranium-238	pCi/L	1.62	2.47	2.05	1.5	2	1.57	5.71	3.64	2.7	2	3
Vanadium	µg/L				0.5	0	0.92	0.92	0.92	0.7	1	3
Zinc	µg/L	9.80	24.60	17.20	11.5	2	23.9	132	61.4	61.4	3	3

1. Mean Concentration: Calculated using all data, but values equal to 1/2 of Detection Limit were substituted for non-detect values

Table 4-24. SLDS Filtered and Unfiltered Comparison

Chemical	Units	Filtered					Unfiltered					Total Samples
		Detects			Mean Concentration ¹	Number of Detects	Detects			Mean Concentration ¹	Number of Detects	
		Minimum	Maximum	Average			Minimum	Maximum	Average			
Arsenic	µg/L	2.3	194	44.5	37.76	11	5.2	189	45.3	38.43	11	13
Cadmium	µg/L				0.11	0				0.11	0	13
Radium-226	pCi/L	1.19	2.41	1.8	1.19	2	7.62	15.46	11.54	2.61	2	13
Thorium-228	pCi/L	0.7	0.7	0.7	0.67	1	0.59	0.59	0.59	0.68	1	13
Thorium-230	pCi/L	0.62	1.9	1.091667	0.77	6	0.83	5.21	2.4	1.04	4	13
Thorium-232	pCi/L	0.0	0.0	0.0	0.39	1				0.43	0	13
Uranium-234	pCi/L	1.68	37.92	21.89167	10.32	6	0	37.9	12	9.39	10	13
Uranium-235	pCi/L	1.76	1.93	1.86	0.90	3	0	2.11	1.25	0.85	3	13
Uranium-238	pCi/L	0.44	37.55	18.88857	10.36	7	0	40.4	16.9	9.35	7	13

1. Mean Concentration: Calculated using all data, but values equal to 1/2 of detection limit were substituted for non-detect values

There were thirteen SLDS ground-water wells from which a filtered sample was collected in CY01. There were no statistically significant differences between unfiltered and filtered sample results in CY01 as shown in Table 4-24. These results may indicate that the levels of colloid- or sediment-bound COCs in ground water are low relative to the dissolved concentrations.

Based on the CY01 data, differences in concentrations of most constituents between unfiltered and filtered samples are not significant. While a few analytes (aluminum, chromium, and zinc at SLAPS and aluminum and Zinc at HISS) showed significant differences in the filtered and unfiltered concentrations, filtering did not significantly impact the concentrations of the remaining analytes. In particular the data supports that the concentrations of the more soluble metals (such as barium, magnesium, and molybdenum) and of radionuclides are negligibly affected by filtering. The similarity in filtered and unfiltered ground-water results for radionuclides and the majority of metals may indicate that relatively insignificant levels of those analytes are present in colloid- or sediment-bound form.

4.5 EVALUATION OF TRANSDUCER DATA

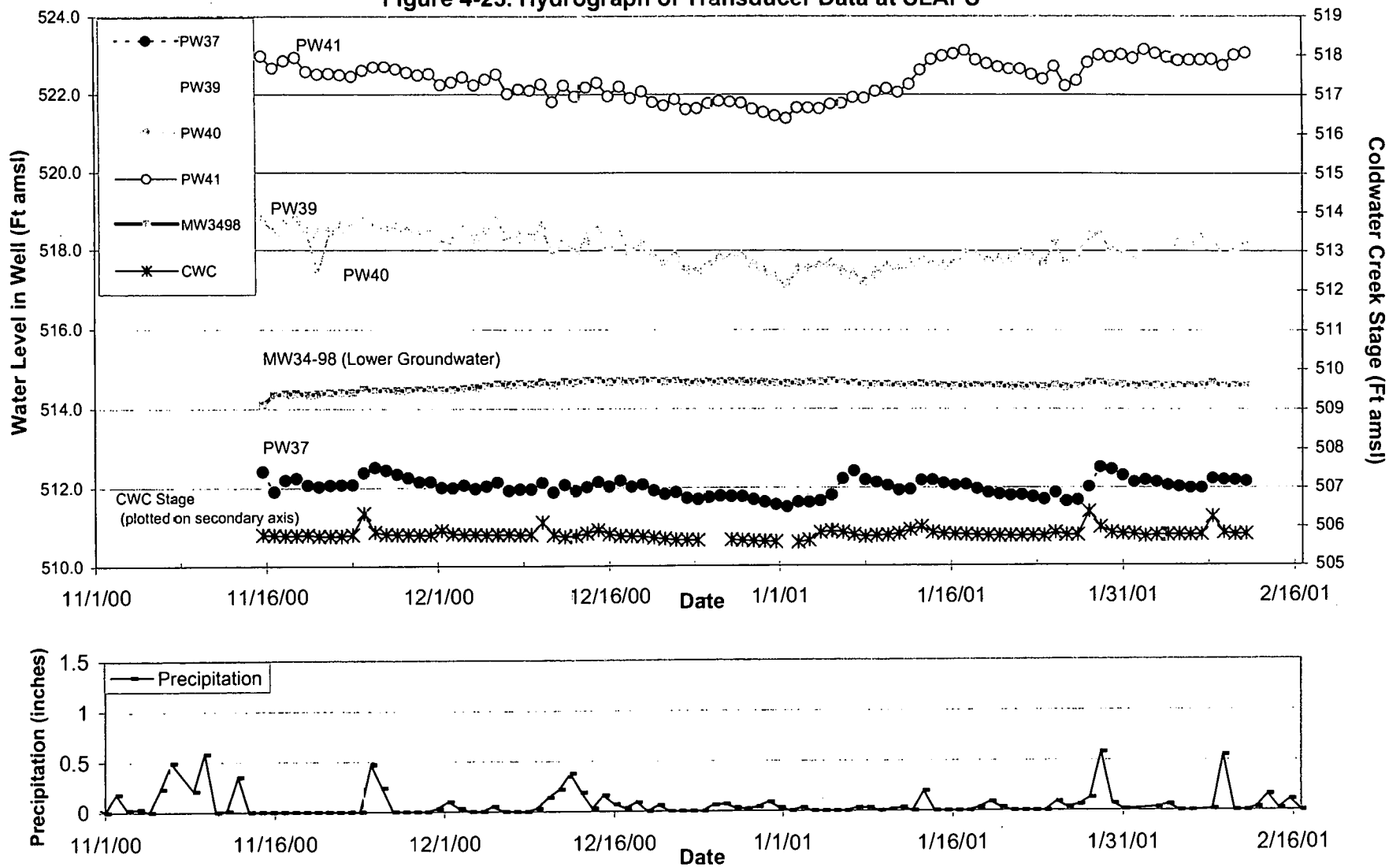
Periodic water-level measurements are conducted manually with an electric tape at quarterly intervals in all monitoring wells at the SLS. In addition, pressure transducers and electronic data loggers are being used at selected monitoring wells to measure water levels on a daily basis to provide a more continual representation of water-level fluctuations. The daily water-level data is being collected in wells B16W11S, B16W07D, B16W08D, and DW19 at SLDS and in wells PW37, PW38, PW39, PW40, PW41, and MW34-98 at SLAPS. The transducer data from these wells are calibrated with the manual water-level measurements and retrieved periodically from the field. Daily water levels were also measured during the first four months of CY01 in SLDS well B16W11S. This well was decommissioned in CY01. Due to uncertainties regarding the ground-water zones it was monitoring, the water-level data for this well is not presented here.

4.5.1 SLAPS Transducer Data

The continuous water-level measurements recorded for November 16, 2000 through February 12, 2001 for five SLAPS wells (PW37, PW39, PW40, PW41, and MW34-98) have been plotted in the hydrograph shown in Figure 4-25. This figure also provides plots of the Coldwater Creek stage and daily precipitation measurements over the same period to assist in determining if the water-level fluctuations in these wells are impacted by these two factors.

The transducer data indicate that the shallow (HZ-A) wells exhibit varying responses to recharge events. The height and general trend of the hydrographs is influenced by the local precipitation and the distance from Coldwater Creek. The well located nearest to Coldwater Creek (PW37) responds most rapidly to precipitation events and has the greatest similarity to surface-water levels in Coldwater Creek. Water levels in PW37 fluctuate between one to five inches in response to local precipitation. The water surface of the stream is below the shallow water table during this period, indicating that ground water is moving toward the creek (i.e., Coldwater Creek is a gaining stream). The ground-water levels for those wells located farther from the creek (PW39 and PW41) are higher and do not show a clear relationship to

Figure 4-25. Hydrograph of Transducer Data at SLAPS



Coldwater Creek stage. The shape of the hydrographs shows a relatively slow response to precipitation events. These results demonstrate that the HZ-A is not sufficiently permeable to permit water to percolate quickly from the surface. The HZ-A material between the stream channel and these wells also limits ground-water flow between the creek and the wells. Recharge from precipitation may be higher in wells near the creek (PW37) due to less cover or the presence of coarser-grained fluvial deposits.

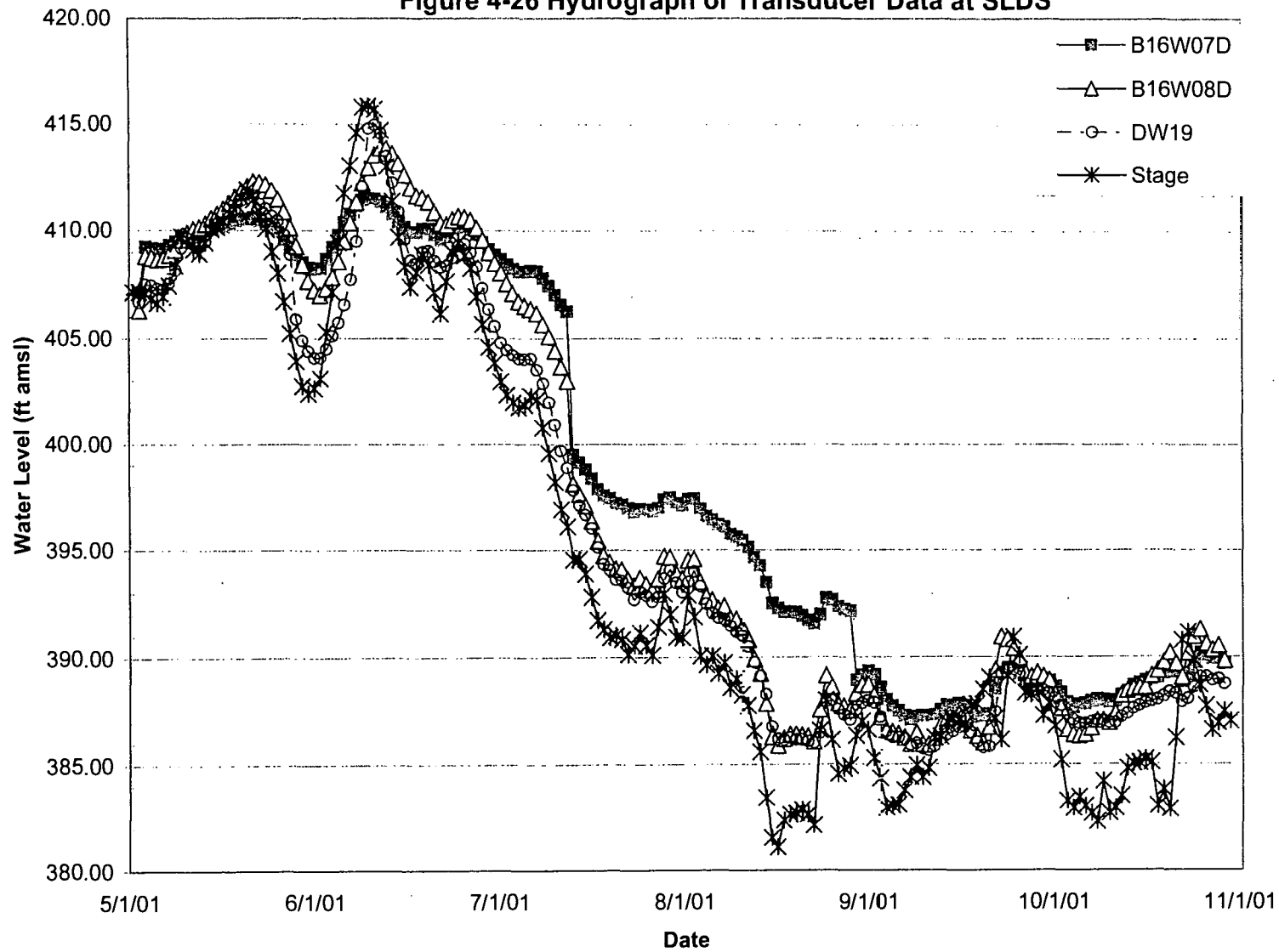
Unlike the hydrographs of the HZ-A wells, the hydrograph for the HZ-C well (MW34-98) is relatively flat, supporting the view that the HZ-A and HZ-C ground-water zones have limited hydraulic connection. The HZ-C water levels do not appear to be influenced by Coldwater Creek. The hydrograph of well MW34-98 also shows little or no correlation with local precipitation events. This indicates that very little of the water from local precipitation reaches HZ-C through the overlying HZ-A and HZ-B ground-water zones. The Unit 3 silts and clays, which have a low permeability, retard the downward movement of water.

4.5.2 SLDS Transducer Data

The transducer data recorded for May 3, 2001 through October 30, 2001 for three HU-B SLDS wells (B16W07D, B16W08D and DW19) are presented in the hydrograph shown in Figure 4-26. These water levels are compared with the Mississippi River stage elevations for the same period. The stage elevations were derived from the daily stage measurements from two gaging stations, one located upstream and the other located downstream from SLDS. The downstream gage 0179A is located at the foot of Market Street, 15 miles downstream from the mouth of the Missouri River and at mile 179.6 above the mouth of the Ohio River. Water stage measurements were also obtained upstream of SLDS at gage "L+D 27 (Tailwater)", which is located at mile 185.1 above the mouth of the Ohio River. Both gages are operated and maintained by the St. Louis District USACE. The stage elevation values used in the SLDS hydrograph were spatially interpolated using the data for these two stations.

As shown in Figure 4-26, there is a close relationship between the Mississippi River stage and the ground-water level hydrographs. In general, ground-water levels were higher in the HU-B wells than in the river, indicating ground-water flow is towards the river for most of this period. However, during high water stages the direction of movement of the ground water with respect to the river could be reversed and the Mississippi River could provide recharge to HU-B ground water. Ground-water levels fluctuate from a few inches to several feet in response to the river stage, depending on the aquifer characteristics and distance between the monitoring well and the river. The hydrographs indicate that the Mississippi River Alluvial Aquifer allows for rapid movement of water, as indicated by the strong similarity in the fluctuations of water levels in the wells and in the river. Although wells B16W08D and B16W07D are closer to the river, the water level elevations for DW19 show the greatest similarity to the river stage data. This may indicate preferential flow paths exist between the river and this well.

Figure 4-26 Hydrograph of Transducer Data at SLDS



5.0 ENVIRONMENTAL QUALITY ASSURANCE PROGRAM

5.1 PROGRAM OVERVIEW

The environmental quality assurance program includes management of the quality assurance (QA) and quality control (QC) programs, plans, and procedures governing environmental monitoring activities at the FUSRAP SLS 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 quality problems from the time a sample was collected until the associated data are evaluated. Key elements in achieving the goals of this program are: compliance with the QA program; personnel training; compliance assessments; use of quality control 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 contaminants of concern (PCOCs), meet the requirements of the Environmental Monitoring Guide (EMG), supplement the FS, develop a ROD for the North County Sites, and support the ROD for SLDS.
- 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 (QAPP)

The QAPP for activities performed at SLS is described within Section 3.0 of the *Sampling and Analysis Guide* (SAG) for SLS (USACE, 2000). The QAPP provides the organization, objectives, functional activities and specific QA/QC activities associated with investigations and sampling activities at SLS.

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

5.3 SAMPLING AND ANALYSIS GUIDE (SAG)

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, and describes administrative procedures for managing environmental data and governs sampling plan preparation, data verification and validation, database administration, and data archiving. The structure for identified sampling/monitoring was delineated through programmatic documents such as the EMG for SLS (USACE, 1999a), which is an upper tier companion document to the SAG. The EMIFY01 and EMIFY02 documents outline the analytes to be sampled at each site for various media (USACE, 2001a and b).

Flexibility to address non-periodic environmental sampling, such as boundary delineation for remedial design, verification sampling, or in-situ waste characterization was provided for in this integrated strategy by issuance of a Work Description (WD) and/or Final Status Surveys. Environmental monitoring data obtained through these upper and lower tier plans were typically reported to the EPA Region VII quarterly as required by the FFA.

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 EM-200-1-3 (USACE, 1994b).

At any point in the process of sample collection or data or document review, a non-conformance report (NCR) may be initiated if nonconformances are identified, and 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 were conducted to verify that sampling and analysis activities were performed in accordance with the procedures established in the SAG and activity-specific WD or EMIFY documents.

5.5.1 Field Assessments

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

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

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

5.5.2 Laboratory Audits

The USACE Hazardous, Toxic and Radioactive Waste-Center of Expertise (HTRW CX) conducts on-site audits and validates laboratories on a regular basis. Every eighteen months, these USACE independent on-site systems audits, in conjunction with performance evaluation samples (performance audits), qualify laboratories to perform USACE environmental analyses.

These system audits include examining laboratory documentation of sample receiving, sample log-in, sample storage, chain-of-custody procedures, sample preparation and analysis, and instrument operating records. Performance audits consist of sending performance evaluation samples to USACE laboratories for ongoing assessment of laboratory precision and accuracy. The analytical results of the analysis of performance evaluation samples are evaluated by USACE HTRW CX 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 receiving, 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.

The contractor is not contracted to perform laboratory audits; however, additional audits of laboratories were planned and budgeted within specific USACE task scopes. These project-specific laboratory performance review audits were conducted by the contractor only at the direction of, and in conjunction with, the USACE.

External audits may be conducted in conjunction with, or at the direction of, the EPA Region or the MDNR.

5.6 SUBCONTRACTED LABORATORY PROGRAMS

All samples collected during environmental monitoring activities were analyzed by USACE-approved laboratories and were reviewed and/or validated. QA samples were collected for ground water, soil, air, and direct radiation monitoring and were analyzed by the designated USACE QA laboratory. Each laboratory supporting this work maintained statements of qualifications including organizational structure, QA Manual, and SOPs.

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

5.7 QA AND QC SAMPLES

These samples were analyzed for the purpose of assessing the quality of the sampling effort and the reported analytical data. QA and QC samples to be used are duplicates, equipment rinsate blanks, trip blanks, source-water blanks, and split samples.

5.7.1 Field Duplicate QC Samples

These samples, collected by the sampling teams, were submitted for analysis to the on-site laboratory or contract laboratories. The identity of duplicate QC samples is held blind to the analysts and the purpose of these samples is to provide activity-specific, field-originated information regarding the homogeneity of the sampled matrix and the consistency of the sampling effort. These samples were collected concurrently with the primary environmental samples and equally represent the medium at a given time and location. Duplicate samples were collected from each medium addressed by this project, and were submitted to the contractor laboratories for analysis. The chemical and radiological analyses are presented in Table 5-1 and Table 5-2, respectively.

5.7.2 USACE QA Split Samples

QA split samples for chemical analysis 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. QA split samples for radiological analysis were collected by the contractor and submitted to the USACE-approved radiological QA laboratory. The chemical and radiological analyses are presented in Table 5-3 and Table 5-4, respectively.

5-5

[illegible]

Table 5-1. Chemical Field Duplicate QC Sample Analysis (Cont'd)

Grab ID/Field Dup ID	HIS01467 / HIS01467-1	HIS01487 / HIS01487-1	HIS27074 / HIS27074-1	HIS5733 / HIS5733-1	SLA08153 / SLA08153-1	SLA08337 / SLA08337-1	SLA08337F / SLA08337-1F	SLA27091 / SLA27091-1	SLA27104 / SLA27104-1
Lithium	NC	NC	11.3%	NC	NC	NC	NC	NC	NC
Magnesium	0.6%	0.6%	0.0%	1.7%	0.5%	2.2%	0.0%	0.0%	18.5%
Manganese	2.6%	0.5%	0.0%	0.0%	NC	2.3%	0.4%	7.3%	12.2%
Mercury	NC	NC	NC	NC	NC	NC	NC	NC	NC
Molybdenum	NC	NC	NC	15.2%	NC	5.1%	OK (+- CRDL)	NC	OK (+-CRDL)
Nickel	8.5%	NC	OK (+-CRDL)	5.6%	NC	OK (+-CRDL)	7.2%	NC	OK (+-CRDL)
Potassium	NC	NC	OK (+-CRDL)	OK (--CRDL)	NC	NC	5.3%	NC	NC
Selenium	0.0%	0.8%	NC	11.1%	2.0%	NC	NC	0.4%	53.7%
Silver	NC	NC	NC	NC	NC	NC	NC	NC	NC
Sodium	0.4%	1.2%	1.1%	2.1%	0.8%	NC	1.7%	0.2%	21.1%
Strontium	0.9%	1.0%	1.0%	2.6%	0.6%	1.1%	0.1%	0.4%	OK (+-CRDL)
Thallium	NC	NC	0.0%	NC	NC	NC	NC	NC	NC
Uranium	NC	NC	NC	NC	NC	NC	NC	NC	OUT (> +- CRDL)
Vanadium	NC	NC	NC	NC	NC	NC	NC	13.2%	10.5%
Zinc	NC	2.7%	OUT (> +- CRDL)	0.0%	OK (+-CRDL)	OK (+-CRDL)	NC	NC	NC
Miscellaneous									
Alkalinity	NC	2.6%	0.9%	NC	NC	1.6%	NC	3.4%	8.9%
Chloride	NC	0.4%	0.0%	NC	NC	NC	NC	0.7%	OK (+-CRDL)
Hardness, Total	NC	0.4%	2.0%	NC	NC	0.9%	NC	1.8%	3.4%
Nitrate/Nitrite - Nitrogen	NC	3.8%	OK (+-CRDL)	NC	NC	OK (+-CRDL)	NC	3.4%	4.4%
Sulfate	NC	1.8%	NC	NC	NC	NC	NC	1.2%	3.7%
Total Dissolved Solids (TDS)	NC	6.6%	16.8%	NC	NC	5.7%	NA	8.6%	19.9%
Total Suspended Solids (TSS)	NC	NC	4.4%	NC	NC	0.0%	NA	NC	NC
Semi-Volatile Organics									
1,2,4-Trichlorobenzene	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,2-Dichlorobenzene	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,3-Dichlorobenzene	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,4-Dichlorobenzene	NC	NC	NC	NC	NC	NC	NA	NC	NC

Table 5-1. Chemical Field Duplicate QC Sample Analysis (Cont'd)

Grab ID/Field Dup ID	HIS01467 / HIS01467-1	HIS01487 / HIS01487-1	HIS27074 / HIS27074-1	HIS65733 / HIS65733-1	SLA08153 / SLA08153-1	SLA08337 / SLA08337-1	SLA08337F / SLA08337-1F	SLA27091 / SLA27091-1	SLA27104 / SLA27104-1
2,4,5-Trichlorophenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
2,4,6-Trichlorophenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
2,4-Dichlorophenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
2,4-Dimethylphenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
2,4-Dinitrophenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
2,4-Dinitrotoluene	NC	NC	NC	NC	NC	NC	NA	NC	NC
2,6-Dinitrotoluene	NC	NC	NC	NC	NC	NC	NA	NC	NC
2-Chloronaphthalene	NC	NC	NC	NC	NC	NC	NA	NC	NC
2-Chlorophenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
2-Methylnaphthalene	NC	NC	NC	NC	NC	NC	NA	NC	NC
2-Methylphenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
2-Nitroaniline	NC	NC	NC	NC	NC	NC	NA	NC	NC
2-Nitrophenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
3,3'-Dichlorobenzidine	NC	NC	NC	NC	NC	NC	NA	NC	NC
3-Nitroaniline	NC	NC	NC	NC	NC	NC	NA	NC	NC
4,6-Dinitro-2-methylphenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
4-Bromophenyl phenyl ether	NC	NC	NC	NC	NC	NC	NA	NC	NC
4-Chloro-3-methylphenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
4-Chloroaniline	NC	NC	NC	NC	NC	NC	NA	NC	NC
4-Chlorophenyl phenyl ether	NC	NC	NC	NC	NC	NC	NA	NC	NC
4-Methylphenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
4-Nitroaniline	NC	NC	NC	NC	NC	NC	NA	NC	NC
4-Nitrophenol	NC	NC	NC	NC	NC	NC	NA	NC	0.0%
Acenaphthene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Acenaphthylene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Anthracene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Benzo(a)anthracene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Benzo(a)pyrene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Benzo(b)fluoranthene	NC	NC	NC	NC	NC	NC	NA	NC	NC

Table 5-1. Chemical Field Duplicate QC Sample Analysis (Cont'd)

Grab ID/Field Dup ID	HIS01467 / HIS01467-1	HIS01487 / HIS01487-1	HIS27074 / HIS27074-1	HIS65733 / HIS65733-1	SLA08153 / SLA08153-1	SLA08337 / SLA08337-1	SLA08337F / SLA08337-1F	SLA27091 / SLA27091-1	SLA27104 / SLA27104-1
Benzo(g,h,i)perylene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Benzo(k)fluoranthene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Bis(2-chloroethoxy) methane	NC	NC	NC	NC	NC	NC	NA	NC	NC
Bis(2-chloroethyl) ether	NC	NC	NC	NC	NC	NC	NA	NC	NC
Bis(2-chloroisopropyl) ether	NC	NC	NC	NC	NC	NC	NA	NC	NC
Bis(2-ethylhexyl) phthalate	NC	NC	NC	NC	NC	NC	NA	NC	NC
Butyl benzyl phthalate	NC	NC	NC	NC	NC	NC	NA	NC	NC
Carbazole	NC	NC	NC	NC	NC	NC	NA	NC	NC
Chrysene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Dibenzo(a,h)anthracene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Dibenzofuran	NC	NC	NC	NC	NC	NC	NA	NC	NC
Diethyl phthalate	NC	NC	NC	NC	NC	NC	NA	NC	NC
Dimethyl phthalate	NC	NC	NC	NC	NC	NC	NA	NC	NC
Di-n-butyl phthalate	NC	NC	NC	NC	NC	NC	NA	NC	NC
Di-n-octyl phthalate	NC	NC	NC	NC	NC	NC	NA	NC	NC
Fluoranthene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Fluorene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Hexachlorobenzene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Hexachlorobutadiene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Hexachlorocyclopentadiene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Hexachloroethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
Indeno(1,2,3-cd)pyrene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Isophorone	NC	NC	NC	NC	NC	NC	NA	NC	NC
Naphthalene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Nitrobenzene	NC	NC	NC	NC	NC	NC	NA	NC	NC
N-Nitroso-di-n-propylamine	NC	NC	NC	NC	NC	NC	NA	NC	NC
N-Nitrosodiphenylamine	NC	NC	NC	NC	NC	NC	NA	NC	NC
Pentachlorophenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
Phenanthrene	NC	NC	NC	NC	NC	NC	NA	NC	NC

Table 5-1. Chemical Field Duplicate QC Sample Analysis (Cont'd)

Grab ID/Field Dup ID	HIS01467 / HIS01467-1	HIS01487 / HIS01487-1	HIS27074 / HIS27074-1	HIS65733 / HIS65733-1	SLA08153 / SLA08153-1	SLA08337 / SLA08337-1	SLA08337F / SLA08337-1F	SLA27091 / SLA27091-1	SLA27104 / SLA27104-1
Phenol	NC	NC	NC	NC	NC	NC	NA	NC	NC
Pyrene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Volatile Organics									
1,1,1-Trichloroethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,1,2,2-Tetrachloroethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,1,2-Trichloro-1,2,2-trifluoroethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,1,2-Trichloroethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,1-Dichloroethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,1-Dichloroethene	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,2-Dichloroethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,2-Dichloroethene (Total)	NC	NC	NC	NC	11.3%	NC	NA	3.8%	2.4%
1,2-Dichloropropane	NC	NC	NC	NC	NC	NC	NA	NC	NC
1,4-Dichlorobenzene	NC	NC	NC	NC	NC	NC	NA	NC	NC
2-Butanone	NC	NC	NC	NC	NC	NC	NA	NC	NC
2-Hexanone	NC	NC	NC	NC	NC	NC	NA	NC	NC
4-Methyl-2-pentanone	NC	NC	NC	NC	NC	NC	NA	NC	NC
Acetone	NC	NC	NC	NC	NC	NC	NA	NC	NC
Benzene	NC	NC	NC	NC	NC	NC	NA	NC	7.7%
Bromodichloromethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
Bromoform	NC	NC	NC	NC	NC	NC	NA	NC	NC
Bromomethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
Carbon disulfide	NC	OK (+CRDL)	NC	NC	NC	NC	NA	NC	NC
Carbon tetrachloride	NC	NC	NC	NC	NC	NC	NA	NC	NC
Chlorobenzene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Chlorodibromomethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
Chloroethane	NC	NC	NC	NC	NC	NC	NA	NC	NC
Chloroform	NC	NC	NC	7.7%	NC	NC	NA	NC	NC
Chloromethane	NC	NC	NC	NC	NC	NC	NA	NC	NC

Table 5-1. Chemical Field Duplicate QC Sample Analysis (Cont'd)

Grab ID/Field Dup ID	HIS01467 / HIS01467-1	HIS01487 / HIS01487-1	HIS27074 / HIS27074-1	HIS65733 / HIS65733-1	SLA08153 / SLA08153-1	SLA08337 / SLA08337-1	SLA08337F / SLA08337-1F	SLA27091 / SLA27091-1	SLA27104 / SLA27104-1
cis-1,3-Dichloropropene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Ethylbenzene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Methylene chloride	NC	NC	NC	NC	NC	NC	NA	NC	NC
Styrene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Tetrachloroethene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Toluene	NC	NC	NC	NC	NC	NC	NA	NC	NC
trans-1,3-Dichloropropene	NC	NC	NC	NC	NC	NC	NA	NC	NC
Trichloroethene	NC	0.0%	NC	8.9%	3.8%	NC	NA	12.5%	9.5%
Vinyl chloride	NC	NC	NC	NC	NC	NC	NA	NC	NC
Xylenes, total	NC	NC	NC	NC	NC	NC	NA	NC	NC

NC = not calculated due to one of both activities being non-detected.

NA = not available

Shaded areas are outside of control limits.

Table 5-2. Radiological Field Duplicate QC Sample Analysis

Analyte	HIS01467 / HIS01467-1		HIS01487 / HIS01487-1		HIS27074 / HIS27074-1		HIS65733 / HIS65733-1		SLA08153 / SLA08153-1		SLA08337 / SLA08337-1		SLA27091 / SLA27091-1		SLA27104 / SLA27104-1	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
Radium-226	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	1.49
Radium-228	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Thorium-228	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Thorium-230	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	0.89	19.1%	NAD
Thorium-232	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	3.9%	NAD
Uranium-234	NC	NC	49.2%	0.56	NC	NC	75.9%	0.92	NC	NC	NC	NC	NA	0.55	NA	2.74
Uranium-235	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	1.94
Uranium-238	NA	0.31	45.2%	0.39	NC	NC	54.7%	0.65	NA	1.63	NC	NC	NA	0.47	NA	2.78

NC = not calculated due to one of both activities being non-detected.

NA = not available

Shaded areas are outside of control limits.

RPD=Relative Percent Difference

NAD= Normalized Absolute Difference

Table 5-3. Chemical QA Split Samples

Analyte	HIS01487 / HIS01487-2	HIS27074 / HIS27074-2	HIS65733 / HIS65733-2	SLA08337 / SLA08337-2	SLA27091 / SLA27091-2	SLA27104 / SLA27104-2
Inorganics						
Aluminum	NC	NC	NC	NC	NC	NC
Antimony	NC	NC	NC	NC	NC	NC
Arsenic	NC	NC	NC	10.7%	NC	NC
Bismuth	6.5%	17.3%	5.3%	4.5%	7.3%	8.9%
Barium	NC	NC	NC	NC	NC	NC
Boron	NC	NC	NC	NC	NC	NC
Cadmium	NC	NC	NC	NC	NC	NC
Calcium	14.4%	8.0%	4.0%	17.7%	9.9%	16.3%
Chromium	NC	NC	NC	NC	NC	NC
Cobalt	NC	OK (+CRDL)	NC	NC	NC	NC
Copper	NC	NC	NC	NC	NC	NC
Iron	NC	7.7%	NC	14.8%	NC	NC
Lead	NC	NC	NC	NC	NC	NC
Lithium	NC	NC	NC	NC	NC	NC
Magnesium	13.9%	9.8%	0.3%	8.6%	8.5%	OUT(>+CRDL)
Manganese	1.0%	2.0%	3.2%	1.5%	NC	6.2%
Mercury	NC	NC	NC	NC	NC	NC
Molybdenum	NC	NC	NC	NC	NC	NC
Nickel	10.5%	NC	NC	NC	NC	NC
Potassium	NC	19.9%	NC	NC	NC	OK (+CRDL)
Selenium	5.1%	NC	6.7%	NC	NC	OUT
Silver	NC	NC	NC	NC	NC	NC
Sodium	0.5%	12.9%	0.2%	NC	2.4%	15.8%
Strontium	NC	NC	NC	NC	NC	NC
Thallium	NC	NC	NC	NC	NC	NC
Uranium	NC	NC	NC	NC	NC	NC
Vanadium	NC	NC	NC	NC	NC	NC
Zinc	4.7%	OUT(>+CRDL)	17.8%	18.9%	NC	NC

NC = not calculated due to one of both activities being non-detected.

NA = not available

Shaded areas are outside of control limits.

Table 5-4. Radiological QA Split Samples

Analyte	HIS01467 / HIS01467-2		HIS01487 / HIS01487-2		HIS27074 / HIS27074-2		HIS65733 / HIS65733-2		SLA08153 / SLA08153-2		SLA08337 / SLA08337-2		SLA27091 / SLA27091-2		SLA27104 / SLA27104-2	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
Radium-226	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	1.96
Radium-228	NC	NC	NA	0.88	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	0.75
Thorium-228	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Thorium-230	NC	NC	NC	NC	NC	NC	NA	0.99	NC	NC	NC	NC	NC	NC	NA	1.41
Thorium-232	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	1.29
Uranium-234	NC	NC	NA	0.61	NC	NC	NA	0.81	NC	NC	NC	NC	NA	0.58	NA	2.81
Uranium-235	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	1.71
Uranium-238	NA	0.37	NA	0.67	NC	NC	NA	0.85	NA	0.58	NC	NC	NA	0.24	NA	2.86

NC = not calculated due to one of both activities being non-detected.

NA = not available

Shaded areas are outside of control limits.

RPD= Relative Percent Difference

NAD= Normalized Absolute Difference

5.7.3 Trip Blank Samples

These samples consist of containers of organic-free reagent water that are kept with the field sample containers from the time they leave the laboratory until they are returned for analysis. The purpose of trip blanks is to determine whether samples are being contaminated from VOCs during transit or sample collection. Trip blanks were taken during the CY01 ground-water monitoring program specifically for volatile organic compounds (VOCs). The only compound detected in the trip blanks, not attributed to laboratory contamination, was toluene. Although toluene was detected, the concentrations were at estimated quantities below the quantitation limit. Those samples which contained toluene and were associated with the contaminated trip blanks were qualified accordingly due to the associated trip blank contamination.

5.7.4 Equipment Rinsate Blanks

These samples are typically taken from the water rinsate collected from equipment decontamination activities, and are comprised of samples of analyte-free water, which have been rinsed over decontaminated sampling equipment, collected, and submitted for analysis of the parameters of interest. Since all of the monitoring wells have dedicated sampling equipment, equipment rinsate blanks were not employed to assess the effectiveness of the decontamination process since it does not apply.

5.7.5 Source-water Blanks

A sample from the site water supply used for equipment decontamination, well development, and other activities was acquired and submitted for analysis with the primary samples. In addition, samples of on-site, analyte-free water sources were also submitted for analysis. For radon flux sampling, un-deployed carbon canisters were submitted for analysis with the exposed canisters. Generally, no more than one sample is needed for a sampling task.

5.8 DATA VERIFICATION AND VALIDATION

All data packages received from the analytical laboratory were reviewed, evaluated, and 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 EPA regional or National Functional Guidelines or project-specific guidelines. General chemical data quality management guidance found in ER-1110-1-263 (USACE, 1998a) 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 (SAIC, 1999). Data assessment guidance, to determine the usability of data from HTRW projects, was provided in EM-200-1-6 (USACE, 1997).

One hundred percent of the data generated from all analytical laboratories underwent independent data review and evaluation. Data reviews document 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. Data evaluation uses the results of the data review to determine the usability of the data. 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) and contract compliance.

Consistent with the data quality requirements, as defined in the DQOs, greater than 10% of all project data was validated and qualified per the outcome of the review.

5.9 PRECISION, ACCURACY, REPRESENTATIVENESS, COMPARABILITY AND COMPLETENESS

Precision was determined through the use of spike analyses conducted on duplicate pairs of environmental samples (matrix spike/matrix spike duplicate) or comparison of positive duplicate pair responses. The relative percent difference (RPD) between the two results was calculated and used as an indication of the precision of the analyses performed. Sample collection precision was measured in the laboratory by the analyses of field duplicates. With the exception of a few outliers, which were qualified accordingly, the overall precision for the CY01 environmental monitoring sampling activities was very good.

The fundamental QA objectives for precision and accuracy of laboratory analytical data are the QC acceptance criteria of the analytical protocols. Analytical accuracy is expressed as the percent recovery of an analyte that has been added to a blank sample or environmental sample at a known concentration before analysis. Accuracy was determined in the laboratory through the use of matrix spike analyses, laboratory control sample (LCS) analyses, and blank spike analyses. The percent recoveries for specific target analytes were calculated and used as an indication of the accuracy of the analyses performed.

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is a qualitative parameter that depends upon the proper design of the sampling program and proper laboratory protocol. Representativeness was 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 overall representativeness of the CY01 environmental monitoring sampling activities was good.

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 (i.e., post CY97) analytical data, however, may not be directly comparable to existing data because of differences in QA objectives.

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 CY01 environmental monitoring sampling activities, the data completeness was 99.8% (FUSRAP DQO for completeness is 90%).

6.0 DOSE ASSESSMENT

This section evaluates the cumulative dose to a hypothetically impacted individual from exposure to radiological contaminants at the SLS. The regulatory dose limit for members of the public is 100 mrem/yr as stated in 10 CFR 20.1301. 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 SLS 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 do 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 (mrem/hr).

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

Dose calculations are presented for hypothetical maximally exposed individuals at SLAPS, SLDS, HISS, and Coldwater Creek. In addition, a dose calculation is presented for a transient receptor who frequently passes SLAPS on McDonnell Boulevard. The monitoring data used in the dose calculations are reported in 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 Attachment 1, the SLS FUSRAP CY01 radionuclide emissions NESHAPs Report.

Although USACE has elected to demonstrate compliance as stated above, measurements of effluent water concentrations and dose from external sources are also taken at site boundaries (i.e., method 2 (i) above). The average annual concentration for contaminants of concern at the SLS (i.e., HISS, SLAPS, and SLDS) in water effluents are less than the values specified in Table 2 to Appendix B of Part 20 and doses at site boundaries from external sources are less than those specified in §20.1302(b)(2)(ii).

6.1 HIGHLIGHTS

- The TEDE from SLAPS to a hypothetical maximally exposed individual from all complete/applicable pathways combined was 9.7 mrem/yr, estimated for an individual who works full time at a location approximately 160 m south of the SLAPS perimeter.

- The TEDE from HISS to a hypothetical maximally exposed individual from all complete/applicable pathways combined was 8.2 mrem/yr, estimated for an individual who works full time at a location approximately 50 m east of the HISS perimeter.
- The TEDE from SLDS to the receptor from all complete/applicable pathways combined was less than 1.0 mrem/yr, estimated for an individual who works full-time at Thomas and Proetz Lumber Company.
- The TEDE from Coldwater Creek to a hypothetical maximally exposed individual from all complete/applicable pathways combined was 0.1 mrem/yr, estimated for a youth spending time as a recreational user of Coldwater Creek.
- The TEDE from SLAPS to a hypothetical exposed transient receptor from all complete/applicable pathways combined was 3.5 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 CY01, and were thus incorporated into radiological dose estimates.

Table 6-1. Complete Radiological Exposure Pathways for SLS

Exposure Pathway	Pathway Description	Applicable to CY01 Dose Estimate				
		SLAPS	HISS	SLDS	Coldwater Creek	Transient
Liquid A	Ingestion of ground water from local wells down-gradient from the site.	N	N	N	N	N
Liquid B	Ingestion of fish inhabiting Coldwater Creek.	NC	NC	NC	N	N
Liquid C	Ingestion of surface water ¹ and sediments.	NC	NC	NC	Y ²	N
Airborne A	Inhalation of particulates dispersed through wind erosion and remedial action.	Y	Y	Y	NC	Y
Airborne B	Inhalation of Rn-222 and decay products emitted from contaminated soils/wastes.	Y	Y	Y	NC	Y
External	Direct gamma radiation from contaminated soils/wastes.	Y	Y	Y	N	Y

¹ Surface water includes stormwater run-off from SLS, MSD discharges, and the water in Coldwater Creek.

² The pathway is only applicable to a recreational receptor (youth) exposed to contaminants present in Coldwater Creek water and sediments. Data from SLS stormwater 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

Y applicable

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 CY01. If this is the case, the pathway is termed applicable. Only applicable pathways are considered in estimates of dose.

Table 6-1 shows the pathways that are not applicable to the CY01 dose estimates for SLS and 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 not applicable in CY01 for the following reasons:

- Liquid A is not applicable because the aquifer is considered to be of naturally low quality and it is not known to be used for any domestic purpose in the vicinity of the St. Louis FUSRAP Sites (ANL, 1992).
- 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% 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 ($\mu\text{rem}/\text{yr}$). 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 emitting from the contaminants is indistinguishable from background gamma radiation.

The applicable radiological public dose limits for the SLS are as follows:

- NESHAPs limit of 10 millirem (mrem) effective dose equivalent annually due to airborne emissions other than Rn-222 at off-site receptor locations.
- Nuclear Regulatory Commission (NRC) limit of 100 mrem TEDE for all exposure pathways on an annual basis (excluding background).

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 SLS. First, conditions were set to determine the TEDE to a maximally exposed individual at each of the main site locations (SLAPS, SLDS, and HISS). A second dose equivalent for Coldwater Creek was calculated. A third set of dose equivalent calculations were performed to meet NESHAPs requirements (Attachment 1).

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 St. Louis FUSRAP. This methodology provides for reasonable 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 (ICRP) Reports 26 and 30 for a fifty-year committed effective dose equivalent (CEDE). Fifty-year CEDE conversion factors were obtained from the EPA *Federal Guidance Report No. 11* (EPA, 1989d).

6.4 DOSE EQUIVALENT ESTIMATES EXPOSURE SCENARIOS

Dose equivalent estimates for the exposure scenarios were calculated using CY01 monitoring data. Calculations for dose scenarios are provided in Appendix E. Dose equivalent estimates are well below the standards set by the NRC for annual public exposure and EPA NESHAPs limits.

The CY01 TEDEs for hypothetical maximally exposed individuals near the SLAPS, HISS, SLDS, and Coldwater Creek are 9.7 mrem/yr, 8.2 mrem/yr, 1.0 mrem/yr, and 0.1 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 (BEIR V, 1990). Assumptions are detailed in the following sections.

6.4.1 Radiation Dose Equivalent from SLAPS to a Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent the perimeter of SLAPS 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%. A full time employee business receptor was considered to be the maximally exposed individual from SLAPS.

The exposure scenario assumptions are as follows:

- Exposure from airborne radioactive particulates was calculated using 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, 2002b).
- 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 external gamma radiation occurs to the maximally exposed individual while working full-time outside at the receptor location facility located approximately 160 meters south of the SLAPS perimeter. Exposure time is 2,000 hours per year (SAIC, 2002b).
- 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, 2002b).

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor facility 160 m from the SLAPS perimeter received 9.4 mrem/yr from airborne radioactive particulates, 0.1 mrem/yr from external gamma, and 0.2 mrem/yr from Rn-222 for a TEDE of 9.7 mrem/yr (SAIC, 2002b).

6.4.2 Radiation Dose Equivalent from HISS to a Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent the perimeter of HISS 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%. A full time employee business receptor was considered to be the maximally exposed individual from HISS.

The exposure scenario assumptions are as follows:

- Exposure from airborne radioactive particulates was calculated using soil characterization 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, 2002a).
- 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 external gamma radiation occurs to the maximally exposed individual while working full-time outside at the receptor location facility located approximately

50 m east of the HISS perimeter. Exposure time is 2,000 hours per year (SAIC, 2002a).

- 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, 2002a).

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor location facility 50 m east from the HISS perimeter received 7.8 mrem/yr from airborne radioactive particulates, 0.2 mrem/yr from external gamma, and 0.2 mrem/yr from Rn-222 for a TEDE of 8.2 mrem/yr (SAIC, 2002a).

6.4.3 Radiation Dose Equivalent from SLDS to a Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent the perimeter of SLDS 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%. A full time employee business receptor was considered to be the maximally exposed individual from SLDS.

The exposure scenario assumptions are as follows:

- Exposure from airborne radioactive particulates was estimated using air particulate monitoring data to determine a source term and then running the CAP-88 PC modeling code to estimate dose to the receptor (SAIC, 2002c).
- 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 external gamma radiation occurs to the maximally exposed individual while working full-time outside at the receptor location facility located approximately 50 m from the assumed linesource. Exposure time is 2,000 hours per year (SAIC, 2002c).
- 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 receptor (SAIC, 2002c).

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor location facility received 0.7 mrem/yr from airborne radioactive particulates, 0.1 mrem/yr from external gamma, and 0.2 mrem/yr from Rn-222 for a TEDE of 1.0 mrem/yr (SAIC, 2002c).

6.4.4 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%. 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 2 hours at Coldwater Creek during each visit, and visits once every two weeks. It is likely that 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 2 liters per day (EPA, 1989c).
- Average radionuclide concentrations in Coldwater Creek surface water/sediment samples taken in CY01 were assumed to be present in the water/sediment ingested by the maximally exposed individual (SAIC, 2002d).
- Dose equivalent conversion factors for ingestion, are: Total U, $2.5\text{E-}5$ millirem per picocurie (mrem/pCi); Ra-226, $1.33\text{E-}3$ mrem/pCi; Ra-228, $1.44\text{E-}3$ mrem/pCi; Th-228, $3.96\text{E-}4$ mrem/pCi; Th-230, $5.48\text{E-}4$ mrem/pCi; and Th-232, $2.73\text{E-}3$ mrem/pCi (EPA, 1989b).

Based on the exposure scenario and assumptions described above, a maximally exposed individual using Coldwater Creek for recreational purposes received 0.007 mrem/yr from soil/sediment ingestion, and 0.096 mrem/yr from water ingestion for a TEDE of 0.1 mrem/yr (SAIC, 2002d).

6.4.5 Radiation Dose Equivalent from SLAPS to a Transient Receptor

This section discusses the estimated TEDE to a hypothetical transient receptor that passes SLAPS daily during the workweek. Therefore, all calculations of dose equivalent due to the applicable pathway assume a realistic residence time is less than 100%.

The exposure scenario assumptions are:

- The transient spends 30 minutes per day passing SLAPS, and passes every day during the normal work year.
- Exposure from airborne particulate radionuclides was calculated using air particulate monitoring data to determine a source term and then running the CAP-88 PC modeling code to estimate dose to the receptor (SAIC, 2002e).

- Exposure from external gamma radiation occurs to the transient receptor passing the SLAPS at approximately 25 m north of the SLAPS perimeter. Exposure time is 125 hours per year (SAIC, 2002e).
- Exposure from Rn-222 (and progeny) was estimated using Rn-222 (alpha track) monitoring data at the site perimeter between the source and the receptor and then running the CAP-88 PC modeling code to calculate dose to the transient receptor located approximately 25 m north of the SLAPS perimeter along McDonnell Boulevard (SAIC, 2002e).

Based on the exposure scenario and assumptions described above, the exposed transient receptor passing SLAPS along McDonnell Boulevard 25 m north of the SLAPS perimeter received 3.4 mrem/yr from airborne particulate radionuclides, 0.1 mrem/yr from external gamma, and 0.0 mrem/yr from Rn-222 for a TEDE of 3.5 mrem/yr (SAIC, 2002e).

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ACRONYMS AND ABBREVIATIONS

$\mu\text{Ci}/\text{cm}^3$	microcurie per cubic centimeter
$\mu\text{Ci}/\text{mL}$	microcurie per milliliter
AEC	Atomic Energy Commission
C°	degree(s) Celsius (centigrade)
CFR	Code of Federal Regulations
Ci/yr	curie per year
cm/yr	centimeter per year
CY	calendar year
DOE	Department of Energy
EDE	effective dose equivalent
EPA	Environmental Protection Agency
ft	feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
ha	hectares
HEPA	high efficiency particulate air
HISS	Hazelwood Interim Storage Site
IA	investigation area
m	meter (s)
m/min	meters per minute
MED	Manhattan Engineering District
mrem/yr	millirem per year
NESHAP	National Emission Standard for Hazardous Air Pollutants
NRC	Nuclear Regulatory Commission
pCi/g	picocurie per gram
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geologic Survey
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) Sites for calendar year 2001 (CY01). NESHAP requires the calculation of the effective dose equivalent from radionuclide emissions to critical receptors. The report follows the requirements and procedures contained in 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*.

This report evaluates three sites: the St. Louis Airport Site (SLAPS), the Hazelwood Interim Storage Site (HISS), and the St. Louis Downtown Site (SLDS). 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 CY01 to provide a conservative estimate of total emissions.

The NESHAP standard of effective dose equivalent (EDE) to a critical receptor from radionuclide emissions is 10 millirem per year (mrem/yr). None of the sites exceeded this standard. The EDE from radionuclide emissions at the HISS, SLAPS, and SLDS were calculated using soil characterization data, air particulate monitoring data, and the Environmental Protection Agency (EPA) CAP-88PC modeling code, which resulted in EDEs of 7.8 mrem/yr, 9.4 mrem/yr, and 0.7 mrem/yr, 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 Environmental Protection Agency (EPA) CAP-88PC modeling code, which resulted in less than 0.1 mrem/yr.

Evaluations for the SLDS and the USACE Radioanalytical Laboratory resulted in less than 10% 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.C. 1001.

Signature

Date

Office: U.S. Army Corp of Engineers, St. Louis District Office
Address: 8945 Latty Ave.
Berkeley, MO 63134
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1.0 PURPOSE

This report calculates the effective dose equivalent (EDE) from radionuclide emissions (exclusive of radon) to critical receptors from the USACE Radioanalytical Laboratory and each of the three St. Louis Formerly Utilized Sites Remedial Action Program (FUSRAP) locations: Hazelwood Interim Storage Site (HISS), St. Louis Airport Site (SLAPS), and St. Louis Downtown Site (SLDS). The air emissions from each site are ground releases of particulate radionuclides in soil from windblown *in situ* and remedial activity sources. The air emissions from the laboratory are fume hood stack releases of particulate radionuclides from sample preparation and separation activities.

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", (EPA, 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 EPA computer code CAP88-PC along with appropriate meteorological data and distances to critical receptors¹ to obtain the EDE from the air emissions. In the 1998 NESHAP report for the SLAPS, a comparison run was made for the highest critical receptor (business) located 160 m from the site in the south sector using COMPLY Version 1.5d and CAP88-PC. COMPLY provided an EDE result of 5.1 mrem/yr with CAP88-PC providing a result of 7.6 mrem/yr. The general agreement of these two results and the CAP88-PC results providing a greater annual EDE result indicates that CAP88-PC is a comparable method of demonstrating compliance with 40 CFR 61 Subpart I.

In the 1998 NESHAP report for the SLAPS, a comparison run was made for the highest critical receptor (business) located 160 m from the site in the south sector using COMPLY Version 1.5d and CAP88-PC. COMPLY provided an EDE result of 5.1 mrem/yr with CAP88-PC providing a result of 7.6 mrem/yr. The general agreement of these two results and the CAP88-PC results providing a greater annual EDE result indicates that CAP88-PC is a comparable method of demonstrating compliance with 40 CFR 61 Subpart I.

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 were evaluated using air sampling data at the excavation perimeters when site perimeter air particulate data was not available.

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

2.2 EFFECTIVE DOSE EQUIVALENT

The EDE to critical receptors is obtained using EPA computer code CAP88-PC Version 2.0 (EPA, 1997a). CAP88-PC uses a Gaussian plume equation to estimate the dispersion of radionuclides and is referenced by the EPA to demonstrate compliance with the National Emission Standard for Hazardous Air Pollutants (NESHAP) emissions criterion in 40 CFR 61.

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.

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
Average Annual Precipitation Rate	111 cm/yr
Average Annual Air Temperature	14.18 °C

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

Table 3-1. St. Louis Wind Speed Frequency

Wind Speed Group, Knots*	Frequency
0 - 3	0.10
4 - 7	0.29
8 - 12	0.36
13 - 18	0.21
19 - 24	0.03
25 - 31	0.01

*knot = 1.151 miles/hr

Wind direction frequency was obtained from the CAP-88 wind file, 13994.WND (see Table 3-2).

Table 3-2. St. Louis Wind Rose Frequency

Wind direction (wind towards)	Wind From	Wind Frequency	Wind direction (wind towards)	Wind From	Wind Frequency
N	S	0.1310	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

4.0 ST. LOUIS AIRPORT SITE AND ADJACENT VICINITY PROPERTIES UNDER ACTIVE REMEDIATION

4.1 SITE HISTORY

The Manhattan Engineering District (MED) acquired the SLAPS in 1946 to store uranium-bearing residuals generated at the 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. Various characterization studies have been performed on the site.

4.2 MATERIAL HANDLING AND PROCESSING FOR CY01

Excavation activities were performed at the SLAPS at the East End and Phase I areas of the site. The excavated soils were removed from the site by rail and truck. Environmental air samples were collected around the perimeter of the site during CY01 with the results used to determine the excavation and windblown *in situ* emissions.

4.3 SOURCE DESCRIPTION – RADIONUCLIDE SOIL CONCENTRATIONS

The radionuclide concentrations, as they exist in the surface soils at the SLAPS, were obtained from statistical summaries of the investigative areas (IAs) contained in the *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). Appendix A contains a summary table of the radionuclide concentrations for each area or site used to calculate the emission rate from each area or site, as applicable. For the SLAPS, areas IA-1 through IA-8 were averaged to determine the radionuclide concentrations that apply to site emissions. For calculations that apply to specific areas, the average for the area is used.

4.4 LIST OF ASSUMED AIR RELEASES FOR CY01

Wind erosion during periods of site inactivity and the remedial action excavations are assumed for the particulate radionuclide emission determinations from the SLAPS. Vicinity properties (VPs) do not contribute to the emission determinations for periods of inactivity due to the low activity and vegetation cover.

4.5 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown in Figure 4-1 and Table 4-1. Distances and directions to critical receptors are based on measurements on the USGS 7.5-minute Florissant Quadrangle Map.

Table 4-1. SLAPS Critical Receptors

Receptor	Direction from site	Distance (mi)	Distance (m)
Nearest Resident	E	1	1,600
School	SE	1.4	2,300
Business	S	0.1	160 ¹
Farm	NE	0.84	1,400

¹ Distance from receptor to fenceline is 160 meters. Distance from receptor to center of source is 314 meters for emissions determination.

4.6 EMISSIONS DETERMINATION

4.6.1 Measured Particulate Emissions

Particulate air samples are collected from six locations around the perimeter of the SLAPS to measure the radionuclide emissions. The samplers provide the basis for determining the radionuclide emission rates during all of CY01. The average gross alpha and beta concentrations [microcurie per milliliter ($\mu\text{Ci/mL}$)] are determined for each site location for CY01. The site gross alpha and beta emission concentration is determined by averaging the six locations. The location and the site average concentrations are presented in Table 4-2.

Table 4-2. SLAPS Average Gross Alpha and Beta Particulate Emissions

Sampler Location	Average Concentration ($\mu\text{Ci/mL}$)	
	alpha	beta
PAP1	4.78E-15	5.70E-14
PAP2	5.57E-15	5.70E-14
PAP3	5.52E-15	7.39E-14
PAP4	7.70E-15	6.34E-14
PAP5	4.27E-15	6.16E-14
Average Concentration =	5.57E-15	6.26E-14

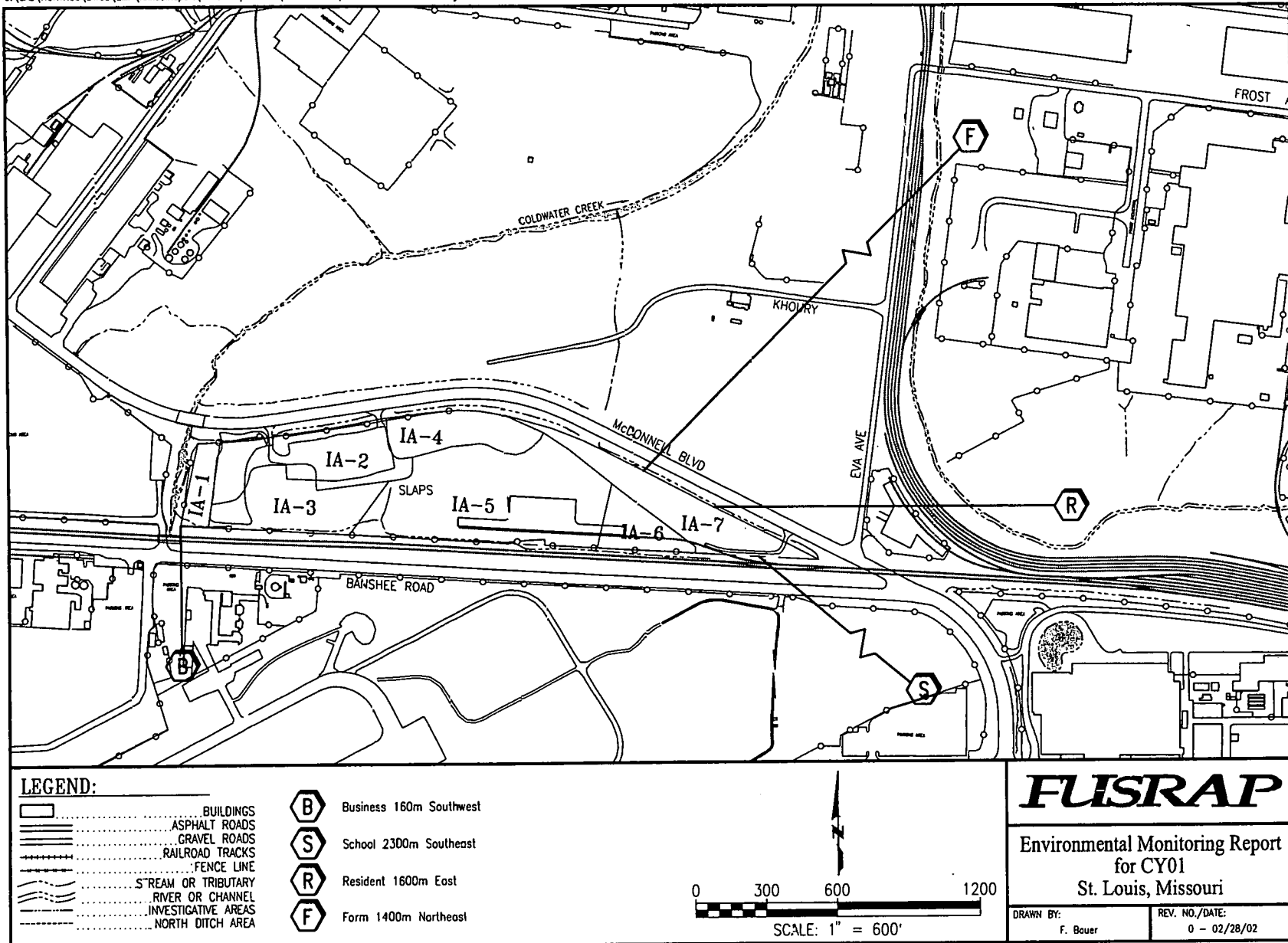


Figure 4-i. St. Louis Airport Site Critical Receptors

Radionuclide activity fractions are determined for alpha and beta from the average radionuclide concentration data contained in the *St. Louis FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). The product of each radionuclide activity fraction and the gross concentration provides the radionuclide emission concentration [microcurie per cubic centimeter ($\mu\text{Ci}/\text{cm}^3$)]. The gross average concentration ($\mu\text{Ci}/\text{cm}^3$) is converted to a release rate [curie per year (Ci/yr)] using Equations (1) and (2) below and illustrated in Table 4-3.

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

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

where

D is the effective diameter of the release [meters (m)], and

A is the area of the stack, vent, or release point [square meters (m^2)].

For the SLAPS, the area within the perimeter of the air samples is $88,000 \text{ m}^2$ resulting in an effective diameter of 338 m.

The average annual wind speed for the St. Louis Lambert International Airport is provided in CAP88-PC as 4.446 meters/second. Conversion of this wind speed to a flow rate through a stack with an effective diameter of 338 m is completed using Equation (2).

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

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 site to an effective flow rate results in a site release flow rate of $2.4\text{E}+7 \text{ m}^3/\text{min}$. The product of the flow rate, the average radionuclide concentration for the SLAPS, and the appropriate conversion factors provide the site emission rate for each radionuclide as illustrated in Table 4-3.

Table 4-3. Particulate Radionuclide Emission Rates Based on Site Perimeter Air Samples

Radionuclide	⁸ Activity Fraction	⁹ Emission Conc. ($\mu\text{Ci}/\text{cm}^3$)	¹⁰ Emission Rate(Ci/yr)
U-238	7.5E-02	4.5E-16	5.7E-03
U-235	3.5E-03	2.1E-17	2.6E-04
U-234	7.7E-02	4.6E-16	5.8E-03
Ra-226	7.0E-02	4.2E-16	5.3E-03
Th-232	5.4E-03	3.2E-17	4.1E-04
Th-230	7.6E-01	4.5E-15	5.7E-02
Th-228	3.2E-03	1.9E-17	2.4E-04
¹ Ra-224	3.2E-03	1.9E-17	2.4E-04
² Th-234	4.7E-01	3.0E-14	3.8E-01
³ Pa-234m	4.7E-01	3.0E-14	3.8E-01
⁴ Th-231	2.2E-02	1.4E-15	1.7E-02
Ra-228	1.5E-02	9.7E-16	1.2E-02
⁵ Ac-228	1.5E-02	9.7E-16	1.2E-02
⁶ Pa-231	3.5E-03	2.1E-17	2.6E-04
⁷ Ac-227	3.5E-03	2.1E-17	2.6E-04

¹ Assumed to be in secular equilibrium with parent Th-228.

² Assumed to be in secular equilibrium with parent U-238.

³ Assumed to be in secular equilibrium with parent Th-234.

⁴ Assumed to be in secular equilibrium with parent U-235.

⁵ Assumed to be in secular equilibrium with parent Ra-228.

⁶ Assumed to be in secular equilibrium with parent Th-231.

⁷ Assumed to be in secular equilibrium with parent Pa-231.

⁸ Derived from the average soil radionuclide concentrations for SLAPS IA-1 to IA-8 as presented in USACE 1999.

⁹ Product of gross alpha or beta emission concentration from Table 4-2 and the radionuclide activity fraction.

¹⁰ Emission rate based on 365 day sampling period at a flow rate of $2.4\text{E}+7 \text{ m}^3/\text{min}$ as determined from Equations (1) and (2).

4.6.2 SLAPS Total Emission Rates

The total CY01 emission rates which were input into the EPA codes are shown in Table 4-4 as the measured emission rates from the air samples collected from the perimeter of the site.

Table 4-4. CY01 SLAPS Total Emission Rates

Radionuclide	Emission (Ci/yr)
U-238	5.7E-03
U-235	2.6E-04
U-234	5.8E-03
Ra-226	5.3E-03
Th-232	4.1E-04
Th-230	5.7E-02
Th-228	2.4E-04
¹ Ra-224	2.4E-04
² Th-234	3.8E-01
³ Pa-234m	3.8E-01
⁴ Th-231	1.7E-02
Ra-228	1.2E-02
⁵ Ac-228	1.2E-02
⁶ Pa-231	2.6E-04
⁷ Ac-227	2.6E-04

¹ Assumed to be in secular equilibrium with parent Th-228. ⁵ Assumed to be in secular equilibrium with parent Ra-228.

² Assumed to be in secular equilibrium with parent U-238.

⁶ Assumed to be in secular equilibrium with parent Th-231.

³ Assumed to be in secular equilibrium with parent Th-234. ⁷ Assumed to be in secular equilibrium with parent Pa-231.

⁴ Assumed to be in secular equilibrium with parent U-235.

4.7 CAP88-PC RESULTS

The CAP88-PC report is contained in Appendix B. The area factor input was the total for the SLAPS of 88,000 m². Results show compliance with the 10 millirem per year (mrem/yr) criterion for all critical receptors. Table 4-5 summarizes the results.

Table 4-5. SLAPS CAP88-PC Results for Critical Receptors

Receptor	Direction from site	Distance (m)	(mrem/yr)
Nearest Resident	E	1,600	5.1
School ¹	SE	2,300	0.4
Business ¹	S	160 ²	9.4
Farm	NE	1400	3.5

¹ Corrected for the 23 percent occupancy factor (50 weeks/yr 40 hours/wk).

² Distance from receptor to fenceline is 160 m. Distance from receptor to center of source is 314 m for emissions determination.

5.0 ST. LOUIS DOWNTOWN SITE PROPERTIES UNDER ACTIVE REMEDIATION

5.1 SITE HISTORY

From 1942 until 1957, Mallinckrodt Chemical Works was contracted by MED and AEC to process uranium ore for the production of uranium metal. Residuals of the process, including spent pitchblende ore, process chemicals, and radium, thorium, and uranium, were inadvertently released from the Mallinckrodt Plant and into the environment through handling and disposal practices. Residuals from the uranium process had elevated levels of radioactive radium, thorium, and uranium. From 1942 to 1945, Plants 1, 2, 6, 7, and 4 (now Plant 10) were involved in the development of uranium-processing techniques, uranium compounds and metal production, and uranium metal recovery from residues and scrap. Uranium-bearing process residues from these operations were stored at the SLAPS and the Latty Avenue Properties from 1946 to 1966. Relocation and storage of these processed wastes at SLAPS and the Latty Avenue Properties resulted in the subsequent contamination of the SLAPS VPs. Mallinckrodt decontaminated Plants 1 and 2 from 1948 through 1950 to meet the AEC criteria then in effect, and the AEC released these plants for use without radiological restrictions in 1951.

5.2 MATERIAL HANDLING AND PROCESSING FOR CY01

Excavation activities were performed at SLDS Plant 1, Plant 6, and Midwest Waste areas of the site. The excavated soils were removed from the site by rail. General area air samples were collected around excavation perimeters during CY01 with the results used to determine the excavation emissions. *In situ* emissions from inactive areas of SLDS were not calculated because the ground surface soil at SLDS is generally covered with asphalt or concrete that limits the potential for material to become airborne.

5.3 SOURCE DESCRIPTION – RADIONUCLIDE SOIL CONCENTRATIONS

The radionuclide concentrations for Plants 1 and 6, as they exist in the soils at SLDS, were obtained from statistical summaries of Plant areas contained in the *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). The radionuclide concentrations for Midwest Waste, as they exist in the soils at SLDS, were obtained from screening data provided by the Remedial Action (RA) contractor, IT Corporation. Appendix A contains a summary table of the radionuclide concentrations for each area or Plant used to calculate the emission rate from each area or at each Plant, as applicable. For the SLDS, Plant 1, Plant 6, and Midwest Waste air particulate concentrations were averaged at each area or Plant to determine the radionuclide concentrations that apply to site emissions during the open excavations.

5.4 LIST OF ASSUMED AIR RELEASES FOR CY01

Wind erosion during periods of remedial action excavations is assumed for the particulate radionuclide emission determinations from the SLDS. VPs do not contribute to the emission determinations for periods of inactivity due to the low activity and cover.

5.5 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown in Figure 5-1 and listed in Table 5-1. Distances and directions to critical receptors are based on measurements on the USGS 7.5 minute Florissant Quadrangle Map.

Table 5-1. SLDS Critical Receptors

Receptor	Direction from site	Distance (miles)	Distance (m)
Nearest Resident	NE	0.6	970
School	SW	2.8	4500
Business	SE	0.03	50 ¹
Farm	NE	0.6	970

¹ Distance from receptor to fenceline is 50 m. Distance from receptor to center of source is 267 m for emissions determination.

5.6 EMISSIONS DETERMINATION

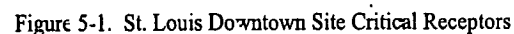
5.6.1 Measured Particulate Emissions

Particulate air samples were collected from several locations around the perimeter of the Plant 1, Plant 6, and Midwest Waste excavations to measure the radionuclide emissions from remedial activities. The samplers were established at the start of remedial activity and provide the basis for determining the radionuclide emission rates during all of CY01. The average gross alpha and beta concentrations ($\mu\text{Ci/mL}$) are determined for each plant location for the CY01. The site gross alpha and beta emission concentration is determined by averaging the locations surrounding the excavation. The plant average concentrations are presented in Table 5-2.

Table 5-2. SLDS Average Gross Alpha and Beta Particulate Emissions

Sampler Location	Average Concentration ($\mu\text{Ci/mL}$)	
	alpha	beta
Plant 1	6.21E-15	6.39E-14
Plant 6	4.17E-15	6.00E-14
Midwest Waste	5.03E-15	3.82E-14
Average Concentration¹ =	5.61E-15	6.51E-14

¹ Average concentration for combined Plant 1, Plant 6, and Midwest Waste data. Not used for dose assessment.



Plant 1 and Plant 6 radionuclide activity fractions are determined for alpha and beta from the average radionuclide concentration data contained in the *St. Louis FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). Midwest Waste radionuclide activity fractions are determined for alpha and beta from the average radionuclide concentration data obtained from screening data provided by IT Corporation. The product of each radionuclide activity fraction and the gross concentration provides the radionuclide emission concentration ($\mu\text{Ci}/\text{cm}^3$). The gross average concentration ($\mu\text{Ci}/\text{cm}^3$) is converted to a release rate (Ci/yr) using Equations (1) and (2) below and illustrated in Table 5-3.

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

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

where

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

For Plant 1, Plant 6, and Midwest Waste excavations, the area within the perimeter of the air samples is 106 m^2 , 4027 m^2 , and 3800 m^2 respectively. This results in an effective diameter of 12 m, 72 m, and 70 m respectively.

The average annual wind speed for the St. Louis Lambert International Airport is provided in CAP88-PC as 4,446 meters/second. Conversion of this wind speed to a flow rate through stacks with effective diameters of 12, 72, and 70 m is completed using Equation (2).

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

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 site to an effective flow rate results in a site release flow rate of $2.9\text{E}4 \text{ m}^3/\text{min}$ for Plant 1, $1.1\text{E}6 \text{ m}^3/\text{min}$ for Plant 6, and $1.0\text{E}6 \text{ m}^3/\text{min}$ for Midwest Waste. The product of the flow rate, the average radionuclide concentration for the SLDS, and the appropriate conversion factors provide the site emission rate for each radionuclide as illustrated in Table 5-3.

Table 5-3. Particulate Radionuclide Emission Rates Based on Site Perimeter Air Samples

Radionuclide	Plant 1			Plant 6			Midwest Waste		
	Activity Fraction	Emission Conc. ($\mu\text{Ci}/\text{cm}^3$)	Emission Rate (Ci/yr)	Activity Fraction	Emission Conc. ($\mu\text{Ci}/\text{cm}^3$)	Emission Rate (Ci/yr)	Activity Fraction	Emission Conc. ($\mu\text{Ci}/\text{cm}^3$)	Emission Rate (Ci/yr)
U-238	1.4E-01	8.4E-16	1.3E-05	3.5E-01	1.4E-15	8.1E-04	2.3E-01	1.2E-15	6.2E-04
U-235	6.3E-03	3.8E-17	5.8E-07	1.7E-02	6.6E-17	3.8E-05	1.5E-02	7.5E-17	3.9E-05
U-234	1.4E-01	8.4E-16	1.3E-05	3.5E-01	1.4E-15	8.1E-04	2.3E-01	1.2E-15	6.2E-04
Ra-226	5.5E-01	3.3E-15	5.0E-05	6.8E-02	2.7E-16	1.6E-04	1.0E-01	5.2E-16	2.7E-04
Th-232	1.4E-02	8.4E-17	1.3E-06	1.7E-02	6.6E-17	3.8E-05	4.1E-02	2.0E-16	1.1E-04
Th-230	1.1E-01	6.5E-16	9.9E-06	1.3E-01	5.2E-16	3.0E-04	2.5E-01	1.2E-15	6.4E-04
Th-228	1.4E-02	8.4E-17	1.3E-06	1.7E-02	6.6E-17	3.8E-05	4.8E-02	2.4E-16	1.3E-04
¹ Ra-224	1.4E-02	8.4E-17	1.3E-06	1.7E-02	6.6E-17	3.8E-05	4.8E-02	2.4E-16	1.3E-04
² Th-234	4.5E-01	2.7E-14	4.1E-04	4.7E-01	2.8E-14	1.6E-02	4.3E-01	1.6E-14	8.5E-03
³ Pa-234m	4.5E-01	2.7E-14	4.1E-04	4.7E-01	2.8E-14	1.6E-02	4.3E-01	1.6E-14	8.5E-03
⁴ Th-231	2.0E-02	1.2E-15	1.8E-05	2.2E-02	1.3E-15	7.6E-04	2.7E-02	1.0E-15	5.4E-04
Ra-228	4.5E-02	2.7E-15	4.1E-05	2.2E-02	1.3E-15	7.6E-04	6.1E-02	2.3E-15	1.2E-03
⁵ Ac-228	4.5E-02	2.7E-15	4.1E-05	2.2E-02	1.3E-15	7.6E-04	6.1E-02	2.3E-15	1.2E-03
⁶ Pa-231	6.3E-03	6.3E-17	9.6E-07	1.7E-02	6.6E-17	3.8E-05	1.5E-02	7.5E-17	3.9E-05
⁷ Ac-227	6.3E-03	6.3E-17	9.6E-07	1.7E-02	6.6E-17	3.8E-05	1.5E-02	7.5E-17	3.9E-05

¹ Assumed to be in secular equilibrium with parent Th-228.

² Assumed to be in secular equilibrium with parent U-238.

³ Assumed to be in secular equilibrium with parent Th-234.

⁴ Assumed to be in secular equilibrium with parent U-235.

⁵ Assumed to be in secular equilibrium with parent Ra-228.

⁶ Assumed to be in secular equilibrium with parent Th-231.

⁷ Assumed to be in secular equilibrium with parent Pa-231.

5.6.2 SLDS Total Emission Rates

The total CY01 emission rates which were input into the EPA codes are shown in Table 5-4 and are calculated based on the measured emission rates from the air samples collected from the perimeter of the Plants 1 and 6 and Midwest Waste excavations.

Table 5-4. CY01 SLDS Total Emission Rates

Radionuclide	Emission (Ci/yr)		
	Plant 1	Plant 6	Midwest Waste
U-238	1.3E-05	8.1E-04	6.2E-04
U-235	5.8E-07	3.8E-05	3.9E-05
U-234	1.3E-05	8.1E-04	6.2E-04
Ra-226	5.0E-05	1.6E-04	2.7E-04
Th-232	1.3E-06	3.8E-05	1.1E-04
Th-230	9.9E-06	3.0E-04	6.4E-04
Th-228	1.3E-06	3.8E-05	1.3E-04
¹ Ra-224	1.3E-06	3.8E-05	1.3E-04
² Th-234	4.1E-04	1.6E-02	8.5E-03
³ Pa-234m	4.1E-04	1.6E-02	8.5E-03
⁴ Th-231	1.8E-05	7.6E-04	5.4E-04
Ra-228	4.1E-05	7.6E-04	1.2E-03
⁵ Ac-228	4.1E-05	7.6E-04	1.2E-03
⁶ Pa-231	9.6E-07	3.8E-05	3.9E-05
⁷ Ac-227	9.6E-07	3.8E-05	3.9E-05

¹ Assumed to be in secular equilibrium with parent Th-228.

² Assumed to be in secular equilibrium with parent U-238.

³ Assumed to be in secular equilibrium with parent Th-234.

⁴ Assumed to be in secular equilibrium with parent U-235.

⁵ Assumed to be in secular equilibrium with parent Ra-228.

⁶ Assumed to be in secular equilibrium with parent Th-231.

⁷ Assumed to be in secular equilibrium with parent Pa-231.

5.7 CAP88-PC RESULTS

The CAP88-PC report is contained in Appendix B. The area factor input was 106 m², 4027 m², and 3800 m² for Plants 1, Plant 6, and Midwest Waste, respectively. This evaluation demonstrates that all SLDS critical receptors receive less than 10 percent of the dose standard in 40 CFR 61.102 and therefore, SLDS is exempt from the reporting requirements of 40 CFR 61.104(a). Table 5-5 summarizes the results.

Table 5-5. SLDS CAP88-PC Results for Critical Receptors

Receptor	Direction from site	Distance (m)	(mrem/yr)
Nearest Resident	NE	970	0.4
School ¹	SW	4500	<0.1
Business ¹	SE	50 ²	0.7
Farm	NE	970	0.4

¹ Corrected for the 23 percent occupancy factor (50 weeks/yr 40 hours/wk).

² Distance from receptor to fenceline is 50 m. Distance from receptor to center of source is 267 m for emissions determination.

6.0 HAZELWOOD INTERIM STORAGE SITE AND ADJACENT VICINITY PROPERTIES UNDER ACTIVE REMEDIATION

6.1 SITE HISTORY

In 1966, Continental Mining and Milling Company of Chicago, Illinois, purchased the wastes stored at 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 and shipped much of the material to Canon City, Colorado, after drying. 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 property excavated approximately 13,000 cubic yards (yd³) 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 remedial action activities, including clearing, cleanup, and excavation of the property at 9200 Latty Avenue and surrounding VPs. This action created about 14,000 yd³ of additional contaminated soil, which was stockpiled on 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 HISS. This action resulted in an additional 4,600 yd³ of material being placed at 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 yd³ of soil and debris in two interim storage piles located in the southwestern portion of the Latty Avenue VP-2. These piles will be referred to as the Eastern Piles.

In 2000 and 2001, the U.S. Army Corps of Engineers (USACE) removed the main, supplemental, and Eastern piles and shipped them by rail to EnviroSAFE landfill in Utah.

6.2 MATERIAL HANDLING AND PROCESSING FOR CY01

Excavation activities were performed at the HISS Main Pile. The excavated soils were removed from the site by rail. Environmental air samples were collected around the perimeter of the site during CY01 from January to December with the results used to determine the excavation and windblown *in situ* emissions during that time.

6.3 SOURCE DESCRIPTION – RADIONUCLIDE SOIL CONCENTRATIONS

The radionuclide concentrations, as they exist in the soil piles at the HISS, were obtained from statistical summaries of the piles contained in the *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). Appendix A contains a summary table of the radionuclide concentrations for each pile used to calculate the emission rate from each pile, as applicable.

6.4 LIST OF ASSUMED AIR RELEASES FOR CY01

Wind erosion during periods of site inactivity and the remedial action excavations are assumed for the particulate radionuclide emission determinations from the HISS. VPs do not contribute to the emission determinations for periods of inactivity due to the low activity and vegetation cover.

6.5 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown in Figure 6-1 and Table 6-1. Distances and directions to critical receptors are based on measurements on the USGS 7.5-minute Florissant Quadrangle Map.

Table 6-1. HISS Critical Receptors

Receptor	Direction from site	Distance (miles)	Distance (m)
Nearest Resident	E	0.8	1300
School	SE	1.3	2100
Business	E	0.1	50 ¹
Farm	E	0.8	1300

¹ Distance from receptor to fenceline is 50 m. Distance from receptor to emissions sources from the HISS is 110 m.

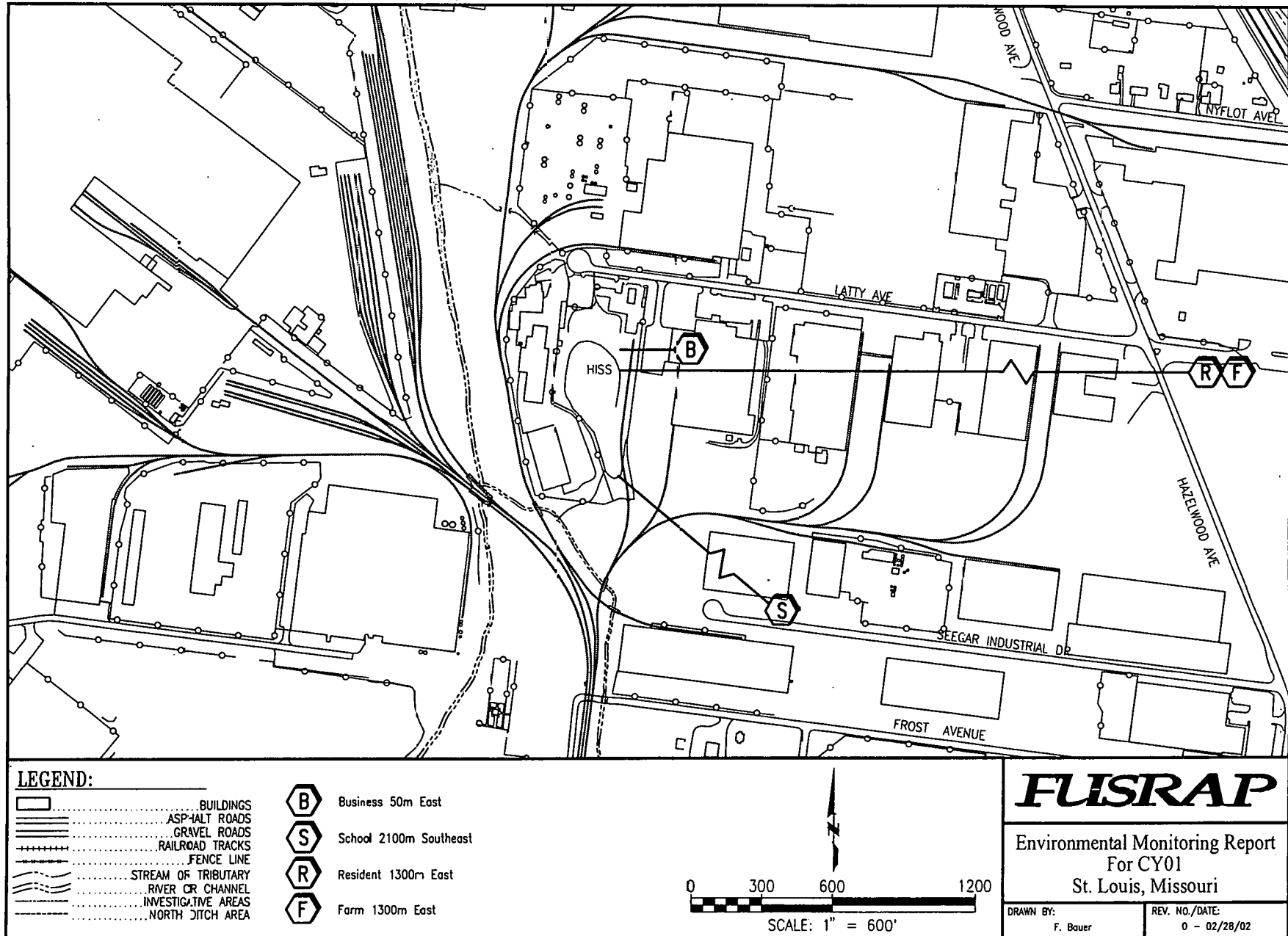


Figure 6-1. Hazelwood Interim Storage Site Critical Receptors

6.6 EMISSIONS DETERMINATIONS

6.6.1 Measured Particulate Emissions

Particulate air samples are collected from four locations around the perimeter of the HISS to measure the radionuclide emissions. The samplers were established in October of CY00 and provide the basis for determining the radionuclide emission rates during CY01. The average gross alpha and beta concentrations ($\mu\text{Ci/mL}$) are determined for each sample location for CY01. The site gross alpha and beta emission concentration is determined by averaging the four locations. The location and site average concentrations are presented in Table 6-2.

Table 6-2. HISS Average Gross Alpha and Beta Particulate Emissions

Sampler Location	Average Concentration ($\mu\text{Ci/mL}$)	
	Alpha	Beta
HAP1	1.91E-15	2.56E-14
HAP2	2.01E-15	3.06E-14
HAP3	1.91E-15	3.00E-14
HAP4	2.05E-15	2.96E-14
Average Concentration =	1.97E-15	2.90E-14

Radionuclide activity fractions are determined for alpha and beta from the average radionuclide concentration data contained in the *St. Louis FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). The product of each radionuclide activity fraction and the gross concentration provides the radionuclide emission concentration ($\mu\text{Ci/cm}^3$). The gross average concentration ($\mu\text{Ci/cm}^3$) is converted to a release rate (Ci/yr) using Equations (1) and (2) below and illustrated in Table 6-3.

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

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

where

D is the effective diameter of the release (m), and

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

For the HISS, the area within the perimeter of the air samples is $22,000 \text{ m}^2$ resulting in an effective diameter of 169 m.

The average annual wind speed for the St. Louis Lambert International Airport is provided in CAP88-PC as 4.446 meters/second. Conversion of this wind speed to a flow rate through a stack with an effective diameter of 169 m is completed using Equation (2).

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

Equation (2)

where

- V is the wind velocity (m/min) = 266.76 m/min,
 F is the flow rate (m³/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 site to an effective flow rate results in a site release flow rate of 6.0E6 m³/min. The product of the flow rate, the average radionuclide concentration for the HISS, and the appropriate conversion factors provide the site emission rate for each radionuclide as illustrated in Table 6-3.

Table 6-3. Particulate Radionuclide Emission Rates Based on Site Perimeter Air Samples

Radionuclide	⁸ Activity Fraction	⁹ Emission Conc. (μCi/cm ³)	¹⁰ Emission Rate (Ci/yr)
U-238	3.9E-01	7.8E-16	2.5E-03
U-235	1.8E-02	3.7E-17	1.2E-04
U-234	3.9E-01	7.8E-16	2.5E-03
Ra-226	4.2E-02	8.3E-17	2.6E-04
Th-232	6.0E-03	1.2E-17	3.8E-05
Th-230	1.1E-01	2.1E-16	6.7E-04
Th-228	6.0E-03	1.2E-17	3.8E-05
¹ Ra-224	6.0E-03	1.2E-17	3.8E-05
² Th-234	4.8E-01	1.4E-14	4.6E-02
³ Pa-234m	4.8E-01	1.4E-14	4.6E-02
⁴ Th-231	2.3E-02	6.8E-16	2.1E-03
Ra-228	7.4E-03	2.2E-16	7.0E-04
⁵ Ac-228	7.4E-03	2.2E-16	7.0E-04
⁶ Pa-231	1.8E-02	3.7E-17	1.2E-04
⁷ Ac-227	1.8E-02	3.7E-17	1.2E-04

¹ Assumed to be in secular equilibrium with parent Th-228.

² Assumed to be in secular equilibrium with parent U-238.

³ Assumed to be in secular equilibrium with parent Th-234.

⁴ Assumed to be in secular equilibrium with parent U-235.

⁵ Assumed to be in secular equilibrium with parent Ra-228.

⁶ Assumed to be in secular equilibrium with parent Th-231.

⁷ Assumed to be in secular equilibrium with parent Pa-231.

⁸ Derived from the average soil radionuclide concentrations for HISS Piles as presented in USACE 1999.

⁹ Product of gross alpha or beta emission concentration from Table 6-2 and the radionuclide activity fraction.

¹⁰ Emission rate based on 85 day sampling period at a flow rate of 6.0E+6 m³/min as determined from Equations (1) and (2).

6.6.2 HISS Total Emission Rates

The HISS total CY01 emission rates which were not input into the EPA codes. The total emission rates are shown in Table 6-4 as the sum of: (1) calculated emission rates from excavations, (2) measured emission rates from the air samples collected from the perimeter of the site, and (3) in-situ emission rates during periods of inactivity. The excavation emission rates, measured emission rates, and *in situ* emission rates were input into the EPA CAP-88PC code separately to accurately represent distance from the source to the receptor and the area of the individual sources contributing to emissions.

Table 6-4. CY01 HISS Total Emission Rates

Radionuclide	Emission (Ci/yr)
U-238	2.5E-03
U-235	1.2E-04
U-234	2.5E-03
Ra-226	2.6E-04
Th-232	3.8E-05
Th-230	6.7E-04
Th-228	3.8E-05
¹ Ra-224	3.8E-05
² Th-234	4.6E-02
³ Pa-234m	4.6E-02
⁴ Th-231	2.1E-03
Ra-228	7.0E-04
⁵ Ac-228	7.0E-04
⁶ Pa-231	1.2E-04
⁷ Ac-227	1.2E-04

- ¹ Assumed to be in secular equilibrium with parent Th-228.
² Assumed to be in secular equilibrium with parent U-238.
³ Assumed to be in secular equilibrium with parent Th-234.
⁴ Assumed to be in secular equilibrium with parent U-235.
⁵ Assumed to be in secular equilibrium with parent Ra-228.
⁶ Assumed to be in secular equilibrium with parent Th-231.
⁷ Assumed to be in secular equilibrium with parent Pa-231.

6.7 CAP88-PC RESULTS

The CAP88-PC reports for HISS are contained in Appendix B. The individual area factor input was 22,000 m² for the entire HISS. Results show compliance with the 10 mrem/yr criterion for all critical receptors. Table 6-5 summarizes the results.

Table 6-5. HISS CAP88-PC Results for Critical Receptors

Receptor	Direction from site	Distance (m)	(mrem/yr)
Nearest Resident	E	1,300	0.9
School ¹	SE	2,100	0.1
Business ¹	E	50 ²	7.8
Farm	E	1,300	0.9

¹ Corrected for the 23 percent occupancy factor (50 weeks/yr 40 hours/wk).

² Distance from receptor to fenceline is 50 m. Distance from receptor to emission source from the HISS is 110 m.

7.0 USACE RADIOANALYTICAL LABORATORY

7.1 SITE DESCRIPTION

The USACE radioanalytical laboratory is located on VP-38. VP-38 is a St. Louis FUSRAP VP, owned by SuperValue, Inc. The VP-38 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.

7.2 LIST OF ASSUMED AIR RELEASES FOR CY01

Emissions from USACE Radioanalytical Laboratory operations are assumed for the particulate radionuclide emission determinations from the Laboratory Site. The VP is assumed not to have contributed to the emission determinations during CY01 due to prior remediation, low activity, and vegetation cover.

7.3 EFFLUENT CONTROLS

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

7.4 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown on Figure 7-1 and in Table 7-1. Distances and directions to critical receptors are based on measurements on the USGS 7.5 minute Florissant Quadrangle Map.

Table 7-1. Laboratory Critical Receptors

Receptor	Direction from site	Distance (miles)	Distance (m)
Nearest Resident	E	0.5	830
School	SE	1.2	1950
Business	S	0.04	60
Farm	E	0.5	830

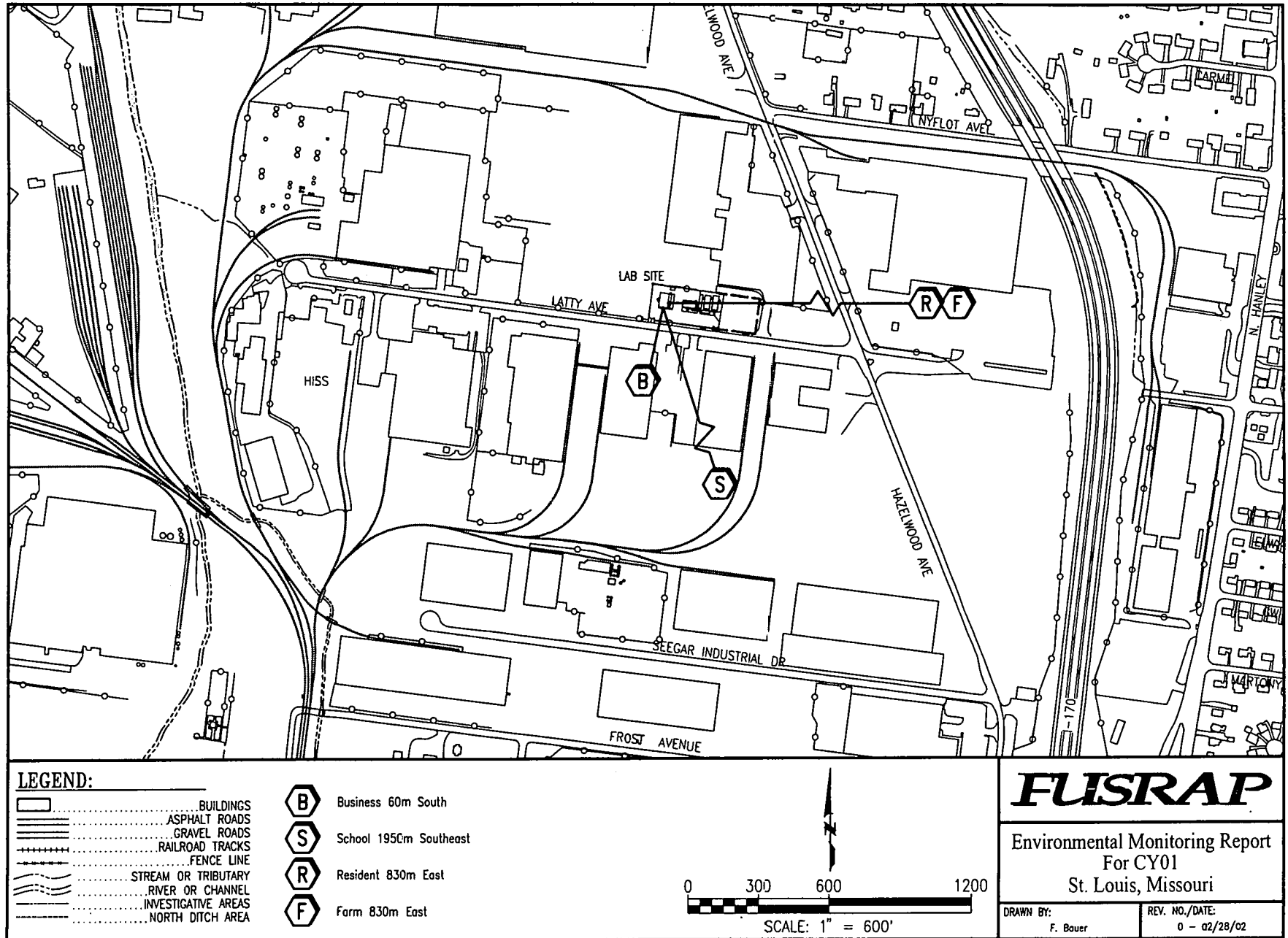


Figure 7-1. Laboratory Site Critical Receptors

7.5 EMISSIONS DETERMINATIONS

7.5.1 Stack Emissions from USACE 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 might 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. Since 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 5-gram aliquot to the 1-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 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 EPA guidance in 40 CFR 61.

To determine whether the laboratory complies with the 10 mrem/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 7-2. With this data, the following equation was used to calculate laboratory emissions from the operations conducted in CY01.

$$\text{Emission Rate (Ci/yr)} = C * N * 1000 \text{ g/sample} * 1 \text{E} - 12 (\text{Ci/pCi})$$

where:

C = the concentration of a radionuclide of concern in a sample type (pCi/g),
N = the number of samples of that type processed by the laboratory in CY01.

Table 7-2. Laboratory Samples Annual Inventory

Site	Type	Gamma Spectroscopy	Isotopic Radium	Isotopic Thorium	Isotopic Uranium	Total Drying and Grinding ^a	Total Separations ^{b,c}
CWC ^d	Soil	6		6		12	6
CWC ^d	Water		6	6	6		18
HISS	Soil	413		13		426	13
HISS	Water	4	51	51	51		153
SLAPS	Soil	968		435	23	1426	458
SLAPS	Water		237	237	140		614
SLDS	Soil	2366		1649		4015	1649
SLDS	Water	5	158	158	158		474
SVP	Soil	1706		1088		2794	1088
HISS and SVP Total						3220	1254
SLAPS and CWC Total						1438	1096
SLDS Total						4015	2123

^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

^d CWC – Coldwater Creek

7.5.2 Laboratory Total Emission Rates

The Laboratory total CY01 emission rate was input into the EPA CAP88-PC code. The total emission rates are shown in Table 7-3 as the calculated emissions from laboratory operations. The result was then used to calculate total dose to the hypothetical maximally exposed receptor.

Table 7-3. Laboratory CY01 Total Emission Rates

Radionuclide	Emission (Ci/yr)
U-238	3.3E-06
U-235	1.6E-07
U-234	3.3E-06
Ra-226	1.0E-06
Th-232	9.8E-08
Th-230	3.1E-06
Th-228	9.3E-08
¹ Ra-224	9.3E-08
² Th-234	3.3E-06
³ Pa-234m	3.3E-06
⁴ Th-231	1.6E-07
Ra-228	8.9E-08
⁵ Ac-228	8.9E-08
⁶ Pa-231	1.6E-07
⁷ Ac-227	1.6E-07

¹ Assumed to be in secular equilibrium with parent Th-228.

² Assumed to be in secular equilibrium with parent U-238.

³ Assumed to be in secular equilibrium with parent Th-234.

⁴ Assumed to be in secular equilibrium with parent U-235.

⁵ Assumed to be in secular equilibrium with parent Ra-228.

⁶ Assumed to be in secular equilibrium with parent Th-231.

⁷ Assumed to be in secular equilibrium with parent Pa-231.

7.6 CAP88-PC RESULTS

The CAP88-PC report is contained in Appendix B. The stack factor input was 3 m height and 0.3 m 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 7-4 summarizes the results.

Table 7-4. Laboratory CAP88-PC Results for Critical Receptors

Receptor	Direction from site	Distance (m)	(mrem/yr)
Nearest Resident	E	830	<0.1
School ¹	SE	1950	<0.1
Business ¹	S	60	<0.1
Farm	E	830	<0.1

¹ Corrected for the 23 percent occupancy factor (50 weeks/yr 40 hours/wk).

8.0 REFERENCES

EPA 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.

EPA 1997a. CAP88-PC Version 2.0 Computer Code, U.S. Environmental Protection Agency.

EPA 1997b. CAP88-PC Version 2.0 User's Guide, U.S. Environmental Protection Agency, June 1997.

EPA 1998. Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, September.

USACE 1999. *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual*. U.S. Army Corps of Engineers, St. Louis District Office, FUSRAP, November.

USACE 2001. *Federal Facilities Agreement Progress Report for USACE St. Louis FUSRAP Sites*. U.S. Army Corps of Engineers, St. Louis District Office, FUSRAP.

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

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

APPENDIX A

CALCULATED EMISSION RATES FROM SLS PROPERTIES

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
1	Table 2. St. Louis FUSRAP Area Radionuclide Release Rates.														
2															
3	SLAPS	Nuclide											Total Area Release Rate (Ci/y)	Total SLAPS Emissions (Ci/y)	
4	Env. Air Sampling												SLAPS Env. Air Sampling	Env. Air Sampling	
5	Exc and Insitu	U-238											5.7E-03	5.7E-03	
6	Exc and Insitu	U-235											2.6E-04	2.6E-04	
7	Exc and Insitu	U-234											5.8E-03	5.8E-03	
8	Exc and Insitu	Ra-226											5.3E-03	5.3E-03	
9	Exc and Insitu	Th-232											4.1E-04	4.1E-04	
10	Exc and Insitu	Th-230											5.7E-02	5.7E-02	
11	Exc and Insitu	Th-228											2.4E-04	2.4E-04	
12	Exc and Insitu	Ra-224											2.4E-04	2.4E-04	
13	Exc and Insitu	Th-234											3.8E-01	3.8E-01	
14	Exc and Insitu	Pa-234m											3.8E-01	3.8E-01	
15	Exc and Insitu	Th-231											1.7E-02	1.7E-02	
16	Exc and Insitu	Ra-228											1.2E-02	1.2E-02	
17	Exc and Insitu	Ac-228											1.2E-02	1.2E-02	
18	Exc and Insitu	Pa-231											2.6E-04	2.6E-04	
19	Exc and Insitu	Ac-227											2.6E-04	2.6E-04	
20															
21	SLDS	Nuclide											Total Area Release Rate (Ci/y)	Total SLDS Emissions (Ci/y)	
22	Plant 1 Air Sampling												Plant 1 Air Sampling	Midwest Waste Air Sampling	
23	Exc and Insitu	U-238											1.3E-05	1.4E-03	
24	Exc and Insitu	U-235											5.8E-07	7.8E-05	
25	Exc and Insitu	U-234											1.3E-05	1.4E-03	
26	Exc and Insitu	Ra-226											5.0E-05	4.8E-04	
27	Exc and Insitu	Th-232											1.3E-06	1.5E-04	
28	Exc and Insitu	Th-230											9.9E-06	9.6E-04	
29	Exc and Insitu	Th-228											1.3E-06	1.7E-04	
30	Exc and Insitu	Ra-224											1.3E-06	1.7E-04	
31	Exc and Insitu	Th-234											4.1E-04	2.5E-02	
32	Exc and Insitu	Pa-234m											4.1E-04	2.5E-02	
33	Exc and Insitu	Th-231											1.8E-05	1.3E-03	
34	Exc and Insitu	Ra-228											4.1E-05	2.0E-03	
35	Exc and Insitu	Ac-228											4.1E-05	2.0E-03	
36	Exc and Insitu	Pa-231											9.6E-07	7.9E-05	
37	Exc and Insitu	Ac-227											9.6E-07	7.9E-05	
38															
39	SLDS	Nuclide											Total Area Release Rate (Ci/y)		
40	Plant 6 Air Sampling												Plant 6 Air Sampling		
41	Exc and Insitu	U-238											8.1E-04		
42	Exc and Insitu	U-235											3.8E-05		
43	Exc and Insitu	U-234											8.1E-04		
44	Exc and Insitu	Ra-226											1.6E-04		
45	Exc and Insitu	Th-232											3.8E-05		
46	Exc and Insitu	Th-230											3.0E-04		
47	Exc and Insitu	Th-228											3.8E-05		
48	Exc and Insitu	Ra-224											3.8E-05		
49	Exc and Insitu	Th-234											1.5E-02		
50	Exc and Insitu	Pa-234m											1.6E-02		
51	Exc and Insitu	Th-231											7.6E-04		
52	Exc and Insitu	Ra-228											7.6E-04		
53	Exc and Insitu	Ac-228											7.6E-04		
54	Exc and Insitu	Pa-231											3.8E-05		
55	Exc and Insitu	Ac-227											3.8E-05		
56															

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Table 2. St. Louis FUSRAP Area Radionuclide Release Rates.													
57	SLDS	Nuclide											Total Area Release Rate (Ci/y)	
58	Midwest Waste Air Sampling												Midwest Waste Air Sampling	
59	Exc and Insitu	U-238											6.2E-04	
60	Exc and Insitu	U-235											3.9E-05	
61	Exc and Insitu	U-234											6.2E-04	
62	Exc and Insitu	Ra-226											2.7E-04	
63	Exc and Insitu	Th-232											1.1E-04	
64	Exc and Insitu	Th-230											6.4E-04	
65	Exc and Insitu	Th-228											1.3E-04	
66	Exc and Insitu	Ra-224											1.3E-04	
67	Exc and Insitu	Th-234											8.5E-03	
68	Exc and Insitu	Pa-234m											8.5E-03	
69	Exc and Insitu	Th-231											5.4E-04	
70	Exc and Insitu	Ra-228											1.2E-03	
71	Exc and Insitu	Ac-228											1.2E-03	
72	Exc and Insitu	Pa-231											3.9E-05	
73	Exc and Insitu	Ac-227											3.9E-05	
74														
75	HISS	Nuclide											Total Area Release Rate (Ci/y)	
76	Env. Air Sampling												HISS Env. Air Sampling	
77	Exc and Insitu	U-238											2.5E-03	
78	Exc and Insitu	U-235											1.2E-04	
79	Exc and Insitu	U-234											2.5E-03	
80	Exc and Insitu	Ra-226											2.6E-04	
81	Exc and Insitu	Th-232											3.8E-05	
82	Exc and Insitu	Th-230											6.7E-04	
83	Exc and Insitu	Th-228											3.8E-05	
84	Exc and Insitu	Ra-224											3.8E-05	
85	Exc and Insitu	Th-234											4.6E-02	
86	Exc and Insitu	Pa-234m											4.6E-02	
87	Exc and Insitu	Th-231											2.1E-03	
88	Exc and Insitu	Ra-228											7.0E-04	
89	Exc and Insitu	Ac-228											7.0E-04	
90	Exc and Insitu	Pa-231											1.2E-04	
91	Exc and Insitu	Ac-227											1.2E-04	
92														
93	Laboratory	Nuclide											Total Area Release Rate (Ci/y)	
94	Stack Emissions												Laboratory Stack Emissions	
95	Stack emissions	U-238											3.29E-06	
96	Stack emissions	U-235											1.55E-07	
97	Stack emissions	U-234											3.30E-06	
98	Stack emissions	Ra-226											1.00E-06	
99	Stack emissions	Th-232											9.81E-08	
100	Stack emissions	Th-230											3.08E-06	
101	Stack emissions	Th-228											9.29E-08	
102	Stack emissions	Ra-224											9.29E-08	
103	Stack emissions	Th-234											3.29E-06	
104	Stack emissions	Pa-234m											3.29E-06	
105	Stack emissions	Th-231											1.55E-07	
106	Stack emissions	Ra-228											8.88E-08	
107	Stack emissions	Ac-228											8.88E-08	
108	Stack emissions	Pa-231											1.55E-07	
109	Stack emissions	Ac-227											1.55E-07	

	O	P	Q	R	S	T
1		Table 3. St. Louis FUSRAP Sites Annual Radionuclide Emissions (Ci/y)				
2		Radionuclide	SLAPS	SLDS ¹	HISS	LAB
3		U-238	5.7E-03	1.4E-03	2.5E-03	3.3E-06
4		U-235	2.6E-04	7.8E-05	1.2E-04	1.6E-07
5		U-234	5.8E-03	1.4E-03	2.5E-03	3.3E-06
6		Ra-226	5.3E-03	4.8E-04	2.6E-04	1.0E-06
7		Th-232	4.1E-04	1.5E-04	3.8E-05	9.8E-08
8		Th-230	5.7E-02	9.6E-04	6.7E-04	3.1E-06
9		Th-228	2.4E-04	1.7E-04	3.8E-05	9.3E-08
10		Ra-224	2.4E-04	1.7E-04	3.8E-05	9.3E-08
11		Th-234	3.8E-01	2.5E-02	4.6E-02	3.3E-06
12		Pa-234m	3.8E-01	2.5E-02	4.6E-02	3.3E-06
13		Th-231	1.7E-02	1.3E-03	2.1E-03	1.6E-07
14		Ra-228	1.2E-02	2.0E-03	7.0E-04	8.9E-08
15		Ac-228	1.2E-02	2.0E-03	7.0E-04	8.9E-08
16		¹ Total emission rates from SLDS are not used to demonstrate compliance with NESHAPS.				
17		The total area release rates are used in individual CAP88-PC runs and results summed to demonstrate compliance.				
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APPENDIX B

CAP88-PC RUNS FOR SLS PROPERTIES

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 27, 2002 07:57 am

Facility: HISS
Address: Latty Avenue
City: Berkeley
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2001

Comments:

Dataset Name: HISS 2001
Dataset Date: Mar 27, 2002 07:57 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	3.13E-01
BREAST	1.17E-01
R MAR	1.02E+01
LUNGS	2.40E+02
THYROID	1.04E-01
ENDOST	1.28E+02
RMNDR	1.73E+00
EFFEC	3.44E+01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	6.86E-01
INHALATION	3.37E+01
AIR IMMERSION	3.01E-05
GROUND SURFACE	1.71E-02
INTERNAL	3.44E+01
EXTERNAL	1.71E-02
TOTAL	3.44E+01

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	1.04E+01
U-235	5.31E-01
U-234	1.17E+01
RA-226	1.11E-01
TH-232	4.80E-01
TH-230	5.88E+00
TH-228	3.37E-01
RA-224	4.69E-03
TH-234	8.23E-02
PA-234M	1.09E-05
TH-231	7.41E-05
RA-228	1.01E-01
AC-228	2.13E-03
PA-231	2.07E+00
AC-227	2.71E+00
TOTAL	3.44E+01

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	8.72E-06
BONE	5.67E-06
THYROID	2.23E-08
BREAST	2.39E-07
LUNG	3.79E-04
STOMACH	1.72E-07
BOWEL	4.95E-07
LIVER	3.25E-06
PANCREAS	9.93E-08
URINARY	1.53E-06
OTHER	1.21E-07
TOTAL	3.99E-04

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.66E-06
INHALATION	3.95E-04
AIR IMMERSION	7.08E-10
GROUND SURFACE	3.93E-07
INTERNAL	3.99E-04
EXTERNAL	3.94E-07
TOTAL	3.99E-04

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.38E-04
U-235	7.13E-06
U-234	1.54E-04
RA-226	1.97E-06
TH-232	2.71E-06
TH-230	4.85E-05
TH-228	6.76E-06
RA-224	1.06E-07
TH-234	3.61E-06
PA-234M	2.79E-10
TH-231	2.16E-09
RA-228	1.29E-06
AC-228	4.29E-08
PA-231	1.15E-05
AC-227	2.35E-05
TOTAL	3.99E-04

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

Direction	Distance (m)		
	110	1300	2100
N	2.8E+01	9.5E-01	7.1E-01
NNW	3.1E+01	7.5E-01	6.2E-01
NW	2.9E+01	7.8E-01	6.4E-01
WNW	2.7E+01	8.4E-01	6.6E-01
W	2.3E+01	7.6E-01	6.3E-01
WSW	1.9E+01	6.4E-01	5.7E-01
SW	1.8E+01	6.8E-01	5.9E-01
SSW	1.8E+01	7.2E-01	6.1E-01
S	1.8E+01	7.0E-01	6.0E-01
SSE	1.8E+01	6.5E-01	5.8E-01
SE	2.3E+01	7.0E-01	6.0E-01
ESE	3.0E+01	8.3E-01	6.6E-01
E	3.4E+01	9.2E-01	6.9E-01
ENE	3.2E+01	8.5E-01	6.7E-01
NE	2.7E+01	7.2E-01	6.1E-01
NNE	2.8E+01	6.9E-01	6.0E-01

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

Distance (m)

Direction	110	1300	2100
N	3.3E-04	7.0E-06	5.0E-06
NNW	3.6E-04	5.4E-06	3.9E-06
NW	3.3E-04	5.8E-06	4.1E-06
NNW	3.1E-04	6.4E-06	4.4E-06
W	2.7E-04	5.5E-06	4.0E-06
WSW	2.2E-04	4.1E-06	3.4E-06
SW	2.0E-04	4.6E-06	3.6E-06
SSW	2.1E-04	5.1E-06	3.8E-06
S	2.0E-04	4.8E-06	3.7E-06
SSE	2.1E-04	4.2E-06	3.4E-06
SE	2.6E-04	4.9E-06	3.7E-06
ESE	3.5E-04	6.4E-06	4.4E-06
E	4.0E-04	7.4E-06	4.8E-06
ENE	3.7E-04	6.6E-06	4.5E-06
NE	3.2E-04	5.1E-06	3.8E-06
NNE	3.3E-04	4.8E-06	3.7E-06

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
Feb 13, 2002 01:25 pm

Facility: SLDS
Address: Broadway Ave
City: St. Louis
State: MO Zip: 63120

Source Category: Area
Source Type: Area
Emission Year: 2001

Comments: Excavation Emissions Midwest Waste by Air Sampling

Dataset Name: Midwest Waste
Dataset Date: Feb 13, 2002 01:23 pm
Wind File: C:\CAP88PC2\WINDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	3.97E-02
BREAST	2.46E-02
R MAR	1.92E+00
LUNGS	2.29E+01
THYROID	2.35E-02
ENDOST	2.39E+01
RMNDR	1.39E-01
EFPEC	3.75E+00

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	6.20E-02
INHALATION	3.69E+00
AIR IMMERSION	6.56E-06
GROUND SURFACE	1.57E-03
INTERNAL	3.75E+00
EXTERNAL	1.58E-03
TOTAL	3.75E+00

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	6.17E-01
U-235	4.13E-02
U-234	6.94E-01
RA-226	2.70E-02
TH-232	3.32E-01
TH-230	1.34E+00
TH-228	2.76E-01
RA-224	3.84E-03
TH-234	3.54E-03
PA-234M	3.22E-07
TH-231	4.56E-06
RA-228	3.99E-02
AC-228	8.72E-04
PA-231	1.61E-01
AC-227	2.11E-01
TOTAL	3.75E+00

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	1.65E-06
BONE	1.07E-06
THYROID	4.43E-09
BREAST	4.13E-08
LUNG	3.71E-05
STOMACH	3.09E-08
BOWEL	3.81E-08
LIVER	3.05E-07
PANCREAS	2.15E-08
URINARY	9.19E-08
OTHER	2.63E-08
TOTAL	4.04E-05

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.37E-07
INHALATION	4.00E-05
AIR IMMERSION	1.57E-10
GROUND SURFACE	3.62E-08
INTERNAL	4.03E-05
EXTERNAL	3.64E-08
TOTAL	4.04E-05

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	8.19E-06
U-235	5.55E-07
U-234	9.14E-06
RA-226	4.85E-07
TH-232	1.88E-06
TH-230	1.11E-05
TH-228	5.54E-06
RA-224	8.70E-08
TH-234	1.59E-07
PA-234M	8.22E-12
TH-231	1.33E-10
RA-228	5.19E-07
AC-228	1.76E-08
PA-231	8.96E-07
AC-227	1.82E-06
TOTAL	4.04E-05

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

Distance (m)			
Direction	267	970	4500
N	3.8E+00	3.7E-01	7.0E-02
NNW	1.9E+00	2.1E-01	5.8E-02
NW	2.3E+00	2.4E-01	6.0E-02
WNW	2.8E+00	2.8E-01	6.3E-02
W	2.1E+00	2.2E-01	5.9E-02
WSW	1.0E+00	1.3E-01	5.2E-02
SW	1.5E+00	1.6E-01	5.4E-02
SSW	1.8E+00	1.9E-01	5.6E-02
S	1.6E+00	1.8E-01	5.5E-02
SSE	1.1E+00	1.4E-01	5.2E-02
SE	1.6E+00	1.8E-01	5.6E-02
ESE	2.7E+00	2.8E-01	6.3E-02
E	3.5E+00	3.4E-01	6.8E-02
ENE	2.9E+00	2.9E-01	6.4E-02
NE	1.8E+00	2.0E-01	5.7E-02
NNE	1.5E+00	1.7E-01	5.5E-02

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

	Distance (m)		
Direction	267	970	4500
N	4.0E-05	3.8E-06	5.2E-07
NNW	2.1E-05	2.1E-06	3.9E-07
NW	2.5E-05	2.4E-06	4.1E-07
NNW	3.0E-05	2.8E-06	4.4E-07
W	2.3E-05	2.2E-06	3.9E-07
WSW	1.1E-05	1.2E-06	3.2E-07
SW	1.5E-05	1.5E-06	3.4E-07
SSW	1.9E-05	1.9E-06	3.7E-07
S	1.7E-05	1.7E-06	3.6E-07
SSE	1.2E-05	1.3E-06	3.2E-07
SE	1.7E-05	1.7E-06	3.6E-07
ESE	2.9E-05	2.7E-06	4.4E-07
E	3.8E-05	3.5E-06	4.9E-07
ENE	3.2E-05	2.9E-06	4.5E-07
NE	1.9E-05	1.9E-06	3.7E-07
NNE	1.6E-05	1.6E-06	3.5E-07

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
Feb 13, 2002 01:25 pm

Facility: SLDS
Address: Broadway Ave
City: St. Louis
State: MO Zip: 63120

Source Category: Area
Source Type: Area
Emission Year: 2001

Comments: Excavation Emissions from Plant 1 by Air Sampling

Dataset Name: Plant 1 2001
Dataset Date: Feb 13, 2002 01:00 pm
Wind File: C:\CAP88PC2\WINDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	1.56E-03
BREAST	1.19E-03
R MAR	3.48E-02
LUNGS	4.37E-01
THYROID	1.16E-03
ENDOST	4.28E-01
RMNDR	3.97E-03
EFPEC	7.13E-02

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	2.60E-03
INHALATION	6.86E-02
AIR IMMERSION	2.32E-07
GROUND SURFACE	7.22E-05
INTERNAL	7.12E-02
EXTERNAL	7.24E-05
TOTAL	7.13E-02

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	1.29E-02
U-235	6.14E-04
U-234	1.45E-02
RA-226	4.99E-03
TH-232	3.93E-03
TH-230	2.08E-02
TH-228	2.76E-03
RA-224	3.84E-05
TH-234	1.71E-04
PA-234M	1.56E-08
TH-231	1.52E-07
RA-228	1.36E-03
AC-228	2.98E-05
PA-231	3.95E-03
AC-227	5.18E-03
TOTAL	7.13E-02

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	3.05E-08
BONE	1.94E-08
THYROID	2.22E-10
BREAST	1.98E-09
LUNG	7.37E-07
STOMACH	1.54E-09
BOWEL	1.76E-09
LIVER	7.89E-09
PANCREAS	1.09E-09
URINARY	2.28E-09
OTHER	1.33E-09
TOTAL	8.05E-07

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	1.43E-08
INHALATION	7.89E-07
AIR IMMERSION	5.55E-12
GROUND SURFACE	1.67E-09
INTERNAL	8.03E-07
EXTERNAL	1.68E-09
TOTAL	8.05E-07

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.72E-07
U-235	8.25E-09
U-234	1.92E-07
RA-226	8.99E-08
TH-232	2.22E-08
TH-230	1.71E-07
TH-228	5.54E-08
RA-224	8.70E-10
TH-234	7.66E-09
PA-234M	3.96E-13
TH-231	4.44E-12
RA-228	1.77E-08
AC-228	6.01E-10
PA-231	2.20E-08
AC-227	4.49E-08
TOTAL	8.05E-07

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

Distance (m)			
Direction	267	970	4500
N	7.1E-02	8.0E-03	2.4E-03
NNW	3.7E-02	5.0E-03	2.1E-03
NW	4.4E-02	5.5E-03	2.2E-03
WNW	5.3E-02	6.3E-03	2.2E-03
W	4.1E-02	5.2E-03	2.2E-03
WSW	2.0E-02	3.5E-03	2.0E-03
SW	2.8E-02	4.1E-03	2.1E-03
SSW	3.5E-02	4.7E-03	2.1E-03
S	3.0E-02	4.4E-03	2.1E-03
SSE	2.2E-02	3.6E-03	2.0E-03
SE	3.1E-02	4.4E-03	2.1E-03
ESE	5.2E-02	6.2E-03	2.2E-03
E	6.8E-02	7.5E-03	2.3E-03
ENE	5.6E-02	6.5E-03	2.2E-03
NE	3.5E-02	4.7E-03	2.1E-03
NNE	2.9E-02	4.3E-03	2.1E-03

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

Distance (m)

Direction	267	970	4500
N	8.0E-07	8.0E-08	1.6E-08
NNW	4.2E-07	4.6E-08	1.3E-08
NW	4.9E-07	5.2E-08	1.4E-08
INW	6.0E-07	6.1E-08	1.4E-08
W	4.5E-07	4.9E-08	1.3E-08
WSW	2.2E-07	2.9E-08	1.2E-08
SW	3.1E-07	3.6E-08	1.2E-08
ISW	3.8E-07	4.2E-08	1.3E-08
S	3.3E-07	3.9E-08	1.3E-08
SSE	2.4E-07	3.0E-08	1.2E-08
SE	3.4E-07	4.0E-08	1.3E-08
ISE	5.8E-07	6.0E-08	1.4E-08
E	7.6E-07	7.4E-08	1.5E-08
ENE	6.3E-07	6.3E-08	1.4E-08
NE	3.9E-07	4.3E-08	1.3E-08
NE	3.3E 07	3.0E-08	1.3E-08

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
Feb 27, 2002 09:19 am

Facility: SLDS
Address: Broadway Ave
City: St. Louis
State: MO Zip: 63120

Source Category: Area
Source Type: Area
Emission Year: 2001

Comments: Excavation Emissions from Plant 6 by Air Sampling

Dataset Name: Plant 6 2001
Dataset Date: Feb 27, 2002 09:19 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	3.07E-02
BREAST	1.59E-02
R MAR	1.03E+00
LUNGS	2.02E+01
THYROID	1.48E-02
ENDOST	1.28E+01
RMNDR	1.37E-01
EFFEC	2.99E+00

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	5.77E-02
INHALATION	2.93E+00
AIR IMMERSION	4.86E-06
GROUND SURFACE	1.44E-03
INTERNAL	2.99E+00
EXTERNAL	1.45E-03
TOTAL	2.99E+00

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	8.06E-01
U-235	4.02E-02
U-234	9.06E-01
RA-226	1.60E-02
TH-232	1.15E-01
TH-230	6.30E-01
TH-228	8.05E-02
RA-224	1.12E-03
TH-234	6.66E-03
PA-234M	6.07E-07
TH-231	6.42E-06
RA-228	2.53E-02
AC-228	5.52E-04
PA-231	1.56E-01
AC-227	2.05E-01
TOTAL	2.99E+00

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	8.86E-07
BONE	5.74E-07
THYROID	2.93E-09
BREAST	2.89E-08
LUNG	3.23E-05
STOMACH	2.16E-08
BOWEL	4.38E-08
LIVER	2.64E-07
PANCREAS	1.39E-08
URINARY	1.11E-07
OTHER	1.70E-08
TOTAL	3.43E-05

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.18E-07
INHALATION	3.39E-05
AIR IMMERSION	1.16E-10
GROUND SURFACE	3.32E-08
INTERNAL	3.42E-05
EXTERNAL	3.33E-08
TOTAL	3.43E-05

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.07E-05
U-235	5.40E-07
U-234	1.19E-05
RA-226	2.88E-07
TH-232	6.49E-07
TH-230	5.20E-06
TH-228	1.62E-06
RA-224	2.54E-08
TH-234	2.99E-07
PA-234M	1.55E-11
TH-231	1.88E-10
RA-228	3.28E-07
AC-228	1.11E-08
PA-231	8.73E-07
AC-227	1.78E-06
TOTAL	3.43E-05

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

	Distance (m)		
Direction	267	970	4500
<hr/>			
N	3.0E+00	3.0E-01	6.2E-02
NNW	1.5E+00	1.8E-01	5.2E-02
NW	1.8E+00	2.0E-01	5.4E-02
WNW	2.2E+00	2.3E-01	5.7E-02
W	1.7E+00	1.8E-01	5.3E-02
WSW	8.3E-01	1.1E-01	4.7E-02
SW	1.2E+00	1.4E-01	4.9E-02
SSW	1.4E+00	1.6E-01	5.1E-02
S	1.2E+00	1.5E-01	5.0E-02
SSE	8.8E-01	1.2E-01	4.8E-02
SE	1.3E+00	1.5E-01	5.0E-02
ESE	2.2E+00	2.3E-01	5.6E-02
E	2.8E+00	2.8E-01	6.0E-02
ENE	2.3E+00	2.4E-01	5.7E-02
NE	1.4E+00	1.6E-01	5.1E-02
NNE	1.2E+00	1.4E-01	5.0E-02

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

	Distance (m)		
Direction	267	970	4500
<hr/>			
N	3.4E-05	3.2E-06	4.7E-07
NNW	1.8E-05	1.8E-06	3.5E-07
NW	2.1E-05	2.0E-06	3.7E-07
NNW	2.5E-05	2.4E-06	4.0E-07
W	1.9E-05	1.9E-06	3.6E-07
WSW	9.3E-06	1.0E-06	2.9E-07
SW	1.3E-05	1.3E-06	3.1E-07
SSW	1.6E-05	1.6E-06	3.4E-07
S	1.4E-05	1.5E-06	3.3E-07
SSE	9.9E-06	1.1E-06	3.0E-07
SE	1.4E-05	1.5E-06	3.3E-07
ESE	2.5E-05	2.4E-06	4.0E-07
E	3.2E-05	3.0E-06	4.4E-07
ENE	2.7E-05	2.5E-06	4.1E-07
NE	1.6E-05	1.6E-06	3.4E-07
NNE	1.4E-05	1.4E-06	3.2E-07

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
Feb 13, 2002 01:26 pm

Facility: SLAPS
Address: McDonnell BLVD
City: Hazelwood
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2001

Comments: Evaluation Radionuclide Emissions SLAPS Transient

Dataset Name: SLAPS Transient
Dataset Date: Feb 11, 2002 09:54 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	1.73E+00
BREAST	1.54E+00
R MAR	2.42E+02
LUNGS	1.24E+03
THYROID	1.49E+00
ENDOST	3.01E+03
RMNDR	6.55E+00
EFFEC	2.71E+02

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	6.67E+00
INHALATION	2.65E+02
AIR IMMERSION	1.70E-04
GROUND SURFACE	4.06E-02
INTERNAL	2.71E+02
EXTERNAL	4.08E-02
TOTAL	2.71E+02

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	1.14E+01
U-235	5.55E-01
U-234	1.31E+01
RA-226	1.55E+00
TH-232	2.42E+00
TH-230	2.34E+02
TH-228	9.91E-01
RA-224	1.39E-02
TH-234	4.77E-01
PA-234M	3.52E-05
TH-231	2.79E-04
RA-228	1.39E+00
AC-228	1.70E-02
PA-231	2.17E+00
AC-227	2.80E+00
TOTAL	2.71E+03

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	2.05E-04
BONE	1.35E-04
THYROID	2.59E-07
BREAST	2.34E-06
LUNG	2.00E-03
STOMACH	2.02E-06
BOWEL	4.61E-06
LIVER	1.04E-05
PANCREAS	1.29E-06
URINARY	4.80E-06
OTHER	1.58E-06
TOTAL	2.37E-03

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.14E-05
INHALATION	2.34E-03
AIR IMMERSION	4.03E-09
GROUND SURFACE	9.20E-07
INTERNAL	2.37E-03
EXTERNAL	9.24E-07
TOTAL	2.37E-03

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.49E-04
U-235	7.28E-06
U-234	1.68E-04
RA-226	2.11E-05
TH-232	1.36E-05
TH-230	1.92E-03
TH-228	1.99E-05
RA-224	3.13E-07
TH-234	1.57E-05
PA-234M	8.96E-10
TH-231	8.15E-09
RA-228	1.44E-05
AC-228	3.43E-07
PA-231	1.18E-05
AC-227	2.41E-05
TOTAL	2.37E 03

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

Distance (m)

Direction 169

N	2.4E+02
NNW	2.6E+02
NW	2.6E+02
WNW	2.2E+02
W	2.0E+02
WSW	1.9E+02
SW	1.6E+02
SSW	1.5E+02
S	1.6E+02
SSE	1.8E+02
SE	2.1E+02
ESE	2.5E+02
E	2.7E+02
ENE	2.6E+02
NE	2.7E+02
NNE	2.5E+02

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

Distance (m)

Direction 169

N	2.1E-03
NNW	2.3E-03
NW	2.3E-03
WNW	1.9E-03
W	1.8E-03
WSW	1.6E-03
SW	1.4E-03
SSW	1.3E-03
S	1.3E-03
SSE	1.5E-03
SE	1.8E-03
ESE	2.2E-03
E	2.4E-03
ENE	2.3E-03
NE	2.4E-03
NNE	2.2E-03

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
Feb 13, 2002 01:26 pm

Facility: SLAPS
Address: McDonnell BLVD
City: Hazelwood
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2001

Comments: Evaluation of Radionuclide Emissions from SLAPS

Dataset Name: SLAPS2001
Dataset Date: Feb 11, 2002 09:22 am
Wind File: C:\CAP88PC2\WINDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	4.02E-01
BREAST	3.49E-01
R MAR	7.70E+01
LUNGS	4.07E+02
THYROID	3.31E-01
ENDOST	9.58E+02
RMNDR	1.29E+00
EFFEC	8.74E+01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	6.95E-01
INHALATION	8.67E+01
AIR IMMERSION	5.24E-05
GROUND SURFACE	1.36E-02
INTERNAL	8.74E+01
EXTERNAL	1.37E-02
TOTAL	8.74E+01

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	3.60E+00
U-235	1.75E-01
U-234	4.12E+00
RA-226	3.33E-01
TH-232	7.88E-01
TH-230	7.61E+01
TH-228	3.23E-01
RA-224	4.51E-03
TH-234	9.96E-02
PA-234M	6.75E-06
TH-231	9.13E-05
RA-228	2.50E-01
AC-228	5.54E-03
PA-231	6.80E-01
AC-227	8.92E-01
TOTAL	8.74E+01

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	6.49E-05
BONE	4.26E-05
THYROID	5.76E-08
BREAST	5.40E-07
LUNG	6.55E-04
STOMACH	4.17E-07
BOWEL	6.92E-07
LIVER	3.06E-06
PANCREAS	2.81E-07
URINARY	6.02E-07
OTHER	3.43E-07
TOTAL	7.69E-04

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.26E-06
INHALATION	7.65E-04
AIR IMMERSION	1.24E-09
GROUND SURFACE	3.09E-07
INTERNAL	7.68E-04
EXTERNAL	3.10E-07
TOTAL	7.69E-04

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	4.79E-05
U-235	2.35E-06
U-234	5.44E-05
RA-226	6.04E-06
TH-232	4.45E-06
TH-230	6.28E-04
TH-228	6.50E-06
RA-224	1.02E-07
TH-234	4.50E-06
PA-234M	1.72E-10
TH-231	2.67E-09
RA-228	3.27E-06
AC-228	1.12E-07
PA-231	3.80E-06
AC-227	7.73E-06
TOTAL	7.69E-04

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

Direction	Distance (m)			
	314	1400	1600	2300
N	7.2E+01	6.9E+00	5.6E+00	3.2E+00
NNW	7.2E+01	3.8E+00	3.1E+00	1.9E+00
NW	6.5E+01	4.3E+00	3.5E+00	2.1E+00
WNW	6.8E+01	5.1E+00	4.2E+00	2.5E+00
W	5.6E+01	4.0E+00	3.3E+00	2.0E+00
WSW	4.1E+01	2.2E+00	1.8E+00	1.2E+00
SW	4.0E+01	2.8E+00	2.3E+00	1.5E+00
SSW	4.5E+01	3.4E+00	2.8E+00	1.7E+00
S	4.1E+01	3.1E+00	2.6E+00	1.6E+00
SSE	3.8E+01	2.3E+00	1.9E+00	1.3E+00
SE	4.9E+01	3.2E+00	2.6E+00	1.6E+00
ESE	7.3E+01	5.0E+00	4.1E+00	2.4E+00
E	8.7E+01	6.3E+00	5.1E+00	3.0E+00
ENE	7.8E+01	5.3E+00	4.3E+00	2.5E+00
NE	5.7E+01	3.5E+00	2.9E+00	1.8E+00
NNE	6.3E+01	3.0E+00	2.5E+00	1.6E+00

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

Distance (m)

Direction	314	1400	1600	2300
<hr/>				
N	6.3E-04	5.9E-05	4.7E-05	2.6E-05
NNW	6.3E-04	3.1E-05	2.5E-05	1.5E-05
NW	5.7E-04	3.6E-05	2.9E-05	1.7E-05
NNW	6.0E-04	4.3E-05	3.5E-05	2.0E-05
W	4.9E-04	3.3E-05	2.7E-05	1.5E-05
WSW	3.6E-04	1.7E-05	1.4E-05	8.6E-06
SW	3.5E-04	2.3E-05	1.9E-05	1.1E-05
WSW	4.0E-04	2.8E-05	2.3E-05	1.3E-05
S	3.6E-04	2.5E-05	2.1E-05	1.2E-05
SSE	3.3E-04	1.8E-05	1.5E-05	9.2E-06
SE	4.3E-04	2.6E-05	2.1E-05	1.2E-05
SSE	6.4E-04	4.2E-05	3.4E-05	1.9E-05
E	7.7E-04	5.3E-05	4.3E-05	2.4E-05
ESE	6.8E-04	4.5E-05	3.6E-05	2.0E-05
NE	5.0E-04	2.8E-05	2.3E-05	1.3E-05
ENE	5.5E-04	2.4E-05	2.0E-05	1.2E-05

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, 2002 10:54 am

Facility: USACE FUSRAP Radioanalytical Laboratory
Address: Latty Ave
City: Berkeley
State: MO Zip: 63134

Source Category: Stack
Source Type: Stack
Emission Year: 2001

Comments: Evaluation of Radionuclide Emissions from Lab

Dataset Name: LAB 2001
Dataset Date: Mar 28, 2002 10:54 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	5.85E-04
BREAST	2.57E-04
R MAR	4.22E-02
LUNGS	5.22E-01
THYROID	2.29E-04
ENDOST	5.27E-01
RMNDR	2.69E-03
EFFEC	8.45E-02

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	1.01E-03
INHALATION	8.34E-02
AIR IMMERSION	5.11E-09
GROUND SURFACE	3.40E-05
INTERNAL	8.45E-02
EXTERNAL	3.40E-05
TOTAL	8.45E-02

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	1.76E-02
U-235	9.06E-04
U-234	1.98E-02
RA-226	5.18E-04
TH-232	1.59E-03
TH-230	3.49E-02
TH-228	1.06E-03
RA-224	1.47E-05
TH-234	7.10E-06
PA-234M	1.42E-09
TH-231	7.26E-09
RA-228	1.51E-05
AC-228	3.48E-07
PA-231	3.52E-03
AC-227	4.62E-03
TOTAL	8.45E-02

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	3.57E-08
BONE	2.34E-08
THYROID	4.72E-11
BREAST	4.98E-10
LUNG	8.26E-07
STOMACH	3.00E-10
BOWEL	2.91E-10
LIVER	6.08E-09
PANCREAS	2.10E-10
URINARY	2.11E-09
OTHER	2.56E-10
TOTAL	8.95E-07

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	4.86E-09
INHALATION	8.89E-07
AIR IMMERSION	1.20E-13
GROUND SURFACE	7.83E-10
INTERNAL	8.94E-07
EXTERNAL	7.83E-10
TOTAL	8.95E-07

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual
	Total Lifetime Fatal Cancer Risk
U-238	2.34E-07
U-235	1.22E-08
U-234	2.61E-07
RA-226	9.56E-09
TH-232	8.97E-09
TH-230	2.88E-07
TH-228	2.13E-08
RA-224	3.34E-10
TH-234	3.28E-10
PA-234M	3.62E-14
TH-231	2.12E-13
RA-228	2.01E-10
AC-228	7.02E-12
PA-231	1.97E-08
AC-227	4.01E-08
TOTAL	8.95E-07

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

Direction	Distance (m)		
	60	830	1950
N	8.4E-02	2.6E-03	1.1E-03
NNW	4.8E-02	1.7E-03	9.1E-04
NW	4.4E-02	1.8E-03	9.5E-04
WNW	4.8E-02	2.1E-03	1.0E-03
W	4.3E-02	1.7E-03	9.3E-04
WSW	2.2E-02	1.2E-03	8.0E-04
SW	2.5E-02	1.4E-03	8.5E-04
SSW	2.9E-02	1.6E-03	8.9E-04
S	4.0E-02	1.5E-03	8.7E-04
SSE	3.0E-02	1.2E-03	8.1E-04
SE	4.0E-02	1.5E-03	8.7E-04
ESE	5.3E-02	2.0E-03	1.0E-03
E	5.5E-02	2.4E-03	1.1E-03
ENE	4.2E-02	2.1E-03	1.0E-03
NE	3.6E-02	1.6E-03	8.9E-04
NNE	3.3E-02	1.4E-03	8.6E-04

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

Distance (m)			
Direction	60	830	1950
N	9.0E-07	2.3E-08	7.9E-09
NNW	5.1E-07	1.4E-08	5.7E-09
NW	4.6E-07	1.5E-08	6.1E-09
NNW	5.1E-07	1.8E-08	6.7E-09
W	4.5E-07	1.4E-08	5.8E-09
WSW	2.3E-07	8.6E-09	4.5E-09
SW	2.6E-07	1.1E-08	5.0E-09
SSW	3.0E-07	1.3E-08	5.4E-09
S	4.2E-07	1.1E-08	5.2E-09
SSE	3.1E-07	9.1E-09	4.6E-09
SE	4.2E-07	1.2E-08	5.2E-09
ESE	5.6E-07	1.8E-08	6.6E-09
E	5.8E-07	2.2E-08	7.5E-09
ENE	4.4E-07	1.9E-08	6.8E-09
NE	3.8E-07	1.3E-08	5.5E-09
NNE	3.5E-07	1.1E-08	5.1E-09

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Further Info?
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St. Louis Sites

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Area

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