FINAL

ANNUAL ENVIRONMENTAL MONITORING DATA AND ANALYSIS REPORT FOR CY98

ST. LOUIS, MISSOURI

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Prepared by

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ACRONYMS AND ABBREVIATIONS

ACM	asbestos containing materials
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
amsl	above mean sea level
AOC	Area of Contamination
ARARs	applicable or relevant and appropriate requirements
AWQC	Ambient Water Quality Criteria
AWQS	Ambient Water Quality Standards
bgs	below ground surface
BMPs	Best Management Practices
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COD	Chemical Oxygen Demand
CSR	Code of State Regulations
CY	calendar year
DMR	Discharge Monitoring Reports
DOE	U.S. Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
EM	Environmental Monitoring
EMIFY	Environmental Monitoring Implementation Fiscal Year
EMG	Environmental Monitoring Guide
EMP	Environmental Monitoring Program
EPA	U.S. Environmental Protection Agency
FDEP	Florida Department of Environment Protection
FFA	Federal Facilities Agreement
FS	feasibility study
FUSRAP	Formerly Utilized Sites Remedial Action Program
FY	Fiscal Year
HISS	Hazelwood Interim Storage Site
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCLGs	maximum contaminant level goals
MCLs	maximum contaminant levels
MCW	Mallinckrodt Chemical Works
MDAs	minimum detectable activities
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineering District
MOE	Ministry of Environment
NCP	National Contingency Plan
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List

ACRONYMS AND ABBREVIATIONS (cont'd)

NRC	Nuclear Regulatory Commission
O/G	oil/grease
PAH	polynuclear aromatic hydrocarbons
PAM	Potential Contaminant of Concern Assessment Memorandum
PCBs	polychlorinated biphenyls
PEL	Probable Effects Level
POTW	publicly owned treatment works
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	Record of Decision
SDWA	Safe Drinking Water Act
SIU	significant industrial user
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site.
SLS	St. Louis Site
SQB	Sediment Quality Benchmarks
SQRT	Sediment Quick Reference Tables
SVOCs	semi volatile organic compound
TCE	trichloroethene
TCLP	Toxicity Characteristic Leeching Procedure
TEDE	total effective dose equivalent
TEL	Thresholds Effects Level
TLDs	tissue equivalent thermoluminescent dosimeters
TOC	total organic carbon
TOX	total organic halides
TPH	Total Petroleum Hydrocarbons
TSS	total suspended solids
UCL	Upper Confidence Limit
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UTL	Upper Tolerance Limit
VOCs	volatile organic compounds
VPs	vicinity properties
WD	work description
WL	working levels

1.0 INTRODUCTION

This Annual Environmental Monitoring Data and Analysis Report (Annual EMDAR) for calendar year (CY) 1998 provides an evaluation of the data collected as part of the implementation of the environmental monitoring program for the St. Louis Sites (SLS) within the Formerly Utilized Sites Remedial Action Program (FUSRAP). Environmental monitoring of various media at each of the SLS is a requirement under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and a commitment outlined in the Federal Facilities Agreement (FFA).

The SLS with active data collection are the St. Louis Downtown Site (SLDS), St. Louis Airport Site (SLAPS), the Hazelwood Interim Storage Site (HISS). On October 4, 1989, SLAPS, HISS and certain vicinity properties (VPs) were listed on the National Priority List (NPL) (USEPA, 1989a). The FUSRAP program was initiated in 1974 by the Atomic Energy Commission (AEC), the predecessor to the U.S. Department of Energy (DOE). The FUSRAP, transferred to the U.S. Army Corps of Engineers (USACE) on October 13, 1997, 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.

The purposes of this report include:

- Providing information on the SLS of FUSRAP and current status of remedial activities;
- Presenting summary data and interpretations for CY98 environmental monitoring program;
- Reporting compliance status with federal and state applicable or relevant and appropriate requirements (ARARs);
- Providing dose assessments for radiological compounds as appropriate;
- Summarizing trends and/or changes in contaminant concentrations to support remedial actions, public safety, and maintain surveillance monitoring requirements; and,
- Evaluating the adequacy of the monitoring network, and reporting and evaluation of data from inter-related media, identifying data gaps and optimizing future environmental monitoring needs.

2.0 SITE BACKGROUND AND STATUS

The SLS (Figure 2-1) collectively represents the SLDS, SLAPS, and HISS locations and their respective VPs that 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 at SLDS under contract to the Manhattan Engineering District (MED) and AEC between the early 1940s, and the mid1950's.

The SLDS and VPs comprise 45-acres of industrial property within the easternmost portion of St. Louis (Figure 2-2). These sites are located approximately 300 feet west of the Mississippi River. The land is owned by Mallinckrodt, Inc., which produces various chemical products. The industrial facility consists of a number of separate production complexes (plants) and auxiliary support buildings and offices. The VPs impacted by SLDS operations include McKinley Iron Company to the north; PVO Foods (defunct) and City of St. Louis properties to the east; Thomas and Proetz Lumber Company to the south; and North Broadway Avenue and small businesses to the west. The St. Louis Terminal Railroad Association; Norfolk and Western Railroad; and the Chicago, Burlington, and Quincy Railroad all have active rail lines passing through the Mallinckrodt facility.

By-products from the production activities at SLDS included spent pitchblende ore, process chemicals, and uranium, radium, and thorium-bearing residues. The by-products of the production activities of SLDS were staged or stored at various locations within the site for subsequent transport to the SLAPS.

The SLAPS is a 21.7 acre site located in St. Louis County approximately 11 miles northwest of the SLDS. The site is immediately north of the Lambert St. Louis International Airport and is bordered by McDonnell Boulevard and inactive recreational areas (ballfields) to the north and east, and Coldwater Creek to the west of McDonnell Boulevard (Figure 2-3). The property was acquired by the MED, which used the site for storing raffinate, radium bearing residues, uranium contaminated dolomite and magnesium fluoride slag, uranium bearing sand, and other process wastes from SLDS. The AEC inventoried the property and found 121,000 tons of uranium refinery residues and contaminated materials on the open ground at the site.

Most of the stored residues were sold to Continental Mining and Milling Company, removed from the site, and transported to HISS. 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 (USEPA, 1989a). One to three feet of fill was spread over the disposal area to achieve surface radioactivity levels acceptable at that time.

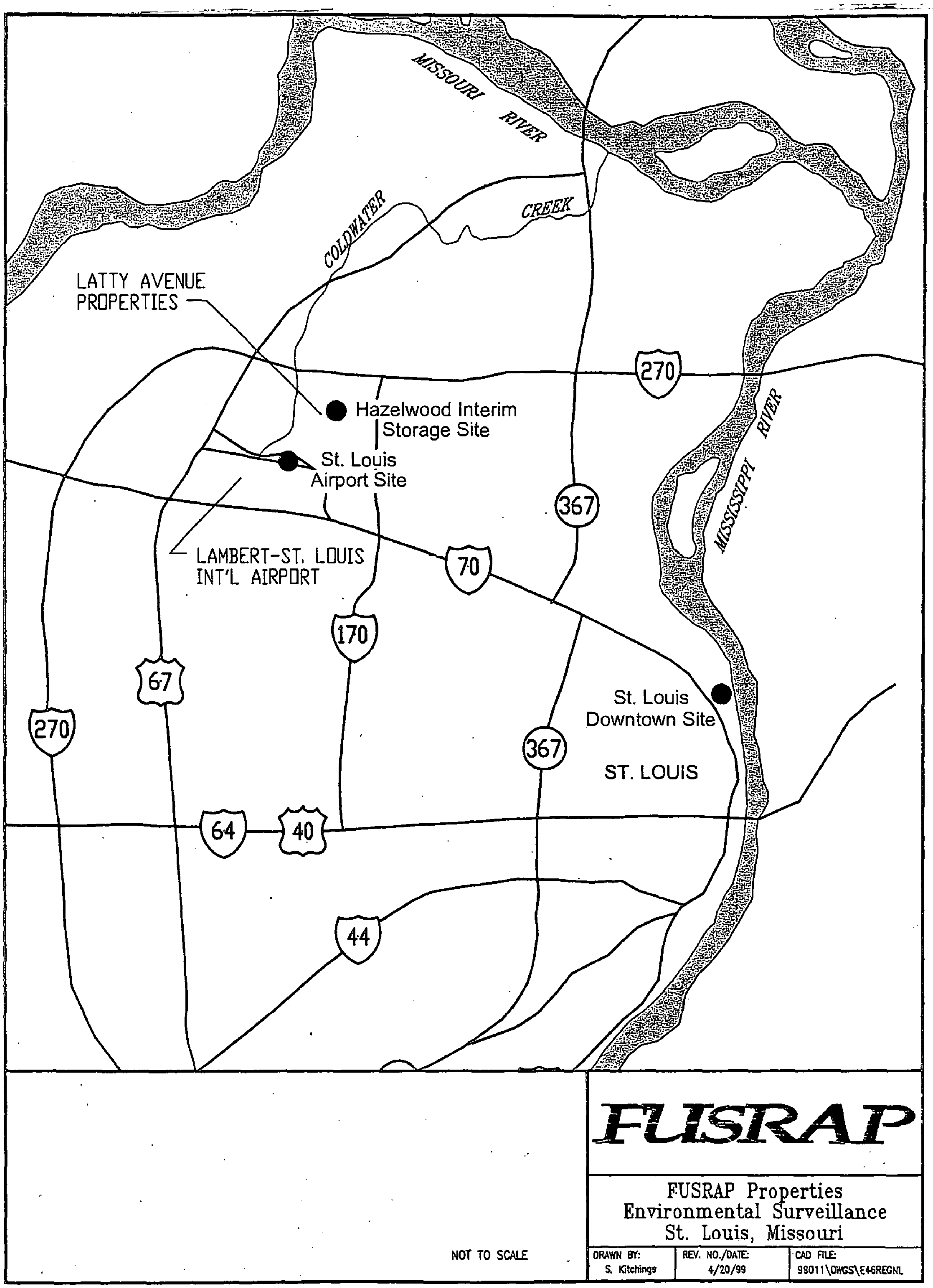

Figure 2-1. Location Map of the St. Louis Sites

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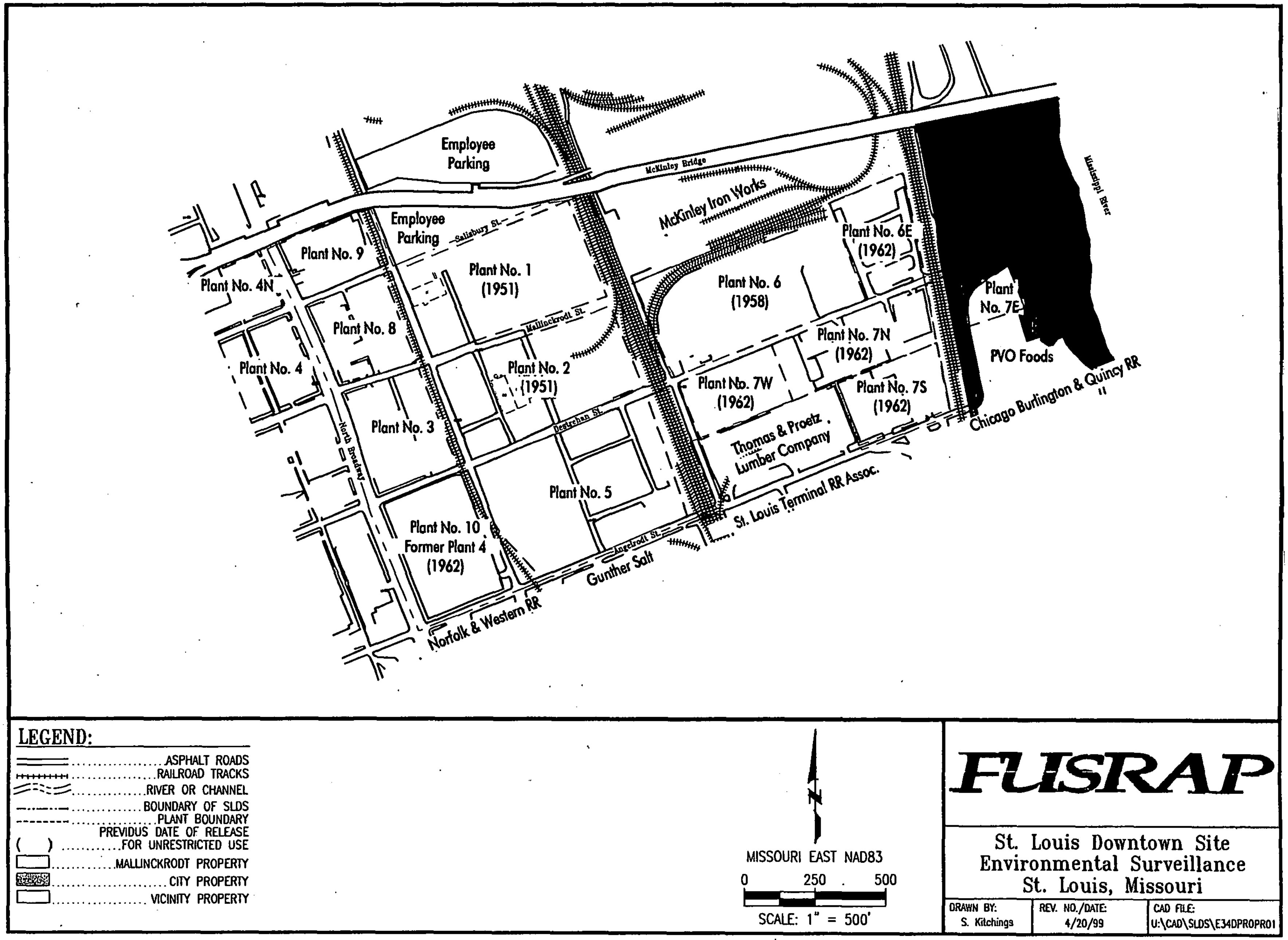

Figure 2-2. Plan view of SLDS

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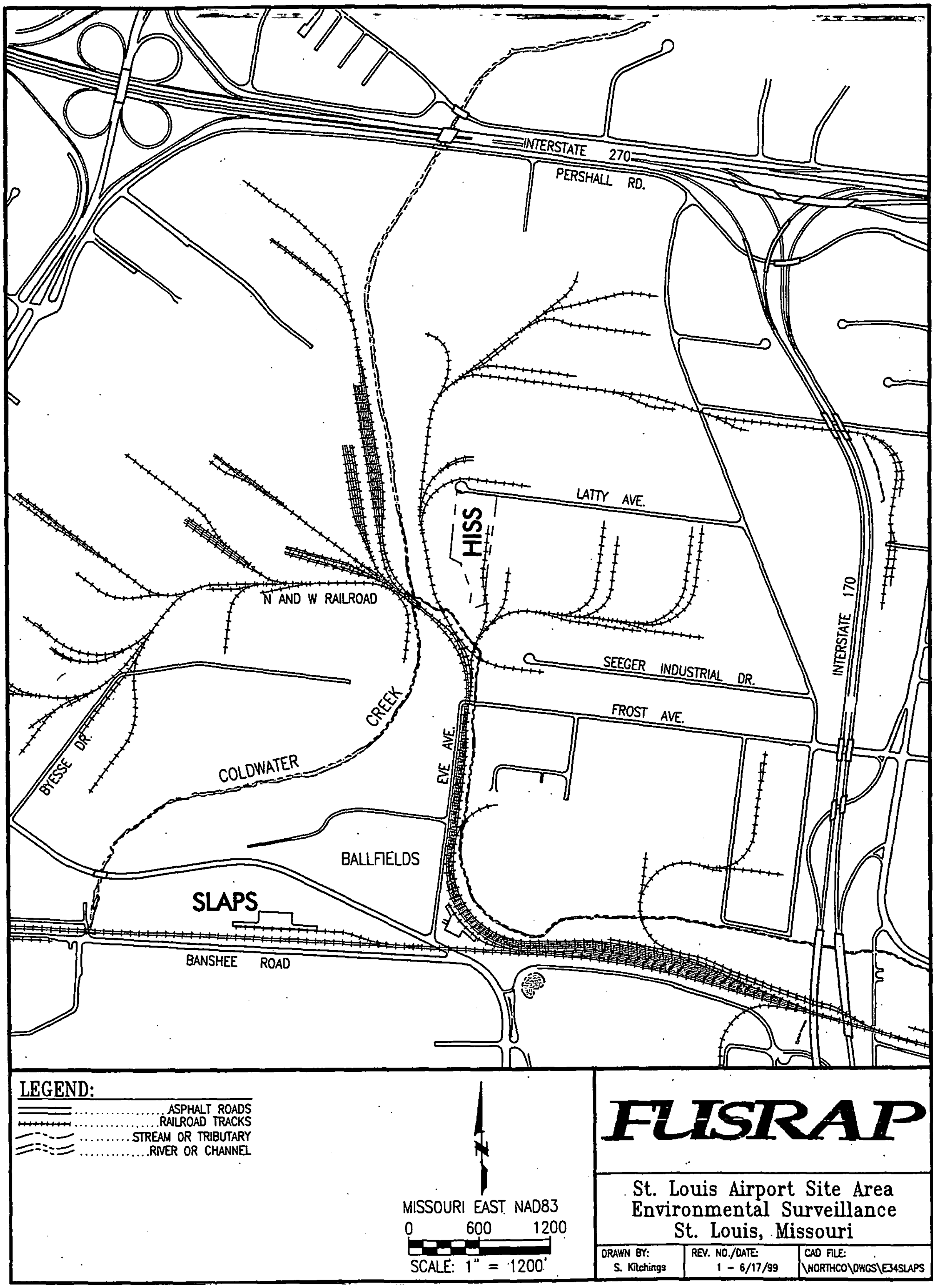

Figure 2-3. Plan View of SLAPS

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Characterization activities to date have also addressed Coldwater Creek and a number of VPs including the ballfields, Norfolk and Western Railroad, and Banshee Road to the south, and the former transportation routes between HISS and SLAPS (Latty Avenue, McDonnell Road, Pershall Road, Hazelwood Avenue, Eva Avenue, and Frost Avenue). The property surrounding SLAPS and vicinity is currently zoned light industrial. The nearest residential areas are located about 0.5 miles to the west in an industrial zoned area of Hazelwood. Residential areas are also located approximately 0.7 miles northeast of SLAPS.

HISS is an 11-acre industrial site located in northern St. Louis County approximately 1 mile northeast of the SLAPS. The site is located on Latty Avenue and is bordered to the east by The Stone Container Property (known as Latty Ave VP 2). HISS is bordered to its north by Latty Avenue and other VPs, to the south by undeveloped lots, and to the west by FUTURA Industries (Figure 2-4). Multiple rail lines owned by the Norfolk and Western Railroad also lie to the west and south of the site. The primary waste materials that were historically stored at HISS were uranium extraction and refining residues. These materials included an estimated 106,000 tons of barium sulfate cake and 350 tons of miscellaneous waste.

On October 4, 1989, SLAPS, HISS, and certain VPs were listed on the NPL (USEPA, 1989a). The initial Remedial Investigation (RI), completed by DOE in 1994, addressed SLAPS and provided limited characterization of radioisotopic contamination in the ballfields (DOE, 1994). Two Engineering Evaluation/Cost Analysis Reports (EE/CAs) were performed (DOE, 1997 and USACE, 1998 a and b).

In October 1998, the United States Environmental Protection Agency (USEPA) Region VII and the USACE signed the *Record of Decision for the St. Louis Downtown Site* (SLDS ROD)(USACE, 1998c). The ROD addresses contamination related to the historical activities in the accessible soils and ground water. The selected treatment involves excavation of approximately 100,000 yd^3 of accessible soils on the basis that the contamination varies with depth and location and long-term monitoring of the lower aquifer, B unit. If long term monitoring of the this unit shows significant exceedances of the thresholds by the contaminants of concern (COCs) specified in the ROD, a ground-water remedial action alternative will be evaluated. Inaccessible soils at SLDS were not addressed in the ROD.

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 St. Louis Airport Site (SLAPS)* (EE/CA) (DOE, 1997 and USACE, 1998a), *Engineering Evaluation/Cost Analysis for Hazelwood Interim Storage Site (HISS)* (EE/CA) (USACE, 1998b) *Record of Decision for the St. Louis Downtown Site* (ROD) (USACE, 1998c) and the *Environmental Monitoring Guide fot the St. Louis Sites (EMG)* (USACE, 1999a).

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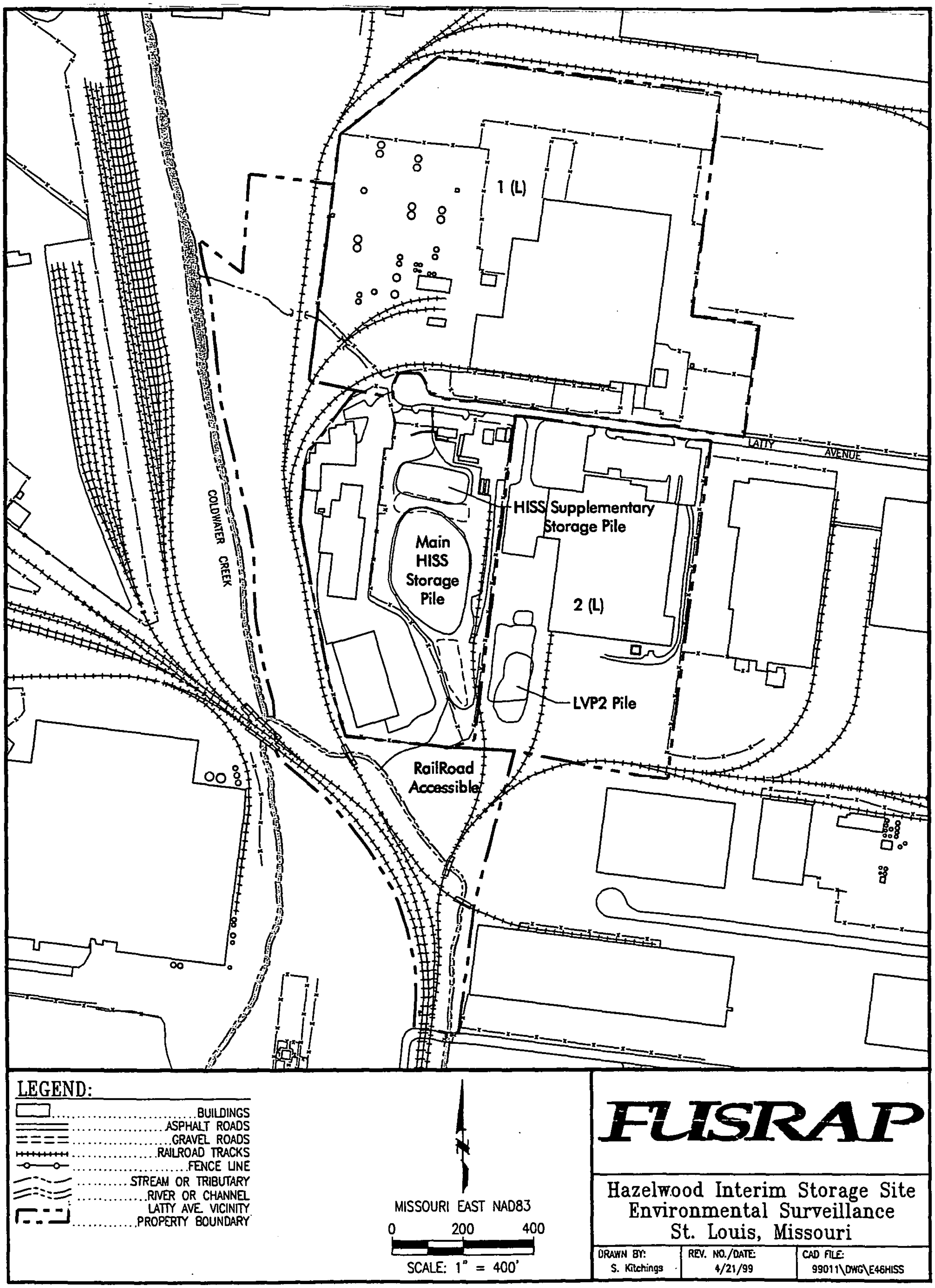

Figure 2-4. Plan view of HISS and Latty Avenue Vicinity Properties

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3.0 EVALUATION OF CY98 ENVIRONMENTAL MONITORING RESULTS

Environmental monitoring is conducted to measure and monitor effluents and to provide surveillance of effects on the environment and public health. In addition to these objectives, environmental monitoring activities support remedial activities under CERCLA. This requires a careful integration of FUSRAP activities to implement all the environmental and public health requirements of the CERCLA, relevant Federal and State regulations, and other commitments.

The FUSRAP environmental protection program involves radiological and chemical environmental monitoring and is separated into two distinct functions: effluent monitoring and environmental surveillance. Effluent monitoring assesses the quantities of substances in environmental media at the facility boundary, in contaminant migration pathways, and in pathways subject to compliance with applicable regulations (e.g., National Emission Standards for Hazardous Air Pollutants [NESHAPs]). Environmental surveillance consists of analyzing environmental conditions within or outside the facility boundary for the presence and concentrations of contaminants. Surveillance data are used to assess the presence and magnitude of radiological and chemical exposures and to assess the potential effects to the general public and the environment. The following sections discuss the results of the data collected during the CY98 for various environmental media.

3.1 EVALUATION OF ENVIRONMENTAL MONITORING DATA FOR 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 (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 estimates the typical gamma radiation dose is 35 mrem/year from the earth and 30 mrem/year from cosmic sources (UNSCEAR, 1982). The total estimated naturally occurring background radiation dose equivalent due to gamma exposure is thus 65 mrem/year.

Gamma radiation is monitored at the SLS of FUSRAP sites using tissue equivalent thermoluminescent dosimeters (TLDs) at 13 monitoring stations: four at the SLAPS site perimeter, eight at the HISS site perimeter, and one offsite background station located in Florissant, Missouri. Two sets (two dosimeters in each set) of TLDs were placed at each monitoring location to provide data at midyear and end of year 1998.

3.1.1 SLAPS

Gamma radiation monitoring was performed at SLAPS during CY98 at four locations around the perimeter of the site (Figure 3-1). In addition to these locations, one background monitoring station located in Florissant, Missouri was utilized to compare on and offsite background exposure.

In January 1998, four TLDs were placed at each monitoring location in order to obtain two midyear and two end of year readings. The two midyear TLDs were collected from each location in July 1998 and analyzed. The remaining two TLDs were collected in January 1999, one year after placement and analyzed. The program utilizes two TLDs at each monitoring station (for each monitoring period) to provide additional quality control of monitoring data.

TLD monitoring results for CY98 are found in Table 3-1. The end of year reading was not obtained at stations 5 and 9 because the TLDs were missing from the monitoring location at the time of collection. Thus, the results for stations 5 and 9 are based on midyear data. Station 1 and 2 results are based on the year end data. All monitoring data was corrected for background by subtracting the average uncorrected background for that monitoring period from the reported data for that monitoring station. The monitoring data was then corrected for shelter adsorption and normalized to project gamma radiation exposure for one year. Monitoring station 2 had the highest dose measurement (2451.2 mrem/yr) due to its proximity to an area of known contamination along the north fence. This station has historically had elevated radiation levels. Monitoring station 1 (46.9 mrem/yr), station 5 (31.6 mrem/yr), and station 9 (74.1 mrem/yr) also exceeded background levels.

Table 3-1. External Gamma Radiation St. Louis Airport Site (SLAPS)

Monitoring Location	**Monitoring Station ID#**	Midyear **TLD Data[a] (mrem/yr)** Recorded/Corrected	End of Year **TLD Data[a]** (mrem/yr) Recorded/Corrected	**TLD corrected average [b] (mrem/yr)**
SLAPS Perimeter	1	63.0 / 57.3	116.6 / 46.3	46.9
		62.4 / 56.1	118.0 / 47.5	
	2	1304.0 / 2534.9	2816.8 / 2480.8	2451.2
		1290.2 / 2507.3	2751.0 / 2421.5	
	5	52.8 / 36.9	c	31.6
		47.4 / 26.2	c	
	9	73.0 / 77.3	c	74.1
		69.8 / 70.9	c	
Background	16	35.2 / ---	68.0 / ---	34.3 / 65.3 [b]
		33.4 / ---	62.6 / ---	

[a] TLD readings have been normalized to exactly one year's exposure. Midyear exposure time was 28 weeks and end of year exposure time was 55 weeks. All TLD readings have been corrected for shelter/adsorption factor (s/a = 1.075).

[b] Uncorrected background average of 34.3 mrem/yr has been subtracted from station 5 and 9 reported data and 65.3 mrem/yr has been subtracted from station 1 and 2 reported data prior to correcting the data for shelter adsorption and exposure time.

[c] TLDs were missing at time of collection for year end results.

Hypothetical member of the public individual would be at these locations 24 hours/day, 365 days a year. Offsite 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 offsite worker-based receptors. However, gamma radiation exposure measured at the perimeter fenceline assumes that a residence-based offsite exposure assumes a 100% occupancy rate at a given location, however; exposure is greatly reduced due to the proximity of public areas and residences relative to SLAPS site. There are no public areas or residences near the SLAPS site. An offsite worker exposure assumes that a worker's occupancy rate is 23%, based on an 8 hour/day, 5 day/week, 50 week/year schedule. The offsite worker-based receptor is a

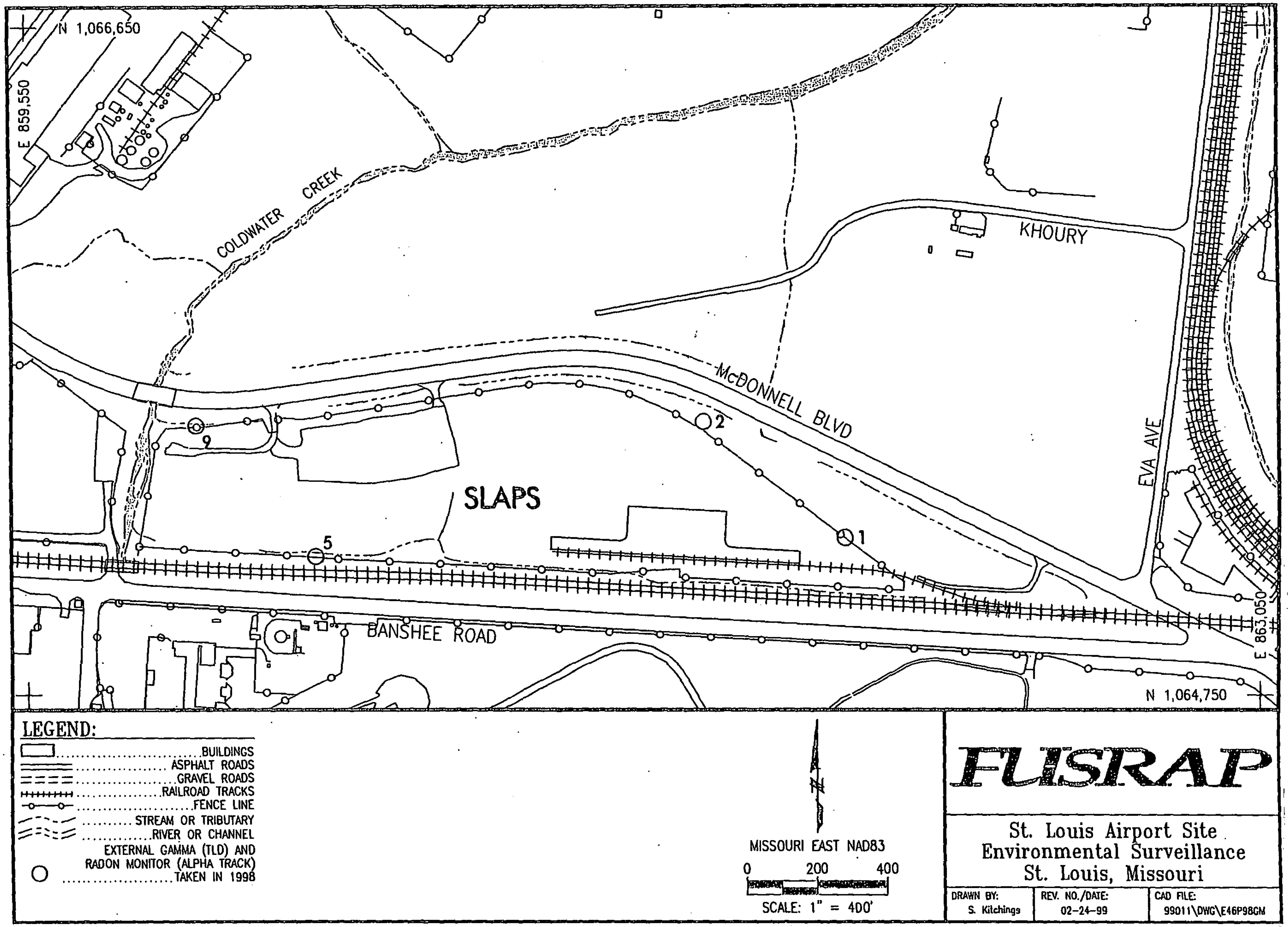

Figure 3-1. Environmental Monitoring Program External Gamma and Ra-222 Monitoring Stations at SLAPS

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more realistic choice to represent the hypothetically maximally exposed individual because of the proximity of the receptor, approximately 160 meters south of the SLAPS site, 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 offsite worker, 160 meters south of the site) has been calculated at approximately 0.1 mrem/year (SAIC, 1999a).

Historically, gamma radiation levels have been relatively high at monitoring station 2. TLD data taken at this location in CY98 and previous years has shown that this station has consistently exceeded 2,000 mrem/year due to its proximity to radiological contamination. However, previous gamma radiation data taken at the site indicates that the remainders of the monitoring stations (stations 1, 5, and 9) have generally been at or near background levels of gamma radiation. Current gamma radiation data indicates elevated levels at these stations on the site. The elevated levels are most likely attributable to onsite remedial activities, which occurred at SLAPS during 3rd and 4th quarters in CY98. Evaluating the year end results and comparing them to the projected midyear data shows a slight increase in dose rate during the 3rd and 4th quarters, as should be expected. Contaminated soil was excavated and either moved or temporarily stored onsite during these remedial efforts. Disturbance (i.e. excavation, storage piles, offsite transport, construction) of contaminated soil can increase dose due to decreased shielding (reduced vegetation coverage) and an increase of exposed surface area of contaminated soil (storage piles, excavation).

3.1.2 HISS

Gamma radiation monitoring was performed at HISS during CY98 at eight locations around the perimeter of the site (Figure 3-2). In addition to these locations, one background location located in Florissant, Missouri was utilized to compare on and offsite background exposure. In January 1998, four TLDs were placed at each monitoring location in order to obtain two midyear and two end of year readings. The two midyear TLDs were collected from each location in July 1998 and analyzed. The remaining two TLDs were collected in January 1999, one year after placement and analyzed. The program utilizes two TLDs at each monitoring station (for each monitoring period) to provide additional quality control of monitoring data.

TLD monitoring data for CY98 is found in Table 3-2. All monitoring data was corrected for background by subtracting the average uncorrected background for that monitoring period from the reported data for that monitoring station. The monitoring data was then corrected for shelter adsorption and normalized to project gamma radiation exposure for one year. Final results are based on year end data. The midyear data is used for comparison purposes only. Monitoring data at stations 3, 6, and 8 were below background levels. Monitoring station 2 had the highest dose measurement (100.5 mrem/yr) due to its proximity to an area of known contamination. This station has historically had elevated radiation levels. Monitoring station 1 (27.0 mrem/yr), station 4 (43.2 mrem/yr), station 5 (24.1 mrem/yr), and station 7 (59.3 mrem/yr) exceeded background levels.

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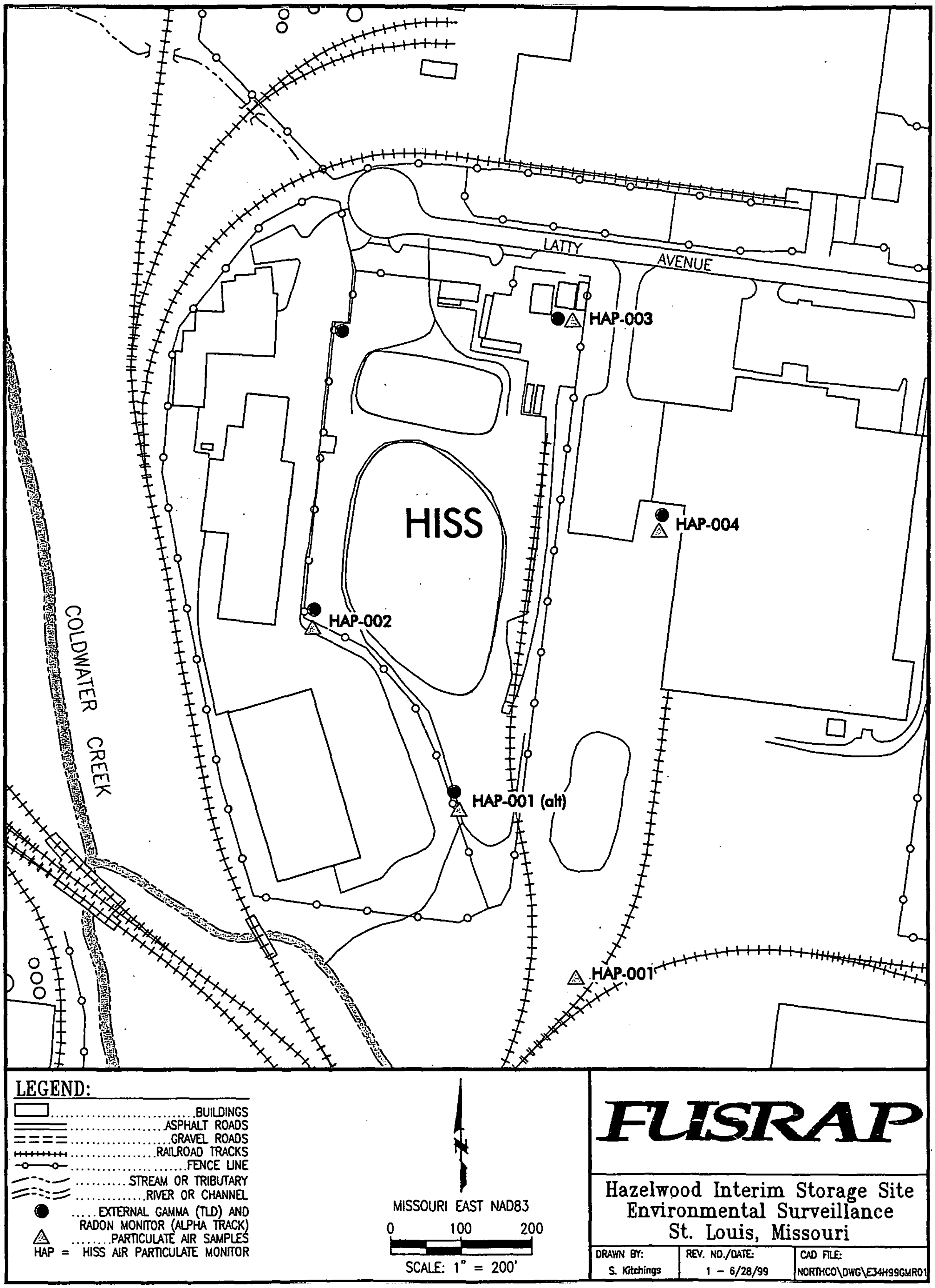

Figure 3-2. Enviromental Monitoring Program External Gamma and Ra-222 Monitoring Stations at HISS

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However, gamma radiation exposure measured at the perimeter fenceline assumes that a hypothetical public individual would be at these locations 24 hours/day, 365 days a year. Offsite 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 offsite worker-based receptors. A residence-based offsite exposure assumes a 100% occupancy rate at a given location. Exposure is greatly reduced due to the distance of public areas and residences relative to HISS site. There are no public areas or residences near the HISS site. An offsite worker exposure assumes that a worker's occupancy rate is 23%, based on an 8 hour/day, 5 day/week, 50 week/year schedule. The offsite worker-based receptor is a more realistic choice to represent the hypothetically maximally exposed individual because of the proximity of the receptor, approximately 164 feet west of the HISS site, 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 offsite worker, 164 feet west of the site) has been calculated at approximately 0.3 mrem/year (SAIC, 1999b).

Table 3-2. External Gamma Radiation Hazelwood Interim Storage Site (HISS)

Monitoring Location	**Monitoring Station ID#**	Midyear **TLD Data[a] (mrem/yr) Recorded/Corrected**	End of Year **TLD Data[a]** (mrem/yr) **Recorded/Corrected**	**TLD Corrected Average [b] (mrem/yr)**
HISS Perimeter	1	45.4 / 22.2	97.2 / 28.8	27.0
		45.8 / 23.0	93.2 / 25.2	
	2	100.8 / 132.8	176.4 / 100.2	100.5
		109.0 / 149.1	177.0 / 100.7	
	3	27.4 / -13.8	53.2 / -10.9	-8.7
		31.0 / -6.6	58.2 / -6.4	
	4	61.6 / 54.5	119.6 / 49.0	43.2
		57.8 / 46.9	106.8 / 37.4	
	5	43.8 / 19.0	91.8 / 23.9	24.1
		42.2 / 15.8	92.3 / 24.3	
	6	31.2 / -6.2	64.4 / -0.8	-1.6
		31.6 / -5.4	62.6 / -2.4	
	7	66.2 / 63.7	134.4 / 62.3	59.3
		66.6 / 64.5	127.6 / 56.2	
	8	29.0 / -10.6	56.2 / -8.2	-8.9
		27.6 / -13.4	54.6 / -9.6	
Background	16	35.2 / ---	68.0 / ---	34.3 / 65.3[b]
		33.4 / ---	62.6 / ---	

[a] TLD readings have been normalized to exactly one year's exposure. Midyear exposure time was 28 weeks and end of year exposure time was 55 weeks. . All TLD readings have been corrected for shelter/adsorption factor (s/a = 1.075).

[b] Uncorrected background average of 65.3 mrem/yr has been subtracted from stations 1 – 8 reported data

3.2 EVALUATION OF AIRBORNE RADIONUCLIDES

The St. Louis FUSRAP sites 1998 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 three SLS (SLDS, SLAPS, and HISS) and their adjacent VPs under active remediation were evaluated. For each site, emissions from remedial actions were evaluated and added to the emissions from the site during no activity. The only site with results above 10 percent of the standard is the SLAPS. An effective dose equivalent of 7.6 mrem/yr to a critical receptor located 525 feet south of the SLAPS was calculated using EPA CAP-88 PC code. Results to the same receptor using the COMPLY code were 5.1 mrem/yr.

The effective dose equivalent was also calculated for the HISS and SLDS using the EPA CAP-88 PC code. The evaluations of effective dose equivalent to critical receptors at HISS and SLDS resulted in less than 10 percent of the dose standard in 40 CFR 61.102. These sites are therefore exempt from the reporting requirements of 40 CFR 61.104(a).

The results from the EPA CAP-88 PC dose assessment are included in the 1998 SLS NESHAPs Report located in Appendix A.

3.3 EVALUATION OF AIRBORNE RADON DATA

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 St. Louis FUSRAP sites 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 constitutes the largest source of radon, although secondary contributors include oceans, natural gas, geothermal fluids, volcanic gases, ventilation from caves and mines, and coal combustion. Radon levels in the atmosphere have been observed to vary with height above the ground, season, time of day, and location. The chief meteorological parameter governing airborne radon concentration is atmospheric stability; however, the largest variations in atmospheric radon occur spatially (USEPA, 1987).

3.3.1 SLAPS

Airborne radon monitoring was performed at SLAPS using alpha track etch detectors placed around the site perimeter to measure Rn-222 emissions from site. Four detectors were co-located with TLD locations as identified in Figure 3-1. One additional detector was located at monitoring station 2 as a quality control duplicate and one background detector was located in Florissant, Missouri. The track etch detectors were placed at each monitoring location in January 1998, 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 Rn-222 concentrations are listed in pCi/l, and are evaluated based on 40 CFR 192.02 regulatory criteria of ≤ 0.5 pCi/l.

Although significant remediation activities occurred at SLAPS during CY98, Rn-222 monitoring results at SLAPS show (Table 3-3) minimal impact from these activities and are consistent with measured concentrations found in previous environmental surveillance monitoring data taken at the site. Three monitoring locations (stations 1, 5, and 9) have concentrations <0.2 pCi/l, the detection limit of the track etch detectors. The station 2 detector and duplicate detector recorded concentrations of 0.4 and 0.2 pCi/l respectively. Although these concentrations exceeded the background station concentration of < 0.2 pCi/l, station 2 has historically recorded above background Rn-222 concentrations due to its close proximity to a known area of contamination along the northern fenceline. The increase in radon concentrations at station 2 during the second half of 1998 was expected due to remedial activities at the North Ditch area during this time period. The readings are consistent with data taken at SLAPS in previous years, and are below the 40 CFR 192.02 regulatory criteria of ≤ 0.5 pCi/l.

Table 3-3. 1998 Radon Gas Concentrations St Louis Airport Site (SLAPS)

		Average Annual Concentration (pCi/l)		
Monitoring Location	Monitoring Station ID#	(Midyear) 01/07/98 to 07/23/98 [a] (uncorrected)	**(End of Year) 07/23/98 to 01/28/99 [a]** (uncorrected)	**Average [d]**
SLAPS perimeter	1	0.2*	0.3	0.2*
	2	0.4	1.2	0.4
Duplicate[b]	2	0.3	0.9	0.2
	5	0.2	c	0.2*
	9	0.2*	c	0.2*
Background	16	0.2*	0.7	

[a] Detectors were installed and removed on the dates listed.
[b] 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.
[c] Detectors were missing at time of collection in January 1999.
[d] Average annual concentration (pCi/l) above background
* Indicates data results below the analytical detection limit. Results below the detection limit are assumed to be equal to the detection limit.

3.3.2 HISS

Radon emissions at HISS were monitored using two sampling methods during CY98. Perimeter monitoring using alpha track etch detectors was used to evaluate ambient air concentrations of Rn-222 at the fenceline. Radon flux sampling was used to measure emission rates of Rn-222 at the ground surface. A description of these methods and the monitoring results are listed below.

3.3.2.1 Radon-222 Monitoring

Airborne radon monitoring was performed at HISS using alpha track etch detectors placed around the site perimeter to measure Rn-222 emissions from site. Nine detectors were co-located with TLD locations as identified in Figure 3-2. Additional detectors used during the monitoring period include a quality control duplicate at station 6, one background detector (station 16) located in Florissant, Missouri, and one detector (station 20) located within the HISS trailer to measure radon levels near high occupancy areas. The track etch detectors were deployed in January 1998 at each monitoring location, collected for analysis after approximately

Table 3-5. 1998 Radon-222 Flux Monitoring Results Hazelwood Interim Storage Site

Sample ID	Radon-222 Flux $pCi/m^2/s$	Sample ID	Radon-222 Flux $pCi/m^2/s$	Sample ID	Radon-222 Flux $pCi/m^2/s$
Main Pile		**Main Pile**		**Main Pile**	
M01	0.40	M33	0.15	M65	0.30
M02	0.74	M34	0.39	M65[a]	-0.02
M03	0.28	M35	0.64	M65[b]	0.34
M04	0.04	M35[b]	-0.04		
M05	0.53	M35[a]	0.60		
M05[b]	0.15	M36	0.45		
M05[a]	0.77	M37	1.16		
M06	1.34	M38	0.37		
M07	1.16	M39	0.00	*Secondary Pile*	
M08	0.37	M40	-0.03	S01	0.04
M09	0.36	M41	0.27	S02	0.06
M10	0.34	M42	0.05	S03	0.04
M11	0.11	M43	0.77	S04	0.11
M12	0.04	M44	0.60	S05	0.40
M13	0.26	M45	0.32	S06	0.06
M14	0.44	M45[b]	0.07	S07	0.17
M15	1.47	M45[a]	0.27	S08	0.10
M15[b]	-0.17	M46	0.34	S09	0.18
M15[a]	1.32	M47	0.31	S10	-0.02
M16	0.92	M48	0.08	S10[b]	0.02
M17	1.12	M49	0.22	S10[a]	0.14
M18	0.13	M50	0.21	S11	0.18
M19	0.32	M51	0.10	S12	0.32
M20	0.06	M52	-0.03	S13	-0.02
M21	0.01	M53	0.35	S14	0.01
M22	0.11	M54	0.47	S15	0.36
M23	0.15	M55	0.36	S16	0.06
M24	0.04	M55[b]	-0.18	S17	0.13
M25	0.97	M55[a]	0.35	S18	0.06
M25[b]	0.03	M56	0.40	S19	-0.01
M25[a]	1.11	M57	0.25	S20	0.03
M26	9.16	M58	0.06	S20[b]	0.10
M27	0.56	M59	0.10	S20[a]	0.03
M28	0.11	M60	0.63	S21	0.21
M29	0.09	M61	0.20	S22	0.08
M30	0.20	M62	0.01	S23	0.10
M31	0.26	M63	0.49	S24	0.28
M32	0.26	M64	0.06	S25	0.08

a. 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.

b. The canisters are counted twice in the laboratory as quality control duplicates to evaluate analytical precision

Note: The EPA standard for Rn-222 flux is 20 $pCi/m^2/s$.

6 months of exposure, and replaced with another set that would represent radon exposure for the rest of the year. Recorded Rn-222 concentrations are listed in pCi/l, and are evaluated based on 40 CFR 192.02 regulatory criteria of ≤ 0.5 pCi/l. Although the average annual Rn-222 monitoring results (Table 3-4) are consistent with measured concentrations found in previous environmental monitoring data, the results from 3rd and 4th quarters are slightly elevated. The increase may have been due to excavations at the HISS rail spur or to atmospheric conditions during the monitoring period. The monitoring data at the background station was also elevated during this time, which supports at least part of the increase being due to atmospheric conditions. All monitoring locations (stations 1, 2, 3, 4, 5, 6, 7, 8, 11, and 20) have average annual concentrations <0.2 pCi/l, which is the detection limit of the alpha track etch detectors. The Rn-222 concentrations are below the 40 CFR 192.02 regulatory criterion of <0.5 pCi/l.

Table 3-4. 1998 Radon Gas Concentrations Hazelwood Interim Storage Site (HISS)

		Average Annual Concentration (pCi/l)		
Monitoring Location	**Monitoring Station ID#**	**01/07/98 to 07/22/98 [a]**	**07/22/98 to 01/28/99 [a]**	**Average [c]**
HISS perimeter	1	0.2*	0.4	0.2*
	2	0.2*	0.5	0.2*
	3	0.2*	0.3	0.2*
	4	0.2*	0.4	0.2*
	5	0.2*	0.2	0.2*
	6	0.2*	0.2	0.2*
Duplicate[b]	6	0.2*	0.3	0.2*
	7	0.2	0.3	0.2*
	8	0.2*	0.3	0.2*
	11	0.2*	0.5	0.2*
Trailer Interior	20	0.2*	0.3	0.2*
Background	16	0.2*	0.7	

a Detectors were installed and removed on the dates listed.

b 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.

c Average annual concentration (pCi/l) above background.

* Indicates data results below analytical detection limit. Results below the detection limit are assumed to be equal to the detection limit.

3.3.2.2 Radon Flux Sampling

Radon flux sampling was performed in October 1998 using 10-inch diameter activated charcoal canisters placed approximately 26 feet apart on a predetermined grid. The canisters were sealed to the storage pile's cover surface for 24 hours, and then the canisters were retrieved and sent to an offsite laboratory for analysis (EPA Method 115). Sixty-five locations were sampled on the HISS main storage pile and 25 locations on the secondary storage pile (Figure 3-3). Results from the sampling event are shown in Table 3-5.

All measurements from both the primary and secondary pile were well below the 40 CFR 192.02 regulatory criteria of 20 pCi/m^2/s. Rn-222 flux sampling results for CY98 at the storage piles are consistent with measured concentrations found in previous flux sampling data taken at the site.

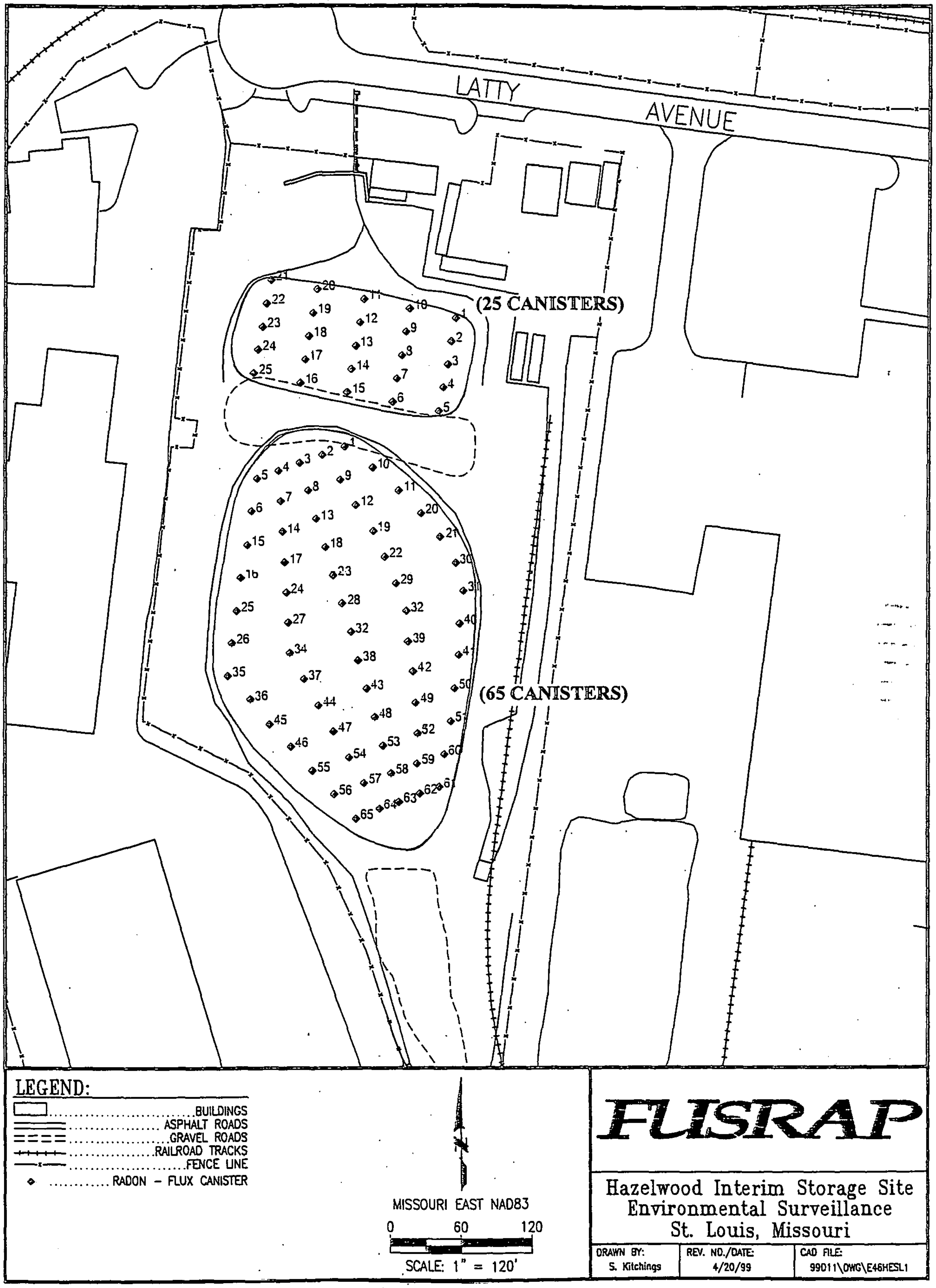

Figure 3-3. Enviromental Monitoring Program Radon-Flux Monitoring Stations at HISS

3.4 1998 STORM-WATER DISCHARGE MONITORING RESULTS

This section will provide a description of the storm-water monitoring activities conducted at the SLS during 1998. The monitoring results obtained from these activities are presented and compared with the evaluation criteria presented in the Environmental Monitoring Implementation Fiscal Year (EMIFY) for the SLS (USACE, 1999b). The 1998 results are also discussed with reference to historical results for the SLS.

3.4.1 Evaluation of 1998 Storm-Water Discharge Monitoring Results at SLDS

Storm-water and waste-water effluents at the SLDS 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 environmental monitoring program (EMP). In October 1998, the St. Louis Metropolitan Sewer District (MSD) issued a separate local use permit for discharges of run-on/run-off, ground-water infiltration, or other accumulated waste-water that results from remedial activities. The pollutants identified in the local permit include pH, suspended solids, chemical oxygen demand, metal parameters (total values) which have numeric limits established in Ordinance 8472 Article V, Section Two, B., volatile organics by wastewater Method 624, Semivolatile organics by Method 625, PCBs by Method 608, gross alpha radioactivity, gross beta radioactivity, Uranium 235 and 238, Radium 226 and 228, and Thorium 230 and 232. There were no remedial-related discharges of storm water or ground water at SLDS in 1998. Future monitoring of these discharges at SLDS will be addressed under a Work Description (WD) or incorporated into the subsequent EMIFY as described by Environmental Monitoring Guide (EMG) for the SLS and data results reported in the annual EMDAR for the following calendar year (USACE, 1999a).

3.4.2 Evaluation of the 1998 Storm-Water Discharge Monitoring Results at SLAPS

Historical monitoring of storm-water discharges at the SLAPS under the EMP has involved semi-annual sampling of the effluent from two outfalls for evaluation of pH, specific conductance, gross alpha activity, gross beta activity, Ra-226, Ra-228, Th-228, Th-230, Th-232, Pb-210, and total uranium. The first of the SLAPS historical outfalls (STW-001) is located at the northwest entrance to the site and the second historical outfall (STW-002) is located in the southwest corner of the site (Figure 3-4). These sampling activities have been conducted during the second and fourth quarters of the calendar year. It has been observed that the run-off from the south side of the site has rarely provided sufficient volume or duration to result in flow at STW-002. An interim removal action conducted in late 1997 removed soils from along the west side of SLAPS, and the corresponding grading activities further reduced the probability of discharge from STW-002. As a result of this insufficient flow, storm-water effluent samples were not collected from STW-002 during 1998. During 1998, storm-water discharges at SLAPS were sampled in accordance with historical EMP protocols in January and July. An additional storm-water sampling event was conducted in accordance with revised protocols in November 1998.

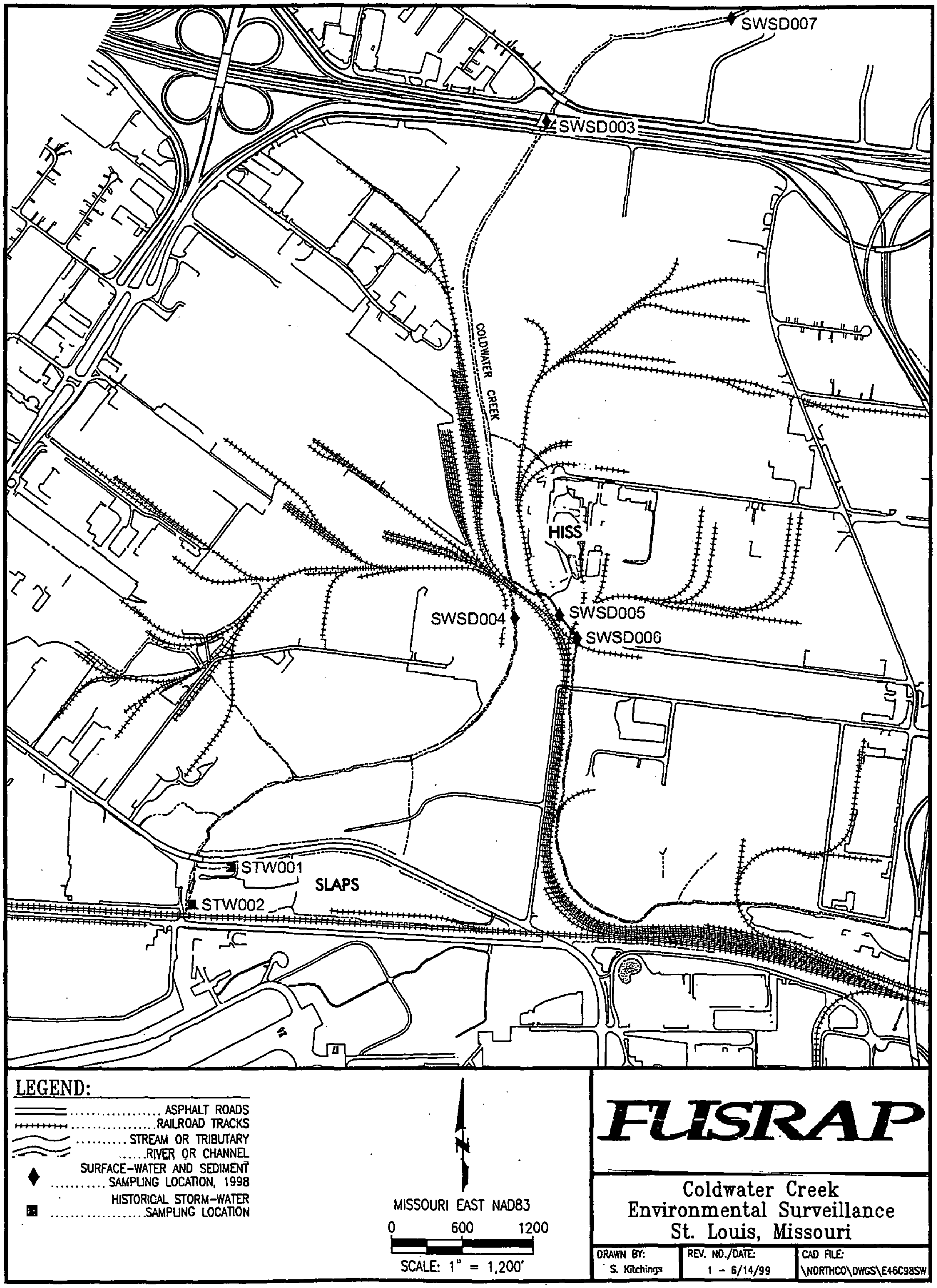

Figure 3-4. Historical Storm Water, Surface Water and Sediment Sampling Locations at SLAPS

In the fall of 1998, the Missouri Department of Natural Resources (MDNR) issued discharge requirements for three outfalls at SLAPS in conjunction with the proposed construction of a sedimentation basin at the site. Currently, there are three NPDES outfalls at the SLAPS: PN01, PN02, and PN03 (Figure 3-5). 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" will be 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 Blvd. 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 outfall monitoring station is located where the drainage ditch crosses under McDonnell Blvd.

Under the discharge requirements issued by MDNR in 1998, monthly monitoring is required for flow, pH, total suspended solids (TSS), oil and grease (O/G), total petroleum hydrocarbons (TPH), chemical oxygen demand (COD), polychlorinated biphenyls (PCBs), certain metals (Arsenic (As), Cadmium (Cd), Cooper (Cu), Chromium (Cr), and Lead (Pb)), and total radium, thorium, and uranium. Effluent monitoring for gross alpha, gross beta, Pa-231, Ac-227, and total radium, thorium, and uranium is also required for each discharge event. The storm water discharge monitoring results for SLAPS July of 1998 are presented in Table 3-6. Required monitoring was limited to TSS, total organic carbon (TOC), total organic halides (TOX), and metals in the STW-001 effluent during July 1998 and TSS in the STW-001 discharge in January 1998.

In 1998, the November 4, 10, and 14 sampling events monitored water from standing run-off that had accumulated in the drainage ditches leading to PN01b and PN02 (the water from these ditches was pumped to Coldwater Creek). These samples were analyzed for COD, TPH, toxaphene, TSS, pH, TOX, certain metals (Silver (Ag), As, barium (Ba), Cd, Cr, Mercury (Hg), Pb, Selenium (Se)), and radionuclides (Ac-227, Americium (Am-241), Cesium (Cs-137), Potassium, Protactinium (Pa-231), Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, U-238). The November 1998 storm water sample results are listed in Table 3-7. For all of the three storm-water sampling events, effluent TSS levels were below the discharge limit of 1.0 ml/L/hr, with the highest reading occurring on November 4, 1998 at outfall PN03 with a level of 0.4 ml/L/hr.

The concentrations of the eight Resource Conservation Recovery Act (RCRA) Toxicity Characteristic (TC) metals (Ag, As, Ba, Cd, Cr, Hg, Pb, and Se) in the effluent from STW-001 in July are also presented in Table 3-6. With the exception of barium and selenium, the concentrations of these metals were below 10 μg/l for the July sampling event. Barium was detected at concentrations of 128 μg/l (filtered) and 165 μg/l (unfiltered). Selenium was detected at 752 μg/l (filtered) and 734 μg/l (unfiltered). Results from the November sampling events also indicate elevated concentrations of Ba and Se. Barium concentrations varied from 85.4 μg/l on November 4 at the Sediment Trap North Location to 230 μg/l on November 14 at the location east of the west culvert. Selenium concentrations varied from 25.8 μg/l on November 4 at the

Sediment Trap North Location to 849 μg/l on November 14 at the location east of the west culvert. The Ambient Water Quality Criteria (AWQC) requires a 5 μg/l concentration limit for selenium. Selenium concentrations exceeded this AWQC at all locations in the November sampling events.

Table 3-6. SLAPS Storm-Water Analytical Results for July 1998

Date Collected	Station[a]	Parameter	Results	Detection Limit	Filtered[b]
07/22/1998	ECUL	Alkalinity, Total (mg/l)	88.5	5	F
07/22/1998	ECUL	Alkalinity, Total (mg/l)	89.7	5	UF
07/22/1998	ECUL	Chloride (mg/l)	135	10	F
07/22/1998	ECUL	Chloride (mg/l)	136	10	UF
07/22/1998	ECUL	Fluoride (mg/l)	0.5	0.5	F
07/22/1998	ECUL	Fluoride (mg/l)	0.5	0.5	UF
07/22/1998	ECUL	Nitrate (mg/l)	131	2	F
07/22/1998	ECUL	Nitrate (mg/l)	135	4	UF
07/22/1998	ECUL	Nitrite (mg/l)	0.82	0.1	F
07/22/1998	ECUL	Nitrite (mg/l)	0.748	0.1	UF
07/22/1998	ECUL	Sulfate (mg/l)	77.9	2.5	F
07/22/1998	ECUL	Sulfate (mg/l)	75.6	2.5	UF
07/22/1998	ECUL	Ammonia (μg/l)	362	50	F
07/22/1998	ECUL	Ammonia (μg/l)	415	50	UF
07/22/1998	ECUL	Hardness (mg/l)	544	1	F
07/22/1998	ECUL	Hardness (mg/l)	531.6	5	UF
07/22/1998	ECUL	Phosphorus (μg/l)	133	50	F
07/22/1998	ECUL	Phosphorus (μg/l)	376	50	UF
07/22/1998	ECUL	Aluminum (μg/l)	234	200	F
07/22/1998	ECUL	Aluminum (μg/l)	399	200	UF
07/22/1998	ECUL	Antimony (μg/l)	54.9	60	F
07/22/1998	ECUL	Antimony (μg/l)	29.1	60	UF
07/22/1998	ECUL	Arsenic (μg/l)	2	10	F
07/22/1998	ECUL	Arsenic (μg/l)	2	10	UF
07/22/1998	ECUL	Barium (μg/l)	128	200	F
07/22/1998	ECUL	Barium (μg/l)	165	200	UF
07/22/1998	ECUL	Beryllium (μg/l)	0.6	5	F
07/22/1998	ECUL	Beryllium (μg/l)	0.6	5	UF
07/22/1998	ECUL	Boron (μg/l)	129	200	F
07/22/1998	ECUL	Boron (μg/l)	121	200	UF
07/22/1998	ECUL	Cadmium (μg/l)	2.5	5	F
07/22/1998	ECUL	Cadmium (μg/l)	2.5	5	UF
07/22/1998	ECUL	Calcium (μg/l)	153000	5000	F
07/22/1998	ECUL	Calcium (μg/l)	159000	5000	UF
07/22/1998	ECUL	Chromium (μg/l)	4.2	10	F
07/22/1998	ECUL	Chromium (μg/l)	4.2	10	UF
07/22/1998	ECUL	Cobalt (μg/l)	14.9	50	F
07/22/1998	ECUL	Cobalt (μg/l)	18.1	50	UF
07/22/1998	ECUL	Copper (μg/l)	26	25	F
07/22/1998	ECUL	Copper (μg/l)	29.5	25	UF
07/22/1998	ECUL	Iron (μg/l)	60.5	100	F
07/22/1998	ECUL	Iron (μg/l)	374	100	UF
07/22/1998	ECUL	Lead (μg/l)	1.6	3	F
07/22/1998	ECUL	Lead (μg/l)	5.5	3	UF
07/22/1998	ECUL	Lithium (μg/l)	3	50	F
07/22/1998	ECUL	Lithium (μg/l)	3	50	UF
07/22/1998	ECUL	Magnesium (μg/l)	30400	5000	F
07/22/1998	ECUL	Magnesium (μg/l)	31800	5000	UF
07/22/1998	ECUL	Manganese (μg/l)	58	15	F
07/22/1998	ECUL	Manganese (μg/l)	66.1	15	UF

Table 3-6. SLAPS Storm-Water Analytical Results for July 1998 (cont'd)

Date Collected	Station[a]	Parameter	Results	Detection Limit	Filtered[b]
07/22/1998	ECUL	Mercury (µg/l)	0.1	0.2	F
07/22/1998	ECUL	Mercury (µg/l)	0.1	0.2	UF
07/22/1998	ECUL	Molybdenum (µg/l)	18.2	40	F
07/22/1998	ECUL	Molybdenum (µg/l)	19.1	40	UF
07/22/1998	ECUL	Nickel (µg/l)	32.3	40	F
07/22/1998	ECUL	Nickel (µg/l)	37.2	40	UF
07/22/1998	ECUL	Potassium (µg/l)	6480	5000	F
07/22/1998	ECUL	Potassium (µg/l)	6410	5000	UF
07/22/1998	ECUL	Selenium (µg/l)	752	5	F
07/22/1998	ECUL	Selenium (µg/l)	734	5	UF
07/22/1998	ECUL	Silver (µg/l)	6	10	F
07/22/1998	ECUL	Silver (µg/l)	6	10	UF
07/22/1998	ECUL	Sodium (µg/l)	123000	5000	F
07/22/1998	ECUL	Sodium (µg/l)	122000	5000	UF
07/22/1998	ECUL	Strontium (µg/l)	487	50	F
07/22/1998	ECUL	Strontium (µg/l)	508	50	UF
07/22/1998	ECUL	Thallium (µg/l)	3.3	10	F
07/22/1998	ECUL	Thallium (µg/l)	3.3	10	UF
07/22/1998	ECUL	Titanium (µg/l)	35.6	50	F
07/22/1998	ECUL	Titanium (µg/l)	48.6	50	UF
07/22/1998	ECUL	Uranium (µg/l)	301	500	F
07/22/1998	ECUL	Uranium (µg/l)	275	500	UF
07/22/1998	ECUL	Vanadium (µg/l)	17.6	50	F
07/22/1998	ECUL	Vanadium (µg/l)	17.7	50	UF
07/22/1998	ECUL	Zinc (µg/l)	15.7	20	F
07/22/1998	ECUL	Zinc (µg/l)	18.4	20	UF
07/22/1998	ECUL	Total Dissolved Solids (mg/l)	1523	5	UF
07/22/1998	ECUL	Total Suspended Solids (mg/l)	15	1	UF
07/22/1998	ECUL	2,4,5-T (µg/l)	1	1	UF
07/22/1998	ECUL	2,4,5-TP (Silvex) (µg/l)	1	1	UF
07/22/1998	ECUL	2,4-D (µg/l)	4	4	UF
07/22/1998	ECUL	2,4-DB (µg/l)	4	4	UF
07/22/1998	ECUL	Dalapon (µg/l)	2	2	UF
07/22/1998	ECUL	Dicamba (µg/l)	2	2	UF
07/22/1998	ECUL	Dichloroprop (µg/l)	4	4	UF
07/22/1998	ECUL	Dinoseb (µg/l)	0.6	0.6	UF
07/22/1998	ECUL	MCPA (µg/l)	400	400	UF
07/22/1998	ECUL	MCPP (Mecoprop) (µg/l)	400	400	UF
07/22/1998	ECUL	4,4'-DDD (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	4,4'-DDE (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	4,4'-DDT (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Aldrin (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Alpha Chlordane (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Alpha-BHC (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Aroclor-1016 (µg/l)	1	1	UF
07/22/1998	ECUL	Aroclor-1221 (µg/l)	1	1	UF
07/22/1998	ECUL	Aroclor-1232 (µg/l)	1	1	UF
07/22/1998	ECUL	Aroclor-1242 (µg/l)	1	1	UF
07/22/1998	ECUL	Aroclor-1248 (µg/l)	1	1	UF
07/22/1998	ECUL	Aroclor-1254 (µg/l)	1	1	UF
07/22/1998	ECUL	Aroclor-1260 (µg/l)	1	1	UF
07/22/1998	ECUL	Beta-BHC (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Delta-BHC (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Dieldrin (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Endosulfan I (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Endosulfan II (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Endosulfan Sulfate (µg/l)	0.05	0.05	UF

Table 3-6. SLAPS Storm-Water Analytical Results for July 1998 (cont'd)

Date Collected	Station[a]	Parameter	Results	Detection Limit	Filtered[b]
07/22/1998	ECUL	Endrin (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Endrin Aldehyde (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Endrin Ketone (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Gamma Chlordane (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Gamma-BHC (Lindane) (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Heptachlor (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Heptachlor Epoxide (µg/l)	0.05	0.05	UF
07/22/1998	ECUL	Methoxychlor (µg/l)	0.5	0.5	UF
07/22/1998	ECUL	Toxaphene (µg/l)	2	2	UF
07/22/1998	ECUL	1,2,4-Trichlorobenzene (µg/l)	10	10	UF
07/22/1998	ECUL	1,2-Dichlorobenzene (µg/l)	10	10	UF
07/22/1998	ECUL	1,3-Dichlorobenzene (µg/l)	10	10	UF
07/22/1998	ECUL	1,4-Dichlorobenzene (µg/l)	10	10	UF
07/22/1998	ECUL	2,2'-oxybis (1-chloropropane) (µg/l)	10	10	UF
07/22/1998	ECUL	2,4,5-Trichlorophenol (µg/l)	25	10	UF
07/22/1998	ECUL	2,4,6-Trichlorophenol (µg/l)	10	10	UF
07/22/1998	ECUL	2,4-Dichlorophenol (µg/l)	10	10	UF
07/22/1998	ECUL	2,4-Dimethylphenol (µg/l)	10	10	UF
07/22/1998	ECUL	2,4-Dinitrophenol (µg/l)	25	25	UF
07/22/1998	ECUL	2,4-Dinitrotoluene (µg/l)	10	10	UF
07/22/1998	ECUL	2,6-Dinitrotoluene (µg/l)	10	10	UF
07/22/1998	ECUL	2-Chloronaphthalene (µg/l)	10	10	UF
07/22/1998	ECUL	2-Chlorophenol (µg/l)	10	10	UF
07/22/1998	ECUL	2-Methylnaphthalene (µg/l)	10	10	UF
07/22/1998	ECUL	2-Methylphenol (µg/l)	10	10	UF
07/22/1998	ECUL	2-Nitroaniline (µg/l)	25	25	UF
07/22/1998	ECUL	2-Nitrophenol (µg/l)	10	10	UF
07/22/1998	ECUL	3,3'-Dichlorobenzidine (µg/l)	10	10	UF
07/22/1998	ECUL	3-Nitroaniline (µg/l)	25	25	UF
07/22/1998	ECUL	4,6-Dinitro-o-Cresol (µg/l)	25	25	UF
07/22/1998	ECUL	4-Bromophenyl-phenyl Ether (µg/l)	10	10	UF
07/22/1998	ECUL	4-chloro-3-methylphenol (µg/l)	10	10	UF
07/22/1998	ECUL	4-Chloroaniline (µg/l)	10	10	UF
07/22/1998	ECUL	4-Chlorophenyl-phenylether (µg/l)	10	10	UF
07/22/1998	ECUL	4-Methylphenol (µg/l)	10	10	UF
07/22/1998	ECUL	4-Nitroaniline (µg/l)	25	25	UF
07/22/1998	ECUL	4-Nitrophenol (µg/l)	25	25	UF
07/22/1998	ECUL	Acenaphthene (µg/l)	10	10	UF
07/22/1998	ECUL	Acenaphthylene (µg/l)	10	10	UF
07/22/1998	ECUL	Anthracene (µg/l)	10	10	UF
07/22/1998	ECUL	Benzo(a)anthracene (µg/l)	10	10	UF
07/22/1998	ECUL	Benzo(a)pyrene (µg/l)	10	10	UF
07/22/1998	ECUL	Benzo(b)fluoranthene (µg/l)	10	10	UF
07/22/1998	ECUL	Benzo(g,h,i)perylene (µg/l)	10	10	UF
07/22/1998	ECUL	Benzo(k)fluoranthene (µg/l)	10	10	UF
07/22/1998	ECUL	Bis(2-chloroethoxy)methane (µg/l)	10	10	UF
07/22/1998	ECUL	Bis(2-chloroethyl)ether (µg/l)	10	10	UF
07/22/1998	ECUL	Bis(2-ethylhexyl)phthalate (µg/l)	10	10	UF
07/22/1998	ECUL	Butyl Benzyl Phthalate (µg/l)	10	10	UF
07/22/1998	ECUL	Carbazole (µg/l)	10	10	UF
07/22/1998	ECUL	Chrysene (µg/l)	10	10	UF
07/22/1998	ECUL	Dibenzo(a,h)anthracene (µg/l)	10	10	UF
07/22/1998	ECUL	Dibenzofuran (µg/l)	10	10	UF
07/22/1998	ECUL	Diethyl Phthalate (µg/l)	10	10	UF
07/22/1998	ECUL	Dimethyl Phthalate (µg/l)	10	10	UF
07/22/1998	ECUL	Di-n-butyl Phthalate (µg/l)	10	10	UF
07/22/1998	ECUL	Di-n-octyl Phthalate (µg/l)	10	10	UF

Table 3-6. SLAPS Storm-Water Analytical Results for July 1998 (cont'd)

Date Collected	Station[a]	Parameter	Results	Detection Limit	Filtered[b]
07/22/1998	ECUL	Fluoranthene (μg/l)	10	10	UF
07/22/1998	ECUL	Fluorene (μg/l)	10	10	UF
07/22/1998	ECUL	Hexachlorobenzene (μg/l)	10	10	UF
07/22/1998	ECUL	Hexachlorobutadiene (μg/l)	10	10	UF
07/22/1998	ECUL	Hexachlorocyclopentadiene (μg/l)	10	10	UF
07/22/1998	ECUL	Hexachloroethane (μg/l)	10	10	UF
07/22/1998	ECUL	Indeno(1,2,3-cd)pyrene (μg/l)	10	10	UF
07/22/1998	ECUL	Isophorone (μg/l)	10	10	UF
07/22/1998	ECUL	Naphthalene (μg/l)	10	10	UF
07/22/1998	ECUL	Nitrobenzene (μg/l)	10	10	UF
07/22/1998	ECUL	N-Nitroso-di-n-propylamine (μg/l)	10	10	UF
07/22/1998	ECUL	N-Nitrosodiphenylamine (μg/l)	10	10	UF
07/22/1998	ECUL	Pentachlorophenol (μg/l)	25	25	UF
07/22/1998	ECUL	Phenanthrene (μg/l)	10	10	UF
07/22/1998	ECUL	Phenol (μg/l)	10	10	UF
07/22/1998	ECUL	Pyrene (μg/l)	10	10	UF
07/22/1998	ECUL	Total Organic Carbon (mg/l)	23.9	1	F
07/22/1998	ECUL	Total Organic Carbon (mg/l)	28	1	UF
07/22/1998	ECUL	1,1,1-Trichloroethane (μg/l)	5	5	UF
07/22/1998	ECUL	1,1,2,2-Tetrachloroethane (μg/l)	5	5	UF
07/22/1998	ECUL	1,1,2-Trichloro-1,2,2-trifluoroethane (μg/l)	10	10	UF
07/22/1998	ECUL	1,1,2-Trichloroethane (μg/l)	5	5	UF
07/22/1998	ECUL	1,1-Dichloroethane (μg/l)	5	5	UF
07/22/1998	ECUL	1,1-Dichloroethene (μg/l)	5	5	UF
07/22/1998	ECUL	1,2-Dichloroethane (μg/l)	5	5	UF
07/22/1998	ECUL	1,2-Dichloroethene (μg/l)	5	5	UF
07/22/1998	ECUL	1,2-Dichloropropane (μg/l)	5	5	UF
07/22/1998	ECUL	1,3-cis-Dichloropropene (μg/l)	5	5	UF
07/22/1998	ECUL	1,3-trans-Dichloropropene (μg/l)	5	5	UF
07/22/1998	ECUL	2-Butanone (μg/l)	10	10	UF
07/22/1998	ECUL	2-Hexanone (μg/l)	10	10	UF
07/22/1998	ECUL	4-Methyl-2-pentanone (μg/l)	10	10	UF
07/22/1998	ECUL	Acetone (μg/l)	10	10	UF
07/22/1998	ECUL	Benzene (μg/l)	5	5	UF
07/22/1998	ECUL	Bromodichloromethane (μg/l)	5	5	UF
07/22/1998	ECUL	Bromoform (μg/l)	5	5	UF
07/22/1998	ECUL	Bromomethane (μg/l)	10	10	UF
07/22/1998	ECUL	Carbon Disulfide (μg/l)	5	5	UF
07/22/1998	ECUL	Carbon Tetrachloride (μg/l)	5	5	UF
07/22/1998	ECUL	Chlorobenzene (μg/l)	5	5	UF
07/22/1998	ECUL	Chloroethane (μg/l)	10	10	UF
07/22/1998	ECUL	Chloroform (μg/l)	5	5	UF
07/22/1998	ECUL	Chloromethane (μg/l)	10	10	UF
07/22/1998	ECUL	Dibromochloromethane (μg/l)	5	5	UF
07/22/1998	ECUL	Ethylbenzene (μg/l)	5	5	UF
07/22/1998	ECUL	Methylene Chloride (μg/l)	5	5	UF
07/22/1998	ECUL	Styrene (μg/l)	5	5	UF
07/22/1998	ECUL	Tetrachloroethene (μg/l)	5	5	UF
07/22/1998	ECUL	Toluene (μg/l)	5	5	UF
07/22/1998	ECUL	Trichloroethene (μg/l)	14	5	UF
07/22/1998	ECUL	Vinyl Chloride (μg/l)	10	10	UF
07/22/1998	ECUL	Xylenes, Total (μg/l)	5	5	UF
07/22/1998	ECUL	Radium-226 (pCi/l)	2.9	1.19	F
07/22/1998	ECUL	Radium-226 (pCi/l)	3.07	1.94	UF
07/22/1998	ECUL	Thorium-228 (pCi/l)	0.3	0.93	F
07/22/1998	ECUL	Thorium-228 (pCi/l)	0.4	0.9	UF
07/22/1998	ECUL	Thorium-230 (pCi/l)	1.83	1.12	F
07/22/1998	ECUL	Thorium-230 (pCi/l)	16.86	1.08	UF

Table 3-6. SLAPS Storm-Water Analytical Results for July 1998 (cont'd)

Date Collected	Station[a]	Parameter	Results	Detection Limit	Filtered[b]
07/22/1998	ECUL	Thorium-232 (pCi/l)	0.22	0.3	F
07/22/1998	ECUL	Thorium-232 (pCi/l)	0	0.29	UF
07/22/1998	ECUL	Uranium-234 (pCi/l)	102.4	0.31	F
07/22/1998	ECUL	Uranium-234 (pCi/l)	108.2	1.98	UF
07/22/1998	ECUL	Uranium-235 (pCi/l)	3.35	0.86	F
07/22/1998	ECUL	Uranium-235 (pCi/l)	8.11	1.99	UF
07/22/1998	ECUL	Uranium-238 (pCi/l)	103.2	0.31	F
07/22/1998	ECUL	Uranium-238 (pCi/l)	117.9	0.72	UF

a ECUL = East of West Culvert
b F = Filtered, UF = Unfiltered

As shown in Table 3-7, in the November 1998 results the primary isotopes in the samples of pumped water were Th-230, U-234 and U-238. Th-230 exceeded the AWQC of 15 pCi/l at all locations with concentrations ranging from 1.33 to 320.3 pCi/l. U-238 also had elevated readings for the November sampling events, with concentrations ranging from 10.15 to 1,005 pCi/l.

Historical EMP results from 1996 indicated that gross alpha activity in the STW-001 effluent ranged from ~880 pCi/l to ~2300 pCi/l with the majority of this activity attributable to U-238. Historically, maximum alpha activity occurred in the month of June, and the lower activity was found in the October discharge. It should be noted that the regulatory derived evaluation criteria of 15 pCi/l for total alpha activity does not include uranium. Historical storm-water discharge results from 1996 for STW-001 indicate that the concentrations of radium and thorium isotopes were <1.0 pCi/l. The sedimentation basin's development should preclude elevated releases of metals, including radionuclides.

Figure 3-5. 1998 Storm-Water, Surface-Water and Sediment Sampling Locations at SLAPS

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Table 3-7. Results from November 1998 Storm-water Discharge Monitoring at SLAPS[a]

Sampling Station[b]	Parameter (units)	Analytical Results by Sampling Date			Mean Concentration	Discharge Requirement	Ambient Water Quality Criteria
		Nov 4[c]	Nov 10	Nov 14			
East of West Culvert	Radium-226 (pCi/l)	0.32(-0.45)	2.08	3.83	1.56	NL[d]	5.0
	Radium-228 (pCi/l)	1.64			1.64	NL[d]	5.0
	Uranium-234 (pCi/l)	51.65	73.35	304	143	NL[d]	
	Uranium-235 (pCi/l)	3.07(2.49)	3.3	10.86	4.93	NL[d]	
	Uranium-238 (pCi/l)	51.18(24.82)	91.67	308.1	118.94	NL[d]	
	Thorium-228 (pCi/l)	1.64(-0.15)	1.59	0.2	0.86	NL[d]	15.0[e]
	Thorium-230 (pCi/l)	60.59(7.92)	5.98	1.33	18.95	NL[d]	15.0[e]
	Thorium-232 (pCi/l)	1.64(0.0)	0.61	0.76	0.75	NL[d]	15.0[e]
	Potassium-40 (pCi/l)	-7.42					
	Cesium-137 (pCi/l)	0.03					
	Actinium-227 (pCi/l)	0.15				NL[d]	
	Protectinium-231 (pCi/l)	3.37				NL[d]	15.0[e]
	Americium-241 (pCi/l)	0.29					15.0[e]
	Total Settleable Solids (ml/l/hr)		0.1	0.1	0.1)	1.0(1.5)[f]	
	COD (mg/l)		29.0	7.0	18	90(120)[f]	
	pH		7.84	7.74	7.79	6-9	
	TOX (mg/l)		0.0146	0.0132	0.014		
	Total Petroleum Hydrocarbon (mg/l)		0.0005	0.0005	0.0005	10.0	
	Arsenic (mg/l)		0.0026	0.0018	0.0022	0.1	0.02
	Barium (mg/l)		0.121	0.230	0.1755		
	Cadmium (mg/l)		0.0004	0.0004	0.0004	0.094	0.094
	Chromium (mg/l)		0.0022	0.008	0.0011	0.28	0.28
	Lead (mg/l)		0.0036	0.0009	0.0018	0.19	0.15
	Mercury (mg/l)		0.0001	0.0001	0.0001		0.0024
	Selenium (mg/l)		0.229	0.849	0.539		0.005
	Silver (mg/l)		0.0013	0.0015	0.0014		
West of West Culvert	Radium-226 (pCi/l)	1.87(0.54)	1.61	0.33	1.088	NL[d]	5.0
	Radium-228 (pCi/l)	0.67			0.67	NL[d]	5.0
	Uranium-234 (pCi/l)	155.1	545.8	980.5	560.4	NL[d]	
	Uranium-235 (pCi/l)	9.16(7.95)	19.78	36.85	18.43	NL[d]	
	Uranium-238 (pCi/l)	146.7(13.5)	546.6	1005	427.95	NL[d]	
	Thorium-228 (pCi/l)	3.47(0.67)	0.37	1.88	1.6	NL[d]	15.0[e]
	Thorium-230 (pCi/l)	60.5(19.32)	11.22	4.23	23.82	NL[d]	15.0[e]
	Thorijm-232 (pCi/l)	0.67(0.0)	0.1	0.85	0.38	NL[d]	15.0[e]
	Potassium-40 (pCi/l)	6.7					
	Cesium-137 (pCi/l)	-0.04					
	Actinium-227 (pCi/l)	-4.0				NL[d]	
	Protectinium-231 (pCi/l)	-0.86				NL[d]	15.0[e]

Table 3-7. Results from November 1998 Storm-water Discharge Monitoring at SLAPS[a] (cont'd)

Sampling Station[b]	Parameter (units)	Analytical Results by Sampling Date			Mean Concentration	Discharge Requirement	Ambient Water Quality Criteria
	Americium-241 (pCi/l)	0.15					15.0[e]
	Total Settleable Solids (ml/l/hr)		0.1(U)	0.1(U)	0.1	1.0(1.5)[f]	
	COD (mg/l)		27	27	27	90(120)[f]	
	pH		8.05	8.78	8.42	6-9	
	TOX (mg/l)		0.0124	0.0768	0.0446		
	Total Petroleum Hydrocarbon (mg/l)		0.5(U)	0.5(U)	0.5	10.0	
	Arsenic (mg/l)		0.0058(U)	0.0041	0.0021	0.1	0.02
	Barium (mg/l)		0.185	0.102	.1435		
	Cadmium (mg/l)		0.0004(U)	0.0004(U)	0.0004	0.094	0.094
	Chromium (mg/l)		0.0066	0.0017	0.0042	0.28	0.28
	Lead (mg/l)		0.0137	0.0043(U)	0.0068	0.19	0.15
	Mercury (mg/l)		0.0001(U)	0.0001(U)	0.0001		0.0024
	Selenium (mg/l)		0.0748	0.0806	0.0777		0.005
	Silver (mg/l)		0.0019(U)	0.002(U)	0.002		
Sediment Trap North	Radium-226 (pCi/l)	0.19(0.11)			0.15	NL[d]	5.0
	Radium-228 (pCi/l)	1.87			1.87	NL[d]	5.0
	Uranium-234 (pCi/l)	3.55(-1.29)			1.78	NL[d]	
	Uranium-235 (pCi/l)	-0.11			-0.11	NL[d]	
	Uranium-238 (pCi/l)	14.25(10.15)			12.2	NL[d]	
	Thorium-228 (pCi/l)	1.87(-0.14)			0.94	NL[d]	15.0[e]
	Thorium-230 (pCi/l)	320.3(16.75)			168.53	NL[d]	15.0[e]
	Thorium-232 (pCi/l)	1.87(0.0)			0.94	NL[d]	15.0[e]
	Potassium-40 (pCi/l)	0.6					
	Cesium-137 (pCi/l)	0.01					
	Actinium-227 (pCi/l)	-5.84					
	Protectinium-231 (pCi/l)	-2.72				NL[d]	15.0
	Americium-241 (pCi/l)	1.11					15.0

[b] Accumulated runoff collected at the locations identified as west of west culvert and east of west culvert were discharged through Outfall PN01b. Accumulated runoff collected at the location identifiedas sediment trap north was discharged through Outfall PN02.
[c] The November 4, 1998 event included collection of replicate samples. Results for both samples are reported.
[d] NL = Not Limited. Total radium, total thorium, total Uranium, Ac-227 and Pc-231 must be monitored and reported at SLAPS.
[e] The AWQC for gross alpha of 15.0 pCi/l is applied to alpha emitting isotopes except for uranium.
[f] Limits are monthly average and (daily maximum).

3.4.3 Evaluation of the 1998 Storm-Water Discharge Monitoring Results at HISS

The MDNR renewed a National Pollutant Discharge Elimination System (NPDES) operating permit for the discharge of storm water from two outfalls at the HISS in 1995. These outfall locations, HN01 and HN02, are depicted in Figure 3-6. The permit requires monthly monitoring at the outfalls for TSS and establishes daily maximum limit for TSS of 1.5 ml/l/hr and a cumulative daily average limit per month of 1.0 ml/l/hr for TSS. Quarterly monitoring of pH, specific conductance, TOC, TOX, and radiological parameters is also required at HISS. Historically, monitoring of storm-water discharges at HISS has been conducted to comply with these discharge requirements. During 1998, storm-water discharges from the two HISS outfalls were sampled for TSS each month that flow occurred. Storm-water discharge monitoring for TSS was not conducted in August or December due to insufficient precipitation and/or duration of event. Results for storm water discharge monitoring at HISS during 1998 are presented in Table 3-8.

Table 3-8. TSS Results from 1998 Storm-water Discharge Monitoring at HISS

Station	Date Collected	Parameters	Results
STW001	7/26/98	Total Suspended Solids (ml/l/hr)	0.1
STW002	7/30/98	Total Suspended Solids (ml/l/hr)	0.1
STW001	8/18/98	Total Suspended Solids (ml/l/hr)	0.1
STW002	8/18/98	Total Suspended Solids (ml/l/hr)	0.1
STW001	10/6/98	Total Suspended Solids (ml/l/hr	0.1
STW002	10/6/98	Total Suspended Solids (ml/l/hr)	0.1

In addition to monthly monitoring for TSS, storm-water discharges at HISS were sampled during the first, second, and third quarters of the 1998 calendar year for pH, specific conductance, TOX, TOC, total uranium, gross alpha, gross beta, and the primary radium and thorium isotopes associated with the site. Samples were not taken for fourth quarter due to insufficient discharge in December. As mandated by the permit, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs) were analyzed if positive results were obtained for TOX. Quarterly sampling for these parameters did not occur in September, but a third quarter sampling event had been previously conducted in July.

The available results for TSS for both outfalls were below detection limits and therefore below the daily maximum and monthly average limits. Results for pH indicate that this effluent limit was met.

At HISS outfall HN01, the gross alpha and beta activities for the March 1998, sampling event were 35.47 and 42.33 pCi/l, respectively. Based on the isotopic concentrations, the gross activities in the effluent are primarily attributable to the primary isotopes associated with the HISS site (Ra-226, Th-230, and U-238). Gross alpha and beta activities in the March effluent sample are greater than the gross activities reported for the June and July effluent samples. These differences likely correlate to higher TSS loads in the form of colloidal clay fines in the springtime run-off as a result of greater storm intensity. Higher radioactivity is expected in water

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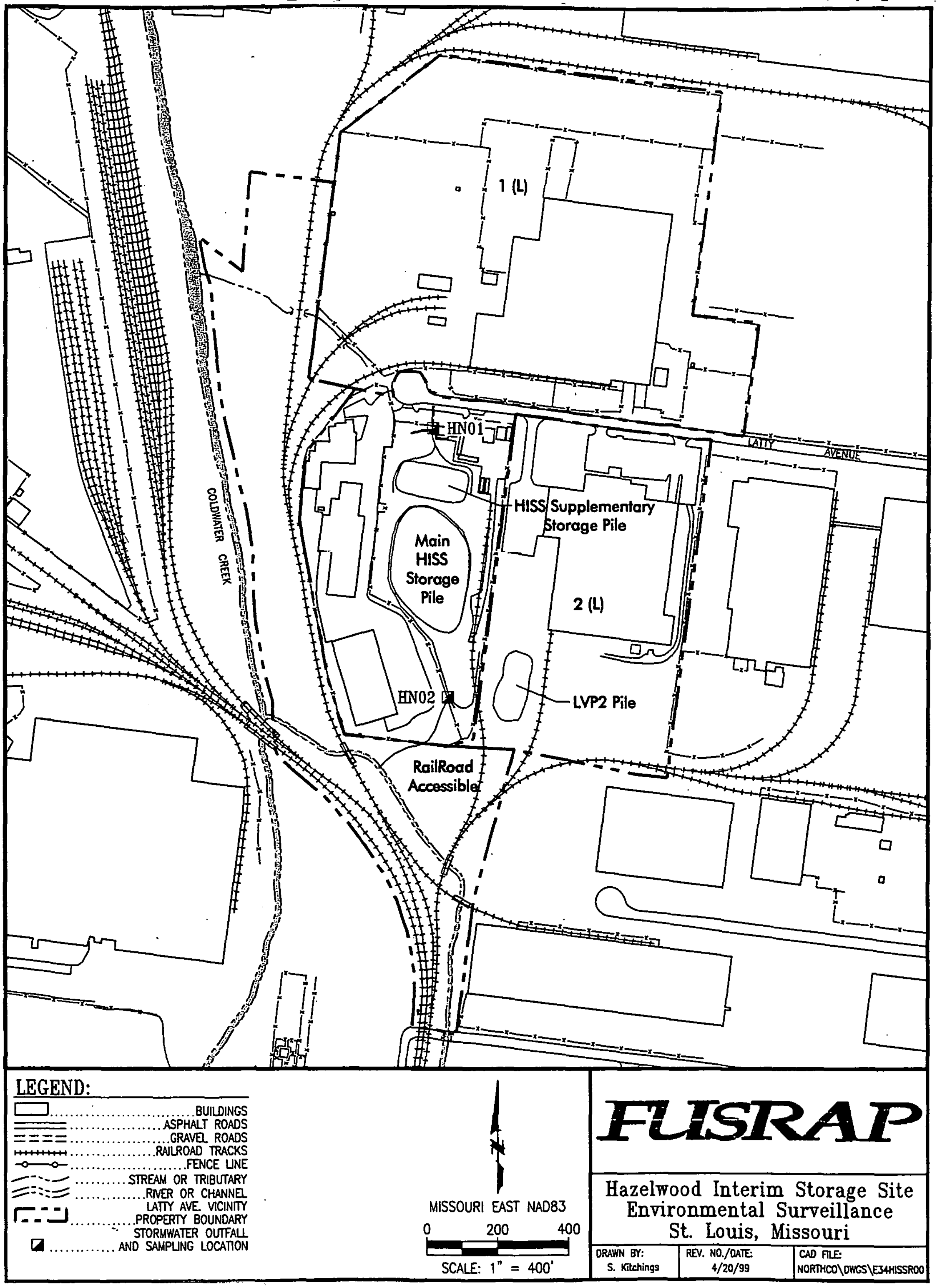

Figure 3-6. Storm Water Sampling Locations at HISS

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samples with greater sediment load because of the propensity of radionuclides to adsorb onto particulate material. At HN02, the gross alpha and beta activities detected in the sample of the March 1998 effluent were 129.9 pCi/l and 36.3 pCi/l, respectively. The gross activities are also largely attributable to Ra-226, Th-230, and uranium. The gross alpha and beta activities in the March effluent were greater than in the subsequent effluent sample with the differences likely resulting from a higher TSS load from a greater storm intensity. A review of historical results from recent EMP annual reports indicated that effluent samples obtained in March tend to exhibit greater activities than samples collected in latter portions of the year. For example, EMP results for 1996 indicated gross alpha and beta activities in the effluent from HN01 were 50%-100% greater in March than in the subsequent discharges. In 1997, the gross alpha and beta activities measured in the effluents from both outfalls in March were three to ten times greater than the activities measured in the summer discharges.

The gross activities in the effluent from HN02 in March 1998, were the activities in the HN01 discharge. These differences in the gross activities associated with the effluents from the two outfalls are not evident in the effluent samples collected later in the year. Increased gross activities in the HN02 effluent relative to the HN01 discharge also occurred in 1996 but were not found in 1997.

In March, the TOC and TOX concentrations measured in the effluent from HN01 were 4.8 mg/l and <0.012 mg/l, respectively. Similar results were obtained for these parameters in the effluent from HN02. Analysis of the VOCs and SVOCs in the HN01 effluent indicated trace concentrations of phenol (1 μg/l), bromacil (12 μg/l), bis (2-ethylhexyl) phthalate (2 μg/l) and silane (7 μg/l). Methylene chloride and acetone were also detected but were present in the blanks. The VOCs and SVOCs detected in the HN02 effluent included di-n-butyl phthalate (0.6 μg/l), bromacil (23 g/l), bis (2-ethylhexyl) phthalate (11 μg/l), and toluene (2 μg/l). Six peaks for unidentified SVOCs at concentrations of 7 to 10 μg/l were found in quantitation of the HN02 effluent. Bromacil is an ingredient of a herbicidal formulation may have been historically applied in the vicinity of HISS. Di-n-butyl and bis (2-ethylhexyl) phthalates are commonly used plasticizers that are common to samples of environmental media from urbanized areas.

Both TSS and pH were within the discharge limits at both outfalls for the sampling events in 1998. However, the maximum and mean gross alpha activities for both outfalls exceeded the AWQC of 15 pCi/l. Additionally, the mean and maximum concentrations of radium isotopes in the HN02 effluent exceeded the AWQC for combined Ra-226 and Ra-228 of 5 pCi/l. None of the AWQC for the chemical pollutants was exceeded. . Furthermore, the measured concentrations of the detected organic pollutants were below the health advisory levels for bromacil (90 g/l) and AWQC for the phthalate esters of 10 CSR 20-7 for a drinking water supply.

3.5 1998 COLDWATER CREEK SURFACE-WATER MONITORING RESULTS

Historical monitoring of Coldwater Creek under the EMP has been limited to evaluation of radium isotopes, thorium isotopes, total uranium, and certain general water quality parameters such as dissolved oxygen, pH, and turbidity. The 1998 EMP surface-water data for Coldwater Creek will be evaluated relative to background evaluation guidelines, risk screening levels, and guidelines derived from environmental regulatory programs. The background criteria were derived for the human health risk assessment addressed by the *North County Potential Contaminants of Concern Assessment Memorandum* (PAM) (USACE, 1999c). These criteria are twice the mean concentration found in the upstream sampling location where Coldwater Creek emerges from underneath Banshee Road directly upstream of SLAPS (location C002). 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. The AWQC for Class I and Class V streams are listed in Table 3-9.

The EMP has historically conducted semi-annual sampling of surface water and sediment in Coldwater Creek during the second and fourth quarters of the calendar year. For 1998, the sampling events for surface water at Coldwater Creek took place in April, July, and August. These EMP samples were collected from the surface water stations along the creek as identified previously in Figure 3-5 as C002, C003, C004, C005, C006, and C007. Station C002 is the historical EMP background location at the northern end of St. Louis International Airport. Sampling stations C005 and C006 are located at the confluence of tributary streams and Coldwater Creek in the vicinity of HISS.

Parameters that were analyzed historically for these surface water samples include unfiltered water samples for the analytes Ra-226, Ra-228, Th-228, Th-230, Th-232, and total uranium. During April 1998, the six EMP sampling stations along Coldwater Creek were sampled for the indicated parameters. Results for radiological parameters measured during the April 1998 monitoring of surface-water quality in Coldwater Creek are presented in Table 3-10. Total uranium concentrations ranged from 1 to 2 µg/l (~1.4 pCi/l) at stations C002, C005, and C006. Total uranium concentrations of 16 µg/l (~11.2 pCi/l) were found at stations C003 and C007 which are the locations downstream of HISS. The maximum total uranium concentration of 22.9 µg/L (~16 pCi/l) was found at station C004 which is downstream of SLAPS and 500 ft. upstream of HISS.

For the April 1998 sampling event, the maximum activity-based concentrations of Th-228, Ra-226, and Ra-228 also occurred at sampling station C004 (Table 3-10). The Th-228 concentrations range from 0.05 to 0.31 pCi/l, with the lowest concentration occurring at C006. The Ra-226 concentrations range from 0.07 to 0.47 pCi/l, with the lowest reading again occurring at C006. Ra-228 concentrations also follow this trend; the highest concentration of 0.31 pCi/l occurs at C004, and the lowest concentration of 0.05 pCi/l is found at C006. For Th-230, the concentrations range from 0.15 pCi/l at C002 to 0.3 pCi/l at C005. Th-232 concentrations range from 0.05 pCi/l at C002 to 0.54 pCi/l at C003.

Table 3-9. Surface-water AWQC

Parameter	Ambient Water Quality Criteria
Chloride (mg/l)	230.0
Fluoride (mg/l)	4.0
Nitrate (mg/l)	
Nitrite (mg/l)	
Sulfate (mg/l)	
Gross Alpha (pCi/l)	15.0[a]
Gross Beta (pCi/l)	
Total Uranium (mg/l)	
U-234 (pCi/l)	
U-235 (pCi/l)	
U-238 (pCi/l)	15.0[a]
Total Thorium (pCi/l)	15.0[a]
Th-228 (pCi/l)	15.0[a]
Th-230 (pCi/l)	15.0[a]
Th-232 (pCi/l)	15.0[a]
Total Radium (pCi/l)	
Ra-226 (pCi/l)	5.0/15.0[a, b]
Ra-228 (pCi/l)	5.0/15.0[a, b]
Pa-231 (pCi/l)	15.0[a]
Ac-227 (pCi/l)	
Pb-210 (pCi/l)	

[a] AWQC for gross alpha includes radium but excludes uranium.
[b] AWQC for combined Ra-226 and Ra-228.

Table 3-10. April 1998 Radiological Monitoring Results for Surface-Water in Coldwater Creek

Date Sampled	Parameter	C002	C003	C004	C005	C006	C007	Mean Concentration
4/6/98	Total Uranium (pCi/l)	1.4	11.48	16.03	1.33	1.11	11.2	7.09
4/6/98	Th-228 (pCi/l)	0.1	0.08	0.31	0.18	0.05	0.1	0.14
4/6/98	Th-230 (pCi/l)	0.15	0.3	0.25	0.35	0.31	0.24	0.27
4/6/98	Th-232 (pCi/l)	0.05	0.54	0.25	0.12	0.11	0.1	0.21
4/6/98	Ra-226 (pCi/l)	0.2	0.21	0.47	0.19	0.07	0.22	0.23
4/6/98	Ra-228 (pCi/l)	0.1	0.08	0.31	0.18	0.05	0.1	0.14

The surface-water monitoring results from April 1998 which are presented in Table 3-10, were compared with the most recent (1996-1997) historical EMP results at the indicated monitoring locations and the historical data from 1992-1997 (Table 3-12). Radionuclide concentrations measured at the background station C002 in 1998 were consistent with results from 1992 through 1997. In general, the concentrations of the radium and thorium isotopes at the downstream stations in 1998 were consistent with their levels from 1996 and 1997. The concentrations of the radium and thorium isotopes at the downstream sampling locations were also generally consistent with previous results from 1992 through 1995.

Total uranium concentrations detected in 1998 at the monitoring stations (C005 and C006), which are located at the confluence of Coldwater Creek and tributaries in the vicinity of HISS remained consistent with their historical levels. However, the in-stream concentration of uranium at the station downstream of SLAPS (C004) was greater than the concentrations reported in 1996 and 1997. The total uranium concentration at station C004 in 1998 was greater than the historical mean but below the upper tolerance limit (UTL). Uranium concentrations at the monitoring stations downstream of HISS (C003 and C007) were also greater than measured in 1996. At these locations, the uranium concentrations measured in 1998 were greater than their historical means and approached or exceeded the corresponding UTL. Comparison of the April 1998 surface water monitoring results with the historical data is provided in Table 3-12.

The Coldwater Creek surface-water sampling that took place in July and August involved sampling at station C002 only. Complete results from the July and August 1998 sampling can be seen in Table 3-11. The data in Table 3-11 shows the July and August sampling efforts included gathering both unfiltered and filtered water samples for evaluation. This was the first time that the filtered samples had been taken at these locations, so for comparison with the historic data at C002, the unfiltered concentrations will be used.

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
7/22/98	ECUL	Alkalinity, Total (mg/l)	88.5		5	F
7/22/98	ECUL	Alkalinity, Total (mg/l)	89.7		5	UF
7/22/98	ECUL	Chloride (mg/l)	135		10	F
7/22/98	ECUL	Chloride (mg/l)	136		10	UF
7/22/98	ECUL	Fluoride (mg/l)	0.5		0.5	F
7/22/98	ECUL	Fluoride (mg/l)	0.5		0.5	UF
7/22/98	ECUL	Nitrate (mg/l)	131		2	F
7/22/98	ECUL	Nitrate (mg/l)	135		4	UF
7/22/98	ECUL	Nitrite (mg/l)	0.82		0.1	F
7/22/98	ECUL	Nitrite (mg/l)	0.748		0.1	UF
7/22/98	ECUL	Sulfate (mg/l)	77.9		2.5	F
7/22/98	ECUL	Sulfate (mg/l)	75.6		2.5	UF
7/22/98	ECUL	Ammonia (µg/l)	362		50	F
7/22/98	ECUL	Ammonia (µg/l)	415		50	UF
7/22/98	ECUL	Hardness (mg/l)	544		1	F
7/22/98	ECUL	Hardness(mg/l)	531.6		5	UF
7/22/98	ECUL	Phosphorus (µg/l)	133		50	F
7/22/98	ECUL	Phosphorus (µg/l)	376		50	UF
7/22/98	ECUL	Aluminum (µg/l)	234		200	F
7/22/98	ECUL	Aluminum (µg/l)	399		200	UF
7/22/98	ECUL	Antimony (µg/l)	54.9		60	F
7/22/98	ECUL	Antimony (µg/l)	29.1		60	UF
7/22/98	ECUL	Arsenic (µg/l)	2		10	F
7/22/98	ECUL	Arsenic (µg/l)	2		10	UF
7/22/98	ECUL	Barium (µg/l)	128		200	F
7/22/98	ECUL	Barium (µg/l)	165		200	UF
7/22/98	ECUL	Beryllium (µg/l)	0.6		5	F
7/22/98	ECUL	Beryllium (µg/l)	0.6		5	UF
7/22/98	ECUL	Boron (µg/l)	129		200	F

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
7/22/98	ECUL	Boron (µg/l)	121		200	UF
7/22/98	ECUL	Cadmium (µg/l)	2.5		5	F
7/22/98	ECUL	Cadmium (µg/l)	2.5		5	UF
7/22/98	ECUL	Calcium (µg/l)	153000		5000	F
7/22/98	ECUL	Calcium (µg/l)	159000		5000	UF
7/22/98	ECUL	Chromium (µg/l)	4.2		10	F
7/22/98	ECUL	Chromium (µg/l)	4.2		10	UF
7/22/98	ECUL	Cobalt (µg/l)	14.9		50	F
7/22/98	ECUL	Cobalt (µg/l)	18.1		50	UF
7/22/98	ECUL	Copper (µg/l)	26		25	F
7/22/98	ECUL	Copper (µg/l)	29.5		25	UF
7/22/98	ECUL	Iron (µg/l)	60.5		100	F
7/22/98	ECUL	Iron (µg/l)	374		100	UF
7/22/98	ECUL	Lead (µg/l)	1.6		3	F
7/22/98	ECUL	Lead (µg/l)	5.5		3	UF
7/22/98	ECUL	Lithium (µg/l)	3		50	F
7/22/98	ECUL	Lithium (µg/l)	3		50	UF
7/22/98	ECUL	Magnesium (µg/l)	30400		5000	F
7/22/98	ECUL	Magnesium (µg/l)	31800		5000	UF
7/22/98	ECUL	Manganese (µg/l)	58		15	F
7/22/98	ECUL	Manganese (µg/l)	66.1		15	UF
7/22/98	ECUL	Mercury (µg/l)	0.1		0.2	F
7/22/98	ECUL	Mercury (µg/l)	0.1		0.2	UF
7/22/98	ECUL	Molybdenum (µg/l)	18.2		40	F
7/22/98	ECUL	Molybdenum (µg/l)	19.1		40	UF
7/22/98	ECUL	Nickel (µg/l)	32.3		40	F
7/22/98	ECUL	Nickel (µg/l)	37.2		40	UF
7/22/98	ECUL	Potassium (µg/l)	6480		5000	F
7/22/98	ECUL	Potassium (µg/l)	6410		5000	UF
7/22/98	ECUL	Selenium (µg/l)	752		5	F
7/22/98	ECUL	Selenium (µg/l)	734		5	UF
7/22/98	ECUL	Silver (µg/l)	6		10	F
7/22/98	ECUL	Silver (µg/l)	6		10	UF
7/22/98	ECUL	Sodium (µg/l)	123000		5000	F
7/22/98	ECUL	Sodium (µg/l)	122000		5000	UF
7/22/98	ECUL	Strontium (µg/l)	487		50	F
7/22/98	ECUL	Strontium (µg/l)	508		50	UF
7/22/98	ECUL	Thallium (µg/l)	3.3		10	F
7/22/98	ECUL	Thallium (µg/l)	3.3		10	UF
7/22/98	ECUL	Titanium (µg/l)	35.6		50	F
7/22/98	ECUL	Titanium (µg/l)	48.6		50	UF
7/22/98	ECUL	Uranium (µg/l)	301		500	F
7/22/98	ECUL	Uranium (µg/l)	275		500	UF
7/22/98	ECUL	Vanadium (µg/l)	17.6		50	F
7/22/98	ECUL	Vanadium (µg/l)	17.7		50	UF

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
7/22/98	ECUL	Zinc (µg/l)	15.7		20	F
7/22/98	ECUL	Zinc (µg/l)	18.4		20	UF
7/22/98	ECUL	Total Dissolved Solids (mg/l)	1523		5	UF
7/22/98	ECUL	Total Suspended Solids (mg/l)	15		1	UF
7/22/98	ECUL	2,4,5-T (µg/l)	1		1	UF
7/22/98	ECUL	2,4,5-TP (Silvex) (µg/l)	1		1	UF
7/22/98	ECUL	2,4-D (µg/l)	4		4	UF
7/22/98	ECUL	2,4-DB (µg/l)	4		4	UF
7/22/98	ECUL	Dalapon (µg/l)	2		2	UF
7/22/98	ECUL	Dicamba (µg/l)	2		2	UF
7/22/98	ECUL	Dichloroprop (µg/l)	4		4	UF
7/22/98	ECUL	Dinoseb (µg/l)	0.6		0.6	UF
7/22/98	ECUL	MCPA (µg/l)	400		400	UF
7/22/98	ECUL	MCPP (Mecoprop) (µg/l)	400		400	UF
7/22/98	ECUL	4,4'-DDD (µg/l)	0.05		0.05	UF
7/22/98	ECUL	4,4'-DDE (µg/l)	0.05		0.05	UF
7/22/98	ECUL	4,4'-DDT (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Aldrin (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Alpha Chlordane (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Alpha-BHC (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Aroclor-1016 (µg/l)	1		1	UF
7/22/98	ECUL	Aroclor-1221 (µg/l)	1		1	UF
7/22/98	ECUL	Aroclor-1232 (µg/l)	1		1	UF
7/22/98	ECUL	Aroclor-1242 (µg/l)	1		1	UF
7/22/98	ECUL	Aroclor-1248 (µg/l)	1		1	UF
7/22/98	ECUL	Aroclor-1254 (µg/l)	1		1	UF
7/22/98	ECUL	Aroclor-1260 (µg/l)	1		1	UF
7/22/98	ECUL	Beta-BHC (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Delta-BHC (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Dieldrin (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Endosulfan I (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Endosulfan II (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Endosulfan Sulfate (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Endrin (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Endrin Aldehyde (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Endrin Ketone (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Gamma Chlordane (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Gamma-BHC (Lindane) (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Heptachlor (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Heptachlor Epoxide (µg/l)	0.05		0.05	UF
7/22/98	ECUL	Methoxychlor (µg/l)	0.5		0.5	UF
7/22/98	ECUL	Toxaphene (µg/l)	2		2	UF
7/22/98	ECUL	1,2,4-Trichlorobenzene (µg/l)	10		10	UF
7/22/98	ECUL	1,2-Dichlorobenzene (µg/l)	10		10	UF
7/22/98	ECUL	1,3-Dichlorobenzene (µg/l)	10		10	UF

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
7/22/98	ECUL	1,4-Dichlorobenzene (µg/l)	10		10	UF
7/22/98	ECUL	2,2'-oxybis (1-chloropropane) (µg/l)	10		10	UF
7/22/98	ECUL	2,4,5-Trichlorophenol (µg/l)	25		10	UF
7/22/98	ECUL	2,4,6-Trichlorophenol (µg/l)	10		10	UF
7/22/98	ECUL	2,4-Dichlorophenol (µg/l)	10		10	UF
7/22/98	ECUL	2,4-Dimethylphenol (µg/l)	10		10	UF
7/22/98	ECUL	2,4-Dinitrophenol (µg/l)	25		25	UF
7/22/98	ECUL	2,4-Dinitrotoluene (µg/l)	10		10	UF
7/22/98	ECUL	2,6-Dinitrotoluene (µg/l)	10		10	UF
7/22/98	ECUL	2-Chloronaphthalene (µg/l)	10		10	UF
7/22/98	ECUL	2-Chlorophenol (µg/l)	10		10	UF
7/22/98	ECUL	2-Methylnaphthalene (µg/l)	10		10	UF
7/22/98	ECUL	2-Methylphenol (µg/l)	10		10	UF
7/22/98	ECUL	2-Nitroaniline (µg/l)	25		25	UF
7/22/98	ECUL	2-Nitrophenol (µg/l)	10		10	UF
7/22/98	ECUL	3,3'-Dichlorobenzidine (µg/l)	10		10	UF
7/22/98	ECUL	3-Nitroaniline (µg/l)	25		25	UF
7/22/98	ECUL	4,6-Dinitro-o-Cresol (µg/l)	25		25	UF
7/22/98	ECUL	4-Bromophenyl-phenyl Ether (µg/l)	10		10	UF
7/22/98	ECUL	4-chloro-3-methylphenol (µg/l)	10		10	UF
7/22/98	ECUL	4-Chloroaniline (µg/l)	10		10	UF
7/22/98	ECUL	4-Chlorophenyl-phenylether (µg/l)	10		10	UF
7/22/98	ECUL	4-Methylphenol (µg/l)	10		10	UF
7/22/98	ECUL	4-Nitroaniline (µg/l)	25		25	UF
7/22/98	ECUL	4-Nitrophenol (µg/l)	25		25	UF
7/22/98	ECUL	Acenaphthene (µg/l)	10		10	UF
7/22/98	ECUL	Acenaphthylene (µg/l)	10		10	UF
7/22/98	ECUL	Anthracene (µg/l)	10		10	UF
7/22/98	ECUL	Benzo(a)anthracene (µg/l)	10		10	UF
7/22/98	ECUL	Benzo(a)pyrene (µg/l)	10		10	UF
7/22/98	ECUL	Benzo(b)fluoranthene (µg/l)	10		10	UF
7/22/98	ECUL	Benzo(g,h,i)perylene (µg/l)	10		10	UF
7/22/98	ECUL	Benzo(k)fluoranthene (µg/l)	10		10	UF
7/22/98	ECUL	Bis(2-chloroethoxy)methane (µg/l)	10		10	UF
7/22/98	ECUL	Bis(2-chloroethyl)ether (µg/l)	10		10	UF
7/22/98	ECUL	Bis(2-ethylhexyl)phthalate (µg/l)	10		10	UF
7/22/98	ECUL	Butyl Benzyl Phthalate (µg/l)	10		10	UF
7/22/98	ECUL	Carbazole (µg/l)	10		10	UF
7/22/98	ECUL	Chrysene (µg/l)	10		10	UF
7/22/98	ECUL	Dibenzo(a,h)anthracene (µg/l)	10		10	UF
7/22/98	ECUL	Dibenzofuran (µg/l)	10		10	UF
7/22/98	ECUL	Diethyl Phthalate (µg/l)	10		10	UF
7/22/98	ECUL	Dimethyl Phthalate (µg/l)	10		10	UF
7/22/98	ECUL	Di-n-butyl Phthalate (µg/l)	10		10	UF
7/22/98	ECUL	Di-n-octyl Phthalate (µg/l)	10		10	UF

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
7/22/98	ECUL	Fluoranthene (µg/l)	10		10	UF
7/22/98	ECUL	Fluorene (µg/l)	10		10	UF
7/22/98	ECUL	Hexachlorobenzene (µg/l)	10		10	UF
7/22/98	ECUL	Hexachlorobutadiene (µg/l)	10		10	UF
7/22/98	ECUL	Hexachlorocyclopentadiene (µg/l)	10		10	UF
7/22/98	ECUL	Hexachloroethane (µg/l)	10		10	UF
7/22/98	ECUL	Indeno(1,2,3-cd)pyrene (µg/l)	10		10	UF
7/22/98	ECUL	Isophorone (µg/l)	10		10	UF
7/22/98	ECUL	Naphthalene (µg/l)	10		10	UF
7/22/98	ECUL	Nitrobenzene (µg/l)	10		10	UF
7/22/98	ECUL	N-Nitroso-di-n-propylamine (µg/l)	10		10	UF
7/22/98	ECUL	N-Nitrosodiphenylamine (µg/l)	10		10	UF
7/22/98	ECUL	Pentachlorophenol (µg/l)	25		25	UF
7/22/98	ECUL	Phenanthrene (µg/l)	10		10	UF
7/22/98	ECUL	Phenol (µg/l)	10		10	UF
7/22/98	ECUL	Pyrene (µg/l)	10		10	UF
7/22/98	ECUL	Total Organic Carbon (mg/l)	23.9		1	F
7/22/98	ECUL	Total Organic Carbon (mg/l)	28		1	UF
7/22/98	ECUL	1,1,1-Trichloroethane (µg/l)	5		5	UF
7/22/98	ECUL	1,1,2,2-Tetrachloroethane (µg/l)	5		5	UF
7/22/98	ECUL	1,1,2-Trichloro-1,2,2-trifluoroethane (µg/l)	10		10	UF
7/22/98	ECUL	1,1,2-Trichloroethane (µg/l)	5		5	UF
7/22/98	ECUL	1,1-Dichloroethane (µg/l)	5		5	UF
7/22/98	ECUL	1,1-Dichloroethene (µg/l)	5		5	UF
7/22/98	ECUL	1,2-Dichloroethane (µg/l)	5		5	UF
7/22/98	ECUL	1,2-Dichloroethene (µg/l)	5		5	UF
7/22/98	ECUL	1,2-Dichloropropane (µg/l)	5		5	UF
7/22/98	ECUL	1,3-cis-Dichloropropene (µg/l)	5		5	UF
7/22/98	ECUL	1,3-trans-Dichloropropene (µg/l)	5		5	UF
7/22/98	ECUL	2-Butanone (µg/l)	10		10	UF
7/22/98	ECUL	2-Hexanone (µg/l)	10		10	UF
7/22/98	ECUL	4-Methyl-2-pentanone (µg/l)	10		10	UF
7/22/98	ECUL	Acetone (µg/l)	10		10	UF
7/22/98	ECUL	Benzene (µg/l)	5		5	UF
7/22/98	ECUL	Bromodichloromethane (µg/l)	5		5	UF
7/22/98	ECUL	Bromoform (µg/l)	5		5	UF
7/22/98	ECUL	Bromomethane (µg/l)	10		10	UF
7/22/98	ECUL	Carbon Disulfide (µg/l)	5		5	UF
7/22/98	ECUL	Carbon Tetrachloride (µg/l)	5		5	UF
7/22/98	ECUL	Chlorobenzene (µg/l)	5		5	UF
7/22/98	ECUL	Chloroethane (µg/l)	10		10	UF
7/22/98	ECUL	Chloroform (µg/l)	5		5	UF
7/22/98	ECUL	Chloromethane (µg/l)	10		10	UF
7/22/98	ECUL	Dibromochloromethane (µg/l)	5		5	UF
7/22/98	ECUL	Ethylbenzene (µg/l)	5		5	UF
7/22/98	ECUL	Methylene Chloride (µg/l)	5		5	UF

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
7/22/98	ECUL	Styrene (μg/l)	5		5	UF
7/22/98	ECUL	Tetrachloroethene (μg/l)	5		5	UF
7/22/98	ECUL	Toluene (μg/l)	5		5	UF
7/22/98	ECUL	Trichloroethene (μg/l)	14		5	UF
7/22/98	ECUL	Vinyl Chloride (μg/l)	10		10	UF
7/22/98	ECUL	Xylenes, Total (μg/l)	5		5	UF
7/22/98	ECUL	Radium-226 (pCi/l)	2.9	1.36	1.19	F
7/22/98	ECUL	Radium-226 (pCi/l)	3.07	1.63	1.94	UF
7/22/98	ECUL	Thorium-228 (pCi/l)	0.3	0.52	0.93	F
7/22/98	ECUL	Thorium-228 (pCi/l)	0.4	0.56	0.9	UF
7/22/98	ECUL	Thorium-230 (pCi/l)	1.83	1.03	1.12	F
7/22/98	ECUL	Thorium-230 (pCi/l)	16.86	3.49	1.08	UF
7/22/98	ECUL	Thorium-232 (pCi/l)	0.22	0.31	0.3	F
7/22/98	ECUL	Thorium-232 (pCi/l)	0	0	0.29	UF
7/22/98	ECUL	Uranium-234 (pCi/l)	102.4	17.35	0.31	F
7/22/98	ECUL	Uranium-234 (pCi/l)	108.2	25.88	1.98	UF
7/22/98	ECUL	Uranium-235 (pCi/l)	3.35	1.5	0.86	F
7/22/98	ECUL	Uranium-235 (pCi/l)	8.11	3.76	1.99	UF
7/22/98	ECUL	Uranium-238 (pCi/l)	103.2	17.46	0.31	F
7/22/98	ECUL	Uranium-238 (pCi/l)	117.9	27.98	0.72	UF
7/28/98	UPSTR	Alkalinity, Total (mg/l)	212		5	F
7/28/98	UPSTR	Alkalinity, Total (mg/l)	182		5	UF
7/28/98	UPSTR	Chloride (mg/l)	122		8	F
7/28/98	UPSTR	Chloride (mg/l)	105		8	UF
7/28/98	UPSTR	Fluoride (mg/l)	0.66		0.2	F
7/28/98	UPSTR	Fluoride (mg/l)	0.72		0.2	UF
7/28/98	UPSTR	Nitrate (mg/l)	2.47		0.1	F
7/28/98	UPSTR	Nitrate (mg/l)	2.51		0.1	UF
7/28/98	UPSTR	Nitrite (mg/l)	0.19		0.1	F
7/28/98	UPSTR	Nitrite (mg/l)	0.15		0.1	UF
7/28/98	UPSTR	Sulfate (mg/l)	89.9		2.5	F
7/28/98	UPSTR	Sulfate (mg/l)	92.8		2.5	UF
7/28/98	UPSTR	Ammonia (μg/l)	250		50	F
7/28/98	UPSTR	Ammonia (μg/l)	232		50	UF
7/28/98	UPSTR	Hardness (μg/l)	281		5	F
7/28/98	UPSTR	Hardness (μg/l)	280		5	UF
7/28/98	UPSTR	Phosphorus (μg/l)	50		50	F
7/28/98	UPSTR	Phosphorus (μg/l)	50		50	UF
7/28/98	UPSTR	Aluminum (μg/l)	31.9		200	F
7/28/98	UPSTR	Aluminum (μg/l)	998		200	UF
7/28/98	UPSTR	Antimony (μg/l)	29.1		60	F
7/28/98	UPSTR	Antimony (μg/l)	29.1		60	UF
7/28/98	UPSTR	Arsenic (μg/l)	2.2		10	F
7/28/98	UPSTR	Arsenic (μg/l)	3.5		10	UF
7/28/98	UPSTR	Barium (μg/l)	115		200	F

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
7/28/98	UPSTR	Barium (μg/l)	114		200	UF
7/28/98	UPSTR	Beryllium (μg/l)	0.6		5	F
7/28/98	UPSTR	Beryllium (μg/l)	0.7		5	UF
7/28/98	UPSTR	Boron (μg/l)	85.8		200	F
7/28/98	UPSTR	Boron (μg/l)	92		200	UF
7/28/98	UPSTR	Cadmium (μg/l)	2.5		5	F
7/28/98	UPSTR	Cadmium (μg/l)	3.1		5	UF
7/28/98	UPSTR	Calcium (μg/l)	78600		5000	F
7/28/98	UPSTR	Calcium (μg/l)	63700		5000	UF
7/28/98	UPSTR	Chromium (μg/l)	4.2		10	F
7/28/98	UPSTR	Chromium (μg/l)	6.1		10	UF
7/28/98	UPSTR	Cobalt (μg/l)	4		50	F
7/28/98	UPSTR	Cobalt (μg/l)	4		50	UF
7/28/98	UPSTR	Copper (μg/l)	7		25	F
7/28/98	UPSTR	Copper (μg/l)	21.1		25	UF
7/28/98	UPSTR	Iron (μg/l)	58.6		100	F
7/28/98	UPSTR	Iron (μg/l)	2070		100	UF
7/28/98	UPSTR	Lead (μg/l)	1.6		3	F
7/28/98	UPSTR	Lead (μg/l)	9.4		3	UF
7/28/98	UPSTR	Lithium (μg/l)	10		50	F
7/28/98	UPSTR	Lithium (μg/l)	8.6		50	UF
7/28/98	UPSTR	Magnesium (μg/l)	30900		5000	F
7/28/98	UPSTR	Magnesium (μg/l)	25600		5000	UF
7/28/98	UPSTR	Manganese (μg/l)	284		15	F
7/28/98	UPSTR	Manganese (μg/l)	292		15	UF
7/28/98	UPSTR	Mercury (μg/l)	0.1		0.2	F
7/28/98	UPSTR	Mercury (μg/l)	0.1		0.2	UF
7/28/98	UPSTR	Molybdenum (μg/l)	8		40	F
7/28/98	UPSTR	Molybdenum (μg/l)	12.4		40	UF
7/28/98	UPSTR	Nickel (μg/l)	11.2		40	F
7/28/98	UPSTR	Nickel (μg/l)	11.2		40	UF
7/28/98	UPSTR	Potassium (μg/l)	12200		5000	F
7/28/98	UPSTR	Potassium (μg/l)	8480		5000	UF
7/28/98	UPSTR	Selenium (μg/l)	3.6		5	F
7/28/98	UPSTR	Selenium (μg/l)	2.6		5	UF
7/28/98	UPSTR	Silver (μg/l)	6		10	F
7/28/98	UPSTR	Silver (μg/l)	6		10	UF
7/28/98	UPSTR	Sodium (μg/l)	62200		5000	F
7/28/98	UPSTR	Sodium (μg/l)	60300		5000	UF
7/28/98	UPSTR	Strontium (μg/l)	481		50	F
7/28/98	UPSTR	Strontium (μg/l)	375		50	UF
7/28/98	UPSTR	Thallium (μg/l)	3.3		10	F
7/28/98	UPSTR	Thallium (μg/l)	3.3		10	UF
7/28/98	UPSTR	Titanium (μg/l)	8.6		50	F
7/28/98	UPSTR	Titanium (μg/l)	34.9		50	UF

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
7/28/98	UPSTR	Uranium (µg/l)	122		500	F
7/28/98	UPSTR	Uranium (µg/l)	122		500	UF
7/28/98	UPSTR	Vanadium (µg/l)	11.9		50	F
7/28/98	UPSTR	Vanadium (µg/l)	9.9		50	UF
7/28/98	UPSTR	Zinc (µg/l)	29.4		20	F
7/28/98	UPSTR	Zinc (µg/l)	56.8		20	UF
7/28/98	UPSTR	Total Dissolved Solids (mg/l)	535		5	UF
7/28/98	UPSTR	Total Suspended Solids (mg/l)	68		1	UF
7/28/98	UPSTR	1,2,4-Trichlorobenzene (µg/l)	10		10	UF
7/28/98	UPSTR	1,2-Dichlorobenzene (µg/l)	10		10	UF
7/28/98	UPSTR	1,3-Dichlorobenzene (µg/l)	10		10	UF
7/28/98	UPSTR	1,4-Dichlorobenzene (µg/l)	10		10	UF
7/28/98	UPSTR	2,2'-oxybis (1-chloropropane) (µg/l)	10		10	UF
7/28/98	UPSTR	2,4,5-Trichlorophenol (µg/l)	25		25	UF
7/28/98	UPSTR	2,4,6-Trichlorophenol (µg/l)	10		10	UF
7/28/98	UPSTR	2,4-Dichlorophenol (µg/l)	10		10	UF
7/28/98	UPSTR	2,4-Dimethylphenol (µg/l)	10		10	UF
7/28/98	UPSTR	2,4-Dinitrophenol (µg/l)	25		25	UF
7/28/98	UPSTR	2,4-Dinitrotoluene (µg/l)	10		10	UF
7/28/98	UPSTR	2,6-Dinitrotoluene (µg/l)	10		10	UF
7/28/98	UPSTR	2-Chloronaphthalene (µg/l)	10		10	UF
7/28/98	UPSTR	2-Chlorophenol (µg/l)	10		10	UF
7/28/98	UPSTR	2-Methylnaphthalene (µg/l)	10		10	UF
7/28/98	UPSTR	2-Methylphenol (µg/l)	10		10	UF
7/28/98	UPSTR	2-Nitroaniline (µg/l)	25		25	UF
7/28/98	UPSTR	2-Nitrophenol (µg/l)	10		10	UF
7/28/98	UPSTR	3,3'-Dichlorobenzidine (µg/l)	10		10	UF
7/28/98	UPSTR	3-Nitroaniline (µg/l)	25		25	UF
7/28/98	UPSTR	4,6-Dinitro-o-Cresol (µg/l)	25		25	UF
7/28/98	UPSTR	4-Bromophenyl-phenyl Ether (µg/l)	10		10	UF
7/28/98	UPSTR	4-chloro-3-methylphenol (µg/l)	10		10	UF
7/28/98	UPSTR	4-Chloroaniline (µg/l)	10		10	UF
7/28/98	UPSTR	4-Chlorophenyl-phenylether (µg/l)	10		10	UF
7/28/98	UPSTR	4-Methylphenol (µg/l)	10		10	UF
7/28/98	UPSTR	4-Nitroaniline (µg/l)	25		25	UF
7/28/98	UPSTR	4-Nitrophenol (µg/l)	25		25	UF
7/28/98	UPSTR	Acenaphthene (µg/l)	10		10	UF
7/28/98	UPSTR	Acenaphthylene (µg/l)	10		10	UF
7/28/98	UPSTR	Anthracene (µg/l)	10		10	UF
7/28/98	UPSTR	Benzo(a)anthracene (µg/l)	10		10	UF
7/28/98	UPSTR	Benzo(a)pyrene (µg/l)	10		10	UF
7/28/98	UPSTR	Benzo(b)fluoranthene (µg/l)	10		10	UF
7/28/98	UPSTR	Benzo(g,h,i)perylene (µg/l)	10		10	UF
7/28/98	UPSTR	Benzo(k)fluoranthene(µg/l)	10		10	UF
7/28/98	UPSTR	Bis(2-chloroethoxy)methane (µg/l)	10		10	UF

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
7/28/98	UPSTR	Bis(2-chloroethyl)ether (μg/l)	10		10	UF
7/28/98	UPSTR	Bis(2-ethylhexyl)phthalate (μg/l)	5		10	UF
7/28/98	UPSTR	Butyl Benzyl Phthalate (μg/l)	10		10	UF
7/28/98	UPSTR	Carbazole (μg/l)	10		10	UF
7/28/98	UPSTR	Chrysene (μg/l)	10		10	UF
7/28/98	UPSTR	Dibenzo(a,h)anthracene (μg/l)	10		10	UF
7/28/98	UPSTR	Dibenzofuran (μg/l)	10		10	UF
7/28/98	UPSTR	Diethyl Phthalate (μg/l)	10		10	UF
7/28/98	UPSTR	Dimethyl Phthalate (μg/l)	10		10	UF
7/28/98	UPSTR	Di-n-butyl Phthalate (μg/l)	10		10	UF
7/28/98	UPSTR	Di-n-octyl Phthalate (μg/l)	10		10	UF
7/28/98	UPSTR	Fluoranthene (μg/l)	10		10	UF
7/28/98	UPSTR	Fluorene (μg/l)	10		10	UF
7/28/98	UPSTR	Hexachlorobenzene (μg/l)	10		10	UF
7/28/98	UPSTR	Hexachlorobutadiene (μg/l)	10		10	UF
7/28/98	UPSTR	Hexachlorocyclopentadiene (μg/l)	10		10	UF
7/28/98	UPSTR	Hexachloroethane (μg/l)	10		10	UF
7/28/98	UPSTR	Indeno(1,2,3-cd)pyrene (μg/l)	10		10	UF
7/28/98	UPSTR	Isophorone (μg/l)	10		10	UF
7/28/98	UPSTR	Naphthalene (μg/l)	10		10	UF
7/28/98	UPSTR	Nitrobenzene (μg/l)	10		10	UF
7/28/98	UPSTR	N-Nitroso-di-n-propylamine (μg/l)	10		10	UF
7/28/98	UPSTR	N-Nitrosodiphenylamine (μg/l)	10		10	UF
7/28/98	UPSTR	Pentachlorophenol (μg/l)	25		25	UF
7/28/98	UPSTR	Phenanthrene (μg/l)	10		10	UF
7/28/98	UPSTR	Phenol (μg/l)	10		10	UF
7/28/98	UPSTR	Pyrene (μg/l)	10		10	UF
7/28/98	UPSTR	Total Organic Carbon (mg/l)	5.08		1	F
7/28/98	UPSTR	Total Organic Carbon (mg/l)	7.03		1	UF
7/28/98	UPSTR	1,1,1-Trichloroethane (μg/l)	5		5	UF
7/28/98	UPSTR	1,1,2,2-Tetrachloroethane (μg/l)	5		5	UF
7/28/98	UPSTR	1,1,2-Trichloro-1,2,2-trifluoroethane (μg/l)	10		10	UF
7/28/98	UPSTR	1,1,2-Trichloroethane (μg/l)	5		5	UF
7/28/98	UPSTR	1,1-Dichloroethane (μg/l)	5		5	UF
7/28/98	UPSTR	1,1-Dichloroethene (μg/l)	5		5	UF
7/28/98	UPSTR	1,2-Dichloroethane (μg/l)	5		5	UF
7/28/98	UPSTR	1,2-Dichloroethene (μg/l)	1		5	UF
7/28/98	UPSTR	1,2-Dichloropropane (μg/l)	5		5	UF
7/28/98	UPSTR	1,3-cis-Dichloropropene (μg/l)	5		5	UF
7/28/98	UPSTR	1,3-trans-Dichloropropene (μg/l)	5		5	UF
7/28/98	UPSTR	2-Butanone (μg/l)	10		10	UF
7/28/98	UPSTR	2-Hexanone (μg/l)	10		10	UF
7/28/98	UPSTR	4-Methyl-2-pentanone (μg/l)	10		10	UF
7/28/98	UPSTR	Acetone (μg/l)	82		10	UF
7/28/98	UPSTR	Benzene (μg/l)	5		5	UF

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
7/28/98	UPSTR	Bromodichloromethane (μg/l)	5		5	UF
7/28/98	UPSTR	Bromoform (μg/l)	5		5	UF
7/28/98	UPSTR	Bromomethane (μg/l)	10		10	UF
7/28/98	UPSTR	Carbon Disulfide (μg/l)	5		5	UF
7/28/98	UPSTR	Carbon Tetrachloride (μg/l)	5		5	UF
7/28/98	UPSTR	Chlorobenzene (μg/l)	5		5	UF
7/28/98	UPSTR	Chloroethane (μg/l)	10		10	UF
7/28/98	UPSTR	Chloroform (μg/l)	5		5	UF
7/28/98	UPSTR	Chloromethane (μg/l)	10		10	UF
7/28/98	UPSTR	Dibromochloromethane (μg/l)	5		5	UF
7/28/98	UPSTR	Ethylbenzene (μg/l)	5		5	UF
7/28/98	UPSTR	Methylene Chloride (μg/l)	5		5	UF
7/28/98	UPSTR	Styrene (μg/l)	5		5	UF
7/28/98	UPSTR	Tetrachloroethene (μg/l)	5		5	UF
7/28/98	UPSTR	Toluene (μg/l)	5		5	UF
7/28/98	UPSTR	Trichloroethene (μg/l)	5		5	UF
7/28/98	UPSTR	Vinyl Chloride (μg/l)	10		10	UF
7/28/98	UPSTR	Xylenes, Total (μg/l)	5		5	UF
7/28/98	UPSTR	Radium-226 (pCi/l)	0	0	0.46	F
7/28/98	UPSTR	Radium-226 (pCi/l)	0.07	0.46	1.17	UF
7/28/98	UPSTR	Thorium-228 (pCi/l)	0.8	0.74	0.78	F
7/28/98	UPSTR	Thorium-228 (pCi/l)	-0.06	0.5	1.21	UF
7/28/98	UPSTR	Thorium-230 (pCi/l)	3.67	1.47	0.35	F
7/28/98	UPSTR	Thorium-230 (pCi/l)	0.85	0.61	0.29	UF
7/28/98	UPSTR	Thorium-232 (pCi/l)	0.13	0.26	0.35	F
7/28/98	UPSTR	Thorium-232 (pCi/l)	0	0.26	0.78	UF
7/28/98	UPSTR	Uranium-234 (pCi/l)	2.73	1.37	0.88	F
7/28/98	UPSTR	Uranium-234 (pCi/l)	3.9	1.54	0.74	UF
7/28/98	UPSTR	Uranium-235 (pCi/l)	0	0	0.49	F
7/28/98	UPSTR	Uranium-235 (pCi/l)	-0.15	0.22	1.12	UF
7/28/98	UPSTR	Uranium-238 (pCi/l)	2.57	1.33	0.88	F
7/28/98	UPSTR	Uranium-238 (pCi/l)	5.05	1.77	0.33	UF
8/10/98	UPSTR	1,3-trans-Dichloropropene (μg/l)	5		5	UF
8/10/98	UPSTR	2-Butanone (μg/l)	10		10	UF
8/10/98	UPSTR	2-Hexanone (μg/l)	10		10	UF
8/10/98	UPSTR	4-Methyl-2-pentanone (μg/l)	10		10	UF
8/10/98	UPSTR	Acetone (μg/l)	10		10	UF
8/10/98	UPSTR	Benzene (μg/l)	5		5	UF
8/10/98	UPSTR	Bromodichloromethane (μg/l)	5		5	UF
8/10/98	UPSTR	Bromoform (μg/l)	5		5	UF
8/10/98	UPSTR	Bromomethane (μg/l)	10		10	UF
8/10/98	UPSTR	Carbon Disulfide (μg/l)	5		5	UF
8/10/98	UPSTR	Carbon Tetrachloride (μg/l)	5		5	UF
8/10/98	UPSTR	Chlorobenzene (μg/l)	5		5	UF
8/10/98	UPSTR	Chloroethane (μg/l)	10		10	UF

Table 3-11. Coldwater Creek Surface-Water Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter	Results	Error	Detection Limit	Filtered[b]
8/10/98	UPSTR	Chloroform (µg/l)	5		5	UF
8/10/98	UPSTR	Chloromethane (µg/l)	10		10	UF
8/10/98	UPSTR	Dibromochloromethane (µg/l)	5		5	UF
8/10/98	UPSTR	Ethylbenzene (µg/l)	5		5	UF
8/10/98	UPSTR	Methylene Chloride (µg/l)	5		5	UF
8/10/98	UPSTR	Styrene (µg/l)	5		5	UF
8/10/98	UPSTR	Tetrachloroethene (µg/l)	5		5	UF
8/10/98	UPSTR	Toluene (µg/l)	5		5	UF
8/10/98	UPSTR	Trichloroethene (µg/l)	5		5	UF
8/10/98	UPSTR	Vinyl Chloride (µg/l)	10		10	UF
8/10/98	UPSTR	Xylenes, Total (µg/l)	5		5	UF
8/10/98	UPSTR	Radium-226 (pCi/l)	0.37	0.53	0.89	F
8/10/98	UPSTR	Radium-226 (pCi/l)	0.23	0.6	1.3	UF
8/10/98	UPSTR	Thorium-228 (pCi/l)	0.82	0.69	0.7	F
8/10/98	UPSTR	Thorium-228 (pCi/l)	0.19	0.37	0.7	UF
8/10/98	UPSTR	Thorium-230 (pCi/l)	1.7	0.94	0.7	F
8/10/98	UPSTR	Thorium-230 (pCi/l)	0.87	0.68	0.7	UF
8/10/98	UPSTR	Thorium-232 (pCi/l)	0.23	0.33	0.32	F
8/10/98	UPSTR	Thorium-232 (pCi/l)	0.12	0.23	0.31	UF
8/10/98	UPSTR	Uranium-234 (pCi/l)	0.89	0.76	0.94	F
8/10/98	UPSTR	Uranium-234 (pCi/l)	1.14	0.83	0.39	UF
8/10/98	UPSTR	Uranium-235 (pCi/l)	0.24	0.47	0.94	F
8/10/98	UPSTR	Uranium-235 (pCi/l)	-0.09	0.18	1.06	UF
8/10/98	UPSTR	Uranium-238 (pCi/l)	0.83	0.7	0.76	F
8/10/98	UPSTR	Uranium-238 (pCi/l)	1.42	0.93	0.39	UF

[a]ECUL = East of west culvert. UPSTR = upstream (analgous to C002)
[b]UF = Unfiltered, F = filtered

Table 3-12. Comparison of Historical Surface Water Results for Coldwater Creek

Location	Radionuclide	Units	Average Result	Results >Detection Limit	95% UCL of Mean	03/28/92	09/30/92	04/07/93	10/12/93	04/19/94	10/13/94	04/04/95	10/24/95	04/25/96	10/29/96	05/15/97	04/06/98
C002	Uranium	mg/l	0.001	11/ 11	0.002	0.00163	0.0015	0.0017	0.00147		0.00046	0.0011	0.00069	0.00182	0.00066	0.00136	0.00205
C002	Radium-226	pCi/l	0.37	6/ 11	1.81	0.35	<0.32	<0.14	0.27		<0.12	<0.3	0.67	0.35	0.28	0.88	<0.2
C002	Radium-228	pCi/l	0.15	1/ 4	0.34									<0.05	<0.09	0.34	<0.1
C002	Thorium-228	pCi/l	0.15	1/ 4	0.34									<0.05	<0.09	0.34	<0.1
C002	Thorium-230	pCi/l	0.20	4/ 11	0.56	0.19	<0.26	<-0.01	<0.05		0.15	<0.06	<0.2	<0.18	0.56	0.43	<0.15
C002	Thorium-232	pCi/l	0.07	0/ 9	0.22			<0.02	<0		<0.07	<0.02	<0.14	<0.04	<0.22	<0.1	<0.05
C003	Uranium	mg/l	0.005	12/ 12	0.009	0.00535	0.0033	0.0097	0.00601	0.01365	0.00096	0.0037	0.00304	0.00917	0.00303	0.00378	0.01641
C003	Radium-226	pCi/l	0.36	7/ 12	5.91	1.07	0.34	<0.07	<0.08	0.3	0.3	<0.02	0.5	0.41	0.26	<0.63	<0.21
C003	Radium-228	pCi/l	0.11	0/ 4	0.17									<0.17	<0.09	<0.09	<0.08
C003	Thorium-228	pCi/l	0.11	0/ 4	0.17									<0.17	<0.09	<0.09	<0.08
C003	Thorium-230	pCi/l	0.34	7/ 12	6.31	0.51	<0.04	<0.1	<0.02	<0.17	0.33	0.13	0.25	0.68	0.92	0.6	<0.3
C003	Thorium-232	pCi/l	0.10	0/ 10	0.19			<0.14	<-0.01	<0.01	<0.1	<0.07	<0.17	<0.14	<0.09	<0.19	<0.54
C004	Uranium	mg/l	0.006	12/ 12	0.04	0.00699	0.0039	0.0118	0.00952	0.00152	0.001	0.0048	0.00374	0.01311	0.00378	0.00471	0.02297
C004	Radium-226	pCi/l	0.31	8/ 12	0.77	0.38	0.35	0.38	0.24	<0.06	0.23	0.28	<0.46	0.18	<0.16	0.66	<0.47
C004	Radium-228	pCi/l	0.19	1/ 4	0.36									<0.07	0.36	<0.14	<0.31
C004	Thorium-228	pCi/l	0.19	1/ 4	0.36									<0.07	0.36	<0.14	<0.31
C004	Thorium-230	pCi/l	0.22	5/ 12	0.51	0.22	<0.27	<-0.04	<0.03	<0.06	<0.16	0.24	0.51	<0.14	0.4	0.42	<0.25
C004	Thorium-232	pCi/l	0.07	1/ 10	0.17			<-0.01	<0.03	<0.06	<0.11	<0.02	<0.05	<0.17	<0.13	<0.05	0.25
C005	Uranium	mg/l	0.002	11/ 11	0.008	0.00477	0.0033	0.0015	0.00173		0.00068	0.0016	0.00248	0.00161	0.00163	0.00143	0.00199
C005	Radium-226	pCi/l	0.31	7/ 11	2.12	1.01	0.25	0.21	<-0.01		<0.09	<0.17	0.35	0.52	0.34	<0.18	0.19
C005	Radium-228	pCi/l	0.28	2/ 4	1.62									0.33	0.43	<0.09	<0.18
C005	Thorium-228	pCi/l	0.28	2/ 4	1.62									0.33	0.43	<0.09	<0.18
C005	Thorium-230	pCi/l	0.82	8/ 11	5.2	0.32	<0.4	0.31	0.19		0.18	5.2	0.39	<0.24	0.42	0.55	<0.35
C005	Thorium-232	pCi/l	0.07	0/ 9	0.18			<-0.1	<0		<0.14	<0.07	<0.14	<0.04	<0.05	<0.18	<0.12
C006	Uranium	mg/l	0.001	11/ 11	0.006	0.00375	0.0027	0.0014	0.00165		0.00068	0.0015	0.00255	0.00184	0.00161	0.00146	0.00158
C006	Radium-226	pCi/l	0.52	6/ 11	6.36	3.01	0.41	<0.09	<0.13		<0.08	<0.1	0.64	0.15	0.3	0.25	<0.07
C006	Radium-228	pCi/l	0.15	0/ 4	0.18									<0.11	<0.18	<0.17	<0.05

Table 3-12. Comparison of Historical Surface Water Results for Coldwater Creek (cont'd)

Location	Radionuclide	Units	Average Result	Results >Detection Limit	95% UCL of Mean	03/28/92	09/30/92	04/07/93	10/12/93	04/19/94	10/13/94	04/04/95	10/24/95	04/25/96	10/29/96	05/15/97	04/06/98
C006	Thorium-228	pCi/l	0.15	0/ 4	0.18									<0.11	<0.18	<0.17	<0.05
C006	Thorium-230	pCi/l	0.27	5/ 11	6.0	0.18	<0.48	<-0.05	<0.06		<0.02	<0.09	0.25	0.32	0.43	0.92	<0.31
C006	Thorium-232	pCi/l	0.07	0/ 9	0.14			<-0.01	<0.02		<0.07	<0.04	<0.1	<0.14	<0.04	<0.12	<0.1
											10/27/94						
C007	Uranium	mg/l	0.006	11/ 11	0.02	0.0059	0.005	0.0094	0.00546	0.01028		0.0028	0.00344	0.01045	0.00254	0.0041	0.01602
C007	Radium-226	pCi/l	0.28	4/ 12	0.87	0.87	<0.17	<0.13	<0.15	<0.09	0.16	<0.1	0.42	<0.2	0.54	<0.28	<0.22
C007	Radium-228	pCi/l	0.14	0/ 4	0.31									<0.09	<0.31	<0.05	<0.1
C007	Thorium-228	pCi/l	0.14	0/ 4	0.31									<0.09	<0.31	<0.05	<0.1
C007	Thorium-230	pCi/l	0.33	4/ 12	0.55	0.19	<1.7	<0.08	<0.1	<0.05	<0.23	<0.08	0.27	<0.09	0.4	0.55	<0.24
C007	Thorium-232	pCi/l	0.07	0/ 10	0.29			<0.03	<0	<0.01	<-0.02	<0.01	<0.04	<0.29	<0.04	<0.2	<0.1

3.6 1998 COLDWATER CREEK SEDIMENT MONITORING RESULTS

Monitoring of Coldwater Creek sediments for calendar year 1998 is summarized in this section. The results obtained from these monitoring activities are presented and evaluated with respect to historical data and the appropriate evaluation criteria.

The EMP has historically conducted semi-annual monitoring of Coldwater Creek sediments during the second and fourth quarters of the calendar year. Sediment samples were collected from the previously described surface-water stations (Figures 3-4 and 3-5) and analyzed for Ra-226, Ra-228, Th-228, Th-230, Th-232, and total uranium. Sediment sampling in accordance with this protocol was conducted during April and August 1998.

The available results from monitoring of Coldwater Creek sediments in 1998 are presented in Table 3-13 and Table 3-14. The activity-based concentrations of Ra-228, Th-228, and Th-232 remained constant among all of the sampled stations. The concentrations of Ra-226 and Th-230 ranged from 0.96 pCi/g to 5.14 pCi/g and 1.61 to 201.2 pCi/g, respectively. Minimum concentrations of these isotopes occurred at the background station C002 that is located at the southern boundary of the airport. Maximum concentrations of these radionuclides occurred at sampling station C005 that is located downstream of surface drainage from HISS and certain VPs. The minimum concentration of total uranium (2.33 ppm) occurred at station C006 and is essentially equivalent to the background concentration of 2.75 ppm. The maximum concentration of uranium (10.23 ppm) was also found at station C005. At sampling station C007, which is ~ 3700 ft. downstream of HISS, the Th-230 concentration was greater than background. 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.

Table 3-13. Coldwater Creek Sediment Analytical Results for 1998

Date collected	Station[a]	Parameter Name	Results	Error	Detection Limit	Filtered
8/20/98	UPSTR	Alkalinity, Total (mg/l)	244		5	FALSE
8/20/98	UPSTR	Alkalinity, total (mg/l)	247		5	TRUE
8/20/98	UPSTR	Chloride (mg/l)	136		10	FALSE
8/20/98	UPSTR	Chloride (mg/l)	136		10	TRUE
8/20/98	UPSTR	Fluoride (mg/l)	0.479		0.2	TRUE
8/20/98	UPSTR	Fluoride (mg/l)	0.498		0.2	FALSE
8/20/98	UPSTR	Nitrate (mg/l)	1.52		0.04	FALSE
8/20/98	UPSTR	Nitrate (mg/l)	1.79		0.04	TRUE
8/20/98	UPSTR	Nitrite (mg/l)	0.1		0.1	FALSE
8/20/98	UPSTR	Nitrite (mg/l)	0.1		0.1	TRUE
8/20/98	UPSTR	Sulfate (mg/l)	74		2.5	FALSE
8/20/98	UPSTR	Sulfate (mg/l)	74.8		2.5	TRUE
8/20/98	UPSTR	Ammonia (µg/l)	134		50	TRUE
8/20/98	UPSTR	Ammonia (µg/l)	222		50	FALSE
8/20/98	UPSTR	Hardness (mg/l)	8.98		5	TRUE
8/20/98	UPSTR	Hardness (mg/l)	9.3		5	FALSE

Table 3-13. Coldwater Creek Sediment Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter Name	Results	Error	Detection Limit	Filtered
8/20/98	UPSTR	Phosphorus (µg/l)	103		50	TRUE
8/20/98	UPSTR	Phosphorus (µg/l)	171		50	FALSE
8/20/98	UPSTR	Aluminum (µg/l)	192		200	FALSE
8/20/98	UPSTR	Aluminum (µg/l)	23.6		200	TRUE
8/20/98	UPSTR	Antimony (µg/l)	29.1		60	TRUE
8/20/98	UPSTR	Antimony (µg/l)	40.2		60	FALSE
8/20/98	UPSTR	Arsenic (µg/l)	2.5		10	TRUE
8/20/98	UPSTR	Arsenic (µg/l)	4		10	FALSE
8/20/98	UPSTR	Barium (µg/l)	135		200	TRUE
8/20/98	UPSTR	Barium (µg/l)	139		200	FALSE
8/20/98	UPSTR	Beryllium (µg/l)	0.6		5	TRUE
8/20/98	UPSTR	Beryllium(µg/l)	0.82		5	FALSE
8/20/98	UPSTR	Boron (µg/l)	68.4		200	FALSE
8/20/98	UPSTR	Boron (µg/l)	78.8		200	TRUE
8/20/98	UPSTR	Cadmium (µg/l)	2.5		5	FALSE
8/20/98	UPSTR	Cadmium (µg/l)	2.5		5	TRUE
8/20/98	UPSTR	Calcium (µg/l)	90100		5000	FALSE
8/20/98	UPSTR	Calcium (µg/l)	92700		5000	TRUE
8/20/98	UPSTR	Chromium (µg/l)	4.2		10	FALSE
8/20/98	UPSTR	Chromium (µg/l)	4.2		10	TRUE
8/20/98	UPSTR	Cobalt (µg/l)	4		50	FALSE
8/20/98	UPSTR	Cobalt (µg/l)	4		50	TRUE
8/20/98	UPSTR	Copper (µg/l)	11.1		25	FALSE
8/20/98	UPSTR	Copper (µg/l)	6.2		25	TRUE
8/20/98	UPSTR	Iron (µg/l)	56.6		100	TRUE
8/20/98	UPSTR	Iron (µg/l)	830		100	FALSE
8/20/98	UPSTR	Lead (µg/l)	1.6		3	FALSE
8/20/98	UPSTR	Lead (µg/l)	1.6		3	TRUE
8/20/98	UPSTR	Lithium (µg/l)	12.5		50	TRUE
8/20/98	UPSTR	Lithium (µg/l)	12.6		50	FALSE
8/20/98	UPSTR	Magnesium (µg/l)	33500		5000	FALSE
8/20/98	UPSTR	Magnesium (µg/l)	34700		5000	TRUE
8/20/98	UPSTR	Manganese (µg/l)	257		15	TRUE
8/20/98	UPSTR	Manganese (µg/l)	282		15	FALSE
8/20/98	UPSTR	Mercury (µg/l)	0.1		0.2	FALSE
8/20/98	UPSTR	Mercury (µg/l)	0.1		0.2	TRUE
8/20/98	UPSTR	Molybdenum (µg/l)	7.3		40	FALSE
8/20/98	UPSTR	Molybdenum (µg/l)	9.6		40	TRUE
8/20/98	UPSTR	Nickel (µg/l)	11.2		40	FALSE
8/20/98	UPSTR	Nickel (µg/l)	11.2		40	TRUE
8/20/98	UPSTR	Potassium (µg/l)	8430		5000	FALSE
8/20/98	UPSTR	Potassium (µg/l)	9470		5000	TRUE
8/20/98	UPSTR	Selenium (µg/l)	2.6		5	FALSE
8/20/98	UPSTR	Selenium (µg/l)	2.8		5	TRUE
8/20/98	UPSTR	Silver (µg/l)	6		10	FALSE
8/20/98	UPSTR	Silver (µg/l)	6		10	TRUE
8/20/98	UPSTR	Sodium (µg/l)	56500		5000	FALSE
8/20/98	UPSTR	Sodium (µg/l)	59700		5000	TRUE
8/20/98	UPSTR	Strontium (µg/l)	584		50	FALSE
8/20/98	UPSTR	Strontium (µg/l)	593		50	TRUE
8/20/98	UPSTR	Thallium (µg/l)	3.3		10	FALSE

Table 3-13. Coldwater Creek Sediment Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter Name	Results	Error	Detection Limit	Filtered
8/20/98	UPSTR	Thallium (μg/l)	3.3		10	TRUE
8/20/98	UPSTR	Titanium (μg/l)	8.6		50	FALSE
8/20/98	UPSTR	Titanium (μg/l)	8.6		50	TRUE
8/20/98	UPSTR	Uranium (μg/l)	122		500	FALSE
8/20/98	UPSTR	Uranium (μg/l)	122		500	TRUE
8/20/98	UPSTR	Vanadium (μg/l)	15.1		50	FALSE
8/20/98	UPSTR	Vanadium (μg/l)	15.4		50	TRUE
8/20/98	UPSTR	Zinc (μg/l)	11.3		20	TRUE
8/20/98	UPSTR	Zinc (μg/l)	19.8		20	FALSE
8/20/98	UPSTR	Total Dissolved Solids (mg/l)	613		5	FALSE
8/20/98	UPSTR	Total Suspended Solids (mg/l)	11		1	FALSE
8/20/98	UPSTR	2,4,5-T (μg/l)	1		1	FALSE
8/20/98	UPSTR	2,4,5-TP (Silvex) (μg/l)	1		1	FALSE
8/20/98	UPSTR	2,4-D (μg/l)	6.5		4	FALSE
8/20/98	UPSTR	2,4-DB (μg/l)	4		4	FALSE
8/20/98	UPSTR	Dalapon (μg/l)	2		2	FALSE
8/20/98	UPSTR	Dicamba (μg/l)	2		2	FALSE
8/20/98	UPSTR	Dichloroprop (μg/l)	4		4	FALSE
8/20/98	UPSTR	Dinoseb (μg/l)	0.6		0.6	FALSE
8/20/98	UPSTR	MCPA (μg/l)	400		400	FALSE
8/20/98	UPSTR	MCPP (Mecoprop) (μg/l)	400		400	FALSE
8/20/98	UPSTR	4,4'-DDD (μg/l)	0.1		0.1	FALSE
8/20/98	UPSTR	4,4'-DDE (μg/l)	0.1		0.1	FALSE
8/20/98	UPSTR	4,4'-DDT (μg/l)	0.1		0.1	FALSE
8/20/98	UPSTR	Aldrin (μg/l)	0.05		0.05	FALSE
8/20/98	UPSTR	Alpha Chlordane (μg/l)	0.05		0.05	FALSE
8/20/98	UPSTR	Alpha-BHC (μg/l)	0.05		0.05	FALSE
8/20/98	UPSTR	Aroclor-1016 (μg/l)	0.5		0.5	FALSE
8/20/98	UPSTR	Aroclor-1221 (μg/l)	0.5		0.5	FALSE
8/20/98	UPSTR	Aroclor-1232 (μg/l)	0.5		0.5	FALSE
8/20/98	UPSTR	Aroclor-1242 (μg/l)	0.5		0.5	FALSE
8/20/98	UPSTR	Aroclor-1248 (μg/l)	0.5		0.5	FALSE
8/20/98	UPSTR	Aroclor-1254 (μg/l)	0.5		0.5	FALSE
8/20/98	UPSTR	Aroclor-1260 (μg/l)	0.5		0.5	FALSE
8/20/98	UPSTR	Beta-BHC (μg/l)	0.05		0.05	FALSE
8/20/98	UPSTR	Delta-BHC (μg/l)	0.05		0.05	FALSE
8/20/98	UPSTR	Dieldrin (μg/l)	0.1		0.1	FALSE
8/20/98	UPSTR	Endosulfan I (μg/l)	0.05		0.05	FALSE
8/20/98	UPSTR	Endosulfan II (μg/l)	0.1		0.1	FALSE
8/20/98	UPSTR	Endosulfan Sulfate (μg/l)	0.1		0.1	FALSE
8/20/98	UPSTR	Endrin (μg/l)	0.1		0.1	FALSE
8/20/98	UPSTR	Endrin Aldehyde (μg/l)	.05		0.1	FALSE
8/20/98	UPSTR	Endrin Ketone (μg/l)	0.1		0.1	FALSE
8/20/98	UPSTR	Gamma Chlordane (μg/l)	0.05		0.05	FALSE
8/20/98	UPSTR	Gamma-BHC (Lindane) (μg/l)	0.05		0.05	FALSE
8/20/98	UPSTR	Heptachlor (μg/l)	0.05		0.05	FALSE
8/20/98	UPSTR	Heptachlor Epoxide (μg/l)	0.05		0.05	FALSE
8/20/98	UPSTR	Methoxychlor (μg/l)	0.5		0.5	FALSE
8/20/98	UPSTR	Toxaphene (μg/l)	5		5	FALSE
8/20/98	UPSTR	1,2,4-Trichlorobenzene (μg/l)	10		10	FALSE
8/20/98	UPSTR	1,2-Dichlorobenzene (μg/l)	10		10	FALSE

Table 3-13. Coldwater Creek Sediment Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter Name	Results	Error	Detection Limit	Filtered
8/20/98	UPSTR	1,3-Dichlorobenzene (µg/l)	10		10	FALSE
8/20/98	UPSTR	1,4-Dichlorobenzene (µg/l)	10		10	FALSE
8/20/98	UPSTR	2,2'-oxybis (1-chloropropane) (µg/l)	10		10	FALSE
8/20/98	UPSTR	2,4,5-Trichlorophenol (µg/l)	25		25	FALSE
8/20/98	UPSTR	2,4,6-Trichlorophenol (µg/l)	10		10	FALSE
8/20/98	UPSTR	2,4-Dichlorophenol (µg/l)	10		10	FALSE
8/20/98	UPSTR	2,4-Dimethylphenol (µg/l)	10		10	FALSE
8/20/98	UPSTR	2,4-Dinitrophenol (µg/l)	25		25	FALSE
8/20/98	UPSTR	2,4-Dinitrotoluene (µg/l)	10		10	FALSE
8/20/98	UPSTR	2,6-Dinitrotoluene (µg/l)	10		10	FALSE
8/20/98	UPSTR	2-Chloronaphthalene (µg/l)	10		10	FALSE
8/20/98	UPSTR	2-Chlorophenol (µg/l)	10		10	FALSE
8/20/98	UPSTR	2-Methylnaphthalene (µg/l)	10		10	FALSE
8/20/98	UPSTR	2-Methylphenol (µg/l)	10		10	FALSE
8/20/98	UPSTR	2-Nitroaniline (µg/l)	25		25	FALSE
8/20/98	UPSTR	2-Nitrophenol (µg/l)	10		10	FALSE
8/20/98	UPSTR	3,3'-Dichlorobenzidine (µg/l)	10		10	FALSE
8/20/98	UPSTR	3-Nitroaniline (µg/l)	25		25	FALSE
8/20/98	UPSTR	4,6-Dinitro-o-Cresol (µg/l)	25		25	FALSE
8/20/98	UPSTR	4-Bromophenyl-phenyl Ether (µg/l)	10		10	FALSE
8/20/98	UPSTR	4-Chloroaniline (µg/l)	10		10	FALSE
8/20/98	UPSTR	4-Chlorophenyl-phenylether (µg/l)	10		10	FALSE
8/20/98	UPSTR	4-Methylphenol (µg/l)	10		10	FALSE
8/20/98	UPSTR	4-Nitroaniline (µg/l)	25		25	FALSE
8/20/98	UPSTR	4-Nitrophenol (µg/l)	25		25	FALSE
8/20/98	UPSTR	4-chloro-3-methylphenol (µg/l)	10		10	FALSE
8/20/98	UPSTR	Acenaphthene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Acenaphthylene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Anthracene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Benzo(a)anthracene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Benzo(a)pyrene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Benzo(b)fluoranthene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Benzo(g,h,I)perylene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Benzo(k)fluoranthene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Bis(2-chloroethoxy)methane (µg/l)	10		10	FALSE
8/20/98	UPSTR	Bis(2-chloroethyl)ether (µg/l)	10		10	FALSE
8/20/98	UPSTR	Bis(2-ethylhexyl)phthalate (µg/l)	10		10	FALSE
8/20/98	UPSTR	Butyl Benzyl Phthalate (µg/l)	10		10	FALSE
8/20/98	UPSTR	Carbazole (µg/l)	10		10	FALSE
8/20/98	UPSTR	Chrysene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Di-n-butyl Phthalate (µg/l)	10		10	FALSE
8/20/98	UPSTR	Di-n-octyl Phthalate (µg/l)	10		10	FALSE
8/20/98	UPSTR	Dibenzo(a,h)anthracene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Dibenzofuran (µg/l)	10		10	FALSE
8/20/98	UPSTR	Diethyl Phthalate (µg/l)	10		10	FALSE
8/20/98	UPSTR	Dimethyl Phthalate (µg/l)	10		10	FALSE
8/20/98	UPSTR	Fluoranthene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Fluorene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Hexachlorobenzene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Hexachlorobutadiene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Hexachlorocyclopentadiene (µg/l)	10		10	FALSE

Table 3-13. Coldwater Creek Sediment Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter Name	Results	Error	Detection Limit	Filtered
8/20/98	UPSTR	Hexachloroethane (µg/l)	10		10	FALSE
8/20/98	UPSTR	Indeno(1,2,3-cd)pyrene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Isophorone (µg/l)	10		10	FALSE
8/20/98	UPSTR	N-Nitroso-di-n-propylamine (µg/l)	10		10	FALSE
8/20/98	UPSTR	N-Nitrosodiphenylamine (µg/l)	10		10	FALSE
8/20/98	UPSTR	Naphthalene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Nitrobenzene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Pentachlorophenol (µg/l)	25		25	FALSE
8/20/98	UPSTR	Phenanthrene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Phenol (µg/l)	10		10	FALSE
8/20/98	UPSTR	Pyrene (µg/l)	10		10	FALSE
8/20/98	UPSTR	Total Organic Carbon (mg/l)	3.5		1	TRUE
8/20/98	UPSTR	Total Organic Carbon (mg/l)	4.47		1	FALSE
8/20/98	UPSTR	1,1,1-Trichloroethane (µg/l)	5		5	FALSE
8/20/98	UPSTR	1,1,2,2-Tetrachloroethane (µg/l)	5		5	FALSE
8/20/98	UPSTR	1,1,2-Trichloro-1,2,2-trifluoroethane (µg/l)	10		10	FALSE
8/20/98	UPSTR	1,1,2-Trichloroethane (µg/l)	5		5	FALSE
8/20/98	UPSTR	1,1-Dichloroethane (µg/l)	5		5	FALSE
8/20/98	UPSTR	1,1-Dichloroethene (µg/l)	5		5	FALSE
8/20/98	UPSTR	1,2-Dichloroethane (µg/l)	5		5	FALSE
8/20/98	UPSTR	1,2-Dichloroethene (µg/l)	5		5	FALSE
8/20/98	UPSTR	1,2-Dichloropropane (µg/l)	5		5	FALSE
8/20/98	UPSTR	1,3-cis-Dichloropropene (µg/l)	5		5	FALSE
8/20/98	UPSTR	1,3-trans-Dichloropropene (µg/l)	5		5	FALSE
8/20/98	UPSTR	2-Butanone (µg/l)	10		10	FALSE
8/20/98	UPSTR	2-Hexanone (µg/l)	10		10	FALSE
8/20/98	UPSTR	4-Methyl-2-pentanone (µg/l)	10		10	FALSE
8/20/98	UPSTR	Acetone (µg/l)	16		10	FALSE
8/20/98	UPSTR	Benzene (µg/l)	5		5	FALSE
8/20/98	UPSTR	Bromodichloromethane (µg/l)	5		5	FALSE
8/20/98	UPSTR	Bromoform (µg/l)	5		5	FALSE
8/20/98	UPSTR	Bromomethane (µg/l)	10		10	FALSE
8/20/98	UPSTR	Carbon Disulfide (µg/l)	5		5	FALSE
8/20/98	UPSTR	Carbon Tetrachloride (µg/l)	5		5	FALSE
8/20/98	UPSTR	Chlorobenzene (µg/l)	5		5	FALSE
8/20/98	UPSTR	Chloroethane (µg/l)	10		10	FALSE
8/20/98	UPSTR	Chloroform (µg/l)	5		5	FALSE
8/20/98	UPSTR	Chloromethane (µg/l)	10		10	FALSE
8/20/98	UPSTR	Dibromochloromethane (µg/l)	5		5	FALSE
8/20/98	UPSTR	Ethylbenzene (µg/l)	5		5	FALSE
8/20/98	UPSTR	Methylene Chloride (µg/l)	5		5	FALSE
8/20/98	UPSTR	Styrene (µg/l)	5		5	FALSE
8/20/98	UPSTR	Tetrachloroethene (µg/l)	5		5	FALSE
8/20/98	UPSTR	Toluene (µg/l)	5		5	FALSE
8/20/98	UPSTR	Trichloroethene (µg/l)	5		5	FALSE
8/20/98	UPSTR	Vinyl Chloride (µg/l)	10		10	FALSE
8/20/98	UPSTR	Xylenes, Total (µg/l)	5		5	FALSE
8/20/98	UPSTR	Radium-226 (pCi/l)	0.24	0.62	1.35	FALSE
8/20/98	UPSTR	Radium-226 (pCi/l)	0.31	0.58	1.14	TRUE
8/20/98	UPSTR	Thorium-228 (pCi/l)	0.39	0.54	0.89	FALSE
8/20/98	UPSTR	Thorium-228 (pCi/l)	1.03	0.81	0.89	TRUE

Table 3-13. Coldwater Creek Sediment Analytical Results for 1998 (cont'd)

Date collected	Station[a]	Parameter Name	Results	Error	Detection Limit	Filtered
8/20/98	UPSTR	Thorium-230 (pCi/l)	0.79	0.62	0.63	FALSE
8/20/98	UPSTR	Thorium-230 (pCi/l)	4.12	1.52	0.33	TRUE
8/20/98	UPSTR	Thorium-232 (pCi/l)	0.05	0.24	0.63	FALSE
8/20/98	UPSTR	Thorium-232 (pCi/l)	0.12	0.24	0.33	TRUE
8/20/98	UPSTR	Uranium-234 (pCi/l)	0.36	0.42	0.32	TRUE
8/20/98	UPSTR	Uranium-234 (pCi/l)	0.87	0.73	0.91	FALSE
8/20/98	UPSTR	Uranium-235 (pCi/l)	-0.08	0.15	0.91	FALSE
8/20/98	UPSTR	Uranium-235 (pCi/l)	0.29	0.42	0.4	TRUE
8/20/98	UPSTR	Uranium-238 (pCi/l)	1.19	0.77	0.32	TRUE
8/20/98	UPSTR	Uranium-238 (pCi/l)	1.35	0.9	0.91	FALSE

[a] UPSTR = upstream sample location (analogous to C002).

Sediment monitoring results from 1998 were compared with recent historical EMP results from 1996 and 1997. The 1998 results were also compared with other historical EMP sediment monitoring results from 1992-1995. These data are provided in Table 3-15. In general, the concentrations of the radium isotopes, thorium isotopes, and uranium detected at background location C002 and at station C006 in 1998 were consistent with their historical mean concentrations and below their historical maximum detections. It should be noted that the UTLs for many of these parameters at these locations are elevated because the data sets are of limited size and log-normally distributed.

At the monitoring station between SLAPS and HISS (station C004), the concentrations of the thorium isotopes and uranium detected in 1998 were consistent with their concentrations in 1996. The concentrations of the radium isotopes were approximately twice their 1996 levels and slightly greater than their historical mean. The concentration of radium isotopes detected at C004 in 1998 was below the historical UTL and maximum detection. Both Th-230 and total uranium at C004 in 1998 were approximately twice their concentrations in 1997, but were consistent with the historical mean concentrations, UTLs, and maximum detections.

Table 3-14. 1998 Monitoring Results for Sediments in Coldwater Creek

Parameter (Units)	C002	C003	C004	C005	C006	C007
Total Uranium[a]	2.75 (1.92)	3.31 (2.316)	3.3 (2.309)	10.23 (7.16)	2.33 (1.631)	3.84 (2.68)
U-234 (pCi/g)	0.918	1.105	1.1017	3.415	0.7778	1.282
U-235 (pCi/g)	0.0885	0.1066	0.1062	0.329	0.075	0.1236
U-238 (pCi/g)	0.918	1.105	1.1017	3.415	0.7778	1.282
Th-228 (pCi/g)	1.22	1.04	0.96	1.17	1.47	.94
Th-230 (pCi/g)	1.61	4.14	3.34	201.2	2.21	23.8
Th-232 (pCi/g)	1.19	1.06	0.96	1.63	1.36	1.07
Ra-226 (pCi/g)	0.96	2.04	1.57	5.14	1.88	2.16
Ra-228 (pCi/g)	1.22	1.04	0.96	1.17	1.47	.94

[a] Total uranium concentrations are expressed in both sets of units with the activity based concentration (pCi/g) in parentheses.

At sampling station C005, which is located in closest proximity to surface drainage from HISS and certain of its VPs, the concentrations of Ra-228 and Th-232 measured in 1998 remained constant with results from 1996 an 1997. The concentration of Ra-226 was above its 1997 level and historical mean. The concentrations of Th-230 and uranium detected at this station in 1998 were higher than the 1997 results. The concentrations of these species at C005 in 1998 were also similarly elevated above the monitoring results obtained in the spring of 1996, but were comparable to those found in the fall of 1996. The elevated Th-230 concentrations detected in the fall of 1996 and in 1998 were also higher than the historical mean concentration at this station. Concentrations of total uranium and Ra-226 found at C005 in the spring of 1996 and in 1998 were approximately twice their historical mean and approached previous maximum detections. These variations may relate to extended periods of reduced flow velocity in the tributary stream that result in a temporal increase in localized deposition of the radionuclides in the sediment.

At the first sampling station located downstream of both SLAPS and HISS (C003), the concentrations of the major radionuclides remained constant between 1996 and 1998. The greatest change in the concentration of any major isotope of this location during this time period was an increased concentration of Ra-226 that was detected at approximately twice the level found in 1996. The Th-230 concentration remained similar to its historical mean. Further downstream at sampling station C007, the 1998 concentrations of Th-230 were approximately four times the levels measured in 1997 and the spring of 1996.

As indicated for station C005, the concentrations of Th-230 at C007 in 1998 were similar to the fourth quarter results of 1996. Elevated Th-230 concentrations have sporadically occurred at this section in the fall, as indicated by 1993, 1994, and 1996 sampling results. A hypothesis for the similarity in these results may be that extended periods of reduced flow occurred before the sampling events, and the reduced velocities resulted in increased localized deposition of the radionuclides in the streambed. During winter or early spring, increased stream velocities may scour the streambed sufficiently to transport these deposits further downstream. Furthermore, the elevated concentrations of Th-230 and uranium detected during the fall of 1996 and in the 1998 monitoring events at C005 and C007 imply that contaminants are possibly being transported from HISS and the VPs by surface-water run-off.

Table 3-15. Comparison of Historical Sediment Results for Coldwater Creek

Location	Chemical	Units	Average Result	Results >Detection Limit	95% UTL of Mean	03/28/92	09/30/92	04/07/93	10/12/93	04/19/94	10/13/94	04/04/95	10/24/95	04/25/96	10/29/96	05/15/97	04/06/98
C002	Uranium	mg/kg	2.61	9/ 10	11.20	6.24	2.6	3.7	1.7	2.7	<2.4	3	<1.73	1.51	2.12	1.63	2.75
C002	Radium-226	pCi/g	1.43	9/ 11	4.87	1	1.1	0.85	1.5	0.95	1.8	<1.2	<-0.01	1.6	0.83	4.87	0.96
C002	Radium-228	pCi/g	0.82	3/ 4	8.05					<0.76				1.32	0.43	0.78	1.22
C002	Thorium-228	pCi/g	0.81	5/ 5	7.96								0.69	1.32	0.43	0.78	1.22
C002	Thorium-230	pCi/g	1.26	10/ 12	5.68	0.88	0.57	<0.38	0.7	2.04	<1.6	2.2	0.95	2.17	0.92	1.48	1.61
C002	Thorium-232	pCi/g	0.71	10/ 10	1.54			0.38	0.94	1.1	0.64	0.96	0.37	0.86	0.42	0.71	1.19
C003	Uranium	mg/kg	3.44	11/ 12	8.57	6.28	3.3	4.7	1.8	2.8	3.4	3.2	<2.81	3.14	3.14	2.67	3.25
C003	Radium-226	pCi/g	0.95	10/ 12	4.60	0.56	0.9	0.62	0.63	0.98	2	<1.8	<0.22	0.54	1.06	1.11	1.54
C003	Radium-228	pCi/g	0.79	5/ 5	3.10					0.61				0.65	1.12	0.76	1.02
C003	Thorium-228	pCi/g	0.74	5/ 5	5.6								0.42	0.65	1.12	0.76	1.02
C003	Thorium-230	pCi/g	3.70	12/ 12	8.57	2.82	3.3	2.5	0.87	2.43	4.6	6.2	4.61	6.1	5.09	2.15	3.5
C003	Thorium-232	pCi/g	0.71	8/ 10	2.47			<0.41	<0.39	0.59	1.1	0.74	0.4	0.81	1.31	0.62	0.87
C004	Uranium	mg/kg	3.54	12/ 12	10.0	7.9	3.3	3.3	1.9	5.1	2.9	3.3	3.95	2.47	2.51	2.32	3.3
C004	Radium-226	pCi/g	1.20	11/ 12	3.34	0.72	0.88	0.78	0.95	1.2	2.1	<1.5	1.63	0.64	1.14	1.66	1.57
C004	Radium-228	pCi/g	0.68	5/ 5	5.7					1.1				0.54	0.68	0.4	0.96
C004	Thorium-228	pCi/g	0.52	5/ 5	1.65								0.46	0.54	0.68	0.4	0.96
C004	Thorium-230	pCi/g	4.83	12/ 12	21.9	21.9	4	3	2.5	3.5	3.5	4.4	2.6	3.61	2.59	1.51	3.34
C004	Thorium-232	pCi/g	0.60	9/ 10	2.13			0.72	<0	1.3	0.54	0.81	0.44	0.72	0.49	0.36	0.96
C005	Uranium	mg/kg	5.20	11/ 12	36.4	5.93	3.2	5.2	17.2	2.2	3.1	2.7	<1.98	2.76	11.62	2.33	10.23
C005	Radium-226	pCi/g	2.37	11/ 12	11.70	1.4	0.84	1.9	0.76	1.3	3.7	<1.7	2.77	2.72	5.66	3.29	5.14
C005	Radium-228	pCi/g	1.21	5/ 5	1.70					1.1				1.02	1	1.7	1.17
C005	Thorium-228	pCi/g	1.28	5/ 5	3.00								1.39	1.02	1	1.7	1.17
C005	Thorium-230	pCi/g	27.00	12/ 12	366.00	5.33	2.4	4	14.5	1.76	10.1	12.7	1.34	7.23	229.7	8.12	201.2
C005	Thorium-232	pCi/g	1.01	9/ 10	2.4			0.92	<0.61	1.1	0.84	1.4	0.93	0.9	1.65	0.75	1.63
C006	Uranium	mg/kg	3.11	11/ 12	8.85	6.56	2.8	4.4	1.7	2.5	3.1	2.7	<2.74	2.54	2.8	1.95	2.18
C006	Radium-226	pCi/g	1.29	11/ 12	2.42	1.3	0.81	0.91	0.34	1.4	1.9	<1.4	1.34	0.89	1.5	1.93	1.88

Table 3-15. Comparison of Historical Sediment Results for Coldwater Creek (cont'd)

Location	Chemical	Units	Average Result	Results >Detection Limit	95% UTL of Mean	03/28/92	09/30/92	04/07/93	10/12/93	04/19/94	10/13/94	04/04/95	10/24/95	04/25/96	10/29/96	05/15/97	04/06/98
C006	Radium-228	pCi/g	1.22	5/ 5	4.38					1.5				0.89	1.44	1.04	0.96
C006	Thorium-228	pCi/g	1.17	5/ 5	2.46								1.32	0.89	1.44	1.04	0.96
C006	Thorium-230	pCi/g	1.65	11/ 12	4.57	1.42	0.78	<0	0.49	1.57	2.8	2.7	1.65	1.83	3.48	1.41	2.21
C006	Thorium-232	pCi/g	1.22	10/ 10	1.95			1.3	0.93	1.5	0.86	1.5	0.96	1.3	1.25	1.34	1.36
											10/27/94						
C007	Uranium	mg/kg	4.16	11/ 12	11.40	7.2	2.9	4.4	5.1	2.3	5.5	3	<3.43	3.23	5.04	2.88	3.84
C007	Radium-226	pCi/g	1.27	11/ 12	2.30	1.3	0.62	0.88	1.7	0.95	1.5	<1.6	1.03	1.75	1.43	1.18	2.16
C007	Radium-228	pCi/g	0.91	5/ 5	2.87					0.69				0.81	1.18	0.94	0.94
C007	Thorium-228	pCi/g	0.98	5/ 6	2.27						1.2		<0.78	0.81	1.18	0.94	0.94
C007	Thorium-230	pCi/g	13.00	12/ 12	254.00	11.6	0.85	1.4	44.96	2.68	31.4	2.9	4.53	5.64	32.38	4.52	23.8
C007	Thorium-232	pCi/g	0.80	7/ 10	2.11	<0.00	<0.00	0.56	<0.00	<0.64	1.2	0.86	0.82	0.76	1.12	1.24	1.07

Table 3-16 provides an evaluation of the radiological results for the sediment monitoring. With the exception of sampling station C005, the concentration of uranium was below the background screening criteria derived for the North County PAM (USACE, 1999c). These screening levels are equal to twice the mean concentration of the analyte in the background soils. In general, the concentrations of Th-228 and Th-232 were below the background screening criteria. At C005, the concentration of Th-232 slightly exceeded this level. However, the concentrations of Th-230 at all of the downstream sampling locations were above the screening level and the concentrations at C005 and C007 were greater than the background criterion. Additionally, the Ra-226 concentrations at all of the downstream stations slightly exceeded the human health screening level.

Table 3-16. Summary Evaluation of 1998 Coldwater Creek Sediment Monitoring Results

Parameter (Units)	Mean Concentration	Maximum Concentration	Background Criteria[b]
Total Uranium[a] (mg/kg)	4.102 (3.22)	10.23 (7.16)	8.69
U-234 (pCi/g)	1.53	3.415	1.72
U-235 (pCi/g)	0.148	0.329	0.25
U-238 (pCi/g)	1.53	3.415	8.60
Total Thorium (mg/kg)			17.0
Th-228 (pCi/g)	1.16	1.47	1.78
Th-230 (pCi/g)	46.94	201.2	2.20
Th-232 (pCi/g)	1.216	1.63	1.19
Total Radium			
Ra-226 (pCi/g)	2.558	5.14	4.87
Ra-228 (pCi/g)	1.16	1.47	1.80

[a] Total uranium is expressed in both units with the activity-based concentrations in parentheses.
[b] Sources of evaluation criteria are North County PAM for background screening criteria.

3.7 EVALUATION OF ENVIRONMENTAL MONITORING DATA FOR GROUNDWATER

The ground-water monitoring activities conducted under the EMP during 1998 are described in this section. For CY98, ground-water samples were collected during March, April, October, and December. Appendix B lists the field parameters for the fourth quarter 1998 sampling event and identifies the monitoring well construction details for the SLS. Field parameters or indicator parameters are measured continuously during purging of the wells before sampling. The ground water is considered to be representative of the aquifer when these field parameters have stabilized.

3.7.1 SLDS

Ground water at the SLDS is found in three hydrostratigraphic zones (Figure 3-7). These zones are the upper soil unit, referred to as the A Unit; the lower soil unit, referred to as either the Mississippi River Alluvial Aquifer or the B Unit; and the limestone bedrock referred to as the C Unit (Figure 3-8). The A Unit is not an aquifer and is not considered a potential source of drinking water because it has insufficient yield, poor natural water quality, and susceptibility to surface water contaminants of the industrial setting. The long-term industrial filling of the site and the current industrial setting are also factors in the consideration that the A Unit, the most shallow hydrostratigraphic horizon, is not a drinking water resource. The use of the B Unit for a drinking water resource is highly unlikely for several reasons: the industrial setting of the SLDS, the site's proximity to both the Mississippi and the city's drinking water supply, and the poor natural water quality of the B Unit. However, the B Unit does qualify as a potential source of drinking water under the *Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy* (USEPA, 1986). The C Unit surface slopes from the western uplands to the river. The limestone bedrock has nearly horizontal bedding, which slopes only a few degrees to the east. Solution channels and fractures dominate the water routes through the bedrock. Upland recharge of the C Unit flows downgradient to the river valley may provide some recharge to the B Unit, the Mississippi River Alluvial Aquifer. The C Unit would be an unlikely water supply source, as it is deeper and a less productive hydrostratigraphic unit. The EMP monitoring well network for SLDS is identified in Figure 3-9.

Prior to the long-term monitoring requirements for the B Unit aquifer specified in the SLDS ROD (USACE, 1998c), there was no EMP sampling at SLDS. A total of 17 ground-water monitoring wells were installed at the site from 1988 to 1992. Ground-water sampling was conducted during 1988 and 1989 for both radiological and nonradiological constituents for the remedial investigation (BNI, 1994). The December 1997 and January 1998 baseline sampling event was the first at the site since 1989. There were fifteen wells sampled during the December 1998 and early 1999 ground-water sampling and data collection efforts at the SLDS. These sampling efforts were part of the fourth quarter monitoring activities for SLDS ground water.

3.7.1.1 Evaluation of the 1998 Environmental Monitoring Program (EMP)Ground-water Sampling at SLDS

A total of fifteen wells were sampled for various parameters in January and February of 1999. The results of the ground-water analytical data are presented in three major categories: radiological compounds, metals and organic compounds. The ground-water data that was sampled for the fourth quarter 1998 monitoring events at SLDS are compared to the maximum contaminant levels (MCLs) as designated by the USEPA, secondary maximum contaminant levels (SMCLs), and maximum contaminant level goals (MCLGs). A comparison of sampling results for the A Unit with the appropriate monitoring guidelines can be seen in Table 3-17. The four most notable parameters that illustrated elevated levels in the shallow, A Unit ground water include As, manganese (Mg), Se, and total uranium.

Arsenic levels in the shallow ground-water samples taken at SLDS in early 1999 varied from 2.5 µg/l to 242 µg/l (Graph 1). Arsenic appeared at the lower level of 2.5 µg/l at several SLDS wells, including B16W02S, B16W06D, B16W11S, B16W12S, and B16W13SR. The highest levels for arsenic showed up at well B16W06S, with a level of 240 µg/l for the filtered sample and 242 µg/l for the unfiltered sample. The EPA's MCL for arsenic is 50 µg/l., and well B16W06S is the only well that showed a concentration above this MCL for the fourth quarter 1998 SLDS ground water sampling.

Unit Designation	Graphic Column	Approximate Thickness (ft)	Description
Upper Hydrostratigraphic Unit (A)		0-25	**RUBBLE and FILL** Grayish black (N2) to brownish black (5YR2/1). Dry to slightly moist, generally becoming moist at 5-6 ft and saturated at 10-12 ft. Slight cohesion, variable with depth, moisture content and percentage of fines present. Consistency of relative density is unrepresentative, due to large rubble fragments. Rubble is concrete, brick, glass, and coal slag. Percentage of fines as silt or clay increases with depth from 5 to 30 percent. Some weakly cemented aggregations of soil particles. Adhesion of fines to rubble increases with depth and higher moisture content. Degree of compaction is slight to moderate with frequent large voids.
		0-10	**Silty CLAY (CH)** Layers are mostly olive gray (5Y2/1), with some olive black (5Y2/1). Predominantly occurs at contact of undisturbed material, or at boundary of material with elevated activity. Abundant dark, decomposed organics. Variable percentages of silt and clay composition.
		0-5	**CLAY (CL)** Layers are light olive gray (5Y5/2), or dark greenish gray (5GY4/1). Slightly moist to moist, moderate cohesion, medium stiff consistency. Tends to have lowest moisture content. Slight to moderate plasticity.
		0-2.5	**Interbedded CLAY, silty CLAY, SILT and Sandy SILT (CL, MM, SM)** Dark greenish gray (5GY4/1) to Light olive gray (5Y6/1). Moist to saturated, dependent on percentage of particle size. Contacts are sharp, with structure normal to sampler axis to less than 15 degrees downdip. Layer thicknesses are variable, random in alternation with no predictable vertical gradiation or lateral continuity. Some very fine-grained, rounded silica sand as stringers. Silt in dark mafic, biotite flakes. Some decomposed organics.
Lower Hydrostratigraphic Unit (B)		0-10	**Sandy SILT (ML)** Olive gray (5Y4/1). Moist with zones of higher sand content saturated. Slight to moderate cohesion, moderate compaction. Stiff to very stiff consistency, rapid dilatancy, nonplastic. Sand is well sorted, very fine and fine-grained rounded quartz particles.
		0-50	**Silty SAND and SAND (SM, SP, SW)** Olive gray (5Y4/1). Saturated, slight cohesion, becoming noncohesive with decrease of silt particles with depth. Dense, moderate compaction. Moderate to well-graded, mostly fine- and medium-grained, with some fine- and coarse-grained particles. Mostly rounded with coarse grains slightly subrounded. Gradual gradation from upper unit, silty sand has abundant dark mafic/biotite flakes. Sand is well-graded, fine gravel to fine sand. Mostly medium-grained, with some fine-grained and few coarse-grained and fine gravel.
Bedrock Unit (C)		Total thickness not penetrated during drilling	**LIMESTONE** Light olive gray (5Y4/1) with interbedded chert nodules. Generally hard to very hard; difficult to scratch with knife. Slightly weathered, moderately fresh with little to no discoloration or staining. Top 5 ft is moderately fractured, with 99 percent of joints normal to the core axis. Joints are open, planar, and smooth. Some are slightly discolored with trace of hematite staining.

SOURCE: MODIFIED FROM BNI 1992.
NOTE: THE CODES IN PARENTHESES FOLLING LITHOLOGIES ARE THE UNIFIED SOIL CLASSIFICATION SYSTEMS CODES.

NOT TO SCALE

FUSRAP

St. Louis Downtown Site
Environmental Surveillance
St. Louis, Missouri

DRAWN BY:	REV. NO./DATE:	CAD FILE:
S. Kitchings	4/20/99	SLDS\EMG\E340STATR00

Figure 3-7. Generalized Stratigraphic Column at SLDS

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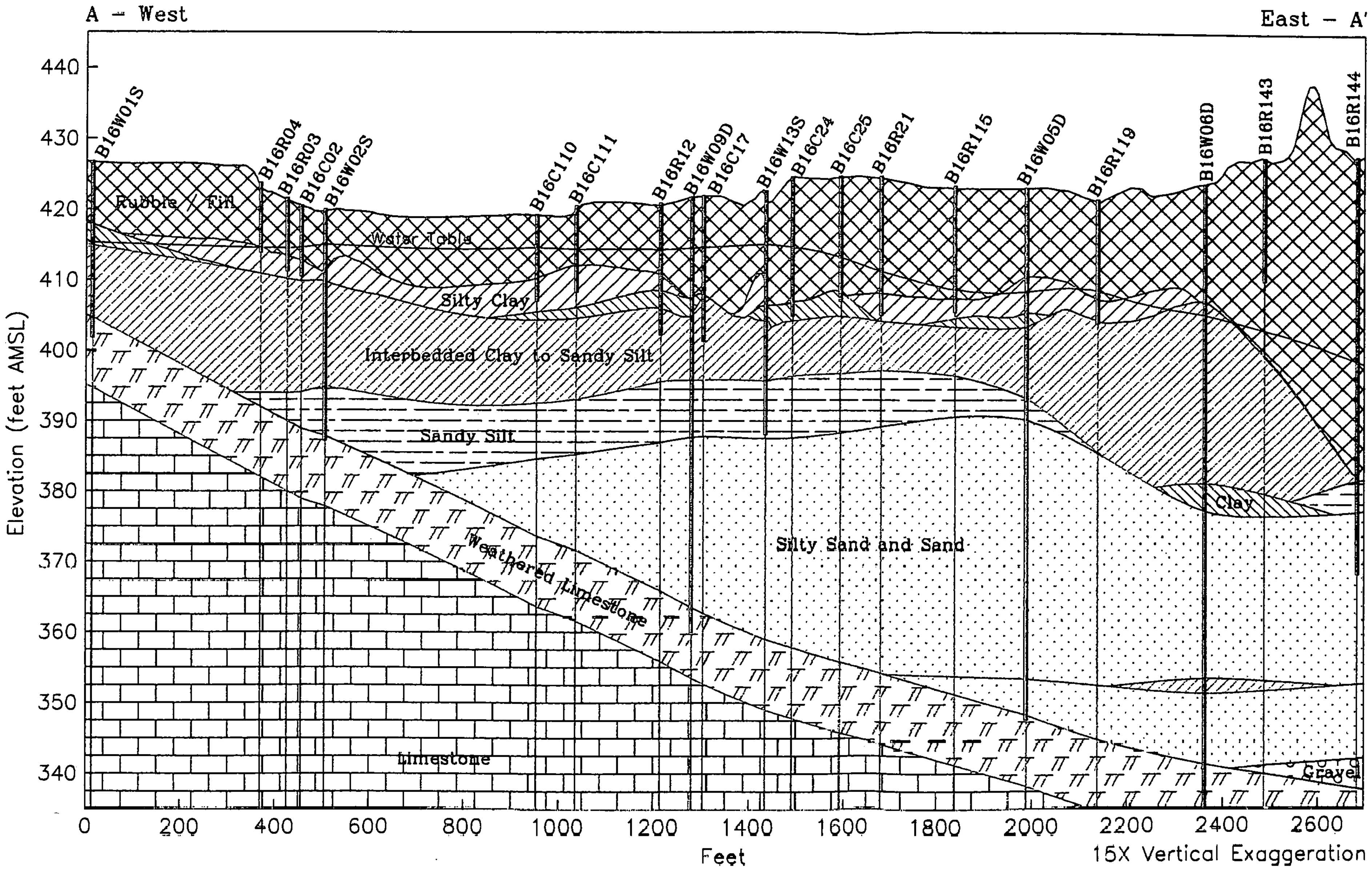

Geologic Cross Section A – A' at SLDS

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

Cross Section Location

Figure 3–8. Hydrostratigraphic Cross–Section of the SLDS Area

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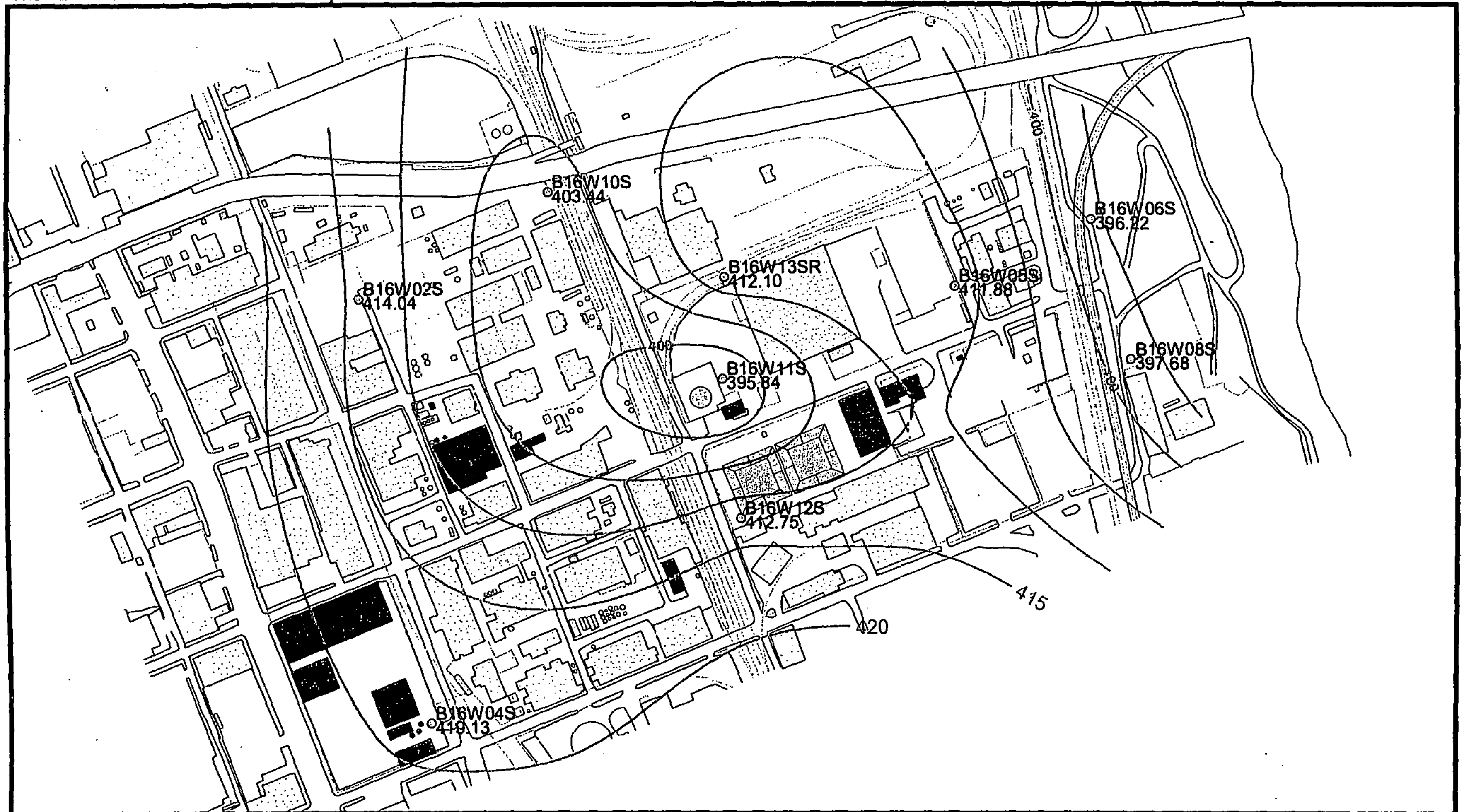

Legend:

⊙ Shallow Monitoring Well Location Where 3 Dec. 98 Water Level Measurement Was Taken (water level elevation in feet AMSL).

Interpreted Shallow Piezometric Surface (based on measured water level elevations and topography). Five Foot Contour Interval.

400 0 400 800 Feet

N

MO-East State Plane Coordinate System (NAD83, feet)

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SLDS
3 Dec. 98 Shallow Piezometric Surface
St. Louis, Missouri

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R. Smith / S. Kitchings	1 - 9/16/99

Figure 3-10. Upper Potentiometric Surface at SLDS

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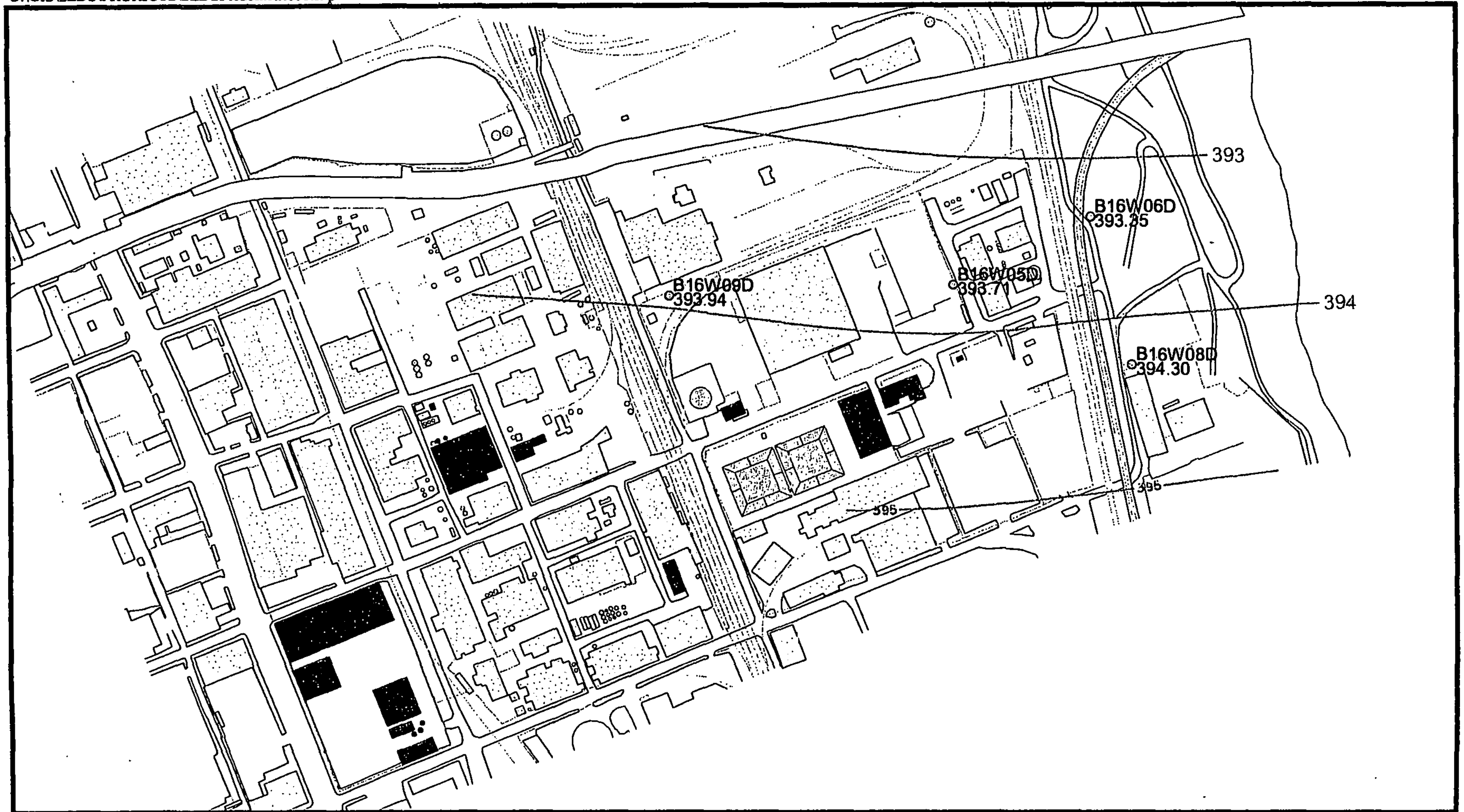

Legend:

⊙ Deep Monitoring Well Location Where 3 Dec. 98 Water Level Measurement Was Taken (water level elevation in feet AMSL).

Interpreted Deep Piezometric Surface. One Foot Contour Interval.

400 0 400 800 Feet

N

MO-East State Plane Coordinate System (NAD83, feet)

FUSRAP

SLDS
3 Dec. 98 Deep Piezometric Surface
St. Louis, Missouri

DRAWN BY:	REV. - DATE:
R. Smith / S. Kitchings	1 - 9/16/99

Figure 3-11. Lower Potentiometric Surface at SLDS

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Manganese appeared at elevated levels in the SLDS fourth quarter 1998, shallow ground-water sampling results (Graph 2). The highest level of 2,970 µg/l occurred at well B16W05S for the unfiltered sample, and the highest filtered result of 2,930 µg/l also occurred at this well. The lowest manganese levels of 31.1 µg/l (filtered) and 34 µg/l (filtered) occurred in samples taken from well B16W13SR. The MCL for manganese is 50 µg/l, and both wells B16W05S and B16W12S showed concentrations exceeded this limit.

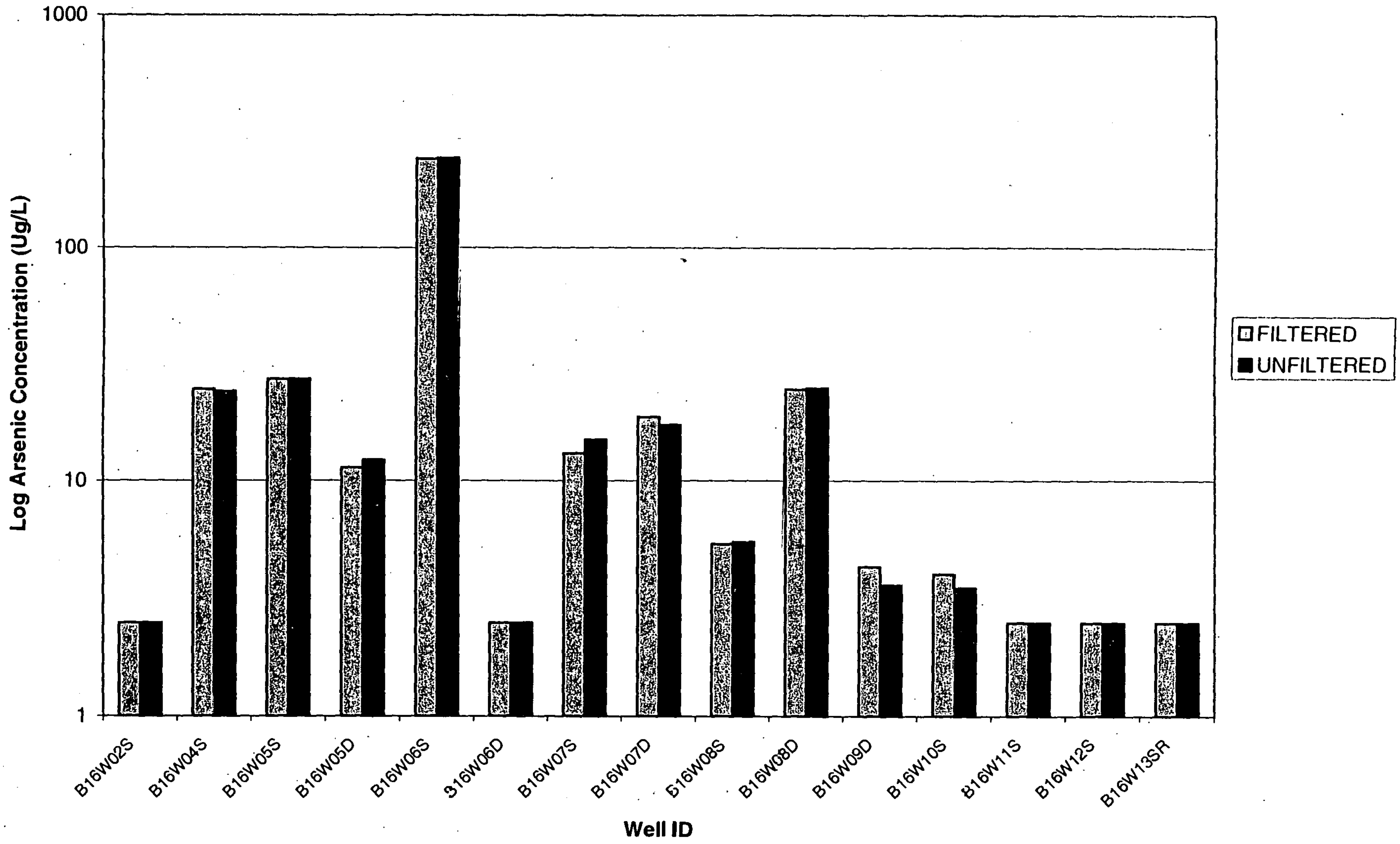
Selenium levels in the SLDS fourth quarter, shallow ground-water samples ranged from 2.9 µg/l at wells B16W05S and B16W12S to 13.2 µg/l for the unfiltered sample at well B16W13SR (Graph 3). Only three wells were sampled for selenium during the fourth quarter ground-water sampling effort at SLDS.

Total uranium appeared at elevated levels of 397.43 pCi/l for the unfiltered, shallow ground-water sample and 353.22 pCi/l for the filtered sample in well B16W02S at SLDS (Graph 4). Well B16W11S also showed elevated total uranium level of 69.19 µg/l for the unfiltered sample and 63.57 µg/l for the filtered sample. The lowest total uranium levels of near 0 occurred at well B16W06S and B16W08D. The total uranium concentrations at well B16W11S, B16W13SR, and well B16W02S have concentrations that are above the EPA's MCL of 20 µg/l.

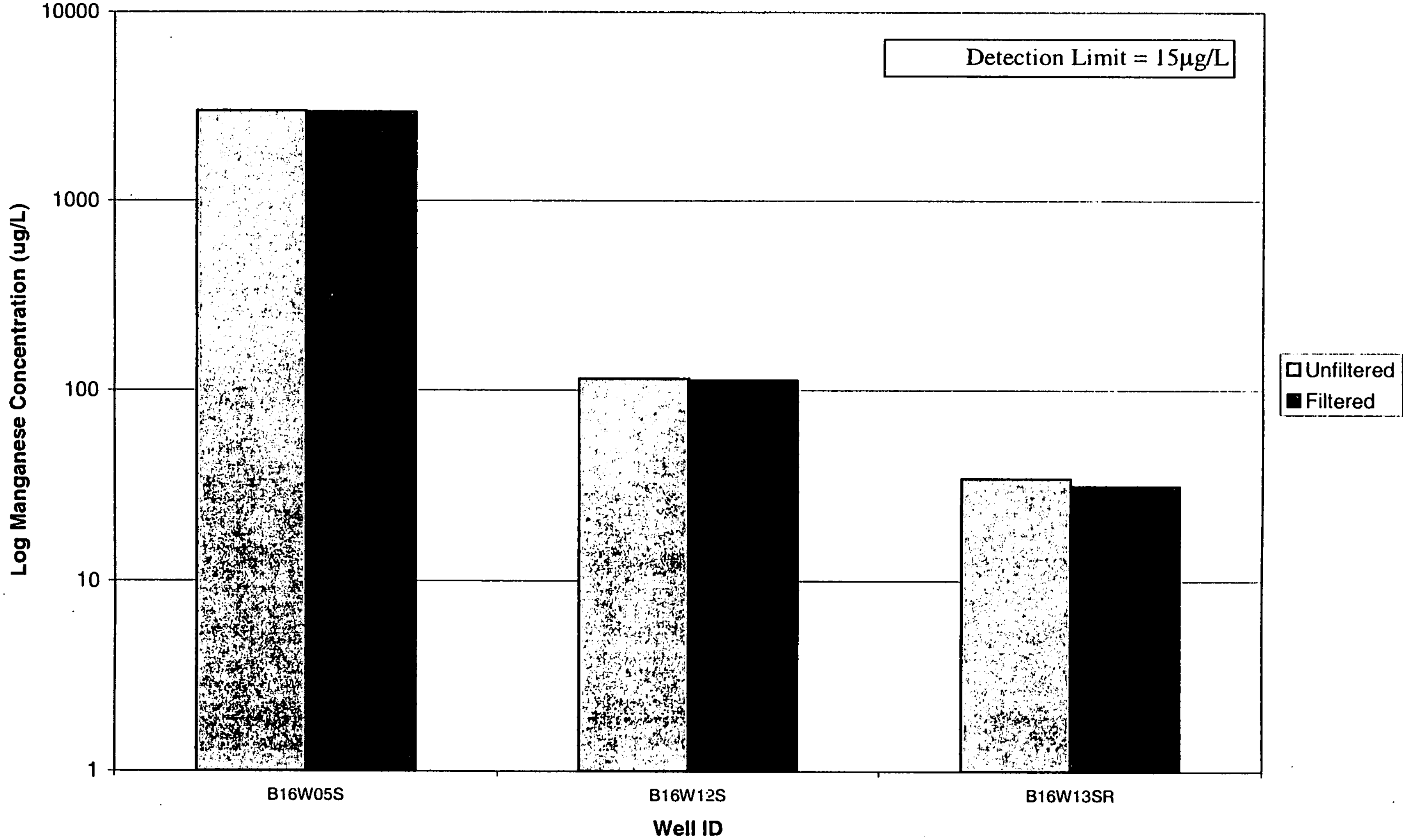
3.7.1.2 Evaluation of the December 1998 Potentiometric Surfaces at SLDS

The depth to ground water at SLDS ranged between approximately 5 to 34 feet bgs during the sampling event. The ground-water flow direction in the Upper Zone is generally eastward beneath the site (Figure 3-10). The lowest area of ground water elevation found in the center of the site occurs in an area where it could be influenced by the fill placed there or by man-made drainage zones. The Lower Zone flow directions are defined at the northeastern quarter of the site and flow to the south and west towards an apparent ground-water surface depression near well B16W05D (Figure 3-11). Ground water in the Lower Zone is hydraulically connected to the Mississippi River. The potentiometric surface and ground-water flow directions of this zone vary and are influenced by river stage.

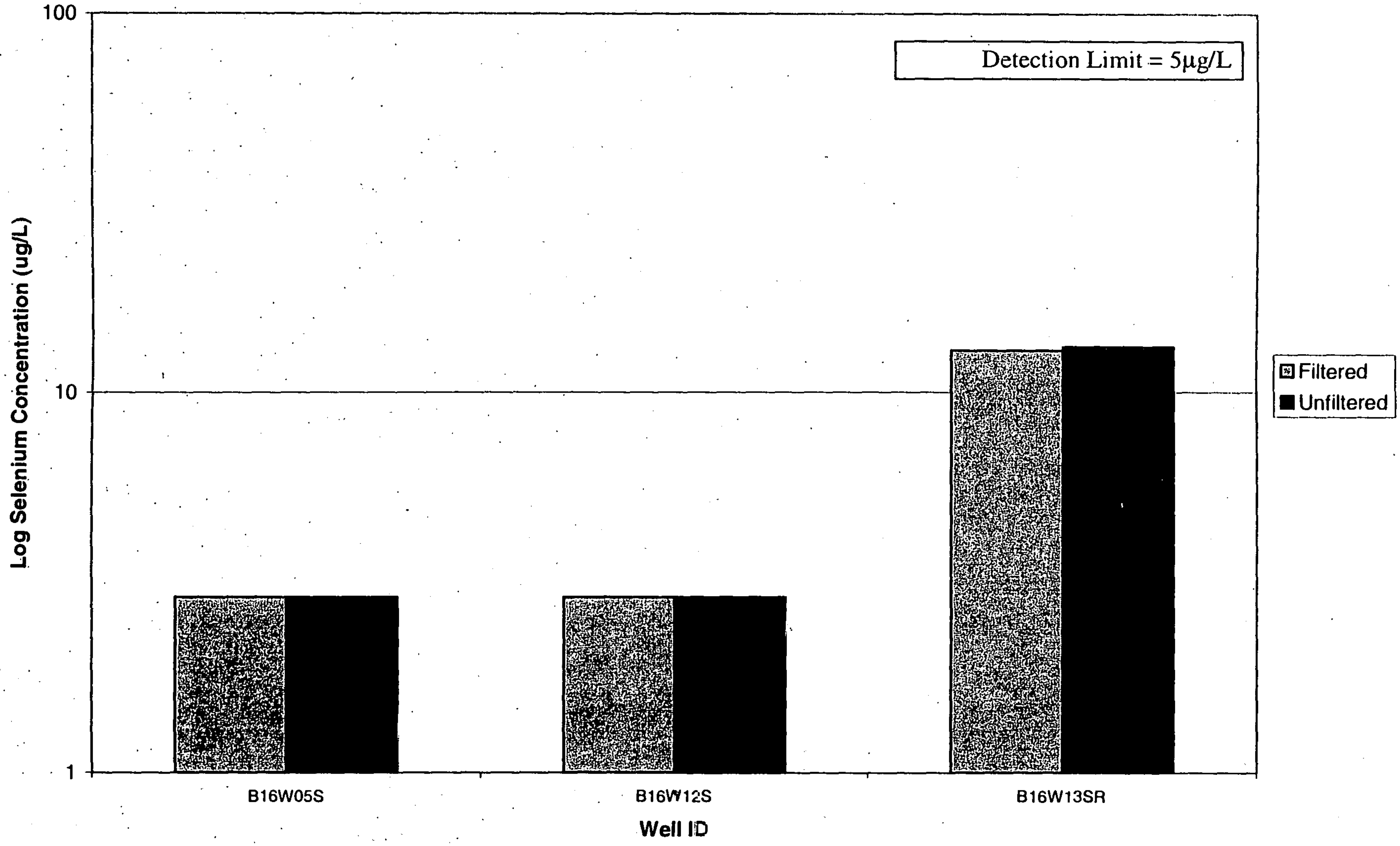
Graph 1. SLDS Arsenic Groundwater Sampling Results for the Fourth Quarter 1998



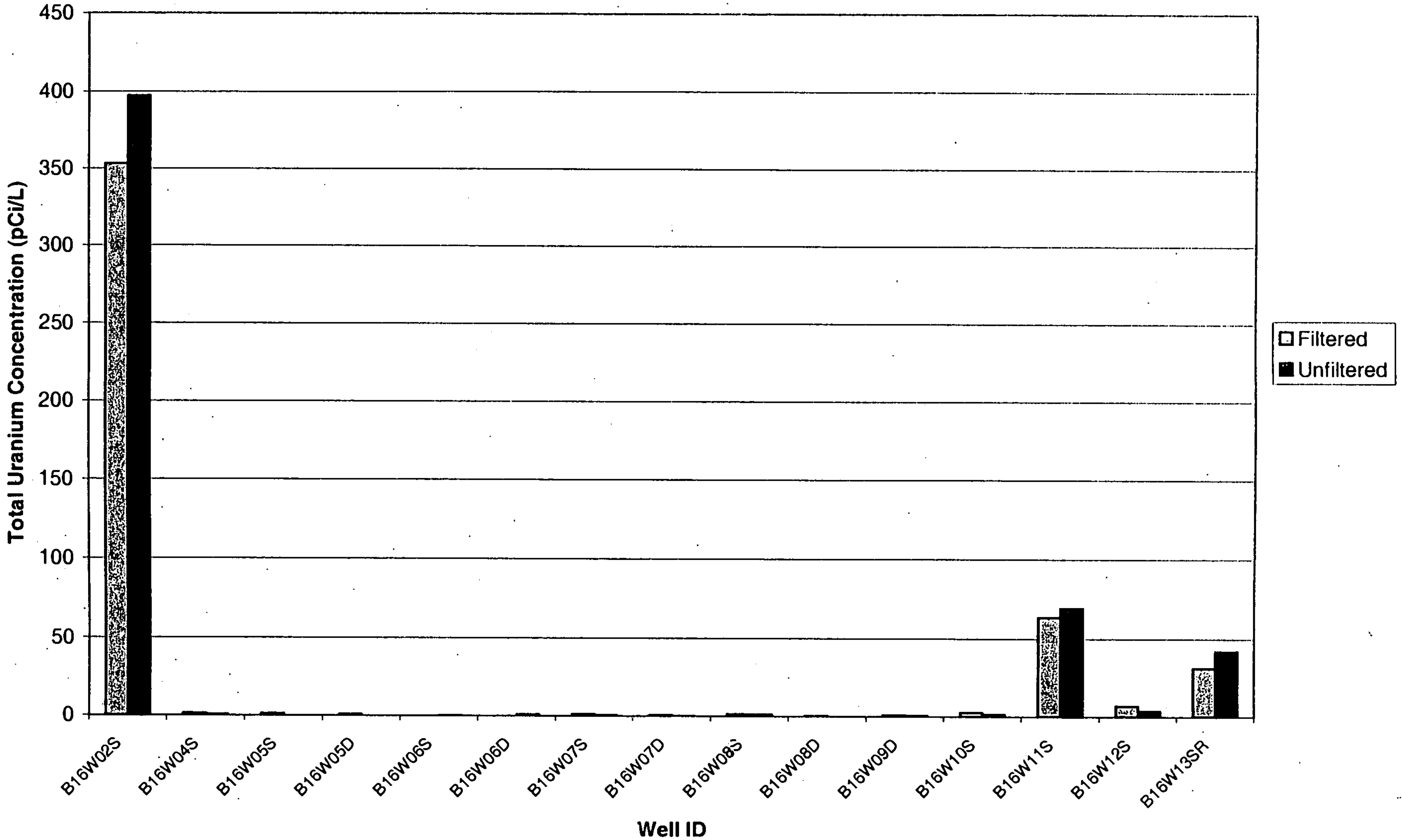
Graph 2. SLDS Manganese Groundwater Sampling Results for the Fourth Quarter 1998



Graph 3. SLDS Selenium Groundwater Sampling Results for the Fourth Quarter 1998



Graph 4. SLDS Total Uranium Groundwater Sampling Results for the Fourth Quarter 1998



Hydrostratigraphic Zone	Period	Epoch	Stratigraphic	Columnar	Thickness (ft.)	Description
HZ-A	Quaternary	Holocene	FILL/TOPSOIL		0-14	UNIT 1 Fill – Sand, silt, clay, concrete, rubble. Topsoil – Organic silts, clayey silts, wood, fine sand.
		Pleistocene	LOESS (CLAYEY SILT)		11-32	UNIT 2 Clayey silts, fine sands, commonly mottled with iron oxide staining. Scattered roots and organic material, and a few fossils.
			GLACIO-LACUSTRINE SERIES: SILTY CLAY		19-75 (3) 9-27 (3T)	UNIT 3 Silty clay with scattered organic blebs and peat stringers. Moderate plasiticity. Moist to saturated. (3T)
HZ-B			VARVED CLAY		0-8	Alternating layers of dark and light clay as much as1/16 inch thick. (3M)
			CLAY		0-26	Dense, stiff, moist, highly plastic clay. (3M)
HZ-C			SILTY CLAY		0-29	Similiar to upper silty clay. Probable unconformable contact with highly plastic clay. (3B)
			BASAL CLAYEY & SANDY GRAVEL		0-6	UNIT 4 Glacial clayey gravels, sands, and sandy gravels. Mostly Chert.
HZ-D	Pennsylvanian		CHEROKEE (?) GROUP (undifferentiated)		0-35	UNIT 5 BEDROCK: Interbedded silty clay/shale, lignite/coal, sandstone, and siltstone. Erosionally truncated by glasiolacustrine sequences. (Absent at HISS).
HZ-E	Mississippian		STE. GENEVIEVE (?) LIMESTONE		10+	UNIT 6 BEDROCK: Hard, white to olive, well-cemented, sandy limestone with interbedded shale laminations.

SOURCE: BNI 1993.

NOT TO SCALE

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St. Louis Airport Site
Environmental Surveillance
St. Louis, Missouri

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S. Kitchings	4/20/99	NORTHCO\DWGS\E34PSTATR00

Figure 3-12. Generalized Stratigraphic Column at SLAPS and HISS

3.7.2 SLAPS

Ground-water monitoring wells were installed at SLAPS by several investigators from the period of 1979 to 1998. Currently, the monitoring well network consists of 38 ground-water monitoring wells. Four monitoring wells were installed in 1998 to fill data gaps pertaining to subsurface lithology, hydraulic gradient and ground-water quality issues; while seven monitoring wells were abandoned due to their proximity to remedial activities in the SLAPS proper. Ground-water monitoring wells have been installed to identify site stratigraphy and ground-water chemistry, and to determine ground-water migration pathways. Ground-water samples have been collected from the existing wells for both radiological and nonradiological constituents; however, the main focus of ground-water sampling has been for radiological parameters. Some ground-water sample collection has been conducted from 1984 to present. The EMP ground-water sampling resumed in 1995 and also took place in 1996. The 1997 baseline sampling effort was the most comprehensive sampling that has been conducted at the site (USACE, 1998d). There was additional ground-water sampling that took place at SLAPS during the summer of 1998 as part of a specific characterization effort. The results of this investigation will be thoroughly detailed in *Results of Implementation of Sampling and Analysis Plan at the St. Louis Airport Site* for the summer of 1999 (USACE, 1999e).

There are five hydrostratigraphic zones recognized beneath SLAPS (Figure 3-12). The surficial deposits include topsoil and anthropogenic fill (Unit 1) and the Pleistocene glacially-related sediments of stratigraphic Unit 2 and subunit 3T comprise the hydrostratigraphic zone (HZ-A). A clay with low vertical permeability comprising subunit 3M of stratigraphic Unit 3 is HZ-B. HZ-C is comprised of the stratigraphic subunit 3B and Unit 4. The shale and limestone are recognized as HZ D and HZ E, respectively. The EMP monitoring well network for SLAPS and VPs is identified in Figure 3-13.

The 3M Unit of hydrostatigraphic zone (HZ) B acts as the western vertical barrier to ground-water movement. Each of the subunits in Unit 3 has lower hydraulic conductivities than Units 1, 2 and 4. The HZ Band the Pennsylvanian shale, HZ D, limit the passage of ground water vertically across the entire SLAPS. The anthropogenic fill (Unit 1) and the Loess (Unit 2) are the upper portions of the HZ A impacted by contaminants. The lower portion of HZ A (Unit 3T) and units below have not shown soil and ground-water impacts. Many of the monitoring wells are screened across the HZs; therefore, for discussion purposes HZ-A and HZ-B are considered the upper zone, while HZ-C and the units beneath HZ-C are considered the lower zone. This designation of upper and lower HZs are made at the 3M unit. The radionuclide contamination, consisting primarily of uranium isotopes, is largely confined to the southwestern region of the SLAPS proper, east of Coldwater Creek, in the upper HZs. Ground-water data from the different zones indicate localized ground water impacted in the upper HZs. This contamination is not present in lower HZs, indicating that mixing between the upper and lower HZs is insignificant.

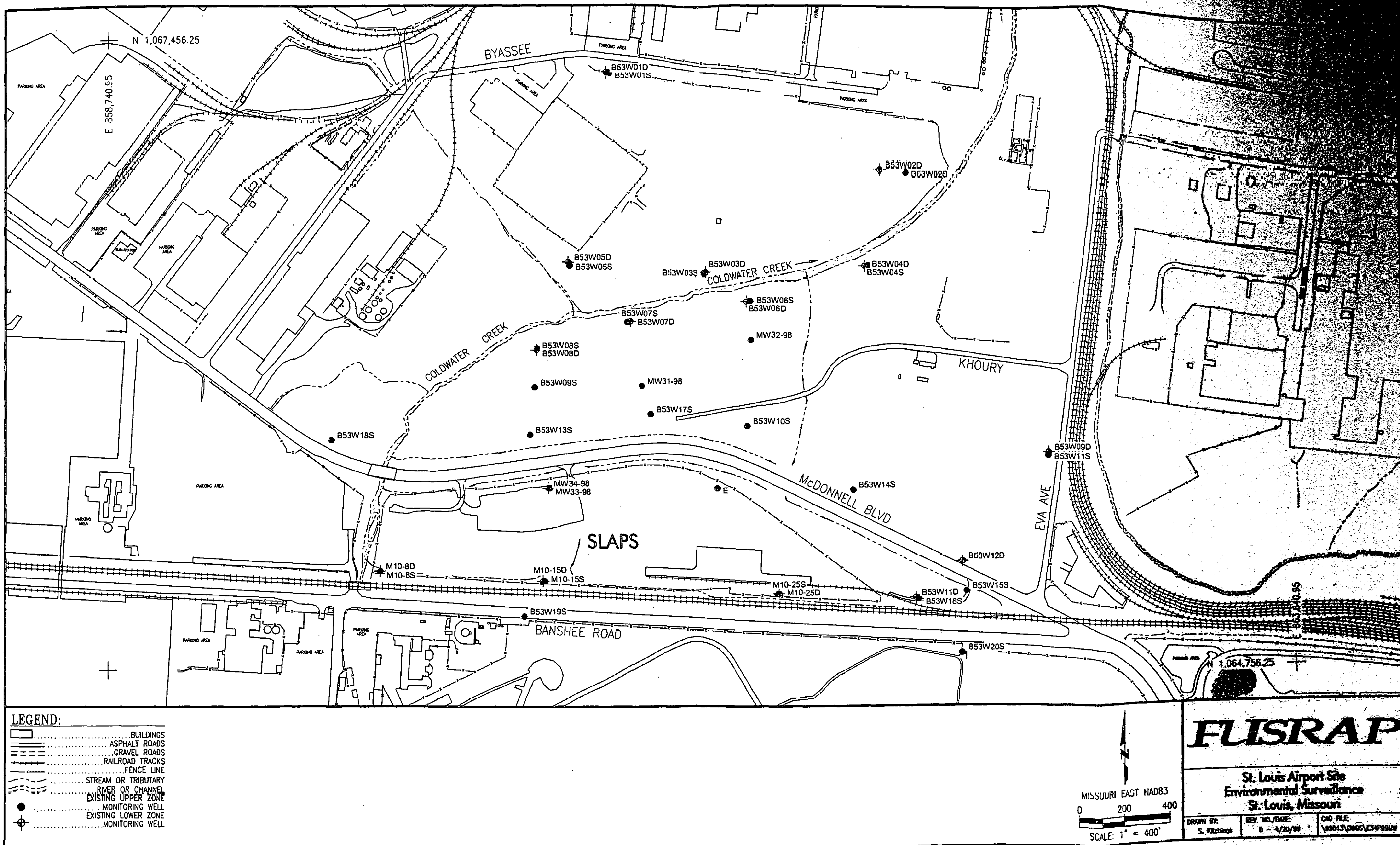


Figure 3-13. Ground-Water Monitoring Wells at SLAPS

3.7.2.1 Evaluation of the 1998 Environmental Monitoring Program (EMP)Ground-water Sampling at SLAPS

A total of 28 wells were sampled for various parameters in July and August of 1998, and 38 wells sampled in the fourth quarter of 1998. The results of the ground-water analytical data are represented in three major categories: radiological compounds, metals and inorganics, and organic compounds. The ground-water chemistry data acquired in the 1998 sampling events at SLAPS are compared to USEPA-designated MCLs, secondary maximum contaminant levels (SMCLs), MCLGs, and other historical data of the various parameters, as applicable.

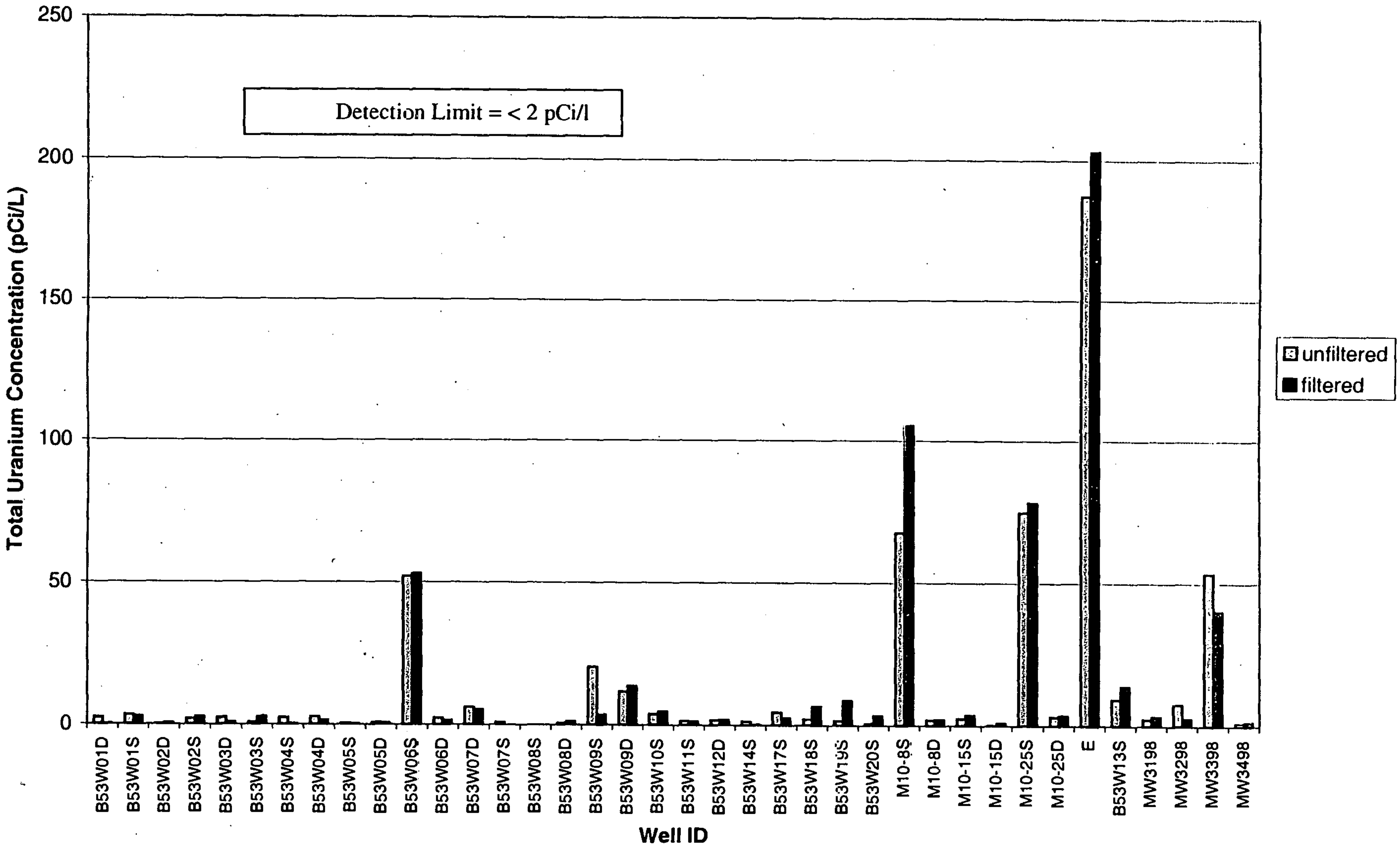
Based on historical and baseline data, ground water in the upper HZ, beneath SLAPS has been impacted by total uranium, manganese, selenium, nitrate, and trichloroethylene (TCE), (USACE, 1998e). The highest concentrations of total uranium have been detected beneath the western portion of SLAPS specifically in monitoring wells A, B, C, and D (DOE, 1995). Uranium concentrations in the ground water are generally lower when comparing 1997 data to previous analytical results. For discussion purposes the analytical results for these constituents were graphed and are shown in Graphs 5 through 10.

Elevated total uranium concentrations above its proposed MCL were detected in some shallow ground-water samples from SLAPS and surrounding off-site wells. The EPA proposed MCL for total uranium is 20 μg/l. The concentrations of total uranium detected in the fourth quarter 1998 ground-water sampling event at SLAPS are presented in Graph 5. The most elevated concentrations continue to occur beneath SLAPS proper at well M11-9S and wells D and E, M10-8S, MW33-98 and M10-25S. An elevated uranium concentration was again detected at well B53W06S located north of SLAPS along Coldwater Creek.

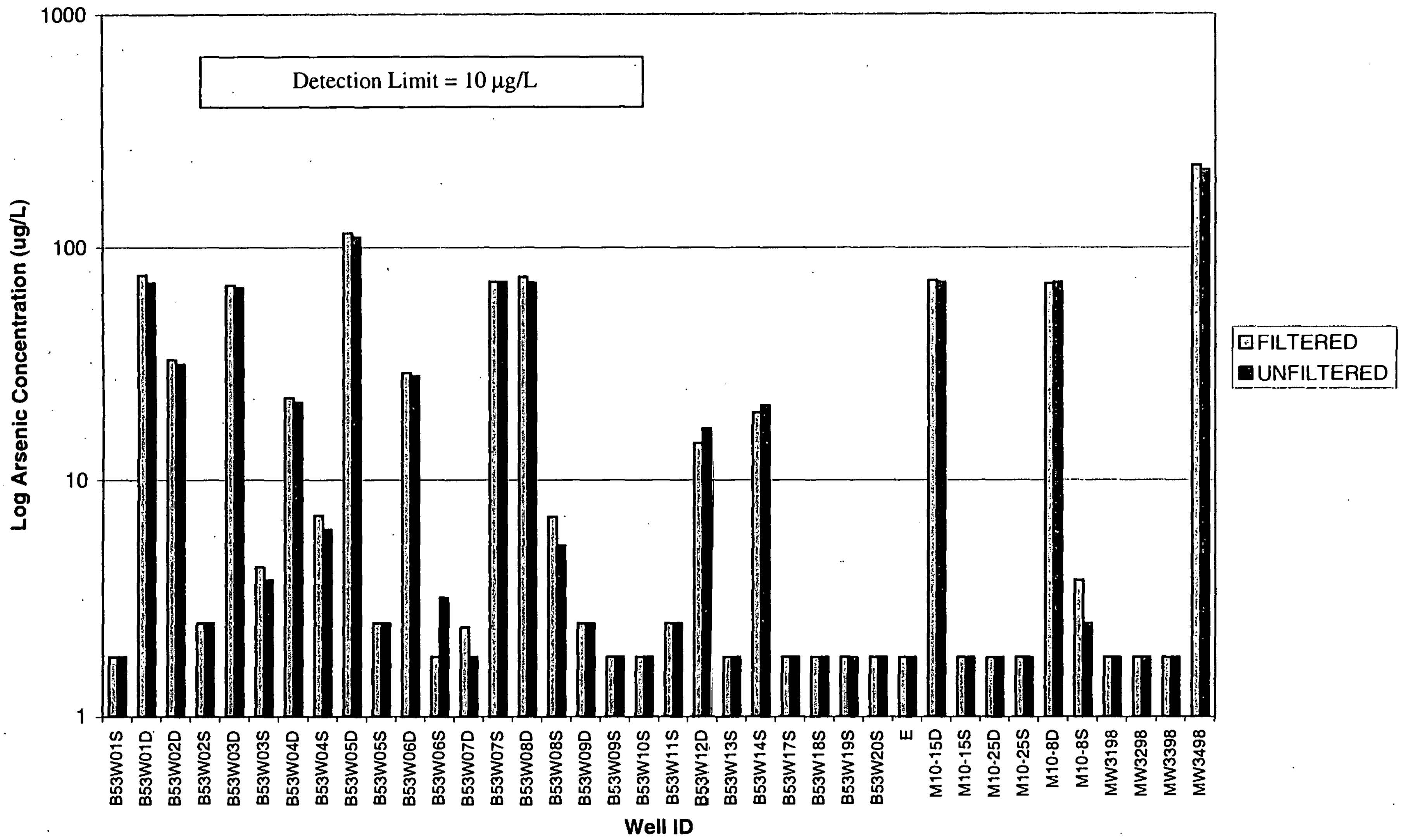
Of the 28 wells sampled in July and August 1998, the upper HZ ground-water samples from 4 wells contained arsenic above its MCL of 50 μg/l. These four wells are exposed to ground water of the HZ-C. Of the 38 wells sampled in the fourth quarter of 1998, seven wells exceeded the MCL, six of these are completed in the deeper zone. The highest arsenic concentration detected in groundwater of the MW34-98 at a concentration of 226 μg/l is shown in Graph 6. Elevated concentrations of arsenic, which likely result from a natural source, occur in ground water of the lower hydrostratigraphic zone, with the exception of B53W07S. Limited historical data is available about its presence.

Concentrations of manganese above its SMCL of 50 μg/l were detected in the upper HZ ground-water samples from 21 of the 28 wells sampled in July and August 1998, and 32 of the 38 sampled in fourth quarter, as shown in Graph 7. These ground-water samples were collected from both Unit A and C wells. The highest concentrations of manganese in the upper HZ wells are at well D (4,150 μg/l) and at well M11-9 (3,240 μg/l), in the July and August sampling; however, these wells were abandoned prior to fourth quarter sampling. In addition, an elevated manganese concentration of 2,560 μg/l in July and August and 2,950 μg/l in the fourth quarter 1998 was detected in the ground-water sample from well B53W06S. The estimated background concentration for manganese for lower HZ ground-water is reported at 215 μg/l (BNI, 1997). There are ten wells in the upper HZ greater than 250 μg/l and ten wells in the lower HZ greater than 250 μg/l. The highest manganese concentration detected in the lower HZ ground water was

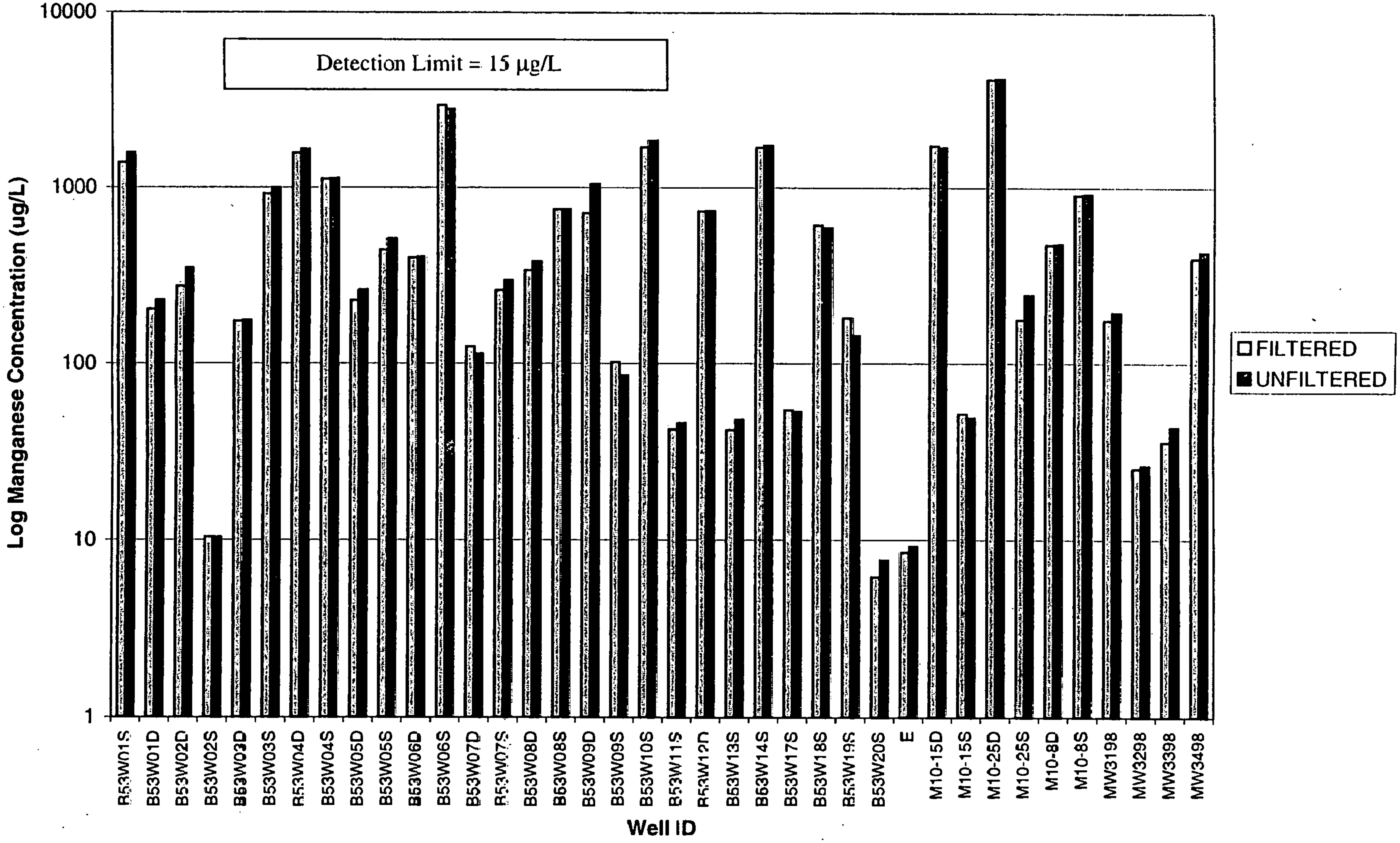
Graph 5. SLAPS Total Uranium Ground-water Sampling Results for the Fourth Quarter 1998



Graph 6. SLAPS Arsenic Ground-water Sampling Results for the Fourth Quarter 1998



Graph 7. SLAPS Manganese Ground-water Sampling Results for the Fourth Quarter 1998



at well M10-25D at 3,740 $\mu g/l$ and 4220 $\mu g/l$ for both sample events, respectively. The occurrence of manganese in the lower HZ ground water is likely due to natural conditions, and the estimated background concentration in the lower HZ appears greater than 215 $\mu g/l$ (USACE, 1998e). Twelve wells in the lower HZ exceeded this background concentration.

The selenium above its MCL of 50 $\mu g/l$ was detected in 7 of the 28 wells sampled in July and August and 8 wells sampled in fourth quarter 1998 as can be seen in Figure 3. These eight wells are screened in upper HZ. The maximum concentration of selenium in 1998 was detected in well E at 3,910 $\mu g/l$ in July and August and 3,940 $\mu g/l$ in fourth quarter 1998.

Dissolved nitrate above its MCL of 10 mg/l was detected in 11 of the 28 wells sampled in July and August of 1998 at SLAPS. The distribution of nitrate concentrations in the sampled wells is illustrated in Graph 9. The highest nitrate concentration was detected in well M11-9S at 613 mg/l. Other elevated concentrations of nitrates above 100 mg/l were detected in wells E, B53W13S, B53W17S, and M10-15S. The ground-water sample from well M11-9S also contained the maximum nitrate concentration detected in 1997. Elevated nitrates occur in the HZ-A ground water beneath the western part of SLAPS and along Coldwater Creek as exhibited in wells B53W06S and B53W07S. This condition also existed in 1997. The distribution of nitrate appears limited to the upper HZ. The maximum nitrate concentration in the lower HZ was reported at less than 0.5 mg/l.

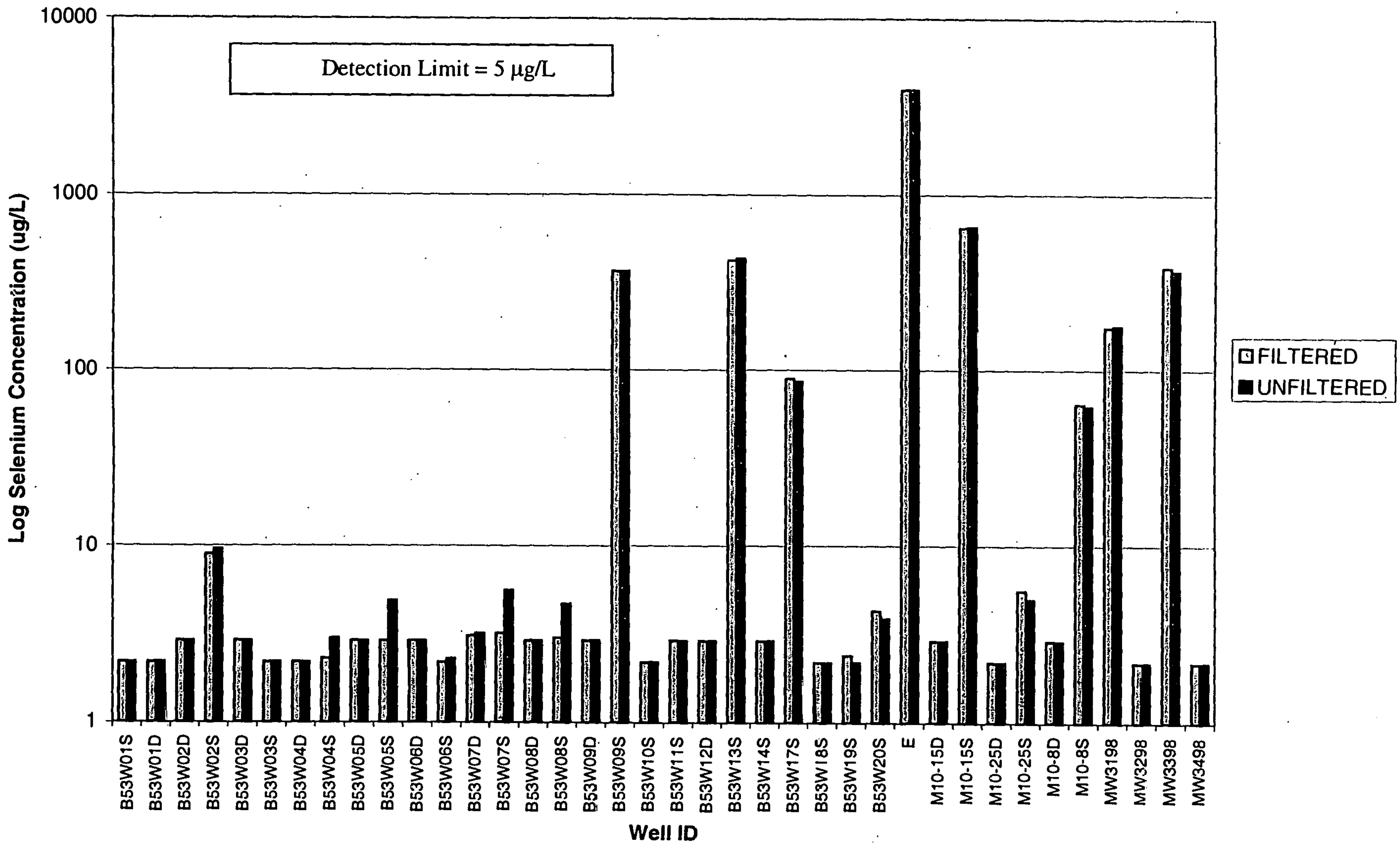
TCE was detected above its detection limit and MCL of 5 $\mu g/l$ in upper HZ ground-water samples from four wells (B53W12S, B53W13S, B53W17S, and M11-9) in July and August 1998 sample event, but only two wells in the fourth quarter event, B53W17S and MW33-98. MW33-98 was installed in the fall of 1998 and sampled for the first time in fourth quarter 1998. Graph 10 illustrates TCE results for the fourth quarter. The maximum TCE concentration was detected in the ground-water sample from well B53W17S at 840 $\mu g/l$ and increased to a concentration of 970 $\mu g/l$. A comparison of TCE concentrations of 1997 and 1998 indicate higher concentrations at most sampled wells in 1998. For example, TCE increased from 600 to 840 to 940 $\mu g/l$ at off-site well B53W17S and from 91 to 140 $\mu g/l$ at well M11-9 (not sampled in fourth quarter). These concentration variations may be seasonal fluctuations.

No herbicides or PCBs were detected in the ground-water samples collected at SLAPS in 1998.

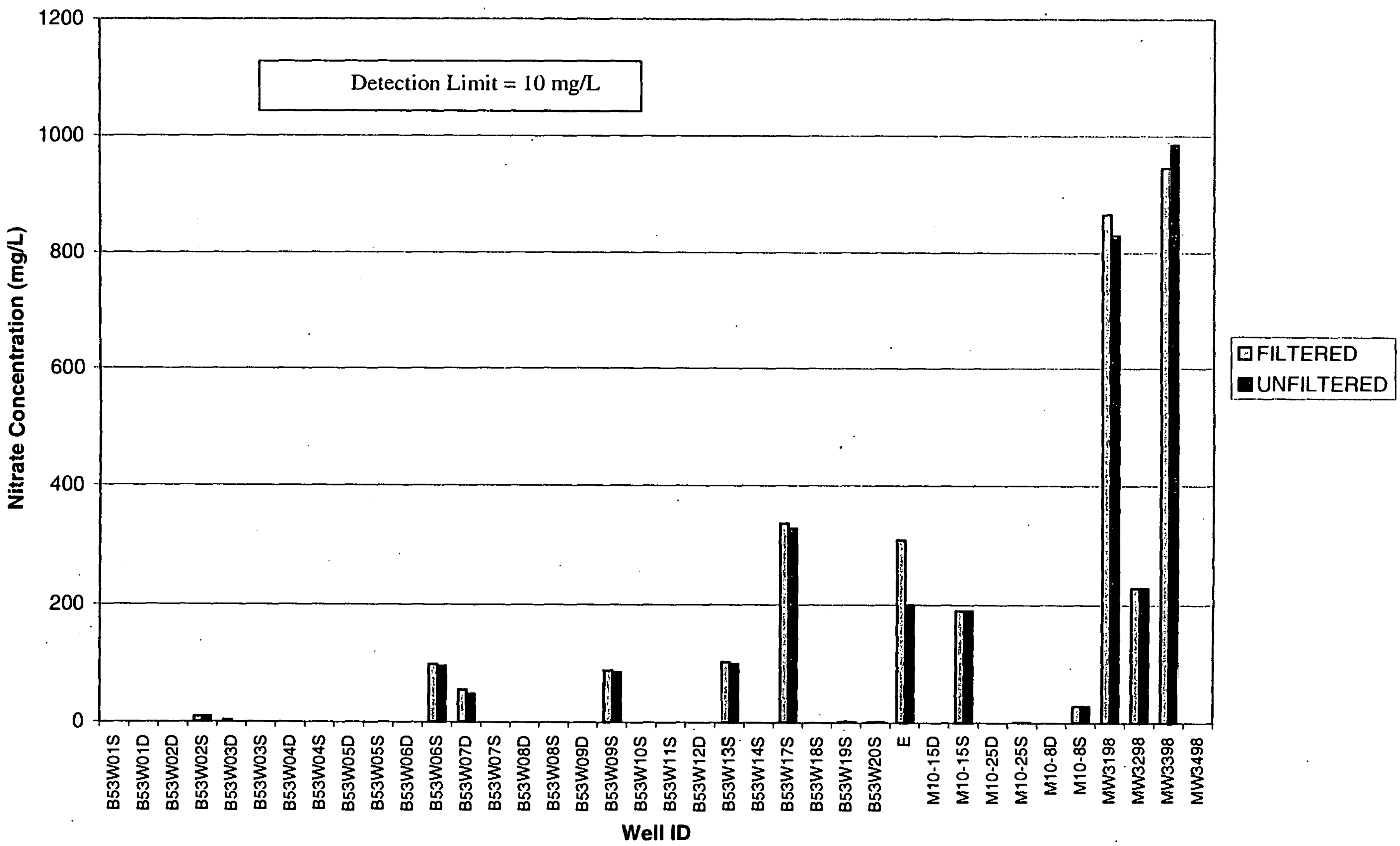
3.7.2.2 Comparison of Historical Ground-Water Data at SLAPS

Comparisons to available historical data are made for EMP analytes. Some variations in concentrations over time in collected ground-water samples may be related to or caused by varied ground-water sampling techniques or changes in subsurface conditions such as ground-water turbidity and ground-water elevation. In addition, this evaluation may also compare filtered samples for "dissolved" concentrations to historical unfiltered samples for "total" concentrations.

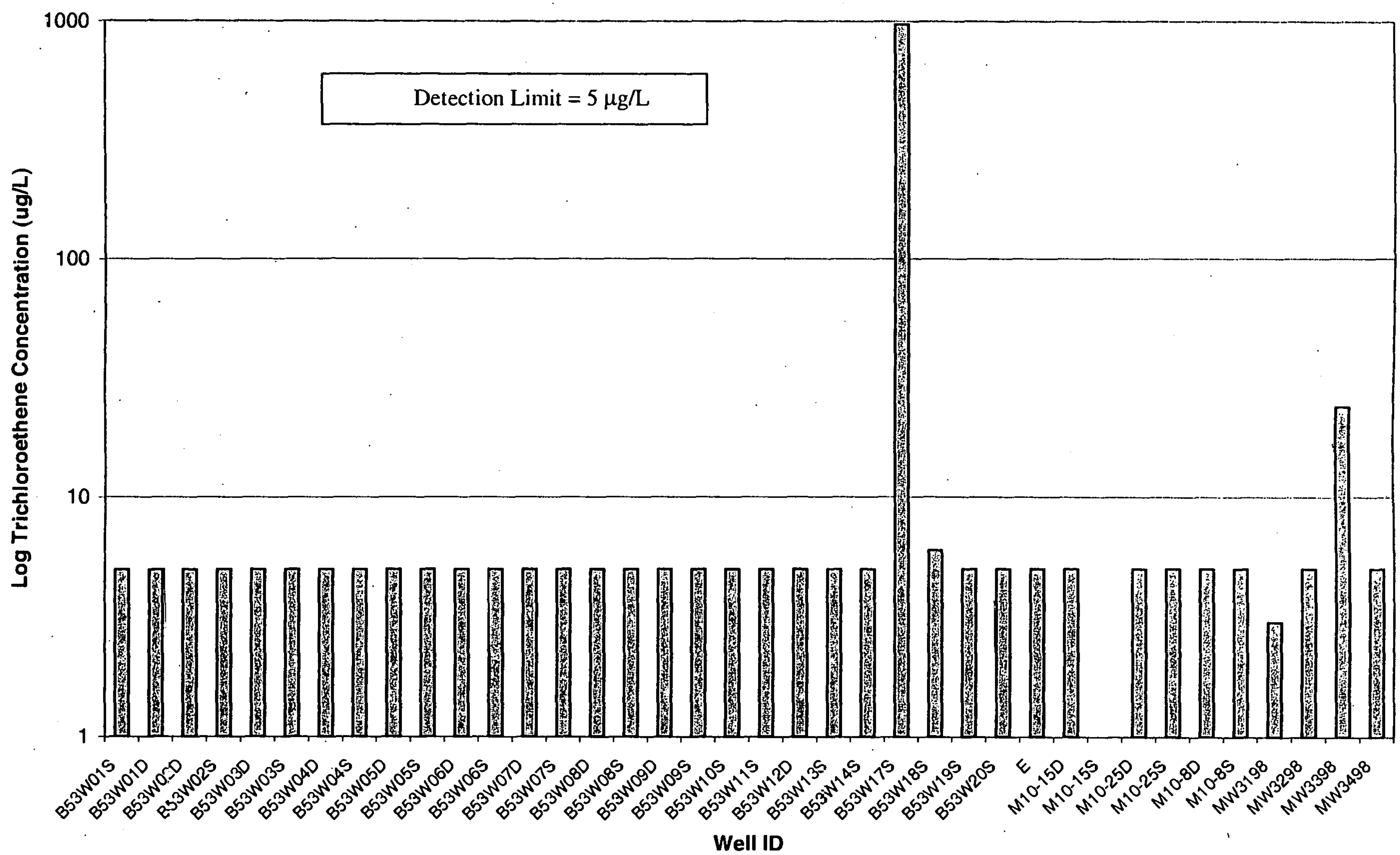
Graph 8. SLAPS Selenium Ground-water Sampling Results for the Fourth Quarter 1998



Graph 9. SLAPS Nitrate Ground-water Sampling Results for the Fourth Quarter 1998



Graph 10. SLAPS Trichloroethene Ground-water Sampling Results for the Fourth Quarter 1998



The historical trend for total uranium is moderately consistent for the upper HZ wells monitored, as shown in Table 3-18. Concentrations are fairly constant for the wells monitored. The trends for Ra-226 and Th-230 consistently show low concentrations as shown in Tables 3-19 and 3-20, respectively. A comparison of historical Th-230 concentrations in ground water to the 1998 results indicate that slightly higher Th-230 concentrations were detected in the 1998 samples. The 1998 results correlate better with thorium results of 1991 and 1992.

3.7.2.3 Evaluation of the December 1998 Potentiometric Surfaces at SLAPS

The ground-water flow direction from SLAPS in the upper HZ, interpreted to be perpendicular to ground-water equipotential contours, is westerly to northwesterly towards Coldwater Creek (Figure 3-14). Shallow ground water beneath properties located north of the creek also converges to the creek as shown. The hydraulic gradient increased near the southern side of Coldwater Creek. The shallow-most ground water of the unconfined upper zone is interpreted to discharge into Coldwater Creek, which divides the shallow ground-water system south and east of the creek from areas north and west of Coldwater Creek. One anomalous point is located at monitoring well B53W10S. It is interpreted to be an invalid reading or the location has been influenced by remedial activities in the vicinity.

Potentiometric surface elevation for the lower HZ is highest at well M10-25D located at the southeastern corner of the site. Figure 3-15 illustrates the potentiometric surface contours the lower HZ. This contour configuration of two radial types of surface patterns northeast and west of SLAPS was also observed in September 1995. The potentiometric surface of the lower zone does not appear influenced by Coldwater Creek because the "confined" the lower HZ ground-water potentiometric surface is higher than the upper zone and the creek (creek elevation is about 500 feet above mean sea level). This condition is also supported by the absence of a potentiometric trend paralleling the creek, the apparent extension of the potentiometric surface beneath the creek, and other hydrogeologic data (presence of 3M unit, the boundary of the upper and lower HZ). The orientation and thickness of the lower HZ material probably influences the configuration of the lower HZ potentiometric surface in the buried channel system, which is oriented similar to the present course of Coldwater Creek.

Table 3-18. Historical Concentrations of Total Uranium (µg/l) in Ground-water at SLAPS

Well ID	1984*	1985*	1986*	1987*	1988*	1989*	1990*	1991*	1992*	1997*	1998**
A	1812.7	3345.1	1667.6	1604.2	2394.4	2908.5	3429.6	5312	---	6060	abandoned
B	8028	6669	9254	8210	7873	7438	6413	9318	---	7330	abandoned
C	56.3	50.7	22.5	18.3	25.4	28.2	26.8	22.5	---	42.5	abandoned
D	328.2	667.6	1129.6	897.2	669	1088.7	971.8	1242	---	540	abandoned
E	182	161	761	811	278	1154	266	287	---	182	
F	199	249	206	149	373	375	285	569	---	467	abandoned
B53W01D	---	---	---	---	5.6	---	---	7	---	<1.5	0.2
B53W01S	---	---	---	---	4.2	---	---	8.5	---	2.3	20.93
B53W02D	---	---	---	---	---	---	---	---	---	<1.5	0.5
B53W02S	---	---	---	---	---	---	---	---	---	50.3	20.66
B53W03D	---	---	---	---	---	---	---	---	---	<1.5	0.84
B53W03S	---	---	---	---	---	---	---	---	---	20.4	20.74
B53W04D	---	---	---	---	---	---	---	---	---	<1.5	10.5
B53W04S	---	---	---	---	---	---	---	---	---	<1.5	0.33
B53W05D	---	---	---	---	---	---	---	---	---	<1.5	0.51
B53W05S	---	---	---	---	---	---	---	---	---	<1.5	0.27
B53W06D	---	---	---	---	---	---	---	---	---	<1.5	10.63
B53W06S	---	---	---	---	---	---	---	---	---	75.4	53.12
B53W07D	---	---	---	---	---	---	---	---	---	<1.5	50.43
B53W07S	---	---	---	---	---	---	---	0.8	---	11.8	O
B53W08D	---	---	---	---	---	---	---	---	---	<1.5	13.96
B53W08S	---	---	---	---	---	---	---	---	---	<1.5	30.59
B53W09D	---	---	---	---	---	---	---	---	---	10.5	---
B53W09S	---	---	---	---	---	---	---	---	---	70.1	40.86
B53W10D	---	---	---	---	---	---	---	6.7	---	<1.5	---
B53W10S	---	---	---	---	---	---	---	3.1	3.9	30.8	10.38
B53W11D	---	---	---	---	---	---	5.6	23.9	26.2	30.6	10.98
B53W11S	---	---	---	---	---	---	---	---	---	<1.5	---
B53W12D	---	---	---	---	---	---	---	---	---	20.1	---

Table 3-18. Historical Concentrations of Total Uranium (μg/l) in Ground-water at SLAPS (cont'd)

Well ID	1984*	1985*	1986*	1987*	1988*	1989*	1990*	1991*	1992*	1997*	1998**
B53W12S	---	---	---	---	---	---	---	7.3	20	17.6	19.5
B53W13S	---	---	---	---	---	---	---	4.5	12.7	14.3	13.98
B53W14S	---	---	---	---	---	---	---	---	0.6	<1.5	0.23
B53W15S	---	---	---	---	---	---	---	11.3	80.7	10.7	---
B53W16S	---	---	---	---	---	---	---	8.5	---	20.6	<1.0
B53W17S	---	---	---	---	---	---	---	---	70.1	3.6	20.73
B53W18S	---	---	---	---	---	---	---	---	8	6.6	60.72
B53W19S	---	---	---	---	---	---	---	---	20.9	10.7	80.81
B53W20S	---	---	---	---	---	---	---	---	5	<1.5	43.49
M10-8D	---	---	---	7	5.6	7	5.6	5.6	0.1	<1.5	2.12
M10-8S	---	---	---	45.1	26.8	29.6	8.5	46.5	8.6	191	---
M10-15D	---	---	---	12.7	7	4.2	8.5	8.5	---	<1.5	10.03
M10-15S	---	---	---	15.5	12.7	15.5	7	15.5	---	6	30.75
M10-25D	---	---	---	5.6	5.6	4.2	4.2	11.3	---	20.6	30.67
M10-25S	---	---	---	35.2	54.9	46.5	81.7	50.7	---	113	78.43
M11-9S	---	---	---	6448	6507	6770	2727	8654	7409	6420	---
M11-21S	---	---	---	63.4	103	135	117	231	---	151	---
M13.5-8.5D	---	---	---	---	---	---	8.5	7	0.8	<1.5	---
M13.5-8.5S	---	---	---	5.6	5.6	4.2	5.6	8.5	14.4	40.3	---

Notes:
--- Data not available.
*Annual averaged data.
**Based on fourth quarter 1998 data.
All results reported to the nearest 0.1 μg/l for concentrations below 100 μg/l.
The detection limit for 1997 results is 1.5 μg/l.
Historic data from BNI (1994) and SAIC (1995).
< - Reported concentration below sample quantitation limit based on either "Laboratory" or "Reviewer Qualifier".
All 1984-92 samples are assumed to be unfiltered.
Includes only filtered sample data.

Table 3-19. Historical Concentrations of Radium-226 (pCi/l) in Ground-water at SLAPS

Well ID	1984*	1985*	1986*	1987*	1988*	1989*	1990*	1991*	1992*	1997*	1998**
A	0.3	0.2	0.3	0.3	0.4	0.4	0.5	0.3	---	<0.1	abandoned
B	0.3	0.2	0.3	0.3	0.6	0.6	0.6	0.4	---	0.2	abandoned
C	0.3	0.2	0.3	0.4	0.5	0.5	0.5	0.3	---	0.4	abandoned
D	0.2	0.1	0.3	0.1	0.3	0.5	0.4	0.2	---	0.2	abandoned
E	0.6	0.2	0.5	0.3	0.6	0.6	0.5	0.5	---	0.4	---
F	0.2	0.1	0.2	0.3	0.6	0.4	0.5	0.2	---	0.1	abandoned
B53W01D	---	---	---	---	1.1	1	1	0.9	---	0.8	0.7
B53W01S	---	---	---	---	0.6	0.7	0.4	0.9	---	<0.1	0
B53W02D	---	---	---	---	---	---	---	---	---	0.6	0.1
B53W02S	---	---	---	---	---	---	---	---	---	<0.1	0.4
B53W03D	---	---	---	---	---	---	---	---	---	0.7	-0.33
B53W03S	---	---	---	---	---	---	---	---	---	0.1	0.69
B53W04D	---	---	---	---	---	---	---	---	---	0.4	0.45
B53W04S	---	---	---	---	---	---	---	---	---	<0.1	0.19
B53W05D	---	---	---	---	---	---	---	---	---	0.7	0.36
B53W05S	---	---	---	---	---	---	---	---	---	0.2	10.3
B53W06D	---	---	---	---	---	---	---	---	---	0.2	10.71
B53W06S	---	---	---	---	---	---	---	---	---	<0.1	0.24
B53W07D	---	---	---	---	---	---	---	---	---	0.6	-0.11
B53W07S	---	---	---	---	---	---	---	0.8	---	0.1	-0.06
B53W08D	---	---	---	---	---	---	---	---	---	0.8	10.23
B53W08S	---	---	---	---	---	---	---	---	---	0.8	0.75
B53W09D	---	---	---	---	---	---	---	---	---	0.5	10.05
B53W09S	---	---	---	---	---	---	---	---	---	0.3	0.86
B53W10D	---	---	---	---	---	---	---	0.2	---	0.3	---
B53W10S	---	---	---	---	---	---	---	0.3	1.3	0.5	0.42
B53W11D	---	---	---	---	---	---	0.8	0.5	33.8	0.1	---
B53W11S	---	---	---	---	---	---	---	---	---	<0.1	0.31

Table 3-19. Historical Concentrations of Radium-226 (pCi/l) in Ground-water at SLAPS (cont'd)

Well ID	1984*	1985*	1986*	1987*	1988*	1989*	1990*	1991*	1992*	1997*	1998**
B53W12D	---	---	---	---	---	---	---	---	1.6	0.2	20.83
B53W12S	---	---	---	---	---	---	---	0.1	---	0.2	0.4
B53W13S	---	---	---	---	---	---	---	0.2	1.7	0.4	0.23
B53W14S	---	---	---	---	---	---	---	---	1.76	0.2	10.09
B53W15S	---	---	---	---	---	---	0.3	0.8	2.3	0.1	---
B53W16S	---	---	---	---	---	---	0.2	0.5	---	0.2	---
B53W17S	---	---	---	---	---	---	---	---	0.6	0.2	0
B53W18S	---	---	---	---	---	---	---	---	1	0.8	-0.13
B53W19S	---	---	---	---	---	---	---	---	0.2	0.3	0.57
B53W20S	---	---	---	---	---	---	---	---	0.3	0.1	10.19
M10-8D	---	---	---	0.3	0.6	0.6	0.8	0.9	0.9	0.4	-0.12
M10-8S	---	---	---	0.4	0.5	0.4	0.5	0.4	0.9	0.3	0.11
M10-15D	---	---	---	0.4	0.9	0.9	0.6	1.2	---	0.4	0.28
M10-15S	---	---	---	0.3	0.8	0.4	0.5	1.2	---	0.2	0.06
M10-25D	---	---	---	0.2	0.4	0.7	0.7	1.6	---	0.4	0.18
M10-25S	---	---	---	0.2	0.6	0.5	0.5	0.6	---	0.3	---
M11-9S	---	---	---	0.5	0.8	0.5	0.3	0.3	---	0.2	---
M11-21S	---	---	---	0.5	0.7	0.7	0.5	2.3	---	0.1	---
M13.5-8.5D	---	---	---	0.5	0.6	0.6	1.5	0.6	1.8	0.2	<1.0
M13.5-8.5S	---	---	---	0.5	0.8	0.5	0.7	0.9	2.6	0.3	---

Notes:
--- Data not available.
*Annual averaged data.
**Based on fourth quarter 1998 data.
All results reported to the nearest 0.1 pCi/l.
The detection limit for 1997 results is 0.1 pCi/l.
Historic data from BNI (1994) and SAIC (1995).
< - Reported concentration below sample quantitation limit based on either "Laboratory" or "Reviewer Qualifier".
All 1984-92 samples are assumed to be unfiltered.
Includes only filtered sample data.

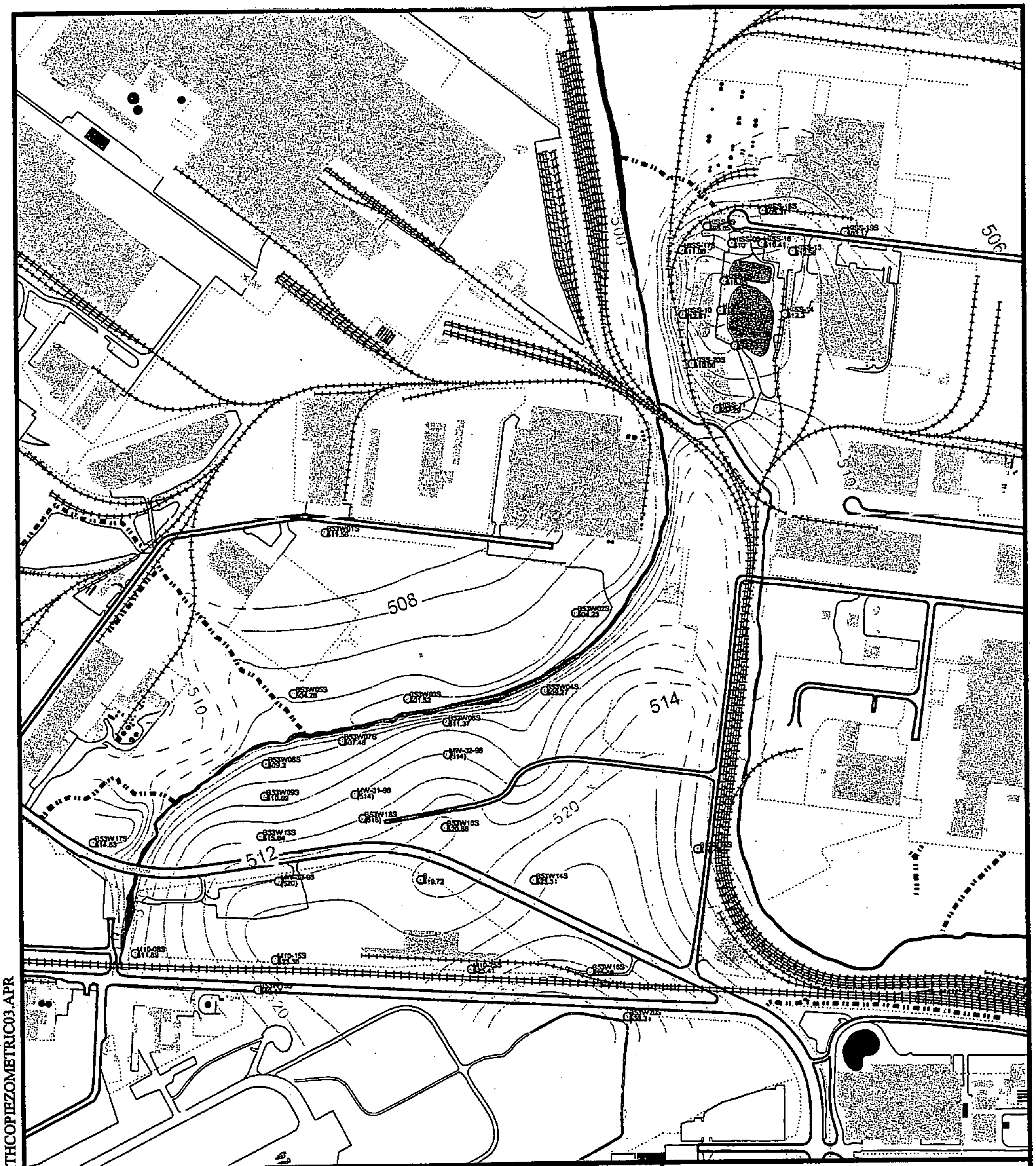
Table 3-20. Historical Concentrations of Thorium-230 (pCi/l) in Ground-water at SLAPS

Well ID	1984*	1985*	1986*	1987*	1988*	1989*	1990*	1991*	1992*	1997*	1998**
A	9.5	2.3	<0.4	0.8	2.8	2.9	4.1	2.7	---	0.2	Abandoned
B	0.3	0.3	1.2	1.4	2	1.1	1.2	0.9	---	<0.1	Abandoned
C	0.2	0.2	0.2	0.9	0.3	0.1	0.2	0.7	---	<0.1	Abandoned
D	0.9	1.3	0.3	0.9	0.9	1.4	1.4	1.5	---	<0.1	Abandoned
E	0.3	1	0.4	0.9	4.8	1.7	0.6	1.3	---	0.2	---
F	0.4	1.1	0.2	1.7	2	0.8	0.4	1.2	---	<0.1	abandoned
B53W01D	---	---	---	---	0.2	0.4	0.4	0.6	---	<0.1	0.75
B53W01S	---	---	---	---	0.2	0.3	0.2	0.7	---	<0.1	0.3
B53W02D	---	---	---	---	---	---	---	---	---	<0.1	10.94
B53W02S	---	---	---	---	---	---	---	---	---	<0.1	80.55
B53W03D	---	---	---	---	---	---	---	---	---	<0.1	10.05
B53W03S	---	---	---	---	---	---	---	---	---	<0.1	0.59
B53W04D	---	---	---	---	---	---	---	---	---	<0.1	10.16
B53W04S	---	---	---	---	---	---	---	---	---	<0.1	10.07
B53W05D	---	---	---	---	---	---	---	---	---	<0.1	20.58
B53W05S	---	---	---	---	---	---	---	---	---	<0.1	10.87
B53W06D	---	---	---	---	---	---	---	---	---	<0.1	10.38
B53W06S	---	---	---	---	---	---	---	---	---	<0.1	0.88
B53W07D	---	---	---	---	---	---	---	---	---	<0.1	10.27
B53W07S	---	---	---	---	---	---	---	0.2	---	<0.1	0.84
B53W08D	---	---	---	---	---	---	---	---	---	<0.1	10.62
B53W08S	---	---	---	---	---	---	---	---	---	<0.1	20.45
B53W09D	---	---	---	---	---	---	---	---	---	<0.1	10.07
B53W09S	---	---	---	---	---	---	---	---	---	<0.1	10.07
B53W10D	---	---	---	---	---	---	---	0.2	---	<0.1	---
B53W10S	---	---	---	---	---	---	---	0.2	0.9	<0.1	10.21
B53W11D	---	---	---	---	---	---	2	0.8	8.9	<0.1	---
B53W11S	---	---	---	---	---	---	---	---	---	<0.1	20.28
B53W12D	---	---	---	---	---	---	---	---	---	<0.1	10.37

Table 3-20. Historical Concentrations of Thorium-230 (pCi/l) in Ground-water at SLAPS (cont'd)

Well ID	1984*	1985*	1986*	1987*	1988*	1989*	1990*	1991*	1992*	1997*	1998**
B53W12S	---	---	---	---	---	---	---	0.2	2.6	<0.1	0.5
B53W13S	---	---	---	---	---	---	---	0.2	0.4	<0.1	0.72
B53W14S	---	---	---	---	---	---	---	---	0.34	<0.1	20.81
B53W15S	---	---	---	---	---	---	0.7	1.4	0.6	<0.1	---
B53W16S	---	---	---	---	---	---	0.2	0.7	---	<0.1	---
B53W17S	---	---	---	---	---	---	---	---	0.1	<0.1	10.53
B53W18S	---	---	---	---	---	---	---	---	<0.2	<0.1	0.72
B53W19S	---	---	---	---	---	---	---	---	0.1	<0.1	0.31
B53W20S	---	---	---	---	---	---	---	---	0.6	<0.1	10.23
M10-8D	---	---	---	<0.1	0.3	0.3	0.9	1	0.3	<0.1	20.73
M10-8S	---	---	---	0.2	0.5	0.3	0.2	0.6	0.9	<0.1	0.48
M10-15D	---	---	---	1.8	5.3	1.3	1	24.1	---	<0.1	10.6
M10-15S	---	---	---	0.4	1.3	1.1	0.5	0.8	---	<0.1	-0.07
M10-25D	---	---	---	0.8	0.5	0.8	0.9	1.5	---	<0.1	0.24
M10-25S	---	---	---	0.2	0.4	0.1	0.3	1.2	---	<0.1	10.38
M11-9S	---	---	---	0.3	1	0.8	0.2	1.6	1.4	0.1	---
M11-21S	---	---	---	15.2	52	11	11.9	28	---	<0.1	---
M13.5-8.5D	---	---	---	<0.1	0.7	0.6	0.6	0.5	0.4	<0.1	---
M13.5-8.5S	---	---	---	0.4	0.7	0.2	0.3	1.6	0.8	<0.1	---

Notes:
--- Data not available.
*Annual averaged data.
**Based on fourth quarter 1998 data.
All results reported to the nearest 0.1 pCi/l.
The detection limit for 1997 results is 0.1 pCi/l.
Historic data from BNI (1994) and SAIC (1995).
< - Reported concentration below sample quantitation limit based on either "Laboratory" or "Reviewer Qualifier".
All 1984-92 samples are assumed to be unfiltered.
Includes only filtered sample data.



Legend:

- ⊙ Shallow Monitoring Well Location Where 3 Dec. 98 Water Level Measurement Was Taken (water level elevation in feet AMSL, in parenthesis where inferred).
- ╱╲ Interpreted Shallow Piezometric Surface (based on measured water level elevations, surficial drainage, and topography). Dashed where inferred. Two Foot Contour Interval.

300 0 300 600 Feet

N

MO-East State Plane Coordinate System (NAD83, feet)

FUSRAP

SLAPS & HISS
3 DEC 98 Shallow Piezometric Surface
St. Louis, Missouri

DRAWN BY:	REV. - DATE:
R. Smith / S. Kitchings	3 - 9/16/99

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Figure 3-14. Upper Potentiometric Surface at SLAPS and HISS

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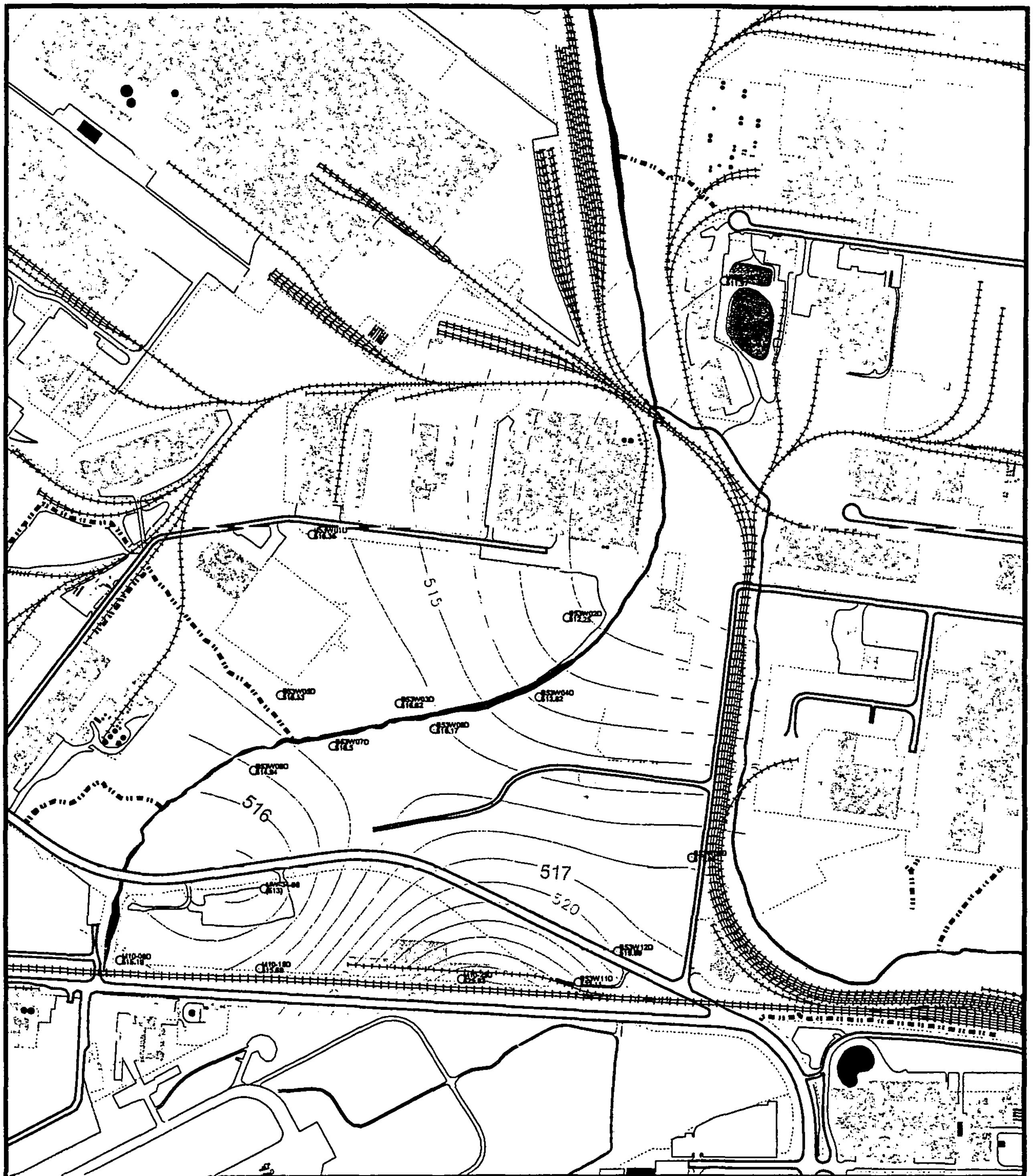

Legend:

- ○ Deep Monitoring Well Location Where 3 Dec. 98 Water Level Measurement Was Taken (water level elevation in feet AMSL, in parenthesis where inferred).
- Interpreted Deep Piezometric Surface. Dashed where inferred. One Foot Contour Interval.

300 0 300 600 Feet

N

MO-East State Plane Coordinate System (NAD83, feet)

FUSRAP

SLAPS & HISS
3 DEC 98 Deep Piezometric Surface
St. Louis, Missouri

DRAWN BY:	REV. - DATE:
R. Smith / S. Kitchings	3 - 9/16/99

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Figure 3-15. Lower Potentiometric Surface at SLAPS and HISS

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3.7.3 HISS

The hydrogeologic and geologic setting at the HISS site is similar to that at SLAPS, with two exceptions. The Pennsylvanian shale bedrock unit, present at SLAPS, is absent at HISS. Secondly, the 3M unit is present throughout the HISS site, whereas it is absent at eastern portions of SLAPS (USACE, 1998e). The EMP well network for HISS is identified in Figure 3-16.

A total of 21 ground-water monitoring wells have been installed at the HISS. These wells were installed in the time period of 1979 to 1992. EMP ground-water samples have been collected from HISS from 1984 to the present. In the early 1990s, ground-water samples were collected from three or four wells at the site on an annual or quarterly (every three months) basis. Eighteen monitoring wells existed at HISS during the 1997 baseline sampling event; there are presently fifteen wells at HISS. The 1997 baseline ground-water sampling event was the most comprehensive ground-water monitoring program conducted at the site.

Statistical summaries of all of the analytes detected at HISS during the 1997 baseline sampling event are shown in Table 3-21. Based on historical hydrogeologic information and the findings of the 1997 baseline ground-water sampling event at HISS, several conclusions were drawn regarding hydrogeology and ground-water chemistry that helped define site conditions. The type, occurrence, and distribution of ground-water contamination were also identified and evaluated as part of this sampling effort.

The 3M unit of HZ-B acts as a barrier to vertical ground-water movement based on the differences in ground-water chemistry between the upper and lower HZs. With the exception of monitoring well, HISS-5D, which is screened in the HZ-C, all of the monitoring wells at the HISS are screened in the HZ-A. Using historical and the 1997 baseline data, HZ-A ground water at HISS contains elevated concentrations of total uranium, nitrate, and selenium. Elevated manganese in site and off-site wells is also detected, although its cause is unknown. No new PCOCs were detected compared to previous data. TCE concentrations were also recently detected in HISS ground water, consistent with previous results. The occurrence of TCE is believed to be unrelated to previous or existing site activities. No PCOCs (except manganese) were detected in HZ-C (well HISS-5D) at HISS.

Concentrations of total uranium in the 1997 baseline, HZ-A data are both higher and lower at different locations compared to previous results. Some higher concentrations of nitrate and selenium were recently detected at certain locations compared to historical data. The recent high concentrations at some HZ-A locations may suggest a local influx of PCOCs into parts of the shallow ground-water system at HISS.

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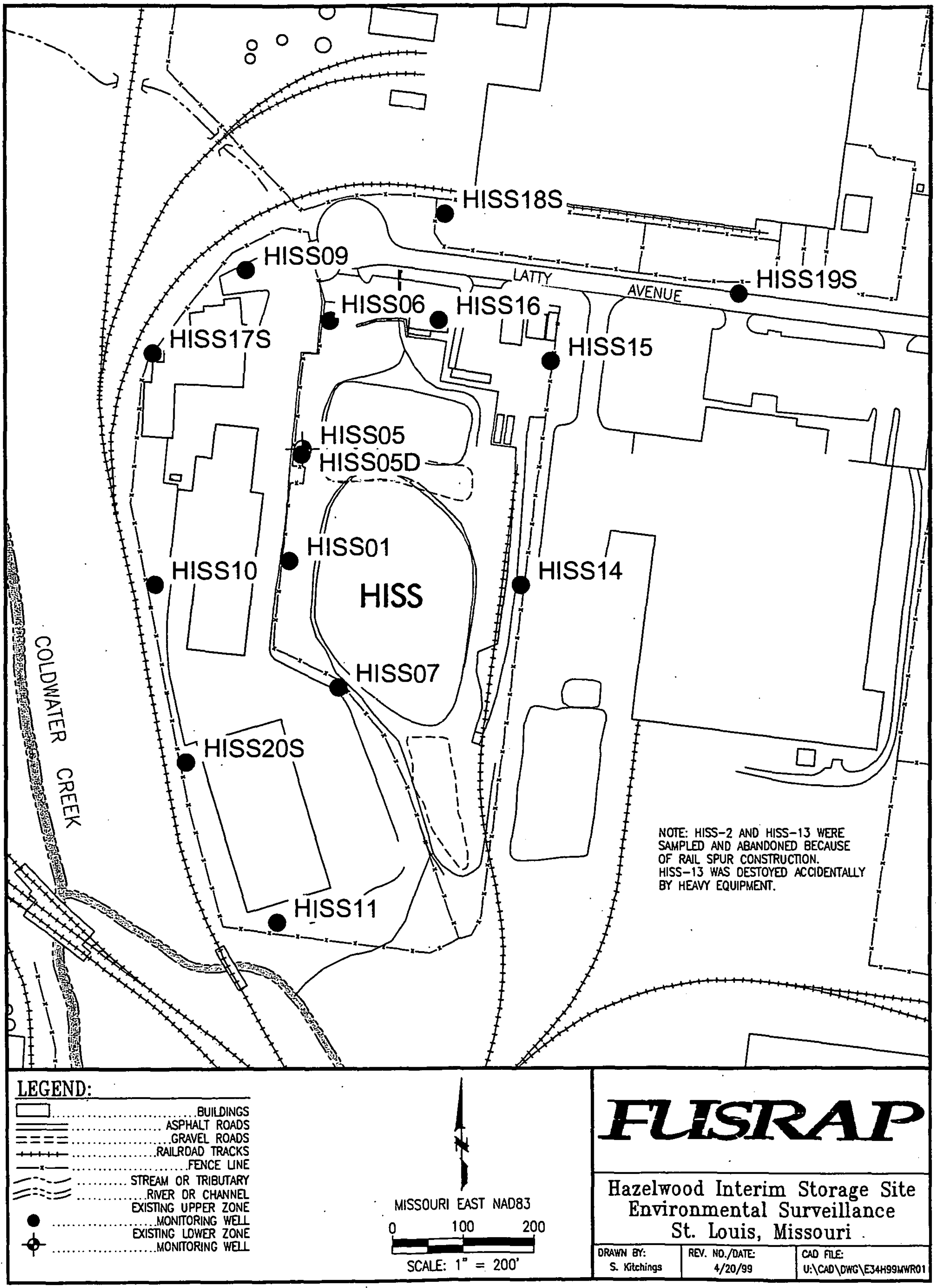

Figure 3-16. Ground-Water Monitoring Wells at HISS

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Table 3-21. Analytes Detected in Ground-water Samples from the 1997 Baseline Survey at HISS

Hydrostratigraphic Zone	Parameter	Units	Average Result	Standard Deviation	Minimum Detect	Maximum Detect	Results >Detection Limit
HZ-C	Ammonia	µg/l	12500		12500	12500	1/ 1
HZ-C	Silicon	µg/l	10200		10200	10200	1/ 1
HZ-C	Arsenic	µg/l	36.6		36.6	36.6	1/ 1
HZ-C	Barium	µg/l	619		619	619	1/ 1
HZ-C	Boron	µg/l	280		280	280	1/ 1
HZ-C	Calcium	µg/l	119000		119000	119000	1/ 1
HZ-C	Cobalt	µg/l	2.5		2.5	2.5	1/ 1
HZ-C	Iron	µg/l	9920		9920	9920	1/ 1
HZ-C	Magnesium	µg/l	46900		46900	46900	1/ 1
HZ-C	Manganese	µg/l	609		609	609	1/ 1
HZ-C	Molybdenum	µg/l	1.1		1.1	1.1	1/ 1
HZ-C	Nickel	µg/l	5.1		5.1	5.1	1/ 1
HZ-C	Potassium	µg/l	18000		18000	18000	1/ 1
HZ-C	Sodium	µg/l	85200		85200	85200	1/ 1
HZ-C	Strontium	µg/l	1100		1100	1100	1/ 1
HZ-C	Uranium	µg/l	0.0786		0.0786	0.0786	1/ 1
HZ-C	Lead-210	pCi/l	2.57		2.57	2.57	1/ 1
HZ-C	Radium-226	PCi/l	0.805		0.805	0.805	1/ 1
HZ-A	Chloride	µg/l	35500	62300	13700	259000	9/ 17
HZ-A	Fluoride	µg/l	547	565	200	2300	10/ 17
HZ-A	Nitrate	µg/l	202000	266000	1600	729000	16/ 17
HZ-A	Nitrite	µg/l	263	297	1000	1000	1/ 15
HZ-A	Sulfate	µg/l	111000	56000	21100	233000	17/ 17
HZ-A	Ammonia	µg/l	815	1260	5700	5700	1/ 17
HZ-A	Silicon	µg/l	8740	1260	5660	10800	17/ 17
HZ-A	Aluminum	µg/l	93.1	334	22.6	1390	2/ 17
HZ-A	Arsenic	µg/l	9.9	34.6	2.5	144	4/ 17
HZ-A	Barium	µg/l	274	184	71.7	780	17/ 17
HZ-A	Beryllium	µg/l	0.161	0.0671	0.26	0.26	1/ 17
HZ-A	Boron	µg/l	36.3	24.4	79.9	90.3	2/ 17
HZ-A	Cadmium	µg/l	0.561	0.968	0.33	4	6/ 17
HZ-A	Calcium	µg/l	299000	294000	68300	1070000	17/ 17
HZ-A	Cobalt	µg/l	1.13	1.18	0.85	4.7	7/ 17
HZ-A	Copper	µg/l	5.83	18.6	1.7	78	4/ 17
HZ-A	Iron	µg/l	679	2250	742	9310	3/ 17
HZ-A	Lead	µg/l	0.876	1.66	7.3	7.3	1/ 17
HZ-A	Lithium	µg/l	21.5	11.1	45.8	45.8	1/ 17

Table 3-21. Analytes Detected in Ground-water Samples from the 1997 Baseline Survey at HISS

Hydrostratigraphic Zone	Parameter	Units	Average Result	Standard Deviation	Minimum Detect	Maximum Detect	Results >Detection Limit
HZ-A	Magnesium	μg/l	105000	93400	36300	367000	17/ 17
HZ-A	Manganese	μg/l	257	736	11.4	3090	9/ 17
HZ-A	Mercury	μg/l	0.0768	0.0612	0.21	0.26	2/ 17
HZ-A	Molybdenum	μg/l	4.29	5.67	1.3	22.9	9/ 17
HZ-A	Nickel	μg/l	5.28	5.62	1.4	17	12/ 17
HZ-A	Potassium	μg/l	1410	2120	525	9210	11/ 17
HZ-A	Selenium	μg/l	115	133	10.6	386	12/ 17
HZ-A	Silver	μg/l	0.535	0.122	1	1	1/ 17
HZ-A	Sodium	μg/l	73900	69900	18800	301000	17/ 17
HZ-A	Strontium	μg/l	833	867	198	3120	17/ 17
HZ-A	Uranium	μg/l	21.2	34.8	0.794	130	17/ 17
HZ-A	Vanadium	μg/l	1.11	0.994	1.1	4.1	7/ 17
HZ-A	Zinc	μg/l	43.9	142	7.7	593	6/ 17
HZ-A	Bis(2-ethylhexyl)phthalate	μg/l	11.2	39.7	160	160	1/ 16
HZ-A	1,2-Dichloroethene	μg/l	0.588	0.364	2	2	1/ 17
HZ-A	Chloroform	μg/l	0.629	0.615	3	3	1/ 17
HZ-A	Ethylbenzene	μg/l	0.529	0.121	1	1	1/ 17
HZ-A	Toluene	μg/l	0.647	0.606	3	3	1/ 17
HZ-A	Trichloroethene	μg/l	0.6	0.387	2	2	1/ 15
HZ-A	Xylenes, Total	μg/l	0.824	1.33	6	6	1/ 17
HZ-A	Lead-210	pCi/l	1.61	0.688	1	3.8	14/ 17
HZ-A	Radium-226	pCi/l	0.447	0.588	0.163	2.58	11/ 17
HZ-A	Radium-228	pCi/l	0.0203	0.0267	0.112	0.112	1/ 17
HZ-A	Thorium-228	pCi/l	0.0203	0.0267	0.112	0.112	1/ 17
HZ-A	Thorium-230	pCi/l	0.433	1.39	0.106	5.77	5/ 17

3.7.3.1 Evaluation of the 1998 Environmental Monitoring Program (EMP) Ground-water Sampling at HISS

The EMP has recently conducted the 1998 semi-annual collection of ground water at HISS during the second and fourth quarters. The 1998 EMP ground-water sampling took place during March and April and the fourth quarter sampling which was conducted in early 1999. EMP ground-water monitoring at HISS has focused on sampling upgradient and downgradient wells in HZ-A. This sampling strategy is in accordance with the conclusion of the 1997 baseline sampling event that HZ-C ground water has not been impacted. Two additional wells, HISS 2 and HISS 12, were sampled at the same time as the EMP wells in the spring of 1998 because they were scheduled to be abandoned because of a rail spur construction at the site. These wells have been abandoned. All of the EMP ground-water samples collected during the spring 1998 were filtered.

Parameters that were historically analyzed in these ground-water samples included dissolved oxygen, Eh, turbidity, temperature, pH, specific conductance, Ra-226, Ra-228, Th-228, Th-230, Th-232, total uranium, and Se. Table 3-22 displays the complete ground-water sample results for HISS second quarter ground-water sampling. A statistical summary of the ground-water sample results is shown in Table 3-23.

For the spring 1998 event, the majority of the analytical results were reviewed against regulatory limits and risk-based criteria. The total uranium concentration in Well HISS 16 was 63.54 μg/l (93.85 pCi/l), significantly elevated compared to the EPA MCL of 20.5 μg/l (14 pCi/l).

For the HISS ground-water sampling event that occurred in January and February of 1999 for the EMP fourth quarter data. Eight parameters that were sampled for this fourth quarter showed results that exceeded the relevant MCLs. The parameters that had elevated levels in HZ-A are arsenic, cadmium, manganese, nitrate, selenium, sulfate, TCE, and total uranium.

Arsenic results for the fourth quarter HISS ground water sampling event ranged from 95 μg/l (unfiltered) and 88 μg/l (filtered) at well HISS-19S to 3 μg/l (filtered and unfiltered) at 14 of the 15 HISS wells (Graph 11). The MCL for arsenic is 50 μg/l, and well HISS-19S is the only to show an arsenic level above this contamination guideline. Cadmium also showed one well with an elevated contamination level (Graph 12). This maximum level of 21 μg/l for both the unfiltered and filtered samples occurred at well HISS-14.

Several wells showed manganese contamination above the MCL of 50 μg/l. The highest concentration of 3,980 μg/l (filtered and unfiltered) occurred at well HISS-19S (Graph 13). At HISS-5D, manganese results of 710 μg/l (filtered) and 665 μg/l (unfiltered) occurred. At HISS-9, manganese levels of 306 μg/l (filtered) and 277 μg/l (unfiltered) occurred. Manganese levels of 138 μg/l (filtered) and 159 μg/l (unfiltered) were seen at HISS-15. Both wells HISS-14 and HISS-11 showed manganese levels of ~ 100 μg/l. The lowest concentrations of manganese for the fourth quarter sampling event are 0 (filtered) and 5 μg/l (unfiltered) at HISS-6.

The nitrate levels for the HISS fourth quarter 1998 ground-water sampling event also indicated several HZ-A locations with elevated levels (Graph 14). The highest nitrate levels of 2,900 mg/l (filtered) and 2,920 mg/l (unfiltered) occurred at HISS-14. Well HISS-20S had nitrate levels of 676 mg/l (filtered) and 661 mg/l (unfiltered). Both HISS-1 and HISS-7 showed nitrate results between 300 mg/l and 400 mg/l. HISS-5D, HISS-18S, and HISS 19S all showed nitrate concentrations of 0 for both the filtered and unfiltered samples.

Selenium contamination occurred at elevated levels at HZ-A wells HISS-1, HISS-7, HISS-14, and HISS-20S (Graph 15). The highest levels of 434 μg/l (filtered) and 415 μg/l (unfiltered) occurred at HISS-7. The results from wells HISS-1, HISS-14, and HISS-20S ranged from ~190-250. The lowest selenium level of 3 μg/l occurred at wells HISS-10, HISS-11, HISS-18S, HISS-19S, and HISS-5D.

The highest sulfate results of 282 mg/l (filtered) and 281 mg/l (unfiltered) occurred at well HISS-20S (Graph 16). This well is also the only HISS well to exceed the MCL of 250 mg/l. The lowest level of 1 mg/l for the filtered and unfiltered samples of sulfate occurred at HISS-5D. Trichloroethene results ranged from 1,300 μg/l (unfiltered) at HISS-9 to 5 μg/l at 20 of the sampling well at HISS (Graph 17). The MCL for TCE is 5 μg/l.

Total uranium results indicated elevated levels in all of the HISS fourth quarter ground-water samples (Graph 18). The EPA MCL for total uranium is 20 μg/l. The greatest exceedence of this limit occurred at HISS-14 with concentrations of 356 μg/l (filtered and unfiltered). HISS-5 had total uranium levels of 307 μg/l (filtered) and 245 μg/l (unfiltered). The remaining HISS well had total uranium levels of 71 μg/l for both the filtered and unfiltered sample.

3.7.3.2 Comparison of Historical Ground-Water Data at HISS

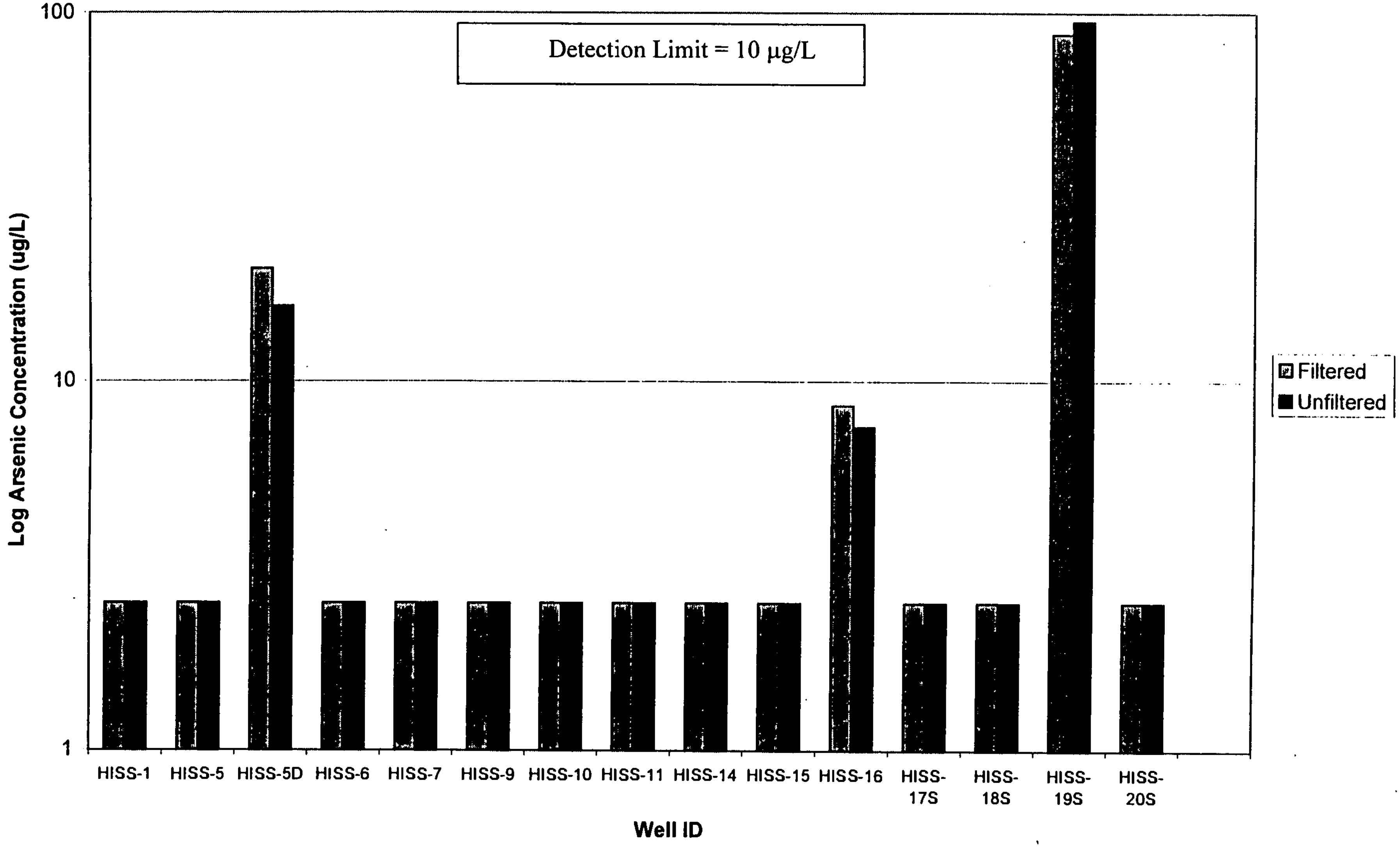
Comparisons to available historical data are made for EMP analytes. Some variations in concentrations over time in collected ground-water samples may be related to or caused by varied ground-water sampling techniques or changes in subsurface conditions, such as ground-water turbidity and ground-water surface elevation. In addition, this evaluation may also compare filtered samples for "dissolved" concentrations to historical unfiltered samples for "total" concentrations.

The historical trend for total uranium at HISS are shown in Table 3-24. Concentrations are fairly constant for the wells monitored. Well HISS 16 consistently displays an elevated near the EPA MCL of 20 μg/l. The trends for Ra-226 and Th-230 are consistently show low concentrations as shown in Tables 3-25 and 3-26, respectively.

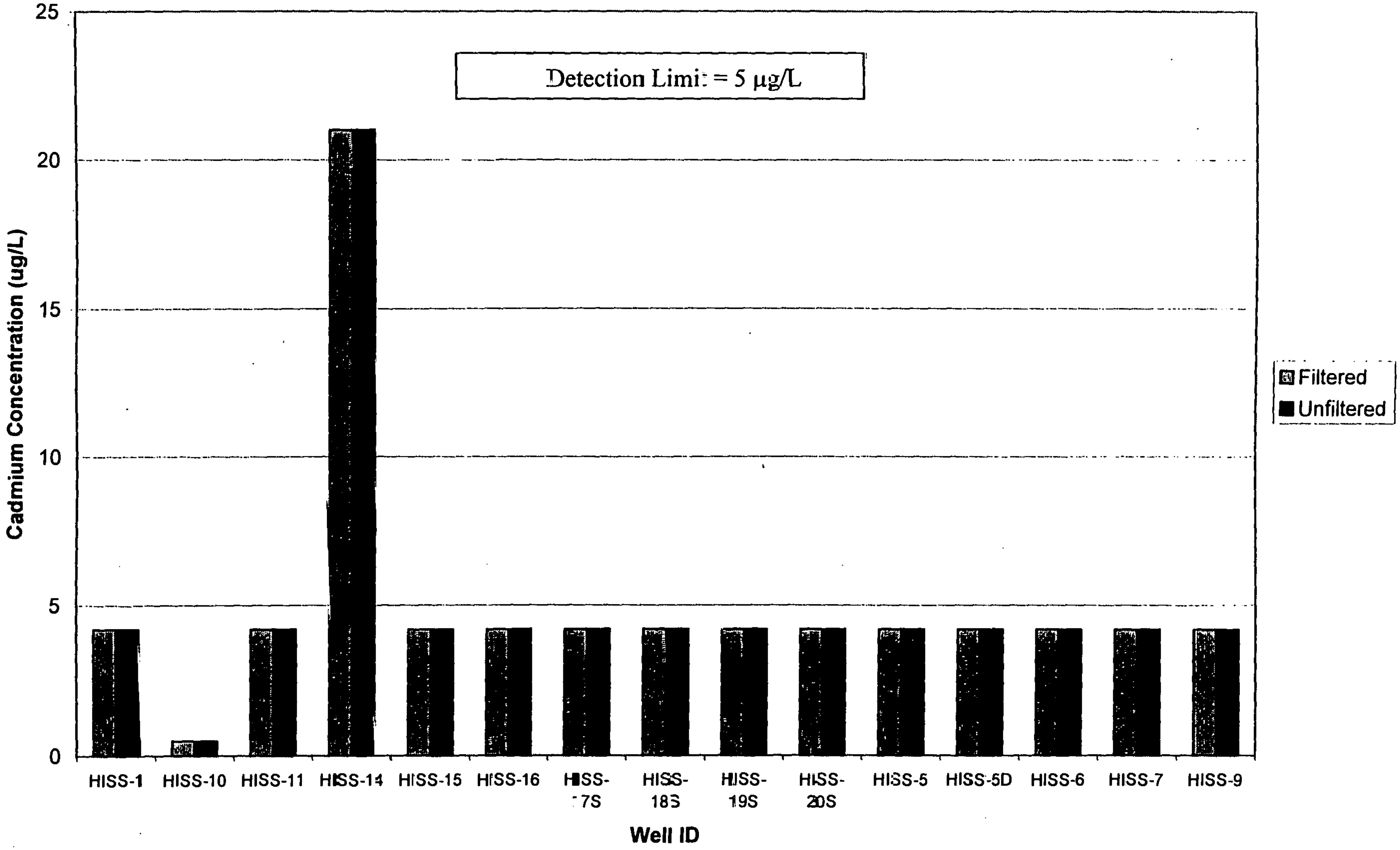
3.7.3.3 Evaluation of the December 1998 Potentiometric Surfaces at HISS

Potentiometric surface elevation data was collected and determined by BNI during June. The depth to ground water ranged between about 5 and 15 feet bgs in September 1998. The top of the saturated zone occurs in the low conductivity silts and clays of stratigraphic Units 2 and 3T. The potentiometric surface configuration of the upper zone ground water using the December 1998 data is illustrated in Figure 3-14. A near-radial potentiometric surface contour pattern is interpreted at HISS. Ground-water data from the late 1980s and early 1990s also indicate a radial contour pattern. Wells HISS-1 and HISS-5 near the center of the site have the highest potentiometric surface with decreased surrounding ground-water elevations. The potentiometric surface elevation directly west of the ground-water mound flattens and appears to correspond to influences of the Coldwater Creek. This can not be substantiated due to the absence of wells in this area. The area of central ground-water mound corresponds to a low wet area on the ground surface, which collects some surface water run-off from the main covered soil pile.

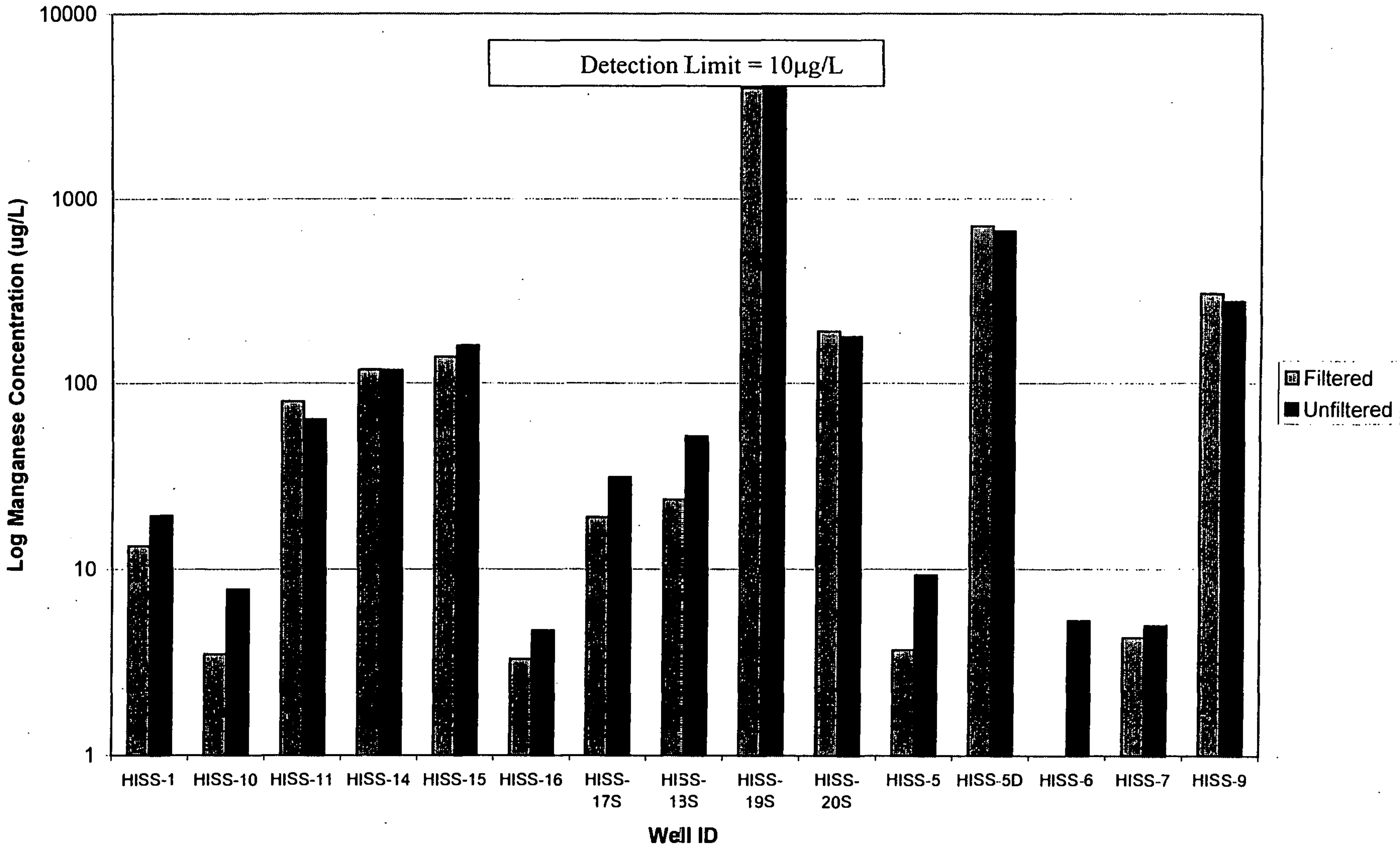
Graph 11. HISS Arsenic Groundwater Sampling Results for the Fourth Quarter 1998



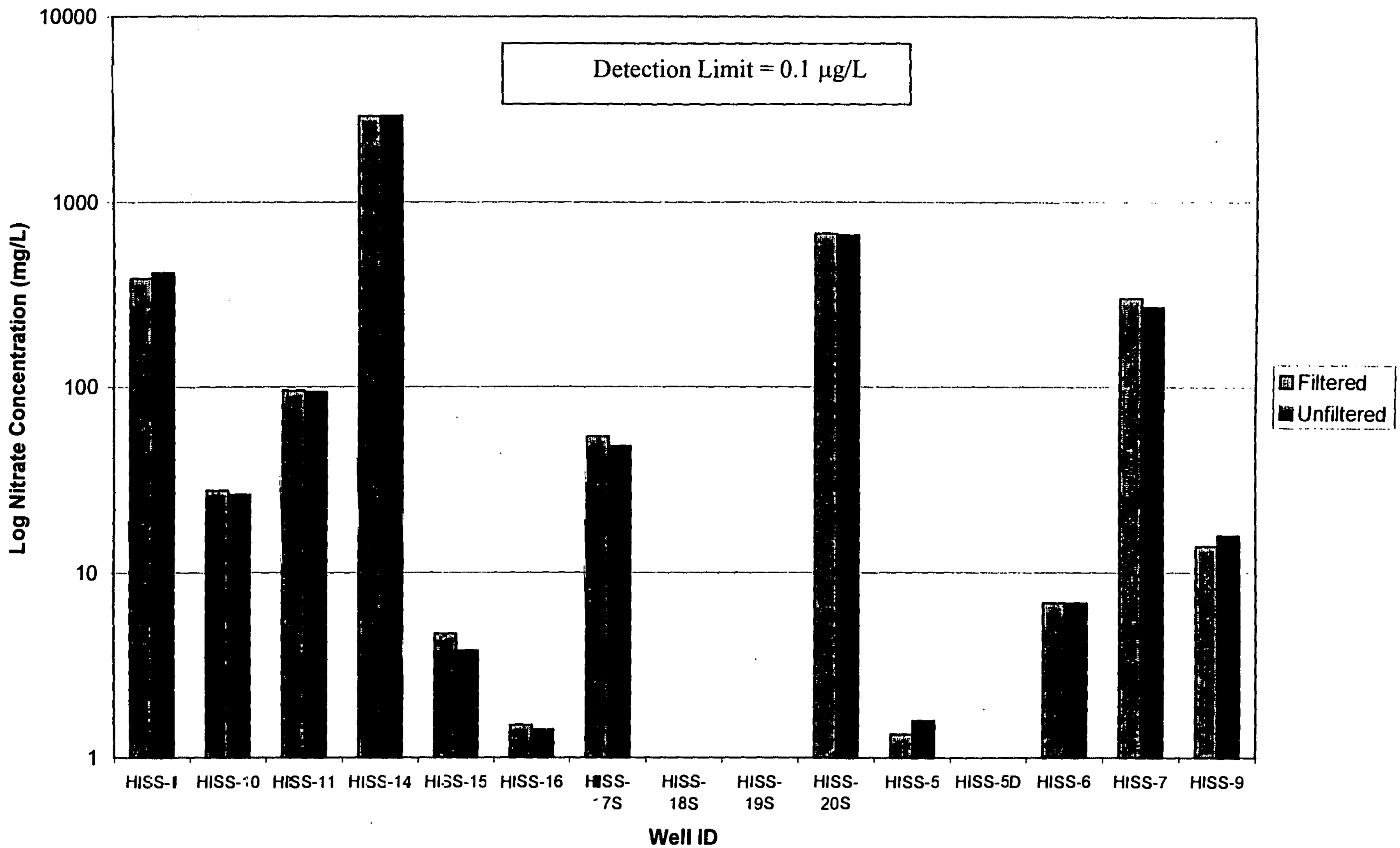
Graph 12. HISS Cadmium Groundwater Sampling Results for the Fourth Quarter 1998



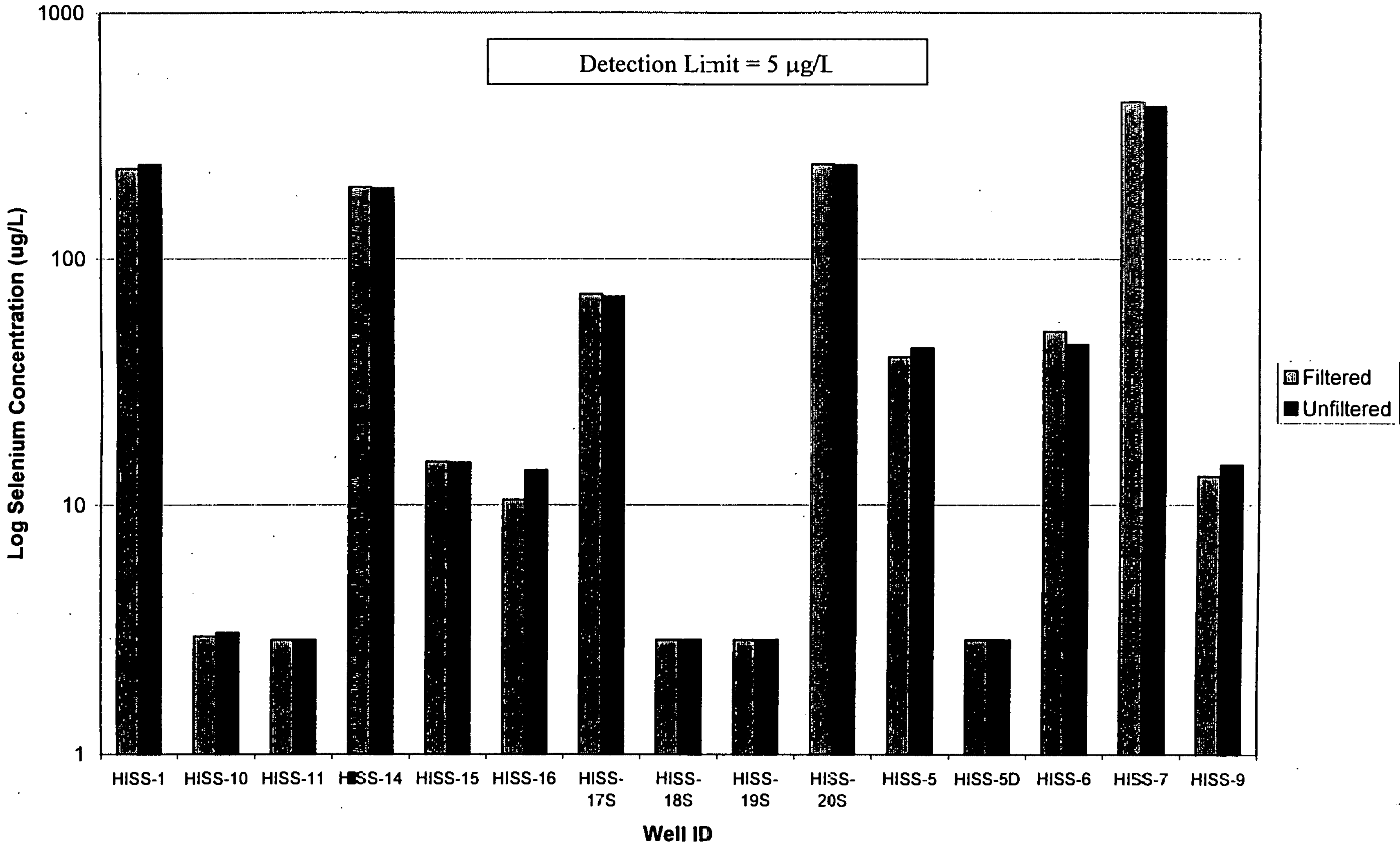
Graph 13. HISS Manganese Groundwater Sampling Results for the Fourth Quarter 1998



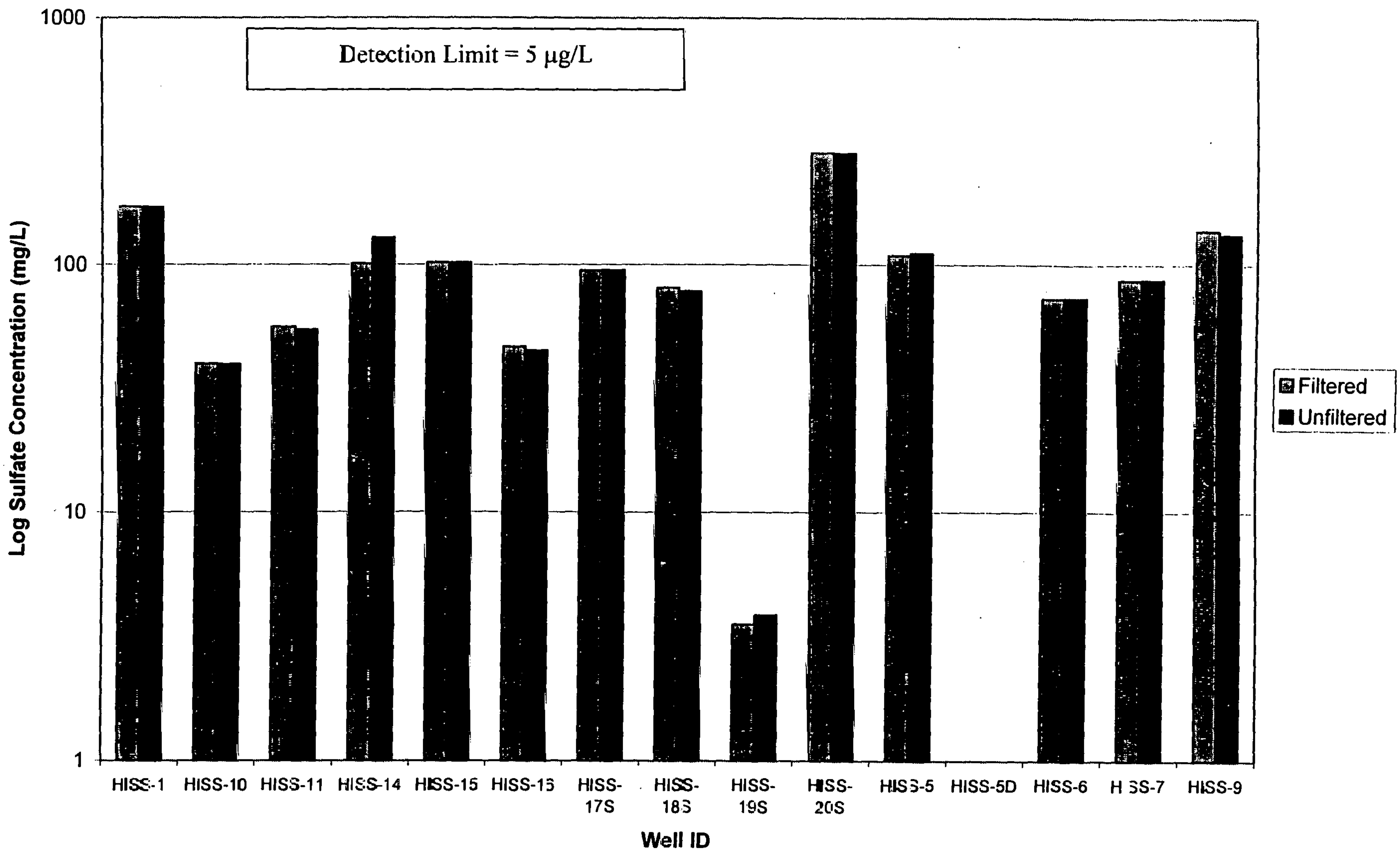
Graph 14. HISS Nitrate Groundwater Sampling Results for the Fourth Quarter 1998



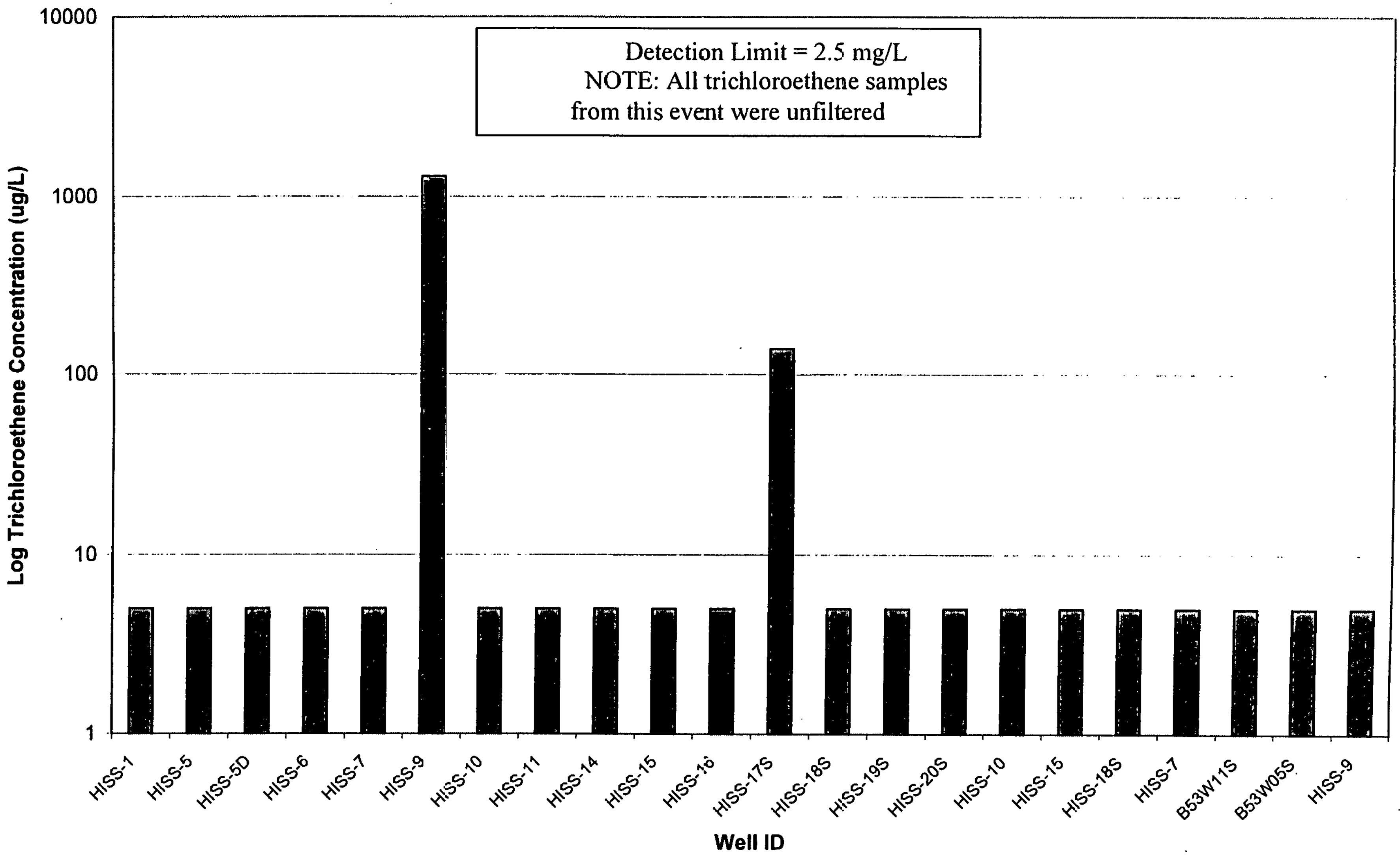
Graph 15. HISS Selenium Groundwater Sampling Results for the Fourth Quarter 1998



Graph 16. HISS Sulfate Groundwater Sampling Results for the Fourth Quarter 1998



Graph 17. HISS Trichloroethene Groundwater Sampling Results for the Fourth Quarter 1998



Graph 18. HISS Total Uranium Groundwater Sampling Results for the Fourth Quarter 1998

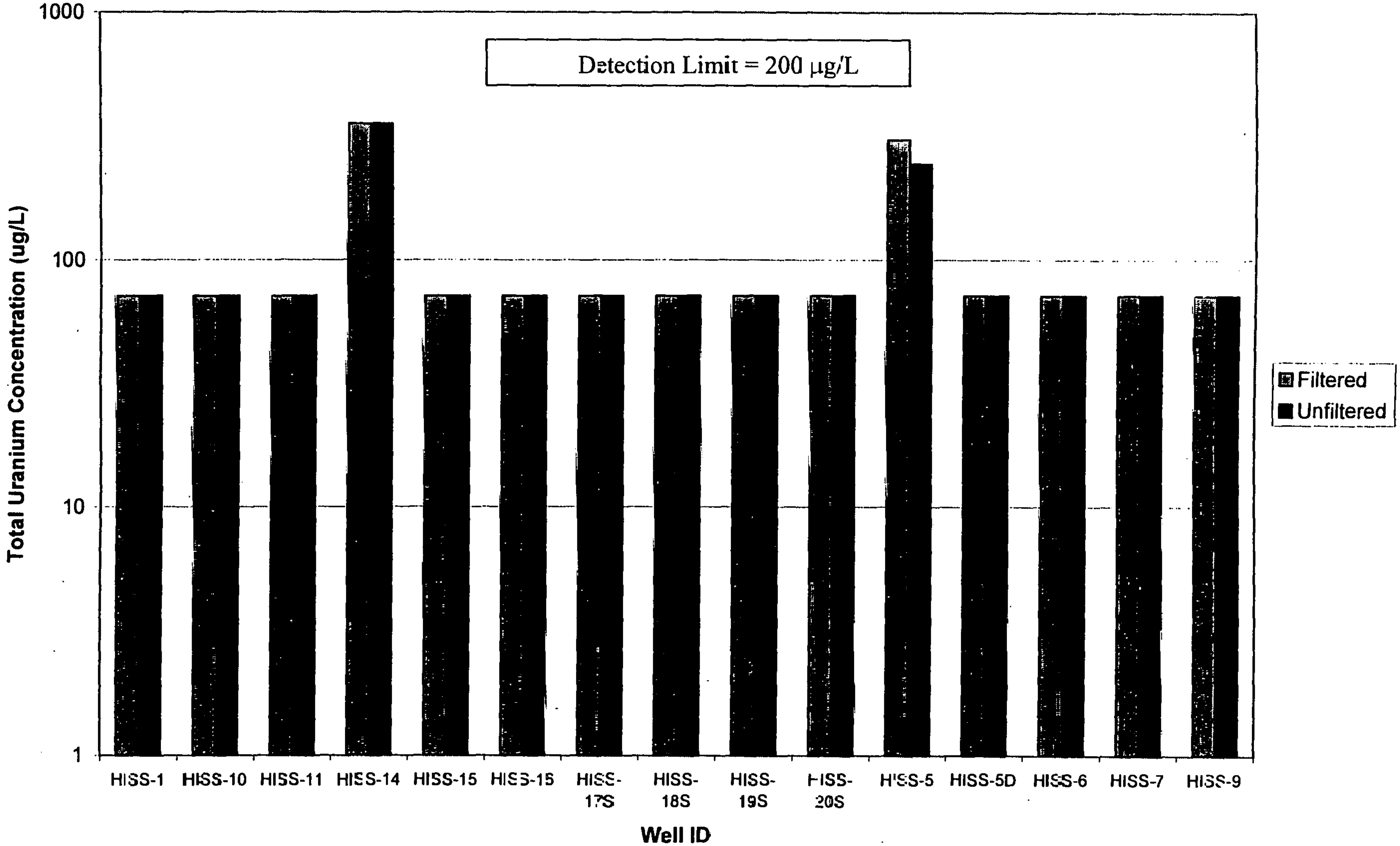


Table 3-22. 1998 Environmental Monitoring Program Ground-Water Sample Results at HISS (Second Quarter)

Station	Group	Parameter	Units	Results[a]	UNC	Date Collected
HISS02	HZ-A	Radium-226	pCi/l	0.17	0.15	03/30/98
HISS12	HZ-A	Radium-226	pCi/l	0.15	0.14	03/30/98
HISS13	HZ-A	Radium-226	pCi/l	0.22	0.18	04/10/98
HISS13	HZ-A	Radium-228	pCi/l	0.16	0.19	04/10/98
HISS13	HZ-A	Thorium-228	pCi/l	0.16	0.19	04/10/98
HISS13	HZ-A	Thorium-230	pCi/l	0.41	0.30	04/10/98
HISS13	HZ-A	Thorium-232	pCi/l	0.10	0.15	04/10/98
HISS13	HZ-A	Uranium	μg/l	8.48	0.21	04/10/98
HISS15	HZ-A	Radium-226	pCi/l	0.10	0.12	04/09/98
HISS15	HZ-A	Radium-228	pCi/l	0.27	0.25	04/09/98
HISS15	HZ-A	Thorium-228	pCi/l	0.27	0.25	04/09/98
HISS15	HZ-A	Thorium-230	pCi/l	0.79	0.43	04/09/98
HISS15	HZ-A	Thorium-232	pCi/l	0.16	0.18	04/09/98
HISS15	HZ-A	Uranium	μg/l	2.66	0.07	04/09/98
HISS16	HZ-A	Radium-226	pCi/l	1.77	0.63	04/10/98
HISS16	HZ-A	Radium-228	pCi/l	0.11	0.16	04/10/98
HISS16	HZ-A	Thorium-228	pCi/l	0.11	0.16	04/10/98
HISS16	HZ-A	Thorium-230	pCi/l	0.54	0.35	04/10/98
HISS16	HZ-A	Thorium-232	pCi/l	0.32	0.27	04/10/98
HISS16	HZ-A	Uranium	μg/l	63.54	4.28	04/10/98
HISS17S	HZ-A	Radium-226	pCi/l	0.27	0.19	04/10/98
HISS17S	HZ-A	Radium-228	pCi/l	0.27	0.22	04/10/98
HISS17S	HZ-A	Thorium-228	pCi/l	0.27	0.22	04/10/98
HISS17S	HZ-A	Thorium-230	pCi/l	0.22	0.20	04/10/98
HISS17S	HZ-A	Thorium-232	pCi/l	0.20		04/10/98

Table 3-22. 1998 Environmental Monitoring Program Ground-Water Sample Results at HISS (Second Quarter) (cont'd)

Station	Group	Parameter	Units	Results[a]	UNC	Date Collected
HISS17S	HZ-A	Uranium	µg/l	6.89	0.17	04/10/98
HISS20S	HZ-A	Radium-226	pCi/l	0.35	0.25	04/10/98
HISS20S	HZ-A	Radium-228	pCi/l	0.17	0.20	04/10/98
HISS20S	HZ-A	Thorium-228	pCi/l	0.17	0.20	04/10/98
HISS20S	HZ-A	Thorium-230	pCi/l	0.11	0.16	04/10/98
HISS20S	HZ-A	Thorium-232	pCi/l	0.37		04/10/98
HISS20S	HZ-A	Uranium	µg/l	12.62	0.91	04/10/98

[a] filtered samples

Please see graphs for fourth quarter data.

Table 3-23. Statistical Summary of Analytes Detected in Groundwater During the 1998 EMP Sampling at HISS

Hydrostratigraphic Zone	Parameter	Units	Average Result	Standard Deviation	Minimum Detect	Maximum Detect	Results >Detection Limit
HZ-A	Uranium	µg/l	18.80	25.20	2.66	63.54	5/ 5
HZ-A	Radium-226	pCi/l	0.43	0.60	0.35	1.77	2/ 7
HZ-A	Thorium-230	pCi/l	0.41	0.27	0.41	0.79	3/ 5

Table 3-24 Historical Concentrations of Total Uranium in Ground Water at HISS (1984-1997)

Well ID	1984*	1985*	1986*	1987*	1988*	1989*	1990*	1991*	1992*	1993*	1994*	1995*	1996*	1997*	1998*
HISS-1	16.9	---	---	---	---	---	---	---	---	---	---	---	---	33.7	
HISS-2	14.1	4.2	---	---	---	---	---	---	---	---	---	---	---	10.0	
HISS-3	26.8	8.3	---	---	---	---	---	---	---	closed	closed	Closed	Closed	closed	
HISS-4	42.3	18.3	---	---	---	---	---	---	---	closed	closed	Closed	Closed	closed	
HISS-5	11.3	---	---	---	---	---	80.3	112.7	---	---	---	---	---	39.9	
HISS-5D	---	---	---	---	---	---	---	---	0.1	---	---	---	---	<1.5	
HISS-6	94.4	101	46.5	56.3	70.4	116	67.6	56.3	65.8	---	---	---	---	129	
HISS-7	18.3	---	---	---	---	---	4.8	14.1	6.5	---	---	---	---	3.8	
HISS-8	40.8	---	---	---	---	---	---	---	---	closed	closed	closed	Closed	closed	
HISS-9	---	36.1	<4.2	<4.2	<4.2	<4.2	<4.2	8.5	3.2	---	---	---	---	<1.5	
HISS-10	---	4.4	8.5	5.6	5.6	7	<4.2	9.9	6.8	---	---	---	---	3.5	
HIS-11	---	<4.2	7	5.6	7	8.5	<4.2	14.1	5.9	---	---	---	---	4.2	
HIS-12	---	<4.2	5.6	7	8.5	6.3	5.6	12.7	6.6	---	---	---	---	2.7	
HIS-13	---	<4.2	11.3	11.3	11.3	6.7	7	12.7	8.3	8.2	8.9	8.9	8.5	7.6	8.5
HIS-14		11.1	---	---	---	---	8.5	12.7	11.8	---	---	---	---	18	
HIS-15	---	<4.2	7	4.2	8.5	7	<4.2	12.7	4.1	1.8	2	1.8	2.7	2.5	2.7
HIS-16	---	---	---	---	---	---	31	11.3	16.5	8.7	16.2	34.6	36.1	81.3	63.54
HIS-17S	---	---	---	---	---	---	---	---	6.5	4.4	6	5.2	5.4	6.3	6.9
HIS-18S	---	---	---	---	---	---	---	---	11.4	---	---	---	---	2.0	
HIS-19S	---	---	---	---	---	---	---	---	3	---	---	---	---	<1.5	
HIS-20S	---	---	---	---	---	---	---	---	4.1	9.1	10.5	11.3	12.1	10.5	12.62

Notes:
--- Data not available.
- Yearly averaged data.
Wells HISS-3, -4, and –8 were closed in 1992.
All results reported to the nearest 0.1 pCi/l.
The detection limit for 1997 results is 0.1 pCi/l.
There is not established EPA MCL for Thorium-230.
Historic data from BNI (1994) and SAIC (1995).
Historic data (1984-1996) may be "total" concentrations from unfiltered sample analyses.
All 1998 samples are filtered.

Table 3-25. Historical Concentrations of Radium-226 in Ground Water at HISS (1984-1997)

Well ID	1984*	1985*	1986*	1987*	1988*	1989*	1990*	1991*	1992*	1993*	1994*	1995*	1996*	1997*	1998*
HISS-1	0.7	---	---	---	---	---	---	---	---	---	---	---	---	0.2	
HISS-2	0.4	0.5	---	---	---	---	---	---	---	---	---	---	---	0.1	0.2
HISS-3	2.7	0.6	---	---	---	---	---	---	---	closed	closed	closed	Closed	closed	
HISS-4	3.2	0.1	---	---	---	---	---	---	---	closed	closed	closed	Closed	closed	
HISS-5	0.3	---	---	---	---	---	0.6	0.2	---	---	---	---	---	<0.1	
HISS-5D	---	---	---	---	---	---	---	---	0.9	---	---	---	---	0.8	
HISS-6	1.5	0.8	0.7	1.2	1.8	1.6	1	1	3.1	---	---	---	---	0.4	
HISS-7	1.6	---	---	---	---	---	1	1	1.3	---	---	---	---	0.6	
HISS-8	0.2	---	---	---	---	---	---	---	---	closed	closed	closed	Closed	closed	
HISS-9	---	0.4	0.2	0.2	0.6	0.6	0.4	1	8.9	---	---	---	---	0.1	
HISS-10	---	0.2	0.1	0.2	0.4	0.3	0.2	1	4.5	---	---	---	---	<0.1	
HIS-11	---	0.3	0.4	0.2	1	0.7	0.5	3	4.9	---	---	---	---	0.2	
HIS-12	---	0.4	0.4	0.5	1.3	0.7	0.6	1	2.9	---	---	---	---	<0.1	0.2
HIS-13	---	0.1	0.3	0.3	0.6	0.7	0.6	2	2.3	0.5	0.5	0.2	0.4	0.3	0.2
HIS-14		1.1	---	---	---	---	0.8	3.5	0.9	---	---	---	---	0.8	---
HIS-15	---	0.3	0.4	0.4	0.8	1.2	0.8	0.8	5.6	0.4	0.3	0.4	0.3	0.2	0.1
HIS-16	---	---	---	---	---	---	0.4	2.3	4.7	1.7	2.4	1.3	1.9	2.6	1.8
HIS-17S	---	---	---	---	---	---	---	---	0.4	0.2	0.3	0.2	0.3	0.3	0.3
HIS-18S	---	---	---	---	---	---	---	---	0.4	---	---	---	---	0.2	
HIS-19S	---	---	---	---	---	---	---	---	0.5	---	---	---	---	0.4	
HIS-20S	---	---	---	---	---	---	---	---	0.4	0.5	0.7	0.6	1.1	0.7	0.4

Notes:
--- Data not available.
- Yearly averaged data.

Wells HISS-3, -4, and –8 were closed in 1992.
All results reported to the nearest 0.1 pCi/l.
The detection limit for 1997 results is 0.1 pCi/l.
There is not established EPA MCL for Thorium-230.
Historic data from BNI (1994) and SAIC (1995).
Historic data (1984-1996) may be "total" concentrations from unfiltered sample analyses.
All 1998 samples are filtered.

Table 3-26. Historical Concentrations of Thorium-230 in Ground Water at HISS (1984-1997)

Well ID	1984*	1985*	1986*	1987*	1988*	1989*	1990*	1991*	1992*	1993*	1994*	1995*	1996*	1997*	1998*
HISS-1	0.9	---	---	---	---	---	---	---	---	---	---	---	---	<0.1	
HISS-2	8.7	0.8	---	---	---	---	---	---	---	---	---	---	---	<0.1	
HISS-3	3.4	0.2	---	---	---	---	---	---	---	closed	closed	closed	Closed	closed	
HISS-4	0.8	3.6	---	---	---	---	---	---	---	closed	closed	closed	Closed	closed	
HISS-5	106.8	---	---	---	---	---	0.5	1	---	---	---	---	---	<0.1	
HISS-5D	---	---	---	---	---	---	---	---	---	---	---	---	---	<0.1	
HISS-6	2.2	5.5	2.6	2.9	24	5	3.7	7.7	4.5	---	---	---	---	<0.1	
HISS-7	1.6	---	---	---	---	---	0.7	3	1.4	---	---	---	---	<0.1	
HISS-8	0.8	---	---	---	---	---	---	---	0.3	closed	closed	closed	Closed	closed	
HISS-9	---	0.2	0.6	0.2	0.2	0.2	0.2	1	2.7	---	---	---	---	<0.1	
HISS-10	---	0.2	0.7	0.3	0.7	0.1	0.2	0.7	2.7	---	---	---	---	<0.1	
HIS-11	---	0.9	1.3	0.8	1.5	0.7	0.4	4	3.4	---	---	---	---	<0.1	
HIS-12	---	0.4	2	0.8	2.3	2.3	2	5	3	---	---	---	---	<0.1	
HIS-13	---	0.3	1	0.3	0.6	0.9	0.7	2	7.8	<0.1	0.1	0.4	0.2	<0.1	0.4
HIS-14	---	0.2	---	---	---	---	0.8	6	1.7	---	---	---	---	<0.1	---
HIS-15	---	0.5	1.3	0.8	5.7	8.6	11	35.8	5.4	0.1	0.2	0.2	0.4	<0.1	0.8
HIS-16	---	---	---	---	---	---	0.5	3.1	1.9	0.8	0.9	0.5	0.5	<0.1	0.5
HIS-17S	---	---	---	---	---	---	---	---	<0.2	<0.1	<0.1	<0.1	0.2	<0.1	0.2
HIS-18S	---	---	---	---	---	---	---	---	<0.3	---	---	---	---	<0.1	
HIS-19S	---	---	---	---	---	---	---	---	<0.3	---	---	---	---	<0.1	
HIS-20S	---	---	---	---	---	---	---	---	0.2	<0.1	0.1	0.3	0.6	<0.1	0.1

Notes:
--- Data not available.
- Yearly averaged data.

Wells HISS-3, -4, and –8 were closed in 1992.
All results reported to the nearest 0.1 pCi/l.
The detection limit for 1997 results is 0.1 pCi/l.
There is not established EPA MCL for Thorium-230.
Historic data from BNI (1994) and SAIC (1995).
Historic data (1984-1996) may be "total" concentrations from unfiltered sample analyses.
All 1998 samples are filtered.

3.8 DOSE ASSESSMENT

This section evaluates the cumulative dose to a hypothetically impacted individual from exposure to radiological contaminants at the St. Louis FUSRAP sites. Dose calculations are presented for hypothetically maximally exposed individuals at two of SLS (SLAPS and HISS) and Coldwater Creek. The radiation dose equivalent from SLDS to a maximally exposed individual was not calculated due to data gaps in the EMP at the SLDS during CY98. 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 Appendix A, NESHAPs Report and Calculation Package Supporting Airborne Dose.

3.8.1 Highlights

- The Total Effective Dose Equivalent (TEDE) from SLAPS to a hypothetically maximally exposed individual from all complete/applicable pathways combined was 7.7 mrem/yr, estimated for an individual who works full time at a location approximately 160 meters south of the SLAPS perimeter.

- The TEDE from HISS to a hypothetically maximally exposed individual from all complete/applicable pathways combined was 0.5 mrem/yr, estimated for an individual who works full time at a location approximately 50 meters west of the HISS perimeter.

- The effective dose equivalent from SLDS to the receptor from airborne radioactive particulate emissions was 0.3 mrem/yr, estimated for an individual who works full-time at a location approximately 210 meters southwest of the SLDS perimeter. Dose to the receptor from all pathways was not calculated due to insufficient monitoring data at the site during CY98.

- The TEDE from Coldwater Creek to a hypothetically maximally exposed individual from all complete/applicable pathways combined was 0.4 mrem/yr, estimated for a youth spending time as a recreational user of Coldwater Creek.

3.8.2 Pathway Analysis

Table 3-27 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 1998, and were thus incorporated into radiological dose estimates.

Table 3-27. Complete Radiological Exposure Pathways for the SLS

Exposure Pathway	Pathway Description	Applicable to 1998 Dose Estimate			
		SLAPS	HISS	SLDS	Coldwater Creek
Liquid A	Ingestion of groundwater from local wells down-gradient from the site.	N	N	N	N
Liquid B	Ingestion of fish inhabiting Coldwater Creek.	NC	NC	NC	N
Liquid C	Ingestion of surface water and sediments.	NC	NC	NC	Y
Airborne A	Inhalation of particulates dispersed through wind erosion and remedial action.	Y	Y	Y	NC
Airborne B	Inhalation of Rn-222 and decay products emitted from contaminated soils/wastes.	N	N	A	NC
External	Direct gamma radiation from contaminated soils/wastes.	Y	Y	A	N

A-Applicability to receptor dose is uncertain due to data gaps in the environmental monitoring data collected in CY98.
NC -Not a complete pathway for the respective site.
N – not applicable
Y- applicable

In developing specific elements of the St. Louis FUSRAP environmental monitoring program, 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 CY98. If this is the case, the pathway is termed applicable. Only applicable pathways are considered in estimates of dose.

Table 3-28 shows the pathways that are not applicable to the 1998 dose estimates for the SLS and Coldwater Creek. The pathways that are not complete (NC) listed in Table 3-25 were not considered in the dose assessment and are only listed because the were complete for at least one receptor location. The pathways listed as not applicable (N) were not applicable in CY98 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 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

- Exposure from Rn-222 (and associated progeny) is not applicable at SLAPS and HISS for CY98 because the monitoring data at stations between the source and receptors were indistinguishable from the annual average background Rn-222 concentration.

- 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 (1foot of water shielding and dry) for 52 hours/yr. The highest estimated whole body dose to the youth was 0.3 μrem/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 guidelines for the St. Louis FUSRAP sites are as follows:

- NESHAPs standard of 10 mrem effective dose equivalent annually due to airborne emissions other than Rn-222 at off-site receptor locations.

- Nuclear Regulatory Commission (NRC) guideline of 100 mrem total effective dose equivalent for all exposure pathways on an annual basis (excluding background).

3.8.3 Exposure Scenarios

Dose calculations were performed for maximally exposed individuals at critical receptor locations for applicable exposure pathways (see Table 3-28) to assess dose due to radiological releases from the St. Louis FUSRAP sites. First, conditions were set to determine the TEDE to a maximally exposed individual at each of the main site locations (SLAPS, and HISS). A second dose equivalent for Coldwater Creek was calculated. A third set of dose equivalent calculations was performed to meet NESHAPs requirements (Appendix A).

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. The maximum concentrations of each radionuclide for the corresponding media was used to in the calculations instead of the 95 UCL as would be required for CERCLA risk determinations. This methodology provides for reasonable maximum exposure to the public and maintains a conservative approach. The scenarios and resulting estimated doses are outlined in Section 3.8.4 below.

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

3.8.4 Dose Equivalent Estimates Exposure Scenarios

Dose equivalent estimates for the exposure scenarios were calculated using 1998 monitoring data. Calculations for dose scenarios are provided in Appendix C. Dose equivalent estimates are well below the standards set by the NRC for annual public exposure and EPA NESHAPs limits.

The 1998 TEDEs for hypothetical maximally exposed individuals near the SLAPS, HISS, and Coldwater Creek are 7.7 mrem, 0.5 mrem, and 0.3 mrem, 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.

3.8.4.1 Radiation Dose Equivalent From the SLAPS to a Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent the perimeter of the 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 the SLAPS.

The exposure scenario assumptions are as follows:

- Exposure from airborne radioactive particulates was estimated using soil characterization data to determine a source term and then running the CAP-88 PC modeling code to estimate dose to the receptor.

- Exposure from external gamma radiation occurs to the maximally exposed individual while working full-time outside receptor location facility located approximately 160 meters south of the SLAPS perimeter. Exposure time is 2000 hours per year.

- Net annual gamma exposure rates of 32 mrem/yr and 74 mrem/yr were measured (continuous exposure) at stations 5 and 9, respectively. For 1998 continuous exposure was 8760 hours.

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor facility 160 meters from the SLAPS perimeter received 7.6 mrem/yr from airborne radioactive particulates, and 0.1 mrem/yr from external gamma for a TEDE of 7.7 mrem/yr.

3.8.4.2 Radiation Dose Equivalent From the HISS to a Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent the perimeter of the 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 the HISS.

The exposure scenario assumptions are as follows:

- Exposure from airborne radioactive particulates stored on the HISS site is not applicable because the contaminant piles were covered during 1998. However, potential emissions from the FUSRAP Radioanalytical laboratory were considered applicable. Exposure from the radioanalytical laboratory was estimated using soil characterization data to determine a source term and then running the CAP-88 PC modeling code to estimate dose to the receptor (SAIC, 1999c).

- Exposure from external gamma radiation occurs to the maximally exposed individual while working full-time outside at the receptor location facility located approximately 50 meters west of the HISS perimeter. Exposure time is 2000 hours per year.

- Net annual gamma exposure rates of 27 mrem/yr, 101 mrem/yr, and 59 mrem/yr were measured (continuous exposure) at stations 1, 2 and 7, respectively. For 1998 continuous exposure was 8760 hours.

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor location facility 50 meters from the HISS perimeter received 0.1 mrem/yr from airborne radioactive particulates, and 0.4 mrem/yr from external gamma for a TEDE of 0.5 mrem/yr.

3.8.4.3 Radiation Dose Equivalent From SLDS to a Maximally Exposed Individual

The radiation dose equivalent from SLDS to a maximally exposed individual, from all pathways, was not calculated due to data monitoring gaps in the environmental monitoring program during CY98. Exposure from airborne radioactive particulates was estimated using soil characterization data to determine a source term and then running the CAP-88 PC modeling code to estimate dose to the receptor. Based on the information explained above, an individual working outside the receptor location 210 meters southwest of the SLDS perimeter received 0.3 mrem/yr from airborne radioactive particulate emissions.

3.8.4.4 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 per year.

- The soil/sediment ingestion rate is 50 mg/day, and water ingestion rate is 2 L/day (EPA, 1989c).

- Maximum radionuclide concentrations in Coldwater Creek surface water/sediment samples taken in 1998 were assumed to be present in the water/sediment ingested by the maximally exposed individual.

- Dose equivalent conversion factors for ingestion, are: total uranium, 2.5E-5 mrem/pCi; Ra-226, 1.33E-3 mrem/pCi; Ra-228, 1.44E-3 mrem/pCi; Th-228, 3.96E-4 mrem/pCi; Th-230, 5.48E-4 mrem/pCi, Th-232, 2.73E-3 mrem/pCi (USEPA, 1989b).

Based on the exposure scenario and assumptions described above, a maximally exposed individual using Coldwater Creek for recreational purposes received 0.2 mrem/yr from soil/sediment ingestion, and 0.2 mrem/yr from water ingestion for a TEDE of 0.4 mrem/yr.

4.0 SUMMARY

Summary of SLDS

Air

The effective dose equivalent was calculated for SLDS using the EPA CAP-88 PC code. The evaluations of effective dose equivalent to critical receptors at SLDS resulted in less 10 percent of the dose standard in 40 CFR 61.102. SLDS is therefore exempt from the reporting requirements of 40 CFR 61.104(a).

Storm Water

St. Louis metropolitan Sewer District issued a permit for release of effluents on October 1998. No releases under the permit occurred in 1998.

Ground Water

The lower, fine-grained portion of the A unit limits the vertical movement of ground water. Water within the course fill is perched on fine-grained, native soils in some locations. Elevated levels of total uranium are observed at two A unit ground-water wells at SLDS. One of these wells is the western-most well at the site, and the other is located in the center region of SLDS. Elevated levels of arsenic occurred in the A unit ground water of the northeast section of the SLDS; this sampling location one of the two locations closest to the Mississippi River. The B unit at SLDS did not show elevated levels in the parameters sampled during the 1998 sampling events.

Summary of SLAPS

Air and Gamma Radiation

An effective dose equivalent of 7.6 mrem/yr to a critical receptor located 525 feet south of SLAPS was calculated using EPA CAP-88 PC code. Results to the same receptor using the COMPLY code were 5.1 mrem/yr. This is below the dose standard in 40 CFR 61.102. The results to other critical receptors were well below the standard.

Airborne radon monitoring was also performed at SLAPS. Three monitoring locations (stations 1, 5, and 9) have concentrations <0.2 pCi/l, the detection limit of the track etch detectors. The station 2 detector and duplicate detector recorded concentration of 0.4 and 0.2 pCi/l, respectively. Although these concentrations exceeded the background station concentration of <0.2 pCi/l. They are below the 40 CFR 192.02 regulatory criteria of 0.5 pCi/l. Station 2 has historically recorded above background Rn-222 concentrations due to its close proximity to a known area of contamination along the northern fenceline, and to the remedial activities at the North Ditch.

Gamma radiation monitoring was performed using TLDs placed around the site perimeter to measure gamma radiation emissions from the site. The annual dose from external gamma radiation to the hypothical maximally exposed individual was calculated at approximately 0.1 mrem/yr. The calculation was based on monitoring data and conservative assumptions of occupancy rate a distance from the source.

Storm Water

Elevated levels of barium, lead, and selenium occurred in the SLAPS storm-water samples for the 1998 monitoring. Elevated levels of barium and lead occurred at the storm water outfall located north of the sediment trap along McDonnell Blvd. and at the outfall east of the west culvert. Selenium levels exceeded its Ambient Water Quality Criteria of 5μg/l at all of the sampling locations for the November 1998 sampling event. All applicable or relevant and appropriate parameter limits were met during 1998 and all outfalls.

Ground Water

The 3M unit of the HZ-B appears to act as a barrier to vertical ground-water movement based on the differences in ground-water chemistry between the upper and the lower hydrostratigraphic zones (HZs). HZ-A and HZ-B are considered to comprise the shallow or upper HZ, while the HZ-C and the units beneath it make up the lower HZ. Ground-water data from the different zones indicate localized ground water impacted in upper HZ. This impact is not present in lower HZ indicating that mixing between HZs is insignificant.

Elevated manganese, nitrate, and selenium occur in the upper zone ground water at on-site and off-site locations. Manganese concentrations above its maximum concentration limits (MCL) also occur in the lower zone ground water, which is likely from natural sources. The occurrences of nitrate and selenium are in a broad northwestward trending area from the south-central part of the site towards Coldwater Creek. Selenium concentrations are currently lower compared to previous data. No historical data are available for nitrate for comparison. Trichloroethene exists in ground water at SLAPS and the surrounding properties at two general locations: the western end of SLAPS and in the central ballfield area. Recent trichloroethene concentrations have increased slightly as compared to previous data. Historical data indicated non-detectable to low concentrations for Ra-226 and Ra-228 compounds. No herbicides or PCBs were detected in the ground-water samples collected at SLAPS in 1998.

Summary of Hiss

Air and Gamma Radiation

An evaluation of effective dose equivalent to critical receptors at HISS resulted in less than 10 percent of the dose standard in 40 CFR 61.102 and is therefore exempt from the reporting requirements of 40 CFR 61.104(a).

Airborne radon monitoring was performed using alpha track etch detectors placed around the site perimeter to measure Rn-222 emissions from the site. All monitoring locations (stations 1, 2, 3, 4, 5, 6, 7, 8, 11, and 20) have average annual concentrations <0.2 pCi/l, which is the detection limit of the alpha track etch detectors. The Rn-222 concentrations are below the 40 CFR 192.02 regulatory criterion of <0.5 pCi/l. Radon flux sampling was performed in October 1998 using 10-inch diameter activated charcoal canisters placed approximately 26 feet apart on a predetermined grid. All measurements from both the primary and secondary pile were well below the 40 CFR 192.02 regulatory criteria of 20 pCi/m^2/s.

Gamma radiation monitoring was performed using TLDs placed around the site perimeter to measure gamma radiation emissions from the site. The annual dose from external gamma radiation to the hypothetical maximally exposed individual was calculated at approximately 0.3 mrem/yr. The calculation was based on monitoring data and conservative assumptions of occupancy rate and distance from the source.

Storm Water

Gross alpha and gross beta activities, which are largely attributed to Ra-226, Th-230, and uranium, appeared at levels that are several times higher than the levels observed for previous sampling at HISS. This excess may be due to high run-off carrying more sediment. All permit monitored parameters were met in 1998 and both outfalls.

Ground Water

The 3M unit of the HZ-B acts as a vertical barrier to the ground water. Only the upper portion of the HZ-A are contaminated. Elevated arsenic, cadmium, manganese, nitrate, selenium, sulfate, trichloroethene, and total uranium occurred in the ground water at the HISS during the 1998 sampling events. The highest levels of total uranium occurred in the HZ-A ground water at two wells in the central section of the site. Elevated manganese contamination was seen in HZ-C ground water at one HISS well, which is located in the north-central area of HISS. Elevated manganese is likely naturally occurring.

Summary of Coldwater Creek

Surface Water and Sediment

At the surface-water monitoring station between SLAPS and HISS, the concentrations of thorium isotopes and uranium detected in 1998 remained consistent with historical concentrations. The radium isotopes concentration were above their historical concentrations at this location. Total uranium concentrations detected in 1998 at surface-water monitoring stations located at the confluence of Coldwater Creek and tributaries in the area of HISS remained consistent with their historical concentrations. Uranium concentrations measured in 1998 at the monitoring stations downstream of HISS were elevated in comparison to their historical concentrations.

The EMP has historically conducted semi-annual monitoring of Coldwater Creek sediments during the second and fourth quarters of the calendar year. Sediment samples were collected from the previously described surface-water stations and analyzed for Ra-226, Ra-228, Th-228, Th-230, Th-232, and total uranium. Sediment sampling in accordance with this protocol was conducted during April and August 1998. The activity-based concentrations of Ra-228, Th-

228, and Th-232 remained constant among all of the sampled stations. The concentrations of Ra-226 and Th-230 ranged from 0.96 to 5.14 pCi/g and 1.61 to 201.2 pCi/g, respectively.

The concentrations of the radium isotopes, thorium isotopes, and uranium detected at background location C002 and at station C006 in 1998 were consistent with their historical mean concentrations and below their historical maximum detections

At the monitoring station between SLAPS and HISS (station C004), the concentrations of the thorium isotopes and uranium detected in 1998 were consistent with their concentrations in 1996. The concentrations of the radium isotopes were approximately twice their 1996 levels and slightly greater than their historical mean. The concentration of radium isotopes detected at C004 in 1998 was below the historical UTL and maximum detection. Both Th-230 and total uranium at C004 in 1998 were approximately twice their concentrations in 1997, but were consistent with the historical mean concentrations, UTLs, and maximum detections.

At sampling station C005, which is located in closest proximity to surface drainage from HISS and certain of its VPs, the concentrations of Ra-228 and Th-232 measured in 1998 remained consistent with results from 1996 an 1997.

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St. Louis FUSRAP Sites 1998 Radionuclide Emissions
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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
EPA	U.S. Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
HISS	Hazelwood Interim Storage Site
IA	investigation areas
NESHAP	National Emission Standard for Hazardous Air Pollutants
NRC	Nuclear Regulatory Commission
SAIC	Science Applications International Corporation
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geologic Survey

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EXECUTIVE SUMMARY AND DECLARATION STATEMENT

This report presents results from calculations of the effective dose equivalent from radionuclide emissions to critical receptors in accordance with the National Emission Standard for Hazardous Air Pollutants for the St. Louis FUSRAP sites during 1998. 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.*

Three sites and their adjacent vicinity properties under active remediation were evaluated. For each site, emissions from remedial actions were evaluated and added to the emissions from the site during no activity. The only site with results above 10% of the standard is the St. Louis Airport Site (SLAPS). An effective dose equivalent of 7.6 mrem/yr to a critical receptor located 160 meters south of the SLAPS was calculated using EPA CAP-88 PC code. Results to the same receptor using the EPA COMPLY code were 5.1 mrem/yr.

Evaluations for the Hazelwood Interim Storage Site and the St. Louis Downtown Site 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 that 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
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	Berkeley, MO 63134
Contact	Denis Chambers, CHP

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1. PURPOSE

This report calculates the effective dose equivalent from radionuclide emissions (exclusive of radon) to critical receptors from each of the three St. Louis FUSRAP locations: St. Louis Airport Site (SLAPS), Hazelwood Interim Storage Site (HISS), and St. Louis Downtown Site (SLDS). The air emissions from each site are ground releases of particulate radionuclides from soil contamination and remedial activities which potentially enhance these emissions.

2. METHOD

Emission rates were modeled using guidance documents referenced in 40 CFR 61, Subpart I. Emission rates were input into EPA computer codes along with appropriate meteorological data and distances to critical receptors[1] to obtain the effective dose equivalent from the air emissions.

2.1 EMISSION RATE

Regulatory Guide 3.59, *Methods For Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations* (NRC 1987), was used to estimate emission rate from the soil contamination from the sites. Regulatory Guide 3.59 is referenced in 40 CFR 61 Appendix D, *Methods for Estimating Radionuclide Emissions*[2]. Conditions of no activity and for excavations were evaluated and summed together to obtain the annual emission rate for each site.

2.2 EFFECTIVE DOSE EQUIVALENT

The effective dose equivalent is obtained using EPA computer code CAP88-PC version 1.0 (EPA 1992b). The results obtained using CAP88-PC are comparable to those obtained using COMPLY Version 1.5d (EPA 1992c). Both codes use a Gaussian plume equation to estimate the dispersion of radionuclides, and both codes are referenced by the EPA to demonstrate compliance with the National Emission Standard for Hazardous Air Pollutants (NESHAP) emissions criterion in 40 CFR 61.

The CAP88-PC program uses a modified Gaussian plume equation to estimate the dispersion of radionuclides. Doses are estimated by combining doses from ingestion, inhalation, air immersion and external ground surface. CAP88-PC offers an advantage over the COMPLY

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

[2] It is recognized that there are more recent EPA publications which could be used to perform these calculations equally well. The publications referenced within the regulations are used in this assessment to provide a consistent and clear path to compliance with 40 CFR 61.

code in that it contains built in 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.

The COMPLY program has various levels of complexity, the simplest being a computerized version of the tables of annual possession quantities and concentration levels for environmental compliance contained in 40 CFR 61 Appendix E. The most complicated level (Level 4) is an air dispersion calculation using a wind rose and a Gaussian plume equation. A detailed description can be found in the user's guide (EPA 1989b).

3. METEOROLOGICAL DATA

Meteorological data was obtained from the St. Louis/Lambert Airport (314) 441-8467, and the National Climatic Data Center (828)-271-4800.

1998 Annual Precipitation Rate	43.62 inches/yr (110.79 cm/yr)
1998 Annual Ambient Temp	58.7 °F (14.83 °C)

The average wind speed for December, 1998 was not available yet so the average annual wind speed of 9.6 miles/hr (4.3 meters/s) for St. Louis was obtained from the National Climatic Data Center representing the average from 1961 through 1990.

Wind speed frequency data was obtained from St. Louis 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 weather data library, STL0603 (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	0.110	S	N	0.041
NNW	SSE	0.084	SSE	NNW	0.047
NW	SE	0.079	SE	NW	0.075
WNW	ESE	0.061	ESE	WNW	0.101
W	E	0.042	E	W	0.079
WSW	ENE	0.035	ENE	WSW	0.061
SW	NE	0.039	NE	SW	0.054
SSW	NNE	0.038	NNE	SSW	0.053

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

4.1 SITE DESCRIPTION

The SLAPS (SLAPS) is an unincorporated property, owned by the City of St. Louis, in St. Louis County. SLAPS is bounded on the north and east by McDonnell Boulevard, on the south by Banshee Road, the Norfolk and Western Railroad, and St. Louis/Lambert airport, and by Coldwater Creek on the west. SLAPS covers 8.8 hectares (ha) (22 acres) and is surrounded by security fencing. The north ditch is a vicinity property adjacent to SLAPS that is included in this NESHAPS assessment because remedial activities on this site are assumed to have produced increased radionuclide emission rates.

Site History

The Manhattan Engineering District acquired SLAPS in 1946 to store uranium-bearing residuals generated at the St. Louis Downtown Site (SLDS) from 1946 until 1966. In 1966, these residuals were purchased by Continental Mining and Milling Company of Chicago, removed from SLAPS, and placed in storage at the Latty Avenue, Hazelwood Interim Storage Site (HISS) under an 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 1998

Excavation activities were performed at SLAPS at the east end, North Ditch (just north of McDonnell Boulevard), and Sediment Basin (west end) areas of the site. In addition a rail spur was constructed which involved removal of contaminated soils. The excavated soils were removed from the site by rail and truck. The activity, duration, and volume are shown in Table 4-1.

Table 4-1. 1998 SLAPS Excavations

Activity	Investigation Area	Duration* (days)	Volume (yd³)	Volume (m³)
Excavation for Rail Spur	IA-5 & IA-6	109	4,500	3,400
East End Excavations	IA-7	60	9,000	6,900
Sediment Basin Excavations	IA-1	137	13,000	9,900
North Ditch Excavations	IA-9	137	10,000	7,600
Estimated Total			37,000	28,000

* Durations were obtained from documented progress reports from the USACE to the EPA. Excavations for IA-5, IA-6, and IA-9 were completed and re-seeded in 1998. The duration these areas were open without cover will be the durations as tabulated plus a 28 day growth period. IA-5 and IA-6 were effectively uncovered for 137 days. IA-7 remained open for remediation through 1998. IA-1 was remediated but not reseeded. Volumes were obtained from USACE (1999).

4.3 SOURCE DESCRIPTION – RADIONUCLIDE SOIL CONCENTRATIONS

The radionuclide concentrations as they exist in the surface soils at SLAPS were obtained from statistical summaries of the investigation areas (IA) contained in the 1998 North County Data Base maintained by SAIC and as documented in USACE (1998). Appendix A contains a summary table of the activities by area. The average radionuclide soil activity for each area will be used to calculate the emission rate from each area.

Radionuclide concentrations for excavated soils were obtained from the database for soil characterization prior to 1998 for investigation areas IA-1, IA-5, and IA-7 (this characterization data is assumed to be representative of soil concentrations removed from these areas). The highest average radionuclide concentration will be applied to all 1998 excavated soils to conservatively estimate the emissions. Table 4-2 shows the data for the three areas.

Table 4-2. 1998 SLAPS Estimated Excavated Soil Concentrations

Radionuclide	IA-1		IA-5		IA-7		Assumed Excavation Concentration* (pCi/g)
	Average (pCi/g)	UCL_{95} (pCi/g)	Average (pCi/g)	UCL_{95} (pCi/g)	Average (pCi/g)	UCL_{95} (pCi/g)	
Ac-227	1.2	3.26			26.1	64.8	26.1
Pa-231	2.55	6.47					2.55
Ra-226	115	299	17.7	26.7			115
Ra-228							*1.29*
Th-228							*3.93*
Th-230	29.3	59.7	190	255	116	172	190
Th-232	4.62	8.8	2.9	3.07	2.26	2.79	4.62
U-234							*76.4*
U-235							*3.51*
U-238	76.4	157	41.3	50.9	19.6	29.6	76.4

* When data were not available for nuclides assumed to be present, the concentrations were estimated using ratios established in Table 2.15 of DOE 1993 for the St. Louis Sites. These values are shown in italics and were obtained by: Ra-228 = 0.28*Th-232; Th-228 = 0.85*Th-232; U-234 = U-238; U-235 = 0.046*U-238.

4.4 LIST OF ASSUMED AIR RELEASES FOR 1998

Wind erosion during periods of site inactivity and the remedial action excavations are assumed for the particulate radionuclide emissions determinations from SLAPS. Adjacent vicinity properties do not contribute to the emissions determinations for periods of inactivity due to the low activity and vegetation cover.

4.5 EFFLUENT CONTROLS

Effluent controls for SLAPS include various cover materials that will reduce particulate emissions. Control factors were obtained from Regulatory Guide 3.59 Appendix C (NRC 1987). Table 4-3 lists the investigation areas, the surface area of each area, the cover materials and the assumed reduction in particulate emissions.

Table 4-3. Area Emission Control Factors

Investigation Area	Surface Area (ft^2)	Cover Material	*Emission Reduction %	Effective Reduction in Emission [1]
IA-1	98,000	grass before excavations [2]	75/0	0.75*0.5 = 0.38
IA-2	150,000	soil/gravel parking lot	100	1.00
IA-3	140,000	grass or gravel	75	0.75
IA-4	92,000	grass/vegetation	75	0.75
IA-5	350,000	grass except during excavations	75	0.75*(365-137)/365 = 0.49
IA-6	60,000	grass except during excavations	75	0.49
IA-7	140,000	grass except during excavations	75	0.75*(365-60)/365 = 0.63

* % Emission Reduction from Appendix C of Regulatory Guide 3.59

[1] The effective reduction in emission is based on excavation durations contained in Table 4-1.

[2] Note – excavation of IA-1 began in July.

All excavations were conducted using water spray to suppress the fugitive dust emission and therefore the particulate radionuclide emissions. Water spray is reported to reduce the emission by 50% (NRC 1987).

4.6 DISTANCES TO CRITICAL RECEPTORS

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

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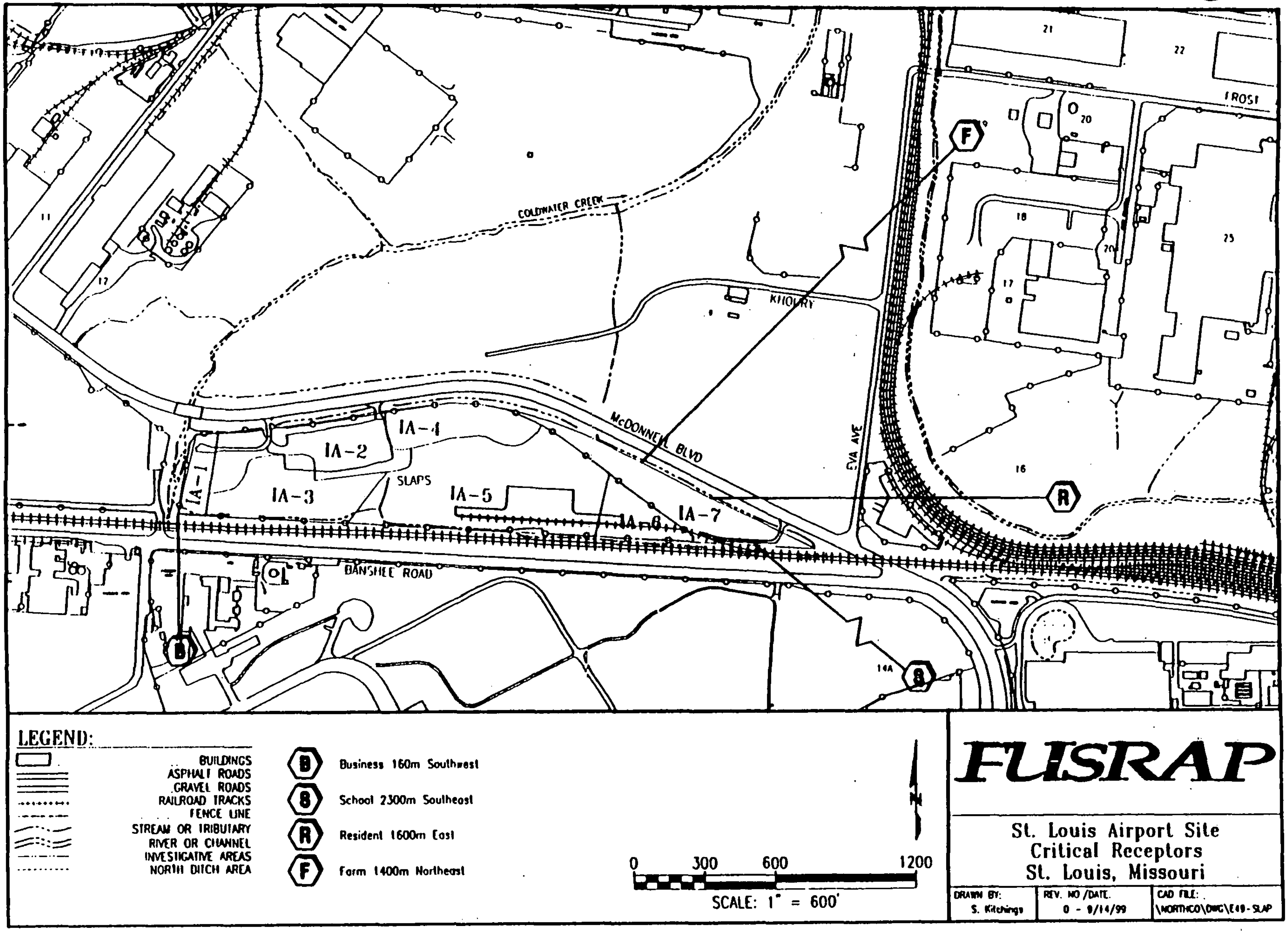

Figure 4-1. St. Louis Airport Site Critical Receptors

Table 4-4. 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
Farm	NE	0.84	1400

4.7 EMISSIONS DETERMINATIONS

4.7.1 *In Situ* Windblown Particle Emissions

Windblown particle emissions per unit area are estimated using equation 2 from Regulatory Guide 3.59 (NRC 1987). The equation is:

$$E_w = \frac{3.156E7}{0.5} \times \sum R_s F_s$$

where

- E_w is the annual dust loss per unit area (g/m^2yr),
- F_s is the annual average wind speed frequency for St. Louis (Table 3-1),
- R_s is the resuspension rate at the average wind speed for particles <20 µm (g/m^2s) in diameter, Table 4-5 below,
- 3.156E7 is the number of seconds per year, and
- 0.5 is the fraction of dust loss by particles < 20 µm in diameter.

Table 4-5. Fugitive Dust Emission Calculation

Wind Speed Group, knots	Frequency F_s	Resuspension Rate R_s (g/m^2s)	$F_s R_s$
0 – 3	0.10	0	0
4 – 7	0.29	0	0
8 – 12	0.36	3.92 E-7	1.41 E-7
13 – 18	0.21	9.68 E-6	2.03 E-6
19 – 24	0.03	5.71 E-5	1.71 E-6
25 – 31	0.01	2.08 E-4	2.08 E-6
		Σ =	5.97 E-6

The annual dust loss per unit area is calculated to be 377 **g/m^2yr**.

The total annual wind blown *in situ* emission rate, by radionuclide activity, from each of the SLAPS investigation areas are calculated using equation 3 from Regulatory Guide 3.59 (NRC 1987).

$$S_{Ci/yr} = E_w \times A \times C_{pCi/g} \times \frac{Ci}{10^{12}\,pCi} \times (1 - R)$$

where

E_w	is the annual dust loss per unit area = 377 g/m^{2}y,
A	is the surface area (m^2· Table 4-3),
C	is the soil concentration (Appendix A average values), and
R	is a unitless control factor (Effective Reduction in Emission) determined in Table 4-3.

Wind blown *in situ* emission rates for each radionuclide are calculated and shown in Table 4-6.

Table 4-6. 1998 SLAPS *In Situ* Emission Rates

Radionuclide	Emission Rate Ci/yr
Ac-227	2.3E-04
Pa-231	2.5E-04
Ra-226	6.0E-04
Ra-228	1.2E-05
Th-228	1.3E-05
Th-230	6.1E-03
Th-232	3.8E-05
U-234	*5.1E-4*
U-235	3.1E-05
U-238	5.1E-04

U-234 is assumed to be present, the estimate in italics is based on Table 2.15 of DOE (1993): U-234 = U-238.

4.7.2 Emissions From Excavations

The emission rate from the excavations is calculated using equation 1 of Regulatory Guide 3.59. The concentrations from Table 4-2 are used to calculate the radionuclide emission rate. Results are shown in Table 4-7.

$$S_{Ci/yr} = M \times C \times E \times \frac{Ci}{10^{12}\,pCi} \times \frac{454\,g}{lb} \times (1-R)$$

where

M	is the volume of material excavated = 37,000 yd^3 (Table 5-1)
C	is the soil concentration (pCi/g Appendix A, average values),
E	is the emission factor = 0.04 lb/yd^3 for truck end dump (Appendix B of Regulatory Guide 3.59), and
R	is the emission reduction factor = 50% for water spray.

Finally the total 1998 emission rates which were input into the EPA codes are shown in Table 4-8 as the sum of the *in situ* emission rates from windblown emissions and the emissions from excavations.

4.8 CAP88-PC RESULTS

The CAP88-PC report is contained in Appendix B. The area factor input was the sum of all areas from Table 4-3, calculated to be 1.0 E6 ft^2 (9.6 E4 m^2). Results show compliance with the 10 mrem/yr criterion for all critical receptors. Table 4-9 summarizes the results.

Table 4-7. 1998 SLAPS Emission Rate During Excavated Soil

Radionuclide	Assumed Excavation Concentration (pCi/g)	Emission (Ci/y)
Ac-227	26.1	8.8 E-6
Pa-231	2.55	8.6 E-7
Ra-226	115	3.9 E-5
Ra-228	*1.29*	*4.5 E-7*
Th-228	*3.93*	*1.4 E-6*
Th-230	190	6.4 E-5
Th-232	4.62	1.6 E-6
U-234	*76.4*	*2.6 E-5*
U-235	*3.51*	*1.2 E-6*
U-238	76.4	2.6 E-5
When data were not available for radionuclides assumed to be present values estimated in italics are based on Table 2.15 of DOE (1993): Ra-228 = 0.28*Th-232; Th-228 = 0.85*Th-232; U-234 = U-238; U-235 = 0.046*U-238.		

Table 4-8. 1998 SLAPS Total Emission Rates

Radionuclide	*In Situ* Emission Rate Ci/vr	Excavation Emission Ci/vr	Total Emission Rate Ci/vr
Ac-227	2.3E-04	8.8 E-6	2.4 E-4
Pa-231	2.5E-04	8.6 E-7	2.5 E-4
Ra-226	6.0E-04	3.9 E-5	6.4 E-4
Ra-228	1.2E-05	*4.5 E-7*	1.2 E-5
Th-228	1.3E-05	*1.4 E-6*	1.4 E-5
Th-230	6.1E-03	6.4 E-5	6.2 E-3
Th-232	3.8E-05	1.6 E-6	4.0 E-5
U-234	*5.1 E-4*	*2.6 E-5*	5.4 E-4
U-235	3.1E-05	*1.2 E-6*	3.2 E-5
U-238	5.1E-04	2.6 E-5	5.4 E-4

Table 4-9. SLAPS CAP88-PC Results for Critical Receptors

Receptor	Direction from site	Distance (m)	(mrem/vr)
Nearest Resident	E	1.600	1.2
School	SE	2.300	0.53
Business*	S	160	7.6
Farm	NE	1400	0.77

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

4.9 COMPLY COMPARISON RUN

A comparison run was made for the highest critical receptor (business) using COMPLY version 1.5d. The report is contained in Appendix C. The effective dose equivalent of 5.1 mrem/yr is calculated for the business receptor after correcting for the 23% occupancy. The results are in agreement with those from the CAP88-PC south sector for 160 meter distance.

5. ST. LOUIS SITES EXEMPT FROM REPORTING

Evaluations performed for the Hazelwood Interim Storage Site (HISS) and the St. Louis Downtown Site (SLDS) showed all critical receptors receiving less than the 10% of the dose standard in 40 CFR 61.102 and are, therefore, exempt from the reporting requirements of 40 CFR 61.104(a).

6. REFERENCES

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USACE 1999. *Draft 1998 Environmental Monitoring Program Annual Data Analysis Report, St. Louis, Missouri*, U.S. Army Corps of Engineers, St. Louis District Office, FUSRAP, February.

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

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

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

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APPENDIX A

INVESTIGATION AREA SURFACE SOIL STATISTICAL SUMMARIES AND CALCULATED EMISSION RATES FROM IN SITU SLAPS SOILS

Table A-1. Summary of Radionuclide Concentrations By Area

Area	Radionuclide	Average (pCi/g)	Notes	Area (ft²)	Cover	Emission Reduction	Emission (Ci/yr)
IA-1	Ac-227	1.2	samples prior to remediation	9.8E-04	grass	38.00%	2.6E-06
IA-1	Pa-231	2.55	samples prior to remediation	9.8E-04		38.00%	5.4E-06
IA-1	Ra-226	115	samples prior to remediation	9.8E-04		38.00%	2.4E-04
IA-1	Ra-228		samples prior to remediation	9.8E-04		38.00%	0.0E-00
IA-1	Th-228		samples prior to remediation	9.8E-04		38.00%	0.0E-00
IA-1	Th-230	29.3	samples prior to remediation	9.8E-04		38.00%	6.2E-05
IA-1	Th-232	4.62	samples prior to remediation	9.8E-04		38.00%	9.8E-06
IA-1	U-235		samples prior to remediation	9.8E-04		38.00%	0.0E-00
IA-1	U-238	76.4	samples prior to remediation	9.8E-04		38.00%	1.6E-04
IA-2	Ra-226	38.6	Detected above Background	1.5E-05	Soil	100.00%	0.0E-00
IA-2	Ra-228	1.19	Detected above Background	1.5E-05		100.00%	0.0E-00
IA-2	Th-228	1.39	Detected above Background	1.5E-05		100.00%	0.0E-00
IA-2	Th-230	584	Detected above Background	1.5E-05		100.00%	0.0E-00
IA-2	Th-232	2.71	Detected above Background	1.5E-05		100.00%	0.0E-00
IA-2	U-235	4.65	Detected above Background	1.5E-05		100.00%	0.0E-00
IA-2	U-238	67.8	Detected above Background	1.5E-05		100.00%	0.0E-00
IA-3	Ac-227	4.99	Detected above Background	1.4E-05	grass	75.00%	6.1E-06
IA-3	Pa-231	3.87	Detected above Background	1.4E-05		75.00%	4.7E-06
IA-3	Ra-226	10.1	Detected above Background	1.4E-05		75.00%	1.2E-05
IA-3	Ra-228	0.846	Detected above Background	1.4E-05		75.00%	1.0E-06
IA-3	Th-228	1.04	Below Background				0.0E-00
IA-3	Th-230	226	Detected above Background	1.4E-05		75.00%	2.8E-04
IA-3	Th-232	1.96	Detected above Background	1.4E-05		75.00%	2.4E-06
IA-3	U-235	1.46	Detected above Background	1.4E+05		75.00%	1.8E-06
IA-3	U-238	23.6	Detected above Background	1.4E-05		75.00%	2.9E-05
IA-4	Ac-227	3	Detected above Background	9.2E-04	grass	75.00%	2.4E-06
IA-4	Pa-231	3.12	Detected above Background	9.2E-04		75.00%	2.5E-06
IA-4	Ra-226	166	Detected above Background	9.2E-04		75.00%	1.3E-04
IA-4	Ra-228	1.05	Below Background				0.0E-00
IA-4	Th-228	1.36	Detected above Background	9.2E-04		75.00%	1.1E-06
IA-4	Th-230	416	Detected above Background	9.2E-04		75.00%	3.4E-04
IA-4	Th-232	4.67	Detected above Background	9.2E-04		75.00%	3.8E-06
IA-4	U-235	2.39	Detected above Background	9.2E-04		75.00%	1.9E-06
IA-4	U-238	77.5	Detected above Background	9.2E-04		75.00%	6.2E-05
IA-5	Ac-227	10.4	Detected above Background	3.5E-05	grass	49.00%	6.5E-05
IA-5	Pa-231	12.2	Detected above Background	3.5E-05		49.00%	7.6E-05
IA-5	Ra-226	18.8	Detected above Background	3.5E-05		49.00%	1.2E-04
IA-5	Ra-228	1.09	Detected above Background	3.5E-05		49.00%	6.8E-06
IA-5	Th-228	1.33	Detected above Background	3.5E-05		49.00%	8.3E-06
IA-5	Th-230	417	Detected above Background	3.5E-05		49.00%	2.6E-03
IA-5	Th-232	2.45	Detected above Background	3.5E-05		49.00%	1.5E-05
IA-5	U-235	1.98	Detected above Background	3.5E-05		49.00%	1.2E-05
IA-5	U-238	40.1	Detected above Background	3.5E-05		49.00%	2.5E-04
IA-6	Ac-227	7.19	Detected above Background	6.0E-04	grass	49.00%	7.7E-06
IA-6	Pa-231	7.51	Detected above Background	6.0E-04		49.00%	8.0E-06
IA-6	Ra-226	5.85	Detected above Background	6.0E-04		49.00%	6.3E-06

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Table A-1. Summary of Radionuclide Concentrations By Area (continued)

Area	Radionuclide	Average (pCi/g)	Notes	Area (ft²)	Cover	Emission Reduction	Emission (Ci/yr)
IA-6	Ra-228	1.16	Detected above Background	6.0E-04		49.00%	1.2E-06
IA-6	Th-228	1.49	Below Background				0.0E+00
IA-6	Th-230	204	Detected above Background	6.0E-04		49.00%	2.2E-04
IA-6	Th-232	2.91	Detected above Background	6.0E-04		49.00%	3.1E-06
IA-6	U-235	2.42	Detected above Background	6.0E-04		49.00%	2.6E-06
IA-6	U-238	32.2	Detected above Background	6.0E-04		49.00%	3.5E-05
IA-7	Ac-227	83.3	Detected above Background	1.4E-05	grass	63.00%	1.5E-04
IA-7	Pa-231	85.2	Detected above Background	1.4E-05		63.00%	1.5E-04
IA-7	Ra-226	48.8	Detected above Background	1.4E-05		63.00%	8.9E-05
IA-7	Ra-228	1.87	Detected above Background	1.4E-05		63.00%	3.4E-06
IA-7	Th-228	2.12	Detected above Background	1.4E-05		63.00%	3.8E-06
IA-7	Th-230	1470	Detected above Background	1.4E-05		63.00%	2.7E-03
IA-7	Th-232	2.18	Detected above Background	1.4E-05		63.00%	4.0E-06
IA-7	U-235	7.03	Detected above Background	1.4E-05		63.00%	1.3E-05
IA-7	U-238	22	Detected above Background	1.4E-05		63.00%	4.0E-05

Table A-2. Summary of Annual In Situ Windblown Emissions from SLAPS by IA

	IA-1	IA-2	IA-3	IA-4	IA-5	IA-6	IA-7	Total (Ci/y)
	grass/soil	soil	grass	grass	grass except during excavation			
	(Ci/y)	(Ci/y)	(Ci/y)	(Ci/y)	(Ci/y)	(Ci/y)	(Ci/y)	
Actinium-227	2.6E-06	0.0E+00	6.1E-06	2.4E-06	6.5E-05	7.7E-06	1.5E-04	2.3E-04
Pa-231	5.4E-06	0.0E+00	4.7E-06	2.5E-06	7.6E-05	8.0E-06	1.5E-04	2.5E-04
Radium-226	2.4E-04	0.0E+00	1.2E-05	1.3E-04	1.2E-04	6.3E-06	8.9E-05	6.0E-04
Radium-228	0.0E+00	0.0E+00	1.0E-06	0.0E+00	6.8E-06	1.2E-06	3.4E-06	1.2E-05
Thorium-228	0.0E+00	0.0E+00	0.0E+00	1.1E-06	8.3E-06	0.0E+00	3.8E-06	1.3E-05
Thorium-230	6.2E-05	0.0E+00	2.8E-04	3.4E-04	2.6E-03	2.2E-04	2.7E-03	6.1E-03
Thorium-232	9.8E-06	0.0E+00	2.4E-06	3.8E-06	1.5E-05	3.1E-06	4.0E-06	3.8E-05
Uranium-235	0.0E+00	0.0E+00	1.8E-06	1.9E-06	1.2E-05	2.6E-06	1.3E-05	3.1E-05
Uranium-238	1.6E-04	0.0E+00	2.9E-05	6.2E-05	2.5E-04	3.5E-05	4.0E-05	5.8E-04

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Version 1.00

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 24, 1999   1:04 am

Facility: St Louis Airport Site
Address: McDonnell Boulevard
City: St. Louis
State: MO   Zip:

Source Category: Particulate Radionuclides
Source Type: Area
Emission Year: 1998

Comments: Prepared by SAIC for
U.S Army Corp of Engineers, St. Louis District

Dataset Name: SLAPS 1998
Dataset Date: Mar 24, 1999   1:04 am
Wind File: WNDFILES\STL0603.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	5.39E-01
BREAST	1.88E-01
R MAR	5.32E+01
LUNGS	2.84E+02
THYROID	1.75E-01
ENDOST	6.62E+02
RMNDR	1.91E+00
EFFEC	6.11E+01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	4.69E-01
INHALATION	6.06E+01
AIR IMMERSION	3.59E-07
GROUND SURFACE	1.20E-02
INTERNAL	6.10E+01
EXTERNAL	1.20E-02
TOTAL	6.11E+01

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
AC-227	4.72E+00
PA-231	3.75E+00
RA-226	2.30E-01
RA-228	1.43E-03
TH-230	4.75E+01
TH-232	4.41E-01
U-235	1.23E-01
U-238	1.96E+00
TH-228	1.08E-01
U-234	2.20E+00
TOTAL	6.11E+01

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	4.46E-05
BONE	2.92E-05
THYROID	3.10E-08
BREAST	2.98E-07
LUNG	4.38E-04
STOMACH	1.99E-07
BOWEL	1.51E-07
LIVER	6.37E-06
PANCREAS	1.45E-07
URINARY	3.26E-07
OTHER	1.77E-07
TOTAL	5.19E-04

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	1.87E-06
INHALATION	5.17E-04
AIR IMMERSION	8.34E-12
GROUND SURFACE	2.74E-07
INTERNAL	5.19E-04
EXTERNAL	2.74E-07
TOTAL	5.19E-04

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
AC-227	4.10E-05
PA-231	2.09E-05
RA-226	4.18E-06
RA-228	1.87E-08
TH-230	3.92E-04
TH-232	2.49E-06
U-235	1.66E-06
U-238	2.60E-05
TH-228	2.18E-06
U-234	2.90E-05
TOTAL	5.19E-04

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

	Distance (m)			
Direction	160	1400	1600	2300
N	5.3E+01	1.1E+00	9.6E-01	6.6E-01
NNW	5.8E+01	1.2E+00	9.7E-01	6.6E-01
NW	6.1E+01	1.5E+00	1.2E+00	7.8E-01
WNW	5.7E+01	1.1E+00	9.1E-01	6.3E-01
W	5.3E+01	8.9E-01	7.6E-01	5.5E-01
WSW	4.3E+01	8.1E-01	7.0E-01	5.2E-01
SW	3.6E+01	9.4E-01	8.0E-01	5.7E-01
SSW	3.3E+01	7.8E-01	6.8E-01	5.1E-01
S	3.3E+01	6.7E-01	5.9E-01	4.7E-01
SSE	3.7E+01	6.6E-01	5.9E-01	4.7E-01
SE	4.6E+01	8.3E-01	7.2E-01	5.4E-01
ESE	5.1E+01	1.2E+00	1.0E+00	6.8E-01
E	5.3E+01	1.4E+00	1.2E+00	7.6E-01
ENE	5.1E+01	9.6E-01	8.2E-01	5.8E-01
NE	4.9E+01	7.8E-01	6.8E-01	5.2E-01
NNE	4.6E+01	7.2E-01	6.3E-01	4.9E-01

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

	Distance (m)			
Direction	160	1400	1600	2300
N	4.5E-04	8.1E-06	6.6E-06	4.1E-06
NNW	5.0E-04	8.3E-06	6.8E-06	4.1E-06
NW	5.2E-04	1.1E-05	8.9E-06	5.1E-06
WNW	4.8E-04	7.7E-06	6.3E-06	3.8E-06
W	4.5E-04	6.0E-06	5.0E-06	3.2E-06
WSW	3.6E-04	5.4E-06	4.5E-06	2.9E-06
SW	3.1E-04	6.5E-06	5.3E-06	3.4E-06
SSW	2.8E-04	5.1E-06	4.3E-06	2.8E-06
S	2.8E-04	4.2E-06	3.5E-06	2.5E-06
SSE	3.1E-04	4.1E-06	3.5E-06	2.5E-06
SE	3.9E-04	5.6E-06	4.7E-06	3.1E-06
ESE	4.3E-04	8.8E-06	7.1E-06	4.3E-06
E	4.5E-04	1.1E-05	8.4E-06	4.9E-06
ENE	4.3E-04	6.7E-06	5.5E-06	3.4E-06
NE	4.2E-04	5.1E-06	4.3E-06	2.9E-06
NNE	3.9E-04	4.6E-06	3.9E-06	2.7E-06

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APPENDIX C

COMPLY RUN FOR ST. LOUIS AIRPORT SITE

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40 CFR Part 61
National Emission Standards
for Hazardous Air Pollutants

REPORT ON COMPLIANCE WITH

THE CLEAN AIR ACT LIMITS FOR RADIONUCLIDE EMISSIONS

FROM THE COMPLY CODE, VERSION 1.5d

Prepared by:

U.S. Army Corps of Engineers - St. Louis District
FUSRAP - St. Louis Airport Site

Denis Chambers, CHP

Prepared for:

U.S. Environmental Protection Agency
Office of Radiation Programs
Washington, D.C. 20460

St. Louis Airport Site - 1998

SCREENING LEVEL 4

DATA ENTERED:

Nuclide		Release Rate (curies/YEAR)
AC-227	D	2.400E-04
PA-231	W	2.500E-04
RA-226	W	6.400E-04
RA-228	W	1.200E-05
TH-228	Y	1.400E-05
TH-230	W	6.200E-03
TH-232	W	4.000E-05
U-234	Y	5.400E-04
U-235	Y	3.200E-05
U-238	Y	5.400E-04

STACK DISTANCES, FILE: xc

DIR	Distance (meters)
N	2300.0
NNE	2300.0
NE	2300.0
ENE	2300.0
E	2300.0
ESE	2300.0
SE	2300.0
SSE	2300.0
S	160.0
SSW	2300.0
SW	2300.0
WSW	2300.0
W	2300.0
WNW	2300.0
NW	2300.0
NNW	2300.0

WINDROSE DATA, FILE: windc

Source of wind rose data: CAP88-PC
Dates of coverage: 1960 through 1964
Wind rose location: St. Louis Lambert Airport
Distance to facility: approximately 2 miles

Percent calm: 0.00

Wind FROM	Frequency	Speed (meters/s)
N	0.041	2.96
NNE	0.038	2.81
NE	0.039	2.69
ENE	0.035	2.68
E	0.042	2.75
ESE	0.061	2.82
SE	0.079	2.89
SSE	0.084	3.21
S	0.110	3.18
SSW	0.053	3.15
SW	0.054	3.08
WSW	0.061	3.09
W	0.079	3.02
WNW	0.101	3.25
NW	0.075	3.18
NNW	0.047	3.06

Distance from the SOURCE to the FARM producing VEGETABLES is 1400 meters.

Distance from the SOURCE to the FARM producing MILK is 1400 meters.

Distance from the SOURCE to the FARM producing MEAT is 1400 meters.

NOTES:

Default air temperature not used.
Air temperature 59.0 (degrees F).

Default stack temperature not used.
Stack temperature 59.0 (degrees F).

The stack flow rate is zero or negative.
It has been set to 0.3 cubic meters/sec.

The receptor exposed to the highest concentration is located 160. meters from the source in the S sector.

Cataloging Form

{Technical/Project Managers fill in C through G, K through Q. RM completes other fields}

A. Document ID Number: Assigned by database 00-382 **B.** *Further Information Required?:* ☐

C. *Operable Unit (Choose One):*
- USACE ☐
- St. Louis Sites ☒
- Downtown ☐
- North County ☐
- Madison Sites ☐
- Inaccessible Areas ☐
- PRP ☐
- Oversight Committee ☐

D. *Site (Optional):*
- SLDS VPs ☐
- Mallinckrodt ☐
- SLAPS ☐
- SLAPS VPs ☐
- CWC ☐
- HISS ☐
- Madison ☐

E. *Area (Optional):* ____________

F. *Primary Document Type (Choose One):*
- Site Management Records ☒
- Removal Response ☐
- Remedial Investigation ☐
- Feasibility Study ☐
- Record of Decision ☐
- Remedial Design ☐
- ~~Remedial Action~~ ~~☒~~
- Public Affairs/Community Relations ☐
- Congressional Relations ☐
- Freedom of Information Act ☐
- Real Estate ☐
- Project Management ☐

G. *Secondary Document Type (see back of form):* Sampling/Analysis Data and Plans

H. *Bechtel Number:* — **I.** *SAIC Number:* —

J. *MARKS Number(Choose One):* FN: 1110-1-8100e ☐ FN: 1110-1-8100f ☐ FN: 1110-1-8100g ☐

K. *Subject:/Title:* Final Annual Environmental Monitoring Data & Analysis Report CY98

L. *Author:* — **M.** *Author's Company:* —

N. *Recipient(s):* — **O.** *Recipient(s) Company:* —

P. *Version (Choose One):* Draft ☐ Final ☑ **Q.** Date: July 99

R. *Include in the ARF?* ☑ **S.** *Include in the AR?* ☑ **T.** *Filed as Confidential/Privileged?* ☐

U. *Document Format (Choose one):*
- Paper ☑
- Electronic ☐
- Photographic ☐
- Audio-visual ☐
- Cartographic/Oversize ☐
- Microform ☐

V. *Filed in AR Volume Number:* ____________

W. *Physical Location (Choose One):*
- Central Files ☑
- Records Holding Area ☐
- Microfilm Vendor ☐
- Department of Energy ☐
- In ARF ☐
- In AR ☐

X. *Associated with Document(s):* ____________