EM U.S. Department of Energy
Office Of Environmental Management

Land Area Historical Site Assessment for the Separation Process Research Unit (SPRU) Disposition Project

December 2006

Prepared by
Environmental Resource Group, LLC

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U.S. Department of Energy
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1. ACRONYMS AND GLOSSARY

UNITS OF MEASURE

centi	hundred, or hundredth part
Ci	Curie
cpm	counts per minute
g	gram
hr	hour
micro	millionth
milli	thousandth
mCi	milliCurie
mR	milliRoentgen
mrad	millirad
mRem	milliRem
pCi	picoCurie
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
pico	one trillionth (10^{-12}) part
R	Roentgen
rad	radiation absorbed dose
Rem	Roentgen equivalent man
µCi	microCurie
µCi/cc	microCurie per cubic centimeter
µCi/ml	microCurie per milliliter
µg	microgram

ACRONYMS

Ag	silver
Al	aluminum
Am	americium
Ba	barium
Bi	bismuth
C	carbon
C-(six digit number)	correspondence referenced
Ca	calcium
Cd	cadmium
Ce	cerium
Cl	chlorine
Co	cobalt
Cr	chromium
Cs	cesium
Cu	copper
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
Eu	europium
F	fluorine
Fe	iron
H	hydrogen
H-3	tritium
Hg	mercury
I	iodine
K	potassium
KAPL	Knolls Atomic Power Laboratory
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
Mg	magnesium
Mn	manganese
N	nitrogen
Na	sodium
Nb	niobium
Ni	nickel
NRC	Nuclear Regulatory Commission
NYSDEC	New York State Department of Environmental Conservation
O	oxygen
P	phosphorous
Pa	protactinium

PAH	polynuclear aromatic hydrocarbon
Pb	lead
PCB	polychlorinated biphenyls
Pr	praseodymium
Pu	plutonium
PUREX	plutonium uranium extraction
Ra	radium
R-(six digit number)	report reference
RCRA	Resource Conservation and Recovery Act
REDOX	reduction-oxidation
Ru	ruthenium
S	sulfur
Se	selenium
Si	silicon
SPRU	Separations Process Research Unit
SPUD	Surface Penetrating Underground Detector
Sr	strontium
SVOC	semi-volatile organic compound
SWMU	solid waste management unit
Th	thorium
Ti	titanium
TPH	tributyl phosphate
U	uranium
USGS	United States Geological Survey
VOC	volatile organic compound
Y	yttrium
Zn	zinc
Zr	zirconium

GLOSSARY

actinide. A group of elements that are very dense, radioactive metals. The elements are actinium, thorium, protactinium, uranium, neptunium, plutonium, americium, curium, berkelium, californium, einsteinium, fermium, mendelevium, nobelium, and lawrencium.

alpha. A particle emitted from the nucleus of an atom that contains two protons and two neutrons.

aquiclude. A subsurface rock, soil, or sediment unit that does not yield useful quantities of water.

background radiation. Radiation from: (1) naturally occurring radioactive materials which have not been technologically enhanced; (2) cosmic sources; (3) global fallout as it exists in the environment (such as from the testing of nuclear explosive devices); (4) radon and its progeny in concentrations or levels existing in buildings or the environment which have not been elevated as a result of current or prior activities; and (5) consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation (DOE-STD-1098-99, CN1, June 2004). Background radiation is typically less than 10 microrad per hour.

beta. A high-speed particle, identical to an electron, that is emitted from the nucleus of an atom.

cell. A shielded enclosure within a structure where hazardous processes can be remotely conducted and controlled. Cells are typically constructed of thick concrete walls to isolate radioactive materials and fission products that have high gamma radiation emissions.

Curie. A measure of radioactivity based on the observed decay rate of approximately 1 gram of radium. The Curie was named in honor of Pierre and Marie Curie, pioneers in the study of radiation. One Curie of radioactive material has 37 billion atomic transformations (disintegrations) in 1 second. It is defined as the number of nuclear transformations occurring per minute. One Curie = 2.22×10^{12} disintegrations per minute.

decommissioning. The process of closing and securing a nuclear facility or nuclear materials storage facility so as to provide adequate protection from radiation exposure and isolate radioactive contamination from the human environment.

decontamination. The process of removing chemical, biological, or radiological contaminants from, or neutralizing the potential effect on persons, objects, or the environment by washing, chemical action, mechanical cleaning, or other techniques. Deactivation processes also may be used as part of the treatment and disposal of wastes generated during decontamination efforts.

effluent. Treated or untreated liquid emitted from a manufacturing facility wastewater treatment plant, including storm drainage water and groundwater.

exponential notation. The following exponential notations are examples of those used in this document:

$$1 \times 10^{4} = 10{,}000$$
$$1 \times 10^{2} = 100$$
$$1 \times 10^{0} = 1$$
$$1 \times 10^{-2} = 0.01$$
$$1 \times 10^{-4} = 0.0001$$

fission product. A usually radioactive isotope produced as a result of the fission of a massive atom such as U-235. The REDOX and PUREX runs for the separation of plutonium and uranium from fission products by solvent extraction were tested in the SPRU Building G2.

fixed contamination. Radioactivity remaining on a surface after repeated decontamination attempts fail to significantly reduce the contamination level.

gamma. Electromagnetic waves or photons (rays) emitted from the nucleus (center) of an atom.

impacted. MARSSIM defines impacted areas as those with a reasonable possibility of containing residual radioactivity in excess of natural background or fallout level (MARSSIM Glossary, G1-10).

interceptor. A plumbing trap that collects particulates and solids in a piping system.

low-level radioactive waste (LLW). See *radioactive waste*.

non-impacted. MARSSIM defines non-impacted areas as those without a reasonable possibility of containing residual radioactivity in excess of natural background or fallout level (MARSSIM Glossary, G1-10).

non-process areas (versus process areas). Areas in G2 that were not used to chemically separate plutonium from uranium. The non-process areas are currently accessible.

polynuclear aromatic hydrocarbons (PAHs). Hydrocarbon compounds with multiple benzene rings. PAHs are typical components of asphalts, fuels, oils, and greases. They are also called polycyclic aromatic hydrocarbons.

picoCurie. One one-trillionth (1/1,000,000,000,000) of a Curie.

plenum. An air-filled space in a structure through which air is distributed from a blower (as in a ventilation system).

process areas (versus non-process areas). SPRU areas that were used to chemically separate plutonium from uranium. SPRU process areas (about 7,500 square feet [R-001949]) are inaccessible and include Cells Nos. 1, 2, 3, 4, and 5; the cell access corridor, Process and Hot Tunnels, Upper and Lower Sampling Aisles, and the Pipe and Motor Generator Room.

protective storage mode. A non-operating status with continuing surveillance and monitoring.

PUREX. A plutonium and uranium extraction process using the solvent tributyl phosphate. SPRU was a PUREX pilot plant.

pyrophoric. A substance that ignites spontaneously in air.

rad, radiation absorbed dose. A unit for measuring energy absorbed in any material. Absorbed dose results from energy deposited by radiation. It is defined for any material and applies to all types of radiation. Rad is a measurement of absorbed dose but does not consider the potential biological effects that different types of radiation have on the human body. Greater than 100 rad must be imparted in a short period over a substantial portion of the body before most individuals will show significant clinical symptoms.

radiological work permit (RWP). Permit that identifies radiological conditions, establishes worker protection and monitoring requirements, and contains specific approvals for radiological work activities. The radiological work permit serves as an administrative process for planning and controlling radiological work and informing workers of radiological conditions (DOE-STD-1098-99, CN1, June 2004).

radiation. Energy in the form of high-speed particles and electromagnetic waves. The large spectrum of radiation energy includes visible light, radio and television waves, ultraviolet, and microwaves. Electromagnetic waves do not cause ionization of atoms because they do not carry enough energy to separate molecules or remove electrons from atoms.

radioactive waste. Per DOE M 435.1-1, high-level waste is the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation. Low-level radioactive waste is radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material, or naturally occurring radioactive material.

During SPRU operations, high-level radioactive liquid waste was defined as 0.05 microCuries or more per liter and low-level radioactive waste was defined as less than 0.05 microCuries per liter. Note: These are not current DOE definitions of high- and low-level radioactivity.

REDOX (reduction-oxidation). A chemical extraction process for separating uranium and plutonium. SPRU was a REDOX research and development plant.

Rem, Roentgen equivalent man. A unit for measuring the biological effects of radiation on the human body. Rem is the most commonly used unit for dose reporting. The Rem takes into account the absorbed dose and biological effects of different types of radiation. It is a measurement of biological dose equivalence. The unit applies to both internal and external doses.

removable contamination. Radioactivity that can be transferred from a surface to an absorbent material, such as filter paper or cotton swabs, by rubbing with moderate pressure and swabbing an area of at least 100 square centimeters.

Roentgen. A unit for measuring ionization caused by gamma or x-rays in air. Roentgen is a measurement of exposure. Therefore, it does not relate to the biological effects of radiation on the human body.

solvent extraction. A process to recover, purify, or separate metals during liquid extraction by transferring one or more components between two immiscible (or nearly immiscible) liquid phases. Many solvents can extract uranium, plutonium, or thorium from acid solutions.

staging. Temporary storage of waste prior to shipment offsite.

surficial. Of or pertaining to a surface, especially land surface; a surficial geologic deposit.

tributyl phosphate (TPH). A solvent used to recover, purify, or separate metals during a liquid (solvent) extraction process. TPH is always diluted in an organic matrix, or diluent, to improve the physical characteristics of the organic phase.

2. EXECUTIVE SUMMARY

The *Land Areas Historical Site Assessment for the SPRU Nuclear Facility Disposition Project* presents the history and assessment of current conditions for the SPRU Land Areas associated with the Separations Process Research Unit (SPRU) Nuclear Facility Disposition Project. The report covers available information up to and through 2001 only and also updates the *Outside Areas Historical Site Assessment, SPRU Project,* TSM-11, November 2003. It was developed in accordance with guidance provided in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) for developing historical site assessments.

The SPRU facilities were constructed and operated to research plutonium and uranium separation processes. It operated between February 1950 and October 1953, when research activities ceased following successful development of the process. The research was performed on a laboratory scale; SPRU was never a production plant. Decommissioning of SPRU facilities and land areas began in October 1953 and continued through the 1990s. SPRU facility history and current conditions are addressed separately in the *Nuclear Facility Historical Site Assessment for the Separations Process Research Unit (SPRU) Disposition Project* (April 2006).

The SPRU land areas occupy approximately 24 acres on the Knolls Atomic Power Laboratory (KAPL) property in Niskayuna, New York. KAPL is owned by the U.S. government and operated by the U.S. Department of Energy (DOE) Office of Naval Reactors and KAPL, Inc., a Lockheed Martin Company.

This report addresses the SPRU land areas as three separate sections. The Upper Level area consists primarily of the land near the main SPRU Buildings G2 and H2. The Lower Level area include the Railroad Staging Area and associated land and structures where waste was managed prior to shipment by rail for off-site disposal. The North Field area is associated with the Slurry Drum Storage Area where waste was stored prior to shipment by rail for off-site disposal.

This historical site assessment describes and assesses soil and groundwater conditions affected by SPRU operations. Some areas, structures, and infrastructure associated with SPRU operations were cleaned up, decommissioned, and/or demolished prior to 2001, and are therefore not part of the current SPRU Nuclear Facility Disposition Project. However, they are essential to a historically complete document and are included in this assessment, but identified according to their current (2001) status.

Following MARSSIM guidance, this historical site assessment addresses whether areas are impacted or not impacted by radioactive contamination, contamination sources, the potential for contamination migration, threat to human health, and further characterization needs.

Impacted versus Non-impacted

Upper Level soil and groundwater adjacent to Building G2, Building H2, the H2 Tank Farm, the Pipe Tunnels, the H2-K4 Laundry Lines, and the F5 Slurry Drum Storage Area are classified as impacted. The soil and groundwater near the H1 Cooling Tower and Pump House, Hot Incinerator, and are not contaminated with residual radioactivity in excess of natural background or fallout levels and are classified as non-impacted. In the Lower Level, the Lower Level Parking Lot Area, Railroad Staging Area, K5 Retention Basin Area, and K6 Storage Pad Area are classified as impacted. Non-impacted areas are the K4 and Laundry Lines, K7 Storage Pad, and the Cold Incinerator. The Slurry Drum Staging Area in the North Field is also classified as impacted.

Although some SPRU groundwater monitoring wells exceeded background levels for radioactivity, no levels exceeded 0.1 percent of the DOE derived concentration guide. The estimated dose to the population within 50 miles of KAPL was less than 0.001 percent of the natural background radiation dose.

Sources of Contamination

SPRU land areas soil and groundwater contamination sources are related to activities that supported SPRU operations and post-SPRU operation cleanup activities. Upper Level contamination sources are primarily G2, H2, H2 Tank Farm, and incidents associated with waste and/or material handling. Lower Level contamination sources are related to managing and staging waste prior to shipping off site and incidents involving contaminated soil movement. The North Field contamination source is the Slurry Drum Storage Area.

Likelihood of Contamination Migration

Based on groundwater monitoring data collected as part of the KAPL environmental monitoring program and presented in the 1987 through 2001 KAPL environmental monitoring reports, radiological contamination is not present in groundwater at levels presenting a potential for impact. In addition, groundwater at the KAPL site is contained in a perched aquifer of limited extent and quantity composed of impermeable glacial tills. There is no historical evidence of contamination migration off the KAPL site.

Threat to Human Health

The Upper Level has radiological soil and groundwater impacts. However, these areas are not accessible to the public. Some areas are vegetated, which decreases potential wind and water erosion. KAPL cooperates with regulators, including the NYSDEC and the EPA Region II, to monitor potential public health concerns.

The EPA Region II KAPL fact sheet states “no imminent danger to human health or the environment has been identified. The on-going routine monitoring programs undertaken by KAPL, in addition to the corrective action programs, are designed to alert KAPL and the NYSDEC of any health or environmental risks” (R-000430). On-site workers are protected through health and safety training and monitoring.

Further Characterization Needs

As of 2001, radiological impacts to the Upper Level, Lower Level, and North Field had not been fully characterized. More comprehensive surveys may be necessary (R-002171).

Conditions after 2001 are addressed in the *Task IV RCRA Facility Investigation Report for Groundwater Upper and Lower Levels SPRU Project, Revision 2* (R-002220) and the *Radiological Characterization Report for SPRU Outside Areas Separations Process Research Unit Project, Revision 2* (R-002222).

3. HISTORICAL SITE ASSESSMENT PURPOSE AND SCOPE

3.1 Purpose

The purpose of a historical site assessment is to determine and document the status of a site or facilities. This historical site assessment summarizes the Separations Process Research Unit (SPRU) Land Areas history from the start of SPRU activities in 1947 through the year 2001, and is an update to the November 2003 *Outside Areas Historical Site Assessment*, SPRU Project, TSM-11 (R-000432).[1] Conditions after the year 2001 are addressed in characterization reports prepared from 2001 to 2006. The *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) guidance that resulted from the U.S. Department of Energy (DOE), Environmental Protection Agency (EPA), and Nuclear Regulatory Commission (NRC) concurrence on an approach to conducting radiation surveys and investigations at potentially contaminated sites was followed in developing this document.

3.2 Scope

The SPRU Land Areas historical site assessment scope includes radioactive and chemical soil and groundwater contamination within Knolls Atomic Power Laboratory (KAPL) boundaries that likely resulted from SPRU operations or decontamination and cleanup activities. This report organizes the Land Areas into three sections: the Upper Level, Lower Level, and North Field (shown in Figure 3-1). Information applicable to more than one area is repeated where appropriate.

Sub-areas of the three Land Areas are:

- Upper Level
  - Soil and groundwater near:
    - Building G2
    - Building H2
    - H2 Tank Farm (east of Building H2)
    - Pipe Tunnels
    - Hillside Drain System (west of Building H2)
    - H1 Cooling Tower and Pump House
    - Hot Incinerator
    - H2-K4 Laundry Line
    - F5 Slurry Drum Storage Area

- Lower Level
  - Soil and groundwater near:
    - Lower Level Parking Lot
    - Railroad Staging Area
    - K4 Laundry and Lower Level Laundry Lines
    - LT1, LT2, and LT3 Storage Sheds
    - K5 Retention Basin
    - K6 Storage Pad
    - K7 Storage Pad

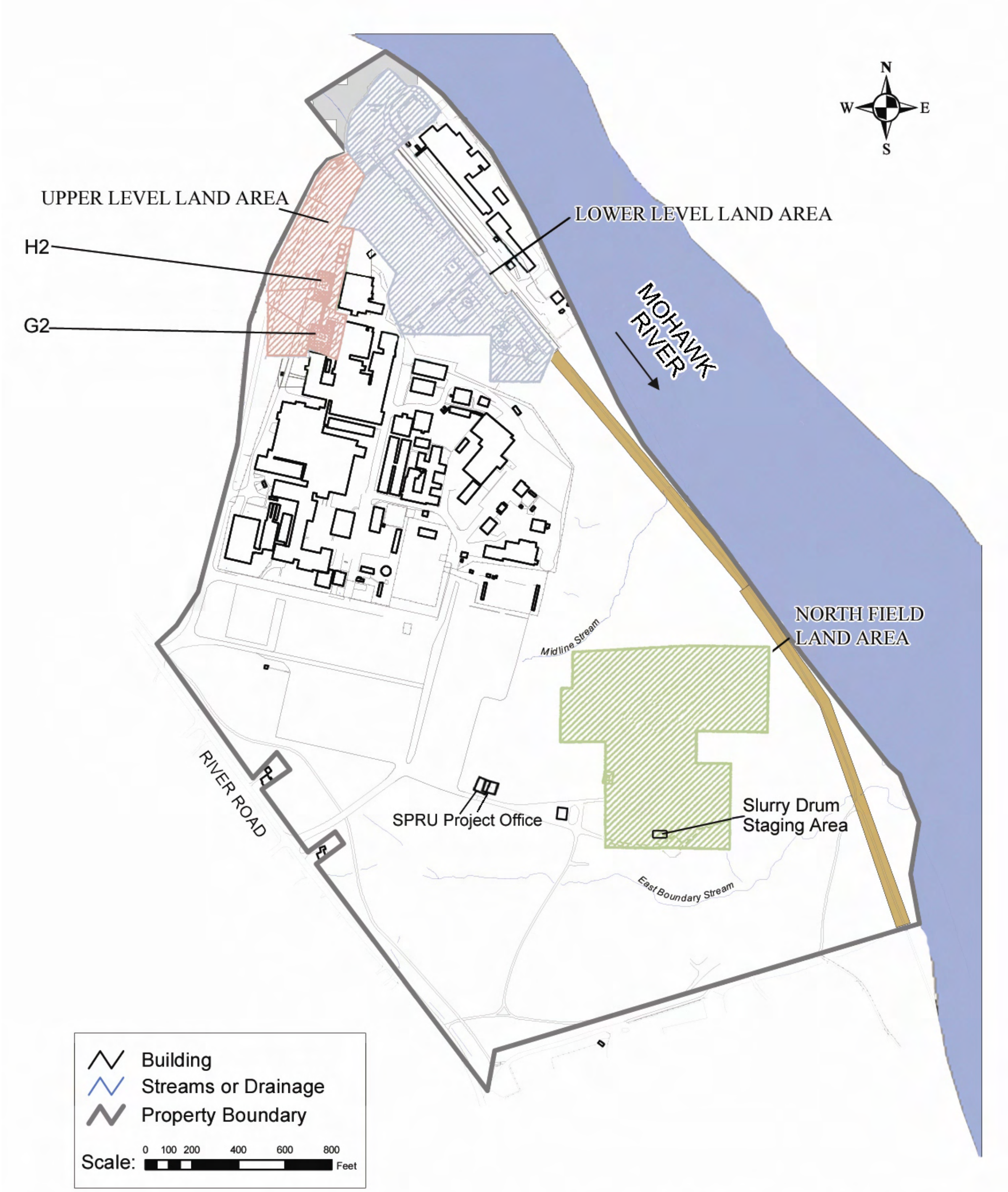
[1] References in this historical site assessment are noted with parenthetical numbers that are listed in the Appendix - List of References.

        - J3 Cold Incinerator
        - J4 and J5 Sand Filter Beds

    - Mohawk River (adjacent to the KAPL property boundary)

- North Field
    - Soil and groundwater in and around:
        - Slurry Drum Storage Area (also known as the Slurry Drum Area and the Former Slurry Drum Station)

The Mohawk River also is included in this document, but is not part of the current cleanup initiative for the SPRU Disposition Project. The river is monitored by KAPL.



Notes: 1) Basemap Reference Drawing: O'Brien & Gere Engineers, Inc., File No.: 10350.23931-001, Sept. 1999 as modified using Figure A-1 from the CH2M Hill, *Outside Characterization Plan*, TSM-08, Rev. 2, Separations Process Research Unit Project, March 2004 (R-000431).

2) Total SPRU Areas approximately 24 acres.

Figure 3-1. Land Areas in the Historical Site Assessment

4. PROPERTY IDENTIFICATION AND DESCRIPTION

SPRU is located on the KAPL site in eastern New York State, approximately 2 miles east of the City of Schenectady. KAPL is located along River Road, on the south bank of the Mohawk River. Figure 4-1 illustrates the SPRU regional setting.

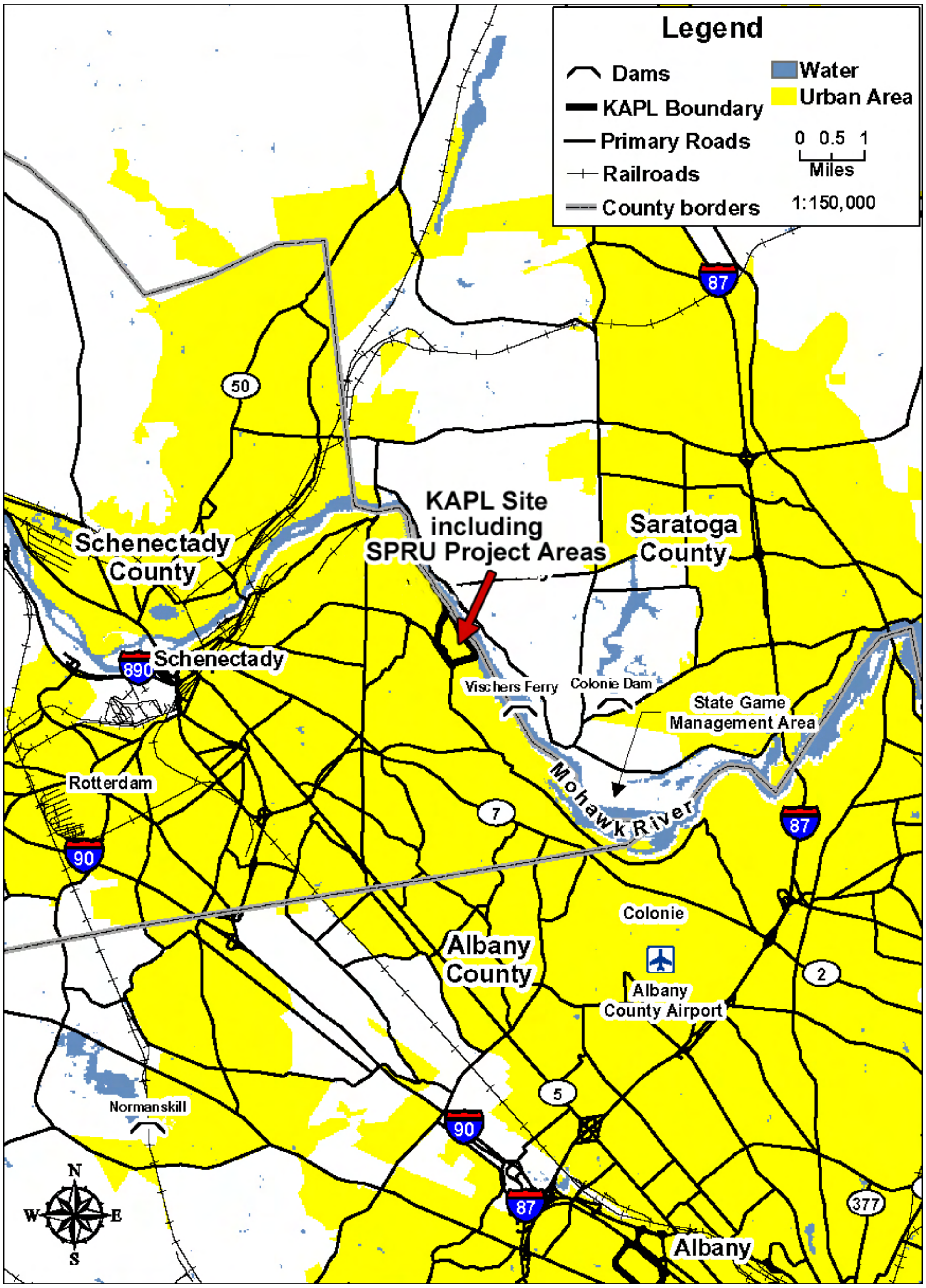


Figure 4-1. SPRU Regional Area Map

4.1 Physical Characteristics

The KAPL site and SPRU areas are located on a bluff overlooking the south bank of the Mohawk River. Surface elevations at the site range between approximately 330 feet above mean sea level at the top of the bluff to 230 feet on the lower portions of the site along the river. SPRU-related areas (Land Areas and facilities) occupy approximately 24 acres of the 170-acre KAPL site and consist of the Upper Level, Lower Level, and the North Field. The facilities described in the *Nuclear Facility Historical Site Assessment for the Separations Process Research Unit (SPRU) Disposition Project* (April 2006) occupy approximately 5 acres. The SPRU Project Office is located at 2425 River Road, Niskayuna, New York, 12309.

The KAPL site has been used since 1950. KAPL is owned by the U.S. government and operated by the U.S. Department of Energy (DOE) Office of Naval Reactors and KAPL, Inc., a Lockheed Martin Company. The site houses administrative offices; chemistry, physics, and radioactive materials laboratories; engineering offices; computer facilities; machine shops; a sewage pumping station; a boiler house; oil storage facilities; cooling tower; and Resource Conservation and Recovery Act (RCRA)-permitted hazardous and mixed waste storage and treatment facilities.

4.2 Adjacent Land Use

Southwest of the KAPL boundaries, land use consists of medium- to high-density residential housing in Niskayuna, New York. A closed municipal landfill and Niskayuna recreational land consisting of hiking trails and a bike path are located to the southeast. To the northeast, the Mohawk River is under the jurisdiction of the Canal Corporation. Across the Mohawk River is low-density residential housing in the Town of Clifton Park. Figure 4-2 depicts land use adjacent to SPRU.

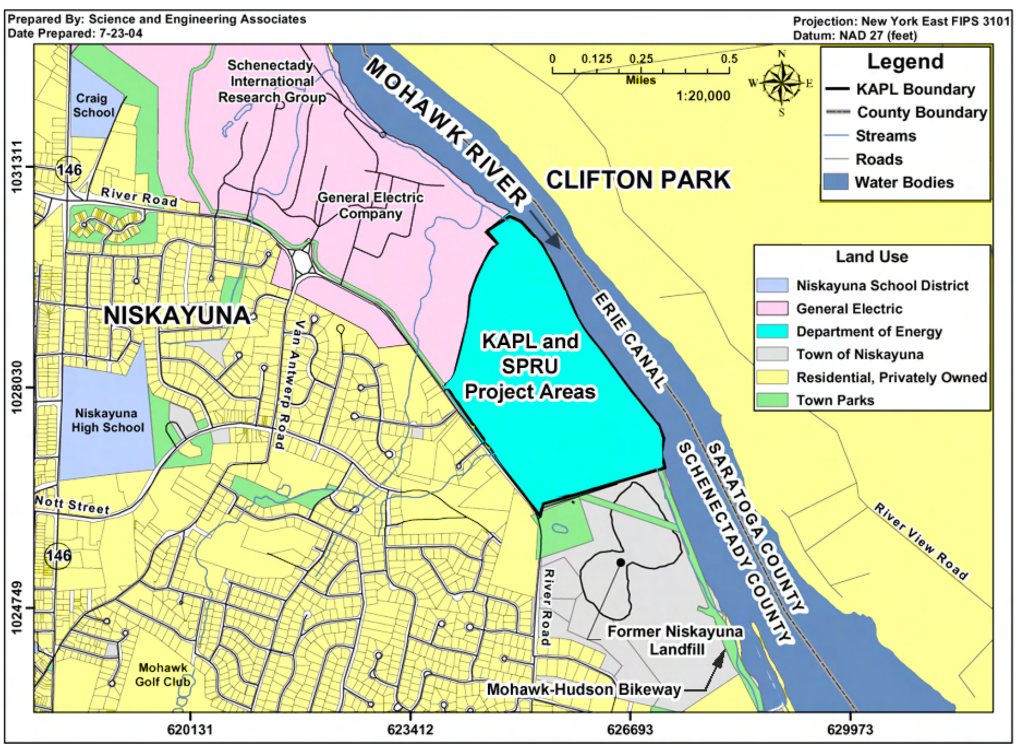


Figure 4-2. KAPL and SPRU Site Surrounding Area Land Use

General Electric continues to operate a research and development facility adjacent to and northwest of KAPL. The Schenectady International Research Group, which specializes in the production of a wide range of products including resins, electronic and specialty chemicals, and imaging products, is located farther to the northwest, along the river.

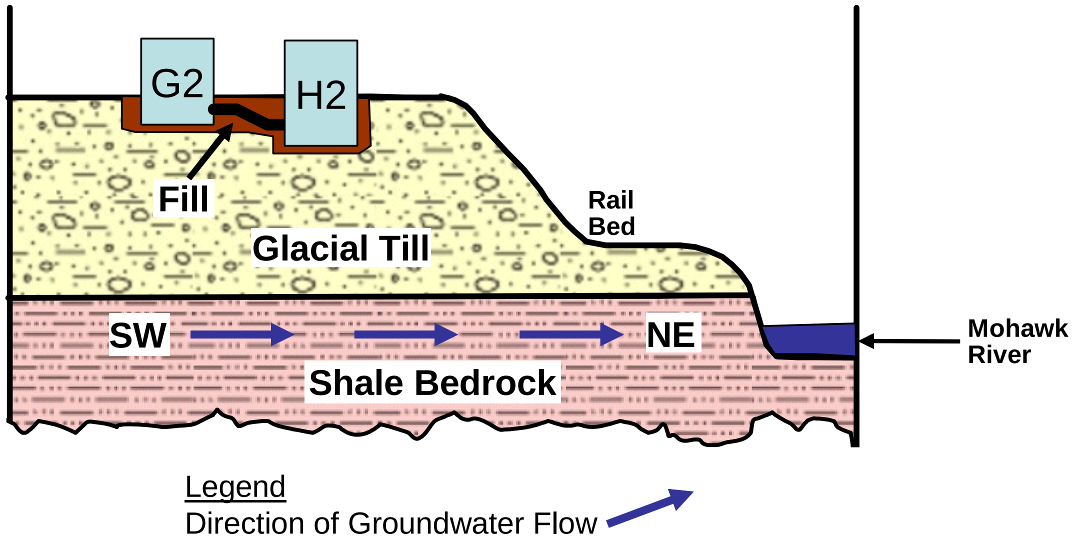
4.3 Environmental Setting

In the eastern portion of New York State near SPRU, the Mohawk River flows from west to east toward its confluence with the Hudson River approximately 15 miles downstream. The Mohawk River drains the southern portion of the Adirondack Mountains to the northwest and portions of the Catskill Mountains to the south. Median monthly discharge from the river ranges between 2,000 and 10,000 cubic feet per second (United States Geological Survey [USGS], 1996). Average annual precipitation near the site is 38 inches per year and average runoff is 18 inches per year. Surface water from the KAPL property drains to the northeast into the Mohawk River by way of three ephemeral streams; the East Boundary Stream, West Boundary Stream, and the Midline Stream.

Surficial deposits at KAPL consist of tightly compacted glacial till up to 70 feet thick that act as an aquiclude, minimizing the downward infiltration of water. The till thins toward the Mohawk River, where it is absent or up to a maximum of 10 feet thick. Glacial lake deposits of silt and fine sand are present at the surface in isolated areas on the KAPL site (R-000159). The surficial glacial deposits are underlain by bedrock consisting predominantly of Ordovician Schenectady Formation shale with some interbedded siltstone that is up to 600 feet thick. The bedrock typically has low porosity and permeability (R-000159).

Figure 4-3 illustrates the typical site hydrogeology. At the KAPL site, shallow north and northeasterly perched groundwater flow patterns are perturbed by streams, topography, and artificial fill for building and piping around G2, H2, and the tunnels (R-000431). The perched groundwater is generally between 5 and 10 feet below grade and occurs intermittently (R-002032, R-000159).

Shallow groundwater flows preferentially through the more permeable backfill around the tunnels, piping corridors, and buildings than the undisturbed glacial till. It is locally affected by footer drains which are part of the Hillside Drain System along the exterior of the H2 foundation. As an indicator of the volume of water collected in the Hillside Drain System, a 1983 investigation reported that 80,700 gallons of water was pumped from the hillside sump west of H2; it was monitored and treated before being released to the storm water system (C-000154).



Schematic Stratigraphic Cross Section
(Not to Scale)

Modified from ERM-Northeast, 1992, *Final Report – Hydrogeologic Evaluation of the Knolls Atomic Power Laboratory – Knolls Site*, July 8, 1992.

Figure 4-3. SPRU Groundwater Schematic

4.4 Sole Source Aquifer

The Safe Drinking Water Act states that if an aquifer is the sole drinking water source for an area, the aquifer can be designated a "sole source" aquifer. In 1982, the mayor of Schenectady petitioned for this status for the Schenectady Aquifer. In 1983, the Town of Niskayuna requested that their wellfield be included in the petition, since the wellfields both draw from the sand and gravel aquifer that is recharged from precipitation and infiltration from the Mohawk River. EPA approved the petition.

SPRU facilities do overlie the Niskayuna aquifer, but because of the dense glacial fill and low-porosity bedrock beneath the site, which act as an aquiclude, there is no hydrological connection of the shallow groundwater under the site to the aquifer. Water is provided to the site from the Town of Niskayuna water system. Thus the site cannot contaminate the Schenectady-Niskayuna sole source aquifer due to its geological setting (R-000159, R-002246).

4.5 Solid Waste Management Units (SWMUs)

Neither the KAPL site, nor the SPRU facilities or Land Areas are on the EPA National Priorities List (C-000536, C-000537). In 1998, the New York State Department of Environmental Conservation (NYSDEC) completed a *RCRA Facility Assessment, Preliminary Review – Visual Site Inspection Report of KAPL* that included SPRU Land Areas and facilities (R-001546).

SPRU solid waste management units (SWMUs) and the area of concern listed in Table 4-1 are under the KAPL Part 373 NYSDEC Permit #4-4224-00024/00001. The site EPA identification number used for tracking hazardous waste is NY6890008992 (R-002213).

Table 4-1. SPRU SWMUs and Area of Concern

Name	SWMU Number	Description
UPPER LEVEL		
H2 Processing Facility	SWMU-030	Waste treatment facility
H2 Tank Farm	SWMU-031	One 5,000-gallon and six 10,000-gallon stainless steel storage tanks in seven underground concrete vaults on the east side of H2
Pipe Tunnels	SWMU-057	Tunnels located in and connecting the basements of Building G2 and H2
LOWER LEVEL		
K-6 Storage Pad	SWMU-036	23- by 48-foot concrete shielded storage pad
K-7 Storage Pad	SWMU-037	Fenced concrete pad
Railroad Staging Area	SWMU-038	Land adjacent to and south of the former SPRU railroad bed
K-5 Retention Basin	SWMU-040	In-ground, open top concrete basin containing 2 30,000-gallon holding basins
Lower Level Parking Lot	Area of Concern -003	Approximately 0.5 acre
NORTH FIELD		
Former Slurry Drum Storage Area	SWMU-035	Approximately 900 square feet inside an earthen bermed area

5. HISTORICAL SITE ASSESSMENT METHODOLOGY

Information contained in the *Land Areas Historical Site Assessment for the SPRU Nuclear Facility Disposition Project* was compiled and reviewed following MARSSIM guidance. A project team with expertise in waste management, environmental remediation, and historical site assessment development conducted the research and prepared the report. Site visits were made to observe existing conditions in accessible SPRU Land Areas and interview knowledgeable people. This historical site assessment updates the November 2003 *Outside Areas Historical Site Assessment, SPRU Project, TSM-11* (R-000432).

5.1 Documents Reviewed

This assessment documents SPRU activities through 2001. Some documents referenced were prepared after 2001; only information representative of the period prior to 2002 is incorporated and cited.

The project team screened approximately 2,200 documents for potential relevance to the *Land Areas Historical Site Assessment for the SPRU Nuclear Facility Disposition Project*. Of these, approximately 650 documents were reviewed for information pertinent to the assessment; more than 150 documents and 400 drawings, maps, and historical photographs were researched. In addition, interviews were conducted with past and present employees possessing historical knowledge. Documents reviewed included correspondence, reports, radiological surveys, environmental sampling and monitoring data, permits, authorizations, and KAPL records. Information concerning the chronology of activities was derived from technical drawings, maps, photographs, and survey reports.

Historical records sometimes described planned activities, the outcomes of which are unknown. In these cases, if the information was deemed relevant to this historical site assessment, it was included.

5.2 Land Areas Nomenclature

SPRU Land Areas are variously designated throughout the historical records. Therefore, the following nomenclature was assigned to SPRU Land Areas described in this document to ensure consistency and clarity.

Upper Level

- Building G2
- Building H2
- H2 Tank Farm
- Pipe Tunnels
- Hillside Drain System
- H1 Cooling Tower and Pump House
- Hot Incinerator
- H2-K4 Laundry Line
- F5 Slurry Drum Storage Area

Lower Level

- Lower Level Parking Lot
- Railroad Staging Area
- K4 Laundry and Lower Level Laundry Lines
- LT1, LT2, and LT3 Storage Sheds
- K5 Retention Basin
- K6 Storage Pad
- K7 Storage Pad
- J3 Cold Incinerator
- J4 and J5 Sand Filter Beds
- Mohawk River

North Field

- Slurry Drum Storage Area

5.3 Radiological Data

MARSSIM defines impacted areas as those with a reasonable possibility of containing residual radioactivity in excess of natural background or fallout level (MARSSIM Glossary, G1-10). Available historical information and data were compiled and analyzed to determine data gaps, whether SPRU land areas are radiologically impacted or non-impacted, sources of contamination, the potential for contaminant releases to the off-site environment, and additional characterization needs.

In addition to MARSSIM, DOE sites use the DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, to determine if members of the public and the environment are subject to risk from radiation. This order uses the DOE derived concentration guide. The DOE radiation protection standard for individuals in off-site areas is 100 milliRem (mRem) per year effective dose equivalent. Results of modeling based on DOE Order 5400.5, *Radiation Protection of the Public and the Environment* are documented in annual KAPL environmental monitoring reports and incorporated in this document, quantifying the risk to the public or the environment from radioactivity on the site.

This historical site assessment presents radiological data in many different units, which are taken directly from reference documents. These different units are not typically equivalent to each other and should not be directly compared. For instance, counts per minute (cpm) is a qualitative measurement of radioactivity present in the area being surveyed, while Curies (Ci) are a quantitative unit of radioactive decay measured in disintegrations per minute. Similarly, Roentgen equivalent man (Rem) is a measurement of the specific effect of radioactivity on human tissue, while radiation absorbed dose (rad) is a measurement of energy absorbed by any material.

Maps in Sections 7, 8, and 9 indicate areas of (1) surface radiological contamination; (2) subsurface radiological surveys using the Surface Penetrating Underground Detector (SPUD) (described in Section 5.3.1); and (3) groundwater monitoring wells in the three land areas. These maps reflect only data known through 2001. Surface radiological data comes from soil surveys referenced in Sections 7, 8, and 9.

The map used for locating the SPRU monitoring wells and background wells is KAPL drawing Y-Y-12328, Knolls Site Radiological Facilities and Areas, April 2, 2002.

5.3.1 SURFACE AND SUBSURFACE SOIL RADIOLOGICAL DATA

Surface soil radiological data were collected during various sampling events and summarized in Sections 7, 8, and 9. Subsurface radiological data was collected using conventional soil sampling techniques and a KAPL-developed technique called SPUD. SPUD utilized a portable detector calibrated for cesium-137 and housed in a stainless steel tube. The tube was inserted into previously punched pilot holes and the surrounding soil counted for cesium-137 at the surface and various depths. SPUD was used from 1981 to approximately 1991, when KAPL discontinued routine soil sampling (C-000215). SPUD and other data are the basis for the historical site assessment tables and figures in Sections 7, 8, and 9.

5.3.2 GROUNDWATER RADIOLOGICAL DATA

Groundwater radiological data were mostly derived from KAPL Environmental Monitoring Reports (1987 through 2001), which were available beginning in 1987 when KAPL was required to submit formal monitoring reports to NYSDEC. This historical site assessment includes data from designated SPRU wells. Monitoring wells included in this document as "SPRU wells" were selected based on proximity to the SPRU structures or operating areas. Wells are listed in Table 5-1and their locations mapped in Figures 7-11, 8-16, and 9-5. Detailed well data is included in Appendix B. Groundwater radiological data pre-dating the formal KAPL monitoring program (1987) were available only for the Upper Level (Section 7).

Table 5-1. SPRU Monitoring Wells and Background Wells

SPRU Wells	Background Wells
Upper Level	W-1 KH-IS KH-2 KH-3S SHUGG
B-5 B-6 B-7 B-8 B-9 B-11 B-14 B-15 B-16 B-26 KH-15 KH-16 KH-17	
Lower Level	
KH-18 KH-19 KH-20 KH-21 KH-22 KH-23	
North Field	
W-2 W-3 W-4 W-8 NTH-1 NTH-1A NTH-4	

5.4 Chemical Data

The *KAPL Hazardous Waste Management Permit*, EPA ID No. NY6890008992, NYSDEC Permit number 4-4224-00024/00001, July 21, 1998, (R-002213), the *RCRA Facility Assessment, Preliminary Review - Visual Site Inspection Report Final Version*, July 20, 1998 (R-001546), and annual KAPL Environmental Monitoring Reports (1987 through 2001) were used as the sources of information on chemical contamination of the SPRU Land Areas (R-002187 through R-002201). MARSSIM does not specify requirements for chemical contamination. However, this historical site assessment briefly addresses chemical contamination in the Upper and Lower Level Areas. Although this historical site assessment is limited to site conditions through 2001, further investigations were conducted between 2001 and 2006, and this information is documented in the *Task IV RCRA Facility Investigation Report for Groundwater Upper and Lower Levels SPRU Project, Revision 2* (April 2006).

6. SPRU LAND AREA HISTORY

SPRU Land Area history is closely connected to the SPRU facilities, operations, and decommissioning. Therefore, SPRU facility history is briefly included for better understanding of the land areas history. A detailed history of SPRU facilities is provided in the *Nuclear Facility Historical Site Assessment for the Separations Process Research Unit (SPRU) Disposition Project* (DOE, April 2006).

SPRU facility construction began in 1947 through a contract between the General Electric Company and the Atomic Energy Commission. Originally, KAPL had a dual purpose; to design and develop nuclear reactors for naval nuclear power systems, and to conduct pilot tests on chemical processes to separate plutonium and uranium. The SPRU facilities were constructed to address the latter mission on a laboratory scale; SPRU was never a production plant (R-001546).

The SPRU Buildings G2 and H2, connecting tunnels, Tank Farm, and Cooling Tower were constructed in the KAPL Upper Level between 1947 and 1949 to perform the pilot-scale tests (R-000255). Research pilot-scale tests commenced in February 1950 and continued until 1953, when research activities ceased following successful development of the separation processes. SPRU pilot plant decommissioning began in 1953 (R-001949).

From the mid-1950s to the early 1990s, portions of Building G2 in the Upper Level were modified and used by KAPL office workers and laboratory personnel (R-000255). Building H2 and the Tank Farm were partially shut down, but some areas remain in use for SPRU decommissioning activities and other KAPL waste management functions (R-000255). SPRU support facilities and infrastructure were located in three Land Areas: the Upper Level, Lower Level, and North Field. These areas are divided into sub-areas, described in Sections 7, 8, and 9 of this historical site assessment. Sections 7, 8, and 9 include history, known contamination, and 2001 conditions. Aerial photographs of the areas are provided in Figures 7-1, 8-1, and 9-1.

Land areas environmental history is documented primarily through periodic environmental sampling between 1953 and 1992 that focused on potential radioactive contamination; annual sampling for potential chemical and radioactive contamination documented in annual KAPL reports for the NYSDEC between 1987 and 2001 (R-002187 through R-002201); descriptions of activities conducted on structures and infrastructure; reports concerning waste management activities; and descriptions of cleanup activities. Data gaps, impacted and non-impacted areas, contamination sources, likelihood of contamination migration, threat to human health, and further characterization needs are addressed in Sections 7, 8, and 9.

6.1 Radiological History

Table 6-1 summarizes radioactive materials that were used or generated during SPRU operations, and as a result, could be present in soil and groundwater.

Table 6-1. Potential SPRU Radionuclide Contaminants in Land Areas

Radionuclide (half-life)		
Am-241 (430 yrs)	Pr (isotope unknown)	Th-231 (26 hours)
Ba-137m (2.6 minutes)	Pu-238 (88 yrs)	Th-234 (24 days)
Cs-134 (2.1 yrs)	Pu-239 (24,000 yrs)	U-234 (240,000 yrs)
Cs-137 (30 yrs)	Pu-240 (6,500 yrs)	U-235 (700 million yrs)
Eu-154 (8.8 yrs)	Pu-241 (14 yrs)	U-238 (4.5 billion yrs)
Eu-155 (5 yrs)	Ra-226 (1,600 yrs)	Y-90 (64 hours)
H-3 (12 yrs)	Sr-90 (30 yrs)	
Pa-234m (1.2 minutes)	Th (isotope unknown)	

6.2 Chemical History

SPRU chemical process work began at KAPL in 1950 and ceased in 1953. Chemical processing involved dissolving test quantities of fuel in acids and treating them with various chemicals (R-001949). Table 6-2 lists chemicals potentially used in SPRU processes in order to identify the chemical constituents that could be present in the Land Areas due to SPRU operations.

During the early 1950s, chemicals associated with SPRU activities were used in Buildings G2 and H2. Slurry waste was placed in containers and temporarily staged adjacent to H2 before being moved for storage to the F5 Slurry Drum Storage Area (R-000255), Slurry Drum Storage Area, the K6 Storage Pad, K7 Storage Pad, or the Railroad Staging Area (R-001949).

Table 6-2. Potential SPRU-Related Chemical Constituents and Products

Chemical/Compound/Product	Description and Reference
Acetone	Control valve cleaning following degreasing using CCl_4 and acetone (R-000009).
Acidified methyl isobutyl ketone	Unknown (R-001949).
Aluminum (Al)	Detected in 1965, Tank Farm Vault. See aluminum nitrate and aluminum oxide below (R-000026, R-000048).
Aluminum nitrate $Al(NO_3)_3$	Used in uranium (U) transfer, reduction-oxidation (REDOX) process only (R-000026).
Aluminum oxide, Alumina (Al_2O_3)	Nitric acid solution, Ultrasene, and a slurry of Al_2O_3 in water and in acid were used as decontaminating agents for small pieces of equipment such as the caps of sample bases and the interface liquid level floats from the 1C bank (located in Cell No. 5A) (R-000048).
Ammonium bifluoride (NH_4HF_2)	Tank decontamination Cell No. 1 (R-000046).
Amsco (Product)	Purchased from the American Spirits Company, possibly used as a diluting agent and as a calibrating fluid or solvent (C-000493).
Bismuth (Bi(III))	Laboratory studies. Retention of iodine in process solutions by mercuric salts was studied as a way to hold iodine in solution during various steps of the bismuth phosphate process according to a document dated 1953. It was not clear from the reference whether this activity was associated with SPRU processes in Buildings G2 or H2 (R-000025).
Cadmium (Cd)	Elevated concentration noted during 1998 Tank Farm Vault inspection. Vault #509C had the greatest concentration. Vaults No. 509D and No. 505 did not have detectable concentrations (R-000025).
Calcium (Ca)	Detected in 1965, Tank Farm Vault. See calcium hypochlorite below (R-000034).
Calcium hypochlorite $(Ca(ClO))_2$	Perchloron. Prevents algae growth in cooling tower. Also used in internal tank decontamination (R-000034).
Carbon tetrachloride (CCl_4)	Control valve degreasing (R-000009).
Cerium (Ce)	Rare earth found in 1BP (located in Cell No. 4) (R-000048).
Copper (Cu)	Detected in 1965, Tank Farm Vault. Laboratory studies involving complexing agents included copper (Cu(II)). It was not clear from the reference whether this activity was associated with SPRU processes in Buildings G2 or H2. Also, possible result of copper piping deterioration (R-000025).

Chemical/Compound/Product	Description and Reference
Floor sealant (Product)	Unknown constituents. The sealant was described generally as a combustible material.
Hexone	Used in SPRU. Open air burning proposed in 1958. Hexone was distilled (relatively free of radioactivity) then proposed to ship to Hanford (C-001957). REDOX process Cell No. 5 - Flammable solvent (R-001949).
Hydrocarbons	Back-up generators, pumps/motors, tar, grease.
Hydrofloric acid (HF)	Reacts with solvents and metals. Decontamination of tanks in Cell No. 1 (R-000046).
Iodine (I)	Cake wash, radioiodine analysis. The iodine balance in the plutonium uranium extraction (PUREX) head-end was described as a method for radioiodine analysis based on extraction and carrier precipitation and was used for dissolver and hot feed solutions (R-000026).
Iron (Fe)	Detected in 1965, Tank Farm Vault. Associated with the second Pu cycle. Iron powder was used in SPRU. Hanford report Hw-22086 reported that sponge iron is satisfactory for use in REDOX plant for making ferrous sulfamate (R-000039, C-000493).
Kerosene (Product)	Amsco (a diluent) and Ultrasene kerosene (R-000001).
Lead (Pb)	Flooring, plating, paint (lead-based). Lead shields were placed around the flange connections at the top of the simmer tank and the centrifuge agitator shaft to reduce the radiation level. Also, final degradation of radioactive materials. Laboratory studies (R-000046).
Magnesium (Mg)	Detected in 1965, Tank Farm Vault. See magnesium oxide (R-000001).
Magnesium oxide (MgO)	Cake. Magnesium oxide (MnO_2)) during centrifuging (R-000001).
Manganese (Mn)	Elevated concentration noted during 1998 Tank Farm Vault Inspection and detected in 1965. Vault No. 509D had the greatest concentration. See manganese dioxide, manganese nitrate, sodium permanganate and potassium permanganate (R-000026).
Manganese dioxide (MnO_2)	Cake in the centrifuge (R-000026).
Manganese nitrate ($Mn(NO_3)_2$)	Added with permanganate as a part of the head-end treatment in Runs 1-7, July 1952, KAPL 785. Discussed as general use in process (R-000026).
Manganese (II) (Mn(II))	Formed by the radiation-induced decomposition of the MnO_2 cake in the centrifuge (R-000041).
Mercury (Hg, Hg (II))	Elevated concentration noted during 1998 Tank Farm Vault Inspection. Vaults No. 509B and No. 509C had the greatest concentrations. Air sparging/iodine laboratory studies. It was not clear from the air sparging reference whether or not this activity was associated with SPRU processes in Buildings G2 or H2. Equipment that may also contain mercury as follows: meters, fluorescent lamps, batteries, switches and relays, vacuum gauges/tubes, thermostats, mercoid switches, thermowells, thermocouples, thermometers (R-000025, C-000031).
Niobium (Nb)	Detected in 1965, Tank Farm Vault. Nb-Zr decontamination. Used in centrifugation (Cell No. 1). Following the completion of the PUREX runs, the pilot plant was reportedly used from at least December 1953 through March 1954 to prepare source material for another project, which was concerned with the isolation of radioactive Nb-Zr (R-000014, R-000001).
Nitric Acid (HNO_3)	Used for Cell No. 1 decontamination (R-002087).
Nitrogen gas	Nitrogen was blown through service lines to displace water the in the vessel hosting jackets before the entry of steam in order to prevent steam hammering. Nitrogen is not likely to remain in G2 (C-000503, R-001949).
Oil (Product)	Spindle oil, pump oil, motor oil, oil to suppress dust. May contain PCBs or other constituents (R-001949, R-002087).
Oxalic acid $(COOH)_2$	Tank decontamination Cell No. 1 (R-000046).
Permanganate (MnO_4)	Water treatment, head-end step. Added with manganese nitrate as a part of the head-end treatment in Runs 1-7, July 1952, KAPL 785. Sodium permanganate was substituted for potassium permanganate to take advantage of greater solubility and ease of solution (R-000049).
Peroxide	Peroxide preparation. Second Pu cycle to concentrate Pu solution. The elute is precipitated with peroxide. Sulfamic acid introduced as a part of a flush process. Additional steps described included mention of a sulfate wash of the resin and elution with nitric acid plus sulfamic acid produced an elute, which was precipitated with peroxide prior to shipment to Los Alamos (June 1952) in the second Pu cycle, resulting in a concentration of the plutonium solution (R-000038).
Potassium permanganate ($KMnO_4$)	Sodium permanganate was substituted for potassium permanganate to take advantage of greater solubility and ease of solution (R-000049).

Chemical/Compound/Product	Description and Reference
Ruthenium (Ru)	Scrubber contaminant. Approximately 3 percent of the Ru was found in the scrubber. What was described as a "major portion of ruthenium" evolved in the simmer tank and plated out on the walls of the tank (R-000026, R-000046).
Shop Coolant D-3 (Product)	Unidentified coolant. Possibly ethylene glycol or similar.
Silica	Entrained silica particles heavily laden with Zr and Nb accounted for most excess activity in runs 18 and 19 resulting in low gamma decontamination factor of the uranium streams. Postulated that the silica particles resulted from dissolution of Al jacket loading material (R-000049).
Silver (Ag, Ag (II))	Elevated concentration noted during 1998 Tank Farm Vault Inspection. Vaults No. 509B and No. 509C had the greatest concentration. It was not clear from the reference whether this activity was associated with SPRU processes in Buildings G2 or H2. Complexing agents tried included Ag (I) (R-000025).
Sodium (Na)	Detected in 1965, Tank Farm Vault. See discussion of sodium carbonate, sodium hydroxide, and other sodium compounds below (R-000026).
Sodium carbonate (Na_2CO_3)	Washing agent (decontamination solvent) (R-000026).
Sodium chloride	Unknown (R-001949).
Sodium citrate ($C_6H_5Na_3O_7$)	Decontamination of Cell No. 1 Cake Dissolving. Originally, the procedure described sending solid material directly to storage in mild steel tanks without further concentration and with little or no neutralization. Sodium citrate and nitric acid (solvents) were considered and several tests were made (R-000046).
Sodium dichromate	Corrosion prevention in cooling towers south of G2 and adjacent to H2. Sodium dichromate was added to the basin to reduce the amount of corrosion in pipes (R-000034).
Sodium hydroxide (NaOH)	Used to adjust the pH. Washing agent (decontamination solvent). Reacts with solvents and acids. NaOH spray is a part of the G2 cleaning process. Decontamination of Cell No. 1 (R-001949).
Sodium nitrate ($NaNO_2$)	Sodium nitrate ($NaNO_2$) was used in the second U run (November 1952-January 1953) to treat the feed mixture. Sodium nitrate was also added to manganese dioxide (MnO_2) particles as they pass through the centrifuge to the feed during the plutonium valence adjustment, resulting in a deterioration of the Nb-Zr decontamination. By product of nitric acid + solvent + metal. Part of flush in second Pu cycle run with Na_2SO_4 and Fe (NO_3) (R-000047).
Sodium permanganate ($NaMnO_4$)	Sodium permanganate was substituted for potassium permanganate to take advantage of greater solubility and ease of solution (R-000049, R-000001).
Sodium sulfate (Na_2SO_4)	Cold 2AF mixture with Fe (NO_3) and $NaNO_2$ second Pu cycle.
Sulfamic acid (NH_2SO_3H)	Part of flush process. Ion exchange for second Pu sequence additive (R-000001).
Tributyl phosphate (TPH)	At least some needed to be butanol free, of the purest grade to avoid possible formation of nitration products (C-000493).
Trisodium phosphate (Na_3PO_4)	Decontamination of cells (R-000046).
Ultrasene	Type of kerosene that replaced Amsco (a diluent) because of flash point. Closed-cup flash point of Ultrasene is 160 degrees F, approximately 15 degrees higher than Amsco (R-000049).
Versene	Ethylene diamine tetracetic acid. Chelating agent used to control metal ions over a broad pH range in aqueous systems.
Zinc (Zn (II))	Elevated concentration noted during 1998 Tank Farm Vault Inspection. Vault #509C had the greatest concentration. Laboratory studies involving retention of iodine in process solutions by mercuric salts. It was not clear from the reference whether this activity was associated with SPRU processes in Buildings G2 or H2. Complexing agents tried included zinc Zn (II) (R-000025).
Zirconium (Zr)	Detected in 1965, Tank Farm Vault. Head-end step during SPRU (R-000001).

7. UPPER LEVEL

This section describes the SPRU Upper Level history and conditions through 2001. Information regarding contamination is derived from documented incidents, radiological and chemical surveys, and correspondence (DOE 2006).

The Upper Level assessment includes soil and groundwater near the following areas:

- Building G2
- Building H2
- H2 Tank Farm (east of Building H2)
- Pipe Tunnels
- Hillside Drain System (west of Building H2)
- H1 Cooling Tower and Pump House
- Hot Incinerator (dismantled and removed)
- H2-K4 Laundry Line (removed)
- F5 Slurry Drum Storage Area (demolished and removed)

Figure 7-1 is a labeled aerial photograph of the Upper Level.

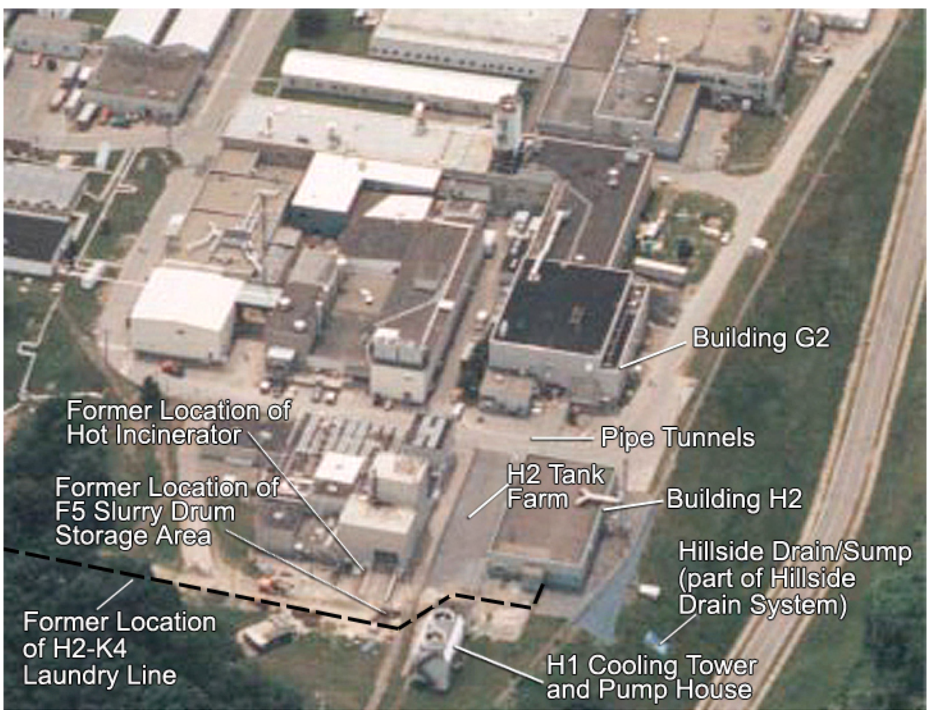


Figure 7-1. Aerial Photograph of Upper Level Looking South (Photo #A-1, 1987)

7.1 Upper Level Areas

This section provides physical and functional descriptions of the Upper Level areas. Section 7.2 describes current (2001) environmental conditions.

Building G2 Area

Building G2 was used between 1950 and 1953 for research and development of processes for separating plutonium and uranium (R-000255, DOE, 2006). Figure 7-2 is a photograph of the north side of G2.

Figure 7-2. G2 Looking North

Building H2 Area

The H2 waste processing building, H1 Cooling Tower and Pump House, and Pipe Tunnels were used for processing liquid radioactive waste from Building G2, waste from the Hot Incinerator, and KAPL wastes (R-001949). Most of the original equipment and tanks remain in H2, and a small portion of the facility is still used for processing liquid waste. Figure 7-3 is the north side of H2.

Figure 7-3. H2 Looking South, June 2004

H2 Tank Farm Area

The H2 Tank Farm, used from approximately 1950 to 1978 for storing liquid waste, is located below ground level on the east side of H2. This area consists of one 5,000-gallon and six 10,000-gallon stainless steel storage tanks located in underground concrete vaults. The vaults are arranged in a north-south row on the east side of H2. The floors and walls of the vaults range from 2- to 8-feet thick. Processed separations material and waste were accumulated in the tanks from 1950 until 1954, and remained in storage until the mid-1960s, when they were removed and transported off site for disposal. Subsequent to SPRU operations, tanks were used to accumulate and store liquid waste from the radioactive material and chemistry laboratories. The tanks were drained in 1978, but they and the vaults in which they are located contain radioactive residue (R-001949, R-001546). Figure 7-4 is a cross-section of the Tank Farm vault looking south. Figure 7-5 is a photograph of the Tank Farm roof looking south along the west side of H2.

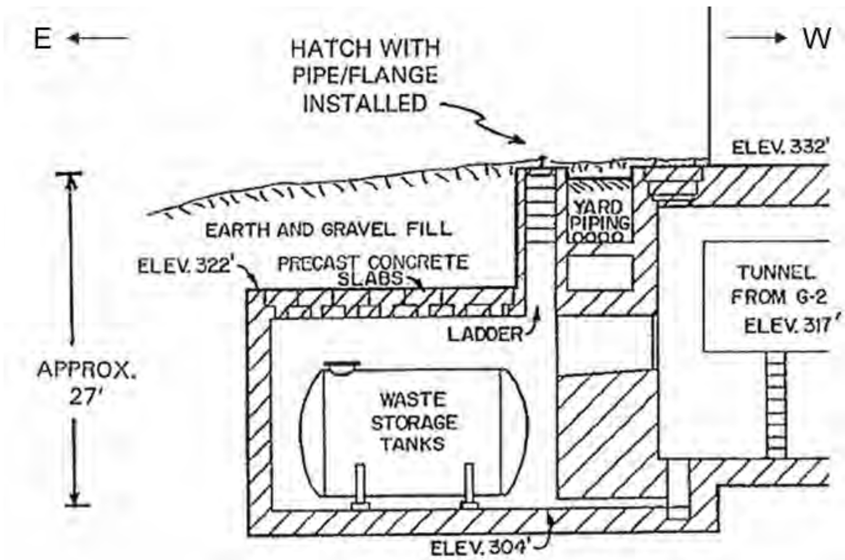


Figure 7-4. Vertical Section of a Tank Farm Vault Looking South

Figure 7-5. Tank Farm Roof Looking South

Pipe Tunnels Area

The Pipe Tunnels were used for SPRU operations between 1950 and 1953, to transport liquid waste for treatment. They remain on site (R-001546). The Pipe Tunnel system consists of reinforced concrete pipes that transported liquid waste, process chemicals, and reuse water between the SPRU buildings, laboratories, equipment, and nearby non-SPRU laboratories and buildings. These tunnels include:

- E1 Tunnels (east and west)
- G1 Tunnels (north and south)
- G2-H2 Tunnel (also called the Transfer Tunnel, Common Tunnel, Connecting Tunnel, and Under Road Tunnel)
- G2 Crossover Tunnel (east and west)

Hillside Drain System Area

The Hillside Drain System is active. It consists of a series of foundation drains around the H2 perimeter connected to a sump on the lower hillside (see Figure 7-6), from which water is pumped back to H2 for processing and discharge (C-000154). The process equipment is located in the west bay area of H2.

Since the mid-1970s, KAPL has processed liquid effluent collected in the Hillside Drain System surrounding H2 prior to discharge. The water comes from surface water percolation into the H2 foundation drains (C-000429). The drain system was modified in 1989 to utilize five 1,000-gallon tanks located along the north-south building centerline and a process train along the north wall. Water from the hillside sump is pumped into three tanks. The raw water is pumped through the ion exchange process train, sampled, pumped into the stormwater system, and discharged into the Mohawk River. Ion exchange resin beds are periodically disposed as low-level solid waste. This system will remain in operation until Building H2 is decommissioned (R-000255).

Figure 7-6. Hillside Drain System Sump

H1 Cooling Tower and Pump House Area

The H1 Cooling Tower and Pump House (Figure 7-7) originally provided cooling water to the various G2 and H2 process condensers, coolers, and tank jackets (R-001949) and later, cooling water to the KAPL computer facility and Building F closed-circuit cooling units (C-000413). The H1 Cooling Tower and Pump House were permanently shut down in 1992 (C-000413).

Figure 7-7. H1 Cooling Tower and Pump House

Hot Incinerator Area

The Hot Incinerator, also referred to as the Pilot Incinerator, was located northeast of H2. It was constructed to incinerate solid combustible radioactive waste from SPRU operations and maintenance activities. The Hot Incinerator was firebrick lined, initially burning propane, and later natural gas. It had a series of scrubbers and filters to remove radioactivity from exhaust gas (R-001949).

Hot Incinerator operations began in 1951. To ensure that radioactive residue passed through the scrubber and filter, the incinerator operated in a partial vacuum. During the 12 months that the Hot Incinerator operated, approximately 20,000 pounds of low-level radioactive combustible waste was burned. It was placed in standby status, dismantled, and removed by 1952, and incinerated ash was shipped off site (R-001949).

H2-K4 Laundry Line Area (Upper Level portion)

Building K4 was built in 1948 and was used as the site laundry facility. Wastewater from the laundry was pumped to H2 through the laundry lines for treatment. The laundry line consisted of two, three-inch black steel pipes wrapped with 30-pound roofing felt that was waterproofed with hot pitch or wrapped with a bituminous-type coating. In 1953, a hillside valve pit equipped with 10 valves and associated piping was added, enabling transfer of waste in the laundry line to the K5 Retention Basin for confirmatory sampling of the treated wastewater prior to its discharge into the stormwater system and the river. The H2-K4 Laundry Line was removed in 1988 (C-001016).

F5 Slurry Drum Storage Area

The F5 Slurry Drum Storage shed was used for temporary staging of H2 slurry drums (R-000255). It was demolished in 1978. Buildings F4 and F6 were constructed after the shed was removed. Figure 7-8 is a photograph of the shed prior to demolition, and Figure 7-9 is a photograph of the shed during removal operations in 1978.

Figure 7-8. F5 Slurry Drum Storage Shed

Figure 7-9. F5 Slurry Drum Storage Shed Removal

7.2 Conditions Through 2001

This section describes the Upper Level history and conditions through 2001. Soil radiological analysis was conducted in 1963, 1973, 1974, 1979, 1985, and 1992-1993. Radiological groundwater data is derived from annual KAPL environmental monitoring reports from 1987 through 2001.

Soil and groundwater chemical data is derived from information in the environmental monitoring reports (R-002187 through R-002201), the *RCRA Facility Assessment – Visual Site Inspection Report* (R-001546), and *RCRA Facility Assessment Sampling Visit Report* (R-000541).

7.2.1 SOIL RADIOLOGICAL CONTAMINATION

Known Upper Level radiological surface and subsurface soil sampling that produced data indicating contamination in areas adjacent to the facilities indicated on Figure 7-10 (C-000111, R-000138, C-000445, C-000429, C-000179, and C-000223).

Data supporting these surveys are found in Tables 7-1, 7-2, and 7-3.

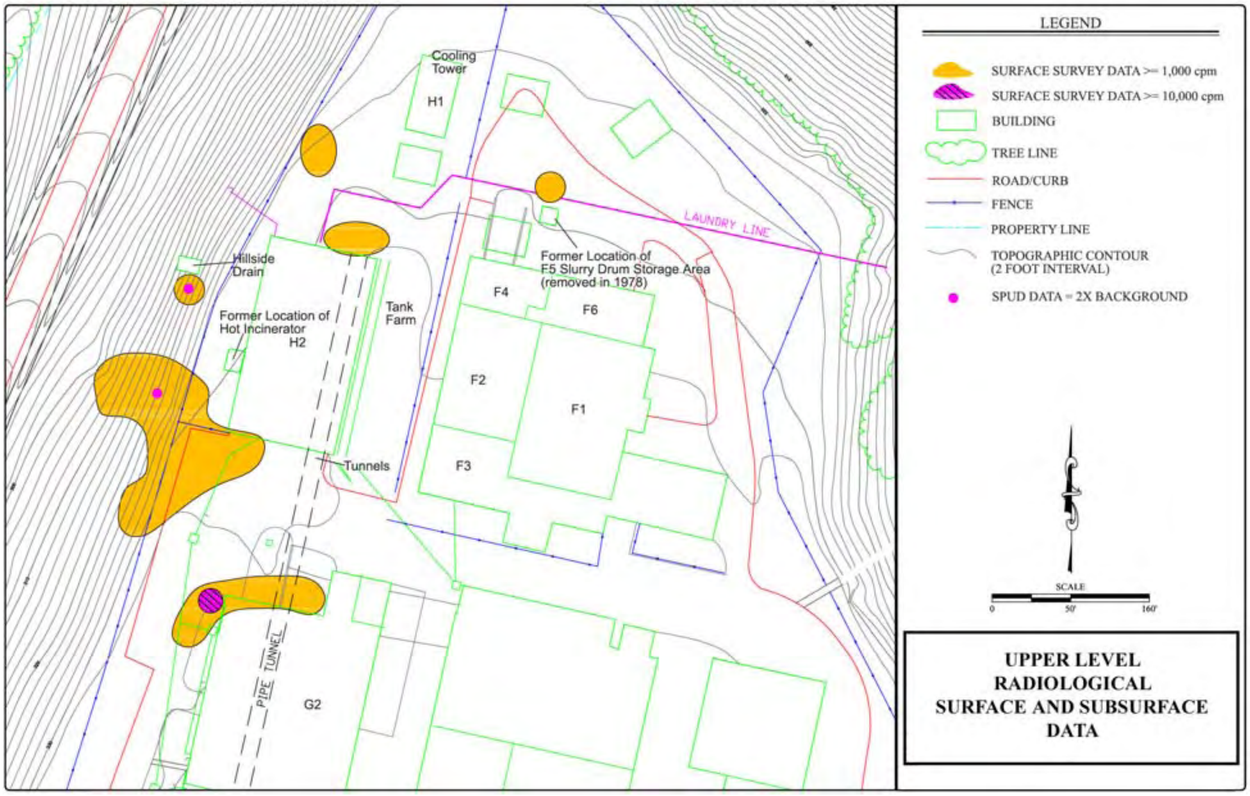


Figure 7-10. Upper Level Surface and Subsurface Radiological Contamination

Buildings G2 and H2 Areas

In the spring of 1973, an investigation was conducted to determine if radioactive contamination was present in the soil around G2 and H2 (and the K5 Retention Basin in the Lower Level). The investigation consisted of measuring radioactivity of soil samples from soil core drillings made along the peripheries of G2 and H2. Holes along the north and east sides of H2 and the west wall of G2 were drilled as close to the buildings as the drill rig could be positioned. Maximum hole depths were 40 feet at H2, and 25 feet at G2. Samples were screened for cesium-137, and selected samples were analyzed for strontium-90, uranium, and plutonium content. Results indicated the absence of contamination in the soil outside the building footings. However, low level contamination was present near the surface of H2 (R-000138).

A 1979 surface radiological survey of the H2 west (to approximately 35 feet from the security fence) and north (to approximately 35 feet from the building) sides was conducted as part of a study to determine how to reduce the amount of contaminated liquid effluent that must be processed and discharged (C-000429).

In 1985, the hillside area on the west side of H2 bordering the Lower Level access road was surveyed using SPUD. The results of the survey data indicated sporadic, low level radioactive contamination (C-000179).

A soil survey of the Upper Level was conducted in 1992 and continued in 1993. Approximately 50 percent of the designated area was surveyed through January 1993, before survey operations were suspended due to bad weather. Of 11,435 square meters surveyed, 120 square meters were found to be greater than twice background. A hand-held instrument read between five and six times background for a verification soil sample taken in areas north of H2 (C-000233).

Survey data are summarized in Table 7-1.

Table 7-1. Buildings G2, H2, and Tank Farm Areas Radiological Soil Survey History

Date	Survey Type	Data Summary
1963	Surface	Ground surface radiation measurements at a distance of 3 feet around the 509C hatch cover were a maximum of 750 mrad/hr of beta activity and 60 mR/hr of gamma activity. Ground surface radiation from adjacent ground between the 509B and 509D tank hatch covers and the associated vent sample lines was up to 150 mrad/hr of beta activity and five to 25 mR/hr of gamma activity. The total area surveyed covered approximately 600 square feet (C-000111).
1973	Subsurface	Cs-137 detected from ≤ 0.4 to 5.0 ± 1.8 pCi/g for depths up to 40 feet for H2 and ≤0.4 to 0.62 ± 0.5 pCi/g for depths up to 25 feet for G2. Sr-90 readings ranged from ≤0.02 to 2.7 ±0.18 pCi/g for H2 and ≤0.06 to 0.2±0.07 pCi/g for G2. Alpha readings ranged from 0.24 ± 0.10 to 1.7 ± 0.27 pCi/g for H2 and 0.83 ± 0.21 to 0.86 ± 0.19 pCi/g for G2 (R-000138).
1974	Subsurface	Core boring samples taken in the vicinity of the Tank Farm did not detect discernible levels of ground contamination (C-000445).
1979	Surface	Surface radiological surface surveys of the west and north sides of H2 indicate areas having greater than background levels (C-000429).
1985	Surface	Approximately 24 square meters of contaminated surface area and 8 cubic meters of contaminated soil volume were detected when surveying the hillside area bordering the Lower Level access road. Cs-137 soil concentrations ranged up to a maximum of 224 pCi/g as measured with the SPUD system (C-000179).
1992-1993	Surface and Subsurface	Surface contamination was 35.7 pCi/g of Cs-137; at one foot, contamination dropped to 7.2 pCi/g. Low levels of uranium were concentrated south of H2. Small local areas of contamination were north of H2 and east and west of G2. One area adjacent to the north wall of H2 showed greater than background results, probably the result of sources inside the building and not from the ground (C-000223).

H2 Tank Farm Area

Tank Farm Area soil contamination survey was conducted following a high background reading (2,000 counts per minute) in the H2 control room aisle in late 1963. Specifically, measurements were taken around the outside hatch cover to the 509C underground storage tank adjacent to the east wall of H2 (between the 509B and 509D hatch covers and vent sample lines). Three feet of soil around the hatch cover and 10 inches of soil over the remaining 600 square foot area were removed. Soil samples taken after removal indicated detectable beta-gamma activity at 4 to 30 times the more restrictive background environmental standards. It was not known if soil contamination existed at other depths (down to 40 feet around the vault walls). However, a decision was made to cease soil removal activities until background environmental standards were established. Following decontamination, the Tank Farm Area was backfilled, sealed, and posted for radiological controls. Since the high radiation dose rates were measured around the 509C hatch cover, it was suspected that activity had been released from the 509C tank through cracks in the caulking around the hatch cover (C-000111).

Core boring samples taken near the Tank Farm Area in 1974 failed to demonstrate discernible levels of soil contamination (C-000445) (see Table 7-1).

Pipe Tunnels Area

Pipe Tunnel contamination was contained physically; there is no evidence of contamination leakage from inside the tunnels to the surrounding areas. However, there is evidence of groundwater seeping into the G2-H2 Tunnel. Inspections indicate that groundwater accumulated in the sumps through cracks and deteriorated copper water-stops (C-000196).

Hillside Drain System Area

During a 1979 radiological surface survey and core boring in the area surrounding the Hillside Drain System sump, no surface activity above background was observed. Core borings on the north, south, and east sides of the sump confirmed that subsurface soil activity was lower than the release limits for soil (C-000429).

H1 Cooling Tower and Pump House Area

No radiological contamination data were found for the H1 Cooling Tower and Pump House Area.

Hot Incinerator Area

No radiological contamination data were found for the Hot Incinerator Area.

Building H2-K4 Laundry Lines Area (Upper Level portion)

Leakage from one of the laundry waste lines near the north end of H2 was reported in 1952 (C-000040). However, no consistent pattern of significant activity was detected in 1952 sampling. The frequency of significant levels increased markedly during 1953, but beta-gamma measurements increased only slightly above minimum significant levels. The apparent source of this contamination was leakage from Lower Level laundry lines directly over the drain tile just north of H2. After the laundry lines were repaired in 1953, the contamination in the samples decreased (R-000057).

In 1962, KAPL stopped using and decommissioned the laundry lines but left them in place. The H2-K4 Laundry Line was partially excavated in 1969 and the end sealed with concrete to separate it from the storm sewer. In 1988, the K4 and hillside valve pits were decommissioned and the laundry lines connecting H2 to K4 were removed. No degradation of the piping was observed and no soil contamination was associated with removal of the piping or valve pits. The underground transfer lines connecting the K4 valve pit to the hillside valve pit and the H2 waste processing building were removed in 1987 (C-000445, R-000205).

F5 Slurry Drum Storage Area

It was reported that residual soil contamination existed in the F5 Slurry Drum Storage Area but no specific data are available (R-000255).

7.2.2 GROUNDWATER RADIOACTIVE CONTAMINATION

7.2.2.1 Pre-1987 Groundwater Sampling

H2 Tank Farm Area

In 1951 and 1952, four test wells were drilled adjacent to the H2 Tank Farm Area. A representative of the USGS participated in choosing the locations of the wells (R-000057). Wells #1 and #2 were drilled north of the Tank Farm, at 40 feet and 100 feet deep, respectively. Well #3 (east of the Tank Farm) and Well #4 (south of the Tank Farm) were both 40 feet deep, in unfilled (native) soil. Sampling occurred weekly from April 1952 to September 1953 and monthly thereafter. Well #1 was the only well to yield significant readings for any extended period. The logical explanation for this high activity was that the tanks/vaults contained radioactive liquids consisting of sump back-up and rainwater seepage, and the natural course of groundwater flow in this area was primarily vertical with some lateral movement toward the river (R-000057).

As part of the H2 Hillside Drain Water Investigation performed in 1983, two core samples were obtained just east of the Tank Farm Area (C-000154). A 1984 evaluation of data from the 1983 investigation and other surveys concluded that the principal source of low level radioactivity reaching the site drainage system was probably groundwater from the vicinity of H2 and adjacent Tank Farm foundations not reaching the Hillside Drain System (C-000165).

Survey data are summarized in Table 7-2.

Table 7-2. Tank Farm Area Groundwater Survey History

Date	Survey Type	Data Summary
1952-1953	Well testing	Samples from the drainage ditch and test wells during the sampling period of May 1952 through December 1953 yielded beta-gamma activity readings ranging from 4.1 to 26.0 x 10^{-8} μCi/cc (R-000057).
1983	H2 Hillside Drain Water Investigation	Two core samples were taken from the area around the drains on the east side of the Tank Farm. Boring readings from the northern end of the east side were ≤ 4.3 x 10^{-9} of gross beta activity and 2.2 ± 2. 5 x10^{-8} of gross gamma activity. Boring readings from the southern end of the east side were ≤ 4.3x10^{-9} of gross beta activity and ≤2.0 x10^{-8} of gross gamma activity. Readings are in μCi/ml (C-000154).

Hillside Drain System Area

In 1983, a tarp was installed over the Tank Farm to stop infiltration and divert water from the Tank Farm Area to the H2 Hillside Drain System (R-002101).

In 1984, KAPL concluded that the principal source of radioactivity reaching the site drainage system was probably groundwater from the vicinity of Building H2 and the adjacent Tank Farm foundations. This groundwater was not being collected in the Hillside Drain System because it was following the natural hydraulic gradient to the Lower Level (C-000165).

A new plastic tarp was installed over the Tank Farm and covered with gravel following the 1989 inspection. The second tarp is still in place. Plans to periodically pump down the vaults following the 1989 inspection were abandoned and the vaults were not pumped down before the 1998 inspection (C-000396). Vaults No. 509A and No. 509E were pumped intermittently from April to August 2000 (R-002101), after which KAPL planned to pump down the Tank Farm vaults approximately every 3 years (R-002101, C-001304).

Building H2-K4 Laundry Lines Area (Upper Level portion)

Surveys conducted in 1952 and 1953 indicated a decrease in groundwater radioactivity during the last three months of 1953. It is likely that the decrease in radioactivity was the result of repairing the laundry lines in June 1953 (R-000057).

Table 7-3 summarizes 1952-1953 test well data.

Table 7-3. Building H2-K4 Laundry Lines Areas Soil Survey History

Date	Survey Type	Data Summary
1952-1953	Well testing	Samples from the drainage ditch and test wells during the sampling period of May 1952 through December 1953 yielded beta-gamma activity readings ranging from 4.1 to 26.0 x 10^{-8} μCi/cc (R-000057).

7.2.2.2 1987-2001 Groundwater Sampling

SPRU groundwater wells are shown in Figure 7-11. KAPL environmental monitoring reports from 1987 through 2001 (R-002187 through R-002201) contain sampling results for beta/gamma, alpha, strontium-90, cesium-137, and tritium. This well data is provided in Appendix B. No measurements exceeded applicable regulatory limits, but well B-15 in the Upper Level has consistently higher readings than other wells. The overall conclusion of the groundwater monitoring program is that previous operations and waste disposal practices have resulted in some small, although measurable, effects on the groundwater quality in localized areas of the Knolls Site (R-002201).

In 1996, tritium was detected near the former F5 Slurry Drum Storage Area in well KH-17, and documented in the 1996 KAPL Environmental Monitoring Report (R-002196). Elevated tritium levels in well KH-17 are attributable to KAPL operations in H2.

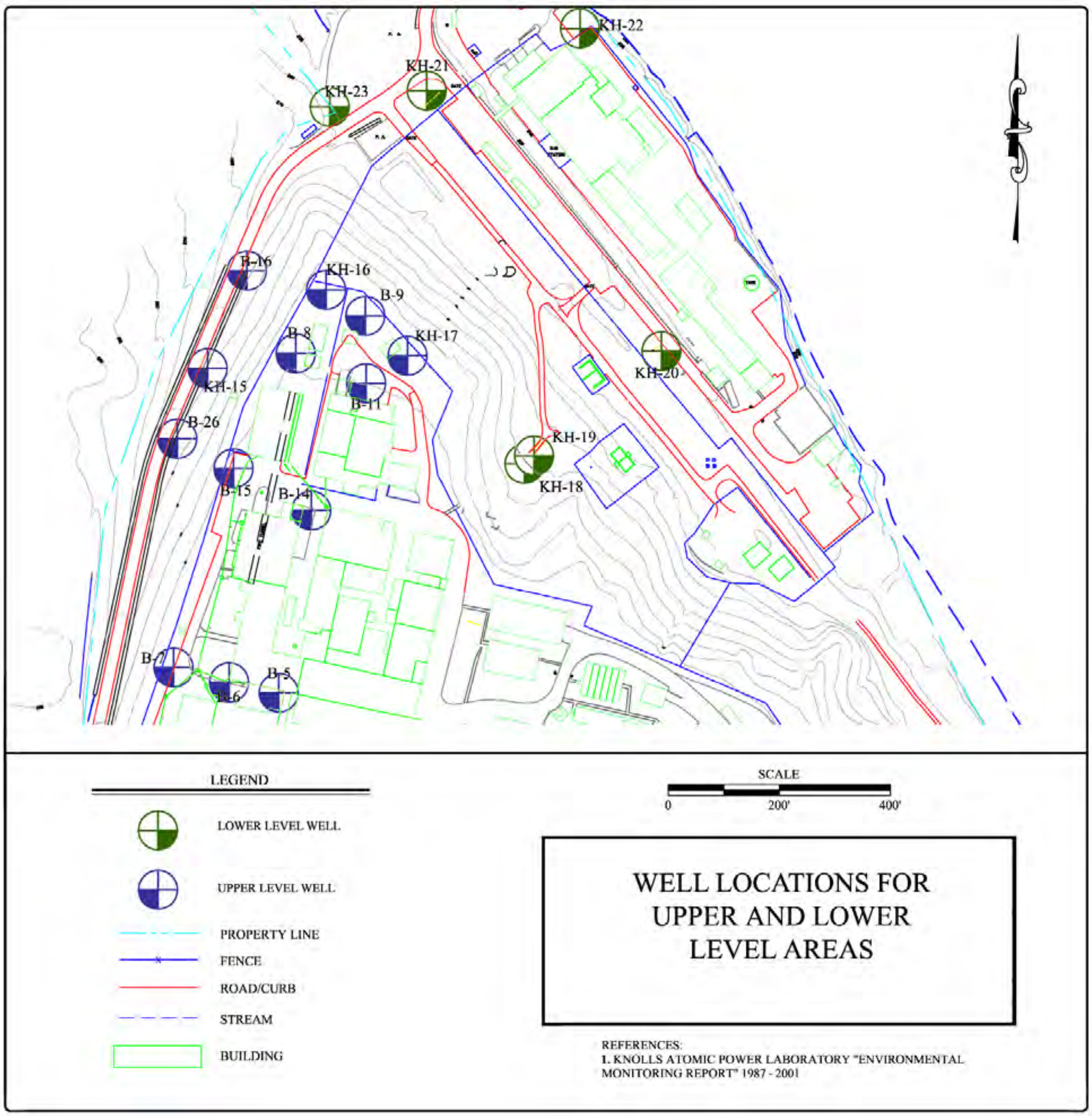


Figure 7-11. Upper Level Well Locations

7.2.3 Chemical Contamination

Upper Level groundwater wells monitored since 1988 for chemical contamination indicated elevated volatile organic compounds (VOCs) and metals. The most common VOCs identified were trichloroethylene, 1,1 dichloroethylene, and 1,2 trans-dichloroethylene (R-000541).

When tested for metals, groundwater analyses showed metals contamination from copper, chromium, antimony, and iron, and minor amounts of others (R-002187 through R-002201).

Soil borings analyses conducted during a RCRA facility assessment in 2000 and 2001 indicated the same contaminants as found in the groundwater.

7.3 Findings

Data Gaps

Upper Level groundwater monitoring is performed annually in designated existing wells. However, existing wells do not necessarily provide adequate groundwater information; additional wells and monitoring may be necessary to fully characterize area groundwater. Additional soil sampling may also be required to fully characterize the area (R-002171).

Impacted and Non-impacted Areas

MARSSIM defines radiologically impacted areas as those with a reasonable possibility of containing residual radioactivity in excess of natural background or fallout level (MARSSIM Glossary, G1-10). Applying this definition, the following Upper Level areas are considered impacted:

Soil and groundwater adjacent to and under:

- Building G2
- Building H2
- H2 Tank Farm
- Pipe Tunnels
- H2-K4 Laundry Lines
- F5 Slurry Drum Storage Area

The following areas are identified as not contaminated with residual radioactivity in excess of natural background or fallout levels and are classified as non-impacted.

- Hillside Drain
- H1 Cooling Tower and Pump House
- Former Hot Incinerator
- H2-K4 Laundry Lines

Although some wells exceeded background levels of radioactivity, no levels exceeded 0.1 percent of the DOE derived concentration guide (DOE, 1993). The estimated dose to the population within 50 miles of KAPL was less than 0.001 percent of the natural background radiation dose (R-002187 through R-002201).

Sources of Contamination

Soil and groundwater contamination sources are associated with one or more of the following.

- G2 operations
- H2 operations
- Tank Farm leaks

- H2-K4 Laundry Lines leaks (R-001949)
- Migration of effluents from the Hillside Drain System
- Drum leaks and/or spills

Likelihood of Contamination Migration

Based on groundwater monitoring data collected as part of the KAPL environmental monitoring program and presented in the 1987 through 2001 KAPL environmental monitoring reports, radiological contamination is not present in groundwater at levels presenting a potential for impact. In addition, groundwater at the KAPL site is contained in a perched aquifer of limited extent and quantity composed of impermeable glacial tills. There is no historical evidence of contamination migration off the KAPL site.

Threat to Human Health

The Upper Level has radiological soil and groundwater impacts. However, these areas are not accessible to the public. Some areas are vegetated, which decreases potential wind and water erosion. KAPL cooperates with regulators, including the NYSDEC and the EPA Region II, to monitor potential public health concerns.

The EPA Region II KAPL fact sheet states "no imminent danger to human health or the environment has been identified. The on-going routine monitoring programs undertaken by KAPL, in addition to the corrective action programs, are designed to alert KAPL and the NYSDEC of any health or environmental risks" (R-000430). On-site workers are protected through health and safety training and monitoring.

Further Characterization Needs

As of 2001, radiological impacts to the Upper Level had not been fully characterized. A more comprehensive survey may be necessary (R-002171).

Conditions after 2001 are addressed in the *Task IV RCRA Facility Investigation Report for Groundwater Upper and Lower Levels SPRU Project, Revision 2* (R-002220) and the *Radiological Characterization Report for SPRU Outside Areas Separations Process Research Unit Project, Revision 2* (R-002222).

8. LOWER LEVEL

This section describes the SPRU Lower Level history and conditions through 2001. Information regarding contamination is derived from documented incidents, radiological and chemical surveys, and correspondence.

The Lower Level consists of land near the following areas:

- Lower Level Parking Lot (currently used by both SPRU and KAPL)
- Railroad Staging Area (currently not used)
- K4 Laundry and Lower Level Laundry Lines (Building K4 currently used by KAPL and Laundry Lines demolished)
- LT1, LT2, and LT3 Storage Sheds (decommissioned and demolished)
- K5 Retention Basin (decommissioned and no longer used)
- K6 Storage Pad (partially demolished)
- K7 Storage Pad (demolished)
- J3 Cold Incinerator (dismantled and removed)
- J4 and J5 Sand Filter Beds (decommissioned and partially dismantled)
- Mohawk River

Figure 8-1 is a labeled aerial photograph of the Lower Level.

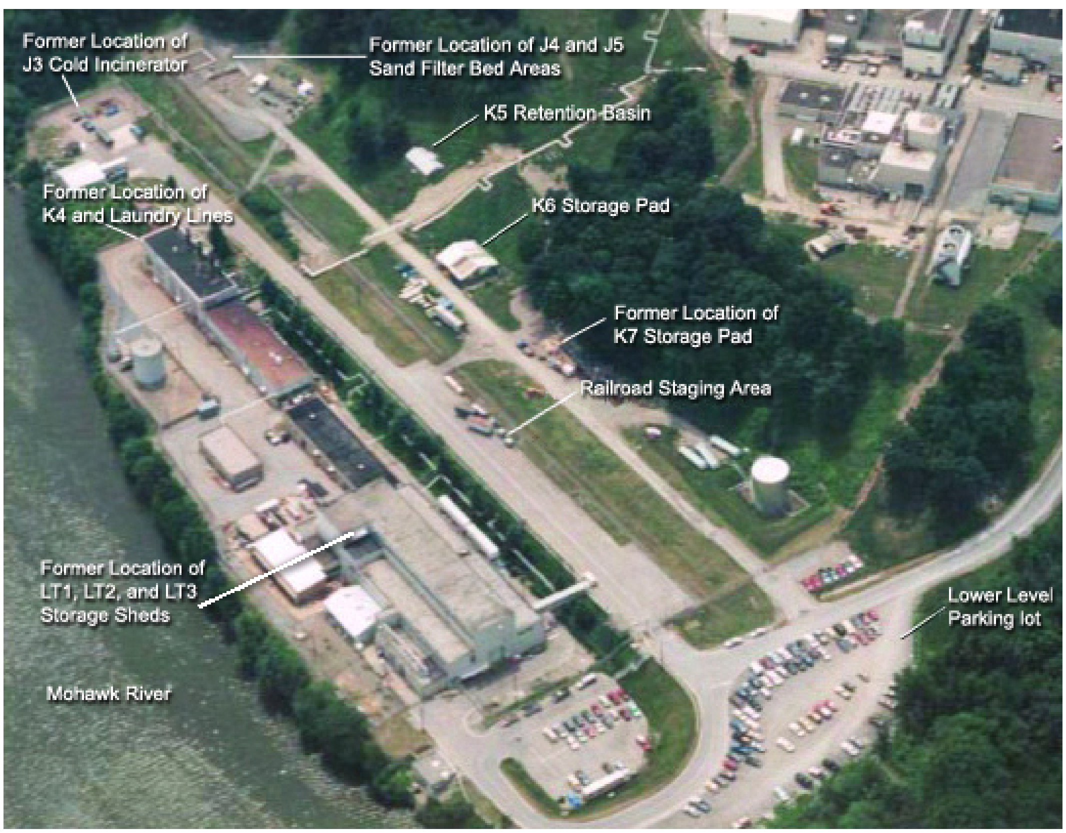


Figure 8-1. Aerial Photograph of the Lower Level (Looking South)

8.1 Lower Level Areas

This section provides physical and functional descriptions of the Lower Level areas. Section 8.2 describes current (2001) environmental conditions.

Historical documentation indicates that impacted soils throughout the Lower Level were relocated from area to area from 1962 through the 1970s. For example, soil was moved from the Railroad Staging Area to provide fill material for the Lower Level Parking Lot; it was subsequently moved again to the J4 and J5 Filter Beds.

Lower Level Parking Lot Area

The Lower Level Parking Lot was established around 1950. It is near the northern boundary of the KAPL property. SPRU and KAPL personnel currently use the Parking Lot (C-000193, C-000108, R-000355).

In 1985, an additional piece of land for the Parking Lot was purchased from General Electric (C-00177).

Figure 8-2 is a photograph of the Lower Level Parking Lot.

Figure 8-2. Lower Level Parking Lot

Railroad Staging Area

The Railroad Staging Area was used during and after SPRU operations until the late 1960s, for storing waste in 4-foot square wooden boxes and 55-gallon drums. Waste included slurry from Building H2 operations stored prior to shipment off site for disposal. The Railroad Staging Area also was used to store contaminated waste from the K5 Retention Basin (R-000355).

Figure 8-3 is a 1950s photograph of waste loading in the Railroad Staging Area.

Figure 8-3. Waste Loading in Railroad Staging Area

K4 Laundry and Laundry Lines Area (Lower Level portion)

The former SPRU Building K4 was the laundry for radioactively contaminated clothing. After SPRU operations ceased in 1953, KAPL continued to use the building as a laundry until 1959 (R-001949). The building is currently a KAPL facility.

The laundry lines from K4 to H2 were built in 1948 to transfer wastewater between the buildings. In 1953, the hillside valve pit was added, enabling wastewater to be transferred to the K5 Retention Basin. In 1962, KAPL stopped using and decommissioned the laundry lines but left them in place (R-000205). The laundry line was partially excavated and the end sealed with concrete to separate it from the storm sewer in 1969 (C-000445). In 1988, the K4 and hillside valve pits were decommissioned and the laundry lines connecting K4 to H2 were removed (R-000205).

Figure 8-4 is a photograph of the SPRU K4 Laundry building in 1988.

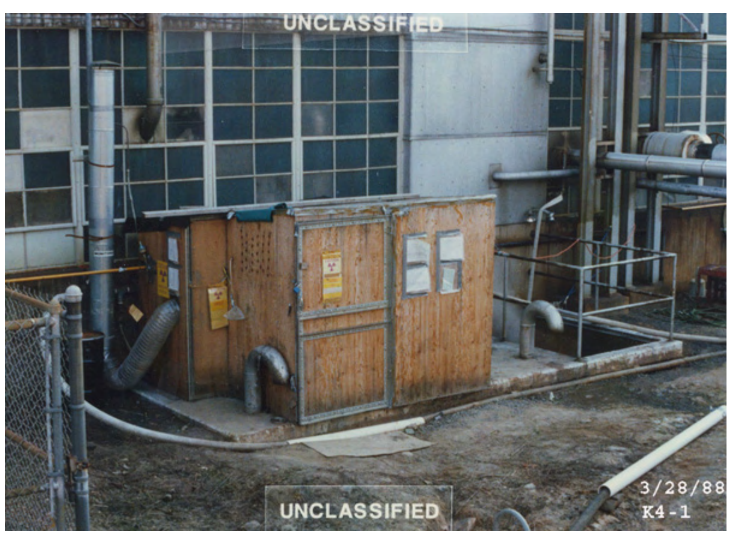


Figure 8-4. K4 Laundry Building in 1988

LT1, LT2, and LT3 Waste Storage Sheds Area

LT1, LT2, and LT3 Waste Storage Sheds were wood frame structures northwest of K4, located near the railroad site (Figure 8-5). They were used to bale and store waste. LT1 contained a solid radioactive waste baler, above-ground storage for small quantities of liquid and solid waste, and in-ground high-level waste storage pits. LT2 and LT3 were storage buildings used for storage of filters, crates of solid waste, and slurry drums. Figure 8-6 shows the LT1 Storage Shed. All three sheds were removed in the mid-to-late 1950s. The in-ground storage pits within LT1 were not removed when the building was demolished but were decommissioned in 1981. Buildings L2, L3 and L4 are currently located on the sheds' sites (C-002211).

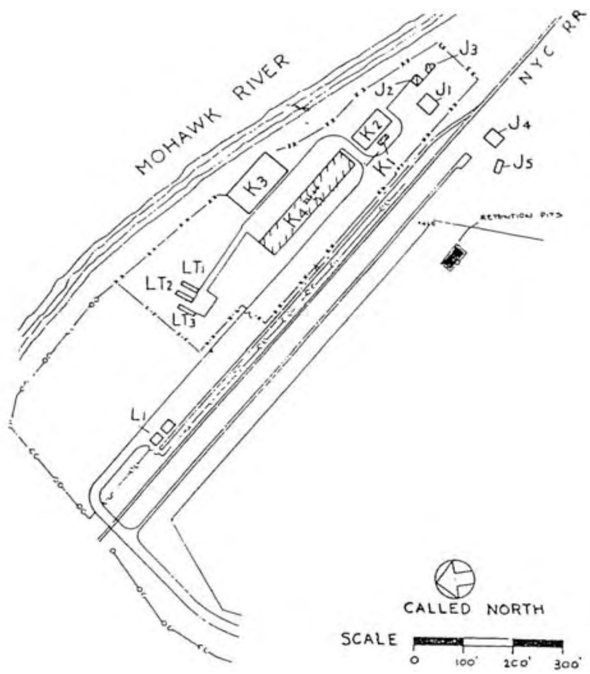


Figure 8-5. 1950 Map of the Lower Level (C-002211) as modified by ERG, August 2006

Figure 8-6. LT1 Storage Shed, Circa 1952

K5 Retention Basin Area

The K5 Retention Basin was constructed as two open-topped, in-ground concrete basins, covering an area approximately 22 feet wide by 43 feet long by 11 feet deep, with 1-foot thick concrete walls. Each basin has a 30,000-gallon capacity. During the 1950s and 1960s, the basins were used as sampling stations and for storing low-level radioactive liquid waste from Building H2 and the K4 Laundry (R-000355, R-001546). A roof was installed over the basin in 1970 (R-001778).

Memoranda dated 1954 and 1957 describe the process for discharging effluent from the K5 Retention Basin. Both documents indicate that sludge was agitated, diluted with water, and discharged into the Mohawk River (C-000513, C-001970). The K5 Retention Basin Area was last used in the late 1960s (C-000445).

Figure 8-7 is a photograph of the K5 Retention Basin Area.

Figure 8-7. K5 Retention Basin Area, 1988

K6 Storage Pad Area

The K6 Storage Pad Area was a 23-foot by 48-foot reinforced concrete pad used in the 1950s and 1960s for outdoor storage of radioactive waste prior to off-site transfer. The pad was divided into two cells surrounded by concrete shield walls. The southern wall and cell divider walls were one foot thick and approximately eight feet high; the other walls were 2 feet 8 inches thick, also approximately 8 feet high. An 8-foot wide access pad existed along each side of the K6 Storage Pad (R-000205).

In 1962, 4 cubic yards of soil from between K6 and K7 was moved to the Lower Level Parking Lot. The excavated hole was found to still have readings of 5 to 500 mRem/hr, so the hole was filled with clean gravel and soil to prevent exposure to site workers (C-000108).

Figure 8-8 is a photograph of the K6 Storage Pad Area in 1987.

Figure 8-8. K6 Storage Pad Area in 1987

K7 Storage Pad Area

The K7 Storage Pad was located west of the K6 Storage Pad. It was used to store solid waste prior to off-site disposal (R-001949). Figure 8-9 and Figure 8-10 are photographs of the K7 Storage Pad Area before and after removal.

Figure 8-9. K7 Storage Pad Before Removal in 1988

Figure 8-10. K7 Storage Pad After Removal

J3 Cold Incinerator Area

The J3 Cold Incinerator (unregulated) was located in Building J3 in the Lower Level. According to industrial practices of the time, uncontaminated combustible office and laboratory wastes (materials such as paper and plastic) were burned in the Cold Incinerator (R-001949). The J3 Cold Incinerator was dismantled and removed (date unknown).

J4 and J5 Sand Filter Bed Area

The J4 and J5 Sand Filter Beds (Figure 8-11) were approximately 30-foot by 40-foot concrete basins used until 1959 to filter K4 laundry wastewater and until 1962 to filter effluent from the sewage treatment plant (R-001778). The beds were used until 1966 as storage facilities for contaminated soil from areas including the K7 Storage Pad, G2 dock area, Slurry Drum Storage Area spills (R-001778), and the Lower Level Parking Lot (C-000108).

In 1966, approximately 7,000 cubic feet of radioactively contaminated soil was removed from the beds with the exception of approximately 3 feet on the bottom (R-001778) and deposited in the North Field Slurry Drum Storage Area (C-000124).

In 1987, the beds were cleaned out and decontaminated (R-000191).

Figure 8-11 is a photograph of the J4 and J5 Sand Filter Bed Area.

Figure 8-11. J4 and J5 Sand Filter Bed Area

Mohawk River

The Mohawk River flows adjacent to SPRU Areas east of the KAPL site. Radioactive liquids related to SPRU operations and KAPL's continuing operations at the site were discharged to the Mohawk River (R-001949, R-001975).

8.2 Conditions Through 2001

This section describes the Lower Level history and conditions through 2001. Soil radiological analysis was conducted in 1955 and 1962, following specific contamination events. Additional radiological surface and subsurface soil sampling of the Lower Level occurred during 1983, 1984, 1985, 1988, and 1991. Radiological groundwater data is derived from annual KAPL environmental monitoring reports from 1992 through 2001.

Soil and groundwater chemical data is derived from information in the environmental monitoring reports (R-002192 through R-002201), the *RCRA Facility Assessment – Visual Site Inspection Report* (R-001546), and *RCRA Facility Assessment Sampling Visit Report* (R-000541).

8.2.1 SOIL RADIOLOGICAL CONTAMINATION

Soil contamination in the Lower Level is shown on Figures 8-12 through 8-15.

Figure 8-12 shows areas of surface radiological contamination in the Lower Level, excluding the Lower Level Parking Lot, and Figure 8-14 is an enlarged map of surface contamination in the Lower Level Parking Lot.

SPUD monitoring was conducted in 1983 in the Lower Level (C-000160). In addition to monitoring for cesium-137, surface and subsurface soil samples were analyzed to measure strontium-90, uranium, and plutonium concentrations. Figures 8-13 and 8-15 show contaminated subsurface areas greater than two times background. Available data supporting these surveys are found in Tables 8-1 through 8-6.

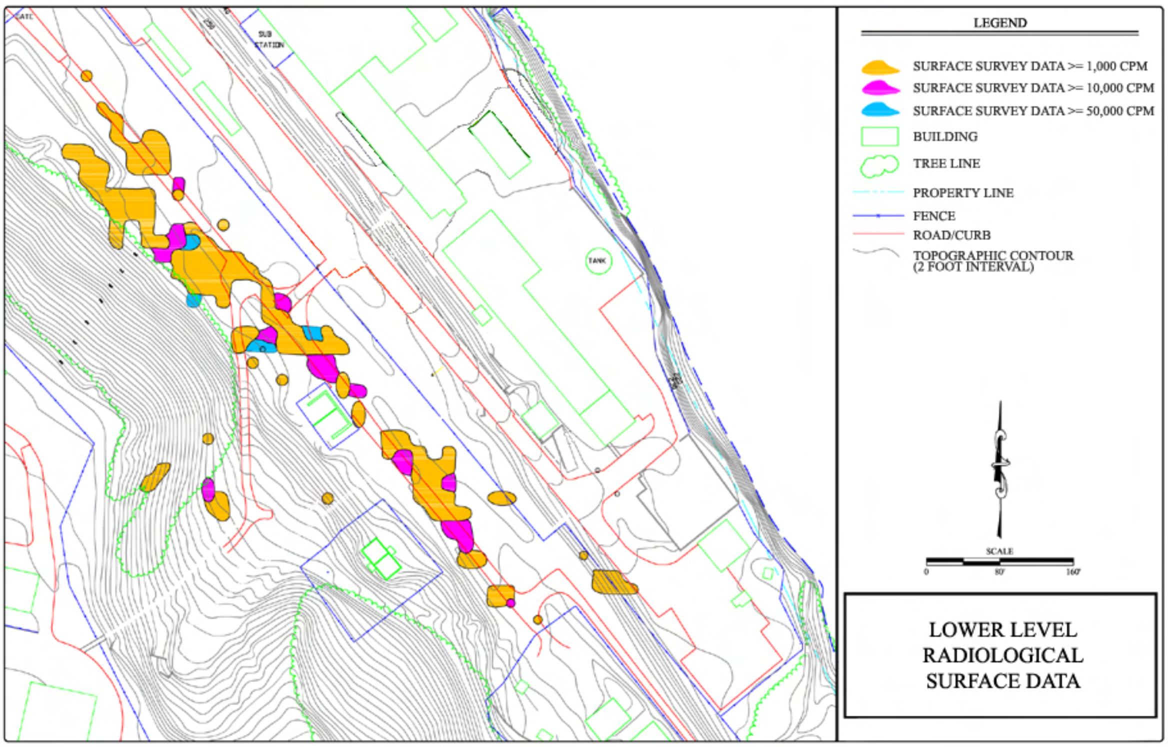


Figure 8-12. Lower Level Surface Radiological Contamination (excluding the Parking Lot)

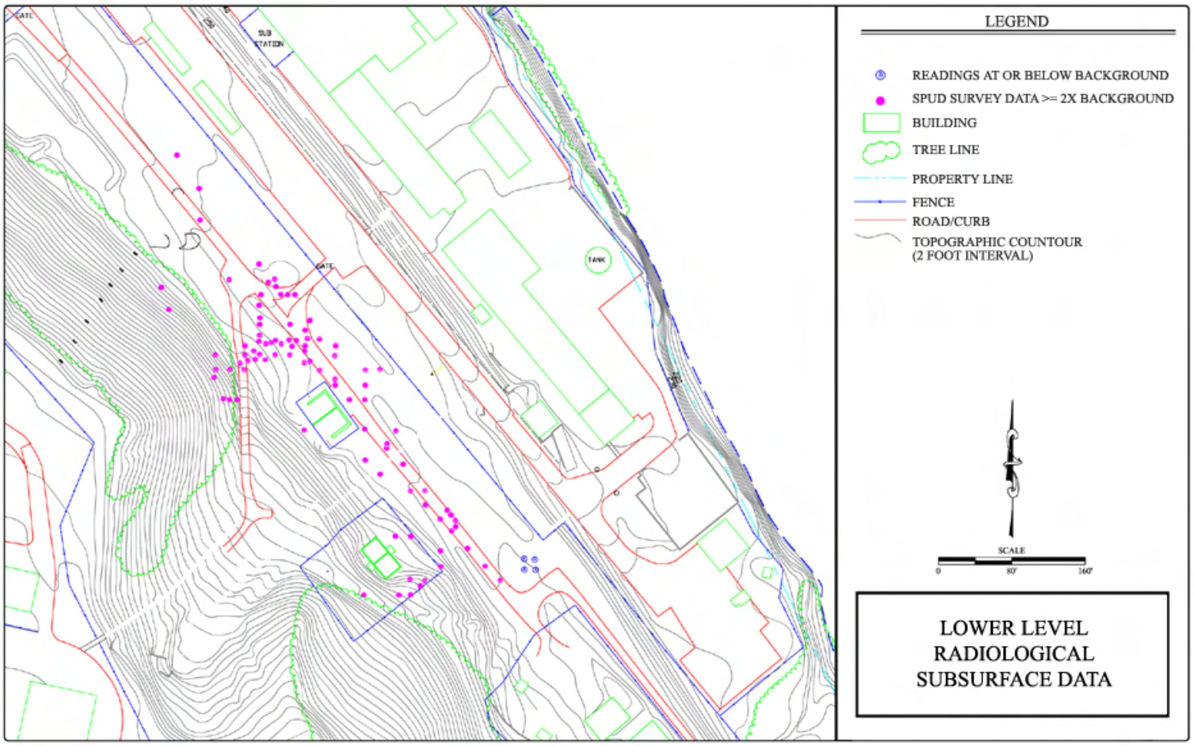


Figure 8-13. Lower Level Subsurface Radiological Contamination (excluding the Parking Lot)

Lower Level Parking Lot Area

Figure 8-14 shows surface contamination areas in the Lower Level Parking Lot as of 2001. Figure 8-15 shows subsurface contamination in the Lower Level Parking Lot.

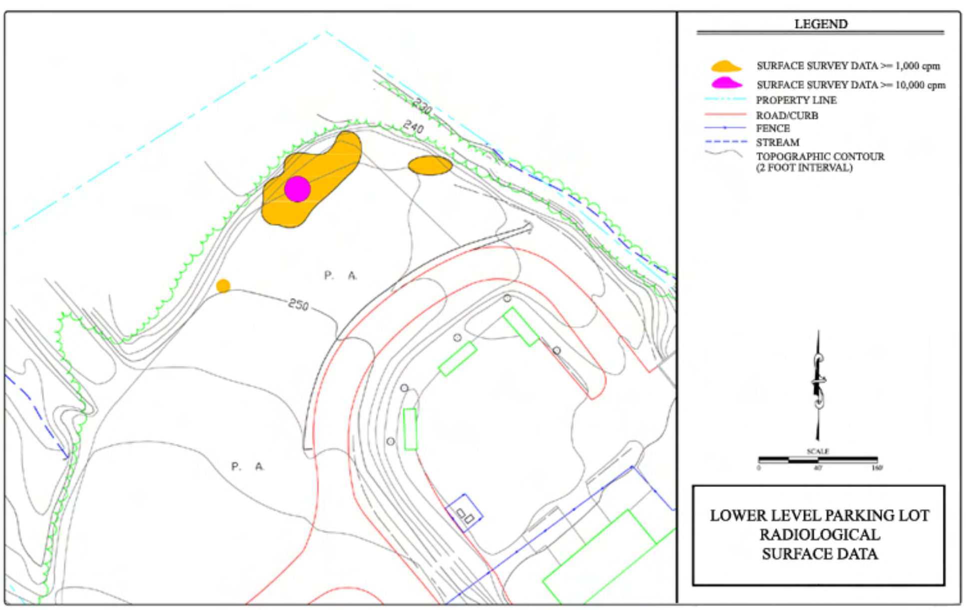


Figure 8-14. Lower Level Parking Lot Surface Radiological Contamination

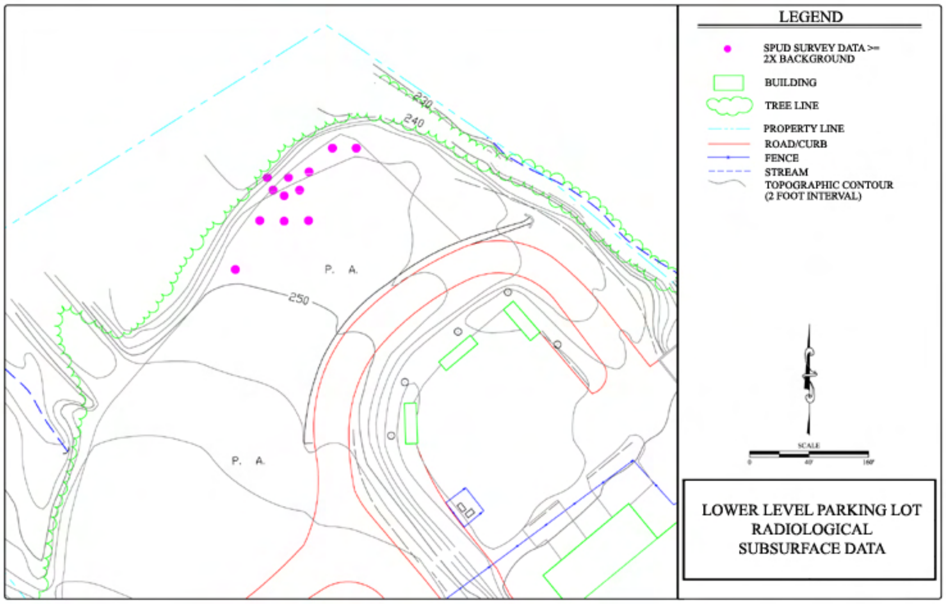


Figure 8-15. Lower Level Parking Lot Subsurface Radiological Contamination

In 1962, soil was moved to the northwest corner of the Lower Level Parking Lot for fill from an area between K6 and K7 in the Railroad Staging Area. The excavation hole was surveyed and it was determined that not all of the contaminated soil had been removed, so the hole was backfilled with clean soil. The area was then removed from radiological control. The contaminated soil in the Parking Lot was moved to the J4 and J5 Filter Beds later in 1962 (C-000193, R-000355, R-002178).

Approximately 5,000 square feet of the Lower Level Parking Lot were surveyed in 1980, using a scintillation detector, and subsurface using SPUD (C-000149).

In 1983, KAPL revised previous estimates of contaminated fill along the north side of the Lower Level Parking Lot (C-000157), and again described the contaminated area on the northwest corner of the Lower Level Parking Lot in 1985, when alternatives for property disposition to DOE were presented (C-000177).

In June 1988, KAPL obtained limited soil samples from the parking area and adjacent land for radiochemistry analysis (C-000193). An additional survey was conducted in 1991 (C-000215).

Table 8-1 summarizes Lower Level Parking Lot soil survey data.

Table 8-1. Lower Level Parking Lot Soil Survey History

Date	Survey Type	Data Summary
1962	Surface and subsurface	Dose rates measured from the contaminated dirt 120 placed in the Lower Level Parking Lot from the area between K6 and K7 were 500 mRem/hr at two inches. Approximately 4 cubic yards of contaminated soil was removed and placed into a sand filter pit. Radiation levels at the parking lot were thereby reduced to less than 1 mRem/hr at two inches (C-000108, C-000193, R-001949).
1980	Surface	An area of about 5,000 square feet in the Lower Level Parking Lot was surveyed using a scintillation detector and SPUD. A total of 472 holes with a uniform horizontal separation of 40 inches were punched, allowing surveying of 29,860 square feet. A volume of 1656 cubic feet had results greater than 20 cpm, 422 cubic feet greater than 50 cpm, and 199 cubic feet greater than 100 cpm. The conclusion was that approximately 2277 cubic feet of the soil exhibited Cs-137 contamination in excess of 20 pCi/g. The highest level of contamination was approximately 1,700 pCi/g of Cs-137 (C-000193, C-000149).

1983	Surface and subsurface	Refined previous estimates of contaminated fill to 1000 cubic meters, and identified an adjacent area with another 600 cubic meters of contaminated soil over background at 10.1 pCi/g Cs-137 and .30 pCi/g Sr-90 (C-000157).
1984	Surface and subsurface	Approximately 29,100 square meters of the Lower Level Parking Lot were surveyed for surface and subsurface radioactivity, using gamma scintillation detectors and SPUD. Of the area surveyed, 550 square meters exhibited surface activity in excess of 20 pCi/g of Cs-137. Using surface survey techniques, the background count rate was determined to be 20 cpm. Approximately 500 square meters showed surface contamination above background, up to 1000 cpm. Surface contamination between 1000 and 15,000 cpm was found on 50 square meters. For measurement of subsurface activity, 468 pilot holes were punched on 5-meter centers, or on one-meter centers where contamination was known. A total of 20,000 cubic meters were surveyed. Results ranged from 0.01 to 0.94 pCi/g of Cs-137; from 0.05 to 12.8 pCi/g of Sr-90; from 0.4 to 2.14 pCi/g of natural uranium; and one sample from mixed and enriched uranium of 1.51 pCi/g. Sixteen soil samples also were analyzed. Results ranged from 0.08 to 5783 pCi/g of Cs-137; 0.56 to 12.8 pCi/g of Sr-90; 0.98 to 3.56 pCi/g of enriched uranium; and 0.006 to 0.48 pCi/g of plutonium. The survey report estimated that 1000 cubic meters may be contaminated with Cs-137 in excess of 20 pCi/g (C-000177).
1988	Soil samples	Limited soil samples analyzed indicated that the highest level of contamination was 306 pCi/g Cs-137 (C-000193).
1988	Surface	June 1988 spot surveys included: overbank 11,000 cpm; adjacent spot 7,000-14,000 cpm; grass area off edge of lot 10,000 cpm; hot spot along edge of woods 36,000 cpm; sample near grass 36,000; parking rubble 2,000 cpm; another rubble area 4,000 cpm; 3 feet off parking area 31,000 cpm; edge of woods, top of bank 21,000; and 15 feet from the edge of the parking lot, 15,000. A hand-drawn map indicates the contours of cpm ranges (C-000193).
1991	Surface	Surface soil measurements were taken using scintillation detectors. The background count was established at 21 cpm. Results indicated no significant changes from the 1984 survey (C-000215).

Railroad Staging Area

The Railroad Staging Area adjacent to the former rail bed has radiological and heavy metal contamination (R-001546).

In 1962, it was determined that soil between the K6 Storage Pad Area and the K7 Storage Pad was radioactively contaminated. The contaminated soil was removed and placed in the Lower Level Parking Lot, and the area was released from radiological control (C-000108).

A 1983 soil survey recommended further surveys of the hillside east of the Railroad Staging Area (C-000160).

Table 8-2 summarizes Railroad Staging Area soil survey data.

Table 8-2. Railroad Staging Area Soil Survey History

Date	Survey Type	Data Summary
1962	Surface	Dose rates measured from soil moved from the area between K6 and K7 to the Lower Level Parking Lot were 500 mRem/hr at two inches. Approximately 4 cubic yards were removed and placed in a sand filter pit, reducing parking lot radiation to less than 1 mRem/hr at two inches (C-000108, C-000193, R-001949).
1983	Surface	Approximately 16,300 square meters were surveyed for surface contamination. About 4,000 square meters exhibited surface contamination above background up to 1,000 cpm. Five hundred square meters showed surface contamination between 1000 cpm, and 10,000 cpm covered 500 square meters, 25 square meters had activity in excess of 50,000 cpm, and 5 square meters had activity in excess of 50,000 cpm. The 5 square meters consisted of 5 individual spots where beta-gamma surface dose rates were between 1 and 2 mRem/hr at 1 inch from the surface. When converted to activity levels, 4,500 square meters exhibited surface activity in excess of 20 pCi/g of Cs-137 (C-000160).
	Subsurface	Subsurface contamination was measured from 757 designated holes punched on 5-meter centers, or on 2-meter centers on the edges of the suspected contaminated zones and 1-meter or 0.5-meter centers in high-activity areas. A total of 149 holes showed twice background levels or greater on the surface; 53 were twice background or greater at a depth of 0.5 meters; 32 holes had twice background or greater at 1.0 meter; 13 had twice background or greater at 1.5 meters; and 7 holes showed twice background or greater at a depth of 2.0 meters. The total estimated volume of contaminated soil was 3000 square meters. The maximum level of contamination was 2,862 pCi/g Cs-137 (C-000160).

K4 Laundry and Lower Level Laundry Lines Area (Lower Level portion)

The K4 Laundry was decontaminated in 1988. After sampling was performed, the facility was released for unrestricted KAPL use (R-001949). The K4 wastewater pit also was decommissioned and decontaminated in 1988.

In 1962, KAPL surveyed the laundry lines and associated system during decommissioning. Two pipe stubs and the connecting transfer pipe in the wall between the K4 valve and retention pit were left in place (R-000205). The laundry line pipe stubs and connecting transfer pipe between the pits were removed and disposed of as radioactive waste in 1988, and the K4 retention pit was decontaminated.

A 1989 K4 underground fuel tank area survey was conducted prior to removal of the tank (C-000202). Contaminated soil discovered during this survey was removed in 1991 (C-000212).

Table 8-3 summarizes SPRU K4 Laundry and Lower Level Laundry Lines Area soil survey data.

Table 8-3. K4 Laundry and Lower Level Laundry Lines Soil Survey History

Date	Survey Type	Data Summary
1962	Unknown	KAPL survey(s) of the laundry lines and associated resulted in decommissioning. No specific data are available (R-000205).
1988	Surface and sample analysis	Laundry pipe stub and transfer pipe area spot surveys showed beta-gamma contamination, but no alpha. Before decontamination, the K4 retention pit showed extensive beta-gamma contamination, with alpha on the floor and walls. A completed survey conducted after concrete decontamination and paint removal resulted in the release of both K4 pits for unrestricted use (R-000205).
1989	Surface and sample analysis	K4 underground fuel tank area surface sample analysis results were pCi/g <=20 and 35 total uranium. The soil was removed in 1991, stored along the Lower Level security fence and north of the former railroad bed, and disposed off site (C-000202).

LT1, LT2, and LT3 Storage Sheds Area

LT1, LT2, and LT3 were waste storage sheds in the Lower Level, located where buildings L2, L3, and L4 currently stand (see Figures 8-1 and 8-5). The LT1, LT2, and LT3 Storage Sheds are not included in the current SPRU Disposition Project. The buildings were removed in the mid-to-late 1950s. The in-ground storage pits within LT1 were decommissioned in 1981, and contaminated soil was also removed at this time (C-002211).

K5 Retention Basin Area

In 1970, sludge was removed from the basins and loose radioactively contaminated material cleaned from interior surfaces. A sealer was applied (R-000234, C-000445).

K5 Retention Basin Area soil sampling was conducted in 1974. Two boreholes were sampled at the surface and at depths of 5, 10, and 13 feet. Levels were significantly higher at the top of the boreholes than at the bottom. According to the soil sampling report, “several areas where low level contamination was found near K5… can probably be attributed to spills which took place early in KAPL history” (C-000140, C-000138).

A 1977 summary report documented that approximately 50 microCuries of radioactivity remained in the concrete basins as fixed contamination (C-000445).

K5 Retention Basin Area conditions are described in the *Stabilization Report for Building K-5, KAPL Lower Level* (R-000234). A project was initiated in 1992 to evaluate and stabilize (clean loose contamination and seal and repair walls and roof to prevent further degradation of the facility and potential contamination migration) the K5 Retention Basin Area. After preliminary readings, the stabilization team posted the area as a high radiation area until a more thorough survey could be conducted. In general, the high readings were from the effluent and soil on the east end of the facility (R-000234). The K5 Retention Basin Area is posted as a high radiation area.

Table 8-4 summarizes K5 Retention Basin soil survey data.

Table 8-4. K5 Retention Basin Soil Survey History

Date	Survey Type	Data Summary
1970	Subsurface	Dose rates measured 15 Sr-90 at 47,000 pCi/g, and Pu-239 at 580 pCi/g, with lesser amounts of Pu-238, Pu-240, and Am-241 (R-000234).
1974	Subsurface	Two boreholes were sampled at the surface and at depths of 5, 10, and 13 feet. Cs-137 was detected at a maximum level of 31.0 pCi/g, Sr-90 at 7.54 pCi/g, and alpha activity at 3.07 pCi/g. Levels were significantly higher at the top of the boreholes than at the bottom (R-000138, C-000140).
1977	Surface	Approximately 50 μCi of radioactivity remained as fixed contamination in the concrete (C-000445).
1992	Surface	Prior to stabilization, preliminary readings in the basins showed no readings above 4 x 10^{-13} μCi/ml alpha. Maximum recorded dose levels on the floor of the retention basins were 1.5 to 2.0 mRem/hr. The stabilization team posted the area as a high radiation area until a more thorough survey could be conducted. Later readings of 40 cpm were attributed to radon. Survey and swipe data show a maximum of 2808 pCi/g Cs-137;10.2 pCi/g for U-235; 1.5 pCi/g for U-238; 1.1 pCi/g of Am-241; 13.2 pCi/g for Pu-239; 2.4 pCi/g for Pu-240; 11.6 pCi/g for Pu-241. In general, the high readings were from the effluent and soil on the east end of the facility (R-000234).

K6 Storage Pad Area

In 1973, the K6 Storage Pad floor drains were excavated and sealed with concrete (C-000445).

A roof was added in 1987, the walls decontaminated, floor removed, and adjacent soil registering residual radioactivity excavated and placed under the roof area (R-000355).

The K6 Storage Pad floors, concrete ramps, drains, and underlying soil contaminated with cesium-137 and strontium-90 were removed and disposed in 1989. Remaining contaminated soil was covered with approximately 800 cubic feet of previously excavated contaminated soil, clean fill, and gravel. No barrier was placed between the contaminated soil and clean fill. Analysis performed on soil samples and the walls indicated that extensive soil contamination remained (R-000205).

Table 8-5 summarizes soil survey data from the K6 Storage Pad Area.

Table 8-5. K6 Storage Pad Soil Survey History

Date	Document Type	Data Summary
1962	Surface	Contaminated soil between K6 and K7 pads had a maximum dose rate of 500 mRem/hr gamma. The soil was moved to the Lower Level Parking Lot (R-001949).
1989	Surface	Building K6 was reported as extensively contaminated with both Cs-137 and Sr-90. All concrete floors, ramps, and drains were removed and disposed of as radioactive waste. However, extensive quantities of contaminated soil remained. It was estimated that 2 to 3 mCi of Cs-137 and Sr-90 remained on the K6 Storage Pad (R-000205).

K7 Storage Pad Area

An undated document reported radioactivity in soils adjacent to the K7 Storage Pad Area (R-000355). However, no K7 Storage Pad Area soil survey data were found in available references.

J3 Cold Incinerator Area

The J3 Cold Incinerator was intended to burn only uncontaminated waste. However, in several instances, low-level radioactive waste was incinerated in error. Although the resulting radioactivity in the ash was very low, it was disposed off site as radioactive waste (R-001949).

The current status of the J3 Cold Incinerator Area is unknown.

J4 and J5 Sand Filter Bed Areas

In 1962, four cubic yards of contaminated soil originally from between K6 and K7, and later from the Lower Level Parking Lot Area, were removed and placed in the filter beds. The beds were surveyed at that time (C-000108).

The beds continued to be used until 1966 as storage facilities for contaminated soil (C-000108).

In 1966, approximately 7,000 cubic feet of radioactively contaminated soil was removed from the beds with the exception of approximately 3 feet on the bottom (R-001778) and deposited in the North Field Slurry Drum Storage Area (C-000124).

In 1985, soil surveys showed background levels of cesium-137 (C-000179).

In 1987, the beds were decontaminated and released for unrestricted use (R-000191).

J4 and J5 Sand Filter Beds Area decontamination was initiated in 1986 and completed in 1988. The concrete walls were surveyed and unconditionally released (R-001778).

In 2000, An “air relief station and hydrant” was installed near the J4 Sand Filter Bed. A survey conducted during this project found no contamination in the area (C-001738).

Table 8-6 summarizes J4 and J5 Sand Filter Beds Area soil survey data.

Table 8-6. J4 and J5 Sand Filter Beds Area Soil Survey History

Date	Survey Type	Data Summary
1962	Soil Survey	Four cubic yards of soil (first removed from between K6 and K7, and later from the Lower Level Parking Area) with a maximum dose rate of 6 mRem/hr was removed and placed in the J4 and J5 Sand Filter Beds (C-000108).
1966	Soil Survey	Soil surveys showed background levels of Cs-137 (C-000124). Concentrations detected in the sand averaged 9.1-7 µCi /g alpha and $8.8E^{-5}$ µCi/g beta-gamma (R-001778).
2000	Surface	An “air relief station and hydrant” was installed near the J4 Retention Bed in 2000. As a part of this project, a survey found the area radiologically clean (C-001738).

Mohawk River

Permitted outfall releases of treated wastewater to the Mohawk River have occurred since the time of SPRU operations. In 1952, the USGS, with cooperation of the General Electric Company, the New York State Health Department, and Harvard University, investigated the Mohawk River dilution capacity. The toxic radioactive and chemical elements in laboratory waste were investigated by KAPL with respect to standards prescribed by the Atomic Energy Commission and the New York State Waste Pollution Control Board. The Atomic Energy Commission and the Mohawk River Advisory Committee were satisfied that no regulatory standards applicable at that time would be exceeded. Release of low-level radioactive liquid waste began in June 1955 (R-000077).

KAPL annual environmental monitoring reports document results of river sediment sampling and biological surveys. The distribution of residual radioactivity in the Mohawk River sediment near the Knolls Site is well understood.

KAPL conducted an extensive sediment and biological sampling program on the Mohawk River during the summer of 1992. The sampling program was performed to update information on the quantity and distribution of radioactivity in the river sediment attributable to KAPL (and SPRU) operations prior to 1964 (R-002214).

The principal radioactive constituents released to the Mohawk River were strontium-90 and cesium-127. The majority of the radioactivity present is confined to an area along the south side of the Mohawk River that extends from the KAPL Building J-6 outfall to 500 feet downriver. The radioactivity is at least 8 inches below the top of the sediment surface. Elevated radioactive concentrations also were detected further downriver; however, the concentrations are lower and the radioactivity is located even deeper in the sediment. A radiological assessment of the residual radioactivity in the sediment concludes that, even using very conservative assumptions and hypothetical scenarios, no measurable dose to a member of the public would result, even if all the radioactivity in the sediment were released back into river water. The major radiological assessment conclusion is that radioactivity of KAPL (including SPRU) origin in the Mohawk River sediment does not pose a health risk to any member of the public (R-002108).

8.2.2 GROUNDWATER RADIOACTIVE CONTAMINATION

SPRU groundwater wells in the Lower and Upper Levels are shown in Figure 8-16. KAPL environmental monitoring reports from 1987 through 2001 (R-002187 through R-002201) contain sampling results for beta/gamma, alpha, strontium-90, cesium-137, and tritium. This well data is provided in Appendix B.

No measurements exceeded applicable regulatory limits, but well KH-21 in the Lower Level has consistently higher readings than other wells. The overall conclusion of the groundwater monitoring program is that previous operations and waste disposal practices have resulted in some small, although measurable, effects on the groundwater quality in localized areas of the Knolls Site (R-002201).

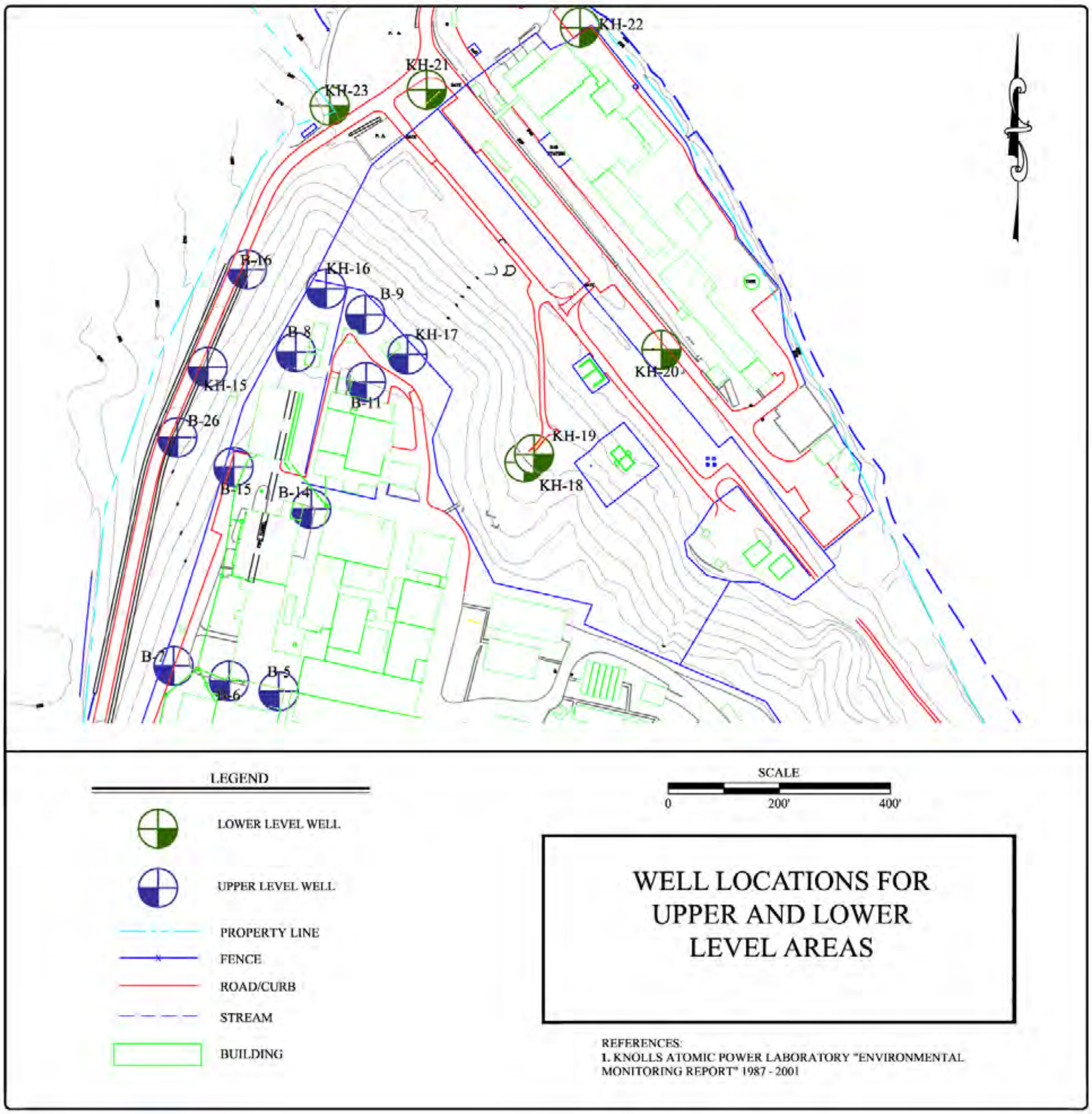


Figure 8-16. Lower and Upper Level Well Locations

8.2.3 CHEMICAL CONTAMINATION

Lower Level groundwater wells were not tested for metals as part of the environmental monitoring program, or for VOCs until 2000. In the 2000 and 2001 environmental monitoring reports, no measurable VOCs were detected (R-002200, R-002201).

Organic substances and elevated levels of metals were found in soil borings conducted during a 2000 and 2001 RCRA facility assessment. Trace levels of the VOCs tetrachloroethylene and trichloroethylene were detected, as well as widespread occurrences of semi-volatile organic compound (SVOC) PAHs. Metals identified in elevated amounts included mercury, arsenic, and lead (R-000541).

Along the length of the former railroad bed, PAHs and metals including antimony, arsenic, copper, and lead were found. These are, however, attributed to railroad construction and operation and not SPRU operations (R-000541).

8.3 Findings

Data Gaps

Lower Level groundwater monitoring is performed annually in designated existing wells. However, existing wells do not necessarily provide adequate groundwater information; additional wells and monitoring may be necessary to fully characterize area groundwater. Additional soil sampling may also be required to fully characterize the area (R-002171).

Impacted and Non-impacted Areas

MARSSIM defines impacted areas as those with a reasonable possibility of containing residual radioactivity in excess of natural background or fallout level (MARSSIM Glossary, G1-10). Applying this definition, the following areas have been identified, as evidenced in the radiological survey history tables and recorded events, as containing residual radioactivity in excess of natural background or fallout levels, and as such, are considered impacted.

- Lower Level Parking Lot
- Railroad Staging
- K5 Retention Basin
- K6 Storage Pad

The following areas are identified as not contaminated with residual radioactivity in excess of natural background or fallout levels and are classified as non-impacted.

- K4 and Laundry Lines
- K7 Storage Pad
- Cold Incinerator
- J4 and J5 Sand Filter Beds

Although some wells exceeded background levels of radioactivity, no levels exceeded 0.1 percent of the DOE derived concentration guide (DOE, 1993). The estimated dose to the population within 50 miles of KAPL was less than 0.001 percent of the natural background radiation dose (R-002187 through R-002201).

Sources of Contamination

Soil and groundwater contamination sources are directly related to:

- Disposal of contaminated soil in the Lower Level Parking Lot
- An accidental spill of contaminated material in the Railroad Staging Area
- K5 Retention Basin spills
- Leaking drums stored at the K6 Storage Pad

Likelihood of Contamination Migration

Groundwater monitoring data collected and presented in the KAPL 1992 through 2001 environmental monitoring reports indicate that groundwater radiological contamination is not at potential impact levels. Additionally, groundwater at the KAPL site is contained in a perched aquifer composed of impermeable glacial tills and of limited extent and quantity. There is no historical evidence of contamination migration off the KAPL site.

Threat to Human Health

The Lower Level has radiological soil and groundwater impacts. However, these areas are not accessible to the public. Some areas are vegetated, which decreases potential wind and water erosion. KAPL cooperates with regulators, including the NYSDEC and the EPA Region II, to monitor potential public health concerns.

The EPA Region II KAPL fact sheet states “no imminent danger to human health or the environment has been identified. The on-going routine monitoring programs undertaken by KAPL, in addition to the corrective action programs, are designed to alert KAPL and the NYSDEC of any health or environmental risks” (R-000430). On-site workers are protected through health and safety training and monitoring.

Further Characterization Needs

As of 2001, radiological impacts to the Lower Level had not been fully characterized. A more comprehensive survey may be necessary because several radiological surveys indicate that the area was impacted (R-002171).

Conditions after 2001 are addressed in the *Task IV RCRA Facility Investigation Report for Groundwater Upper and Lower Levels SPRU Project, Revision 2* (R-002220) and the *Radiological Characterization Report for SPRU Outside Areas Separations Process Research Unit Project, Revision 2* (R-002222).

9. NORTH FIELD

This section describes the SPRU North Field history and conditions through 2001. Information regarding contamination is derived from documented incidents, radiological and chemical surveys, and correspondence.

The SPRU-related area within the North Field is the Slurry Drum Storage Area. The exact location of the Slurry Drum Storage Area is no longer discernable (R-000541, R-000144, C-000193). However, historical records indicate that the North Field and the Slurry Drum Storage Area are generally located in the area shown in the Figure 9-1 aerial photograph. The superimposed dashed line on Figure 9-1 is intended only as a general representation of area boundaries.

Figure 9-1. Aerial Photograph Showing the Approximate Location of the North Field and the Slurry Drum Storage Area (1999)

The North Field also contains several KAPL SWMUs, including landfills and construction and demolition debris sites near the Slurry Drum Storage Area. The KAPL SWMUs are not associated with the SPRU Disposition Project and therefore not included in this historical site assessment.

9.1 Slurry Drum Storage Area

The Slurry Drum Storage Area is between 1,800 and 2,500 square feet. It consisted of an internal staging area of approximately 900 square feet that was surrounded by three approximately 5- to 6-foot thick and 8- to 10-foot high earthen-bermed walls with an opening on the western side. The bermed soil was primarily composed of clay (R-000144).

The Slurry Drum Storage Area was utilized during SPRU operations for staging and temporary storage of slurry generated in H2. The slurry was stored in 55-gallon drums pending off-site disposal (R-000144, C-000193).

In 1955, the berm walls were subsequently bulldozed into the Slurry Drum Storage Area (R-000144, C-000193). Subsequent excavation, fill, and grading made it difficult to precisely locate the original site area; no visible evidence remains (R-000541). Surface topography is mostly flat, and vegetation consists of grasses and small trees (see Figure 9-2).

Figure 9-2. Site View of the Approximate Location of the Slurry Drum Storage Area (date unknown)

9.2 Conditions Through 2001

This section describes the SPRU North Field history and conditions through 2001. Soil radiological analysis was conducted in 1950 through 1957, 1960, 1963, 1966, 1977, 1978, 1982, 1986, and 1989. Radiological groundwater data is derived from annual KAPL environmental monitoring reports from 1987 through 2001.

Soil and groundwater chemical data is derived from information in the environmental monitoring reports (R-002187 through R-002201), the *RCRA Facility Assessment – Visual Site Inspection Report* (R-001546), and *RCRA Facility Assessment Sampling Visit Report* (R-000541).

9.2.1 SOIL RADIOLOGICAL CONTAMINATION

Information about the North Field Slurry Drum Storage Area soil and groundwater is based on historic documents including KAPL radiological survey reports, environmental groundwater monitoring program data (R-002187 through R-002201), historic references, and correspondence documents. Known Slurry Drum Storage Area radiological surface and subsurface soil sampling that produced data indicating contamination are indicated on Figures 9-3 and 9-4.

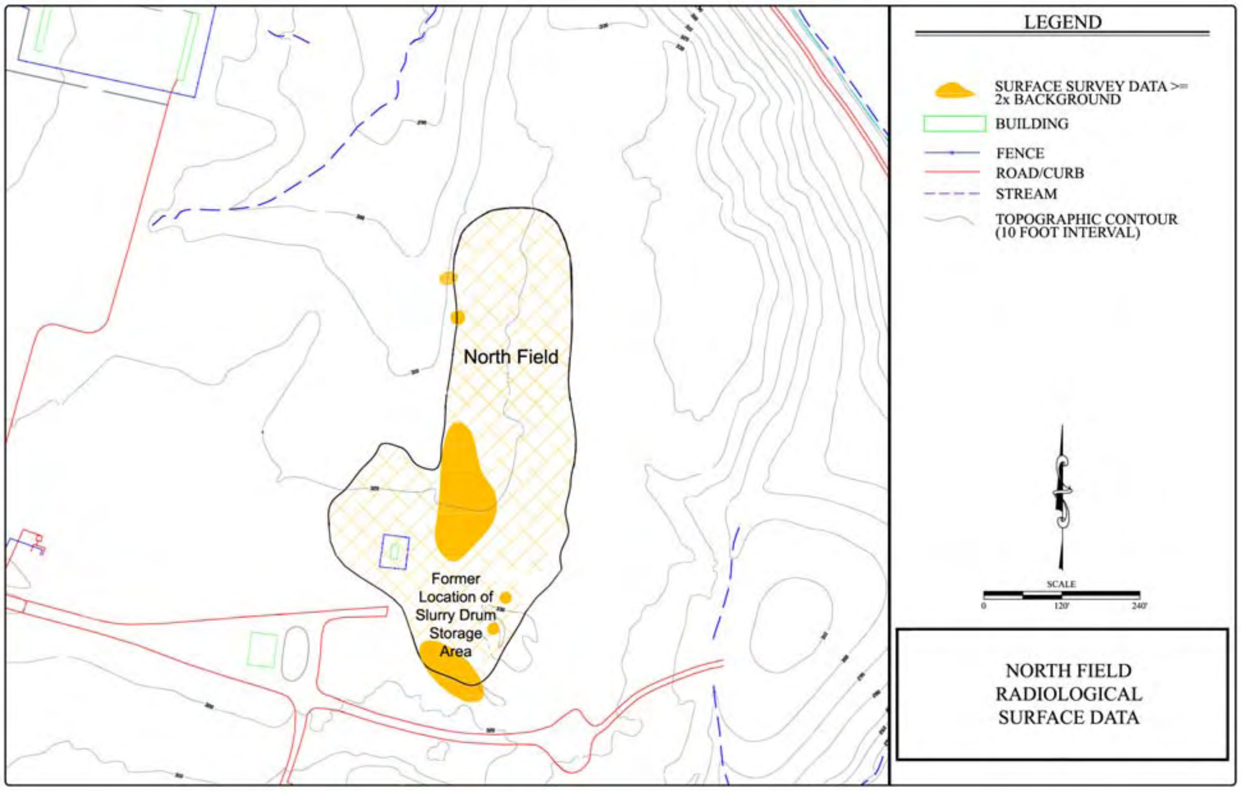


Figure 9-3. Slurry Drum Storage Area Surface Radiological Contamination

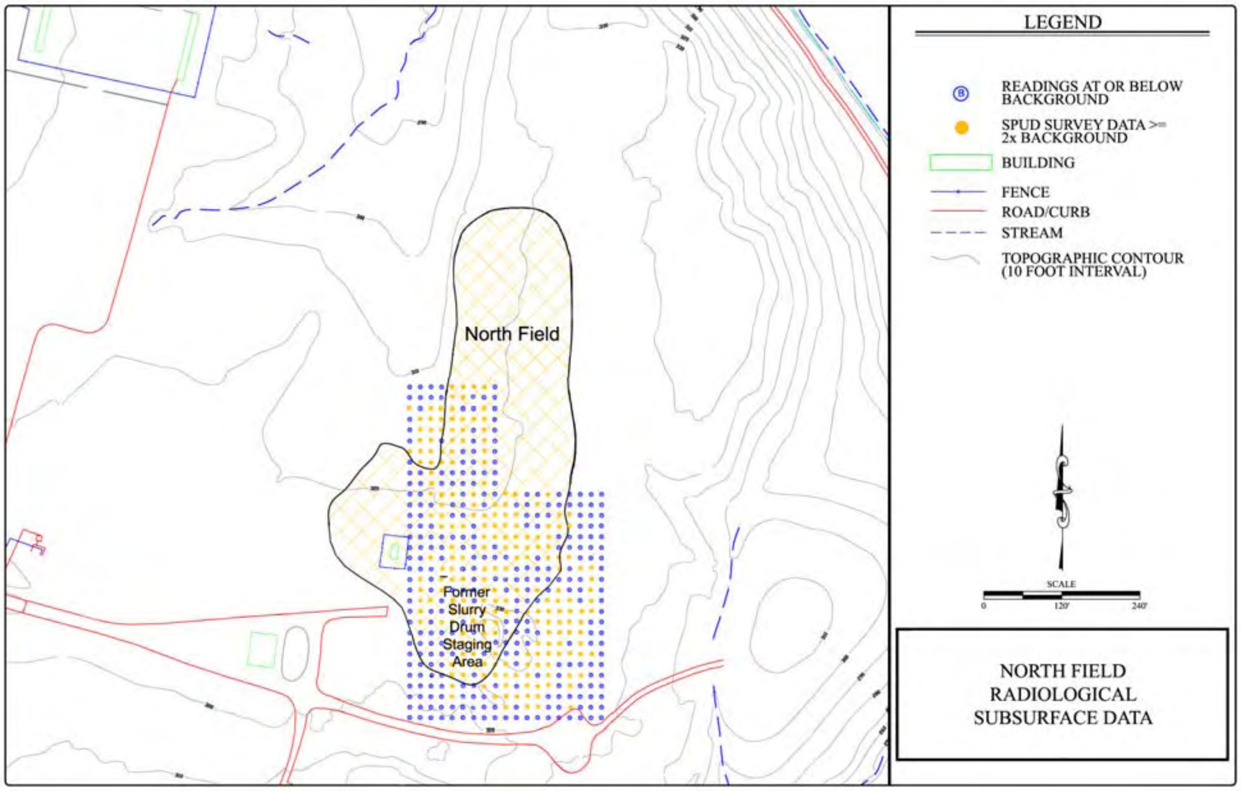


Figure 9-4. Slurry Drum Storage Area Subsurface Radiological Contamination

As described in subsection 9.1, Slurry Drum Storage Area contamination migrated outside of the staging area berm walls before they were bulldozed in 1955. Surface soil samples collected from the area in 1955 indicated impacts within a 12-foot-wide area extending 100 feet north of the Slurry Drum Storage Area (R-000144).

Table 9-1 chronologically summarizes surface and subsurface soil contamination surveys conducted at the Slurry Drum Storage Area to evaluate the volume of radioactively contaminated soil.

Table 9-1. Slurry Drum Storage Area Soil Survey History

Date	Survey Type	Data Summary
1950-1957	Surface	On-contact drum readings ranged from 1 R/hr to 30 R/hr. Estimated disturbed soil contamination was 30 mCi of fission products (C-000193).
1955	Soil	Before drum removal and run-off bed cleanup, surface soil samples ranged from 50 pCi/g at 60 feet from the Slurry Drum Storage Area to 2,350 pCi/g at 10 feet from the Slurry Drum Storage Area. Subsequent soil column samples from the perimeter and entrance to the Slurry Drum Storage Area showed activity levels less than 50 pCi/g. One sample was collected from the center of the area, with results of 670 pCi/g at zero to 1-inch depth, 70 pCi/g at 2 to 10 inch depth, and 30 pCi/g at 10 to 19 inch depth (R-000144).
1957	Surface	Reading near a partially buried fence post showed 2,000 cpm beta-alpha (R-000144).
1960	Soil	Three locations were sampled and readings ranged from 200 to 1,200 cpm (R-000144).
1963	Soil	4,590 cubic feet of contaminated soil were removed from the Slurry Drum Storage Area. Of the 4,590 cubic feet of soil, 3,400 cubic feet were handled as low level contaminated soil (stored in the J4 Sand Filter Beds) and the remaining 1,190 cubic feet were handled as higher level contaminated soil (shipped off site for disposal). Soil dose rates were as high as 250 mR/hr (C-000193).
1966	Soil	648 cubic feet of soil were excavated, placed in steel boxes, and shipped off site for disposal (R-000144). Soil

Date	Survey Type	Data Summary
		sample results ranged from 18.5 to 690,000 pCi of Cs-137. A rough estimate of 1,100 pCi/g of Cs-137 was made (C-000193). Results of samples from the bottom of the excavation were 630 to 1,000 pCi/g of Cs-137. Results for the walls were between 1,000 and 1,900 pCi/g of Cs-137 (R-000144).
1977	Soil	Eight soil samples were collected and analyzed for Cs-137 at various depths in the approximate area of the Slurry Drum Storage Area, south of the access road. Cs-137 activity ranged from 225 to 620 pCi/g at 1 foot below grade, 100 pCi/g at 2 feet, 69 pCi/g at 3 feet, from 7.9 to 10,000 pCi/g at 4 feet, from 16 to 50 pCi/g at 5 feet, and from 4.5 to 450 pCi/g at 6 feet below ground surface. Two soil samples were collected and analyzed for Cs-137 at various depths in the suspected area of the Slurry Drum Storage Area north of the access road. Cs-137 activity ranged from 592 to 5,000 pCi/g at 1 foot below grade, 344 pCi/g at 2 feet, and from 21 to 40 pCi/g at 6 feet below ground surface. Five samples were collected north of the suspected Slurry Drum Storage Area. These samples showed Cs-137 activity at 1.7 to 9.7 pCi/g at zero to 5 feet below ground surface (R-000144).
1977	Soil	Approximately 11,670 cubic feet of soil were excavated and transported for off-site disposal (R-000144, C-000193).
1978	Soil	Remedial action at the Slurry Drum Storage Area included excavating and transporting approximately 16,910 cubic feet of soil for off-site disposal (C-000193).
1978	Surface	In order to determine Slurry Drum Storage Area boundaries, three trenches approximately 55 feet long encompassed both sides of the access road. Elevated scintillation detector readings were observed in western and southern portions of the test pit area (R-000144).
1981	Surface and Subsurface	Of 21,500 square meters surveyed in 1981, 3,700 cubic meters showed general or sporadic surface activity exceeding 20 pCi/g of Cs-137 (R-000150).
1985	Surface and Subsurface	Approximately 3000 square meters near the Slurry Drum Storage Area (and Red Pines) were surveyed (C-000189). Of the 3,000 square meters, 10 square meters, and approximately 3 cubic meters showed Cs-137 levels above the background level of 130 pCi/g. A maximum Cs-137 reading of 719 pCi/g was observed. Sr-90 laboratory results were less than 0.4 pCi/g (R-000179).
1988	Geophysical	A geophysical survey in the vicinity of the Slurry Drum Storage Area (and a former landfill) indicated that conductivity and magnetic field variations observed were likely general debris and not buried metal (R-000194).
1988	Surface	Approximately 1,200 square meters in the run-off area registered activity between 300 and 500 cpm and 1 square meter indicated a value of 1,200 cpm. There were no indications of Cs-137 surface contamination above the 20 pCi/g background level west of the Slurry Drum Storage Area (C-000199).

9.2.2 GROUNDWATER RADIOACTIVE CONTAMINATION

SPRU groundwater wells in the North Field are shown in Figure 9-5. KAPL environmental monitoring reports from 1987 through 2001 (R-002187 through R-002201) contain sampling results for beta/gamma, alpha, strontium-90, cesium-137, and tritium. This well data is provided in Appendix B.

The overall conclusion of the groundwater monitoring program is that previous operations and waste disposal practices have resulted in some small, although measurable, effects on the groundwater quality in localized areas of the Knolls Site (R-002201).

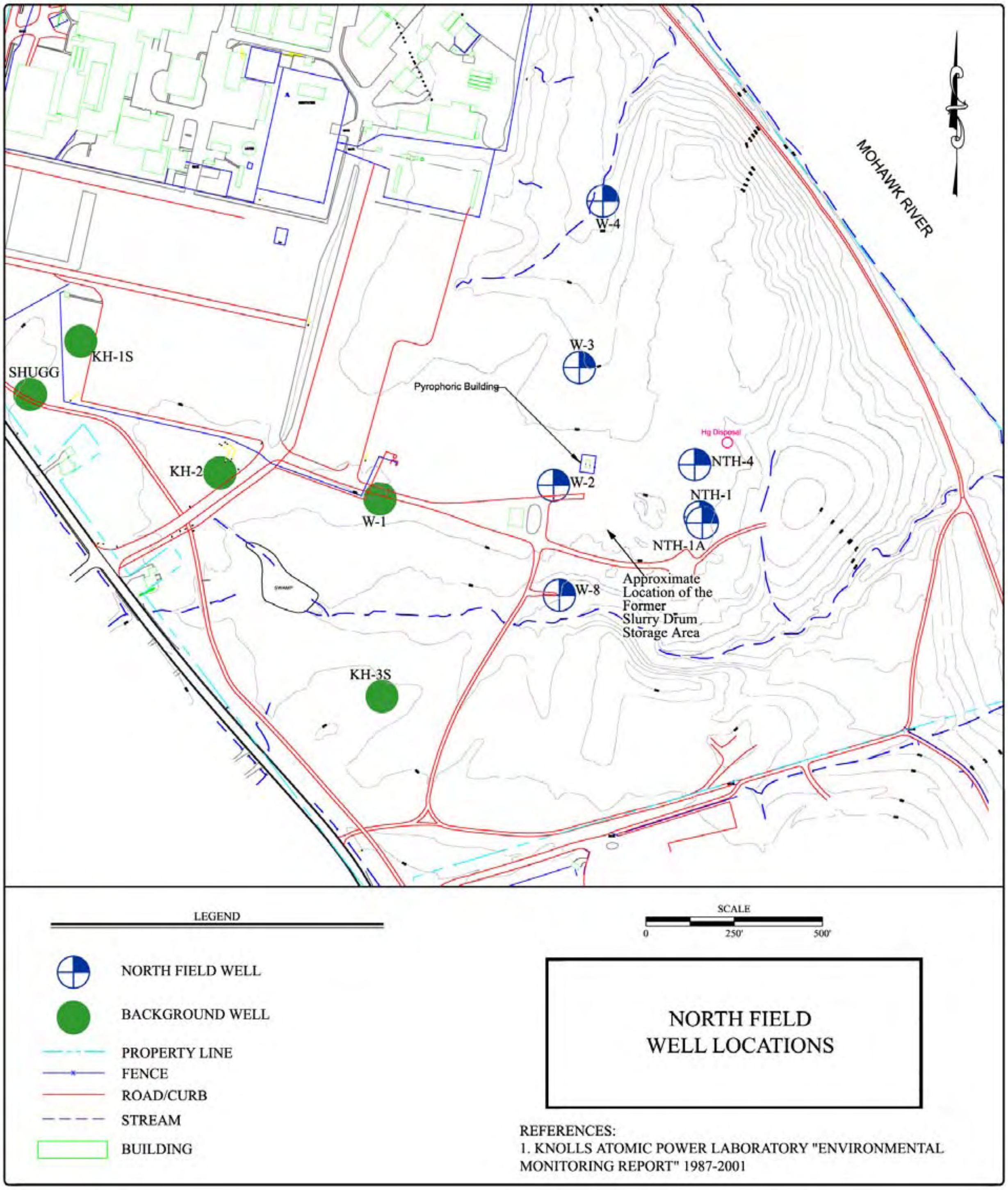


Figure 9-5. North Field Well Locations

9.2.3 CHEMICAL CONTAMINATION

In 1998, heavy metals and other unknown constituents were identified for further investigation in the Slurry Drum Storage Area (R-001546).

A subsequent investigation (circa 2000 – 2001) identified slightly elevated heavy metals such as antimony, arsenic, and cobalt. It was determined that no hazardous constituent releases were attributable to SPRU operations (R-000541). The Slurry Drum Storage Area (SWMU 035) was proposed for no further action (R-000506).

9.3 Findings

Data Gaps

North Field groundwater monitoring is performed annually in designated wells. However, existing wells do not necessarily provide adequate groundwater information; additional wells and monitoring may be necessary to fully characterize area groundwater (R-002171).

Impacted or Non-impacted

MARSSIM defines impacted areas as those areas with a reasonable possibility of containing residual radioactivity in excess of natural background or fallout level (MARSSIM Glossary, G-10). Applying this definition, the soil in the Slurry Drum Storage Area has been identified as containing residual radioactivity in excess of natural background or fallout levels, and as such, is considered impacted.

Although some wells exceeded background levels of radioactivity, no levels exceeded 0.1 percent of the DOE derived concentration guide (DOE, 1993). The estimated dose to the population within 50 miles of KAPL was less than 0.001 percent of the natural background radiation dose (R-002187 through R-002201).

Sources of Contamination

Radiological contamination in the Slurry Drum Storage Area was associated with SPRU and non-SPRU KAPL activities. The historic record indicates that radiological contamination in the area originated from temporarily stored 55-gallon drums containing evaporate slurry (R-000144, C-000193). It was reported that prior to 1955, contamination migrated outside of the Slurry Drum Storage Area earthen berm walls during heavy rain events with surface run-off flowing north. A 1955 survey indicated that a 12-foot wide area extending 100 feet north of the Slurry Drum Storage Area (R-000144) was impacted. Excavation activities removed the radiological soil associated with the Slurry Drum Storage Area run-off area, but subsequent soil survey results indicate that cesium-137 above background levels remains.

Likelihood of Contamination Migration

Groundwater monitoring data collected and presented in the KAPL 1987 through 2001 environmental monitoring reports indicate that groundwater radiological contamination is not at potential impact levels. Groundwater at the KAPL site is contained in a perched aquifer composed of impermeable glacial tills and of limited extent and quantity. There is no historical evidence of contamination migration off the KAPL site.

Threat to Human Health

The Slurry Drum Storage Area has radiological soil and groundwater impacts. However, these areas are not accessible to the public. Some areas are vegetated, which decreases potential wind and water erosion. KAPL cooperates with regulators, including the NYSDEC and the EPA Region II, to monitor potential public health concerns.

The EPA Region II KAPL fact sheet states “no imminent danger to human health or the environment has been identified. The on-going routine monitoring programs undertaken by KAPL, in addition to the corrective action programs, are designed to alert KAPL and the NYSDEC of any health or environmental risks” (R-000430). On-site workers are protected through health and safety training and monitoring.

Further Characterization Needs

As of 2001, radiological impacts to the North Field had not been fully characterized. A more comprehensive survey may be necessary because several radiological surveys indicate that the area was impacted (R-002171).

Conditions after 2001 are addressed in the *Task IV RCRA Facility Investigation Report for Groundwater Upper and Lower Levels SPRU Project, Revision 2* (R-002220) and the *Radiological Characterization Report for SPRU Outside Areas Separations Process Research Unit Project, Revision 2* (R-002222).

Appendix A– List of References

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Appendix B – Groundwater Well Monitoring Data from 1987 – 2001 KAPL Environmental Monitoring Reports for Upper Level, Lower Level, and North Field

(R-002187 through R-002201)

Upper Level		Radioactivity Concentration						
Well	**Year**	**Gross beta**	**Alpha**	**Sr-90**	**Cs-137**	**(Units)***	**H-3**	**(Units)**
B-5	1987	3.5	2.7	<0.27	<1.0	10^{-9} μ/Ci/ml	No data	—
	1988	8.3	2.6	<0.18	<1.0		5.3	10^{-7} μCi/ml
	1989	8.0	<7.0	<0.7	<0.98		<2.2	
	1990	6.4	<7.0	<0.8	<0.94		<3.8	
	1991	2.2	1.8	0.3	<0.46		<1.7	
	1992	4.6	1.8	0.2	<0.64		<1.0	
	1993	5.2	1.3	<0.2	<0.6		<0.9	
	1994	6.0	0.8	0.3	<0.7		<0.9	
	1995	39.8	2.8	0.4	<0.5		<1.5	
	1996	11.1	1.9	0.4	<1.3		<1.5	
	1997	17.7	1.6	<0.2	<1.1		<1.4	
	1998	8.2	1.4	<0.2	<0.9	pCi/L	<1.5	10^{2}pCi/L
	1999	2.4	1.2	<0.2	<0.7		<1.4	
	2000	<6.9	1.7	<0.4	<0.6		<2.4	
	2001	8.2	<18.5	<0.6	<0.8		<2.5	
B-6	1987	5.1	4.4	<0.22	<1.0	10^{-9} μ/Ci/ml	No data	10^{-7} μCi/ml
	1988	5.3	2.3	<0.30	<1.1		<2.6	
	1989	5.7	<5.0	1.9	<1.0		<2.2	
	1990	9.4	<6.0	<0.7	<1.0		<3.8	
	1991	5.9	5.3	0.2	<0.49		<1.7	
	1992	9.9	3.2	<0.3	<0.66		<1.0	
	1993	15.3	2.8	0.3	<0.7		<0.9	
	1994	11.8	2.8	0.5	<0.7		<0.9	
	1995	12.6	0.8	0.4	<0.5		<1.5	
	1996	11.3	0.4	0.3	<1.3		<1.5	
	1997	10.0	7.6	0.3	<1.0		<1.4	
	1998	8.8	3.4	<0.2	<0.9	pCi/L	<1.5	10^{2}pCi/L
	1999	7.6	4.1	0.3	<1.0		<1.4	
	2000	<6.7	2.9	<0.4	<0.6		<2.4	
	2001	7.3	<7.2	<0.5	<0.8		<2.5	
B-7	1987	5.6	2.2	<0.4	<1.0	10^{-9} μ/Ci/ml	No data	—
	1988	11.1	2.5	<0.27	<1.0		<2.6	10^{-7} μCi/ml
	1989	13	<7.0	<0.5	<0.9		<2.2	
	1990							
	1991							
	1992							
	1993							
	1994							
	1995							
	1996							
	1997							
	1998	7.6	1.6	<0.3	<1.0	pCi/L	<1.5	10^{2}pCi/L
	1999	5.5	1.4	0.2	<0.8		<1.4	
	2000	8.4	1.3	<0.4	<0.6		<2.4	
	2001	7.6	<10.5	<0.7	<1.0		<2.5	

Upper Level		**Radioactivity Concentration**						
Well	**Year**	**Gross beta**	**Alpha**	**Sr-90**	**Cs-137**	**(Units)***	**H-3**	**(Units)**
B-8	1987	4.1	3.7	<0.13	<1.0	10^{-9} μ/Ci/ml		
	1988	6.1	3.2	0.37	<1.1		<2.6	10^{-7} μCi/ml
	1989	13	<5.0	<0.6	<1.0		<2.2	
	1990	7.3	<8.0	<1.0	<0.98		<3.8	
	1991	4.1	1.6	<0.2	<0.46		<1.7	
	1992							
	1993							
	1994							
	1995							
	1996							
	1997							
	1998							
	1999							
	2000							
	2001							
B-9	1987	4.8	2.8	<0.16	<1.0	10^{-9} μ/Ci/ml		
	1988	5.4	2.3	<0.24	<1.0		<2.6	10^{-7} μCi/ml
	1989	14	<3.0	<1.0	<0.93		<2.2	
	1990							
	1991							
	1992							
	1993							
	1994							
	1995							
	1996							
	1997							
	1998							
	1999							
	2000							
	2001							
B-11	1987	7.6	3.6	<0.32	<1.0	10^{-9} μ/Ci/ml		
	1988	6.3	1.5	<0.23	<1.0		<2.6	10^{-7} μCi/ml
	1989	8.4	<5.0	<0.5	<1.0		<2.2	
	1990							
	1991							
	1992							
	1993							
	1994							
	1995							
	1996							
	1997							
	1998							
	1999							
	2000							
	2001							

Upper Level		**Radioactivity Concentration**						
Well	**Year**	**Gross beta**	**Alpha**	**Sr-90**	**Cs-137**	**(Units)***	**H-3**	**(Units)**
B-14	1987							
	1988							
	1989	18	<5.0	<0.6	<0.94	10^{-9} µ/Ci/ml	<2.2	10^{-7} µCi/ml
	1990	11	<7.0	<0.9	<0.98		<3.8	
	1991	5.4	1.9	0.3	<0.50		<1.7	
	1992							
	1993							
	1994							
	1995							
	1996							
	1997							
	1998							
	1999							
	2000							
	2001							
B-15	1987	13.4	4.2	1.12	<1.1	10^{-9} µ/Ci/ml		
	1988	12.4	4.9	2.51	<1.0		5.8	10^{-7} µCi/ml
	1989	34	<5.0	4.8	<0.95		<2.2	
	1990	2.4	<9.0	<1.0	<1.0		<3.8	
	1991	14.8	3.0	2.6	<0.52		<1.7	
	1992	22.9	4.2	2.3	<0.65		<1.0	
	1993	14.4	2.4	2.4	<0.7		<0.9	
	1994	18.2	3.1	2.3	<0.7		<0.9	
	1995	24.1	3.3	2.5	<0.5		<1.5	
	1996	25.5	2.8	2.6	<1.3		<1.5	
	1997	24.3	2.8	3.6	<1.0		<1.4	
	1998	21.3	2.7	2.9	<1.0	pCi/L	<1.5	10^{2}pCi/L
	1999	16.6	2.1	2.5	<1.0		<1.4	
	2000	18.6	1.5	2.1	<0.7		<2.4	
	2001	17.0	<14.5	4.0	<0.8		<2.5	
B-16	1987	4.1	2.5	<0.19	<1.0	10^{-9} µ/Ci/ml		
	1988	8.7	6.6	<0.25	<1.1		<2.6	10^{-7} µCi/ml
	1989	11	<4.0	<0.6	<1.0		<2.2	
	1990	4.4	<4.0	<0.6	<0.96		<3.8	
	1991	3.2	2.6	<0.2	<0.47		<1.7	
	1992	6.2	2.5	<0.3	<0.69		<1.0	
	1993	5.7	2.5	<0.2	<0.7		<0.9	
	1994	4.4	3.1	0.9	<0.7		<0.9	
	1995	2.8	2.2	0.2	<0.6		<1.5	
	1996	5.4	3.0	0.9	<1.3		<1.5	
	1997	4.1	3.1	<0.2	<1.0		<1.4	
	1998	4.2	3.6	<0.2	<1.0	pCi/L	<1.4	10^{2}pCi/L
	1999	2.9	2.0	<0.2	<1.0		<1.4	
	2000	4.0	2.6	<0.4	<0.6		<2.4	
	2001	<2.4	<4.8	<0.5	<1.0		<2.5	

Upper Level		Radioactivity Concentration						
Well	**Year**	**Gross beta**	**Alpha**	**Sr-90**	**Cs-137**	**(Units)***	**H-3**	**(Units)**
B-26	1987	2.2	1.3	<0.24	<1.0	10^{-9} μ/Ci/ml		
	1988	8.2	3.7	0.27	<1.0		<2.6	10^{-7} μCi/ml
	1989	4.7	<3.0	<0.7	<0.98		<2.2	
	1990	<4.0	<3.0	<0.9	<0.95		<3.8	
	1991	3.0	1.3	<0.2	<0.47		<1.7	
	1992	5.9	1.3	<0.2	<0.65		<1.0	
	1993	3.1	0.7	<0.2	<0.6		<0.9	
	1994	3.3	0.9	0.3	<0.7		<0.9	
	1995	3.8	1.4	<0.2	<0.5		<1.4	
	1996	5.3	1.4	<0.2	<1.3		<1.5	
	1997	4.5	2.2	<0.2	<1.0		<1.5	
	1998	5.3	1.4	<0.2	<1.0	pCi/L	<1.4	10^{2}pCi/L
	1999	2.6	1.7	<0.2	<0.8		<1.4	
	2000	3.5	2.9	<0.4	<0.6		<2.4	
	2001	3.1	<5.1	<0.6	<1.0		<2.5	
KH-15	1987							
	1988							
	1989							
	1990							
	1991							
	1992	3.8	2.3	0.4	<0.65	10^{-9} μ/Ci/ml	<1.0	10^{-7} μCi/ml
	1993	2.6	0.3	<0.2	<0.6		<0.9	
	1994	2.7	0.7	0.3	<0.8		<0.9	
	1995	2.6	0.4	<0.2	<0.5		<1.4	
	1996	3.7	0.4	0.2	<1.1		<1.5	
	1997	4.0	1.0	<0.2	<1.0		<1.5	
	1998	4.0	1.5	<0.2	<0.9	pCi/L	<1.4	10^{2}pCi/L
	1999	4.0	2.0	<0.2	<0.8		<1.4	
	2000	5.8	2.0	<0.4	<0.6		<2.4	
	2001	5.0	<3.0	<0.7	<1.0		<2.5	
KH-16	1987							
	1988							
	1989							
	1990							
	1991							
	1992	6.9	3.9	<0.2	<0.57	10^{-9} μ/Ci/ml	<1.0	10^{-7} μCi/ml
	1993	5.6	2.5	<0.2	<0.7		<0.9	
	1994	2.0	2.2	<0.2	<0.7		<0.9	
	1995	4.6	2.8	<0.2	<0.6		<1.4	
	1996	4.5	2.7	<0.2	<1.1		<1.5	
	1997	3.9	2.9	<0.2	<1.0		<1.5	
	1998	4.6	3.0	<0.6	<1.0	pCi/L	<1.5	10^{2}pCi/L
	1999	4.8	3.6	<0.2	<1.0		<1.4	
	2000	5.4	3.3	<0.4	<0.6		<2.4	
	2001	5.6	<5.9	<0.6	<0.8		<2.5	

Upper Level		**Radioactivity Concentration**						
Well	**Year**	**Gross beta**	**Alpha**	**Sr-90**	**Cs-137**	**(Units)***	**H-3**	**(Units)**
KH-17	1987							
	1988							
	1989							
	1990							
	1991							
	1992	2.3	1.7	<0.2	<0.62	10^{-9} μ/Ci/ml	<1.0	10^{-7} μCi/ml
	1993	2.9	1.6	<0.2	<0.7		<2.2	
	1994	<1.7	1.0	0.2	<0.7		<1.0	
	1995	2.3	1.6	<0.2	<0.5		<1.5	
	1996	2.8	1.6	<0.2	<1.2		5.3	
	1997	2.3	1.1	<0.2	<1.0		<1.4	
	1998	2.4	0.4	<0.2	<0.7	pCi/L	40.6	10^{2}pCi/L
	1999	<1.3	1.9	<0.2	<0.8		15.5	
	2000	<2.6	1.2	<0.4	<0.6		9.5	
	2001	4.5	<4.1	<0.6	<1.0		7.7	

*10^{-9} μ/Ci/ml and pCi/L are equivalent measurements

NOTE: Blank cells indicate no data available.

Lower Level		Radioactivity Concentration						
Well	**Year**	**Gross beta**	**Alpha**	**Sr-90**	**Cs-137**	**(Units)***	**H-3**	**(Units)**
KH-18	1987							
	1988							
	1989							
	1990							
	1991							
	1992	9.7	3.2	0.4	<0.61	10^{-9} μ/Ci/ml	<1.0	10^{-7} μCi/ml
	1993	9.5	2.9	<0.3	<0.8		<0.9	
	1994	<1.8	1.6	0.6	<0.7		<0.9	
	1995	11.0	6.5	0.6	Inadequate sample volume		<1.5	
	1996	9.8	2.2	0.7	<1.1		<1.5	
	1997	7.5	2.1	0.6	<1.0		<1.5	
	1998	8.5	1.8	0.3	<0.9	pCi/L	<1.5	10^{2}pCi/L
	1999	6.5	1.8	0.4	<1.0		<1.4	
	2000	6.9	2.2	<0.5	<0.6		<2.4	
	2001	7.3	7.9	<0.7	<0.8		<2.5	
KH-19	1987							
	1988							
	1989							
	1990							
	1991							
	1992	4.9	3.0	<0.2	<0.67	10^{-9} μ/Ci/ml	<1.0	10^{-7} μCi/ml
	1993	4.1	4.2	<0.2	<0.7		<0.9	
	1994	<1.7	1.2	<0.2	<0.6		<0.9	
	1995	3.5	1.4	<0.2	<0.5		<1.5	
	1996	3.9	1.3	<0.2	<1.0		<1.5	
	1997	4.1	0.5	<0.2	<1.0		<1.5	
	1998	2.8	0.5	<0.2	<1.0	pCi/L	<1.5	10^{2}pCi/L
	1999	3.0	1.2	<0.2	<0.8		<1.4	
	2000	<2.6	0.9	<0.4	<0.7		<2.4	
	2001	4.2	<5.3	<0.6	<1.0		<2.5	
KH-20	1987							
	1988							
	1989							
	1990							
	1991							
	1992	7.3	0.2	0.2	<0.64	10^{-9} μ/Ci/ml	<1.0	10^{-7} μCi/ml
	1993	9.2	<0.1	0.2	<0.7		<0.9	
	1994	6.2	<0.1	0.8	<0.7		<0.9	
	1995	4.2	1.0	<0.2	<0.5		<1.5	
	1996	4.0	0.7	<0.2	<1.0		<1.5	
	1997	7.9	<0.1	0.3	<1.0		<1.5	
	1998	5.0	<0.2	<0.2	<0.9	pCi/L	<1.5	10^{2}pCi/L
	1999	6.2	0.1	<0.2	<0.8		<1.4	
	2000	<7.0	0.2	<0.4	<0.7		<2.4	
	2001	6.9	<14.8	<0.7	<0.8		<2.5	

Lower Level		Radioactivity Concentration						
Well	**Year**	**Gross beta**	**Alpha**	**Sr-90**	**Cs-137**	**(Units)***	**H-3**	**(Units)**
KH-21	1987							
	1988							
	1989							
	1990							
	1991							
	1992	51.0	4.3	17.4	<0.65	10^{-9} μ/Ci/ml	<1.0	10^{-7} μCi/ml
	1993	55.2	3.3	20.3	<0.7		<0.9	
	1994	34.7	3.3	17.8	<0.7		<0.9	
	1995	41.2	2.2	9.8	<0.5		<1.4	
	1996	24.5	1.6	9.3	<1.1		<1.5	
	1997	28.6	3.0	9.6	<1.0		<1.5	
	1998	28.6	1.5	10.2	<0.9	pCi/L	<1.4	10^{2}pCi/L
	1999	42.3	4.4	17.5	<1.0		<1.4	
	2000	33.1	2.6	10.1	<0.6		<2.4	
	2001	31.1	<4.5	9.4	<1.0		<2.5	
KH-22	1987							
	1988							
	1989							
	1990							
	1991							
	1992	5.4	1.1	0.8	<0.69	10^{-9} μ/Ci/ml	<1.0	10^{-7} μCi/ml
	1993	6.2	0.5	0.7	<0.6		<0.9	
	1994	3.4	0.9	0.9	<0.7		<0.9	
	1995	6.3	1.4	0.7	<0.5		<1.4	
	1996	6.6	1.4	1.0	<1.1		<1.5	
	1997	3.5	0.9	0.6	<1.0		<1.5	
	1998	4.9	1.3	0.6	<0.9	pCi/L	<1.4	10^{2}pCi/L
	1999	4.8	1.5	1.0	<0.8		<1.4	
	2000	2.6	0.6	<0.4	<0.6		<2.4	
	2001	2.1	<2.2	<0.5	<0.8		<2.5	
KH-23	1987							
	1988							
	1989							
	1990							
	1991							
	1992	6.9	0.2	0.2	<0.66	10^{-9} μ/Ci/ml	<1.0	10^{-7} μCi/ml
	1993	9.0	0.3	<0.2	<0.6		<0.9	
	1994	6.4	0.3	0.3	<0.7		<0.9	
	1995	8.5	0.3	0.3	<0.5		<1.4	
	1996	6.1	0.2	<0.1	<1.0		<1.5	
	1997	4.9	0.3	0.6	<1.0		<1.5	
	1998	6.1	0.2	<0.3	<1.0	pCi/L	<1.4	10^{2}pCi/L
	1999	5.9	0.3	<0.2	<1.0		<1.4	
	2000	5.6	0.6	<0.5	<0.6		<2.4	
	2001	7.8	4.3	<0.9	<1.0		<2.5	

*10^{-9} μ/Ci/ml and pCi/L are equivalent measurements

NOTE: Blank cells indicate no data available.

North Field		**Radioactivity Concentration**						
Well	**Year**	**Gross beta**	**Alpha**	**Sr-90**	**Cs-137**	**(Units)***	**H-3**	**(Units)**
W-2	1987	15.9	2.5	<0.32	<1.0	10^{-9} μ/Ci/ml		
	1988	7.6	1.6	<0.27	<1.0		<2.6	10^{-7} μCi/ml
	1989	13.0	<5.0	<0.6	<1.0		<1.9	
	1990	8.0	<3.0	<0.6	<0.89		<1.8	
	1991							
	1992	5.6	0.6	<0.2	<0.61	10^{-9} μ/Ci/ml	<1.0	10^{-7} μCi/ml
	1993	7.3	0.6	<0.5	<0.7		<0.7	
	1994	5.4	0.9	<0.2	<0.7		<0.9	
	1995	4.4	1.1	<0.2	<0.7		<1.4	
	1996	2.9	1.0	<0.3	<1.1		<1.5	
	1997	6.1	1.4	<0.2	<1.0		<1.4	
	1998	4.6	0.8	<0.2	<1.0	pCi/L	<1.4	10^{2}pCi/L
	1999	4.8	0.7	<0.2	<0.8		<1.4	
	2000	5.2	0.8	<0.7	<0.8		<2.4	
	2001	6.9	<4.4	<0.6	<1.0		<2.5	
W-3	1987	20.9	1.7	2.90	<1.0	10^{-9} μ/Ci/ml		
	1988	9.2	1.4	0.57	<1.0		<2.6	10^{-7} μCi/ml
	1989	15	<4.0	1.0	<1.0		<1.9	
	1990	<3.0	<2.0	<1.0	<0.84		<1.8	
	1991							
	1992	6.0	0.6	0.3	<0.70		<1.0	
	1993	7.7	0.4	0.7	<0.7		<0.7	
	1994	3.3	0.4	0.7	<0.7		<0.9	
	1995	5.5	0.9	0.4	<0.7		<1.4	
	1996	6.7	0.5	0.4	<1.1		<1.5	
	1997	5.7	1.0	0.5	<1.0		<1.5	
	1998	4.2	0.3	<0.2	<1.0	pCi/L	<1.4	10^{2}pCi/L
	1999	3.8	0.2	<0.2	<1.0		<1.4	
	2000	5.1	0.7	<0.6	<0.8		<2.4	
	2001	4.0	<4.7	<0.6	<0.8		<2.5	
W-4	1987	6.9	2.2	<0.27	<1.0	10^{-9} μ/Ci/ml		
	1988	4.4	1.1	<0.32	<1.1		<2.6	10^{-7} μCi/ml
	1989	4.4	<3.0	<0.6	<0.99		<1.9	
	1990	5.2	<2.0	<1.0	<0.99		<3.8	
	1991	3.5	0.7	0.2	<0.51		<1.7	
	1992	3.0	0.4	<0.3	<0.69		<1.0	
	1993	2.5	0.2	<0.5	<0.7		<0.7	
	1994	2.5	0.6	0.3	<0.7		<0.9	
	1995	3.2	0.5	<0.2	<0.8		<1.4	
	1996	1.8	0.4	0.3	<1.1		<1.5	
	1997	2.0	0.6	<0.2	<1.0		<1.5	
	1998	<1.0	0.4	<0.2	<0.9	pCi/L	<1.4	10^{2}pCi/L
	1999	3.3	0.3	<0.2	<0.8		<1.4	
	2000	<2.5	0.5	<0.7	<0.8		<2.4	
	2001	3.4	<4.7	<0.5	<1.0		<2.5	

North Field		Radioactivity Concentration						
Well	**Year**	**Gross beta**	**Alpha**	**Sr-90**	**Cs-137**	**(Units)***	**H-3**	**(Units)**
W-8	1987	3.7	0.6	<0.30	<1.0	10^{-9} µ/Ci/ml		
	1988	2.9	0.2	<0.30	<1.0		<2.6	10^{-7} µCi/ml
	1989	4.4	<3.0	<0.6	<0.97		<1.9	
	1990	4.0	<2.0	<1.0	<0.94		<3.8	
	1991	3.2	<0.1	<0.2	<0.46		<1.7	
	1992	1.8	<0.2	<0.2	<0.63		<1.0	
	1993	4.2	<0.2	<0.6	<0.7		<0.7	
	1994	3.7	0.1	0.2	<0.7		<0.9	
	1995							
	1996	2.9	0.3	<0.4	<1.1		<1.5	
	1997	2.4	0.2	<0.3	<1.0		<1.5	
	1998	3.2	<0.2	<0.3	<1.0	pCi/L	<1.4	10^{2}pCi/L
	1999	3.9	<0.1	<0.2	<1.0		<1.4	
	2000	3.3	0.7	<0.6	<0.8		<2.4	
	2001	4.2	<2.5	<0.6	<0.8		<2.5	
NTH-1	1987	2.5	0.6	0.27	<1.0	10^{-9} µ/Ci/ml		
	1988	1.7	0.9	<0.22	<1.0		<2.6	10^{-7} µCi/ml
	1989	2.6	<2.0	<0.34	<1.0		<1.9	
	1990							
	1991							
	1992							
	1993							
	1994							
	1995							
	1996							
	1997							
	1998							
	1999							
	2000							
	2001							
NTH-1A	1987							
	1988	3.9	0.5	0.36	<1.1	10^{-9} µ/Ci/ml	<2.3	10^{-7} µCi/ml
	1989	2.3	<2.0	<1.0	<1.0		<2	
	1990	<3.0	<2.0	<1.0	<0.99		<3.8	
	1991	1.1	0.7	0.3	<0.57		<2.2	
	1992	1.6	0.7	<0.2	<0.69		<1.0	
	1993	0.9	0.6	<0.6	<0.7		<0.9	
	1994	2.7	0.7	0.2	<0.8		<1.3	
	1995	2.4	0.9	<0.4	<0.7		<1.5	
	1996	1.5	1.0	<0.3	<1.3		<1.5	
	1997	2.5	0.8	0.6	<1.0		<1.6	
	1998	1.8	1.4	<0.6	<1.0	pCi/L	<1.5	10^{2}pCi/L
	1999	3.1	0.9	<0.2	<0.8		<1.4	
	2000	<2.2	2.3	<0.5	<0.8		<2.4	
	2001	<2.0	<1.1	<0.6	<1.0		<2.4	

North Field		**Radioactivity Concentration**						
Well	**Year**	**Gross beta**	**Alpha**	**Sr-90**	**Cs-137**	**(Units)***	**H-3**	**(Units)**
NTH-4	1987	1.6	1.0	.38	<1.0	10^{-9} μ/Ci/ml		
	1988	2.7	0.3	<0.26	<1.0		<2.6	10^{-7} μCi/ml
	1989	<3.0	<3.0	<1.0	<0.91		<1.9	
	1990							
	1991							
	1992							
	1993							
	1994							
	1995							
	1996							
	1997							
	1998							
	1999							
	2000							
	2001							

*10^{-9} μ/Ci/ml and pCi/L are equivalent measurements

NOTE: Blank cells indicate no data available.