FINAL

VOLUME I:

FEASIBILITY STUDY FOR THE ST. LOUIS NORTH COUNTY SITE

MAY 1, 2003

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

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prepared by

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

with assistance from

Science Applications International Corporation
under Contract No. DAC43-00-D-0515, Task Order 0005

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ACRONYMS, ABBREVIATIONS

ACL	alternate concentration limit
AOC	Administrative Order or Consent
AEA	Atomic Energy Act of 1954
AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
ARAR	applicable or relevant and appropriate requirement
BERA	baseline ecological risk assessment
BHE	BHE Environmental, Inc.
BNAE	base/neutral and acid extractable
BNI	Bechtel National, Inc.
BRA	baseline risk assessment
CAS	chemical abstract service
CD	Consent Decree
CDC	Commercial Discount Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMM	Continental Mining & Milling Company
COC	contaminant of concern
CTC	Clemson Technical Center
CWA	Clean Water Act
d	day
DOE	U.S. Department of Energy
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EM31	electromagnetic terrain conductivity tool
EM61	high sensitivity metal detector
EMS	emergency medical services
EPA	U.S. Environmental Protection Agency
EP-TOX	extraction procedure toxicity
ERA	ecological risk assessment
ERDA	Energy Research and Development Administration
EWDAA	Energy and Water Development Appropriations Act
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FFA	Federal Facilities Agreement
FS	Feasibility Study
FS-EIS	Feasibility Study/Environmental Impact Statement
FUSRAP	Formerly Utilized Sites Remedial Action Program
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
GIFREHC	General Investment Funds Real Estate Holding Company
gpd	gallons per day
GRA	general response action

ACRONYMS, ABBREVIATIONS (CONT'D)

HI	hazard index
HISS	Hazelwood Interim Storage Site
HQ	hazard quotients
HZ	hydrostratigraphic zone
I-270	Interstate 270
IA	Investigation Area
ICRP	International Commission on Radiological Protection
ISA	initial screening of alternatives
LDR	Land Disposal Restrictions
MARSSIM	Multi-Agency Radiation Site Survey and Investigation Manual
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCW	Mallinckrodt Chemical Works
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineer District
MMI	Modified Mercalli intensity
MSA	Metropolitan Statistical Area
MSD	St. Louis Metropolitan Sewer District
MSL	mean sea level
NCP	National Contingency Plan
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
O&M	operations and maintenance
ORNL	Oak Ridge National Laboratory
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PCOC	potential chemicals of concern
POTW	publicly owned treatment works
PP	Proposed Plan
PRG	preliminary remediation goal
RA	Remedial Action
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RG	remediation goal
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
ROD	Record of Decision

ACRONYMS, ABBREVIATIONS (CONT'D)

s	second			
SAIC	Science Applications International Corporation			
SARA	Superfund Amendments and Reauthorization Act			
SDWA	Safe Drinking Water Act			
SERA	Supplemental Ecological Risk Assessment			
SHPO	State Historical Preservation Office (Missouri)			
SLAPS	St. Louis Airport Site			
SLDS	St. Louis Downtown Site			
SOR	sum of ratios			
sp.	species			
SVOC	semi-volatile organic compound			
TBC	to be considered			
TCLP	toxicity characteristic leaching procedure			
TDS	total dissolved solids			
TOC	total organic compound			
TOX	total organic halogens			
UAO	Unilateral Administrative Orders			
UF_4	uranium tetrafluoride			
UMTRCA	Uranium Mill Tailings Radiation Control Act			
USACE	United States Army Corps of Engineers			
USCS	Unified Soil Classification System			
VOC	volatile organic compound			
VP	vicinity property			
yr	year			
°C	degree(s) Celsius (centigrade)			
°F	degree(s) Fahrenheit			
1×10^{-2}	=	1/100	=	one in one hundred
1×10^{-3}	=	1/1,000	=	one in one thousand
1×10^{-4}	=	1/10,000	=	one in ten thousand
1×10^{-5}	=	1/100,000	=	one in one hundred thousand
1×10^{-6}	=	1/1,000,000	=	one in one million
1×10^{-7}	=	1/10,000,000	=	one in ten million
1×10^{-8}	=	1/100,000,000	=	one in one hundred million

MEASUREMENTS

Name	Abbreviation
Length	
centimeter	cm
feet, foot	ft
inches	in
kilometer	km
meter	m
mile	mi
yard	yd
Area	
hectare	ha
square kilometer	km^2
square mile	mi^2
Volume	
cubic meters	m^3
cubic yards	yd^3
gallons	gal
liter	L
milliliter	mL
Mass or Weight	
gram	g
kilogram	kg
milligram	mg
microgram	µg
pound	lb
ton	T
Radiological Units	
becquerel	Bq
curie	Ci
microroentgen	µR
millirad	mrad
millirem	mrem
picocurie	pCi
microcuries	µCi
sievert	Sv

MEASUREMENT CONVERSIONS

Multiply number of →	**→ by →**	**→ to obtain number of**
	Length	
cm	0.3937	in
m	3.2808	ft
m	1.0936	yd
km	0.62137	mi
	Area	
acre	640	mi^2
acre	2.4712	hectare
km^2	2.59	mi^2
	Volume	
mL	1000	L
L	0.26418	gal
	Mass or Weight	
µg	1000	mg
mg	1000	g
g	28.35	oz
g	1000	kg
kg	2.205	pound
	Radiological Units	
pCi	10^{-2}	Ci
Ci	$3.7x10^{10}$	Bq
rem	0.01	Sv

to obtain number of ←	**← by ←**	**← Divide number of**

CHEMICAL SYMBOLS AND FORMULAS

Ac	actinium
$BaCO_3$	barium carbonate
$BaSO_4$	barium sulfate
DCE	dichloroethene
H_2SO_4	sulfuric acid
MCPA	2-methyl-4-chloro phenoxyacetic acid
MCPP	2-(2-methyl-5-chlorophenoxy) propionic acid
MgF_2	magnesium fluoride
Na_2CO_3	sodium carbonate
Pa	protactinium
Pb	lead
$PbSO_4$	lead sulfate
Ra	radium
$RaSO_4$	radium sulfate
TCE	trichloroethene
Th	thorium
U	uranium
UF_4	uranium tetrafluoride
UNH	uranyl nitrate hexahydrate
UO_2	uranium dioxide
$UO_2(NO_3)_2$	uranyl nitrate
UO_3	uranium trioxide

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The North County Site is part of the St. Louis Formerly Utilized Sites Remedial Action Program (FUSRAP) Site, which is comprised of multiple properties located in two distinct areas: the St. Louis North County Site (North County Site) and the St. Louis Downtown Site (SLDS). The North County Site is located in northern St. Louis County near the Lambert-St. Louis International Airport. The North County Site includes the St. Louis Airport Site (SLAPS); the Latty Avenue properties [which are: the Hazelwood Interim Storage Site, Futura Coatings (HISS/Futura), and the Latty Avenue Vicinity Properties (VPs)]; and SLAPS VPs. SLAPS VPs include properties near SLAPS and areas along Coldwater Creek. The North County Site includes three properties on the U.S. Environmental Protection Agency's (EPA's) National Priorities List (NPL): SLAPS, HISS, and Futura Coatings. This Feasibility Study (FS) addresses all of the properties that constitute the North County Site.

SLDS is located in downtown St. Louis near the Mississippi River. Remediation of wastes in accessible soils and ground water at SLDS that resulted from uranium manufacturing and processing activities was addressed in a separate Record of Decision (ROD), which was signed in 1998.

Authority

USACE is conducting response actions under the legislative authority contained in Public Law 107-66, the Energy and Water Development Appropriations Act (EWDAA) for Fiscal Year 2002 (FY02). This law establishes the authority of the United States Corps of Engineers (USACE) to conduct response actions for releases related to the nation's early atomic energy program as the lead federal agency, subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP). This plan is being submitted as part of USACE's public participation responsibilities under Section 117(a) of CERCLA.

Actions taken at the North County Site will be conducted under FUSRAP. FUSRAP was initiated to identify and clean up or otherwise control sites where residual radioactive material remains because of uranium manufacturing and processing activities conducted during the nation's atomic energy program. FUSRAP also addresses commercial operations that Congress has authorized or directed FUSRAP to remediate. The Department of Energy (DOE) managed FUSRAP until 1997. On October 13, 1997, the U.S. Congress transferred responsibility for FUSRAP from the DOE to USACE through the 1998 EWDAA.

The scope of this FS is limited to FUSRAP wastes. As defined by the Federal Facility Agreement (FFA), these wastes include the following types of materials:

- All wastes, including but not limited to radiologically contaminated wastes, resulting from or associated with uranium manufacturing or processing activities conducted at SLDS; and

- other chemical or non-radiological wastes that have been mixed or commingled with radiologically contaminated wastes resulting from or associated with uranium manufacturing or processing activities conducted at SLDS.

Those contaminants not resulting from FUSRAP-related activities are outside the scope of this FS.

CERCLA Process

Several CERCLA documents preceded the development of this FS. The DOE completed and received EPA approval of the Remedial Investigation (RI) Report and Baseline Risk Assessment (BRA) prior to the transfer of FUSRAP to USACE. The RI report (BNI, 1992a) characterizes the nature and extent of contamination. The BRA (ANL, 1993) describes the risks to human health and the environment posed by radiological and associated chemical contamination. The BRA also evaluates the need for action by defining the potential risks associated with taking no action to mitigate or eliminate the risks. The results from the RI and BRA reports were used by USACE to prepare the FS for the North County Site in accordance with procedures developed under CERCLA. Supplementary documents (such as the SLAPS Implementation Report and the Ecological Risk Assessment) have been prepared to analyze new data and to evaluate new guidance that was generated or issued since the RI and BRA were prepared.

USACE, and previously DOE, have for many years involved the regulators and public in the CERCLA process for the St. Louis Sites. As a result, USACE has a good understanding of the regulator and public positions. USACE provides monthly briefings at the St. Louis Oversight Committee meetings. A Citizens Remediation Task Force actively investigated the St. Louis Sites from 1994 to 1996 and published their report that included specific recommendations and hundreds of pages of analysis. (The Citizens Remediation Task Force became the St. Louis Oversight Committee after publishing their report.) EPA Region VII has been actively involved and has provided informal comments from region staff and from the National Remedy Review Board pursuant to DOE's FFA. The Missouri Department of Natural Resources (MDNR) has a local office working on FUSRAP and interacts regularly with USACE staff.

Public input regarding remedial activities conducted at the North County Site has been received from these and many other sources. Public meetings have been held, including monthly meetings with a local interest group (St. Louis Oversight Committee) and concerned members of the public. Another source of input was comments received from the public and the regulators on the draft FS/Environmental Impact Statement prepared by the DOE before FUSRAP was transferred to USACE. Comments were also received on the engineering evaluation/cost analysis (EE/CA) documents, prepared to evaluate and select removal actions at North County Site properties. In addition, some comments relevant to the North County Site were received on the Proposed Plan (PP) and FS for SLDS, which resulted in the 1998 ROD for accessible soils and ground water for SLDS.

This FS identifies, develops, and evaluates six remedial action alternatives to achieve a final remedy for the North County Site. This FS addresses all media within all of the properties

that constitute the North County Site. Media addressed specifically include soil, sediment, surface water, ground water, and structures. Alternatives are developed on the basis of the nature and extent of FUSRAP-related contamination documented in the RI, the BRA, this FS, and related reports. This FS report evaluates the potential impact of the remedial action alternatives based on the nine CERCLA evaluation criteria that are discussed in subsequent sections of this document. The FS process includes regulatory agency and public review.

SITE HISTORY

From 1942 to 1957, under contracts with the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC), the SLDS was used for processing various forms of uranium compounds. In 1946, MED acquired the 21.7 acre tract of land now known as SLAPS to store residues and scrap from uranium processing at the Mallinckrodt (SLDS) facility. In 1966 and 1967, most of the stored residues were sold and removed from SLAPS. On-site structures at SLAPS were razed and buried on the property. Buried deposits of uranium-238 (U-238), radium-226 (Ra-226) and thorium-230 (Th-230) remain on the SLAPS property. The company that purchased the vast majority of the material stored at the SLAPS moved the materials to the HISS/Futura on Latty Avenue. Most of this material was later shipped to Colorado. Over time, residues migrated from the sites or were released or otherwise deposited when waste was hauled along transportation routes, contaminating the soils and sediments at the SLAPS VPs.

Initially the uranium-bearing feed materials were relatively pure “black oxides,” which had been extracted from uranium ores by other companies located throughout the United States. As the demand for purified uranium continued to increase, SLDS began extracting uranium directly from uranium ores rather than only purifying uranium extracted by other companies.

In 1944, Belgian Congo Shinkolobwe ore containing unusually high percentages of uranium (greater than 30% by weight) were processed. The supplier of the ores retained title to the ore residuals after processing (these residuals are called "raffinate cake").

Because there was no room to store the raffinate cake at the downtown site, the AEC began searching for a suitable storage location for the raffinate cake. The AEC ultimately obtained title to SLAPS by condemnation proceedings on January 3, 1947.

The uranium production process at SLDS is described in more detail in Section 2.1 of the FS. Several wastes and by-products were transported from SLDS to SLAPS for storage:

- Radium-bearing residues, referred to as “K-65” residues;
- AM-7 Pitchblende raffinate cake;
- AM-10 or Colorado raffinate cake;
- AJ-4 Barium Sulfate Cake (unleached) and AJ-4 Barium Cake (leached);
- C-liner slag that was created during metal forming operations; and
- Empty drums, contaminated steel and alloy scrap, and building debris.

The scrap metal stored at SLAPS was sold in 1962 and moved to Knoxville, Tennessee, and the SLAPS residues were purchased by a private company, Continental Mining & Milling Company (CMM) in 1966. The conditions of CMM's license specified that it was only for removal of stockpiled residues from 50 Brown Road (SLAPS) and storage at the licensee's facility at 9200 Latty Avenue.

In February 1967, CMM became insolvent and its lender, the Commercial Discount Corporation (CDC) of Chicago obtained possession of the Latty property and the residues. On June 26, 1967, CDC began shipping the residues to Cotter Corporation facilities. CDC sold remaining residuals at Latty Avenue to Cotter Corporation in 1969. In 1973, Cotter shipped undried AM-10 Colorado raffinate cake to Canon City and transported the leached AJ-4 barium sulfate cake, mixed with topsoil, to Westlake landfill in western St. Louis County.

Several removal actions conducted in accordance with approved engineering evaluation/cost analyses (EE/CAs) are either on-going or completed at the North County Site. These removal actions were conducted at numerous properties from 1994 to the present. Table ES-8 summarizes the response status of each of the designated properties in North County. Removal actions started under the EE/CAs are complete at the time the ROD is approved. The ROD criteria would supercede commitments to cleanup criteria in previously issued documents, (e.g., EE/CAs).

The first removal action at SLAPS was conducted in Spring 1985, when gully erosion occurred in the western portion of the site along Coldwater Creek. A retaining wall (gabion wall) was constructed along the bank to combat the erosion problem. In Fall 1997, an interim removal action was conducted at SLAPS to address contamination in an area immediately east of the gabion wall. Approximately 3,900 cubic meters (m^3) [5,100 cubic yards (yd^3)] of contaminated material were removed from the western end of SLAPS under this action and transported off-site. In 1998, a removal action was begun at SLAPs and the Ballfields (a SLAPS Vicinity Property) in accordance with an approved May 1998 EE/CA. As part of this action, a sedimentation basin was constructed in 1999 at the west end of SLAPS to limit the migration of contamination offsite via surface-water runoff. Other components of this removal action include excavation of contaminated soils from SLAPS and the Ballfields (excluding the ditch north of McDonnell Boulevard), offsite disposal of the excavated materials, and backfilling with approved fill material. A rail spur was installed on SLAPS in 1998 to provide a load-out area and staging area for shipment of contaminated materials to off-site disposal or recycling locations.

During 2000 and 2001, removal actions were conducted in the eastern portion of SLAPS and at the barium/radium pits. These actions resulted in the removal of approximately 20,600 m^3 (27,000 yd^3) of contaminated soils from the East End of SLAPS and 38,100 m^3 (49,800 yd^3) of contaminated soils from the Radium Pits area. Additional removals are ongoing at the East End Extension of SLAPS, which includes the areas of contaminated soil between the Radium Pits and the East End and in the drainage ditch immediately south of McDonnell Boulevard. By Fall 2001, approximately 45,900 m^3 (60,000 yd^3) had been removed from portions of the East End Extension. Removal of contaminated soils located in the central portion of SLAPS, referred to as Phase 1, was initiated in Fall 2001 and continued through 2002. Phase 1 is expected to be completed by May 2003. A total of 74,200 m^3 (97,000 yd^3) will have been removed from the

Phase I area. To date, all material has been shipped to properly permitted or licensed off-site disposal facilities.

Removal actions have also been conducted at several SLAPS VPs and Latty VPs. In 1995, DOE excavated contaminated soils from six residential SLAPS VPs and two industrial Latty Avenue VPs and transported 3,500 m^3 (4,610 yd^3) of material off-site for disposal (DOE, 1995). Another removal action resulted in the excavation and disposal of about 8,600 m^3 (11,300 yd^3) (ex-situ) of contaminated soils from the North Ditch between McDonnell Boulevard and the former ballfield area. During 2000, approximately 5,400 m^3 (7,100 yd^3) of contaminated soils were excavated from a portion of VP-38, a haul road vicinity property located at the northwest corner of Latty Avenue and Hazelwood Avenue.

At HISS, removal of all storage and spoil piles has been conducted under the 1998 HISS EE/CA. Preparation for the removal action included the construction of a railroad spur along the eastern boundary of HISS that was completed in early 1999. Removal of the stockpiles began in March 2000 and was completed approximately 18 months later. Nearly 44,300 m^3 (58,000 yd^3) of material from the two Spoil Piles, two Eastern Piles, the HISS Supplemental Storage Pile, and the HISS Main Pile were removed.

SITE CHARACTERISTICS

Site Description

The North County Site properties are located in northern St. Louis County, Missouri and involve five local municipal jurisdictions. Specific sites include SLAPS, Latty Avenue properties (HISS/Futura and Latty Avenue VPs), and SLAPS VPs. A total of more than 87 properties are involved. Coldwater Creek, which is a SLAPS VP, flows adjacent to SLAPS and drains the North County Site. Average annual precipitation for the area is approximately 36 inches per year. Depth to ground water varies from 27 to 75 feet (ft). The population of this immediate area is approximately 38,000 and is located within the St. Louis Metropolitan area, which has a population of 2.7 million.

In the 1940s, the area was primarily agricultural with a few private residences. In the 1950s and 1960s, private residences and commercial/industrial developments began to populate the North County Site. In the last twenty years, commercial/industrial development of the area has continued. This urban area consists predominately of commercial and industrial properties, although it also includes private residences, vacant lots, a farming area, a community garden, a recreation area, and Coldwater Creek. The reasonably anticipated future land use for most habitable properties is industrial. Given the rapid changes in the uses of these properties in the last 50 years, however, reasonably anticipated land uses may include residential with some limited agricultural.

Coldwater Creek is the major drainage mechanism for the SLAPS and HISS/Futura areas. Coldwater Creek flows adjacent to SLAPS, then meanders near HISS/Futura and other Latty Avenue properties and continues to flow through northern St. Louis County until it discharges into the Missouri River. Coldwater Creek floods areas of the North County Site including

portions of SLAPS, HISS/Futura, and several VPs. Periodic maintenance and flood control measures are regularly undertaken. From the airport through the industrial areas, the water quality in Coldwater Creek is generally poor. Coldwater Creek is protected for livestock and wildlife watering and aquatic-life usage from its intersection with U.S. Highway 67 downstream to the mouth of the creek at the Missouri River. This portion of the Creek is classified by the state as a Class "C" waterway, which means there are periods of no flow in the creek, but permanent pools are always present.

Studies of aquatic life in Coldwater Creek have shown the stream ecology is severely impacted by industrial and other operations in North County unrelated to the FUSRAP-related activities. Pollutants enter the stream in storm water from commercial and industrial facilities, residential areas, and the Lambert-St. Louis International Airport. SLAPS storm-water run-off also flows into Coldwater Creek. More than a dozen facilities, which are permitted under the National Pollutant Discharge Elimination System (NPDES) program, discharge directly into the stream, including Ford Motor Company, Lambert-St. Louis International Airport, and Boeing Corp. Discharges include storm-water runoff, airport deicing fluids, and manufacturing discharges.

The North County Site is situated on a modest upland area between the Missouri and Mississippi River flood plains in northern St. Louis County. The upland area surrounds a topographic depression known as the Florissant Basin. Pleistocene soils and recent fill overlay shale and limestone bedrock. Faulting is not evident at the site, and the limestone bedrock appears to be almost flat.

The North County Site is underlain by a sequence consisting of loess, clay, sands, and gravel that was deposited by wind, stream and lake processes. This sedimentary sequence was deposited on limestone bedrock, which lies at a depth of approximately 100 ft below ground surface at the North County Site. Pennsylvanian shale overlies the limestone on the east side of SLAPS, but is absent to the west and absent at HISS/Futura. Chemical and hydrologic characteristics define five hydrostratigraphic (water property) zones (HZs) at the North County Site. The shallow ground-water zone, HZ-A, consists of fill, silts, and clays. Underlying HZ-A are HZ-B, which consists of highly impermeable clay, and HZ-C, which consists of silty clay and clayey silt deposits. The underlying shale and limestone bedrock are recognized as HZ-D and HZ-E, respectively. The limestone aquifer (HZ-E) is the protected aquifer for the site. All five HZs (HZ-A through HZ-E) occur beneath SLAPS; HZ-D (shale) is not found beneath HISS/Futura.

The uppermost hydrostratigraphic zone, HZ-A, has a low recharge rate. HZ-A cannot be considered a viable source of potable water because of the low recharge rate and the presence of chemical pollutants from the highly industrialized North County region. The ground water in HZ-A generally flows to the west and northwest. Water flow through soil is interpreted to discharge into Coldwater Creek from SLAPS and the Latty Avenue properties.

Chemical compositions of ground-water samples collected from the shallow hydrostratigraphic zone, HZ-A, are highly variable and include major anions and cations, radionuclides, metals, and organic compounds. On the other hand, chemical compositions of ground-water samples collected from lower zones are remarkably similar to each other but distinctly different from the bulk of the ground-water samples collected from HZ-A.

Additionally, while contaminants of potential concern (COPCs) were found in HZ-A no contaminants of concern (COCs) were identified for the potential drinking water zone, the limestone aquifer (HZ-E). The rate of vertical contaminant movement suggests times exceeding 1,000 years to reach the Limestone Aquifer. This arrival period assumes continued soil contamination. Removal of the soil source of contamination will result in lower concentrations reaching ground water and will lengthen the arrival period to still greater time lengths. Combined with low measured hydraulic conductivities in HZ-A, HZ-B, and HZ-D, these characteristics indicate that ground water in HZ-A has limited communication with water in the lower HZs (DOE, 1994a).

This interpretation is supported by tritium concentrations in samples from HZ-A and the lower HZs. Tritium concentrations in HZ-A are significantly higher than in any of the other HZs, indicating that HZ-A has communication with atmospheric tritium. Tritium is not a FUSRAP-related contaminant but is present in the atmosphere as a result of a natural process (the interaction of cosmic rays with the atmosphere) and man-made processes (nuclear weapon fallout). The uniform tritium concentrations in HZ-B through HZ-E indicate an older tritium reservoir (likely naturally-occurring) that has not been connected with the contaminated shallow zone.

The EPA has developed a ground-water classification system to assess ground water on the basis of ground-water value and vulnerability to contamination. Using EPA's Superfund Ground-Water Classification Flow Chart, the ground-water classification was evaluated as part of the FS. The water-bearing units of the HZ-E limestone aquifer meet the requirements for a Class IIB designation. Class IIB means the ground-water source could be used for drinking water, but is not currently used. The upper HZ-A water-bearing unit at the airport areas meets Class III definitions. Class III includes ground waters that "are so contaminated by naturally occurring conditions, or by the affects of broad-scale human activity (i.e., unrelated to a specific activity), that they cannot be cleaned up using treatment methods reasonably employed in public water-supply systems." Class III also encompasses ground waters where yields are insufficient to meet the needs of an average size family. The low permeability of the upper ground water units confirms that these units are unlikely to produce water in sufficient quantities to serve as a drinking water supply. Except for HZ-E, the water bearing units (HZ-A, B, C and D) were classified as Class IIIA, because the site is surrounded by industrial activities and the creek feeds surface water bodies (the Missouri River) that are used for drinking water.

No threatened or endangered species have been found at the North County Site. The only federal and state designated endangered or threatened species that have any significant possibility of occurring within the area of the North County Site are the pallid sturgeon and the bald eagle. Pallid sturgeons are found in the Mississippi and Missouri Rivers, but Coldwater Creek does not provide adequate water quality or quantity for a suitable habitat. No sightings of Bald Eagles have been reported at this site.

Potential wetlands have been identified along Coldwater Creek, and portions of the North County Site lie within the 100-year flood plain.

No known archeological or historical sites are impacted by the contamination at the North County Site.

NATURE AND EXTENT OF CONTAMINATION

The media affected by contamination are soils and sediments. The total risk from COPCs in surface water (Coldwater Creek) do not exceed acceptable risk levels; therefore, surface water is not a medium of concern. Some COPCs were identified in the upper hydrostratigraphic zone (HZ-A) of ground water under the SLAPS, but this zone is not currently used as a water supply source, and does not communicate with the water in the lower zones. COPCs were not found in lower hydrostratigraphic zones. Therefore, useable ground water is not impacted and the media of concern are soils and sediments.

The patterns of soil contamination around SLAPS and HISS/Futura indicate that airborne transport has been a significant contributor in the past [e.g., from SLAPS north to Investigation Area 9 (IA-9), the former ballfield and park area]. Spillage from trucks was also a major mechanism for contaminant transport to haul road properties when materials were transported from SLAPS to the site on Latty Avenue (HISS/Futura). Contamination in Coldwater Creek has been affected by flood events that moved contaminated sediment within the floodplain as well as downstream.

Soil: Elevated levels of radioactive materials in the uranium, thorium, and actinium decay series including Ra-226, Th-230, and U-238 have been detected in SLAPS soil. The remedial investigations found concentrations ranging from background to 5,600 picocuries per gram (pCi/g), 37,780 pCi/g, and 1,700 pCi/g, respectively. (However, some slightly higher values for Th-230 were found at test pits for IA-4 removals.) The characterization data indicate that non-radiological contaminants related to uranium manufacturing and processing activities at SLDS are present. However, these chemicals would be addressed by remediating the radionuclides at the North County Site because the FUSRAP-related chemicals are generally co-located with the radionuclides. Chemical sampling will be done to confirm that chemicals are addressed. Contamination at SLAPS covers most of the surface, and subsurface soils down to about 20 ft deep. Contaminated scrap and building rubble were also reportedly buried on SLAPS. Geotechnical investigations have identified features on SLAPS consistent with burials of this type. Sampling indicates that the radioactively contaminated soils generally do not exhibit Resource Conservation and Recovery Act (RCRA) hazardous waste characteristics. Although some volatile organic compounds (VOCs) were found, there is no documentation or other evidence to date to indicate that organic COCs were released at these sites from uranium ore processing wastes that originated at SLDS. A records search of industrial facilities surrounding the Latty Avenue properties has identified processes that could generate RCRA-listed wastes. The remedial design investigations done prior to any soil removal must consider the presence of these contaminants.

The results of investigations conducted at the Latty Avenue properties are similar to results for investigations conducted at SLAPS. Radioanalytical studies indicate that Ra-226, Th-230, and U-238 are present in HISS/Futura surface soils at concentrations as high as 700 pCi/g, 830 pCi/g, and 800 pCi/g, respectively.

Ground Water: Current risks associated with exposure to contaminated ground water are minimal. Although some contaminants are present in the shallow HZ-A ground water, their

presence does not require action because a complete pathway to receptors does not exist. Because the potential yield is very low for HZ-A ground water, it does not constitute a source of potable drinking water. In addition, sample data show that there are no COCs in HZ-E ground water, the potential water resource. The hydrologic and chemical data also show that the water in the contaminated ground-water zone (HZ-A) has limited connection with the lower ground-water zones. The existence of from 50 to 80 ft of low permeability clay-rich soils, together with limited mobility of the radionuclides of interest, strongly suggest that contamination from the HZ-A unit is not likely to migrate to the lower water-bearing units. Ground water from HZ-A at SLAPS flows toward Coldwater Creek. Hydrological studies of SLAPS indicate that the slow discharge of ground water to Coldwater Creek is not significantly impacting the creek.

SUMMARY OF SITE RISKS

The BRA and related studies were prepared to evaluate the risk to human health and the environment from radioactive materials and chemicals if no cleanup were conducted at the North County Site. The BRA concluded that remedial action at the site was warranted. However, because additional data have been gathered, a supplemental risk assessment was included in the FS. The FS risk assessment evaluated risks at the site (for the no action alternative) and evaluated the potential risk in the future following cleanup for each of the remedial alternatives presented in the FS. The results of the FS risk evaluation are discussed below.

The primary health risks include cancer (carcinogenic) and toxic (non-carcinogenic) human health effects. Cancer risk estimates were compared to the CERCLA risk range of one in one million (10^{-6}) to one in ten thousand (10^{-4}) outlined in the NCP. As defined in the NCP, acceptable exposure levels are generally levels that represent an excess upper-bound lifetime cancer risk to an individual in the range of 10^{-6} to 10^{-4}. The potential for non-carcinogenic effects from chemicals was evaluated by dividing the intake ratios by published chronic reference dose values. These values were then added for each chemical to obtain a hazard index. A hazard index (HI) greater than one indicated a potential for adverse health effects.

An ecological risk screening was also conducted. The screening process involved comparing the maximum concentrations of contaminants at the site to screening values. The ecological evaluation also considered the rarity, diversity, and importance of habitats at the site.

Table ES-1 presents the total risk for the reasonable maximum exposure (RME) expected to occur under current and future land use. The excess lifetime cancer risk and dose for the RME receptor at all the North County Site properties are summarized in Table ES-2. The dose represents the energy absorbed from exposure to ionizing radiation and is expressed in units of mrem/year. Risks and doses from exposure to radionuclides were calculated for year 0 through year 1000. For each property unit, receptors were evaluated for a range of current and future uses, including residential land use, an industrial worker, a construction worker, a maintenance worker, a recreational user (or trespasser), and a utility worker. The resident is assumed to live at the site for 350 days per year for 30 years. The industrial worker is assumed to be at the site for 8 hours per day, 250 days per year, for 25 years. The maintenance worker is assumed to be present for 8 hours per week and holds the position for 6.6 years. The recreational user (or

Table ES-1. RME Receptors Risk Summary

Carcinogens								
Scenario Timeframe:	Current							
Receptor Population:	Maintenance Worker							
Receptor Age:	Adult							
Receptor Location:	SLAPS							
				Carcinogenic Risk				
Medium	**Exposure Medium**	**Exposure Route-Pathway**	**Contaminant of Concern**	**Ingestion**	**Inhalation**	**Dermal**	**External (Radiation)**	**Exposure Route Total**
Soil	Soil	Soil On-Site - Direct Contact	None [a]	Note b	Note b	Note b	Note b	Note b
	Dust	Soil On-Site – Inhalation of Soil as Dust	None [a]	Note b	Note b	Note b	Note b	Note b
							Chemical Soil Risk Total	Note b
				Carcinogenic Risk				
Medium	**Exposure Medium**	**Exposure Route-Pathway**	**Contaminant of Concern**	**Ingestion**	**Inhalation**	**Dermal**	**External (Radiation)**	**Exposure Route Total**
Soil	Soil/Dust	Soil On-Site - Direct Contact and Inhalation of Soil as Dust	Radionuclides	Note c	Note c	-	Note c	4.8E-05
							Radiological Soil Risk Total	4.8E-05
Carcinogens								
Scenario Timeframe:	Future							
Receptor Population:	Resident							
Receptor Age:	Adult/Child							
Receptor Location:	SLAPS							
				Carcinogenic Risk				
Medium	**Exposure Medium**	**Exposure Route-Pathway**	**Contaminant of Concern**	**Ingestion**	**Inhalation**	**Dermal**	**External (Radiation)**	**Exposure Route Total**
Soil	Soil	Soil On-Site - Direct Contact	Arsenic [d]	8.0E-05	doesn't apply to direct contact	6.6E-07	doesn't apply to direct contact	8.1E-05
	Dust	Soil On-Site - Inhalation of Soil as Dust	Arsenic [d]	doesn't apply to inhalation	4.6E-08	doesn't apply to inhalation	doesn't apply to inhalation	4.6E-08
							Chemical Soil Risk Total	8.1E-05
				Carcinogenic Risk				
Medium	**Exposure Medium**	**Exposure Route-Pathway**	**Contaminant of Concern**	**Ingestion**	**Inhalation**	**Dermal**	**External (Radiation)**	**Exposure Route Total**
Soil	Soil/Dust	Soil On-Site - Direct Contact and Inhalation of Soil as Dust	Radionuclides	Note c	Note c	-	Note c	3.7E-03
							Radiological Soil Risk Total	3.7E-03
								Total Risk Note e

Table ES-1. RME Receptors Risk Summary (Cont'd)

Medium	Exposure Medium	Exposure Route-Pathway	Contaminant of Concern	Primary Target Organ(s)	Non-Carcinogenic Hazard Quotient			
Non-Carcinogens								
Scenario Timeframe: Current **Receptor Population:** Maintenance Worker **Receptor Age:** Adult **Receptor Location:** SLAPS								
Medium	**Exposure Medium**	**Exposure Route-Pathway**	**Chemical of Concern [f]**	**Primary Target Organ(s)**	**Non-Carcinogenic Hazard Quotient**			
					Ingestion	**Inhalation**	**Dermal**	**Exposure Route Total**
Soil	Soil	Soil On-Site - Direct Contact	Arsenic	Cardiovascular, Skin/Hair	1.1E-01	doesn't apply to direct contact	1.1E-04	1.1E-01
		Soil On-Site - Direct Contact	Nickel	Lungs, Immune System	4.2E-02	doesn't apply to direct contact	6.5E-05	4.3E-02
		Soil On-Site - Direct Contact	Thallium	CNS, Skin/Hair	2.0E-03	doesn't apply to direct contact	4.2E-06	2.0E-03
		Soil On-Site - Direct Contact	Vanadium	Lungs	2.0E-02	doesn't apply to direct contact	8.4E-04	2.1E-02
	Dust	Soil On-Site – Inhalation of Soil as Dust	Arsenic	Cardiovascular, Skin/Hair	doesn't apply to inhalation	-	doesn't apply to inhalation	-
		Soil On-Site - Inhalation of Soil as Dust	Nickel	Lungs, Immune System	doesn't apply to inhalation	-	doesn't apply to inhalation	-
		Soil On-Site - Inhalation of Soil as Dust	Thallium	CNS, Skin/Hair	doesn't apply to inhalation	-	doesn't apply to inhalation	-
		Soil On-Site - Inhalation of Soil as Dust	Vanadium	Lungs	doesn't apply to inhalation	-	doesn't apply to inhalation	-
							Chemical Soil Hazard Index Total	1.7E-01
							Cardiovascular System Total Hazard Index	1.1E-01
							Central Nervous System (CNS) Total Hazard Index	2.0E-03
							Immune System Total Hazard Index	4.3E-02
							Respiratory System (Lungs) Total Hazard Index	6.3E-02
							Skin/Hair Total Hazard Index	1.1E-01
					Ingestion	**Inhalation**	**Dermal**	**Exposure Route Total**
Soil	Soil/Dust	Soil On-Site - Direct Contact and Inhalation of Soil as Dust	Radionuclides	Note g	Note g	Note g	Note g	Note g
							Radiological Soil Total Dose (mrem/yr)	2.2E+01

Table ES-1. RME Receptors Risk Summary (Cont'd)

Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult/Child
Receptor Location: SLAPS

Medium	Exposure Medium	Exposure Route-Pathway	Contaminant of Concern [h]	Primary Target Organ(s)	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Route Total
Soil	Soil	Soil On-Site - Direct Contact	Arsenic	Cardiovascular, Skin/Hair	4.2E-01	doesn't apply to direct contact	3.4E-03	4.2E-01
		Soil On-Site - Direct Contact	Barium	Cardiovascular	9.8E-02	doesn't apply to direct contact	4.7E-03	1.0E-01
		Soil On-Site - Direct Contact	Chromium	Lungs	3.8E-01	doesn't apply to direct contact	6.4E-02	4.5E-01
		Soil On-Site - Direct Contact	Nickel	Lungs, Immune System	1.6E-01	doesn't apply to direct contact	2.0E-03	1.6E-01
		Soil On-Site - Direct Contact	Thallium	CNS, Skin/Hair	7.7E-02	doesn't apply to direct contact	1.3E-03	7.8E-02
		Soil On-Site - Direct Contact	Vanadium	Lungs	7.7E-02	doesn't apply to direct contact	2.6E-02	1.0E-01
		Soil On-Site - Direct Contact	Zinc	Blood	5.2E-03	doesn't apply to direct contact	8.8E-05	5.3E-03
	Dust	Soil On-Site - Inhalation of Soil as Dust	Arsenic	Cardiovascular, Skin/Hair	doesn't apply to inhalation	-	doesn't apply to inhalation	-
		Soil On-Site - Inhalation of Soil as Dust	Barium	Cardiovascular	doesn't apply to inhalation	2.7E-03	doesn't apply to inhalation	2.7E-03
		Soil On-Site - Inhalation of Soil as Dust	Chromium	Lungs	doesn't apply to inhalation	2.3E-03	doesn't apply to inhalation	2.3E-03
		Soil On-Site - Inhalation of Soil as Dust	Nickel	Lungs, Immune System	doesn't apply to inhalation	-	doesn't apply to inhalation	-
		Soil On-Site - Inhalation of Soil as Dust	Thallium	CNS, Skin/Hair	doesn't apply to inhalation	-	doesn't apply to inhalation	-
		Soil On-Site - Inhalation of Soil as Dust	Vanadium	Lungs	doesn't apply to inhalation	-	doesn't apply to inhalation	-
		Soil On-Site - Inhalation of Soil as Dust	Zinc	Blood	doesn't apply to inhalation	-	doesn't apply to inhalation	-
							Chemical Soil Hazard Index Total	1.3E+00
							Blood Total Hazard Index	5.3E-03
							Cardiovascular System Total Hazard Index	5.2E-01
							Central Nervous System (CNS) Total Hazard Index	7.8E-02
							Immune System Total Hazard Index	1.6E-01
							Respiratory System (Lungs) Total Hazard Index	7.1E-01
							Skin/Hair Total Hazard Index	5.0E-01

Table ES-1. RME Receptors Risk Summary (Cont'd)

Medium	Exposure Medium	Exposure Point	Contaminant of Concern	Primary Target Organ(s)	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Route Total
Soil	Soil/Dust	Soil On-Site - Direct Contact and Inhalation of Soil as Dust	Radionuclides	Note g	Note g	Note g	Note g	Note g

Notes: **Radiological Soil Total Dose (mrem/yr)** 3.2E+02

[a] No Contaminants of Concern (COC) were identified for this property or any other property for the Maintenance Worker receptor.
[b] Not applicable since there are no COCs.
[c] The risk for radionuclides was calculated based only as a total across applicable exposure pathways and are not presented for each individual pathway.
[d] Although not a COC for this property, this contaminant was identified as a COC for another property for the Resident receptor. Risks are shown here for all carcinogenic residential COCs.
[e] The total risk (e.g., sum of chemical and radionuclide risks) may not be directly additive but the risk from exposure to radionuclides far exceeds the risk from exposure to non-radionuclides. Therefore the total risk is approximately the same as the radiological risk.
[f] Although none of the chemicals listed are COCs at this site, these chemicals have been identified as COCs for another property for the Maintenance Worker receptor. Hazards are shown here for all non-carcinogenic maintenance worker COCs.
[g] Radionuclide exposure is not presented in terms of hazard quotient (see dose in mrem/yr).
[h] Although none of the chemicals listed are COCs at this site (since all target organs produce a total HI < 1), these chemicals have been identified as COCs for another property for the Resident receptor. Hazards are shown here for all non-carcinogenic residential COCs except for antimony, which was not evaluated for risk at this site since it was eliminated in the soil screening process.
- Toxicity criteria are not available to quantitatively address this route of exposure

Table ES-2. Supplemental Human Health Risk Evaluation Summary Table

Property Name	RESIDENTIAL SCENARIO				INDUSTRIAL SCENARIO				CONSTRUCTION SCENARIO			
	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000
VPs (highest value)	60	51	9E-04	7E-04	18	15	2E-04	2E-04	47	42	2E-05	2E-05
VPs (average value)	2.7	4.3	6E-05	7E-05	0.8	1.3	2E-05	2E-05	2.3	3.2	9E-07	2E-06
Coldwater Creek	not applicable				not applicable				8.6	2.9	3E-06	2E-06
Railroad	not applicable				not applicable				6.7	5.4	3E-06	2E-06
Road Right-of-Way	29	37	4E-04	5E-04	8.0	11	1E-04	1E-04	25	31	9E-06	1E-05
HISS	42	9.3	5E-04	1E-04	12	2.7	1E-04	4E-05	34	7.4	1E-05	3E-06
Futura	294	18	3E-03	3E-04	79	5.3	8E-04	7E-05	251	14	8E-05	6E-06
IA-1	3407	78	4E-02	1E-03	946	24	9E-03	3E-04	2801	56	1E-03	3E-05
IA-2	382	180	5E-03	3E-03	105	51	1E-03	7E-04	322	149	1E-04	6E-05
IA-3	492	65	6E-03	9E-04	144	18	2E-03	2E-04	369	54	2E-04	2E-05
IA-4	1159	315	2E-02	4E-03	337	90	4E-03	1E-03	890	262	4E-04	1E-04
IA-5	179	89	2E-03	1E-03	48	25	5E-04	3E-04	156	73	5E-05	3E-05
IA-6	84	68	9E-04	1E-03	21	20	2E-04	3E-04	80	55	2E-05	2E-05
IA-7	621	256	6E-03	4E-03	164	72	2E-03	9E-04	557	213	2E-04	8E-05
IA-8	341	221	3E-03	3E-03	87	63	8E-04	8E-04	325	184	8E-05	7E-05
IA-9	24	16	2E-04	2E-04	6.0	4.5	6E-05	6E-05	22	13	6E-06	5E-06
IA-10	24	5.0	3E-04	8E-05	6.5	1.5	7E-05	2E-05	20	3.6	7E-06	2E-06
IA-11	0.0	0.0	1E-07	4E-07	0.0	0.0	2E-08	1E-07	0.0	0.0	5E-10	1E-08
IA-12	30	42	4E-04	6E-04	7.6	12	9E-05	2E-04	30	35	7E-06	1E-05
IA-13	10	4.8	1E-04	8E-05	2.8	1.5	3E-05	2E-05	8.8	3.3	3E-06	2E-06
SLAPS	321	110	4E-03	2E-03	89	31	1E-03	4E-04	267	91	1E-04	4E-05
Property Name	**MAINTENANCE SCENARIO**				**RECREATIONAL/TRESPASSER SCENARIO**				**UTILITY WORKER SCENARIO**			
	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000
VPs (highest value)	3.8	3.4	1E-05	8E-06	0.9	0.8	5E-06	4E-06	1.9	1.7	8E-07	7E-07
VPs (average value)	0.2	0.3	5E-07	7E-07	0.0	0.1	3E-07	3E-07	0.1	0.1	3E-08	6E-08
Coldwater Creek	0.7	0.2	1E-06	8E-07	0.1	0.1	5E-07	4E-07	0.3	0.1	1E-07	6E-08
Railroad	0.5	0.4	2E-06	1E-06	0.1	0.1	8E-07	6E-07	0.3	0.2	1E-07	1E-07
Road Right-of-Way	2.1	2.5	5E-06	6E-06	0.4	0.6	2E-06	3E-06	1.0	1.2	4E-07	5E-07
HISS	2.8	0.6	7E-06	2E-06	0.6	0.1	3E-06	7E-07	1.3	0.3	6E-07	1E-07
Futura	21	1.1	4E-05	3E-06	4.0	0.3	2E-05	1E-06	10	0.6	3E-06	2E-07
IA-1	233	4.2	5E-04	1E-05	49	1.3	2E-04	7E-06	112	2.2	4E-05	1E-06
IA-2	27	12	6E-05	3E-05	5.4	2.7	2E-05	1E-05	13	6.0	5E-06	2E-06
IA-3	29	4.3	8E-05	1E-05	7.6	1.0	4E-05	5E-06	15	2.1	7E-06	8E-07
IA-4	71	21	2E-04	5E-05	18	4.7	9E-05	2E-05	36	10	2E-05	4E-06
IA-5	13	6.0	3E-05	1E-05	2.5	1.3	1E-05	6E-06	6.2	2.9	2E-06	1E-06
IA-6	6.9	4.5	1E-05	1E-05	1.1	1.0	4E-06	5E-06	3.2	2.2	8E-07	9E-07
IA-7	48	17	8E-05	4E-05	8.3	3.8	3E-05	2E-05	22	8.5	7E-06	3E-06
IA-8	28	15	4E-05	4E-05	4.3	3.3	2E-05	2E-05	13	7.4	3E-06	3E-06
IA-9	1.9	1.0	3E-06	3E-06	0.3	0.2	1E-06	1E-06	0.9	0.5	2E-07	2E-07
IA-10	1.7	0.3	3E-06	9E-07	0.3	0.1	1E-06	4E-07	0.8	0.1	3E-07	7E-08
IA-11	0.0	0.0	6E-10	5E-09	0.0	0.0	2E-10	2E-09	0.0	0.0	2E-11	4E-10
IA-12	2.6	2.8	4E-06	7E-06	0.4	0.6	2E-06	3E-06	1.2	1.4	3E-07	5E-07
IA-13	0.7	0.3	1E-06	9E-07	0.1	0.1	6E-07	4E-07	0.4	0.1	1E-07	7E-08
SLAPS	22	7.4	5E-05	2E-05	4.6	1.6	2E-05	8E-06	11	3.6	4E-06	1E-06

Note: doses are in mrem/yr.

trespasser) is assumed to be on-site for 2 hours per day, 26 days per year, for 9 years. The construction worker is assumed to be exposed 8 hours per day, 250 days per year, for one year. (The construction worker scenario best represents the current risks at SLAPS where removal actions are being performed.) For road and rail work, the construction worker is assumed to be exposed 8 hours per day, 90 days per year, for one year, (36% of the construction worker exposure duration). A utility worker is classified as a subset of the construction worker scenario. While the exposure parameters for a utility worker would be similar to a construction worker, the exposure durations for a utility worker would be much less. Input from local utility companies suggests that a reasonable exposure duration is 8 hours per day, 10 days per year, for one year (4% of the construction worker exposure duration).

The data show that the non-radiological contaminants associated with FUSRAP-related activities are commingled with radiological contaminants, and that, at most properties, the risks from exposure to non-radionuclides are at least an order of magnitude lower than the risks from exposure to radionuclides. As shown in Table D-4a in Appendix D, the risks due to radiological COCs at most properties at the North County Site for the current RME receptor scenario are within the CERCLA risk range (10^{-6} to 10^{-4}), whereas the risks due to non-radiological COCs for the current RME receptor scenario are generally between 10^{-8} to 10^{-4}. Additional information concerning non-radiological risk calculations is presented in Appendix D.

Risk levels determined using the actual current land uses indicate that most properties included in the North County Site (including all designated residential properties) are within the CERCLA risk range (10^{-6} to 10^{-4}) specified for protection of human health. This results from current practices used to control exposures (e.g., USACE radiation safety support to utility operations). As shown in Table ES-2, current risks for several properties exceed the CERCLA risk range for some scenarios. If land uses should change in the future (e.g., properties that are currently under commercial/industrial uses become residential), risks exceeding the CERCLA risk range could exist at many of the property units.

CONCLUSIONS OF RISK EVALUATION

The risk evaluation indicates there is a need for cleanup action within the North County Site. Under current land use conditions, the cancer risks and hazard indices are calculated to exceed the CERCLA risk range for plausible scenarios (recreational/trespasser, maintenance, industrial, and construction workers) within the North County Site. In addition, for reasonably anticipated future land use scenarios (industrial and residential), the risks and/or the HIs could exceed the CERCLA risk range and/or a HI of 1 at many properties. Chemicals of potential concern were screened based on potential risks and hazards to identify COCs. Those contaminants related to FUSRAP uranium manufacturing or processing activities that were detected at the site at levels that present a risk greater than 10^{-6} (given that the media-specific and receptor-specific total risk is above 10^{-4}) or a hazard quotient greater than 0.1 (given that the media-specific and receptor-specific total hazard is above 1) were identified as COCs for the North County Site.

Soils: The radionuclides identified as COCs in soils and sediments include isotopes of thorium, uranium, radium, protactinium, and actinium. Eleven metals are identified as non-

radiological surface soil COCs: antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, and vanadium. Four non-radionuclide subsurface soil COCs are identified. They are antimony, arsenic, thallium, and uranium.

Ground Water: An assessment of ground water concluded that there are no COCs in HZ-E ground water, the protected water resource. Although some soil contaminants have entered the shallow HZ-A ground water, their presence does not require action. The HZ-A ground water has no defined COCs because a complete pathway to receptors does not exist. Therefore the chemicals do not meet the definition of COC.

Although the chemical trichloroethene (TCE) was found in HZ-A, it was not identified as a COC because the shallow ground water is not a source of potable drinking water and because TCE is not identified as FUSRAP-related. The USACE will continue to monitor the ground water for TCE where appropriate if TCE is co-located with FUSRAP COCs requiring remediation. In addition, soils containing TCE source-term commingled with FUSRAP COCs will be remediated.

Surface Water: Several COPCs were identified in surface-water samples from Coldwater Creek. However, an evaluation of the data against background, risk, and hazard criteria indicates that the levels present are within the acceptable risk range. For that reason, no COCs were identified for surface water, and surface water is not a medium of concern.

Sediments: As with soils, radionuclides are identified as COCs in Coldwater Creek sediments. One metal (arsenic) and five organics also exceed risk criteria in Coldwater Creek sediment. Organic and arsenic concentrations increase with distance downstream from SLAPS and HISS/Futura. Thus, the elevated concentrations are most likely the result of the heavy industrial activity in the area, and are not FUSRAP-related. For this reason, neither the organics nor arsenic are retained as COCs in the sediments, limiting COCs for sediments to radionuclides only.

Ecological Risk: A screening level ecological risk evaluation was conducted for the site. Further risk evaluation was not needed because of the low risks relative to the uncertainty in the risk estimates; the low probability of significant ecological effects on local populations; and the lack of unique, rare, and critical habitat at the North County Site. The ecological risk evaluation concluded that remediation of the site was not required to protect the environment.

REMEDIAL ACTION OBJECTIVES

USACE is conducting response actions under the legislative authority contained in Public Law 107-66, the EWDAA for FY02. This law establishes the authority of USACE to conduct response actions for releases related to the nation's early atomic energy program as the lead federal agency, subject to CERCLA and the NCP. CERCLA requires that a remedial action "shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release at a minimum which assures protection of human health and the environment." In addition, CERCLA requires that the remedial action selection "shall require, at the completion of the remedial action, a level or standard of control

for such hazardous substance or pollutant or contaminant which at least attains such legally applicable or relevant and appropriate standard, requirement, criteria, or limitation." For that reason, the second primary remedial action objective is to attain the criteria or standards of control that are established in the ARARs for the site COCs.

To determine the appropriate remedial action, the NCP sets forth a requirement for establishing remedial action objectives (RAOs). RAOs are based on the nature and extent of contamination, threatened resources, the potential for human and environmental exposure, and reasonably anticipated land uses. The RAOs for the North County Site are established, in general, to eliminate or minimize potential human exposure to soils and sediments contaminated with FUSRAP-related COCs at levels that exceed the standards established in the ARARs or the site-specific risk-based RGs. Although risk levels based on a commercial/industrial future anticipated land use are within the CERCLA risk range (10^{-6} to 10^{-4}) for most properties in the North County Site, action is required to comply with ARARs and site-specific RGs. Remediation will result in residual site conditions that allow for unlimited use and unrestricted exposure. There are no goals for HZ-A ground-water improvement. The pathways and risks are such that the HZ-A ground water does not require remediation. COC removal from soil will lessen the impact of contaminants upon HZ-A ground water. The media-specific RAOs developed for the North County Site for soils and sediments are shown in Table ES-3.

Table ES-3. Remedial Action Objectives for Remediation of the North County Site

Media	Remedial Action Objectives
Soils and Sediments	Eliminate or minimize potential human exposure to soils and sediments contaminated with FUSRAP-related COCs at levels that exceed the standards established in the ARARs or the site-specific remediation goals. Prevent exposures from residual contamination in soils and sediments with concentrations greater than remediation goals Eliminate or minimize volume, toxicity, and mobility of contaminated soils and sediments Eliminate or minimize the potential migration of contaminants off-site, including the potential for migration to ground water and surface water, by removing the sediment and soil sources.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires the selection of a remedial action that is protective of human health and the environment and complies with "applicable or relevant and appropriate requirements (ARARs)." CERCLA states this is a standard, requirement, criteria, or limitation under a Federal environmental law or a more stringent State environmental or facility siting law, which is not legally applicable to the hazardous substance or pollutant or contaminant, but which is relevant and appropriate under the circumstances of the release of the hazardous substance or pollutant or

contaminant. With respect to ARARs, CERCLA specifically requires that "the remedial action selected shall require, at the completion of the remedial action, a level or standard of control for [a] hazardous substance or pollutant or contaminant which at least attains such legally applicable or relevant and appropriate standard, requirement, criteria, or limitation (ARAR)." Pursuant to 40 CFR 300.430(e)(9)(iii)(B) the alternatives "shall be assessed to determine whether they attain applicable or relevant and appropriate requirements (ARARs) under Federal environmental laws and state environmental or facility siting laws."

The proposed ARARs for the radionuclides addressed in this response action includes Title 40 Code of Federal Regulations Part 192 (40 CFR 192), Subparts A, B and C; and 10 CFR 40, Appendix A, Criterion 6(6).

40 CFR Subpart A defines the "standards for control of residual radioactive materials from inactive uranium processing sites." This section sets several standards that provide protection for stabilized residual materials disposal areas at uranium processing sites. 40 CFR 192.02(a) states that control of residual radioactive materials must be designed to be effective for up to 1000 years to the extent achievable, and in any case, for at least 200 years.

Subpart B identifies EPA's standards for remedial actions of land and buildings contaminated with residual radioactive materials at inactive uranium processing sites and provides cleanup standards for Ra-226 in soil, among other things.

Subpart C provides regulations for the implementation of standards established in Subparts A and B. Among other things, it sets forth conditions appropriate for the development of supplemental standards. Supplemental standards are derived pursuant to 40 CFR 192 Subpart C for subsurface materials at the primary storage areas (i.e., SLAPS and HISS/Futura) for use with the containment and treatment alternatives. The supplemental standards are appropriate in accordance with 40 CFR 192.21 (c) which specifies that supplemental standards may be applied under circumstances that would result in excessive remedial action costs relative to the long-term benefits and where the residual radioactive materials do not pose a clear present or future hazard. The supplemental standards for the primary storage areas in the containment and treatment alternatives (Alternatives 2 and 3) are to be used in conjunction with institutional controls.

10 CFR 40, Appendix A, is the Nuclear Regulatory Commission's (NRC's) regulations for active uranium processing sites, and these regulations conform to the standards set by EPA in 40 CFR 192. Criterion 6(6) is the NRC process for developing remediation goals (RGs) for other radionuclides to be consistent with the Ra-226 limits. 10 CFR 40, Appendix A, Criterion 6(6) is used in the North County Site as an ARAR to derive cleanup goals for non-radium radionuclides, particularly uranium and thorium, which are not explicitly included in EPA's 40 CFR 192 standards. In addition, this criteria requires the use of the unity rule when multiple contaminants are present. The unity rule sums the ratio of the residual concentration to remediation goals for each radiological contaminant of concern. Criterion 6(6) also provides relevant and appropriate radiological criteria for decommissioning lands and structures associated with uranium recovery facilities.

Criteria which are the basis of ARARs (40 CFR Part 192 and 10 CFR Part 40) are protective for all future anticipated land uses. This protectiveness has been upheld by judicial action.

DERIVATION OF REMEDIATION GOALS AND CLEANUP LEVELS

The remediation goals proposed for the North County Site comply with ARARs, are protective of human health and environment and are consistent with the NCP. They are protective under conditions of RME for residential site conditions (see Preamble to the final rule for 40 CFR 192 as specified in 48 FR 600). No directly applicable chemical-specific requirements are identified. Relevant and appropriate requirements are identified for radioactive contaminants in soil. Remediation goals for other contaminants in soil are derived using site-specific evaluations. Risk and dose assessments were also performed to assure protectiveness in light of multiple contaminants and multiple pathways (e.g., inhalation, ingestion, and direct exposure) at the North County Site. The remediation goal for Ra-226 is set forth in 40 CFR 192, Subpart B. Site-specific remediation goals for U-238 and Th-230 are derived in accordance with 10 CFR 40, Appendix A, Criterion 6(6) and 40 CFR 192, Subpart A. Table D-11 lists concentrations that produce the radium benchmark doses for the key St Louis North County Site radionuclides for a range of potential receptors. The remediation goal for Th-230 accounts for the in-growth of Ra-226 which is the limiting risk consideration.

No chemical-specific requirements were identified for non-radiological contaminants. Remediation goals were derived based on site-specific exposure assumptions and with the objective of meeting the acceptable risk range as provided in the NCP (See Appendix D, Section D.2.2.2). According to the NCP, acceptable exposure levels to known or suspected carcinogens are levels that represent an excess upper bound lifetime cancer risk to an individual of between one in 1,000,000 (10^{-6}) and one in 10,000 (10^{-4}). The EPA establishes preliminary remediation goals (PRGs) for all carcinogenic chemicals at the 10^{-6} level, also known as the point of departure. Final remediation goals may be different based on factors such as uncertainty, technical limitations on detection, or other considerations consistent with the remedy selection criteria defined in the NCP. In this case, practical limits on the ability to distinguish between naturally occurring background levels and very small increments above background require the use of final remediation goals that exceed the 10^{-6} level for some of the non-radiological contaminants; however, final cleanup levels remain within the acceptable risk range. Aggregate risks from final cleanup levels are also within the risk range. Remediation goals for non-carcinogens were developed to ensure that the cumulative toxic effects would result in a HI < 1.0.

The soil cleanup standards found in 40 CFR 192, Subpart B, were developed specifically for the cleanup of uranium mill tailings sites designated under Section 102 (a)(1) of the Uranium Mill Tailings Radiation Control Act (UMTRCA). These standards are intended to provide for unrestricted use of remediated properties. These standards address contaminants and circumstances similar to those found at the North County Site and are, therefore, considered relevant and appropriate to soil cleanup at the North County Site. The surface and subsurface soil criteria in 40 CFR 192, Subpart B for radium–226 are 5 and 15 pCi/g, respectively. The surface remediation goal applies to the 100 m^2 areal average concentration above background in the top

15 cm (6 in.) layer. The subsurface remediation goal applies to the $100m^2$ areal average concentration above background in any subsequent 15 cm (6 in) layer. The Ra-226 remediation goal of 5 and 15 pCi/g in surface and subsurface soils has been used with St Louis sites pursuant to the Record of Decision for the St Louis Downtown Site and to Engineering Evaluation/Cost Analyses for the St Louis North County Site. Implementation of the subsurface remediation criterion for Ra-226 results in actual average residual concentrations of Ra-226 significantly less than 5 pCi/g. This is based on cleanup results of a number of different areas and properties within the St Louis North County Site and St Louis Downtown Site, using cleanup goals of 15 pCi/g subsurface criterion for Ra-226 in combination with subsurface cleanup goals of 15 and 50 pCi/g for Th-230 and U-238, respectively. Table D-9 (Section D.2.1) lists the residual radionuclide concentrations at properties where response actions have been completed.

The site-specific Th-230 and U-238 remediation goals are derived based on the 10 CFR 40, Appendix A, Criterion 6(6), also referred to as the benchmark dose approach. These requirements supplement the standards found in 40 CFR 192.

The U-238 goal was established using U-238 as a surrogate for all of the uranium isotopes (including U-234 and U-235) and certain uranium decay products. Using the U-238 as a surrogate, the residual concentration was determined to be about 81 pCi/g. However, since some of the decay products are present above the natural abundance, the site-specific remediation goal of 50 pCi/g for U-238 is considered appropriate. Site experience shows that a 50 pCi/g limit is reasonably achievable at little extra cost. This limit has been used on the St Louis North County Site for removal actions conducted by USACE and the DOE since 1991 and is the site-specific remediation goal for U-238 established in the Record of Decision for the St Louis Downtown Site.

Table D-11 presents the calculation resulting from 10 CFR Part 40, Appendix A, Criterion 6(6) and lists the most restrictive Th-230 concentration as 330 pCi/g. This concentration, although protective with respect to Th-230, would result in the in-growth of Ra-226 such that future concentrations of Ra-226 would exceed the limits specified in ARARs. 40 CFR 192.02(a) requires the selected remedial action be designed to be effective for up to 1000 years to the extent reasonably achievable, and in any case, for at least 200 years. To ensure ARAR is met, the in-growth of Ra-226 from the Th-230 decay process must be calculated and examined. A soil concentration of 14 pCi/g of Th-230 would result in the in-growth of 5 pCi/g Ra-226 concentration at the end of the1000-year time period stated in 40 CFR 192.02(a). Although a subsurface soil concentration of 43 pCi/g would result in the in-growth of 15 pCi/g Ra-226, EPA's guidance documents for the cleanup of CERCLA sites using 40 CFR 192 as ARAR set forth EPA's expectation that remediation of subsurface soil contamination will, in practice, achieve the surface cleanup criterion of 5 pCi/g for Ra-226. (See OSWER 9200.4-25, "Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites). EPA approval of this ROD is contingent upon satisfying EPA's expectations for cleanup of CERCLA sites; therefore, USACE has adopted, on a site specific basis, Th-230 surface and subsurface soil cleanup levels that are consistent with a residual Ra-226 concentration of 5 pCi/g. Constraining the concentration of Th-230 in surface soils to 14 pCi/g and subsurface soils to 15 pCi/g along with the use of the unity rule assures that the concentration of Ra-226 does not exceed 5 pCi/g during the 1000-year time period.

No remediation goal is developed for Th-232. Removal of Th-230 to the remediation goals will effectively remove Th-232 present in site soils. Analytical data indicate that Th-232 is co-located with Th-230 and is present at relatively low concentrations. Removal of soils to the radionuclide criteria results in Th-232 concentrations of less than 1.5 pCi/g including background for SLAPS, SLDS, and North County VPs. Residual concentrations do not produce risks significantly above background.

Remediation goals for radiological contaminants of concern for the St Louis North County Site soils are 5/14/50 pCi/g for Ra-226, Th-230 and U-238 in surface soils and 15/15/50 pCi/g for subsurface soils. These remediation goals are consistent with the remediation standards used in Engineering Evaluation/Cost Analyses (EE/CAs) by DOE prior to transfer of FUSRAP execution to USACE, in USACE EE/CAs and in local Records of Decision both at the St Louis Downtown Site and by DOE at Weldon Springs Remedial Action Project. These remediation goals meet the threshold criteria of overall protection of human health and the environment and compliance with ARARs and will achieve a final status that requires no restrictions on land use.

Supplemental cleanup standards have been developed for subsurface materials at the primary storage areas (SLAPS and HISS/Futura) under the containment and treatment alternatives (Alternatives 2 and 3) to ensure protectiveness under commercial/industrial use. These supplemental standards are appropriate in accordance with criteria specified in 40 CFR 192.21 (c), which states that supplemental standards may be applied under circumstances where removal would result in excessive remedial action costs relative to the long-term benefits and the residual radioactive materials do not pose a clear present or future hazard. The supplemental standards for subsurface materials at the primary storage areas are to be used in conjunction with institutional controls. For those remedial alternatives involving land use restrictions at SLAPS and HISS/Futura (Alternatives 2 and 3), supplemental standards of 25/70/250 pCi/g above background for Ra-226/Th-230/U-238 would be used for subsurface soils. These supplemental standards would protect the most likely current and future receptors (e.g., construction and utility workers) and ensure that doses to the general public would be limited to less than 100 mrem/yr if institutional controls were lost.

The Benchmark dose approach defined in Criterion 6(6) was applied in development of the Coldwater Creek subsurface sediment remediation goals. The remediation goal derived for subsurface sediments (i.e., 15 pCi/g of Ra-226, 43 pCi/g of Th-230 and 150 pCi/g of U-238 above background) is implemented for soils and sediments under the mean water gradient for Coldwater Creek. This remediation goal assures protectiveness of Coldwater Creek under all future anticipated land use conditions (e.g., recreational/trespasser, maintenance, construction, and utility uses) and minimizes adverse environmental impact associated with greater excavation in Coldwater Creek.

Other site contaminants derived from the uranium ores tend to be co-located with the principal radionuclides such that remediation of the contaminated soil to the cleanup levels described above is expected to adequately remove all ore-related contaminants. Supporting information is presented in Appendix D (Section D.2.1 and Table D-10). To verify that removal of radiological contaminants achieve remediation goals for non-radiological contaminants associated with the uranium processing activities, chemical sampling will be conducted as

required during pre-design investigation and as part of the final status survey pending confirmation of co-location with radiological contaminants.

No ARARs have been identified for the non-radiological contaminants in soils at the North County Site. The remediation goals for non-radiological COCs were developed based on site-specific risk assessments and hazard evaluations. At the North County Site, eleven non-radionuclides are identified as COCs for soils: antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, and vanadium. These noncarcinogens have different effects on different organs or systems in the body. The remediation goals for noncarcinogens were developed to ensure that the cumulative effect of the chemical levels of the COCs produces a HI < 1.0 for each target organ/system affected. In addition, remediation goals were selected at levels above detection limits and background levels.

Toxicologists evaluated the primary effects of the 11 metals in the soils at North County. The HIs were calculated for all six different types of receptors – residential, industrial, construction worker, maintenance worker, recreational/trespasser, and utility worker. Generally, the construction worker was identified as the most sensitive receptor, except for a few cases where the residential receptor was the most sensitive or restrictive scenario. The remediation goals for all non-radionuclides were calculated based on the HIs for the different primary target organs. The protectiveness to each primary organ was tested by adding up the HIs of the corresponding COCs targeted to that primary organ. In each case, the HI value was less than one.

Remediation goals have been derived for the 11 surface soil and 4 subsurface soil non-radiological COCs, based on their noncarcinogenic effects. These proposed remediation goals are presented in Table ES-6. Surface and subsurface soil remediation goals for antimony, arsenic, thallium, and uranium are 15/25 mg/kg, 36/40 mg/kg, 25/30 mg/kg, and 150/150 mg/kg, respectively. Seven additional non-radiological COCs were identified for surface soil only. The applicable remediation goals are as follows: 2800 mg/kg barium, 12 mg/kg cadmium, 350 mg/kg chromium, 1,000 mg/kg molybdenum, 1,500 mg/kg nickel, 300 mg/kg selenium, and 112 mg/kg vanadium. Antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, and vanadium are identified as COCs for SLAPS and contiguous areas; and antimony, arsenic, barium, cadmium, molybdenum, nickel, selenium, thallium, and vanadium are identified as COCs for HISS/Futura and Latty Avenue VPs 2L and 10k530087. The non-radiological COCs will be evaluated in the final status survey pending confirmation of their co-location with radiological COCs to verify that risk and hazard criteria are fully protective under CERCLA and have been satisfied.

The proposed remediation goals (summarized in Table ES-4 for radionuclides and Table ES-5 for other chemicals) are protective based on the future anticipated land use, are achievable, and can be implemented. Further cleanup goals comply with the ARAR criteria for radionuclides and would achieve protectiveness to levels within the CERCLA risk range and below a HI of 1.0.

SUMMARY OF FEASIBILITY STUDY ALTERNATIVES

Six cleanup alternatives were developed in the FS and evaluated using the nine criteria outlined in the NCP. Per EPA's FS guidance, the cost estimates include a 30-year performance period for ongoing actions, such as monitoring and maintenance, and identify any continuing costs beyond the 30 year period. Technologies were identified that might have potential application at the North County Site. These technologies were evaluated in the Initial Screening of Alternatives document developed by DOE and subsequently re-evaluated by USACE as part of the FS.

The first step in the alternative selection process was to identify potential remedial technologies for the North County Site. In the second step, the technologies and process options for each technology were further evaluated using effectiveness, implementability, and cost criteria. Several technologies and process options were screened out as a result of the evaluations. Disposal of contamination into a permanent on-site cell located at the North County Site was eliminated due to the time and expense necessary to develop such an option. Public comments that have been received indicate strong public opposition to an on-site cell. Immobilization and stabilization technologies were narrowed to a few process options. Vitrification, biological techniques, and incineration were eliminated. The technology screening is summarized in Table ES-6. In the third step of alternatives development, the technologies and process options were combined to form six site-wide alternatives.

Emphasis was placed on the development of site-wide alternatives that ensure adequate protection of human health and the environment, achieve ARARs, and permanently and significantly reduce the volume, toxicity, or mobility of site-related contaminants. The alternatives cover a broad range from no further action to complete removal of contamination. For each alternative, USACE would conduct post-remedial action surveys to ensure that remediated areas meet the site-specific remediation goals. Table ES-7 provides a summary of soil removals under each alternative. Table ES-8 provides a summary of current and future land-use assumptions by property. The reasonable future land uses were determined based on current land uses and other considerations, including the public preference expressed for remedial alternatives that would allow unrestricted use of the North County Site. By evaluating a range of alternatives that provide for both unrestricted and restricted use, costs of restricted and unrestricted use can be compared relative to the degree of protectiveness of human health and the environment that is achieved and relative probability that institutional controls will assure future protectiveness.

Alternative 1, No Further Action

Alternative 1 includes no further remedial actions for the North County Site. This no-further-action alternative provides a baseline against which to compare other remedial alternatives and is required by the NCP and CERCLA guidance.

This alternative assumes that no additional remedial actions would be implemented at the North County Site. The rail spurs at SLAPS and HISS would be left in place. Contaminated soil and sediment would remain at current locations. The limited site security (e.g., fencing) would

Table ES-4. Summary of Proposed Remediation Goals

Remediation Goals for Unrestricted Land Use	Remediation Goals for Use with Institutional Controls at SLAPS and HISS/Futura
Surface soils would be remediated if the radionuclide concentrations above background averaged over 100 m^2 exceed 5 pCi/g of Ra-226, 14 pCi/g of Th-230, or 50 pCi/g of U-238 in the top 15 cm (6 in). Subsurface soils would be remediated if the radionuclide concentrations above background averaged over 100 m^2 exceed 15 pCi/g of Ra-226, 15 pCi/g of Th-230, or 50 pCi/g of U-238 in any subsequent 15 cm (6 in) layer. Soils and sediments below the mean water gradient of Coldwater Creek would be remediated if the radionuclide concentrations above background averaged over 100m^2 exceed 15 pCi/g of Ra-226, 43 pCi/g of Th-230, or 150 pCi/g of U-238. Soil remediation goals apply to soils above the mean water gradient of Coldwater Creek. Confirmation would include surveys and residual risk calculations to ensure that total residual site risk is within the CERCLA risk range. Final status surveys compatible with MARSSIM would be used to document achievement of the remediation goals for radiological COCs.	Supplemental standards are developed for Alternatives 2 and 3 in accordance with 40 CFR 192, Subpart C. These supplemental standards are used in conjunction with institutional controls at SLAPS and HISS/Futura (the primary areas used for storage of FUSRAP materials). Supplemental standards are appropriate for the primary storage areas under the containment and treatment alternatives because excavation to the RGs for unrestricted use would result in excessive remediation costs relative to the long-term benefits, and because the residual materials will not pose a present or future hazard. The supplemental criteria constrain doses so that public exposure limits would not be exceeded should the institutional controls be lost. The supplemental criteria for subsurface soil limit contamination to average above background concentrations of 25 pCi/g of Ra-226, 70 pCi/g of Th-230, and 250 pCi/g of U-238 or combinations of radionuclides. Institutional controls are implemented to ensure that future land use is fully protective. Supporting information concerning the derivation of these RGs is presented in Appendix D of the Feasibility Study (Section D.2.2).

Table ES-5. Proposed Remediation Goals (RGs) for Non-radionuclide Contaminants of Concern (COCs)[a]

Surface		
Analyte	Units	Proposed RG[b]
Antimony	mg/kg	15
Arsenic	mg/kg	36
Barium	mg/kg	2,800
Cadmium	mg/kg	12
Chromium	mg/kg	350
Molybdenum	mg/kg	1,000
Nickel	mg/kg	1,500
Selenium	mg/kg	300
Thallium	mg/kg	25
Uranium	mg/kg	150
Vanadium	mg/kg	112
Subsurface		
Analyte	Units	Proposed RG
Antimony	mg/kg	25
Arsenic	mg/kg	40
Thallium	mg/kg	30
Uranium	mg/kg	150

[a] Non-radionuclide COCs were only identified for SLAPS and contiguous areas (IAs 1-13), HISS/Futura, and Latty Avenue VPs 2L and 10k530087. Remediation of non-FUSRAP related wastes based on the RGs for non-radionuclide COCs will be conducted in areas where they are co-located with FUSRAP COCs requiring remediation.

[b] The calculated HIs for different primary target organs were based on the construction worker. Thus the same RGs are proposed for unrestricted use and for use with institutional controls.

Table ES-6. Summary of Technology Screening at the North County Site

Response Action	Technologies	Process Options	Used in the North County Alternatives				
			Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Access Controls	Site security	Signs	X	X	X	X	
		Physical barriers, e.g., fencing		X			
Institutional Controls	Land use restrictions and notices	Land use restrictions	X	X	X	X	
		• SLAPS • HISS/Futura • Buildings, roads, bridges, and railroads • Creek (within banks) • Remaining VPs	Indust. Indust. Utility Rec. None	Indust. None Utility None None	Indust. Indust. Utility Rec. All	None None Utility None None	None None None None None
		Deed notices	X	X	X	X[b]	
		Well drilling prohibitions	X	X	X		
		Commercial/industrial zoning	X	X	X	X[b]	
Monitoring	Long-term monitoring[a]	Air, sediment, ground water, surface water	Ground water	Ground water	Ground water	Ground water (unlikely)	
Containment	Cap	Multi-media cap	SLAPS, HISS/Futura				
		Asphalt or concrete	Roads	Roads	Roads	Roads	
Removal	Excavation		Limited for SLAPS, HISS/Futura, roads, bridges, railroads and other permanent structures	Limited for SLAPS, roads, bridges, railroads, and other permanent structures	None	Limited for roads, bridges railroads, and other permanent structures	All Areas
Treatment	Soil sorting			X		Option	
	Soil washing	Enhanced soil washing		X			
	Phytoremediation	Rhizofiltration, phytoaccumulation		X			
Technologies Common to Alternatives 2 through 6							
Monitoring	Short-term monitoring (During remedial action)	Air, sediment, ground water, surface water	X	X		X	X
Containment	Revegetation		X	X		X	
	Dust mitigation	Water spray, foam	X	X		X	X
	Storage pile covers	Geotextile, spray coatings, tarps	X	X		X	X
Removal	Dredging	Hydraulic	Creek	Creek		Creek	Creek
Treatment	Recycle to uranium mill	Permitted facilities	Option	Option		Option	Option
	Size reduction	Crushing, cutting	X	X		X	X
	Dewatering	Evapotranspiration, filters, drying	X	X		X	X
Transportation	Rail	Covered rail cars, containers	X	X		X	X
	Truck	Covered trucks, containers	X	X		X	X
Disposal	Licensed or permitted off-site facility	Radioactive wastes, hazardous wastes, solid wastes	X	X		X	X

[a] In areas where contamination remains above unrestricted levels in sufficient quantities to significantly impact ground-water quality, ground-water monitoring could continue until terminated as part of the 5-year reviews. Long-term monitoring of HZ-A and long-term monitoring of Unit 4 in HZ-C (as a surrogate for HZ-E) is proposed for Alternatives 2, 3, and 4. For Alternative 5, the results of short-term monitoring would be used to determine if long-term ground-water is required to access potential contaminant migration from contaminated soils remaining beneath roads, bridges, railroads, and other permanent structures.

[b] May be needed until areas under buildings at Futura are made available for remediation.

Table ES-7. Removals Included in the Site-wide Alternatives

	Alternative 1, No Further Action	Alternative 2, Partial Excavation and Capping at SLAPS and HISS/Futura	Alternative 3, Partial Excavation and Treatment at SLAPS	Alternative 4, Institutional Controls (No Further Excavation)	Alternative 5, Excavation with Institutional Controls Under Roads, Bridges, Railroads, and Other Permanent Structures	Alternative 6, Excavation at All Properties
Total Soil Removal, Thousands of Cubic Yards						
[a]Impacted volume to be excavated, yd^3	0	150	190	0	230	300
Excavation volume, yd^3	Excavation volume: the in-situ volume of soil plus the excavation allowance needed to remove the impacted volume; (about 20%) i.e., the size of the hole; generally 20% larger than impacted volume.					
Ex-situ, yd^3	Ex-situ volume: the volume after soil swelling as a result of excavation; generally 25% larger than the excavation volume.					

[a] Impacted volume to be excavated, in-situ volume of soil above the cleanup criteria rounded to two significant figures

Table ES-8. Land Use by Property

Property ID [a]	Current Receptor	RME Receptor	Removal Status
Primary Areas Used for Storage			
Futura	Industrial	Industrial	
HISS	Construction	Industrial	Piles removed
IA-1 (Part of SLAPS)	Construction	Industrial	Partial Removal
IA-2 (Part of SLAPS)	Construction	Industrial	Partial Removal
IA-3 (Part of SLAPS)	Construction	Industrial	Partial Removal
IA-4 (Part of SLAPS)	Construction	Industrial	Removal Action
IA-5 (Part of SLAPS)	Construction	Industrial	Partial Removal
IA-6 (Part of SLAPS)	Construction	Industrial	Removal Action
IA-7 (Part of SLAPS)	Construction	Industrial	Removal Action
Areas Immediately Adjacent to Storage Areas			
VP-1(L)[c]	Industrial	Industrial	
10K530087, west of VP-1(L)	Industrial	Industrial	
VP-2(L)[c]	Industrial	Industrial	Removal Action
IA-9	Construction	Recreational	Partial Removal
IA-11	Industrial	Industrial	
IA-13	Industrial	Industrial	
VP-40(A)	Industrial	Industrial	
Properties with Small Amounts of Contamination			
VP-1 (C)[b]	Industrial	Industrial	
VP-2(C)[b]	Industrial	Industrial	
VP-3 (C)[b]	Industrial	Industrial	
VP-4 (C)[b]	Industrial	Industrial	
VP-5 (C)[b]	Industrial	Industrial	
VP-7	Industrial	Industrial	
VP-8 (C)[b]	Industrial	Industrial	
VP-9	Industrial	Industrial	
VP-10	Industrial	Industrial	
VP-11	Industrial	Industrial	
VP-12	Industrial	Industrial	
VP-13	Industrial	Industrial	
VP-15	Industrial	Industrial	
VP-35(A)	Construction	Industrial	
VP-38	Industrial	Industrial	Partial Removal
VP-57	Industrial	Industrial	
VP-58	Industrial	Industrial	
VP-59	Industrial	Industrial	
IA-10	Recreational	Recreational	
10K620452, south of Latty East	Industrial	Industrial	
Coldwater Creek, inside banks	Recreational	Recreational	
Roads, Bridges, Railroads			
Norfolk Southern	Industrial	Industrial	
Roads, bridges and railroads	Utility	Utility	
IA-8	Utility	Utility	Partial Removal
VP-14(A)	Utility	Utility	

Table ES-8. Land Use by Property (Cont'd)

Property ID [a]	Current Receptor	RME Receptor	Removal Status
Properties with No Expected Removal Volume			
10k620412, north of Latty east	Industrial	Industrial	
11k630221, NE of McDonnell rail siding	Industrial	Industrial	
11L520011, airport south of IA-13	Industrial	Industrial	
10k530076, north of VP-1(L)	Industrial	Industrial	
10k520165, southeast of VP-3(L)	Industrial	Industrial	
10k240182, north of VP-23	Industrial	Industrial	
10k240207, west of VP-27	Industrial	Industrial	
09k220029, east of VP-44	Residential	Residential	
VP-1	Industrial	Industrial	
VP-2	Industrial	Industrial	
VP-3	Industrial	Industrial	
VP-4	Industrial	Industrial	
VP-5	Industrial	Industrial	
VP-6	Industrial	Industrial	
VP-6 (C)[b]	Industrial	Industrial	
VP-7 (C)[b]	Industrial	Industrial	
VP-8	Industrial	Industrial	
VP-9 (C)[b]	Industrial	Industrial	
VP-10(C)[b]	Industrial	Industrial	
VP-14	Industrial	Industrial	
VP-16	Industrial	Industrial	
VP-17	Industrial	Industrial	
VP-18	Industrial	Industrial	
VP-19	Residential	Residential	Removal Action
VP-20	Residential	Residential	Removal Action
VP-21	Industrial	Industrial	Removal Action
VP-22	Industrial	Industrial	Removal Action
VP-23	Industrial	Industrial	Removal Action
VP-25	Industrial	Industrial	
VP-26	Industrial	Industrial	Removal Action
VP-27	Industrial	Industrial	Removal Action
VP-28	Industrial	Industrial	
VP-29	Residential	Residential	
VP-30	Industrial	Industrial	Removal Action
VP-31	Industrial	Industrial	
VP-36	Industrial	Industrial	Removal Action
VP-37	Industrial	Industrial	Removal Action
VP-41	Residential	Residential	Removal Action
VP-45	Industrial	Industrial	Removal Action
VP-46	Industrial	Industrial	
VP-48(A)	Industrial	Industrial	Removal Action
VP-49	Residential	Residential	
VP-50	Industrial	Industrial	

Table ES-8. Land Use by Property (Cont'd)

Property ID [a]	Current Receptor	RME Receptor	Removal Status
VP-51	Industrial	Industrial	
VP-52	Industrial	Industrial	
VP-54	Industrial	Industrial	
VP-55	Industrial	Industrial	
VP-56	Industrial	Industrial	Removal Action
VP-60	Industrial	Industrial	
VP-61	Industrial	Industrial	
VP-62	Industrial	Industrial	
VP-63	Industrial	Industrial	
VP-63(A)	Industrial	Industrial	
Properties with previous DOE removal actions that will require additional investigation			
VP-3(L)[c]	Industrial	Industrial	Removal Action
VP-4(L)[c]	Industrial	Industrial	Removal Action
VP-5(L)[c]	Industrial	Industrial	Removal Action
VP-6(L)[c]	Industrial	Industrial	Removal Action
VP-24	Industrial	Industrial	Removal Action
VP-31(A)	Industrial	Industrial	Removal Action
VP-32	Industrial	Industrial	Removal Action
VP-33	Industrial	Industrial	Removal Action
VP-34	Construction	Industrial	Removal Action
VP-35	Construction	Industrial	Removal Action
VP-39	Industrial	Industrial	Removal Action
VP-40	Industrial	Industrial	Removal Action
VP-42	Industrial	Industrial	Removal Action
VP-43	Residential	Residential	Removal Action
VP-44	Residential	Residential	Removal Action
VP-47	Industrial	Industrial	Removal Action
VP-48	Industrial	Industrial	Removal Action
VP-53	Industrial	Industrial	Removal Action

[a] All properties designated into FUSRAP and any additional property for which analytical data are available.

[b] Coldwater Creek VP

[c] Latty Avenue VP

be left in place, but would not be maintained. Continued routine monitoring of air, buildings, ground water, and storm water would not be performed. Five-year reviews are conducted pursuant to CERCLA for areas in which contamination is such that conditions do not allow for unlimited use and unrestricted exposure.

Technologies and Processes Common to Alternatives 2 through 6

Alternatives 2 through 6 share certain features; these similar elements are discussed in the following text.

On-going Removal Actions: Removal actions started under the EE/CAs are complete at the time the ROD is approved. The ROD criteria would supersede commitments to cleanup criteria in previously issued documents (e.g., EE/CAs). Excavation under buildings would be done when the areas are made available by the owner. Final status surveys would be conducted to ensure that remediated areas meet the cleanup criteria. Final status surveys performed pursuant to EE/CAs prior to the Multi-Agency Radiation Site Survey and Investigation Manual (MARSSIM) effective date would be compared to ROD criteria using the existing confirmation approaches.

Excavation: Consistent with the scope defined in the FFA, for alternatives that involve excavation, remediation of soils containing non-radionuclide contaminants would be conducted in those areas where they are co-located with North County Site COCs. Non-radiological COCs include antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, and vanadium for SLAPS and contiguous areas; and antimony, arsenic, barium, cadmium, molybdenum, nickel, selenium, thallium, and vanadium for HISS/Futura and Latty Avenue VPs 2L and 10k530087. To verify that removal of radiological contaminants also achieves the RGs for non-radiological COCs, chemical sampling will be conducted as required during pre-design investigation and as part of the final status survey, pending confirmation of co-location with radiological contamination.

Institutional Controls: For alternatives that use institutional controls, a long-term stewardship plan would be developed to address notification requirements for property owners for changes in land use as well as future monitoring and maintenance requirements. This plan would include provisions addressing the process by which property owners can contact the federal government agency responsible for long-term control of impacted areas and periodic reviews, maintenance, and monitoring. Institutional controls would be imposed only to assure protectiveness in those areas in which the residual soil contamination exceeds the concentrations specified in ARARs or the site-specific RGs for unrestricted use.

Transportation and Waste Management: Local transportation of contaminated materials (e.g., from VPs to rail spurs) would use sealed or covered trucks. On-site movement would be performed using open trucks and conventional construction equipment. Long distance shipment would be primarily by rail from the rail spurs to off-site licensed or permitted disposal facilities. Trucking may also be used for long distance shipping. Rubble and similar materials would be crushed as appropriate for disposal. Site soils could be used as backfill if they are unimpacted, or if they meet the cleanup criteria for surface soils.

Uranium would be recycled if the costs are similar to the cost for disposal of the materials.

As necessary, pre-remedial design investigation sampling for COCs would be conducted to define the extent of contamination. Those properties where current or past activities unrelated to uranium processing have resulted in RCRA characteristic or listed waste being co-located with radioactive waste will be evaluated and sampled, as necessary, prior to remediation for the purpose of treatment and disposal.

Monitoring: Short-term monitoring would be continued during the remedial actions. Monitoring would be used to assure that contamination from the soils and the unusable ground water zone (HZ-A) does not significantly impact surface water or potable ground water. The results of the short-term monitoring of surface water, sediment, and HZ-A ground water would be used to assess any potential impacts to Coldwater Creek resulting from the remedial actions and would assist in evaluating the effectiveness of the remedial actions. In addition, monitoring will support evaluation of impacts resulting from the remaining soils unavailable for remedial action (not in Alternative 6) or residual contamination left in place. The protective nature of existing geologic deposits to resist vertical water passage would not be changed by any FUSRAP remedial alternatives.

Remedial Action Control Measures: Water encountered during remedial actions will be characterized, treated, if necessary, and released to the publicly owned treatment works (POTW) or to Coldwater Creek or its tributaries, as permitted. The treatment would address chemicals and radionuclides consistent with relevant and appropriate federal and state regulations. Excavation waters contaminated with TCE or its degradation products will not be released off-site above appropriate levels. Supporting technologies would be used to prevent the spread of contamination. These include revegetation, dust mitigation, storage pile covers, sedimentation basins, and dewatering as required during the excavation process. Backfill would be added, and the site graded to ensure appropriate surface water drainage. Erosion and sediment controls would be used.

Wetlands: Any wetlands designated using the 1987 Corps of Engineers Wetlands Delineation Manual which are impacted during removals would be restored, or equivalent wetlands would be created.

FAA Restrictions: USACE construction activities during remedial action would comply with the Federal Aviation Administration (FAA) restriction of air space around the airport, such as limits on the height of structures and equipment.

The following text presents unique features of Alternatives 2 through 6.

Alternative 2, Partial Excavation and Capping at SLAPS and HISS/Futura

Alternative 2 consists of partial excavation and capping with institutional controls. The specific components include:

- *Capping*: A multi-layer cover (cap) would be constructed at SLAPS and HISS/Futura to provide an additional barrier to limit exposures. SLAPS and HISS/Futura would be contoured and covered with 1 ft of stone intrusion barrier and 3 ft of clean soil.

- *Excavation*: All soils exceeding the RGs for unrestricted land use would be excavated at SLAPS VPs and Latty Avenue VPs, with the exception of soils beneath roads, bridges, railroads, and other permanent structures. Soils under roads, bridges, railroads, and other permanent structures are inaccessible and will not be remediated as part of this response action. When and as the inaccessible soils become available as a result of decisions by the entities that control their accessibility, new decision documents will identify the response actions to address the inaccessible soils as appropriate. Inaccessible soils for the North County Site are identified in Figure ES-3. Additional soils may be identified as inaccessible during implementation and will be deferred for separate action as documented in the post remedial action report. Institutional controls may be applied under this alternative to properties with inaccessible soils as appropriate. At SLAPS and HISS/Futura, subsurface soils exceeding the supplemental standards of 25/70/250 pCi/g above background for Ra-226/Th-230/U-238 would be shipped offsite to a permitted disposal facility. Those soils having contaminant levels exceeding the RGs for unrestricted release but below the supplemental standards would be disposed of onsite beneath a multilayer cover at SLAPS and HISS/Futura. The use of supplemental standards at SLAPS and HISS/Futura is appropriate in accordance with 40 CFR 192.21 (c) because excavation to unrestricted criteria would result in excessive remedial action costs relative to the long-term benefits and the residual radioactive materials remaining beneath the cap do not pose a clear present or future hazard. The supplemental standards for subsurface materials at the primary storage areas are to be used in conjunction with institutional controls to allow commercial/industrial use of SLAPS and HISS/Futura.

- *Dredging*: Dredging of contaminated sediments from Coldwater Creek is not part of Alternative 2. Sediments removed by other projects such as flood control would be monitored, and any sediment exceeding criteria would be shipped for off-site disposal at a licensed or permitted facility.

- *Institutional Controls:* No institutional controls would be required for accessible soils at SLAPS VPs and Latty Avenue VPs. However, institutional controls would be imposed to restrict land use at SLAPS, HISS/Futura, Coldwater Creek, and for areas beneath roads, bridges, railroads, and other permanent structures as appropriate. The controls could include deed notices to ensure that future owners are made aware of the presence of residual contamination; land use restrictions to limit activities that could disturb soils; and well-drilling prohibitions. Controls could also include zoning restrictions at SLAPS and HISS/Futura. Land use would be restricted to commercial/industrial uses at SLAPS and HISS/Futura, recreational uses at Coldwater Creek, and transportation/utility uses for roads, bridges, and railroad beds.

Five-year reviews would be conducted pursuant to CERCLA, and long-term ground-water monitoring would be performed near SLAPS and HISS/Futura as part of the five-year

review process. Long-term monitoring of HZ-A and long-term monitoring of Unit 4 in HZ-C (as a surrogate for HZ-E) would be required.

Alternative 3, Partial Excavation and Treatment at SLAPS

Alternative 3 emphasizes consolidation and treatment of site soils at SLAPS. It involves excavation of contaminated soils followed by treatment. Specific components include:

- *Excavation*: All soils exceeding the RGs for unrestricted land use would be excavated at SLAPS VPs, HISS/Futura, and Latty Avenue VPs, with the exception of soils beneath roads, bridges, railroads, and other permanent structures. SLAPS would be excavated to meet the supplemental standards of 25/70/250 pCi/g above background for Ra-226/Th-230/U-238 to allow commercial/industrial land use with the use of institutional controls. Soils not meeting the supplemental standards would be shipped offsite to a permitted disposal facility. Soils under roads, bridges, railroads, and other permanent structures are inaccessible and will not be remediated as part of this response action. When and as the inaccessible soils become available as a result of decisions by the entities that control their accessibility, new decision documents will identify the response actions to address the inaccessible soils as appropriate. Inaccessible soils for the North County Site are identified in Figure ES-3. Additional soils may be identified as inaccessible during implementation and will be deferred for separate action as documented in the post remedial action report.

- *Dredging*: Soils and sediments above the Coldwater Creek criteria for unrestricted release discussed in Table ES-4 would be dredged from Coldwater Creek and consolidated at SLAPS for treatment.

- *On-site Treatment*: Excavated soils and sediments would be consolidated at SLAPS for treatment (soil sorting and enhanced soil washing). Treated soils that meet the supplemental standards for subsurface soil would be used as backfill at SLAPS and covered with clean soils. Any materials not meeting the supplemental standards for subsurface soil would be shipped off-site to a permitted disposal facility. Limited phytoremediation (planting and harvesting of selected plant species to draw contamination from soils) would be conducted in the Coldwater Creek floodplain in areas where sediments accumulate downstream of Pershall Road. The residual material would be disposed of at properly licensed or permitted disposal facilities.

- *Institutional Controls:* No institutional controls would be required for accessible soils at SLAPS VPs, Latty Avenue VPs, and HISS/Futura. Institutional controls would be used to restrict land use at SLAPS and roads, bridges, railroads, and other permanent structures as appropriate. The controls could include deed notices to ensure that future owners are made aware of the presence of residual contamination; land use restrictions to limit activities that could disturb soils; and well-drilling prohibitions. Controls could also include zoning restrictions at SLAPS. Land use would be restricted to commercial/industrial uses at SLAPS and transportation/utility uses for roads, bridges, and railroad beds.

Five-year reviews and long-term ground-water monitoring near SLAPS are included as part of this alternative. Long-term monitoring of HZ-A and long-term monitoring of Unit 4 in HZ-C (as a surrogate for HZ-E) would be required.

Alternative 4, Institutional Controls (No Further Excavation)

Alternative 4 emphasizes the use of institutional controls. It consists of the following:

- *Institutional Controls:* Institutional controls would be imposed to limit land use at SLAPS, HISS/Futura, roads, bridges, railroads, and other permanent structures, Coldwater Creek, and the VPs. Other than specific areas zoned for commercial and industrial uses and FAA limitations, no known land use controls or restrictive easements exist on the subject properties. Potential administrative problems are anticipated with enforcement, access and monitoring, and voluntary compliance with regulatory controls. Further, property owners are often less than willing participants in subordinating their fee title interests for residual site contamination. Missouri real estate law is amenable and supportive of restrictive land use controls, conveyance by quitclaim, and zoning overlay districts. The controls would vary by property and could include deed notices to assure future owners are made aware of the presence of residual contamination, land use restrictions to limit activities that could disturb soils; and well-drilling prohibitions. Zoning restrictions at SLAPS, HISS/Futura, and Vicinity Properties are also potential institutional controls. Land use would be restricted to commercial/industrial uses at SLAPS, HISS/Futura, and vicinity properties, recreational uses at Coldwater Creek, and transportation/utility uses for roads, bridges, and railroad beds. Although the implementation of institutional controls at SLAPS, HISS/Futura, under buildings, roads, bridges, and railroads, and at the VPs is technically feasible, it involves complex administrative requirements. Maintaining controls at numerous properties would be difficult. The controls would have to be maintained for a considerable period of time and would have to be enforced through a government or municipal entity. A requirement that land use restrictions "run with the land" despite ownership changes would be used to help ensure that controls are not lost. Details of institutional controls will be documented in the site long-term stewardship plan.

Five-year reviews would be accomplished in accordance with CERCLA. Long-term monitoring of ground water is included as part of this alternative until stopped as part of the five-year review process. Long-term monitoring of HZ-A and long-term monitoring of Unit 4 in HZ-C (as a surrogate for HZ-E) would be required. Title to the properties with residual contamination would remain with current landowners and would not be transferred to the federal or state government.

Alternative 5, Excavation with Institutional Controls Under Roads, Bridges, Railroads, and Other Permanent Structures

Alternative 5 emphasizes excavation and dredging with off-site disposal for all property units except under roads, bridges, railroads, and other permanent structures. Remediation of

inaccessible soils in not included in this alternative and will be deferred for action at the time property becomes accessible as a result of decisions by entities that control accessibility. Institutional controls may be applied under this alternative to properties with inaccessible soils as appropriate. When and as the soils become available, new decision documents will identify the response actions to address the inaccessible soils as appropriate. Specific components include:

- *Excavation*: All soils exceeding the RGs for unrestricted land use would be excavated and shipped for off-site disposal or recycle at all properties, with the exception of soils beneath roads, bridges, railroads, and other permanent structures. Soils under roads, bridges, railroads, and other permanent structures are inaccessible and will not be remediated as part of this response action. When and as the inaccessible soils become available as a result of decisions by the entities that control their accessibility, new decision documents will identify the response actions to address the inaccessible soils as appropriate. Inaccessible soils for the North County Site are identified in Figure ES-3. Additional soils may be identified as inaccessible during implementation and will be deferred for separate action as documented in the post remedial action report.

- *Dredging*: Coldwater Creek sediments below the mean water gradient that exceed the subsurface soil criteria defined in Table ES-4 would be dredged and disposed.

- *Institutional Controls:* Institutional controls are used to assure protectiveness for alternatives at areas in which the residual soil contamination exceeds the concentrations specified in ARARs for residential use. No institutional controls would be required for accessible soils. Institutional controls would be used to restrict land use beneath roads, bridges, railroads, and other permanent structures as appropriate. The controls could include deed notices to ensure that future owners are made aware of the presence of residual contamination and land use restrictions to limit activities that could disturb soil. Controls could also include zoning restrictions at Futura. Roads, bridges, and railroad beds would be limited to use as transportation/utility corridors.

- *Monitoring:* Long-term monitoring is not required for the limestone aquifer (HZ-E). Under this alternative, the majority of the contaminant sources and all highly contaminated soils at the site will be removed. The few contaminant sources remaining in HZ-A soils, unavailable for RA at the present, are separated from HZ-E by a low hydraulic conductivity clay aquitard, Unit 3M, and the low conductivity of Unit 3 in general. The potential for contaminant migration to HZ-E is very small, as noted by prior study. In addition, although HZ-E meets the definition of a potential source of drinking water (Class IIB), it is not a current source of drinking water in the area so an exposure pathway from HZ-E ground water to receptors does not exist. Short-term ground-water monitoring of Unit 4 of HZ-C is proposed to prove continued protection of the limestone aquifer. Short-term monitoring of HZ-A ground-water would be used to assess the effects the remedial action has on HZ-A ground-water quality and the approximate contaminant transport rate through HZ-A ground water to Coldwater Creek. Short-term surface water and sediment monitoring

of Coldwater will be conducted to provide additional data to assess, if Coldwater Creek is being significantly impacted by contaminant migration from HZ-A, and to determine if remedial actions are having any adverse impacts on the creek. Long-term monitoring for Unit 2 of HZ-A may be required depending upon the contamination of the post-remedial action HZ-A ground water and the rate of contaminant delivery to Coldwater Creek. HZ-A long-term monitoring is not anticipated. Short-term monitoring of HZ-A ground water after removal/remedial actions and base flow contaminant evaluation of Coldwater Creek will resolve whether long-term monitoring of HZ-A is warranted.

Inaccessible soils are not included in this remedial action and will be deferred for action until such time that they become accessible as a result of decisions by the entities that control their accessibility. The inaccessible areas at the North County Sites are shown in ES-3. Additional areas may be identified as inaccessible during implementation and will be deferred for separate action as documented in the post remedial action report. When and as the inaccessible areas become available, new decision documents will identify the response actions to address the inaccessible soils as appropriate.

Five-year reviews would be conducted only for those areas where contamination remains above unrestricted use criteria (i.e., roads, bridges, railroads, and other permanent structures).

Alternative 6, Excavation at all Properties

Alternative 6 emphasizes excavation of all contaminated material, regardless of location or accessibility. All soils exceeding the RG for unrestricted land use would be removed for all property units and disposed off-site. Unlike other alternatives, roads, bridges, railroads, and other permanent structures would be removed as required to allow excavation of soils that exceed the unrestricted use criteria. Five-year reviews and institutional controls would not be necessary.

EVALUATION OF ALTERNATIVES

The six alternatives were evaluated using the nine CERCLA evaluation criteria established in Section 300.430(d)(9)(iii) of the NCP to determine the most favorable alternative for cleanup of the North County Site. These criteria are described below.

CERCLA Evaluation Criteria

Threshold Criteria (must be met)

- ***Overall Protection of Human Health and the Environment –*** addresses whether an alternative provides adequate protection and describes how potential exposures to COCs are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

- ***Compliance with Applicable or Relevant and Appropriate Requirements –*** addresses whether a remedy would meet all of the site ARARs. ARARs are federal and state environmental laws and promulgated regulations identified for the North County Site.

Primary Balancing Criteria (identifies major trade-offs among alternatives)

- ***Long-Term Effectiveness and Permanence –*** addresses the remaining risk and the ability of an alternative to protect human health and the environment over time once cleanup goals have been met.

- ***Short-Term Effectiveness and Environmental Impacts –*** addresses the impacts to the community and site workers during cleanup including the amount of time required for completing the action.

- ***Reduction in Toxicity, Mobility, or Volume through Treatment –*** addresses the anticipated performance of treatment that permanently and significantly reduces the toxicity, mobility, or volume of the contamination.

- ***Implementability –*** addresses the technical and administrative feasibility of an alternative, including the availability of materials and services required for cleanup.

- ***Cost –*** compares the differences in cost, including capital, operation, and maintenance costs.

Modifying Criteria (formally evaluated after the comment period)

- ***State Acceptance –*** evaluates whether the State agrees with, opposes, or has no comment on the preferred alternative. This criterion is evaluated formally when comments on the FS are reviewed.

- ***Community Acceptance –*** addresses the issues and concerns the public may have regarding each of the alternatives. This criterion is evaluated formally when comments on the FS are reviewed.

ALTERNATIVE EVALUATION AND COMPARISON

Alternative 1, No Further Action

Alternative 1 is the No-Further-Action alternative required by the NCP and CERCLA guidance. Alternative 1 would not achieve the threshold criteria, because it would not be protective of human health and the environment as required by the NCP. Because it does not meet the threshold criteria, no further evaluation is required. The cost of this alternative is $1.5 million, due to the cost of recurrent 5-year reviews.

Alternative 2, Partial Excavation and Capping at SLAPS and HISS/Futura

This alternative is protective of human health and the environment and compliant with ARARs. The long-term effectiveness and permanence is good at all of the VPs where material is removed to the unrestricted RGs. For the areas at SLAPS, HISS/Futura, Coldwater Creek, and roads, bridges, railroad, and other permanent structures, this alternative is less permanent because institutional controls could be lost in the future. Land at SLAPS and HISS/Futura would be restricted and the economic benefit to the local community would likely be reduced if there is no appropriate commercial/industrial use of the property after capping. There is a short-term risk to workers during the excavation and removal actions, and a short-term risk to members of the public due to construction and transportation activities. There is no reduction in mobility, toxicity, or volume through treatment. However, mobility would be reduced by the contaminant design. Technically this alternative is implementable, but administratively it would be difficult. MDNR has objected to placement of radioactive material on land in Missouri, and this objection may also apply to leaving existing contaminated soils in place at SLAPS and HISS/Futura. Condemnation may be required to obtain the necessary real estate interests. On-site remedies have received strong objections from local stakeholders in the past. This is the fourth most expensive alternative. The cost of this alternative is $205 million.

Alternative 3, Partial Excavation and Treatment at SLAPS

This alternative is protective of human health and the environment and is compliant with ARARs. The long-term effectiveness and permanence is good at all of the VPs where material is removed to the unrestricted RGs. Criteria for Coldwater Creek ensure protectiveness of soils and sediment below the mean water gradient. For the areas at SLAPS and roads, bridges, railroads, and other permanent structures, this alternative is less permanent because institutional controls could be lost in the future. Future development of land at SLAPS would be restricted. Some economic benefit from cleanup of other properties is expected. There is a short-term risk to workers during the excavation and removal actions. The added complexity of the treatment operation would increase short-term impacts and there would be a small increase in short-term risks to the public. There is a reduction in volume through treatment. There would be little change to toxicity.

Technically this alternative is implementable, but administratively it would be difficult. MDNR has stated objections to placement of radioactive material on land in Missouri, which is likely to be applied to the use of the treated soils as backfill. On-site remedies have received strong objections from local stakeholders in the past. Soil washing enhanced with chemical extraction has been proven effective for reducing the levels of contamination in the North County Site soils. Laboratory and conceptual design studies were conducted on soils from the North County Site to investigate treatment processes that would provide a volume reduction and reduce the remediation costs. The primary focus of the investigation was soil washing, including both physical and chemical processes (Clemson Technical Center, 1996). A bench scale selective chemical extraction process was developed that was able to consistently meet the RGs for the North County Site. Removal efficiencies of the radionuclides of interest, particularly Th-230, were consistently greater than 96%, and frequently in excess of 98%. It is expected that all of the site soils containing less than 500 pCi/g of Th-230 could be treated to meet the cleanup

goals with this process. Based on limited evaluations of higher activity soils, the process may even be able to successfully treat soils containing Th-230 activities as high as 2,000 pCi/g. Based on the results of these tests a (conceptual) process design and cost estimate for a full-scale system was developed. The conceptual cost estimates show that treatment by soil washing could be cost effective if process improvements were incorporated to minimize the amount of reagents/chemicals required and effectively treat the unrecycled process waste water.

Institutional controls consisting of a restrictive covenant would be required to ensure commercial/industrial use and other developmental restrictions. It is likely that this real estate instrument would need to be obtained through condemnation.

This is the second most expensive alternative. The cost is estimated to be $284 million.

Alternative 4, Institutional Controls (No Further Excavation)

Institutional controls are used at all remaining properties. These controls are consistent with the present and expected future land use for these areas. This alternative is protective of human health and the environment as long as the controls are effective. Because no additional soils are excavated, the risks could exceed the CERCLA risk range and doses could exceed 100 mrem/yr should institutional controls fail. This alternative does not achieve either the 40 CFR 192, Subpart B or C standards. In addition, Alternative 4 does not comply with 40 CFR 192 Subpart A standards for the control of residual radioactive materials from inactive uranium processing sites. Subpart A requires that controls be maintained for at least 200 years and up to 1,000 years. Inability to meet the threshold criteria of compliance with ARARs is a significant problem with this alternative. Section 121(d) of CERCLA and the NCP § 300(f)(l)(ii)(B) require that remedial actions at CERCLA sites attain ARARs, unless such ARARs are waived under CERCLA Section 121(d)(4). Alternative 4 is less permanent because institutional controls could be lost in the future. Land use would be restricted. Short-term risks would be unchanged until institutional controls are implemented. There is no reduction in mobility, toxicity, or volume through treatment.

Technically this alternative is implementable, but administratively it would be very difficult. The implementation of institutional controls is a complicated process. Maintaining controls at numerous properties under control of private and governmental agencies would be very difficult. Condemnation may be required to obtain some land rights. On-site remedies have received strong objections from local stakeholders in the past. Alternative 4 is one of the cheaper alternatives because much of the material is being left on-site. Total cost is estimated to be $129 million.

Alternative 5, Excavation with Institutional Controls Under Roads, Bridges, Railroads, and Other Permanent Structures

This alternative is protective of human health and the environment and compliant with ARARs. Removal of accessible soils to the unrestricted RGs, sediment to the criteria for Coldwater Creek, and the use of institutional controls for roads, bridges, railroads, and other permanent structures would ensure proper remediation consistent with CERCLA protectiveness.

In general, the long-term effectiveness and permanence for this alternative is high. However, under roads, bridges, railroads, and other permanent structures, it is less permanent because institutional controls could be lost in the future. Remediation of inaccessible soils are not included in Alternative 5 and will be deferred for action until such time that they become available as a result of decisions by the entities that control their accessibility. The inaccessible areas at the North County Sites are shown in Figure ES-3. Additional areas may be identified during implementation and will be deferred for separate action as documented in the post remedial action report. When and as these areas become available, new decision documents will identify the response actions to address the inaccessible soils as appropriate. Under Alternative 5, land would be returned to economic benefit. There is a moderate short-term risk to workers during the excavation and removal actions. There is no reduction in toxicity or volume through treatment. Mobility would be slightly reduced since material would be consolidated and placed in a properly designed and permitted disposal facility. Technically and administratively this alternative is highly implementable. Also administratively this alternative would not conflict with state polices regarding radioactive contaminated material in Missouri. This is the third most expensive alternative. This alternative balances the cost and the permanence, long-term effectiveness, and state and community acceptance. The cost is estimated to be $223 million. This cost does not include costs for remediating soils under roads, bridges, railroads, or other permanent structures at a future date.

Alternative 6, Excavation at All Properties

This alternative is protective of human health and the environment and is compliant with ARARs. Alternative 6 would provide the highest long-term effectiveness and permanence, because all of the radiologically contaminated materials would be recycled or sent to permanent off-site disposal. Short-term effectiveness and environmental impacts would be in the moderate to high range. The removal of soil, particularly under the roads, bridges, railroads, and other permanent structures would increase the potential for accidents. Due to traffic disruption there could be significant economic impacts to the local community. There is, as in Alternatives 2 through 5, a short-term risk to workers during the excavation and removal actions. This is slightly greater for this alternative due to the greater volume of soil being excavated and the nature of the excavation under roads, bridges, railroads, and other permanent structures. There is no reduction in toxicity, mobility or volume through treatment because there is no treatment component of this alternative. However, mobility will be slightly reduced because the contaminated material would be placed in a regulated and properly designed disposal facility. While technically implementable, this alternative would require additional safety considerations in areas of excavation under roads, bridges, railroads, and other permanent structures. Administratively this alternative would require considerable coordination with federal, state and local departments of transportation and with railroads. Also administratively this alternative would not conflict with state polices regarding radioactive contaminated material in Missouri. Alternative 6 is the most expensive alternative. The cost of this alternative is estimated to be $286 million.

Overall Difference Among Alternatives

Overall Protectiveness: Each of the alternatives, except Alternative 1, is protective of human health and the environment. Alternatives 2, 3, 4, and 5 require the effective use of institutional controls. Alternative 4 relies only on institutional controls and is the least likely to provide a permanent protective solution. Alternative 6 removes the most soil and provides the greatest long-term permanence at the St. Louis Site, but it is also the most costly and disruptive to the community and has the highest risks over the short-term. Removal of soils to an off-site disposal location provides an improvement in overall protection at the North County Site compared to treatment and containment. Removal and consolidation actions provide an increase in protection by moving material from the current location to a more controlled location. The least benefit in terms of risk and hazard reduction is from areas where the potential for exposure is limited. This includes the deeper areas at SLAPS and HISS/Futura, areas under roads, bridges, railroads, and other permanent structures, and material below the mean water gradient in Coldwater Creek.

Alternatives 5 and 6 allow use without restrictions at SLAPS and HISS/Futura, while Alternatives 2, 3, and 4 impose institutional controls at SLAPS and/or HISS/Futura.

Compliance with ARARs: All alternatives except Alternative 1 (No-Action) and Alternative 4 (Institutional Controls with No Further Excavation) comply with ARARs. Alternative 4 does not achieve either the 40 CFR 192, Subpart A, B, or C standards.

Long-term Effectiveness and Permanence: Removal of contamination results in the greatest long-term effectiveness and permanence for Alternative 6 followed by Alternative 5. Next are Alternatives 2 and 3 because more contaminated materials are left under institutional control. Alternative 4 involves the use of institutional controls with no further excavation. This alternative is less permanent and effective than Alternatives 2, 3, 5, and 6. Alternative 1 has the least long-term effectiveness and permanence.

Reduction in Mobility, Toxicity, and Volume Through Treatment: Alternative 3 provides a reduction in contaminant volume and mobility through treatment.

Short-term Effectiveness: The biggest difference in short-term effectiveness is due to the increased potential for construction and traffic-related accidents if soil is removed from beneath roads, bridges, railroads, and other permanent structures and the increased risk of construction and transportation-related accidents due to additional shipment of materials. Comparing Alternatives 5 and 6 shows the impacts of this variation. The increase in operational risk is very large for removals from areas under major traffic corridors. The implementation of Alternatives 2, 3, 5, and 6 may temporarily impact wetlands, temporarily affect surface drainage in the floodplain, and create non-point source surface water discharges, but all of these impacts will be managed in compliance with the substantive requirements of applicable laws and regulations, and therefore are not considered to be significant obstacles to the implementation of these remedial alternatives. Materials and services are readily available and implementable for all of the alternatives.

Implementability: The most implementable alternative is Alternative 5, followed by 6 and 2 then 3. Alternative 4 is the least implementable of the action alternatives due to lack of state and community support.

Costs: Costs are greatest for Alternative 6, which removes the largest volume of soil to an off-site disposal facility. Similarly, costs are lowest for the No-Further-Action Alternative. Costs are shown in the Table below.

Costs of the Alternatives in 2003 Dollars
(Includes Monitoring if Required During 30 Year Evaluation Period)

Alternative	Cost (Million $)
Alternative 1, No-Further-Action	1.5
Alternative 2, Partial Excavation and Capping at SLAPS and HISS/Futura	205
Alternative 3, Partial Excavation and Treatment at SLAPS	284
Alternative 4, Institutional Controls (No Further Excavation)	129
Alternative 5, Excavation with Institutional Controls Under Roads, Bridges, Railroads, and Other Permanent Structures	223
Alternative 6, Excavation at All Properties	286

Note: Costing assumptions and component costs are described in Appendix C.

Modifying Criteria

State and community acceptance have been considered in the CERCLA process and will be further evaluated following review of comments received during the public comment period on the North County Site FS and PP. The state and community have expressed strong opposition to on-site remedies and alternatives that restrict future land use.

EXECUTIVE SUMMARY

FIGURES

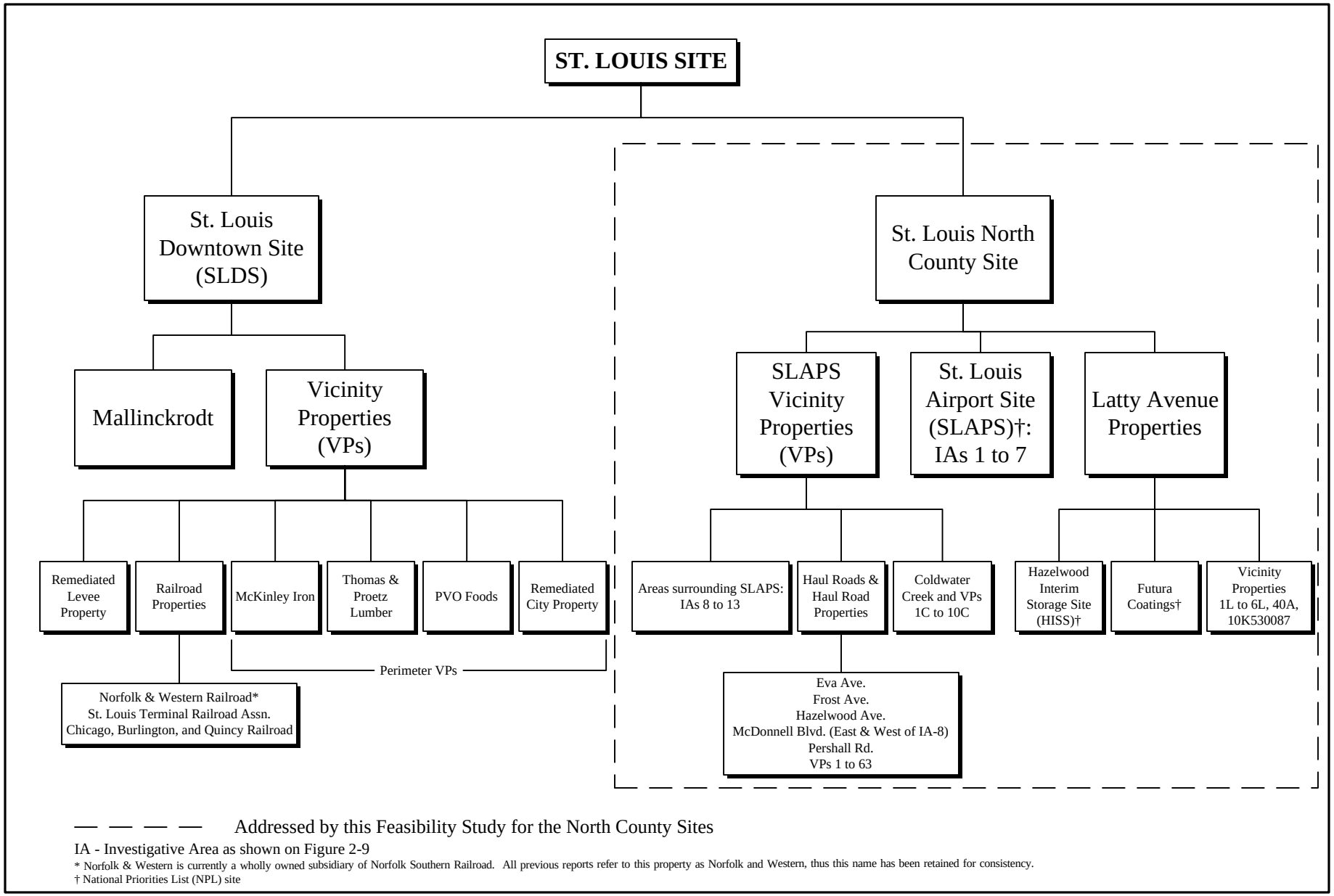


Figure ES-1. Schematic Representation of the FUSRAP St. Louis Site

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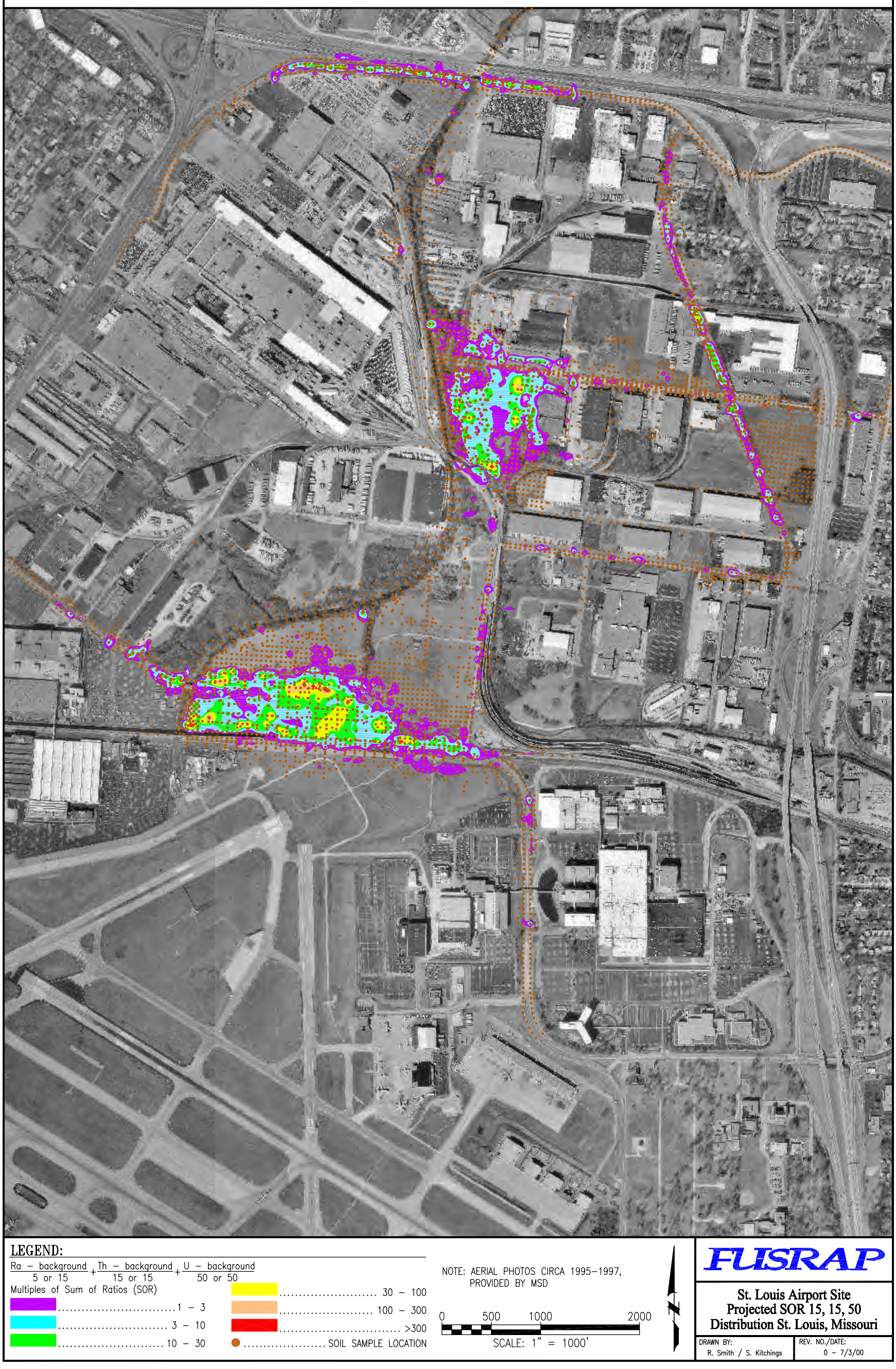


Figure ES-2. Projected Radioactivity Exceeding 5 pCi/g of Radium-226, 14 pCi/g of Thorium-230, 50 pCi/g of Uranium-238 or Combinations Such That the Sum of the Ratios =1 in Surface Soil and Exceeding 15 pCi/g of Radium-226, 15 pCi/g of Thorium-230, 50 pCi/g of Uranium-238 or Combinations Such That the Sum of the Ratios =1 in Subsurface Soil

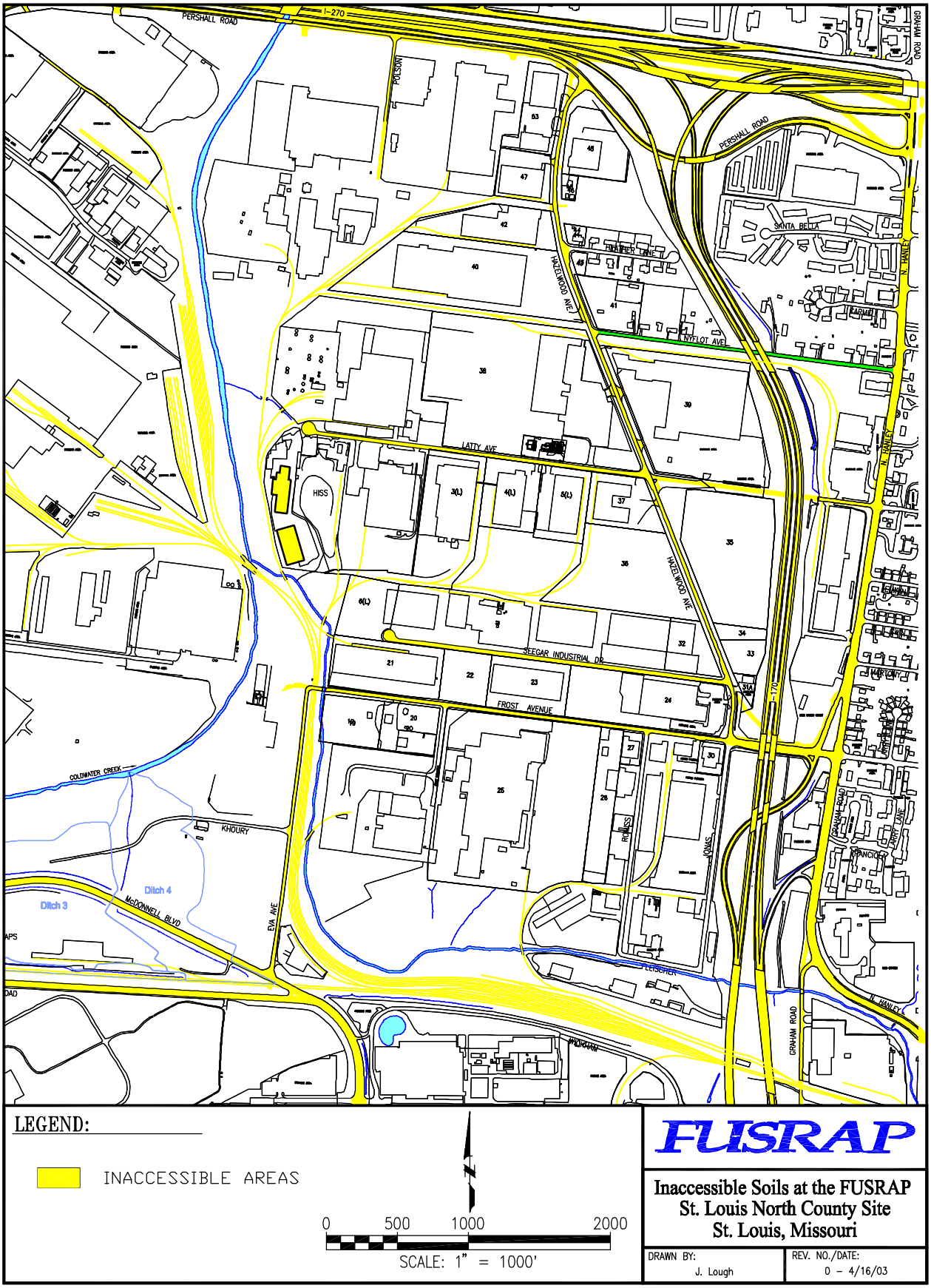


Figure ES-3. Inaccessible Soils at the North County Site.

SECTION 1

INTRODUCTION AND NEED FOR ACTION

1 INTRODUCTION AND NEED FOR ACTION

1.1 AUTHORITY FOR ACTION

The United States Army Corps of Engineers (USACE) is implementing a program for the management and remediation of radioactive contamination at the North County Site in St. Louis, Missouri. In 1974, the U.S. Congress authorized the U.S. Atomic Energy Commission (AEC) to institute the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was initiated to identify and clean up or otherwise control sites where residual radioactivity remains either from activities conducted under contract to the Manhattan Engineer District (MED) and the AEC during the early years of the nation's atomic energy program, or from commercial operations as directed by Congress. On October 13, 1997 the U.S. Congress transferred responsibility for FUSRAP from the U.S. Department of Energy (DOE) to USACE as part of the 1998 Energy and Water Development Appropriations Act (EWDAA).

USACE is conducting response actions under the legislative authority contained in Public Law 107-66, and the EWDAA for Fiscal Year 2002 (FY02). This law establishes the authority of USACE to conduct response actions for releases related to the nation's early atomic energy program as the lead federal agency, subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP). The federal government has adopted the lead role for remediation of these properties in response to a set of directives including the Atomic Energy Act (AEA) of 1954, CERCLA, and the EWDAA of 1985. In the 1985 EWDAA legislation, Congress specifically directed DOE to implement a remediation effort for the St. Louis Airport Site (SLAPS), Latty Avenue [now the Hazelwood Interim Storage Site (HISS) /Futura property], and associated haul route properties. After this Congressional direction, the U.S. Environmental Protection Agency (EPA) placed three of the North County properties onto the National Priorities List (NPL) in October 1989. The NPL is a list of sites identified for remedial action under CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA). Pursuant to Section 120 of CERCLA, a Federal Facilities Agreement (FFA) for the St. Louis Site was established between the DOE and the EPA in 1990.

The properties shown in Figure 1-1 comprise the St. Louis Site and are being cleaned up as part of FUSRAP. The St. Louis Downtown Site (SLDS) includes Mallinckrodt Chemical Works (MCW) and several vicinity properties (VPs). Accessible soils and ground water at the downtown site were addressed in a separate Record of Decision (ROD) in 1998 (USACE, 1998c). The North County Site is in the northern portion of St. Louis County. The North County Site includes the SLAPS, SLAPS VPs, and Latty Avenue Properties (Figure 1-2). SLAPS, HISS, and Futura Coatings are on the EPA's NPL.

1.2 BACKGROUND

The history of the St. Louis Sites began when Edward Mallinckrodt, President of MCW, was contacted by Dr. Arthur Compton, head of the nation's effort to develop an atomic bomb at the Metallurgical Laboratory at the University of Chicago. Dr. Compton inquired if MCW could undertake a project to prepare highly purified uranium compounds in support of the war effort.

This launched activities in St. Louis and numerous other areas in the country. These activities supported the Nation's strategic effort from the development of the first atomic bombs during World War II through the extended Cold War period that followed. From 1942 to 1957, SLDS was used for separation of uranium ores. These processing activities, conducted under MED and AEC contracts, resulted in radioactive residuals and contamination at the MCW in downtown St. Louis. Ore was imported from multiple sources, including the Belgian Congo (currently known as Zaire), Canada, and western States. The ore processing was part of a contract between MCW and the MED. The Belgian Congo ore was somewhat unique and highly desirable because it was an extremely rich ore containing as much as 70% uranium.

The extraction of the uranium from ores generated large quantities of by-products, including raffinate cake. Because of the significant quantities of other potentially valuable elements contained in the raffinate cake, the original supplier of the Belgian Congo ores, African Metals Corporation, retained ownership of the raffinate cake. Because the raffinate cake could not be disposed of, and because there was no room to store it at the MCW site, by late 1945 the AEC began searching for a suitable location to store the raffinate cake until African Metals retook possession of it. On March 2, 1946 the MED obtained consent to use 21.7 acres of land near the Lambert-St. Louis International Airport in north St. Louis County. On January 3, 1947, the MED acquired the site by condemnation proceedings for $20,000. From 1947 to 1953, the site was used first by the MED, and then by the AEC. MCW used the site under contract to the AEC from 1953 to 1967.

Several different materials were transferred to the SLAPS. Collectively referred to as the "airport residues", these materials included pitchblende raffinate cake, radium-bearing wastes, barium cake residue, Colorado raffinate cake residues, and other wastes. Much of the material was hauled in trucks and stored on the ground in uncovered piles. Subsequent disposal and relocation of the airport residues resulted in radioactive contamination at other locations near the Lambert-St. Louis International Airport.

Between March 1962 and November 1964, the AEC made four unsuccessful attempts to sell the airport residues after African Metals Corporation transferred ownership of the pitchblende raffinate cake to the U.S. Government. In 1966, the airport residues were sold to the Continental Mining and Milling Company (CMM) by the AEC. CMM began moving materials to 9200 Latty Avenue in Hazelwood (currently referred to as HISS/Futura) in order to extract uranium and other valuable metals.

On December 29, 1966, Continental's lender, the Commercial Discount Corporation of Chicago (CDC), began foreclosure proceedings against CMM and ultimately took possession of the airport residues. HISS/Futura was not owned or used for government operations. Rather, the commercial company used these areas to store the materials on the ground. Most of the materials were later sold and transferred to the Cotter Corporation processing facility in Canon City, Colorado. However, about 8,700 tons of barium sulfate waste was mixed with an estimated 39,000 tons of soil and shipped to the Westlake Landfill in St. Louis County. Westlake Landfill is an NPL site (listed August 30, 1990). EPA Region VII is the lead agency for the Westlake Landfill Remedial Investigation/Feasibility Study (RI/FS), and is the lead agency for Westlake Landfill.

Several key documents prepared for the RI/FS process are listed in Table 1-1. In June 1990, the FFA addressing the St. Louis Site was executed by EPA and DOE. This agreement was established to define implementation and oversight roles for the respective agencies involved.

USACE is preparing this FS in accordance with CERCLA and the NCP. This document evaluates the alternatives for remedial action at the site. It is based on historical data and the results of the RI, which contains information on the nature and extent of contamination, and the Baseline Risk Assessment (BRA), which evaluates potential health and ecological risks if no remedial action is taken at the site. The BRA established that action is warranted at the North County Site based on the potential for unacceptable exposure if existing access restrictions and controls are not maintained in the future. Site characterization and risk data from the RI and BRA are used in the FS process to evaluate and develop remedial action alternatives to address potential risk at the North County Site.

The RI report (BNI, 1992a) summarizes the data and analytical results from radiological and chemical characterization surveys and field investigations conducted at the St. Louis Site from 1982 through 1991. These studies were undertaken to determine the nature and extent of contamination and to characterize the geological and hydrogeological features of the properties. In general, the results from the RI indicate that the highest levels of radioactive contamination are at SLAPS and HISS, and the principal radioactive contaminants are isotopes of thorium (Th-230), radium (Ra-226), uranium (U-238), and their radioactive decay products. Contamination was found at several VPs which were not directly associated with uranium processing or waste storage. The principal radioactive contaminants at the VPs are Ra-226, Th-230, Th-232, and U-238, with Th-230 detected at the highest concentrations. Additional characterization data were collected and reported in the Remedial Investigation Addendum (SAIC, 1995) and the 2000 *SLAPS Implementation Report* (USACE, 2001).

The BRA report (ANL, 1993) evaluated the potential risk for both current and hypothetical future users of the St. Louis Site properties. Potential carcinogenic and non-carcinogenic risks to human health and the environment were quantified and compared to determine whether risks associated with the site were within acceptable ranges. On the basis of conservative estimates of carcinogenic risk levels for current users, several properties were identified as having potential carcinogenic risks in excess of the EPA target risk range. Potential future risks and hazards were found to be unacceptable for some future scenarios involving residential use of the affected properties. Based on these BRA future risk and hazard results, further response actions were warranted at the North County Site.

The RI, BRA, and FS comprise the primary evaluation documents. The Proposed Plan (PP) is published as a separate document, but is considered an integral part of the process, for it identifies the preferred alternative. The RI/FS/PP process will include appropriate agencies [e.g., EPA and Missouri Department of Natural Resources (MDNR)] and public participation. The process will conclude with the issuance of a ROD that identifies the selected remedial alternative for the North County Site.

Table 1-1. Listing of Key Documents Prepared for the North County Site

Document	Reference	Comment
National Priority List	EPA, 1989b	
Federal Facilities Agreement	DOE, 1990	Executed by EPA and DOE
Initial RI/FS Work Plan	BNI, 1992b	
EE/CA / EA for Properties in Vicinity of HISS	DOE, 1992	
Initial Screening of Alternatives	SAIC, 1992	
Remedial Investigation	BNI, 1992a	
Baseline Risk Assessment	ANL, 1993	
Draft FS/EIS	DOE, 1994b	
Remedial Investigation Addendum	SAIC, 1995	
Treatability Studies	Clemson, 1995, 1996	Detailed evaluation of soil washing
St. Louis Task Force Report	Task Force, 1996	Recommendations of an independent panel formed in 1994
EE/CA for SLAPS	USACE, 1998a	
EE/CA for HISS	USACE, 1998b	
SLAPS Implementation Report	USACE, 2001	Results of additional SLAPS area investigations performed in 1998

1.3 PURPOSE AND SCOPE OF THIS FEASIBILITY STUDY

This FS for the North County Site identifies, develops, and evaluates remedial action alternatives to achieve a final remedy for soil, sediment, surface water, ground water, and structures. The alternatives address all contamination, including but not limited to radiological contamination, resulting from or associated with uranium manufacturing or processing activities. The alternatives also address other chemical or non-radiological contaminants that have been mixed or commingled with radiological contaminants resulting from or associated with uranium manufacturing or processing activities conducted at SLDS. Contamination present at the North County Site that is not related to work under FUSRAP is beyond the scope of this document. Surface water and ground water are not addressed as source media within this FS, but are addressed only as potential transport mechanisms for soil and sediment contamination. The FS addresses all of the properties that constitute the North County Site, as shown in Figure 1-1: SLAPS and HISS/Futura (listed on the NPL); and Latty Avenue VPs and SLAPS VPs (not listed on the NPL). SLAPS VPs include tracts near SLAPS and areas along Coldwater Creek. Alternatives are developed on the basis of the nature and extent of contamination documented in the RI, the BRA, the FS, and related reports.

The evaluation of remedial action alternatives provided in this FS has been used by USACE in order to select the preferred alternative for remediation of the site. The USACE preferred alternative has been documented in the PP for the North County Site issued for public comment. As described in the preceding section, the final remedy for the site will be selected in a ROD for the North County Site, after public comment on the PP is received.

1.4 CONSULTATION AND COORDINATION WITH OTHER AGENCIES

USACE is the lead agency responsible for response actions at the North County Site pursuant to Public Law 107-66 and the EWDAA (of 1998 and 2002). An FFA for the site has been negotiated with EPA Region VII consistent with CERCLA Section 120. Plans and activities are being coordinated with appropriate Missouri State agencies, including the MDNR. The State's role is defined in a Cooperative Agreement signed July 20, 1998. The identification of federal and state regulations, which may impact site remediation, is being coordinated with the EPA Region VII and the MDNR, respectively.

The agencies responsible for natural or cultural resources addressed in the RI/FS have been consulted. These include the Missouri State Historic Preservation Office (SHPO), the U.S. Fish and Wildlife Service (FWS), county, and municipal agencies. Information on Threatened and Endangered Species has been received from the FWS and the Missouri Department of Conservation (MDC), and is described in Appendix B.

1.5 ORGANIZATION OF THE FEASIBILITY STUDY

This FS for the North County Site is organized in accordance with guidance from USACE and the EPA. Volume I contains Sections 1-6, and Volume II contains the FS Appendices. Section 1 defines the proposed action and includes the authority for action, background, purpose and scope, and consultations with other agencies. Section 2 describes the St. Louis Site, its history, the affected environment, and the nature and extent of contamination and summarizes the findings of the BRA. Section 3 defines applicable or relevant and appropriate requirements (ARARs) and remediation goals (RGs) and screens remedial technologies. Section 4 develops, screens, and evaluates remedial action alternatives for the site-wide alternatives. Section 5 presents a detailed analysis of potential remedial alternatives using CERCLA guidance evaluation criteria. Section 5 also provides a comparative analysis of the site-wide alternatives for remediation of the North County Site. Section 6 contains the report references. ARARs, correspondence, cost analysis, dose and risk analysis, and post-remedial action data are contained in Volume II, Appendices A through E, respectively.

SECTION 1

FIGURES

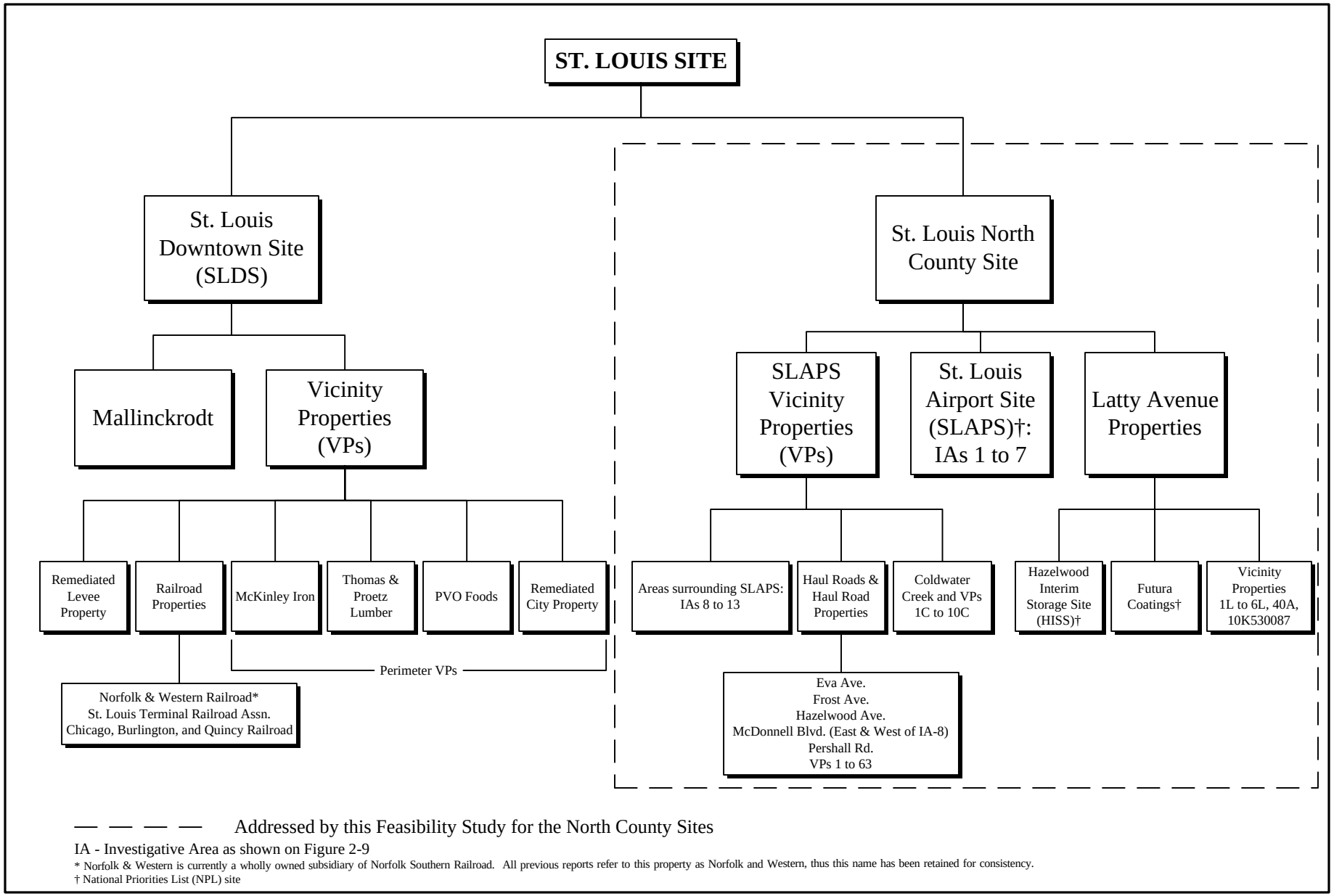


Figure 1-1. Schematic Representation of the FUSRAP St. Louis Site

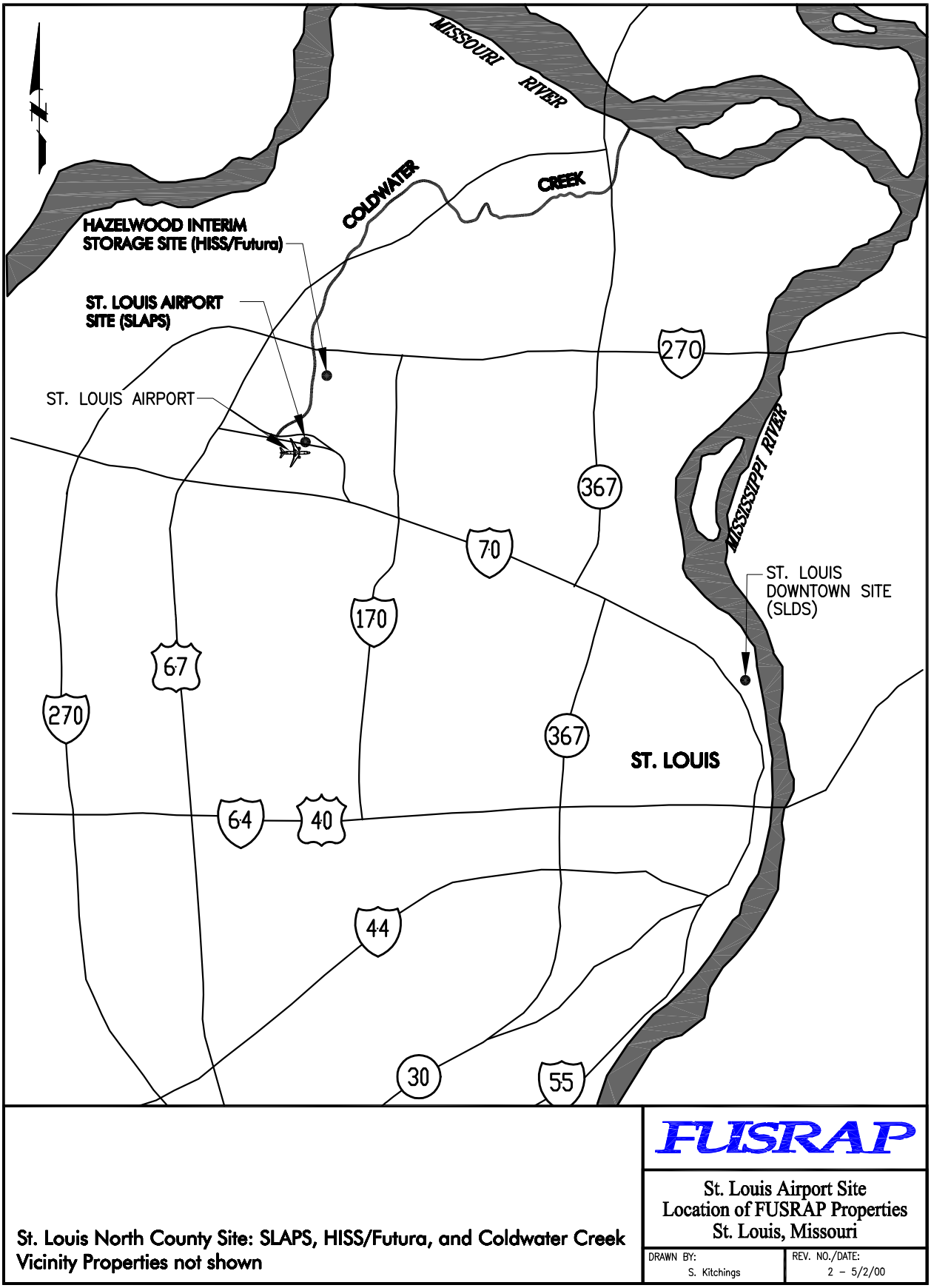


Figure 1-2. Location of Key FUSRAP Properties in the St. Louis, Missouri Area

SECTION 2

SITE CHARACTERIZATION

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2 SITE CHARACTERIZATION

2.1 SITE DESCRIPTION AND HISTORY

The St. Louis Site consists of two locations designated in this report as the St. Louis Downtown Site (SLDS) and the North County Site. Both areas consist of multiple properties as defined in Figure 1-1. A separate Record of Decision (ROD) was prepared for SLDS in 1998 (USACE, 1998c).

The North County Site lies in St. Louis County, 24 kilometers (km) [15 miles (mi)] from downtown St. Louis, 18 km (11 mi) northwest of SLDS, and immediately north of Lambert-St. Louis International Airport. It includes the St. Louis Airport Site (SLAPS), the Latty Avenue Properties, and the SLAPS Vicinity Properties (VPs). The Latty Avenue Properties are: the Hazelwood Interim Storage Site (HISS), Futura Coatings, and the Latty Avenue VPs. The SLAPS VPs are properties along the haul roads, Coldwater Creek and nearby railroad lines. Recent aerial photos of the North County Site are shown in Figures 2-1 and 2-2. The properties are described in several reports including the *Remedial Investigation (RI) Report Addendum* (SAIC, 1995) and the *SLAPS Implementation Report* (USACE, 2001).

Characterization activities at the North County Site indicate that contamination is present in the soils and other media. This contamination is related to the nation's early atomic energy activities and also to the activities of others. As agreed to under the Federal Facilities Agreement (FFA), hazardous substances on the site resulting from uranium manufacturing or processing activities are included in this Feasibility Study (FS).

2.1.1 Source and Characteristics of the FUSRAP-Authorized Materials

Uranium production processes were conducted at SLDS beginning in 1942. The SLDS processes included the digestion of ore and the extraction of uranium metal. A schematic of the uranium metal production process is shown in Figure 2-3. The original feed material used at SLDS was uranium black oxide that was extracted from uranium ore and concentrated at non-St. Louis facilities. Because of pre-processing, this black oxide was relatively free of radium and radium daughter products. Later, in about 1946, Belgian Congo Shinkolobwe ores containing high percentages of uranium (greater than 30% by weight as compared to less than 1% for other ore bodies) were processed. The Shinkolobwe ore had large amounts of radium [e.g., ~0.3 curies per ton (Ci/T) of uranium], which were further concentrated by the processing at SLDS. Processing activities at SLDS also included other ores with much lower concentrations of uranium in the ore. These less concentrated ores resulted in generation of larger quantities of by-product material waste with correspondingly lower activity concentrations (particularly with respect to daughter products).

The ore extraction processes for the uranium ores, which are the first steps of Figure 2-3, are shown in more detail in Figure 2-4. The top half of Figure 2-4 shows the process for pitchblende ore and the bottom half shows the process for ore concentrates. The ore or concentrate was digested in acid for both processes. For the pitchblende ores, precipitation and filtration processes were used to remove radium and other unwanted materials by adding sulfuric acid (H_2SO_4) to precipitate radium sulfate and lead sulfate ($RaSO_4$ and $PbSO_4$.) This cake was leached with sodium carbonate (Na_2CO_3) to recover more uranium and was designated as K-65.

Excess sulfate ion was removed by adding barium carbonate ($BaCO_3$) and removing the resulting barium sulfate ($BaSO_4$) precipitate in a centrifuge. Barium has chemical properties similar to radium and served to scavenge the remaining very small mass (but high radioactivity) of radium from the aqueous solution by co-precipitation. Most of this barium sulfate cake was leached with sodium carbonate solution to recover more uranium. Both leached and unleached barium sulfate cake were stored in bulk at SLAPS and designated barium sulfate cake (AJ-4). Sometimes the leached barium sulfate cake has been called the "barium cake". The product of these ore digestion and purification steps was a partially purified aqueous solution that was then fed to an ether solvent extraction process.

The uranium was extracted from the aqueous solution into diethyl ether and then stripped from the ether phase back into the aqueous phase. This solvent extraction process resulted in an aqueous solution of uranyl nitrate [$UO_2 (NO_3)_2$]. The nitrate was then driven off using a high temperature denitrification process to form uranium trioxide (UO_3). The next step was a high temperature reduction of the uranium trioxide under hydrogen to form uranium dioxide (UO_2). The uranium was then fluorinated to form uranium tetrafluoride (UF_4). The fluorine was removed by reacting the uranium fluoride with magnesium. This step of the process produced uranium metal and magnesium fluoride (MgF_2).

Several waste and by-product streams were produced in these processes. The K-65 residues included filter cake generated by filtration of crude uranyl nitrate hexahydrate (UNH), undigested ore and tailings, lead/radium sulfate filter cake, filter cake, and radium sulfate. The raffinate cake is the filter cake generated by lime precipitation of the raffinate (or aqueous stream) after the extraction of the uranyl nitrate hexahydrate into ether. These materials were transported from the downtown site to SLAPS for storage. The K-65 residues were shipped in drums. Other waste materials were shipped in bulk quantities in trucks and covered vehicles.

2.1.2 Summary of FUSRAP-Authorized Materials at North County Sites

The Formerly Utilized Sites Remedial Action Program (FUSRAP)-authorized materials at the North County Sites originated from uranium processing. The materials were shipped to SLAPS for storage. The K-65 residues were eventually shipped to federal facilities in Ohio and New York. Most of the remaining materials were sold to a commercial firm and moved to the HISS/Futura site for subsequent transfer to Colorado while some of the leached barium sulfate was mixed with soil and transferred to Westlake Landfill. Material spread to other properties by spillage during transfers between sites and also by wind and water erosion. The primary FUSRAP-authorized materials are summarized in Table 2-1.

Table 2-1. Summary of FUSRAP-Authorized Materials Used at North County Sites

FUSRAP-Authorized Material	Comments
K-65 residues	Radium−bearing residues (also referred to as "K-65") were stored at the site from 1946 until 1948. Storage of these materials was originally planned to be in the concrete pit at the site, but due to health concerns associated with subjecting the loose material to the elements, the material remained in drums. All of the K-65 residues were transferred to the Lake Ontario, New York, and Fernald, Ohio federal facilities in 1948 and 1949.
AM-7 Pitchblende Raffinate Cake	The pitchblende raffinate cake was defined as the solid residue that resulted from the initial digestion with nitric acid and purification of Belgian Congo pitchblende. The raffinate cake was filtered from neutralized acidic raffinate from the ether extraction of uranyl nitrate hexahydrate. This residue was re-slurried with sodium carbonate solution to improve the recovery of uranium from the pitchblende raffinate. The approximate gross weight of this material was estimated to be 74,000 tons containing about 113 tons of uranium. Based on samples collected in June of 1953, it was estimated that this residue also contained approximately 1,553,000 lbs. (780 tons) of cobalt, 1,845,000 lbs. (925 tons) of nickel, and 971,000 lbs. (490 tons) of copper. Additions to the raffinate cake stored at the site after 1953 resulted in an adjustment of this estimate by an additional 13%.
AM-10 Colorado Raffinate Cake	The Colorado raffinate cake was described as being a heterogeneous residue primarily resulting from the initial digestion with nitric acid and purification of domestic uranium concentrates, such as Colorado ore. The raffinate cake was filtered from neutralized acidic raffinate from the ether extraction of uranyl nitrate hexahydrate. This residue was re-slurried with sodium carbonate solution to improve the recovery of uranium from the pitchblende raffinate cake. This material had an estimated gross weight of 32,500 tons and contained an estimated 48 tons of uranium.
AJ-4 Unleached Barium Sulfate Cake	AJ-4 unleached barium sulfate cake was the residue created by adding barium carbonate to the dissolved uranium in nitric acid to precipitate excess sulfate (SO_4^{2-}) that had been added previously to precipitate lead and radium from the solution containing uranium (Note: AJ-4 was only generated when pitchblende was processed). The barium sulfate precipitated along with the final traces of radium and lead that were not removed in the previous precipitation step. The material was estimated to contain approximately 22 tons of uranium in a residue with a gross weight of 1,500 tons. This unleached residue was shipped to Cotter in Colorado for recovery of the uranium.
AJ-4 Leached Barium Sulfate Cake	The leached barium sulfate cake (as described above) was leached with sodium carbonate solution to recover the last traces of uranium (Note: AJ-4 was only generated when pitchblende was processed). This cake would have been predominately barium sulfate with traces of lead and radium as sulfates. The leached barium sulfate cake, also described as resulting from the initial digestion with nitric acid and purification, contained an estimated 7 tons of uranium with a gross weight of 8,700 tons. This is the residue that is believed to be buried at Westlake Landfill after being mixed with 39,000 cubic yards (yd^3) of soil at HISS/Futura.
C-701 U scalping of Magnesium Fluoride (MgF_2)	Magnesium fluoride is the by-product of the thermal reaction between magnesium metal and uranium tetrafluoride to give uranium metal. Until 1953, this magnesium fluoride was shipped to Vitro Corp.
Miscellaneous Residues and Metal Scrap	The "miscellaneous residues" were described to include an estimated 350 tons in deteriorated drums, and contained an estimated 2 tons of uranium. By 1960 there were approximately 50,000 empty drums and approximately 3,500 tons of contaminated steel and alloy scrap (generated during the decommissioning and demolition of the Destrehan Street Plant) stored on-site at SLAPS. By 1962 the majority of these materials had been sold for their metal salvage values. The bulk of the scrap metal was purchased by David Witherspoon, Inc., of Knoxville, TN, for $500 under contract number AT-(23-2)-47 on June 8, 1962.
Barrels	As shown on Figure 2-7 and 2-8, SLAPS was used extensively for barrel (drum) storage.
C-liner slag	The material described as "C-Liner Slag" (also referred to as dolomite liner slag) was also stored and later removed from SLAPS. This material was estimated to be approximately 3,500 tons. The material was described as slag created during the reduction step in the metal operations at Destrehan Street. Initially the reduction bombs were lined with dolomite. The slag was the "used dolomite". In 1953 the dolomite liner was replaced with recycled magnesium fluoride. Approximately half of the original quantity of C-liner slag was shipped to Fernald for recovery of the uranium material. The rest was sold to Cotter as an amendment to the Sale of Airport Residues.
C-Oxide, Japanese precipitates, and Vitro residues	Another material that was stored at SLAPS was a material referred to as "C-Oxide". Records indicate that the C-Oxide was shipped to Fernald for reprocessing and uranium recovery (Booz-Allen FUSRAP Archive, AEC Memo of 6/23/64). An inventory of the material stored at SLAPS, performed on April 11, 1959, also included an estimated 60 gross tons of captured Japanese uranium precipitates containing an estimated 0.2 tons of uranium. Also included in this inventory were 290 gross tons of "Vitro residues" containing approximately 1.9 tons of uranium. This material is believed to have resulted from the Vitro Corporation's facility in Canonsburg, PA, reprocessing magnesium fluoride liner material for the recovery of uranium. (Booz-Allen FUSRAP Archive, MO.1. Airport Site, Robertson, Missouri, April 11, 1959).
Building Debris	During grading and filling of the site by the Airport Authority, several contaminated areas on the west end of the site were uncovered and exhibited radiation exposure rates from 2 to 60 mrad/hr. Rubble (presumably concrete rubble) and wooden "super structures" were buried on the east end of the site. Broken concrete, from the concrete "pit", storage pad, and wash slab (decontamination pad) remained on the site under the clean fill.
Oil Dump	A Mallinckrodt Chemical Works drawing from 1955 shows an oil dump located in the vicinity of the larger AM-10 storage location shown on Figure 2-8. This alleged oil dump is not referenced in any other known literature, and can not be confirmed by aerial photos of the same vintage, or sampling results from previous investigations.

2.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

2.2.1 Surface Features

2.2.1.1 Description of SLAPS

SLAPS is an unincorporated property in St. Louis County owned by the City of St. Louis. SLAPS is bounded by McDonnell Boulevard to the north, Banshee Road and the Norfolk Southern Railroad on the south, and Coldwater Creek on the west. SLAPS covers 8.8 hectares (ha) (22 acres) and most of the property is surrounded by a security fence. A water main crosses the northwest corner of SLAPS and runs parallel to the railroad tracks to the south. This water main was relocated in 1998 and now runs south of the Norfolk Southern Railroad. There are no sewer lines or overhead utility lines within the perimeter fence of SLAPS, but utilities run parallel to the fence along McDonnell Boulevard.

Manhattan Engineer District (MED) obtained the title to SLAPS by condemnation proceedings on January 3, 1947, to store uranium-bearing residuals from SLDS. Storage operations were conducted from 1946 until 1966. The conditions at SLAPS prior to disposal activities are shown in a 1941 aerial photograph in Figure 2-5. The present locations of McDonnell Boulevard and Coldwater Creek are drawn on the photo to provide present day reference points.

The 1958 aerial photographs in Figure 2-6 show SLAPS and adjacent areas during the active period of storage operations at SLAPS. The large quantity of drums, metal scrap, and other by-product materials that were stored at SLAPS are shown in the photographs of Figure 2-7. The photographs further highlight the large open piles of material that were stored at SLAPS. The general layout for storage of materials in about 1958 is depicted in Figure 2-8. Concentrated radium and barium sulfate cake were stored near the center of the site near the north boundary, in the areas designated AJ-4 in Figure 2-8. The storage sheds near the gate were later abandoned in place. Through time, various meanders in Coldwater Creek were backfilled to support construction, resulting in some commingling with wastes brought to SLAPS. The alignment of McDonnell Boulevard has also changed through time. Both of these activities have resulted in off-site movement of residuals stored at SLAPS.

In November 1965, the U.S. Atomic Energy Commission's (AEC's) Airport Committee issued a report that summarized the history of SLAPS up to that point. At that time the committee reported that scrap metal and other debris had been placed in low areas on the western end of the property and covered (in 1952) with dirt to make a level storage area. The date appears to be in error since the Destrehan Street Plant at SLDS was not demolished until the 1960s.

The report also indicates that "by 1960 there were approximately 50,000 empty drums and approximately 3,500 tons of miscellaneous contaminated steel and alloy scrap (generated during the decommissioning and demolition of the Destrehan Street Plant) stored onsite at SLAPS. However, by 1962 the majority of these materials had been sold for their metal salvage values". The bulk of the scrap metal was purchased by David Witherspoon, Inc. of Knoxville, TN for $500 under contract number AT-(23-2)-47 on June 8, 1962. Terms of the contract

specified that all metal scrap above existing ground level, "that was capable of being removed without excavation equipment", was to be considered part of the scrap materials offered for sale. The contract also specified that the material purchased under this contract was considered to contain source material subject to licensing requirements and AEC regulations. David Witherspoon, Inc. was already licensed by the AEC to receive source material.

A status report from February 15, 1963 indicated that the contractor (Witherspoon) was crushing drums on site by use of an "electro magnet drop hammer". At the time of the status report, Witherspoon had been on site for approximately 8 months and it was anticipated that it would take an additional two months to complete the removal of the scrap. It was noted that the cleanup of the miscellaneous general scrap had been slowed because of stored conditions (dozed into place and mixed with earth). The report further elaborated that the working crew's progress was slowed by frozen ground. Based on this information, it appears that the majority of scrap metal at the site was either used to fill very shallow depressions or piled high above ground. When Witherspoon bought the scrap, every reasonable effort was made to remove as much of the scrap as possible, including the shallow buried materials.

In 1966 and 1967, the residuals stored at SLAPS were purchased for mineral recovery by the Continental Mining and Milling Company (CMM) of Chicago. The CMM removed the materials from SLAPS and placed them in storage at what is now the HISS/Futura site on Latty Avenue under an AEC license. In 1969, after most of the residuals were removed, site structures at SLAPS were demolished and buried on the property (EPA, 1989a). Additional fill material and rubble were placed on SLAPS in the 1970s. Clean fill material was spread over the disposal area from 0.3 to 1.0 meter (m) [1 to 3 feet (ft)] to achieve surface radioactivity levels acceptable at that time. In 1973, the U.S. Government and the City of St. Louis agreed to transfer ownership of SLAPS by quitclaim deed from the AEC to the St. Louis Airport Authority. The quitclaim deed limits land use to aeronautical or aviation purposes and imposes institutional controls consisting of restrictions on excavation and drilling.

In 1986, an extensive radiological and limited chemical characterization determined that radioactive contamination extended as deep as 5.5 m (18 ft) below grade (BNI, 1987a). A radiological characterization of airport area properties was subsequently conducted from 1986 through 1990 to define the extent of radioactive contamination and to evaluate possible disposal alternatives. The U.S. Environmental Protection Agency (EPA) placed SLAPS on the National Priorities List (NPL) in 1989.

In 1998, additional soil and ground-water sampling was performed to provide additional characterization of SLAPS (USACE, 2001). SLAPS and the contiguous VPs were divided into several investigation units for purposes of analysis and description. SLAPS was divided into investigation areas (IA) 1 through 7 based on areas of former storage and other factors, such as drainage patterns (see Figure 2-8). The IAs are shown in Figure 2-9.

Several soil removal actions have been conducted at SLAPS in accordance with approved engineering evaluation/cost analyses (EE/CAs). The general locations of removal actions at the North County Site are shown in Figure 2-10.

At the western end of SLAPS, contaminated soils were moved in the area immediately east of the gabion wall on the bank of Coldwater Creek. Excavation, which began in September

1997, ran the length of the gabion wall and extended approximately 90 ft (27 m) to the east. The excavation was accomplished in six discrete areas. Area 1 was located at the southern end of the gabion wall and excavated to the maximum design depth of 13 ft (4 m) below ground surface. Ground water was encountered at 12.25 to 13.3 ft (3.75 to 4 m) below the ground surface. Excavation was halted after the design depth was achieved and the water table was encountered. Radiologically contaminated soils remain below the ground-water table in Area 1. Removal actions at Areas 2 to 6 were conducted using the cleanup criteria described in the EE/CA (USACE, 1998a). For radionuclides the cleanup criteria used were the greater of 5/15 picocuries per gram (pCi/g) for radium-226 (Ra-226) and thorium-230 (Th-230), and 50 pCi/g for uranium-238 (U-238) (all above background averages). Approximately 5,100 cubic yards (yd^3) of contaminated material (in-situ) were removed from the western end of SLAPS under this action and transported off-site. Backfilling of the excavation was completed in December 1997.

A rail spur was installed on SLAPS in 1998 to provide a load out area and staging area for shipment of contaminated materials to off-site disposal or recycling locations. About 3,000 yd^3 of contaminated soil was shipped off-site in 1998.

A sedimentation basin was constructed in 1999 at the west end of SLAPS to control surface-water runoff. The basin is lined with an impermeable liner to prevent ground-water infiltration and recharge in this area of SLAPS.

During 2000 and 2001, removals were conducted in the eastern portion of SLAPS and at the barium/radium pits. Removal of approximately 20,600 m^3 (27,000 yd^3) of contaminated soils from the East End of SLAPS was completed in February 2000 under the 1998 SLAPS EE/CA (USACE, 1998a). In November 2000, USACE completed excavation of approximately 38,100 m^3 (49,800 yd^3) of contaminated soils from the Radium Pits area and began the first phase of the East End Extension removal action. The East End Extension includes the areas of contaminated soil between the Radium Pits and the East End and in the drainage ditch immediately south of McDonnell Boulevard. By Fall 2001, approximately 45,900 m^3 (60,000 yd^3) had been removed from portions of the East End Extension. Removal of contaminated soils located in the central portion of SLAPS, referred to as Phase 1, was initiated in Fall 2001 and continued through 2002. Phase 1 is expected to be completed by May 2003. A total of 74,200 m^3 (97,000 yd^3) will have been removed from the Phase I area. To date, all material has been shipped to properly permitted or licensed off-site disposal facilities.

2.2.1.2 Description of SLAPS VPs

SLAPS VPs consist of approximately 78 properties along the roads and rail line transportation routes, Coldwater Creek, and the open fields immediately north of SLAPS (the former ballfield area). These properties were formally designated by the U.S. Department of Energy (DOE) as VPs based on preliminary characterizations. Locations for these properties are shown in Figure 2-11. Based on the results of additional characterization activities by the United States Corps of Engineers (USACE), additional properties along Coldwater Creek may require remediation. This FS is intended to address all properties at the North County Site determined to be impacted by contaminants resulting from uranium manufacturing or processing activities conducted at SLDS. The contiguous properties surrounding SLAPS were grouped into IAs for the Science Applications International Corporation (SAIC) 1999 study. These were designated

as IAs 8 through 13, as shown on Figure 2-9. These properties are located within the City of Hazelwood, the City of Berkeley, the airfield owned by the City of St. Louis, and on property controlled by Boeing, Inc.

Radioactive contamination of the VPs occurred as a result of contaminated soil spillage from transport vehicles and by erosion and subsequent deposition of residual and waste stockpiles. Additionally, road and underground utility construction and Coldwater Creek flooding and sediment transport have resulted in the spread of contamination into adjacent areas.

The affected transportation routes include Eva Avenue, Frost Avenue, Hazelwood Avenue, McDonnell Boulevard, Pershall Road, and their frontage properties. For the most part, these sites are located within the City of Berkeley. However, Pershall Road, the north side of McDonnell Boulevard, and a portion of Hazelwood Avenue are within the City of Hazelwood. These routes are referred to as the haul roads. They were likely used during transfer of uranium-bearing residuals from SLDS to SLAPS, from SLAPS to HISS/Futura, from SLAPS to areas out of the region, and from HISS/Futura to sites out of the region.

Coldwater Creek flows for 153 m (500 ft) along the western border of SLAPS. The creek originates 5.8 km (3.6 mi) to the south and continues for 24 km (15 mi) in a northeasterly direction to the Missouri River. Coldwater Creek continues through Hazelwood, Florissant, and unincorporated areas of the county, and along the northern edge of the unincorporated community of Black Jack, until it discharges into the Missouri River. The creek, except for 1.2 miles under the Lambert-St. Louis International Airport, is generally accessible to the public (SAIC, 1992). The Missouri Department of Natural Resources (MDNR) has classified a portion of Coldwater Creek as a Class C waterway. Class C waterways are streams that may cease to flow in dry periods, but maintain permanent pools that can support aquatic life. Flooding occurs annually along the creek. This section of Coldwater Creek is protected for livestock and wildlife watering and aquatic use (from the intersection with U.S. 67 downstream to the mouth of the creek at the Missouri River).

A 1982 radiological characterization indicated that the ditches that drain to Coldwater Creek (BNI, 1983) contained radiological contamination levels exceeding cleanup guidelines being used at the time.

In December 1984, a mobile gamma scanning survey of potential transportation routes between SLAPS and HISS/Futura found anomalies on Hazelwood Avenue, McDonnell Boulevard, and Pershall Road (ORNL, 1985). Gamma exposure rates of up to 90 microroentgen/hour (μR/h) were found on the surface of McDonnell Boulevard. As a result, sampling along these roads was initiated to determine the concentrations of FUSRAP radionuclides. In 1985, a radiological survey of Hazelwood Avenue, McDonnell Boulevard, and Pershall Road (ORNL, 1986a) found Th-230 to be the contaminant present in soil in the highest concentrations.

Removal actions have been conducted in the North Ditch between McDonnell Boulevard and the former ballfield area. Excavation and disposal of about 11,300 yd^3 (ex-situ) of contaminated materials from the soils in the ditch on the north side of McDonnell Boulevard was performed as a removal action. The North Ditch removal areas are shown in Figure 2-10.

During 2000, approximately 5,400 m^3 (7,100 yd^3) of contaminated soils were excavated from a portion of VP-38, a haul road vicinity property located at the northwest corner of Latty Avenue and Hazelwood Avenue.

2.2.1.3 Description of Latty Avenue Properties

The Latty Avenue properties, which include HISS, Futura Coatings, and eight VPs [designated 1 (L) – 6(L), 40A, and 10k530087on Figure 2-11] are 1.2 km (0.75 mi) northeast of SLAPS. Key features of the HISS/Futura properties, located at 9200 Latty Avenue, are shown on Figure 2-12. These properties cover a 4.5-ha (11 acre) tract. The HISS and Futura (HISS/Futura) properties are in the City of Hazelwood. The VPs lie mostly within the City of Berkeley.

From 1966 to 1973, HISS/Futura was used to store radioactive material purchased from the AEC. In the 1960s, a private corporation, CMM, purchased the ore residues and the uranium process wastes being stored at SLAPS. The material was purchased for private commercial purposes including the planned extraction of the radioactive and other metals. The transfer and storage activities were licensed by the AEC. By the time CMM obtained their license, extracting the uranium on-site at SLAPS had been ruled out in favor of moving the material to HISS/Futura. The conditions of CMM's license specified that it was for the removal of the stockpiled residues from 50 Brown Road (SLAPS) and storage only at the licensee's facility at 9200 Latty Avenue. Although CMM had applied to the AEC for a license to allow processing of the materials, the AEC required additional process information before they would amend the license to allow processing. CMM never provided the necessary information to the AEC. The material purchased included:

- 74,500 tons of pitchblende (Congo) raffinate cake (AM-7) containing 113 tons of uranium;
- 32,500 tons of Colorado raffinate cake (AM-10) containing 48 tons of uranium;
- 8,700 tons of leached barium sulfate cake (AJ-4 – also sometimes called barium cake) containing 7 tons of uranium;
- 1,500 tons of unleached barium sulfate cake (AJ-4) containing 22 tons of uranium; and
- 350 tons of miscellaneous material in drums containing 2 tons of uranium.

These residues were removed from SLAPS and placed directly on the ground at HISS/Futura.

The Commercial Discount Corporation of Chicago (CDC) purchased the residues from the CMM in January 1967, dried, and shipped a majority of them to Cotter Corporation facilities in Canon City, Colorado. CDC applied for and was granted an AEC license to possess (and store) the material. Later the AEC amended CDC's license to allow them to "condition" the material by drying (to 15% moisture), load it into rail cars, and ship the dried material to Cotter's facility. Other remaining residuals at HISS/Futura were sold to Cotter Corporation in 1969. These residues included 10,000 tons of Colorado raffinate cake (raffinate cake generated when Colorado ore was substituted for pitchblende) and 8,700 tons of leached barium sulfate. In 1970, Cotter Corporation dried and shipped some more of the Colorado raffinate to its mills in Canon City. Cotter's activities in Colorado were covered by a separate license issued by the state of

Colorado. In 1973, Cotter shipped the remaining undried Colorado raffinate cake to Canon City and transported the leached barium sulfate, mixed with topsoil, to the Westlake Landfill in western St. Louis County. Cotter informed the AEC of this activity in early 1974. Westlake Landfill is not within the scope of this FS, and is being addressed by EPA and others in a separate action.

The first investigation of the Cotter property at Latty Avenue (now HISS/Futura) occurred on June 22-24, and August 11, 1976. During this investigation only four samples were collected at the Latty site. Of these, the two soil samples were analyzed for "natural uranium" and Ra-226. This information is included in the U.S. Nuclear Regulatory Commission (NRC) inspection report dated (approved) January 5, 1977.

In July 1977, a more detailed survey of HISS/Futura was conducted by the Energy Research and Development Administration (ERDA) on behalf of the NRC. The NRC report entitled "Preliminary Report on the Results of a Radiological Survey Conducted at the Former Cotter Property", produced by ERDA, contains the concentrations of radionuclides in soil samples taken inside and near buildings (at what is now Futura) (ERDA, 1977). A total of 12 samples were taken and analyzed for Ra-226, U-238, and actinium (Ac-227). The ERDA report indicates that a limited number of samples would be analyzed for Th-230, but at the time of the Preliminary Report, this had not yet occurred. It should be noted that "inside buildings" is the correct description for some of the samples since the largest building (where the drying operation took place) originally had a dirt floor.

Ranges of concentrations reported in the ERDA report were:

Ra-226	3 – 2,700 pCi/g
U-238	2.1 – 1,100 pCi/g
Ac-227	1.3 – 1,300 pCi/g

In June 1977, Jarboe Realty and Investment purchased the buildings and grounds on Latty Avenue (now HISS/Futura). The property was leased to Futura to prepare the site for commercial use. One existing building was demolished, the property was excavated and leveled, several areas were paved, three new buildings were erected, and a 1.4-ha (3.5 acre) tract of land surrounding the area was cleared.

Since the removal of the residues by CDC and Cotter, several developmental activities have resulted in the generation of contaminated soil storage piles at HISS and an adjacent property. The first interim storage pile at HISS was created in 1979 when 9,900 cubic meter (m^3) (13,000 yd^3) of contaminated soil and material was moved from the adjacent Futura parcel to the eastern half of HISS to allow construction of a manufacturing facility to proceed. In 1984, Bechtel National, Inc. (BNI) performed cleanup activities at the property at 9200 Latty Avenue that resulted in the storage of 10,700 m^3 (14,000 yd^3) of contaminated soil in the main pile at HISS. In 1986, DOE directed BNI to provide radiological monitoring support for work involving drainage and street improvements along Latty Avenue. As a result of these efforts, 3,500 m^3 (4,600 yd^3) of contaminated soil was added to a supplemental storage pile at HISS. In 1996, additional storage piles (the East Piles) were created when the owner of the property, General Investment Funds Real Estate Holding Company (GIFREHC), made commercial parking and drainage improvements on the property to the east of HISS and consolidated the excavated

material into two piles on the southwest portion of Latty Avenue VP 2L. In early 1999, two additional spoils piles (Piles A and B) were created when the rail spur was installed at HISS.

Additional characterization of the main and supplemental HISS piles was conducted in 1997. The sampling was done to characterize the distribution of radiological and chemical contamination in the piles, identify the presence of any mixed waste, and support the evaluation of cleanup alternatives. The removal of all the existing storage and spoil piles shown on Figure 2-12 was conducted during 2000 and 2001 under an approved EE/CA (USACE, 1998b). Preparations included construction of a railroad spur along the eastern boundary of HISS that was completed in early 1999. Removal of 12,200 m^3 (15,900 yd^3) of contaminated soil and debris comprising the East Piles and Spoils Piles was completed in May 2000. In October 2000, USACE removed approximately 5,400 m^3 (7,100 yd^3) of material from the Supplemental Storage Pile. Work on the removal of the Main Pile began in Fall 2000, and by Summer 2001, approximately 15,300 m^3 (20,000 yd^3) of contaminated soils and debris had been loaded onto railcars for transport to an out-of-state disposal facility. Removal of the Main Pile began in September 2001. By the end of October 2001, a total of approximately 44,300 m^3 (58,000 yd^3) of material had been removed from HISS.

Currently, the Futura Site is the location of a coatings manufacturing facility that is known to generate Resource Conservation and Recovery Act (RCRA) listed wastes. Any future remediation activities on the Futura Site will evaluate the presence of listed waste with any radiological waste associated with uranium manufacturing or processing activities at SLDS. To date no evidence exists that listed wastes are co-located with the FUSRAP-related wastes. It is recognized that the presence of radiological waste mixed with listed waste may severely impact USACE's ability to treat and dispose of this waste as well as add considerable cost to the remediation of the Futura Site.

2.2.2 Meteorology

The climate of the St. Louis area is characterized as warm and moist in summer and cold and dry in winter. The region is dominated by warm, moist maritime tropical air masses, which flow northward from the Gulf of Mexico region during the summer and by colder, drier polar air masses, which drift down from the Canadian Provinces during the winter. Climatological and meteorological data from the Lambert-St. Louis International Airport over a 30-year period are summarized in Table 2-2.

In general, southerly and northwesterly winds dominate the wind regime of the St. Louis region. Southerly winds predominate from May through November, and northwesterly winds predominate from December through April. Annual normal monthly high and low temperatures are 31°C and -5°C (88°F and 23°F), respectively. The area averages 91 centimeters (cm) [36 inches (in)] per year in total (water equivalent) precipitation (i.e., rainfall plus water content of melted snowfall). Average annual snowfall is roughly 66 cm (26 in).

The tornado is the most common form of severe weather observed in this region. From 1916 through 1985, 52 recorded tornadoes occurred in the St. Louis metropolitan area. Based on records obtained from 1953 to 1990, Missouri is ranked seventh nationally in the occurrence of tornadoes and averages 11 tornado and 27 storm days per year (NOAA, 1990).

Tropical hurricanes, storms, and disturbances are much less frequent than tornadoes. Between 1886 and 1986, only eight tropical storms have crossed within a 2 × 2 degree (latitude and longitude) box centered on the St. Louis area (Tropical Cyclone Data Tape-TD9267). The consequences of such storms in the St. Louis area result in heavy rains and flooding rather than destructive winds.

Ambient air quality and the conditions for air emission control are at their worst on summer mornings in the St. Louis area because of the pattern of strong temperature inversions at night. These results reflect atmospheric stability and mixing height. Table 2-3 summarizes the seasonal distribution of stability classes [after Pasquill (1961) and Gifford (1961)] and morning and afternoon mixing heights for the St. Louis region. Three stability classes (D, E, and F), which represent neutral to stable conditions, are relatively evenly distributed for the St. Louis region with each occurring roughly 28 percent of the time on an annual basis (O'Donnell, 1981). Class D stability is associated generally with cloudy and moderately windy conditions, which tend to counteract surface layer stratification. Classes E and F are indicative of inversion conditions and occur during cool, clear nights under low to calm wind speeds. The resulting dense air trapped near the ground resists vertical mixing and creates poor dispersion conditions. The mixing height is the depth of the atmosphere over which a pollutant release will be effectively dispersed. Thus, relatively low mixing heights give rise to higher surface level concentrations due to reduced vertical mixing.

Table 2-2. Climatological and Meteorological Conditions at the Lambert-St. Louis International Airport, St. Louis, Missouri

	Temperature (°F)						
	Normal			Extreme			
Month	**Max**	**Min**	**Avg**	**High**	**Year**	**Low**	**Year**
January	39.9	22.6	31.3	76	1970	-14	1977
February	44.2	26.0	35.1	85	1972	-10	1979
March	53.0	33.5	43.3	88	1963	-5	1960
April	67.0	46.0	56.5	92	1970	22	1975
May	76.0	55.5	65.8	92	1978	31	1976
June	84.9	64.8	74.9	98	1971	43	1969
July	88.4	68.8	78.6	107	1980	51	1972
August	87.2	67.1	77.2	105	1980	47	1965
September	80.1	59.1	69.6	100	1971	36	1974
October	69.8	48.4	59.1	94	1963	23	1976
November	54.1	34.9	45.0	82	1978	1	1964
December	42.7	26.5	34.6	76	1970	-10	1976
Annual	88.4	22.6	55.9	107	1980	-14	1977

	Precipitation (in)			Relative Humidity (%)				Wind	
Month	**Max**	**Min**	**Avg**	**12 a.m.**	**6 a.m.**	**12 p.m.**	**6 p.m.**	**Speed (mph)**	**Dir**
January	5.38	0.22	1.85	78	83	66	71	10.4	NW
February	4.17	0.25	2.06	78	82	63	66	10.9	NW
March	6.67	1.09	3.03	75	82	59	60	11.9	WNW
April	9.09	0.99	3.92	71	79	55	53	11.5	WNW
May	7.25	1.02	3.86	76	83	56	56	9.4	S

Month	Precipitation (in)			Relative Humidity (%)				Wind	
	Max	Min	Avg	12 a.m.	6 a.m.	12 p.m.	6 p.m.	Speed (mph)	Dir
June	8.65	0.47	4.42	78	84	56	55	8.8	S
July	10.71	0.60	3.69	78	86	57	56	7.9	S
August	6.44	0.08	2.87	81	89	57	58	7.6	S
September	6.21	Trace	2.89	82	91	59	61	7.9	S
October	5.77	0.21	2.79	77	86	55	60	8.7	S
November	5.74	0.44	2.47	78	85	63	68	9.9	S
December	6.50	0.32	2.04	81	85	69	74	10.3	WNW
Annual	10.71	0.08	2.99	78	84	60	62	9.6	S

Source: *Local Climatological Data*, Annual Summary with Comparative Data (NOAA, 1981).

Table 2-3. Seasonal Distribution of Stability Classes and Mixing Heights for the St. Louis, Missouri Area

Season	Mixing Height (m)		Stability Class (%)					
	a.m.	p.m.	A	B	C	D	E	F
Winter	500	900	0.0	0.8	5.9	30.8	39.6	22.9
Spring	500	1600	0.6	4.9	9.5	29.1	32.2	23.7
Summer	300	1700	1.8	10.0	16.8	27.1	11.0	33.3
Fall	400	1400	0.1	3.3	9.5	24.5	29.5	33.1
Annual	400	1400	0.6	4.8	10.5	27.9	28.0	28.2

[a] Adapted from O'Donnell (1981).
[b] Mixing heights interpolated from maps generated by Holzworth (1972).

2.2.3 Surface-water Hydrology

Coldwater Creek: Coldwater Creek is the main drainage for the North County Site. Coldwater Creek and tributaries are shown in Figure 2-13. The creek is classified by MDNR as a Class "C" waterway downstream of SLAPS, for 5.5 miles from the mouth of the creek to its first intersection with Lindbergh (Section C as shown on Figure 2-14). Class C means there are periods of no flow in the creek, but permanent pools are always present. Coldwater Creek, the main surface-water drainage for SLAPS, flows through the Florissant Basin, a shallow, oval-shaped depression filled with glacial lake sediments. The stratified sands, silts, and clays filling the basin can be up to 30 m (100 ft) deep and are often covered by a layer of loess 1.5 to 7.6 m (5 to 25 ft) thick. The basin is approximately 16 km (10 mi) long on its north-south axis and 5.6 km (3.5 mi) wide on its east-west axis. The basin is bounded on the north and west by the steep bluffs of the Missouri River and on the south and east by rolling upland. The basin is nearly flat with slopes of less than 5 percent and elevations ranging from 120 to 220 m (400 to 720 ft) above mean sea level (MSL). The highest point in the watershed is located at the headwaters near Overland located approximately 6 km (4 mi) southwest of SLAPS. The lowest point is located where Coldwater Creek discharges into the Missouri River, approximately 24 km (15 mi) northeast of the SLAPS property.

Coldwater Creek empties into the Missouri River at River Mile 7 (Creek Mile 0). The creek is the primary surface-water feature in the airport area but is not used for municipal drinking water. The closest municipal water intakes are located on the Mississippi River approximately 8 km (5 mi) downstream of where the Missouri River discharges into the Mississippi River (BNI, 1992a), or 20 km (12 mi) from the mouth of Coldwater Creek.

The main channel of Coldwater Creek is 31.5 km (19.5 mi) long and has relatively short tributary streams. SLAPS is at Creek Mile 13.8, and HISS is at Creek Mile 12.9. At McDonnell Boulevard, which forms the northern boundary of SLAPS, the drainage area is 32 square kilometers (km^2) [12 square mile (mi^2)] (Hauth and Spencer, 1971). Coldwater Creek, which originates south of SLAPS, generally flows north between the cities of Overland and Florissant and then east to the Missouri River. Just up-gradient (south) of SLAPS, the creek flows in culverts under the Lambert-St. Louis International Airport. The total watershed area of Coldwater Creek is 120 km^2 (47 mi^2). The annual average flow rate of Coldwater Creek (SAIC, 1993b) is 41 ft^3 per second or equivalent to 100 million liters per day (L/d) [65 million gallons per day (gpd)].

Flooding in Coldwater Creek occurs annually. Most of the flooding results from short-term, high-intensity thunderstorms that cause flash floods. The portion of the Creek beneath the airport is buried within a concrete culvert. Coldwater Creek is the recipient of surface-water/storm-water drainage from Lambert-St. Louis International Airport. For purposes of analysis the creek has been divided into three sections: A, B, and C. Section C of Coldwater Creek, as shown on Figure 2-14, is protected for livestock/wildlife watering and aquatic-life usage (from the intersection with Lindbergh downstream to the mouth of the creek at the Missouri River).

The water quality in Coldwater Creek is generally poor. Studies of aquatic life (SAIC, 1999) indicate that the stream ecology is severely impacted. The nature of pollution causing this impact is not definitively known but is believed to result from storm-water runoff (i.e., salt, oil, antifreeze, jet fuel, etc.). In addition, high ammonia levels and low levels of dissolved solids have been detected downstream from the Metropolitan Sewer District (MSD) sewage treatment plant (Ford, 1992; USACE, 1987a). Pollutants enter the stream in storm water from commercial and industrial facilities, residential areas, and the Lambert-St. Louis International Airport. SLAPS runoff also flows into Coldwater Creek. More than a dozen facilities that are permitted under the National Pollutant Discharge Elimination System (NPDES) program discharge directly into the stream, including Ford Motor Company, Lambert-St. Louis International Airport, and the McDonnell Douglas Corporation. These discharges include storm-water runoff, cooling water discharge, water treatment, airport deicing, and manufacturing runoff. USACE currently holds an NPDES permit to discharge water runoff at HISS into the sewer system that ultimately empties into Coldwater Creek. There also is a storm-water permit for HISS. Discharges to the Publicly Owned Treatment Works (POTW) from the North County Site are subject to the provisions of the MSD.

SLAPS Drainage: From the 1970s when the site was closed until recently when removal actions were started, drainage ditches located along the northern and southern boundaries of SLAPS drained the west end. Drainage from the central and eastern ends of the site and a portion of the former ballfields was directed beneath McDonnell Boulevard and flowed west to Coldwater Creek in a drainage ditch located adjacent to the north side of McDonnell Boulevard. A drainage ditch flowing northward through the ballfields conveyed surface-water run off from the eastern end of SLAPS and eastern portions of the ballfields to Coldwater Creek.

Implementation of the non-time critical removal actions as described in the previously mentioned EE/CA has changed these drainage patterns. Contaminated soils have been excavated

along the northern, southern, and western boundaries of the site that are drained by the first two of the indicated ditches. Stabilized drainage ways have been constructed along the northern and southern boundaries of the site to convey the run off currently captured by the first three ditches into a sedimentation basin that has been constructed along the western boundary of SLAPS. The primary outfall (Outfall 001a) from this basin to Coldwater Creek is at its south end. An emergency overflow spillway is located at the northwest corner of SLAPS.

2.2.4 Geology and Soils

SLAPS, HISS/Futura, and the other North County areas are situated on a modest upland area between the Missouri and Mississippi River floodplains in northern St. Louis County. The upland area surrounds a topographic depression known as the Florissant Basin. Pleistocene sediments and recent fill overlies shale and limestone bedrock. Faulting is not evident at the site, and bedrock at depth appears to be almost flat. The soils over the North County Site are predominately silty deposits that originated from former glacial advances, historical Missouri and Mississippi River flooding, and more recent fill activities.

2.2.4.1 Regional Geology

The North County Site lies within the Dissected Till Plains Section of the Central Lowlands Province of the Interior Plains Division (Fenneman, 1938). The region surrounding the Missouri and Mississippi Rivers is characterized by mature topography with short, steep valleys draining into large streams. In other areas, stream development is distinct; floodplains are broad, and streams are flood-prone. In some cases, streams may follow buried, preglacial channels (Stohr, St. Ivany, and Williams, 1981). In the vicinity of SLAPS and HISS/Futura, the channel of Coldwater Creek follows the path of an ancient channel buried by glacial sediments. The present surface topography in the area is essentially flat.

2.2.4.2 Stratigraphy

A generalized stratigraphic column for the St. Louis area is shown in Figure 2-15. The stratigraphy of the area consists of 10 to 30 m of Pleistocene sediments and recent fill overlying Desmoinesian shale, and Chesterian, and Meramecian limestone bedrock. Figure 2-16 shows a generalized surficial geologic map of the St. Louis area including the approximate western limit of Illinoisan glaciation. The approximate southern limit of Kansan and Nebraskan glaciation was just north of the Missouri River (Howe and Koenig, 1961).

Mississippian System

Meramecian Series: The Meramecian Series consists of three formations: Warsaw, Salem, and St. Louis. These formations, with the exception of the Warsaw whose upper part in eastern Missouri is shale, are composed mainly of limestone and some dolomite. Chert is not common but does occur in all of the formations. All three formations are present in east central Missouri, which is regarded as the type area (i.e., has typical features) for the St. Louis Formation. Warsaw and Salem are the only formations of this series that have been definitely identified in central Missouri. Limestones of the Mississippian System are reported subject to the development of karst features in the St. Louis area (Goodfield, 1965). The Warsaw and Salem Formations are not covered in the following discussion because they do not occur as bedrock near SLAPS and HISS.

St. Louis Limestone: The St. Louis Limestone reaches its greatest thickness and displays all of its stratigraphic features at its type area in St. Louis County and in adjacent parts of east-central and southeastern Missouri. Here, the formation is a gray, lithologic to finely crystalline, medium- to massively-bedded limestone as much as 300 m (1,000 ft) thick. Limestone breccia is common in, but not necessarily confined to, the lower part of the formation. Shale occurs as a matrix between the blocks of breccia. Blue and bluish-gray shales also form thin beds throughout the formation and increase in abundance in the northeastern part of the state. Chert is uncommon, and parts of the formation are locally dolomitic.

The compound corals *Lithostrotionella castelnaui* and *Lithostrotion proliferum* are considered to be diagnostic, and the coral *Syringopora* is common. The contact between the St. Louis and Salem Formations appears to be gradational. Limestone from the St. Louis Limestone is quarried in the St. Louis area for manufacturing cement and aggregate.

Chesterian Series

Ste. Genevieve Limestone: The Ste. Genevieve Limestone overlies the St. Louis Limestone and is typically present in the east-central and southeastern parts of Missouri in Ste. Genevieve and St. Louis counties , as well as eastern Perry County. It is also present in adjacent parts of Illinois and Kentucky, where it has been subdivided into members. In the St. Louis area, the Ste. Genevieve is a white, massively bedded, sandy clastic limestone. It is generally coarsely crystalline and oolitic but also contains a few beds of finely crystalline limestone. Fossils are irregularly distributed throughout the formation. The lower part of the formation contains layers of chert, as well as lenses and beds of sandstone. The lithology of Ste. Genevieve changes laterally, which makes individual units difficult to trace.

The formation is 9 m (30 ft) thick in St. Louis County. Its unconformable contact with the underlying St. Louis Limestone is marked by a basal conglomerate, and solution channels are present in numerous places. A significant erosional surface marks the top of the Ste. Genevieve Limestone.

At the North County Site, the Ste. Genevieve formation is overlain by either beds of the Pennsylvanian System or Pleistocene deposits. The Ste. Genevieve and (underlying) St. Louis Limestones were confirmed as the bedrock beneath SLAPS by examining 4.5 m (15 ft) of rock core sample from MW-35.

Pennsylvanian System

Atokan Series: Searight and Howe (Howe and Koenig, 1961) have provided a description of this series. They found that “Fossil evidence indicates the presence in Missouri of pre-Desmoinesian rocks which are assignable to the Atokan age. The lowermost of these rocks are the Cheltenham clays of eastern Missouri…"

Desmoinesian Series: The Cherokee and Marmaton Groups compose the Desmoinesian Series.

Cherokee Group: This group consists of all the strata included in the Krebs and Cabaniss Subgroups. The Krebs Subgroup is made up of sandstone, siltstone, shale, limestone, and coal beds. In many places, the Krebs consists predominately of sandstone.

The strata in the Cabaniss Subgroup consist of sandstone, siltstone, shale, underclay, limestone, and coal beds. These strata occur in 12 widely recognized successions, each of which (with certain exceptions as noted in formational descriptions elsewhere) is a cyclic unit that includes a coal bed at the top. Each succession has been named and is treated as a formation. The Lagonda Formation, which constitutes most of the Cherokee Group in the area of the North County Site (Saeger, 1975), consists of shales that are locally sandy and micaceous. Interbeds of sandstone and siltstone that are up to 3 m (10 ft) thick, plant remains, and fossils may also be present.

Marmaton Group: The Marmaton consists of a succession of shale, limestone, clay, and coal beds with more abundant limestone units that are thicker and more laterally continuous than in the Cabaniss Subgroup. The Marmaton Group in Missouri is divided into the Fort Scott and Appanoose Subgroups.

The Missourian Series does not underlie SLAPS. Any younger Mesozoic and Tertiary sediments that may have been deposited in the St. Louis area have been removed by erosion.

Post-Paleozoic (Soil) Sediments

Plio-Pleistocene sediments, which overlie Paleozoic deposits in the SLAPS and HISS area, consist of clay, silt, sand, and gravel that were deposited by glacial, alluvial, lacustrine, and eolian processes (Howe and Koenig, 1961). These sediments were deposited during several glacial stages and associated interglacial stages. From oldest to youngest, these glacial stages are Nebraskan, Kansan, Illinoisan, and Wisconsinan. The interglacial stages, which are characterized by the development of soil horizons, are not described in the following sections because of their limited occurrence.

Pre-Illinoisan Deposits: The complex nature of pre-Illinoisan sedimentation makes time, stratigraphic, and lithostratigraphic correlations difficult (Richmond and Fullerton, 1986). Deposits in the City of St. Louis area reach a maximum thickness of 13 m (42 ft), because most of the sediments in St. Louis were deposited during the pre-Illinoisan stage.

Illinoisan Stage: The Loveland Loess is the only recognized deposit associated with Illinoisan glaciation. This loess in the St. Louis area is composed of medium- to coarse-grained, noncalcareous silt. The unit reaches a maximum thickness of 6 m (20 ft) in St. Louis County.

Wisconsinan Stage: Deposits associated with Wisconsinan glaciation consist of several loess units. The Roxana Silt and the Peoria Loess are the most widespread glacial units in the St. Louis area. Both units are composed of well-sorted, medium to coarse silt with some sand. The Peoria Loess also contains occasional carbonate and manganese nodules and limonite tubes. The Peoria Loess reaches a maximum thickness of 15 m (50 ft) in the St. Louis area and is probably the uppermost sedimentary unit at SLAPS.

2.2.4.3 Structural Development

Lateral tectonic forces from the southwest created most of the faulting and folding in Missouri. As a result, the structural grain of basement crystalline rocks is aligned in a predominately northwest/southeast pattern. Numerous investigators (such as McCracken, 1971) have described a subordinate northeast/southwest structural pattern. The presence of these patterns is important in understanding the geologic and structural history of the region. The orientation of fractures in bedrock underlying SLAPS is expected to be similar to the predominant regional structural orientation.

The Ozark uplift, a region of repeated upward movement, is south of the City of St. Louis. Six episodes of regional deformation that resulted from continued uplift have been identified. The initial and most intense structural deformation episode occurred in the Precambrian era. In response to this tectonic activity, extensive block fault systems developed along northwestern-trending lineaments (McCracken, 1971).

Northwest of the St. Louis area, the Cap Au Gres fault system developed in response to the second episode of Ozark uplift in mid-Ordovician time, continued with deformation in the Devonian era (third episode), and culminated with minor deformation in the pre-Pennsylvanian period (fourth episode). Vertical movement of the Cap Au Gres fault created the Lincoln fold and a broad asymmetrical anticline known as the Eureka-House Springs anticline. Developed above a Precambrian lineament, the Eureka-House Springs anticline trends northwest to southeast and is approximately 24 km (15 mi) southwest of SLAPS. The fifth Paleozoic deformation period occurred at the end of the Pennsylvanian period (McCracken, 1971) in conjunction with movements along existing fault systems in the Precambrian basement. Rejuvenation of uplift in the Ozark region (sixth episode) with differential depression of the Mississippi Embayment occurred in pre-Pliocene time. Only minor movements along existing structures have been attributed to this final episode. Intermittent uplift appears to be continuing, as evidenced by entrenched meanders and Pleistocene terrace remnants.

Folding of bedrock formations was minimal. Steeply dipping beds are restricted to the immediate vicinity of faults, and the regional dip of strata is generally less than three degrees.

The St. Louis fault developed as an offset of secondary stress feature in response to the Ozark tectonics. The present course of the Mississippi River parallels this structural feature. The Dupo-Waterloo anticline and the Cheltenham syncline of East St. Louis and Illinois also parallel this structure. The convergence of these two regional features has created the Florissant Dome.

The Florissant Basin has formed independent of these features. Faulting is not evident at the site; bedrock at depth appears to be almost flat, dipping 11 m/km (60 ft/mi) to the north-northeast to the Cheltenham syncline, which formed because of the tectonic episodes related to the Ozark uplift. The Florissant Basin consists of variable thicknesses of unconsolidated Pleistocene sand, silt, and clay deposited on Paleozoic bedrock. These deposits represent a wide variety of origins, including glacially derived outwash and aeolian-deposited loess and alluvial deposits of the Mississippi and Missouri River systems.

The Florissant Basin was created through erosion of the bedrock surface by a tributary of the Mississippi River (Goodfield, 1965). The river and tributary were blocked by glacial advance during the Illinoisan period, creating a lake. As a result, sediment-laden waters flowed into the areas from the northeast, slowly filling the former tributary channel that cut into the top of the bedrock surface. During the subsequent glacial readvance of 10,000 to 15,000 years, a loess cover blanketed the lake sediments.

This depositional history is supported by the fine texture and lithology of the lacustrian (lake) sediments observed in soil borings from the basin and by the very flat nature of the topography. Correlation of terrace remnants in the basin northeast of the study area with high-level (flow) terrace remnants at the same elevation along the Mississippi, Missouri, and Illinois Rivers also supports this theory of origin.

The North County Site is in a tectonically inactive region about 150 miles from the tectonically active New Madrid seismic zone. A search of reported seismic events from 1795 to 1984 found 31 events of intensity III through VII on the Modified Mercalli intensity (MMI) scale within a 50-km (30-mi) radius around St. Louis (Weston, 1979; BNI, 1992a). An earthquake of intensity VII may cause structural damage, but no surface faulting would result.

2.2.4.4 Soil Development

The soil types mapped over SLAPS, HISS, and adjacent areas by the Soil Survey of St. Louis County and St. Louis City, Missouri (USDA-SCS, 1982), are predominantly the Nevin silt loam, the Nevin-Urban land complex, and the Menfro silt loam. According to the Unified Soil Classification System (USCS), a silt loam texture would be considered an ML and a silty clay loam would be a CL classification. A CL classified soil has higher clay content than an ML classification.

The Nevin silt loam is a nearly level, somewhat poorly drained soil located in moderately wide to wide depressional (formerly glacial lake) basins on uplands. This loam has formed in silty loess and lacustrine deposits. The Menfro silt loam is a gently to moderately sloping, well-drained soil located on ridge tops and side slopes of uplands and has formed in loess deposits in these adjacent upland areas. The Nevin-Urban land complex consists of intermingled areas of native Nevin soils and disturbed soils that have been developed and built upon. The complex may have had fill material placed to improve surface drainage.

The Nevin silt loam soils and undisturbed areas of Nevin soils within the Nevin-Urban land complex typically have a very dark gray to black surface layer of silt loam approximately 28 cm (11 in) thick. The first subsurface layer is a very dark gray to black silt loam about 33 cm (13 in) thick. The subsoil is a mottled dark grayish-brown and yellowish-brown, silty clay loam and silt loam about 53 cm (21 in) thick. The substratum (parent material) to a depth of about 1.5 m (60 in) is light brownish-gray, mottled silt loam. The soil permeability is moderate, surface runoff is slow, and the available water capacity is very high. A seasonal high water table may be apparent at a depth of 0.6 to 1.2 m (2 to 4 ft) below the soil surface during winter and early spring if the soil is not frozen. The Menfro silt loam soils typically have a surface layer of brown silt loam about 18 cm (7 in) thick, a subsurface layer of brown silt loam about 15 cm (6 in) thick, and a subsoil of brown silty clay loam about 107 cm (42 in) thick. The substratum (parent material) to a depth of about 1.5 m (60 in) is yellowish-brown silt loam. The soil

permeability is moderate, and surface runoff is medium. This soil also has a very high available water capacity (USDA-SCS, 1982).

Soil borings completed across SLAPS penetrated predominantly the Nevin silt loam soil that has been relatively undisturbed over some of the site. Depths of disturbed soil and fill reportedly range from absent to approximately 4.3 m (14 ft) near where the drainage ditch that crosses the ballfields enters Coldwater Creek. A review of the soil boring data over most of the middle and eastern sections of SLAPS indicates predominantly undisturbed native Nevin soils with very thick black surface layers that are classified as mollic epipedons (indicative of soils formed under prairie grassland conditions). In this area of SLAPS, surface fill layers ranging from 0 to 60 cm (0 to 2 ft) thick consist of clayey subsoil materials which reportedly were placed over the site in an effort to "clay cap" the site. Other areas of SLAPS to the west and closer to Coldwater Creek reportedly encountered much thicker fill materials consisting of concrete, metal, asphalt, etc. Common, prominent soil drainage mottling was observed in the soil borings consistent with the soil survey description, and manganese stains and nodules and iron-cemented concretions were also present. The depth of the pedogenic (acted upon by current soil-forming processes) soil materials ranges from approximately 1 to 1.5 m (40 to 60 in), and below that, a mixture of silty loess and lacustrine deposits was encountered consisting of light brownish-gray silt loams (ML/CL) and silty clay loams (CL) with apparent zones of saturation.

Geotechnical analyses previously performed on SLAPS soil samples from a depth of 0 to 60 cm (0-2 ft) revealed that characteristics of the soils are consistent with reported values (USDA-SCS, 1982). Three of the four samples were from the Nevin silt loam, and one was from the Nevin-Urban land complex. The samples from the Nevin silt loam had liquid limits ranging from 34 to 35 percent and plasticity indexes of 13 to 14 percent. This agrees with reported values of 35 to 45 percent for liquid limits and 10 to 20 percent for plasticity indexes. One subsoil sample [collected from the 0.6 to 1.2 m (2 to 4 ft) depth interval] from the Nevin silt loam had values of 51 percent for liquid limit and 28 percent for plasticity index. Reported values for this interval are 40 to 50 percent for liquid limits and 20 to 30 percent for plasticity indexes. The sample from the Nevin-Urban land complex had a liquid limit of 35 percent and a plasticity index of 14 percent, which also agree with reported values. Data summarized in the soil survey indicate that soil permeability ranges from 1.5 to 5 cm (0.6 to 2 in) per hour in the 0 to 1.5 m (0 to 60 in) depth in both the Nevin and Menfro soils. The average available water capacity is approximately 0.2 inches per inch on a volume basis (USDA-SCS, 1982).

2.2.5 Hydrogeology

2.2.5.1 Greater St. Louis Area Ground Water

Water Bearing Bedrock Units: Miller et al. (1974) found that large amounts of water are stored in the bedrock and alluvium underlying the area. Water occurs in the bedrock along fractures and bedding planes as well as in solution openings in the bedrock. Shale is generally impervious to the movement of water and is usually not a source of supply. The availability of water from bedrock depends upon the amount of fracturing and solution which the rocks have undergone and the degree to which these openings are interconnected (Miller et al., 1974).

The water-bearing bedrock units are assigned to five groups in the City of St. Louis area based on similar lithologic characteristics, geographic distribution, and overall similarity of

water quality (Miller et al., 1974). Intervening, non-productive strata also create natural boundaries between water-bearing bedrock units. The division of the stratigraphic system into five groups is also pragmatic, because individual stratigraphic units typically do not have the yield or water quality to produce significant yields of high quality water. Therefore, wells for domestic production are usually open to large sequences of strata that correspond to the five major water-bearing stratigraphic groups.

Figure 2-17 provides the generalized hydrostratigraphic column for SLAPS and HISS/Futura. The five major groups are discussed from youngest to oldest (i.e., shallowest to deepest bedrock). Five major hydrostratigraphic aquifer groups present in the St. Louis area are described in the following paragraphs.

Group 1 (Post-Maquoketa) includes all soil and rock units above the Maquoketa Shale, which acts as a confining bed in the study area (St. Louis area). Pennsylvanian and Mississippian rocks (Ste. Genevieve, St. Louis Limestones) at the upper boundary of Group 1 are relatively impermeable and may yield very little water to wells. Mississippian limestones have yields from secondary permeability. All units of Figure 2-17 are within Group 1.

Group 2 (Kimmswick-Joachim) includes all aquifers between the base of the Maquoketa Formation and the base of the Joachim Formation. The Joachim is not considered to be a good aquifer in other parts of the state and, although it is not a confining bed, it probably does not yield water in quantities large enough for it to be considered an aquifer.

Group 3 (St. Peter-Everton) includes the St. Peter Sandstone and the Everton Formation.

Group 4 (Powell-Gasconade) includes all units in the Canadian Series of Early Ordivician age. The lower part of the Everton Formation and the upper three units of the Canadian (Powell, Cotter, and Jefferson City Dolomites) are not prolific water-bearing units. Small supplies can be developed in these units, but they are subject to failure during extended periods of drought or sustained pumping.

Group 5 (Eminence-Lamotte) includes all units below the base of the Gasconade Dolomite. The Eminence Dolomite is similar to the upper three units of the Canadian Series in its water-bearing characteristics and, hence, constitutes a good boundary marker between more prolific aquifers (Miller et al., 1974).

Miller et al. (1974) concluded that all bedrock units are locally capable of yielding water in varying amounts to wells. However, they noted that SLAPS and HISS are located within the portion of the region where ground-water yields for development of future high-yield water supplies is not recommended. This is because yields in the Post-Maquoketa and Kimmswick-Joachim are insufficient, and the deeper aquifers are saline (Miller et al., 1974).

Clearly, the most significant sources of drinking water in the St. Louis area are the Missouri and Mississippi Rivers, which supply nearly all of the water used in the area. “Little of the ground water in storage is used” (Miller, et. al., 1974). It is possible that low-yield residential, domestic wells can be installed in the Post-Maquoketa interval in the vicinity of SLAPS and HISS. This is the primary bedrock aquifer in the SLAPS and HISS area (Miller, et al., 1974).

Water Quality in the Group 1 (Post-Maquoketa) Aquifers

Water from Group 1 aquifers varies from a calcium-magnesium-bicarbonate type to a sodium-sulfate, sodium-bicarbonate, or a sodium-chloride type. The dissolved solids content is quite variable, ranging from 246 to 6,880 milligrams per liter (mg/L). The water is generally low in iron and very hard (Hem, 1970). Slightly more than 75 percent of the wells sampled (ninety-nine wells were analyzed) yielded water containing less than 0.3 mg/L of iron. Hardness of the water from most of the wells was greater than 180 mg/L. Fluoride content of the water is relatively high. In 50 percent of the samples, the fluoride content was greater than 1.4 mg/L (Miller et al., 1974). Miller et al. (1974) reported the following ground-water conditions:

> *"Just over 50 percent of the wells sampled yielded potable water. These wells are, for the most part, near the outcrop line of the Meramecian Series rocks (St. Louis, Salem, and Warsaw Formations) of Mississippian age, and, based upon the 25th percentile values, they yield predominantly calcium-magnesium-bicarbonate type of water. The higher dissolved-solids contents in water from Group 1 aquifers are from an area just north and northwest of the city of St. Louis in St. Louis County, and in extreme southeastern St. Louis County. Water in these areas generally is a sodium-chloride type, but it may also contain large amounts of calcium and sulfate. Variations in the predominant chemical characteristics between calcium-magnesium-bicarbonate type and the sodium-chloride type are presumably related to the effects of geologic structure, the movement of water from overlying or underlying formations into Group 1 aquifers, and to the presence of certain minerals in the parent rock.*
>
> *Water having a high sulfate content is, for the most part, limited to the area underlain by rocks of Pennsylvanian age. These rocks comprise shales, sandstones, and siltstones that locally have minor amounts of pyrite and gypsum. These fine-grained rocks are relatively impermeable; however, over a large area, they could yield enough seepage to explain some of the sulfate anomalies in the study area."*

2.2.5.2 Hydrostratigraphy of the North County Sites

Local Hydrostratigraphy at SLAPS

The geology of the St. Louis area was briefly summarized in Section 2.2.4. In the vicinity of SLAPS and HISS/Futura, surficial deposits (Unit 1) include topsoil and anthropogenic fill (rubble, scrap metal, gravel, glass, slag, and concrete). Figure 2-18 provides a conceptual sketch of shallow ground-water flow at SLAPS. Deeper ground-water flow cannot easily be inferred from site data, especially on the scale of the model.

Pleistocene loess and glacial lacustrine deposits underlie the fill (Units 2, 3, and 4). Unit 2 corresponds to loess. Unit 3, which is subdivided into subunits 3T, 3M, and 3B, consists primarily of clay and silt lacustrian (lakebed) deposits. Unit 4 consists of clayey gravel with increasing fine- to very-fine sand and sandy gravel near the bedrock contact.

Five hydrostratigraphic zones (HZs) have been identified beneath SLAPS on the basis of different ground-water flow and chemical characteristics. As would be expected, there is overlap

between the HZs and the stratigraphic units described above because the differing lithologies described above impart different hydraulic properties to the stratigraphy. The HZs are: HZ-A which corresponds to stratigraphic Units 1, 2, and 3T; HZ-B which corresponds to stratigraphic unit 3M; HZ-C which corresponds to stratigraphic Units 3B and 4; HZ-D which corresponds to shale Unit 5; and, HZ-E which corresponds to limestone bedrock Unit 6. In general, HZ-A through C have low vertical hydraulic conductivities ranging from 2.5×10^{-6} cm/s in HZ-A to 5.5×10^{-8} cm/s in HZ-B. The low hydraulic conductivities in these hydrostratigraphic units are regularly manifested by slow recharge rates in monitoring wells screened in them.

Refinements have been made to the conceptual site model based on additional geologic data and a re-evaluation of historical boring logs. The refinements were made in two principal areas: the continuity of the shallow stratigraphic units and the designation of ground-water flow vectors. The stratigraphic revisions focus on the thickness and continuity of Units 3B and 3M in the eastern portion of SLAPS. Unlike the previous conceptual models, Figure 2-18 shows the 3M Unit as continuous across SLAPS and Unit 3B as truncating against the edge of the shale slope. The upper boundary of Unit 3M is not easily differentiated from the base of 3T, but is inferred to be relatively flat due to the depositional environment and so is shown as a dashed line at the eastern edge of SLAPS where it overlies the shale (Unit 5). In addition, ground-water flow vectors are no longer depicted below the loess (Unit 2) because there is insufficient data concerning the magnitude of the gradient in Unit 3T. The majority of the flow in the upper flow regime is within the loess as opposed to the 3T unit, based on the geologic characteristics of Units 2 and 3T. The present conceptual model, although varying from earlier geometry, does not have a substantial hydrogeologic consequence.

Forty-eight ground-water wells were installed from 1979 to 1992 at SLAPS and surrounding properties. Seven of these were decommissioned in the fall of 1997 and in April 1998 (wells A, B, C, M13.5-8.5s, M13.5-8.5D, F and M11-21s). Four additional wells were installed in 1998. Four additional wells were installed in 1999, two just south of SLAPS and two at the west end of SLAPS.

Thirty-two monitoring wells penetrate HZ-A. These wells penetrate stratigraphic Units 1 and 2, but none penetrate the entire 3M Unit. Sixteen wells were finished beneath the 3M Unit. Fourteen are in the silty clay and clayey gravels of HZ-C (stratigraphic Units 3B and 4). Two were completed in HZ-D, the shale bedrock occurring beneath the eastern end of the site.

A potentiometric map for the shallow HZ-A was constructed based on water-level measurements made in December 1998 from wells near SLAPS and HISS/Futura (Figure 2-19). Ground-water flow in HZ-A is westerly to north westerly towards Coldwater Creek at a fairly uniform gradient, and ground water of HZ-A is interpreted to discharge into Coldwater Creek. Potentiometric surfaces for the remaining four HZs have not been calculated because most wells drilled deeper than HZ-A are screened across more than one of the other HZs.

The chemical character of ground water in HZ-A at SLAPS is variable and cannot be easily characterized into an average overall composition. The Stiff diagrams in Figure 2-20 help demonstrate this complex nature by illustrating the variable anion and cation compositions of ground-water samples collected from SLAPS monitoring wells in 1997. There are no characteristic ion compositions of SLAPS HZ-A ground water except that calcium is typically the dominant cation. The complex chemical signature of SLAPS HZ-A ground water that is

evident in the Stiff diagrams in Figure 2-20 is apparently due to impacts from surficial sources. In contrast, the ground water of the HZs underlying HZ-A has a remarkably uniform chemical character. Anion and cation compositions of ground-water samples collected from the lower HZs at SLAPS in 1997 are illustrated in the Stiff diagrams in Figure 2-21. Ion concentrations are relatively low in the lower HZs with calcium the dominant cation and bicarbonate the dominant anion. The Stiff diagrams in Figures 2-20 and 2-21 indicate that there is little to no communication between ground water in HZ-A and the lower HZs.

The interpretation of negligible communication between HZ-A and the lower HZs is supported by Piper diagrams in Figures 2-22 to 2-25. Figure 2-22 plots the anion and cation compositions of HZ-A ground-water samples collected from both SLAPS and HISS in 1997 (SAIC, 1998a and b). The data points on Figure 2-22 show significant spread. Total dissolved solids (TDS) in the samples plotted on Figure 2-22 ranges between 482 and 5153 mg/L as shown on Figure 2-23 (USACE, 2001). In terms of anions, HZ-A ranges between carbonate, chloride, and sulfate water types. One sample (from well 53W01S) plots near the sulfate apex on the Piper diagram. The reason for this is that, unlike the remainder of the samples, its bicarbonate concentration is very low, therefore anion proportions in the sample are dominated by sulfate. In terms of cations, the bulk of the HZ-A samples are calcium/magnesium water types but two samples are significantly more calcic (from well M11-9S and well B) than the others and two samples are more sodium+potassium rich (from well 53W18S and well 53W19S).

Major ion compositional data for monitoring well samples collected at SLAPS (SAIC, 1998a) and HISS (SAIC, 1998b) from hydrostratigraphic zones deeper than HZ-A (i.e., HZ-B through HZ-E) in 1997 are plotted on the Piper diagram in Figure 2-24. Except for one sample (from well B53W12D) the compositions portrayed on Figure 2-24 are remarkably uniform. One sample (from SLAPS well B53W12D) plots as a sulfate water type on Figure 2-24 because the reported concentration of carbonate+bicarbonate in the sample is zero (SAIC 1998a), therefore the anion proportions in this sample are dominated by sulfate. The remainder of the samples from the deeper ground water at SLAPS and HISS have carbonate+bicarbonate concentrations ranging from 360 to 722 mg/L. Given the uniformity in deeper ground-water major ion compositions and the fact that no other water sample from the North County Site, including water from HZ-A, has zero carbonate + bicarbonate, it is concluded that the carbonate species analysis for the 1997 sample from well B53W12D is incorrect. Additionally, as shown on Figure 2-25, TDS in the ground-water samples from beneath HZ-A are typically lower than what was observed in the HZ-A samples. In the lower HZ samples TDS range between 250 and 1011 mg/L. The uniformity of the major ion compositions in the four hydrologically distinct hydrostratigraphic zones HZ-B, HZ-C, HZ-D, and HZ-E argues for relatively undisturbed ground water below HZ-A.

Additional evidence supporting the existence of distinct upper and lower hydrostratigraphic zones are the tritium data collected in 1997 from selected well locations at SLAPS. Tritium was detected in ground-water samples from upper and lower zones ranging between 0.02 picocuries per liter (pCi/L) and 47 pCi/L at SLAPS and 0.08 pCi/L to 139 pCi/L at HISS. Each lower zone sample contains less than 1 pCi/L of tritium. The upper zone samples at SLAPS contain greater than 1 pCi/L of tritium with 10 samples containing greater than 10 pCi/L of tritium (SAIC, 1998a and b). Figure 2-26 demonstrates the distribution of tritium ground-water concentration at SLAPS. Tritium is a Hydrogen-3 isotope with a half-life of 12.3 years. It is produced in atmosphere by natural radiation and is brought to the earth's surface by

precipitation. Additional tritium was introduced into the atmosphere during nuclear weapons testing in the 1950s and 1960s. Sufficient tritium was added to the global water cycle so as to make pre-1950 water distinguishable from post-1950 water. Higher concentrations of tritium are indicative of relatively young water that has not had the time to allow for tritium decay. Lower concentrations of tritium are indicative of relatively older water that has undergone longer residence times, greater amounts of tritium decay, and has not received tritium from man-made sources (Hem, 1970). At SLAPS, an order of magnitude or more difference in tritium concentrations exist between upper zone ground-water samples and lower zone ground-water samples. These results indicate that ground water in the upper zone is recent (less than 50 years old) and the ground water in the lower zone is older (at least 50 years). Water recharge to the upper zone is evidenced by these data. The varied tritium concentrations also suggest no or limited hydraulic communications between the zones, otherwise more uniform concentrations would exist (by ground water mixing between zones) (SAIC, 1998a). There is no evidence of contaminated transport below HZ-A regardless of vertical potentiometric gradient or the presence of Subunit 3M.

In summary, the following data supports the determination that unacceptable levels of contamination will not migrate to HZ-E due to the limited connection between the shallow and deep ground-water systems:

- Lithologic data: a highly impermeable clay aquitard (Unit 3M) separates the upper ground-water system from the underlying ground-water zones. The geometric mean vertical hydraulic conductivity of the Unit 3M aquitard, based on laboratory tests, is 3.1×10^{-8} cm/s (DOE, 1994a;USACE, 2001). The underlying silty clay layer Unit 3B (geometric mean vertical hydraulic conductivity $=3.1 \times 10^{-7}$ cm/s) provides an additional barrier to vertical contaminant migration. Most chemical species will sorb to some extent to the clay particles.
- Potentiometric data: A comparison of the ground-water elevation measurements from shallow and deep monitoring well pairs indicates they exhibit different hydraulic heads. This demonstrates that the shallow and deep zones are distinct and independent ground-water systems with limited hydraulic connection.
- Chemical analysis of the major, naturally-occurring cations and anions in ground water: The different ground-water chemistry of the shallow and deep ground-water systems indicates minimal mixing occurs. The lower tritium concentrations observed in the deep ground-water also supports the determination that little downward migration occurs from the upper zone.
- Ground-water modeling results indicate the peak contaminant concentrations reaching HZ-E are well below risk levels (BNI, 1996). The rate of vertical contaminant movement suggests times exceeding 1,000 years to reach the Limestone Aquifer. This arrival period assumes continued soils contamination. There are several reasons to suggest that the arrival periods for contaminants to reach HZ-E are longer than 1,000 years. Soil source-term removal would lengthen the arrival period and would reduce the concentrations reaching HZ-E.

The ground-water monitoring data indicate localized impacts to ground water in HZ-A and an absence of impacts to lower HZ water. Uranium, manganese, nitrate, selenium, trichloroethene (TCE), and 1,2-dichloroethene (DCE) were found in HZ-A. Manganese was found in the lower HZs and may be from natural sources, as concentrations approximated those

in background wells (SAIC, 1998a). Arsenic, interpreted to be from natural sources, was also found in the lower HZs. The highest uranium concentrations were found at the western end of SLAPS in HZ-A.

Recharge to HZ-A occurs from precipitation, off-site inflow of ground water, and creek-bed infiltration during high creek stage. Discharge dominantly occurs by seepage into Coldwater Creek during low creek stage (BNI, 1992a). Vertical water movement is possible under "leaky" (low hydraulic conductivity) conditions with an adequate driving pressure gradient. The lacustrian clays (Units 3T, 3M, and 3B) and the shale (Unit 5) greatly inhibit vertical water movement at HISS/Futura and SLAPS.

Local Hydrostratigraphy at HISS

Lithologic logs for wells in the area indicate that HISS is underlain by the same stratigraphic sequence as is found at SLAPS with the exception of stratigraphic Unit 5, the shale lithology, which is missing at HISS. As a result, the HZs beneath HISS are identical to those beneath SLAPS (except that HZ-D is missing).

Twenty-one ground-water monitoring wells have been installed at HISS. Of these, 20 are completed in HZ-A; only one well, HISS-5D, is completed in the lower HZs. The ground-water level measurements for the wells in HZ-A indicate a radial ground-water contour pattern at HISS as shown in Figure 2-19 that was discussed previously for SLAPS. Ground-water elevations decline from the central part of the site and movement is interpreted to be minimal in the low conductivity saturated materials. The area of the central ground-water mound corresponds to a low, wet area on the ground surface. A downward vertical gradient or hydraulic head differential existed at well cluster HISS-5/HISS-5D.

The major ion compositions of HZ-A ground water at HISS are similar to those observed at SLAPS. Figure 2-27 is the Stiff diagram for HISS ground-water samples collected in 1997 (SAIC, 1998b). The samples collected from HZ-A (all samples plotted on Figure 2-27 with the exception of the sample from well HISS-5D) show the same variation in ion compositions as observed for the SLAPS HZ-A samples. The HISS ground-water sample collected from beneath HZ-A (the sample from well HISS-5D) has the same relatively uniform composition as observed among the SLAPS deeper ground-water samples.

Ground Water Classification

At this time, neither the State of Missouri nor EPA Region VII has formally classified any of the aquifers in the St. Louis area. Using EPA's Superfund Ground Water Classification Flow Chart (EPA, 1988a), the ground-water classification was evaluated as part of this study. The water-bearing units of the limestone bedrock aquifer at SLAPS and HISS meet the requirements for a Class IIB designation. Class IIB means that the ground water is a potential source of drinking water, but not a current source.

The upper water-bearing unit at the North County Site near the former storage areas at SLAPS and HISS/Futura is of poor quality and low yield. This unit does not act as an aquifer at these areas but could fall under the Class III definitions. Class III includes ground water that is not a source of drinking water and of limited beneficial use. The guidance states that Class III includes ground waters that "are so contaminated by naturally occurring conditions, or by the

effects of broad-scale human activity (i.e., unrelated to a specific activity), that they cannot be cleaned up using treatment methods reasonably employed in public water-supply systems" (EPA 1988c). Therefore, Class III designation was selected because the St. Louis Site is surrounded by industrial activities and/or an airport, which are common sources of ground-water contamination.

Class III also encompasses those ground waters which are not potential sources of drinking water due to high salinity (i.e., > 10,000 mg/L TDS) or insufficient yield. The key criteria used to evaluate a Class III designation for the shallow ground-water system at the North County Site is insufficient yield, which is defined as a level of production below that needed to meet the "long-term basic needs of an average family by a well or spring." Using an average family size of 3 and a per capita water need of approximately 50 gpd, the EPA determined the sufficient yield criterion to be a sustainable rate of 150 gpd (EPA, 1988c). The following data supports the determination that the shallow ground-water Unit HZ-A (comprised of Units 1, 2 and 3T) meets the criterion of insufficient yield.

- Regional studies of water supplies in the St. Louis area indicate that the shallow loess and the glaciolacustrine clay and silt units of the Pleistocene Series are "essentially not water yielding" (Miller et al., 1974).
- Data concerning well yields for these units are not available because the shallow deposits are not used as drinking water aquifers. However, the purge rates for shallow monitoring wells at the site can be used to estimate the yield for the shallow units. The maximum daily yield was estimated as 50 gpd for Unit 2 and 5 gpd for Subunit 3T based on first and second Quarter 1999 field data.
- The lithological character of the loess and fine-grained lacustrine deposits and their low measured hydraulic conductivities (on the order of 10^{-5} to 10^{-8} cm/s) confirm that these strata are unlikely to produce water in sufficient quantities to serve as a drinking water supply. The geometric mean hydraulic conductivity values measured at the North County Site are presented in Table 2-4."

Subclasses are differentiated based primarily of the degree of interconnection of the ground water to adjacent surface water and/or ground water. The guidance manual states that if the aquifer feeds a surface-water body (e.g., the Missouri River) that could be used for drinking water, the aquifer should be designated Class IIIA. The rationale behind this designation is that the ground water is needed to feed the baseflow of the river or creek. Based on the above rationale, the upper water-bearing units at the North County Site are being treated as Class IIIA aquifers.

More recent EPA ground-water protection guidance states that the goal for ground water which is hydrologically connected to surface water should be to reduce constituent concentrations to levels such that the discharge of ground water to surface water does not exceed water quality standards established under the Clean Water Act (CWA) (EPA, 1992). Due to the low ground-water flow rates at the North County Site near the former storage areas at SLAPS and HISS/Futura and the dispersion of contaminants in Unit 2, discharge of ground water to Coldwater Creek surface water does not result in contaminant levels above water quality standards in surface water.

Table 2-4. Hydraulic Conductivity Data for the North County Site

Hydro-stratigraphic Zone	Lithologic Unit	Dominant Lithology (Unified Soil Classification)	Type of Tests	Number of tests	Geometric Mean Hydraulic Conductivity [a] (cm/sec)	Range of Measured Hydraulic Conductivities (cm/sec)	Reference for Test Data [b]	Literature K Values [a,c] (cm/sec)
HZ-A	**Unit 1**	Topsoil, Fill	Laboratory Permeabilities (Triaxial)	1	$K_v = 2.7 \times 10^{-6}$	2.7×10^{-6}	4	Not Available
	Unit 2	Loess (ML-CL)	Field Permeabilities (Slug tests)	5	$K_h = 1.2 \times 10^{-4}$	4.8×10^{-5} to 3×10^{-4}	1,3	10^{-8} to 10^{-4} [f]
			Laboratory Permeabilities (Triaxial)	12	$K_v = 1.6 \times 10^{-6}$	7.5×10^{-9} to 2×10^{-4}	1,2,3,4	
	Unit 3T	Silty Clay (CL)	Field Permeabilities (Slug tests)	8	$K_h = 1.2 \times 10^{-5}$	1.2×10^{-6} to 1.5×10^{-4}	1,3	10^{-7} to 10^{-6} [e]
			Laboratory Permeabilities (Triaxial)	18	$K_v = 1.5 \times 10^{-6}$	3.0×10^{-8} to 7.0×10^{-5}	1,2,3,4	
HZ-B	**Unit 3M**	Highly Plastic Clay (CH)	Laboratory Permeabilities (Triaxial)	9	$K_v = 3.1 \times 10^{-8}$	1.4×10^{-8} to 7×10^{-7}	1,2,4	10^{-8} to 10^{-6} [e]
	Unit 3B	Silty clay (CL)	Field Permeabilities (Slug tests)	6	$K_h = 1.1 \times 10^{-5}$	1.2×10^{-6} to 2.9×10^{-4}	1,3	10^{-7} to 10^{-6} [e]
			Laboratory Permeabilities (Triaxial)	4	$K_v = 3.1 \times 10^{-7}$	1.7×10^{-7} to 5.7×10^{-7}	2,3,4	
HZ-C	**Unit 4**	Clayey, Sandy Gravel (GC-SM-ML)	Field Permeabilities (Slug tests)	2	$K_h = 1.5 \times 10^{-5}$	4.1×10^{-6} to 2.2×10^{-4}	3	10^{-7} to 10^{-3} [e]
			Laboratory Permeabilities (Triaxial)	4	$K_v = 1.3 \times 10^{-6}$	2×10^{-8} to 2×10^{-5}	1	
HZ-D	**Unit 5**	Shale	Field Permeabilities (Slug tests)	2	$K_h = 1.3 \times 10^{-6}$	7.5×10^{-7} to 2.3×10^{-6}	3	10^{-12} to 10^{-8} [f]
HZ-E	**Unit 6**	Sandy Limestone	Field Permeabilities (Packer Tests[d])	2	$K_h = 2.9 \times 10^{-6}$	7.5×10^{-7} to 1.1×10^{-5}	2	10^{-7} to 10^{-3} [f]

[a] K_v = vertical hydraulic conductivity, K_h = horizontal hydraulic conductivity, K= hydraulic conductivity (includes both horizontal and vertical components)

[b] References:

1. Weston, 1982. *St. Louis Airport Storage Site (SLAPS) Technical Series: Vol. 1 Site Characterization No. 1 Site History, Topographical and Radiological Data Analysis, Geological and Hydrological Data.* January
2. BNI, 1989. *Preliminary Geological, Hydrogeological, and Chemical Characterization Report for the Ball Field Area, Hazelwood and Berkeley, MO*, February.
3. DOE, 1994a. *Site Suitability Study for the St. Louis Airport Site, St. Louis, Missouri*, February
4. USACE, 2001. *SLAPS Implementation Report*, June Final

[c] Literature values are based on representative results for similar lithologies and/or soil textures

[d] Packer Tests conducted over 10 ft. interval in the upper portion of the Ste. Genevieve Limestone

[e] Based on Watson, I. And A.D. Burnett, 1993, *Hydrology An Environmental Approach*, Buchanon Books, Ft. Lauderdale, FL

[f] Based on Freeze, R.A., and J.A. Cherry, 1979, *Groundwater*, Prentice Hall, Inc., Englewood Cliffs, NJ

The EPA ground-water protection guidance (EPA, 1992) emphasizes that because funding resources are limited, states cannot focus their ground-water efforts statewide. Consequently, aquifers should not simply be discussed as having the potential for use in the future, but rather as having an expected use in the future. With this approach, aquifers that have the greatest value or benefit can be afforded greater attention (EPA, 1992). Given the proximity of the Missouri and Mississippi Rivers, and other nearby surface-water sources such as Coldwater Creek, the expected future use of ground water near the former storage areas at SLAPS and HISS/Futura is minimal. This is further reinforced by the aquifer's poor water-quality characteristics (high turbidity and high total dissolved solids) and low yield.

The unconsolidated sediment underlying the North County Site near the former storage areas at SLAPS and HISS/Futura consists of loess, lacustrine, and glacial deposits. These types of deposits are typically heterogeneous and can contain a high percentage of fine-grained materials such as silt and clay. Two relatively permeable zones (Units 2 and 4) within these unconsolidated sediments are separated by a confining layer (3T, 3M, and 3B clay subunits) and shale (Unit 5) in some locations, which are zones of less permeable material. Subunits 3B, 3M, 3T, and Unit 5 together provide a continuous low permeability layer across SLAPS that restricts communication between the upper and lower aquifer.

A total of eight private wells have been identified within a 4.8 km (3 mi) radius of SLAPS and HISS. These wells range in depth from 10.6 to 122 m (35 to 400 ft), and none of these are used for drinking water. Four of the wells had been used for irrigation and one for industrial purposes. The three other wells had been used for domestic use and were capped and abandoned in 1962, 1968, and 1979 (BNI, 1992a). Most of these wells are installed deep into fractured bedrock where better yields can be obtained as compared to the shallow unconsolidated formation.

2.2.6 Demography and Land Use

The North County Site is located in urban and suburban settings within St. Louis County. Analyses of census and other data for the City of St. Louis and for St. Louis County are compared to data for the St. Louis Metropolitan Statistical Area (MSA). The MSA includes the City of St. Louis plus St. Louis, St. Charles, Franklin, and Jefferson counties in Missouri; and five counties in Illinois.

Recent trends in population growth and density continue to show decreases for the City of St. Louis and increases for St. Louis County, as shown in Table 2-5. St. Louis County, which contains the airport area, had a 1990 population of 993,529 (EWGCC, 2001), an increase of 2.0 percent from 1980. The population data for the period from 1990 to 1992 indicate that the historical trend of decreasing population in the city and increasing population in the county is continuing. The housing trends follow these population trends. The City of St. Louis has 19 percent of the single family units, and 55 percent of the multi-family units in the area. The overall occupancy rate is 85 percent for the City of St. Louis and 95 percent for St. Louis County. The average owner vacancy rate in the city is almost double the rate in the county. These trends are shown in Tables 2-6, 2-7, and 2-8.

The North County Site properties are primarily within the municipalities of Hazelwood and Berkeley. The population of both these municipalities decreased from 1980 to 1990. The

population of Berkeley was 15,922 in 1980 and 12,450 in 1990, a decrease of 21.8 percent (EWGCC, 2001). The population of Hazelwood was 16,170 in 1980 and 15,324 in 1990, a decrease of 5.2 percent. SLAPS is located within Census Tract 2115 with a population of 4,041.

The population center nearest SLAPS, with 75 to 100 people, is located approximately 0.8 km (0.5 mi) west of the property in an industrially zoned area of Hazelwood. The next closest population center, with approximately 1,500 people, is approximately 1.6 km (1 mi) northwest of SLAPS along Chapel Ridge Drive. The nearest residential areas to the Latty Avenue properties are located to the east, in the City of Berkeley. Several high-density residential areas, which include single-family homes and apartment buildings, are located east of Interstate-170. A residential area is located northeast of HISS and Hazelwood Avenue.

Table 2-5. Total Population and Population Density for the St. Louis Region, 1980–1990

Region	1980	1990	1990 Land Area		1990 Persons per	
	Population	Population	km^2	mi^2	km^2	mi^2
City of St. Louis	452,804	396,685	61	159	2,501	6,503
St. Louis County	974,180	993,529	506	1,316	755	1,964
Regional MSA	2,376,968	2,444,099	5,341	13,887	176	458

[a] Source: EWGCC 2001.

Table 2-6. Housing Units in the St. Louis Region, 1980–1990[a]

Area	Total Housing Units 1980	Total Housing Units 1990	% Change (1980-1990)
City of St. Louis	202,113	194,919	-0.3
St. Louis County	358,040	401,839	+1.1
Regional MSA	887,425	991,000[b]	1.5[c]

[a] Source: EWGCC 2001.
[b] Total housing units for the year 1987 (City of St. Louis, Community Development Agency 1992).
[c] Percent change reflects 1980-1987.

Table 2-7. Housing Characteristics 1990[a]

Region	Single-Family Units	Multi-Family Units	Mobile Homes	Total Housing Units	Total Occupied Units	Average Number Persons Per Unit	Average Owner Vacancy Rate %	Renter Vacancy Rate %
City of St. Louis	71,809	121,752	2,078	194,919	164,931	2.34	3.3	13.2
St. Louis County	302,271	98,345	1,223	401,839	380,110	2.57	1.8	9.4

[a] Source: BEA 1991; RCGA (St. Louis Regional Commerce and Growth Association) 1992.

Table 2-8. Housing and Population Characteristics[a]

Census Tract	Pop.[b]	Dwelling Units[c]	Mean Pop./Unit	Population Ages[b]		
				0-18	19-49	50 & Over
St. Louis County	993,529	380,110	2.6	257,126	489,789	273,638
2115 (SLAPS and Latty Avenue)	4,041	1,273	3.2	1,341	1,875	825
2112	9,172	3,999	2.3	1,955	4,109	3,108
2114.02	2,398	1,202	2.0	421	1,427	550
2129	3,920	1,319	3.0	1,343	1,708	869
2130	221	123	1.8	34	150	37
2116	6,647	2,438	2.7	1,857	3,041	1,749
Total (Census Tract)	26,399	10,399	2.5	6,951	12,310	7,138

[a] Source: U.S. Census Bureau 1990.
[b] Figures reported represent population within the entire census tract.
[c] Figures reported represent the total number of occupied dwelling units.

Land use for the area is described in the City of Hazelwood *Comprehensive Master Plan* (Harland, Bartholomew, and Associates, 1998) and the City of Berkeley Southeast Corridor Master Plan (Parsons, Harland, Bartholomew, and Associates, 1998) and is shown in Figure 2-28.

SLAPS and Vicinity Properties

SLAPS is located within unincorporated St. Louis County, managed by the St. Louis Airport Authority, and owned by the City of St. Louis. SLAPS is currently zoned M-1 (light industrial). The south-central and eastern portions of the property are in the approach zones of runways 17 and 24, respectively. They are just north of the adjacent Lambert-St. Louis International Airport. Land use restrictions at the site include Federal Aviation Administration (FAA) regulations restricting or prohibiting the construction, erection, alteration, or growth of any structure, tree, or other object in the approach area of the runways that interfere with the use, operation, or future development of the airport. A chain-link fence surrounds most of SLAPS. The portion of the site adjacent to Coldwater Creek is zoned M-1/FP, which indicates that it is zoned for light industrial use, and is also within the floodplain.

Land use in the vicinity of the Lambert-St. Louis International Airport is dominated by industrial and commercial uses. More than two-thirds of the land within 0.8 km (0.5 mi) of SLAPS is used for transportation-related purposes. The remaining land is used for commercial and industrial uses. Several properties in the vicinity of the airport would be expected to continue under commercially/industrial use in the foreseeable future. Immediately south of SLAPS are the Norfolk and Southern Railroad, Banshee Road, and the Lambert-St. Louis International Airport. West of SLAPS is Coldwater Creek and the Boeing property. The nearest residential properties to SLAPS are located approximately 0.6 km (0.4 mi) to the northeast on Frost Avenue in the City of Berkeley.

The property north of McDonnell Boulevard is owned by the City of St. Louis and leased to the cities of Berkeley and Hazelwood. The eastern portion of the property, within Berkeley, is referred to as the Berkeley Athletic Complex and includes Khoury League Park. Removal actions are occurring in some of this property, and the remaining fields are vacant. This eastern area is zoned "P" (park district). This zone permits the property to be used for parks, trails, golf courses, ballfields, and similar uses (Zoning Code, City of Berkeley, Section 23.14, 1992). The

western portion of the property is located in the City of Hazelwood and is zoned "I" (heavy industrial). This zone allows a variety of manufacturing, storage, and assembly uses, as well as commercial and retail establishments. Additional uses are permitted upon granting of a Special Land Use Permit by the City Council (Zoning Code, City of Hazelwood, Section 32.75, 1992). Because a portion of the site within the City of Hazelwood is also within the floodplain of Coldwater Creek, all uses must also meet Municipal Code requirements pertaining to the floodplain. The City of Hazelwood has developed a *Comprehensive Master Plan* for local development, which proposes that parks, recreation fields, railroad yards, or parking lots can be located in the floodplain in accordance with zoning restrictions (Harland, Bartholomew, and Associates, 1998).

Although primarily a commercial and industrial area, Hazelwood Avenue also provides access to a residential area north of Latty Avenue along Heather Lane. This area is zoned for single-family residential use, but the land use plan indicates that this area is expected to change to business uses (Harland, Bartholomew, and Associates, 1998).

Latty Avenue Properties

HISS is owned by Jarboe Realty and Investment and leased to USACE. The area occupies the eastern portion of the 9200 Latty Avenue property and is located on a level, grassy area surrounded by a chain-link security fence. HISS has a laboratory, office trailers, and other facilities to support USACE's FUSRAP operations. Four covered and two coated surface storage piles that contain approximately 45,200 yd^3 of soil and debris contaminated with radioactive material are also on the site.

Jarboe Realty and Investment owns the Futura property. Futura is the current tenant of the western portion of the 9200 Latty Avenue property. Futura manufactures plastic coating products.

The HISS and Futura properties are zoned "I" (heavy industrial) by the City of Hazelwood (Harland, Bartholomew, and Associates, 1998). The Hazelwood *Comprehensive Master Plan* calls for continued industrial development in this area, encouraging modernization and expansion of existing industries. Three spurs of the Norfolk and Western Railroad parallel the western boundary of HISS. Norfolk and Western own the main spur. Wagner Electric Corporation, a landowner on the north side of Latty Avenue, owns the other two spurs. The easternmost railroad spur is unused, but the other two spurs are active in the area around HISS (BNI, 1992b). A recently constructed spur along the eastern edge of HISS will be used during removal of material from the Latty Avenue properties.

The closest residential properties to HISS/Futura are located approximately 0.3 km (0.2 mi) to the southwest along Frost Avenue and 0.5 km (0.3 mi) to the northeast along Hazelwood Avenue.

All of the Latty Avenue properties are located in industrial areas and are currently zoned "M-1" (light industrial) (Harland, Bartholomew, and Associates, 1998). Traffic along Latty Avenue consists primarily of large trucks and employee vehicles.

Coldwater Creek

Coldwater Creek is divided into three sections for purposes of analysis, as shown earlier on Figure 2-14. Section A, between SLAPS and Interstate 270 (I-270), flows through a predominantly industrial area. Section B, north of I-270, flows through a residential section of Hazelwood, with commercial and retail establishments nearby. Small businesses and shopping centers occur near the first intersection of the creek and Lindbergh Boulevard, 9.6 km (6 mi) downstream of SLAPS. After the first Lindbergh Boulevard/Coldwater Creek intersection, the creek flows past Florissant and through St. Ferdinand Park. The surrounding land use is predominantly residential communities and forested land until the creek intersects New Halls Ferry Road. The St. Louis MSD treatment plant is located next to the creek north of the community of Black Jack. Section C begins where the creek again intersects Lindbergh Boulevard and flows through mainly residential and natural settings and through large tracts of unincorporated land in northeastern St. Louis County. Section C ends at the mouth of the creek at the Missouri River.

Three recreational parks are located along Coldwater Creek: Fort Bellefontaine County Park, Coldwater Creek Park, and Veterans Memorial County Park. St. Louis County Department of Parks and Recreation has jurisdiction over each of these parks. Fort Bellefontaine County Park covers 14.5 ha (36 acres) on the opposite bank of Coldwater Creek 22 km (13.5 mi) downstream from SLAPS. Coldwater Creek County Park covers 95 ha (234 acres) on the east bank, near the mouth of the creek. Veteran's Memorial County Park covers 100 ha (246 acres), a small portion of which is located in the Coldwater Creek drainage area, 15 km (9.6 mi) downstream from SLAPS.

Several municipal parks also border the creek. Khoury Park is immediately north of SLAPS and is sometimes referred to as the former ballfield. St. Cin Park is located in Hazelwood, immediately north of I-270, 2.4 km (1.5 mi) from Khoury Park. Duchesne Park, 3.2 km (2 mi) downstream, is within Florissant. St. Ferdinand Park, 5.1 km (3.1 mi) downstream, is also located within Florissant. Black Jack Park is located on the southern bank of Coldwater Creek between stream kilometers 7.7 and 8.5 (miles 4.8 and 5.3).

Section A of Coldwater Creek (which is the portion of the creek that would be most affected by potential remediation activities) is considered by the City of Hazelwood to be a flood way or floodplain, thereby limiting potential development of this area. One of the goals stated in the Hazelwood *Comprehensive Master Plan* is to reduce flooding and storm drainage problems along Coldwater Creek. One of the adopted policies to accomplish this goal is to discourage incompatible development and encourage appropriate uses such as parks, ballfields, and parking lots.

2.2.7 Ecology

The biological resources were evaluated using a literature study and site reconnaissance. The reconnaissance was conducted during daylight hours (0615 to 1630 hours) on May 14 and 15, 1992. The literature review included Orzell, 1979; St. Louis County Department of Planning, 1986; and Weston, 1979. The evaluations were done for all of the North County Site areas including SLAPS, HISS/Futura, VPs, and locations downstream from SLAPS and HISS along Coldwater Creek.

The North County Site is located in the Oak-Hickory-Bluestem Parkland section of the Prairie Parkland Province (Bailey, 1980) and within the Florissant Basin (Lark, 1992). Topography is gently rolling with low bluffs north of the Missouri River. Presettlement vegetation is characterized by deciduous woodlands intermixed with open prairie (Bailey, 1980). The Missouri and Mississippi Rivers are a major influence on the vegetation of the area. Common trees before development included oaks (*Quercus* sp.), hickories (*Carya* sp.), elms (*Ulmus* sp.), sycamores (*Platanus* sp.), cottonwoods (*Populus* sp.), redbuds (*Cercis* sp.), hackberries (*Celtis* sp.), and buckeyes (*Aesculus* sp.) (Bailey, 1980). Tall grass prairie species in presettlement times included big bluestem (*Andropogon gerardi*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and prairie junegrass (*Koleria cristata*) (Weston, 1979). Today, little presettlement vegetation exists in the area around the North County Site.

2.2.7.1 SLAPS

Vegetation at SLAPS changed little between the 1979 survey (Weston, 1979) and the 1992 surveys. Recent construction and removal actions have disturbed extensive areas of SLAPS. A grass-forb type of community dominates the vegetation at SLAPS. Perennial bromegrass (*Bromus* sp.) and bluegrass (*Poa* sp.) appear to be the dominant grasses. Forbs include thistle (*Cirsiuim arvense*), vetch (*Vicia* sp.), sunflower (*Helianthus* sp.), goldenrod (*Solidago* sp.), and ragweed. Woody shrubs, including sumac, are present on the southern border. Cottonwoods (*Populus deltoides*) are present on the western border of the creek. Cottonwoods, maples (*Acer* sp.), and other species of deciduous trees are abundant along the creek north of SLAPS.

Song sparrows (*Melospiza melodia*), swifts, and red-winged blackbirds were the most common birds observed during the May 1992 reconnaissance. Three American goldfinches (*Carduelis tristis*) were seen along the creek woodlands north of SLAPS. In addition, a Mississippi kite (*Ictinia mississippiensis*) was observed hunting in the park and a red-tailed hawk (*Buteo jamaicensis*) was seen perched in a cottonwood just north of SLAPS. Numerous gopher (*Geomys* sp.) holes and more than 10 cottontail rabbits (*Sylvilagus* sp.) were observed on SLAPS. Squirrels (*Scirurus* sp.) were observed in the woodlands lining Coldwater Creek and raccoon (*Procyon lotor*) tracks were observed on mud flats by the creek just north of SLAPS.

2.2.7.2 Latty Avenue Properties

The Latty Avenue properties are mainly developed properties. Annual bromegrass (*Bromus* sp.) and annual mustard (*Lepidium* sp.) are the most common species of residual vegetation. Understory herbaceous vegetation is relatively dense and dominated by vines and nettle. Swifts, sparrows, and American goldfinches were the only birds observed in the area during the May 1992 reconnaissance.

2.2.7.3 Coldwater Creek

Less than 10 percent of the area is open space or forest, because the Coldwater Creek watershed is developed for human use (FWS, 1987). The banks of the creek are steep and void of vegetation for the first 0.6 to 0.9 m (2 to 3 ft) above the water surface during mean flow conditions. The water surface during the May 1992 survey was approximately 2.5 to 3 m (8 to 10 ft) below the bank of the creek, but flooding frequently occurs.

Biological resources in and along Coldwater Creek are less diverse than those of similar creeks in rural areas because of the poor water quality from the chemical and physical pollutants in the creek. No significant amounts of continuous vegetation are found in the watershed, and the quality of the remaining forests is rated "marginal" (Parker and Szlemp, 1987). Coldwater Creek is lined with cottonwoods, maples, elms (*Ulmus* sp.), black locust (*Robinia* sp.), box elder (*Acer nequndo*), beech (*Fagus* sp.), and mulberry (*Morus* sp.). Trees intermittently shade the creek, and herbaceous vegetation is composed of vines, forbs, and grasses. The largest vegetated areas occur downstream from the airport area, closer to the mouth of Coldwater Creek. A pair of mallards (*Anas platyrhynchos*) were observed on the creek approximately 91 m (300 ft) downstream from SLAPS. Red-eared turtles (*Chrysemys scripta*) were observed in the creek approximately 5 km (3 mi) downstream from HISS and Futura.

Previous surveys identified 19 benthic and 6 fish taxa (Nash, 1982; Parker and Szlemp, 1987). Benthic organisms were dominated by tubificids and chironomids, which are tolerant of organic pollution. Fathead minnows (*Pimephales promelas*) represented 97% of the 221 fish collected during a survey (Parker and Szlemp, 1987). This species tolerates waters with low oxygen, high temperatures, and turbidity, which characterize much of the creek.

2.2.7.4 Threatened and Endangered Species

The only federally and state designated, endangered or threatened species that may occur within the area of the proposed action (U.S. Department of Interior and Missouri Department of Conservation letters) are the pallid sturgeon (*Scaphirhynchus albus*) and bald eagle (*Haliaeetus leucocephalus*). Current federal actions are being taken to remove the bald eagle from the endangered species list. Pallid sturgeon are found in both the Mississippi and Missouri Rivers, but Coldwater Creek does not provide adequate water quality or quantity for them. Bald eagles are known to stay through the winter in the region (FWS, 1993; MDC, 1992). It is doubtful that they use the airport areas because of poor habitat quality (i.e., sparse vegetation, significant noise and human activity, and limited hunting opportunity along Coldwater Creek). The habitat suitable for bald eagles is limited on and near SLAPS (Weston, 1979; Parker and Szlemp, 1987). In addition, the U.S. Fish and Wildlife Service (FWS) reviewed another Coldwater Creek project and found that it is "highly unlikely" that the proposed USACE project on the Coldwater Creek would affect any federally-listed species (USACE, 1987a). That creek project involves a substantially greater amount of land clearing and stream bed disturbance than contemplated for this remedial action.

2.2.7.5 Wetlands and Floodplains

The FWS has identified four remnant wetlands, totaling approximately 32 ha (80 acres), along Coldwater Creek between SLAPS and HISS/Futura (Figure 2-29) (FWS, 1993). These wetlands, located on the creek bank, are classified as Palustrine/Forested/Broad-leafed/Deciduous/Temporarily Flooded. The site visit in May 1992 confirmed that broad-leafed forest communities are present in the wetland areas. The closest identified wetland is an approximate 1.6-ha (4 acres) stand on the southwest boundary of Futura. The wetlands identified along Coldwater Creek between SLAPS and HISS/Futura have not been formally defined as wetlands using the 1987 Corps of Engineers Wetlands Delineation Manual. The FWS definition of wetlands is more broadly inclusive than the definition in the Corps of Engineers Manual. The

1987 Manual also states that temporarily flooded wetlands like these should be "viewed with particular caution" (USACE, 1987b).

Hydric soils can occur in any of the soil associations in St. Louis County. However, soil units mapped along Coldwater Creek between SLAPS and Futura were not identified as typically hydric in the county soil survey (USDA-SCS, 1982). The Nevin-Urban soil association underlying the wetlands along Coldwater Creek can possess hydric properties including poor drainage, mottling, and shallow water table depth. The May 1992 site visit confirmed that the wetland areas have signs of seasonal flooding.

Portions of the North County Site lie within the 100-year floodplain. The elevation at SLAPS varies from approximately 155 to 161 m (510 to 530 ft) from east to west and land surface ranges from 4.5 to 6 m (15 to 20 ft) above Coldwater Creek. Generally, the property surface is flat. Compaction, revegetation, differential settling and erosion have created an irregular surface, because the fill placed over the property in the early 1970s was not spread evenly. The surface has been further modified as a result of construction of the rail spur and removal actions at SLAPS and the nearby ditches. The 100-year flood level at SLAPS is 159 m (522 ft) above MSL (FEMA, 1983). Figure 2-30 shows the extent of the 100-year floodplain.

The ground surface at HISS/Futura ranges from approximately 157 m (513 ft) above MSL near Latty Avenue to 160 m (525 ft) above MSL near the piles. The main waste storage pile at HISS extends approximately 8 m (26 ft) above grade. The surface slopes gently from the waste storage piles at HISS to the west and south toward Coldwater Creek. The 100-year flood level at HISS is approximately 159 m (520 ft) above MSL (FEMA, 1983). In the event of a flood of 100-year or greater magnitude, most of the property would be flooded.

2.3 NATURE AND EXTENT OF CONTAMINATION

As shown in Table 2-9, numerous characterization studies have been completed for the North County Site. The Remedial Investigation (RI) was conducted to determine the nature and extent of contamination, and to characterize the geological and hydrogeological features of the North County Site. Analytical results for radiological and chemical characterization surveys are summarized in the RI Report and appendices (BNI, 1992a), the RI Addendum (SAIC, 1995), and the *SLAPS Implementation Report* (USACE, 2001). Multiple characterization analyses were performed during these characterizations including Th-230, Th-232, Ra-226, U-238, other radionuclides, volatile organic compounds (VOCs), base/neutral and acid extractable (BNAE) compounds metals, RCRA hazardous waste characteristics, pH, specific conductance, total organic halogens (TOX), and total organic compounds (TOC). Table 2-10 presents a summary of surface soil analytical results for the North County Site (see Figure 2-10 for the location of IAs). Table 2-11 presents a summary of subsurface soil analytical results. These tables include statistical summaries of site data to illustrate both the range of concentration and the limitation of data at some properties. The data in Table 2-10 and 2-11 include only data from properties with both radiological and non-radiological results. The full set of radiological data are not presented here given the large data volume. All radiological soil data are presented in Appendix D.

A review of the past processing activities at SLDS and at the North County Site was conducted to identify process-related radioactive materials and other chemicals. The primary contaminants are radionuclides. Belgian Congo pitchblende used for uranium processing also

contained arsenic, lead, manganese, and thorium, whereas domestic ores may have been enriched with arsenic, cobalt, copper, molybdenum, nickel, selenium, vanadium, and zinc in addition to the radionuclides associated with the uranium. However, based on the analyses of the residues provided in the Invitation to Bid on March 7, 1962, arsenic, beryllium and zinc are only considered trace elements. Arsenic, beryllium and zinc were among a group of 20 metals that were reported at < 0.1% in the Colorado Raffinate and not mentioned at all for the analyses of the Pitchblende Raffinate. The processes used to manufacture uranium dioxide, uranium trioxide, uranium tetrafluoride, uranyl fluoride, and uranium metal involved the use of acids, such as hydrofluoric, nitric, and sulfuric acids. These acids would likely remain in the environment as anions (e.g., fluorides, nitrates, and sulfates). In addition, because the North County Site is located in an industrialized area, it is likely that organic compounds unrelated to uranium processing activities [e.g., polycyclic aromatic hydrocarbons (PAHs) from industrial processing activities and vehicle emissions] are present. Industrial activities in the area of the airport site are a potential source of organic and non-radioactive inorganic contamination (e.g., refueling, deicing, and maintenance of aircraft) that is not related to ore processing activities at SLDS. A more detailed description of contaminants associated with uranium ore processing is provided in Section 2.3.2.

Table 2-9. Summary of Characterization Studies at the North County Sites

	Report/Date	Summary	Area
SLAPS			
	Weston, 1982	Site Characterization; site history, topographical and radiological data analysis, geological and hydrological data	SLAPS, portion of Coldwater Creek
	ORNL, 1979	Radiological survey of SLAPS	SLAPS
	BNI, 1983	Radiological survey of SLAPS ditches	SLAPS
	BNI, 1987a	Radiological and limited chemical characterization	SLAPS
	BNI, 1989	Preliminary Geological, Hydrogeological, and Chemical Characterization Report for the Ball Field Area	Ballfield
	BNI, 1990b	Chemical characterization report for SLAPS and Latty Avenue properties	SLAPS, Latty Avenue properties
	BNI, 1990a	Radiological Characterization Report for FUSRAP Properties in St. Louis	North County Site
	ORNL, 1991	Results of Mobile Gamma Scanning Activities	Transportation routes to and from SLAPS; transportation routes from HISS/Futura
	BNI, 1992a	RI Report	North county Site
	DOE, 1994a	Site Suitability Study for SLAPS	SLAPS, ballfield
	SAIC, 1995	RI Addendum	North County Site
	BNI, 1998	Post Remedial Action Report	West end excavation at SLAPS, Vicinity Properties
	SAIC, 1998a	1997 Baseline Ground-water Characterization for SLAPS Environmental Monitoring Summaries since 1983	SLAPS, Ballfield SLAPS
Latty Avenue Properties			
	ORNL, 1977	Radiological Survey at 9200 Latty Avenue	Futura
	ORAU, 1981	Radiological survey of decontamination debris at 9200 Latty Avenue	Futura
	BNI, 1985	Report on drilling and observation well installation at HISS	HISS
	BNI, 1987b	Characterization Report for HISS	HISS
	SAIC, 1998b	1997 Baseline Ground-water Characterization for HISS	
	BNI, 1987c	Environmental Monitoring Summaries –since 1985 Radiological Characterization Report for Futura Coatings	HISS Futura

Table 2-9. Summary of Characterization Studies at the North County Sites (Cont'd)

	Report/Date	Summary	Area
SLAPS Vicinity Properties			
	EWGCC, 1993	Coldwater Creek watershed toxic agent study	Coldwater Creek
	ORNL, 1985	Results of Mobile Gamma Scanning Activities in Berkeley, Bridgeton and Hazelwood	Vicinity Properties
	ORNL, 1986a	Results of the radiological measurements taken on transportation routes (LM004) in Hazelwood, MO	Vicinity Properties
	ORNL, 1986b	Radiological survey of the perimeter fence line of the former Cotter site, Hazelwood, MO (LM002)	Vicinity Properties
	BNI, 1997	Draft summary of recent Coldwater Creek data (radiological sampling in 1996 and 1997)	Coldwater Creek

Table 2-10. North County Surface Soil Data Summary

Data Grouping	Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
Soil - All Depths	09K220205/VP-54	Aluminum	10/10	mg/kg			4260	7880	5530	L	6180	6180	u
Soil - All Depths	09K220205/VP-54	Arsenic	10/10	mg/kg			0.84	11.9	5.85	N	7.75	7.75	u
Soil - All Depths	09K220205/VP-54	Barium	10/10	mg/kg			40.7	279	143	N	183	183	u
Soil - All Depths	09K220205/VP-54	Beryllium	10/10	mg/kg			0.41	0.56	0.489	L	0.524	0.524	u
Soil - All Depths	09K220205/VP-54	Calcium	10/10	mg/kg			2320	15500	5190	X	7590	7590	u
Soil - All Depths	09K220205/VP-54	Chromium	10/10	mg/kg			10	12	10.7	N	11.1	11.1	u
Soil - All Depths	09K220205/VP-54	Cobalt	10/10	mg/kg			5.5	9.6	7.41	L	8.39	8.39	u
Soil - All Depths	09K220205/VP-54	Copper	10/10	mg/kg			9.6	16.4	13.4	N	14.5	14.5	u
Soil - All Depths	09K220205/VP-54	Iron	10/10	mg/kg			7270	28200	12800	L	16900	16900	u
Soil - All Depths	09K220205/VP-54	Lead	10/10	mg/kg			7.3	30.9	12.8	L	17.2	17.2	u
Soil - All Depths	09K220205/VP-54	Magnesium	10/10	mg/kg			1610	9940	3550	X	5020	5020	u
Soil - All Depths	09K220205/VP-54	Manganese	10/10	mg/kg			68.3	4690	1250	L	5960	4690	m
Soil - All Depths	09K220205/VP-54	Molybdenum	10/10	mg/kg			6.3	22.7	10.5	L	13.5	13.5	u
Soil - All Depths	09K220205/VP-54	Nickel	10/10	mg/kg			10.1	23.4	14.6	L	17.7	17.7	u
Soil - All Depths	09K220205/VP-54	Potassium	10/10	mg/kg			436	827	634	N	711	711	u
Soil - All Depths	09K220205/VP-54	Silver	1/10	mg/kg	1.25	1.3	2.6	2.6	1.39	D	1.64	1.64	u
Soil - All Depths	09K220205/VP-54	Sodium	10/10	mg/kg			51.8	78	66.5	N	71.8	71.8	u
Soil - All Depths	09K220205/VP-54	Vanadium	10/10	mg/kg			9.5	16.3	12.7	L	13.8	13.8	u
Soil - All Depths	09K220205/VP-54	Zinc	10/10	mg/kg			30.6	52.8	40.6	L	44.8	44.8	u
Soil - All Depths	09K220205/VP-54	Anthracene	1/10	mg/kg	0.205	0.22	0.031	0.031	0.194	D	0.227	0.031	m
Soil - All Depths	09K220205/VP-54	Benz(a)anthracene	1/10	mg/kg	0.205	0.22	0.17	0.17	0.208	D	0.216	0.17	m
Soil - All Depths	09K220205/VP-54	Benzo(a)pyrene	1/10	mg/kg	0.205	0.22	0.15	0.15	0.206	D	0.217	0.15	m
Soil - All Depths	09K220205/VP-54	Benzo(b)fluoranthene	1/10	mg/kg	0.205	0.22	0.21	0.21	0.212	D	0.214	0.21	m
Soil - All Depths	09K220205/VP-54	Benzo(ghi)perylene	1/10	mg/kg	0.205	0.22	0.084	0.084	0.199	D	0.222	0.084	m
Soil - All Depths	09K220205/VP-54	Benzo(k)fluoranthene	1/10	mg/kg	0.205	0.22	0.18	0.18	0.209	D	0.215	0.18	m
Soil - All Depths	09K220205/VP-54	Chrysene	1/10	mg/kg	0.205	0.22	0.19	0.19	0.21	D	0.214	0.19	m
Soil - All Depths	09K220205/VP-54	Dibenz(a,h)anthracene	1/10	mg/kg	0.205	0.22	0.035	0.035	0.194	D	0.227	0.035	m
Soil - All Depths	09K220205/VP-54	Fluoranthene	1/10	mg/kg	0.205	0.22	0.41	0.41	0.232	D	0.268	0.268	u
Soil - All Depths	09K220205/VP-54	Indeno(1,2,3-cd)pyrene	1/10	mg/kg	0.205	0.22	0.13	0.13	0.204	D	0.219	0.13	m
Soil - All Depths	09K220205/VP-54	Phenanthrene	1/10	mg/kg	0.205	0.22	0.18	0.18	0.209	D	0.215	0.18	m
Soil - All Depths	09K220205/VP-54	Pyrene	1/10	mg/kg	0.205	0.22	0.34	0.34	0.225	D	0.248	0.248	u
Soil - All Depths	09K220205/VP-54	Acetone	1/10	mg/kg	0.0065	0.0065	0.017	0.017	0.00755	D	0.00947	0.00947	u
Soil - All Depths	09K220205/VP-54	Toluene	7/9	mg/kg	0.003	0.0065	0.002	0.11	0.0248	L	0.192	0.11	m
Soil - All Depths	11K630221	Aluminum	1/1	mg/kg			10400	10400	10400	D		10400	m
Soil - All Depths	11K630221	Arsenic	1/1	mg/kg			16.3	16.3	16.3	D		16.3	m
Soil - All Depths	11K630221	Barium	1/1	mg/kg			172	172	172	D		172	m
Soil - All Depths	11K630221	Beryllium	1/1	mg/kg			0.65	0.65	0.65	D		0.65	m
Soil - All Depths	11K630221	Boron	1/1	mg/kg			6.2	6.2	6.2	D		6.2	m
Soil - All Depths	11K630221	Calcium	1/1	mg/kg			4320	4320	4320	D		4320	m
Soil - All Depths	11K630221	Chromium	1/1	mg/kg			16.3	16.3	16.3	D		16.3	m
Soil - All Depths	11K630221	Cobalt	1/1	mg/kg			11.6	11.6	11.6	D		11.6	m
Soil - All Depths	11K630221	Copper	1/1	mg/kg			20	20	20	D		20	m
Soil - All Depths	11K630221	Iron	1/1	mg/kg			16600	16600	16600	D		16600	m
Soil - All Depths	11K630221	Lead	1/1	mg/kg			52.1	52.1	52.1	D		52.1	m
Soil - All Depths	11K630221	Lithium	1/1	mg/kg			5.9	5.9	5.9	D		5.9	m
Soil - All Depths	11K630221	Magnesium	1/1	mg/kg			2700	2700	2700	D		2700	m
Soil - All Depths	11K630221	Manganese	1/1	mg/kg			807	807	807	D		807	m
Soil - All Depths	11K630221	Molybdenum	1/1	mg/kg			1.6	1.6	1.6	D		1.6	m
Soil - All Depths	11K630221	Nickel	1/1	mg/kg			20.7	20.7	20.7	D		20.7	m
Soil - All Depths	11K630221	Potassium	1/1	mg/kg			1470	1470	1470	D		1470	m
Soil - All Depths	11K630221	Selenium	1/1	mg/kg			0.41	0.41	0.41	D		0.41	m
Soil - All Depths	11K630221	Sodium	1/1	mg/kg			143	143	143	D		143	m
Soil - All Depths	11K630221	Strontium	1/1	mg/kg			15.8	15.8	15.8	D		15.8	m
Soil - All Depths	11K630221	Titanium	1/1	mg/kg			189	189	189	D		189	m
Soil - All Depths	11K630221	Vanadium	1/1	mg/kg			25.2	25.2	25.2	D		25.2	m
Soil - All Depths	11K630221	Zinc	1/1	mg/kg			72.7	72.7	72.7	D		72.7	m
Soil - All Depths	11K630221	Benz(a)anthracene	1/1	mg/kg			0.059	0.059	0.059	D		0.059	m

Table 2-10. North County Surface Soil Data Summary (Cont'd)

Data Grouping	Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
Soil - All Depths	11K630221	Benzo(a)pyrene	1/1	mg/kg			0.064	0.064	0.064	D		0.064	m
Soil - All Depths	11K630221	Benzo(b)fluoranthene	1/1	mg/kg			0.057	0.057	0.057	D		0.057	m
Soil - All Depths	11K630221	Benzo(ghi)perylene	1/1	mg/kg			0.061	0.061	0.061	D		0.061	m
Soil - All Depths	11K630221	Benzo(k)fluoranthene	1/1	mg/kg			0.058	0.058	0.058	D		0.058	m
Soil - All Depths	11K630221	Bis(2-ethylhexyl)phthalate	1/1	mg/kg			0.091	0.091	0.091	D		0.091	m
Soil - All Depths	11K630221	Chrysene	1/1	mg/kg			0.11	0.11	0.11	D		0.11	m
Soil - All Depths	11K630221	Fluoranthene	1/1	mg/kg			0.14	0.14	0.14	D		0.14	m
Soil - All Depths	11K630221	Indeno(1,2,3-cd)pyrene	1/1	mg/kg			0.052	0.052	0.052	D		0.052	m
Soil - All Depths	11K630221	Phenanthrene	1/1	mg/kg			0.048	0.048	0.048	D		0.048	m
Soil - All Depths	11K630221	Pyrene	1/1	mg/kg			0.11	0.11	0.11	D		0.11	m
Soil - All Depths	11K630221	Actinium-227	1/1	pCi/g			0.29	0.29	0.29	D		0.29	m
Soil - All Depths	11K630221	Cesium-137	1/1	pCi/g			0.21	0.21	0.21	D		0.21	m
Soil - All Depths	11K630221	Potassium-40	1/1	pCi/g			16.05	16.05	16.1	D		16.1	m
Soil - All Depths	11K630221	Radium-226	1/1	pCi/g			0.84	0.84	0.84	D		0.84	m
Soil - All Depths	11K630221	Radium-228	1/1	pCi/g			0.9	0.9	0.9	D		0.9	m
Soil - All Depths	11K630221	Thorium-228	1/1	pCi/g			0.91	0.91	0.91	D		0.91	m
Soil - All Depths	11K630221	Thorium-230	1/1	pCi/g			12.13	12.13	12.1	D		12.1	m
Soil - All Depths	11K630221	Thorium-232	1/1	pCi/g			0.75	0.75	0.75	D		0.75	m
Surface Soil (<0.5 ft)	11K630221	Aluminum	1/1	mg/kg			10400	10400	10400	D		10400	m
Surface Soil (<0.5 ft)	11K630221	Arsenic	1/1	mg/kg			16.3	16.3	16.3	D		16.3	m
Surface Soil (<0.5 ft)	11K630221	Barium	1/1	mg/kg			172	172	172	D		172	m
Surface Soil (<0.5 ft)	11K630221	Beryllium	1/1	mg/kg			0.65	0.65	0.65	D		0.65	m
Surface Soil (<0.5 ft)	11K630221	Boron	1/1	mg/kg			6.2	6.2	6.2	D		6.2	m
Surface Soil (<0.5 ft)	11K630221	Calcium	1/1	mg/kg			4320	4320	4320	D		4320	m
Surface Soil (<0.5 ft)	11K630221	Chromium	1/1	mg/kg			16.3	16.3	16.3	D		16.3	m
Surface Soil (<0.5 ft)	11K630221	Cobalt	1/1	mg/kg			11.6	11.6	11.6	D		11.6	m
Surface Soil (<0.5 ft)	11K630221	Copper	1/1	mg/kg			20	20	20	D		20	m
Surface Soil (<0.5 ft)	11K630221	Iron	1/1	mg/kg			16600	16600	16600	D		16600	m
Surface Soil (<0.5 ft)	11K630221	Lead	1/1	mg/kg			52.1	52.1	52.1	D		52.1	m
Surface Soil (<0.5 ft)	11K630221	Lithium	1/1	mg/kg			5.9	5.9	5.9	D		5.9	m
Surface Soil (<0.5 ft)	11K630221	Magnesium	1/1	mg/kg			2700	2700	2700	D		2700	m
Surface Soil (<0.5 ft)	11K630221	Manganese	1/1	mg/kg			807	807	807	D		807	m
Surface Soil (<0.5 ft)	11K630221	Molybdenum	1/1	mg/kg			1.6	1.6	1.6	D		1.6	m
Surface Soil (<0.5 ft)	11K630221	Nickel	1/1	mg/kg			20.7	20.7	20.7	D		20.7	m
Surface Soil (<0.5 ft)	11K630221	Potassium	1/1	mg/kg			1470	1470	1470	D		1470	m
Surface Soil (<0.5 ft)	11K630221	Selenium	1/1	mg/kg			0.41	0.41	0.41	D		0.41	m
Surface Soil (<0.5 ft)	11K630221	Sodium	1/1	mg/kg			143	143	143	D		143	m
Surface Soil (<0.5 ft)	11K630221	Strontium	1/1	mg/kg			15.8	15.8	15.8	D		15.8	m
Surface Soil (<0.5 ft)	11K630221	Titanium	1/1	mg/kg			189	189	189	D		189	m
Surface Soil (<0.5 ft)	11K630221	Vanadium	1/1	mg/kg			25.2	25.2	25.2	D		25.2	m
Surface Soil (<0.5 ft)	11K630221	Zinc	1/1	mg/kg			72.7	72.7	72.7	D		72.7	m
Surface Soil (<0.5 ft)	11K630221	Benz(a)anthracene	1/1	mg/kg			0.059	0.059	0.059	D		0.059	m
Surface Soil (<0.5 ft)	11K630221	Benzo(a)pyrene	1/1	mg/kg			0.064	0.064	0.064	D		0.064	m
Surface Soil (<0.5 ft)	11K630221	Benzo(b)fluoranthene	1/1	mg/kg			0.057	0.057	0.057	D		0.057	m
Surface Soil (<0.5 ft)	11K630221	Benzo(ghi)perylene	1/1	mg/kg			0.061	0.061	0.061	D		0.061	m
Surface Soil (<0.5 ft)	11K630221	Benzo(k)fluoranthene	1/1	mg/kg			0.058	0.058	0.058	D		0.058	m
Surface Soil (<0.5 ft)	11K630221	Bis(2-ethylhexyl)phthalate	1/1	mg/kg			0.091	0.091	0.091	D		0.091	m
Surface Soil (<0.5 ft)	11K630221	Chrysene	1/1	mg/kg			0.11	0.11	0.11	D		0.11	m
Surface Soil (<0.5 ft)	11K630221	Fluoranthene	1/1	mg/kg			0.14	0.14	0.14	D		0.14	m
Surface Soil (<0.5 ft)	11K630221	Indeno(1,2,3-cd)pyrene	1/1	mg/kg			0.052	0.052	0.052	D		0.052	m
Surface Soil (<0.5 ft)	11K630221	Phenanthrene	1/1	mg/kg			0.048	0.048	0.048	D		0.048	m
Surface Soil (<0.5 ft)	11K630221	Pyrene	1/1	mg/kg			0.11	0.11	0.11	D		0.11	m
Surface Soil (<0.5 ft)	11K630221	Actinium-227	1/1	pCi/g			0.29	0.29	0.29	D		0.29	m
Surface Soil (<0.5 ft)	11K630221	Cesium-137	1/1	pCi/g			0.21	0.21	0.21	D		0.21	m
Surface Soil (<0.5 ft)	11K630221	Potassium-40	1/1	pCi/g			16.05	16.05	16.1	D		16.1	m
Surface Soil (<0.5 ft)	11K630221	Radium-226	1/1	pCi/g			0.84	0.84	0.84	D		0.84	m
Surface Soil (<0.5 ft)	11K630221	Radium-228	1/1	pCi/g			0.9	0.9	0.9	D		0.9	m
Surface Soil (<0.5 ft)	11K630221	Thorium-228	1/1	pCi/g			0.91	0.91	0.91	D		0.91	m
Surface Soil (<0.5 ft)	11K630221	Thorium-230	1/1	pCi/g			12.13	12.13	12.1	D		12.1	m
Surface Soil (<0.5 ft)	11K630221	Thorium-232	1/1	pCi/g			0.75	0.75	0.75	D		0.75	m
Soil - All Depths	Futura	Arsenic	1/1	mg/kg			320	320	320	D		320	m
Soil - All Depths	Futura	Barium	1/1	mg/kg			3480	3480	3480	D		3480	m
Soil - All Depths	Futura	Boron	1/1	mg/kg			182	182	182	D		182	m
Soil - All Depths	Futura	Cadmium	4/14	mg/kg	0.5	0.6	1.3	15.5	1.85	D	3.73	3.73	u
Soil - All Depths	Futura	Cobalt	6/6	mg/kg			42.4	14000	2460	X	7110	7110	u
Soil - All Depths	Futura	Copper	2/2	mg/kg			401	9090	4750	D	32200	9090	m
Soil - All Depths	Futura	Lead	1/1	mg/kg			529	529	529	D		529	m
Soil - All Depths	Futura	Magnesium	6/6	mg/kg			7360	43400	23400	N	35500	35500	u
Soil - All Depths	Futura	Molybdenum	5/14	mg/kg	9.9	12.95	20.9	947	83	D	201	201	u
Soil - All Depths	Futura	Nickel	1/1	mg/kg			17300	17300	17300	D		17300	m
Soil - All Depths	Futura	Selenium	1/14	mg/kg	9.8	12.95	1040	1040	84.6	D	215	215	u
Soil - All Depths	Futura	Vanadium	1/1	mg/kg			2180	2180	2180	D		2180	m
Soil - All Depths	Futura	Toluene	3/3	mg/kg			0.0015	0.015	0.00607	D	0.0191	0.015	m
Soil - All Depths	Futura	Trichlorofluoromethane	1/1	mg/kg			0.0013	0.0013	0.0013	D		0.0013	m
Soil - All Depths	Futura	Radium-226	359/361	pCi/g	1	1	0.4	2300	29.7	X	46	46	u
Soil - All Depths	Futura	Thorium-230	172/173	pCi/g	1.2	1.2	0.5	2000	68.9	X	102	102	u

Table 2-10. North County Surface Soil Data Summary (Cont'd)

Data Grouping	Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
Soil - All Depths	Futura	Thorium-232	333/361	pCi/g	1	6	0.7	26	2.17	X	2.33	2.33	u
Soil - All Depths	Futura	Uranium-238	48/361	pCi/g	3	37	2.3	2500	37	D	54.2	54.2	u
Soil - All Depths	HISS	Nitrate	1/1	mg/kg			1030	1030	1030	D		1030	m
Soil - All Depths	HISS	Sulfate	1/1	mg/kg			824	824	824	D		824	m
Soil - All Depths	HISS	Antimony	1/13	mg/kg	5.4	7.8	242	242	24.8	D	57	57	u
Soil - All Depths	HISS	Arsenic	2/2	mg/kg			51.3	1010	531	D	3560	1010	m
Soil - All Depths	HISS	Barium	2/2	mg/kg			3010	4360	3690	D	7950	4360	m
Soil - All Depths	HISS	Boron	1/1	mg/kg			1010	1010	1010	D		1010	m
Soil - All Depths	HISS	Cadmium	5/13	mg/kg	0.45	0.65	1.2	26.6	2.91	D	6.44	6.44	u
Soil - All Depths	HISS	Cobalt	6/6	mg/kg			125	1470	374	X	817	817	u
Soil - All Depths	HISS	Copper	4/4	mg/kg			109	946	334	D	815	815	u
Soil - All Depths	HISS	Lead	1/1	mg/kg			464	464	464	D		464	m
Soil - All Depths	HISS	Magnesium	4/4	mg/kg			7690	11400	9520	D	11700	11400	m
Soil - All Depths	HISS	Molybdenum	4/13	mg/kg	9.05	13.05	19.1	1100	99.8	D	248	248	u
Soil - All Depths	HISS	Nickel	1/1	mg/kg			1780	1780	1780	D		1780	m
Soil - All Depths	HISS	Selenium	2/13	mg/kg	9	13.05	41.1	1020	91.1	D	229	229	u
Soil - All Depths	HISS	Silver	1/1	mg/kg			18.3	18.3	18.3	D		18.3	m
Soil - All Depths	HISS	Thallium	2/13	mg/kg	9	13.05	51.8	959	87.3	D	217	217	u
Soil - All Depths	HISS	Vanadium	1/1	mg/kg			712	712	712	D		712	m
Soil - All Depths	HISS	Zinc	1/1	mg/kg			308	308	308	D		308	m
Soil - All Depths	HISS	Toluene	2/2	mg/kg			0.0028	0.0029	0.00285	D	0.00317	0.0029	m
Soil - All Depths	HISS	Actinium-227	8/21	pCi/g	-0.01	0.58	0.29	5.36	1.06	D	1.68	1.68	u
Soil - All Depths	HISS	Cesium-137	1/21	pCi/g	-0.05	0.05	0.1	0.1	0.00667	D	0.0179	0.0179	u
Soil - All Depths	HISS	Potassium-40	9/9	pCi/g			13.67	16.89	15.8	N	16.4	16.4	u
Soil - All Depths	HISS	Radium-226	537/544	pCi/g	1	2	0.5	700	6.91	X	9.6	9.6	u
Soil - All Depths	HISS	Radium-228	20/21	pCi/g	0.78	0.78	0.29	1.16	0.915	X	0.986	0.986	u
Soil - All Depths	HISS	Thorium-228	20/21	pCi/g	0.78	0.78	0.29	1.16	0.915	X	0.986	0.986	u
Soil - All Depths	HISS	Thorium-230	215/228	pCi/g	-3.76	20.03	0.8	830	37.9	Z	51.9	51.9	u
Soil - All Depths	HISS	Thorium-232	481/544	pCi/g	0.78	4	0.29	5	1.73	X	1.79	1.79	u
Soil - All Depths	HISS	Uranium-238	62/543	pCi/g	-0.49	55	4	800	13.9	D	17.1	17.1	u
Surface Soil (<5 ft)	IA-1	Magnesium	2/2	mg/kg			6110	10200	8160	D	21100	10200	m
Surface Soil (<5 ft)	IA-1	Molybdenum	1/2	mg/kg	8.6	8.6	17.7	17.7	13.2	D	41.9	17.7	m
Surface Soil (<5 ft)	IA-1	TOX	1/2	UG/G	30.35	30.35	56.9	56.9	43.6	D	127	56.9	m
Surface Soil (<5 ft)	IA-1	PCB-1254	1/2	mg/kg	0.0205	0.0205	0.26	0.26	0.14	D	0.896	0.26	m
Surface Soil (<5 ft)	IA-1	Toluene	2/2	mg/kg			0.003	0.0031	0.00305	D	0.00337	0.0031	m
Surface Soil (<5 ft)	IA-1	Radium-226	7/13	pCi/g	1.6	3.9	1	2700	216	X	585	585	u
Surface Soil (<5 ft)	IA-1	Thorium-230	4/4	pCi/g			1.8	110	33.7	D	94.3	94.3	u
Surface Soil (<5 ft)	IA-1	Thorium-232	6/13	pCi/g	1	4.3	1.1	63	7.14	D	15.5	15.5	u
Surface Soil (<5 ft)	IA-1	Uranium-238	3/13	pCi/g	5	78.4	40	1200	128	D	287	287	u
Surface Soil (<0.5 ft)	IA-10	Aluminum	4/4	mg/kg			8200	9100	8510	D	8990	8990	u
Surface Soil (<0.5 ft)	IA-10	Arsenic	4/4	mg/kg			4.7	5.9	5.45	D	6.13	5.9	m
Surface Soil (<0.5 ft)	IA-10	Barium	4/4	mg/kg			127	149	140	D	151	149	m
Surface Soil (<0.5 ft)	IA-10	Beryllium	4/4	mg/kg			0.56	0.63	0.585	D	0.622	0.622	u
Surface Soil (<0.5 ft)	IA-10	Boron	4/4	mg/kg			5.8	7.7	6.48	D	7.48	7.48	u
Surface Soil (<0.5 ft)	IA-10	Calcium	4/4	mg/kg			6680	10200	8100	D	10100	10100	u
Surface Soil (<0.5 ft)	IA-10	Chromium	4/4	mg/kg			15.5	16.3	15.9	D	16.3	16.3	u
Surface Soil (<0.5 ft)	IA-10	Cobalt	4/4	mg/kg			6.5	7.2	6.73	D	7.11	7.11	u
Surface Soil (<0.5 ft)	IA-10	Copper	4/4	mg/kg			31.2	70.9	43.6	D	65.2	65.2	u
Surface Soil (<0.5 ft)	IA-10	Iron	4/4	mg/kg			14100	15900	14700	D	15700	15700	u
Surface Soil (<0.5 ft)	IA-10	Lead	4/4	mg/kg			52.8	73.5	60.2	D	71	71	u
Surface Soil (<0.5 ft)	IA-10	Lithium	4/4	mg/kg			5.1	5.9	5.38	D	5.8	5.8	u
Surface Soil (<0.5 ft)	IA-10	Magnesium	4/4	mg/kg			3320	5140	4030	D	5060	5060	u
Surface Soil (<0.5 ft)	IA-10	Manganese	4/4	mg/kg			407	577	512	D	600	577	m
Surface Soil (<0.5 ft)	IA-10	Molybdenum	3/4	mg/kg	0.55	0.55	1.2	1.6	1.24	D	1.82	1.6	m
Surface Soil (<0.5 ft)	IA-10	Nickel	4/4	mg/kg			14	17.1	15.5	D	17.1	17.1	u
Surface Soil (<0.5 ft)	IA-10	Potassium	4/4	mg/kg			968	1360	1170	D	1360	1360	u
Surface Soil (<0.5 ft)	IA-10	Selenium	4/4	mg/kg			0.44	0.7	0.543	D	0.687	0.687	u
Surface Soil (<0.5 ft)	IA-10	Sodium	4/4	mg/kg			91.3	101	95.7	D	101	101	u
Surface Soil (<0.5 ft)	IA-10	Strontium	4/4	mg/kg			18.3	22.7	20.1	D	22.3	22.3	u
Surface Soil (<0.5 ft)	IA-10	Titanium	4/4	mg/kg			124	168	148	D	169	168	m
Surface Soil (<0.5 ft)	IA-10	Vanadium	4/4	mg/kg			19.1	21.3	20.1	D	21.4	21.3	m
Surface Soil (<0.5 ft)	IA-10	Zinc	4/4	mg/kg			75	88.7	83	D	90.9	88.7	m
Surface Soil (<0.5 ft)	IA-10	Anthracene	2/4	mg/kg	0.21	0.215	0.046	0.14	0.153	D	0.246	0.14	m
Surface Soil (<0.5 ft)	IA-10	Benz(a)anthracene	4/4	mg/kg			0.06	0.76	0.325	D	0.696	0.696	u
Surface Soil (<0.5 ft)	IA-10	Benzo(a)pyrene	4/4	mg/kg			0.066	0.79	0.349	D	0.734	0.734	u
Surface Soil (<0.5 ft)	IA-10	Benzo(b)fluoranthene	4/4	mg/kg			0.065	0.69	0.316	D	0.647	0.647	u
Surface Soil (<0.5 ft)	IA-10	Benzo(ghi)perylene	4/4	mg/kg			0.071	0.95	0.435	D	0.903	0.903	u
Surface Soil (<0.5 ft)	IA-10	Benzo(k)fluoranthene	4/4	mg/kg			0.059	0.65	0.292	D	0.607	0.607	u
Surface Soil (<0.5 ft)	IA-10	Bis(2-ethylhexyl)phthalate	4/4	mg/kg			0.058	0.84	0.375	D	0.764	0.764	u
Surface Soil (<0.5 ft)	IA-10	Butyl benzyl phthalate	2/4	mg/kg	0.215	0.215	0.045	0.12	0.149	D	0.246	0.12	m
Surface Soil (<0.5 ft)	IA-10	Carbazole	1/4	mg/kg	0.21	0.215	0.048	0.048	0.172	D	0.269	0.048	m
Surface Soil (<0.5 ft)	IA-10	Chrysene	4/4	mg/kg			0.12	1.3	0.58	D	1.21	1.21	u
Surface Soil (<0.5 ft)	IA-10	Fluoranthene	4/4	mg/kg			0.12	1.3	0.583	D	1.2	1.2	u
Surface Soil (<0.5 ft)	IA-10	Indeno(1,2,3-cd)pyrene	4/4	mg/kg			0.059	0.82	0.372	D	0.777	0.777	u
Surface Soil (<0.5 ft)	IA-10	Phenanthrene	4/4	mg/kg			0.071	0.76	0.313	D	0.682	0.682	u
Surface Soil (<0.5 ft)	IA-10	Pyrene	4/4	mg/kg			0.14	1.6	0.693	D	1.47	1.47	u

Table 2-10. North County Surface Soil Data Summary (Cont'd)

Data Grouping	Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
Surface Soil (<0.5 ft)	IA-10	Cesium-137	4/4	pCi/g			0.13	0.21	0.163	D	0.203	0.203	u
Surface Soil (<0.5 ft)	IA-10	Potassium-40	4/4	pCi/g			14.99	16.54	15.7	D	16.5	16.5	u
Surface Soil (<0.5 ft)	IA-10	Radium-226	95/119	pCi/g	0	2	0.3	2.8	1.19	Z	1.29	1.29	u
Surface Soil (<0.5 ft)	IA-10	Radium-228	4/4	pCi/g			0.88	0.94	0.908	D	0.94	0.94	u
Surface Soil (<0.5 ft)	IA-10	Thorium-228	4/4	pCi/g			1.23	2.29	1.71	D	2.23	2.23	u
Surface Soil (<0.5 ft)	IA-10	Thorium-230	112/121	pCi/g	0	0.8	0.4	29	3.8	Z	4.44	4.44	u
Surface Soil (<0.5 ft)	IA-10	Thorium-232	88/119	pCi/g	0	2.8	0.5	4	1.39	Z	1.52	1.52	u
Surface Soil (<0.5 ft)	IA-13	Aluminum	6/6	mg/kg			8920	12900	10600	L	12000	12000	u
Surface Soil (<0.5 ft)	IA-13	Arsenic	6/6	mg/kg			5.1	19.9	11.6	L	24.9	19.9	m
Surface Soil (<0.5 ft)	IA-13	Barium	6/6	mg/kg			105	181	150	N	172	172	u
Surface Soil (<0.5 ft)	IA-13	Beryllium	3/6	mg/kg	0.335	0.37	0.63	0.78	0.521	D	0.682	0.682	u
Surface Soil (<0.5 ft)	IA-13	Boron	6/6	mg/kg			5.5	9.2	7.6	N	8.65	8.65	u
Surface Soil (<0.5 ft)	IA-13	Calcium	6/6	mg/kg			3110	68900	15000	X	36800	36800	u
Surface Soil (<0.5 ft)	IA-13	Chromium	6/6	mg/kg			11.9	18.3	15.5	N	17.3	17.3	u
Surface Soil (<0.5 ft)	IA-13	Cobalt	6/6	mg/kg			6.7	13.3	9.87	L	13.1	13.1	u
Surface Soil (<0.5 ft)	IA-13	Copper	6/6	mg/kg			19.3	29.7	23	L	27.1	27.1	u
Surface Soil (<0.5 ft)	IA-13	Iron	6/6	mg/kg			12400	21000	17200	N	19700	19700	u
Surface Soil (<0.5 ft)	IA-13	Lead	6/6	mg/kg			17.2	137	57.3	L	214	137	m
Surface Soil (<0.5 ft)	IA-13	Lithium	6/6	mg/kg			5.2	7.4	6.35	L	7.36	7.36	u
Surface Soil (<0.5 ft)	IA-13	Magnesium	6/6	mg/kg			1960	9210	3920	X	6090	6090	u
Surface Soil (<0.5 ft)	IA-13	Manganese	6/6	mg/kg			463	743	615	N	712	712	u
Surface Soil (<0.5 ft)	IA-13	Mercury	1/6	mg/kg	0.03	0.035	0.08	0.08	0.04	D	0.0562	0.0562	u
Surface Soil (<0.5 ft)	IA-13	Molybdenum	4/6	mg/kg	0.47	0.55	1.2	2.1	1.25	D	1.8	1.8	u
Surface Soil (<0.5 ft)	IA-13	Nickel	6/6	mg/kg			15.1	26.2	19.6	L	23.6	23.6	u
Surface Soil (<0.5 ft)	IA-13	Potassium	6/6	mg/kg			1230	1730	1470	N	1620	1620	u
Surface Soil (<0.5 ft)	IA-13	Selenium	3/6	mg/kg	0.165	0.195	0.66	0.78	0.447	D	0.692	0.692	u
Surface Soil (<0.5 ft)	IA-13	Sodium	6/6	mg/kg			66.7	145	114	N	139	139	u
Surface Soil (<0.5 ft)	IA-13	Strontium	6/6	mg/kg			14.9	79.4	30.6	X	50.5	50.5	u
Surface Soil (<0.5 ft)	IA-13	Thallium	1/6	mg/kg	0.345	0.95	1.4	1.4	0.734	D	1.05	1.05	u
Surface Soil (<0.5 ft)	IA-13	Titanium	6/6	mg/kg			155	303	221	L	305	303	m
Surface Soil (<0.5 ft)	IA-13	Uranium	1/6	mg/kg	4.3	9.05	10.2	10.2	7.32	D	9.31	9.31	u
Surface Soil (<0.5 ft)	IA-13	Vanadium	6/6	mg/kg			23.7	30.1	27.3	L	29.8	29.8	u
Surface Soil (<0.5 ft)	IA-13	Zinc	6/6	mg/kg			56.6	81.6	69.9	N	78.8	78.8	u
Surface Soil (<0.5 ft)	IA-13	Benz(a)anthracene	4/6	mg/kg	0.21	0.245	0.044	0.21	0.151	D	0.218	0.21	m
Surface Soil (<0.5 ft)	IA-13	Benzo(a)pyrene	4/6	mg/kg	0.21	0.245	0.049	0.12	0.137	D	0.199	0.12	m
Surface Soil (<0.5 ft)	IA-13	Benzo(b)fluoranthene	4/6	mg/kg	0.21	0.245	0.046	0.26	0.164	D	0.235	0.235	u
Surface Soil (<0.5 ft)	IA-13	Benzo(ghi)perylene	3/6	mg/kg	0.21	0.245	0.055	0.13	0.163	D	0.222	0.13	m
Surface Soil (<0.5 ft)	IA-13	Benzo(k)fluoranthene	3/6	mg/kg	0.21	0.245	0.044	0.092	0.15	D	0.218	0.092	m
Surface Soil (<0.5 ft)	IA-13	Bis(2-ethylhexyl)phthalate	3/6	mg/kg	0.21	0.245	0.11	0.13	0.17	D	0.219	0.13	m
Surface Soil (<0.5 ft)	IA-13	Butyl benzyl phthalate	1/6	mg/kg	0.205	0.245	0.061	0.061	0.192	D	0.246	0.061	m
Surface Soil (<0.5 ft)	IA-13	Chrysene	4/6	mg/kg	0.21	0.245	0.084	0.19	0.18	D	0.224	0.19	m
Surface Soil (<0.5 ft)	IA-13	Fluoranthene	6/6	mg/kg			0.094	0.3	0.179	N	0.25	0.25	u
Surface Soil (<0.5 ft)	IA-13	Indeno(1,2,3-cd)pyrene	4/6	mg/kg	0.21	0.245	0.046	0.35	0.177	D	0.269	0.269	u
Surface Soil (<0.5 ft)	IA-13	Phenanthrene	3/6	mg/kg	0.205	0.245	0.058	0.094	0.149	D	0.215	0.094	m
Surface Soil (<0.5 ft)	IA-13	Pyrene	4/6	mg/kg	0.21	0.245	0.098	0.32	0.216	D	0.275	0.275	u
Surface Soil (<0.5 ft)	IA-13	1,1,2,2-Tetrachloroethane	1/6	mg/kg	0.003	0.0035	0.006	0.006	0.00358	D	0.00457	0.00457	u
Surface Soil (<0.5 ft)	IA-13	1,1,2-Trichloroethane	1/6	mg/kg	0.003	0.0035	0.003	0.003	0.00308	D	0.00325	0.003	m
Surface Soil (<0.5 ft)	IA-13	2-Butanone	1/6	mg/kg	0.006	0.0075	0.014	0.014	0.00783	D	0.0104	0.0104	u
Surface Soil (<0.5 ft)	IA-13	4-Methyl-2-pentanone	1/6	mg/kg	0.006	0.0075	0.011	0.011	0.00733	D	0.00887	0.00887	u
Surface Soil (<0.5 ft)	IA-13	Bromoform	1/6	mg/kg	0.003	0.0035	0.004	0.004	0.00325	D	0.00359	0.00359	u
Surface Soil (<0.5 ft)	IA-13	Toluene	1/6	mg/kg	0.003	0.0035	0.002	0.002	0.00292	D	0.00332	0.002	m
Surface Soil (<0.5 ft)	IA-13	Actinium-227	26/38	pCi/g	0.02	0.19	0.2	0.71	0.328	X	0.382	0.382	u
Surface Soil (<0.5 ft)	IA-13	Americium-241	1/38	pCi/g	-0.02	0.07	0.06	0.06	0.0303	D	0.0358	0.0358	u
Surface Soil (<0.5 ft)	IA-13	Cesium-137	35/37	pCi/g	0	0	0.05	0.55	0.242	Z	0.281	0.281	u
Surface Soil (<0.5 ft)	IA-13	Potassium-40	37/37	pCi/g			3.69	17.61	14.2	X	15.2	15.2	u
Surface Soil (<0.5 ft)	IA-13	Protactinium-231	2/38	pCi/g	-0.34	1.03	1.55	1.92	0.391	D	0.514	0.514	u
Surface Soil (<0.5 ft)	IA-13	Radium-226	110/111	pCi/g	1	1	0.54	3.3	1.48	X	1.59	1.59	u
Surface Soil (<0.5 ft)	IA-13	Radium-228	37/37	pCi/g			0.14	1.13	0.844	X	0.911	0.911	u
Surface Soil (<0.5 ft)	IA-13	Thorium-228	38/38	pCi/g			0.39	2.14	1.11	N	1.2	1.2	u
Surface Soil (<0.5 ft)	IA-13	Thorium-230	108/109	pCi/g	1.2	1.2	0.42	110	11.4	L	15.4	15.4	u
Surface Soil (<0.5 ft)	IA-13	Thorium-232	103/112	pCi/g	1	1	0.44	4	1.44	L	1.54	1.54	u
Surface Soil (<0.5 ft)	IA-13	Uranium-235	11/38	pCi/g	-0.01	0.26	0.2	0.51	0.168	D	0.195	0.195	u
Surface Soil (<0.5 ft)	IA-13	Uranium-238	3/112	pCi/g	0.26	13	2.8	7	3.58	D	4.03	4.03	u
Surface Soil (<5 ft)	IA-2	Arsenic	2/2	mg/kg			205	237	221	D	322	237	m
Surface Soil (<5 ft)	IA-2	Cadmium	4/12	mg/kg	0.45	0.55	1	5.9	1.38	D	2.31	2.31	u
Surface Soil (<5 ft)	IA-2	Cobalt	4/4	mg/kg			46.7	228	144	D	245	228	m
Surface Soil (<5 ft)	IA-2	Copper	3/3	mg/kg			187	440	307	D	521	440	m
Surface Soil (<5 ft)	IA-2	Magnesium	5/5	mg/kg			8180	24900	12700	L	25500	24900	m
Surface Soil (<5 ft)	IA-2	Molybdenum	3/12	mg/kg	8.75	11.25	30.3	151	32.5	D	57.6	57.6	u
Surface Soil (<5 ft)	IA-2	Vanadium	2/2	mg/kg			782	862	822	D	1070	862	m
Surface Soil (<5 ft)	IA-2	Toluene	5/5	mg/kg			0.0025	0.0104	0.00716	N	0.0104	0.0104	u
Surface Soil (<5 ft)	IA-2	Actinium-227	11/13	pCi/g	0.1	0.19	0.18	130.4	13.1	X	30.9	30.9	u
Surface Soil (<5 ft)	IA-2	Americium-241	4/13	pCi/g	0	0.11	0.06	2.58	0.333	D	0.687	0.687	u
Surface Soil (<5 ft)	IA-2	Cesium-137	6/13	pCi/g	-0.04	0.04	0.03	3.09	0.278	D	0.697	0.697	u
Surface Soil (<5 ft)	IA-2	Potassium-40	12/13	pCi/g	8.43	8.43	5.69	17.74	13	N	14.8	14.8	u
Surface Soil (<5 ft)	IA-2	Protactinium-231	5/13	pCi/g	-0.03	0.7	2.66	179.3	17.1	D	41.4	41.4	u
Surface Soil (<5 ft)	IA-2	Radium-226	32/53	pCi/g	1.5	5	0.85	590	38.6	X	68.2	68.2	u

Table 2-10. North County Surface Soil Data Summary (Cont'd)

Data Grouping	Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
Surface Soil (<5 ft)	IA-2	Radium-228	13/13	pCi/g			0.38	4.82	1.19	X	1.74	1.74	u
Surface Soil (<5 ft)	IA-2	Thorium-228	13/13	pCi/g			0.5	4.82	1.39	X	1.92	1.92	u
Surface Soil (<5 ft)	IA-2	Thorium-230	30/30	pCi/g			0	14070	584	Z	1380	1380	u
Surface Soil (<5 ft)	IA-2	Thorium-232	23/53	pCi/g	2	13.4	0.44	4.82	2.71	D	3.15	3.15	u
Surface Soil (<5 ft)	IA-2	Uranium-235	10/13	pCi/g	-0.03	0.12	0.25	37.21	4.65	Z	9.68	9.68	u
Surface Soil (<5 ft)	IA-2	Uranium-238	14/54	pCi/g	0.33	304	6.02	706	67.8	D	98.1	98.1	u
Surface Soil (<5 ft)	IA-3	Aluminum	3/3	mg/kg			13100	23200	17000	D	26200	23200	m
Surface Soil (<5 ft)	IA-3	Antimony	2/7	mg/kg	1.65	6	5.3	53.2	11.3	D	24.9	24.9	u
Surface Soil (<5 ft)	IA-3	Arsenic	3/3	mg/kg			7.2	9	8.2	D	9.75	9	m
Surface Soil (<5 ft)	IA-3	Barium	3/3	mg/kg			152	209	178	D	227	209	m
Surface Soil (<5 ft)	IA-3	Beryllium	3/3	mg/kg			0.84	2.4	1.36	D	2.88	2.4	m
Surface Soil (<5 ft)	IA-3	Boron	3/3	mg/kg			8.4	9.6	9.07	D	10.1	9.6	m
Surface Soil (<5 ft)	IA-3	Cadmium	2/7	mg/kg	0.14	0.5	0.52	50.4	7.52	D	21.4	21.4	u
Surface Soil (<5 ft)	IA-3	Calcium	3/3	mg/kg			4860	29500	13400	D	36900	29500	m
Surface Soil (<5 ft)	IA-3	Chromium	4/4	mg/kg			18.6	3240	830	D	2720	2720	u
Surface Soil (<5 ft)	IA-3	Cobalt	3/3	mg/kg			8.3	11.8	10.1	D	13.1	11.8	m
Surface Soil (<5 ft)	IA-3	Copper	3/3	mg/kg			14.1	31.8	21.8	D	37.1	31.8	m
Surface Soil (<5 ft)	IA-3	Iron	3/3	mg/kg			19400	26800	21900	D	29100	26800	m
Surface Soil (<5 ft)	IA-3	Lead	4/4	mg/kg			19.6	1200	336	D	1010	1010	u
Surface Soil (<5 ft)	IA-3	Lithium	3/3	mg/kg			8.9	14.6	11.6	D	16.4	14.6	m
Surface Soil (<5 ft)	IA-3	Magnesium	5/5	mg/kg			3730	14700	7600	L	20000	14700	m
Surface Soil (<5 ft)	IA-3	Manganese	3/3	mg/kg			552	1330	852	D	1560	1330	m
Surface Soil (<5 ft)	IA-3	Molybdenum	3/7	mg/kg	0.415	10.05	2.5	58.9	13.3	D	28.3	28.3	u
Surface Soil (<5 ft)	IA-3	Nickel	3/3	mg/kg			20.2	66.9	36.4	D	81	66.9	m
Surface Soil (<5 ft)	IA-3	Potassium	3/3	mg/kg			1320	2070	1650	D	2300	2070	m
Surface Soil (<5 ft)	IA-3	Sodium	3/3	mg/kg			124	382	239	D	460	382	m
Surface Soil (<5 ft)	IA-3	Strontium	3/3	mg/kg			24.1	53.2	42.7	D	70	53.2	m
Surface Soil (<5 ft)	IA-3	Thallium	2/7	mg/kg	0.8	10.05	1.2	1.4	5.94	D	9.27	1.4	m
Surface Soil (<5 ft)	IA-3	Titanium	3/3	mg/kg			260	416	321	D	462	416	m
Surface Soil (<5 ft)	IA-3	Uranium	2/3	mg/kg	6.9	6.9	15.6	129	50.5	D	165	129	m
Surface Soil (<5 ft)	IA-3	Vanadium	3/3	mg/kg			35.6	57.2	43.6	D	63.6	57.2	m
Surface Soil (<5 ft)	IA-3	Zinc	4/4	mg/kg			49.8	4330	1130	D	3640	3640	u
Surface Soil (<5 ft)	IA-3	MCPP	1/3	mg/kg	4.5	4.7	11	11	6.73	D	13	11	m
Surface Soil (<5 ft)	IA-3	Benz(a)anthracene	2/3	mg/kg	0.19	0.19	0.09	0.18	0.153	D	0.246	0.18	m
Surface Soil (<5 ft)	IA-3	Benzo(a)pyrene	2/3	mg/kg	0.19	0.19	0.077	0.18	0.149	D	0.254	0.18	m
Surface Soil (<5 ft)	IA-3	Benzo(b)fluoranthene	1/3	mg/kg	0.185	0.19	0.083	0.083	0.153	D	0.254	0.083	m
Surface Soil (<5 ft)	IA-3	Benzo(ghi)perylene	1/3	mg/kg	0.19	0.195	0.19	0.19	0.192	D	0.197	0.19	m
Surface Soil (<5 ft)	IA-3	Benzo(k)fluoranthene	1/3	mg/kg	0.19	0.195	0.066	0.066	0.15	D	0.274	0.066	m
Surface Soil (<5 ft)	IA-3	Butyl benzyl phthalate	1/3	mg/kg	0.185	0.19	0.1	0.1	0.158	D	0.244	0.1	m
Surface Soil (<5 ft)	IA-3	Chrysene	1/3	mg/kg	0.19	0.195	0.21	0.21	0.198	D	0.216	0.21	m
Surface Soil (<5 ft)	IA-3	Fluoranthene	2/3	mg/kg	0.19	0.19	0.1	0.31	0.2	D	0.378	0.31	m
Surface Soil (<5 ft)	IA-3	Indeno(1,2,3-cd)pyrene	2/3	mg/kg	0.19	0.19	0.089	0.18	0.153	D	0.247	0.18	m
Surface Soil (<5 ft)	IA-3	Phenanthrene	2/3	mg/kg	0.19	0.19	0.042	0.19	0.141	D	0.285	0.19	m
Surface Soil (<5 ft)	IA-3	Pyrene	2/3	mg/kg	0.19	0.19	0.046	0.27	0.169	D	0.36	0.27	m
Surface Soil (<5 ft)	IA-3	1,2-Dichloroethene	1/3	mg/kg	0.003	0.003	0.003	0.003	0.003	D	0.003	0.003	u
Surface Soil (<5 ft)	IA-3	Dimethylbenzene	1/3	mg/kg	0.003	0.003	0.01	0.01	0.00533	D	0.0121	0.01	m
Surface Soil (<5 ft)	IA-3	Methylene chloride	1/3	mg/kg	0.003	0.004	0.13	0.13	0.0457	D	0.169	0.13	m
Surface Soil (<5 ft)	IA-3	Toluene	3/6	mg/kg	0.003	0.003	0.0015	0.055	0.0176	D	0.037	0.037	u
Surface Soil (<5 ft)	IA-3	Trichloroethene	1/3	mg/kg	0.003	0.003	0.005	0.005	0.00367	D	0.00561	0.005	m
Surface Soil (<5 ft)	IA-3	Actinium-227	11/15	pCi/g	0.12	0.24	0.19	47.16	4.99	X	10.7	10.7	u
Surface Soil (<5 ft)	IA-3	Americium-241	1/15	pCi/g	-0.02	0.37	2.09	2.09	0.185	D	0.428	0.428	u
Surface Soil (<5 ft)	IA-3	Cesium-137	10/15	pCi/g	-0.01	0.06	0.03	0.12	0.0507	Z	0.0662	0.0662	u
Surface Soil (<5 ft)	IA-3	Potassium-40	15/15	pCi/g			7.02	17.01	12.2	L	14.2	14.2	u
Surface Soil (<5 ft)	IA-3	Protactinium-231	6/15	pCi/g	-0.06	0.46	1.56	31.66	3.87	D	7.86	7.86	u
Surface Soil (<5 ft)	IA-3	Radium-226	59/74	pCi/g	1.5	4.7	0.7	208	10.1	X	15.9	15.9	u
Surface Soil (<5 ft)	IA-3	Radium-228	15/15	pCi/g			0.33	1.81	0.846	L	1.1	1.1	u
Surface Soil (<5 ft)	IA-3	Thorium-228	15/15	pCi/g			0.34	1.81	1.04	N	1.23	1.23	u
Surface Soil (<5 ft)	IA-3	Thorium-230	36/36	pCi/g			1.09	5335	226	X	482	482	u
Surface Soil (<5 ft)	IA-3	Thorium-232	51/74	pCi/g	0.5	7.5	0.4	5	1.96	L	2.27	2.27	u
Surface Soil (<5 ft)	IA-3	Uranium-235	11/15	pCi/g	-0.02	0.16	0.22	8.21	1.46	Z	2.61	2.61	u
Surface Soil (<5 ft)	IA-3	Uranium-238	18/74	pCi/g	0.9	173.4	3.04	270	23.6	D	31.4	31.4	u
Surface Soil (<5 ft)	IA-4	Fluoride	2/2	mg/kg			9.58	43.3	26.4	D	133	43.3	m
Surface Soil (<5 ft)	IA-4	Sulfide	1/2	mg/kg	13.6	13.6	21	21	17.3	D	40.7	21	m
Surface Soil (<5 ft)	IA-4	Aluminum	2/2	mg/kg			18500	19000	18800	D	20300	19000	m
Surface Soil (<5 ft)	IA-4	Arsenic	3/3	mg/kg			8.5	50.8	22.9	D	63.6	50.8	m
Surface Soil (<5 ft)	IA-4	Barium	4/4	mg/kg			266	3750	1340	D	3270	3270	u
Surface Soil (<5 ft)	IA-4	Beryllium	2/2	mg/kg			0.98	1	0.99	D	1.05	1	m
Surface Soil (<5 ft)	IA-4	Boron	1/2	mg/kg	4.45	4.45	11.9	11.9	8.18	D	31.7	11.9	m
Surface Soil (<5 ft)	IA-4	Cadmium	1/7	mg/kg	0.155	0.55	4.5	4.5	0.995	D	2.14	2.14	u
Surface Soil (<5 ft)	IA-4	Calcium	2/2	mg/kg			3610	3920	3770	D	4740	3920	m
Surface Soil (<5 ft)	IA-4	Chromium	2/2	mg/kg			20.6	20.8	20.7	D	21.3	20.8	m
Surface Soil (<5 ft)	IA-4	Cobalt	7/7	mg/kg			4.7	1510	313	L	120000	1510	m
Surface Soil (<5 ft)	IA-4	Copper	4/4	mg/kg			13.1	876	283	D	762	762	u
Surface Soil (<5 ft)	IA-4	Iron	2/2	mg/kg			22500	24200	23400	D	28700	24200	m
Surface Soil (<5 ft)	IA-4	Lead	4/4	mg/kg			8.6	408	176	D	406	406	u
Surface Soil (<5 ft)	IA-4	Lithium	2/2	mg/kg			8.9	9.6	9.25	D	11.5	9.6	m
Surface Soil (<5 ft)	IA-4	Magnesium	3/3	mg/kg			3510	13200	6820	D	16100	13200	m

Table 2-10. North County Surface Soil Data Summary (Cont'd)

Data Grouping	Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
Surface Soil (<5 ft)	IA-4	Manganese	2/2	mg/kg			172	692	432	D	2070	692	m
Surface Soil (<5 ft)	IA-4	Mercury	1/2	mg/kg	0.03	0.03	0.07	0.07	0.05	D	0.176	0.07	m
Surface Soil (<5 ft)	IA-4	Molybdenum	3/7	mg/kg	0.465	11.1	8.2	71.9	20.5	D	38.6	38.6	u
Surface Soil (<5 ft)	IA-4	Nickel	3/3	mg/kg			19	2010	684	D	2620	2010	m
Surface Soil (<5 ft)	IA-4	Potassium	2/2	mg/kg			1060	1350	1210	D	2120	1350	m
Surface Soil (<5 ft)	IA-4	Selenium	1/7	mg/kg	0.5	11.1	29.3	29.3	10.4	D	17.4	17.4	u
Surface Soil (<5 ft)	IA-4	Sodium	2/2	mg/kg			197	242	220	D	362	242	m
Surface Soil (<5 ft)	IA-4	Strontium	2/2	mg/kg			23.7	26.3	25	D	33.2	26.3	m
Surface Soil (<5 ft)	IA-4	Thallium	2/7	mg/kg	9.55	11.1	1	3.3	8.09	D	11.1	3.3	m
Surface Soil (<5 ft)	IA-4	Titanium	2/2	mg/kg			170	243	207	D	437	243	m
Surface Soil (<5 ft)	IA-4	Uranium	1/2	mg/kg	7.8	7.8	73.6	73.6	40.7	D	248	73.6	m
Surface Soil (<5 ft)	IA-4	Vanadium	2/2	mg/kg			29.5	39.1	34.3	D	64.6	39.1	m
Surface Soil (<5 ft)	IA-4	Zinc	2/2	mg/kg			52.3	59.3	55.8	D	77.9	59.3	m
Surface Soil (<5 ft)	IA-4	Toluene	4/5	mg/kg	0.003	0.003	0.0018	0.12	0.0273	D	0.0768	0.0768	u
Surface Soil (<5 ft)	IA-4	Actinium-227	6/6	pCi/g			0.23	4.76	1.61	L	108	4.76	m
Surface Soil (<5 ft)	IA-4	Americium-241	2/6	pCi/g	0.06	0.09	0.18	0.24	0.118	D	0.179	0.179	u
Surface Soil (<5 ft)	IA-4	Potassium-40	6/6	pCi/g			13.85	16.65	14.9	L	15.8	15.8	u
Surface Soil (<5 ft)	IA-4	Protactinium-231	3/6	pCi/g	-0.12	0.45	2.49	3.98	1.75	D	3.29	3.29	u
Surface Soil (<5 ft)	IA-4	Radium-226	20/40	pCi/g	1.2	4.4	0.82	1518	170	X	267	267	u
Surface Soil (<5 ft)	IA-4	Radium-228	6/6	pCi/g			0.95	1.2	1.04	L	1.13	1.13	u
Surface Soil (<5 ft)	IA-4	Thorium-228	6/6	pCi/g			1.02	2.2	1.4	L	1.86	1.86	u
Surface Soil (<5 ft)	IA-4	Thorium-230	15/15	pCi/g			1.1	2440	398	L	30800	2440	m
Surface Soil (<5 ft)	IA-4	Thorium-232	8/38	pCi/g	2	20.4	1.15	4	4.76	D	5.97	4	m
Surface Soil (<5 ft)	IA-4	Uranium-235	5/6	pCi/g	0.14	0.14	1.21	3.89	1.96	N	3.06	3.06	u
Surface Soil (<5 ft)	IA-4	Uranium-238	4/38	pCi/g	1.4	406	14.83	72.35	79.2	D	106	72.4	m
Surface Soil (<5 ft)	IA-5	Fluoride	2/2	mg/kg			4.42	21.1	12.8	D	65.4	21.1	m
Surface Soil (<5 ft)	IA-5	Aluminum	7/7	mg/kg			10700	17100	13600	L	15500	15500	u
Surface Soil (<5 ft)	IA-5	Arsenic	7/7	mg/kg			7.3	26.2	11	X	16	16	u
Surface Soil (<5 ft)	IA-5	Barium	8/8	mg/kg			166	4550	744	X	1770	1770	u
Surface Soil (<5 ft)	IA-5	Beryllium	6/7	mg/kg	0.375	0.375	0.7	1.4	0.865	N	1.09	1.09	u
Surface Soil (<5 ft)	IA-5	Boron	7/7	mg/kg			2.3	15.1	8.53	N	11.3	11.3	u
Surface Soil (<5 ft)	IA-5	Cadmium	3/18	mg/kg	0.155	0.55	0.63	4.2	0.66	D	1.03	1.03	u
Surface Soil (<5 ft)	IA-5	Calcium	7/7	mg/kg			2230	9310	5650	N	7290	7290	u
Surface Soil (<5 ft)	IA-5	Chromium	7/7	mg/kg			15.1	34.6	20.2	L	25.9	25.9	u
Surface Soil (<5 ft)	IA-5	Cobalt	13/13	mg/kg			7.6	308	107	L	653	308	m
Surface Soil (<5 ft)	IA-5	Copper	9/9	mg/kg			13.2	191	63.6	L	369	191	m
Surface Soil (<5 ft)	IA-5	Cyanide	1/3	mg/kg	0.3105	0.3225	0.772	0.772	0.468	D	0.912	0.772	m
Surface Soil (<5 ft)	IA-5	Iron	7/7	mg/kg			16100	21400	19300	N	20800	20800	u
Surface Soil (<5 ft)	IA-5	Lead	7/7	mg/kg			10.3	49	21	L	39.6	39.6	u
Surface Soil (<5 ft)	IA-5	Lithium	7/7	mg/kg			6	10.1	8.59	N	9.71	9.71	u
Surface Soil (<5 ft)	IA-5	Magnesium	9/9	mg/kg			2010	26900	7150	X	12200	12200	u
Surface Soil (<5 ft)	IA-5	Manganese	7/7	mg/kg			373	823	658	N	773	773	u
Surface Soil (<5 ft)	IA-5	Molybdenum	7/18	mg/kg	0.465	11.25	1.2	27.9	10.3	D	13.6	13.6	u
Surface Soil (<5 ft)	IA-5	Nickel	7/7	mg/kg			21.2	108	45.1	X	70.3	70.3	u
Surface Soil (<5 ft)	IA-5	Potassium	7/7	mg/kg			827	2820	1390	L	2080	2080	u
Surface Soil (<5 ft)	IA-5	Selenium	7/18	mg/kg	1	11.35	0.38	19.6	8.61	D	10.7	10.7	u
Surface Soil (<5 ft)	IA-5	Silver	1/7	mg/kg	0.315	0.385	0.81	0.81	0.421	D	0.549	0.549	u
Surface Soil (<5 ft)	IA-5	Sodium	7/7	mg/kg			69.5	201	134	L	194	194	u
Surface Soil (<5 ft)	IA-5	Strontium	7/7	mg/kg			14.8	243	79.5	X	154	154	u
Surface Soil (<5 ft)	IA-5	Thallium	4/18	mg/kg	0.6	11.35	1.9	2	6.97	D	8.85	2	m
Surface Soil (<5 ft)	IA-5	Titanium	7/7	mg/kg			99.1	338	225	N	284	284	u
Surface Soil (<5 ft)	IA-5	Uranium	3/7	mg/kg	4.95	7.85	11.1	45.1	14.5	D	25.1	25.1	u
Surface Soil (<5 ft)	IA-5	Vanadium	7/7	mg/kg			27.4	111	43.7	X	65.8	65.8	u
Surface Soil (<5 ft)	IA-5	Zinc	7/7	mg/kg			41.4	79.7	56.2	L	68.5	68.5	u
Surface Soil (<5 ft)	IA-5	MCPP	1/5	mg/kg	4.9	10.5	30	30	12.1	D	22	22	u
Surface Soil (<5 ft)	IA-5	Benz(a)anthracene	1/5	mg/kg	0.2	0.21	0.19	0.19	0.202	D	0.209	0.19	m
Surface Soil (<5 ft)	IA-5	Benzo(b)fluoranthene	1/5	mg/kg	0.2	0.21	0.36	0.36	0.237	D	0.303	0.303	u
Surface Soil (<5 ft)	IA-5	Bis(2-ethylhexyl)phthalate	1/5	mg/kg	0.2	0.295	0.21	0.21	0.224	D	0.262	0.21	m
Surface Soil (<5 ft)	IA-5	Butyl benzyl phthalate	1/5	mg/kg	0.2	0.21	0.31	0.31	0.226	D	0.271	0.271	u
Surface Soil (<5 ft)	IA-5	Chrysene	1/5	mg/kg	0.2	0.21	0.14	0.14	0.192	D	0.22	0.14	m
Surface Soil (<5 ft)	IA-5	Di-n-octylphthalate	1/5	mg/kg	0.2	0.21	0.13	0.13	0.19	D	0.222	0.13	m
Surface Soil (<5 ft)	IA-5	Fluoranthene	2/5	mg/kg	0.2	0.21	0.079	0.26	0.191	D	0.255	0.255	u
Surface Soil (<5 ft)	IA-5	Phenanthrene	1/5	mg/kg	0.2	0.21	0.078	0.078	0.18	D	0.234	0.078	m
Surface Soil (<5 ft)	IA-5	Pyrene	2/5	mg/kg	0.2	0.21	0.29	0.31	0.243	D	0.293	0.293	u
Surface Soil (<5 ft)	IA-5	Toluene	5/10	mg/kg	0.003	0.003	0.0024	0.9	0.116	X	0.281	0.281	u
Surface Soil (<5 ft)	IA-5	Actinium-227	34/43	pCi/g	0	0.27	0.19	292.7	10.4	Z	22	22	u
Surface Soil (<5 ft)	IA-5	Americium-241	3/43	pCi/g	-5.04	0.2	0.5	1.5	-0.000233	D	0.212	0.212	u
Surface Soil (<5 ft)	IA-5	Cesium-137	14/43	pCi/g	-0.03	0.09	0.04	2.35	0.0965	D	0.188	0.188	u
Surface Soil (<5 ft)	IA-5	Potassium-40	42/43	pCi/g	5.21	5.21	10.66	17.12	14.3	X	14.8	14.8	u
Surface Soil (<5 ft)	IA-5	Protactinium-231	12/43	pCi/g	-0.18	1.16	0.9	346.4	12.2	D	25.9	25.9	u
Surface Soil (<5 ft)	IA-5	Radium-226	107/160	pCi/g	1	4.8	0.6	900	18.8	X	29.4	29.4	u
Surface Soil (<5 ft)	IA-5	Radium-228	42/43	pCi/g	0.95	0.95	0.61	3.56	1.09	X	1.2	1.2	u
Surface Soil (<5 ft)	IA-5	Thorium-228	42/43	pCi/g	1.04	1.04	0.71	3.56	1.32	X	1.44	1.44	u
Surface Soil (<5 ft)	IA-5	Thorium-230	106/106	pCi/g			1	14680	419	X	662	662	u
Surface Soil (<5 ft)	IA-5	Thorium-232	88/160	pCi/g	1	7.2	0.64	7.5	2.45	X	2.63	2.63	u
Surface Soil (<5 ft)	IA-5	Uranium-235	30/43	pCi/g	-0.04	0.24	0.2	32.11	2.05	Z	3.45	3.45	u
Surface Soil (<5 ft)	IA-5	Uranium-238	34/160	pCi/g	0.89	256	6	1000	40	D	51.6	51.6	u

Table 2-10. North County Surface Soil Data Summary (Cont'd)

Data Grouping	Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
Surface Soil (<5 ft)	IA-6	Fluoride	1/1	mg/kg			62.9	62.9	62.9	D		62.9	m
Surface Soil (<5 ft)	IA-6	Cobalt	1/1	mg/kg			62.3	62.3	62.3	D		62.3	m
Surface Soil (<5 ft)	IA-6	Magnesium	1/1	mg/kg			12200	12200	12200	D		12200	m
Surface Soil (<5 ft)	IA-6	Actinium-227	1/1	pCi/g			17.89	17.89	17.9	D		17.9	m
Surface Soil (<5 ft)	IA-6	Potassium-40	1/1	pCi/g			13.87	13.87	13.9	D		13.9	m
Surface Soil (<5 ft)	IA-6	Protactinium-231	1/1	pCi/g			18.78	18.78	18.8	D		18.8	m
Surface Soil (<5 ft)	IA-6	Radium-226	11/24	pCi/g	1.6	2.6	1	39.4	5.98	D	9.62	9.62	u
Surface Soil (<5 ft)	IA-6	Radium-228	1/1	pCi/g			1.37	1.37	1.37	D		1.37	m
Surface Soil (<5 ft)	IA-6	Thorium-228	1/1	pCi/g			1.37	1.37	1.37	D		1.37	m
Surface Soil (<5 ft)	IA-6	Thorium-230	15/15	pCi/g			1.4	2100	211	X	464	464	u
Surface Soil (<5 ft)	IA-6	Thorium-232	8/24	pCi/g	2	4.9	1.2	7	3.04	D	3.45	3.45	u
Surface Soil (<5 ft)	IA-6	Uranium-235	1/1	pCi/g			4.33	4.33	4.33	D		4.33	m
Surface Soil (<5 ft)	IA-6	Uranium-238	7/24	pCi/g	6	127.4	12	32	33.6	D	42.9	32	m
Surface Soil (<5 ft)	IA-7	Aluminum	2/2	mg/kg			15500	15700	15600	D	16200	15700	m
Surface Soil (<5 ft)	IA-7	Arsenic	2/2	mg/kg			6.1	11.8	8.95	D	26.9	11.8	m
Surface Soil (<5 ft)	IA-7	Barium	4/4	mg/kg			195	13600	6700	D	15500	13600	m
Surface Soil (<5 ft)	IA-7	Beryllium	1/2	mg/kg	0.48	0.48	0.96	0.96	0.72	D	2.24	0.96	m
Surface Soil (<5 ft)	IA-7	Boron	2/2	mg/kg			9.4	11.6	10.5	D	17.4	11.6	m
Surface Soil (<5 ft)	IA-7	Cadmium	2/4	mg/kg	0.295	0.315	1.5	3.2	1.33	D	2.94	2.94	u
Surface Soil (<5 ft)	IA-7	Calcium	2/2	mg/kg			3540	5120	4330	D	9320	5120	m
Surface Soil (<5 ft)	IA-7	Chromium	2/2	mg/kg			20	22.1	21.1	D	27.7	22.1	m
Surface Soil (<5 ft)	IA-7	Cobalt	4/4	mg/kg			6.8	6050	2430	D	5910	5910	u
Surface Soil (<5 ft)	IA-7	Copper	4/4	mg/kg			15.4	4400	1810	D	4370	4370	u
Surface Soil (<5 ft)	IA-7	Iron	2/2	mg/kg			19800	24600	22200	D	37400	24600	m
Surface Soil (<5 ft)	IA-7	Lead	4/4	mg/kg			12.3	933	409	D	961	933	m
Surface Soil (<5 ft)	IA-7	Lithium	2/2	mg/kg			9	9.3	9.15	D	10.1	9.3	m
Surface Soil (<5 ft)	IA-7	Magnesium	2/2	mg/kg			3530	4120	3830	D	5690	4120	m
Surface Soil (<5 ft)	IA-7	Manganese	2/2	mg/kg			481	761	621	D	1500	761	m
Surface Soil (<5 ft)	IA-7	Molybdenum	2/4	mg/kg	0.75	0.8	170	255	107	D	256	255	m
Surface Soil (<5 ft)	IA-7	Nickel	4/4	mg/kg			21.2	7570	3040	D	7380	7380	u
Surface Soil (<5 ft)	IA-7	Potassium	2/2	mg/kg			916	1320	1120	D	2390	1320	m
Surface Soil (<5 ft)	IA-7	Selenium	2/4	mg/kg	0.2	0.215	96	183	69.9	D	173	173	u
Surface Soil (<5 ft)	IA-7	Sodium	2/2	mg/kg			119	135	127	D	178	135	m
Surface Soil (<5 ft)	IA-7	Strontium	2/2	mg/kg			20.6	23.6	22.1	D	31.6	23.6	m
Surface Soil (<5 ft)	IA-7	Titanium	2/2	mg/kg			256	267	262	D	296	267	m
Surface Soil (<5 ft)	IA-7	Vanadium	3/3	mg/kg			35	630	234	D	812	630	m
Surface Soil (<5 ft)	IA-7	Zinc	2/2	mg/kg			56.9	57.2	57.1	D	58	57.2	m
Surface Soil (<5 ft)	IA-7	1,2-Dichloroethane	1/2	mg/kg	0.0025	0.0025	0.001	0.001	0.00175	D	0.00649	0.001	m
Surface Soil (<5 ft)	IA-7	2-Butanone	1/2	mg/kg	0.005	0.005	0.001	0.001	0.003	D	0.0156	0.001	m
Surface Soil (<5 ft)	IA-7	Acetone	2/2	mg/kg			0.005	0.009	0.007	D	0.0196	0.009	m
Surface Soil (<5 ft)	IA-7	Actinium-227	9/19	pCi/g	-0.13	0.19	0.32	695.7	56.5	D	127	127	u
Surface Soil (<5 ft)	IA-7	Americium-241	1/19	pCi/g	-2.6	0.05	0.08	0.08	-0.216	D	0.0716	0.0716	u
Surface Soil (<5 ft)	IA-7	Potassium-40	18/19	pCi/g	11.07	11.07	13.87	16.6	15	X	15.5	15.5	u
Surface Soil (<5 ft)	IA-7	Protactinium-231	10/19	pCi/g	0.1	0.92	1.2	685.8	56.4	X	126	126	u
Surface Soil (<5 ft)	IA-7	Radium-226	87/92	pCi/g	1.5	5	0.7	1818	42.2	X	82.5	82.5	u
Surface Soil (<5 ft)	IA-7	Radium-228	19/19	pCi/g			0.81	7.54	1.67	X	2.46	2.46	u
Surface Soil (<5 ft)	IA-7	Thorium-228	19/19	pCi/g			1.02	7.54	1.95	X	2.71	2.71	u
Surface Soil (<5 ft)	IA-7	Thorium-230	70/71	pCi/g	0.05	0.05	1	37780	965	X	2010	2010	u
Surface Soil (<5 ft)	IA-7	Thorium-232	80/92	pCi/g	1	25.2	0.7	7.54	2.15	X	2.61	2.61	u
Surface Soil (<5 ft)	IA-7	Uranium-235	5/19	pCi/g	0.04	0.17	0.24	54.18	4.7	D	10.3	10.3	u
Surface Soil (<5 ft)	IA-7	Uranium-238	24/92	pCi/g	0.72	462	5	201.9	19.3	D	28.7	28.7	u
Surface Soil (<0.5 ft)	IA-8	Aluminum	1/1	mg/kg			4400	4400	4400	D		4400	m
Surface Soil (<0.5 ft)	IA-8	Arsenic	1/1	mg/kg			4.5	4.5	4.5	D		4.5	m
Surface Soil (<0.5 ft)	IA-8	Barium	1/1	mg/kg			105	105	105	D		105	m
Surface Soil (<0.5 ft)	IA-8	Boron	1/1	mg/kg			7.2	7.2	7.2	D		7.2	m
Surface Soil (<0.5 ft)	IA-8	Calcium	1/1	mg/kg			105000	105000	105000	D		105000	m
Surface Soil (<0.5 ft)	IA-8	Chromium	1/1	mg/kg			42.6	42.6	42.6	D		42.6	m
Surface Soil (<0.5 ft)	IA-8	Cobalt	1/1	mg/kg			23.2	23.2	23.2	D		23.2	m
Surface Soil (<0.5 ft)	IA-8	Copper	1/1	mg/kg			85.1	85.1	85.1	D		85.1	m
Surface Soil (<0.5 ft)	IA-8	Iron	1/1	mg/kg			13200	13200	13200	D		13200	m
Surface Soil (<0.5 ft)	IA-8	Lead	1/1	mg/kg			500	500	500	D		500	m
Surface Soil (<0.5 ft)	IA-8	Magnesium	1/1	mg/kg			10000	10000	10000	D		10000	m
Surface Soil (<0.5 ft)	IA-8	Manganese	1/1	mg/kg			352	352	352	D		352	m
Surface Soil (<0.5 ft)	IA-8	Mercury	1/1	mg/kg			0.08	0.08	0.08	D		0.08	m
Surface Soil (<0.5 ft)	IA-8	Molybdenum	1/1	mg/kg			3.2	3.2	3.2	D		3.2	m
Surface Soil (<0.5 ft)	IA-8	Nickel	1/1	mg/kg			37.5	37.5	37.5	D		37.5	m
Surface Soil (<0.5 ft)	IA-8	Potassium	1/1	mg/kg			481	481	481	D		481	m
Surface Soil (<0.5 ft)	IA-8	Selenium	1/1	mg/kg			0.62	0.62	0.62	D		0.62	m
Surface Soil (<0.5 ft)	IA-8	Silver	1/1	mg/kg			0.62	0.62	0.62	D		0.62	m
Surface Soil (<0.5 ft)	IA-8	Sodium	1/1	mg/kg			630	630	630	D		630	m
Surface Soil (<0.5 ft)	IA-8	Strontium	1/1	mg/kg			112	112	112	D		112	m
Surface Soil (<0.5 ft)	IA-8	Titanium	1/1	mg/kg			127	127	127	D		127	m
Surface Soil (<0.5 ft)	IA-8	Vanadium	1/1	mg/kg			20.6	20.6	20.6	D		20.6	m
Surface Soil (<0.5 ft)	IA-8	Zinc	1/1	mg/kg			284	284	284	D		284	m
Surface Soil (<0.5 ft)	IA-8	MCPA	1/1	mg/kg			25	25	25	D		25	m
Surface Soil (<0.5 ft)	IA-8	Silvex	1/1	mg/kg			0.03	0.03	0.03	D		0.03	m
Surface Soil (<0.5 ft)	IA-8	4,4'-DDT	1/1	mg/kg			0.0039	0.0039	0.0039	D		0.0039	m

Table 2-10. North County Surface Soil Data Summary (Cont'd)

Data Grouping	Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
Surface Soil (<0.5 ft)	IA-8	2-Methylnaphthalene	1/1	mg/kg			0.36	0.36	0.36	D		0.36	m
Surface Soil (<0.5 ft)	IA-8	Acenaphthene	1/1	mg/kg			0.085	0.085	0.085	D		0.085	m
Surface Soil (<0.5 ft)	IA-8	Anthracene	1/1	mg/kg			0.28	0.28	0.28	D		0.28	m
Surface Soil (<0.5 ft)	IA-8	Benz(a)anthracene	1/1	mg/kg			1.4	1.4	1.4	D		1.4	m
Surface Soil (<0.5 ft)	IA-8	Benzo(a)pyrene	1/1	mg/kg			1.6	1.6	1.6	D		1.6	m
Surface Soil (<0.5 ft)	IA-8	Benzo(b)fluoranthene	1/1	mg/kg			2.1	2.1	2.1	D		2.1	m
Surface Soil (<0.5 ft)	IA-8	Benzo(ghi)perylene	1/1	mg/kg			0.91	0.91	0.91	D		0.91	m
Surface Soil (<0.5 ft)	IA-8	Benzo(k)fluoranthene	1/1	mg/kg			1	1	1	D		1	m
Surface Soil (<0.5 ft)	IA-8	Butyl benzyl phthalate	1/1	mg/kg			0.21	0.21	0.21	D		0.21	m
Surface Soil (<0.5 ft)	IA-8	Carbazole	1/1	mg/kg			0.21	0.21	0.21	D		0.21	m
Surface Soil (<0.5 ft)	IA-8	Chrysene	1/1	mg/kg			1.8	1.8	1.8	D		1.8	m
Surface Soil (<0.5 ft)	IA-8	Di-n-butyl phthalate	1/1	mg/kg			0.15	0.15	0.15	D		0.15	m
Surface Soil (<0.5 ft)	IA-8	Dibenz(a,h)anthracene	1/1	mg/kg			0.28	0.28	0.28	D		0.28	m
Surface Soil (<0.5 ft)	IA-8	Dibenzofuran	1/1	mg/kg			0.046	0.046	0.046	D		0.046	m
Surface Soil (<0.5 ft)	IA-8	Fluoranthene	1/1	mg/kg			3.3	3.3	3.3	D		3.3	m
Surface Soil (<0.5 ft)	IA-8	Fluorene	1/1	mg/kg			0.11	0.11	0.11	D		0.11	m
Surface Soil (<0.5 ft)	IA-8	Indeno(1,2,3-cd)pyrene	1/1	mg/kg			0.88	0.88	0.88	D		0.88	m
Surface Soil (<0.5 ft)	IA-8	Naphthalene	1/1	mg/kg			0.05	0.05	0.05	D		0.05	m
Surface Soil (<0.5 ft)	IA-8	Phenanthrene	1/1	mg/kg			1.6	1.6	1.6	D		1.6	m
Surface Soil (<0.5 ft)	IA-8	Pyrene	1/1	mg/kg			2.8	2.8	2.8	D		2.8	m
Surface Soil (<0.5 ft)	IA-8	Actinium-227	23/23	pCi/g			0.18	442.6	43	X	82.3	82.3	u
Surface Soil (<0.5 ft)	IA-8	Americium-241	3/23	pCi/g	-3.35	0.11	0.12	0.29	-0.323	D	0.00473	0.00473	u
Surface Soil (<0.5 ft)	IA-8	Cesium-137	21/23	pCi/g	-0.01	0.39	0.04	0.96	0.394	Z	0.472	0.472	u
Surface Soil (<0.5 ft)	IA-8	Potassium-40	23/23	pCi/g			5.85	18.46	13.9	X	15.1	15.1	u
Surface Soil (<0.5 ft)	IA-8	Protactinium-231	18/23	pCi/g	0	1.69	0.84	450.3	45.4	Z	86.5	86.5	u
Surface Soil (<0.5 ft)	IA-8	Radium-226	85/86	pCi/g	2.1	2.1	0.7	436.4	23.5	X	34.7	34.7	u
Surface Soil (<0.5 ft)	IA-8	Radium-228	23/23	pCi/g			0.28	4.76	1.29	X	1.64	1.64	u
Surface Soil (<0.5 ft)	IA-8	Thorium-228	23/23	pCi/g			0.49	4.76	1.49	L	1.82	1.82	u
Surface Soil (<0.5 ft)	IA-8	Thorium-230	83/84	pCi/g	0.36	0.36	2.9	20280	917	L	1750	1750	u
Surface Soil (<0.5 ft)	IA-8	Thorium-232	71/86	pCi/g	0	6.8	0.4	5	1.81	Z	2.03	2.03	u
Surface Soil (<0.5 ft)	IA-8	Uranium-235	21/23	pCi/g	0.09	0.19	0.32	38.87	5.35	L	20.2	20.2	u
Surface Soil (<0.5 ft)	IA-8	Uranium-238	29/86	pCi/g	0	160.2	6	190.4	19.9	D	25.9	25.9	u
Surface Soil (<0.5 ft)	IA-9	Aluminum	8/8	mg/kg			1770	11100	8230	N	10300	10300	u
Surface Soil (<0.5 ft)	IA-9	Antimony	1/8	mg/kg	2.1	3.5	4.3	4.3	2.93	D	3.42	3.42	u
Surface Soil (<0.5 ft)	IA-9	Arsenic	8/8	mg/kg			5.5	41	12.9	X	21.4	21.4	u
Surface Soil (<0.5 ft)	IA-9	Barium	8/8	mg/kg			29.8	532	190	L	609	532	m
Surface Soil (<0.5 ft)	IA-9	Beryllium	6/8	mg/kg	0.2	0.255	0.71	1.9	0.826	L	2.14	1.9	m
Surface Soil (<0.5 ft)	IA-9	Boron	6/8	mg/kg	1.1	1.3	4.2	9.2	5.59	N	7.81	7.81	u
Surface Soil (<0.5 ft)	IA-9	Cadmium	2/8	mg/kg	0.165	0.465	1.2	2	0.623	D	1.05	1.05	u
Surface Soil (<0.5 ft)	IA-9	Calcium	8/8	mg/kg			1980	194000	33900	L	630000	194000	m
Surface Soil (<0.5 ft)	IA-9	Chromium	8/8	mg/kg			7.5	22.1	15.1	N	18.3	18.3	u
Surface Soil (<0.5 ft)	IA-9	Cobalt	8/8	mg/kg			2	864	171	L	174000	864	m
Surface Soil (<0.5 ft)	IA-9	Copper	8/8	mg/kg			7.2	632	137	L	4660	632	m
Surface Soil (<0.5 ft)	IA-9	Iron	8/8	mg/kg			4150	20800	14700	N	18200	18200	u
Surface Soil (<0.5 ft)	IA-9	Lead	8/8	mg/kg			11.9	240	79.6	L	573	240	m
Surface Soil (<0.5 ft)	IA-9	Lithium	6/8	mg/kg	0.55	1.75	5.4	8.4	5.58	N	7.59	7.59	u
Surface Soil (<0.5 ft)	IA-9	Magnesium	8/8	mg/kg			1310	70100	12000	X	27800	27800	u
Surface Soil (<0.5 ft)	IA-9	Manganese	8/8	mg/kg			122	810	571	N	709	709	u
Surface Soil (<0.5 ft)	IA-9	Molybdenum	6/8	mg/kg	0.7	0.75	1.4	25.7	6.04	L	78	25.7	m
Surface Soil (<0.5 ft)	IA-9	Nickel	8/8	mg/kg			2.6	1080	219	L	46500	1080	m
Surface Soil (<0.5 ft)	IA-9	Potassium	7/8	mg/kg	119.5	119.5	786	1790	992	N	1310	1310	u
Surface Soil (<0.5 ft)	IA-9	Selenium	4/8	mg/kg	0.17	0.205	0.6	22.3	4.98	D	10.5	10.5	u
Surface Soil (<0.5 ft)	IA-9	Sodium	8/8	mg/kg			58.9	174	106	L	143	143	u
Surface Soil (<0.5 ft)	IA-9	Strontium	8/8	mg/kg			10.3	111	37	L	89.9	89.9	u
Surface Soil (<0.5 ft)	IA-9	Titanium	8/8	mg/kg			48	310	205	N	260	260	u
Surface Soil (<0.5 ft)	IA-9	Uranium	2/8	mg/kg	4.4	6.15	53.6	118	25.3	D	52.8	52.8	u
Surface Soil (<0.5 ft)	IA-9	Vanadium	8/8	mg/kg			10.7	185	53.5	L	191	185	m
Surface Soil (<0.5 ft)	IA-9	Zinc	8/8	mg/kg			24.2	131	71.7	L	131	131	u
Surface Soil (<0.5 ft)	IA-9	Silvex	3/8	mg/kg	0.0125	0.013	0.027	0.042	0.0201	D	0.0275	0.0275	u
Surface Soil (<0.5 ft)	IA-9	4,4'-DDE	1/8	mg/kg	0.0018	0.0025	0.012	0.012	0.00337	D	0.00571	0.00571	u
Surface Soil (<0.5 ft)	IA-9	4,4'-DDT	1/8	mg/kg	0.0018	0.0025	0.033	0.033	0.00599	D	0.0133	0.0133	u
Surface Soil (<0.5 ft)	IA-9	Anthracene	2/8	mg/kg	0.185	0.25	0.061	0.064	0.176	D	0.225	0.064	m
Surface Soil (<0.5 ft)	IA-9	Benz(a)anthracene	8/8	mg/kg			0.13	0.5	0.265	L	0.468	0.468	u
Surface Soil (<0.5 ft)	IA-9	Benzo(a)pyrene	8/8	mg/kg			0.062	0.59	0.238	L	0.8	0.59	m
Surface Soil (<0.5 ft)	IA-9	Benzo(b)fluoranthene	8/8	mg/kg			0.14	0.55	0.319	L	0.541	0.541	u
Surface Soil (<0.5 ft)	IA-9	Benzo(ghi)perylene	4/8	mg/kg	0.185	0.25	0.11	0.54	0.246	D	0.338	0.338	u
Surface Soil (<0.5 ft)	IA-9	Benzo(k)fluoranthene	4/8	mg/kg	0.185	0.25	0.13	0.43	0.232	D	0.297	0.297	u
Surface Soil (<0.5 ft)	IA-9	Bis(2-ethylhexyl)phthalate	3/8	mg/kg	0.185	0.25	0.25	0.32	0.238	D	0.266	0.266	u
Surface Soil (<0.5 ft)	IA-9	Butyl benzyl phthalate	3/8	mg/kg	0.185	0.21	0.17	0.23	0.201	D	0.214	0.214	u
Surface Soil (<0.5 ft)	IA-9	Carbazole	1/8	mg/kg	0.185	0.25	0.082	0.082	0.196	D	0.229	0.082	m
Surface Soil (<0.5 ft)	IA-9	Chrysene	5/8	mg/kg	0.185	0.215	0.11	0.91	0.373	L	0.885	0.885	u
Surface Soil (<0.5 ft)	IA-9	Di-n-butyl phthalate	1/8	mg/kg	0.185	0.25	0.049	0.049	0.193	D	0.234	0.049	m
Surface Soil (<0.5 ft)	IA-9	Di-n-octylphthalate	2/8	mg/kg	0.185	0.22	0.082	0.1	0.178	D	0.214	0.1	m
Surface Soil (<0.5 ft)	IA-9	Fluoranthene	8/8	mg/kg			0.085	1.1	0.468	L	3.16	1.1	m
Surface Soil (<0.5 ft)	IA-9	Indeno(1,2,3-cd)pyrene	5/8	mg/kg	0.185	0.215	0.057	0.47	0.22	L	0.457	0.457	u
Surface Soil (<0.5 ft)	IA-9	Phenanthrene	8/8	mg/kg			0.082	0.39	0.205	L	0.45	0.39	m
Surface Soil (<0.5 ft)	IA-9	Pyrene	8/8	mg/kg			0.12	0.94	0.408	L	1.29	0.94	m
Surface Soil (<0.5 ft)	IA-9	2-Butanone	4/8	mg/kg	0.005	0.0065	0.007	0.034	0.0141	D	0.0222	0.0222	u

Table 2-10. North County Surface Soil Data Summary (Cont'd)

Data Grouping	Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
Surface Soil (<0.5 ft)	IA-9	Dimethylbenzene	2/8	mg/kg	0.0025	0.003	0.001	0.015	0.00406	D	0.00706	0.00706	u
Surface Soil (<0.5 ft)	IA-9	Ethylbenzene	1/8	mg/kg	0.0025	0.003	0.002	0.002	0.00263	D	0.00286	0.002	m
Surface Soil (<0.5 ft)	IA-9	Toluene	4/8	mg/kg	0.0025	0.003	0.002	0.016	0.00431	D	0.00749	0.00749	u
Surface Soil (<0.5 ft)	IA-9	Actinium-227	26/61	pCi/g	-0.04	0.22	0.16	46.85	1.39	D	2.84	2.84	u
Surface Soil (<0.5 ft)	IA-9	Cesium-137	52/61	pCi/g	0	0.05	0.04	0.32	0.0844	Z	0.0955	0.0955	u
Surface Soil (<0.5 ft)	IA-9	Potassium-40	61/61	pCi/g			5.93	18.62	15.1	X	15.7	15.7	u
Surface Soil (<0.5 ft)	IA-9	Protactinium-231	25/61	pCi/g	-0.4	1.25	0.73	51.73	2.12	D	3.69	3.69	u
Surface Soil (<0.5 ft)	IA-9	Radium-226	451/478	pCi/g	0	0.6	0.5	29.27	1.53	Z	1.69	1.69	u
Surface Soil (<0.5 ft)	IA-9	Radium-228	61/61	pCi/g			0.26	1.29	0.924	X	0.964	0.964	u
Surface Soil (<0.5 ft)	IA-9	Thorium-228	61/61	pCi/g			0.6	2.1	1.25	L	1.33	1.33	u
Surface Soil (<0.5 ft)	IA-9	Thorium-230	510/523	pCi/g	0.1	0.8	0.51	2787	23.2	X	34.3	34.3	u
Surface Soil (<0.5 ft)	IA-9	Thorium-232	443/474	pCi/g	0	2	0.47	5	1.59	Z	1.65	1.65	u
Surface Soil (<0.5 ft)	IA-9	Uranium-235	13/61	pCi/g	-0.05	0.2	0.15	6.92	0.324	D	0.549	0.549	u
Surface Soil (<0.5 ft)	IA-9	Uranium-238	19/479	pCi/g	0	18	3.6	42	5.65	D	6.01	6.01	u
Soil - All Depths	ROAD ROW	Aluminum	1/1	mg/kg			15800	15800	15800	D		15800	m
Soil - All Depths	ROAD ROW	Arsenic	1/1	mg/kg			23.2	23.2	23.2	D		23.2	m
Soil - All Depths	ROAD ROW	Barium	1/1	mg/kg			350	350	350	D		350	m
Soil - All Depths	ROAD ROW	Beryllium	1/1	mg/kg			1.5	1.5	1.5	D		1.5	m
Soil - All Depths	ROAD ROW	Boron	1/1	mg/kg			18.8	18.8	18.8	D		18.8	m
Soil - All Depths	ROAD ROW	Calcium	1/1	mg/kg			5050	5050	5050	D		5050	m
Soil - All Depths	ROAD ROW	Chromium	1/1	mg/kg			19.8	19.8	19.8	D		19.8	m
Soil - All Depths	ROAD ROW	Cobalt	1/1	mg/kg			35.1	35.1	35.1	D		35.1	m
Soil - All Depths	ROAD ROW	Copper	1/1	mg/kg			22.9	22.9	22.9	D		22.9	m
Soil - All Depths	ROAD ROW	Iron	1/1	mg/kg			52100	52100	52100	D		52100	m
Soil - All Depths	ROAD ROW	Lead	1/1	mg/kg			39.5	39.5	39.5	D		39.5	m
Soil - All Depths	ROAD ROW	Lithium	1/1	mg/kg			9.1	9.1	9.1	D		9.1	m
Soil - All Depths	ROAD ROW	Magnesium	1/1	mg/kg			2770	2770	2770	D		2770	m
Soil - All Depths	ROAD ROW	Manganese	1/1	mg/kg			6320	6320	6320	D		6320	m
Soil - All Depths	ROAD ROW	Molybdenum	1/1	mg/kg			2.1	2.1	2.1	D		2.1	m
Soil - All Depths	ROAD ROW	Nickel	1/1	mg/kg			32.9	32.9	32.9	D		32.9	m
Soil - All Depths	ROAD ROW	Potassium	1/1	mg/kg			1160	1160	1160	D		1160	m
Soil - All Depths	ROAD ROW	Sodium	1/1	mg/kg			932	932	932	D		932	m
Soil - All Depths	ROAD ROW	Strontium	1/1	mg/kg			21.8	21.8	21.8	D		21.8	m
Soil - All Depths	ROAD ROW	Thallium	1/1	mg/kg			7.2	7.2	7.2	D		7.2	m
Soil - All Depths	ROAD ROW	Titanium	1/1	mg/kg			293	293	293	D		293	m
Soil - All Depths	ROAD ROW	Vanadium	1/1	mg/kg			65.3	65.3	65.3	D		65.3	m
Soil - All Depths	ROAD ROW	Zinc	1/1	mg/kg			73	73	73	D		73	m
Soil - All Depths	ROAD ROW	MCPP	1/1	mg/kg			120	120	120	D		120	m
Soil - All Depths	ROAD ROW	alpha-Chlordane	1/2	mg/kg	0.00115	0.00115	0.03	0.03	0.0156	D	0.107	0.03	m
Soil - All Depths	ROAD ROW	Fluoranthene	1/1	mg/kg			0.1	0.1	0.1	D		0.1	m
Soil - All Depths	ROAD ROW	Pyrene	1/1	mg/kg			0.32	0.32	0.32	D		0.32	m
Soil - All Depths	ROAD ROW	2-Butanone	1/1	mg/kg			0.024	0.024	0.024	D		0.024	m
Soil - All Depths	ROAD ROW	Acetone	1/1	mg/kg			0.077	0.077	0.077	D		0.077	m
Soil - All Depths	ROAD ROW	Toluene	1/1	mg/kg			0.004	0.004	0.004	D		0.004	m
Soil - All Depths	ROAD ROW	Actinium-227	2/4	pCi/g	0.14	0.16	0.27	0.29	0.215	D	0.304	0.29	m
Soil - All Depths	ROAD ROW	Americium-241	1/4	pCi/g	0.03	0.04	0.12	0.12	0.0575	D	0.107	0.107	u
Soil - All Depths	ROAD ROW	Cesium-137	4/4	pCi/g			0.04	0.2	0.138	D	0.221	0.2	m
Soil - All Depths	ROAD ROW	Potassium-40	4/4	pCi/g			12.81	16.18	14.5	D	16.1	16.1	u
Soil - All Depths	ROAD ROW	Radium-226	1730/1757	pCi/g	0.4	4	0.4	92	2.7	X	2.89	2.89	u
Soil - All Depths	ROAD ROW	Radium-228	4/4	pCi/g			0.8	1.02	0.925	D	1.04	1.02	m
Soil - All Depths	ROAD ROW	Thorium-228	4/4	pCi/g			1.14	1.51	1.39	D	1.59	1.51	m
Soil - All Depths	ROAD ROW	Thorium-230	2740/2784	pCi/g	0.3	1.5	0.3	5100	42.2	X	49.9	49.9	u
Soil - All Depths	ROAD ROW	Thorium-232	1520/1752	pCi/g	0	9	0.35	64	2.13	Z	2.22	2.22	u
Soil - All Depths	ROAD ROW	Uranium-235	1/4	pCi/g	0	0.17	0.24	0.24	0.133	D	0.251	0.24	m
Soil - All Depths	ROAD ROW	Uranium-238	47/1754	pCi/g	0	69	2.1	78	11.2	D	11.5	11.5	u
Surface Soil (<5 ft)	SLAPS	Fluoride	5/5	mg/kg			4.42	62.9	28.3	L	888	62.9	m
Surface Soil (<5 ft)	SLAPS	Sulfide	1/4	mg/kg	0.00655	13.6	21	21	10.3	D	20.9	20.9	u
Surface Soil (<5 ft)	SLAPS	Aluminum	14/14	mg/kg			10700	23200	15400	L	17100	17100	u
Surface Soil (<5 ft)	SLAPS	Antimony	2/52	mg/kg	0.19	6.8	5.3	53.2	5.99	D	7.6	7.6	u
Surface Soil (<5 ft)	SLAPS	Arsenic	17/17	mg/kg			6.1	237	37.1	X	66.9	66.9	u
Surface Soil (<5 ft)	SLAPS	Barium	19/19	mg/kg			152	13600	2030	X	3680	3680	u
Surface Soil (<5 ft)	SLAPS	Beryllium	12/14	mg/kg	0.375	0.48	0.7	2.4	0.968	L	1.26	1.26	u
Surface Soil (<5 ft)	SLAPS	Boron	13/14	mg/kg	4.45	4.45	2.3	15.1	8.88	N	10.4	10.4	u
Surface Soil (<5 ft)	SLAPS	Cadmium	12/52	mg/kg	0.14	0.55	0.52	50.4	1.83	D	3.45	3.45	u
Surface Soil (<5 ft)	SLAPS	Calcium	14/14	mg/kg			2230	29500	6860	X	10100	10100	u
Surface Soil (<5 ft)	SLAPS	Chromium	15/15	mg/kg			15.1	3240	236	X	614	614	u
Surface Soil (<5 ft)	SLAPS	Cobalt	32/32	mg/kg			4.7	6050	436	X	804	804	u
Surface Soil (<5 ft)	SLAPS	Copper	23/23	mg/kg			13.1	4400	432	X	807	807	u
Surface Soil (<5 ft)	SLAPS	Cyanide	1/6	mg/kg	0.3	0.3225	0.772	0.772	0.387	D	0.542	0.542	u
Surface Soil (<5 ft)	SLAPS	Iron	14/14	mg/kg			16100	26800	20900	L	22400	22400	u
Surface Soil (<5 ft)	SLAPS	Lead	19/19	mg/kg			8.6	1200	202	X	342	342	u
Surface Soil (<5 ft)	SLAPS	Lithium	14/14	mg/kg			6	14.6	9.4	L	10.5	10.5	u
Surface Soil (<5 ft)	SLAPS	Magnesium	27/27	mg/kg			2010	26900	8240	L	11000	11000	u
Surface Soil (<5 ft)	SLAPS	Manganese	14/14	mg/kg			172	1330	662	N	786	786	u
Surface Soil (<5 ft)	SLAPS	Mercury	1/14	mg/kg	0.03	0.035	0.07	0.07	0.0332	D	0.0383	0.0383	u
Surface Soil (<5 ft)	SLAPS	Molybdenum	19/52	mg/kg	0.415	11.25	1.2	255	24.7	D	35.8	35.8	u
Surface Soil (<5 ft)	SLAPS	Nickel	17/17	mg/kg			19	7570	860	X	1740	1740	u

Table 2-10. North County Surface Soil Data Summary (Cont'd)

Data Grouping	Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
Surface Soil (<5 ft)	SLAPS	Potassium	14/14	mg/kg			827	2820	1380	L	1660	1660	u
Surface Soil (<5 ft)	SLAPS	Selenium	10/52	mg/kg	0.15	11.35	0.38	183	13.5	D	19.9	19.9	u
Surface Soil (<5 ft)	SLAPS	Silver	1/14	mg/kg	0.315	0.41	0.81	0.81	0.396	D	0.454	0.454	u
Surface Soil (<5 ft)	SLAPS	Sodium	14/14	mg/kg			69.5	382	168	L	218	218	u
Surface Soil (<5 ft)	SLAPS	Strontium	14/14	mg/kg			14.8	243	55.6	X	90.4	90.4	u
Surface Soil (<5 ft)	SLAPS	Thallium	8/52	mg/kg	0.6	11.35	1	3.3	7.78	D	8.72	3.3	m
Surface Soil (<5 ft)	SLAPS	Titanium	14/14	mg/kg			99.1	416	248	N	285	285	u
Surface Soil (<5 ft)	SLAPS	Uranium	6/14	mg/kg	4.95	8.35	11.1	129	25	D	41.9	41.9	u
Surface Soil (<5 ft)	SLAPS	Vanadium	17/17	mg/kg			27.4	862	168	X	288	288	u
Surface Soil (<5 ft)	SLAPS	Zinc	15/15	mg/kg			41.4	4330	343	X	844	844	u
Surface Soil (<5 ft)	SLAPS	TOX	1/2	UG/G	30.35	30.35	56.9	56.9	43.6	D	127	56.9	m
Surface Soil (<5 ft)	SLAPS	MCPP	2/11	mg/kg	4.5	10.5	11	30	8.74	D	12.8	12.8	u
Surface Soil (<5 ft)	SLAPS	PCB-1254	1/11	mg/kg	0.0185	0.1	0.26	0.26	0.0493	D	0.0896	0.0896	u
Surface Soil (<5 ft)	SLAPS	Benz(a)anthracene	3/11	mg/kg	0.19	0.225	0.09	0.19	0.192	D	0.212	0.19	m
Surface Soil (<5 ft)	SLAPS	Benzo(a)pyrene	2/11	mg/kg	0.19	0.225	0.077	0.18	0.193	D	0.215	0.18	m
Surface Soil (<5 ft)	SLAPS	Benzo(b)fluoranthene	2/11	mg/kg	0.185	0.225	0.083	0.36	0.208	D	0.243	0.243	u
Surface Soil (<5 ft)	SLAPS	Benzo(ghi)perylene	1/11	mg/kg	0.19	0.225	0.19	0.19	0.205	D	0.21	0.19	m
Surface Soil (<5 ft)	SLAPS	Benzo(k)fluoranthene	1/11	mg/kg	0.19	0.225	0.066	0.066	0.193	D	0.217	0.066	m
Surface Soil (<5 ft)	SLAPS	Bis(2-ethylhexyl)phthalate	1/11	mg/kg	0.185	0.295	0.21	0.21	0.212	D	0.228	0.21	m
Surface Soil (<5 ft)	SLAPS	Butyl benzyl phthalate	2/11	mg/kg	0.185	0.225	0.1	0.31	0.205	D	0.231	0.231	u
Surface Soil (<5 ft)	SLAPS	Chrysene	2/11	mg/kg	0.19	0.225	0.14	0.21	0.2	D	0.212	0.21	m
Surface Soil (<5 ft)	SLAPS	Di-n-octylphthalate	1/11	mg/kg	0.185	0.225	0.13	0.13	0.197	D	0.21	0.13	m
Surface Soil (<5 ft)	SLAPS	Fluoranthene	4/11	mg/kg	0.19	0.225	0.079	0.31	0.2	D	0.235	0.235	u
Surface Soil (<5 ft)	SLAPS	Indeno(1,2,3-cd)pyrene	2/11	mg/kg	0.19	0.225	0.089	0.18	0.194	D	0.214	0.18	m
Surface Soil (<5 ft)	SLAPS	Phenanthrene	3/11	mg/kg	0.19	0.225	0.042	0.19	0.179	D	0.211	0.19	m
Surface Soil (<5 ft)	SLAPS	Pyrene	4/11	mg/kg	0.19	0.225	0.046	0.31	0.215	D	0.253	0.253	u
Surface Soil (<5 ft)	SLAPS	1,2-Dichloroethane	1/11	mg/kg	0.0025	0.003	0.001	0.001	0.00277	D	0.0031	0.001	m
Surface Soil (<5 ft)	SLAPS	1,2-Dichloroethene	1/11	mg/kg	0.0025	0.003	0.003	0.003	0.00291	D	0.00302	0.003	m
Surface Soil (<5 ft)	SLAPS	2-Butanone	1/11	mg/kg	0.005	0.0065	0.001	0.001	0.00541	D	0.00625	0.001	m
Surface Soil (<5 ft)	SLAPS	Acetone	2/10	mg/kg	0.006	0.017	0.005	0.009	0.00985	D	0.0125	0.009	m
Surface Soil (<5 ft)	SLAPS	Dimethylbenzene	1/11	mg/kg	0.0025	0.003	0.01	0.01	0.00355	D	0.00472	0.00472	u
Surface Soil (<5 ft)	SLAPS	Methylene chloride	1/11	mg/kg	0.0025	0.0075	0.13	0.13	0.0155	D	0.0363	0.0363	u
Surface Soil (<5 ft)	SLAPS	Toluene	19/30	mg/kg	0.0025	0.003	0.0015	0.9	0.0483	X	0.1	0.1	u
Surface Soil (<5 ft)	SLAPS	Trichloroethene	1/11	mg/kg	0.0025	0.003	0.005	0.005	0.00309	D	0.00345	0.00345	u
Surface Soil (<5 ft)	SLAPS	Actinium-227	72/98	pCi/g	-0.13	2.6	0.18	695.7	18.3	Z	32.6	32.6	u
Surface Soil (<5 ft)	SLAPS	Americium-241	11/97	pCi/g	-5.04	0.37	0.06	2.58	0.0381	D	0.161	0.161	u
Surface Soil (<5 ft)	SLAPS	Cesium-137	30/97	pCi/g	-0.04	0.35	0.03	3.09	0.0926	D	0.159	0.159	u
Surface Soil (<5 ft)	SLAPS	Potassium-40	94/97	pCi/g	5.21	11.07	5.69	17.74	14	X	14.4	14.4	u
Surface Soil (<5 ft)	SLAPS	Protactinium-231	37/98	pCi/g	-0.18	5.2	0.9	685.8	19.5	D	34.1	34.1	u
Surface Soil (<5 ft)	SLAPS	Radium-226	323/456	pCi/g	1	5	0.6	2700	42.6	X	58.8	58.8	u
Surface Soil (<5 ft)	SLAPS	Radium-228	96/97	pCi/g	0.95	0.95	0.33	7.54	1.18	X	1.35	1.35	u
Surface Soil (<5 ft)	SLAPS	Thorium-228	96/97	pCi/g	1.04	1.04	0.34	7.54	1.42	X	1.59	1.59	u
Surface Soil (<5 ft)	SLAPS	Thorium-230	278/279	pCi/g	0.05	0.05	0	37780	530	Z	823	823	u
Surface Soil (<5 ft)	SLAPS	Thorium-232	264/454	pCi/g	0.5	25.2	0.4	63	2.7	X	2.98	2.98	u
Surface Soil (<5 ft)	SLAPS	Uranium-235	62/97	pCi/g	-0.04	0.24	0.2	54.18	2.84	Z	4.22	4.22	u
Surface Soil (<5 ft)	SLAPS	Uranium-238	104/455	pCi/g	0.33	462	3.04	1200	41.9	D	49.6	49.6	u

UCL95 = 95% upper confidence limit on the mean concentration

PRG = Preliminary Remediation Goal

[a] Distribution flags:

D = Not determined because fewer than 5 detects or < 50% detects; t-statistic used in calculations of UCL_{95}.

L = Lognormal; H-statistic used in calculations of UCL_{95}.

N = Normal; t-statistic used in calculations of UCL_{95}.

X = Neither normal nor lognormal; t-statistic used in calculations of UCL_{95}.

Z = Contains concentrations that are negative and/or zero; t-statistic used in calculations of UCL_{95}.

[b] Basis for determining the exposure concentration:

m = maximum detected concentration.

u = 95% upper confidence limit on the mean concentration.

Table 2-11. SLAPS Subsurface Soil Data Summary

Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
09K220205/VP-54	Aluminum	10/10	mg/kg			4260	7880	5530	L	6180	6180	u
09K220205/VP-54	Arsenic	10/10	mg/kg			0.84	11.9	5.85	N	7.75	7.75	u
09K220205/VP-54	Barium	10/10	mg/kg			40.7	279	143	N	183	183	u
09K220205/VP-54	Beryllium	10/10	mg/kg			0.41	0.56	0.489	L	0.524	0.524	u
09K220205/VP-54	Calcium	10/10	mg/kg			2320	15500	5190	X	7590	7590	u
09K220205/VP-54	Chromium	10/10	mg/kg			10	12	10.7	N	11.1	11.1	u
09K220205/VP-54	Cobalt	10/10	mg/kg			5.5	9.6	7.41	L	8.39	8.39	u
09K220205/VP-54	Copper	10/10	mg/kg			9.6	16.4	13.4	N	14.5	14.5	u
09K220205/VP-54	Iron	10/10	mg/kg			7270	28200	12800	L	16900	16900	u
09K220205/VP-54	Lead	10/10	mg/kg			7.3	30.9	12.8	L	17.2	17.2	u
09K220205/VP-54	Magnesium	10/10	mg/kg			1610	9940	3550	X	5020	5020	u
09K220205/VP-54	Manganese	10/10	mg/kg			68.3	4690	1250	L	5960	4690	m
09K220205/VP-54	Molybdenum	10/10	mg/kg			6.3	22.7	10.5	L	13.5	13.5	u
09K220205/VP-54	Nickel	10/10	mg/kg			10.1	23.4	14.6	L	17.7	17.7	u
09K220205/VP-54	Potassium	10/10	mg/kg			436	827	634	N	711	711	u
09K220205/VP-54	Silver	1/10	mg/kg	1.25	1.3	2.6	2.6	1.39	D	1.64	1.64	u
09K220205/VP-54	Sodium	10/10	mg/kg			51.8	78	66.5	N	71.8	71.8	u
09K220205/VP-54	Vanadium	10/10	mg/kg			9.5	16.3	12.7	L	13.8	13.8	u
09K220205/VP-54	Zinc	10/10	mg/kg			30.6	52.8	40.6	L	44.8	44.8	u
09K220205/VP-54	Anthracene	1/10	mg/kg	0.205	0.22	0.031	0.031	0.194	D	0.227	0.031	m
09K220205/VP-54	Benz(a)anthracene	1/10	mg/kg	0.205	0.22	0.17	0.17	0.208	D	0.216	0.17	m
09K220205/VP-54	Benzo(a)pyrene	1/10	mg/kg	0.205	0.22	0.15	0.15	0.206	D	0.217	0.15	m
09K220205/VP-54	Benzo(b)fluoranthene	1/10	mg/kg	0.205	0.22	0.21	0.21	0.212	D	0.214	0.21	m
09K220205/VP-54	Benzo(ghi)perylene	1/10	mg/kg	0.205	0.22	0.084	0.084	0.199	D	0.222	0.084	m
09K220205/VP-54	Benzo(k)fluoranthene	1/10	mg/kg	0.205	0.22	0.18	0.18	0.209	D	0.215	0.18	m
09K220205/VP-54	Chrysene	1/10	mg/kg	0.205	0.22	0.19	0.19	0.21	D	0.214	0.19	m
09K220205/VP-54	Dibenz(a,h)anthracene	1/10	mg/kg	0.205	0.22	0.035	0.035	0.194	D	0.227	0.035	m
09K220205/VP-54	Fluoranthene	1/10	mg/kg	0.205	0.22	0.41	0.41	0.232	D	0.268	0.268	u
09K220205/VP-54	Indeno(1,2,3-cd)pyrene	1/10	mg/kg	0.205	0.22	0.13	0.13	0.204	D	0.219	0.13	m
09K220205/VP-54	Phenanthrene	1/10	mg/kg	0.205	0.22	0.18	0.18	0.209	D	0.215	0.18	m
09K220205/VP-54	Pyrene	1/10	mg/kg	0.205	0.22	0.34	0.34	0.225	D	0.248	0.248	u
09K220205/VP-54	Acetone	1/10	mg/kg	0.0065	0.0065	0.017	0.017	0.00755	D	0.00947	0.00947	u
09K220205/VP-54	Toluene	7/9	mg/kg	0.003	0.0065	0.002	0.11	0.0248	L	0.192	0.11	m
IA-1	Aluminum	1/1	mg/kg			8020	8020	8020	D		8020	m
IA-1	Arsenic	1/1	mg/kg			3.9	3.9	3.9	D		3.9	m
IA-1	Barium	1/1	mg/kg			89.2	89.2	89.2	D		89.2	m
IA-1	Beryllium	1/1	mg/kg			0.55	0.55	0.55	D		0.55	m
IA-1	Boron	1/1	mg/kg			6.6	6.6	6.6	D		6.6	m
IA-1	Calcium	1/1	mg/kg			26400	26400	26400	D		26400	m
IA-1	Chromium	1/1	mg/kg			13.9	13.9	13.9	D		13.9	m
IA-1	Cobalt	1/1	mg/kg			5.3	5.3	5.3	D		5.3	m
IA-1	Copper	1/1	mg/kg			9.7	9.7	9.7	D		9.7	m
IA-1	Iron	1/1	mg/kg			15300	15300	15300	D		15300	m
IA-1	Lead	1/1	mg/kg			8.4	8.4	8.4	D		8.4	m
IA-1	Lithium	1/1	mg/kg			5.4	5.4	5.4	D		5.4	m
IA-1	Magnesium	4/4	mg/kg			6110	15400	11000	D	15600	15400	m
IA-1	Manganese	1/1	mg/kg			601	601	601	D		601	m
IA-1	Molybdenum	2/8	mg/kg	8.6	11.6	1.3	17.7	9.82	D	12.8	12.8	u
IA-1	Nickel	1/1	mg/kg			13.4	13.4	13.4	D		13.4	m
IA-1	Potassium	1/1	mg/kg			691	691	691	D		691	m
IA-1	Sodium	1/1	mg/kg			286	286	286	D		286	m
IA-1	Strontium	1/1	mg/kg			24.2	24.2	24.2	D		24.2	m
IA-1	Titanium	1/1	mg/kg			239	239	239	D		239	m
IA-1	Vanadium	1/1	mg/kg			19.1	19.1	19.1	D		19.1	m
IA-1	Zinc	1/1	mg/kg			48.3	48.3	48.3	D		48.3	m
IA-1	Toluene	2/3	mg/kg	0.003	0.003	0.003	0.0031	0.00303	D	0.00313	0.0031	m
IA-1	Trichloroethene	1/2	mg/kg	0.003	0.003	0.0066	0.0066	0.0048	D	0.0162	0.0066	m
IA-1	trans-1,2-Dichloroethene	1/1	mg/kg			0.003	0.003	0.003	D		0.003	m
IA-1	Actinium-227	5/14	pCi/g	0.02	2.6	0.2	0.8	0.473	D	0.785	0.785	u
IA-1	Potassium-40	11/11	pCi/g			12.38	16.76	14.8	L	15.7	15.7	u
IA-1	Radium-226	26/35	pCi/g	1.6	3.9	0.8	2700	82	X	212	212	u
IA-1	Radium-228	11/11	pCi/g			0.64	1.01	0.857	N	0.921	0.921	u
IA-1	Thorium-228	11/11	pCi/g			0.7	1.63	1.21	L	1.42	1.42	u
IA-1	Thorium-230	20/20	pCi/g			0	120	14.2	Z	27.7	27.7	u
IA-1	Thorium-232	22/35	pCi/g	1	4.3	0.45	63	3.51	X	6.48	6.48	u
IA-1	Uranium-235	2/11	pCi/g	0	0.16	0.22	0.25	0.112	D	0.155	0.155	u
IA-1	Uranium-238	8/35	pCi/g	0.79	78.4	4.68	1200	52.9	D	110	110	u
IA-10	Aluminum	4/4	mg/kg			6630	8720	7570	D	8580	8580	u
IA-10	Antimony	1/14	mg/kg	1.7	7.5	195	195	18.7	D	42.7	42.7	u
IA-10	Arsenic	5/5	mg/kg			4.9	668	138	X	421	421	u
IA-10	Barium	4/4	mg/kg			136	156	146	D	157	156	m
IA-10	Boron	4/5	mg/kg	3.5	3.5	5.1	761	156	D	479	479	u

Table 2-11. SLAPS Subsurface Soil Data Summary (Cont'd)

Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
IA-10	Cadmium	3/14	mg/kg	0.145	0.65	1.1	17.6	1.73	D	3.9	3.9	u
IA-10	Calcium	4/4	mg/kg			2850	7120	4040	D	6460	6460	u
IA-10	Chromium	4/4	mg/kg			10.7	12.7	11.7	D	12.8	12.7	m
IA-10	Cobalt	5/5	mg/kg			4.8	185	41.5	X	118	118	u
IA-10	Copper	4/4	mg/kg			11	12.5	12	D	12.9	12.5	m
IA-10	Iron	4/4	mg/kg			11600	13700	12700	D	13900	13700	m
IA-10	Lead	4/4	mg/kg			13	21.8	17.4	D	21.7	21.7	u
IA-10	Lithium	3/4	mg/kg	2.6	2.6	4.1	4.5	3.83	D	4.81	4.5	m
IA-10	Magnesium	5/5	mg/kg			1850	7650	3470	L	9370	7650	m
IA-10	Manganese	4/4	mg/kg			474	843	576	D	786	786	u
IA-10	Molybdenum	2/14	mg/kg	0.45	12.5	1.2	754	61.1	D	155	155	u
IA-10	Nickel	4/4	mg/kg			11.3	16.1	13.3	D	15.7	15.7	u
IA-10	Potassium	4/4	mg/kg			696	971	846	D	981	971	m
IA-10	Selenium	2/14	mg/kg	0.15	12.5	29.9	704	58.7	D	147	147	u
IA-10	Silver	1/5	mg/kg	0.35	0.38	13.9	13.9	3.08	D	8.84	8.84	u
IA-10	Sodium	4/4	mg/kg			61.7	494	179	D	427	427	u
IA-10	Strontium	4/4	mg/kg			13	15.9	14.8	D	16.2	15.9	m
IA-10	Thallium	2/14	mg/kg	0.375	12.5	1.3	726	59.1	D	150	150	u
IA-10	Titanium	4/4	mg/kg			208	243	229	D	248	243	m
IA-10	Vanadium	4/4	mg/kg			18.2	20.8	19.7	D	21	20.8	m
IA-10	Zinc	4/4	mg/kg			40.8	53.1	47.5	D	53.7	53.1	m
IA-10	Benzo(a)pyrene	1/4	mg/kg	0.19	0.205	0.11	0.11	0.178	D	0.231	0.11	m
IA-10	Benzo(b)fluoranthene	1/4	mg/kg	0.19	0.205	0.24	0.24	0.21	D	0.235	0.235	u
IA-10	Benzo(ghi)perylene	1/4	mg/kg	0.19	0.205	0.18	0.18	0.195	D	0.209	0.18	m
IA-10	Chrysene	1/4	mg/kg	0.19	0.205	0.15	0.15	0.188	D	0.218	0.15	m
IA-10	Fluoranthene	2/4	mg/kg	0.205	0.205	0.1	0.2	0.178	D	0.238	0.2	m
IA-10	Indeno(1,2,3-cd)pyrene	1/4	mg/kg	0.19	0.205	0.33	0.33	0.233	D	0.309	0.309	u
IA-10	Pyrene	1/4	mg/kg	0.19	0.205	0.3	0.3	0.225	D	0.284	0.284	u
IA-10	2-Butanone	1/4	mg/kg	0.0115	0.0125	0.013	0.013	0.0124	D	0.0131	0.013	m
IA-10	Toluene	7/10	mg/kg	0.003	0.003	0.002	0.048	0.0132	L	0.0521	0.048	m
IA-10	Radium-226	44/58	pCi/g	0	3	0.6	44	2.64	Z	4.36	4.36	u
IA-10	Thorium-230	60/63	pCi/g	0	1	0.4	46	6.04	Z	7.83	7.83	u
IA-10	Thorium-232	43/58	pCi/g	0	4.2	0.7	4	1.78	Z	2.04	2.04	u
IA-10	Uranium-238	2/58	pCi/g	0	57	43.9	45	8.23	D	10.9	10.9	u
IA-2	Fluoride	1/1	mg/kg			32.4	32.4	32.4	D		32.4	m
IA-2	Aluminum	5/5	mg/kg			7180	17200	10100	L	16100	16100	u
IA-2	Arsenic	7/7	mg/kg			3.3	237	68.2	X	145	145	u
IA-2	Barium	5/5	mg/kg			76.1	218	131	L	219	218	m
IA-2	Beryllium	3/5	mg/kg	0.295	0.39	0.67	0.88	0.609	D	0.854	0.854	u
IA-2	Boron	5/5	mg/kg			5.8	11.6	7.72	L	10.9	10.9	u
IA-2	Cadmium	6/26	mg/kg	0.155	0.6	0.32	5.9	0.879	D	1.31	1.31	u
IA-2	Calcium	5/5	mg/kg			4250	52900	17900	L	443000	52900	m
IA-2	Chromium	5/5	mg/kg			11.2	21.6	16	L	21.3	21.3	u
IA-2	Cobalt	9/9	mg/kg			3.7	228	67.5	L	2810	228	m
IA-2	Copper	8/8	mg/kg			10.7	440	124	X	235	235	u
IA-2	Iron	5/5	mg/kg			11700	22400	17000	N	21700	21700	u
IA-2	Lead	5/5	mg/kg			7.4	12.4	9.98	L	13.4	12.4	m
IA-2	Lithium	3/5	mg/kg	4	4.25	7.6	11.1	6.97	D	9.77	9.77	u
IA-2	Magnesium	10/10	mg/kg			3510	24900	10600	L	17300	17300	u
IA-2	Manganese	5/5	mg/kg			165	772	459	L	1630	772	m
IA-2	Molybdenum	6/26	mg/kg	0.465	12.05	1.2	151	19.2	D	30.8	30.8	u
IA-2	Nickel	5/5	mg/kg			13.2	20	16.6	L	19.8	19.8	u
IA-2	Potassium	5/5	mg/kg			680	1710	1070	L	1730	1710	m
IA-2	Selenium	1/26	mg/kg	0.165	12.05	2.1	2.1	8.57	D	9.94	2.1	m
IA-2	Sodium	5/5	mg/kg			114	285	196	L	362	285	m
IA-2	Strontium	5/5	mg/kg			15.2	46.9	25.7	L	47.9	46.9	m
IA-2	Titanium	5/5	mg/kg			238	312	273	L	313	312	m
IA-2	Uranium	2/5	mg/kg	7.65	7.9	18	155	39.3	D	101	101	u
IA-2	Vanadium	7/7	mg/kg			22	862	257	X	541	541	u
IA-2	Zinc	5/5	mg/kg			38.6	60.3	48.7	L	59.6	59.6	u
IA-2	Toxaphene	1/5	mg/kg	0.042	0.11	0.05	0.05	0.0709	D	0.105	0.05	m
IA-2	Benz(a)anthracene	1/5	mg/kg	0.205	0.215	0.1	0.1	0.188	D	0.235	0.1	m
IA-2	Benzo(a)pyrene	1/5	mg/kg	0.205	0.215	0.1	0.1	0.188	D	0.235	0.1	m
IA-2	Butyl benzyl phthalate	3/5	mg/kg	0.21	0.215	0.11	0.26	0.211	D	0.269	0.26	m
IA-2	Chrysene	1/5	mg/kg	0.205	0.215	0.051	0.051	0.178	D	0.246	0.051	m
IA-2	Fluoranthene	1/5	mg/kg	0.205	0.215	0.12	0.12	0.192	D	0.231	0.12	m
IA-2	Indeno(1,2,3-cd)pyrene	1/5	mg/kg	0.205	0.215	0.091	0.091	0.186	D	0.237	0.091	m
IA-2	Phenanthrene	1/5	mg/kg	0.205	0.215	0.087	0.087	0.185	D	0.238	0.087	m
IA-2	Pyrene	1/5	mg/kg	0.205	0.215	0.079	0.079	0.184	D	0.24	0.079	m
IA-2	1,2-Dichloroethene	1/5	mg/kg	0.003	0.003	0.022	0.022	0.0068	D	0.0149	0.0149	u
IA-2	2-Butanone	1/5	mg/kg	0.006	0.0125	0.013	0.013	0.0089	D	0.0123	0.0123	u

Table 2-11. SLAPS Subsurface Soil Data Summary (Cont'd)

Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
IA-2	Toluene	9/12	mg/kg	0.003	0.003	0.0022	0.21	0.0225	X	0.0531	0.0531	u
IA-2	Trichloroethene	2/6	mg/kg	0.003	0.003	0.0018	0.058	0.012	D	0.0305	0.0305	u
IA-2	trans-1,2-Dichloroethene	1/1	mg/kg			0.0019	0.0019	0.0019	D		0.0019	m
IA-2	Actinium-227	44/57	pCi/g	0.04	0.25	0.18	130.4	3.27	X	7.14	7.14	u
IA-2	Americium-241	4/57	pCi/g	-0.03	0.13	0.06	2.58	0.0921	D	0.17	0.17	u
IA-2	Cesium-137	5/57	pCi/g	-0.02	0.08	0.07	3.09	0.0621	D	0.153	0.153	u
IA-2	Potassium-40	56/57	pCi/g	8.43	8.43	9.82	25.2	15.7	X	16.4	16.4	u
IA-2	Protactinium-231	5/57	pCi/g	-0.48	1.06	2.33	179.3	3.99	D	9.28	9.28	u
IA-2	Radium-226	93/130	pCi/g	0.3	5	0.5	590	17.2	X	28.4	28.4	u
IA-2	Radium-228	57/57	pCi/g			0.67	4.82	1.02	X	1.14	1.14	u
IA-2	Thorium-228	57/57	pCi/g			0.74	4.82	1.43	X	1.58	1.58	u
IA-2	Thorium-230	90/91	pCi/g	0	0	0	14070	198	Z	456	456	u
IA-2	Thorium-232	78/130	pCi/g	0.4	7.6	0.6	4.82	2.16	X	2.35	2.35	u
IA-2	Uranium-235	24/57	pCi/g	-0.04	0.25	0.19	37.21	1.16	D	2.28	2.28	u
IA-2	Uranium-238	26/128	pCi/g	0.33	260	3.99	706	36.6	D	49.9	49.9	u
IA-3	Aluminum	7/7	mg/kg			8660	23200	14200	L	19900	19900	u
IA-3	Antimony	3/25	mg/kg	1.65	11.9	3.8	53.2	7.63	D	11	11	u
IA-3	Arsenic	7/7	mg/kg			3.7	11.7	7.36	N	9.28	9.28	u
IA-3	Barium	7/7	mg/kg			70.4	232	154	N	195	195	u
IA-3	Beryllium	5/7	mg/kg	0.31	0.34	0.84	2.4	1.02	L	2.74	2.4	m
IA-3	Boron	7/7	mg/kg			6	14.8	9.27	L	12	12	u
IA-3	Cadmium	7/25	mg/kg	0.14	1	0.48	50.4	2.67	D	6.07	6.07	u
IA-3	Calcium	7/7	mg/kg			4090	81300	25800	L	237000	81300	m
IA-3	Chromium	8/8	mg/kg			14.7	3240	424	X	1190	1190	u
IA-3	Cobalt	10/10	mg/kg			4.8	770	111	X	251	251	u
IA-3	Copper	9/9	mg/kg			12.9	909	130	X	313	313	u
IA-3	Iron	7/7	mg/kg			11700	30200	21300	N	26000	26000	u
IA-3	Lead	9/9	mg/kg			10.3	1200	197	X	441	441	u
IA-3	Lithium	7/7	mg/kg			7	14.6	9.84	L	12.3	12.3	u
IA-3	Magnesium	13/13	mg/kg			21	20200	8720	N	11500	11500	u
IA-3	Manganese	7/7	mg/kg			281	1330	730	L	1570	1330	m
IA-3	Mercury	1/7	mg/kg	0.03	0.035	0.07	0.07	0.0364	D	0.0474	0.0474	u
IA-3	Molybdenum	6/25	mg/kg	0.415	19.85	1.7	74.7	14	D	20	20	u
IA-3	Nickel	8/8	mg/kg			15.4	1460	212	X	550	550	u
IA-3	Potassium	7/7	mg/kg			553	4230	1730	L	3880	3880	u
IA-3	Sodium	7/7	mg/kg			124	405	250	L	384	384	u
IA-3	Strontium	7/7	mg/kg			23.6	146	50.4	L	110	110	u
IA-3	Thallium	6/25	mg/kg	0.8	19.85	0.96	1.8	8.69	D	10.5	1.8	m
IA-3	Titanium	7/7	mg/kg			66.2	416	268	N	351	351	u
IA-3	Uranium	2/7	mg/kg	6.9	8.15	15.6	129	26.1	D	59.5	59.5	u
IA-3	Vanadium	7/7	mg/kg			18.9	57.2	33.9	L	49.6	49.6	u
IA-3	Zinc	9/9	mg/kg			46.7	4330	598	X	1470	1470	u
IA-3	MCPP	1/7	mg/kg	4.5	5.5	11	11	5.77	D	7.48	7.48	u
IA-3	Benz(a)anthracene	2/7	mg/kg	0.19	0.22	0.09	0.18	0.186	D	0.218	0.18	m
IA-3	Benzo(a)pyrene	2/7	mg/kg	0.19	0.22	0.077	0.18	0.184	D	0.22	0.18	m
IA-3	Benzo(b)fluoranthene	1/7	mg/kg	0.185	0.22	0.083	0.083	0.185	D	0.22	0.083	m
IA-3	Benzo(ghi)perylene	1/7	mg/kg	0.19	0.22	0.19	0.19	0.202	D	0.211	0.19	m
IA-3	Benzo(k)fluoranthene	1/7	mg/kg	0.19	0.22	0.066	0.066	0.184	D	0.224	0.066	m
IA-3	Butyl benzyl phthalate	1/7	mg/kg	0.185	0.22	0.1	0.1	0.188	D	0.218	0.1	m
IA-3	Chrysene	1/7	mg/kg	0.19	0.22	0.21	0.21	0.205	D	0.213	0.21	m
IA-3	Fluoranthene	2/7	mg/kg	0.19	0.22	0.1	0.31	0.206	D	0.251	0.251	u
IA-3	Indeno(1,2,3-cd)pyrene	2/7	mg/kg	0.19	0.22	0.089	0.18	0.186	D	0.219	0.18	m
IA-3	Phenanthrene	2/7	mg/kg	0.19	0.22	0.042	0.19	0.18	D	0.226	0.19	m
IA-3	Pyrene	2/7	mg/kg	0.19	0.22	0.046	0.27	0.192	D	0.243	0.243	u
IA-3	1,2-Dichloroethene	1/7	mg/kg	0.003	0.0035	0.003	0.003	0.00307	D	0.00321	0.003	m
IA-3	2-Butanone	1/7	mg/kg	0.0055	0.0065	0.006	0.006	0.00614	D	0.00642	0.006	m
IA-3	Dimethylbenzene	2/7	mg/kg	0.003	0.0035	0.006	0.01	0.0045	D	0.00645	0.00645	u
IA-3	Methylene chloride	2/7	mg/kg	0.003	0.004	0.13	0.13	0.0394	D	0.0849	0.0849	u
IA-3	Toluene	6/13	mg/kg	0.003	0.0035	0.0015	0.055	0.011	D	0.0193	0.0193	u
IA-3	Trichloroethene	6/11	mg/kg	0.003	0.0035	0.0016	0.054	0.00898	X	0.0174	0.0174	u
IA-3	trans-1,2-Dichloroethene	3/3	mg/kg			0.0013	0.0077	0.00403	D	0.0096	0.0077	m
IA-3	Actinium-227	37/54	pCi/g	0	0.51	0.19	99.15	3.58	Z	6.98	6.98	u
IA-3	Americium-241	5/53	pCi/g	-0.03	0.19	0.13	4.28	0.175	D	0.323	0.323	u
IA-3	Cesium-137	5/53	pCi/g	-0.02	0.21	0.03	0.12	0.0145	D	0.024	0.024	u
IA-3	Potassium-40	53/53	pCi/g			7.64	19.71	16	X	16.5	16.5	u
IA-3	Protactinium-231	7/54	pCi/g	-0.41	1.31	1.5	56.27	2.24	D	4.25	4.25	u
IA-3	Radium-226	132/167	pCi/g	1.5	4.7	0.7	5620	57.7	X	116	116	u
IA-3	Radium-228	53/53	pCi/g			0.42	1.61	0.973	X	1.01	1.01	u
IA-3	Thorium-228	53/53	pCi/g			0.59	1.79	1.18	N	1.24	1.24	u
IA-3	Thorium-230	96/97	pCi/g	0	0	0.6	7241	189	Z	347	347	u
IA-3	Thorium-232	114/166	pCi/g	0.5	50.4	0.4	5	2.23	X	2.74	2.74	u
IA-3	Uranium-235	33/53	pCi/g	-0.04	0.31	0.19	17.99	1.04	Z	1.7	1.7	u
IA-3	Uranium-238	47/167	pCi/g	0	212	3.04	1600	49.9	D	72.1	72.1	u

Table 2-11. SLAPS Subsurface Soil Data Summary (Cont'd)

Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
IA-4	Fluoride	11/11	mg/kg			2.26	43.3	7.22	X	13.9	13.9	u
IA-4	Sulfide	3/11	mg/kg	6.4	13.6	13.8	23.8	10.8	D	14.3	14.3	u
IA-4	Aluminum	12/12	mg/kg			5990	19000	11500	L	14700	14700	u
IA-4	Arsenic	13/13	mg/kg			3.1	50.8	9.88	X	16.2	16.2	u
IA-4	Barium	14/14	mg/kg			58.5	3750	469	X	931	931	u
IA-4	Beryllium	2/12	mg/kg	0.245	0.405	0.98	1	0.442	D	0.577	0.577	u
IA-4	Boron	10/12	mg/kg	4.45	5.8	5.7	11.9	7.98	L	9.66	9.66	u
IA-4	Cadmium	4/24	mg/kg	0.155	0.65	0.45	4.5	0.585	D	0.888	0.888	u
IA-4	Calcium	12/12	mg/kg			3610	30200	13800	X	19700	19700	u
IA-4	Chromium	12/12	mg/kg			10.3	23.9	18.2	N	20.5	20.5	u
IA-4	Cobalt	17/17	mg/kg			4.7	1510	133	X	289	289	u
IA-4	Copper	14/14	mg/kg			9.8	876	89.5	X	200	200	u
IA-4	Iron	12/12	mg/kg			2600	24200	15100	N	18100	18100	u
IA-4	Lead	14/14	mg/kg			6.9	408	56.3	X	114	114	u
IA-4	Lithium	12/12	mg/kg			5.2	10.6	7.94	N	8.9	8.9	u
IA-4	Magnesium	17/17	mg/kg			2690	18500	10100	X	12700	12700	u
IA-4	Manganese	12/12	mg/kg			110	1760	472	L	934	934	u
IA-4	Mercury	1/12	mg/kg	0.03	0.035	0.07	0.07	0.0338	D	0.0397	0.0397	u
IA-4	Molybdenum	6/24	mg/kg	0.455	12.7	1.4	71.9	9.63	D	14.9	14.9	u
IA-4	Nickel	13/13	mg/kg			11.4	2010	170	X	443	443	u
IA-4	Potassium	12/12	mg/kg			562	1450	896	L	1090	1090	u
IA-4	Selenium	5/24	mg/kg	0.46	12.7	1.3	29.3	6.81	D	9.24	9.24	u
IA-4	Sodium	12/12	mg/kg			197	300	263	N	281	281	u
IA-4	Strontium	12/12	mg/kg			18.4	28.7	23.7	N	25.3	25.3	u
IA-4	Thallium	11/24	mg/kg	0.21	12.7	0.53	3.3	6.07	D	7.84	3.3	m
IA-4	Titanium	12/12	mg/kg			170	399	281	L	326	326	u
IA-4	Uranium	2/12	mg/kg	7.6	7.95	20.7	73.6	14.3	D	24.2	24.2	u
IA-4	Vanadium	12/12	mg/kg			18.2	39.3	30.7	N	34.2	34.2	u
IA-4	Zinc	12/12	mg/kg			31.8	59.3	44.4	L	49.5	49.5	u
IA-4	Fluoranthene	1/4	mg/kg	0.21	0.21	0.077	0.077	0.177	D	0.255	0.077	m
IA-4	Pyrene	1/4	mg/kg	0.21	0.21	0.28	0.28	0.228	D	0.269	0.269	u
IA-4	Toluene	5/9	mg/kg	0.003	0.003	0.0018	0.12	0.0165	X	0.0406	0.0406	u
IA-4	Actinium-227	26/41	pCi/g	0.08	0.39	0.16	16.18	0.797	X	1.47	1.47	u
IA-4	Americium-241	5/40	pCi/g	-0.02	0.09	0.06	4.69	0.162	D	0.357	0.357	u
IA-4	Cesium-137	1/40	pCi/g	-0.03	0.05	0.05	0.05	0.00225	D	0.00698	0.00698	u
IA-4	Potassium-40	40/40	pCi/g			12.32	17.85	16.1	N	16.4	16.4	u
IA-4	Protactinium-231	2/41	pCi/g	-0.48	2.72	2.49	3.98	0.41	D	0.628	0.628	u
IA-4	Radium-226	64/105	pCi/g	1.2	4.4	0.62	1740	74	X	118	118	u
IA-4	Radium-228	40/40	pCi/g			0.78	1.25	0.93	X	0.955	0.955	u
IA-4	Thorium-228	40/40	pCi/g			0.57	2.2	1.25	L	1.36	1.36	u
IA-4	Thorium-230	74/74	pCi/g			1.08	2440	107	X	182	182	u
IA-4	Thorium-232	50/103	pCi/g	2	18.9	0.56	7	3.18	D	3.69	3.69	u
IA-4	Uranium-235	21/40	pCi/g	-0.04	0.19	0.18	82.19	2.46	Z	5.91	5.91	u
IA-4	Uranium-238	12/104	pCi/g	0.76	352	3.34	1769	56.4	D	86.1	86.1	u
IA-5	Fluoride	16/16	mg/kg			2.54	21.1	4.9	X	6.84	6.84	u
IA-5	Sulfide	2/19	mg/kg	0.00655	14.1	19.4	23.5	8.83	D	11	11	u
IA-5	Aluminum	26/26	mg/kg			6680	17100	9950	L	11000	11000	u
IA-5	Arsenic	26/26	mg/kg			2.9	26.2	8.38	L	10.8	10.8	u
IA-5	Barium	27/27	mg/kg			40.6	4550	318	X	599	599	u
IA-5	Beryllium	8/26	mg/kg	0.255	0.4	0.75	1.4	0.51	D	0.617	0.617	u
IA-5	Boron	23/26	mg/kg	1.15	1.2	2.3	12.8	8.15	X	9.35	9.35	u
IA-5	Cadmium	4/48	mg/kg	0.155	0.8	0.79	4.2	0.491	D	0.64	0.64	u
IA-5	Calcium	26/26	mg/kg			4050	35600	18000	X	21900	21900	u
IA-5	Chromium	26/26	mg/kg			11.4	21.8	16.4	L	17.5	17.5	u
IA-5	Cobalt	33/33	mg/kg			5.1	308	54.2	X	81.2	81.2	u
IA-5	Copper	28/29	mg/kg	5.85	5.85	6.1	191	31.7	X	46.6	46.6	u
IA-5	Iron	26/26	mg/kg			9120	28300	18300	N	19800	19800	u
IA-5	Lead	26/26	mg/kg			6	25.7	10	X	11.3	11.3	u
IA-5	Lithium	26/26	mg/kg			5.1	10.1	7.65	L	8.2	8.2	u
IA-5	Magnesium	36/36	mg/kg			2730	26900	11700	X	13600	13600	u
IA-5	Manganese	26/26	mg/kg			109	1220	556	N	651	651	u
IA-5	Molybdenum	21/48	mg/kg	0.455	12.4	1	29.8	8.29	D	10.1	10.1	u
IA-5	Nickel	26/26	mg/kg			12.1	108	24.6	X	31.8	31.8	u
IA-5	Potassium	26/26	mg/kg			570	1400	921	N	990	990	u
IA-5	Selenium	22/48	mg/kg	0.165	12.4	0.38	19.6	6.18	D	7.47	7.47	u
IA-5	Silver	1/26	mg/kg	0.37	0.44	0.81	0.81	0.403	D	0.431	0.431	u
IA-5	Sodium	26/26	mg/kg			102	534	236	L	274	274	u
IA-5	Strontium	26/26	mg/kg			16.6	210	32.4	X	44.6	44.6	u
IA-5	Thallium	22/48	mg/kg	0.21	12.4	0.74	2.5	5.78	D	6.98	2.5	m
IA-5	Titanium	26/26	mg/kg			99.1	347	257	X	275	275	u
IA-5	Uranium	4/26	mg/kg	7.65	8.95	11.1	45.1	10.2	D	12.8	12.8	u
IA-5	Vanadium	25/26	mg/kg	10.1	10.1	22	111	32.4	X	38.1	38.1	u
IA-5	Zinc	26/26	mg/kg			26.7	67.9	46.5	N	49.8	49.8	u

Table 2-11. SLAPS Subsurface Soil Data Summary (Cont'd)

Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
IA-5	Dalapon	1/12	mg/kg	0.0245	0.05	0.15	0.15	0.0378	D	0.0565	0.0565	u
IA-5	MCPA	2/12	mg/kg	4.9	23.5	19	49	11.4	D	18.3	18.3	u
IA-5	Silvex	4/12	mg/kg	0.012	0.026	0.049	0.083	0.0323	D	0.0468	0.0468	u
IA-5	2-Methylnaphthalene	1/12	mg/kg	0.205	0.215	0.1	0.1	0.2	D	0.217	0.1	m
IA-5	Benz(a)anthracene	2/12	mg/kg	0.205	0.215	0.19	0.26	0.212	D	0.221	0.221	u
IA-5	Bis(2-ethylhexyl)phthalate	1/12	mg/kg	0.205	0.295	0.17	0.17	0.214	D	0.229	0.17	m
IA-5	Butyl benzyl phthalate	2/12	mg/kg	0.205	0.215	0.31	0.31	0.226	D	0.246	0.246	u
IA-5	Chrysene	2/12	mg/kg	0.205	0.215	0.14	0.14	0.198	D	0.212	0.14	m
IA-5	Di-n-octylphthalate	2/12	mg/kg	0.205	0.215	0.13	0.15	0.198	D	0.213	0.15	m
IA-5	Fluoranthene	2/12	mg/kg	0.205	0.215	0.079	0.15	0.194	D	0.214	0.15	m
IA-5	Naphthalene	1/12	mg/kg	0.205	0.215	0.13	0.13	0.203	D	0.215	0.13	m
IA-5	Phenanthrene	3/12	mg/kg	0.205	0.215	0.069	0.23	0.189	D	0.217	0.217	u
IA-5	Pyrene	3/12	mg/kg	0.205	0.215	0.29	0.37	0.236	D	0.263	0.263	u
IA-5	Acetone	2/12	mg/kg	0.006	0.0215	0.016	0.023	0.0115	D	0.015	0.015	u
IA-5	Methylene chloride	1/12	mg/kg	0.003	0.018	0.001	0.001	0.00438	D	0.00667	0.001	m
IA-5	Toluene	8/18	mg/kg	0.003	0.003	0.0024	1.2	0.142	D	0.282	0.282	u
IA-5	Actinium-227	89/131	pCi/g	-0.09	0.32	0.16	292.7	3.54	Z	7.31	7.31	u
IA-5	Americium-241	7/131	pCi/g	-5.04	0.35	0.07	1.5	0.0227	D	0.091	0.091	u
IA-5	Cesium-137	3/131	pCi/g	-0.03	0.06	0.06	2.35	0.0192	D	0.049	0.049	u
IA-5	Potassium-40	130/131	pCi/g	5.21	5.21	11.42	17.84	15	X	15.2	15.2	u
IA-5	Protactinium-231	11/131	pCi/g	-0.42	1.16	1.21	346.4	4.03	D	8.48	8.48	u
IA-5	Radium-226	232/315	pCi/g	1	5.3	0.59	900	13.4	X	19.3	19.3	u
IA-5	Radium-228	130/131	pCi/g	0.95	0.95	0.71	3.56	0.944	X	0.983	0.983	u
IA-5	Thorium-228	130/131	pCi/g	1.04	1.04	0.61	3.56	1.24	X	1.28	1.28	u
IA-5	Thorium-230	246/246	pCi/g			0.78	14680	190	X	296	296	u
IA-5	Thorium-232	197/316	pCi/g	1	12	0.42	7.5	2.19	X	2.33	2.33	u
IA-5	Uranium-235	51/131	pCi/g	-0.05	0.26	0.17	32.11	0.715	D	1.18	1.18	u
IA-5	Uranium-238	41/316	pCi/g	0.37	256	5.08	1000	27.3	D	33.6	33.6	u
IA-6	Fluoride	2/2	mg/kg			40.7	62.9	51.8	D	122	62.9	m
IA-6	Cobalt	1/1	mg/kg			62.3	62.3	62.3	D		62.3	m
IA-6	Magnesium	1/1	mg/kg			12200	12200	12200	D		12200	m
IA-6	Actinium-227	2/5	pCi/g	0.11	0.15	0.22	17.89	3.7	D	11.3	11.3	u
IA-6	Potassium-40	5/5	pCi/g			13.87	16.42	15.4	N	16.4	16.4	u
IA-6	Protactinium-231	1/5	pCi/g	-0.19	0.14	18.78	18.78	3.74	D	11.8	11.8	u
IA-6	Radium-226	16/32	pCi/g	1.4	2.7	0.85	36	3.77	X	5.77	5.77	u
IA-6	Radium-228	5/5	pCi/g			0.84	1.37	1	L	1.24	1.24	u
IA-6	Thorium-228	5/5	pCi/g			1.33	1.67	1.46	L	1.61	1.61	u
IA-6	Thorium-230	25/25	pCi/g			0.6	2100	138	X	287	287	u
IA-6	Thorium-232	13/32	pCi/g	2	4	0.74	7	2.8	D	3.16	3.16	u
IA-6	Uranium-235	3/5	pCi/g	0.08	0.1	0.2	4.33	1.03	D	2.79	2.79	u
IA-6	Uranium-238	8/32	pCi/g	0.58	94.2	8.28	32	29	D	35.9	32	m
IA-7	Fluoride	1/1	mg/kg			2.68	2.68	2.68	D		2.68	m
IA-7	Aluminum	10/10	mg/kg			5810	15700	9740	L	12400	12400	u
IA-7	Arsenic	10/10	mg/kg			2	11.8	5.71	L	8.83	8.83	u
IA-7	Barium	12/12	mg/kg			54.4	13600	2310	X	4950	4950	u
IA-7	Beryllium	1/10	mg/kg	0.28	0.48	0.96	0.96	0.398	D	0.518	0.518	u
IA-7	Boron	10/10	mg/kg			3.8	11.6	6.62	L	8.69	8.69	u
IA-7	Cadmium	5/13	mg/kg	0.155	0.5	0.48	3.2	0.643	D	1.06	1.06	u
IA-7	Calcium	10/10	mg/kg			2450	37000	12500	L	47400	37000	m
IA-7	Chromium	10/10	mg/kg			11.6	22.1	16.5	L	19.4	19.4	u
IA-7	Cobalt	13/13	mg/kg			3.8	6050	755	X	1690	1690	u
IA-7	Copper	12/12	mg/kg			10.2	4400	612	X	1360	1360	u
IA-7	Iron	10/10	mg/kg			9540	24600	15900	L	19100	19100	u
IA-7	Lead	12/12	mg/kg			7.4	933	142	X	305	305	u
IA-7	Lithium	8/10	mg/kg	3	3.15	5.4	9.3	6.81	X	8.09	8.09	u
IA-7	Magnesium	11/11	mg/kg			2740	23000	8440	L	16700	16700	u
IA-7	Manganese	10/10	mg/kg			83.1	2030	672	L	2770	2030	m
IA-7	Mercury	5/10	mg/kg	0.03	0.035	0.08	2.1	0.468	X	0.876	0.876	u
IA-7	Molybdenum	5/13	mg/kg	0.46	10.15	1	255	34.1	D	74.2	74.2	u
IA-7	Nickel	12/12	mg/kg			8.7	7570	1020	X	2280	2280	u
IA-7	Potassium	10/10	mg/kg			436	1320	665	L	854	854	u
IA-7	Selenium	3/13	mg/kg	0.16	10.15	1.6	183	22.5	D	49.7	49.7	u
IA-7	Sodium	10/10	mg/kg			78.5	216	118	L	142	142	u
IA-7	Strontium	10/10	mg/kg			11.1	25.2	18.4	N	21.4	21.4	u
IA-7	Thallium	1/13	mg/kg	0.205	11.35	0.95	0.95	2.77	D	4.96	0.95	m
IA-7	Titanium	10/10	mg/kg			215	373	274	L	305	305	u
IA-7	Vanadium	11/11	mg/kg			17.2	630	82.4	X	182	182	u
IA-7	Zinc	10/10	mg/kg			34.3	57.2	42.4	L	47.7	47.7	u
IA-7	1,2-Dichloroethane	1/9	mg/kg	0.0025	0.003	0.001	0.001	0.00272	D	0.00314	0.001	m
IA-7	2-Butanone	1/9	mg/kg	0.005	0.0065	0.001	0.001	0.00567	D	0.00679	0.001	m
IA-7	Acetone	3/9	mg/kg	0.0065	0.0135	0.005	0.028	0.0111	D	0.0154	0.0154	u
IA-7	Toluene	1/9	mg/kg	0.0025	0.003	0.001	0.001	0.00267	D	0.00308	0.001	m
IA-7	Actinium-227	19/35	pCi/g	-0.13	0.32	0.19	0.68	0.269	Z	0.325	0.325	u

Table 2-11. SLAPS Subsurface Soil Data Summary (Cont'd)

Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
IA-7	Americium-241	1/35	pCi/g	-0.03	0.08	0.08	0.08	0.0217	D	0.0296	0.0296	u
IA-7	Potassium-40	35/35	pCi/g			12.33	18.47	15.6	N	16	16	u
IA-7	Protactinium-231	8/35	pCi/g	-0.3	0.92	1.2	2.38	0.628	D	0.828	0.828	u
IA-7	Radium-226	86/90	pCi/g	1.5	1.8	0.65	27	2.05	X	2.62	2.62	u
IA-7	Radium-228	35/35	pCi/g			0.66	1.15	0.937	N	0.967	0.967	u
IA-7	Thorium-228	35/35	pCi/g			0.69	1.91	1.23	L	1.31	1.31	u
IA-7	Thorium-230	72/73	pCi/g	0.05	0.05	0.86	1400	70.9	X	113	113	u
IA-7	Thorium-232	80/90	pCi/g	1	3.5	0.59	4	1.61	X	1.75	1.75	u
IA-7	Uranium-235	4/35	pCi/g	-0.03	0.17	0.24	0.48	0.108	D	0.137	0.137	u
IA-7	Uranium-238	20/90	pCi/g	-1.76	31.2	5	39	8.12	D	9.59	9.59	u
IA-8	Sulfate	1/1	mg/kg			860	860	860	D		860	m
IA-8	Aluminum	4/4	mg/kg			6340	13500	8780	D	12600	12600	u
IA-8	Arsenic	4/4	mg/kg			4.4	8	6.23	D	7.99	7.99	u
IA-8	Barium	4/4	mg/kg			98.1	185	133	D	178	178	u
IA-8	Boron	3/3	mg/kg			4.3	6	5.27	D	6.74	6	m
IA-8	Cadmium	1/6	mg/kg	0.16	0.6	0.4	0.4	0.338	D	0.476	0.4	m
IA-8	Calcium	4/4	mg/kg			4460	21100	10800	D	20200	20200	u
IA-8	Chromium	4/4	mg/kg			12.2	17.7	14.2	D	17.1	17.1	u
IA-8	Cobalt	4/4	mg/kg			3.8	16.7	7.83	D	14.9	14.9	u
IA-8	Copper	4/4	mg/kg			10.9	28.6	19.7	D	30.1	28.6	m
IA-8	Iron	4/4	mg/kg			15100	18300	16300	D	17900	17900	u
IA-8	Lead	4/4	mg/kg			8.3	44.5	18.3	D	38.9	38.9	u
IA-8	Lithium	2/4	mg/kg	3.1	4.35	6.1	8.8	5.59	D	8.49	8.49	u
IA-8	Magnesium	4/4	mg/kg			3180	12700	7020	D	12500	12500	u
IA-8	Manganese	4/4	mg/kg			142	862	570	D	930	862	m
IA-8	Molybdenum	3/6	mg/kg	0.465	12.1	1.3	1.7	4.18	D	8.13	1.7	m
IA-8	Nickel	4/4	mg/kg			12.6	30	19.2	D	28.4	28.4	u
IA-8	Potassium	4/4	mg/kg			785	1180	932	D	1130	1130	u
IA-8	Selenium	3/6	mg/kg	0.165	12.1	0.52	1.2	3.82	D	7.99	1.2	m
IA-8	Silver	1/4	mg/kg	0.38	0.39	0.72	0.72	0.469	D	0.666	0.666	u
IA-8	Sodium	3/4	mg/kg	141.5	141.5	129	340	231	D	361	340	m
IA-8	Strontium	4/4	mg/kg			16.9	21.1	19.2	D	21.4	21.1	m
IA-8	Titanium	4/4	mg/kg			166	274	242	D	303	274	m
IA-8	Vanadium	3/4	mg/kg	11.7	11.7	22.1	25.1	20.8	D	28	25.1	m
IA-8	Zinc	4/4	mg/kg			39.8	75.6	58.2	D	75.5	75.5	u
IA-8	Benz(a)anthracene	1/4	mg/kg	0.21	0.215	0.2	0.2	0.209	D	0.216	0.2	m
IA-8	Benzo(a)pyrene	1/4	mg/kg	0.21	0.215	0.14	0.14	0.194	D	0.236	0.14	m
IA-8	Benzo(b)fluoranthene	1/4	mg/kg	0.21	0.215	0.29	0.29	0.231	D	0.277	0.277	u
IA-8	Butyl benzyl phthalate	2/4	mg/kg	0.21	0.215	0.18	0.27	0.219	D	0.263	0.263	u
IA-8	Chrysene	1/4	mg/kg	0.21	0.215	0.07	0.07	0.176	D	0.26	0.07	m
IA-8	Fluoranthene	1/4	mg/kg	0.21	0.215	0.24	0.24	0.219	D	0.236	0.236	u
IA-8	Indeno(1,2,3-cd)pyrene	1/4	mg/kg	0.21	0.215	0.049	0.049	0.171	D	0.267	0.049	m
IA-8	Phenanthrene	1/4	mg/kg	0.21	0.215	0.14	0.14	0.194	D	0.236	0.14	m
IA-8	Pyrene	1/4	mg/kg	0.21	0.215	0.25	0.25	0.221	D	0.244	0.244	u
IA-8	1,1,2-Trichloro-1,2,2-trifluoroethane	1/4	mg/kg	0.005	0.0065	0.005	0.005	0.00575	D	0.00677	0.005	m
IA-8	Methylene chloride	1/4	mg/kg	0.0025	0.003	0.091	0.091	0.0249	D	0.0767	0.0767	u
IA-8	Actinium-227	15/28	pCi/g	0.01	0.18	0.23	0.95	0.291	L	0.597	0.597	u
IA-8	Americium-241	1/28	pCi/g	-0.06	0.11	0.07	0.07	0.0271	D	0.0387	0.0387	u
IA-8	Cesium-137	2/28	pCi/g	-0.03	0.02	0.03	0.08	0.00179	D	0.00852	0.00852	u
IA-8	Potassium-40	28/28	pCi/g			13.91	18.26	15.9	L	16.3	16.3	u
IA-8	Protactinium-231	6/28	pCi/g	-0.56	0.65	1.28	2.63	0.567	D	0.798	0.798	u
IA-8	Radium-226	282/294	pCi/g	1	2.7	0.67	130	3.3	X	4.13	4.13	u
IA-8	Radium-228	28/28	pCi/g			0.81	1.15	0.948	X	0.973	0.973	u
IA-8	Thorium-228	28/28	pCi/g			0.68	1.98	1.27	N	1.38	1.38	u
IA-8	Thorium-230	303/303	pCi/g			0.9	15000	91.1	X	175	175	u
IA-8	Thorium-232	229/294	pCi/g	0.7	8	0.68	14	2.24	X	2.37	2.37	u
IA-8	Uranium-235	9/28	pCi/g	-0.01	0.18	0.19	0.44	0.165	D	0.208	0.208	u
IA-8	Uranium-238	24/294	pCi/g	0.54	58	3.87	66	12.7	D	13.6	13.6	u
IA-9	Sulfate	1/1	mg/kg			863	863	863	D		863	m
IA-9	Aluminum	40/40	mg/kg			5070	19600	10900	L	12100	12100	u
IA-9	Antimony	2/61	mg/kg	1.75	7.55	6.1	20.4	3.8	D	4.47	4.47	u
IA-9	Arsenic	41/41	mg/kg			1.8	98.4	9.88	X	13.7	13.7	u
IA-9	Barium	40/40	mg/kg			52.5	5830	434	X	702	702	u
IA-9	Beryllium	25/40	mg/kg	0.25	0.38	0.64	1.4	0.631	X	0.707	0.707	u
IA-9	Boron	39/40	mg/kg	2.6	2.6	4.1	11.5	6.92	N	7.46	7.46	u
IA-9	Cadmium	16/61	mg/kg	0.15	0.65	0.32	4.8	0.47	D	0.602	0.602	u
IA-9	Calcium	40/40	mg/kg			2110	34700	8200	X	10100	10100	u
IA-9	Chromium	40/40	mg/kg			10	21.7	15.3	L	16.1	16.1	u
IA-9	Cobalt	41/41	mg/kg			3.8	648	36.5	X	64.5	64.5	u
IA-9	Copper	40/40	mg/kg			10	599	37.1	X	62.5	62.5	u
IA-9	Iron	40/40	mg/kg			7760	26400	17900	N	18900	18900	u
IA-9	Lead	40/40	mg/kg			7	201	24.6	X	34.5	34.5	u
IA-9	Lithium	39/40	mg/kg	3.15	3.15	4.9	12.5	7.82	N	8.35	8.35	u

Table 2-11. SLAPS Subsurface Soil Data Summary (Cont'd)

Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
IA-9	Magnesium	43/43	mg/kg			2150	21600	6090	X	7170	7170	u
IA-9	Manganese	40/40	mg/kg			97.9	1990	652	L	828	828	u
IA-9	Mercury	2/40	mg/kg	0.03	0.035	0.07	0.15	0.0344	D	0.0397	0.0397	u
IA-9	Molybdenum	18/61	mg/kg	0.44	12.6	1	59.1	5.79	D	7.66	7.66	u
IA-9	Nickel	40/40	mg/kg			11.8	843	53.5	X	89.7	89.7	u
IA-9	Potassium	40/40	mg/kg			459	1960	1140	L	1250	1250	u
IA-9	Selenium	7/61	mg/kg	0.155	12.6	0.45	134	6.49	D	10.2	10.2	u
IA-9	Sodium	40/40	mg/kg			82	310	152	L	166	166	u
IA-9	Strontium	40/40	mg/kg			14.9	79.2	24.9	X	27.7	27.7	u
IA-9	Thallium	7/61	mg/kg	0.195	12.6	0.46	148	6.51	D	10.6	10.6	u
IA-9	Titanium	40/40	mg/kg			174	506	277	L	297	297	u
IA-9	Uranium	3/40	mg/kg	4.8	8.1	36	112	11.6	D	16.3	16.3	u
IA-9	Vanadium	40/40	mg/kg			14.6	97.7	30.8	X	34.2	34.2	u
IA-9	Zinc	40/40	mg/kg			35.6	78.4	53	L	55.9	55.9	u
IA-9	Dalapon	1/39	mg/kg	0.024	0.0475	0.061	0.061	0.0265	D	0.0283	0.0283	u
IA-9	MCPP	2/39	mg/kg	4.75	9.5	19	62	6.91	D	9.44	9.44	u
IA-9	Silvex	1/39	mg/kg	0.012	0.0235	0.031	0.031	0.0133	D	0.0142	0.0142	u
IA-9	4,4'-DDD	2/39	mg/kg	0.00195	1.05	0.0022	0.003	0.0558	D	0.119	0.003	m
IA-9	4,4'-DDE	1/39	mg/kg	0.001	1.05	0.0035	0.0035	0.0558	D	0.119	0.0035	m
IA-9	Dieldrin	4/40	mg/kg	0.001	1.05	0.0039	0.23	0.0628	D	0.125	0.125	u
IA-9	PCB-1260	1/39	mg/kg	0.0195	10.5	0.041	0.041	0.559	D	1.19	0.041	m
IA-9	Benz(a)anthracene	3/39	mg/kg	0.195	0.22	0.22	0.25	0.208	D	0.211	0.211	u
IA-9	Benzo(a)pyrene	2/39	mg/kg	0.195	0.22	0.083	0.099	0.2	D	0.207	0.099	m
IA-9	Benzo(b)fluoranthene	5/39	mg/kg	0.195	0.22	0.073	0.24	0.199	D	0.207	0.207	u
IA-9	Benzo(ghi)perylene	4/39	mg/kg	0.195	0.22	0.13	0.18	0.201	D	0.205	0.18	m
IA-9	Bis(2-ethylhexyl)phthalate	20/39	mg/kg	0.195	0.21	0.024	0.32	0.202	X	0.223	0.223	u
IA-9	Butyl benzyl phthalate	8/39	mg/kg	0.195	0.215	0.29	0.31	0.224	D	0.234	0.234	u
IA-9	Chrysene	6/39	mg/kg	0.195	0.22	0.12	0.18	0.199	D	0.204	0.18	m
IA-9	Di-n-butyl phthalate	4/39	mg/kg	0.195	0.22	0.026	0.1	0.193	D	0.204	0.1	m
IA-9	Di-n-octylphthalate	1/39	mg/kg	0.195	0.22	0.069	0.069	0.202	D	0.208	0.069	m
IA-9	Fluoranthene	2/39	mg/kg	0.195	0.22	0.082	0.093	0.2	D	0.207	0.093	m
IA-9	Indeno(1,2,3-cd)pyrene	4/39	mg/kg	0.195	0.22	0.11	0.32	0.211	D	0.219	0.219	u
IA-9	Pyrene	6/39	mg/kg	0.195	0.22	0.16	0.24	0.208	D	0.212	0.212	u
IA-9	1,1,1-Trichloroethane	6/46	mg/kg	0.0025	0.0035	0.0013	0.0017	0.00279	D	0.00291	0.0017	m
IA-9	2-Butanone	7/40	mg/kg	0.005	0.0275	0.007	0.22	0.017	D	0.0267	0.0267	u
IA-9	Acetone	1/36	mg/kg	0.005	0.06	0.76	0.76	0.0312	D	0.0666	0.0666	u
IA-9	Carbon disulfide	2/40	mg/kg	0.0025	0.0035	0.016	0.021	0.00375	D	0.00468	0.00468	u
IA-9	Carbon tetrachloride	1/40	mg/kg	0.0025	0.0035	0.002	0.002	0.00295	D	0.00301	0.002	m
IA-9	Dimethylbenzene	1/40	mg/kg	0.0025	0.0035	0.004	0.004	0.00301	D	0.00307	0.00307	u
IA-9	Toluene	13/48	mg/kg	0.0025	0.0035	0.001	0.029	0.00422	D	0.00543	0.00543	u
IA-9	Trichloroethene	3/40	mg/kg	0.0025	0.0035	0.001	0.006	0.00298	D	0.00314	0.00314	u
IA-9	Actinium-227	106/140	pCi/g	-0.02	0.22	0.09	189.9	2.85	Z	5.3	5.3	u
IA-9	Americium-241	3/140	pCi/g	-2.29	0.44	0.06	0.12	0.017	D	0.0453	0.0453	u
IA-9	Cesium-137	16/140	pCi/g	-0.03	0.31	0.02	0.7	0.0191	D	0.0307	0.0307	u
IA-9	Potassium-40	140/140	pCi/g			1.51	25.96	15.3	X	15.6	15.6	u
IA-9	Protactinium-231	21/140	pCi/g	-0.46	1.1	1.02	217.1	3.23	D	6.05	6.05	u
IA-9	Radium-226	420/427	pCi/g	0	1	0.15	230.7	2.29	Z	3.28	3.28	u
IA-9	Radium-228	140/140	pCi/g			0.15	2.79	0.969	X	1	1	u
IA-9	Thorium-228	139/140	pCi/g	0.93	0.93	0.6	15.78	1.38	X	1.56	1.56	u
IA-9	Thorium-230	402/407	pCi/g	0.5	1.4	0.6	10140	57.2	X	105	105	u
IA-9	Thorium-232	404/427	pCi/g	0.2	2.25	0.5	10.93	1.65	L	1.7	1.7	u
IA-9	Uranium-235	30/140	pCi/g	-0.07	0.22	0.18	20.23	0.555	D	0.881	0.881	u
IA-9	Uranium-238	13/427	pCi/g	0	24	2	119.7	6.03	D	6.64	6.64	u
ROAD ROW	Aluminum	1/1	mg/kg			15800	15800	15800	D		15800	m
ROAD ROW	Arsenic	1/1	mg/kg			23.2	23.2	23.2	D		23.2	m
ROAD ROW	Barium	1/1	mg/kg			350	350	350	D		350	m
ROAD ROW	Beryllium	1/1	mg/kg			1.5	1.5	1.5	D		1.5	m
ROAD ROW	Boron	1/1	mg/kg			18.8	18.8	18.8	D		18.8	m
ROAD ROW	Calcium	1/1	mg/kg			5050	5050	5050	D		5050	m
ROAD ROW	Chromium	1/1	mg/kg			19.8	19.8	19.8	D		19.8	m
ROAD ROW	Cobalt	1/1	mg/kg			35.1	35.1	35.1	D		35.1	m
ROAD ROW	Copper	1/1	mg/kg			22.9	22.9	22.9	D		22.9	m
ROAD ROW	Iron	1/1	mg/kg			52100	52100	52100	D		52100	m
ROAD ROW	Lead	1/1	mg/kg			39.5	39.5	39.5	D		39.5	m
ROAD ROW	Lithium	1/1	mg/kg			9.1	9.1	9.1	D		9.1	m
ROAD ROW	Magnesium	1/1	mg/kg			2770	2770	2770	D		2770	m
ROAD ROW	Manganese	1/1	mg/kg			6320	6320	6320	D		6320	m
ROAD ROW	Molybdenum	1/1	mg/kg			2.1	2.1	2.1	D		2.1	m
ROAD ROW	Nickel	1/1	mg/kg			32.9	32.9	32.9	D		32.9	m
ROAD ROW	Potassium	1/1	mg/kg			1160	1160	1160	D		1160	m
ROAD ROW	Sodium	1/1	mg/kg			932	932	932	D		932	m
ROAD ROW	Strontium	1/1	mg/kg			21.8	21.8	21.8	D		21.8	m
ROAD ROW	Thallium	1/1	mg/kg			7.2	7.2	7.2	D		7.2	m

Table 2-11. SLAPS Subsurface Soil Data Summary (Cont'd)

Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
ROAD ROW	Titanium	1/1	mg/kg			293	293	293	D		293	m
ROAD ROW	Vanadium	1/1	mg/kg			65.3	65.3	65.3	D		65.3	m
ROAD ROW	Zinc	1/1	mg/kg			73	73	73	D		73	m
ROAD ROW	MCPP	1/1	mg/kg			120	120	120	D		120	m
ROAD ROW	alpha-Chlordane	1/2	mg/kg	0.00115	0.00115	0.03	0.03	0.0156	D	0.107	0.03	m
ROAD ROW	Fluoranthene	1/1	mg/kg			0.1	0.1	0.1	D		0.1	m
ROAD ROW	Pyrene	1/1	mg/kg			0.32	0.32	0.32	D		0.32	m
ROAD ROW	2-Butanone	1/1	mg/kg			0.024	0.024	0.024	D		0.024	m
ROAD ROW	Acetone	1/1	mg/kg			0.077	0.077	0.077	D		0.077	m
ROAD ROW	Toluene	1/1	mg/kg			0.004	0.004	0.004	D		0.004	m
ROAD ROW	Radium-226	1359/1381	pCi/g	0.7	4	0.4	39.9	1.99	X	2.07	2.07	u
ROAD ROW	Thorium-230	2328/2371	pCi/g	0.3	1.5	0.3	1100	11.7	X	13.4	13.4	u
ROAD ROW	Thorium-232	1199/1376	pCi/g	0.1	9	0.4	64	2.19	X	2.28	2.28	u
ROAD ROW	Uranium-238	11/1379	pCi/g	0	69	2.1	48.2	11.3	D	11.6	11.6	u
SLAPS	Fluoride	31/31	mg/kg			2.26	62.9	9.57	X	14.1	14.1	u
SLAPS	Sulfide	5/31	mg/kg	0.00655	14.1	13.8	23.8	9.46	D	11.2	11.2	u
SLAPS	Aluminum	61/61	mg/kg			5810	23200	10700	L	11500	11500	u
SLAPS	Antimony	3/149	mg/kg	0.19	11.9	3.8	53.2	4.94	D	5.57	5.57	u
SLAPS	Arsenic	64/64	mg/kg			2	237	14.6	X	22.6	22.6	u
SLAPS	Barium	66/66	mg/kg			40.6	13600	678	X	1160	1160	u
SLAPS	Beryllium	20/61	mg/kg	0.245	0.48	0.55	2.4	0.545	D	0.628	0.628	u
SLAPS	Boron	56/61	mg/kg	1.15	5.8	2.3	14.8	7.93	N	8.58	8.58	u
SLAPS	Cadmium	26/149	mg/kg	0.14	1	0.32	50.4	0.952	D	1.52	1.52	u
SLAPS	Calcium	61/61	mg/kg			2450	81300	17300	X	20500	20500	u
SLAPS	Chromium	62/62	mg/kg			10.3	3240	69.3	X	156	156	u
SLAPS	Cobalt	84/84	mg/kg			3.7	6050	186	X	328	328	u
SLAPS	Copper	72/73	mg/kg	5.85	5.85	6.1	4400	160	X	281	281	u
SLAPS	Iron	61/61	mg/kg			2600	30200	17500	N	18600	18600	u
SLAPS	Lead	67/67	mg/kg			6	1200	68.3	X	111	111	u
SLAPS	Lithium	57/61	mg/kg	3	4.25	5.1	14.6	7.73	N	8.17	8.17	u
SLAPS	Magnesium	92/92	mg/kg			21	26900	10500	X	11500	11500	u
SLAPS	Manganese	61/61	mg/kg			83.1	2030	571	L	723	723	u
SLAPS	Mercury	7/61	mg/kg	0.03	0.035	0.07	2.1	0.103	D	0.171	0.171	u
SLAPS	Molybdenum	46/149	mg/kg	0.415	19.85	1	255	13.8	D	17.9	17.9	u
SLAPS	Nickel	65/65	mg/kg			8.7	7570	260	X	491	491	u
SLAPS	Potassium	61/61	mg/kg			436	4230	976	L	1060	1060	u
SLAPS	Selenium	31/149	mg/kg	0.15	19.85	0.38	183	8.79	D	11.1	11.1	u
SLAPS	Silver	1/61	mg/kg	0.34	0.44	0.81	0.81	0.39	D	0.402	0.402	u
SLAPS	Sodium	61/61	mg/kg			78.5	534	221	X	240	240	u
SLAPS	Strontium	61/61	mg/kg			11.1	210	29.8	X	36	36	u
SLAPS	Thallium	40/149	mg/kg	0.205	19.85	0.53	3.3	6.86	D	7.54	3.3	m
SLAPS	Titanium	61/61	mg/kg			66.2	416	267	N	280	280	u
SLAPS	Uranium	10/61	mg/kg	6.9	8.95	11.1	155	14.8	D	20.3	20.3	u
SLAPS	Vanadium	63/64	mg/kg	10.1	10.1	17.2	862	65.2	X	97.9	97.9	u
SLAPS	Zinc	63/63	mg/kg			26.7	4330	124	X	239	239	u
SLAPS	Dalapon	1/38	mg/kg	0.0225	0.05	0.15	0.15	0.0292	D	0.0348	0.0348	u
SLAPS	MCPA	2/38	mg/kg	4.5	23.5	19	49	6.99	D	9.16	9.16	u
SLAPS	MCPP	1/38	mg/kg	4.5	10.5	11	11	5.29	D	5.65	5.65	u
SLAPS	Silvex	4/38	mg/kg	0.0115	0.026	0.049	0.083	0.0189	D	0.0237	0.0237	u
SLAPS	Toxaphene	1/36	mg/kg	0.042	0.5	0.05	0.05	0.112	D	0.131	0.05	m
SLAPS	2-Methylnaphthalene	1/38	mg/kg	0.185	0.225	0.1	0.1	0.205	D	0.211	0.1	m
SLAPS	Benz(a)anthracene	5/38	mg/kg	0.19	0.225	0.09	0.26	0.203	D	0.211	0.211	u
SLAPS	Benzo(a)pyrene	3/38	mg/kg	0.19	0.225	0.077	0.18	0.202	D	0.21	0.18	m
SLAPS	Benzo(b)fluoranthene	1/38	mg/kg	0.185	0.225	0.083	0.083	0.205	D	0.211	0.083	m
SLAPS	Benzo(ghi)perylene	1/38	mg/kg	0.19	0.225	0.19	0.19	0.208	D	0.21	0.19	m
SLAPS	Benzo(k)fluoranthene	1/38	mg/kg	0.19	0.225	0.066	0.066	0.205	D	0.212	0.066	m
SLAPS	Bis(2-ethylhexyl)phthalate	1/38	mg/kg	0.185	0.295	0.17	0.17	0.21	D	0.214	0.17	m
SLAPS	Butyl benzyl phthalate	6/38	mg/kg	0.185	0.225	0.1	0.31	0.211	D	0.221	0.221	u
SLAPS	Chrysene	4/38	mg/kg	0.19	0.225	0.051	0.21	0.201	D	0.209	0.209	u
SLAPS	Di-n-octylphthalate	2/38	mg/kg	0.185	0.225	0.13	0.15	0.205	D	0.209	0.15	m
SLAPS	Fluoranthene	6/38	mg/kg	0.19	0.225	0.077	0.31	0.198	D	0.21	0.21	u
SLAPS	Indeno(1,2,3-cd)pyrene	3/38	mg/kg	0.19	0.225	0.089	0.18	0.202	D	0.21	0.18	m
SLAPS	Naphthalene	1/38	mg/kg	0.185	0.225	0.13	0.13	0.206	D	0.21	0.13	m
SLAPS	Phenanthrene	6/38	mg/kg	0.19	0.225	0.042	0.23	0.195	D	0.207	0.207	u
SLAPS	Pyrene	7/38	mg/kg	0.19	0.225	0.046	0.37	0.214	D	0.227	0.227	u
SLAPS	1,2-Dichloroethane	1/38	mg/kg	0.0025	0.0035	0.001	0.001	0.00295	D	0.00304	0.001	m
SLAPS	1,2-Dichloroethene	2/38	mg/kg	0.0025	0.0035	0.003	0.022	0.00349	D	0.00433	0.00433	u
SLAPS	2-Butanone	3/38	mg/kg	0.005	0.0125	0.001	0.013	0.00649	D	0.00697	0.00697	u
SLAPS	Acetone	5/36	mg/kg	0.006	0.06	0.005	0.028	0.0127	D	0.0156	0.0156	u
SLAPS	Dimethylbenzene	2/38	mg/kg	0.0025	0.0035	0.006	0.01	0.00325	D	0.00359	0.00359	u
SLAPS	Methylene chloride	3/37	mg/kg	0.0025	0.018	0.001	0.13	0.0104	D	0.0185	0.0185	u
SLAPS	Toluene	31/64	mg/kg	0.0025	0.0035	0.001	1.2	0.0493	D	0.0886	0.0886	u
SLAPS	Trichloroethene	9/44	mg/kg	0.0025	0.0035	0.0016	0.058	0.00578	D	0.00863	0.00863	u

Table 2-11. SLAPS Subsurface Soil Data Summary (Cont'd)

Aggregate	Analyte	Freq. Det.	Units	Min. Non-det. Conc.	Max. Non-det. Conc.	Min. Det. Conc.	Max. Det. Conc.	Mean Conc.	Dist.[a]	UCL_{95}	Expos. Conc.[b]	
SLAPS	trans-1,2-Dichloroethene	5/5	mg/kg			0.0013	0.0077	0.0034	L	0.0119	0.0077	m
SLAPS	Actinium-227	222/337	pCi/g	-0.13	2.6	0.16	292.7	2.7	Z	4.39	4.39	u
SLAPS	Americium-241	22/332	pCi/g	-5.04	0.35	0.06	4.69	0.0758	D	0.12	0.12	u
SLAPS	Cesium-137	14/332	pCi/g	-0.03	0.21	0.03	3.09	0.0206	D	0.0401	0.0401	u
SLAPS	Potassium-40	330/332	pCi/g	5.21	8.43	7.64	25.2	15.5	X	15.7	15.7	u
SLAPS	Protactinium-231	34/337	pCi/g	-0.48	5.2	1.2	346.4	2.8	D	4.76	4.76	u
SLAPS	Radium-226	649/874	pCi/g	0.3	5.3	0.5	5620	31	X	44.5	44.5	u
SLAPS	Radium-228	331/332	pCi/g	0.95	0.95	0.42	4.82	0.958	X	0.985	0.985	u
SLAPS	Thorium-228	331/332	pCi/g	1.04	1.04	0.57	4.82	1.26	X	1.3	1.3	u
SLAPS	Thorium-230	623/626	pCi/g	0	0.05	0	14680	159	Z	221	221	u
SLAPS	Thorium-232	554/872	pCi/g	0.4	50.4	0.4	63	2.32	X	2.5	2.5	u
SLAPS	Uranium-235	138/332	pCi/g	-0.05	0.31	0.17	82.19	0.975	D	1.47	1.47	u
SLAPS	Uranium-238	162/872	pCi/g	-1.76	352	3.04	1769	35.6	D	42.3	42.3	u

UCL95 = 95% upper confidence limit on the mean concentration

[a] Distribution flags:

D = Not determined because fewer than 5 detects or < 50% detects; t-statistic used in calculations of UCL_{95}

L = Lognormal; H-statistic used in calculations of UCL_{95}.

N = Normal; t-statistic used in calculations of UCL_{95}.

X = Neither normal nor lognormal; t-statistic used in calculations of UCL_{95}.

Z = Contains concentrations that are negative and/or zero; t-statistic used in calculations of UCL_{95}.

[b] Basis for determining the exposure concentration:

m = maximum detected concentration.

u = 95% upper confidence limit on the mean concentration.

Chemicals not associated with uranium manufacturing or processing activities are expected to be present at the North County Site. Substantial development has taken place at the site since the early 1940s. This development would certainly have affected, to some degree, the distribution of chemicals present in soil, sediment, surface water, and ground water at the North County Site. Because the site is located in an industrial area there is limited occurrence of some chemicals associated with industrial activities and vehicle emissions. USACE (and previously the DOE) conducted analyses for a wide range of chemical compounds in broad chemical groups from numerous locations. Materials to be addressed at the site are not expected to require management as hazardous or mixed wastes because the wastes do not exhibit RCRA characteristics. A review of records for industrial facilities surrounding the HISS/Latty area reveals the existence of processes generating RCRA listed waste. While there is no indication from characterization data that these wastes are co-located with radiological contaminants associated with uranium manufacturing and processing activities, the costing evaluation assumes some co-located mixed wastes may be found at HISS/Futura during remediation.

FUSRAP-related contaminants include those chemicals that may be reasonably associated with uranium processing activities and other contaminants which have been mixed or commingled with the wastes resulting from uranium manufacturing or processing activities. The criteria used to differentiate between areas contaminated through uranium manufacturing and processing and areas contaminated through other activities that are beyond the scope of this project are as follows:

FUSRAP-authorized

- Areas having elevated levels of radioactivity where the extent of contamination can be traced to uranium manufacturing and processing activities;

- Areas containing elevated levels of organic and non-radioactive inorganic chemicals traceable to known uranium processing activities in specific areas (no areas have been identified based on history and sampling data); and

- Elevated levels of radiation along haul roads and associated VPs due to transportation activities related to uranium manufacturing and processing activities.

Non-FUSRAP-authorized

- Areas exhibiting background levels of radioactivity and with no record of use of chemicals linked to uranium ore processing activities are considered free of any residual contamination associated with uranium processing activities.

Determination of North County Site contaminants of concern (COCs) is based on the EPA guidelines for data evaluation (EPA, 1989a) and for data usability in risk assessment (EPA, 1990) as described in the Baseline Risk Assessment (BRA) and Appendix D of this FS. The COCs that exceed regulatory standards, EPA's target carcinogenic risk range of 10^{-6} to 10^{-4}, and/or noncarcinogenic hazard rating of 1.0 may require remedial action.

The RI did not identify any radiologically contaminated soil at the North County Site that exhibited any RCRA hazardous waste characteristics. Processes that could generate listed wastes have been identified. There is, however, no documentation or other evidence to date to indicate that soils are contaminated with both radiological and listed wastes. Areas which had exceeded extraction procedure toxicity (EP-TOX) lead levels were reinvestigated including additional spatial coverage. These areas did not exceed toxicity characteristic leaching procedure (TCLP) regulatory thresholds based on this re-investigation (SAIC, 1995).

2.3.1 Nature and Extent of Contamination at the North County Site

The nature and extent of contamination is described in several reports including the RI Report (BNI, 1992a), the RI Addendum (SAIC, 1995), and the *SLAPS Implementation Report* (USACE, 2001).

2.3.1.1 SLAPS

Most surface soils at SLAPS are contaminated with Ra-226, Th-230, and U-238 in excess of background concentrations. Depths of contamination range from the ground surface up to 5.4 m (18 ft) but generally average between 1 to 2 m (4 to 8 ft).

Chemical sampling conducted in the early 1990s indicated that the radiologically contaminated soils do not exhibit RCRA-hazardous waste characteristics. Soil samples did not exceed regulatory thresholds for corrosivity, ignitability, reactivity, and EP-TOX. Of the 100 soil samples taken to re-investigate for compliance with TCLP requirements and to provide additional spatial coverage of the site, only one sample, when analyzed for TCLP, was found to exceed the TCLP regulatory threshold for one analyte (selenium). This sample had a selenium level which exceeded the regulatory threshold of 1.0 mg/L by 0.18 mg/L (BNI, 1992a).

In general, VOCs were detected in soil samples collected in the early 1990s in concentrations ranging from 1 to 1,200 micrograms per kilogram (µg/kg) and were unevenly

distributed among soils at varying depths. As stated in the RI report, none of the VOCs are believed to have been associated with uranium processing. BNAE compounds were detected in 52 of 90 soil samples collected but VOCs and BNAEs were not found to pose unacceptable risks at SLAPS under current or future use scenarios. Metals found to exceed background levels appear to be confined to near-surface depths [0 to 2 m (0 to 7 ft)] (BNI, 1992a). Mobile ions, including sulfate, fluoride, and nitrate, were analyzed in soil samples because of their use in uranium processing at SLDS. Sulfate results showed one sample contained 250 milligrams per kilogram (mg/kg) above the soil background level of 610 mg/kg. Fluoride results were slightly higher (by as much as 30 mg/kg) than the background soil value of 31 mg/kg. All nitrate results (as measured by nitrogen) were below the soil background (BNI, 1990b).

Elevated levels of uranium were detected in shallow ground water. The highest activity levels were recorded on the west end of SLAPS near Coldwater Creek. Ground-water monitoring results indicate relatively stable levels of Ra-226 and Th-230 activity with annual ranges (DOE, 1994a). The highest detection of Th-230 is 6.3 pCi/L in HZ-A. Samples from only 4 of the 24 shallow wells show elevated levels of total uranium with activities ranging between 58 and 6,570 pCi/L (SAIC, 1998a). Background activity levels for total uranium range between 0.2 and 4 pCi/L. The wells exhibiting the highest activity levels are thought to be near pockets of buried radioactive residues, because adjacent wells show substantially lower concentrations. Ground-water samples had low concentrations (0.6 to 430 µg/kg) of five organics. At least eight metals (including arsenic, beryllium, and lead) were measured in ground-water samples at concentrations that exceed background (DOE, 1994a). Detections of organic compounds and background exceedances for radionuclides and metals are largely restricted to HZ-A, except for arsenic that appears to occur naturally in lower hydrostratigraphic units.

USACE performed additional characterization to provide data to support interim removal actions, to provide information on contaminant transport and limits of migration of contaminants, and to support contaminant boundary delineation (USACE, 2001). These data, along with historical data, are summarized in Tables 2-9 and 2-10. SLAPS data are summarized as both an aggregated unit and by IA. SLAPS is divided into seven investigation areas, IA-1 through IA-7 (refer to Figure 2-9 for the location of investigation areas). An aerial photograph of SLAPS and nearby properties, taken in October 1965, is shown in Figure 2-31. When compared to the photographs shown earlier in this chapter (Figures 2-5 and 2-6), one can see that activity inside the fence line at SLAPS was still occurring and buildings were still in place in 1965. A prominent scar in the drainage feature can be seen in the central area of the former ballfields. A small building has been built in the Eva Road load-out area.

Soil samples from the investigation areas (IAs 1 to 13) were collected and analyzed for radionuclides and various chemicals. TCLP analyses were performed on selected soil samples. Some monitoring wells were added and some were abandoned during this activity. Monitoring wells A, B, C, M13.5-8.5S, and M13.5-8.5D at the western end of SLAPS were decommissioned as part of a removal action performed in the fall of 1997.

Geophysical investigations were performed to determine the locations of subsurface features such as utilities, buried metal, and other objects that may be of concern during drilling and remediation activities. An electromagnetic terrain conductivity tool (EM31), a high sensitivity metal detector (EM61), and a cesium magnetometer were used. The results are shown in Figures 2-32 to 2-34.

The USACE investigations reconfirmed the presence of the radionuclides of interest including Ra-226, Th-230, and U-238. Data were also collected for radioactive decay products including protactinium-231 (Pa-231) and actinium-227 (Ac-227). Thorium-230 is present over the area and thus results in the largest widest extent and volume of impacted soil, as shown in Figures 2-35 and 2-36. Th-230 is present at depth in IA-1 to IA-6. Most of the elevated concentrations of radionuclides in IA-1 (west end of SLAPS) were removed during the former west end remediation. However, pockets of material with elevated Th-230 and other radionuclide concentrations remain beneath and around the remediated area. In addition, asbestos containing material has been found in subsurface soils at SLAPS. The extent of contamination around SLAPS is shown in more detail in Figures 2-39 and 2-40.

Four new piezometers (TW-1 to TW-4) were installed at the western end of SLAPS in September 1997 to measure ground-water levels. The piezometers were installed to a maximum depth of 20 ft (6 m) below ground surface. Wells F and M11-21S were abandoned in April 1998. Wells B53W10D, B53W12S, B53W13S, B53W11D, B53W15S, and B53W16S were abandoned in the last quarter of 1998 due to construction activity. Monitoring well locations are shown in Figure 2-41.

Soil samples were analyzed for metals and other inorganics. About 100 samples were analyzed for organics including VOCs, semi-volatile organic compounds (SVOCs), pesticides, herbicides, and polychlorinated biphenyls (PCBs). Chemicals were compared to EPA Region IX Preliminary Remediation Goals (PRGs) to identify chemicals which may contribute significantly to risks or hazards and the North County Site. Tables D-5 and D-6 in Appendix D show which chemicals exceeded their respective Region IX PRG for surface and subsurface soils. Chemicals detected in SLAPS soils above background and Region IX PRGs included many inorganics (sulfide, aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, thallium, titanium, uranium, vanadium, and zinc) and a handful or organics [1,2-dichloroethene (DCE), dimethylbenzene, PCB-1254, and 2-(2-methyl-4-chlorophenoxy) propionic acid (MCPP)]. No sources of VOCs were identified during the investigation. Appendix D compares ground-water samples against their respective Region IX PRGs. Several contaminants exceeded the PRG values. Contaminants detected in SLAPS deep ground water above background and EPA Region IX PRGs included fluoride, nitrate, ammonia, arsenic, barium, boron, chromium, manganese, molybdenum, thallium, uranium, and bis(2-ethylhexyl)phthalate. Ground-water sampling results for uranium, trichloroethene, nitrate, and selenium are shown in Figures 2-42 to 2-45.

To date, waste characterization analysis confirms that hazardous characteristics have not been measured with any of the radionuclide-impacted soils.

2.3.1.2 SLAPS Vicinity Properties

Levels of Ra-226, Th-230, Th-232, and U-238 well above background levels were detected on some VPs, with Th-230 detected in the highest concentrations. Historically, the highest concentrations of Th-230 were found on the Norfolk and Western Railroad property adjacent to 9200 Latty Avenue (26,000 pCi/g above background) and in the ditches adjacent to SLAPS (15,000 pCi/g above background). Many of the VPs have been completely or partially remediated by USACE or DOE. Of the remaining properties, the highest Th-230 concentration

identified is approximately 20,000 pCi/g on IA-8 (under and along McDonnell Boulevard at SLAPS). Table 2-10 summarizes surface soil data for the VPs.

Historical data shows VOC concentrations at VPs range between 1.3 and 43 µg/kg. Only one soil sample analyzed for pesticides/PCBs had levels of dieldrin above the sample detection limit. Results from fluoride and nitrate analyses were within the background soil range. Sulfate was found in one sample at 253 mg/kg above the background soil value of 610 mg/kg (BNI, 1989; DOE, 1994a). In general, historical (pre-1997) non-radiological data for VPs is extremely limited. As part of the additional characterization effort, USACE collected samples for full suite analysis on IA-8, IA-9, IA-10, and IA-13. Results are summarized in Tables 2-10 and 2-11. Metals detected in soils at levels above background and EPA Region IX PRGs included antimony, arsenic, barium, chromium, cobalt, copper, lead, nickel, thallium, titanium, uranium, and vanadium. Organics detected in soils above background and PRGs included 2-methyl-4-chloro phenoxyacetic acid (MCPA), 2-methylnaphthalene, dieldrin, dimethylbenzene, and various PAHs.

2.3.1.3 Coldwater Creek

Historical analytical results for sediment samples collected from Coldwater Creek in the reach between SLAPS and HISS reveal elevated levels of radioactive material at numerous locations, typically in the top 15 cm (6 in) of sediment. Between 1986 and 1991, 939 sediment samples were collected from the center of the creek and the water's edge on both sides of the creek. In 1986 and 1987, sediment samples were collected between SLAPS and Pershall Road. In 1989, samples were collected downstream between Pershall Road and Bruce Drive, which is a reach of 2.4 km (1.5 mi) (Section B). A second survey in 1989 extended the sampling an additional 7.7 km (4.8 mi) to Old Halls Ferry Road and the mouth of the creek at the Missouri River (Section C). Samples at intervals varying from 15 to 150 m (50 to 500 ft) during the surveys, were collected to a depth of 15 cm (0.5 ft) along Section A and 0.9 to 1.2 m (3 to 4 ft) along part of Section B. Also, along the remainder of Sections B and C, the samples were collected to a depth of 0.9 m (3 ft); but only the 0.0 to 15 cm (0.0 to 0.5 ft) interval were analyzed at that time with the remainder of the samples being archived. An additional 23 sediment samples from the 0.3 to 0.6 m (1 to 2 ft) depth interval were retrieved from archive storage and analyzed to determine if radiological contaminants exist at depths below 15 cm (0.5 ft) in depositional areas along Coldwater Creek Sections B and C. Additional radiological data for sediments in Coldwater Creek were collected by SAIC in April 1998 and June 1999, as reported in the Ecological Risk Assessment (ERA) for the North County Site (SAIC, 2001).

Concentrations of Th-230 in sediment ranged from 0.2 to 1400 pCi/g, with the corresponding concentrations of U-238, and Ra-226 ranging from background to 10.9, and background to 25.1, respectively. Sediment with elevated levels of radioactive material is intermittently located in creek bends where natural settling would occur. Contamination levels are highest near SLAPS and HISS, but decrease greatly downstream. Four sediment samples taken from Coldwater Creek revealed four metals (arsenic, manganese, selenium, and thallium) that exceed background levels. Nine BNAE compounds (all PAHs) and one VOC were detected in the samples at less than three times the detection limits. Of these, six PAHs were detected at levels above EPA Region IX PRGs [benzo(a)athracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(k)fluoranthene; dibenzo(a,h)anthracene; and indeno(1,2,3-cd)pyrene].

2.3.1.4 HISS

Th-230 is the radionuclide present in the highest concentrations in soil at the HISS property, with lesser amounts of Ra-226 and U-238 present. The extent of contamination is shown in Figures 2-46 and 2-47 and summarized in Table 2-10 (surface soils only). Based on the results of the RI, the depth of contamination ranges from the surface to 2 m (6 ft) (BNI, 1992a).

Results from analytical tests performed in the early 1990s found that HISS soils did not exhibit characteristics of a RCRA-hazardous waste. Soil samples did not exceed regulatory thresholds for corrosivity, ignitability, reactivity, and EP-TOX. Because concentrations for non-radionuclide chemicals were found to be low, and no EP-TOX regulatory threshold limits were exceeded, no additional samples were collected at HISS for TCLP analysis.

Sixteen metals were detected in soil samples at varying concentrations ranging from below background to greater than background up to as high as 11,400 mg/kg (see Table 2-10). Only two samples submitted for VOC analysis exhibited concentrations exceeding detection limits. The samples contained toluene at 2.8 and 2.9 µg/kg, which may be indicative of a breakdown of petroleum products such as gasoline or diesel fuel. BNAE analyses of two samples contained unidentifiable hydrocarbon compounds. While the analyses failed to fully identify the compounds, it is assumed that the peaks represent breakdown products of substances from activities unrelated to those at the FUSRAP-eligible areas for this site and SLAPS, where one peak was identified as a benzene compound. It is most probable that chemical analyses have detected the weathered remains of the original substance (BNI, 1990b). After comparing HISS soil data against background and EPA Region IX PRGs, eleven inorganics remained after this screening: nitrate, antimony, arsenic, barium, boron, cadmium, molybdenum, nickel, selenium, thallium, and vanadium.

A comparison was made for deep HISS ground-water data against background and EPA Region IX PRG levels. Contaminants detected above these screening levels included ammonia, barium, manganese, thallium, uranium, and MCPP (an herbicide).

2.3.1.5 HISS Main and Supplemental Piles

Characterization of the two primary HISS piles was conducted in 1997 (BNI, 1997). The characterization included collection of radiological and chemical samples at various depth intervals and locations across both piles. Th-230 has an average concentration of 320 pCi/g in the main pile and 49 pCi/g in the supplemental pile. No samples exhibiting RCRA characteristics as specified in 40 CFR 261, Subpart C were identified. The HISS stock-piles were removed during CY00 as part of a removal action conducted at the Latty Avenue Properties.

2.3.1.6 Futura Soil

At Futura, Ra-226, Th-230, Th-232, and U-238 concentrations in soil exceeded background. Th-230 concentrations were detected at levels as high as 2,000 pCi/g above background. The depth of contamination ranges from the surface to 5 m (15 ft) (BNI, 1992a).

Twelve metals are present in soil samples at concentrations ranging from background concentrations to 17,000 mg/kg; two VOC compounds (toluene and trichlorofluoromethane) were detected at 15 µg/kg and 1.3 µg/kg, respectively (BNI, 1990b). The following chemicals were detected in Futura soils above background and EPA Region IX PRGs: arsenic, barium, cadmium, molybdenum, nickel, selenium, and vanadium.

Historical chemical sampling did not find any samples exhibiting RCRA-hazardous waste characteristics. Soil samples did not meet the regulatory definition of RCRA for corrosivity, ignitability, reactivity, and EP-TOX. Concentrations for non-radionuclide chemicals were found to be low, and EP-TOX results were below regulatory levels; therefore, no TCLP analysis was performed.

Documentation indicates that the following regulated hazardous substances have been used and/or stored on the Futura property in underground storage tanks [chemical abstract service (CAS) registration number listed in parenthesis]: Xylol (1330-20-7), Toluene (108-88-3), N-Butyl Acetate (123-86-4), P Naphtha (64-742-89-8), and Methyl Isobutyl Ketone (108-10-1). To date, no sampling has been conducted that confirms the presence of RCRA-listed contaminants (i.e., toluene, xylene, ketones) in soil that is radiologically contaminated.

2.3.1.7 Futura Air/Building Surfaces

Radon and air particulate monitoring were conducted in Futura buildings. No buildings at Futura were found to contain radon or air-particulate radioactive concentrations in excess of DOE guidelines in place at the time (SAIC, 1995). There is no evidence of encapsulated residual contamination (e.g., under painted surfaces) in the Futura buildings. Building surface beta-gamma surveys indicated all surfaces were well below the DOE guidelines in effect at the time of the survey.

2.3.1.8 HISS/Futura Ground Water

Five chemicals were identified in the upper hydrostratigraphic zone (HZ-A) at HISS. While data have been compared to maximum contaminant levels (MCLs), the uppermost hydrostratigraphic zone (HZ-A) is not considered a drinking water source. These five chemicals are total uranium, manganese, nitrate, selenium, and TCE. Of these, only manganese has been detected in the lower hydrostratigraphic zones, and concentrations were similar to results from background wells. Total uranium was detected above its MCL in four upper zone wells and above its background concentration in five additional upper zone monitoring wells. No other radionuclides were detected above their respective MCLs in site ground water in 1997.

Manganese concentrations exceeded background concentrations in shallow wells. Dissolved nitrate and selenium were detected above their respective MCLs and background concentrations in upper zone ground water. Nitrate was detected above its MCL in 11 wells. Selenium was detected above its MCL in ground water from nine wells. The highest concentrations of these two inorganics were detected in several wells in 1997.

TCE was detected above its MCL [5 micrograms per liter (µg/L)] in ground water from two wells located along the western site boundary, in wells B53W175 (screened in HZ-A and HZ-B) and HISS-9 (screened in HZ-A). This organic compound is common to many industrial settings and is not likely to be related to FUSRAP-related activities at HISS because expected

daughter products are not present. If the result of FUSRAP-related activities, a range of TCE breakdown products would be expected to be present due to the length of time since those activities occurred.

In shallow ground water within the HZ-A unit at HISS, thirteen inorganics (fluoride, nitrate, nitrite, ammonia, arsenic, barium, cadmium, manganese, molybdenum, selenium, strontium, uranium, and vanadium) and four VOCs (chloroform, chloronethane, dimethylbenzene, and TCE) were detected at levels above background and EPA Region IX PRGs. Ground-water contaminants exceeding background and EPA Region IX PRGs in deep HISS ground water were: ammonia, barium, manganese, thallium, uranium, and MCPP.

2.3.1.9 Latty Avenue VPs

Radiological characterization of soil on six Latty Avenue VPs [designated 1(L) – 6(L) on Figure 2-11] indicates levels of Ra-226 and Th-230 well above background levels. Th-230 is present in the highest activity concentrations in Latty Avenue soils ranging to a maximum of about 1,200 pCi/g above background.

Potential areas of radiological contamination along transportation routes were identified and sampled. Samples from 28 intersections on these routes between HISS and the Westlake Landfill in western St. Louis County (231 samples) were collected and analyzed for Ra-226, Th-230, Th-232, and U-238. Only 2 out of 231 samples collected exhibited concentrations of Th-230 exceeding proposed criteria.

2.3.1.10 East Piles

The East Piles were formally located on 9150 Latty Avenue, Berkeley, Missouri, which is owned by the GIFREHC and is currently leased to the Stone Container Corporation. This property was extensively contaminated with radioactive isotopes of uranium, thorium, and the actinium series as a result of commercial activities by private parties which managed ores and other materials (BHE 1998a, 1998b, 1998c).

All materials in the piles originated from GIFREHC property pursuant to construction activities. Characterization of the piles was done by BHE Environmental, Inc. (BHE) with limited additional analysis for characterization by USACE (USACE, 2000). Chemical analyses indicate that the soils do not exhibit the characteristics that would define them as characteristically hazardous wastes as defined in 40 CFR 261 (BHE, 1998b). The East Piles were removed during CY00 as part of a removal action conducted at the Latty Avenue Properties.

2.3.1.11 Removal Actions at Latty Avenue

In 1998, USACE issued an EE/CA and selected a preferred removal alternative to mitigate risks from materials at the Latty Avenue properties. The removal action includes installation of the HISS rail spur, and removal of the piles. Construction of the railroad spur along the eastern boundary of HISS was completed in early 1999. Removal of the stockpiles began in March 2000 and was completed approximately 18 months later. Nearly 44,300 m^3 (58,000 yd^3) of material from the two spoil piles, two Eastern Piles, the HISS Supplemental Storage pile, and the HISS Main Pile were removed.

2.3.2 Chemicals Associated with Uranium Processing

As part of the evaluations, chemicals associated with the uranium processing activities at SLDS were identified. This information is used as part of the determination of COCs.

Chemicals associated with the various residues from processing uranium at SLDS include some metals and some radionuclides and their progeny. The inorganic constituents are major, minor, or trace constituents of the ores or chemicals used in processing of uranium and could be present in the residues that were stored at SLAPS or HISS/Futura. Organic chemicals are also associated with the process but are not expected to be present in the environment, as discussed later in this subsection.

In anticipation of their sale in the early 1960s, information about the composition of the major residues at SLAPS was included in the *Invitation to Bid* [AT-(23-2)-46, March 7, 1962]. These analyses identify the major and minor constituents of the residues that could contribute to residual risk. Major constituents that were present in the various residues include:

- Cobalt, nickel and copper which originated as major components of the ores that later became major constituents in the raffinate cakes (AM-7 and AM-10);
- Lead and radium which originated as constituents of pitchblende ore that later became major components of the K-65 residue as sulfate salts precipitated by adding sulfuric acid. (Note: This residue was stored at SLAPS for only a couple of years in drums, but never in bulk.); and
- Barium which was added to remove excess sulfate when processing pitchblende that later became a major constituent of AJ-4.

Minor constituents that could contribute to residual risk include:

- Uranium that became a trace component of all the residues;
- Lead and radium which originated as constituents of pitchblende ore that became trace components of the barium sulfate cake because they co-precipitated as sulfate salts when barium was added to remove excess sulfate ion;
- Thorium which originated as a constituent of pitchblende and Colorado ores that became a trace component of all the residues; and
- Metals such as manganese, molybdenum, selenium, and vanadium which were constituents of the pitchblende or Colorado ores that became trace components of the residues. (Note: Based on the analyses of the residues provided in the Invitation to Bid on March 7, 1962, arsenic, beryllium and zinc are not major or minor constituents. Arsenic, beryllium and zinc were among a group of 20 metals that were reported at < 0.1% in the Colorado raffinate cake and not mentioned at all for the analyses of the pitchblende raffinate cake).

Several inorganic chemicals were used in the uranium processing to produce uranium dioxide, uranium trioxide, uranium tetrafluoride, and uranium metal. These inorganic chemicals included nitric acid, sulfuric acid, hydrofluoric acid, barium carbonate, sodium carbonate, sodium hydroxide, calcium hydroxide and magnesium metal. Except for insoluble barium sulfate and magnesium fluoride (that became some of the residues stored at SLAPS), the by-products of these inorganic chemicals were primarily soluble inorganic salts. These soluble

salts would have been either present as salts in the process waste-waters released at SLDS or as trace levels remaining in the residues placed at SLAPS. Later these salts would have leached from the residues during the open storage at SLAPS and HISS/Futura. These salts would likely remain in the environment as cations (e.g., sodium or calcium) and anions (e.g., nitrates, sulfates, or fluorides).

The only organic chemical used in the uranium processes at SLDS was diethyl ether. It was used as a solvent in the extraction of uranyl nitrate hexahydrate, but it is not expected to be in the environment impacted by the residues because it was not present in the aqueous solutions from which the residues were separated. Other residuals from organic chemicals such as VOCs (e.g., TCE) and BNAEs [including PAHs] and cyanide are not expected to be in the environment impacted by the residues because they were not used in the uranium processing steps. Although TCE is not known to have been used by any uranium processing activities conducted at SLAPS, TCE has been found on and off-site at SLAPS.

Organic compounds (e.g., PAHs) from industrial processing activities and vehicle emissions are present because the site is located in an industrial area. Industrial activities in the area of the airport are a potential source of organic and non-radioactive inorganic contamination (e.g., refueling, deicing and maintenance of aircraft) that is not related to the uranium manufacturing and processing activities at SLDS.

The COCs in the BRA were reevaluated in the supplemental risk assessment. Chemicals that exceed the background screen, are related to the ore processing, and are above risk screening levels are identified as COCs in the reevaluation. The supplemental risk assessment provided in Appendix D identifies eleven metals (in addition to radionuclides) as COCs. These COCs are selected because they produce an estimated carcinogenic risk or non-carcinogenic hazard above criteria within the North County Site to one of the modeled receptors. This list includes antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, and vanadium. Of these, barium and nickel are identified as major constituents of the uranium process while selenium, uranium, and vanadium are identified as minor constituents. Although antimony, arsenic, cadmium, chromium, molybdenum, and thallium were only present at very low concentrations, they were found above risk criteria. Contaminants that exceed the background screen (e.g., 95% UTL value) and are above the site-specific risk screening level can only be omitted as COCs if they: (1) are explicitly not related to the ore processing for uranium or (2) have a low frequency of detection. Risk Assessment Guidance for Superfund (RAGS), Volume 1, Part A, provides guidance for omitting chemicals based on low frequency. Although not the same, the decision logic in RAGS could be used to omit a chemical with low frequency (e.g., five percent) at or near the risk screening level. None of the 11 metal COCs had a frequency of detection at or near risk screening levels that was less than 5%. For this reason, it was determined that none of the COCs could be omitted based on low frequency or because concentrations were close to background or risk-screening levels. A closer look at the site database lends additional insight on the relationship of identified metal COCs relative to FUSRAP-authorized activities.

When the concentrations of major constituents, barium and nickel, are plotted against radionuclide concentrations, the resulting plot shows a proportional relationship. That is, as the radionuclide concentrations increase, so do the concentrations of barium and nickel. However,

very few samples were identified above risk screening levels indicating that the removal of radionuclide contaminants would remove barium and nickel to below risk screens.

Selenium, uranium, and vanadium (minor constituents) also show a proportional relationship when plotted against radionuclide concentrations. As with the major constituents, very few samples were identified near risk threshold criteria. Data for the minor constituents indicate that removal of radionuclide contaminants would remove selenium, uranium, and vanadium to below risk screens (noting that uranium is also considered as a COC for both its radionuclide and chemical properties).

None of the remaining metals show a relationship with radionuclides. In fact, some of these metals are present only at very low concentrations and were retained by the risk analysis only because one or two sample points over the entire site were identified near risk screening levels. Antimony was almost never detected, but a few detects near risk screening levels were identified. Arsenic concentrations were close to background levels or the risk screening level. Only one chromium sample was identified to have concentrations near risk screening levels. All other chromium results are at least an order of magnitude below screening levels. Similar statements can be made for cadmium, molybdenum, and thallium leading to the inference that of the hundreds of analyses, a few random samples identified metals associated with local industrial activities unrelated to uranium processing. However, these metals could not be eliminated as COCs because they were present in trace quantities in the ore and they were found above risk criteria at frequencies greater then 5%.

In conclusion, eleven metals are retained as COCs for soil. While the major and minor constituents do show a proportional relationship with radionuclides, the number of samples (including hundreds of analyses) with results near risk screening levels are minimal. Additionally, the data supports the conclusion that these metals would be remediated with the radionuclides. The data also appears to indicate that the remaining metals identified as COCs were present in trace quantities in the FUSRAP-authorized materials and are present because of natural processes and other activities not related to uranium manufacturing and processing at SLDS. There is no apparent correlation with radionuclide concentrations, and very few samples (with the exception of arsenic) approach risk screening levels. Metals identified as COCs will be subject to pre-design investigation if necessary due to limited data and to final status surveys to assure remediation goals (RGs) established in the ROD are met. Once adequate verification data has been collected to demonstrate co-location of metals with radiological contaminants, sampling of nonradiological COCs will be eliminated from future analysis.

Chemical sampling of one of the previously cleaned up VPs was recently completed to evaluate if cleanup of the radionuclides at a property also cleans up the non-radionuclides. Sixteen chemical samples were collected at one of the VPs (VP-56). The results are shown in Appendix E. An evaluation of the data against background, risk, and hazard criteria was performed for these samples. No COCs were identified. Therefore, the cleanup of VP-56 to the radiological criteria resulted in removal of any associated chemicals at this property.

2.4 CONTAMINANT FATE AND TRANSPORT

The fate and transport of COCs was assessed to identify the environmental media that could be impacted. Possible release mechanisms at the North County Site include the following:

- Potential external gamma irradiation from areas contaminated with radionuclides (i.e., areas of contaminated soil, building interiors, drains, and manholes);

- Radon gas generation from radium-contaminated soil, ground water, and building surfaces;

- Wind dispersal of contamination, including fugitive dust generated from contaminated site soil;

- Surface deposition of airborne particulates (e.g., pursuant to fugitive dust generation or release of building contaminants);

- Surface runoff over contaminated soil following precipitation, with transport to other on-site soil and drainage areas (e.g., Coldwater Creek);

- Leaching from contaminated surface and subsurface soil areas to ground water;

- Transport of contamination from surface and subsurface soil to ground water;

- Transport of contamination from ground water to surface water and sediment (e.g., Coldwater Creek); and

- Contaminant uptake by biota (i.e., animals and plants) from contaminated soil.

Due to site-specific environmental factors, some potential release mechanisms and receiving media do not play a primary role in contaminant fate and transport leading to current human exposure at the North County Site. These mechanisms include wind dispersal of building contamination and eventual surface deposition of such contaminants, and uptake by biota of contaminants from soil. Because of the industrial nature of the site, limited wildlife and vegetation are present, so uptake by biota is not an important release mechanism (ANL, 1993). The fate and transport of contaminated soil particles in ground water are naturally controlled by the low permeability of the site soils. Calculations have shown that the solute migration rate is very slow [e.g., 0.078 m/yr (0.26 ft/yr)].

Surface waters potentially impacted by site contaminants via runoff include Coldwater Creek adjacent to SLAPS and the Latty Avenue Properties (Coldwater Creek flows into the Missouri River). Coldwater Creek sediment contamination is minimal, and bank soil contamination is spotty. Levels of measured radionuclides in surface-water samples from Coldwater Creek were consistent with background levels and are lower than proposed guidelines (BNI, 1992a). Section A of Coldwater Creek is the portion of the creek that would be most affected by potential remediation activities.

Contaminated soil particles may be transported via surface-water or ground-water discharge from contaminated soil. Following remedial action, low levels of residual uranium may be left. The risk due to ground-water discharge to surface water is small without remediation. The risk of ground-water contamination following remedial action is expected to be within the Comprehensive Environmental Response, Compensation, and Liability Act

(CERCLA) risk range. Clean backfill soil will prevent surface-water and particulate contaminant migration.

In summary, the environmental release mechanisms and transport pathways that are considered most important for potential human exposures to site contaminants under current conditions are:

- External gamma radiation from radiologically-contaminated materials (including soil and structural surfaces);
- Radon gas generation from radium-contaminated soil and structural surfaces; and
- Wind dispersal of fugitive dust generated from contaminated site soil.

Other release mechanisms and transport pathways that become factors in future scenarios include leaching of soil contaminants to ground water, contaminated soil particle transport in ground water, and bio-uptake of soil contaminants by plants.

2.5 SUMMARY OF BASELINE RISK ASSESSMENT (BRA)

A BRA (ANL, 1993) was prepared to evaluate potential risks to human health and the environment from radiological and non-radiological contaminants at the St. Louis Site (including the North County Site and SLDS). The risk assessment used site characterization data available at that time to estimate exposure to current and hypothetical future receptors. Results from the BRA indicated the need for remedial action at the North County Site. A list of COCs was also provided in the BRA. The BRA made no distinction between chemicals related to uranium manufacturing and processing activities and chemicals not related to those activities (see Table 2-12). In addition, many of the chemicals were not subjected to cancer and non-cancer risk screens. Because significant additional information has become available since the BRA was issued (additional chemical samples, updated cancer slope factors, etc.), and the BRA does not provide site-specific RGs, a supplemental human health risk assessment is presented in Appendix D and summarized in the following subsections. This risk assessment is used to supplement the conclusions of the BRA. Results from the supplemental risk assessment supercede the COCs identified in the BRA and present site-specific RGs. Table 2-12 identifies some of the differences in the BRA results and the results from the Appendix D supplemental assessment.

The chemicals listed in Table 2-12 are presented by medium (soil, sediment, ground water, and surface water) and area grouping (SLAPS and contiguous areas, Latty Avenue properties, haul roads and remaining VPs, and Coldwater Creek). COCs are also broken into the following three categories:

- COCs identified in both the BRA and supplemental risk assessment;
- COCs that are identified in the BRA that are not COCs based on the supplemental assessment; and
- COCs that are not identified in the BRA, but are COCs according to the supplemental assessment.

Table 2-12. North County Site Contaminants of Concern Identified in the 1993 Baseline Risk Assessment

Soil		Sediment		Ground Water	Surface Water
SLAPS and Contiguous Areas (IAs 1-13)	Radionuclides [a], antimony[d], arsenic, cadmium, molybdenum, nickel, selenium, thallium, and uranium (*beryllium, cobalt, copper, lead*)[b] (*barium, chromium, and vanadium*)[c]	Coldwater Creek	Radionuclides [a] (*antimony, arsenic, beryllium, cadmium, cobalt, lead, molybdenum, nickel, selenium, thallium, zinc, carcinogenic PAHs*)[b] (Same as soils – BRA does not provide separate set for soils and sediments)	[*antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, silver, thallium, uranium, vanadium, and zinc, bis(2-ethylhexyl)phthalate, 1,2-dichloroethene, endosulfan, toluene, and TCE*] [b]	Not evaluated in BRA
HISS/Futura and Latty Avenue VPs 2L and 10k530087	Radionuclides [a], arsenic, cadmium, molybdenum, nickel, selenium, and thallium (*antimony, beryllium, cobalt, copper, lead, and uranium*)[b] (*barium and vanadium*)[c]				
Haul Road Properties and Remaining VPs	Radionuclides [a]				
Coldwater Creek (within banks)	Radionuclides [a] (*antimony, arsenic, beryllium, cadmium, cobalt, lead, molybdenum, nickel, selenium, thallium, zinc, carcinogenic PAHs*)[b]				

[a] Radionuclides in the uranium, thorium, and actinium series
[b] Chemicals identified in the 1993 BRA as COCs which *were not* found to be COCs after reevaluation using additional data and guidance
[c] Chemicals not identified in the 1993 BRA as COCs which *were* found to be COCs after reevaluation using additional data and guidance
[d] Antimony was retained as a COC for IA-3 and IA-10.

Additional ecological assessments were also performed to supplement the assessment presented in the BRA. As with the human health assessment, the more recent ecological assessment uses additional data and supercedes the 1993 BRA as an evaluation of ecological health. Summaries of the supplemental ecological assessments are presented in Section 2.5.4.

2.5.1 Results of the 1999 Supplemental Human Health Risk Evaluations

A supplemental baseline human health risk evaluation was performed for the following reasons: additional analytical data (including radiological and non-radiological analytes) have been collected; site conditions have changed since the BRA was issued; the BRA does not distinguish between chemicals related to uranium manufacturing and processing activities and chemicals unrelated to those activities; and the BRA does not develop site-specific RGs. Details of the supplemental assessment are presented in Appendix D. The approach outlined in Appendix D varies slightly from that of the BRA. The most relevant differences include the following:

- As noted in the BRA, exposure to background concentrations of radon produce risks well above the EPA target risk range. Radon modeling is also extremely uncertain,

and EPA guidelines for radon are based on concentration, not risk. Given these conditions, risk from radon was excluded from Appendix D calculations.

- The EPA target risk range is defined as 10^{-6} to 10^{-4}, where 10^{-6} is known as the point of departure. The EPA's stated position is that the upper boundary of the acceptable risk range is not a discrete line at 1×10^{-4}, although EPA generally uses 1×10^{-4} in making risk management decisions. A specific risk estimate around 10^{-4} may be considered acceptable if justified based on site-specific conditions (OSWER Directive 9200.4-18).

- Radiological doses would be limited to the "benchmark dose" as defined in the 10 CFR Part 40 Appendix A Criterion 6(6) in those areas where other radionuclides such as uranium and thorium are present in significant quantities. The benchmark dose is the dose resulting from exposure to average above background concentrations of 5 pCi/g of Ra-226 in the top 15 cm of soil or 15 pCi/g of Ra-226 in subsequent 15 cm layers of soil. Doses from exposure to all radiological contaminants would be limited to the benchmark value, as appropriate.

- The 100 mrem/yr criterion is used in the development of supplemental standards under 40 CFR Part 192 Subpart C. Benchmark doses which exceed 100 mrem/yr before application of ALARA require the approval of the NRC after consideration of the recommendations of the staff.

- COCs are identified in the BRA and in Appendix D of the FS.

- Radiological risk and dose estimates from Appendix D are projected over a 1,000 year period. Many regulations require projection of exposure over time even assuming baseline conditions.

The basic approach used in Appendix D to identify COCs, is first to subject site data to three screens. These screens are: a background screen; a risk screen against EPA Region IX PRGs; and a weight of evidence screen to eliminate essential human nutrients, and radionuclides like K-40 (from fertilizer or fly ash) that are unrelated to uranium manufacturing and processing activities. Any chemical that passes through these screens is identified as a contaminant of potential concern (COPC). The COPCs are then included in a site-specific risk calculation. If the total risk for a specified receptor (e.g., resident) and medium (e.g., soil) exceeds 10^{-4}, those individual COPCs with a risk greater than 10^{-6} and related to uranium manufacturing and processing activities at the SLDS, are identified as carcinogenic COCs for the North County Site. If the total hazard index (HI) for a specified receptor (e.g., resident) and medium (e.g., soil) exceeds 1.0, those individual COPCs with a HI greater than 0.1, that are related to the uranium ore processing activities, are identified as non-carcinogenic COCs for the North County Site. The list of COCs is then used in the development of site-specific RGs.

The excess lifetime cancer risk and dose for six land-use scenarios at the North County Site properties are summarized in Tables 2-13a and 2-13b. The data show that the non-radiological contaminants associated with FUSRAP-related activities are commingled with radiological contaminants and the risks from exposure to non-radionuclides are at least an order of magnitude lower than risks from exposure to radionuclides at most properties. As shown in

Table 2-13a, the risks due to radiological COCs at most properties at the North County Site for the current RME receptor scenario are within the CERCLA risk range (10^{-6} to 10^{-4}) while risks due to non-radiological COCs for the current RME receptor scenario are generally between 10^{-8} to 10^{-4}.

The radiological results from the supplemental human health risk evaluation are summarized in Table 2-13b. Table 2-13b includes risk and dose estimates for years zero and one thousand (1,000) for each potential receptor and property aggregate (e.g., group of properties). The 1,000-year values are presented because maximum doses or risks will occur in either the current or year 1,000 (given the mix of radiological contaminants present at this site). The potential receptors include residential, industrial, maintenance worker, recreational, utility worker, and construction worker. IAs represent subdivisions of SLAPS and contiguous properties and are shown in Figure 2-9. The current-use conditions at the North County Site are summarized as follows:

- Industrial, utility, and maintenance worker use is used for VPs including IA-9, IA-10, IA-11, and IA-13;
- Recreational/trespasser use is applicable for Coldwater Creek;
- Construction and trespasser use applies to SLAPS (including IA-1 through IA-7), and HISS/Futura; and
- Construction/utility and maintenance worker use is assumed for the railroads, including IA-12 (Railroad area south of SLAPS to Banshee Road), road right-of-ways, and IA-8 (under and along McDonnell Boulevard at SLAPS).

Under current use conditions (including existing restrictions), the radiological results shown in Table 2-13b indicate that the risks are often above the 10^{-6} point of departure, but are within the EPA target risk range for radionuclides[1]. Specifically, recreational/trespasser risks do not exceed the range for Coldwater Creek, SLAPS, HISS/Futura; maintenance worker risks do not exceed the range for VPs, railroads, and road right-of-ways; industrial worker risks do not exceed the range for VPs; and construction worker risks do not exceed the range for the railroads and road right-of-ways unless work is performed in areas with significantly elevated radionuclide concentrations (e.g., south ditch at SLAPS). Construction workers at SLAPS (IA-1 through IA-7) can exceed risk criteria. These current workers are trained for the conditions at SLAPS and are considered occupationally exposed rather than being considered members of the general public.

Given that conditions could change in the future, risk estimates are also evaluated considering reasonably anticipated future land uses. The likely future land use for most habitable properties is industrial, although residential results are also considered as a basis for comparison. The exceptions to industrial use include Coldwater Creek (recreational), transportation routes including roads, railroads and right-of-ways (construction) and existing residential properties. Construction and maintenance activities could occur on any property. Under a likely future land use scenario, several of the IA units, Futura, and SLAPS exhibit risks in excess of the EPA target risk range for an industrial scenario, as shown in Table 2-13b. The construction worker risk exceeds limits in IA-1 and IA-4 (north central portion of SLAPS, including former

1. Note that while EPA generally defines the CERCLA target risk range as 1×10^{-6} to 1×10^{-4} for non-radiological contaminants, EPA has stated that 3×10^{-4} may be considered an acceptable upper boundary for radionuclides.

barium/radium sulfate storage areas). If development is assumed, residential risks at HISS/Futura and the most contaminated of the VPs exceed limits.

The highest calculated dose results under current conditions are: 49 mrem/yr for the recreational/trespasser (IA-1); 28 mrem/yr for the maintenance worker (IA-8); 17.5 mrem/yr for the industrial worker (highest VP); and 325 mrem/yr for the construction worker (IA-8). When assessing potential future conditions, radiological doses for industrial and construction workers range from tens to several hundred mrem/yr. Doses could exceed 1,000 mrem/yr in IA-1 and IA-4 if these properties revert to residential use. (It is notable that external dose rates alone equate to annual doses of up to about 2,500 millirem (mrem) based on continuous exposure.).

A summary of surface soil non-radiological risks and hazards are shown for each property or property grouping (e.g., SLAPS, VPs, etc.) in Table 2-14. Eleven metals are identified as non-radiological surface soil COCs for SLAPS and HISS/Futura: antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, and vanadium. Total non-radiological risks (i.e., risks across all non-radiological COPCs) exceeded 1×10^{-4} for the industrial worker at HISS and for the resident at HISS, Futura, and IA-2. No other risks exceeded 1×10^{-4}. The HI (i.e., sum of the hazard quotients across all appropriate pathways and across all COPCs) exceeded unity for the following receptor/properties: the maintenance worker and industrial worker at HISS/Futura; the construction worker at HISS/Futura, IA-2 to IA-4, IA-7, and SLAPS; and the resident at HISS/Futura, IA-2, IA-3, IA-7, and SLAPS. There were no HIs greater than 1.0 for the recreational/trespasser exposed to the surface soil.

Subsurface soil non-radiological risks and hazards are summarized in Table 2-15 by major area groupings (e.g., VPs, SLAPS, etc.). Five non-radionuclides in subsurface soil exceed risk criteria, based on the evaluation of the construction worker's exposure to subsurface soil: antimony (IA-10), arsenic (IA-2, IA-10, and road right-of-ways), manganese (road right-of-way), thallium (IA-10), and uranium (IA-2). Manganese was below the screening criteria and was not determined to be a COC at SLAPS or HISS. As ore concentrations for contamination in road right-of-ways would be much lower than at SLAPS and HISS, the manganese in road right-of-ways was determined to be unrelated to operations associated with FUSRAP. Removal of manganese as a COC results in elimination of arsenic as a COC as it would not exceed a HI of 1.0. Total risks across all COPCs were less than 1×10^{-4} for all properties, while total FUSRAP-related HIs exceed 1.0 for two areas (IA-2 and IA-10 have HIs of 2.4 and 8.1, respectively).

Table 2-13a. Supplemental Human Health Risk Summary Table

Radiological Reasonable Maximum Exposures - Current Receptors

Properties [a]	RME [b] Receptor	Minimum Dose (mrem/yr)	Maximum Dose (mrem/yr)	Average Dose [c] (mrem/yr)	Minimum Risk [d]	Maximum Risk [d]	Average Risk [c]
IAs 1-13	Maintenance	0.0	233	21	6E-10	5E-04	5E-05
HISS & Futura	Industrial	2.7	79	25	4E-05	8E-04	3E-04
Coldwater Creek	Construction	2.9	8.6	5.8	2E-06	3E-06	3E-06
Buildings/Roads/Bridges/Railroads	Construction	5.4	31	17	2E-06	1E-05	6E-06
VPs (worst-case) [d]	Industrial	15	18	17	2E-04	2E-04	2E-04
VPs (average) [e]	Industrial	0.8	1.3	1.1	2E-05	2E-05	2E-05

Radiological Reasonable Maximum Exposures - Future Receptors

Properties [a]	RME [b] Receptor	Minimum Dose (mrem/yr)	Maximum Dose (mrem/yr)	Average Dose [c] (mrem/yr)	Minimum Risk	Maximum Risk	Average Risk [c]
IAs 1-13	Resident	0.0	3407	311	1E-07	4E-02	4E-03
HISS & Futura	Resident	9.3	294	91	1E-04	3E-03	1E-03
Coldwater Creek	Construction	2.9	8.6	5.8	2E-06	3E-06	3E-06
Buildings/Roads/Bridges/Railroads	Construction	5.4	31	17	2E-06	1E-05	6E-06
VPs (worst-case) [d]	Resident	51	60	56	7E-04	9E-04	8E-04
VPs (average) [e]	Resident	2.7	4.3	3.5	6E-05	7E-05	7E-05

Non-radiological Reasonable Maximum Exposures - Current Receptors [f]

Properties [a]	RME [b] Receptor	Minimum HI [g]	Maximum HI	Average HI	Minimum Risk	Maximum Risk	Average Risk
IAs 1-13	Maintenance	< 0.1	0.5	< 0.2	2E-8	2E-5	3E-6
HISS & Futura	Industrial	1.4	3.5	2.5	9E-5	3E-4	2E-4
Coldwater Creek	Construction	-	-	-	-	-	-
Buildings/Roads/Bridges/Railroads [h]	Construction	1.3	1.3	1.3	2E-6	2E-6	2E-5
VPs [h]	Industrial	< 0.1	< 0.1	< 0.1	-	-	-

Non-radiological Reasonable Maximum Exposures - Future Receptors [f]

Properties [a]	RME [b] Receptor	Minimum HI	Maximum HI	Average HI	Minimum Risk	Maximum Risk	Average Risk
IAs 1-13	Resident	< 0.1	2.5	< 0.8	5E-7	3E-4	5E-5
HISS & Futura	Resident	4.7	13	9	4E-4	1E-3	7E-4
Coldwater Creek	Construction	-	-	-	-	-	-
Buildings/Roads/Bridges/Railroads [h]	Construction	1.3	1.3	1.3	2E-6	2E-6	2E-6
VPs [h]	Resident	0.2	0.2	0.2	-	-	-

[a] VP = vicinity property; IA = investigation area (includes SLAPS)

[b] RME = reasonable maximum exposure

[c] Averaged over year 0.0 and year 1,000 estimates for listed properties

[d] Minimum and maximum values listed for VP with worst-case source term

[e] Results when averaging across all VPs

[f] Results for all non-radionuclides including those that are non-FUSRAP-related

[g] HI = hazard index; only maximum values provided because total risks are dominated by radionuclides

[h] No non-radiological available data except where property also falls under an IA

Table 2-13b. Supplemental Human Health Risk Evaluation Summary Table

Property Name	RESIDENTIAL SCENARIO				INDUSTRIAL SCENARIO				CONSTRUCTION SCENARIO			
	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000
VPs (highest value)	60	51	9E-04	7E-04	18	15	2E-04	2E-04	47	42	2E-05	2E-05
VPs (average value)	2.7	4.3	6E-05	7E-05	0.8	1.3	2E-05	2E-05	2.3	3.2	9E-07	2E-06
Coldwater Creek	not applicable				not applicable				8.6	2.9	3E-06	2E-06
Railroad	not applicable				not applicable				6.7	5.4	3E-06	2E-06
Road right-of-way	29	37	4E-04	5E-04	8.0	11	1E-04	1E-04	25	31	9E-06	1E-05
HISS	42	9.3	5E-04	1E-04	12	2.7	1E-04	4E-05	34	7.4	1E-05	3E-06
Futura	294	18	3E-03	3E-04	79	5.3	8E-04	7E-05	251	14	8E-05	6E-06
IA-1	3407	78	4E-02	1E-03	946	24	9E-03	3E-04	2801	56	1E-03	3E-05
IA-2	382	180	5E-03	3E-03	105	51	1E-03	7E-04	322	149	1E-04	6E-05
IA-3	492	65	6E-03	9E-04	144	18	2E-03	2E-04	369	54	2E-04	2E-05
IA-4	1159	315	2E-02	4E-03	337	90	4E-03	1E-03	890	262	4E-04	1E-04
IA-5	179	89	2E-03	1E-03	48	25	5E-04	3E-04	156	73	5E-05	3E-05
IA-6	84	68	9E-04	1E-03	21	20	2E-04	3E-04	80	55	2E-05	2E-05
IA-7	621	256	6E-03	4E-03	164	72	2E-03	9E-04	557	213	2E-04	8E-05
IA-8	341	221	3E-03	3E-03	87	63	8E-04	8E-04	325	184	8E-05	7E-05
IA-9	24	16	2E-04	2E-04	6.0	4.5	6E-05	6E-05	22	13	6E-06	5E-06
IA-10	24	5.0	3E-04	8E-05	6.5	1.5	7E-05	2E-05	20	3.6	7E-06	2E-06
IA-11	0.0	0.0	1E-07	4E-07	0.0	0.0	2E-08	1E-07	0.0	0.0	5E-10	1E-08
IA-12	30	42	4E-04	6E-04	7.6	12	9E-05	2E-04	30	35	7E-06	1E-05
IA-13	10	4.8	1E-04	8E-05	2.8	1.5	3E-05	2E-05	8.8	3.3	3E-06	2E-06
SLAPS	321	110	4E-03	2E-03	89	31	1E-03	4E-04	267	91	1E-04	4E-05
Property Name	**MAINTENANCE SCENARIO**				**RECREATIONAL/TRESPASSER SCENARIO**				**UTILITY WORKER SCENARIO**			
	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000	Dose Year = 0.0	Dose Year = 1000	Risk Year = 0.0	Risk Year = 1000
VPs (highest value)	3.8	3.4	1E-05	8E-06	0.9	0.8	5E-06	4E-06	1.9	1.7	8E-07	7E-07
VPs (average value)	0.2	0.3	5E-07	7E-07	0.0	0.1	3E-07	3E-07	0.1	0.1	3E-08	6E-08
Coldwater Creek	0.7	0.2	1E-06	8E-07	0.1	0.1	5E-07	4E-07	0.3	0.1	1E-07	6E-08
Railroad	0.5	0.4	2E-06	1E-06	0.1	0.1	8E-07	6E-07	0.3	0.2	1E-07	1E-07
Road right-of-way	2.1	2.5	5E-06	6E-06	0.4	0.6	2E-06	3E-06	1.0	1.2	4E-07	5E-07
HISS	2.8	0.6	7E-06	2E-06	0.6	0.1	3E-06	7E-07	1.3	0.3	6E-07	1E-07
Futura	21	1.1	4E-05	3E-06	4.0	0.3	2E-05	1E-06	10	0.6	3E-06	2E-07
IA-1	233	4.2	5E-04	1E-05	49	1.3	2E-04	7E-06	112	2.2	4E-05	1E-06
IA-2	27	12	6E-05	3E-05	5.4	2.7	2E-05	1E-05	13	6.0	5E-06	2E-06
IA-3	29	4.3	8E-05	1E-05	7.6	1.0	4E-05	5E-06	15	2.1	7E-06	8E-07
IA-4	71	21	2E-04	5E-05	18	4.7	9E-05	2E-05	36	10	2E-05	4E-06
IA-5	13	6.0	3E-05	1E-05	2.5	1.3	1E-05	6E-06	6.2	2.9	2E-06	1E-06
IA-6	6.9	4.5	1E-05	1E-05	1.1	1.0	4E-06	5E-06	3.2	2.2	8E-07	9E-07
IA-7	48	17	8E-05	4E-05	8.3	3.8	3E-05	2E-05	22	8.5	7E-06	3E-06
IA-8	28	15	4E-05	4E-05	4.3	3.3	2E-05	2E-05	13	7.4	3E-06	3E-06
IA-9	1.9	1.0	3E-06	3E-06	0.3	0.2	1E-06	1E-06	0.9	0.5	2E-07	2E-07
IA-10	1.7	0.3	3E-06	9E-07	0.3	0.1	1E-06	4E-07	0.8	0.1	3E-07	7E-08
IA-11	0.0	0.0	6E-10	5E-09	0.0	0.0	2E-10	2E-09	0.0	0.0	2E-11	4E-10
IA-12	2.6	2.8	4E-06	7E-06	0.4	0.6	2E-06	3E-06	1.2	1.4	3E-07	5E-07
IA-13	0.7	0.3	1E-06	9E-07	0.1	0.1	6E-07	4E-07	0.4	0.1	1E-07	7E-08
SLAPS	22	7.4	5E-05	2E-05	4.6	1.6	2E-05	8E-06	11	3.6	4E-06	1E-06

Results for dose in mrem/yr.
VP = vicinity properties
IA = investigation area

Table 2-14. Summary of Non-radiological Surface Soil Risks and Hazards by Properties

Property Name	RESIDENTIAL		INDUSTRIAL		CONSTRUCTION		MAINTENANCE		RECREATIONAL TRESPASSER	
	Chemical Hazard	Chemical Risk	Chemical Hazard	Chemical Risk	Chemical Hazard	Chemical Risk	Chemical Hazard	Chemical Risk	Chemical Hazard	Chemical Risk
VPs (highest value)	0.2		<0.1		0.5		<0.1		<0.1	
VPs (average value)	0.2		<0.1		0.5		<0.1		<0.1	
Road right-of-way	0.9	3E-05	0.3	6E-06	1.3	2E-06	0.1	2E-06	<0.1	3E-07
HISS	12.6	1E-03	3.5	3E-04	20.0	1E-04	2.0	7E-05	0.5	1E-05
Futura	4.7	4E-04	1.4	9E-05	11.8	3E-05	1.2	2E-05	0.2	5E-06
IA-1	<0.1	5E-07	<0.1	2E-07	<0.1	4E-08	<0.1	2E-08	<0.1	1E-08
IA-2	1.8	3E-04	0.5	6E-05	4.6	2E-05	0.5	2E-05	<0.1	3E-06
IA-3	2.5	5E-06	0.9	1E-06	1.9	1E-07	0.1	8E-08	0.2	2E-08
IA-4	0.8	6E-05	0.2	1E-05	1.7	5E-06	0.2	4E-06	<0.1	7E-07
IA-5	0.3	2E-05	<0.1	4E-06	0.5	2E-06	<0.1	1E-06	<0.1	2E-07
IA-7	1.5		0.4		3.7		0.4		<0.1	
IA-8	0.1	2E-05	<0.1	4E-06	0.3	1E-06	<0.1	8E-07	<0.1	3E-07
IA-9	0.3	3E-05	0.1	7E-06	0.9	2E-06	<0.1	2E-06	<0.1	4E-07
IA-10		6E-06		2E-06		5E-07		3E-07		1E-07
IA-13	0.2	2E-05	<0.1	5E-06	0.3	2E-06	<0.1	1E-06	<0.1	3E-07
SLAPS	1.4	8E-05	0.5	2E-05	2.4	7E-06	0.2	5E-06	<0.1	1E-06

Table 2-15. Non-radiological Subsurface Soil Risks and Hazards by Properties

Property Name	Construction Worker	
	Chemical Hazard	Chemical Risk
VPs (highest value)	0.5	
VPs (average value)	0.5	
Road right-of-way	1.2	2E-06
IA-2	2.4	1E-05
IA-3	0.4	5E-08
IA-4	0.3	2E-06
IA-5	0.2	1E-06
IA-7	0.5	
IA-9	0.3	2E-06
IA-10	8.1	4E-05
SLAPS	0.5	2E-06

Ground-water non-radiological risks and hazards were evaluated using SLAPS and HISS data sets. Six metals (arsenic, barium, fluoride, manganese, thallium, and uranium) and two organics [bis(2-ethylhexyl)phthalate and MCPP] are initially identified above risk criteria for the drinking water pathway and the deep aquifer. The maximum detected concentrations of three of these contaminants [barium, fluoride, and bis(2-ethylhexyl)phthalate] in deep ground water are below their drinking water MCLs. In addition, the maximum detected concentration of uranium in the deep aquifer (0.0105 mg/L) is below the proposed uranium SDWA MCL of 0.020 mg/L. Risks and hazards in deep ground water are driven by the remaining four contaminants: MCPP, arsenic, manganese, and thallium. Their presence in deep ground water is not considered to be FUSRAP-related for the following reasons:

- MCPP is an herbicide with no ore-processing connection.
- Manganese was reportedly present in the ores in only trace amounts and was not identified above criteria in soils at either SLAPS or HISS. Additionally, the limited hydraulic connection between the HZ-A unit and deep aquifer precludes introduction into the deep aquifer as a FUSRAP-related COC.
- In the absence of manganese sufficient concentrations of arsenic did not exist to exceed an HI of 1.0 in ground water, thus it was not carried forward as a COC.
- Thallium is found naturally in soils and is widespread in the environment due to its use in many common industries (e.g., electronics, pharmaceuticals, and the manufacture of glass and alloys). The maximum concentration of thallium detected in deep ground water (0.0046 mg/L) is only slightly above its MCL (0.002 mg/L). Given both the lack of hydraulic connection and the fact that thallium is only present in trace amounts in the ores, there is no evidence that the presence of thallium in the deep aquifer is a result of uranium manufacturing or processing activities.

Although some contaminants are present in the shallow ground water, their presence does not require action because a complete pathway to receptors does not exist. Because the potential yield is very low for shallow ground water, it is not a source of potable drinking water therefore, no ground-water COCs are identified.

Since the surface-water total risk across all COPCs is less than 10^{-4} and the total HI across all COPCs is less than 1.0, no surface-water COCs are identified.

Remediation of the sediments is merited, based on potential future human health risk under a residential scenario. Risk estimates for the hot spot with the highest concentration of Th-230 indicate a maximum risk of 3×10^{-4} under the current recreational/trespasser scenario, but a future scenario where no restriction is placed on public use of creek sediments in residential areas would pose a higher, potentially unacceptable risk human health. The relocation of sediments from these hot spots to an adjacent residential property could result in risks exceeding the unrestricted use criteria. To ensure the protectiveness of Coldwater Creek under all future anticipated land use conditions, radionuclides are retained as COCs for Coldwater Creek sediments. Sediment potential carcinogenic risks and HI results for non-radiological contaminants indicate that one metal (arsenic) and five organics [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene] exceed risk criteria. Arsenic is below background in Coldwater Creek adjacent to SLAPS and HISS (i.e., at Reach A). Arsenic concentrations increase in Coldwater Creek with distance downstream. Thus, elevated arsenic in Reaches B and C is most likely due to the heavy industrial activity in the area and is therefore not considered to be a COC for sediments. Similarly, none of the five organics were identified above risk criteria in Reach A. Therefore, given the heavy industrial activity in the area, these organics are not considered as sediment COCs. Only radionuclides are retained as COCs for Coldwater Creek sediments.

Table 2-16 summarizes the eleven metals and radionuclides that are COCs, showing where each analyte is a COC.

Table 2-16. Summary of Contaminants of Concern

Soil		Sediment		Ground Water [a]	Surface Water
SLAPS and Contiguous Areas[b, d]	Radionuclides [c], antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, and vanadium	Coldwater Creek	Radionuclides [c]	None	None
HISS/Futura and Latty Avenue VPs 2L and 10k530087	Radionuclides [c], antimony, arsenic, barium, cadmium, molybdenum, nickel, selenium, thallium, and vanadium				
Haul Road Properties and Remaining VPs	Radionuclides [c]				
Coldwater Creek (within banks)	Radionuclides [c]				

[a] COPCs identified in HZ-A. However, no COCs identified because HZ-A is not a source of potable drinking water.
[b] IA-1 through IA-13
[c] Radionuclides in the uranium, thorium, and actinium series
[d] COCs are applicable only for soil within IAs 2 and 10 as there are no identified COCs for other areas.

The supplemental human health evaluation also developed site-specific RGs. Cleanup of the radiological COCs in the North County Site at the 10^{-6} level would not be achievable and/or would significantly increase cost without significant risk reductions. Movement away from 10^{-6} is based on factors such as technical limitations and uncertainty (i.e., inability to distinguish soil concentrations at the 10^{-6} level from background and limitations of field equipment). Given that movement away from the point of departure is justified, evaluations determined what concentrations were appropriate. The evaluations show that the cleanup goals required by applicable or relevant and appropriate requirement (ARAR) criteria for radionuclides would achieve protectiveness to levels within the CERCLA target risk range and below a HI of 1.0, and have been demonstrated to be implementable. The implementation of ARAR-based RGs for radionuclides would also require the evaluation of non-radiological COCs. Additional detail is provided in Appendix D.

Carcinogenic and non-carcinogenic site-specific RGs were developed. Non-radionuclide and radionuclide site-specific RGs for the North County COCs are provided in Table 2-17. ARAR-based RGs (including supplemental standards) developed in Appendix D are also shown. Note that because there were no COCs for ground water or surface water, no site-specific RGs are calculated for these media.

2.5.2 Results of the Baseline Ecological Risk Assessment

An ecological assessment was conducted to evaluate potential effects from contamination of the St. Louis Site. Due to the urban environment, the airport areas have limited habitat and biotic diversity. The Baseline Ecological Risk Assessment (BERA) compared contaminant concentrations detected in various media (soil, sediment, and water) at the site with literature on the toxicities of the contaminants to biota. This study indicated that only arsenic, thallium, and PAHs are at concentrations that could potentially impact biota. The BERA indicated that ecological effects do not warrant further evaluation given that the habitats and biota at the site are not unique, the biota are not necessary for continued propagation of key species, and they are not highly valued economically, recreationally, or aesthetically (ANL, 1993).

2.5.3 Results of the 1993 Supplemental Risk Assessment for Coldwater Creek

A supplemental risk assessment (SAIC, 1993a) was conducted to evaluate the risk associated with Coldwater Creek. People likely to be exposed to these risks included recreational users of the creek and community members periodically involved in the cleanup of the creek. Neither ingestion of fish nor swimming were considered activities for the recreational user because very few game fish populate the creek and swimming is unlikely due to low water levels and poor water quality. The exposure for recreational use and community cleanup was estimated. Exposure points were evaluated for each of the three segments on Coldwater Creek as shown earlier on Figure 2-14.

Table 2-17. Site-specific Remediation Goals (RGs) for Soil and Sediment in the North County Site

RGs for Unrestricted Release – Surface Soil/Sediment						
Description	**Analyte**	**Units**	**Hazard-Based**	**Risk-Based [a]**	**ARAR-Based**	**Basis**
Unrestricted release concentrations for surface soils. Unrestricted release concentrations for surface sediments above the mean water gradient of Coldwater Creek. Non-radiological RGs apply to SLAPS and Contiguous Areas (IAs 1-13), HISS/Futura, and Latty Avenue VPs 2L and 10k530087. Chromium and uranium (considered as a non-radionuclide) are not COCs at HISS/Futura.	Antimony	mg/kg	15	-	-	Corresponding to Cardiovascular and Respiratory HI = 0.08
	Arsenic	mg/kg	36	-	-	Corresponding to Cardiovascular HI = 0.23
	Barium	mg/kg	2,800	-	-	Corresponding to Cardiovascular HI = 0.08
	Cadmium	mg/kg	12	-	-	Corresponding to Kidney and Respiratory HI = 0.10
	Chromium	mg/kg	350	-	-	Corresponding to Respiratory HI = 0.10
	Molybdenum	mg/kg	1,000	-	-	Corresponding to Skeletal HI = 0.38
	Nickel	mg/kg	1,500	-	-	Corresponding to Immune and Respiratory HI = 0.14
	Selenium	mg/kg	300	-	-	Corresponding to Skin HI = 0.11
	Thallium	mg/kg	25	-	-	Corresponding to Skin and Central Nervous System HI = 0.15
	Uranium	mg/kg	150	-	-	Corresponding to Kidney HI = 0.09
	Vanadium	mg/kg	112	-	-	Corresponding to Respiratory HI = 0.10
	Ra-226	pCi/g	-	-	5.0	As defined by ARARs
	Ra-228	pCi/g	-	-	5.0	As defined by ARARs
	Th-230	pCi/g	-	-	14	Set to limit ingrowth of Ra-226 of 1,000 years
	U-238	pCi/g	-	-	50	Corresponds to benchmark dose for most restrictive receptor plus adjustments to conservatively account for residual decay products out of equilibrium.

RGs for Unrestricted Release – Subsurface Soil/Sediment						
Description	**Analyte**	**Units**	**Hazard-Based**	**Risk-Based [a]**	**ARAR-Based**	**Basis**
Unrestricted release concentrations for subsurface soils. Unrestricted release concentrations for subsurface sediments above the mean water gradient of Coldwater Creek. Non-radiological RGs apply to SLAPS and Contiguous Areas (IAs 1-13), HISS/Futura, and Latty Avenue VPs 2L and 10k530087. Uranium (considered as a non-radionuclide) is not a COC at all Latty Avenue properties.	Antimony	mg/kg	25	-	-	Corresponding to Respiratory HI = 0.14
	Arsenic	mg/kg	40	-	-	Corresponding to Skin HI = 0.23
	Thallium	mg/kg	30	-	-	Corresponding to Central Nervous System HI = 0.08
	Uranium	mg/kg	150	-	-	Corresponding to Kidney HI = 0.09
	Ra-226	pCi/g	-	-	15	As defined by ARARs
	Ra-228	pCi/g	-	-	15	As defined by ARARs
	Th-230	pCi/g	-	-	15	Set to Ra-226 RG to account for uncertainty in future land use, exposure pathways, etc.
	U-238	pCi/g	-	-	50	Set to surface soil RG to account for uncertainty in future land use, exposure pathways, etc.

Table 2-17. Site-specific Remediation Goals (RGs) for Soil and Sediment in the North County Site (Cont'd)

RGs for Unrestricted Release – Sediment						
Description	**Analyte**	**Units**	**Hazard-Based**	**Risk-Based [a]**	**ARAR-Based**	**Basis**
RGs for sediment below the mean water gradient of Coldwater Creek.	Ra-226	pCi/g	-	-	15	Subsurface RG for unconditional release (3 times the surface RG) used for sediment below the mean water line.
	Ra-228	pCi/g	-	-	15	Subsurface RG for unconditional release (3 times the surface RG) used for sediment below the mean water line.
	Th-230	pCi/g	-	-	43	Set to limit ingrowth of Ra-226 of 1,000 years
	U-238	pCi/g	-	-	150	Set to 3 times the RG for unconditional release consistent with the approach for Ra-226.
Supplemental Standards for Restricted Use of Subsurface Soils						
Description	**Analyte**	**Units**	**Hazard-Based**	**Risk-Based [a]**	**ARAR-Based**	**Basis**
Supplemental standards for soils below the top 15 cm (6 inches).	Ra-226	pCi/g	-	-	25	Limits dose to less than 100 mrem/yr if controls are lost (equivalent to 5 times the unconditional release RG)
	Th-230	pCi/g	-	-	70	Set to limit ingrowth of Ra-226 of 1,000 years
	U-238	pCi/g	-	-	250	Scaled to 5 times the unconditional release RG for subsurface soil to be consistent with Ra-266 and Th-230 RGs.
Supplemental Standard for Restricted Use of Deep Soils						
Description	**Analyte**	**Units**	**Hazard-Based**	**Risk-Based [a]**	**ARAR-Based**	**Basis**
Supplemental standards for deep soils[b].	Ra-226	pCi/g	-	-	75	Limits dose to less than 100 mrem/yr if controls are lost
	Th-230	pCi/g	-	-	210	Set to limit ingrowth of Ra-226 of 1,000 years
	U-238	pCi/g	-	-	750	Scaled to a 15 times the unconditional release RG for subsurface soil to be consistent with Ra-266 and Th-230 RGs.

Table 2-17. Site-specific Remediation Goals (RGs) for Soil and Sediment in the North County Site (Cont'd)

RGs for Restricted Release – Surface Soil Non-radionuclides						
Description	**Analyte**	**Units**	**Hazard-Based**	**Risk-Based [a]**	**ARAR-Based**	**Basis**
Provided to limit risk from non-radionuclides assuming institutional controls are applied. RGs apply to SLAPS and Contiguous Areas (IAs 1-13), HISS/Futura, and Latty Avenue VPs 2L and 10k530087. Chromium and uranium (considered as a non-radionuclide) are not COCs at all Latty Avenue properties.	Antimony	mg/kg	15	-	-	Corresponding to Cardiovascular and Respiratory HI = 0.08
	Arsenic	mg/kg	36	-	-	Corresponding to Cardiovascular HI = 0.23
	Barium	mg/kg	2,800	-	-	Corresponding to Cardiovascular HI = 0.08
	Cadmium	mg/kg	12	-	-	Corresponding to Kidney and Respiratory HI = 0.10
	Chromium	mg/kg	350	-	-	Corresponding to Respiratory HI = 0.10
	Molybdenum	mg/kg	1,000	-	-	Corresponding to Skeletal HI = 0.38
	Nickel	mg/kg	1,500	-	-	Corresponding to Immune and Respiratory HI = 0.14
	Selenium	mg/kg	300	-	-	Corresponding to Skin HI = 0.11
	Thallium	mg/kg	25	-	-	Corresponding to Skin and Central Nervous System HI = 0.15
	Uranium	mg/kg	150	-	-	Corresponding to Kidney HI = 0.09
	Vanadium	mg/kg	112	-	-	Corresponding to Respiratory HI = 0.10
RGs for Restricted Release – Subsurface Soil Non-radionuclides						
Description	**Analyte**	**Units**	**Hazard-Based**	**Risk-Based [a]**	**ARAR-Based**	**Basis**
Provided to limit risk from non-radionuclides assuming institutional controls are applied. RGs apply to SLAPS and Contiguous Areas (IAs 1-13), HISS/Futura, and Latty Avenue VPs 2L and 10k530087. Uranium (considered as a non-radionuclide) is not a COC at all Latty Avenue properties.	Antimony	mg/kg	25	-	-	Corresponding to Respiratory HI = 0.14
	Arsenic	mg/kg	40	-	-	Corresponding to Skin HI = 0.23
	Thallium	mg/kg	30	-	-	Corresponding to Central Nervous System HI = 0.08
	Uranium	mg/kg	150	-	-	Corresponding to Kidney HI = 0.09

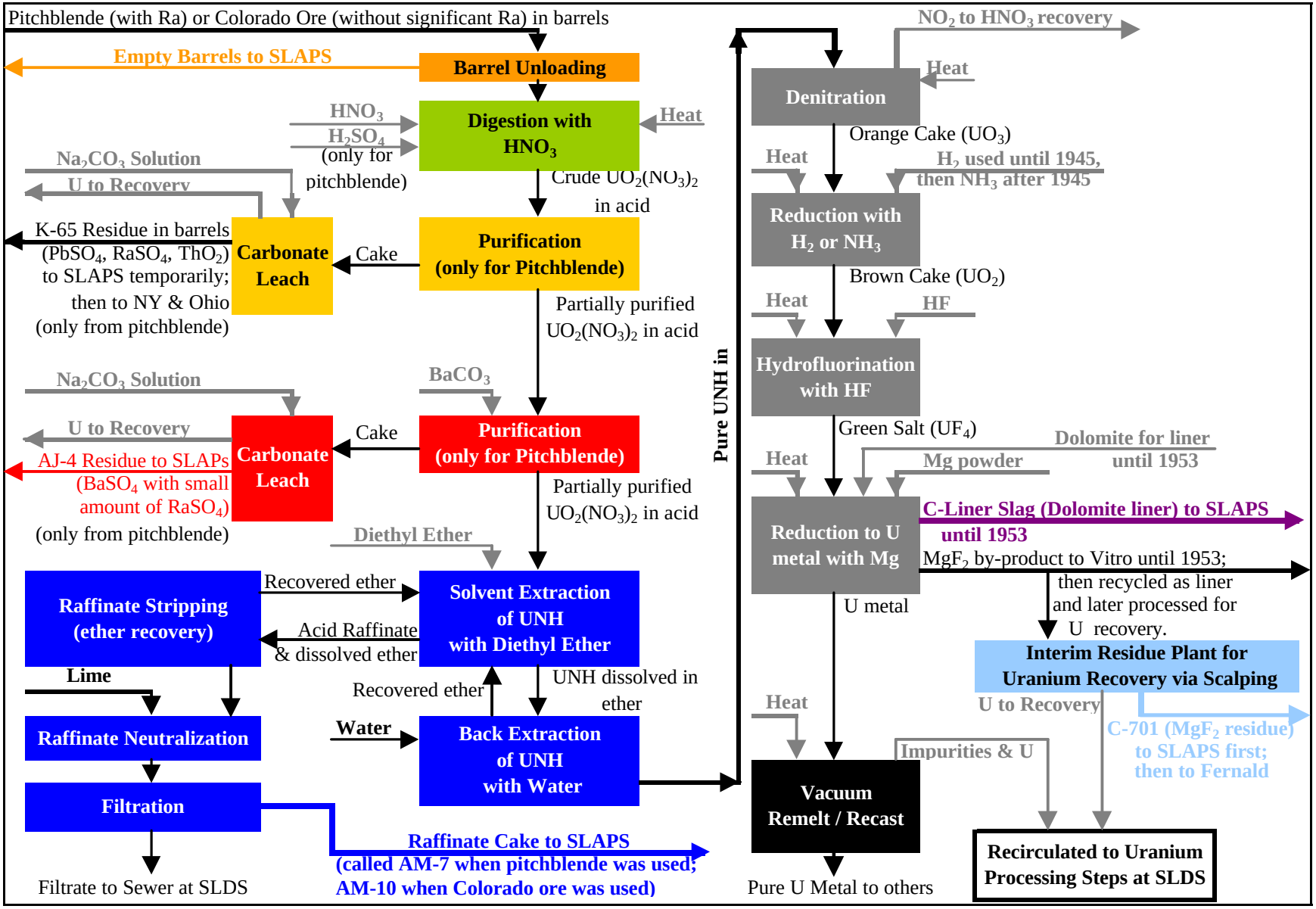
[a] No RGs for North County COCs are limited by carcinogenic risk.
[b] The deep soil criteria were not carried forth in any of the alternatives discussed in the FS, although they have been retained as potential remediation standards.



Figure 2-1 North County Site, looking South - 1998
(HISS shown in foreground)



Figure 2-2 SLAPS, looking East - 1998



The same colors have been used in Figure 2-8 for the areas where these residues were stored at SLAPS.

Figure 2-3 Uranium Production Process at SLDS

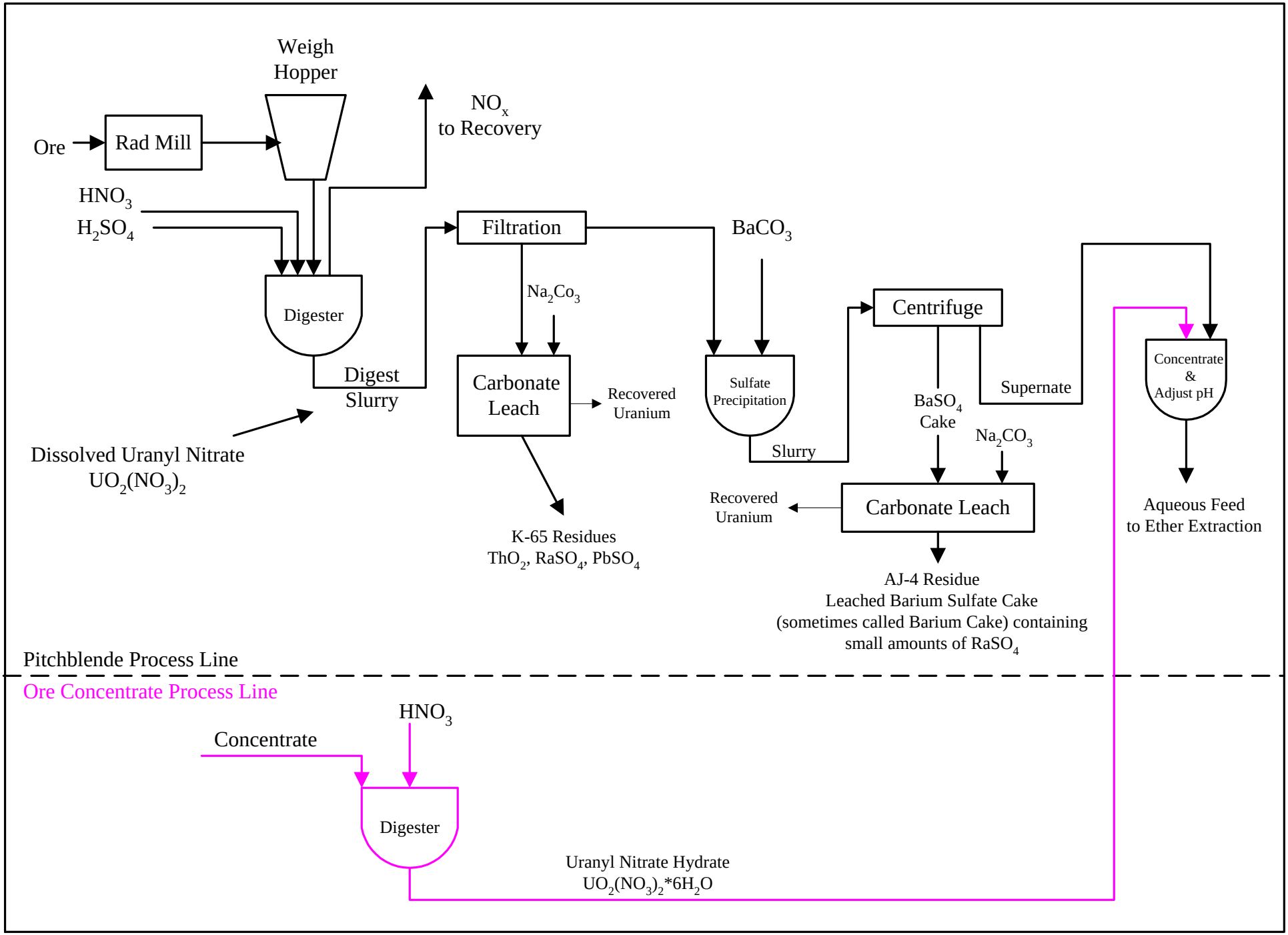


Figure 2-4. Mallinckrodt Ore Digestion Process

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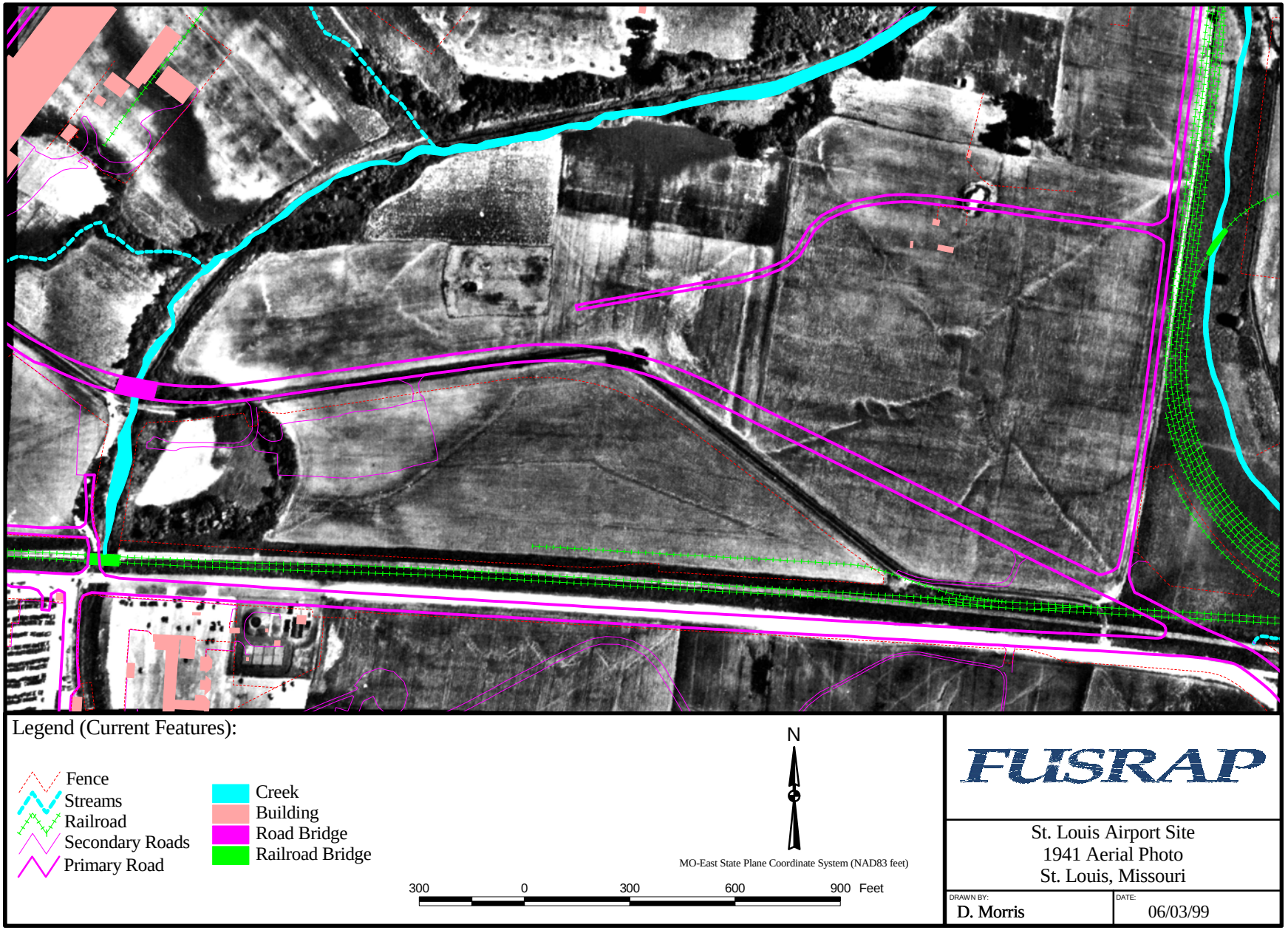


Figure 2-5. St. Louis 1941 Aerial Photo of SLAPS

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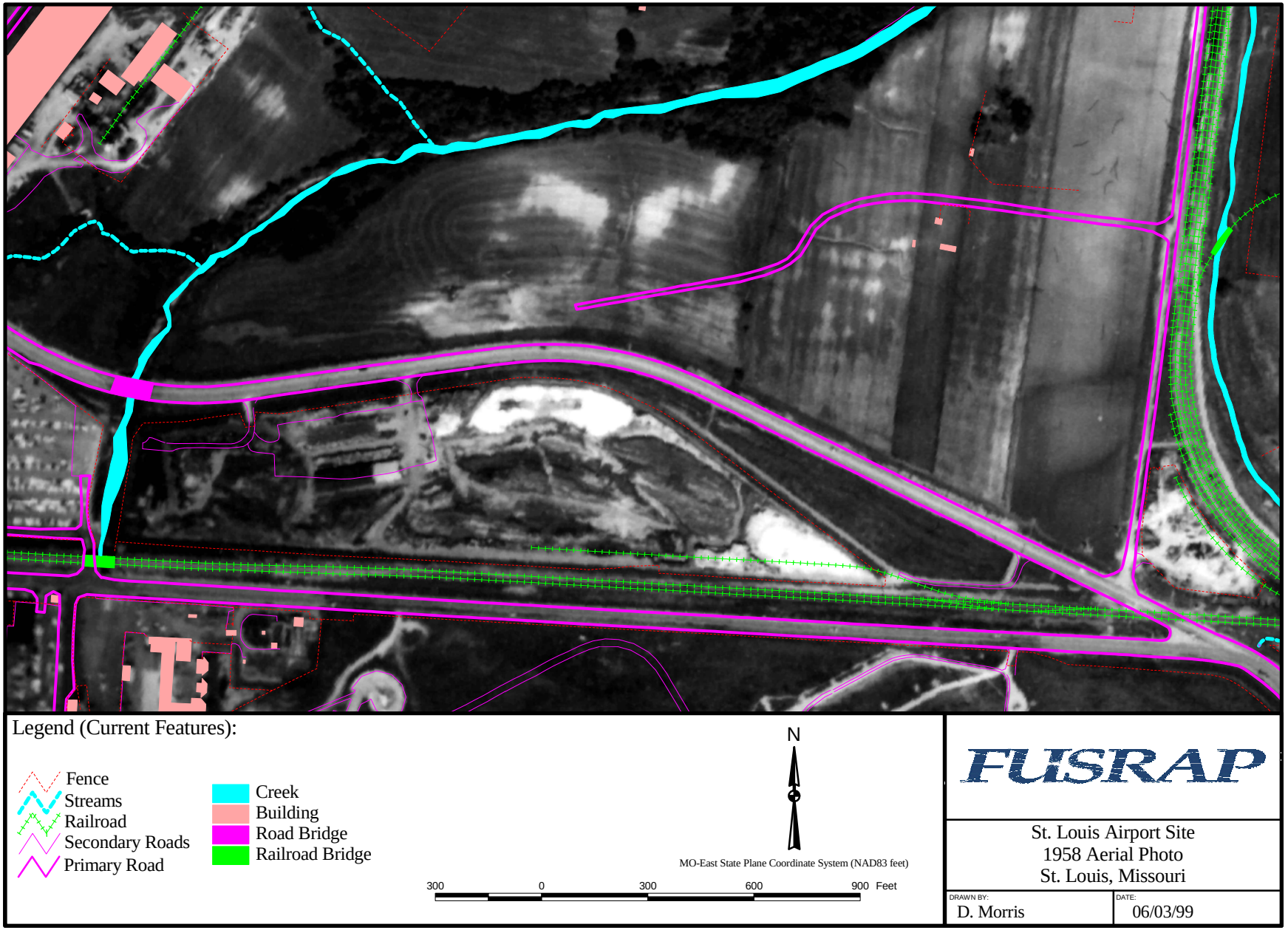


Figure 2-6. St. Louis 1958 Aerial Photo of SLAPS



Drum Storage at North Side of SLAPS



Barium Sulfate Cake (AJ-4) Storage on North Side of SLAPS



Scrap Metal and Residue Storage Near the West End of SLAPS

Figure 2-7 Storage Operations at SLAPS
circa - 1950's

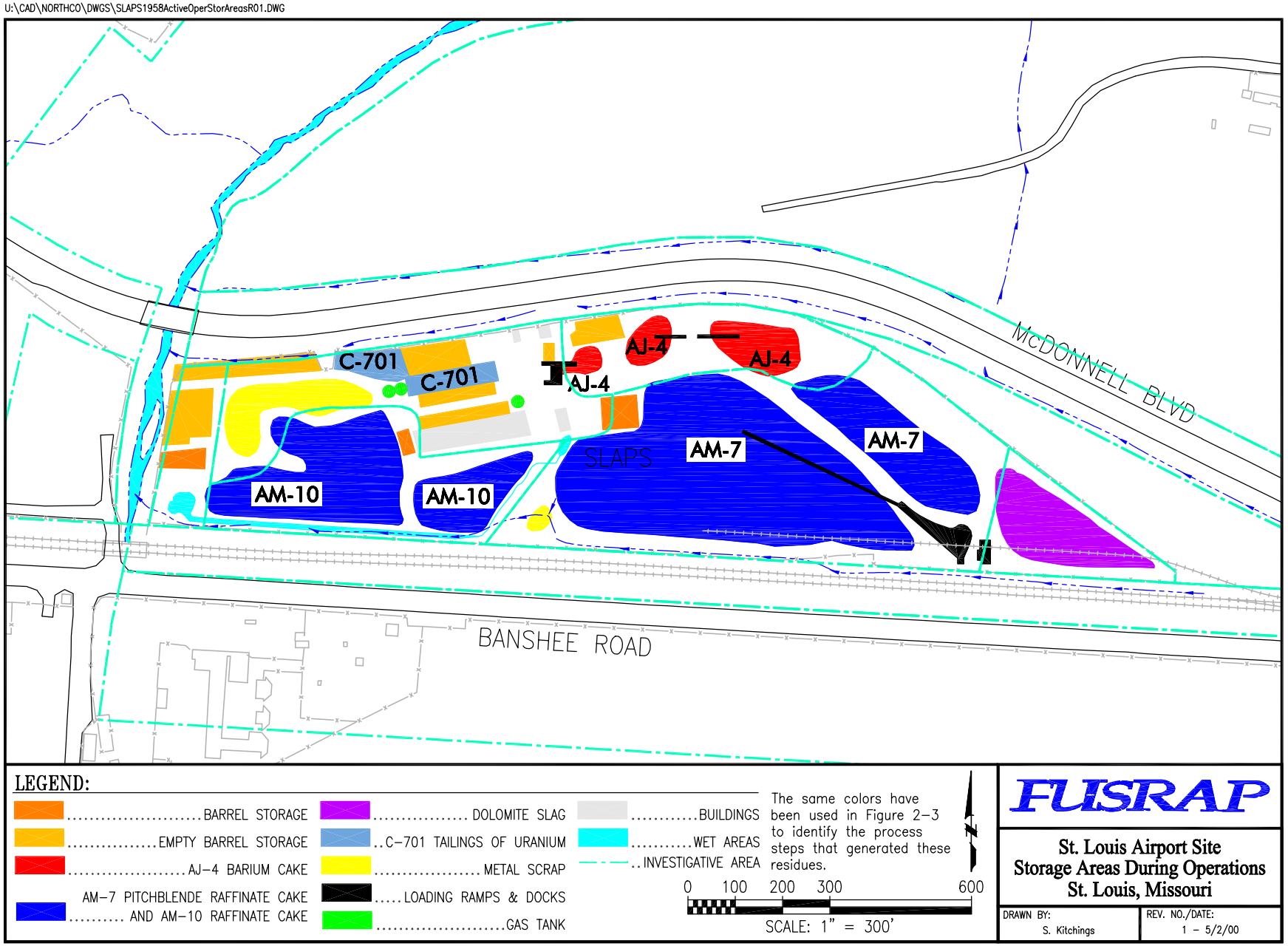


Figure 2-8. Schematic of Storage Areas During Active Operations at SLAPS - Circa 1958

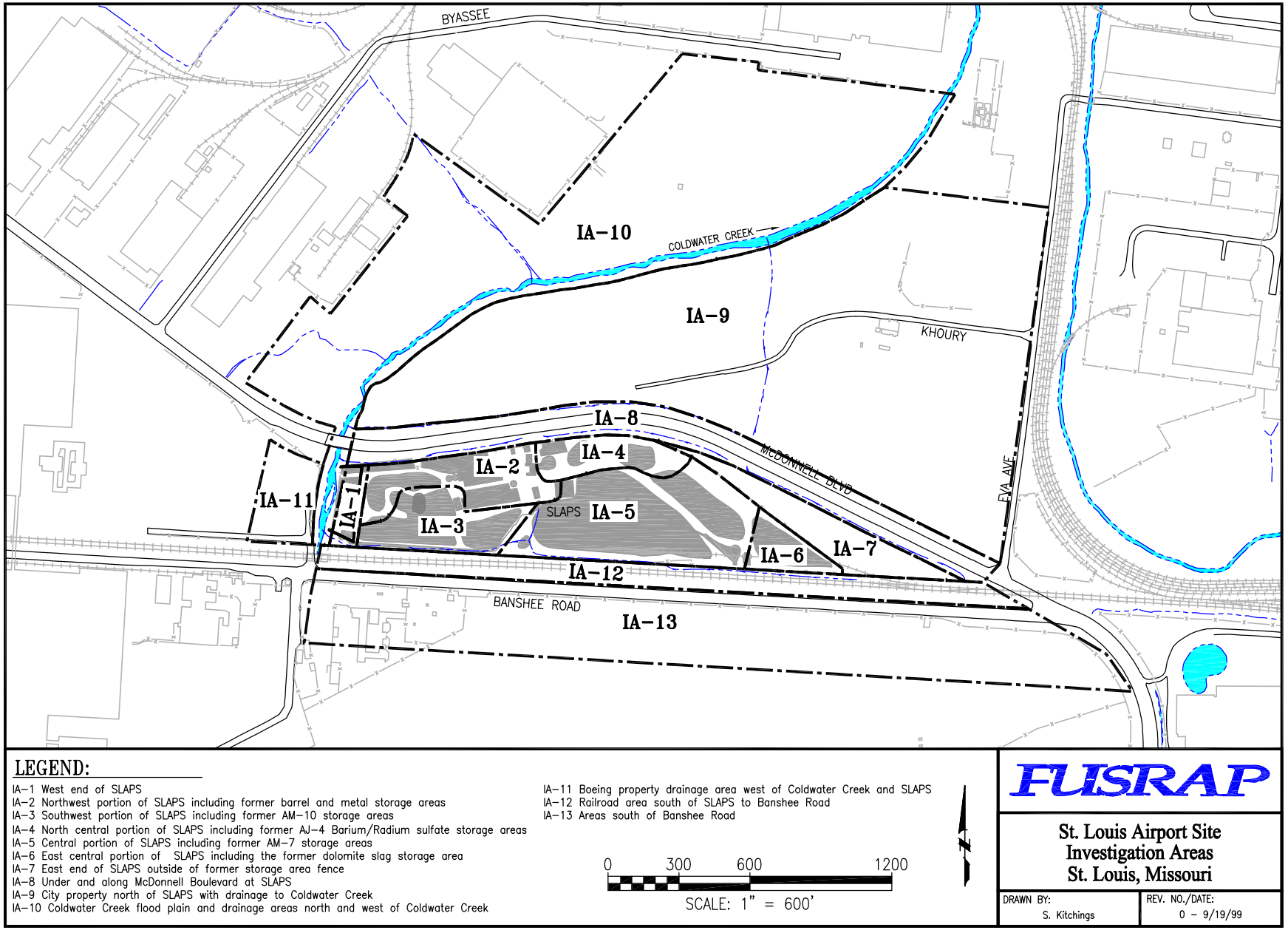


Figure 2-9. Investigation Areas for SLAPS and Contiguous Properties

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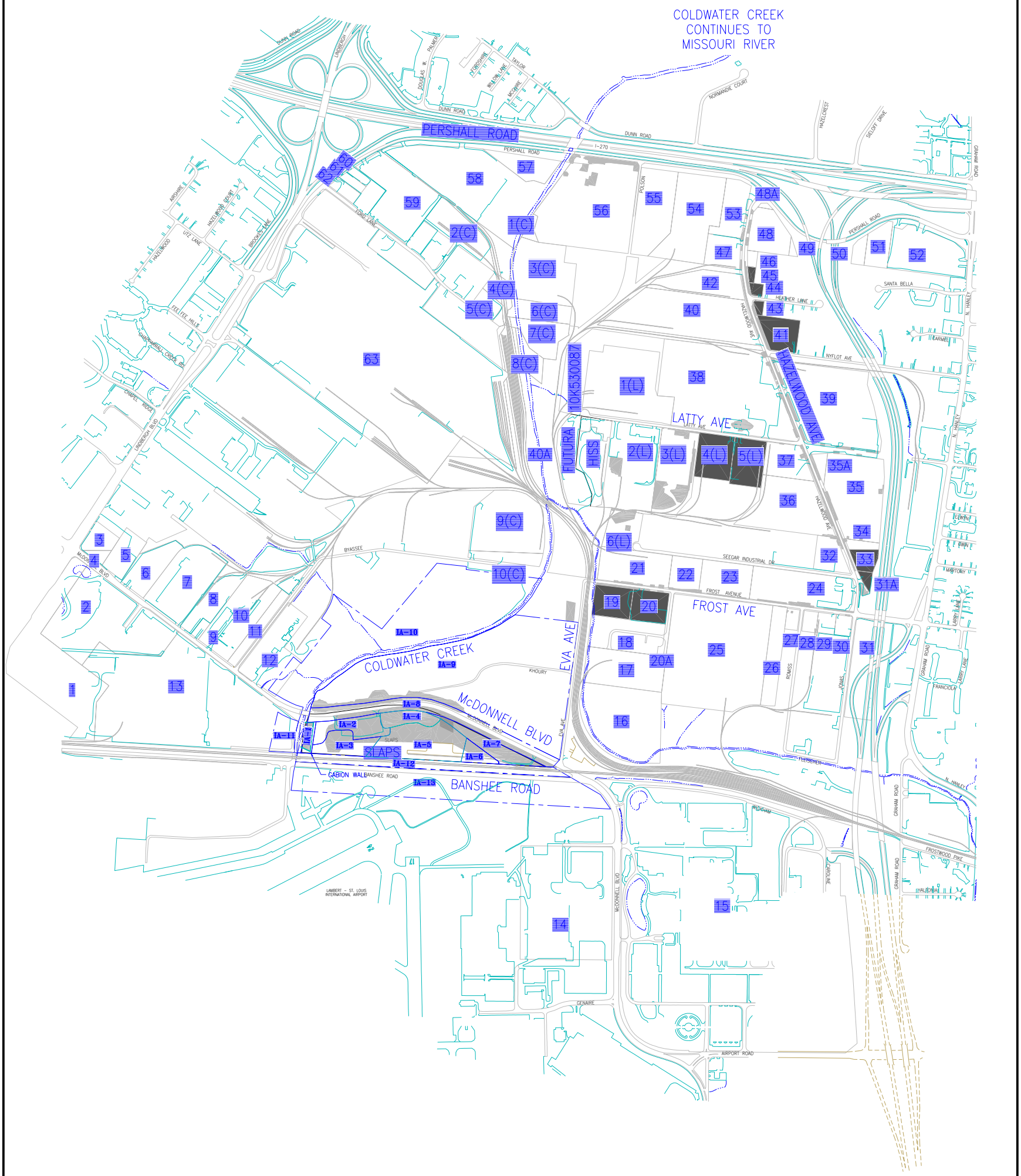


Figure 2-10. Location of Prior Response Actions within the North County Site

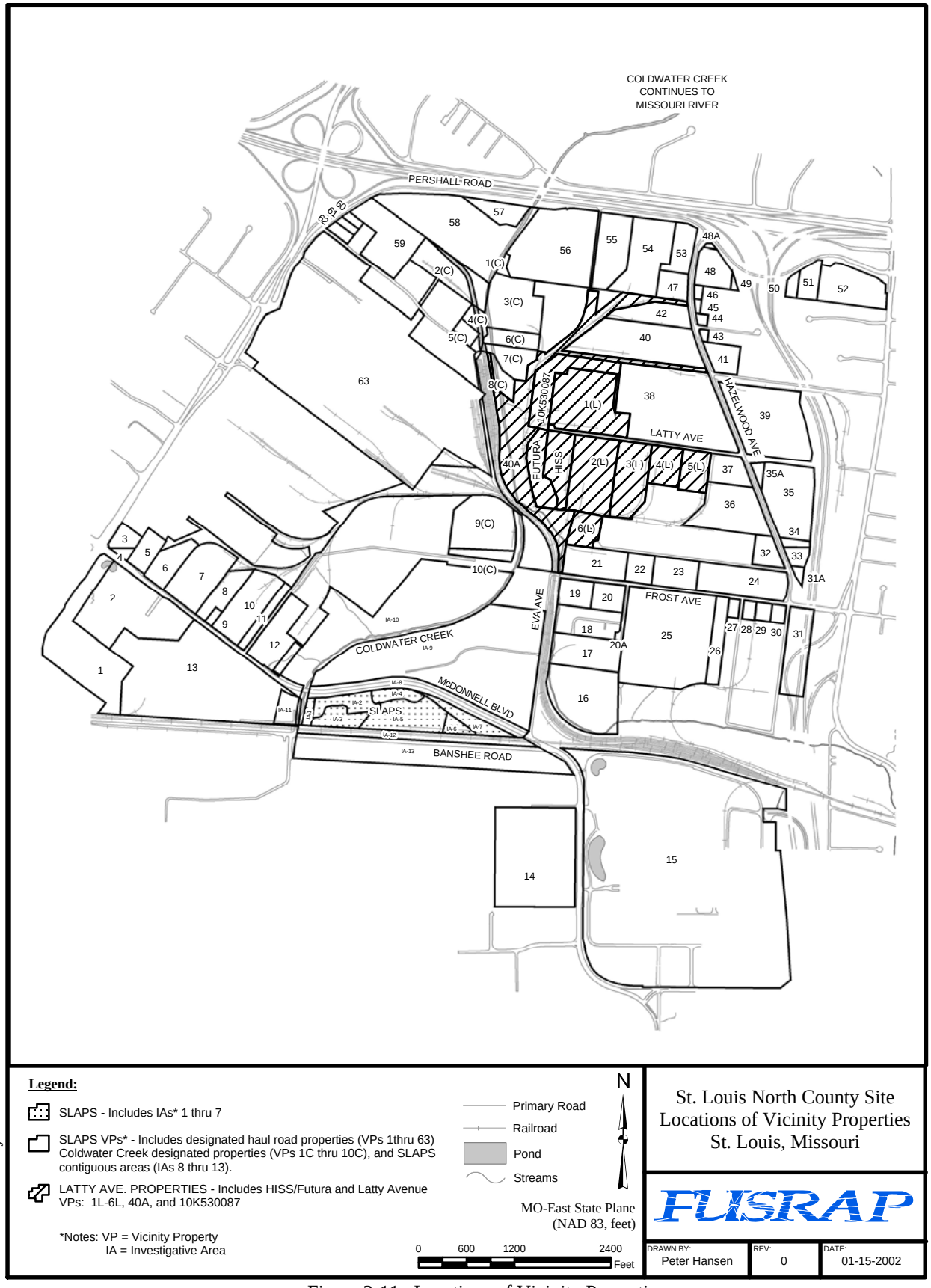


Figure 2-11. Locations of Vicinity Properties

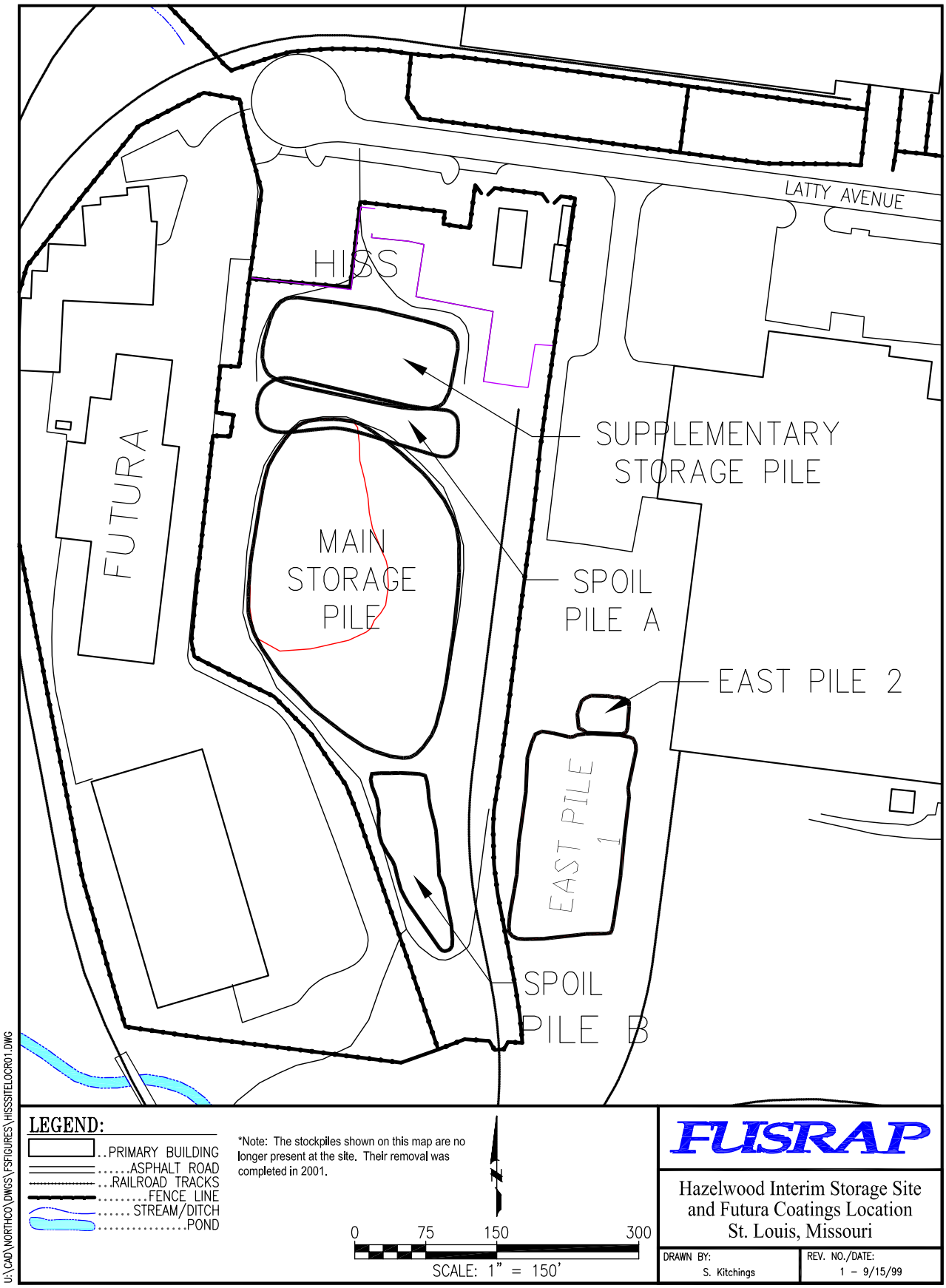


Figure 2-12. Location of Hazelwood Interim Storage Site (HISS) and Futura Coatings Property

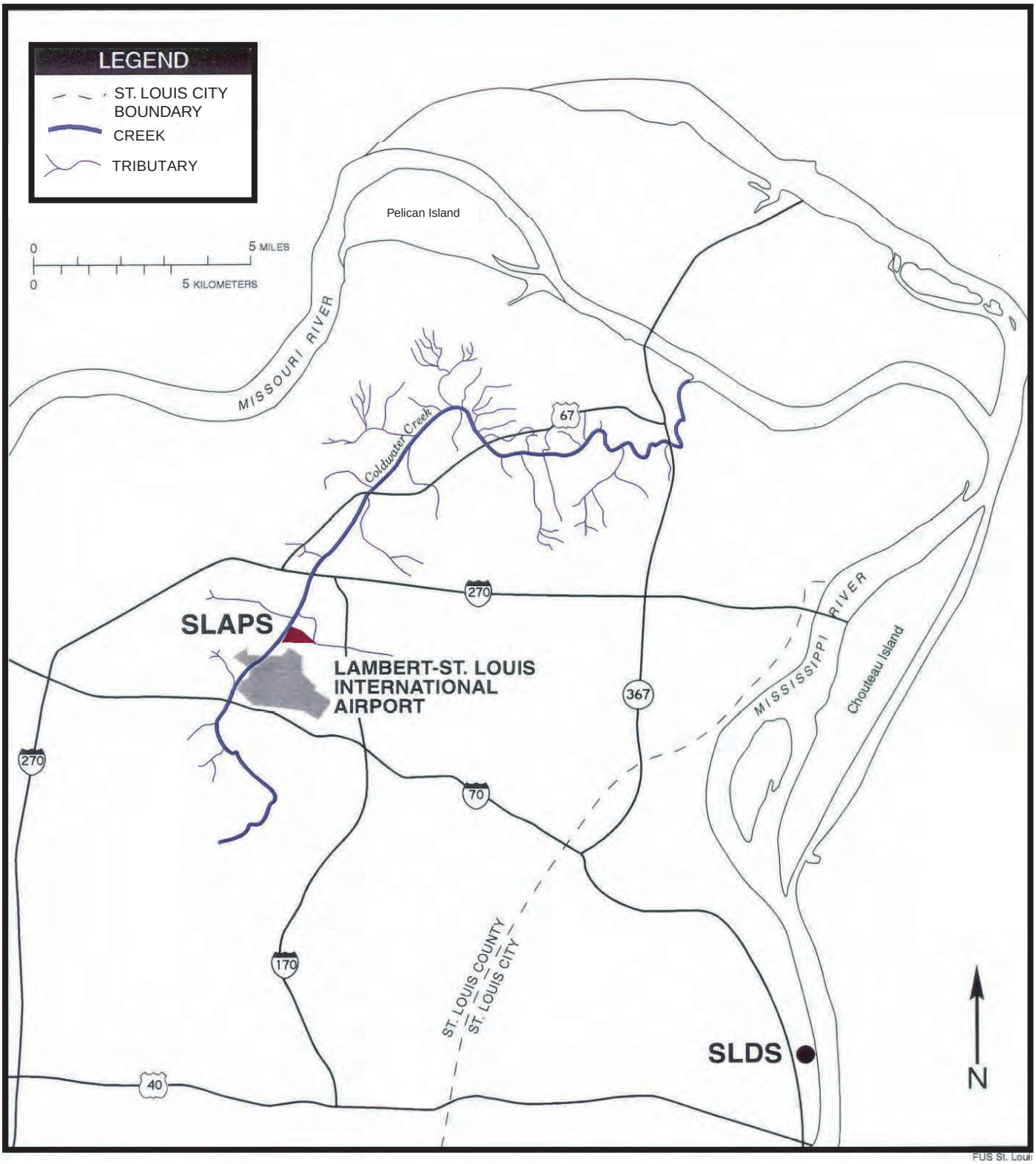


Figure 2-13 Location of Coldwater Creek and Tributaries

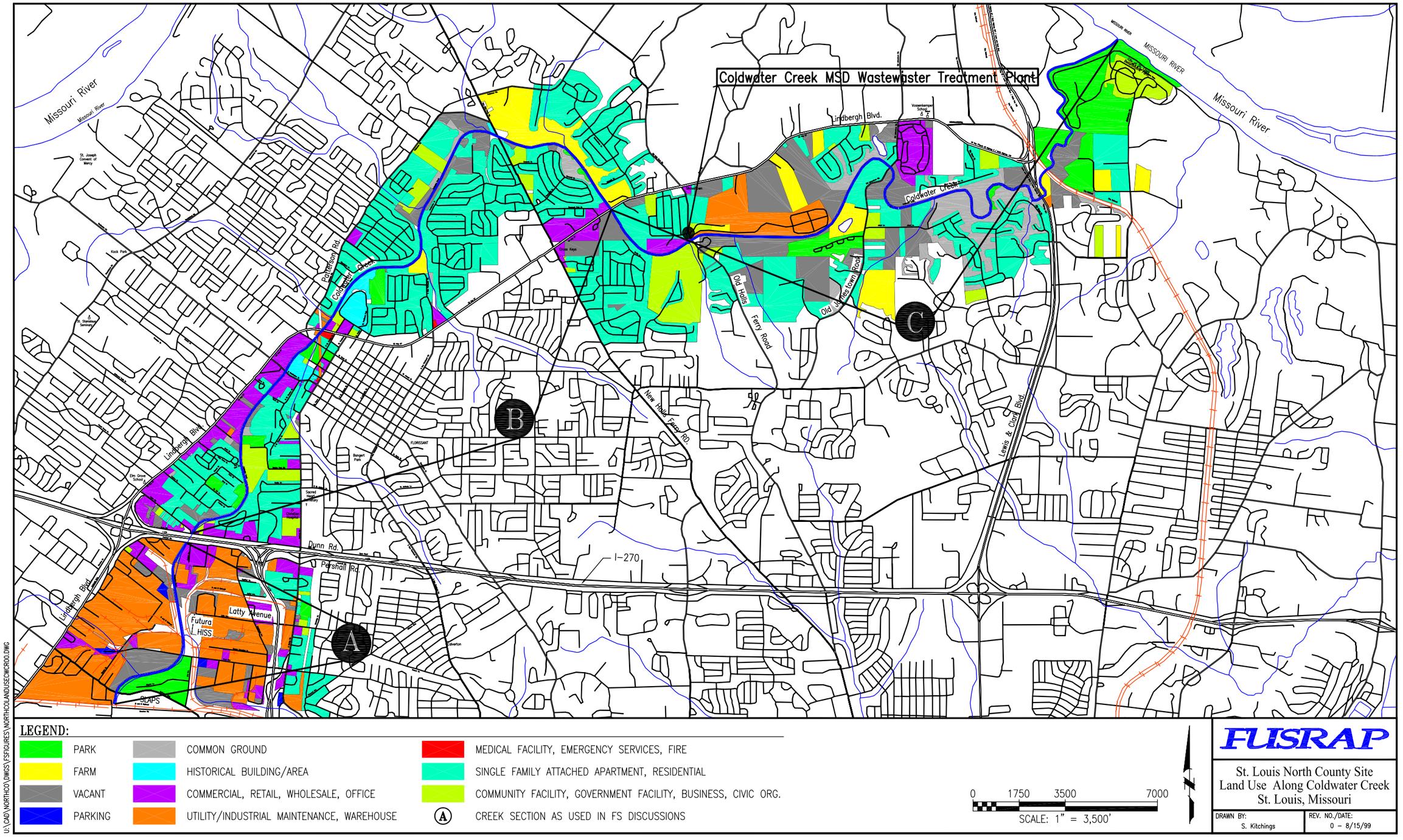


Figure 2-14. Land Use Along Coldwater Creek

System	Series	Group	Formation	Thickness (feet)	Aquifer Group
Quaternary	Holocene		Alluvium	0-150	
	Pleistocene		Loess	0-110	
			Glacial Till	0-55	
Pennsylvanian	Missourian	Pleasanton	Undifferentiated	0-37	
	Desmonian	Marmaton	Undifferentiated	0-90	
		Cherokee	Undifferentiated	0-200	
	Atokan		Undifferentiated		
Mississippian	Chesterian		Ste. Genevieve	0-160	1
	Meramecian		St. Louis Limestone	0-180	
			Salem	0-180	
			Warsaw	0-110	
	Osagean		Burlington-Keokuk Limestone	0-240	
			Fern Glen	0-105	
	Kinderhookian	Chouteau	Undifferentiated	0-122	
Devonian	Upper Devonian Series	Sulphur Springs	Bushberg Sandstone	0-60	
			Glen Park Limestone	0-60	
			Grassy Creek Shale	0-50	
Silurian			Undifferentiated	0-200	
Ordovician	Cincinnatian		Maquoketa Shale	0-163	-
	Champlainian		Cape Limestone	0-5	2
			Kimmswick	0-145	
			Decorah	0-50	
			Plattin	0-240	
			Rock Levee	0-93	
			Joachim Dolomite	0-135	
			St. Peter Sandstone	0-160	3
			Everton	0-130	
	Canadian		Powell Dolomite	0-150	4
			Cotter Dolomite	0-320	
			Jefferson City Dolomite	0-225	
			Roubidoux	0-177	
			Gasconade Dolomite	0-280	
Cambrian	Upper		Eminence Dolomite	0-172	5
			Potosi Dolomite	0-325	
		Elvins	Derby-Doerun Dolomite	0-165	
			Davis	0-150	
			Bonneterre	245-385	
			Lamotte Sandstone	235+	

Sources: USGS 1973, modified from Brill 1991, Howe and Koenig 1961, and MDNR 1993 stratigraphic column

Figure 2-15 Generalized Stratigraphic Column for the St. Louis Region

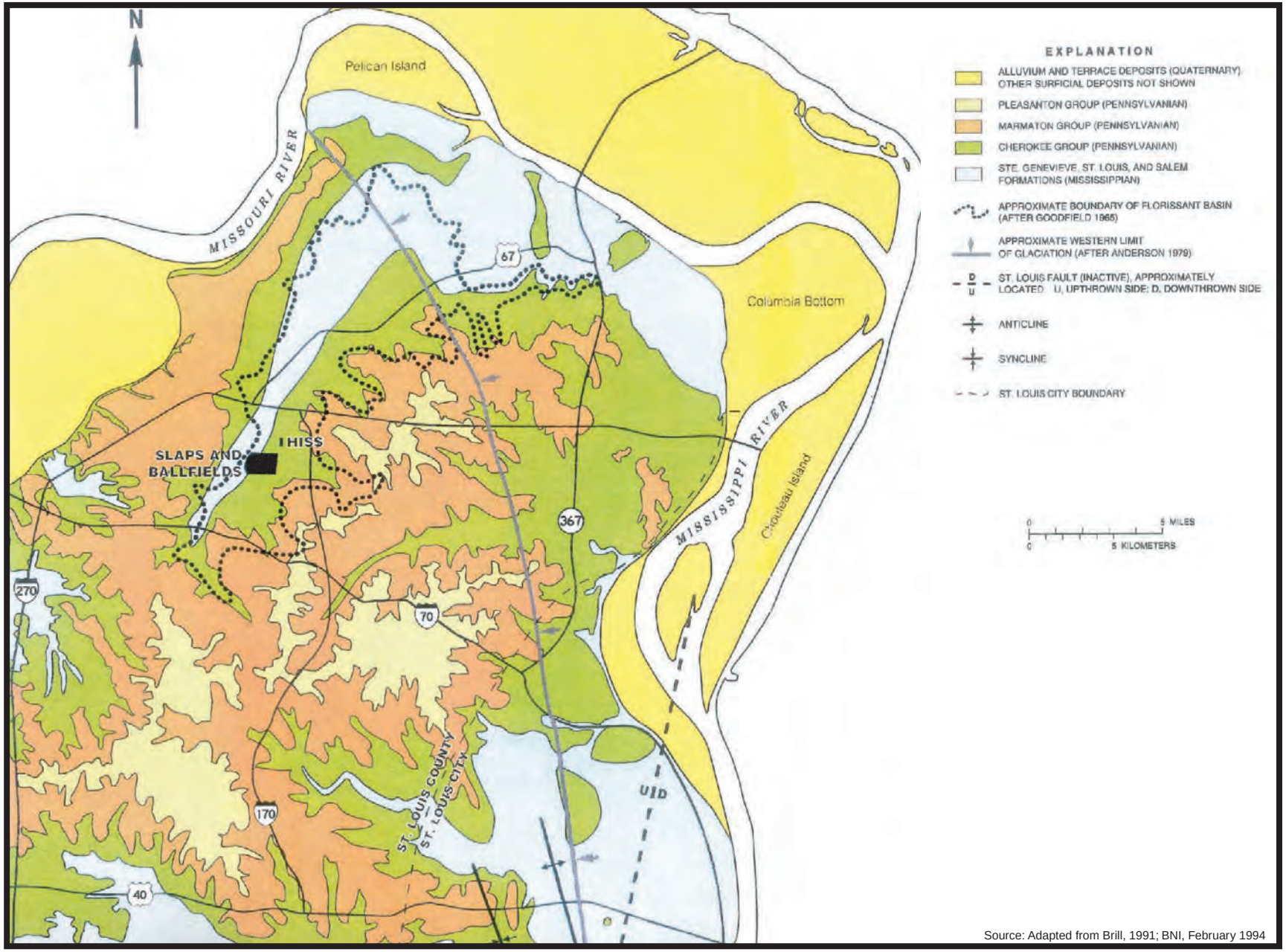


Figure 2-16 Generalized Surface Geologic Map of the St. Louis Region

Zone	Period	Epoch	Stratigraphic	Thickness (ft.)	Description
Hydrostratigraphic zone (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 plasticity. Moist to saturated. (3T)
Hydrostratigraphic zone (HZ)-B			VARVED CLAY	0-8	Alternating layers of dark and light clay as much as 1/16 inch thick (3M)
			CLAY	0-26	Dense, stiff, moist, highly plastic clay. (3M)
Hydrostratigraphic zone (HZ)-C			SILTY CLAY	0-29	Similar 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.
Hydrostratigraphic zone (HZ)-D	Pennsylvanian		Cherokee (?) group (undifferentiated)	0-35	**UNIT 5** BEDROCK: Interbedded silty clay/shale, lignite/coal, sandstone, and siltstone. Erosionally truncated by glaciolacustrine sequences. (Absent at HISS).
Hydrostratigraphic zone (HZ)-E	Mississippian		STE GENEVIEVE ST. LOUIS LIMESTONES	100+	**UNIT 6** BEDROCK: Hard, white to olive, well cemented, sandy limestone with interbedded shale laminations.

Figure 2-17 Generalized Hydrostratigraphic Column for SLAPS and HISS

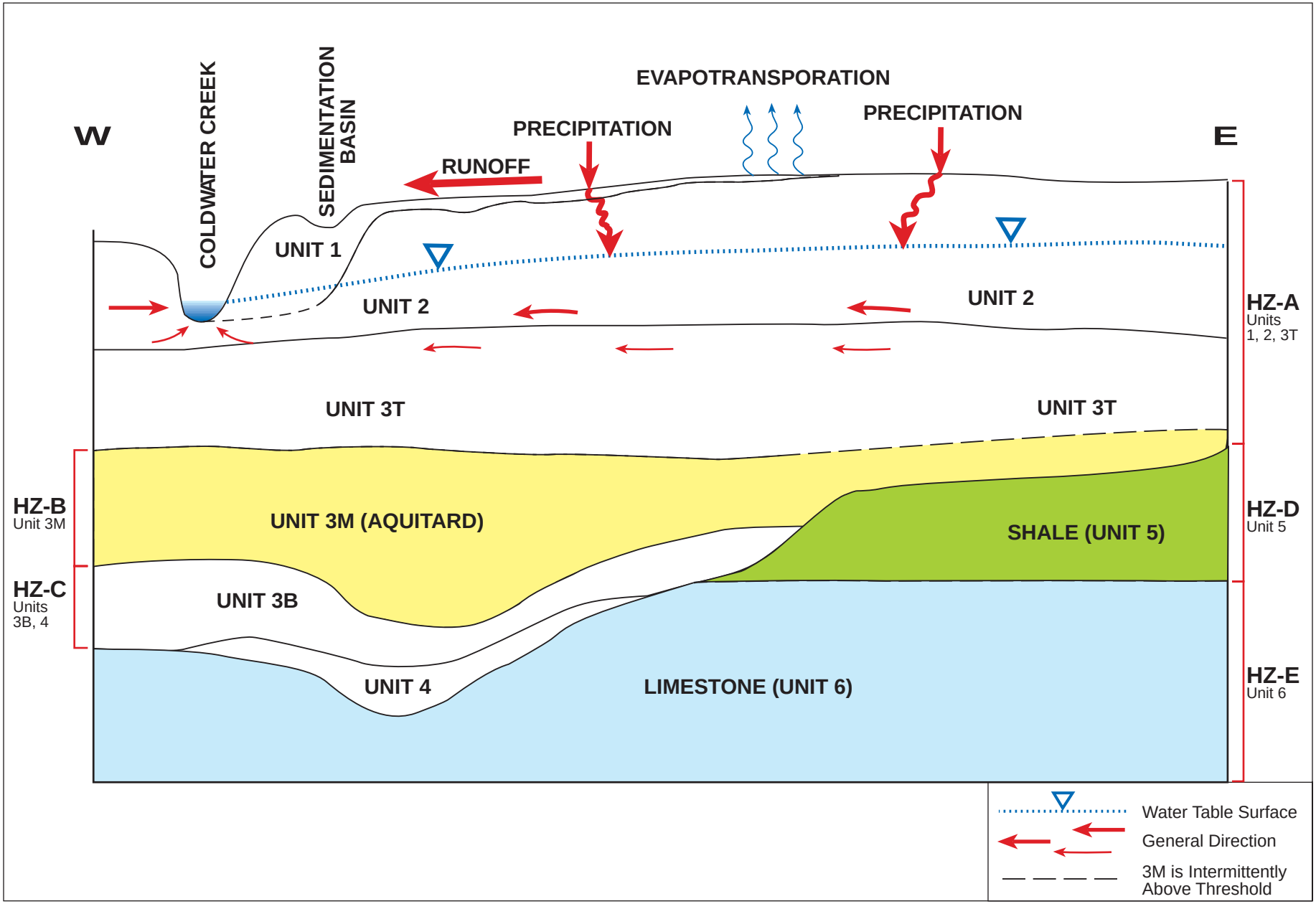
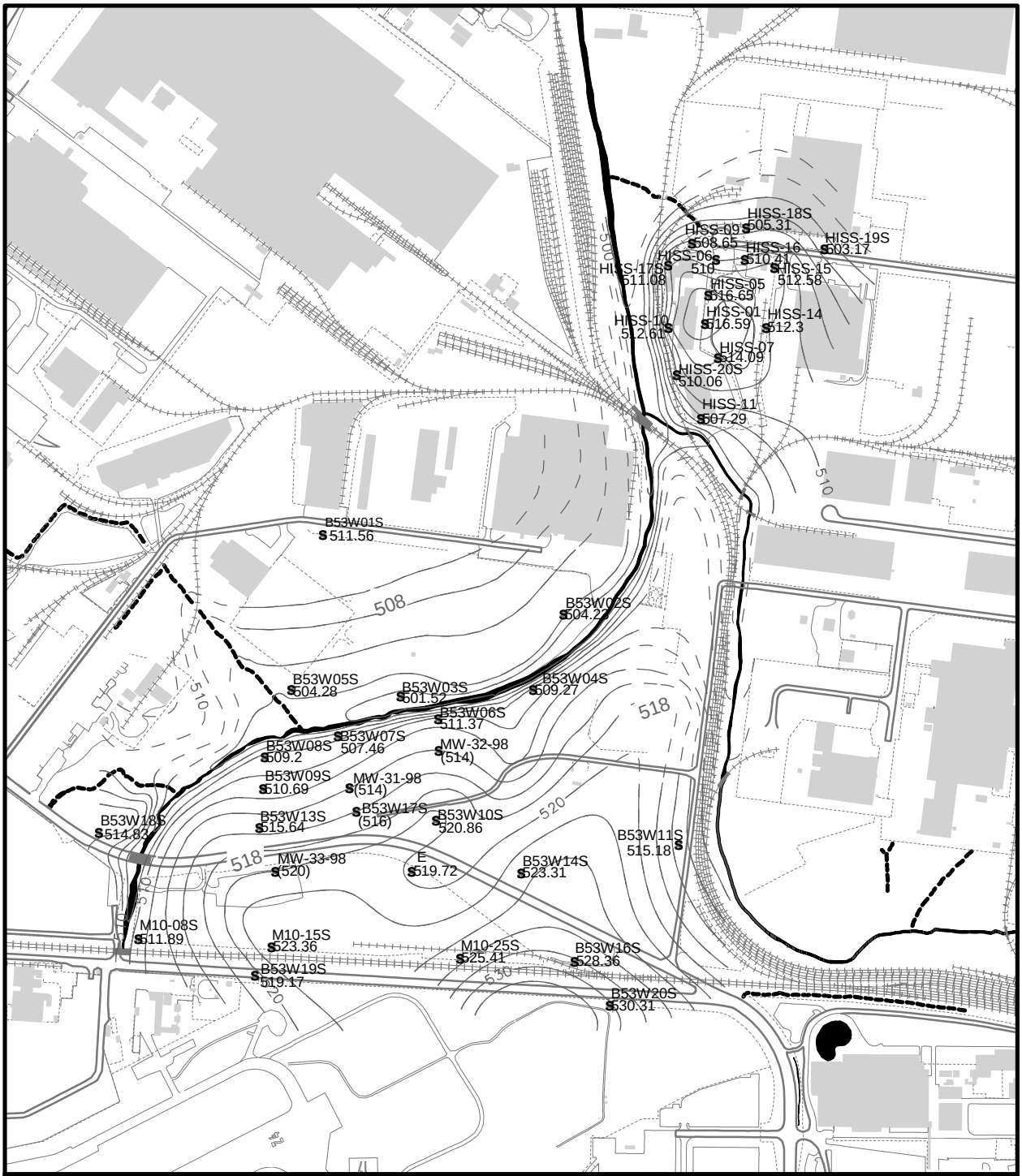


Figure 2-18. Conceptual Model of Ground-water Flow at SLAPS Showing Stratigraphic Units and Hydrostratigraphic Zones (HZs).



Legend:

S 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/Futura
3 DEC 98 Shallow Piezometric Surface
St. Louis, Missouri

DRAWN BY: R. Smith / S. Kitchings

REV. - DATE: 3 - 9/16/99

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Figure 2-19. Potentiometric Surface for HZ-A at SLAPS and HISS/Futura

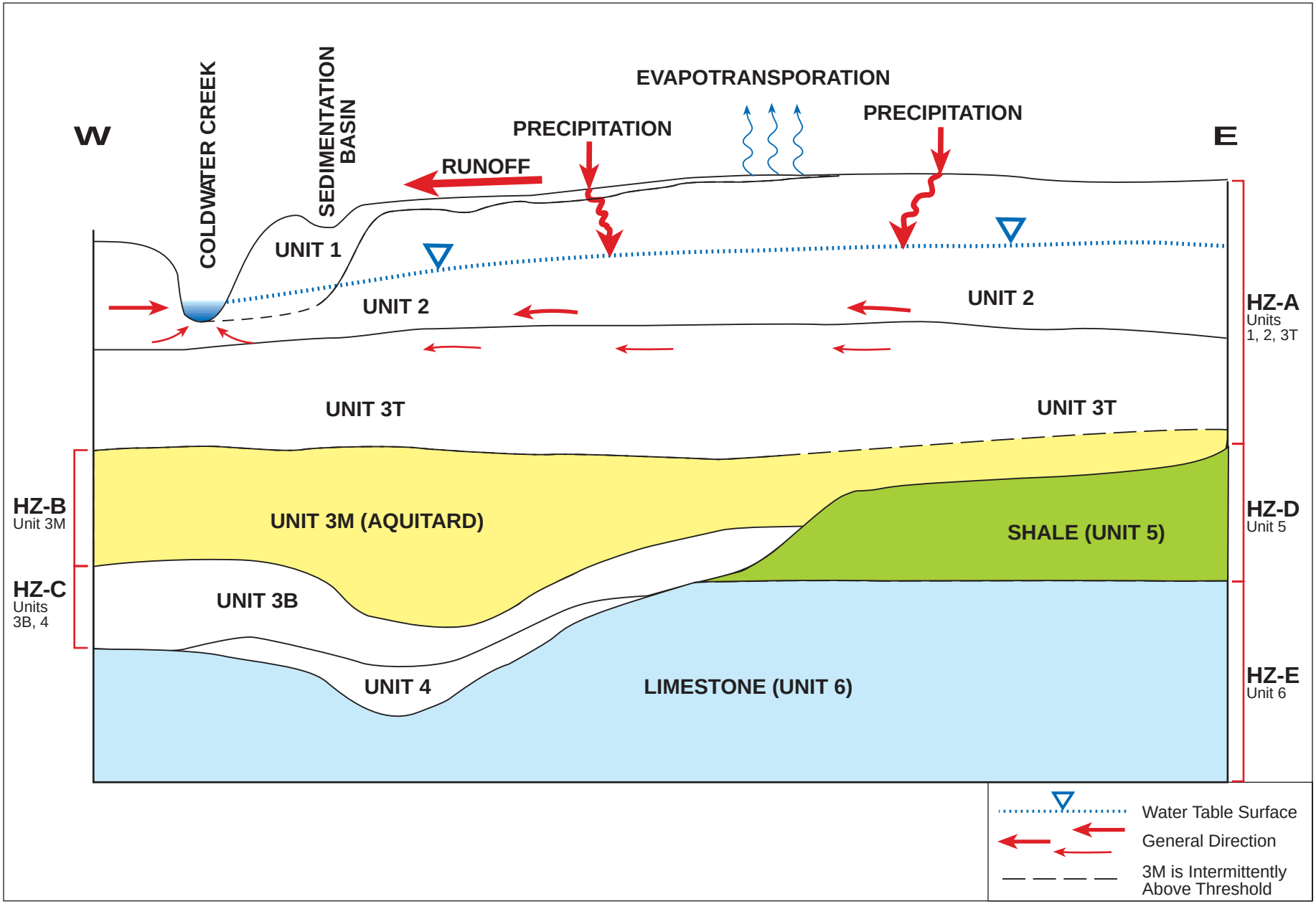


Figure 2-18. Conceptual Model of Ground-water Flow at SLAPS Showing Stratigraphic Units and Hydrostratigraphic Zones (HZs).

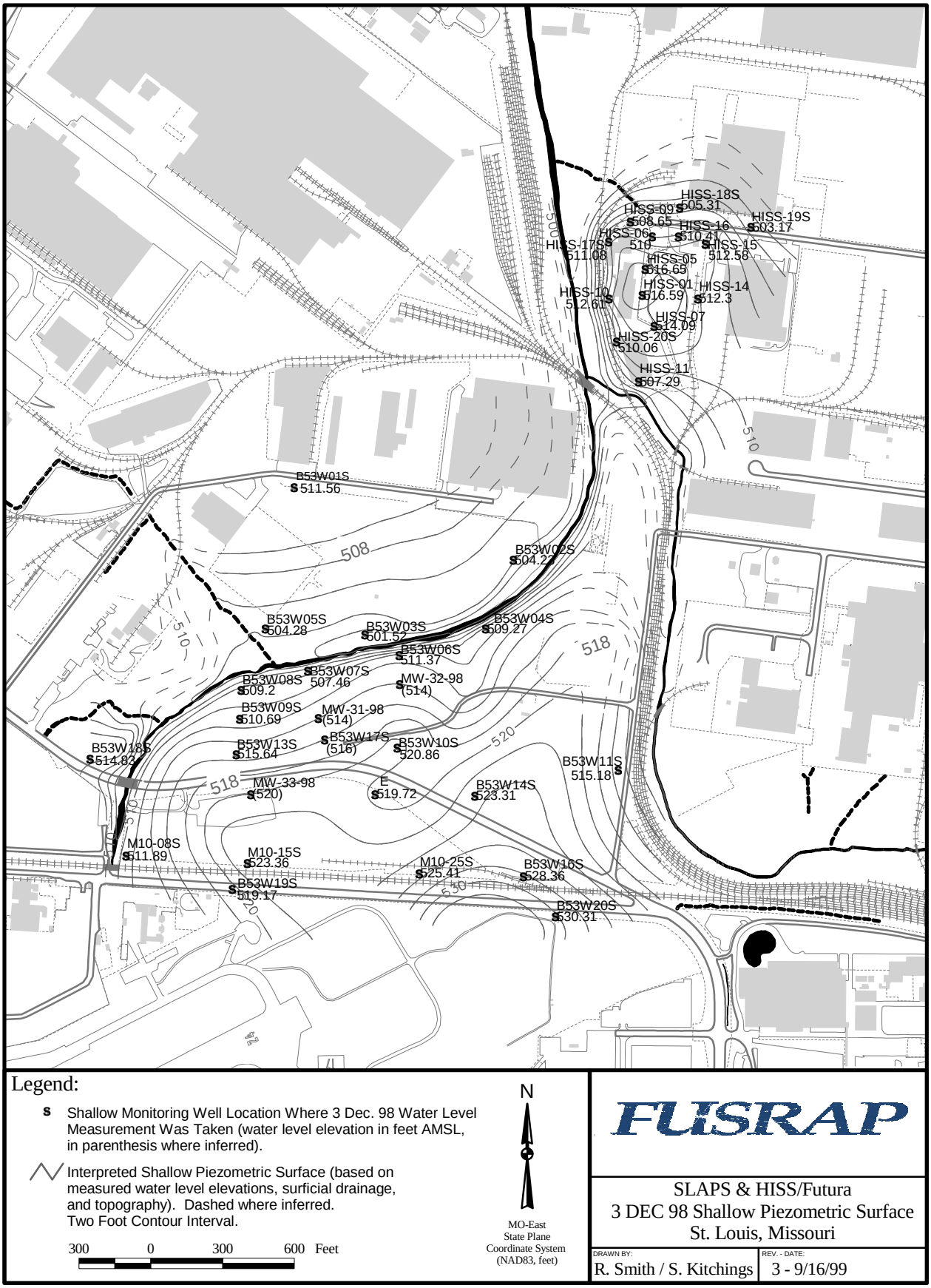
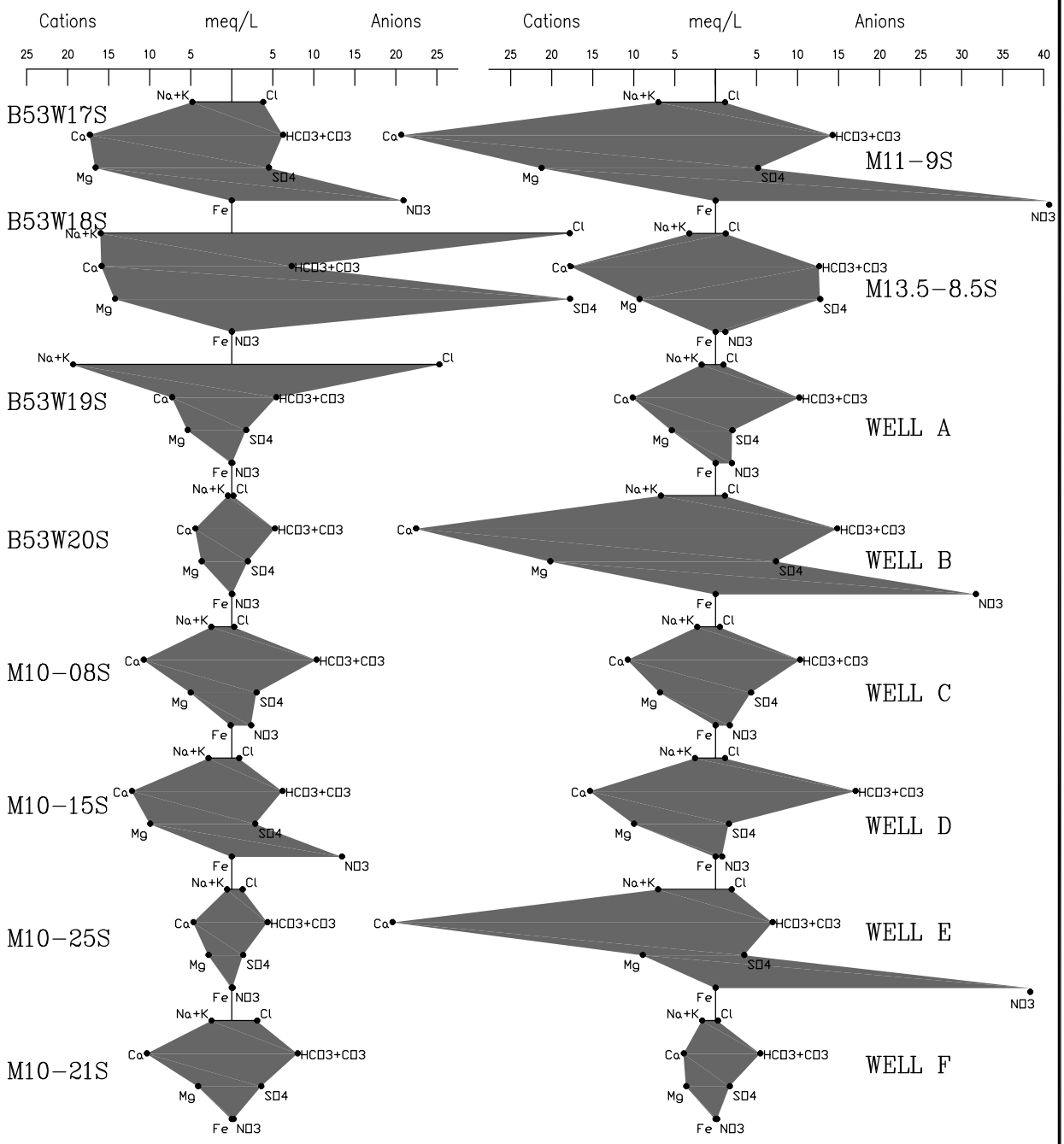


Figure 2-19. Potentiometric Surface for HZ-A at SLAPS and HISS/Futura



LEGEND:

CATIONS	ANIONS
Na – Sodium	Cl – Chloride
K – Potassium	HCO_3+CO_3 – Alkalinity
Ca – Calcium	SO_4 – Sulfate
Mg – Magnesium	NO_3 – Nitrate
Fe – Iron	meq/L – milliequivalents per liter

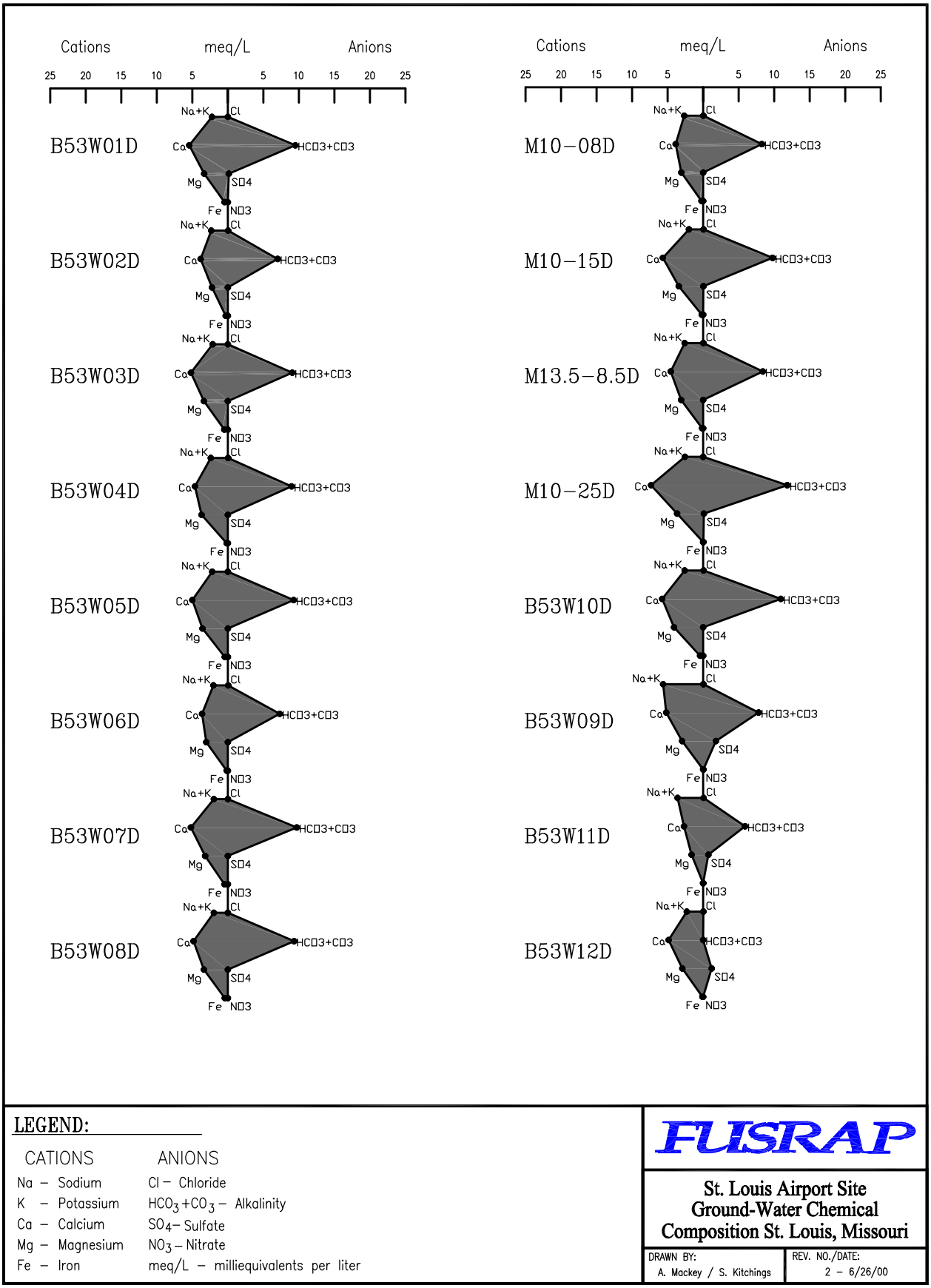
FUSRAP

St. Louis Airport Site
Ground-Water Chemical Composition St. Louis, Missouri

DRAWN BY:	REV. NO./DATE:
A. Mackey / S. Kitchings	3 – 6/26/00

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Figure 2-20. Ground-Water Chemical Composition in HZ-A



LEGEND:

CATIONS	ANIONS
Na – Sodium	Cl – Chloride
K – Potassium	HCO_3+CO_3 – Alkalinity
Ca – Calcium	SO_4 – Sulfate
Mg – Magnesium	NO_3 – Nitrate
Fe – Iron	meq/L – milliequivalents per liter

FUSRAP

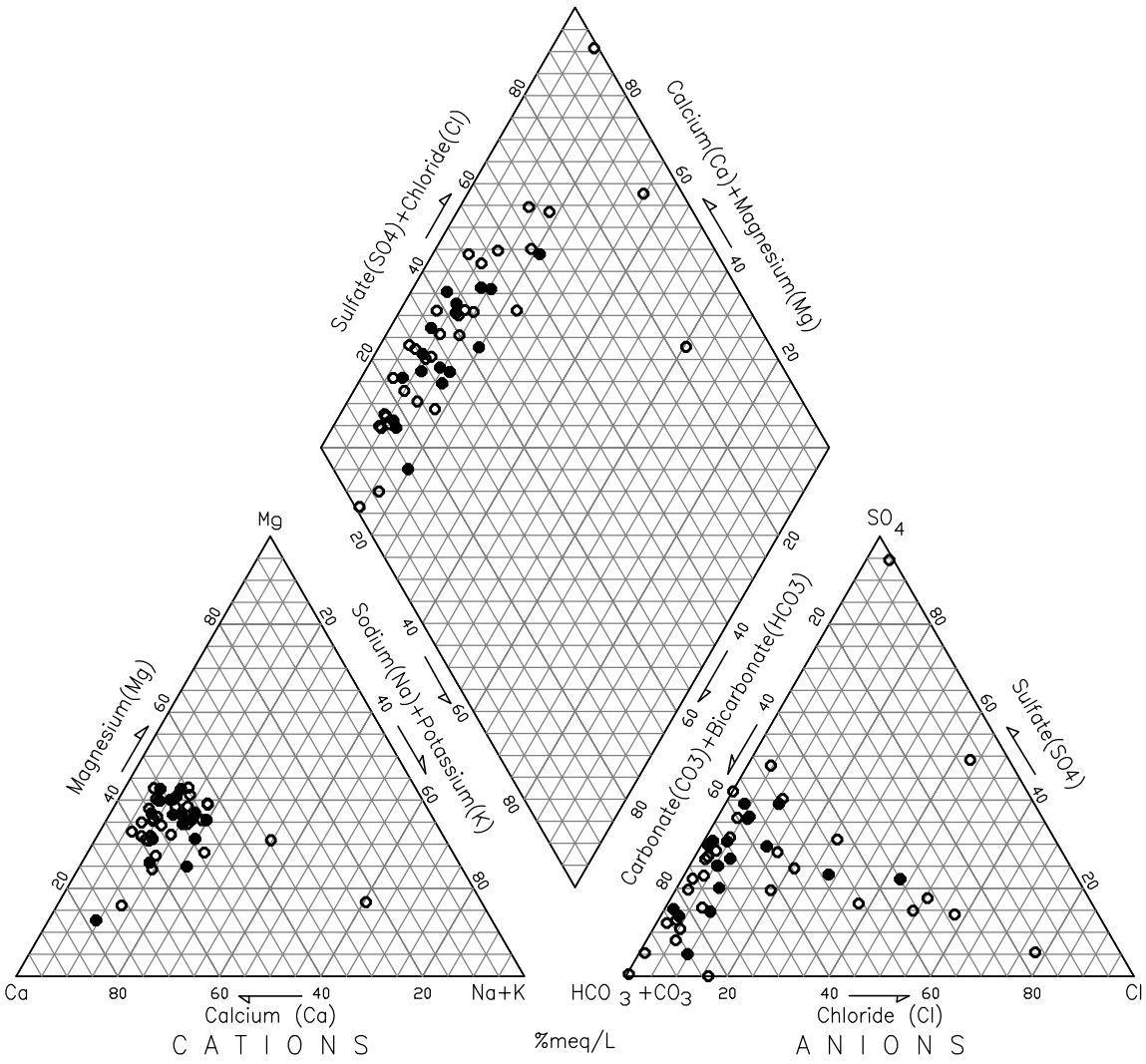
St. Louis Airport Site
Ground-Water Chemical
Composition St. Louis, Missouri

DRAWN BY: A. Mackey / S. Kitchings

REV. NO./DATE: 2 – 6/26/00

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Figure 2-21. Ground-Water Chemical Composition in the Lower Hydrostratigraphic Zones Beneath HZ-A



LEGEND:

- ● Hazelwood Interim Storage Site (HISS)
- ○ St. Louis Airport Site (SLAPS)

meq/L – milliequivalents per liter

FUSRAP

St. Louis North County Sites
Piper Diagram for HZ-A
St. Louis, Missouri

DRAWN BY: P. Salpas / S. Kitchings

REV. NO./DATE: 1 – 5/4/00

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Figure 2-22. Piper Diagram for HZ-A Showing Data Points

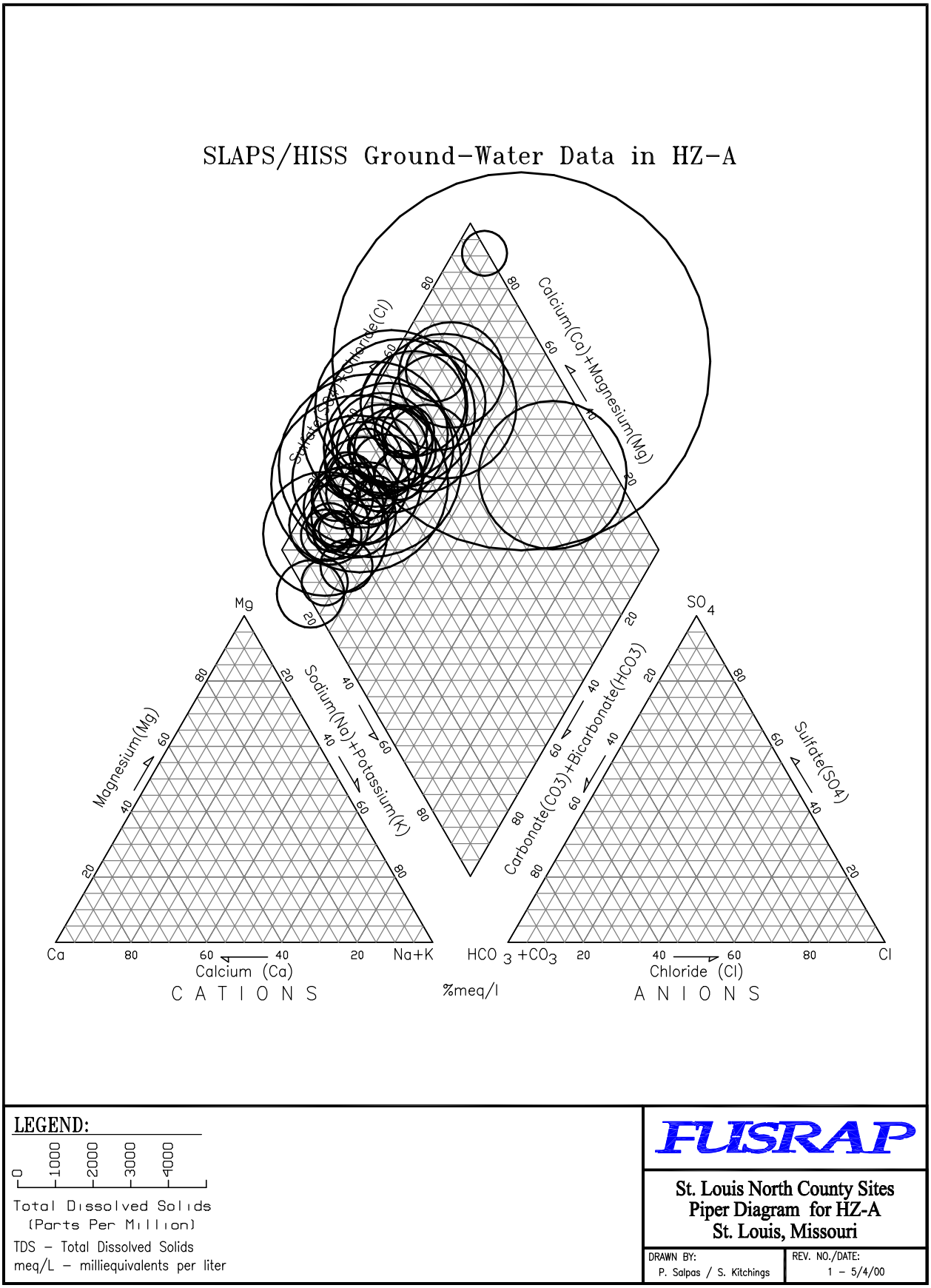
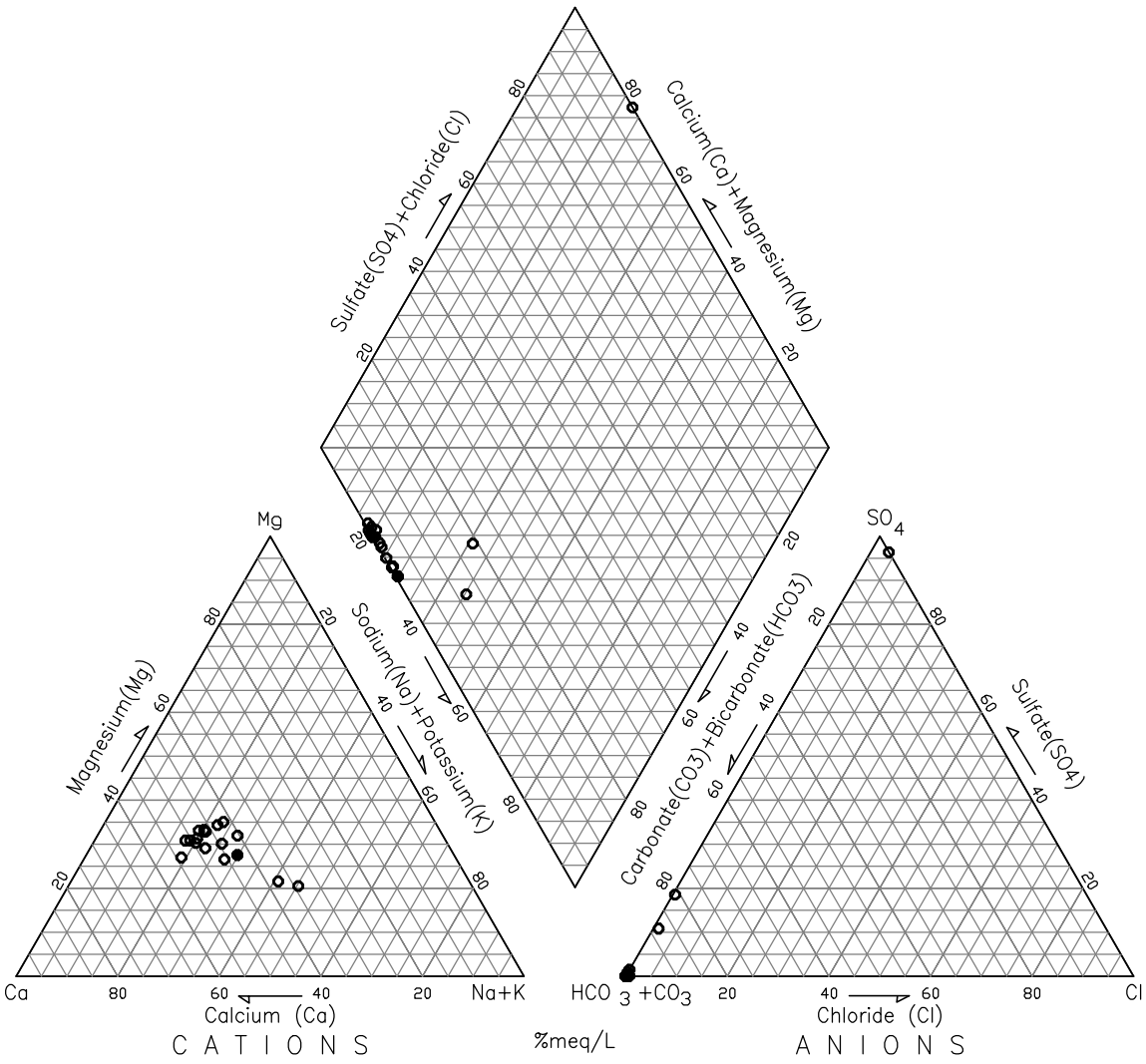


Figure 2-23. Piper Diagram for HZ-A Showing TDS



LEGEND:

- ● Hazelwood Interim Storage Site (HISS)
- ○ St. Louis Airport Site (SLAPS)

meq/L – milliequivalents per liter

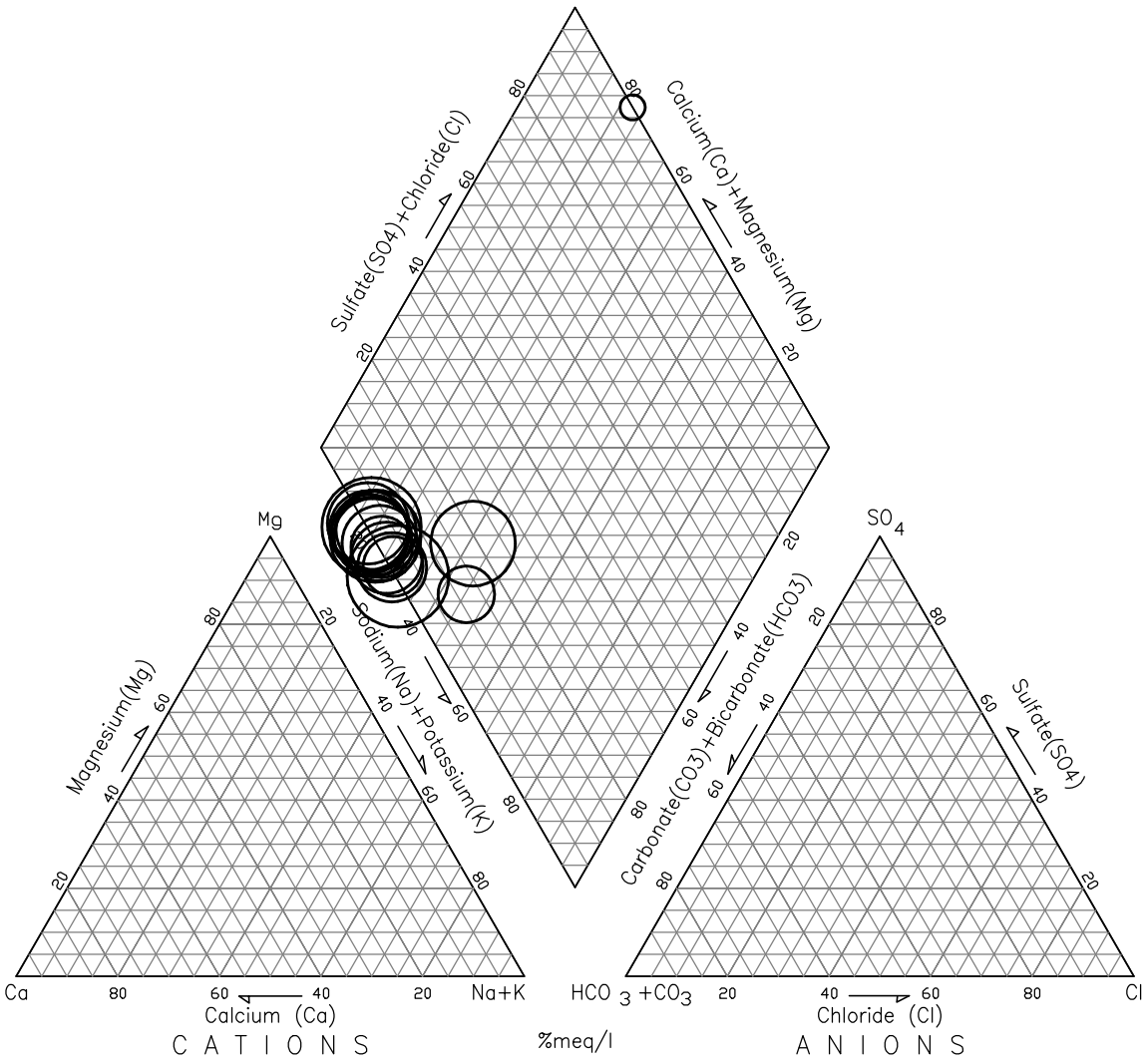
FUSRAP

St. Louis North County Sites
Piper Diagram for HZ-B - HZ-E
St. Louis, Missouri

DRAWN BY:	REV. NO./DATE:
P. Salpas / S. Kitchings	1 – 5/4/00

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Figure 2-24. Piper Diagram for Lower HZs Showing Data Points



LEGEND:

0 1000 2000 3000 4000

Total Dissolved Solids (Parts Per Million)

TDS – Total Dissolved Solids

meq/L – milliequivalents per liter

FUSRAP

St. Louis North County Sites
Piper Diagram for HZ-B - HZ-E
St. Louis, Missouri

DRAWN BY:	REV. NO./DATE:
P. Salpas / S. Kitchings	1 – 5/4/00

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Figure 2-25. Piper Diagram for Lower HZs Showing TDS

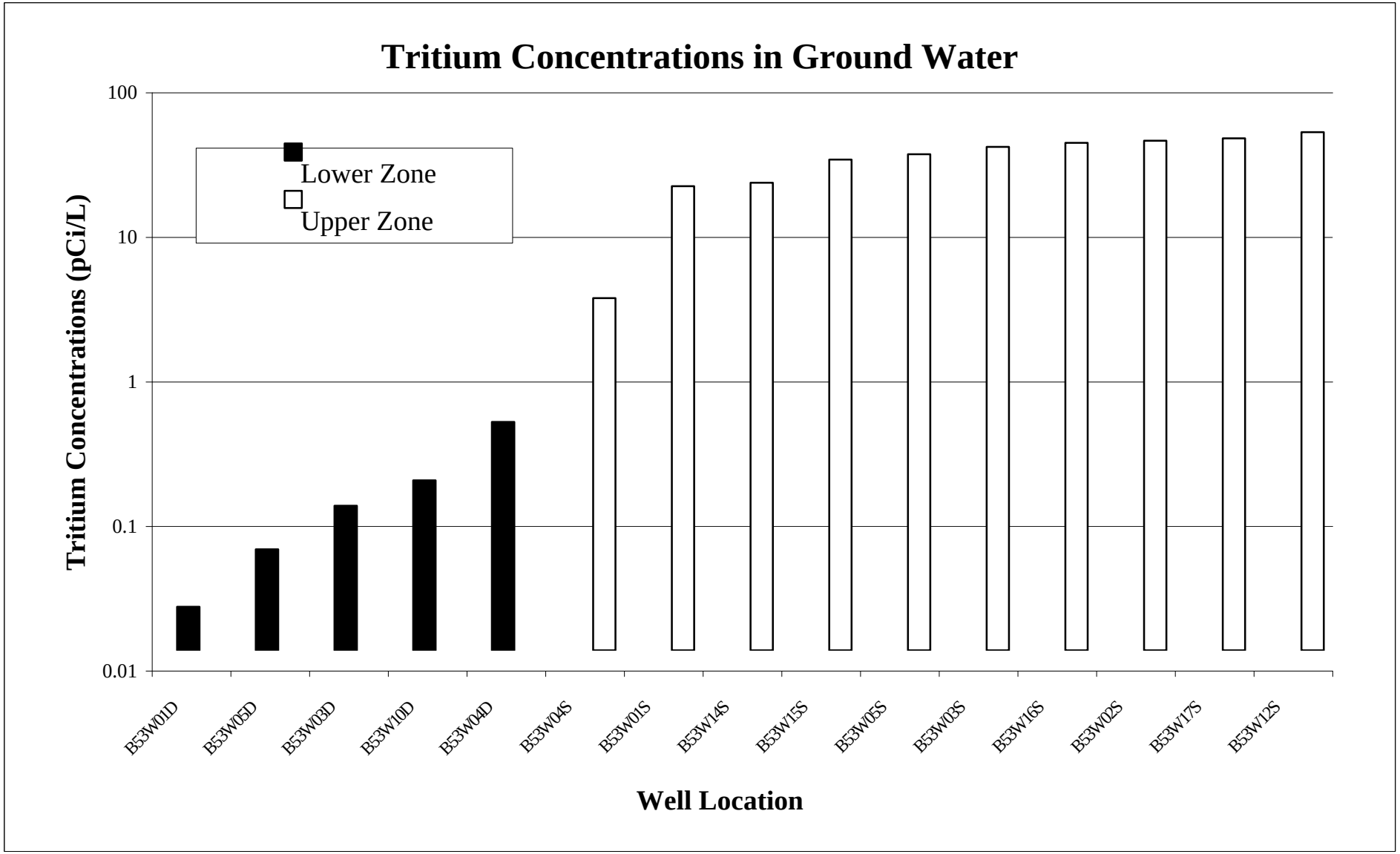


Figure 2-26. Distribution of Tritium Concentrations in Ground Water at SLAPS

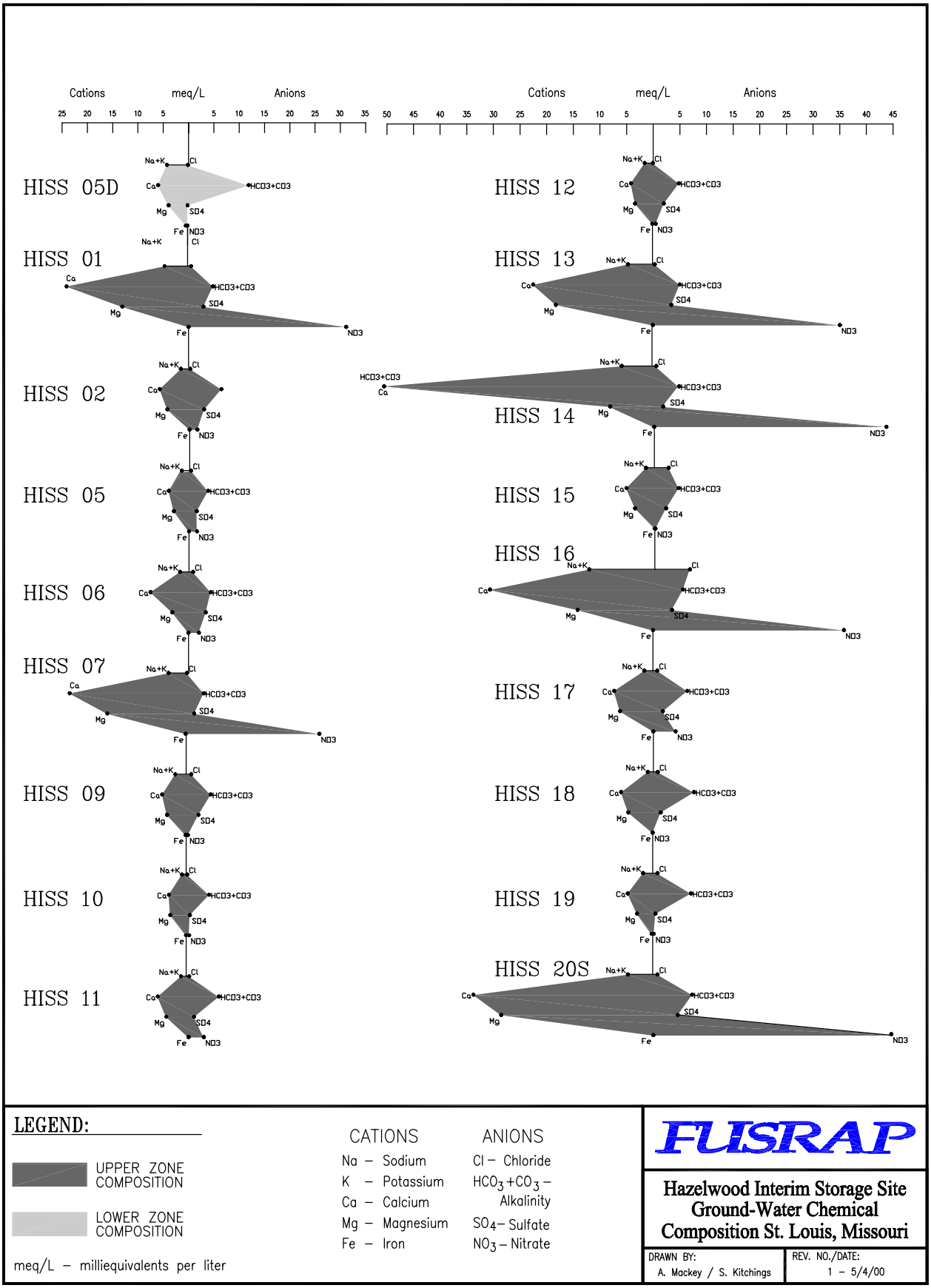


Figure 2-27. Ground-Water Chemical Composition in the Hydrostratigraphic Zones

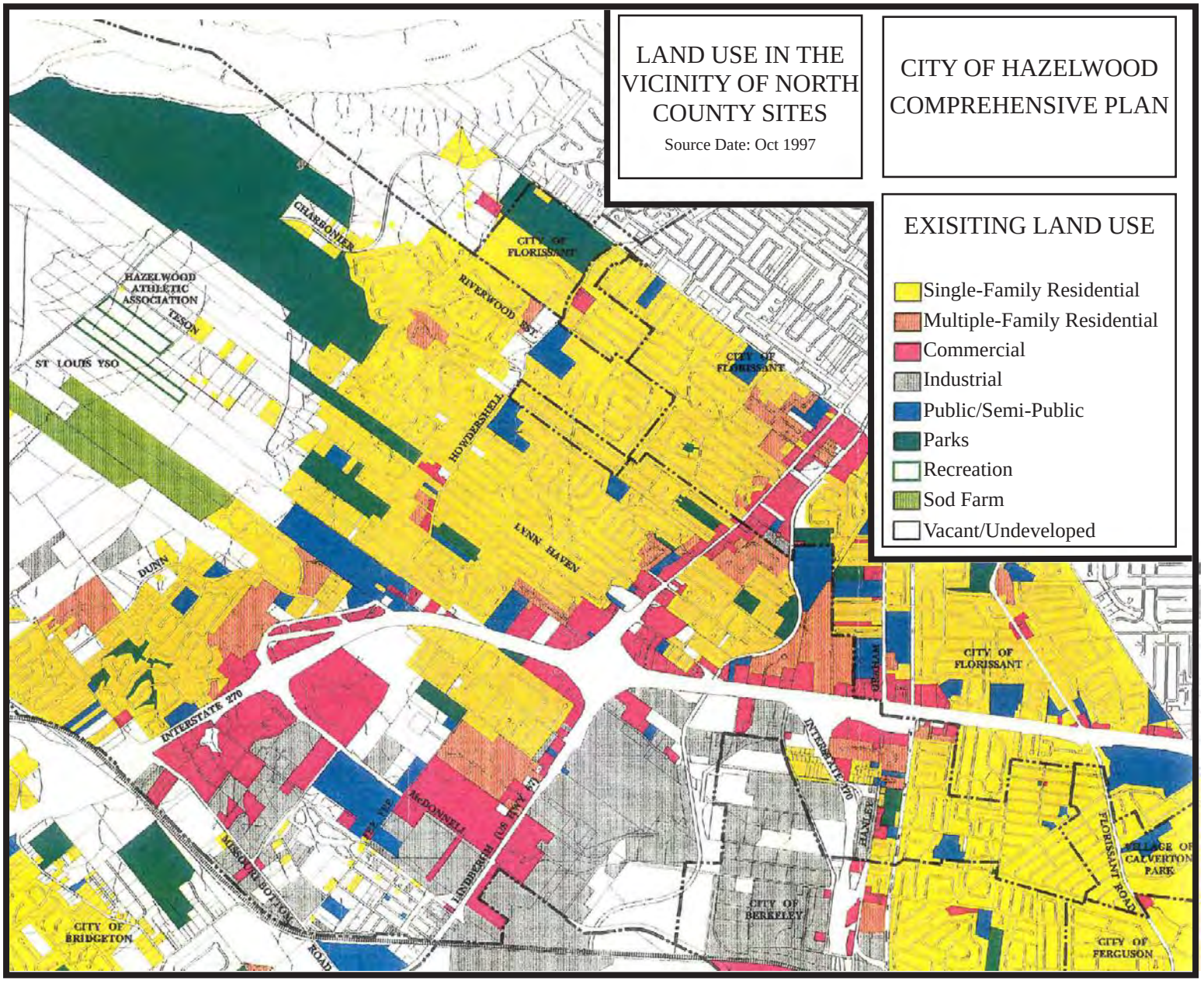


Figure 2-28 - Land Use in the Vicinity of North County Sites

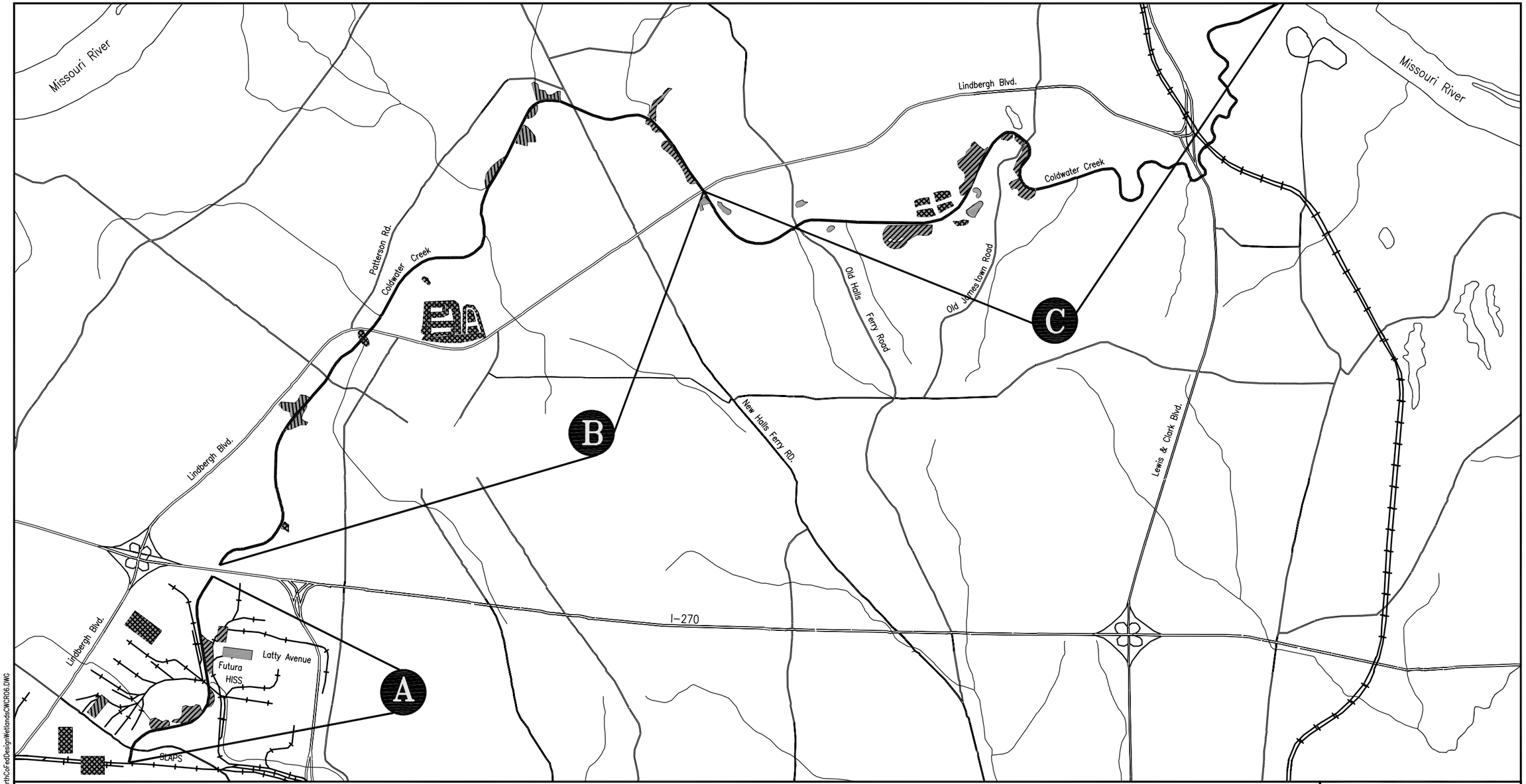


Figure 2-29. Occurrence of Federally Designated Wetlands Along Coldwater Creek

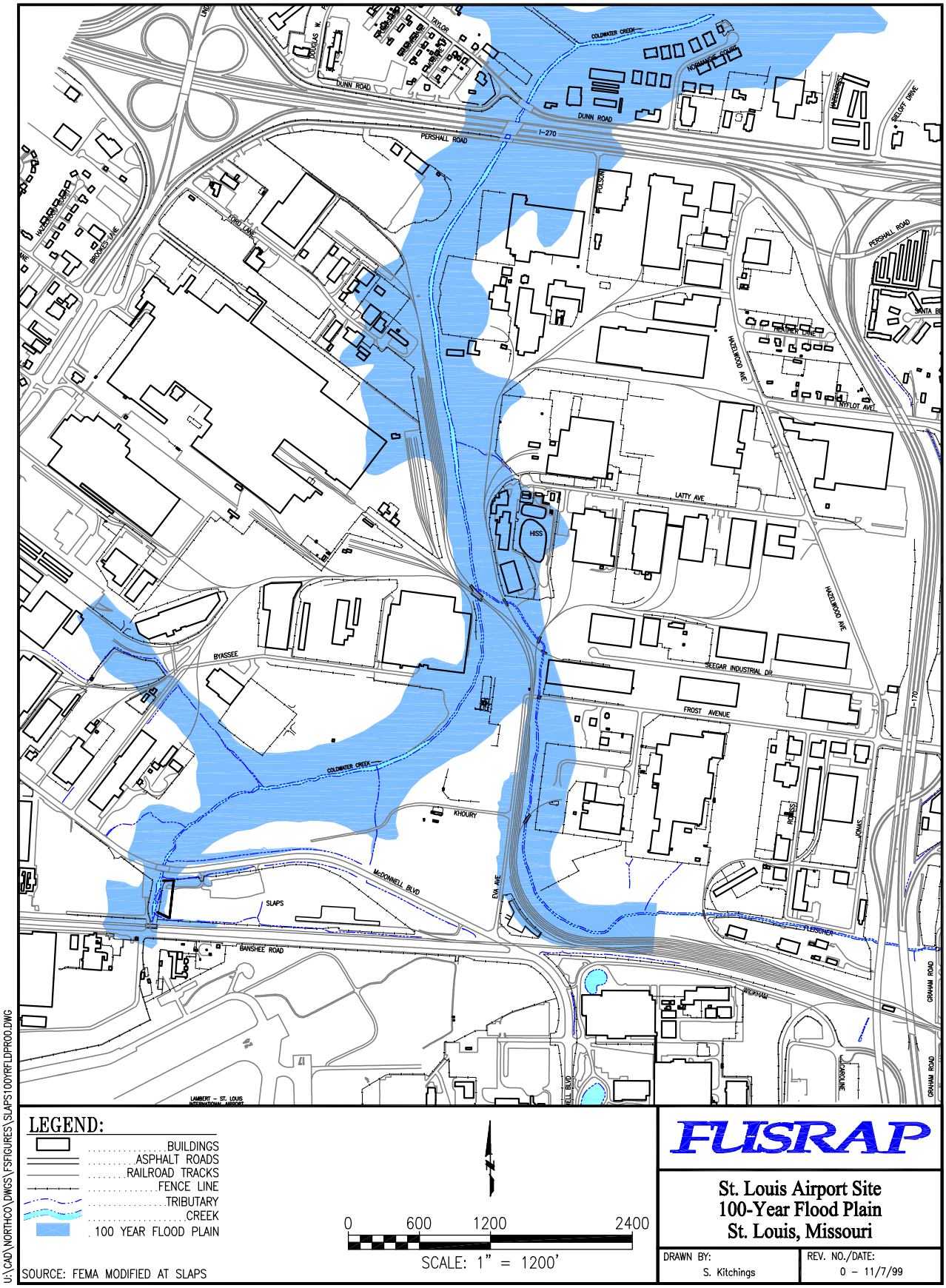


Figure 2-30. Extent of 100-Year Flood Plain



Figure 2-31 SLAPS, looking South - circa 1965

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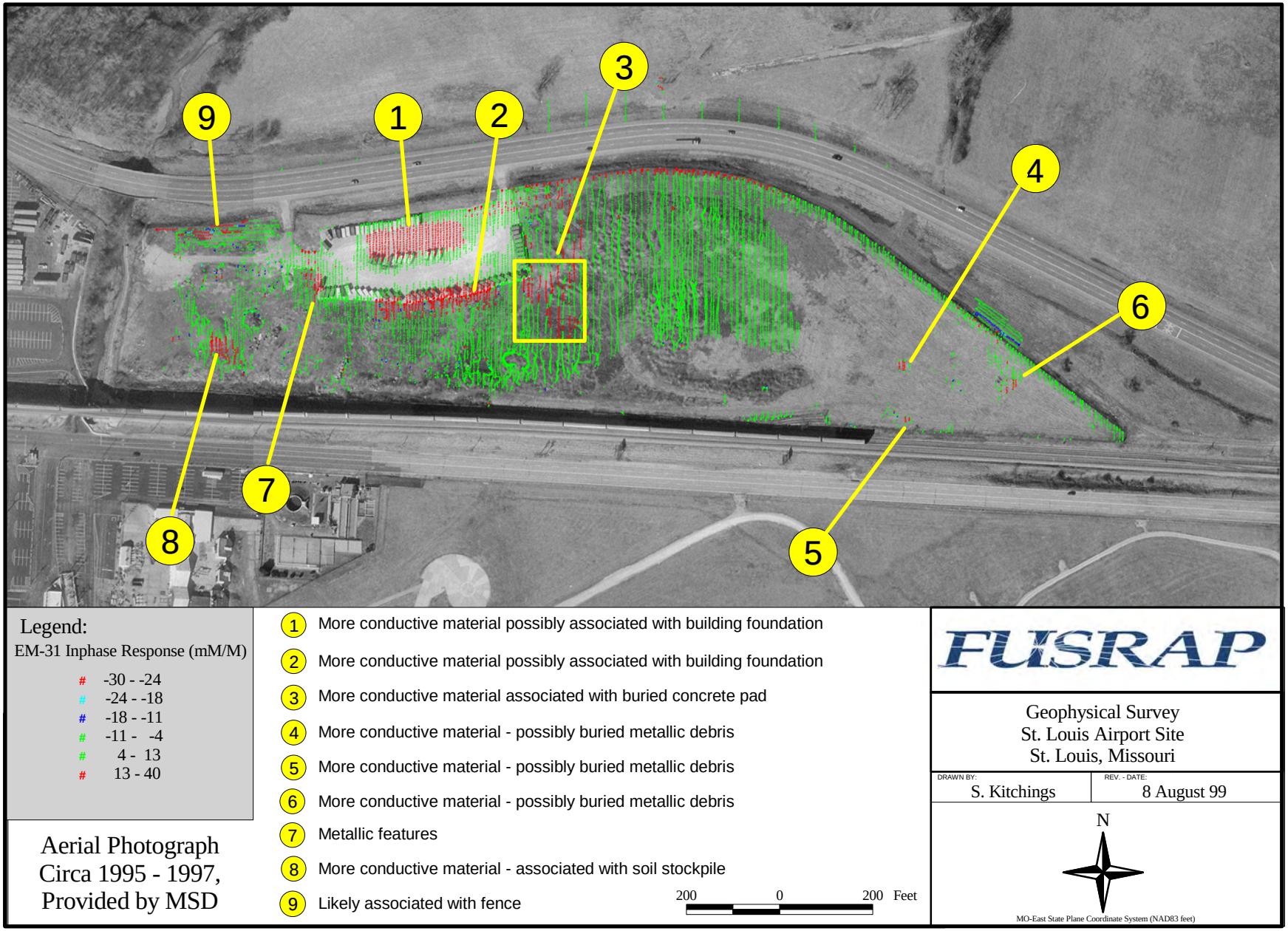


Figure 2-32. EM-31 Inphase Response Data at SLAPS

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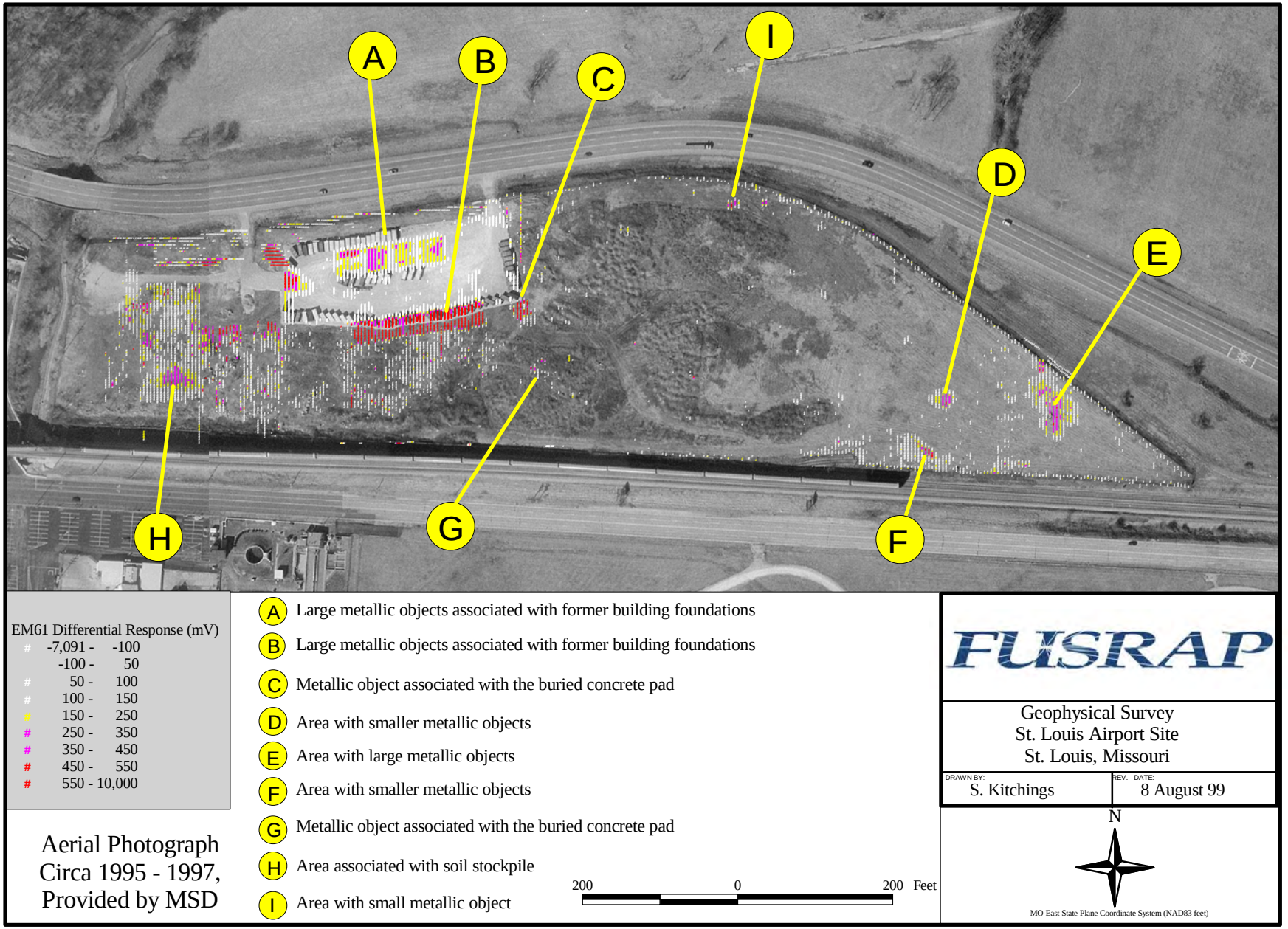


Figure 2-33. EM-61 Differential Response Data at SLAPS

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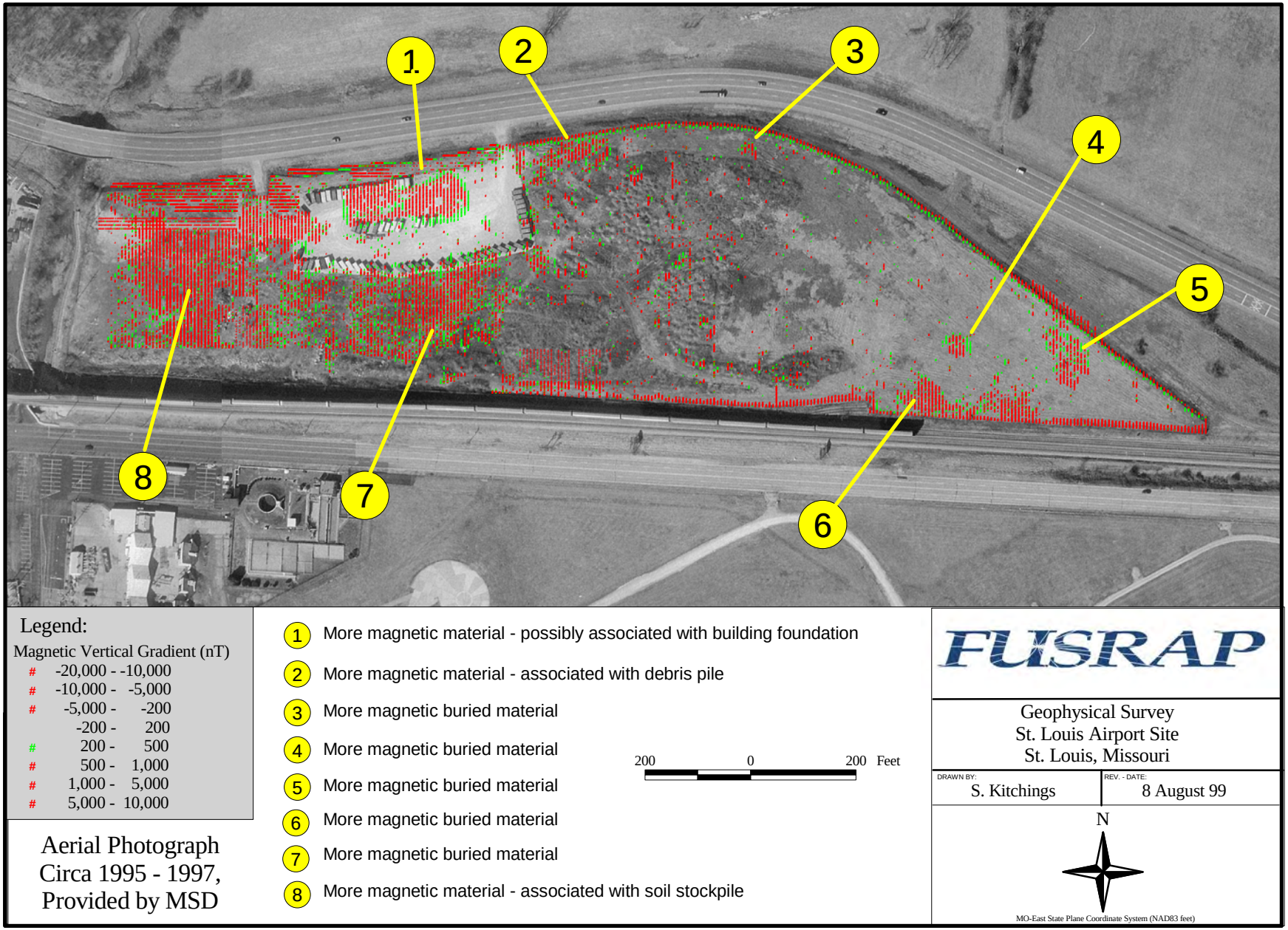


Figure 2-34. Magnetic Vertical Gradient at SLAPS

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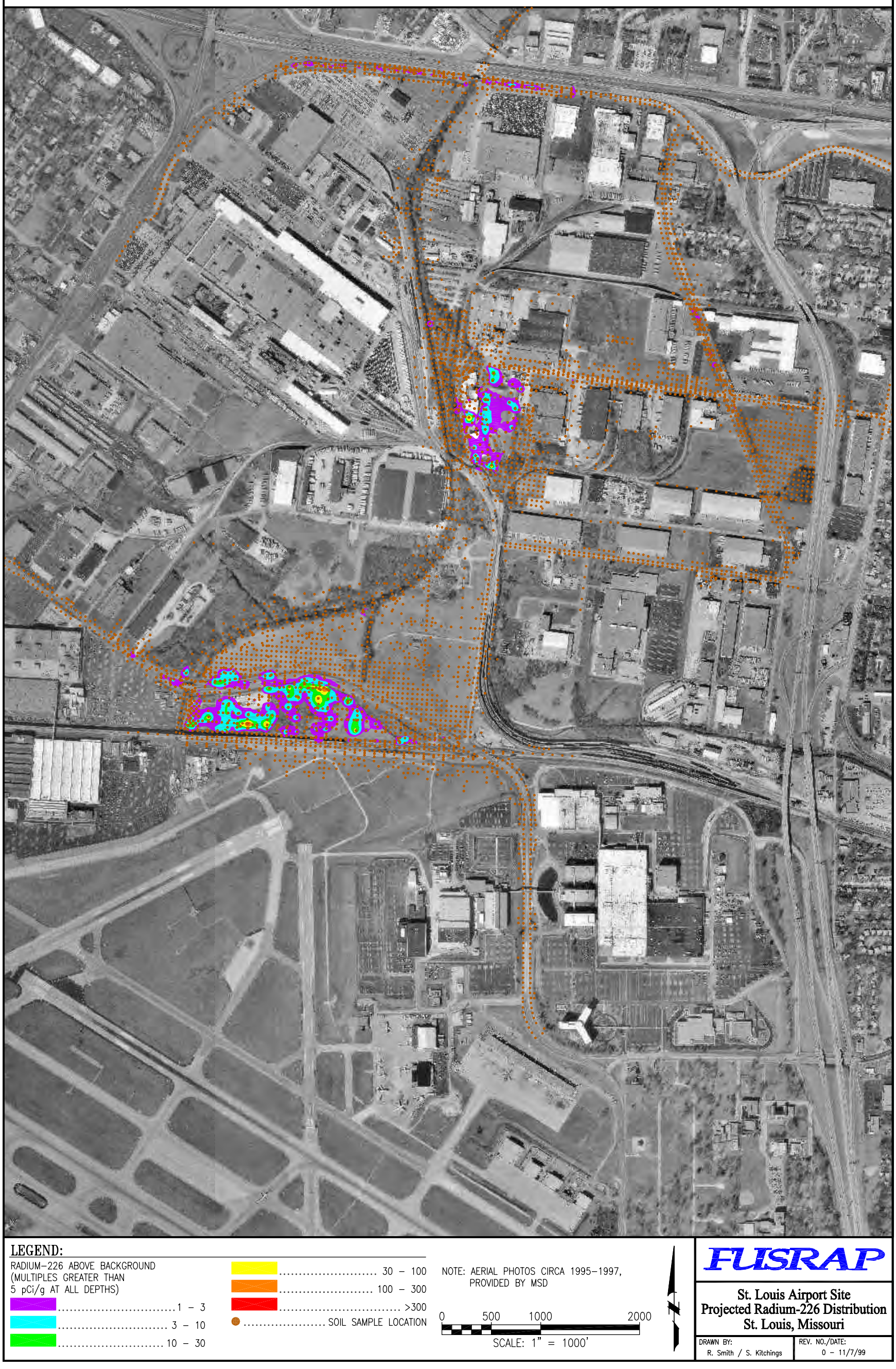


Figure 2-35. Projected Radium-226 Distribution at the North County Site

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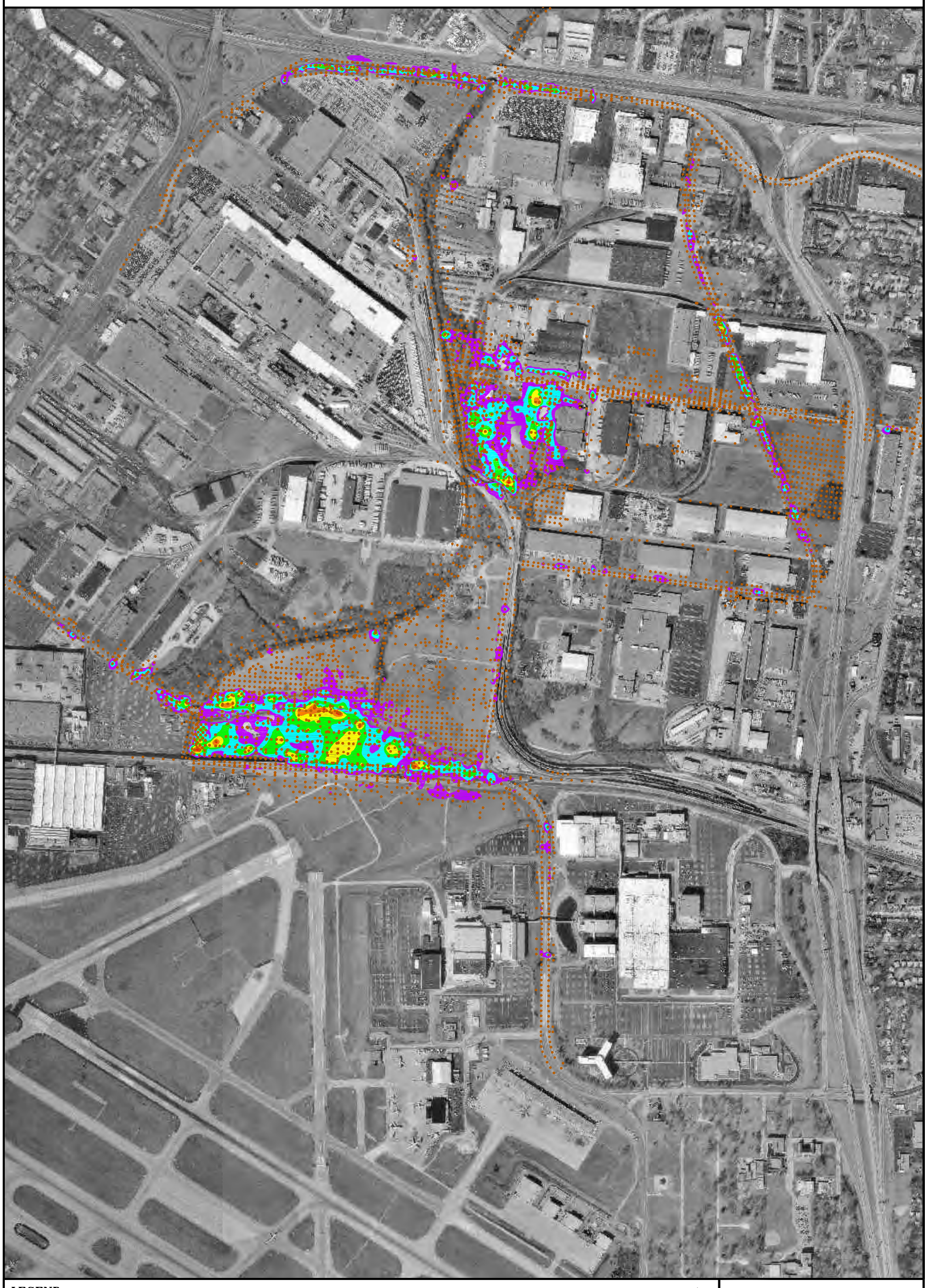


Figure 2-36. Projected Thorium-230 Distribution at the North County Site Before Removal Actions

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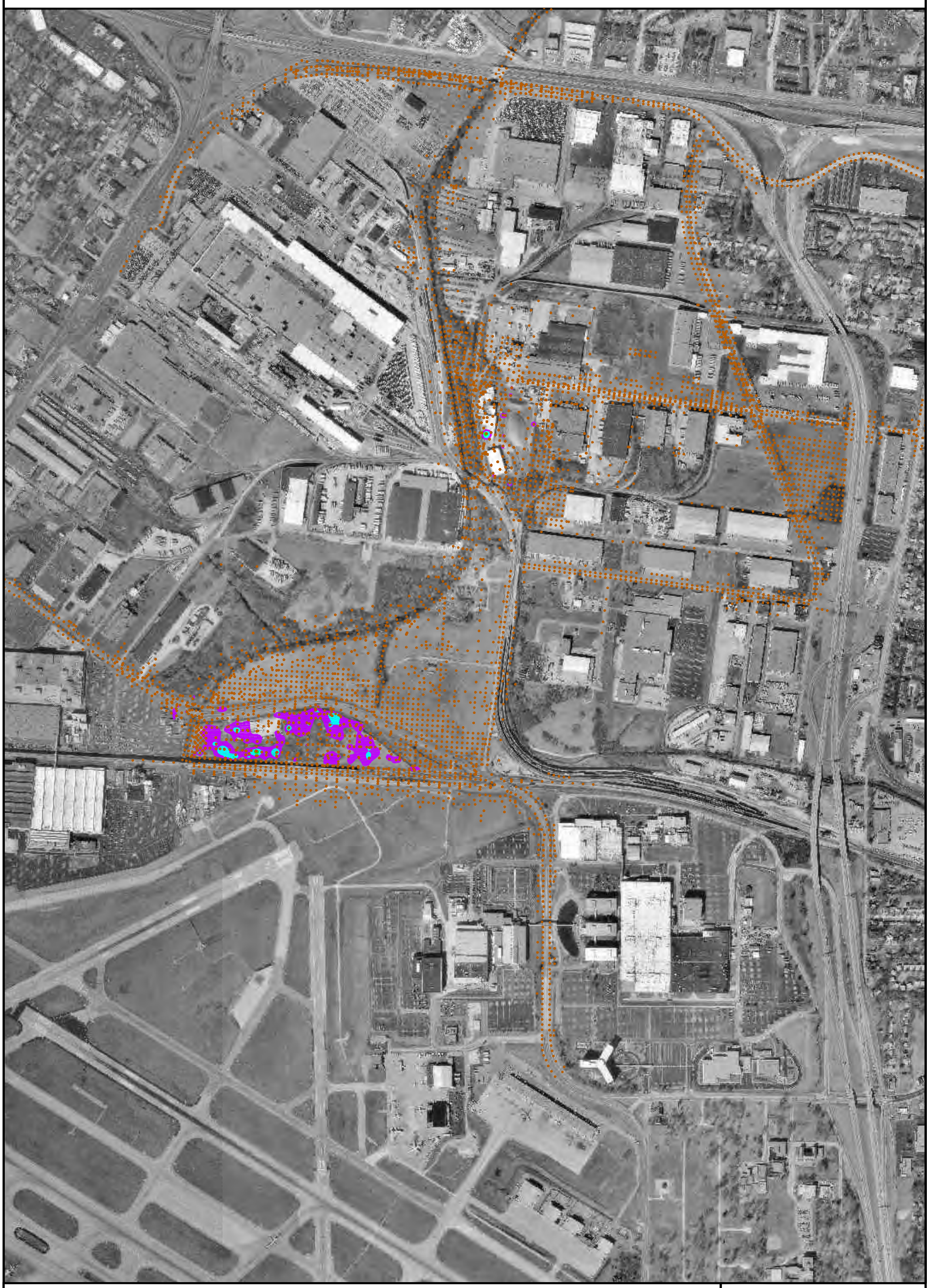


Figure 2-37. Projected Uranium-238 Distribution at the North County Site Before Removal Actions

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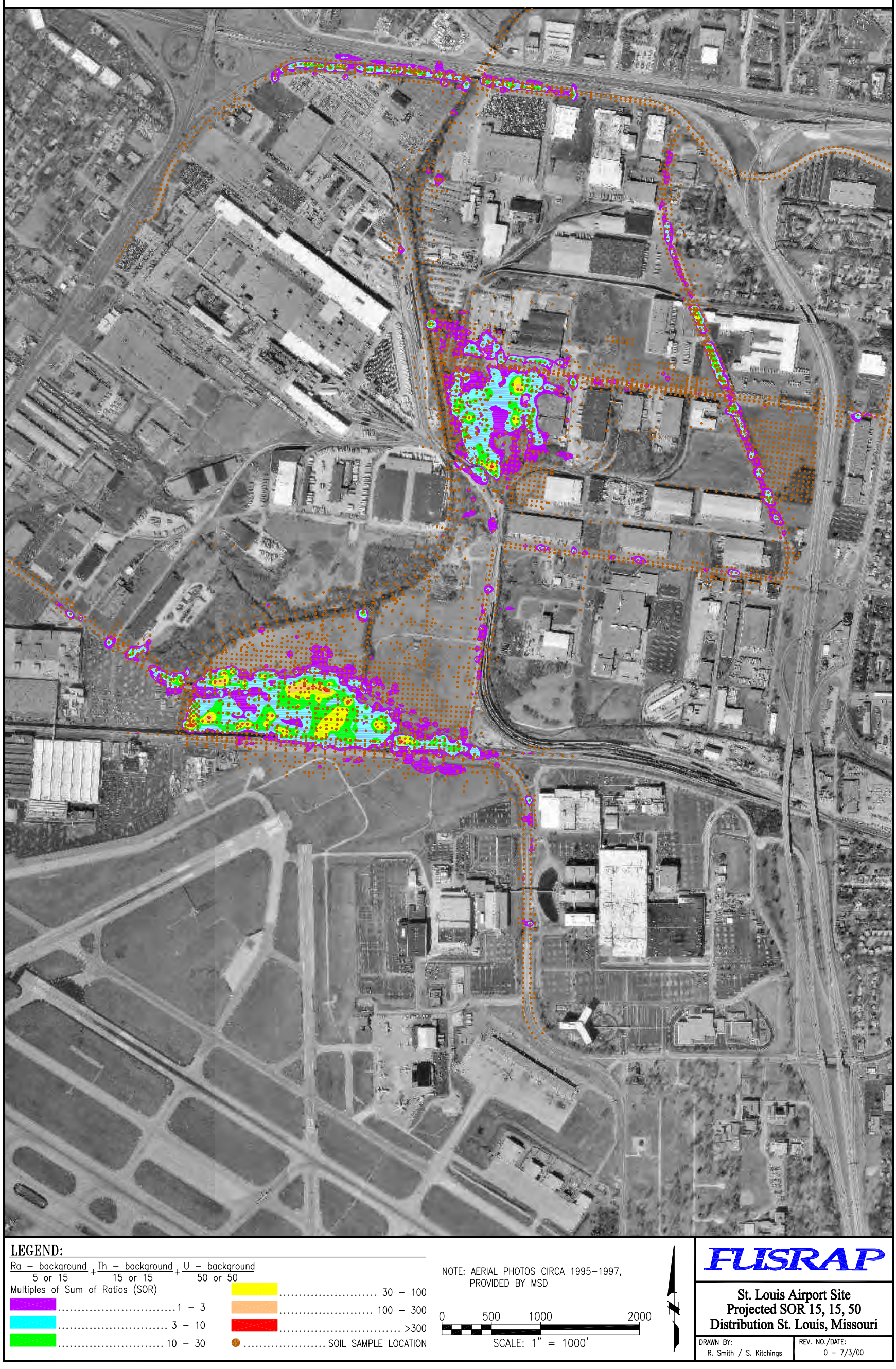


Figure 2-38. Projected Radioactivity Exceeding 5 pCi/g of Radium-226, 14 pCi/g of Thorium-230, 50 pCi/g of Uranium-238 or Combinations Such That the Sum of the Ratios =1 in Surface Soil and Exceeding 15 pCi/g of Radium-226, 15 pCi/g of Thorium-230, 50 pCi/g of Uranium-238 or Combinations Such That the Sum of the Ratios =1 in Subsurface Soil

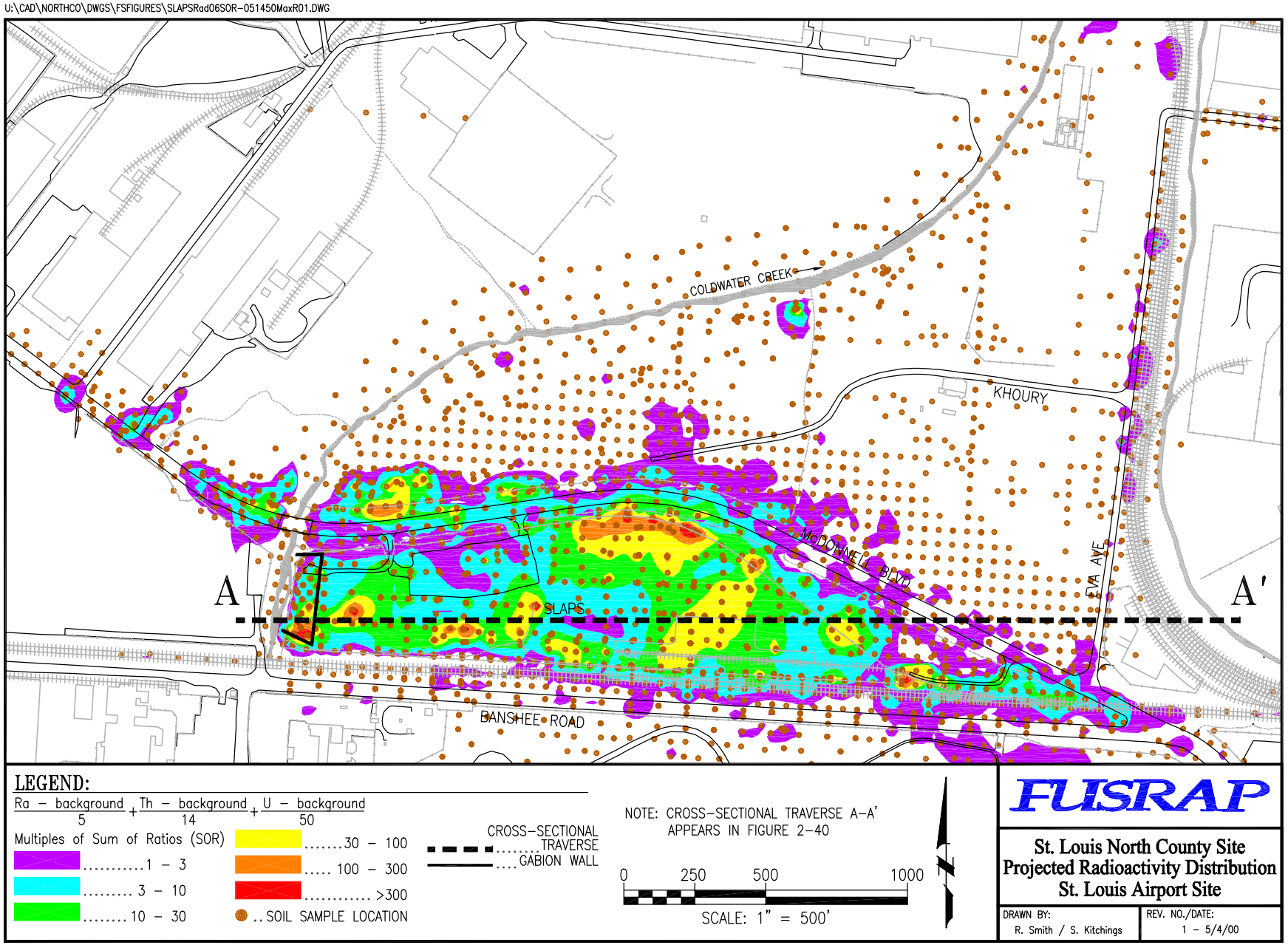


Figure 2-39. Projected Radioactivity Exceeding 5 pCi/g of Radium-226, 14 pCi/g of Thorium-230, 50 pCi/g of Uranium-238 or Combination Such That Sum of Ratio = 1 Around SLAPS

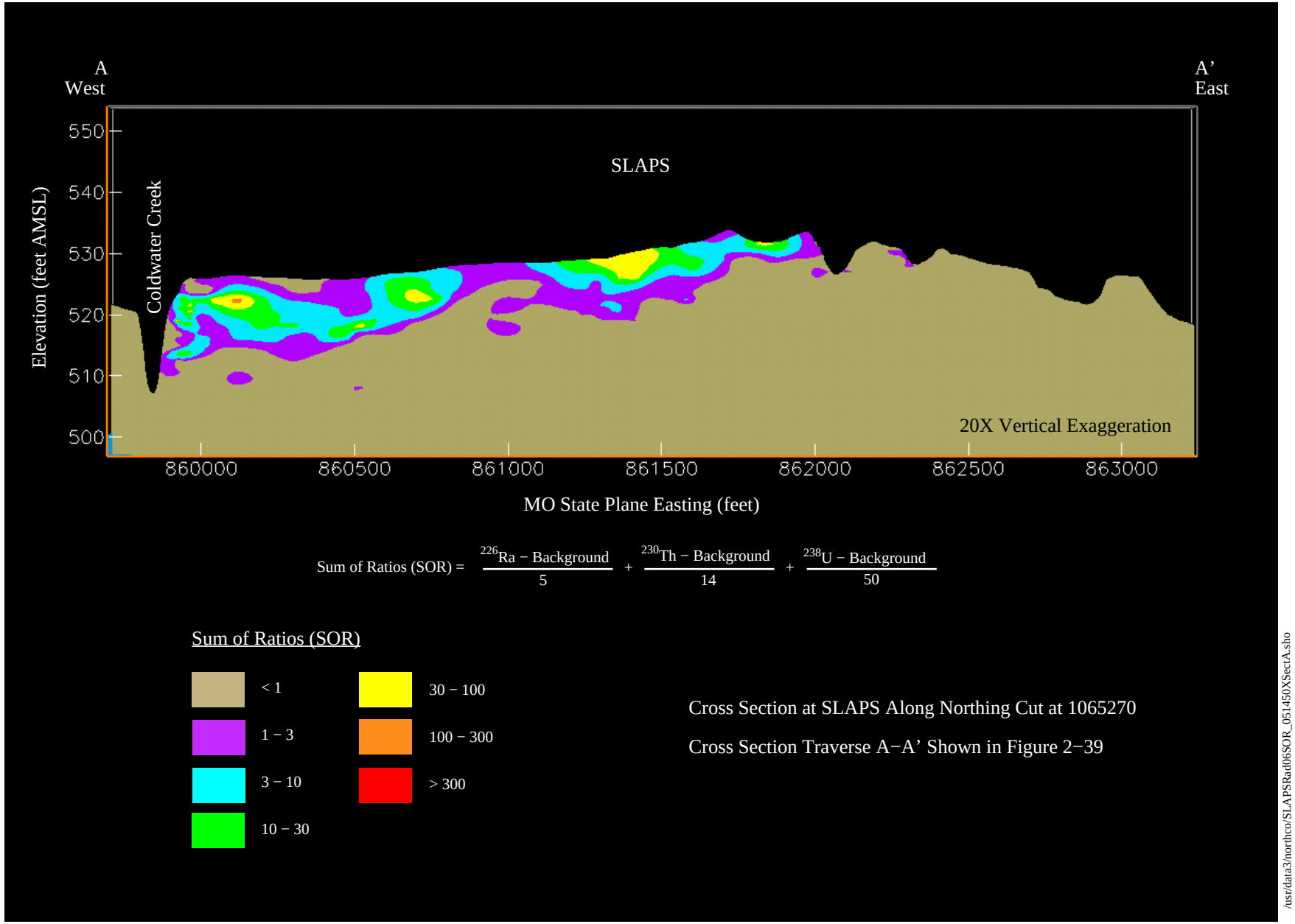


Figure 2−40. Cross Section at SLAPS of Projected Radioactivity Exceeding 5 pCi/g of Radium−226, 14 pCi/g of Thorium−230, and 50 pCi/g of Uranium−238

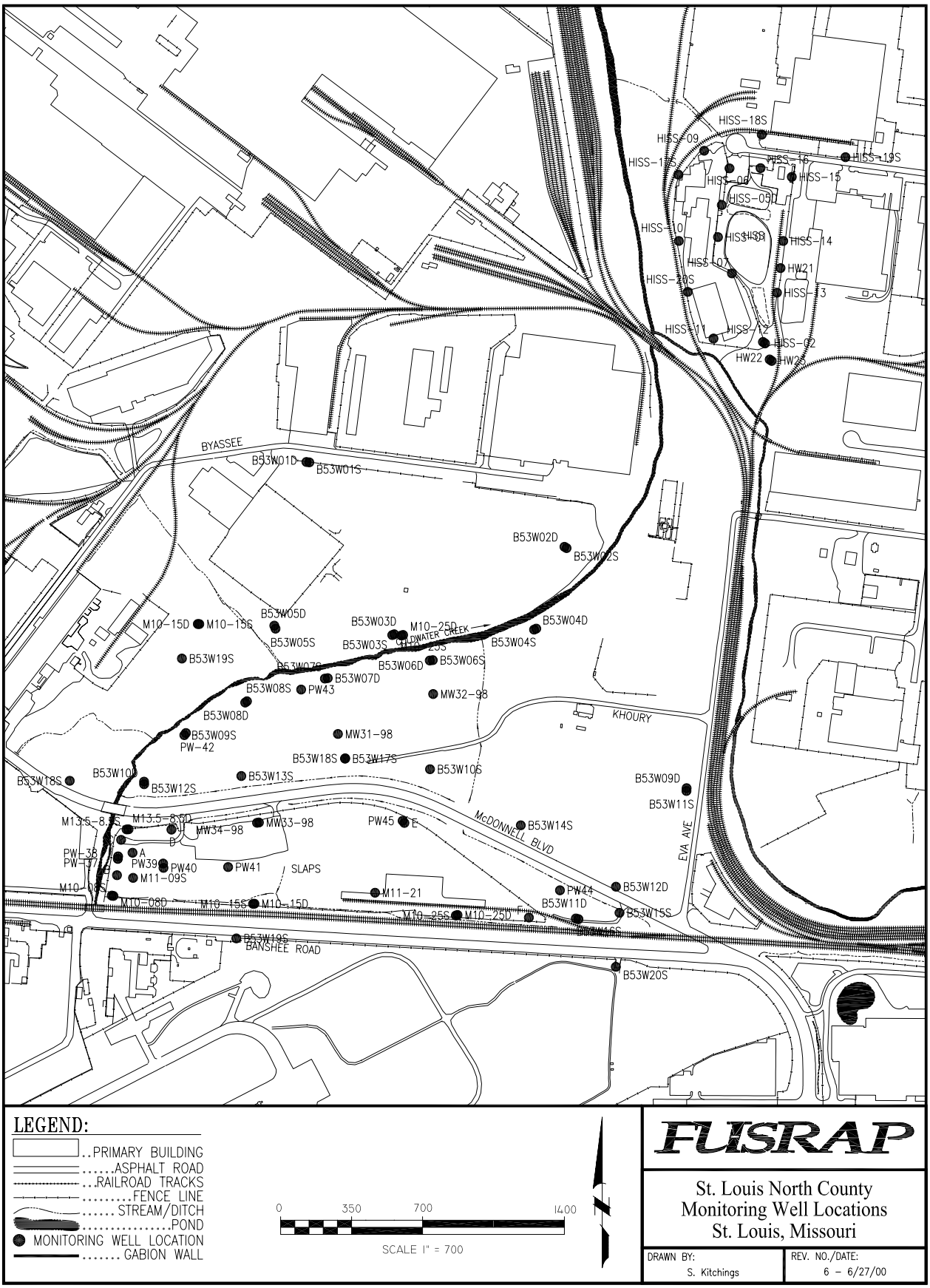


Figure 2-41. Monitoring Well Locations

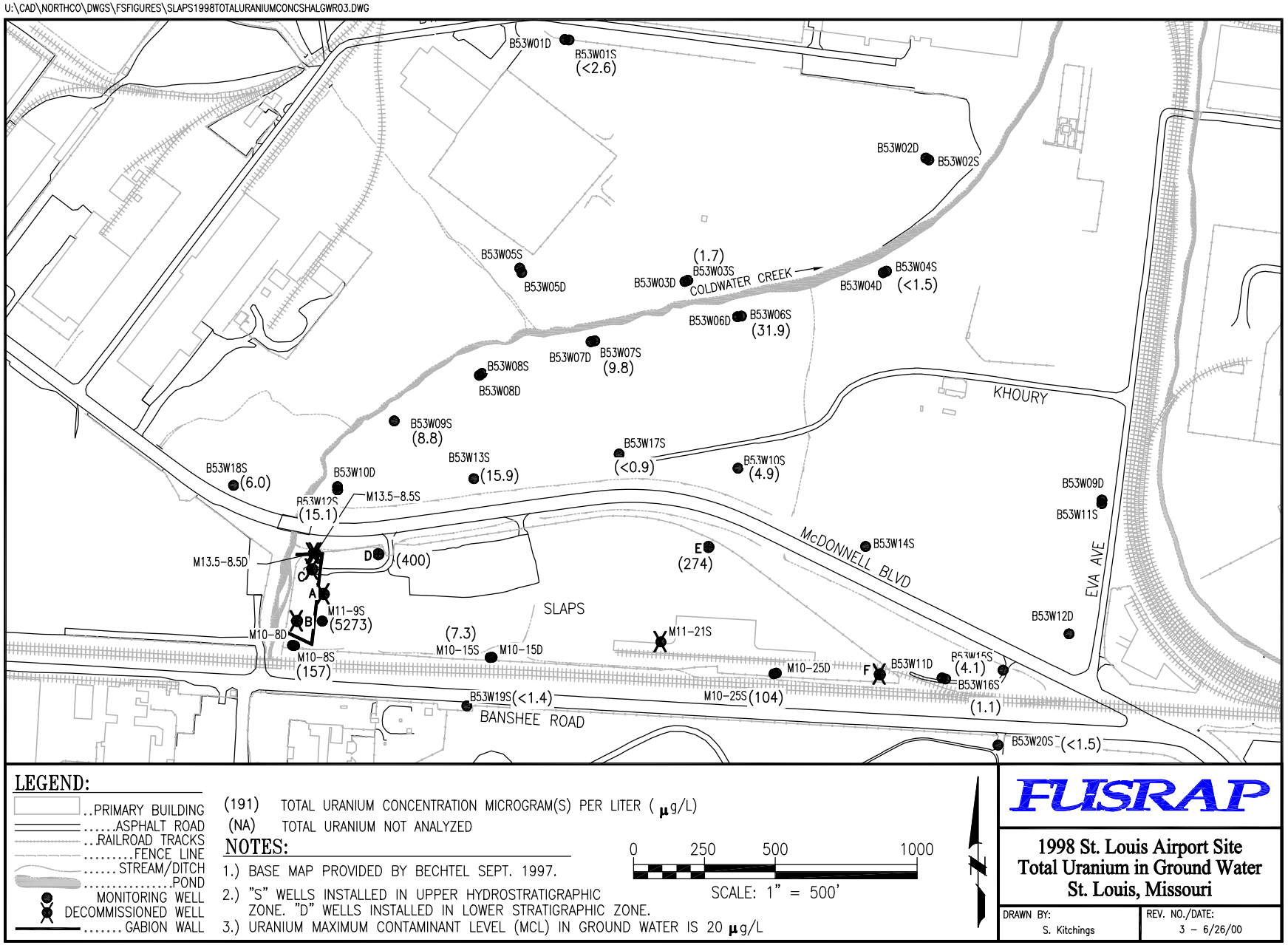


Figure 2-42. 1998 Total Uranium Concentrations in Shallow Ground Water at SLAPS

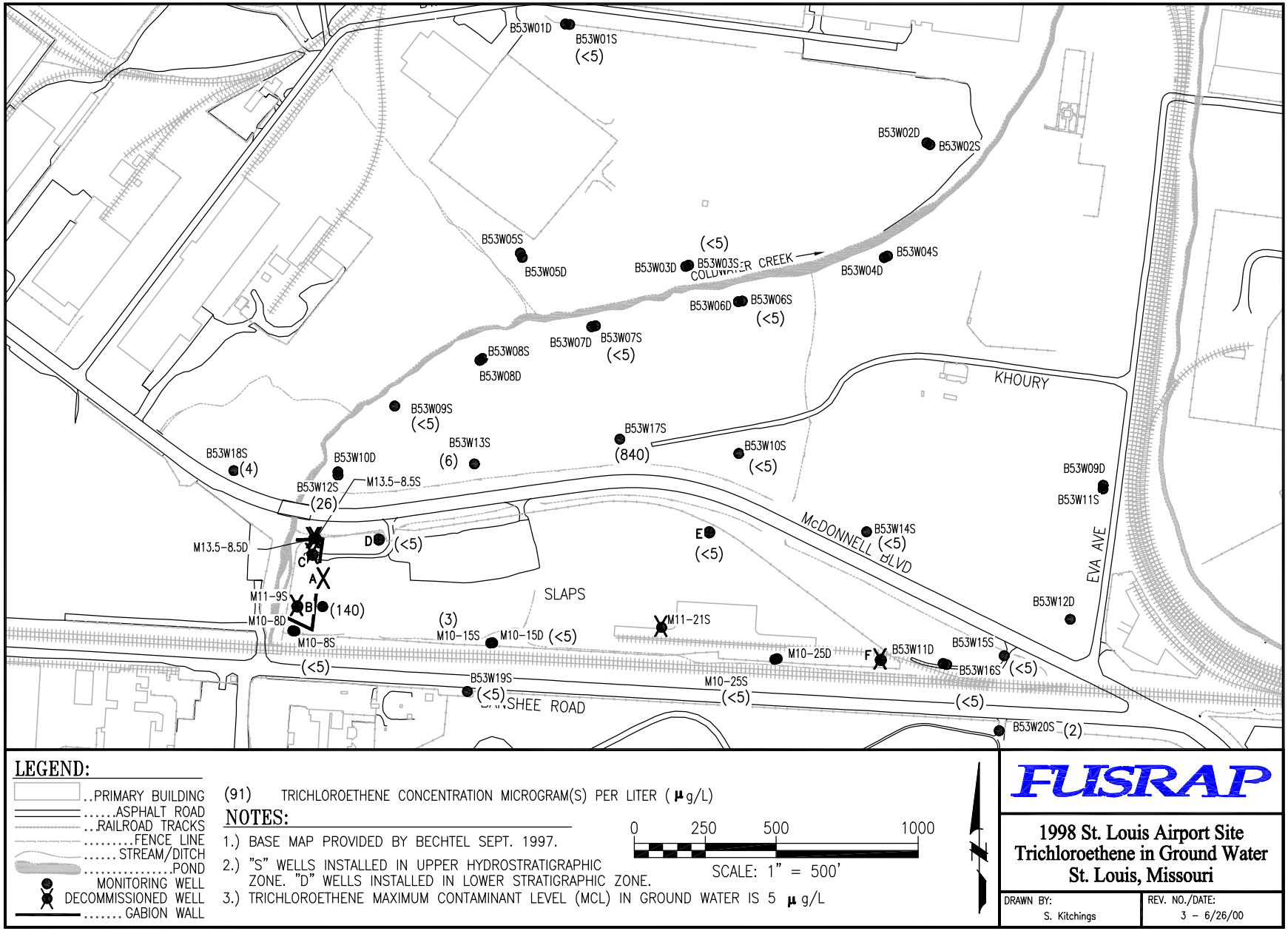


Figure 2-43. 1998 Trichloroethene Concentrations in Shallow Ground Water at SLAPS

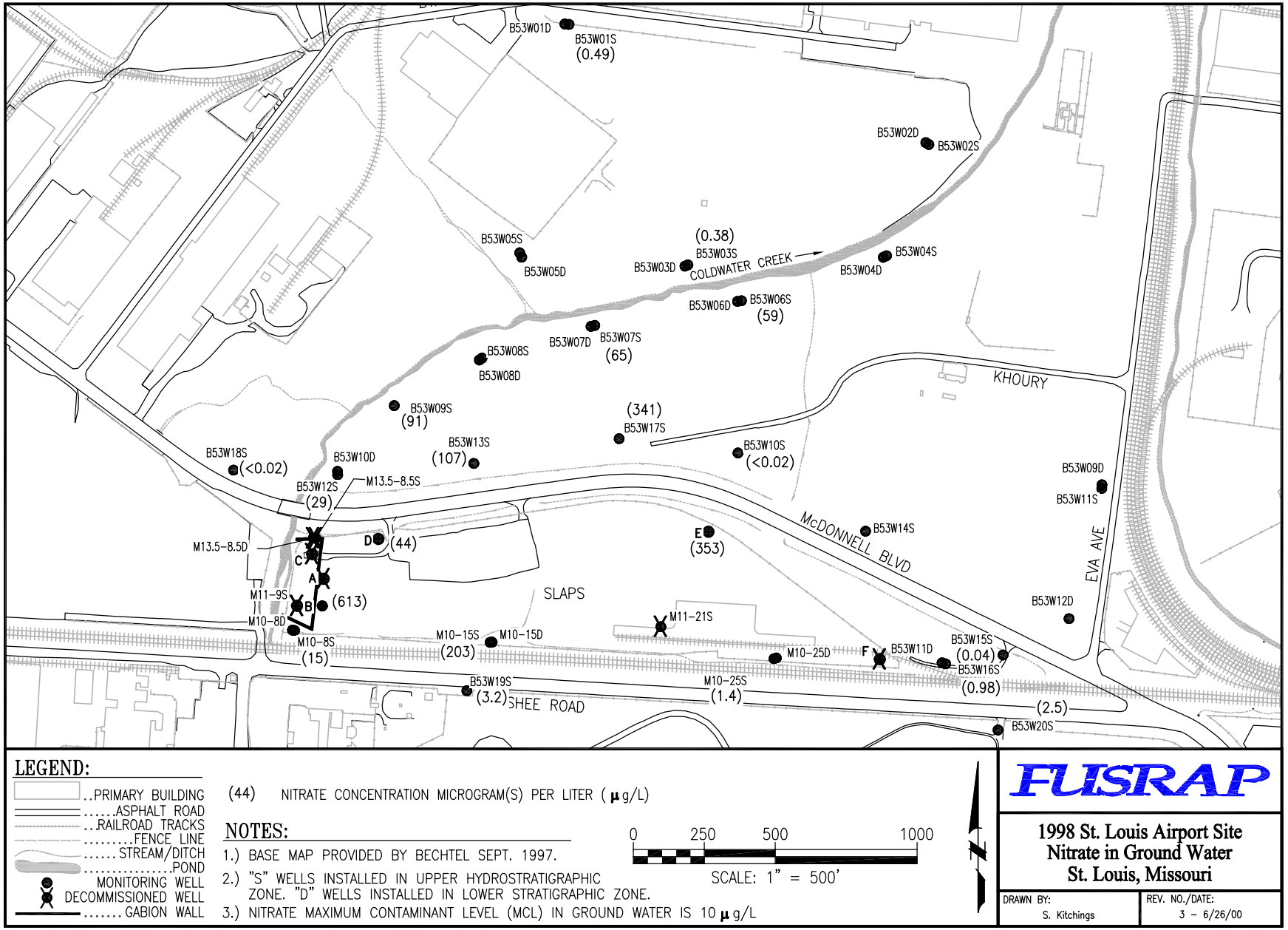


Figure 2-44. 1998 Nitrate Concentrations in Shallow Ground Water at SLAPS

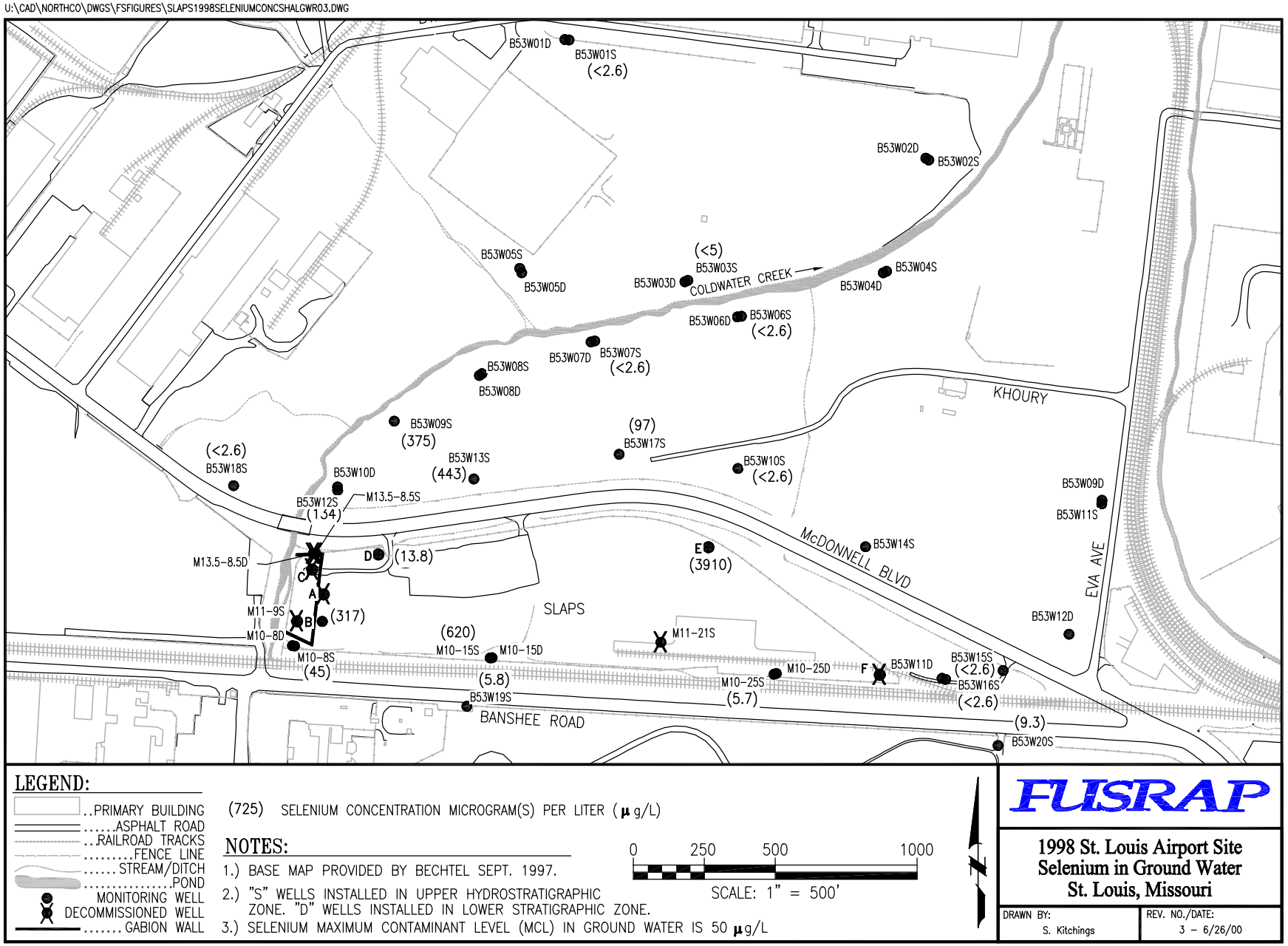


Figure 2-45. 1998 Selenium Concentrations in Shallow Ground Water at SLAPS



Figure 2-46. Projected Radioactivity Exceeding 5 pCi/g of Radium-226, 14 pCi/g of Thorium-230, 50 pCi/g of Uranium-238 or Combination Such That Sum of Ratio = 1 at HISS/Futura

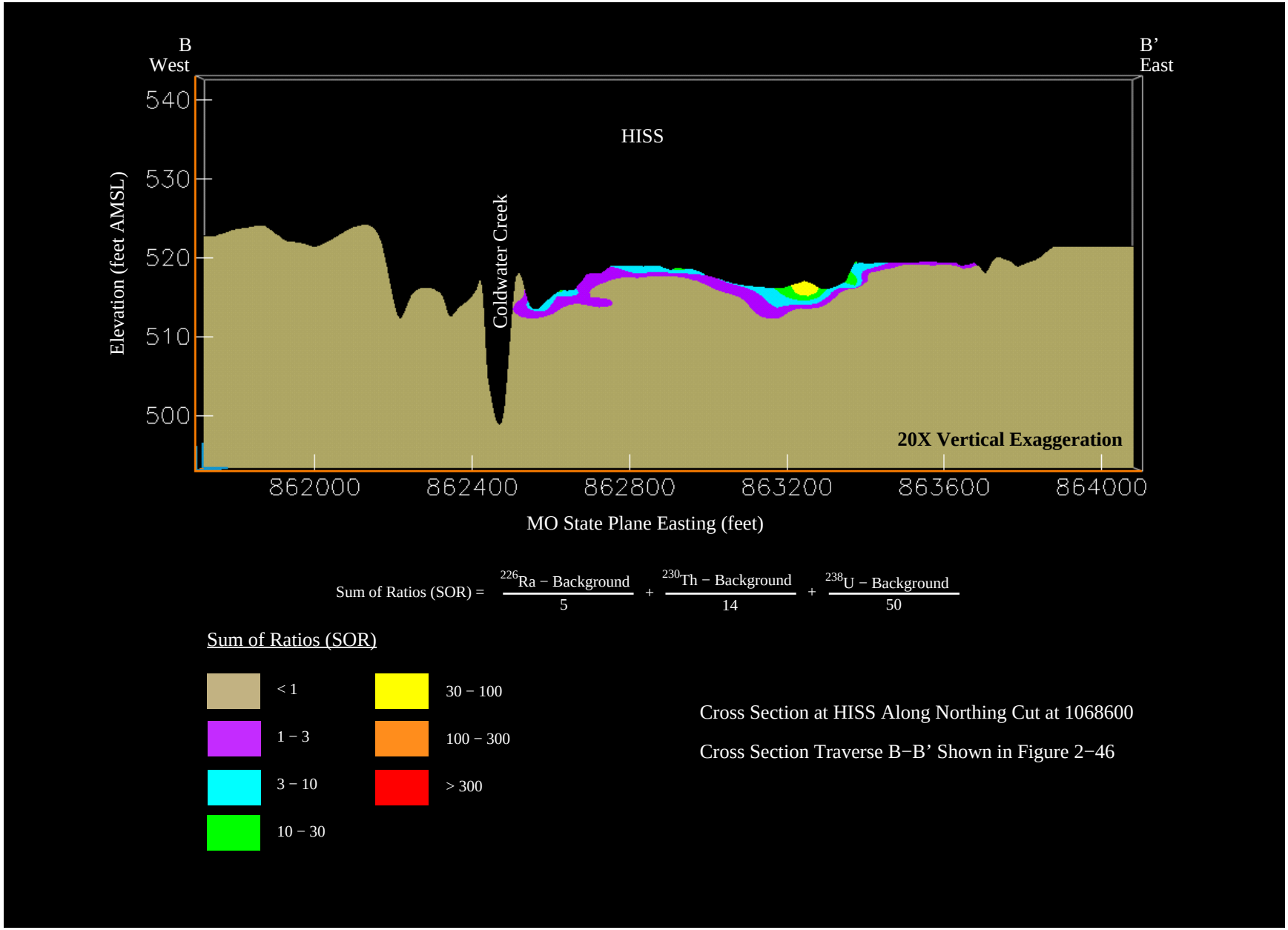


Figure 2−47. Cross Section at HISS of Projected Radioactivity Exceeding 5 pCi/g of Radium−226, 14 pCi/g of Thorium−230, and 50 pCi/g of Uranium−238

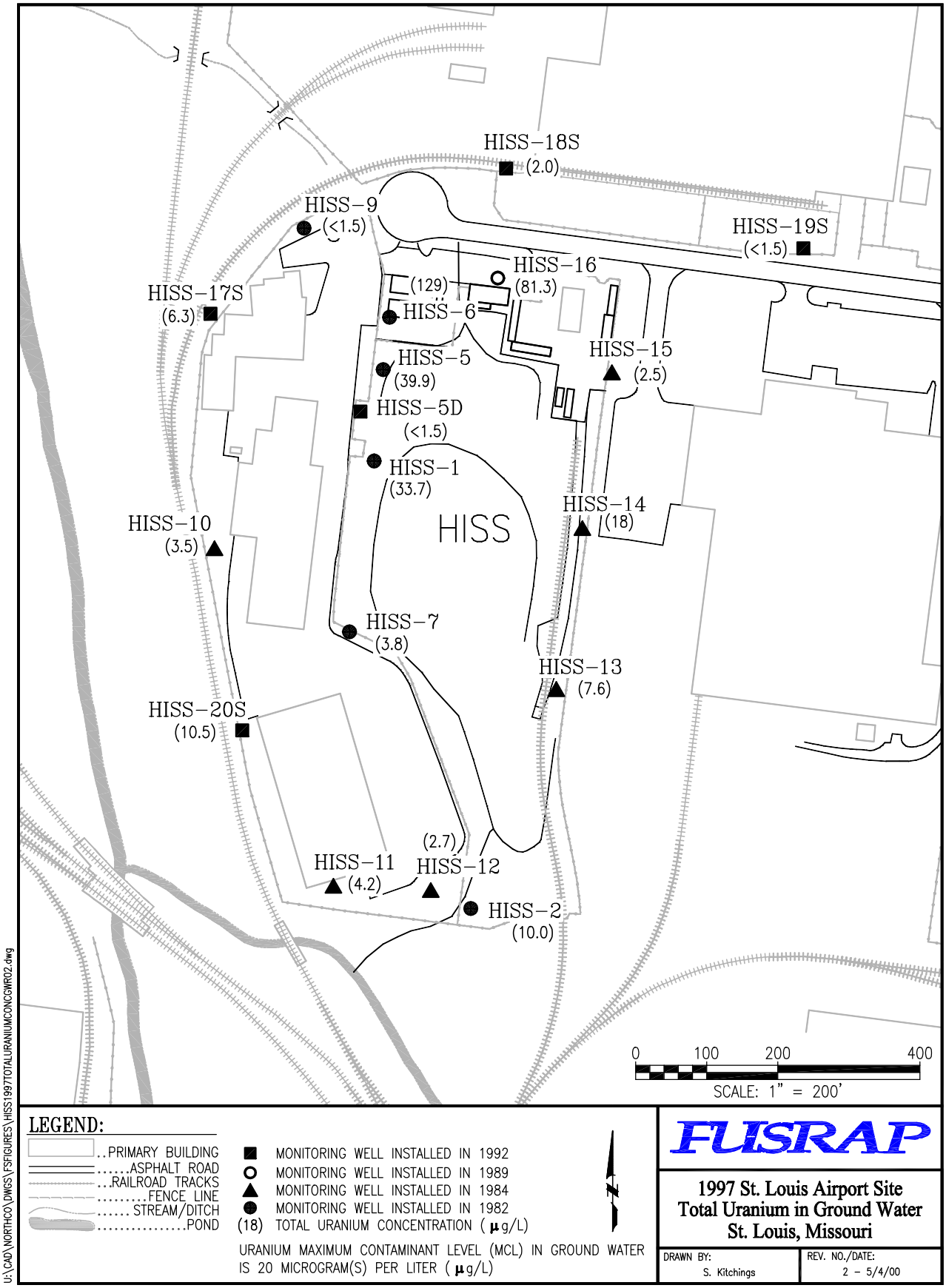


Figure 2-48. 1997 Total Uranium Concentrations in Ground Water at HISS/FUTURA

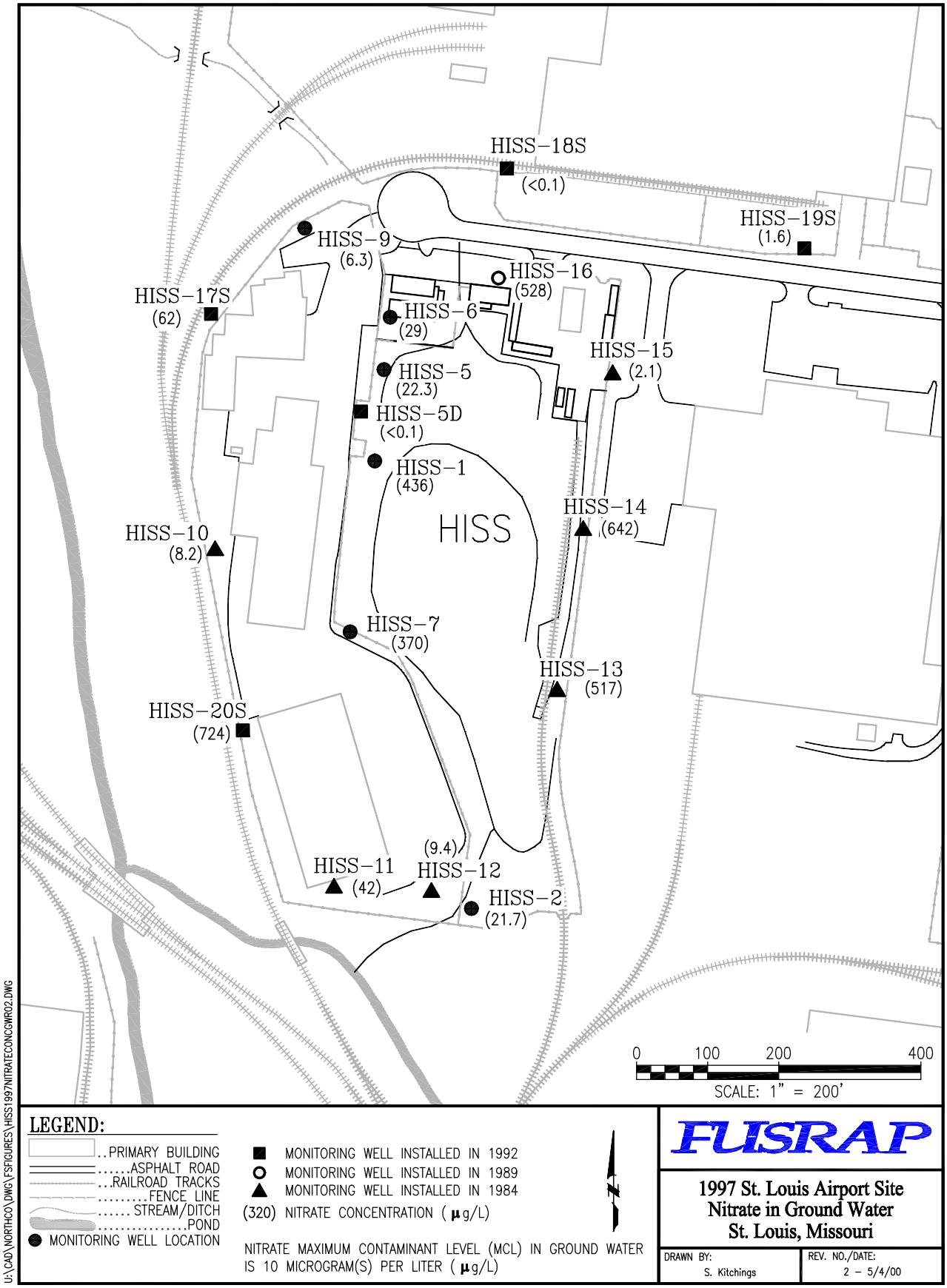


Figure 2-49. 1997 Nitrate Concentrations in Ground Water at HISS/FUTURA

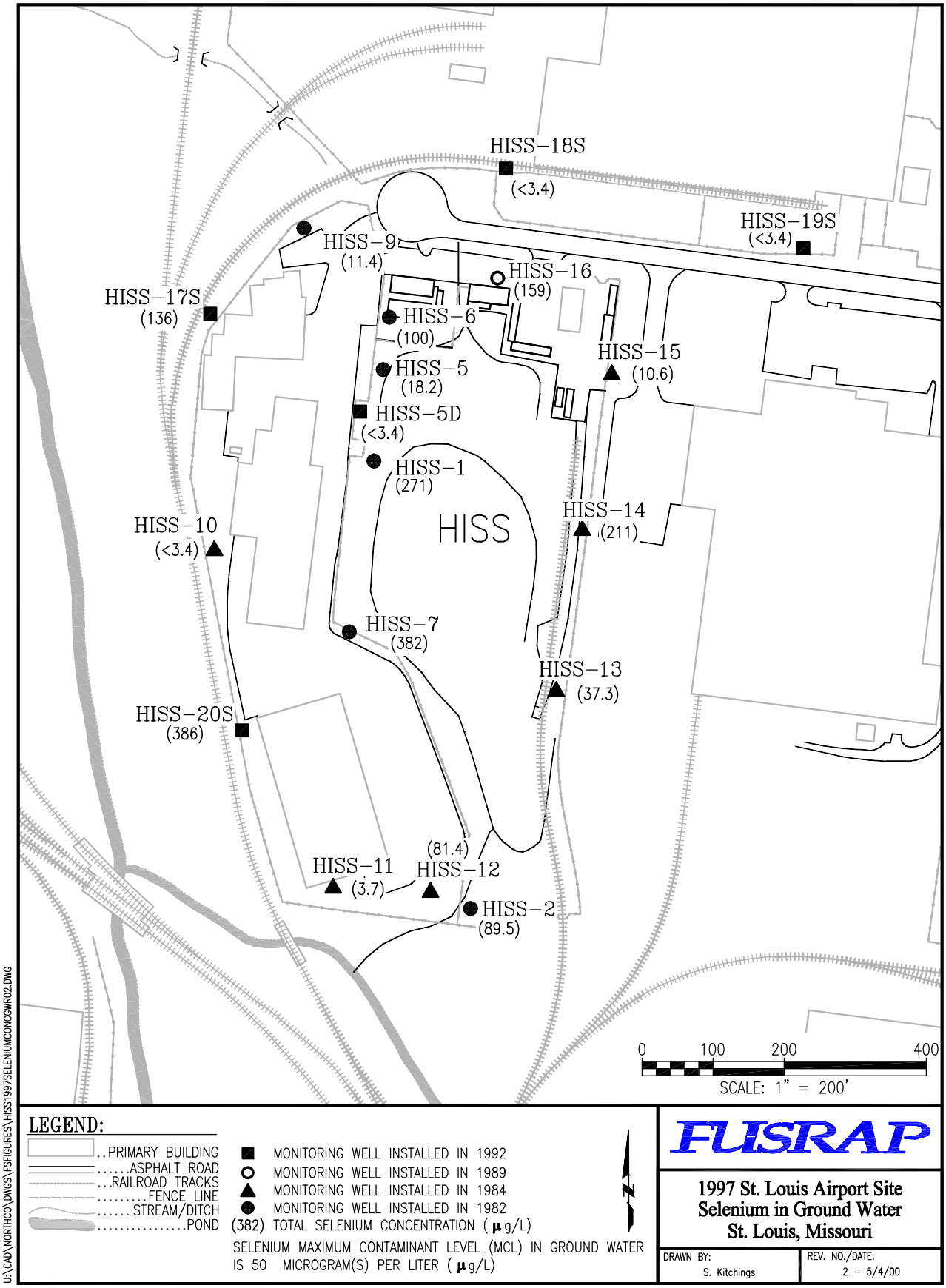


Figure 2-50. 1997 Selenium Concentrations in Ground Water at HISS/Futura

SECTION 3

IDENTIFICATION AND SCREENING OF REMEDIAL ACTION TECHNOLOGIES

3 IDENTIFICATION AND SCREENING OF REMEDIAL ACTION TECHNOLOGIES

This section focuses on identifying and screening remedial action technologies for the North County Site. Retained technologies are used to develop remedial action alternatives for the North County Site as discussed in Section 4.

3.1 INTRODUCTION

Identification of potential remedial action technologies involves the following steps:

- Identifying preliminary remedial action objectives (RAOs) specific to the contaminated environmental media;
- Identifying applicable or relevant and appropriate requirements (ARARs);
- Identifying general response actions (GRAs) (e.g., removal, treatment, and disposal) required to attain the RAOs;
- Identifying remedial action technologies and physical process options that can be applied for each of the GRAs and performing an initial screening to reduce the number of these options for further evaluation; and
- Evaluating retained technologies on the basis of effectiveness, implementability, and cost.

Section 3.2 develops RAOs for each medium of interest. Section 3.3 identifies ARARs. Section 3.4 identifies GRAs that satisfy RAOs for each medium of interest at the site. Section 3.5 identifies remediation goals (RGs) proposed for the North County Site. Section 3.6 presents a summary of remedial action technologies that address the contaminated media at the North County Site. Section 3.7 summarizes the evaluation and screening of remedial technologies.

3.2 REMEDIAL ACTION OBJECTIVES (RAOs)

3.2.1 General Process

RAOs developed in this Feasibility Study (FS) provide the basis for proposed remedial actions at the North County Site. RAOs are based on the nature and extent of contamination, threatened resources, the potential for human and environmental exposure, and reasonably anticipated future land uses. The RAOs for the North County Site are established, in general, to eliminate or minimize potential human exposure to soils and sediments contaminated with FUSRAP-related COCs at levels that exceed the standards established in the ARARs or the site-specific risk-based RGs. Although risk levels based on a commercial/industrial future anticipated land use are within the CERCLA risk range (10^{-6} to 10^{-4}) for most properties in the North County Site, action is required to comply with ARARs and site-specific RGs in order to produce residual

site conditions that allow for unlimited use and unrestricted exposure. As such, portions of the St. Louis North County site require remediation.

Alternatives for site remediation must comply with ARARs. Compliance with individual chemical-specific ARARs is considered to be protective except where multiple chemicals and/or multiple exposure pathways are present. Similarly, ARARs may not exist for a specific chemical or pathway of concern. It may, therefore, be necessary to develop risk-based preliminary remediation goals (PRGs) using site-specific information.

The first step in formulating remedial alternatives is to identify potential exposure pathways, and PRGs that consider reasonable maximum exposure (RME) based on reasonably anticipated future land use. The goals are defined in terms of risk-based exposure levels that are protective of human health and the environment, and are developed by considering ARARs and the following factors [see 1990 National Contingency Plan (NCP) at Section 300.430(e)(2)(i)]:

- For noncarcinogenic toxicants, acceptable threshold levels are those concentrations that the most susceptible human population may be exposed to over a lifetime without adverse effects. The U.S. Environmental Protection Agency (EPA) hazard index (HI) is a measure of the potential for adverse non-carcinogenic health effects due to exposure to site-related chemicals. The HI is based on a comparison of the average daily intake of a receptor to the threshold level at which adverse effects are observed. A HI of one or greater indicates that there may be a concern for non-carcinogenic effects associated with exposure to site-related chemicals.

- For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess lifetime cancer incidence to an individual in the range of 10^{-6} (one in a million) to 10^{-4} (one in ten thousand). This range is intended to provide case-by-case flexibility, although the 10^{-6} risk level is the point of departure for determining goals for alternatives when ARARs are unavailable.

- Risk-based PRGs are developed in the case of multiple contaminants, where the attainment of ARARs will result in a cumulative risk in excess of 10^{-4}.

- Water quality criteria established under sections (sic) 303 or 304 of the Clean Water Act (CWA) shall be attained where relevant and appropriate under circumstances of the release.

- An alternate concentration limit (ACL) may be established in accordance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121(d)(2)(B)(ii).

- Environmental evaluations shall be performed to assess threats to the environment, especially sensitive and critical habitats of species protected under the Endangered Species Act.

- Other factors may be related to technical limitations, uncertainty, reasonable future land use, and other pertinent information.

3.2.2 Development of Media-Specific RAOs for the North County Site

Media-specific RAOs were developed for the North County Site for soils, and sediments and to ensure continued protection of the surface water. In general, mitigation of the exposure pathways of concern and compliance with ARARs provide a framework for media-specific RAOs. Media-based RAOs are shown in Table 3-1. Potential environmental pathways include:

- Direct contact with soils through ingestion and dermal contact;
- External gamma radiation from the soil. Risks are usually dominated by risks from gamma-emitting radionuclides in surface soils;
- Inhalation of fugitive dust from contaminated soils and radon gas emissions due to the radioactive decay of radium-226 (Ra-226);
- Off-site migration of contamination carried by erosion (e.g., surface-water runoff);
- Uptake by biota (i.e., animals and plants) of contamination; and
- Potential transport from contaminated soils and sediments to surface water or drinking water.

Table 3-1. Remedial Action Objectives for Remediation of the North County Site

Media	Remedial Action Objectives
Soils and Sediments	Eliminate or minimize potential human exposure to soils and sediments contaminated with FUSRAP-related COCs at levels that exceed the standards established in the ARARs or the site-specific remediation goals. Prevent exposures from residual contamination in soils and sediments with concentrations greater than remediation goals Eliminate or minimize volume, toxicity, and mobility of contaminated soils and sediments Eliminate or minimize the potential migration of contaminants off-site including the potential for migration to ground water and surface water, by removing the sediment and soil sources.

3.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

3.3.1 Definition of CERCLA Requirements

Section 121(d)(2) of CERCLA sets requirements with respect to any hazardous substance, pollutant, or contaminant that will remain on-site. Remedial actions must, upon completion, achieve a level or standard of control that at least attains legally applicable or relevant and appropriate standards, requirements, criteria, or limitations under Federal environmental law. The actions must also meet any promulgated standard, requirement, criteria or limitation under a State environmental or facility siting law that is more stringent than any

Federal standard, requirement, criteria, or limitation (ARARs). These standards apply unless such standard, requirement, criteria, or limitation is waived in accordance with Section 121(d)(4).

Identifying ARARs involves determining whether a requirement is applicable, and if it is not applicable, then whether a requirement is relevant and appropriate. Individual ARARs for each site must be identified on a site-specific basis. Factors that assist in identifying ARARs include the physical circumstances of the site, contaminants present, and characteristics of the remedial action.

Applicable requirements are defined as "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site" (40 CFR 300.5). A law or rule is applicable if the jurisdictional prerequisites of the law or rule are satisfied. These jurisdictional prerequisites include:

- Who, as specified by the statute or regulation, is subject to its authority;
- The types of substances or activities listed as falling under the authority of the statute or regulation;
- The time period for which the statute or regulation is in effect; and
- The type of activities the statute or regulation requires, limits, or prohibits.

Only those state requirements that are (1) promulgated so that they are of general applicability and legally enforceable, (2) identified by a state in a timely manner, and (3) more stringent than federal standards, may be applicable.

The NCP states that a relevant and appropriate requirement is a standard, requirement, criteria, or limitation under a Federal environmental law or a more stringent State environmental or facility siting law, which is not legally applicable to the hazardous substance or pollutant or contaminant, but which is relevant and appropriate under the circumstances of the release of the hazardous substance or pollutant or contaminant.

Determining whether a requirement is relevant and appropriate is a two-step process that involves determining whether the rule is relevant, and, if so, whether it is appropriate. A requirement is relevant if it addresses problems or situations sufficiently similar to the circumstances of the remedial action contemplated. It is appropriate if it is well suited to the site. In determining whether a requirement is both relevant and appropriate, the following factors may be used to evaluate a requirement.

- The purpose of the requirement and the purpose of the response action;
- The medium regulated or affected by the requirement and the medium contaminated or affected at the site;
- The substances regulated by the requirement and the substances found at the site;
- The actions or activities regulated by the requirement and the remedial action contemplated at the site;

- Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the site;
- The type of place regulated and the type of place affected by the release or response action;
- The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the response action; and
- Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resource at the site.

In addition, it should be considered whether another requirement is available that more fully matches the circumstances at the site.

Only applicable requirements are pertinent for off-site actions, whereas both applicable and relevant and appropriate requirements are pertinent for on-site actions. A determination of relevance and appropriateness may be applied to only portions of a requirement, whereas a determination of applicability is made for the requirement as a whole.

CERCLA Section 121(e) and 42 USC 9621(e) provide that no permit is required for the portion of any removal or remedial action conducted entirely on-site. Although no permit is required, on-site actions must comply with substantive requirements of ARARs, but not with related administrative and procedural requirements. For example, remedial actions conducted on-site would not require a permit but must be conducted in a manner consistent with permitted conditions as if a permit were required.

Subsection 3.3.2 discusses which statutes and regulations are ARARs, as that term is defined in CERCLA, for the cleanup of contamination present at the North County Site.

ARARs have been classified into three types: chemical-specific requirements, location-specific requirements, and action-specific requirements. Chemical-specific requirements are media-specific and health-based limits (criteria) developed for site-specific levels of contaminants in specific media. Location-specific standards are based on particular characteristics or locations of the site. Action-specific requirements are those with which design, performance, and other aspects of implementation of specific remedial activities must comply. No location-specific or action-specific ARARs are identified for the North County Site.

3.3.2 Chemical-Specific ARARs

Chemical-specific ARARs are health- or risk-based numerical values that, when applied to site-specific conditions, can be used to formulate PRGs. These values reflect potentially acceptable amounts or concentrations of a chemical that may remain in affected media or be discharged to the ambient environment. When determining the cleanup level criteria, chemical-specific ARARs are initially used to establish PRGs (55 FR 8715). If a chemical has more than one applicable requirement, then the most stringent generally should apply. The chemicals found with the highest concentrations and that produce the majority of the risks in the North County Site are radium, thorium, uranium and their associated decay products. The additional contaminants of concern (COCs) were described in Section 2.

For establishing cleanup levels for radionuclides in soil and buildings, two rules that establish numerical standards are relevant and appropriate requirements at the North County Site. These standards are: Title 40 Code of Federal Regulations, Part 192 Subparts A, B, and C, established by the EPA under the authority of Uranium Mill Tailings Radiation Control Act (UMTRCA), and 10 CFR Part 40 Appendix A Criterion 6(6), established by U.S. Nuclear Regulatory Commission (NRC) for source and by-product material and patterned to supplement the 40 CFR Part 192 standards. For remediation of the North County Site, 40 CFR Part 192 Subparts A, B, and C will be relied on as the primary standard for cleanup levels in soil, with 10 CFR Part 40 Appendix A Criterion 6(6) used as an ARAR for soils and buildings.

40 CFR Part 192: Subpart A: Standards for Control of Residual Radioactive Materials from Inactive Uranium Processing Sites; Subpart B: Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites; Subpart C: Implementation: 40 CFR Part 192 standards were promulgated to manage mill tailings and residual radioactive material from uranium and thorium processing activities. 40 CFR Part 192 Subparts A, B, and C apply to inactive sites designated either in Title I of UMTRCA or by the U.S. Department of Energy (DOE). 40 CFR Part 192 standards are not applicable to the North County Site because the North County Site is not designated in Title I or by the DOE, and the North County Site is not an active processing facility. However, the materials stored at the North County Site are the residuals from uranium ore processing and are the same kinds of materials as those regulated under UMTRCA. The radiological contaminants within the North County Site are pre-1978 11e(2) by-product materials that resulted from the extraction of uranium from the associated ores. The processing site as defined in 40 CFR Part 192 includes any site, including the mill, and any other "real property or improvement thereupon that is determined to be contaminated with residual radioactive material derived from the site." Each of the North County Site properties is "in the vicinity of such site" (i.e., SLDS). As such, given the type of contaminants, amount of activity, method of deposition, and operational relationship, 40 CFR Part 192 is taken as relevant and appropriate for the North County Site even though this site is physically separate from the ore processing site (i.e. SLDS). The standards in 40 CFR Part 192 Subparts A, B, and C are considered relevant and appropriate for these reasons and as per the following analysis:

- The goals and objectives of the 40 CFR Part 192 standards are to provide for stabilization, disposal, and control of uranium mill tailings located at active and inactive mill operations in a manner protective of human health and the environment. The goals and objectives of the remedial action at the North County Site are to stabilize or clean up residual radioactive material from mill tailings at an inactive site, so that the land is usable in a manner protective of human health and the environment.

- Waste materials at the North County Site derive from inactive uranium processing and are the same kinds of radionuclides as regulated under 40 CFR Part 192 Subparts A, B, and C.

- 40 CFR Part 192 regulates cleanup of radium in soil. Soil (containing elevated radium concentrations) is the primary medium of concern at the North County Site.

- 40 CFR Part 192 considers unrestricted future land use for land cleaned up under Subpart B and supplemental standards under Subpart C. Similarly, at the North County Site, lands will either be released for unrestricted use, or will be considered for remediation using supplemental standards.

- The soil conditions at the North County Site are not significantly different from those at the uranium mill sites for which the 40 CFR Part 192 standards were developed.

- Both the North County Site and the sites managed under UMTRCA are the result of radioactive ore processing activities, and include numerous vicinity properties (VPs) contaminated by relocation of contaminants from erosion, use of contaminated materials as fill material, and spillage during transportation. Although no ore processing took place within the North County Site, the site is in the vicinity of the processing site (i.e., SLDS) and, although physically separate, was an integral part of the overall ore processing operation.

- Both programs address identical contaminants at sites characterized by large volumes of contaminated soil, widely ranging soil contaminant concentrations, and land use ranging from residential to industrial.

- The distribution of radioactive contamination at the North County Site is similar to that at uranium mill tailings sites. Radioactive materials which eroded or were windblown from the site or spilled during transport are spread in thin layers, much the same as the windblown tailings at some uranium mill sites.

Therefore, USACE concludes that circumstances at the North County Site are sufficiently similar to inactive uranium processing sites designated under Section 102 of UMTRCA to warrant 40 CFR Part 192 Subparts A, B, and C being considered relevant and appropriate under CERCLA for surface soil in the North County Site.

The UMTRCA standards for inactive uranium processing sites are organized into standards for control of residual radioactive materials (Subpart A), standards for cleanup (Subpart B), and implementation including supplemental standards (Subpart C). Standards set forth in Subpart A apply to the control of residual radioactive materials at designated processing or depository sites and to the restoration of such sites. Standards set forth in Subpart B apply to the cleanup of residual radioactive materials from land for release without radiological restrictions. Subpart C sets forth supplemental standards that account for the presence of other (i.e., non-radium) radionuclides, and supplemental standards that may be applied under special circumstances that allow the selection and performance of remedial actions that come as close as reasonably achievable to meeting the more stringent standards of Subpart B.

The design period requirement of Subpart A is considered relevant and appropriate for the development of soil RGs for all action alternatives. The standards contained within Subpart A are also potentially relevant and appropriate at the North County Site for remedial actions involving capping or the construction of an on-site disposal cell. 40 CFR Subpart A defines the "standards for control of residual radioactive materials from inactive uranium processing sites." This section sets several standards that provide protection for stabilized residual materials disposal areas at uranium processing sites. Subpart A requires in §192.02(a) that controls for

residual radioactive materials and listed constituents shall be effective for up to 1000 years to the extent reasonably achievable, and, in any case, for at least 200 years. To preclude the necessity for the government to take permanent legal possession of disposal cells and to avoid the presence of soils exceeding disposal cell risk criteria, use of supplemental standards which would result in shipment of higher activities soils off-site are required for Alternatives 2 and 3.

Subpart B identifies EPA's standards for remedial actions of land and buildings contaminated with residual radioactive materials at inactive uranium processing sites and provides cleanup standards for Ra-226 in soil, among other things. Requirements of Subpart B relevant and appropriate to the remedial action alternative include those for soil. Soil requirements specify that Ra-226 concentrations shall not exceed 5 picocuries per gram (pCi/g) above background in top 15 centimeters (cm) [6 inches (in)] and 15 pCi/g above background in lower 15 cm layers averaged over 100 square meter (m^2) [1076 square feet (ft^2)] areas.

Subpart C provides regulations for the implementation of standards established in Subparts A and B. Among other things, it sets forth conditions appropriate for the development of supplemental standards. Supplemental standards in 40 CFR 192.21-22 are relevant and appropriate for some contaminated soils. The standard of selection for a supplemental standard is one that comes as close to meeting the otherwise applicable standard as is reasonable under the circumstances. This type of determination has to be made on a site-by-site basis. Federal agencies may substitute "supplemental standards" subject to one of the following conditions:

- The remedial action would cause environmental harm that is clearly excessive compared to the health benefits to persons living on or near the site, now or in the future;

- The estimated cost of the remedial action is unreasonably high relative to the long-term benefits, and the residual radioactive materials do not pose a clear present or future hazard; and

- Radionuclides other than Ra-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials.

In addition, 40 CFR 192.21 allows imposing supplemental standards as ARARs for establishing alternate limits to those specified in 40 CFR 192.12. Thus, supplemental standards may be considered ARARs for remediation of portions of the North County Site. For example, under a containment (capping) or on-site treatment involving the use of institutional controls, excavation of subsurface soils to unrestricted standards at the primary storage areas could result in unreasonably high remediation costs without achieving a significant reduction in risk. There also would be increased exposure to risk associated with general construction/excavation/demolition activities and increases in the length of time to complete remediation. Supplemental standards are appropriate for subsurface soils at the primary storage areas in accordance with 40 CFR 192.21(c) because radiological materials do not pose a current or future hazard and because use of the 40 CFR 192 Subpart B standards results in unreasonably high remediation costs relative to the benefits. Supplemental standards are derived for subsurface materials at the primary storage areas (i.e., SLAPS and HISS/Futura) in conjunction with the use of institutional controls. Appendix D explains the derivation of these supplemental standards.

Supplemental standards for other radionuclides (i.e., uranium and thorium) are appropriate in accordance with the following condition stated in 40 CFR 192.21 (h): "Radionuclides other than radium-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials".

10 CFR Part 40 Appendix A Criterion 6(6): Like 40 CFR Part 192, 10 CFR Part 40 Appendix A Criterion 6(6) provides standards for the remediation of uranium and thorium mill tailings sites. Until recently, the standards were the same, focusing mainly on limiting radium concentrations in soils. In July of 1999, the NRC amended Criterion 6(6) to include criteria for non-radium radiological contaminants in soils and radiological contaminants in buildings. Because non-radium contaminants such as thorium and uranium derived from the processing of uranium ores are present at the North County Site, Criterion 6(6) is considered for its relevance and appropriateness. [For the reasons presented for 40 CFR 192, 10 CFR 40 Appendix A Criterion 6(6) is not applicable].

Criterion 6(6) was amended specifically to address byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures. (As defined in 10 CFR Part 40, byproduct material is the tailings or wastes produced by the extraction of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes.) Given that materials containing contamination other than Ra-226 are included in the list of North County Site wastes, Criterion 6(6) is relevant and appropriate for addressing the non-radium radionuclides that may be present in these materials.

Criterion 6(6) introduces the concept of a benchmark dose. The benchmark dose is the dose that would result from exposure to 5 pCi/g of Ra-226 in surface soils (top 15 cm) or 15 pCi/g of Ra-226 in subsurface soils (subsequent 15-cm layers). Non-radium contaminants are limited to the level that would produce the benchmark dose. For example, if the benchmark dose is 10 millirem per year (mrem/yr), thorium-230 (Th-230) must be limited to the concentration that would produce no more than 10 mrem/yr. If multiple contaminants such as Ra-226, Th-230, and uranium-238 (U-238) are present, the total dose must not exceed the benchmark dose (e.g., 10 mrem/yr). The benchmark also applies to building surfaces. Contamination on building surfaces must be limited to concentrations that would produce the benchmark dose. Criterion 6(6) is, therefore, used in the North County Site as an ARAR to derive surface soil cleanup goals for non-radium radionuclides, particularly uranium and thorium, which are not explicitly addressed by 40 CFR 192. These cleanup levels are based on doses derived from the 40 CFR 192 radium criteria. The concentration of Th-230 that corresponds to the benchmark dose resulting from exposure to 5 pCi/g Ra-226 in surface soils is 14 pCi/g. The concentration of U-238 that corresponds to the benchmark dose is 50 pCi/g.

40 CFR Part 192: Subpart A: Standards for Control of Residual Radioactive Materials from Inactive Uranium Processing Sites: The 1000-year time period specified in §192.02(a) is considered relevant and appropriate for the development of soil RGs for all action alternatives. The standards contained within Subpart A are also potentially relevant and appropriate at the North County Site for remedial actions involving containment (i.e., capping or the construction of an on-site disposal cell). Subpart A provides standards for the control of residual radioactive

material from inactive uranium processing sites. For reasons similar to those stated previously, the conditions at the North County Site are sufficiently similar to those at inactive uranium processing sites to consider portions of Subpart A as potentially relevant and appropriate requirements. The standard in §192.02(a) requires a cover design that will "be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years...". The standards specified in §192.02(b) require that the design provides reasonable assurance that release of radon from residual radioactive material to the atmosphere will not exceed an average release rate of 20 picocuries per square meter per second ($pCi/m^2/sec$) nor increase the annual average concentration of radon in the air at or above any location outside the disposal site by more than 0.5 picocuries per liter (pCi/L). For remedial actions involving the capping of contaminated soils or the construction of an on-site disposal cell at the North County Site, the requirements of Subpart A are considered ARARs and would ensure adequate protection of human health and the environment.

40 CFR Part 122, Clean Water Act (CWA) – National Pollutant Discharge Elimination System (NPDES): The NPDES Program is considered relevant and appropriate for actions evaluated in the FS. There is a storm water permit for Hazelwood Interim Storage Site (HISS) and a permit equivalent document for St. Louis Airport Site (SLAPS). In the National Pollutant Discharge Elimination System (NPDES) permit or equivalent document, certain limits are established for discharge of pollutants into waters of the state. In a CERCLA action, on-site activities do not require permits. However, activities must meet any substantive requirements for which permits would be otherwise required. Therefore, during remedial activities, any waste water or other water discharged from a point source into waters of the state must meet any limits that would have been established in the NPDES permit. Under 40 CFR § 122.44(i), the discharger must conduct monitoring to determine compliance with effluent limitations and to assist in the development of effluent limitations. The standards addressing site COCs at SLAPS are relevant and appropriate for this remedial action. The effluent limits are 100 ug/L total recoverable arsenic, 94 ug/L total recoverable cadmium, and 280 ug/l total recoverable chromium (both daily maximum and monthly average concentrations). Permit limitation reflects compliance with state water quality standards.

The EPA has developed a ground-water classification system to assess ground water on the basis of ground-water value and vulnerability to contamination. “For a CERCLA action, ground-water classification is used to help set goals for ground-water remediation and determine the appropriate level of remediation. When ground water is classified for a CERCLA action, that classification is only used to determine the scope of site-specific remedial actions and has no bearing outside of the CERCLA action” (55 FR 8733). Using the EPA ground-water classification system, the upper hydrostratigraphic units are most appropriately defined as Class IIIA. As such, the ground water from these zones is not considered a potential source of drinking water. Thus, the Safe Drinking Water Act (SDWA) is not an ARAR for the upper hydrostratigraphic units at the North County Site, because the United States Army Corps of Engineers (USACE) has determined that these units are Class IIIA by applying the EPA guidance.

3.4 GENERAL RESPONSE ACTIONS (GRAs)

GRAs that could be implemented to achieve the remedial action objectives described in Section 3.2 reflect the current understanding of contaminants and environmental conditions at the North County Site. These GRAs include no action, institutional controls, monitoring, containment, removal, and treatment. The GRAs are discussed in more detail in the following subsections.

3.4.1 No Further Action

The no-further-action response means that no new action would be taken. Controls that are in place at the present time, such as perimeter fencing with signs and existing environmental monitoring stations, would not be removed but would not be maintained under the no further action response. The no further action alternative is required by the NCP to provide a baseline for evaluating other GRAs, options, and alternatives. Although interim cleanup activities have previously been implemented at the site, no further action would be taken.

3.4.2 Institutional Controls and Monitoring

The primary goal of institutional controls is to prevent access to contaminated areas. Where active response measures, such as containment, removal, treatment, or beneficial use of source material are determined not to be practicable, the NCP allows the use of institutional controls to supplement engineering controls for short- and long-term management of hazardous substances, pollutants, or contaminants [(40 CFR 300.430(a)(1)(*iii)*(D)]. Zoning, easements, covenants, deed notices, and fee ownership are examples of institutional controls. Institutional controls, either alone or in combination with engineering controls, might be appropriate to achieve protection of human health and the environment.

Institutional controls are legal and administrative mechanisms that manage access to or use of affected property areas, or warn of a hazard. There are four categories of institutional controls: (1) Proprietary Controls, (2) Government Controls, (3) Enforcement and permit tools with institutional control components, and (4) Informational Devices. Details regarding these different types of institutional controls are provided in Section 3.6.3.

In accordance with 10 CFR 40, benchmark doses which exceed 100 mrem/yr before application of ALARA require the approval of the (NRC) Commission after consideration of the recommendation of the staff. This dose criterion is used in the development of supplemental standards in accordance with 40 CFR 192.21 and is consistent with exposure limits applicable to members of the public. Thus, any alternative that includes institutional controls should also be evaluated against this recommended limit in the absence of institutional controls.

The new guidance for remedy selection decision documents (EPA 540-R-98-031) (EPA, 1999a) states, “five-year reviews may be discontinued when no hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure.” Using this guidance, five-year reviews (after a remediation alternative has been completed) will only be necessary when limited use or restricted exposure is part of an alternative. Environmental monitoring would be conducted in conjunction with all remedial alternatives to evaluate contaminant levels during ongoing remedial actions, to assess the effectiveness of remedial actions, and to ensure that off-site migration of contaminants is detected and mitigated. Environmental monitoring would be tailored to the selected remedial

alternative so that monitoring objectives are realized. An adequate monitoring program considers periodic sampling of all media that would be affected by the continued presence of contaminants in environmental media. Periodic monitoring should be conducted for air (for radon emissions, particulates, and external gamma radiation), sediments (to measure surface runoff impacts and levels of contamination in creek sediments further downgradient from the site), and ground water at representative locations comprising the North County Site to assure the continued lack of migration of contaminants from the contaminated soils.

3.4.3 Containment

Containment can effectively reduce contaminant mobility and potential for exposure, but does not reduce contaminant volume or toxicity. The primary containment technologies considered for the North County Site include capping or encapsulation for soils. In addition, vertical or horizontal barriers such as slurry walls or grout injection are considered for protection of ground water and surface water. Although no radon problems have been identified, surface sealing and radon control for buildings are considered as ancillary containment technologies should radon contamination be discovered during the cleanup process.

Capping involves covering an area with a low-permeability material to reduce the migration of contaminants. Capping reduces the infiltration of surface water through contaminated media, but does not reduce the toxicity of source materials. Capping also can minimize the release of dust and vapors into the atmosphere. If side and bottom barriers are added, a full encapsulation of the contaminated material can be achieved. Various designs for disposal cells and containment structures have been developed for materials like those found at the North County Site.

3.4.4 Removal

Removal of contaminated material effectively limits the volume and mobility of COCs at the source area and can facilitate treatment and disposal. The appropriate removal technology and process option is a function of the physical properties of the material.

Excavation with conventional earth-moving equipment (such as excavators, scrapers, and bucket loaders) is used to remove bulk material such as soil. Manual excavation may be required in areas where access is limited. Coldwater Creek sediment can be removed with earth-moving equipment or dredging equipment. Although there are no COCs for ground water, remedial design must consider contamination of HZ-A to prevent off-site release of contaminated water from excavation areas.

3.4.5 Treatment

Treatment can often be used to reduce the contaminant volume, toxicity and/or mobility. Treatment encompasses a wide range of physical, chemical, biological, and thermal technologies. Many of the technologies can be applied both in-situ and ex-situ. The treatment technologies evaluated for the media at the North County Site are described below.

Physical treatment technologies include dewatering, size reduction, soil separation, soil sorting, soil washing and immobilization. Dewatering technologies (such as filtration and evapotranspiration) are used to reduce the water content of the waste materials. Size reduction

involves physically reducing the size, and potentially the volume, of a waste material through the use of shredders, grinders, or compactors. Size reduction is most applicable to construction debris. Dewatering and size reductions do not directly treat the contaminant, but may be used to reduce the waste volume and improve material handling characteristics. Soil separation involves removing large pieces of debris and rock (often referred to as oversized material) from the soils through the use of screens. Soil sorting systems mechanically separate soils containing radioactive particles through the use of gamma radiation detectors. Soil washing involves washing the soils with water (and possibly other additives) to remove the radioactive contaminants. Soil separation, soil sorting and soil washing are used to reduce the volume of soils requiring management as low level radioactive waste. Immobilization processes physically bind the contaminants within a stabilized mass to reduce the mobility of the contaminants.

Chemical processes include chemical stabilization and chemical extraction. Chemical stabilization uses chemicals to cause reactions between the contaminants and the stabilizing agent to reduce their mobility. Chemical extraction uses various chemicals to extract or leach contaminants from the waste to reduce the volume of the radioactive materials requiring management as low level radioactive waste. These technologies are primarily applicable to soils and sediments.

Bioremediation is the use of microorganisms (i.e., fungi, bacteria, and other microbes) to degrade organic contaminants in the soil and/or ground water. Although bioremediation cannot degrade inorganic contaminants such as those in the North County Site soils, it may be able to convert the inorganic contaminants into a stable form.

Thermal treatment processes use high temperatures to volatilize, decompose, or melt the contaminants. Incineration and vitrification are the primary thermal treatment processes. Incineration uses high temperatures to volatilize and combust organics in waste materials. Incineration would not be effective for the inorganic contaminants present in the North County Site soils. Vitrification uses high temperatures to melt soils to form a glasslike matrix. Vitrification is effective in reducing the mobility of the contaminants within the media.

Ancillary treatment technologies that may be used to support the primary remedial actions include ground-water and surface-water treatment, which would be used to treat water that becomes contaminated during removal operations. Air stripping uses air to remove water-borne organics and radon gas. Liquid-phase carbon adsorption is used as a polishing step to treat hard-to-remove organics and radionuclides. Ion exchange and reverse osmosis (membrane filtration) can remove radionuclides and concentrate the radionuclides from the aqueous stream. Ion exchange involves the interchange (or adsorption) of ions between the aqueous solution and a solid resin. Reverse osmosis can be used to remove radioactive contaminants by taking advantage of the differential movement of dissolved material across a membrane. Evaporative recovery uses the distillation process to produce distillate and a waste concentrated stream. It can be a pretreatment step before ion exchange.

Decontamination techniques are retained as ancillary treatment technologies should building contamination be encountered during the remediation. Although the Remedial Investigation (RI) has not identified building contamination, these technologies could be used if building contamination were found during remediation. Physical procedures include vacuuming, scrubbing, scraping, sanding, grinding, scabbling, and blasting. These methods use physical

force to achieve mechanical separation of the contaminant from the surface being treated. Chemical procedures involve the use of chemicals (solvents, complexing agents, acids) to dissolve or suspend the contaminant in the decontamination fluid for removal from the surface being treated.

Metals from the buildings and structures can also be sent to qualified vendors for melting and recycle.

3.5 REMEDIATION GOALS (RGs)

The remediation goals proposed for the North County Site comply with ARARs, are protective of human health and environment and are consistent with the NCP. They are protective under conditions of RME for residential site conditions (see Preamble to the final rule for 40 CFR 192 as specified in 48 FR 600 and the Final Environmental Impact Assessment). No directly applicable chemical-specific requirements are identified. Relevant and appropriate requirements are identified for radioactive contaminants in soil. Remediation goals for other contaminants in soil are derived using site-specific evaluations. Risk and dose assessments were also performed to assure protectiveness in light of multiple contaminants and multiple pathways (e.g., inhalation, ingestion, and direct exposure) at the North County Site. The remediation goal for Ra-226 is set forth in 40 CFR 192, Subpart B. Site-specific remediation goals for U-238 and Th-230 are derived in accordance with 10 CFR 40, Appendix A, Criterion 6(6) and 40 CFR 192, Subpart A. Table D-11 lists concentrations that produce the radium benchmark doses for the key St Louis North County Site radionuclides for a range of potential receptors. The remediation goal for Th-230 accounts for the in-growth of Ra-226 which is the limiting risk consideration.

No chemical-specific requirements were identified for non-radiological contaminants. Remediation goals were derived based on site-specific exposure assumptions, and with the objective of meeting the acceptable risk range as provided in the NCP (See Appendix D, Section D.2.2.2). According to the NCP, acceptable exposure levels to known or suspected carcinogens are levels that represent an excess upper bound lifetime cancer risk to an individual of between one in 1,000,000 (10^{-6}) and one in 10,000 (10^{-4}). The EPA establishes preliminary remediation goals (PRGs) for all carcinogenic chemicals at the 10^{-6} level, also known as the point of departure. Final remediation goals may be different based on factors such as uncertainty, technical limitations on detection, or other considerations consistent with the remedy selection criteria defined in the NCP. In this case, practical limits on the ability to distinguish between naturally occurring background levels and very small increments above background require the use of final remediation goals that exceed the 10^{-6} level for some of the non-radiological contaminants; however, final cleanup levels remain within the acceptable risk range. Aggregate risks from final cleanup levels are also within the risk range. Remediation goals for non-carcinogens were developed to ensure that the cumulative toxic effects would result in a HI < 1.0.

The soil cleanup standards found in 40 CFR 192, Subpart B, were developed specifically for the cleanup of uranium mill tailings sites designated under Section 102 (a)(1) of the Uranium Mill Tailings Radiation Control Act (UMTRCA). These standards are intended to provide for unrestricted use of remediated properties. These standards address contaminants and circumstances similar to those found at the North County Site and are, therefore, considered

relevant and appropriate to soil cleanup at the North County Site. The surface and subsurface soil criteria in 40 CFR 192, Subpart B for radium–226 are 5 and 15 pCi/g, respectively. The surface remediation goal applies to the 100 m^2 areal average concentration above background in the top 15 cm (6 in.) layer. The subsurface remediation goal applies to the 100m^2 areal average concentration above background in any subsequent 15 cm (6 in) layer. The Ra-226 remediation goal of 5 and 15 pCi/g in surface and subsurface soils has been used with St Louis sites pursuant to the Record of Decision for the St Louis Downtown Site and to Engineering Evaluation/Cost Analyses for the St Louis North County Site. Implementation of the subsurface remediation criterion for Ra-226 results in actual average residual concentrations of Ra-226 significantly less than 5 pCi/g. This is based on cleanup results of a number of different areas and properties within the St Louis North County Site and St Louis Downtown Site, using cleanup goals of 15 pCi/g subsurface criterion for Ra-226 in combination with subsurface cleanup goals of 15 and 50 pCi/g for Th-230 and U-238, respectively. Table D-9 (Section D.2.1) lists the residual radionuclide concentrations at properties where response actions have been completed.

The site-specific Th-230 and U-238 remediation goals are derived based on the 10 CFR 40, Appendix A, Criterion 6(6), also referred to as the benchmark dose approach. These requirements supplement the standards found in 40 CFR 192.

The U-238 goal was established using U-238 as a surrogate for all of the uranium isotopes (including U-234 and U-235) and certain uranium decay products. Using the U-238 as a surrogate, the residual concentration was determined to be about 81 pCi/g. However, since some of the decay products are present above the natural abundance, the site-specific remediation goal of 50 pCi/g for U-238 is considered appropriate. Site experience shows that a 50 pCi/g limit is reasonably achievable at little extra cost. This limit has been used on the St Louis North County Site for removal actions conducted by USACE and the DOE since 1991 and is the site-specific Remediation Goal for U-238 established in the Record of Decision for the St Louis Downtown Site.

Table D-11 of Appendix D, presents the calculation resulting from 10 CFR 40, Criterion A, Criterion 6(6), and lists the most restrictive Th-230 concentration as 330 pCi/g. This concentration, although protective with respect to Th-230, would result in the in-growth of Ra-226 such that future concentrations of Ra-226 would exceed the limits specified in ARARs. 40 CFR 192.02(a) requires that the selected remedial action be designed to be effective for up to 1000 years to the extent reasonably achievable, and in any case, for at least 200 years. To ensure ARAR is met, the ingrowth of Ra-226 from the Th-230 decay process must be calculated and examined. A soil concentration of 14 pCi/g of Th-230 would result in the in-growth of 5 pCi/g Ra-226 concentration at the end of the 1000-year time period stated in 40 CFR 192.02(a). Although a subsurface soil concentration of 43 pCi/g would result in the in-growth of 15 pCi/g Ra-226, EPA's guidance documents for the cleanup of CERCLA sites using 40 CFR 192 as ARAR set forth EPA's expectation that remediation of subsurface soil contamination will, in practice, achieve the surface cleanup criterion of 5 pCi/g for Ra-226. (See OSWER 9200.4-25, "Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites). EPA approval of the ROD is contingent upon satisfying EPA's expectations for cleanup of CERCLA sites; therefore, USACE has adopted, on a site-specific basis, Th-230 surface and subsurface soil cleanup levels that are consistent with a residual Ra-226 concentration of 5 pCi/g. Constraining the concentration of Th-230 in surface soils to 14 pCi/g and subsurface soils to 15

pCi/g along with the use of the unity rule assures that the concentration of Ra-226 does not exceed 5 pCi/g during the 1000-year time period.

No remediation goal is developed for Th-232. Removal of Th-230 to the remediation goals will effectively remove Th-232 present in site soils. Analytical data indicate that Th-232 is co-located with Th-230 and is present at relatively low concentrations. Removal of soils to the radionuclide criteria results in Th-232 concentrations of less than 1.5 pCi/g including background for SLAPS, SLDS, and North County VPs. Residual concentrations do not produce risks significantly above background.

Remediation goals for radiological contaminants of concern for the St Louis North County Site soils are 5/14/50 pCi/g for Ra-226, Th-230 and U-238 in surface soils and 15/15/50 pCi/g for subsurface soils. These remediation goals are consistent with the remediation standards used in Engineering Evaluation/Cost Analyses (EE/CAs) by DOE prior to transfer of FUSRAP execution to USACE, in USACE EE/CAs, and in local Records of Decision both at the St Louis Downtown Site and by DOE at the Weldon Spring Site Remedial Action Project. These remediation goals meet the threshold criteria of overall protection of human health and the environment and compliance with ARARs and will achieve a final status that requires no restrictions on land use.

For the North County Site, Ra-226, Th-230, and U-238 have been used as surrogates for other radionuclides. Applying this approach, Th-230 is a surrogate for Th-232 and Th-228 and U-238 is a surrogate for other uranium isotopes (U-234 and U-235) and certain decay products [protactinium-231 (Pa-231) and actinium-227 (Ac-227)].

Supplemental cleanup standards have been developed for subsurface materials at the primary storage areas (SLAPS and HISS/Futura) under the containment and treatment alternatives (Alternatives 2 and 3) to ensure protectiveness under commercial/industrial use. These supplemental standards are appropriate in accordance with criteria specified in 40 CFR 192.21 (c), which states that supplemental standards may be applied under circumstances where removal would result in excessive remedial action costs relative to the long-term benefits and the residual radioactive materials do not pose a clear present or future hazard, given the design configuration and appropriate institutional controls. The supplemental standards for subsurface materials at the primary storage areas are to be used in conjunction with institutional controls. For those remedial alternatives involving land use restrictions at SLAPS and HISS/Futura (Alternatives 2 and 3), supplemental standards of 25/70/250 pCi/g above background for Ra-226/Th-230/U-238 would be used for subsurface soils. These supplemental standards would protect the most likely current and future receptors (e.g., construction and utility workers) and ensure that doses to the general public would be limited to less than 100 mrem/yr if institutional controls were lost.

The benchmark dose approach defined in Criterion 6(6) was applied using EPA methods and exposure factors in development of the Coldwater Creek subsurface sediment remediation goals. The remediation goal derived for subsurface sediments (i.e., 15 pCi/g of Ra-226, 43 pCi/g of Th-230 and 150 pCi/g of U-238 above background) is implemented for soils and sediments under the mean water gradient for Coldwater Creek. This remediation goal assures protectiveness of Coldwater Creek under all future anticipated land use conditions (e.g.,

recreational/trespasser, maintenance, construction, and utility uses) and minimizes adverse environmental impact associated with greater excavation in Coldwater Creek.

Other site contaminants derived from the uranium ores tend to be co-located with the principal radionuclides such that remediation of the contaminated soil to the cleanup levels described above is expected to adequately remove all ore-related contaminants. Supporting information is presented in Appendix D (Section D.2.1 and Table D-10). To verify that removal of radiological contaminants achieve remediation goals for non-radiological contaminants associated with the uranium processing activities, chemical sampling will be conducted as required during pre-design investigation and as part of the final status survey pending confirmation of co-location with radiological contaminants.

No ARARs have been identified for the non-radiological contaminants in soils at the North County Site. The remediation goals for non-radiological COCs were developed based on site-specific risk assessments and hazard evaluations. At the North County Site, eleven non-radionuclides are identified as COCs for soils: antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, and vanadium. These noncarcinogens have different effects on different organs or systems in the body. The remediation goals for noncarcinogens were developed to ensure that the cumulative effect of the chemical levels of the COCs produces a HI < 1.0 for each target organ/system affected. In addition, remediation goals were selected at levels above detection limits and background levels.

Toxicologists evaluated the primary effects of the 11 metals in the soils at North County. The HIs were calculated for all six different types of receptors – residential, industrial, construction worker, maintenance worker, recreational/trespasser, and utility worker. Generally, the construction worker was identified as the most sensitive receptor, except for a few cases where the residential receptor was the most sensitive or restrictive scenario. The remediation goals for all non-radionuclides were calculated based on the HIs for the different primary target organs. The protectiveness to each primary organ was tested by adding up the HIs of the corresponding COCs targeted to that primary organ. In each case, the HI value was less than one.

Remediation goals have been derived for the 11 surface soils and 4 subsurface soil non-radiological COCs, based on their noncarcinogenic effects. These proposed remediation goals are presented in Table ES-6. Surface and subsurface soil remediation goals for antimony, arsenic, thallium, and uranium are 15/25 mg/kg, 36/40 mg/kg, 25/30 mg/kg, and 150/150 mg/kg, respectively. Seven additional non-radiological COCs were identified for surface soil only. The applicable remediation goals are as follows: 2800 mg/kg barium, 12 mg/kg cadmium, 350 mg/kg chromium, 1,000 mg/kg molybdenum, 1,500 mg/kg nickel, 300 mg/kg selenium, and 112 mg/kg vanadium. Antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, and vanadium are identified as COCs for SLAPS and contiguous areas; and antimony, arsenic, barium, cadmium, molybdenum, nickel, selenium, thallium, and vanadium are identified as COCs for HISS/Futura and Latty Avenue VPs 2L and 10k530087. The non-radiological COCs will be evaluated in the final status survey pending confirmation of their co-location with radiological COCs to verify that risk and hazard criteria are fully protective under CERCLA and have been satisfied.

The proposed remediation goals (summarized in Table ES-4 for radionuclides and Table ES-5 for other chemicals) are protective based on the future anticipated land use, are achievable, and can be implemented. Further cleanup goals comply with the ARAR criteria for radionuclides and would achieve protectiveness to levels within the CERCLA risk range and below a HI of 1.0.

3.6 REMEDIAL ACTION TECHNOLOGIES AND PROCESSES IDENTIFIED FOR THE NORTH COUNTY SITE

3.6.1 Overview of the Identification of Technologies

Remedial action technologies were identified and evaluated in detail in the Initial Screening of Alternatives (ISA) Report for the St. Louis Site (SAIC, 1992) and were updated during the preparation of this FS. Table 3-2 summarizes the potentially applicable remedial action technologies that were identified. Table 3-3 provides a summary of potential technologies sorted by medium. Technologies and process options for each response action are discussed in more detail in the following subsections.

Table 3-2. Potential Technologies and Process Options for the North County Site

Response Action	Potential Technology	Process Options
Access Controls	Site security	Physical barriers, signs, security patrols, guards
Institutional Controls	Zoning restrictions	Zoning restrictions
	Land use restrictions, notices, and ownership	Land use notices, deed notices, easements, well use advisories, well drilling prohibitions, government ownership
Containment	On site full encapsulation cells	UMTRCA, UMTRCA like, Subtitle C or D
	Cap	Multi-media, clay, asphalt, concrete, synthetic
	Soil and vegetation cover	
	Storage pile covers	Geotextile, spray coatings, tarps
	Dust mitigation	Water spray, foam
Removal	Excavation	
	Dredging	Hydraulic, pneumatic
Treatment	Immobilization & stabilization	Asphalt, resins, bitumen, cementation, silicate based mixtures
	Soil washing	Size separation, chemical separation, gravity separation, magnetic separation
	Vitrification	Microwave, melter, in-situ
	Recycle to uranium mill	
	Solvent extraction	
	Soil sorting	Physical sorting, radionuclide detection
	Size reduction	Crushing, cutting, shredding
	Bioremediation	
	Phytoremediation	Rhizofiltration, phytoaccumulation
	Dewatering	
	Incineration	

Table 3-3. Potential Technologies Sorted by Media Where COCs Were Identified

General Response Action	Soils	Sediments in Coldwater Creek
Institutional Controls and Access Controls	Zoning restrictions Easements, covenants, deed notices, and ownership	Zoning restrictions Easements, covenants, deed notices, and ownership
Containment	Cap Full encapsulation cell Soil cover Revegetation	Revegetation Combine with soils
Removal of Contamination Sources	Excavation	Dredging of channel
Treatment	Immobilization Vitrification Soil washing Recycle to uranium mill Soil sorting Biological techniques Phytoremediation Dewatering Incineration	Dewatering Phytoremediation Soil washing Combine with soils

3.6.2 No Further Action

No further action provides a baseline for comparison with other alternatives as is required under CERCLA. No further action provides no additional protection of human health and the environment. No remedial actions would be taken to reduce, contain, or remove contaminated soils, and no effort would be taken to prevent or minimize human and environmental exposure to residual contaminants. Off-site migration of contaminants would not be mitigated under a no further action alternative. Five-year reviews would be conducted pursuant to CERCLA for areas in which contamination is such that conditions do not allow for unlimited use and unrestricted exposure.

3.6.3 Technologies and Process Options for Institutional Controls (All Media)

Institutional controls are legal and administrative mechanisms that manage access to or use of property, or warn of a hazard. There are four categories of Institutional controls: (1) Proprietary Controls, (2) Government Controls, (3) Enforcement and permit tools with institutional control components, and (4) Informational Devices.

The implementability of institutional controls depends on arrangements that can be achieved with public and private owners in different government jurisdictions. The NCP has outlined certain criteria to help evaluate whether or not the use of institutional controls would be acceptable in lieu of treatment. The specific characteristics of each site determine which institutional controls are appropriate. The legal impediments and financial costs would affect the implementability and schedule. Several kinds of institutional controls are considered including land-use restrictions through zoning, easements, covenants, advisories and notices, and site ownership. It would still be necessary to continue with monitoring and five-year reviews of any properties that contain residual contamination above levels acceptable for unrestricted use.

In accordance with 10 CFR 40, benchmark doses which exceed 100 mrem/yr before application of ALARA require the approval of the (NRC) Commission after consideration of the recommendation of the staff. This dose criterion is the basis for development of supplemental standards in accordance with 40 CFR 192.21, and is consistent with exposure limits applicable to members of the public. Thus, any alternative that includes institutional controls should also be evaluated against this recommended limit in the absence of institutional controls.

3.6.3.1 Proprietary Controls

A proprietary control is a private contractual mechanism contained in the deed. Proprietary controls involve placement of restrictions on land through use of easements, covenants, and reversionary interests. Easements, covenants, and reversionary interests are nonpossessory interests which give their holders the right to use or restrict the use of land, but not to possess it.

A landowner can impose restrictions on the deed to his property, such as an easement, a covenant, or a reversionary interest. Some restrictions that could be considered for the North County Site include the following requirements:

- the property would not be used for residential purposes, now or in the future;
- ground water would not be used for any purpose;
- gardens would not be planted on the property;
- any buildings placed on the property must be properly ventilated for radon; and
- no construction of any type would be allowed without the written approval of the government.

Restrictions need to exist in perpetuity and the restrictive language must effectively "run with the land". Recordable and permanent interests (easements) are necessary to ensure proper notice to the public until such time as "clean-site" releases are authorized and granted.

Easements allow the holder to use the land of another or to restrict the uses of the land. For example, a conservation easement restricts the owner to uses compatible with conservation of the environment. If an owner violates an easement, the holder may bring suit against the owner.

An appurtenant easement provides a specific benefit to a particular piece of land, such as allowing a neighbor to walk across your land to get to a beach. An easement in gross benefits an individual or company, such as allowing a utility company access to land to lay a gas line.

An affirmative easement allows the holder to use another’s land in a way that, without the easement, would be unlawful. A negative easement prohibits a lawful use of land such as creating a restriction on the type of development that can be conducted on the land.

Covenants are promises that certain actions have been taken, will be taken, or will not be taken. Covenants can bind subsequent owners.

An affirmative covenant is a promise that the owner will do something that the landowner might not otherwise be obligated to do, such as maintain a fence around a landfill. A negative covenant is a promise that an owner will not do something that may otherwise be done, such as restricting the use of ground water on a property.

A reversionary interest places a condition on the transferee's right to own and occupy the land and if the condition is violated, the property is returned to the original owner or successor. Each owner in the chain of title must comply with the conditions that are placed on the property, and if violated, the property returns to the original owner, despite intervening property transfers.

The costs associated with imposition of institutional controls would be expected to include the legal costs and the actual payment to landowners for the legal "taking" of their rights with respect to their properties. The projected costs for such a taking are difficult to project, but could be substantial. Elevated costs would be anticipated for future management of soils not meeting unrestricted release criteria. In the event USACE decides to purchase properties outright, it would have the right to include restrictions to restrict access or use of the property. Such restrictions could last indefinitely.

3.6.3.2 Governmental Control

Governmental controls are restrictions that are within the traditional police powers of state and local governments. Permit programs and planning and zoning limits are examples of governmental controls (U.S. Army, 1997).

Zoning use restrictions are imposed through a local zoning authority and may discourage uses that conflict with a CERCLA remedy. Land use restriction through zoning provides restrictions on the types of land use allowed. Zoning restrictions are intended to prohibit activities that could disturb certain aspects of a remedy or to control certain exposures not otherwise protected under a remedy. Zoning restrictions have inherent weaknesses. Zoning laws can be repealed or exceptions to them can be granted by the government. Also, they are not effective unless a government commits the resources to monitor and enforce the restrictions over the long term.

Pre-existing uses that violate the terms of a new zoning resolution are called non-conforming uses. Frequently, non-conforming uses are excused from the new zoning requirements and are allowed to continue until the use is terminated or abandoned by the property owner. Once the non-conforming use is terminated or abandoned, the new zoning restrictions would apply to any land use. Generally, a non-conforming land use is considered abandoned when there has been a cessation in the land use for a period of about two years.

Other examples of governmental controls include siting restrictions, which control land use in areas subject to natural hazards such as flooding. These restrictions are created by state statutory authority or by local laws and ordinances.

3.6.3.3 Enforcement and Permit Tools with Institutional Controls Component

Under sections 104 and 106(a) of CERCLA, Unilateral Administrative Orders (UAOs) and Administrative Order of Consent (AOCs) can be issued or negotiated to compel the land owner (usually a potentially responsible party) to limit certain site activities at both Federal and

private sites; Consent Decrees (CDs) can also be negotiated at private sites under 122(d). Similarly, EPA can enforce permits, conditions and/or issue orders under RCRA sections 3004(u) and (v), 3008(h), or 7003. These tools can have shortcomings that can jeopardize the protectiveness of the remedy. For example, most enforcement agreements are only binding on the signatories, and the property restrictions are not transferred through a property transaction. In order to prevent loss of protectiveness, the enforcement tool should contain provisions requiring oversight agency notification and/or approval prior to a property transfer. This provision would allow negotiation of an agreement with new owner.

3.6.3.4 Informational Devices

Informational tools provide information or notification that residual or capped contamination exists on-site. Common examples include state registries of contaminated properties, deed notices, and advisories. Due to the nature of some informational devices and their potential nonenforceability, it is important to carefully consider the objective of this category of institutional controls. Informational devices are most likely to be used as a secondary "layer" to help ensure the overall reliability of other institutional controls.

3.6.4 Site Security Measures

Site security measures can be used in conjunction with institutional controls. These measures include the use of fences, berms, and warning signs around a contaminated site to prevent unauthorized access. Security personnel can be used to deter unauthorized access to the site. All of these measures are designed to minimize the potential for direct human contact with contaminated media. Because properties are not owned by USACE, it would be necessary to negotiate an agreement with the property owners, or to negotiate land or resource restrictions with the appropriate local governments.

3.6.5 Short- and Long-Term Environmental Monitoring

Environmental monitoring would be conducted in conjunction with all remedial alternatives in order to evaluate contaminant levels during ongoing remedial actions, to assess the effectiveness of remedial actions, and to ensure that off-site migration of contaminants is detected and mitigated. Environmental monitoring is sometimes considered an institutional control, but monitoring is analyzed separately for this evaluation. Environmental monitoring would be tailored to the selected remedial alternative so that monitoring objectives are realized. An adequate monitoring program considers periodic sampling of all media that would be affected by the continued presence of contaminants on the site. Periodic monitoring should be conducted for air (for radon emissions, particulates, and external gamma radiation), sediments (to measure surface runoff impacts and measure levels of contamination in creek sediments further downgradient from the site), and ground water at representative locations comprising the North County Site.

Air Monitoring

Short-term monitoring of unremediated soil areas would consist of radiation surveys to determine if radon, contaminated particulate, or gamma levels are exceeding proposed levels protective of human health.

Sediment Monitoring

Periodic monitoring of sediments in ditches or in Coldwater Creek would determine whether contaminants are being transported to the creek via surface water runoff or ground water discharges. Contaminant concentrations would be monitored downstream in areas of known sediment deposition and quiescent flow conditions and would be compared with background samples. The degree of monitoring required, whether a short-term assessment or long-term monitoring of creek sediments, would be determined by the selected remedial action.

Ground-Water Monitoring

Ground-water monitoring would consist of radiological and chemical analyses of samples collected from ground water underlying and surrounding the site. Monitoring would be implemented using upgradient and downgradient wells in order to assess potential impacts from contaminated soils and sediments.

Surface-Water Monitoring

Surface-water monitoring includes chemical and radiological monitoring of surface waters in order to determine whether dissolved contamination is present and whether it has any adverse environmental or health safety impact.

3.6.6 Technologies and Process Options for Containment

Containment actions include technologies that protect human health and the environment by physically blocking contact with the contamination. The contaminated media are neither chemically nor physically changed, nor are the volumes of contaminated media reduced. Containment response actions prevent contaminant migration and eliminate exposure paths.

Engineered cells and engineered multi-layered caps with soil covers can be used to cover the contaminated soils and sediment. Applying a sealant can contain the radionuclides present on the surface of buildings and structures. For ground-water containment, actions involve separating the contamination source from the water and controlling migration of ground water from the site through the installation of vertical or horizontal barriers.

3.6.6.1 Engineered Cell

An engineered cell would have to be constructed on land owned or acquired by USACE. Additional acreage would be needed for monitoring wells, a buffer zone, and retention ponds. For a disposal cell, all wastes present at SLAPS would be excavated and set aside in a temporary storage area while an impervious base is built on-site. The disposal facility would incorporate engineered barriers into the design of the bottom clay liner and multilayer cover systems which would provide isolation of the waste from the environment.

Typical operations and maintenance (O&M) requirements for the disposal facility would include:

- *Environmental Monitoring* – Ground water would be monitored as required. This monitoring system must provide early warning of radionuclide release from the disposal site before the material is transported beyond the site boundary.

- *Regular Maintenance of Cover* – Mowing, tree removal, and prevention of human or animal intrusion into stored wastes would be required to maintain the integrity of the disposal facility.

- *Maintenance of Institutional Controls* – Access controls, such as, fences, and signs, and institutional controls would be inspected regularly and maintained as required to control accidental intrusion into the stored waste.

The effectiveness of a disposal cell would be monitored through several systems. During active operation, any runoff generated from the waste placed in the engineered on-site disposal cell would be captured by the passive runoff system, directed to sumps, and treated in the water treatment plant. Percolation through the cell cover due to precipitation would also be captured by the passive runoff system. The disposal cell cover would be visually inspected periodically to identify and repair any areas of erosion, animal burrowing activities, or deep root growth. Radon emanation would also be monitored after closure in order to minimize the potential for exposure. Survey markers would be placed on the disposal cell to aid in assessing settling. Ground-water monitoring wells would be installed to detect changes in ground-water quality. If contamination were detected in the monitoring wells, a thorough inspection and repair program would be initiated. The monitoring system associated with the on-site disposal cell would provide the information needed to determine whether corrective action should be taken to prevent the migration of contaminants into the environment.

3.6.6.2 Engineered Caps

Specific design issues for the cap would be studied and addressed in detail during the remedial design phase. The proposed capping system would be designed and constructed to:

- promote long-term minimization of surface-water infiltration through the waste matrix;
- reduce external gamma radiation and radon emissions;
- function with minimal maintenance; and
- accommodate settling and subsidence to ensure the integrity of the cover.

Native soil, clay, a synthetic liner, or a multimedia cap can provide containment of contaminants in soils. The availability and cost of the material required to construct the cap needs to be considered when planning the final design.

Geotechnical analyses, including permeability testing, density testing, and moisture content would be required if clay or native soil were used as the capping material. Geotechnical logs have shown that in-situ contaminated soil would require compaction to control subsidence. Excavation of contaminated material, screening out of deleterious materials, then spreading and compacting the waste could be used to ensure the viability of a cap. Another approach to addressing subsidence would be to use a temporary cover until the in-situ contaminated soil is stable and the cap could be applied.

3.6.6.3 Ancillary Containment Technologies

Current data indicate that response action alternatives for application to buildings are not required. Although no problems have been found, there is a potential for elevated levels of radon (a decay product of Ra-226) to be discovered during the cleanup process. For that reason, containment technologies for buildings (surface sealing and radon control) are retained as contingencies. Radon controls systems can be either passive or active collection systems. Both containment and removal type systems are described here. Active and passive collection systems around building structures and ventilation systems inside buildings are effective in controlling radon gas from underlying soils. Sealing basement walls and floors will also reduce radon entry into buildings. This method will only be effective if the surfaces are continuous (no cracks or open spaces) and can be completely coated with a nonporous sealant. Electrostatic precipitators are effective in minimizing particulates (e.g., dust), including radon decay products inside buildings.

Remedial actions for addressing surface water and ground water as contaminant source media are not required. However, in order to prevent contact of uncontaminated ground water or surface water with contaminated soils, and in order to prevent migration of contaminated ground water or surface water, surface-water and ground-water containment technologies have been retained as contingency options. Potential containment technologies for ground water include horizontal and vertical hydraulic barriers. Based on the site hydrology, hydraulic barriers for control were determined to be potentially viable. Potential surface water control technologies include grading, revegetation, and diversion controls. Dikes and berms are well-compacted earthen ridges or ledges constructed immediately upslope from, or along the perimeter of, contaminated areas. These structures serve as a diversion for surface-water flow, and are generally designed to provide temporary protection (usually one year) of critical areas by diverting surface runoff around areas of contamination. Dikes and berms could possibly be implemented along Coldwater Creek until contaminated sediments are remediated. This technology could also be implemented at the drainage ditches leading from the site to Coldwater Creek.

3.6.7 Technologies and Process Options for Removal

3.6.7.1 Excavation

Contaminated soil at the site can be partially or completely excavated with conventional earth-moving equipment including backhoes, bulldozers, front-end loaders, and manual techniques. Equipment to be used is determined by many factors, including the area to be remediated, the area available for operations, the depth of the excavation, and the capabilities of the equipment. Manual excavation techniques are used where insufficient space precludes the use of conventional equipment. Conventional construction techniques would be employed to minimize impacts to ground water and surface water during excavation.

Contaminated surface soils that cover smaller areas may be excavated using digging equipment such as backhoes. Bulldozers or front-end loaders can remove relatively shallow, wide areas of contaminated soil. Bulldozers are versatile machines used on a variety of projects such as moving earth for short haul distances, spreading earth fill, backfilling trenches and pits, clearing sites of debris, and pushing debris into loading areas. Front-end loaders are used extensively in construction to load bulk material such as soil, rocks, and rubble into dump trucks;

to move earth forward for short distances; and to excavate. Self-loading scrapers could be used for wide, shallow contaminated soil areas.

Generally effective to a depth of 1 to 2 feet (ft) [0.3 to 0.6 meters (m)], front-end loaders can scoop surface soils either into a temporary pile that can then be loaded in dump trucks, or some other similar container for transport, or directly into the transport container. Loaders are generally most effective on coarse, noncohesive soils. The depth of excavation must be taken into account because there is a physical limitation on the reach of hydraulic arms. If soil removal must extend beyond 1- or 2-ft depths, hoes usually work better because of their greater depth-handling capacity. The term "hoe" applies to any excavating machine of the power-shovel type (e.g., hoe, backhoe, back shovel, or pull shovel). Hoes are most suited to excavating trenches and pits, and to general grading work that requires precise control of excavation depth. They are superior to drag lines for close-range work, and for loading excavated material into dump trucks. Hoes can work from a clean area, contaminating only their buckets. Contaminated soil in certain locations, such as next to buildings or culverts, can be accessed with backhoes using smaller buckets, or with smaller earth removal equipment.

Dump trucks are used to haul soil, rock, aggregate, and other material. Because of their speed, they provide high earth-moving capacity at relatively low hauling cost. They also provide a high degree of flexibility because the number and types of trucks in service may easily be increased or decreased to modify the total hauling capacity of a fleet.

In some cases, it may be necessary to reroute drainage culverts to gain access to soils under them, or to use smaller equipment, possibly to the extent of using shovels to remove soil manually. Excavation and removal of contaminated sewer and drain lines would involve tracing a line through a variety of techniques (dyes, smoke, radio transmitters).

Field monitoring would be conducted during soil excavation to ensure that all contaminated soils have been removed to the specified remediation level. As required, samples may be collected from the excavation side walls and bottom for laboratory analyses to confirm the results obtained during field monitoring.

3.6.7.2 Dredging (Coldwater Creek Sediments)

The process of removing sediments from a water body is known as dredging. There are several types of dredging, but three dredging technologies commonly used in the removal of contaminated sediment are mechanical, hydraulic, and pneumatic.

Mechanical dredging is an excavation operation similar to conventional earth moving. Hydraulic dredging technologies use suction to dislodge, capture, and transport contaminated sediment to the staging area. The third type, pneumatic dredging, is similar to hydraulic dredging, but uses compressed air to pneumatically lift the sediment. Pnuematic dredges pick up less water than hydraulic dredges, but they do not work well in shallow areas. Hydraulic dredging was selected for Coldwater Creek because the technique is applicable in relatively calm streams with very shallow depths. In Coldwater Creek, extended areas of contaminated sediment could be vacuum-dredged with a horizontal auger dredge or a modified cutterhead dredge capable of removing contaminated cohesive sediments at a rate of 10 to 30 cubic yards per hour (yd^3/hr) with minimal disturbance. Hand-held hydraulic dredges controlled by wading operators

could be used in small isolated locations where shallow sewer lines are known to exist as well as in shallow sections of the creek. Slurried sediment could be piped to a mobile filtration system for dewatering.

3.6.8 Technologies and Process Options for Treatment

3.6.8.1 Dewatering (Soil and Sediments)

Dewatering techniques can be used to reduce the water content of the soils and sediments which in turn will reduce the volume and allow easier materials handling. Potential dewatering processes considered for the North County Site soils were filter presses and evapotranspiration.

Filter presses can produce a relatively dry filter cake with up to 60 percent solids. The water removed through the filtration process is likely to have acceptable contaminant concentration levels to allow discharge back into the creek. Evapotranspiration is accomplished by land farming the soils and sediment onto a liner to allow the water to naturally evaporate. With both dewatering processes, the dewatered solids would be transported in dump trucks to the SLAPS staging areas to be consolidated with other soils.

3.6.8.2 Size Reduction

Concrete crushing, metal shredding, and compaction are size reduction techniques that have been successfully used at other FUSRAP Sites. These processes make the materials easier to handle, transport, and dispose, and in some cases reduce the waste volume.

3.6.8.3 Soil Separation

Separation can be accomplished by screening the soils to remove large objects and debris. This process can be used alone or as a pretreatment step for soil washing or soil sorting. The oversized materials removed by the screen are likely to be non-contaminated. Non-contaminated oversized materials could be placed back on the site or disposed of as non-radioactive industrial waste. The remaining soils would be consolidated with other site soils. Soil separation could reduce the volume of soils requiring management as radioactive materials.

3.6.8.4 Soil Sorting

Soil sorting involves the mechanical sorting of soils based on radionuclide concentrations to separate contaminated soils from the clean soils. The most prevalent soil sorting systems use gamma radiation detectors to identify the contaminated soils. Field testing of this technology would be required to ensure its effectiveness due to the presence of Th-230 (an alpha emitter) in the North County Site soils. Two primary advantages of soil sorting as compared to other technologies (such as soil washing) are that this technology does not produce any secondary waste (such as process waste water) and does not require process additives.

3.6.8.5 Soil Washing

Soil washing can achieve volume reduction of the soils and sediments in two ways: (1) by dissolving or suspending the contaminants in the wash solution or (2) by concentrating the contaminants into a smaller volume through particle size separation. Soil washing systems that

incorporate both techniques achieve the greatest success with soils contaminated with radioactive, heavy metal, and organic constituents. Soils containing large amounts of clay and silt, such as those at the North County Site, are typically not effectively treated by conventional soil washing systems. However, soil washing can be enhanced by incorporating other physical and chemical processes to more effectively treat these types of soils. Laboratory characterization and technology screening tests on the North County Site soils indicate that soil washing, enhanced by or combined with chemical extraction, could reduce the volume of soils requiring management as radioactive waste.

Following treatment, the smaller volume contaminated soil fraction could be processed through an additional treatment process (such as stabilization), or could be dewatered and disposed. The clean soils from the treatment process could be placed back on the site, or could be reused at another site. During operation the majority of the soil washing process water is filtered and recycled back into the treatment system. A small volume of this water stream would require periodic discharge.

3.6.8.6 Immobilization

Immobilization technologies use various cement- and silicate-based mixtures to act as binding agents to minimize the migration of the contaminants. However, as discussed in Section 2.2.4.2 of this FS, the contaminants in the North County Site soils are not very mobile, primarily because the clayey soils tend to bind the radionuclides. Most immobilization processes result in a significant increase in volume (up to double the original waste volume). Immobilization was eliminated from further consideration because of the volume and cost increases associated with this technology.

3.6.8.7 Chemical Stabilization

Chemical stabilization is similar to immobilization, except that the decrease in contaminant mobility is achieved by a chemical reaction between the contaminant and the stabilizing agent. Because the contaminants in the St. Louis soils are not very mobile, treatment by chemical stabilization would not be cost effective. Like immobilization, chemical stabilization was eliminated from further consideration because of the volume and cost increases associated with this technology.

3.6.8.8 Chemical Extraction

Chemical extraction technologies use chemicals to leach contaminants from the soil and create a treatable liquid waste stream. The extraction agent is separated from the contaminant, usually in ways that enable the extraction agent to be fully reconstituted and reused. Extracting contaminants from fine soil particles, such as those at the St. Louis Site, may require longer leaching times than would coarser-grained soils. Laboratory testing has been performed on the St. Louis soils to evaluate the use of chemical extraction combined with soil washing. The results of the tests showed that chemical extraction provided significant removals of the radioactive contaminants. Additional discussions regarding chemical extraction are included in the discussions on soil washing.

3.6.8.9 Bioremediation

Bioremediation technologies are destruction or transformation techniques directed towards stimulating microorganisms to grow and use the contaminants as a food and energy source by creating a favorable environment for the microorganisms. Bioremediation is not generally applicable for the treatment of inorganic contaminants, such as those at the St. Louis Site. Therefore, bioremediation was eliminated from further consideration.

3.6.8.10 Phytoremediation

Phytoremediation is an emerging technology that uses metal-accumulating plants to remove toxic contaminants from soils. The plants are harvested and disposed, leaving the soil available for reuse. Phytoremediation is most effective for shallow isolated areas with moderate levels of contamination.

3.6.8.11 Incineration

Incineration uses high temperatures to volatilize and combust (in the presence of oxygen) organics in waste materials. Incineration would not be effective in treating the radioactive contaminants present in the St. Louis soils. Therefore, incineration was eliminated from further consideration.

3.6.8.12 Vitrification

Vitrification uses high temperature to heat and melt contaminated soil, dewatered sludge, and/or sediments into a glasslike matrix. The vitrification process involves blending glassmaking constituents (e.g., silicon and aluminum oxides) and the waste in a high-temperature furnace. The waste materials are melted in the molten glass; upon cooling, a solid mass forms that contains the immobilized waste. Small quantities of organics, heavy metals, and/or radionuclide contaminants may be volatilized during the melting process and require treatment through an off gas system.

Typically, the residual product is a slag approximately ten times stronger than unreinforced concrete, both in tension and compression, with decreased contaminant mobility. It is usually not affected by either wet/dry or freeze/thaw cycling.

Due to the high temperatures required, vitrification requires an enormous amount of costly energy to melt and vitrify the soil. Consequently, vitrification is most appropriately suited for applications where mobile contaminants pose a very significant risk to human health (i.e., high-level radioactive waste), where contamination is highly concentrated, or where the total volume of waste is relatively small.

3.6.8.13 Recycle to Uranium Mill

Often, soils and waste materials contain uranium or other resource materials. These materials can be sent to a licensed uranium mill as an alternate source material. The value of the recovered uranium can offset the price of processing the material and disposing of the resulting waste.

3.6.8.14 Metals Recycling

Several commercial facilities accept metals contaminated with radioactive materials for recycling. The ability and costs to recycle the metal will depend on the type and level of the contamination present, and on the type and configuration of the metal.

3.6.8.15 Ancillary Treatment Technologies

Although no buildings have been identified that require remedial action, decontamination methods are retained as a contingency treatment technology that could be used if building contamination is discovered during the cleanup process or final status surveys. Both physical methods (vacuuming, scrubbing, scraping, sanding, grinding, scabbling, and blasting) and chemical methods (solvents, complexing agents, acids) are retained.

Treatment options for addressing surface water or ground water as contaminant source media are not required. However, because surface water could contact contaminated soils during remediation work and because ground water could seep into the excavation, water treatment technologies have been retained as ancillary options. Treatment technologies considered for ground water and surface water include air stripping, carbon adsorption, ion exchange, reverse osmosis, and evaporative recovery. Precipitation/flocculation/sedimentation, aeration, filtration, soil dewatering, and sludge dewatering are pretreatment technologies that may be required for these water treatment options. Surface water at the site could be collected for treatment through interceptor trenches. Ground water at the site could be collected for treatment by passive interceptor systems or pumping well systems. Passive interceptor systems consist of trenches or drains that are excavated to a depth below the water table and are connected to a collection pipe. The ground water could then be treated and discharged. Pumping well systems could be used for hydrodynamic control of the ground water by manipulating the hydraulic gradient through the injection or extraction of water.

Reaction walls could be used as an in-situ treatment technology to prevent migration of contamination from soil via ground water. Reaction walls are permeable barriers across the ground water flow path that allow the passage of water while prohibiting the movement of contaminants by employing such agents as chelators, sorbents, microbes, etc., within the barriers. The contaminants would either be degraded or retained in a concentrated form by the barrier material. This option has been retained as a contingency should monitoring data indicate significant increases in the migration of contaminants via ground water.

3.6.9 Technologies and Process Options for Disposal

A summary of potential disposal options considered for the North County Site is provided in Table 3-4.

Table 3-4. Summary of Disposal Options

Disposal Options				
In-State FUSRAP Disposal Facility	**FUSRAP-Dedicated Facility**	**Existing Commercial Facility**	**Existing DOE Facility**	**Beneficial Reuse**
USACE would have to purchase property; siting studies would have to be completed; permits would have to be obtained; cell would have to be constructed.	USACE would have to purchase property; siting studies would have to be completed; permits would have to be obtained; cell would have to be constructed.	Multiple facilities are available and being used by USACE for FUSRAP.	Approval for disposal would be required; implementability affected by the availability of capacity. Waste containerization may be required.	Requires siting and design criteria study; modeling done to determine acceptable contaminant levels; must evaluate impact on ground water; approvals would be necessary.

3.6.9.1 New Disposal Facilities

Although new facilities were considered, the implementation of these options is affected by the need for siting studies, facility design, environmental assessments and/or environmental impact statements, and public review. Delays caused by these requirements, individually or collectively, could make implementation untimely by postponing operations beyond the time for remedial action to begin. During the site selection process, activities related to the construction and operation of the facility would be analyzed, and site selection would be performed to eliminate or minimize unacceptable impacts.

3.6.9.2 Licensed or Permitted Disposal Facilities

Under this option, contaminated materials would be excavated and transported off-site to a commercially-licensed disposal facility for permanent disposal. All of the existing commercial disposal facilities for soil and debris use shallow land burial technology (i.e., trenches). Long-term maintenance would be the responsibility of the receiving facility for this disposal option. The receiving facility would need to have all appropriate permits or licenses. Water would be discharged to a publicly owned treatment works (POTW) or surface water as permitted.

3.6.9.3 Beneficial Reuse (All Media)

One alternative to disposing of contaminated soil in a radioactive waste disposal facility is to recycle the soil, using it for activities that would limit the potential for human exposure to within acceptable levels. Examples of beneficial reuse include construction of highways and airport runways. Beneficial reuse has been used previously for the Elza Gate FUSRAP Site, where the soil was used as cover material for another disposal site on the DOE Oak Ridge Reservation. There are other industry examples, such as incorporating fly ash (which also has metals and radioactivity) into concrete. For these uses, the soils would have to meet engineering specifications for the beneficial residue being considered.

As an alternative to disposal, beneficial reuse of the soils is also a possibility at the nuclear sites as a cover for highly contaminated structures and/or wastes. At low-level radioactive waste facilities, North County Site soil could be used as fill material to cover layers of more highly contaminated waste such as retired nuclear reactors. At major construction projects, this soil could be used as fill material for road construction or other uses where exposure to the public would be limited. One possible beneficial reuse of North County Site

soils would be as backfill material for the Lambert-St. Louis International Airport runway expansion. Major modifications, including the construction/refurbishing of four new runways, are planned to occur over the next 10 to 15 years.

3.7 SCREENING OF REMEDIAL TECHNOLOGIES

3.7.1 Evaluation Criteria Used for Screening

Remedial action technologies have been developed for the North County Site in accordance with NCP and EPA guidance and on the basis of GRAs and remedial technologies identified for the specific conditions at the North County Site. As summarized in Table 3-5, the remedial action technologies were evaluated and screened by using the criteria of effectiveness, implementability, and cost, which are three of the NCP's primary balancing criteria for evaluating remedial alternatives. Criteria are defined below:

- Effectiveness is evaluated in terms of protecting human health and the environment in both the short term and the long term and in reducing contaminant toxicity, mobility and/or volume;
- Implementability is evaluated in terms of technical feasibility, administrative feasibility, and resource availability; and
- Cost is evaluated in a comparative manner (i.e., low, moderate, or high) for technologies of similar effectiveness or implementability.

3.7.1.1 Effectiveness

The criterion of effectiveness measures the ability effectively to protect human health and the environment by reducing the toxicity, mobility, or volume of contaminants. Short-term protection involves reducing existing risks to the community and workers during implementation of remedial actions. The ability of a technology to meet RGs was evaluated. The time required for the technology to achieve the RGs was also considered, including the potential length of exposure to which the local public may be subjected. The criterion also includes long-term protectiveness and addresses the magnitude of residual risk and the long-term reliability. The technologies were also evaluated for their effectiveness in preventing further exposure to residual contamination.

3.7.1.2 Implementability

Each technology was evaluated in terms of implementability, including technical feasibility, administrative feasibility, and availability of necessary remedial materials, equipment, and work force. The assessment of short-term technical feasibility considered the ability to construct the given technology and the short-term reliability of the technology. Long-term technical feasibility factors considered include the ease of undertaking additional remedial action if necessary, monitoring the effectiveness of the given remedy; O&M administrative feasibility for implementing a given technology was evaluated by reviewing the ability to obtain approvals from other agencies, the likelihood of favorable community response, and the need to coordinate with other agencies.

Table 3-5. Summary of Technology Screening at the North County Site

Response Action	Potential Technology	Process Options	Effectiveness	Implementability	Cost
Access Controls	Site security	Physical barriers, signs, security patrols, guards	Effective for short term in reducing exposure.	Easily implemented	Low to Moderate
Institutional Controls	Zoning restrictions	Zoning restrictions	Effective for short term.	Easily implemented	Low
	Land use restrictions, notices, and ownership	Land use notices, easements, deed notices, well use advisories, well drilling prohibitions, government ownership	Effective for short term. Government ownership has good potential for long term effectiveness.	Easily implemented at government owned properties	Low to Moderate
Monitoring: Short and Long Term	Air	Particulates, radon	Documents site conditions, but does not reduce risk.	Easily implemented	Low
	Sediment	Chemicals, radioactivity	Documents site conditions, but does not reduce risk.	Easily implemented	Low
	Surface water	Chemicals, radioactivity	Documents site conditions, but does not reduce risk.	Easily implemented	Low
	Ground water	Chemicals, radioactivity	Documents site conditions, but does not reduce risk.	Easily implemented	Low to Moderate
Containment	Engineered Cell	UMTRCA, UMTRCA like, Subtitle C or D	Effective, but requires maintenance.	Easily implemented	High
	Cap	Multi-media, clay, asphalt, concrete, synthetic	Effective, but requires maintenance. Multi-media is the most effective option.	Easily implemented	Moderate
	Cover	Soil & vegetation cover	Effective, but requires maintenance.	Easily implemented	Low
Removal	Excavation		Effective	Easily implemented in most areas	Moderate to high
	Dredging	Hydraulic, pneumatic, mechanical	Effective	Easily implemented	Low
	Demolition (of roads)	Wrecking, dismantling, blasting, cutting, crushing	Effective	Easily implemented	Low to moderate
Treatment	Immobilization & stabilization	Asphalt, resins, bitumen, cementation, silicate-based mixtures, polymers	Effective in stabilizing contaminants but likely to increase volumes	Easy to moderate	Moderate
	Soil washing and Chemical extraction	Size separation, chemical separation, gravity separation, magnetic separation	Effective in removing contaminants, but may not achieve unrestricted cleanup criteria	Easily implemented	Moderate
	Vitrification	Microwave, melter, in-situ	Effective	Moderate to difficult to implement for rubble and metal	High
	Recycle to uranium mill and metals recycling		Effective for most soil streams	Easily implemented	Low to moderate

Table 3-5. Screening of Technologies and Process Options for the North County Site (Cont'd)

Response Action	Potential Technology	Process Options	Effectiveness	Implementability	Cost
Treatment (cont'd)	Soil sorting	Physical sorting, radionuclide detection	Effective for volume reduction	Easy to moderate	Low to moderate
	Size reduction	Crushing, cutting, shredding	Effective	Easily implemented	Low
	Bioremediation				Low
	Phytoremediation		Effective for uranium and some metals	Easily implemented	Low
	Dewatering		Effective	Easily implemented	Moderate
	Incineration		Effective for some contaminants	Moderate to difficult	Moderate to high
Transportation	Rail	Covered gondolas, bimodal containers	Effective	Easily implemented	Low
	Truck	Covered trucks, bimodal containers	Effective	Easily implemented	Moderate
	Barge	Covered transport via barges	Effective	Requires use in conjunction with truck or rail	High, requires transfer to truck or rail.
Off-site Disposal	Licensed or permitted off-site cell		Effective	Easily implemented	Low
	Beneficial reuse of soils	St. Louis Airport, disposal cells	Effective	May be difficult	Low

3.7.1.3 Cost

The cost criterion includes capital costs and O&M costs. O&M costs are estimated for a 30-year period where there are hazardous substances, pollutants, or contaminants that may pose a threat to human health or the environment remaining at the site. Costs for each technology are rated qualitatively on the basis of engineering judgment as high, moderate, or low by comparison to the costs of similar technologies.

3.7.1.4 Recommendations of the St. Louis Task Force

The St. Louis Task Force formed a Technologies Working Group to screen and recommend technologies that might have potential application for the St. Louis Site (Task Force, 1996). They screened size separation, density separation, and attrition scrubbing because of St. Louis soil characteristics. Soil washing and chemical extraction were identified as technologies for further investigation. They also recommended ex-situ microwave vitrification coupled with gamma ray spectroscopy, and indicated that laser ablation nebulization spectroscopy deserved further consideration. They also recommended that the use of barrier technologies be investigated to prevent contamination of underground and surface water. These technologies recommended by the Task Force are evaluated as part of the evaluation of candidate technologies discussed below.

3.7.2 No Further Action

The no further action alternative provides a baseline for comparison with other alternatives, as required under CERCLA. This alternative provides no additional protection of human health and the environment. No remedial actions would be taken to reduce, contain, or remove contaminated soils. No effort would be taken to prevent or minimize human and environmental exposure to residual contaminants on-site. Off-site migration of contaminants would not be mitigated under the no further action alternative.

Potential effects on human health and the environment under this alternative are presented in the BRA (ANL, 1993), supplemental risk evaluations for Coldwater Creek (SAIC, 1993a), Ecological Risk Assessment (SAIC, 2001), and Appendix D of this FS. These studies showed that the radiological risk for current use (maintained by USACE with controls in place) at the North County Site properties is within EPA's acceptable risk range of 10^{-6} to 10^{-4}. However, future uses could lead to unacceptable risk because this alternative provides no controls to limit exposure to contaminants or long-term management measures. For that reason, the overall objective of any remedial action implemented at the North County Site is to comply with ARARs and site-specific RGs, resulting in site conditions that allow for unlimited use and unrestricted exposure. Under the no further action alternative, there would be no reduction in the mobility, volume, or toxicity of site-related contaminants. No unacceptable current or future ecological risk has been identified at the site. Five-year reviews would be conducted under the no further action alternative.

3.7.3 Institutional Control Technologies

3.7.3.1 Institutional Controls for Soils

The selection of a remedy that leaves residual soil contamination at levels that exceed the concentrations specified in ARARs for residential use would necessitate the use of institutional controls.

Effectiveness

Institutional controls are used to either prevent or limit access to contaminated areas, and include a wide variety of security, legal, and administrative controls. SLAPS and HISS/Futura are currently fenced with signs and other security measures.

Institutional controls increase protection of human health and the environment over baseline conditions by limiting direct access to the site using site security measures, and by limiting use of the site using deed or land-use restrictions. Although there would be no reduction in volume, toxicity, or mobility of contaminants in the soil, future risk would be maintained at acceptable levels as a result of access and use restrictions. That is, acceptable risk conditions would be maintained for the North County Site properties in the future by controlling future property uses. To accomplish this, the Federal Government would need to purchase property outright, negotiate deed restrictions with property owners, or negotiate land-use restrictions to be imposed by local zoning jurisdictions.

Implementability

Deed restrictions can be implemented, but may require extensive negotiations with property owners. Implementing deed restrictions at SLAPS would require negotiations with its owner, the City of St. Louis. It would be possible to secure land-use restrictions through the various zoning jurisdictions in the area, but present uses would not be affected; only future uses would be governed by new land-use regulations. Security measures can limit site access and potential exposure. Institutional controls would be more difficult to implement at the VPs because there are multiple private owners and different municipal jurisdictions.

Deed notices or land use restrictions can be applied to prevent, limit, or require permits for excavation, construction, or any other activity that can disturb soils. If the Federal Government purchases the property, it can place conditions, covenants, or restrictions in the deed as it deems appropriate, so long as the restrictions are compatible with state laws. However, currently USACE must negotiate deed restrictions with the owner. The deed restrictions would exist in perpetuity. Land-use restrictions secured from local governments could limit or bar future site development or use by rezoning the property.

Cost

The cost estimate for implementing the institutional controls and site maintenance alternative includes low to moderate capital and low O&M costs. The costs associated with imposition of institutional controls would be expected to include the costs of legally "taking" landowners' property rights whenever landowners do not want to convey them. Potential legal fees and compensation for implementing deed restrictions and property purchases could increase

the costs of this alternative. Deed restrictions negotiated with property owners could generate significant legal fees, depending on the length of negotiations. The lower bounding cost would be only legal fees; however, the upper bounding cost would be full purchase of properties at fair market value.

3.7.3.2 Institutional Controls for Coldwater Creek Sediments

Effectiveness

Institutional controls would maintain acceptable protection of human health and the environment under current use scenarios. If institutional controls and site maintenance are implemented, use limitation restrictions would limit activity within the creek and prevent uncontrolled dredging for residential or industrial use. Disposal of dredged material could be controlled through a joint agreement between USACE and local government agencies. If needed, access to properties for erosion control can be negotiated. These restrictions would control the potential for exposure to contaminated sediments from the creek.

Implementability

Institutional controls would require negotiation with property owners, state/local governments, and USACE to implement restrictions on dredging in limited areas of the creek. Restrictions on future dredging activities would be coordinated with state/local governments.

Cost

This control imposes low O&M costs.

3.7.3.3 Institutional Controls for Ground Water and Surface Water

Effectiveness

Institutional controls would ensure that groundwater will not be available for future use at the site. Restrictions on ground water use offer a means of institutional control for property that is transferred to another owner or operator. Ground water is not presently a source of drinking water, and its potential future use could be prohibited by denying all permits to install new wells.

As described in the no further action alternative, the fate and transport of contaminated soil particles in ground water is naturally controlled by the low permeability of the aquifer soils. This technology would prohibit ground-water well installation or ground water use through deed restrictions. Similar use restrictions could be placed on surface water if determined necessary based on monitoring.

Implementability

Implementing deed restrictions to restrict ground-water use at SLAPS, HISS/Futura, and the ballfields would require negotiation with the responsible public authorities. Coordination between state and local authorities would be required to enforce well permitting restrictions. Ongoing monitoring of ground water would be used to identify any spread of contamination that would require imposing new deed restrictions. Coordination with the public health department,

state, and local governments would be required to restrict the issuance of well installation permits. Personnel and resources to implement the necessary institutional controls are available.

Cost

Capital costs are low to moderate. The costs are those required to develop and negotiate, if necessary, restrictions on water use. Such costs can range widely, depending on the need for and amount of compensation.

3.7.3.4 Screening Results

Physical barrier signs, access restrictions, land use notices, easements, deed notices, well use advisories, well drilling prohibitions, zoning restrictions, and government ownership are retained as institutional control technologies.

3.7.4 Containment Technologies

Containment technologies protect human health and the environment by physically separating the contaminated materials from potential receptors. Two soil containment options were considered (1) construction of an engineered, on-site disposal cell and (2) placement of a multi-layer cap over the contaminated soils.

3.7.4.1 On-Site Engineered Disposal Cell

Under this option, an encapsulated, above-ground disposal cell incorporating a bottom clay liner and a multilayer cover would be constructed at SLAPS and on a portion of the ballfields. Contaminated soils at the proposed disposal site would be excavated and replaced with fill material. The excavated materials would then be set aside in a temporary storage area while a bulldozer and sheepsfoot roller would be used to recompact the fill to ensure a stable base for the disposal cell. A 0.9 m- (3 ft-) thick, low permeability clay liner would be constructed to isolate the wastes from the underlying water-bearing units. The waste soils from the other North County Site properties would be transported to the SLAPS area and added to the disposal cell as they are excavated from their current locations. During active operation, any runoff generated from the waste placed in the cell would be captured by a passive runoff system, directed to sumps, and treated prior to discharge.

At closure, wastes would be covered by a multimedia cap to control erosion and minimize generation of leachate resulting from rain-water infiltration. The cap would consist of an upper vegetative layer, a drainage layer composed of coarse material (sand, gravel, and rip-rap), and a low permeability clay layer with a maximum vertical permeability of 1×10^{-7} cm/sec. The layers of sand, rip-rap, and topsoil overlying the disposal facility would protect the underlying clay layer and divert surface-water drainage away from the site. The area around the cap would be contoured or graded, and vegetation would be used to control runoff and reduce erosion. Percolation through the cover due to precipitation would be captured by the passive runoff system. The cover would be visually inspected periodically to identify and repair any areas of erosion, animal burrowing activities, or deep root growth. Survey markers would be placed on the disposal cell to aid in assessing the effects of subsidence on the long-term integrity of the cap.

The disposal cell would be constructed to meet UMTRCA design standards specified in 40 CFR 192. The disposal cell must be effective for up to one thousand years, to the extent reasonably achievable, and in any case, for at least 200 years. At completion, the disposal facility must provide reasonable assurance that radon-222 from residual radioactive material will not exceed an average release rate of 20 pCi/m^2/s, or increase the annual average concentration of radon-222 in air at or above any location outside the site perimeter by more than 0.5 pCi/L.

Effectiveness

The engineered on-site disposal cell, if installed, operated, and maintained properly, would provide an effective and reliable means of isolating the wastes at SLAPS and would reduce the potential for human exposure to site contaminants. Implementation of this option would be effective in reducing the mobility of the contaminants in the disposal cell because the cap and liner would limit water infiltration through the unit, thereby preventing further leaching of contaminants into the ground water. The cap also would provide a direct reduction in the mobility of surface contamination (i.e., minimizing or eliminating the potential for wind transport and sediment transport through runoff).

USACE would have to obtain land from the Cities of St. Louis, Hazelwood, and Berkeley for construction of the disposal cell. The cell would require approximately 13 ha (33 acres) of land at SLAPS and the ballfields, and a possible additional 4 ha (10 acres) would be required to house support facilities during the remedial action. The spatial requirements for the cap would require the partial relocation of McDonnell Boulevard onto Banshee Road, which is south of SLAPS. In addition, this option would require land-use restrictions at the proposed disposal site to eliminate risks associated with direct contact with the waste in the future. The long-term reliability and effectiveness of these controls depends upon a number of factors, including cooperation and enforcement efforts of federal, state, and local governments and the affected populations. Potential risk under the intruder scenario would be a concern due to the proximity of the disposal cell to the city, and might require management using additional access controls.

Perpetual maintenance of the site would be required because the waste would retain its low-level radioactivity for thousands of years. The cap would require visual inspections periodically to identify and repair any damage to the cap due to erosion, deep root growth, animal burrowing, or other factors. Radon would be monitored after closure to ensure compliance with ARARs. Ground-water monitoring would be conducted during and after remediation to track any changes to ground-water quality. The length of the monitoring program would be based on the results of five-year reviews and could be in perpetuity.

Short-term risks to workers and the community resulting from excavation and construction activities would occur. Risk to the public due to construction of the on-site disposal cell would not be expected to be significant because public access to SLAPS is limited. The construction activities would cause short-term impacts to surrounding land uses (such as traffic delays and additional noise and dust), and could negatively affect some local businesses located near the area. Mitigation measures, such as identifying alternative routes to businesses, providing traffic control personnel, and scheduling work to avoid rush-hour periods, would lower impacts to the affected businesses. The construction of the cell and the installation of the cap would also increase the potential for construction workers to be exposed to COCs in the short term. Potential exposure pathways include ingestion, inhalation of particulates, dermal absorption, and external exposure to ionizing radiation. The short-term risks to a worker resulting from excavation

activities, transport of wastes, and construction of an on-site cell are not expected to exceed acceptable limits due to implementation of a site health and safety plan and the use of mitigation measures such as dust suppression methods.

Implementability

Implementation of the on-site disposal cell option is technically feasible. Construction of an on-site disposal cell is very feasible because materials for construction are commercially available and because no specialized equipment is necessary for installation. Additionally, no specialized workers are necessary for implementation of this action. Other aspects of the alternative, such as truck transport of soil, construction of temporary roads, use of staging area for loading and unloading, soil erosion control, excavation dewatering, and clearing and grubbing, are conventional activities in construction projects of this kind. Special engineering techniques involving precautions on excavation near buildings and structures would be observed during remediation.

An assessment of the suitability of SLAPS for use as a location for the waste disposal cell was performed in support of the FS/Environmental Impact Statement prepared by DOE in 1994. The assessment evaluated the potential effects of an earthquake in the area, the ability of site soils to support a disposal facility, the potential for contaminant transport from the site, and the potential for flooding at the site. The conclusion of the Site Suitability Study (DOE, 1994a) was that SLAPS is a suitable location for a waste disposal facility.

Cost

This option would have high capital and moderate O&M costs. The cost of constructing and maintaining a new cell is similar to the cost of disposal at an offsite licensed or permitted disposal facility with similar features and performance. Information concerning costs for an onsite disposal cell is included in Appendix C of this FS.

3.7.4.2 Engineered Cap

A multilayer cap is another potential containment technology that could be utilized at the North County Site. Contaminated soils would be consolidated and covered with a low permeability cap at a suitable location on-site. The cap would have low permeability and would consist of all-natural materials (no synthetic liners or other man-made materials). The multilayer cap would reduce the potential for human exposure to underlying contaminated materials; it would also reduce both the migration of contaminants into surface water and ground water and the generation of fugitive dust. Remedies to prevent uncontrolled subsidence would be employed as required to stabilize the cap area.

Effectiveness

A multilayer cap is a proven, effective technology that provides a physical barrier between receptors and contaminated soils. The cap would reduce the potential for direct contact (absorption, ingestion, or inhalation) and would minimize potential exposure to external gamma radiation and radon gas. It would also minimize water infiltration and would reduce the mobilization of contaminants by leaching from soil to ground water. Mitigation measures and

proper safety procedures would control the possible short-term increased risk from fugitive dust emissions during construction.

This option would require both institutional controls to limit use of or access to the site and environmental monitoring to detect breaching of the cap and contaminant migration. The Federal Government would acquire the property, build the cap, and provide site maintenance and monitoring.

Implementability

Although no technical problems are anticipated that would limit the implementability, containment options have been opposed by several local stakeholders, including government officials. In addition, capping would require perpetual maintenance. Nevertheless, capping is a well-established technology and would be implementable at the site. Some clearing and grubbing, rerouting of utilities and other site preparation activities would be required before the cap could be constructed. Site monitoring would be required for as long as the media under the cap represent a threat to human health and the environment.

Cost

Capping would have lower capital and O&M costs than the on-site disposal cell option. The capital costs of capping would be higher than institutional controls, but lower than excavation and disposal. The capital costs include soil excavation, transportation, and installation of a cap. O&M costs would be a function of the degree of activity needed to address soil subsidence, and of the long-term monitoring requirements.

3.7.4.3 Screening Results

The ability of USACE to obtain the property needed for the disposal cell and the potential negative public reaction to the siting of the disposal cell at the SLAPS area would limit implementability of the on-site disposal cell option. In addition, the time required to acquire the property, and to obtain design approval for the disposal cell, could potentially cause delays in implementation of that option. The capping option has been shown to be an effective means of preventing human exposure to underlying contaminated materials, but is less disruptive to the community and less costly than the on-site fully encapsulated cell. Therefore, multimedia caps are retained as an option, but on-site engineered disposal cells are not.

3.7.5 Removal Technologies

3.7.5.1 Soil

Effectiveness

Soil removal is protective of human health and the environment. It protects human health and the environment more than the previously outlined technologies, and it achieves RAOs. The future residual risk would be reduced and compliance with ARARs would be achieved. Exposure from fugitive dust, radon gas, external gamma radiation, contaminants leaching into ground water, and contaminated surface-water runoff would be greatly reduced. Short-term risks, including non-radiological occupational injuries and risk of fatalities as well as transportation risk, would increase as the volume of soil being handled and moved increases.

During implementation, there would be possible short-term risk from fugitive dust emissions, which would be readily manageable by means of implementation of a health and safety plan and an environmental protection plan. Although air quality could be adversely affected by release of particulates and radon gas during excavation, mitigation measures, such as dust suppression methods and proper safety procedures, would be implemented to minimize any increased risk to the community or to on-site workers during implementation. Excavation can be more effective when controlled with characterization technologies to limit over-excavation of material.

Implementability

Soil excavation uses readily available resources and conventional earth-moving equipment. Some ancillary construction of temporary roads, a staging area for loading and unloading, soil erosion control, excavation dewatering, water treatment, and additional clearing and grubbing may be necessary. Transportation and disposal of wastes are technologies that are generally combined with excavation.

Cost

Costs related to soil removal are moderate to high.

3.7.5.2 Sediments

Effectiveness

Hydraulic dredging appears to be a good technique for Coldwater Creek because the technique is applicable for moderate-volume projects in relatively calm streams with very shallow depths. Hydraulic dredges are also the most effective dredging technique currently available for minimizing over-dredging and minimizing re-suspension of sediment while operating. Precision dredging is important because lateral sewer lines are known to cross under the contaminated sections of the creek at shallow depths, and to run along creek banks. This technique will be effective in dredging the sediments without damaging the lateral sewer lines. Also, by vacuuming the sediments, the threat of further environmental harm through re-suspension of contaminants will be minimized. In addition, costs associated with hydraulic dredging technologies are generally less than mechanical and pneumatic dredging technologies.

Dredging includes the removal of sediment and dewatering of the sediment. Where contaminated sediment levels are such that the dredged sediment will exceed the ARARs, the sediment could be hydraulically dredged to remove it from these channel bottom areas. The slurry would be dewatered to facilitate handling and disposal. During the dewatering process, the separated water would be tested and, if needed, treated before discharge back into the creek. The dewatered sediment could be transported by truck to SLAPS to be combined with excavated accessible soils. Consistent with CWA regulations, dredging discharge operations would be controlled by complying with the substantive requirements of dredging and discharge for permitting. Monitoring and security measures would be implemented during dredging operations.

Implementability

Dredging is a commonly used technique for remediating contaminated sediments. At Coldwater Creek, a hydraulic dredge would be used to reduce the risk of damaging the lateral

sewer lines that run beneath and along the creek bed. Dredging, dewatering, water treatment, clearing, and hauling equipment would be required. A staging area would be required that is large enough to accommodate the equipment, sediment, and separated water handling. Before startup, the remedial activities would require coordination with the affected property owners, utility companies, Missouri Department of Natural Resources (MDNR), and EPA Region VII. The substantive requirements of permitting would need to be satisfied. Clearing and grubbing activities would be required along the creek before dredging. After dredging, disturbed areas would be restored, where appropriate. Dredging could be conducted safely and practically because only standard procedures and equipment readily adaptable to Coldwater Creek conditions are involved.

Cost

This technology has moderately high capital costs and low O&M costs.

3.7.5.3 Screening Results

Excavation using earth-moving equipment, dredging (with a preference for hydraulic dredging), precision excavation, and road demolition are retained.

3.7.6 Treatment Technologies

With the exception of soil washing, site-specific laboratory or pilot scale data are not available to assess the effectiveness of the technologies. Published literature, previous experience at other FUSRAP Sites, and vendor information was used to judge the technologies effectiveness, implementability, and costs.

3.7.6.1 Immobilization (Soils and Sediments)

Effectiveness

Ex-situ immobilization is one of the most mature remediation technologies. It has been successfully used on radioactive waste to reduce the mobility of the contaminants. Treatment of the soils and sediments by immobilization processes would pose minimum risks to the local community and workers. Some dust may be generated during the excavation operations; however, the amount generated would be equivalent to that generated with any alternative requiring excavation and soils handling (for example, soil sorting and soil washing).

Implementability

The soils/sediments would require excavation and transport to a centralized staging area for on-site treatment. The solidified materials would be significantly greater in volume than the original waste material. The immobilized waste would be sent off-site for disposal. Qualified vendors and equipment are readily available to perform this treatment operation.

Cost

Medium to high. The disposal costs would be significantly increased with this treatment alternative due to the increased volume of the waste requiring disposal.

3.7.6.2 Soil Washing (Soils and Sediments)

Effectiveness

Soil washing enhanced with chemical extraction has been proven effective for reducing the levels of contamination in the North County Site soils. Laboratory and conceptual design studies were conducted on soils from the North County Site to investigate treatment processes which would provide a volume reduction and reduce the remediation costs. The primary focus of the investigation was soil washing, including both physical and chemical processes (Clemson Technical Center, 1996). A bench scale selective chemical extraction process was developed that was able consistently to meet the RGs for the North County Site. Removal efficiencies of the radionuclides of interest, particularly Th-230, were consistently greater than 96 percent, and frequently in excess of 98 percent. It is expected that all of the site soils containing less than 500 pCi/g of Th-230 could be treated to meet the cleanup goals with this process. Based on limited evaluations of higher activity soils, the process may even be able to successfully treat soils containing Th-230 activities as high as 2,000 pCi/g. Based on the results of these tests, a (conceptual) process design and cost estimate for a full-scale system was developed. The conceptual cost estimates show that treatment by soil washing could be cost effective if process improvements were incorporated to minimize the amount of reagents/chemical required, and to treat the un-recycled process waste water.

The soil washing treatment system would be located on-site. The clean soils from the treatment operations could be placed back on-site or beneficially reused at another location. The smaller volume contaminated stream would be sent off-site for disposal. Much of the water used for the soil washing system will be recycled back into the system. A disposal alternative will be required for any waste water removed from the system during operation and for the balance of the waste water at the completion of the treatment process. Approval will be required from the local regulatory agencies to discharge any water generated from the soil washing process. The time required to treat the St. Louis materials by soil washing is anticipated to be shorter than the treatment times required for soil sorting and vitrification.

Implementability

A soil washing system could be located at the airport area, and soils could be trucked from the surrounding areas to the treatment system for processing. Qualified vendors and equipment are readily available to perform this treatment operation.

Cost

Moderate (assuming that the treatment is conducted on-site and the cleaned soil from the treatment operation can be directly placed back onto the site as backfill).

3.7.6.3 Recycle to Uranium Mill (Soils and Sediments)

Effectiveness

This technology would remove contaminated soils and sediments from the North County Site and so would be very effective in meeting the RGs. The recycling technology allows for the recovery of uranium and other valuable minerals that would otherwise be disposed of as wastes,

resulting in a reduction in the volume of contaminants. This is consistent with the intent of CERCLA 121 (b), which states a preference for remedial actions that utilize "permanent solutions and alternate treatment technologies or resource recovery technologies to the maximum extent practicable".

USACE has used value engineering techniques to evaluate various alternatives for the disposition of FUSRAP materials. The recycling of FUSRAP materials as alternate feed in a licensed uranium mill has been identified as a feasible alternative to direct disposal. It reduces the radioactivity and the volume of material to be disposed of, thus satisfying the preference for treatment that reduces volume, toxicity, or mobility as a principal element [40 CFR §300.430(f)(1)(c)]. The treatment and disposal are performed at a single location, and residuals from recycling are disposed of in an NRC-compliant disposal system.

Implementability

Implementation of this technology is relatively easy. Recycle to a uranium mill has been implemented at other FUSRAP Sites and so is a proven technology for processing and disposing of these materials. In addition, the regulatory framework for this option is already in place. The International Uranium Corporation has been licensed to accept St. Louis FUSRAP soils containing low levels of radioactivity as alternate feed material (i.e., an input material for uranium extraction that is different from natural ores containing uranium).

Cost

Costs related to recycling at a licensed uranium mill are moderate. In some cases, disposal at the mill results in lower disposal costs than direct disposal at other types of facilities, in part because of the benefits of recycling. For the North County Site soils, the recycle option has not yet been proven to be more cost-effective than off-site disposal alternatives (such as shipment by rail gondolas using USACE disposal contracts). However, this option can be used when and if it is determined to be more cost-effective.

3.7.6.4 Vitrification (Soils and Sediments)

Effectiveness

Vitrification is effective at immobilizing contaminants and thereby minimizing the migration of contaminants. Vitrification is typically used on highly concentrated mobile contaminants unlike those present at the St. Louis Site. Vitrification poses a much higher risk to on-site workers as compared to the other treatment operations due to the extremely high temperatures and specialized equipment used.

Implementability

Vitrification has been used successfully to treat radioactive contaminants on other projects, but generally for much higher concentrations of contaminants, and for much smaller quantities of wastes. While some volume reduction occurs during the melting, the total volume of the final waste material often increases due to the addition of glass formers. Qualified vendors and equipment are readily available to perform this treatment operation.

Cost

High.

3.7.6.5 Phytoremediation

Effectiveness

Phytoremediation is effective for treating shallow contamination [less than 2 ft (0.6 m) in depth] which is low to moderate in concentration. The technology has been shown to be somewhat effective for uranium, but much less so for thorium. Several sequential crops of plants may be needed to reduce the radionuclide concentrations to acceptable levels.

Implementability

Easily implemented. Qualified vendors and equipment are available to perform this treatment operation. Phytoremediation is likely to be more pleasing to the local community than other ex-situ treatment processes due to its aesthetic appeal.

Cost

Low to moderate.

3.7.6.6 Dewatering (Soils and Sediments)

Effectiveness

Dewatering techniques have been successfully used as part of the St. Louis FUSRAP removal actions.

Implementability

Easily implemented. Equipment is readily available to perform this treatment operation. Approval will be required from local regulatory agencies to discharge any water generated from the dewatering processes.

Cost

Moderate.

3.7.6.7 Size Reduction (Debris)

Effectiveness

Size reduction has been successfully used as an ancillary technology in support of activities at other FUSRAP Sites to reduce waste material volumes, and to provide easier materials handling and transport. Size reduction technologies would be an option if contamination of buildings is discovered during the remedial action of final status surveys.

Implementability

Easily implementable. Qualified vendors and equipment are readily available to perform this treatment operation.

Cost

Moderate

3.7.6.8 Soil Sorting (Soils and Sediments)

Effectiveness

Soil sorting has been used successfully to treat radioactive waste contaminated primarily with gamma emitters such as uranium. Its effectiveness may be limited due to the presence of Th-230. Field tests would be required to determine the volume reduction achievable and treatment times. Due to the slower processing rate (as compared to soil washing) multiple soil sorting systems may be required, operating in parallel. No process additives are required for the soil sorting system, and no process water would be generated.

Implementability

Adequate space exists to locate the soil sorting system. Soils would be transported to a centralized area for staging and processing. Soils that are too moist would require drying prior to processing. Clean soils from the sorting operation would be placed back on site or reused at another location. The smaller volume of contaminated soil would be sent off site for disposal. Qualified vendors and equipment are available for this treatment operation.

Cost

Moderate.

Screening Results

Enhanced soil washing, recycle to uranium mill, soil sorting, size reduction, phytoremediation, and dewatering are retained. Immobilization and stabilization, simple soil washing, vitrification, solvent extraction, and bioremediation were screened out.

3.7.7 Transportation Technologies (Soils, Sediments, and Debris)

Effectiveness

Truck and rail transportation have proven to be very effective in transporting contaminated materials for disposal during previous FUSRAP cleanup actions.

Implementability

Transportation and disposal of contaminated soils, sediments, and debris would use specially lined dump trucks, rail cars or inter-model containers (which can be transported by truck or rail). If soil were moved out of state, coordination would need to be provided ahead of

time to allow the waste to cross state lines. Because not all rail lines and highways can be used to transport waste material, a shipping route would need to be carefully laid out, and an emergency response procedure would need to be developed. The administrative feasibility of an out-of-state shipment would require coordination with the appropriate state and federal agencies. Barge access is not available unless truck transport is also used.

Cost

Low to moderate.

Screening Results

Rail, truck, and barge transportation are retained.

3.7.8 Off-site Disposal Technologies (Soils and Sediments)

Effectiveness

USACE has reviewed the disposal practices used on previous cleanups, and has established contracts with multiple licensed or permitted disposal facilities. Off-site disposal options would be effective in terms of containing wastes generated at the North County Site remediation.

Implementability

The implementability of the disposal options would vary in terms of design, siting, and construction. A number of properly permitted facilities are available within the United States that could serve as locations for disposal of some or all St. Louis FUSRAP wastes. This option would, therefore, be readily implemented. The St. Louis Task Force evaluated potential disposal sites in their report (Task Force, 1996). This information supports the conclusion that existing facilities are more implementable than a new facility for disposal.

A number of commercial facilities have or are likely to have permits or licenses to receive the waste materials at this site. The material that can be accepted by the facilities varies with the terms and conditions in their license or permit.

Cost

The cost of disposal at a licensed or permitted disposal facility is low compared to the cost of constructing a new cell with similar features and performance.

Screening results

Disposal of soils and sediments at licensed or permitted facilities is retained.

3.7.9 Summary

The results of the screening are summarized in Table 3-6.

Table 3-6. Results of Technology Screening

Response Action	Potential Technology	Process Options	Screening Results
Access Controls	Site security	Physical barriers, signs, security patrols, guards	Retained
Institutional Controls	Zoning restrictions	Zoning restrictions	Retained
	Land use restrictions, notices, and ownership	Land use notices, deed notices, easements, well use advisories, well drilling prohibitions, government ownership	Retained, but government ownership would require transfer to DOE or other government agency
Monitoring	Air	Particulates, radon	Retained
	Sediment	Chemicals, radioactivity	Retained
	Surface water	Chemicals, radioactivity	Retained
	Ground water	Chemicals, radioactivity	Retained
Containment	On-site full encapsulation cells	UMTRCA, UMTRCA like, Subtitle C or D	Screened out.
	Cap	Multi-media, clay, asphalt, concrete, synthetic	Synthetic screened out
	Soil & vegetation cover		Retained
	Storage pile covers	Geotextile, spray coatings, tarps,	Retained as temporary measures.
	Dust mitigation	Water spray, foam,	Retained
Removal	Conventional excavation		Retained
	Precision excavation & characterization		Retained
	Dredging	Hydraulic, pneumatic,	Retained (hydraulic preferred)
	Demolition	Wrecking, dismantling, blasting, cutting, crushing	Retained to obtain access to difficult to access soils
Treatment	Immobilization & stabilization	Asphalt, resins, bitumen, cementation, silicate-based mixtures	Eliminated due to potential to increase volume and the moderate to high cost
	Soil Washing	Size separation, chemical separation, gravity separation, magnetic separation	Enhance soil washing retained.
	Vitrification	Microwave, melter, in-situ	Screened out
	Recycle to uranium mill		Retained
	Solvent extraction		Screened out
	Soil sorting	Physical sorting, radionuclide detection	Retained
	Size reduction	Crushing, cutting, shredding	Retained
	Bioremediation		Screened out
	Phytoremediation	Rhizofiltration Phytoaccumulation	Retained for sediments in Coldwater Creek
	Dewatering		Retained

Table 3-6. Results of Technology Screening (Cont'd)

Response Action	Potential Technology	Process Options	Screening Results
Treatment (Cont'd)	Incineration		Screened out except for some mixed wastes that are not expected, but could be encountered.
Transportation	Rail	Covered gondolas, bimodal containers,	Retained
	Truck	Covered trucks, bimodal containers	Retained
	Barge		Screened out due to high cost.
Disposal	On-site disposal cell	UMTRCA, UMTRCA like, Subtitle C or D	Screened out
	Licensed or permitted off-site cell	Radioactive wastes, hazardous wastes, solid wastes	Retained.
	New FUSRAP disposal cell		Screened out
	Beneficial reuse of soils	St. Louis Airport, Other disposal cells	Screened out

SECTION 4

DEVELOPMENT OF REMEDIAL ALTERNATIVES

4 DEVELOPMENT OF REMEDIAL ALTERNATIVES

4.1 INTRODUCTION

This section describes the development of site-wide remedial action alternatives. Emphasis was placed on identifying technologies that could be combined to provide alternatives that ensure adequate protection of human health and the environment, achieve applicable or relevant and appropriate requirements (ARARs), and permanently and significantly reduce the volume, toxicity, or mobility of site-related contaminants.

4.2 DEVELOPMENT OF SITE-WIDE ALTERNATIVES

Site-wide alternatives were formulated using the technologies retained after the screening discussed in Section 3. The alternatives cover a broad range, from no further action to complete removal of the contaminated materials. Site-wide alternatives for the North County Site are summarized in Table 4-1. This table shows the general response actions (GRAs), technologies, and process options that were combined to create six site-wide alternatives. Additional descriptions of each alternative are provided in the following text. Table 4-2 summarizes the excavation and dredging actions incorporated into each alternative. Table 4-3 summarizes the six site-wide alternatives developed for the North County Site. Tables 4-4 and 4-5 summarize the cleanup criteria considered for various property units. Details concerning the derivation of the proposed remediation goals (RGs) are presented in Appendix D. Table 4-6 provides a summary of current and future land use assumptions by property and the removal status of each property.

The rationale for combining response actions, technologies, and process options is briefly summarized below. The no-further-action response required under the National Contingency Plan (NCP) is used to form Alternative 1.

Removal technologies form the main basis for Alternative 6 and supplement other technologies in Alternatives 2, 3, and 5. Dredging is used for Coldwater Creek. However, in Alternative 2 the sediment removal is proposed to be done in conjunction with other non-Formerly Utilized Sites Remedial Action Program (FUSRAP) projects, such as flood control actions planned by the St. Louis Metropolitan Sewer District (MSD) or the United States Army Corps of Engineers (USACE) for Coldwater Creek.

Alternatives 2, 3, and 5 combine institutional controls with other removal, treatment, and containment technologies to form alternatives. Alternative 4 relies only on institutional controls. Short-term monitoring is included for Alternatives 2, 3, 5, and 6. Long-term monitoring and five-year reviews are included whenever enough contamination is left to preclude unrestricted use of the property. Long-term monitoring of HZ-A and long-term monitoring of Unit 4 in HZ-C (as a surrogate for HZ-E) would be required for Alternatives 2, 3, and 4. Long-term monitoring is not expected in Alternative 5, but short-term monitoring will determine whether long-term monitoring of HZ-A is required.

Table 4-1. Summary of Technology Screening at the North County Site

Response Action	Technologies	Process Options	Used in the North County Alternatives				
			Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Access Controls	Site security	Signs	X	X	X	X	
		Physical barriers, e.g., fencing		X			
Institutional Controls	Land use restrictions and notices	Land use restrictions	X	X	X	X	
		• SLAPS	Industrial	Industrial	Industrial	None	None
		• HISS/Futura	Industrial	None	Industrial	None	None
		• Roads, bridges, railroads, and other permanent structures	Utility	Utility	Utility	Utility	None
		• Creek (within banks)	Rec.	None	Rec.	None	None
		• Remaining VPs	None	None	All	None	None
		Deed notices	X	X	X	X[b]	
		Well drilling prohibitions	X	X	X		
		Commercial/industrial zoning	X	X	X	X[b]	
Monitoring	Long-term monitoring[a]	Air, sediment, ground water, surface water	Ground water	Ground water	Ground water	Ground water (unlikely)	
Containment	Cap	Multi-media cap	SLAPS, HISS/Futura				
		Asphalt or concrete	Roads	Roads	Roads	Roads	
Removal	Excavation		Limited for SLAPS, HISS/Futura, roads, bridges, railroads and other permanent structures	Limited for SLAPS, roads, bridges, railroads, and other permanent structures	None	Limited for roads, bridges, railroads, and other permanent structures	All Areas
Treatment	Soil sorting			X		Option	
	Soil washing	Enhanced soil washing		X			
	Phytoremediation	Rhizofiltration, phytoaccumulation		X			
Technologies Common to Alternatives 2 through 6							
Monitoring	Short-term monitoring (During remedial action)	Air, sediment, ground water, surface water	X	X		X	X
Containment	Revegetation		X	X		X	
	Dust mitigation	Water spray, foam	X	X		X	X
	Storage pile covers	Geotextile, spray coatings, tarps	X	X		X	X
Removal	Dredging	Hydraulic	Creek	Creek		Creek	Creek
Treatment	Recycle to uranium mill	Permitted facilities	Option	Option		Option	Option
	Size reduction	Crushing, cutting	X	X		X	X
	Dewatering	Evapotranspiration, filters, drying	X	X		X	X
Transportation	Rail	Covered rail cars, containers	X	X		X	X
	Truck	Covered trucks, containers	X	X		X	X
Disposal	Licensed or permitted off-site facility	Radioactive wastes, hazardous wastes, solid wastes	X	X		X	X

[a] In areas where contamination remains above unrestricted levels in sufficient quantities to significantly impact ground-water quality, ground-water monitoring could continue until terminated as part of the 5-year reviews. Long-term monitoring of HZ-A and long-term monitoring of Unit 4 in HZ-C (as a surrogate for HZ-E) is proposed for Alternatives 2, 3, and 4. For Alternative 5, the results of short-term monitoring would be used to determine whether long-term ground-water monitoring is required to assess potential contaminant migration from contaminated soils remaining beneath roads, bridges, railroads, and other permanent structures.

[b] May be needed until areas under buildings at Futura are made accessible.

Table 4-2. Removals Included in the Site-wide Alternatives

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Removals by Property Units						
HISS/Futura	Leave remaining materials in place	Excavate soils above subsurface soil supplemental limit with institutional controls and add multi-media cap.	Excavate for release without restrictions	Institutional controls with no further excavation	Excavate for release without restrictions	Excavate for release without restrictions
Roadside	No additional removals; leave remaining materials in place	Excavate for release without restrictions	Excavate for release without restrictions	Institutional controls with no further excavation	Excavate for release without restrictions	Excavate for release without restrictions
Directly under roads, bridges, railroads, and other permanent structures	Leave remaining material in place	Defer excavation and use institutional controls	Defer excavation and use institutional controls	Institutional controls with no further excavation	Defer excavation and use institutional controls	Excavate for release without restrictions
Coldwater Creek	Leave remaining material in place	Sort material during removals for projects such as flood control	Excavate to Coldwater Creek criteria below mean water gradient for release without restrictions.	Institutional controls with no further excavation	Excavate to Coldwater Creek criteria below mean water gradient for release without restrictions.	Excavate to Coldwater Creek criteria below mean water gradient for release without restrictions
SLAPS	Leave remaining material in place	Excavate soils above subsurface soil supplemental limit with institutional controls and add multi-media cap	Excavate soils above subsurface soil supplemental limit with institutional controls and consolidate other soils here for treatment	Institutional controls with no further excavation	Excavate for release without restrictions	Excavate for release without restrictions
All other vicinity properties	No additional vicinity property removals	Excavate for release without restrictions	Excavate for release without restrictions	Institutional controls with no further excavation	Excavate for release without restrictions	Excavate for release without restrictions
Total Soil Removal, Thousands						
[a]Impacted volume to be excavated, yd^3	0	150	190	0	230	300
Excavation volume, yd^3	The in-situ volume of soil plus the excavation allowance needed to remove the impacted volume; (about 20%) i.e., the size of the hole; generally 20% larger than impacted volume.					
Ex-situ, yd^3	The volume after soil swelling as a result of excavation; generally 25% larger than the excavation volume.					

[a] Impacted volume to be excavated: in-situ volume of soil above the cleanup criteria rounded to two significant figures.

Table 4-3. Site-wide Alternatives Considered in the Feasibility Study (FS)

Alternative 1	No Further Action
Alternative 2	Partial Excavation and Capping at SLAPS and HISS/Futura; Land Use A
Alternative 3	Partial Excavation and Treatment at SLAPS; Land Use B
Alternative 4	Institutional Controls (No Further Excavation); Land Use C
Alternative 5	Excavation with Institutional Controls Under Roads, Bridges, Railroads, and Other Permanent Structures; Land Use D
Alternative 6	Excavation at all Properties; Land Use E
LAND USE COMBINATIONS FOR ALTERNATIVE ANALYSIS	
Land Use A	Commercial/industrial use of SLAPS and HISS/Futura; Recreational use of Coldwater Creek; Continued use of roads, bridges, and railroads as transportation/utility corridors; and Unrestricted use of all other properties.
Land Use B	Commercial/industrial use of SLAPS; Continued use of roads, bridges, and railroads as transportation/utility corridors; and Unrestricted use of all other properties.
Land Use C	Recreational use of Coldwater Creek; Continued use of roads, bridges, and railroads as transportation/utility corridors; and Restricted use of all other properties.
Land Use D	Continued use of roads, bridges, and railroads as transportation/utility corridors; and Unrestricted use of all other properties.
Land Use E	Unrestricted use of all properties.

Table 4-4. Summary of Proposed Remediation Goals

Remediation Goals for Unrestricted Land Use	Remediation Goals for Use with Institutional Controls At SLAPS and HISS/Futura
Surface soils would be remediated if the radionuclide concentrations above background averaged over 100 m^2 exceed 5 pCi/g of Ra-226, 14 pCi/g of Th-230, or 50 pCi/g of U-238 in the top 15 cm (6 in). Subsurface soils would be remediated if the radionuclide concentrations above background averaged over 100 m^2 exceed 15 pCi/g of Ra-226, 15 pCi/g of Th-230, or 50 pCi/g of U-238 in any subsequent 15 cm (6 in) layer. Soils and sediments below the mean water gradient of Coldwater Creek would be remediated if the radionuclide concentrations above background averaged over 100m^2 exceed 15 pCi/g of Ra-226, 43 pCi/g of Th-230, or 150 pCi/g of U-238. Soil remediation goals apply to soils above the mean water gradient of Coldwater Creek. Confirmation would include surveys and residual risk calculations to ensure that total residual site risk is within the CERCLA risk range. Final status surveys compatible with MARSSIM would be used to document achievement of the remediation goals for radiological COCs.	Supplemental standards are developed for Alternatives 2 and 3 in accordance with 40 CFR 192, Subpart C. These supplemental standards are used in conjunction with institutional controls at SLAPS and HISS/Futura (the primary areas used for storage of FUSRAP materials). Supplemental standards are appropriate for the primary storage areas under the containment and treatment alternatives because excavation to the RGs for unrestricted use would result in excessive remediation costs relative to the long-term benefits, and because the residual materials will not pose a present or future hazard. The supplemental criteria constrain doses so that public exposure limits would not be exceeded should the institutional controls be lost. The supplemental criteria for subsurface soil limit contamination to average above background concentrations of 25 pCi/g of Ra-226, 70 pCi/g of Th-230, and 250 pCi/g of U-238 or combinations of radionuclides. Institutional controls are implemented to ensure that future land use is fully protective. Supporting information concerning the derivation of these RGs is presented in Appendix D of the Feasibility Study (Section D.2.2).

Table 4-5 Proposed Remediation Goals (RGs) for Non-radionuclide Contaminants of Concern (COCs)[a]

Surface		
Analyte	Units	Proposed RG[b]
Antimony	mg/kg	15
Arsenic	mg/kg	36
Barium	mg/kg	2,800
Cadmium	mg/kg	12
Chromium	mg/kg	350
Molybdenum	mg/kg	1,000
Nickel	mg/kg	1,500
Selenium	mg/kg	300
Thallium	mg/kg	25
Uranium	mg/kg	150
Vanadium	mg/kg	112
Subsurface		
Analyte	Units	Proposed RG
Antimony	mg/kg	25
Arsenic	mg/kg	40
Thallium	mg/kg	30
Uranium	mg/kg	150

[a] Non-radionuclide COCs were identified for SLAPS and contiguous areas (IAs 1-13), HISS/Futura, and Latty Avenue VPs 2L and 10k530087. Remediation of non-FUSRAP related wastes based on the RGs for non-radionuclide COCs will be conducted in areas where they are co-located with FUSRAP COCs.

[b] The calculated HIs for different primary target organs were based on the construction worker. Thus the same RGs are proposed for unrestricted use and for use with institutional controls.

Table 4-6. Land Use by Property

Property ID [a]	Current Receptor	RME Receptor	Removal Status
Primary Areas Used for Storage			
Futura	Industrial	Industrial	
HISS	Construction	Industrial	Piles removed
IA-1 (Part of SLAPS)	Construction	Industrial	Partial Removal
IA-2 (Part of SLAPS)	Construction	Industrial	Partial Removal
IA-3 (Part of SLAPS)	Construction	Industrial	Partial Removal
IA-4 (Part of SLAPS)	Construction	Industrial	Removal Action
IA-5 (Part of SLAPS)	Construction	Industrial	Partial Removal
IA-6 (Part of SLAPS)	Construction	Industrial	Removal Action
IA-7 (Part of SLAPS)	Construction	Industrial	Removal Action
Areas Immediately Adjacent to Storage Areas			
VP-1(L)[c]	Industrial	Industrial	
10K530087, west of VP-1(L)	Industrial	Industrial	
VP-2(L)[c]	Industrial	Industrial	Removal Action
IA-9	Construction	Recreational	Partial Removal
IA-11	Industrial	Industrial	
IA-13	Industrial	Industrial	
VP-40(A)	Industrial	Industrial	
Properties with Small Amounts of Contamination			
VP-1 (C)[b]	Industrial	Industrial	
VP-2(C)[b]	Industrial	Industrial	
VP-3 (C)[b]	Industrial	Industrial	
VP-4 (C)[b]	Industrial	Industrial	
VP-5 (C)[b]	Industrial	Industrial	
VP-7	Industrial	Industrial	
VP-8 (C)[b]	Industrial	Industrial	
VP-9	Industrial	Industrial	
VP-10	Industrial	Industrial	
VP-11	Industrial	Industrial	
VP-12	Industrial	Industrial	
VP-13	Industrial	Industrial	
VP-15	Industrial	Industrial	
VP-35(A)	Construction	Industrial	
VP-38	Industrial	Industrial	Partial Removal
VP-57	Industrial	Industrial	
VP-58	Industrial	Industrial	
VP-59	Industrial	Industrial	
IA-10	Recreational	Recreational	
10K620452, south of Latty East	Industrial	Industrial	
Coldwater Creek, inside banks	Recreational	Recreational	
Roads, Bridges, Railroads			
Norfolk Southern	Industrial	Industrial	
Roads, bridges and railroads	Utility	Utility	
IA-8	Utility	Utility	Partial Removal
VP-14(A)	Utility	Utility	

Table 4-6. Land Use by Property (Cont'd)

Property ID [a]	Current Receptor	RME Receptor	Removal Status
Properties with No Expected Removal Volume			
10k620412, north of Latty east	Industrial	Industrial	
11k630221, NE of McDonnell rail siding	Industrial	Industrial	
11L520011, airport south of IA-13	Industrial	Industrial	
10k530076, north of VP-1(L)	Industrial	Industrial	
10k520165, southeast of VP-3(L)	Industrial	Industrial	
10k240182, north of VP-23	Industrial	Industrial	
10k240207, west of VP-27	Industrial	Industrial	
09k220029, east of VP-44	Residential	Residential	
VP-1	Industrial	Industrial	
VP-2	Industrial	Industrial	
VP-3	Industrial	Industrial	
VP-4	Industrial	Industrial	
VP-5	Industrial	Industrial	
VP-6	Industrial	Industrial	
VP-6 (C)[b]	Industrial	Industrial	
VP-7 (C)[b]	Industrial	Industrial	
VP-8	Industrial	Industrial	
VP-9 (C)[b]	Industrial	Industrial	
VP-10(C)[b]	Industrial	Industrial	
VP-14	Industrial	Industrial	
VP-16	Industrial	Industrial	
VP-17	Industrial	Industrial	
VP-18	Industrial	Industrial	
VP-19	Residential	Residential	Removal Action
VP-20	Residential	Residential	Removal Action
VP-21	Industrial	Industrial	Removal Action
VP-22	Industrial	Industrial	Removal Action
VP-23	Industrial	Industrial	Removal Action
VP-25	Industrial	Industrial	
VP-26	Industrial	Industrial	Removal Action
VP-27	Industrial	Industrial	Removal Action
VP-28	Industrial	Industrial	
VP-29	Residential	Residential	
VP-30	Industrial	Industrial	Removal Action
VP-31	Industrial	Industrial	
VP-36	Industrial	Industrial	Removal Action
VP-37	Industrial	Industrial	Removal Action
VP-41	Residential	Residential	Removal Action
VP-45	Industrial	Industrial	Removal Action
VP-46	Industrial	Industrial	
VP-48(A)	Industrial	Industrial	Removal Action
VP-49	Residential	Residential	
VP-50	Industrial	Industrial	
VP-51	Industrial	Industrial	
VP-52	Industrial	Industrial	
VP-54	Industrial	Industrial	

Table 4-6. Land Use by Property (Cont'd)

Property ID [a]	Current Receptor	RME Receptor	Removal Status
VP-55	Industrial	Industrial	
VP-56	Industrial	Industrial	Removal Action
VP-60	Industrial	Industrial	
VP-61	Industrial	Industrial	
VP-62	Industrial	Industrial	
VP-63	Industrial	Industrial	
VP-63(A)	Industrial	Industrial	
Properties with previous DOE removal actions that will require additional investigation			
VP-3(L)[c]	Industrial	Industrial	Removal Action
VP-4(L)[c]	Industrial	Industrial	Removal Action
VP-5(L)[c]	Industrial	Industrial	Removal Action
VP-6(L)[c]	Industrial	Industrial	Removal Action
VP-24	Industrial	Industrial	Removal Action
VP-31(A)	Industrial	Industrial	Removal Action
VP-32	Industrial	Industrial	Removal Action
VP-33	Industrial	Industrial	Removal Action
VP-34	Construction	Industrial	Removal Action
VP-35	Construction	Industrial	Removal Action
VP-39	Industrial	Industrial	Removal Action
VP-40	Industrial	Industrial	Removal Action
VP-42	Industrial	Industrial	Removal Action
VP-43	Residential	Residential	Removal Action
VP-44	Residential	Residential	Removal Action
VP-47	Industrial	Industrial	Removal Action
VP-48	Industrial	Industrial	Removal Action
VP-53	Industrial	Industrial	Removal Action

[a] All properties designated into FUSRAP and any additional property for which analytical data are available.

[b] Coldwater Creek VP

[c] Latty Avenue VP

Containment technologies are used for Alternative 2, and are combined with soil washing and soil sorting in Alternative 3. Containment provided by existing roads is included in Alternatives 2-5. Revegetation and temporary storage are included in the alternatives that use removal technologies (i.e., excavation or dredging).

Treatment using soil washing and soil sorting is a major component of Alternative 3. The option for off-site recycle to a uranium mill is maintained for all alternatives that use removal technologies. Stabilization or immobilization technologies are included as an option in Alternative 3, which emphasizes treatment technologies as a major component of the remedial action.

Truck and rail technologies are included in all alternatives using removal technologies. Permitted off-site disposal or recycle is used for soils and debris. Wastewater generated during the remedial actions would be discharged into either a publicly owned treatment works (POTW) or surface waters.

USACE may use one or more licensed or permitted recycle or disposal facilities. A more detailed description is given in the following sections. No buildings have been identified that require decontamination or radon mitigation. Decontamination and radon mitigation technologies are retained as ancillary technologies, and could be used if building contamination is discovered during this investigation or during the cleanup process.

Institutional controls are used to ensure protectiveness for alternatives at areas in which the residual soil contamination exceeds the concentrations specified in ARARs for residential use.

Technologies and Processes Common to Alternatives 2 Through 6

Alternatives 2 through 6 share certain features. In order to avoid duplicate discussions of the details of these features under each alternative, similar elements are discussed in the following text.

Excavation: Consistent with the scope defined in the FFA, for alternatives that involve excavation, remediation of soils containing non-radionuclide contaminants would be conducted in those areas where they are co-located with North County Site COCs. Non-radiological COCs include antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, and vanadium for SLAPS and contiguous areas; and antimony, arsenic, barium, cadmium, molybdenum, nickel, selenium, thallium, and vanadium for HISS/Futura and Latty Avenue VPs 2L and 10k530087. To verify that removal of radiological contaminants also achieves the RGs for non-radiological COCs, chemical sampling will be conducted, as required, during pre-design investigation, and as part of the final status survey, pending confirmation of co-location with radiological contamination.

Supplemental Limit for Deep Soils: A supplemental standard for deep soils was assessed during development of the FS alternatives as a potential option for addressing deep (greater than 8 ft bgs) soil contamination at SLAPs and HISS/Futura. The deep soil criteria were not carried forth in any of the alternatives discussed in the FS, though they have been retained as potential remediation standards.

Under the Deep Soils Option, a “deep” supplemental standard of 75/210/750 pCi/g [or combination of the radionuclides such that the sum of ratios (SOR) is not greater than 1] would be substituted at depths greater than 8 ft bgs. It is considered unlikely that exposure to contaminated soils deeper than 8 ft in depth will occur. Therefore, the risk to the reasonably likely future receptor would be near the lower end of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) risk range. Other than the remediation worker, the only exposure scenario would involve industrial/utility workers involved in deep (> 8 ft) excavation in areas where elevated radionuclide concentrations remain. If institutional controls were lost and the materials were excavated, the worker exposure scenario would likely be similar to the utility worker scenario and would be less than 10 mrem/yr. If the material were transferred to use in a residential setting, the dose would be less than the 100 mrem/yr standard for cases where institutional controls are lost. (Details concerning the derivation of these supplemental standards are presented in Appendix D of this FS).

On-going Removal Actions: Removal actions started under the engineering evaluation/cost analyses (EE/CAs) are complete at the time the Record of Decision (ROD) is approved. The ROD criteria would supersede commitments to cleanup criteria in previously issued documents (e.g., EE/CAs). Excavation under buildings would be done when the areas are made available by the owner. Final status surveys would be conducted to ensure that remediated areas meet the cleanup criteria. Final status surveys performed pursuant to EE/CAs prior to the Multi-Agency Radiation Site Survey and Investigation Manual (MARSSIM) effective date would be compared to ROD criteria using the existing confirmation approaches.

Institutional Controls: For alternatives that use institutional controls, a long-term stewardship plan would be developed. It would address requirements to notify property owners of changes in land use. It would also address future monitoring and maintenance requirements. The plan would also include provisions addressing the process by which property owners can contact the federal government agency responsible for long-term control of impacted areas and periodic reviews, maintenance, and monitoring. Institutional controls are used to ensure protectiveness for alternatives at areas in which the residual soil contamination exceeds the concentrations specified in ARARs for residential use.

These institutional controls will:

1) Be enforceable against any owner of the affected property and any person who subsequently acquires the property or acquires any rights to use the property;
2) Be enforceable by parties, other than the landowner, who have the legal authority to enforce the restriction;
3) Include provisions to delegate or transfer enforcement authority;
4) Indicate procedures for enforcement of restrictions;
5) Remain in place for the duration they are needed; and
6) Be recorded, including in the deed and in land records, as appropriate.

Transportation and Waste Management: Local transportation of contaminated materials [e.g., from vicinity properties (VPs) to rail spurs] would use sealed or covered trucks. On-site movement would be performed using open trucks and conventional construction equipment. Long distance shipment would be primarily by rail from the rail spurs to off-site licensed or permitted disposal facilities. Trucking may also be used for long distance shipping. Rubble and similar materials would be crushed as appropriate for disposal. Site soils could be used as backfill if they are unimpacted or if they meet the cleanup criteria for surface soils.

Uranium would be recycled if the costs are similar to the cost for disposal of the materials.

As necessary, pre-remedial design investigation sampling for contaminants of concern (COCs) would be conducted to define the extent of contamination. Those properties where current or past activities unrelated to uranium processing have resulted in Resource Conservation and Recovery Act (RCRA) characteristic or listed waste being co-located with radioactive waste will be evaluated and sampled, as necessary, prior to remediation to facilitate treatment and disposal.

Monitoring**:** Short-term monitoring would be continued during the remedial actions. Monitoring would be used to ensure that contamination from the soils and the unusable ground water zone (HZ-A) does not significantly impact surface water or potable ground water. The results of the short-term monitoring of surface water, sediment, and HZ-A ground water would be used to assess any potential impacts to Coldwater Creek resulting from the remedial actions, and would assist in evaluating the effectiveness of the remedial actions. In addition, monitoring will support evaluation of impacts resulting from the remaining soils unavailable for remedial action (not in Alternative 6), or from residual contamination left in place. The ability of existing geologic deposits to resist vertical water passage would not be changed by any FUSRAP remedial alternatives. Radon monitoring will be conducted as necessary in appropriate Futura buildings to ensure that radon concentrations comply with the standards in 40 CFR 192.12(b).

Remedial Action Control Measures: Water encountered during remedial actions will be characterized, treated (if necessary), and released to either a POTW or Coldwater Creek or its tributaries, as permitted. The treatment would address chemicals and radionuclides consistent with relevant and appropriate federal and state regulations. Excavation waters contaminated with TCE or its degradation products will not be released off-site above appropriate levels. Supporting technologies would be used, as required during the excavation process, to prevent the spread of contamination. These could include revegetation, dust mitigation, storage pile covers, sedimentation basins, and dewatering Backfill would be added, and the site would be graded to ensure appropriate surface water drainage. Erosion and sediment controls would be used.

Wetlands: Any wetlands designated using the 1987 Corps of Engineers Wetlands Delineation Manual that are impacted during removals would be restored, or equivalent wetlands would be created.

Federal Aviation Administration (FAA) Restrictions: USACE construction activities during remedial action would comply with the FAA restriction of air space around the airport, such as limits on the height of structures and equipment.

4.2.1 Alternative 1, No Further Action

Under this alternative, no additional remedial actions are implemented at the North County Site. The no-further-action alternative is required by the NCP, which requires a no-action baseline to which all other remedial alternatives are compared. The rail spurs at the St. Louis Airport Site (SLAPS) and Hazelwood Interim Storage Site (HISS) would be left in place. Accessible soils would remain at current locations, and difficult to access contaminated soils under roads, bridges, railroads, and other permanent structures would be left in place. Sediments in Coldwater Creek and depositional material in the flood plain would not be removed. The limited site security, such as fencing, would be left in place, but would not be maintained by USACE. Continued routine monitoring of air, buildings, ground water, and storm water would not be performed. Five-year reviews would be conducted, pursuant to CERCLA, for areas which are too contaminated to allow unlimited use and unrestricted exposure.

4.2.2 Alternative 2, Partial Excavation and Capping at SLAPS and HISS/Futura

Capping: A multi-layer cover (cap) would be constructed at SLAPS and HISS/Futura to provide a barrier to limit exposures. SLAPS and HISS/Futura would be contoured and covered with 1-ft of stone intrusion barrier and 3 ft of clean soil.

Excavation: Surface and subsurface soil would be excavated to the RGs for unrestricted release at all properties except SLAPS, HISS/Futura, and roads, bridges, railroads, and other permanent structures. For surface soils, these RGs are 5/14/50 pCi/g above background for Ra-226/Th-230/U-238 (or combinations of the radionuclides such that the SOR is not greater than 1). For subsurface soils (i.e., soils below 6 inches in depth), the RGs for unrestricted release are 15/15/50 pCi/g above background for Ra-226/Th-230/U-238. At SLAPS and HISS/Futura, soils exceeding the supplemental standards for subsurface soils would be shipped off-site to a permitted disposal facility. (See Appendix D for a description of the derivation of the supplemental criteria). The subsurface soil supplemental standards are 25/70/250 pCi/g above background for Ra-226/Th-230/U-238. Those soils achieving the supplemental standards for subsurface soil would be disposed of on-site beneath a multilayer cover at SLAPS and HISS/Futura. The supplemental standards would be used in conjunction with institutional controls to allow commercial/industrial use of SLAPS and HISS/Futura. Inaccessible soils under roads, bridges, railroads, and other permanent structures would be left in place. When and as the inaccessible soils become available as a result of decisions made by entities that control their accessibility, new decision documents will identify the response action to address the inaccessible soils as appropriate. Inaccessible soils for the North County Site are identified in Figure ES-3. Additional soils may be identified as inaccessible during implementation and will be deferred for separate action as documented in the post remedial action report. Remediation of radiological contaminants is expected to address associated chemical contaminants based on the results of post-remedial action sampling conducted on previously remediated North County properties.

Dredging: Dredging of contaminated sediments from Coldwater Creek is not part of Alternative 2. However, Coldwater Creek sediments removed as part of the separate projects, such as the planned flood control project (USACE, 1987a), would be monitored; any sediment exceeding criteria would be shipped for off-site disposal at a permitted facility.

Institutional Controls: No institutional controls would be required for accessible soils at SLAPS VPs or Latty Avenue VPs. However, institutional controls would be imposed to restrict land use at SLAPS, HISS/Futura, Coldwater Creek, and for areas beneath roads, bridges, railroads, and other permanent structures as appropriate. The controls could include deed notices to ensure that future owners are made aware of the presence of residual contamination; land use restrictions to limit activities that could disturb soils; and well-drilling prohibitions. Controls could also include zoning restrictions at SLAPS and HISS/Futura. Land use would be restricted to commercial/industrial uses at SLAPS and HISS/Futura, recreational uses at Coldwater Creek, and transportation/utility uses for roads, bridges, and railroad beds.

Alternative 2 includes shipment and off-site disposal of excavated soils. On-site movement of soils and contaminated material would be accomplished using conventional construction equipment. Local transportation would be performed using sealed or covered trucks. Long-distance shipment would be primarily by rail from the HISS and SLAPS (and possibly the

Eva Avenue) spurs to off-site permitted disposal facilities. Absorbers and other conditioning would be used, as necessary, to comply with the transportation and disposal requirements.

Alternative 2 also includes use of road cover, use of short and long-term monitoring, short-term containment technologies, and demolition of buildings (option). The following bullets present additional specific components of this alternative:

- Monitoring would be conducted during the remedial actions; long-term monitoring of ground water would be needed as part of this alternative, until determined to be no longer required as part of the five-year review process. Long-term monitoring of HZ-A and long-term monitoring of Unit 4 in HZ-C (as a surrogate for HZ-E) would be required.

- Water collected during remedial actions would be treated, if required, and released to a POTW or to Coldwater Creek or its tributaries.

- Supporting technologies would be used to prevent the spread of contamination. These include revegetation, dust mitigation, storage pile covers, sedimentation basins, and dewatering.

- A long-term stewardship plan would be developed to address notification requirements for property owners, as well as to provide monitoring and maintenance requirements for the future. This plan would include provisions addressing how property owners should contact the agency responsible for long-term control of impacted areas, and how these areas would be reviewed, maintained, and monitored by the federal government.

4.2.3 Alternative 3, Partial Excavation and Treatment at SLAPS

Alternative 3 involves treatment at SLAPS, in combination with excavation, dredging, and institutional controls:

On-site Treatment: Excavated soils and sediments would be consolidated at SLAPS for treatment (soil sorting and enhanced soil washing). Pursuant to the National Oil and Hazardous Substances Contingency Plan (NCP), "on-site" is defined as "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action" [40 CFR300.5]. CERCLA Section 104(d)(4) states that, where two or more noncontiguous facilities are reasonably related on the basis of geography or of threat to public health or the environment, and where wastes at these sites are compatible for a selected treatment or disposal approach, these related facilities may be treated as one site for response purposes. Therefore, treatment at SLAPS would be appropriately classified as “on-site”. Treated soils that meet the ARAR-based criteria for subsurface soil would be used as backfill at SLAPS, and would be covered with clean soils. Any materials not meeting the subsurface soil supplemental criteria listed in Table 4-4 would be shipped off-site to a permitted disposal facility. Limited phytoremediation (using plants to draw contamination from soils) would be conducted for two seasons in Coldwater Creek in areas where sediments accumulate downstream of Pershall Road.

Excavation: All soils exceeding the RGs for unrestricted land use would be excavated at SLAPS VPs, Latty Avenue VPs, and HISS/Futura, with the exception of soils beneath roads, bridges, railroads, and other permanent structures. Soils exceeding the subsurface soil supplemental standards would be excavated at SLAPS. Inaccessible soils under roads, bridges, railroads, and other permanent structures would be left in place. When and as the inaccessible soils become available as a result of decisions made by entities that control their accessibility, new decision documents will identify the response action to address the inaccessible soils as appropriate. Inaccessible soils for the North County Site are identified in Figure ES-3. Additional soils may be identified as inaccessible during implementation and will be deferred for separate action as documented in the post remedial action report. Remediation of radiological contaminants is expected to address associated chemical contaminants based on the results of post-response sampling conducted on other North County properties.

Dredging: Soils and sediments above the Coldwater Creek criteria listed in Table 4-4 would be dredged from Coldwater Creek and would be consolidated at SLAPS for treatment.

Institutional Controls: No institutional controls would be required for accessible soils at SLAPS VPs, Latty Avenue VPs, and HISS/Futura. Institutional controls would be used to restrict land use at SLAPS and beneath roads, bridges, railroads, and other permanent structures as appropriate. The controls could include deed notices to ensure that future owners are made aware of the presence of residual contamination; land use restrictions to limit activities that could disturb soils; and well-drilling prohibitions. Controls could also include zoning restrictions at SLAPS. Land use would be restricted to commercial/industrial uses at SLAPS, and to transportation/utility uses for roads, bridges, and railroad beds. If institutional controls are lost at properties where contaminants are left above levels acceptable for unlimited and unrestricted use, potential exposures for the general public will be less than 100 mrem/yr.

Five-year reviews and long-term ground-water monitoring are included as part of this alternative. Use of road cover, short-term monitoring, short-term containment technologies, long-term containment at SLAPS, truck and rail transportation, and demolition of buildings (option) are also included. The following bullets describe some additional components of this alternative:

- The soils and excavated materials above the criteria after treatment would be shipped primarily by rail from the HISS and SLAPS (and possibly Eva Avenue) spurs to off-site permitted disposal facilities.
- Monitoring would be conducted during the remedial actions, and long-term monitoring of HZ-A and Unit 4 in HZ-C (as a surrogate for HZ-E) would be performed as part of this alternative.
- Site controls would include land surveillance, restricted ground-water use, and environmental monitoring of affected media.
- Water collected during remedial actions would be treated, if required, and released to a POTW or to Coldwater Creek or its tributaries.
- Supporting technologies would be used to prevent the spread of contamination. These include revegetation, dust mitigation, storage pile covers, sedimentation basins, and dewatering. Surface water control and water treatment would be provided, as required, during excavations.

Alternative 3 would remove contamination from most properties at the North County Site. The material would be transferred to SLAPS for treatment rather than being shipped directly for off-site disposal. At SLAPS, the materials would be processed using sorting or enhanced soil washing techniques to remove contamination that could result in risks to a commercial/industrial receptor that exceed the CERCLA risk range. The materials above the subsurface soil supplemental criteria used with institutional controls would be shipped to a permitted disposal facility. The materials below the ARAR-based criteria for subsurface soil would be used as backfill at SLAPS. Areas at SLAPS backfilled with treated soils would be covered with a minimum of one foot of clean soil obtained from a commercial source. Surface water flow would be directed to Coldwater Creek, and flood control measures would be provided as part of the regrading. USACE would comply with FAA air space restrictions during the remedial actions.

Local transportation would be performed using sealed or covered trucks. On-site movement of soils and contaminated materials would be accomplished using conventional construction equipment. Long distance shipment would be by rail or truck, or by a combination that provides cost-effective transportation and disposal. Absorbers and other material conditioning agents would be used, as necessary, to comply with the transportation and disposal requirements.

A long-term stewardship plan would be developed to address notification requirements for property owners, as well as to provide monitoring and maintenance requirements for the future. This plan would include provisions addressing how property owners should contact the agency responsible for long-term control of impacted areas, and how these areas would be reviewed, maintained, and monitored by the federal government.

4.2.4 Alternative 4, Institutional Controls (No Further Excavation)

Alternative 4 emphasizes the use of institutional controls and is protective as long as the controls are in place. It consists of the following:

- *Institutional Controls:* Institutional controls would be imposed to limit land use at SLAPS, HISS/Futura, roads, bridges, railroads, and other permanent structures, Coldwater Creek, and the VPs. Other than specific areas zoned for commercial and industrial uses and FAA limitations, no known land use controls or restrictive easements exist on the subject properties. Potential administrative problems are anticipated with enforcement, access and monitoring, and voluntary compliance with regulatory controls. Further, property owners are often less than willing participants in subordinating their fee title interests for residual site contamination. Missouri real estate law is amenable and supportive of restrictive land use controls, conveyance by quitclaim, and zoning overlay districts. The controls would vary by property and could include deed notices to assure future owners are made aware of the presence of residual contamination, land use restrictions to limit activities that could disturb soils, and well-drilling prohibitions. Zoning restrictions at SLAPS, HISS/Futura, and Vicinity Properties are also potential institutional controls. Land use would be restricted to commercial/industrial uses at SLAPS, HISS/Futura, and vicinity properties, recreational uses at Coldwater Creek, and transportation/utility uses for roads, bridges, and railroad beds. Although the implementation of institutional

controls at SLAPS, HISS/Futura, under buildings, roads, bridges, and railroads, and at the VPs is technically feasible, it involves complex administrative requirements. Maintaining controls at numerous properties would be difficult. The controls would have to be maintained for a considerable period of time and would have to be enforced through a government or municipal entity. A requirement that land use restrictions "run with the land" despite ownership changes would be used to help assure that controls are not lost. Details of institutional controls will be documented in the site long-term stewardship plan.

The following bullets describe the remaining components Alternative 4:

- Five-year reviews are included for areas where contaminants are left above levels acceptable for unrestricted use. Final status surveys of remediated areas would be performed.
- Long-term monitoring would be provided under this alternative at those properties that are not released for unrestricted use. Long-term monitoring of HZ-A and long-term monitoring of Unit 4 in HZ-C (as a surrogate for HZ-E) would be required until terminated as part of the five-year review process.

Alternative 4 would involve leaving in place some contamination above the unrestricted use criteria. This alternative will impose institutional controls to reduce the potential for exposure and human intrusion.

4.2.5 Alternative 5, Excavation with Institutional Controls Under Roads, Bridges, Railroads, and Other Permanent Structures

Alternative 5 includes excavation/dredging with off-site disposal for all property units except inaccessible soils beneath roads, bridges, railroads, and other permanent structures. Institutional controls may be used as appropriate to restrict land use.

Excavation: All soils exceeding the RGs for unrestricted land use would be excavated and shipped for off-site disposal or recycle, with the exception of soils beneath roads, bridges, railroads, and other permanent structures. Soils under roads, bridges, railroads, and other permanent structures are inaccessible and will not be remediated as a part of this response action. When and as the inaccessible soils become available as a result of decisions made by entities that control their accessibility, new decision documents will identify the response action to address the inaccessible soils as appropriate. Inaccessible soils for the North County Site are identified in Figure ES-3. Additional soils may be identified as inaccessible during implementation and will be deferred for separate action as documented in the post remedial action report.

Dredging: Coldwater Creek sediments below the mean water gradient that exceed the Coldwater Creek criteria for unrestricted use defined in Table 4-4 would be dredged and disposed.

Institutional Controls: Institutional controls are used to ensure protectiveness for alternatives at areas in which the residual soil contamination exceeds the concentrations specified in ARARs for residential use. No institutional controls would be required for accessible soils. Institutional controls would be used to restrict land use beneath roads, bridges, railroads, and

other permanent structures as appropriate. The controls could include deed notices to ensure that future owners are made aware of the presence of residual contamination, and land use restrictions to limit activities that could disturb soil. Controls could also include zoning restrictions at Futura. Roads, bridges, and railroad beds would be limited to use as transportation/utility corridors.

Monitoring: For those areas where contaminants are present at levels that allow for unlimited use and unrestricted exposure, short-term ground-water monitoring is proposed where appropriate to ensure the effectiveness of the source removal, and to verify that no significant migration of contamination to useable ground water is occurring. Monitoring could be performed at those areas where contamination remains above unrestricted levels (roads, bridges, railroads, and other permanent structures), until authorized to be discontinued or modified pursuant to the 5-year reviews. Long-term monitoring is not required for the limestone aquifer (HZ-E). Under this alternative, the majority of the contaminant sources and all highly contaminated soils at the site will be removed. The few contaminant sources remaining in HZ-A soils, unavailable for remedial action at the present, are separated from HZ-E by a low hydraulic conductivity clay aquitard, Unit 3M, and the low conductivity of Unit 3 in general. The potential for contaminant migration to HZ-E is very small, as noted by prior study. In addition, although HZ-E meets the definition of a potential source of drinking water (Class IIB), it is not a current source of drinking water in the area, so an exposure pathway from HZ-E ground water to receptors does not exist. Short-term ground-water monitoring of Unit 4 of HZ-C is proposed to ensure continued protection of the limestone aquifer. Short-term monitoring of HZ-A ground-water would be used to assess the effects of the remedial action on HZ-A ground-water quality, and to assess the approximate contaminant transport rate through HZ-A ground water to Coldwater Creek. Short-term surface water and sediment monitoring of Coldwater will be conducted to provide additional data to assess whether Coldwater Creek is being significantly impacted by contaminant migration from HZ-A, and to determine whether remedial actions are having any adverse impacts on the creek. Long-term monitoring for Unit 2 of HZ-A may be required, depending upon the contamination of the post-remedial action HZ-A ground water and the rate of contaminant delivery to Coldwater Creek. HZ-A long-term monitoring is not anticipated. Short-term monitoring of HZ-A ground water after removal/remedial actions and base flow contaminant evaluation of Coldwater Creek will resolve whether long-term monitoring of HZ-A is warranted.

Five-year reviews would be conducted only for those areas in which the residual soil contamination exceeds the concentrations specified in ARARs for residential use (i.e., roads, bridges, railroads, and other permanent structures).

Treatment is not proposed under this alternative, except where needed for release water. State-of-the-art treatment relative to radioactivity-contaminated soil is advancing rapidly, and while current treatment costs for the North County Site soils are greater than excavation and off-site disposal costs, technological advances could narrow or reverse this balance. Implementation of soil washing and/or phytoremediation may be considered under this alternative during the remedial design phase. If implementation of these technologies is determined to be appropriate based on new developments, a change to the remedy may be recommended, in which case appropriate environmental documentation would be issued.

Additional components of this alternative include the following:

- Supporting technologies are used to prevent the spread of contamination. These include revegetation, dust mitigation, storage pile covers, sedimentation basins, and dewatering.
- Water collected during remedial actions would be treated, if required, and released to a POTW or to Coldwater Creek or its tributaries.
- All of the removal actions started under the existing EE/CAs are complete at the time the ROD is approved.
- Post-remedial action surveys would be conducted to assure that remediated areas met the cleanup criteria.
- USACE would comply with the airport restrictions for air space.
- Any wetland areas designated using the 1987 Corps of Engineers Wetlands Delineation Manual that are impacted during the removals would be restored, or equivalent wetland areas would be created.
- Backfill from approved sources would be added and the site would be graded to provide for surface water flow to Coldwater Creek and flood control.

Other technologies included in Alternative 5 include short-term containment technologies, truck and rail transportation, precision excavation and characterization, use of road cover, demolition of buildings (option) and disposal at permitted facilities. Preference would be given to recycling if the cost is similar to the cost for disposal of the materials.

Local transportation would be done using sealed or covered trucks. On-site movement of soils and contaminated materials would use conventional construction equipment. Long distance shipment would be primarily by rail from the rail spurs at HISS and SLAPS to off-site permitted disposal or recycle facilities. The Eva Avenue rail spur may also be used. Absorbers and other conditioning would be used, as necessary, to comply with the transportation and disposal requirements.

4.2.6 Alternative 6, Excavation at all Properties

Alternative 6 includes excavation and dredging, plus off-site disposal, to remove contamination from all areas. All soils exceeding the RGs for unrestricted land use would be removed for all property units. Unlike other alternatives, roads, bridges, railroads, and other permanent structures would be removed, as required, to allow excavation of soils that exceed the unrestricted use criteria. Five-year reviews would not be conducted.

Under Alternative 6, all soils that exceed the criteria for use without radiological restrictions for all property units, regardless of current or likely future land use, would be removed. Contaminated soils and sediments would be removed so that no institutional controls are required for any property. Remediation of radiological contaminants is expected to address associated chemical contaminants based on the results of post-response sampling conducted on other North County properties. All areas of the site would be released for use without radiological or chemical restrictions.

Additional components of this alternative include the following:

- Roads, bridges, and railroads would be removed as required to allow excavation of soils that exceed unrestricted land use.
- Institutional controls would be used for areas under buildings, until the areas are made available by the owner for remediation.
- Monitoring of air, surface water, and sediments would be conducted during the remedial action, but no long-term monitoring after completion of the action is included.
- Final status surveys would be conducted to ensure that remediated areas met the cleanup criteria.
- The excavated materials would be shipped primarily by rail from the rail spurs at HISS and SLAPS to off-site permitted disposal or recycle facilities.
- Water collected during remedial actions would be treated, if required, and released to a POTW or to Coldwater Creek or its tributaries. Preference would be given to recycling if the cost is similar to the cost for disposal of the materials.
- Supporting technologies would be used to prevent the spread of contamination during remedial action. These include revegetation, storage pile covers, and sedimentation basins. Dewatering, surface-water control, and water treatment would be provided as required during the excavation process. Dust mitigation and control would be maintained by using water, mulch, straw, or similar measures.
- USACE would comply with the airport restrictions of air space.
- Any wetland areas designated using the 1987 Corps of Engineers Wetlands Delineation Manual that are impacted during the removals would be restored, or equivalent wetland areas would be created.
- Backfill from approved sources would be used, and the site would be graded to provide for surface water flow to Coldwater Creek, as well as for flood control.

Other technologies include demolition, short-term containment technologies, truck and rail transportation, and disposal at permitted facilities. Local transportation would use sealed or covered trucks. On-site movement of soils and contaminated materials would use conventional construction equipment. Long distance shipment would be by rail or truck, or by a combination that provides a cost-effective method of transportation and disposal. Absorbers and other material conditioning agents would be used, as necessary, to comply with the transportation and disposal requirements. Bulk concrete and crushed concrete, or similar rubble materials, would be decontaminated, if necessary, before disposal.

SECTION 5

DETAILED ANALYSIS OF ALTERNATIVES

5 DETAILED ANALYSIS OF ALTERNATIVES

5.1 INTRODUCTION

The detailed analysis of remedial alternatives provides the basis for identifying a preferred remedial alternative. This section presents the detailed analysis of alternatives using Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) criteria. The detailed and comparative analysis of the site-wide remedial alternatives includes evaluations of overall protection; compliance with applicable or relevant and appropriate requirements (ARARs); long- and short-term effectiveness; reduction in contaminant volume, toxicity, or mobility; implementability; and cost. The preferred alternative will be discussed in the Proposed Plan (PP).

In accordance with statutory requirements under CERCLA, remedial actions (EPA, 1988b) must:

- be protective of human health and the environment;
- attain ARARs or provide grounds for justifying a waiver;
- be cost-effective;
- use permanent solutions and alternative treatment technologies to the maximum extent practicable; and
- satisfy the preference for treatment that reduces volume, toxicity, or mobility as a principal element [40 CFR §300.430(f)(1)(c)].

In addition, long-term effectiveness and other considerations must be taken into account in evaluating each of the alternative remedial actions. These considerations include:

- long-term uncertainties associated with land disposal;
- goals, objectives, and requirements of the Solid Waste Disposal Act;
- persistence, toxicity, and mobility of radionuclides and other hazardous substances and their propensity to bioaccumulate;
- long- and short-term potential for adverse health effects from human exposure;
- potential threat to human health and the environment associated with excavation, transportation, and disposal;
- long-term maintenance costs; and
- potential for future remedial action costs if the alternative being discussed were to fail [40 CFR §300.430(e)(9)].

Accordingly, retained remedial alternatives will undergo detailed comparative analysis using the criteria discussed in the following paragraphs.

CERCLA Threshold Criteria

Overall protection of human health and the environment and compliance with ARARs are "threshold criteria" that any remedial alternative must meet before being considered for implementation. During the detailed analysis of remedial alternatives, each alternative must be evaluated to determine how the alternative achieves and maintains protection of human health

and the environment. Similarly, each remedial alternative must be assessed to determine how the alternative complies with ARARs or, if a waiver is required, an explanation of why the variance is justified.

CERCLA Balancing Criteria

Long-term effectiveness; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost are referred to as "balancing criteria." These represent the primary selection criteria for alternatives determined to be protective of human health and the environment and in compliance with ARARs.

Long-term effectiveness and permanence is an evaluation of the magnitude of residual risk (risk remaining after implementation of the alternative) and the adequacy and reliability of controls used to manage the remaining waste (untreated waste and treatment residuals) over the long-term. Alternatives that afford the highest degrees of long-term effectiveness and permanence leave little or no untreated waste at the site, make long-term maintenance and monitoring unnecessary, and minimize the need for institutional controls.

Reduction of volume, toxicity, or mobility through treatment is an evaluation of the ability of the alternative to reduce the volume, toxicity, or mobility of the waste. The irreversibility of the treatment process and the type and quantity of residuals remaining after treatment are also assessed by this criterion.

Short-term effectiveness addresses the protection of workers and the community during the remedial action, the environmental effects of implementing the action, and the time required to achieve cleanup goals.

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. Technical feasibility assesses the ability to construct and operate a technology, the reliability of the technology, the ease in undertaking additional remedial actions, and the ability to monitor the effectiveness of the alternative. Administrative feasibility is addressed in terms of the ability to obtain approval from federal and state agencies.

Cost of an alternative provides an estimate of the Fiscal Year 2000 (FY00) dollar cost of each alternative. The costs estimated in this report are based on historical costs incurred in previous Formerly Utilized Sites Remedial Action Program (FUSRAP) actions, quotes from suppliers, generic unit costs, vendor information, conventional cost-estimating guides, and other information. The cost estimates are developed for FY00 dollars. The cost estimates have been prepared from the information available at the time of the estimate. They are for guidance in project evaluation and implementation, and are believed to be accurate within a range between -30 percent and +50 percent of actual costs, in accordance with the U.S. Environmental Protection Agency (EPA) guidance (EPA, 1988b). The actual costs for these actions could be higher than estimated because of unexpected site conditions and the potential for delays in taking action.

CERCLA Modifying Criteria

The two modifying criteria described below will be evaluated as part of the Record of Decision (ROD), after the public has had the opportunity to comment.

State Acceptance: This criterion will consider comments received by the State of Missouri on Remedial Investigation/Feasibility Study (RI/FS) documents. The decision-making process for remediation of the North County Site has been developed in consultation with the EPA and the State of Missouri. Because final comments will not be received until after the RI/FS has been issued, this criterion will be addressed in the responsiveness summary of the ROD. Comments received on previous documents were considered in the formulation of alternatives. The State's comments are requested on the PP, in accordance with Section 117 of CERCLA.

CERCLA provides an opportunity for the State to concur or not concur with the selection of the remedial alternative. If the President proposes to select a remedial action that does not attain ARARs and the State desires to have the remedial action conform to such standard, requirement, criteria, or limitation, the State may bring an action for the sole purpose of determining whether the finding of the President is supported by substantial evidence, in accordance with CERCLA 121 (f) (3)(B) (iii). If the court determines that the remedial action need not conform to such standard, requirement, criteria, or limitation, and the State pays or assures the payment of the additional costs attributable to meeting such standard, requirement, criteria, or limitation, the remedial action shall be so modified.

Community Acceptance: This criterion will address the comments made by the community on the alternatives being considered. Because public comments will not be received until after the alternatives have been evaluated in the FS and the preferred alternative has been presented in the PP, this criterion will be addressed in the responsiveness summary and the ROD. However, previous comments and the input from the Task Force were considered in the formulation of the alternatives.

5.2 DETAILED ANALYSIS OF SITE-WIDE ALTERNATIVES

This section presents a detailed analysis of site-wide alternatives. Each alternative is described and evaluated against the criteria outlined in Section 5.1.

5.2.1 Alternative 1, No Further Action

This alternative assumes that no additional remedial actions would be implemented at the North County Site. The no-further-action alternative is required by the National Contingency Plan (NCP) and CERCLA guidance to provide a no-further-action baseline to which all other remedial alternatives are compared. Under Alternative 1, the rail spurs at St. Louis Airport Site (SLAPS) and Hazelwood Interim Storage Site (HISS) would be left in place. Accessible soils would remain at current locations. Difficult-to-access contaminated soils under roads, bridges, railroads, and other permanent structures would be left in place. Sediments in Coldwater Creek and depositional material in the floodplain would not be removed. The limited site security and

fencing would be left in place, but would not be maintained by the United States Army Corps of Engineers (USACE). Continued routine monitoring of air, buildings, ground water, and storm water would not be performed. Five-year reviews would be conducted pursuant to CERCLA for areas that are too contaminated to allow unlimited use and unrestricted exposure.

5.2.1.1 Overall Protection of Human Health and the Environment

Alternative 1 is not protective of human health or the environment for the long-term. The Baseline Risk Assessment (BRA) and the risk analysis presented in Appendix D indicate that potential future risks at the North County Site could exceed the CERCLA target risk range. The risk levels for current receptor conditions are in the 10^{-6} to 10^{-4} range, assuming that site access restrictions apply (including fences, zoning restrictions, etc.), but the risk levels for future receptors could exceed 10^{-4}.

This alternative provides no additional protection to human health and the environment over baseline conditions. The risks from direct contact, ingestion, and inhalation would continue and could increase over time, for current access control measures, such as fencing and the cover on waste piles, would not be maintained. Existing buildings, structures, and paved surfaces that deter human access to underlying soils would also undergo eventual deterioration, thereby increasing the potential for human exposure to site-related contamination. The potential for human exposure to contaminants and the potential for off-site migration could increase over time as a result of disturbances by humans and natural processes. Under Alternative 1, North County Site soils and sediments that pose potentially unacceptable risks under future-use scenarios would not be remediated.

Coldwater Creek sediments do not pose unacceptable risks to human health and the environment under current land use scenarios. However, no control is placed on public use of sediments under this alternative. If contaminated sediments are dredged from the creek, they could pose a potentially unacceptable risk to human health under some future scenarios.

Current risks associated with exposure to contaminated ground water are minimal because the site-related contaminants reside in a non-potable hydrostratigraphic zone (HZ-A). In addition, sample data show that zones that could be used as a source of drinking water do not contain unprotective levels of contamination originating from FUSRAP-related activities. The hydrologic and chemical data also show that the water in the contaminated zone (HZ-A) is not connected and is not likely to migrate to the lower water-bearing units. Ground water from HZ-A at SLAPS migrates towards Coldwater Creek. The hydrological characteristics and modeling studies of SLAPS indicate the slow discharge of ground water to Coldwater Creek is not significantly impacting the creek.

5.2.1.2 Compliance with ARARs

Alternative 1 does not comply with chemical-specific ARARs. The residual radionuclide concentrations in soil would continue to exceed the ARAR for unrestricted use. There are no location- or action-specific ARARs considered under Alternative 1, because no remedial action would take place.

5.2.1.3 Long-Term Effectiveness and Permanence

Alternative 1 includes no long-term management measures to prevent exposures or spread of contamination. All potential future risks remain at levels that exceed the CERCLA target risk range because none of the contaminants of concern (COCs) would be removed. Although existing site security could provide limited control over exposure to site contaminants, this alternative does not ensure that controls remain in place, and provides no additional controls to prevent exposure to contaminants. Under future land-use scenarios, there are potential unacceptable risks to human health and the environment if the contaminated soils and sediments remain in place. Potentially unacceptable risks could arise under future-use scenarios involving the disposal of dredged sediments.

Under Alternative 1, contamination in ground water in HZ-A would remain, but would not pose a risk to human health. The concentration of radiological contaminants in ground water would not significantly decrease in the near future because no remedial actions would be taken. However, ground-water modeling studies have indicated that the rate of migration for these contaminants is low due to low ground-water velocities and relatively high distribution ratios in the soils. Consequently, the potential for human exposure under future-use scenarios is low. The water-bearing units are not used as a source of drinking water and are not likely to become a source of drinking water.

Pursuant to the Superfund Amendments and Reauthorization Act (SARA), a site review would be conducted every 5-years because radioactive contaminants would remain on-site above health-based levels for unrestricted use. Five-year reviews permit evaluation of data obtained from ongoing monitoring, and provide information on the presence and behavior of contaminants in soils, sediments, ground water, and air.

5.2.1.4 Reduction of Contaminant Volume, Toxicity, or Mobility Through Treatment

No reduction in contaminant volume, toxicity, or mobility through treatment is achieved because no treatment process is proposed under this alternative.

5.2.1.5 Short-Term Effectiveness

There are no significant short-term risks associated with the Alternative 1 beyond baseline conditions. There would be no additional short-term health risks to the community, because no remedial actions would be implemented. Workers would not be exposed to any additional health risks.

5.2.1.6 Implementability

Five-year evaluations of site remedy effectiveness can be easily implemented. No other actions are taken for this alternative.

5.2.1.7 Cost

Under this alternative, there are no capital costs. The cost for the five-year reviews is $1.5 million over the 30-year costing period due to the cost of conducting recurrent 5-year reviews. These costs could continue indefinitely.

5.2.2 Alternative 2, Partial Excavation and Capping at SLAPS and HISS/Futura

Alternative 2 includes excavation, dredging, and off-site disposal in conjunction with capping and institutional controls. Institutional controls would be used at SLAPS, HISS/Futura, Coldwater Creek, and under roads, bridges, railroads, and other permanent structures. Table 5-1 provides a summary of the institutional controls required under each alternative. Contamination present above supplemental standards at SLAPS and HISS/Futura would be removed. SLAPS and HISS/Futura would be capped with stone and clean soil after excavation is complete. The cap would reduce the radon emanation to less than the standards specified in 10 CFR 40 and 40 CFR 192. Institutional controls would be implemented to restrict future use of SLAPS and HISS/Futura, preclude any use of ground water, and prevent any activities that could result in exposure to COCs or compromise the integrity of the caps. Coldwater Creek sediments removed as part of separate projects, such as flood control, would be monitored, and any sediments exceeding criteria would be shipped for off-site disposal. Soils under roads, bridges, railroads, and other permanent structures are inaccessible and will not be remediated as part of this response action. Institutional controls would be used in areas under roads, bridges, railroads, and other permanent structures where the actual residual concentrations exceed unrestricted criteria and site-specific remedial design confirms the need for institutional controls. Vicinity properties (VPs) would be remediated to remove contamination from all areas containing soils that exceed CERCLA risk levels and the remediation goals (RGs) for unrestricted use criteria so that no institutional controls are required.

5.2.2.1 Overall Protection of Human Health and the Environment

Alternative 2 includes removal of soil to meet the unconditional release concentrations in surface soil and subsurface soil at SLAPS VPs and Latty Avenue VPs, with the exception of soils beneath roads, bridges, railroads, and other permanent structures. For SLAPS and HISS/Futura, removing soils containing radiological contamination above the supplemental standards for subsurface soil would limit risks to within the CERCLA target risk range and to below dose-based limits for as long as institutional controls are maintained. In fact, the multimedia cap at SLAPS and HISS/Futura would likely reduce residual risks and doses to well below limits. Institutional controls are used to prevent or mitigate potential exposures to COCs at SLAPS; HISS/Futura; under roads, bridges, railroads, and other permanent structures; and within the banks of Coldwater Creek. Land use restrictions would prevent inadvertent intrusion into soils with residual concentrations of COCs. Well-drilling prohibitions would prevent direct exposure to contaminated ground water so that a high degree of risk reduction would be achieved.

Table 5-1. Summary of Institutional Controls Under Each Alternative

Properties	Alternative 2, Partial Excavation and Capping at SLAPS and HISS/Futura	Alternative 3, Partial Excavation and Treatment at SLAPS	Alternative 4, Institutional Controls (No Further Excavation)	Alternative 5, Excavation with Institutional Controls Under Roads, Bridges, Railroads, and Other Permanent Structures	Alternative 6, Excavation at all Properties
SLAPS	Zoning restrictions (commercial/industrial) Land use restrictions[2] Deed notices to warn future property owners about the extent of remediation and any residual contamination that may remain.	Zoning restrictions (commercial/industrial) Land use restrictions[2] Deed notices to warn future property owners about the extent of remediation and any residual contamination that may remain.	Zoning restrictions (commercial/industrial) Land use restrictions[2] Deed notices to warn future property owners about the extent of remediation and any residual contamination that may remain.	None	None
HISS/Futura	Zoning restrictions (commercial/industrial) Land use restrictions[2] Deed notices to warn future property owners about the extent of remediation and any residual contamination that may remain.	None	Zoning restrictions (commercial/industrial) Land use restrictions[2] Deed notices to warn future property owners about the extent of remediation and any residual contamination that may remain.	Zoning restrictions (commercial/industrial) Land use restrictions[2] Deed notices to warn future property owners about the extent of remediation and any residual contamination that may remain.	None
Coldwater Creek	Land use restrictions[1] (recreational)	None	Land use restrictions[1] (recreational)	None	None
Roads, bridges, railroads[3]	Land use restrictions[1] (transportation/utility) Well-drilling prohibitions	Land use restrictions[1] (transportation/utility) Well-drilling prohibitions	Land use restrictions[1] (transportation/utility) Well-drilling prohibitions	Land use restrictions[1] (transportation/ utility)	None
Vicinity Properties	None	None	Zoning restrictions (commercial/industrial) Land use restrictions[2] Deed notices to warn future property owners about the extent of remediation and any residual contamination that may remain.	None	None

Note: Alternative 1 (no action) would allow continuation of existing institutional controls (current fencing and zoning restrictions would be left in place).

Note: All alternatives would comply with FAA height restrictions.

[1] Land use restrictions may take the form of zoning restrictions or easements to restrict the owner to uses that are compatible with the intended use (i.e. transportation/utility corridor for roads/bridges/railroads or recreational uses for Coldwater Creek).

[2] Land use restrictions could include the following:
a). The property can not be used for residential purposes;
b). The ground water can not be used;
c). A garden can not be planted on the property;
d). Any buildings on the property must be properly ventilated for radon; and
e). No construction of any type is allowed without the written approval of the government.

[3] Institutional controls would be used for areas under roads, bridges, railroads, and other permanent structures only where actual residual concentrations of radionuclides exceed the ARAR-based unrestricted criteria and the site-specific remedial design confirms the need for institutional controls to assure protectiveness.

Remedial activities under Alternative 2 would address both non-radiological and radiological contaminants of concern. By doing so, risks would not exceed the CERCLA target risk range, a hazard index (HI) of 1.0 for each primary target organ, or doses above ARAR-based limits, as appropriate. Therefore, the alternative is protective of human health at all properties. The evaluation of risk-based and dose-based criteria is located in Appendix D.

5.2.2.2 Compliance with ARARs

Location-, action-, and chemical-specific ARARs would be achieved at all properties. Institutional controls would be used to maintain risks to within the CERCLA target risk range at SLAPS; HISS/Futura; under roads, bridges, railroads, and other permanent structures; and within the banks of Coldwater Creek.

5.2.2.3 Long-Term Effectiveness and Permanence

Alternative 2 is protective in the long-term. Long-term effectiveness and permanence is good for all of the VPs. For the areas at SLAPS, HISS/Futura, Coldwater Creek, and roads, bridges, railroads, and other permanent structures, this alternative is less permanent because institutional controls could be lost. The excavation and removal of contaminated soils would result in a permanent reduction in site risks. However, some contaminated material would remain at SLAPS, HISS/Futura, Coldwater Creek, and under roads, bridges, railroads, and other permanent structures, requiring continued institutional controls and maintenance of caps and monitoring. The institutional controls would have to be maintained over the long-term to prevent unauthorized and/or inappropriate use of the site. The effectiveness of the institutional controls would be monitored through the CERCLA 5-year review process. For the purpose of this FS, it is assumed that the current environmental monitoring program would continue for 30 years. However, the actual length of the monitoring program would be based on the results of 5-year reviews.

5.2.2.4 Reduction of Contaminant Volume, Toxicity, or Mobility Through Treatment

No reduction in contaminant volume, toxicity, or mobility through treatment is achieved.

5.2.2.5 Short-Term Effectiveness

Small short-term effects on the community could occur during excavation of contaminated soils, transportation of waste materials, and disposal activities. Air quality could be affected by release of particulates and radon during soil excavation. Other short-term impacts to the local community include traffic and property disruptions during excavation of difficult-to-access soils beneath local roads, bridges, railroads, and other permanent structures. Land at SLAPS and HISS/Futura would be restricted, and the economic benefit to the local community would likely be reduced. Alternative 2 makes use of institutional controls at SLAPS; HISS/Futura; under roads, bridges, railroads, and other permanent structures; and within the banks of Coldwater Creek. These controls result in a reduction in short-term impacts due to construction or transportation accidents that otherwise might be expected to occur for alternatives involving more extensive soil removals.

5.2.2.6 Implementability

There are no technical problems that would limit the implementability of this alternative, but administratively it would be difficult. The Missouri Department of Natural Resources (MDNR) has objected to placement of radioactive material on land in Missouri. Excavation of contaminated soils, construction of temporary roads, and truck transport of soil are conventional activities in construction projects of this kind. Condemnation may be required to obtain the necessary real estate interests. On-site remedies have received strong opposition from local stakeholders in the past.

Construction and operation of the components of Alternative 2 would be straightforward. Resources are readily available for removing contaminated soil and sediment, and constructing an on-site cap. Standard excavation/construction equipment would be used to remove contaminated material and construct the disposal facility. Special engineering techniques involving precautions on excavation near buildings and structures would be observed during remediation.

Mitigation measures would be used to ensure minimization of short-term impacts. Borrow sites for backfill, cap, and soil cover material have not been selected, but are locally available. However, implementation of the planned Lambert-St. Louis International Airport expansion would result in a demand for several million cubic meters (2 to 3 million cubic yards) of backfill soil that could impact local backfill availability.

5.2.2.7 Cost

The total costs for 30 years are $205 million. There would be continuing costs for monitoring and review beyond the 30-year costing period.

5.2.3 Alternative 3, Partial Excavation and Treatment at SLAPS

Alternative 3 includes excavation and dredging combined with on-site treatment (soil sorting, soil washing, and limited phytoremediation) plus off-site disposal. The actions would allow commercial/industrial use of SLAPS, continued use of the roads, bridges, railroads, and other permanent structures as transportation/utility corridors, and unrestricted use of all other properties. Demolition, land use and zoning restrictions, deed notices, well-drilling prohibitions, use of road cover, short-term monitoring, short-term containment technologies, long-term containment at SLAPS, and truck and rail transportation are also included. For Alternative 3, all soils that exceed the RGs for unrestricted release would be removed at all property units except the roads, bridges, railroads, other permanent structures, and SLAPS. Soils exceeding the supplemental standards for subsurface soil would be excavated at SLAPS. Soils under roads, bridges, railroads, and other permanent structures are inaccessible and will not be remediated as part of this response action. Institutional controls would be used to ensure protectiveness of the areas under roads, bridges, railroads, and other permanent structures under all future anticipated land use conditions. Excavated materials above the supplemental standards for subsurface soil would be shipped to a permitted disposal facility. Treated soils meeting the ARAR-based criteria for subsurface soil would be used as backfill at SLAPS.

Institutional controls such as deed notices, would be imposed to limit land use for SLAPS. Institutional controls would also be implemented for those areas under roads, bridges,

railroads, and other permanent structures in which residual concentrations would exceed unrestricted criteria if moved to the surface and if remedial design indicates the need for controls. Table 5-1 provides a list of the institutional controls required for this alternative at SLAPS and under roads, bridges, railroads, and other permanent structures.

Soil sorting and soil washing would take place at SLAPS. The materials would be processed using sorting or enhanced soil washing techniques to remove contamination exceeding the supplemental standard for subsurface soil. Phytoremediation is included for areas in the Coldwater Creek flood plain.

5.2.3.1 Overall Protection of Human Health and the Environment

Alternative 3 includes removal of soil to meet the unconditional release concentrations in surface soil and subsurface soil at SLAPS VPs, Latty Avenue VPs, and HISS/Futura, and the supplemental standards for subsurface soil at SLAPS. For SLAPS, removing soils above the supplemental standards for subsurface soil would limit risks to within the CERCLA target risk range and ARAR-based limits for as long as institutional controls are maintained. Soils under roads, bridges, railroads, and other permanent structures are inaccessible and will not be remediated as part of this response action. Institutional controls would be used to ensure protectiveness of the areas under roads, bridges, railroads, and other permanent structures under all future anticipated land use conditions. The implementation of land use restrictions and well-drilling prohibitions at SLAPS and under roads, bridges, railroads, and other permanent structures would increase overall protectiveness by preventing or reducing exposures to COCs. HISS/Futura and the VPs would be remediated to the unrestricted release concentrations. Soils and sediments in Coldwater Creek would be remediated to the Coldwater Creek criteria. The Coldwater Creek criteria limits soils and sediments above the mean water gradient in Coldwater Creek to the unrestricted land-use RGs, and limits sediments below the mean water gradient in Coldwater Creek to the subsurface standard of 15/43/150 pCi/g above background of Ra-226/Th-230/U-238. Therefore, both the CERCLA risk and ARAR-based limits would be satisfied.

Remedial activities under Alternative 3 would address both non-radiological and radiological contaminants of concern. By doing so, risks would not exceed the CERCLA target risk range, a HI of 1.0 for each target organ, or doses above ARAR-based limits, as appropriate. Therefore, the alternative is protective of human health at all properties. The evaluation of risk-based and dose-based criteria is located in Appendix D.

5.2.3.2 Compliance with ARARs

Location-, action-, and chemical-specific ARARs would be achieved at all properties. Institutional controls would be used to maintain risks below criteria at SLAPS, and under roads, bridges, railroads, and other permanent structures.

5.2.3.3 Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence is good at all of the VPs. For the areas at SLAPS and roads, bridges, railroads, and other permanent structures, this alternative is less permanent because institutional controls could be lost and future development at SLAPS could be restricted. The excavation and treatment of some contaminated soils and sediment would

result in a permanent reduction in site risks, but contaminated materials remaining on-site would require continued monitoring and institutional controls. Institutional controls are used for SLAPS, and under roads, bridges, railroads, and other permanent structures. For the purpose of this FS, it is assumed that the current environmental monitoring program would continue for 30 years. However, the actual length of the monitoring program would be based on the results of 5-year reviews, and may be in perpetuity. Site reviews would be conducted.

5.2.3.4 Reduction of Contaminant Volume, Toxicity, or Mobility Through Treatment

Soil washing and soil sorting concentrate the contaminants into a smaller volume. However, the "clean stream" still contains some low levels of residual radioactive materials. The total volume of the clean and concentrated stream is larger than the original volume of contaminated soil before processing. Toxicity and mobility could be affected by changing the chemical composition of the constituents in the soil. Although soil washing mobilizes constituents in order to remove and concentrate them, the process also stabilizes the products of both the clean and concentrated stream. Therefore, the changes to toxicity and mobility are small. Phytoremediation will concentrate some contaminants that are present in the sediments of Coldwater Creek. Phytoremediation has been shown to be effective for uranium and some other metals, but less effective for radium and thorium.

5.2.3.5 Short-Term Effectiveness

Short-term effectiveness of Alternatives 2, 3, 5, and 6 are similar. The impacts are described in more detail under the evaluation of Alternative 2.

5.2.3.6 Implementability

The implementation of enhanced soil washing and soil sorting would require development efforts as part of the implementation. Soil washing enhanced with chemical extraction has been proven effective for reducing the levels of some contaminants in North County Site soils. Laboratory and conceptual design studies were conducted on soils from the North County Site to investigate treatment processes that would provide a volume reduction and reduce the remediation costs. The primary focus of the investigation was soil washing, including both physical and chemical processes (Clemson Technical Center, 1996). A bench scale selective chemical extraction process was developed that was able consistently to meet the RGs for the North County Site. Removal efficiencies of the radionuclides of interest, particularly Th-230, were consistently greater than 96 percent, and frequently in excess of 98 percent. It is expected that all of the site soils containing less than 500 pCi/g of Th-230 could be treated to meet the cleanup goals with this process. Based on limited evaluations of higher activity soils, the process may even be able successfully to treat soils containing Th-230 activities as high as 2,000 pCi/g. Based on the results of these tests a (conceptual) process design and cost estimate for a full-scale system were developed. The conceptual cost estimates show that treatment by soil washing could be cost effective if process improvements were incorporated to minimize the amount of reagents/chemical required, and to treat the unrecycled process wastewater. Treatment of process water is, however, particularly problematic. Other aspects of the alternative, such as excavation of contaminated soils and truck transport of soil, are conventional activities in construction projects of this kind.

Administrative implementation of this alternative would be difficult. MDNR has objected to placement of radioactive materials on land in Missouri. It is likely the real estate instrument would need to be obtained through condemnation. Although the implementation of institutional controls at SLAPS and under roads, bridges, railroads, and other permanent structures is technically feasible, it involves complex administrative requirements.

Construction and operation of the components of Alternative 3 would be straightforward. Resources are readily available for removing contaminated soil and sediment and providing backfill over treated soils. Standard excavation/construction equipment would be used to remove contaminated material.

Minimal sediment dredging from Coldwater Creek can be accomplished using conventional hydraulic dredging equipment (i.e., vacuum dredged with a horizontal auger dredge or modified cutterhead dredge). Hydraulic dredging would use suction to dislodge, capture, and transport contaminated sediment to the staging area. This is a well-developed technology that has been extensively used. Hand-held hydraulic dredges controlled by wading operators would be used in small isolated locations where shallow sewer lines are known to exist as well as in shallow sections of the creek. A temporary staging area for dewatering and hauling equipment would be constructed, and additional clearing activities would be required at some locations along the creek. The wastewater from dredged sediment dewatering would be tested prior to discharge. On-site screening would minimize turn-around-time on releasing wastewater for discharge. Attempts would be made to schedule creek dredging during the dry season, when less flow is in the creek.

Mitigation measures would be used to ensure minimization of short-term impacts. Borrow sites for backfill and soil cover material have not been selected, but are locally available. However, implementation of the planned Lambert-St. Louis International Airport expansion would result in a demand for several million cubic meters (2 to 3 million cubic yards) of backfill soil, which could impact local backfill availability.

5.2.3.7 Cost

The total cost for 30 years is $284 million. There would be continuing costs for monitoring and review beyond the 30-year period.

5.2.4 Alternative 4, Institutional Controls (No Further Excavation)

Alternative 4 consists of institutional controls at HISS/Futura, SLAPS, Coldwater Creek, VPs, and roads, bridges, railroads, and other permanent structures. Table 5-1 provides a summary of the institutional controls required under Alternative 4. Institutional controls are used to prevent inadvertent intrusion into soils with residual concentrations of COCs. A deed restriction prohibiting well drilling would provide additional protection by limiting direct exposure to contaminated ground water. Alternative 4 also includes long-term monitoring, use of road cover, and 5-year reviews.

5.2.4.1 Overall Protection of Human Health and the Environment

The overall protection of human health and the environment is good at all properties for as long as institutional controls are in place. Institutional controls in the form of land use restrictions would be established to prevent unrestricted use of the site. Potential future ground-water exposure pathways are eliminated through the use of well-drilling prohibitions and land use restrictions prohibiting ground-water use. Controls may also include soil excavation restrictions.

Alternative 4 is less permanent than other alternatives because the institutional controls could be lost. The risks under Alternative 4 could exceed the CERCLA target risk range, and doses could exceed 100 mrem/yr if controls are lost. To avoid loss of controls, Alternative 4 includes requirements to verify the maintenance of the institutional controls through the CERCLA 5-year review process.

5.2.4.2 Compliance with ARARs

Alternative 4 does not achieve either the 40 CFR 192, Subpart B or C standards. In addition, Alternative 4 does not comply with 40 CFR 192 Subpart A standards for the control of residual radioactive materials from inactive uranium processing sites. Subpart A requires that controls be maintained for at least 200 years and up to 1,000 years. Inability to meet the threshold criteria of compliance with ARARs is a significant problem with this alternative. Section 121(d) of CERCLA and the NCP § 300(f)(l)(ii)(B) require that remedial actions at CERCLA sites attain ARARs, unless such ARARs are waived under CERCLA Section 121(d)(4).

5.2.4.3 Long-Term Effectiveness and Permanence

Alternative 4 may not be protective in the long term. It relies on institutional controls to eliminate or reduce exposures to site contaminants. Examples of these institutional controls are detailed in Table 5-1. The institutional controls could include land use restrictions to limit activities that could disturb soils under roads, bridges, and railroads and beneath buildings. Controls could also include zoning restrictions and deed notices to ensure that future owners are made aware of the presence of residual contamination. These controls would involve continuation of current land-use restrictions to limit use of roads, bridges, and railroad beds as transportation/utility corridors. The areas under roads, bridges, and railroad rights-of-way presently have institutional controls in place in the form of easements for these uses. The most likely use of additional institutional controls is a system by which notice would be provided by utilities or other entities to the government prior to performance of any construction or maintenance work in contaminated areas remaining beneath roads, bridges, railroads, and other permanent structures so that the necessary remediation can be conducted prior to and in conjunction with this work.

The effectiveness of this alternative is directly related to the adequacy and reliability of the institutional controls. The controls would have to be enforced through a government or municipal entity. It is reasonably expected that institutional controls can be implemented and would be effective in protecting human health and the environment, but they would not result in a permanent reduction in site risks. Title to the properties with residual contamination would

remain with current landowners and would not be transferred to the federal or state government. Institutional controls will be effective in providing a degree of human health protection to the extent they minimize the potential for direct contact with contaminated media. The institutional controls would have to be maintained for a considerable period of time to prevent unauthorized and/or inappropriate use of the site. The materials (e.g., uranium, thorium, and vanadium) left in place will remain for multiple lifetimes because they have very long half-lives and are not typically removed by natural means. A requirement that land use restrictions "run with the land" despite ownership changes would be used to help ensure that controls are not lost. Compliance with land use restrictions would be monitored after cleanup certification through the 5-year review process.

5.2.4.4 Reduction of Contaminant Volume, Toxicity, or Mobility Through Treatment

No reduction of volume, toxicity, or mobility of contaminants through treatment would be obtained under this alternative.

5.2.4.5 Short-Term Effectiveness

There would be no additional short-term risks to the community, worker, or the environment. Because Alternative 4 makes use of institutional controls rather than active remediation to minimize exposures, it avoids adverse short-term impacts due to potential construction or transportation accidents associated with active remedial technologies.

5.2.4.6 Implementability

Administratively this alternative would be difficult to implement. Maintaining controls at numerous properties would be difficult. Condemnation may be required to obtain some land rights. On-site remedies have received strong objection from local stakeholders in the past.

5.2.4.7 Cost

The total costs for the 30-year costing period for Alternative 4 are $129 million. Additional cost for reviews and maintenance of institutional controls would continue indefinitely. The costs associated with establishing institutional controls would be expected to include legal costs and the actual payment to landowners for the legal "taking" of their rights with respect to their properties.

5.2.5 Alternative 5, Excavation with Institutional Controls Under Roads, Bridges, Railroads, and Other Permanent Structures

Alternative 5 includes excavation and dredging plus off-site disposal to allow unrestricted use at all properties except for roads, bridges, railroads, and other permanent structures. Soils under roads, bridges, railroads, and other permanent structures are inaccessible and will not be remediated as part of this response action. Other responses include institutional controls, short-term monitoring, short-term containment technologies, truck and rail transportation, and disposal at licensed or permitted facilities. Coldwater Creek sediments that exceed the Coldwater Creek criteria would be dredged and disposed. The Coldwater Creek criteria limit soils and sediments above the mean water gradient in Coldwater Creek to the unrestricted land-use RGs, and limits sediments below the mean water gradient in Coldwater Creek to the subsurface standard of

15/43/150 pCi/g of Ra-226/Th-230/U-238. Institutional controls would only be necessary to restrict land use under current roads, bridges, railroads, and other permanent structures. Institutional controls would be maintained on a given property until unrestricted remediation goals are achieved.

5.2.5.1 Overall Protection of Human Health and the Environment

In general, the long-term protectiveness of this alternative is high. However, at roads, bridges, railroads, and other permanent structures it is less permanent because institutional controls could be lost. Alternative 5 includes removal of soil to meet the unconditional release concentrations in surface soil and subsurface soil. SLAPS, HISS/Futura, and the VPs would be remediated to the unrestricted release concentrations. Soils and sediments above the mean water gradient in Coldwater Creek would be remediated to the RGs for unrestricted use. Soil and sediments below the mean water gradient in Coldwater Creek would be removed if they exceed 15/43/150 pCi/g of Ra-226/Th-230/U-238. Therefore, both the CERCLA risk and ARAR-based limits would be satisfied. Institutional controls would be used to ensure protectiveness of the areas under roads, bridges, railroads, and other permanent structures under all future anticipated land use conditions.

Remedial activities under Alternative 5 would address both non-radiological and radiological contaminants of concern. By doing so, risks would not exceed the CERCLA target risk range, a HI of 1.0 for each primary target organ, or doses above ARAR-based limits, as appropriate. Therefore, the alternative is protective of human health at all properties. The evaluation of risk-based and dose-based criteria is located in Appendix D.

5.2.5.2 Compliance with ARARs

Location-, action-, and chemical-specific ARARs would be achieved at all properties. Institutional controls would be used to maintain risks below criteria under roads, bridges, railroads, and other permanent structures.

5.2.5.3 Long-Term Effectiveness and Permanence

Alternative 5 is protective in the long-term. This alternative uses a combination of excavation and institutional controls to manage future risk and achieve long-term effectiveness. By removing the most highly contaminated soils from the site, Alternative 5 minimizes the need for institutional controls to areas under roads, bridges, railroads, and other permanent structures. Institutional controls would be maintained in a given area until unrestricted goals are achieved. The excavation of contaminated soils and sediments would result in a permanent reduction in risks.

5.2.5.4 Reduction of Contaminant Volume, Toxicity, or Mobility Through Treatment

Treatment is not proposed under this alternative, except where needed for dewatering and treatment of release water. Therefore, a reduction in the toxicity, mobility, or volume of the contaminated soils through treatment would not occur.

5.2.5.5 Short-Term Effectiveness

Short-term effectiveness is similar to other alternatives. The impacts are described in more detail under the evaluation of Alternative 2.

5.2.5.6 Implementability

Technically and administratively this alternative is highly implementable. There are no technical problems that would limit the implementability of Alternative 5. Excavation of contaminated soils, construction of temporary roads, and truck transport of soil are conventional activities in construction projects of this kind.

Construction and operation of the components of Alternative 5 would be straightforward. Resources are readily available for removing contaminated soil and sediment. Standard excavation/construction equipment would be used to remove contaminated material. Special engineering techniques involving precautions on excavation near buildings and structures would be observed during remediation.

Minimal sediment dredging from Coldwater Creek can be accomplished as described earlier under Alternative 3. Mitigation measures would be used to ensure minimization of short-term impacts.

Borrow sites for backfill material have not been selected, but are locally available. However, implementation of the planned Lambert-St. Louis International Airport expansion would result in a demand for several million cubic meters (2 to 3 million cubic yards) of backfill soil, which could impact local backfill availability.

5.2.5.7 Cost

The total costs for the 30-year costing period are $223 million. There would be very limited continuing costs for monitoring and reviews beyond the 30-year costing period. However, there could be additional costs for removal of areas under roads, bridges, railroads, and other permanent structures once they become accessible beyond the 30-year costing period.

5.2.6 Alternative 6, Excavation at all Properties

Alternative 6 includes excavation and dredging plus off-site disposal to remove contamination from all areas so that no institutional controls are required. This alternative includes excavating soils contaminated above the criteria for unrestricted use. All difficult-to-access soils under roads, bridges, railroads, and other permanent structures would also be excavated under this alternative.

Contaminated sediments would be dredged from Coldwater Creek to the subsurface soil criteria. Contaminated soils would also be excavated from floodplain areas along the Creek. Dredged sediments would be dewatered and transported to a staging area at SLAPS for ultimate disposal. Water from these activities would be collected and treated as necessary before disposal.

5.2.6.1 Overall Protection of Human Health and the Environment

Alternative 6 includes removal of all soil to meet the unconditional release concentrations in the surface and subsurface. Therefore, both the risk-based and dose-based limits would be satisfied at all properties. This alternative has the highest long-term permanence.

Remedial activities under Alternative 6 would address both non-radiological and radiological contaminants of concern. By doing so, risks would not exceed the CERCLA target risk range, a HI of 1.0 for each primary target organ, or doses above ARAR-based limits, as appropriate. Therefore, the alternative is protective of human health at all properties. The evaluation of risk-based and dose-based criteria is located in Appendix D.

5.2.6.2 Compliance with ARARs

Location-, action-, and chemical-specific ARARs would be achieved.

5.2.6.3 Long-Term Effectiveness and Permanence

Removing the soils to the RGs for unrestricted use would be protective of human health under future-use scenarios without dependence upon institutional controls. This alternative is permanent because all materials that pose an unacceptable health risk would be removed and placed in a permanent disposal facility. Therefore, no long-term management of soils or sediment would be required.

5.2.6.4 Reduction of Contaminant Volume, Toxicity, or Mobility Through Treatment

Treatment is not proposed under this alternative, except where needed for dewatering and treatment of release water. Therefore, a reduction in the toxicity, mobility, or volume of the contaminated soils through treatment would not occur. However, the complete removal and disposal of all contaminated material will eliminate sources of runoff, infiltration, fugitive dust, and emissions at the North County Site.

5.2.6.5 Short-Term Effectiveness

Most short-term impacts are described in more detail under the evaluation of Alternative 2. However, removal of difficult-to-access soil under McDonnell Boulevard, Interstate 270, and other roads, bridges, and railroads could have significant negative impacts on local traffic congestion and could increase the risk of traffic accidents. The removal of material from roads, bridges, railroads, and other permanent structures would significantly increase the potential for accidents.

5.2.6.6 Implementability

This alternative would be technically implementable, but removal of roads, bridges, railroads, and other permanent structures would be difficult. Construction and operation of the components of Alternative 6 would be straightforward. Resources are readily available for removing contaminated soil and sediment. Standard excavation/construction equipment would be used to remove contaminated material. Special engineering techniques involving precautions on excavation near buildings and structures would be observed during remediation.

Administratively this alternative would require considerable coordination with federal, state, and local departments of transportation and with railroads.

Borrow sites for backfill material have not been selected, but are locally available. However, implementation of the planned Lambert-St. Louis International Airport expansion would result in a demand for several million cubic meters (2 to 3 million cubic yards) of backfill soil, which could impact local backfill availability.

5.2.6.7 Cost

The total costs for the 30-year costing period are $286 million. There would not be continuing costs beyond the 30-year costing period.

5.3 MONITORING AND MITIGATION MEASURES

The primary monitoring and mitigation measures that would be used at the North County Site are described below. These measures would be effective in minimizing the potential adverse effects associated with implementation of the alternatives.

Construction Activities: Construction practices such as sediment barriers, dikes, siltation ponds, surface grading, and vegetation would be used. Habitat would be restored and mufflers and barriers would be used for noise abatement. Wetting and other dust control measures would be used.

Monitoring Activities: Short-term ground-water, surface-water, air, and sediment monitoring would be conducted during the remedial action to ensure that contamination from the soils and the unusable ground-water zone (HZ-A) does not significantly impact surface water or potable ground water. The results of the short-term monitoring of surface-water, sediment, and HZ-A ground water would be used to assess any potential impacts to Coldwater Creek resulting from the remedial actions, and would assist in evaluating the effectiveness of the remedial actions. The results of the short-term monitoring would also be used to determine whether long-term monitoring is required to assess potential contaminant migration from contaminated soils remaining beneath roads, bridges, railroads, and other permanent structures.

Transportation: Waste would be covered during long distance transport across public roads. Vehicles would be decontaminated and inspected before leaving contaminated areas.

Worker Protection: Activities would be in accordance with approved health and safety plans. Worker monitoring programs would be implemented.

Protection of the General Public: Site air monitoring would be conducted, and access to construction areas would be controlled.

Environmental Restoration: Wetlands and floodplain would be restored or replaced.

5.4 IMPACTS OF POTENTIAL LOSS OF INSTITUTIONAL CONTROLS

For Alternative 1, changes in land use could, in the long-term, result in the release of contaminants, and could cause potential future impacts on human health and the environment. No institutional controls are necessary for the implementation of Alternative 6 because all properties are excavated to meet the unrestricted land use criteria. Institutional controls are used as part of Alternatives 2 through 5. Where supplemental criteria are used (Alternatives 2 and 3), they were developed to limit risk and dose to current users and to limit dose in the event of loss of control to less than 100 mrem/yr to all modeled receptors. However, for Alternative 4, total reliance is placed on institutional controls to limit risk and dose to current users. The loss of these controls could then result in risks in excess of the CERCLA target risk range and doses in excess of 100 mrem/yr.

5.5 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

Implementation of any of the site-wide alternatives would require the use of SLAPS and HISS to support cleanup activities and the use of depletable resources such as construction materials and petroleum-based products. All alternatives that include excavation would require the long-term commitment of land for waste disposal at an off-site facility. Only Alternative 6 releases all properties at the North County Site without any restrictions on land use.

5.6 COMPARATIVE ANALYSIS OF SITE-WIDE ALTERNATIVES

Site-wide alternatives undergo comparative analysis for the purpose of identifying relative advantages and disadvantages of retained alternatives on the basis of the previous detailed analysis (Sections 5.2 and 5.3). The comparative analysis provides a means by which remedial alternatives can be directly compared to one another with respect to common criteria. Overall protection and compliance with ARARs are threshold criteria that must be met by an alternative for it to be eligible for selection. The other five criteria, consisting of short- and long-term effectiveness; reduction of contaminant volume, toxicity, and mobility through treatment; ease of implementation; and cost are the primary balancing criteria used to select a preferred remedy among alternatives satisfying threshold criteria. The community and state acceptance criteria have been considered, but will be fully addressed after the public comment period.

5.6.1 Comparison of the Alternatives Using the CERCLA Threshold and Balancing Criteria

Table 5-2 summarizes the results of the comparative analysis of the seven criteria for the six site-wide alternatives.

5.6.1.1 Overall Protection of Human Health and the Environment

Each of the alternatives, except Alternative 1, is protective of human health and the environment. No further remedial action is required to protect the environment because there is judged to be little to no probability of significant adverse impacts on ecological receptors from chemical and radiological wastes resulting from uranium manufacturing or processing activities.

The degree of protection and permanence of the protectiveness are a function of whether, and to what extent, an alternative uses dedicated engineering containment, removal strategy, or land use and institutional control strategies. Alternative 6 removes the most soil and provides the greatest long-term protection to human health because soil is removed from all areas including roads, bridges, railroads, and other permanent structures. However, the short-term risk due to accidents is greatly increased because of the difficulty in removing soils from under roads, bridges, railroads, and other permanent structures, and because of the need to re-route traffic. Alternatives 2, 3, and 5 better balance the short-term cost and long-term protection benefit by using soil removals to provide an effective and permanent remedy for portions of the site. They also depend on the continued maintenance of institutional controls to provide protectiveness for areas where contamination remains above unrestricted levels. For these alternatives, human health and the environment are protected for as long as institutional controls can be implemented. Alternative 4 results in the highest levels of contamination remaining on the site. Alternative 4 is effective by preventing access to COCs for the institutional control period, but should institutional controls be lost, the long-term effectiveness of the alternative would be compromised.

5.6.1.2 Compliance with ARARs

A summary of the key potential ARARs are presented in Table 5-3. A summary of removal actions is presented in Table 5-4. All of the alternatives except Alternative 1 and Alternative 4 comply with ARARs (sometimes with the use of supplemental standards). Alternatives 2 through 5 use institutional controls as part of the compliance. Table 5-1 provides a summary of possible institutional controls required under each alternative. Alternative 4 does not achieve the 40 CFR 192 Subpart A, B, or C standards and relies totally on use of institutional controls to achieve restricted release.

5.6.1.3 Long-Term Effectiveness and Permanence

The most permanent alternative is Alternative 6, which ships all contaminated soils to an off-site disposal location. Next in terms of permanence is Alternative 5, followed by 2, 3, and 4. The least permanent is Alternative 1. Alternatives 2, 3, 4 and 5 are dependent in varying degrees upon the long-term maintenance of institutional controls to ensure the effectiveness and permanence of the remedy. Alternatives, 2, 3, and 5 are more effective than Alternative 4 in that the most contaminated soils are either removed from the site (Alternative 5), contained (Alternative 2), or treated (Alternative 3). However, these alternatives also rely to some degree on maintenance of institutional controls to ensure continued long-term effectiveness. Alternative 5 is considered the most effective and permanent of these 3 alternatives in the long term because the majority of the contaminated soil above soil RGs is removed and disposed off-site. In addition, fewer areas require institutional controls than for the remaining alternatives, other than Alternative 6.

No area of the North County Site would sustain a long-term impact as a result of this cleanup action.

Pursuant to the SARA, site remedy reviews would be conducted every 5 years for alternatives where radioactive contaminants (i.e., soil and/or ground water) would remain on-site above criteria for unrestricted use.

Table 5-2. Summary of Detailed Analysis of Site-wide Alternatives

Criteria	Alternative 1, No Further Action	Alternative 2, Partial Excavation and Capping at SLAPS and HISS/Futura	Alternative 3, Partial Excavation and Treatment at SLAPS	Alternative 4, Institutional Controls (No Further Excavation)	Alternative 5, Excavation with Institutional Controls Under Roads, Bridges, Railroads, and Other Permanent Structures	Alternative 6, Excavation at all Properties
Overall Protection						
• Human Health	Not protective	Protective. Complete removal at SLAPS VPs and removal of high concentration soils at remaining properties. Uses institutional controls at SLAPS, HISS/Futura, Coldwater Creek, under roads, bridges, railroads, and other permanent structures.	Protective. Complete removal at SLAPS VPs and HISS/Futura, and removal of high concentration soils at remaining properties. Uses institutional controls at SLAPS, under roads, bridges, railroads, and other permanent structures.	Protective. Reliance on successful use of institutional controls in both accessible areas, and areas under roads, bridges, railroads, and other permanent structures.	Protective. Complete removal at all properties except roads, bridges, railroads, and other permanent structures. Uses institutional controls under roads, bridges, railroads, and other permanent structures.	Protective. Complete removal at all properties.
• Environment	Not protective	Protective	Protective	Protective	Protective	Protective
Compliance With ARARs						
• Chemical-specific	Not compliant for soils or sediments	Compliant	Compliant	Does not achieve 40 CFR 192, Subpart A, B, or C standards.	Compliant	Compliant
• Action-Specific	Not applicable	Compliant	Compliant	Compliant	Compliant	Compliant
• Location-Specific	Not applicable	Compliant	Compliant	Compliant	Compliant	Compliant
Long-Term Effectiveness and Permanence						
• Magnitude of Remaining Risk	Medium. Current and future risks could exceed CERCLA risk range if control measures were not in place or land use changes.	Low. Meets risk range without restrictions on future land use for most properties. Remaining risks at SLAPS, HISS, and Futura controlled by installation and maintenance of clean cap and institutional controls. Roads, bridges, railroads, other permanent structures, and Coldwater Creek protective with institutional controls.	Low. Meets risk range without restrictions on future land use for most properties. Remaining risks at SLAPS controlled by maintenance of clean cover and institutional controls. Roads, bridges, railroads, and other permanent structures, protective with institutional controls.	Medium. Current and future risks could exceed CERCLA risk range if control measures were not in place or land use changes.	Very low. Meets risk range without restrictions on future land use for most properties. Roads, bridges, railroads, and other permanent structures, protective with institutional controls.	Very low. Meets risk range without restrictions on future land use.
• Adequacy of Controls	None provided	Good. Properties requiring land use restrictions to commercial/industrial use are unlikely to receive residential development pressure due to proximity to airport and continued commercial/industrial expansion of area.	Good. Property requiring land use restriction to commercial/industrial use is already prohibited from residential use due to location adjacent to airport.	Okay	Very good – limited areas require long term controls	No long term controls required
• Reliability of Controls	None provided	Reliable.	Reliable.	Reliability declines for long-term period.	Very Reliable.	Very Reliable.

Table 5-2. Summary of Detailed Analysis of Site-wide Alternatives (Cont'd)

Criteria	Alternative 1, No Further Action	Alternative 2, Partial Excavation and Capping at SLAPS and HISS/Futura	Alternative 3, Partial Excavation and Treatment at SLAPS	Alternative 4, Institutional Controls (No Further Excavation)	Alternative 5, Excavation with Institutional Controls Under Roads, Bridges, Railroads, and Other Permanent Structures	Alternative 6, Excavation at all Properties
• Long Term Management	5-year review	5-year remedial review; long-term management of caps and environmental monitoring at SLAPS and HISS/Futura necessary.	5-year remedial review; environmental monitoring; and long-term management of soil cover and land use restrictions at SLAPS necessary.	5-year remedial review; environmental monitoring; and maintenance of land use restrictions at SLAPS, HISS, and Futura necessary.	5-year remedial review; only required to ensure continued use of roads, bridges, railroads, and other permanent structures as transportation/utility corridors.	No long-term management required.
Reduction of Contaminant (overall)						
Toxicity, Mobility, or Volume by Treatment	None	None	Volume of soils requiring disposal reduced by soil sorting and soil washing	None	None	None
Short-Term Effectiveness						
• Protection of Community	No additional health effect in the short-term due to no action taken.	Small additional short-term risk to community due to construction and transportation activities. Risks of exposure to contaminated soils protective with use of standard controls such as dust control and use of covered trucks.	Small additional short-term risk to community due to construction and transportation activities. Risks of exposure to contaminated soils protective with use of standard controls such as dust control and use of covered trucks.	No additional short-term risk to community.	Small additional short-term risk to community due to construction and transportation activities. Risks of exposure to contaminated soils protective with use of standard controls such as dust control and use of covered trucks.	Significant increased risk due to removing materials under roads, bridges, railroads, and other permanent structures, which will involve more complete construction techniques and traffic re-routing.
• Protection of Workers	No additional health effect in the short-term due to no action taken.	Short-term occupational risk to workers Protective with controls	Short-term occupational risk to workers Protective with controls	No additional short-term occupational risk to workers Protective with controls	Short-term occupational risk to workers Protective with controls	Short-term occupational risk to workers increased due to removing materials under roads, bridges, railroads, and other permanent structures, which will involve more complete construction techniques and traffic re-routing. Protective with controls
• Environmental Impacts	No additional impacts in the short-term due to no action taken.	Short-term impacts to urban ecosystem Long-term benefit	Short-term impacts to urban ecosystem Long-term benefit	No additional short-term impacts to urban ecosystem	Short-term impacts to urban ecosystem Long-term benefit	Short-term impacts to urban ecosystem Long-term benefit
• Geology and Soils	Continued uncontrolled migration of contaminants	Short-term soil disturbance during excavation	Short-term soil disturbance during excavation	No short-term impacts.	Short-term soil disturbance during excavation	Short-term soil disturbance during excavation
Implementability						
• Technical Feasibility	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible
• Administrative Feasibility	Feasible	Feasible. Possible objection by state regulators and public due to contaminated soils remaining in place at SLAPS and HISS/Futura.	Feasible. Possible objection by state to use of treated soil as backfill at SLAPS.	Feasible. Likely objection by state regulators and public due to contaminated soils remaining in place.	Feasible. Limited objection expected due to location and concentration of remaining contaminants.	Feasible. No objections expected. Administratively complex for roads, bridges, railroads, and other permanent structures.
Cost (Present Worth)						
• Total Cost	$1.5 million	$205 million	$284 million	$129 million	$223 million	$286 million

Table 5-3. Documentation of ARARs

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Chemical-Specific						
40 CFR 192, Subpart A	Not ARAR	Will comply	Will comply	Will not comply	Will comply	Will comply
40 CFR Part 192 Subpart B	Will not comply	Will comply Supplemental standards will be used	Will comply Supplemental standards will be used	Will not comply	Will comply Supplemental standards will be used	Will comply.
10 CFR 40 Appendix A Criterion 6(6)	Will not comply	Will comply.	Will comply.	Will comply.	Will comply.	Will comply.
40 CFR Parts 122 CWA, NPDES	Will not comply	Will comply with substantive requirements	Will comply with substantive requirements	Will comply with substantive requirements	Will comply with substantive requirements	Will comply with substantive requirements
40 CFR Part 192 Subpart C	Will not comply	Will comply	Will comply	Will not comply	Will comply	Will comply

Table 5-4. Summary of Removal Actions

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Removals by Property Unit						
Removal actions started under EE/CAs	Stop removal actions after ROD	Removal actions continue for this alternative	Removal actions continue for this alternative – soils consolidated to SLAPS for treatment	Removal actions continue for this alternative	Removal actions continue for this alternative using unrestricted land use criteria.	Removal actions continue for this alternative using unrestricted land use criteria.
HISS/Futura	Cease pile removal and leave materials in place	Excavate soils above supplemental limit for subsurface soil (for use with institutional controls) and add cover	Excavate for release without radiological restrictions	No additional removals	Excavate for release without radiological restrictions	Excavate for release without radiological restrictions
Roadside	No additional removals. Leave remaining materials in place	Excavate for release without radiological restrictions	Excavate for release without radiological restrictions	No additional removals	Excavate for release without radiological restrictions	Excavate for release without radiological restrictions
Inaccessible areas directly under Roads, Bridges, Railroads, and other Permanent Structures	Leave material in place	Defer excavation and use institutional controls	Defer excavation and use institutional controls	No additional removals	Defer excavation and use institutional controls	Excavate for release without radiological restrictions
Coldwater Creek	Leave material in place	Sort material during removals for flood control project being made as part of a separate project	Excavate to Coldwater creek criteria below the mean water gradient for release without restrictions	No additional removals	Excavate to Coldwater creek criteria below the mean water gradient for release without restrictions	Excavate to Coldwater creek criteria below the mean water gradient for release without restrictions
SLAPS	Leave material in place	Excavate soils above supplemental limit for subsurface soil (for use with institutional controls) and add cover	Excavate soils above supplemental limit for subsurface soil (for use with institutional controls) and consolidate other soils here for treatment	No additional removals	Excavate for release without radiological restrictions	Excavate for release without radiological restrictions
All other VPs	No additional vicinity properties removals	Excavate for release without radiological restrictions	Excavate for release without radiological restrictions	No additional removals	Excavate for release without radiological restrictions	Excavate for release without radiological restrictions

5.6.1.4 Reduction in Contaminant Volume, Toxicity, and Mobility Through Treatment

Alternative 3 provides a reduction in contaminant volume and mobility through treatment.

5.6.1.5 Short-Term Effectiveness

The biggest difference in short-term effectiveness is due to the potential for accidents if soil is removed from beneath roads, bridges, railroads, and other permanent structures in Alternative 6. The potential for increased accidents for workers and the general public is greatly increased. Because Alternatives 2, 3, 5, and 6 involve disposal of various volumes of contaminated soils off-site, they have short-term risks associated with traffic accidents. Alternative 4 (Institutional Controls) would not involve any remedial actions; therefore, there would be no short-term impacts to workers or to natural and cultural resources.

Short-term negative impacts to the environment are likely to occur with soil excavation and sediment dredging considered as part of Alternatives 2, 3, 5, and 6. Excavation and dredging potentially redistribute wastes into new uncontaminated areas; potentially destroy animals and plants residing at the excavated locations; and potentially destroy existing features of the environment that provide habitat or food to plants and animals. The degree of short-term damage to the environment increases with the amount of surface area subjected to removal in each of the alternatives. Phytoremediation of sediments in Coldwater Creek as part of Alternative 3 may have a positive impact on the environment. Although the implementation of Alternatives 2, 3, 5, and 6 may temporarily impact wetlands, temporarily affect surface drainage in the floodplain, and create non-point source surface water discharges, all of these impacts will be managed in compliance with the substantive requirements of applicable laws and regulations, and are not considered to be significant obstacles to the implementation of these remedial alternatives.

5.6.1.6 Implementability

Materials and services for removal of contamination and environmental monitoring activities for the various alternatives are readily available. The degree of difficulty in implementing alternatives increases with the amount and type (i.e., access-restricted soils) of contaminated soils to be excavated, the level of the design/transportation required to dispose soils in accordance with regulations, and the time/coordination involved in completing the alternative. Disposal at an existing commercial facility is considered more implementable than disposal at new disposal facilities, which were eliminated during screening.

Implementability of alternatives involving placement of radioactive materials (Alternatives 2 and 3) will be administratively difficult to achieve. MDNR has objected to leaving or placing radionuclides on land in Missouri. Condemnation may be required to obtain the necessary real estate interests where institutional controls are required. On-site remedies (Alternatives 2 and 3) have received strong objection from stakeholders in the past.

5.6.1.7 Cost

The comparative analysis of costs gives the differences in cost in terms of undiscounted FY03 dollars. Costs for each alternative, itemization of individual components, and the sensitivity analysis for each alternative may be found in Appendix C. The total 30-year cost for the alternatives are:

Alternative	Cost
1	$1.5 million
2	$205 million
3	$284 million
4	$129 million
5	$223 million
6	$286 million

5.6.2 Analysis of the Advantages and Disadvantages of Using the Various Technologies at Individual Property Groups

This section focuses the evaluation on the technologies used for individual property groups. The purpose is to highlight the advantages and disadvantages of technologies that could be combined to develop a preferred plan.

5.6.2.1 The Impact of Institutional Controls and Land Use Restrictions

Institutional controls are used to ensure protectiveness for alternatives at areas in which the residual soil contamination exceeds the concentrations specified in ARARs for residential use. The controls are used in conjunction with supplemental standards for subsurface soil for the two primary areas where wastes were stored: SLAPS and HISS/Futura. Alternative 4 relies primarily on institutional controls. Although the implementation of institutional controls at SLAPS, HISS/Futura, under buildings, roads, bridges, and railroads, and at the VPs is technically feasible, it involves complex administrative requirements. Maintaining controls at numerous properties would be difficult. The controls would have to be maintained for a considerable period of time, and would have to be enforced through a government or municipal entity. A requirement that land use restrictions "run with the land" despite ownership changes would be used to help ensure that controls are not lost. Signs, barriers and other standard controls are retained for use during the remediation.

Land use restrictions are implemented in conjunction with the removal technologies to provide protection while limiting the amount of excavation in areas so that the risk of traffic accidents, environmental impact, or cost are reduced. Restrictions on future land use vary among the alternatives. The balance among risks, benefits, and costs varies dependent on the property group.

Alternatives 5 and 6 allow use without restrictions at SLAPS; while Alternatives 2, 3, and 4 impose commercial/industrial land use restrictions at SLAPS. All of the alternatives are protective for the expected future land use for as long as the institutional controls are effective. Cost is increased for the unrestricted alternatives due to the increased volume of soil that is

removed. Additional long-term effectiveness for the unrestricted use alternatives is provided in the event that subsurface soils with residual levels of COCs were excavated in the future. Alternative 3, which uses treatment, reduces the land use restrictions to only SLAPS because all of the soils are brought to a central treatment location. HISS/Futura could be an alternate location for centralized treatment.

The use of land use restrictions for the roads, bridges, railroads, and other permanent structures balance the cost and the operational risks (e.g., from traffic accidents) with the benefit of removal of the contaminated materials. Comparing Alternatives 5 and 6 shows the impacts. The increase in cost and operational risk is very large for removals from areas under major traffic corridors, and the risk of potential health effect would only be slightly reduced. The benefit of removing materials from under roads, bridges, railroads, and other permanent structures is limited because the risks from taking no action under roads, bridges, railroads, and other permanent structures are small, except for a few limited locations.

Restrictions on land use at the other VPs is included in Alternative 4, and in the no-further-action alternative. Maintaining controls at numerous properties under control of private and governmental agencies would be required.

5.6.2.2 The Relative Advantages and Disadvantages of Soil and Sediment Removals

Removal of soils to an off-site disposal location provides a cost-effective improvement in overall protection compared to treatment and containment for the majority of the site properties. Removal actions provide an increase in protection by moving material from the current location to a more controlled location. Although surface soils at residential properties show the greatest risk for a given concentration of contaminants, removals at residences were conducted under previous removal actions. Surface soils at active industrial and commercial facilities would be next. Higher concentrations of subsurface materials where construction workers could be exposed are next. The least benefit in terms of risk and hazard reduction is from areas where the potential for exposure is limited, including deeper areas at SLAPS and HISS/Futura; areas under roads, bridges, railroads, and other permanent structures; and material within the banks of Coldwater Creek.

The removals in Alternatives 2, 3, 5, and 6 will reduce radionuclide contaminant migration. Although no quantitative model has been developed for water-borne pathways following remedial action, backfill of clean surface soils will eliminate particulate transport of radionuclides both in surface water and at locations of ground-water discharge following remedial actions. The primary radionuclide before remedial action in shallow ground water is dissolved uranium. The risk for ground-water use before and after remedial action is nonexistent without a pathway. Ground water in the near surface zone will not be used for a water supply. Deep potential aquifers have not been impacted. There are several reasons why there will be no change to the dissolved uranium content of the Class IIB limestone aquifer following remedial action. The remedial action will lower the residual uranium source within Unit 2 soil. Ground-water transport of dissolved uranium in HZ-A will remain at low velocity. Transport of dissolved uranium across Units 3 (lacustrine deposits) and 5 (Pennsylvanian shale) will require centuries of time with consistent high potentiometric head. The long duration, high potentiometric head from HZ-A to HZ-C or HZ-E does not exist. The reducing water chemistry

environment below HZ-A limits the dissolution of uranium. Lastly, heavy metals, including uranium, tend to be bound to clay particles within Units 3 and 5. The remedial action's contaminant removal in soil and the native geologic environment at the sites are protective of the Class IIB limestone aquifer. Treatment of HZ-A ground water is not required, except for excavation water being discharged at the surface. Monitoring of Unit 4 ground water will be used as a post-remedial action tool to ensure the protective nature of this remedial action, and of the native geologic environment.

Removal of sediment and soils within the banks of Coldwater Creek can be disruptive to the ecosystem of the creek. The ecosystem is highly impacted by local industry, and activities such as limited dredging should not cause long-term detriment to the ecosystems or loss of habitat important to the survival of the species using the creek.

The removal of soil under the roads, bridges, railroads, and other permanent structures would increase the potential for accidents. The high cost of excavation of material under major thoroughfares such as the Interstate and McDonnell Bridge would result in only minor reductions in the potential health effects due to exposure to contamination in these areas. Removal from the ditches along roadways is more similar to removals from VPs.

For all remedial actions, all soils that meet the unrestricted use criteria for surface soils may be used for backfill in deeper areas. Surface cover will be from authorized backfill locations. Revegetation is cost-effective, and will help stabilize the areas impacted by removal of contaminated soil and sediment. Demolition and crushing of materials facilitates more efficient transportation and disposal while having very little impact on protectiveness.

5.6.2.3 Monitoring

Air, sediment, ground-water, and surface-water monitoring is retained for all of the alternatives during remedial actions (except for the no-further-action alternative). After remediation, monitoring of the ground water is included to ensure that remedial actions are effective, and that no significant migration of contamination to surface water or useable ground water is occurring. Long-term monitoring of HZ-A and long-term monitoring of Unit 4 in HZ-C (as a surrogate for HZ-E) are proposed for Alternatives 2, 3, and 4. For Alternative 5, short-term monitoring of surface water, sediment, and HZ-A (Unit 2) ground water is proposed to assess whether the remedial action is significantly impacting contaminant transport through HZ-A ground water into Coldwater Creek. Short-term monitoring of Unit 4 of HZ-C is proposed to ensure continued protection of the limestone aquifer (HZ-E). The results of the short-term monitoring would be used to determine whether long-term monitoring is required to assess potential contaminant migration from contaminated soils remaining beneath roads, bridges, railroads, and other permanent structures. Long-term monitoring would continue until determined to be no longer required as part of the five-year review process. Long-term monitoring is not considered necessary for Alternative 6 because all of the source material is removed to levels protective for unrestricted use. Monitoring locations would focus on the detection of materials moving toward the creek from the areas around SLAPS and HISS/Futura.

5.6.2.4 Containment

Materials that could result in a dose to a member of the general public above 100 mrem/yr are removed as part of all alternatives, except the no-further-action alternative and Alternative 4 (Institutional Controls). Therefore, the materials that could cause high risks are shipped off-site in most of the alternatives. The effectiveness, implementability, and cost of an on-site disposal cell is discussed as part of the technology screening, where the use of an on-site cell was eliminated from further evaluation. The multi-layer cover used in Alternative 2 reduces the dose to potential receptors because it eliminates exposure pathways and provides a barrier to intrusion.

5.6.2.5 Treatment

Soil washing, which is used in Alternative 3, concentrates the contamination and primarily changes the volume of material requiring off-site disposal. The treatment does not destroy the radioactive materials or the metal COCs. The treatment may change the toxicity or the mobility by changing the chemical forms of the compounds. The costs of the treatment process are likely to more than offset the reduction in the cost of transportation and off-site disposal of the contaminated soils for on-site processes. Recycle to a uranium mill combines the materials with other similar feed materials in an attempt to recover some of the uranium or other materials. In previous procurements, recycle to a uranium mill has sometimes (but not always) been less expensivethan the cost for off-site disposal.

The cost effectiveness of soil sorting depends on how much mixing of the contaminated soils has occurred. If the soils are heterogeneous, then soil sorting removes the material below the unrestricted release criteria rather than sending the material for expensive transportation and off-site disposal. Because most of the contamination is sent off-site, the improvement to protectiveness at the site is similar with or without sorting.

Dewatering and water treatment would be done as part of the soil removal and remediation activities. Sedimentation basins and treatment are cost-effective processes that are retained for all of the alternatives.

Phytoremediation is only effective for some metals. Although uranium is not generally the primary risk driver, phytoremediation may be beneficial and cost-effective for removing uranium from sediments or limited areas of soil.

5.6.2.6 Transportation and Disposal

Both rail and truck transportation are protective. The balancing criteria of cost and implementability will be determined as part of the procurement process. These are used for all of the alternatives, except the no-further-action alternative.

All licensed or permitted facilities are retained for off-site disposal. All of the facilities are protective, and the balancing criteria of cost and implementability will be determined as part of the procurement process. Discharge to a POTW or to surface water is retained and used for all of the alternatives, except the no-further-action alternative.

5.6.3 State and Community Acceptance

This evaluation will be completed after the receipt of comments. However, public input has been encouraged by the USACE (and previously by DOE) to ensure that the remedy selected for the North County Site meets the needs of the local community.

The Administrative Record, which contains the documentation used to prepare this FS, is available at the following locations:

Government Information Section
St. Louis Public Library - Central Library
1301 Olive Street
St. Louis, Missouri 63134

USACE Public Information Center
8945 Latty Avenue
Berkeley, Missouri 63134

The DOE published a Notice of Intent in the Federal Register on January 9, 1992, to present pertinent background on the scope and content of the St. Louis Site RI/FS. The comments, concerns, and written statements from a January 28, 1992, public scoping meeting held at Berkeley Senior High School, Berkeley, Missouri, were published in a Responsiveness Summary and made part of the St. Louis Work Plan for the RI/FS. In addition, the relevant comments from a December 6, 1990, scoping meeting on the Programmatic Environmental Impact Statement were also included in the work plan.

A copy of the Administrative Record File for Actions at the North County Site has been maintained by USACE at the Public Information Center, and at the St. Louis Public Library, and is updated regularly. The community relations program interacts with the public through news releases, public meetings, availability sessions, site tours, public workshops, meetings with local officials and interest groups, and receiving and responding to public comments through correspondence and the information center. The documents describing the results of the integrated process for the North County Site have been made available to the public for review and comment at the information repositories noted above.

From September 1994 through December 1996, a task force known as the St. Louis Site Remediation Task Force studied all aspects of the St. Louis FUSRAP Sites, including the North County Site. They formally transmitted the results of their deliberations to the DOE in the *St. Louis Site Remediation Task Force Report* (Task Force, 1996). Specific areas of focus included: 1) identification of alternative disposal sites, 2) health risk/cleanup standards, 3) development of local priorities with respect to cleanup of the site, 4) identification of remedial action alternatives, 5) a screening of technologies that may be applied at the site, and 6) the development of a communications and public awareness plan. The Task Force was composed of members appointed by the City and County of St. Louis, adjacent communities, the EPA, MDNR, concerned citizens, public utility and local business representatives, representatives of Congressmen, and representatives of local environmental groups.

5.7 PROPOSED PLAN (PP) AND RECORD OF DECISION (ROD)

5.7.1 Proposed Plan

As part of this FS process, a PP will be prepared to solicit public input on the site-wide alternatives and the specific, preferred approach to remediating the North County Site. The PP will present all of the alternatives evaluated in the FS together with the preferred alternative. The PP will review the FS results, select the preferred alternative, and identify the PP for remediating the North County Site. The draft PP will be submitted to both the EPA and the MDNR for their review. Public comments received on the PP will be used to evaluate the CERCLA criteria of "community acceptance".

5.7.2 Record of Decision

The ROD will select the remedy for the North County Site. Comments received from both the regulators and the public on the PP will be considered in drafting the ROD. The ROD will describe the CERCLA selection process and will provide a brief summary of history, characteristics, risks, and alternatives for site remediation. The ROD will include a responsiveness summary to address public comments.

SECTION 6

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6 REFERENCES

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