TSM-27

Task IV RCRA Facility Investigation Report for Groundwater Upper and Lower Levels

Separations Process Research Unit Project

Prepared for

U.S. Department of Energy

April 2006

Revision 2

Prepared by

CH2MHILL

Executive Summary

The U.S. Department of Energy (DOE) Office of Assistant Secretary for Environmental Management (EM) has been working closely with the New York State Department of Environmental Conservation (NYSDEC) to evaluate whether any hazardous constituents related to operations of the Separations Process Research Unit (SPRU) at the Knolls Atomic Power Laboratory (KAPL) have been released to the environment. The SPRU is an inactive complex; however, the Knolls Site is a continuing mission site with no anticipated closure. In February 2002 DOE EM submitted, under the KAPL Resource Conservation and Recovery Act (RCRA) Permit (NYSDEC Permit Number 4-4224-00024/00001), the *SPRU Project RCRA Facility Assessment Sampling Visit Report, Separations Process Research Unit Project* (DOE/CH2M HILL, 2002), which was approved by NYSDEC in February 2006 (NYSDEC, 2006a). The report provides results of the Sampling Visit (SV) characterization of the following SPRU Solid Waste Management Units (SWMUs) and Area of Concern (AOC) shown in Figure ES-1.

Area	SWMU/AOC[a]	Relationship to SPRU Process
Upper Level	H2 Processing Facility (SWMU-030)	Former waste and wastewater processing operations
	H2 Tank Farm (SWMU-031)	Former below-ground process separations material and waste storage
	Pipe Tunnel (SWMU-057)	Waste transportation drain lines between Buildings G2 and H2
Lower Level	Former K6 Storage Pad (SWMU-036)	Former aboveground storage of containerized wastes
	Former K7 Storage Pad (SWMU-037)	Former aboveground staging of solid containerized wastes
	Railroad Staging Area (SWMU-038)	Former waste staging and railroad car loading operations area
	K5 Retention Basin (SWMU-040)	Former containment of nonhazardous process wastewater and laundry wastewater
	Lower Level Parking Lot (AOC-003)	Received fill material from the Railroad Staging Area, and Former K6 and K7 Storage Pads
Land Area	Former Slurry Drum Storage Area (SWMU-035)	Former waste storage area for containerized slurry waste

[a] Additional SWMUs are present in each area and are being addressed by KAPL under the Knolls Site Hazardous Waste Management Permit (NYSDEC, 1998).

The SV Report identified specific gaps in the RCRA corrective action characterization involving groundwater in the Upper and Lower Levels, which were evaluated in accordance with the *Task IV RCRA Facility Investigation Work Plan for Groundwater, Upper and Lower Levels* (DOE/CH2M HILL, 2004a) and are addressed in this RCRA Facility Investigation (RFI). Additional characterization was also performed in response to NYSDEC comments on the SV Report, including resampling of monitoring well MW52-4 for semivolatile organic compounds, collection and analysis of additional major ion data, evaluation of antimony in groundwater, and analysis of thallium at a lower detection limit.[1]

This RFI focuses primarily on groundwater and the transfer of contaminants from soil to groundwater in the Upper and Lower Levels. However, soils data collected from newly installed monitoring well soil borings and from previous surface and subsurface soil characterization are included to develop comprehensive conceptual fate and transport models of the Upper and Lower Level areas. Data from previous investigations, including KAPL's Hillside RFI and the SPRU Outside Area radiological characterization, were used to support the description of the hydrogeologic and contaminant transport conditions reported herein. Exposure to groundwater is unlikely because drinking water is supplied to the Knolls Site. There are no current users of groundwater at the Knolls Site, nor are there expected users of groundwater because of the low groundwater yield in the affected areas.

Previous recommendations were made in the NYSDEC-approved SPRU RFA SV Report involving further characterization of the extent of chemicals in soil in the Lower and Upper Levels. It is recommended that this be addressed during a remedial design to be performed in conjunction with the radiological remediation of SPRU facilities and environs. Radiological remediation will likely include a presumptive remedy of soil removal; however, the extent of soil to be removed is currently under evaluation. The need, if any, to further evaluate the extent of chemicals in soil will be determined when the extent of soil to be removed for radiological remediation is established.

[1] Resampling for volatile organic compounds (VOCs) at soil borings B3824 and B3801 and semivolatile organic compounds (SVOCs) at monitoring well MW52-4 in response to NYSDEC comments on the SV Report will be provided to NYSDEC in a separate letter.

Based on the SV results, in the NYSDEC-approved SV Report, DOE EM recommended no further action for the SWMU in the Land Area. Therefore, an RFI is not required for the former SPRU-related operations in the Land Area.[2]

The objectives, conclusions, and recommendations of this RFI are summarized in the following sections.

Summary of Upper Level RFI Objectives, Conclusions, and Recommendations

The Upper Level contains ten SWMUs, seven of which are aboveground tanks inside Building G2 (SWMU-058 through SWMU-064) designated for no further action based on the Preliminary Report-Visual Site Inspection. The remaining three SWMUs were investigated in the RFA SV, and one of them, the H2 Tank Farm (SWMU-031), was recommended for no further action in the NYSDEC-approved SV Report. This RFI addressed data gaps involving the remaining two SWMUs in the Upper Level: the H2 Processing Facility (SWMU-030) and Pipe Tunnel (SWMU-057).

Upper Level Data Gap 1—Source of VOCs in Pipe Tunnel Footing Drains

This data gap involved determining if the VOCs in the SV wells adjacent to the Pipe Tunnel originated from: (1) groundwater migration along the Building G2 footing drain, (2) soils impacted by the loading dock in the northwest corner of Building G2, and/or (3) the VOCs in soil and groundwater between Buildings G2 and H2 identified by KAPL as part of the Hillside Area RFI.

Sample results for groundwater monitoring wells along the western side of Building G2 did not contain VOCs in sufficient concentration to be the source of VOC levels in the SV wells. Further, water levels in wells along the western side of Building G2 did not indicate flow towards the northwest corner of Building G2 and subsequently towards the Pipe Tunnel.

Groundwater was not sampled near the former loading dock at Building G2 because of the presence of a subsurface obstruction believed to be a concrete slab. However, VOCs were present in soil above the obstruction, which was not penetrated.

[2] As part of the RFA SV, DOE EM is conducting an ongoing investigation of chemical releases to soil and groundwater in the Red Pines area, located in the eastern portion of the Land Area. Results from this investigation will be reported to NYSDEC as an addendum to the SPRU RFA SV Report.

A hydraulic condition has been identified that likely allows groundwater between Buildings H2 and G2 to enter the Pipe Tunnel footing drains from KAPL's Hillside investigation area that is impacted by VOCs. This condition complicates determining the specific source of VOCs in the Pipe Tunnel footing drains. However, the SPRU RFA SV, Groundwater RFI, and KAPL's Hillside RFI have provided sufficient data to establish the nature and extent of VOCs between Buildings G2 and H2, including the Pipe Tunnel and in the footing drains.

Upper Level Data Gap 2—Groundwater Flow and Chemistry at the Northwestern Perimeter of Building H2

The objective of this data gap investigation was to determine: (1) the potential impact to groundwater from metals, primarily antimony, along the northwestern portion of Building H2; and (2) if groundwater containing VOCs is flowing away from Building H2 in a manner that allows it to bypass the Hillside Sump groundwater collection system.

Antimony was not detected in the soils from the base elevation of the Building H2 footing drain, or in the groundwater samples from these locations above the laboratory method detections limits. Antimony is, therefore, no longer considered a contaminant of concern.

Groundwater flow directions and the distribution of chemicals in groundwater demonstrate that the hillside drainage system is effectively intercepting VOC-contaminated groundwater from the Building H2 footing drain. The absence of VOCs in most downgradient wells indicates that VOCs are not widespread in shallow groundwater downgradient of Building H2. However, the detection of trace levels of VOCs below the groundwater quality criteria in groundwater monitoring well B-16 in only one of two groundwater RFI sampling events suggests the potential for some VOC migration in the Upper Level Hillside.

Upper Level Recommendations

No additional characterization is recommended to resolve the origin of the VOCs at the Pipe Tunnel because the entire area is adequately characterized to support remedial design.

Analytical results confirm that antimony is not a contaminant of concern at the H2 Processing Facility, and no further characterization is necessary to close this data gap. Groundwater at the northwest corner of Building H2 flows toward the building foundation, where it is intercepted by the footer drain to the Hillside Sump. No further characterization of this pathway is necessary. However, trace detections of VOCs in groundwater from well B-16 cannot rule out release of low concentrations of VOCs from this portion of Building H2.

Summary of Lower Level RFI Objectives, Conclusions, and Recommendations

The Lower Level contains four SWMUs and one AOC. The SWMUs and AOC were investigated during the RFA SV, and two of the SWMUs, the Former K6 Storage Pad (SWMU-036) and the Former K7 Storage Pad (SWMU-037), were recommended for no further action in the NYSDEC-approved SV Report. As recommended in the NYSDEC-approved RFA SV, because of access restrictions, low levels of VOCs detected at the foundation of one SWMU, the K5 Retention Basin (SWMU-040), will be characterized following D&D of the retention basin. This RFI addressed data gaps involving the remaining SWMU, the Railroad Staging Area (SWMU-038), and AOC, the Lower Level Parking Lot (AOC-003), in the Lower Level.

Lower Level Data Gap 1—Impact to Groundwater in Areas of Elevated Metals and VOCs

The objective of this data gap was to determine: (1) if there has been a release to groundwater from metals and VOCs in the soil in the northern portion of the Railroad Staging Area, and (2) if there has been a release to groundwater from elevated metals, VOCs, and SVOCs in the Lower Level Parking Lot fill materials.

VOCs and metals in groundwater at the Railroad Staging Area were not elevated. Groundwater was found at only one drilling location in the Parking Lot, which indicates a general lack of saturated conditions in the Parking Lot fill and low potential for migration. One metal, thallium, was elevated in the Parking Lot groundwater.

Lower Level Recommendations

Based on the results of this RFI, no further action is recommended for groundwater in the Railroad Staging Area because no release of hazardous chemicals from SPRU operations was identified. Saturated conditions are lacking in the Lower Level Parking Lot fill. Because of its physically limited extent, further characterization of the elevated thallium in groundwater is not required. Therefore, no further action is recommended for the Lower Level Parking Lot.

Contents

Appendixes

Tables

Figures

Plates

Acronyms and Abbreviations

AOC	Area of Concern
amsl	above mean sea level
bgs	below ground surface
CB	catch basin
CMS	corrective measures study
DCA	dichloroethane
DCE	dichloroethylene
D&D	decontamination and decommissioning
DJ	estimated concentration in diluted sample
DOE	Department of Energy
DQO	data quality objective
EM	Office of Assistant Secretary for Environmental Management
EM-61	electromagnetic
EPA	Environmental Protection Agency
EP Tox	Extraction Procedure Toxicity
^{o}F	degrees Fahrenheit
J	estimated concentration or laboratory reporting limit
KAPL	Knolls Atomic Power Laboratory
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
MCB	manhole catch basin
MDL	method detection limit
NTU	nephelometric turbidity unit

NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
QAPP	Quality Assurance Project Plan
PAH	polycyclic aromatic hydrocarbon
PCA	tetrachlorethane
PCE	tetrachloroethylene
PID	photoionization detector
ppm	parts per million
PR	Preliminary Review
RCRA	Resource Conservation and Recovery Act
RDP	remedial design parameter
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RPD	relative percent difference
SNR	Schenectady Naval Reactors
SPRU	Separations Process Research Unit
SPUD	Surface Penetrating Underground Detector
SV	Sampling Visit
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCA	trichloroethane
TCE	trichloroethylene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TOC	total organic carbon
VOC	volatile organic compound
VSI	Visual Site Inspection

1. Introduction

The Separations Process Research Unit (SPRU) is an inactive complex, located at the Knolls Atomic Power Laboratory (KAPL) – Knolls Site in Niskayuna, NewYork (see Figure 1-1). Although SPRU is inactive, the Knolls Site is a continuing mission site with no anticipated closure. SPRU was operated by the Materials Production Division of the U.S. Atomic Energy Commission from 1950 to 1953 as a pilot plant for research on chemical processes to extract uranium and plutonium from irradiated natural uranium. These operations potentially contaminated the SPRU facilities and surrounding environmental media, both radioactively and chemically.

A SPRU Resource Conservation and Recovery Act (RCRA) Corrective Actions Permit (DOE, 2004), prepared under the U.S. Environmental Protection Agency Generator ID NYR 000 096 859, is currently under review by the New York State Department of Environmental Conservation (NYSDEC). In accordance with this permit, a RCRA Facility Investigation (RFI) was implemented for Solid Waste Management Units (SWMUs) and an Area of Concern (AOC) associated with the historical SPRU operations. This work was performed in accordance with the *Task IV RCRA Facility Investigation Work Plan for Groundwater, Upper and Lower Areas* (hereafter referred to as the Groundwater RFI Work Plan), which was initially submitted to NYSDEC in draft in April 2004 (DOE/CH2M HILL, 2004a) and approved by NYSDEC in February 2006 (NYSDEC, 2006b). The Groundwater RFI Work Plan describes the techniques and procedures used to characterize contaminant releases to groundwater from the SWMUs and AOC associated with operation of the SPRU within the Knolls Site Upper Level and Lower Level areas.

The Groundwater RFI Work Plan was based on the findings of a RCRA Facility Assessment (RFA) Sampling Visit (SV) Report submitted in February 2002 (DOE/CH2M HILL, 2002) and approved by NYSDEC in February 2006 (NYSDEC, 2006a). The RFA SV Report recommended additional characterization of groundwater to evaluate the nature and extent of chemicals in the Upper Level and Lower Level investigation areas. Some additional soil characterization was also required to determine if the transfer of chemicals in soil to groundwater was occurring. Additional characterization was also performed in response to

NYSDEC comments on the SV Report, including resampling of monitoring well MW52-4 for semivolatile organic compounds (SVOCs) (NYSDEC Comment 10), collection and analysis of additional major ion data (NYSDEC Comment 11), evaluation of antimony (NYSDEC Comment 12), and analysis of thallium at a lower detection limit (NYSDEC Comment 14).[1] Results of the Groundwater RFI, including results of the additional characterization performed in response to NYSDEC comments, are presented in Sections 4 and 5 for the Upper Level and Lower Level, respectively.

1.1 RFI Objective

An objective of this RFI was to characterize the environmental setting and nature and extent of potential chemical releases resulting from historical SPRU operations at the Upper and Lower Level areas, as described in Section 1.2. The resulting data will be used to confirm the site conceptual models and select corrective action alternative(s). To accomplish this objective, data gaps that remain from previous investigations were identified that require further characterization to support development of potential remedial action alternatives. This RFI focuses primarily on groundwater and the transfer of contaminants from soil to groundwater in the Upper and Lower Levels, although soils data collected from newly installed monitoring well soil borings and from previous surface and subsurface soil characterization are included to develop comprehensive conceptual models of the Upper and Lower Level areas. Previous investigations incorporated into this RFI, such as the RFA SV (see Section 1.3.5), focused on characterization of soils at the SPRU SWMUs and AOC.

The data collection effort used a data quality objective approach that evaluates existing data and identifies additional data needed to support development of corrective action alternatives. For each data gap, the type and quality of data required to satisfy that need were also identified, and a specific data collection strategy was developed.

1.2 RFI Background and Overview

As part of the multi-stage RFA process, NYSDEC conducted a Preliminary Review (PR) of KAPL files. The PR was followed by a Visual Site Inspection (VSI) on September 27, 1995

[1] Resampling for volatile organic compounds (VOCs) at soil borings B3824 and B3801 and SVOCs at monitoring well MW52-4 in response to NYSDEC comments on the SV Report will be provided to NYSDEC in a separate letter.

(Phase I); on April 30, 1997 through May 2, 1997 (Phase II); and on January 15, 1998 (Phase III). The PR and VSI identified 15 SWMUs and 1 AOC related to the historical SPRU operations (NYSDEC, 1997). These SWMUs and AOC are listed in Table 1-1 by geographic area within the Knolls Site and are shown in Figures 1-2 through 1-5. As a result of the PR-VSI, NYSDEC determined that there was no evidence of any release from the seven aboveground SPRU tanks inside Building G2 and that no further action was required for these seven SWMUs. However, as a result of the PR-VSI, an SV, the third stage of the RFA process, was required to be conducted for the remaining SPRU SWMUs and AOC.

At the same time that the final PR-VSI Report was issued, a 6 New York Code of Rules and Regulations (NYCRR) Part 373 Hazardous Waste Management Permit (Part 373 Permit) was issued by NYSDEC to the U.S. Department of Energy (DOE) Schenectady Naval Reactors (SNR), owner, and KAPL, Inc., operator, for the Knolls Site (NYSDEC, 1998a). Module III of the KAPL Part 373 Permit specifies the corrective action process to be implemented for the identified SWMUs and AOCs at the Knolls Site, including the 15 SPRU-related SWMUs and 1 AOC. No further action was specified for the seven tank SWMUs inside Building G2 in the Upper Level.

In April 2000 an RFA SV Work Plan for the SPRU SWMUs/AOC was submitted to NYSDEC (KAPL, 2000a) in accordance with the Part 373 Permit and approved by NYSDEC (NYSDEC, 2000). The purpose of the RFA SV, conducted from October 2000 through July 2001, was to assess whether a release of hazardous waste or constituents was occurring or had occurred from eight SWMUs and one AOC associated with historical SPRU operations. Investigation results, along with conclusions and recommendations, were submitted to NYSDEC in the RFA SV Report (DOE/CH2M HILL, 2002); NYSDEC approved the RFA SV Report in February 2006 (NYSDEC, 2006a). The RFA SV Report established no further action was necessary for three SWMUs: Former K6 Storage Pad (SWMU-036), Former K7 Storage Pad (SWMU-037), and Former Slurry Drum Storage Area (SWMU-035). In addition, because of current access limitations (building structure and topography), additional characterization was recommended for the K5 Retention Basin (SWMU-040) following decontamination and decommissioning (D&D) of the structure. The low concentrations (trace levels) of trichloroethylene (TCE) detected in soil at the northeast corner of Building K5 during the SV do not warrant immediate action, and there is no evidence of migration from SWMU-040 in two downgradient monitoring wells. The additional characterization at SWMU-040 will be addressed in an addendum report to NYSDEC.

Additional investigation (i.e., this RFI) was recommended for the remaining four SWMUs (H2 Processing Facility [SWMU-030], H2 Tank Farm (SWMU-031), Pipe Tunnel [SWMU-057], and Railroad Staging Area [SWMU-038]) and AOC (Lower Level Parking Lot [AOC-003]). Further information regarding the RFA SV conclusions and recommendations is provided in Section 1.3.5.

Although the SPRU SWMUs and AOC were initially included in the KAPL Part 373 Permit, the investigation and corrective action at these units is the responsibility of the DOE Office of Assistant Secretary for Environmental Management (DOE EM). The SWMUs and AOC that are the responsibility of DOE EM are shown in blue in Figures 1-3 through 1-5 for the Upper Level, Lower Level, and Land Area, respectively. SNR and KAPL are responsible for the remaining portions of each of the areas, including the adjacent SWMUs shown in gold on Figures 1-3 through 1-5. (Note: Only the SNR/KAPL SWMUs that are adjacent to and/or overlap the SPRU SWMUs and AOC are shown in the figures).

To separate DOE EM's corrective action responsibilities for the SPRU SWMUs and AOC from SNR's ongoing hazardous waste management and corrective action responsibilities at the Knolls Site, DOE EM submitted an application (review pending) for a RCRA Corrective Actions Permit (Generator ID NYR 000 096 859) for the SPRU AOC and SWMUs identified in Table 1-1 to NYSDEC in September 2004 (DOE, 2004). Pursuant to the pending RCRA Corrective Actions Permit, DOE EM submitted a work plan (DOE/CH2M HILL, 2004a) to NYSDEC for an RFI of the following units:

- Upper Level
  - H2 Processing Facility (SWMU-030)
  - Pipe Tunnel (SWMU-057)
- Lower Level
  - Railroad Staging Area (SWMU-038)
  - Lower Level Parking Lot (AOC-003)

Because the NYSDEC-approved RFI SV Report established no further action was necessary for the single SPRU SWMU in the Land Area, an RFI is not required for the former SPRU-related operations in the Land Area[1]. Therefore, this RFI addresses only SPRU SWMUs and an AOC in the Upper and Lower Levels.

The SWMUs and AOC within the Upper and Lower Level RFI areas are shown in Figures 1-3 and 1-4. The RFI was implemented in accordance with the RFI work plan to address the following specific data gaps from the RFA SV involving transfer of chemicals from soil to groundwater.

1. The extent of the VOC impact to groundwater at the Pipe Tunnel (SWMU-057) and the H2 Processing Facility (SWMU-030) in the Upper Level requires further evaluation to determine the source and extent of VOCs in the Pipe Tunnel and to confirm whether there is an additional release from the foundation of Building H2.

   Potential transfer of metals (antimony) from soil to groundwater along the western side of Building H2 also requires further evaluation. Based on the RFA SV conclusions, the scope of this RFI encompasses further characterization to establish the nature and extent of SPRU-related releases to the environment at these two Upper Level SWMUs (H2 Processing Facility and Pipe Tunnel).

2. Low levels of VOCs and elevated metals located in the southeast portion of the Railroad Staging Area and in the Parking Lot require further evaluation to determine the nature and extent of the releases. Based on the RFA SV conclusions, the scope of this RFI encompasses further characterization to establish the nature and extent of SPRU-related releases to the groundwater at the Railroad Staging Area and the Parking Lot.

In addition to evaluating these data gaps, this RFI Report also responds to several NYSDEC comments on the groundwater investigation conducted during the RFA SV, including evaluation of the sitewide distribution of naturally occurring metals in groundwater to determine if elevated concentrations reported in the RFA SV result from natural conditions, SPRU operations, or other industrial operations unrelated to SPRU.

---

[1] As part of the RFA SV, DOE is conducting an ongoing investigation of chemical releases to soil and groundwater in the Red Pines area, located in the eastern portion of the Land Area. Results from this investigation will be reported to NYSDEC as an addendum to the SPRU SV Report.

While the RFA SV and the RFI focused on potential releases of SPRU-related chemical constituents, limited radiological data were also collected during the RFA SV to support offsite shipment of investigation samples and wastes. In addition, an extensive radiological characterization of the three SPRU Outside Areas was performed in conjunction with this RFI and is documented in a separate report (CH2M HILL, 2005). Borehole geologic information and water levels from soil borings and wells installed during the radiological characterization were incorporated into this RFI Report to provide a comprehensive geologic and hydrogeologic description of the Upper and Lower Levels.

1.3 Overview of Previous Investigations

KAPL and SPRU have conducted other investigations in the Upper and Lower Levels of the Knolls Site. Data and monitoring wells from these previous investigations have been used to support the Groundwater RFI and evaluations. A brief overview of each of the previous investigations is provided in the following subsections. Further information from these investigations as it relates to the specific SWMUs and AOC in the Upper and Lower Levels is presented in Sections 4 and 5 of this report.

1.3.1 1952 KAPL Groundwater Conditions at H2 Tank Farm

Four wells (6-inch inside diameter)—one 140-foot-deep bedrock (MW52-2) and three 35-foot-deep overburden wells (MW52-1, MW52-3, and MW52-4)—were installed in 1952 to assess the groundwater conditions near the H2 Tank Farm (Knapp, 1954). One of the wells, MW52-3, is believed to have been removed or abandoned in-place. Geologic information from these wells was used in this RFI to assess the thickness of low permeability tills that serve as a hydrogeologic barrier to downward migration into bedrock.

1.3.2 1973 KAPL Subsurface Assessment of Building H2 and the H2 Tank Farm

Twenty-six soil borings were installed in 1973 to depths ranging from 18.5 to 40 feet below ground surface (bgs) along the perimeter of Building H2 and the H2 Tank Farm to assess radiological conditions in the subsurface (KAPL, 1974). Soil borings were systematically advanced adjacent to Buildings G2 and H2 and included soils adjacent to the footing drain systems. Six of the borings were fully cased to permit use of downhole radiological monitoring equipment around the foundations of Building H2. Cased borings H-20, H-21, H-24, H-26, and H-28 were sampled during the RFA SV to evaluate potential chemical releases from Building H2. Some cased borings were resampled during this RFI to further assess potential releases.

1.3.3 1986 KAPL Groundwater Assessment

In 1986 the B-series of wells was installed to assess groundwater flow direction in the western part of the Upper Level (ERM, 1992). Six of the wells were installed in the immediate vicinity of Building H2 (B-8, B-9, B-14, B-15, B-16, and B-26) and were sampled during the RFA to further assess chemical releases. Several of these wells were sampled again during the RFI.

1.3.4 1991 KAPL Sitewide Hydrogeologic Assessment

The KH series of wells was installed in 1991 as part of the sitewide hydrogeologic assessment of the Knolls Site (ERM, 1992). Several KH series wells are located in each of the SPRU areas and were sampled during the RFA SV and Groundwater RFI investigations.

1.3.5 SPRU RFA SV

The RFA SV was conducted from October 2000 through July 2001 to assess whether a release of hazardous waste or constituents was occurring or had occurred from eight SWMUs and one AOC associated with historical SPRU operations. Chemical data were generally collected from three depth intervals at each boring, with the exception of the Upper Level for which data was collected from additional intervals in the deeper soil borings adjacent to the building foundations. The number of soil borings, general depth of the soil borings, and number of soil samples collected during the RFA SV are as follows:

Area	No. of Borings	General Depth of Borings (ft bgs)	No. of Soil Samples Collected
Upper Level	13	< 30	43
Lower Level	103	0 to 6	250
Land Area	55	0 to 6 or 0 to 10	125

Investigation results, along with conclusions and recommendations, were submitted to NYSDEC in the RFA SV Report (DOE/CH2M HILL, 2002), which was approved by NYSDEC in February 2006 (NYSDEC, 2006a). Results of the RFA SV are summarized below by area.

Upper Level SWMUs

H2 Processing Facility (SWMU-030)

Surface soil near the southwest corner of Building H2 has elevated antimony, arsenic, and mercury concentrations. Antimony was also detected above the NYSDEC ambient water quality criteria (NYSDEC, 1998b) in dissolved groundwater samples collected along the northwest portion of Building H2; however, the data were analytically suspect. Although soil along the foundation of Building H2 (west and south side) contains VOCs (TCE and total 1,2-dichloroethylene [DCE]), the concentrations are well below the NYSDEC recommended soil cleanup objectives (NYSDEC, 1994). Groundwater along the southern perimeter of Building H2 contains VOCs (TCE and total 1,2-DCE) above the NYSDEC ambient water quality criteria.

H2 Tank Farm (SWMU-031)

Mercury and zinc are elevated above background or NYSDEC recommended soil cleanup objectives in surface soil in the east-central portion of the H2 Tank Farm. Mercury is also elevated above background or NYSDEC recommended soil cleanup objectives in soil at the base of the tank farm vault foundation. These metals are consistent with hazardous constituents managed by SPRU operations.

Pipe Tunnels (SWMU-057)

VOCs below NYSDEC recommended soil cleanup objectives were detected in soil along the western foundation of the Pipe Tunnel. Groundwater also contains traces of VOCs (1,1-dichloroethane [DCA]; 1,1-DCE; total 1,2-DCE; TCE; and vinyl chloride) west of the Pipe Tunnel. Only TCE exceeds the NYSDEC ambient water quality criteria in one well.

Lower Level SWMUs and AOC

Former K6 and K7 Storage Pads (SWMUs-036 and –037)

Except for an isolated detection of elevated zinc above background in one soil boring at the Former K7 Storage Pad (SWMU-037), no hazardous constituent releases were discovered that are associated with the Former K6 Storage Pad (SWMU-036) and the Former K7 Storage Pad (SWMU-037).

Railroad Staging Area (SWMU-038)

Concentrations of silver, mercury, total chromium, and thallium detected in shallow soil above background indicate chemical hazardous constituent releases in the southeastern, central, and northern portions of the Railroad Staging Area. These metals are also above the NYSDEC recommended soil cleanup objectives. Traces of VOCs were detected below these NYSDEC objectives in the northwestern and southeastern portions of the Railroad Staging Area. Elevated metals and VOCs in the southeastern portion of the Railroad Staging Area may have resulted from operations at the former Sewage Treatment Plant, and may not be related to SPRU.

Antimony, copper, arsenic, lead, and polycyclic aromatic hydrocarbon (PAH) compounds are elevated throughout the extent of the former railbed area. These PAHs and metals are attributed to railroad construction materials and operations, and not SPRU or KAPL waste management.

K5 Retention Basin (SWMU-040)

A trace detection of TCE in soil at the northeast corner of the K5 Retention Basin suggests a potential release of VOCs from the building's foundation at a concentration well below NYSDEC recommended soil cleanup objective. Additional characterization of subsurface conditions below the K5 Retention Basin is restricted by the physical configuration of the building and steep ground slope. The NYSDEC-approved SV Report recommended further characterization of the subsurface below the K5 Retention Basin after the structure has been removed.

Lower Level Parking Lot (AOC-003)

Concentrations of antimony, arsenic, cadmium, copper, lead, mercury, and silver are above background or NYSDEC recommended soil cleanup objectives in soil borings primarily in the northern portion of the parking lot. Concentrations of mercury significantly exceed the NYSDEC soil cleanup objective. Metal concentrations indicate a likely chemical hazardous constituent release from SPRU operations.

Overall, concentrations of chemical constituents in groundwater at the Lower Level SWMUs/AOC are consistent with natural conditions; therefore, no release of hazardous constituents was determined in groundwater at the Lower Level. However, additional groundwater monitoring wells are required to evaluate potential impacts to groundwater in all areas of soil contamination.

Land Area SWMU

Former Slurry Drum Storage Area (SWMU-035)

VOCs, including tetrachloroethylene (PCE), TCE, and 1,2-DCE, were detected in soil in the west-central and southwestern portions of the Land Area sampling grid. Detections in the west-central area are near monitoring well W-3, which historically contained 1,2-DCE in groundwater; these detections indicate potential migration of VOCs from soil to groundwater. This area is also near the former Pyrophoric Area (SWMU-005), where activities unrelated to SPRU may have released VOCs. Neither the source nor the extent of the VOCs in the west-central area has been established. VOCs in the southwestern portion of the Land Area are likely associated with trash and refuse disposal at the Former Landfill (SWMU-002), and not related to SPRU operations.

Copper, lead, mercury, nickel, and silver were detected in soil at levels exceeding background or NYSDEC soil cleanup objectives. Overall, the distribution of metals and VOCs in the Land Area do not indicate a SPRU-related source of these chemicals. The NYSDEC-approved RFA SV Report established no further soil or groundwater characterization was necessary in the Land Area for RCRA chemicals.

Summary of SV Recommendations

The SV Report identified soil and groundwater data gaps that required further evaluation. In addition, DOE's response to NYSDEC comments on the SV Report (DOE, 2005) identified additional data needs. Groundwater data gaps and field activities in response to NYSDEC comments are discussed in Section 1.2 of this report. The SV Report required additional soil characterization in areas of the Upper and Lower Levels to completely evaluate the extent of metals. As discussed in Section 1 of the Groundwater RFI Work Plan (DOE/CH2M HILL, 2004a), due to the comprehensive scope of the SPRU SV investigation, additional characterization of the extent of these metals will be addressed during remedial design.

1.3.6 KAPL Hillside RFI (AOC-001)

As required by the KAPL Part 373 Permit and in accordance with the NYSDEC-approved Hillside Area Task IV RFI Work Plan (KAPL, 2000b), KAPL conducted an investigation to evaluate the nature and extent of organic contamination in soil and groundwater in the Hillside Area (AOC-001) in the Upper Level (KAPL, 2005). The first phase of the field work, which was completed in December 2001, evaluated the distribution of VOCs associated with releases along the southern perimeter of Building G1, originating near groundwater monitoring well B-5. The work focused on three general areas: the area around well B-5, the area around well B-15 located south of Building H2, and the general vicinity of the storm sewer system between Buildings H2 and G2. A second phase of field work, which was completed in June 2003, further evaluated soil and groundwater contamination between Buildings H2 and G2 near well B-15. Geologic data, groundwater levels, and chemical data from the Hillside RFI were used in the SPRU Groundwater RFI to establish whether VOCs associated with this AOC could be migrating into the Pipe Tunnel and Building H2 footer drains. Additional information on the KAPL Hillside RFI is provided in Section 4.

1.3.7 2003 KAPL Sewer Leak Investigation

In November 2003 KAPL performed a water pressure test of the storm sewer piping between Buildings H2 and G2 to determine the sewer line integrity because of periodic surcharging of the Hillside Sump during heavy rain events. The test was conducted by blanking off ancillary sewer lines to isolate the portion of the sewer line that was of interest. Water was then added under pressure to the sewer line, and the pressure was monitored. The findings of this investigation were incorporated into the Groundwater RFI evaluation of VOC migration between Buildings G2 and H2. Additional information on the KAPL sewer leak investigation is provided in Section 4.

1.3.8 KAPL Sitewide Groundwater Monitoring

Groundwater throughout the Knolls Site is monitored annually, and the results are reported in annual Environmental Monitoring Reports. Data from annual reports through the Calendar Year 2003 report, KAPL-4851 (KAPL, 2004),have been used to summarize the sitewide groundwater monitoring results for the Knolls Site.

1.4 Report Summary and Organization

This report, including supporting appendixes, provides the basis for the conclusions and recommendations summarized in the Executive Summary and Sections 6 and 7. This report is organized to address the investigation objectives and requirements in a two-tiered approach, allowing development of a fundamental understanding of the RFI of the Upper and Lower Levels, while providing appropriate detail in the appendixes. The main body of the report (first tier) summarizes the RFI and relies on appendixes and, in some cases, other SPRU reports for detail and substantiating documentation (second tier). This approach facilitates review of the overall document through the succinct delivery of the data, conclusions, and recommendations, while allowing for detailed technical material to be provided in appendixes or other SPRU reports for technical review. The general contents and organization of the report are as follows.

- **Executive Summary**. This section presents a brief description of the background and objectives of the RFI and summarizes the results, conclusions, and recommendations of the RFI.
- **Section 1—Introduction**. This section provides an overview of the RFI background, summarizes previous investigations related to the RFI, and presents the RFI objectives.
- **Section 2—SWMUs/AOC Descriptions**. This section describes the SWMUs and AOC in the Upper and Lower Levels, including physical characteristics, operational history, waste types and characteristics, and release information.
- **Section 3—Environmental Setting**. The overall environmental and geologic settings at the Knolls Site and vicinity are presented.
- **Sections 4 and 5—Upper and Lower Level SWMU Characterization**, respectively. These sections provide data from previous studies and ongoing and related investigation work being performed by KAPL. They also identify specific characterization data gaps from the RFA SV requiring investigation during the RFI, evaluate the geologic and hydrogeologic conditions within each area, and present the results of the specific data gaps addressed during the RFI. Section 5 also presents the sitewide distribution of select naturally occurring chemicals, which is applicable to both the Upper and Lower Levels.
- **Section 6—Conclusions**. This section summarizes conclusions regarding the RFI conducted in the Upper and Lower Levels.

- **Section 7—Recommendations**. This section provides recommendations for additional work in the Upper and Lower Levels.
- **Section 8—References**. Detailed reference information for documents cited in this report is provided in this section.

Data and additional evaluations supporting the RFI are provided in the following appendixes:

- Appendix A—Overview of Field Activities
- Appendix B—Data Quality Evaluation
- Appendix C—Laboratory Case Narratives and Contract Laboratory Program Analytical Forms
- Appendix D—Laboratory Reports and Chain of Custody Records for Remedial Design Parameters
- Appendix E—Soil Boring and Monitoring Well Installation Logs
- Appendix F—Land Survey Coordinates
- Appendix G—Naturally Occurring Metal Data
- Appendix H—Hydraulic Conductivity Tests
- Appendix I—Analytical Data Summary

2. SWMU/AOC Descriptions

The following sections describe the SWMUs and AOC in the Upper and Lower Level investigation areas. The locations of these SWMUs and AOC within the Knolls Site are shown in Figure 2-1. For each SWMU and AOC, the descriptions include physical characteristics, operational history, waste types and characteristics, and release information.

2.1 Upper Level SWMU Description

The Upper Level encompasses three SWMUs: H2 Processing Facility (SWMU-030), H2 Tank Farm (SWMU-031), and the Pipe Tunnel (SWMU-057), as described in the following subsections.

2.1.1 H2 Processing Facility (SWMU-030)

Physical

Building H2 (see Figure 1-3), at the northwest end of the Knolls Site Upper Level, was constructed in the late 1940s to house SPRU liquid waste processing equipment and storage tanks (NYSDEC, 1998a; DOE, 1999a; DOE, 1999b). The building resides on a 2- to 3-foot-thick concrete foundation slab and is constructed of concrete walls more than 2 feet thick. Copper water stops were installed at all construction joints. The building consists of approximately 27,900 square feet of floor space on three main floors (332-, 319-, and 308-foot levels; elevation above mean sea level [amsl]). Nearly 70 percent of this space is located below grade. The majority of liquid waste processing equipment is fabricated of stainless steel and resides on two floors at the 319- and 308-foot levels. Liquid waste processing area walls and ceilings were coated with a sealant or cocooning material. The floor areas are generally lined with stainless steel floor pans. Foundation footing drains are plumbed to a sump system, located downslope of the buildings, that pumps collected water back into Building H2 for processing.

Operational

Building H2 was used to process waste and wastewater from Building G2, which was used for research and development between 1950 and 1953 (see Figure 1-1). Chemical processes for separating plutonium and uranium from slugs were performed in Building G2 until mid-1953 and used large quantities of chemicals, including solvents (DOE, 1999a; DOE, 1999b). The SPRU facilities inside Building G2 were decommissioned in 1953. Decontamination activities occurred inside Building G2 throughout the 1950s and 1960s. Since then, the unit has been used to process laboratory wastewater (unrelated to SPRU).

Chemical wastes from Building G2 were processed in Building H2 during the early 1950s. The unit has since been used to process KAPL laboratory wastewater (unrelated to SPRU). The chemical wastes were transferred to one of five stainless steel neutralizers in Building H2, using stainless steel drain lines, where it was neutralized, distilled, and/or concentrated. The neutralizer bottoms were transferred to the H2 Tank Farm (SWMU-031) for storage, the organic distillate was collected and containerized, and excess water generated during concentration was processed with other wastewaters before being discharged.

SPRU wastewaters were accumulated in one of three stainless steel 10,000-gallon storage tanks in Building H2. Accumulated wastewater was transferred to one of two evaporators, where it was concentrated 400-fold. Distillate from the evaporators was collected in a receiver tank, where it was monitored and, if within acceptable Mohawk River Advisory Committee limits, discharged to the Mohawk River via the K5 Retention Basin and/or the stormwater drainage system. Evaporator bottoms, referred to as slurry waste, were dried in one of two drum dryers and containerized in 55-gallon drums. Containerized slurry waste was staged at an undetermined location adjacent to Building H2 before being placed in storage at the Former Slurry Drum Storage Area (SWMU-035), the Former K6 Storage Pad (SWMU-036), or the Railroad Staging Area (SWMU-038).

The evaporative wastewater processing technique was used from 1950 to 1964. After 1964, wastewater was processed using filtration and ion exchange before being discharged. Discharge of treated wastewater ceased in 1977 when a water reuse system was installed. This system is still operational.

In addition to liquid waste processing, solid wastes were compacted in Building H2. The solid waste compaction process began in 1972, after the transfer of equipment from Building L7 to Building H2. The solid waste compaction operation in Building H2 was shut down in 2000.

Waste Type/Characteristics

During the early 1950s, more than 20,000 gallons of corrosive chemical waste containing heavy metals, methyl isobutyl ketone, and/or organic diluents and more than 9 million gallons of wastewater containing heavy metals were processed in Building H2.

Release Information

High water marks on walls in waste processing areas and radioactivity detected in adjacent soil and footing drains indicate a potential chemical constituent release from this unit.

2.1.2 H2 Tank Farm (SWMU-031)

Physical

The subsurface H2 Tank Farm abuts the eastern side of Building H2. One 5,000-gallon and six 10,000-gallon, stainless steel storage tanks are located in seven underground concrete vaults (NYSDEC, 1998a; DOE, 1999a; DOE, 1999b). The vaults are in a row in a north-south direction on the east side of the H2 Processing Facility (see Figure 1-3). The floors and walls of these vaults are constructed of concrete ranging from 2 to 8 feet thick. A waterproof sealant was applied to the vault floors and walls, and copper water-stops were installed during construction. An emulsified asphalt waterproof coating was applied to the exterior of the vault foundations. The vault ceilings are constructed of upright and inverted concrete “T” blocks that are covered with tarpaper, asphalt, and approximately 9 feet of fill. Sealed vault access-ways and tank vent lines penetrate the ground surface. Visual inspections, conducted in 1989 and 1998, of the tanks and vaults showed that they were intact and in good condition. Groundwater seeps were observed in several vault ceilings.

Operational

Processed separations material and waste were accumulated within the various tanks until SPRU research was concluded in 1953. Some materials and waste remained in storage until the mid-1960s, when it was removed, processed via evaporation, and transported offsite for disposal. Subsequent to SPRU operations, several tanks were used to accumulate and store liquid waste from site materials and chemistry laboratories. Before 1964 upset conditions were documented that resulted in the release of the tank’s contents through vents in the tank vaults to the ground surface above. Affected soils were removed. During 1978 all tanks were drained and removed from service. Tank heels remain today. Tank heels are residual waste that remains in storage tanks after as much of the liquid has been removed as can be using available equipment and technology. This includes liquids, suspended solids, and sludges that have settled out of the liquid. Tank heels are typically highly radioactive because the solids and sludges tend to concentrate the radioactive material.

Waste Type/Characteristics

Corrosive liquid wastes that potentially contained methyl isobutyl ketone, organic diluents, and/or heavy metals were accumulated in these tanks. Approximately 2,100 total gallons of residue remain in the tanks (tank heels below the drain level). In 1990 a total metals analysis was performed on the residue in five of the storage tanks for Extraction Procedure Toxicity (EP Tox) metals. In 1998 total metals were reported for debris sampled from five of the tank vault floors. Elevated concentrations of eight metals were observed. The range of analytical results is presented in Table 2-1.

Release Information

High water marks attributed to water seeping from the vault ceilings were observed on vault walls during the 1989 inspection. Radioactivity detected in footing drains indicates a potential chemical constituent release from this unit to the floors within the vaults, although a pathway to the environment is not known to exist.

2.1.3 Pipe Tunnel (SWMU-057)

Physical

This unit consists of a tunnel that is located in and connects the basements of Buildings G2 and H2 (see Figure 1-3). The tunnel is more than 5 feet wide and 8 feet high (NYSDEC, 1998a; DOE, 1999a; DOE, 1999b). Tunnel walls, floors, and ceilings are constructed of concrete more than 6 inches thick. A waterproof sealant was applied to the unit's floor and walls during construction. Copper water-stops and asphalt filler were also installed at all construction joints. With the exception of an expansion joint at the north end of Building G2, the tunnel appeared intact and in good condition during a 1989 visual inspection. Groundwater intrusion was observed at the expansion joint.

Operational

The tunnel was constructed to house industrial and wastewater drain lines from operations in Buildings G2, G1, and E1 (G1 and E1 are not shown but are located south of Building G2). Wastewater accumulation was occasionally reported on the floor of this tunnel.

Waste Type/Characteristics

Wastewater potentially contained heavy metals.

Release Information

High water marks and stains were observed on tunnel walls and floors during a 1989 visual inspection. Radioactivity detected in the Building H2 footing drain indicates a potential chemical constituent release from this unit.

2.2 Lower Level SWMU/AOC Description

The Lower Level includes four SWMUs and one AOC: the Former K6 Storage Pad (SWMU-036), Former K7 Storage Pad (SWMU-037), Railroad Staging Area (SWMU-038), Lower Level Parking Lot (AOC-003), and K5 Retention Basin (SWMU-040), as described in the following subsections.

2.2.1 Former K6 Storage Pad (SWMU-036)

The Former K6 storage pad is described in this section to provide a comprehensive overview of the Lower Level SWMUs. However, no further action was recommended for this SWMU in the RFA SV, which was approved by NYSDEC in February 2006 (NYSDEC, 2006a).

Physical

This unit, centrally located at the Knolls Site Lower Level (see Figure 1-4), is a 23-foot-wide by 48-foot-long, concrete shielded, concrete storage pad with 8-foot-high walls (NYSDEC, 1998a; DOE, 1999a; DOE, 1999b). The inside of the concrete structure is partially divided into two storage cells of equal dimension. With the exception of the pad's southern wall, which is 8 inches thick, the shielding walls are more than 2.5 feet thick. An earthen embankment abuts the southern wall. This unit was fitted with a roof in 1987.

Operational

This unit was used from the late 1950s until the fall of 1968 to store containerized solid waste potentially containing hazardous constituents. The original K6 facility cells were unprotected and exposed to the environment. Floor drains in both storage cells were used to drain the area of rainwater. A 4-inch-diameter drainpipe extended approximately 115 feet east toward a 36-inch storm sewer. The line was plugged and blanked off in 1973. The concrete pad was subsequently removed. No evidence of a release was found when the drain line was blanked off.

Waste Type/Characteristics

Waste containerized in 55-gallon drums or casks generally included slurry waste, filters, and equipment from Building H2. Slurry waste potentially contained heavy metals.

Release Information

Radioactivity detected in soils indicates a potential chemical constituent release from this unit.

2.2.2 Former K7 Storage Pad (SWMU-037)

The Former K7 Storage Pad is described in this section to provide a comprehensive overview of the Lower Level SWMUs. However, no further action was recommended for this SWMU in the RFA SV, which was approved by NYSDEC in February 2006 (NYSDEC, 2006a).

Physical

This former unit, which consisted of a fenced concrete pad, was centrally located at the Knolls Site Lower Level, west of the Former K6 Storage Pad (see Figure 1-4). The fencing and concrete pad have been removed.

Operational

This unit was used during the 1960s to stage solid waste before offsite disposal (NYSDEC, 1998a; DOE, 1999a; DOE, 1999b). Wastes were generally containerized in 4-square-foot wooden boxes.

Waste Type/Characteristics

Solid waste consisted of compacted paper, cardboard, and personal protective equipment (PPE) from Building L7. Employee interviews indicate hazardous waste or hazardous chemical constituents may have been managed at or near this unit.

Release Information

Radioactivity detected in adjacent soils indicated a potential chemical constituent release at this unit.

2.2.3 Railroad Staging Area (SWMU-038)

Physical

This unit consists of the land area adjacent to and south of the former railbed at the Knolls Site Lower Level (see Figure 1-4).

Operational

The Railroad Staging Area was used to fill and stage wooden boxes, concrete transport boxes, and 55-gallon drums of radioactive solid waste, soil, and slurry waste from Building H2 operations before rail shipment for disposal (NYSDEC, 1998a; DOE, 1999a; DOE, 1999b). Waste staging operations commenced in the early 1950s and ceased in the late 1960s. Undated historical photographs (see Section 5), believed to have been taken during this time period, show shipment containers being filled primarily along the west side of the northern portion of the railbed within the Lower Level. Drums were likely handled throughout the extent of the railbed area and particularly near drum storage at the Former K6 and K7 Storage Pads. As evident in the photographs, a fence—present during at least part of the Lower Level waste management operations—would have likely confined waste staging operations along the extent of the current asphalt roadway. Waste containers were staged along the eastern perimeter of the railroad track and railroad track spur. Railroad loading operations occurred on the eastern side of the tracks. Although undocumented, the lack of a gate in the fencing along the eastern perimeter of the Lower Level indicates that waste containers were probably transferred from the western side of the railroad tracks to the eastern side using the roadway along the northern perimeter of the Lower Level.

Waste Type/Characteristics

Slurry waste, potentially containing heavy metals, and solid waste were staged at this unit.

Release Information

Radioactivity detected in adjacent soil indicates a potential chemical constituent release from this unit.

2.2.4 Lower Level Parking Lot (AOC-003)

Physical

This AOC consists of the fill material underneath and adjacent to the Lower Level Parking Lot (see Figure 1-4).

Operational

Fill material obtained from former SPRU waste management areas was used to expand the Lower Level Parking Lot in August 1962 (NYSDEC, 1998a; DOE, 1999a; DOE, 1999b). Soil from west of the Former K6 Storage Pad and east of the Former K7 Storage Pad was removed and used as fill in the Parking Lot. During this process, radioactive contamination was uncovered in an area that was approximately 8 by 12 feet. Radiation dose rates in the excavated area were elevated. The contaminated soil was removed from the Parking Lot and dispositioned by KAPL.

The area of radiological impact within the Parking Lot was identified during the Subsurface Penetrating Underground Detector (SPUD) radiological survey. Radioactive contamination was also identified near soil borings B0303, B0304, and B0305 (see Figure 2-4 of the Task IV RCRA Facility Investigation Work Plan for Groundwater, Upper and Lower Level Areas [DOE/CH2M HILL, 2004a]) during the RFA SV.

Results from a ground-penetrating radar and EM-61 (electromagnetic) conductivity surveys (see Appendix E, Figure 9, of the RFA SV Report [DOE/CH2M HILL, 2002]) indicate the possible presence of a disturbed zone and concrete materials (e.g., construction rubble) in the Parking Lot that may be fill materials from the Railroad Staging Area.

Waste Type/Characteristics

Wastes staged in the areas where fill material was obtained include slurry waste, which potentially contained heavy metals.

Release Information

Radioactivity detected in fill material and surface radioactivity measurements indicate the occurrence of a potential release.

2.2.5 K5 Retention Basin (SWMU-040)

Physical

This unit is an in-ground, open topped, concrete basin on the hillside between the Upper and Lower Levels and south of the Railroad Staging Area (see Figure 1-4). The unit measures approximately 22 feet wide by 43 feet long by 11 feet deep and is constructed of 1-foot-thick concrete walls (NYSDEC, 1998a; DOE, 1999a; DOE, 1999b). The unit is equally divided into two 30,000-gallon holding basins. Cracks have been observed in both basin floors. An influent drainage valve pit and an effluent drainage valve pit are located on the south and north sides of the building, respectively. Each valve pit is plumbed to both basins. The influent valve pit has a floor drain that drains to the hillside to the south-southeast. The effluent valve pit drains to the north into a catch basin.

Operational

This unit was operational from 1950 until the late 1960s. Wastewater, potentially containing hazardous constituents processed in Building H2, and radioactively contaminated laundry wastewater were accumulated in this retention basin before being discharged to a stormwater drain. In 1970 a roof was installed over the basin to minimize weather-related water infiltration and to keep in the residual radioactivity. A hatch in the roof provides access for periodic inspections.

In the fall of 1970, sludge was removed from the K5 Retention Basin, the interior walls were cleaned of radioactivity, and then a sealer was applied to the surfaces.

In December 1992 and continuing into 1993, KAPL performed an inspection and survey of the K5 facility to assess the radiological and physical conditions. It was observed that roof leakage directly into the retention pits was the cause for small amounts of accumulated water, not groundwater as originally predicted. A tarpaulin was installed over the roof to minimize the water infiltration. A concrete surface sample removed from the walls and floors of the retention pits was analyzed for Toxicity Characteristic Leaching Procedure (TCLP) metals. The only metal detected was barium at 0.59 milligram per liter (mg/L).

Waste Type/Characteristics

Non-hazardous wastewaters, potentially containing chemical constituents, and radioactively contaminated laundry wastewater, were temporarily held in the K5 Retention Basin.

Release Information

Basin overflows have been reported, and there is a potential for release attributed to basin integrity loss (e.g., cracks). Trace levels of barium were detected in concrete samples collected during a 1993 tank cleanup effort. Radioactivity detected in adjacent soil indicates a potential release from this unit. Also, RFA SV results indicate a trace VOC release from the northeast corner of the foundation base. Neither radioactivity nor hazardous chemicals were found in groundwater downgradient of the K5 Retention Basin during the RFA SV.

3. Environmental Setting

This section describes the environmental setting of the Knolls Site, including the general layout of the facilities and the SWMUs/AOC, the regional geology and hydrogeology, the climate, and the surface water at the site.

3.1 Facilities and Layout

The Knolls Site is located in the Town of Niskayuna, Schenectady County, New York, on the southern bank of the Mohawk River. The Knolls Site consists of 170 acres, located mostly on a bluff approximately 115 to 120 feet above the Mohawk River surface. Along the northern margin of the Knolls Site, the land surface slopes steeply to a natural bench about 15 to 20 feet above the river's surface. The Knolls Site, which fronts approximately 4,200 feet of the river, is bounded to the north and east by the Mohawk River; to the south by a mixture of open land, parks, and the Town of Niskayuna's closed municipal landfill; to the west and southwest by a low-density suburban residential area; and to the west and northwest by the General Electric Company Global Research Center.

Construction of the Knolls Site began in 1948, and laboratory operations began in 1949. The principal function of the Knolls Site was research and development in the design and operation of Naval nuclear propulsion plants. Facilities include administrative offices, machine shops, a sewage pumping station, wastewater treatment facilities, a boiler house, oil storage facilities, cooling towers, waste storage facilities, and chemistry, physics, and metallurgical laboratories. The buildings and support facilities occupy approximately 60 acres of the property. The remainder of the Knolls Site (about 110 acres) consists of undeveloped woods and fields.

As shown in Figure 3-1, the investigation areas of this groundwater RFI are in separate and distinct geographic areas within the Knolls Site.

- The Upper Level SWMU area comprises an investigation area around Buildings H2 and G2 in the northern portion of the bluff along the northwestern perimeter of the Knolls Site Upper Level facility area. The area is developed and mostly covered by concrete and asphalt. The area surrounding Building H2 is covered by gravel overlying an impermeable geomembrane to the east, west, and north.

- The Lower Level SWMUs/AOC area extends along the parking lot and old railroad spur within the bench between the Lower Level facility area and the hill slope rising up to the Knolls Site Upper Level. The eastern portion of the Lower Level SWMUs/AOC area is primarily a grassy surface with asphalt roadways bisecting the area along the east-west and north-south axes. The western portion of the Lower Level SWMUs/AOC area consists of an asphalt parking lot.

3.2 Geology

The following subsections summarize the general geology, hydrogeology, climate, and surface water at the Knolls Site. The geological and hydrogeological conditions are described in more detail in Sections 4.4 and 5.4.

3.2.1 Regional Geology

Most of the Knolls Site is located on the Upper Level bluff approximately 115 to 120 feet above the Mohawk River surface. Along the northern margin of the Knolls Site, the land surface slopes steeply to a natural bench comprising the Lower Level approximately 15 to 20 feet above the river's surface.

The geology underlying the Knolls Site consists of unconsolidated overburden materials, overlying bedrock. Bedrock at the Lower Level is at depths of approximately 5 to 20 feet below existing grade elevations and in the Upper Level at depths ranging from approximately 40 to 80 feet below existing grade elevations. Bedrock underlying the Knolls Site is mapped as the Upper-Middle Ordovician aged Schenectady Formation, which comprises a series of alternating beds of graywacke, sandstone, siltstone, and shale about 2,000 feet thick, dipping gently to the west and southwest. The Schenectady Formation is underlain by the Canajoharie shale, which is a dark gray to black, thinly bedded, fissile shale.

The unconsolidated materials at the Knolls Site consist mainly of glacial deposits. The till, which directly overlies the bedrock at most locations, consists of a grayish-blue, dense, compact till. This is known as the Mohawk Till, which is commonly referred to as gray till. The gray till extends from the bedrock typically to within 10 to 15 feet of the ground surface, where the gray till transitions into a yellowish-brown till, commonly referred to as brown till. The brown till originally was thought to be a separate depositional sequence from the gray till. However, evidence suggests that the brown till is the weathered surface of the gray till. Occasional lenses of graded material, usually fine sand, exist within the till. In areas of the Knolls Site where construction and site development has occurred, the uppermost portion of the brown till has been removed and re-emplaced as fill as needed. In some areas, excavations penetrated into the gray till, which was removed and included with the fill. Anthropogenic materials (e.g., asphalt and concrete) are commingled with some of the fill. Throughout this report, this interval is referred to as till-derived fill.

3.2.2 General Hydrogeology

The groundwater resources at the Knolls Site are limited because of the low permeability of the bedrock and unconsolidated deposits. The predominant unconsolidated deposits are composed of brown and gray till with occasional lenses of graded material, usually fine sand, within the till. Overlying the till in some areas are thin glacial lake sequences (silts and clays) and discontinuous ice-contact deposits (sand and gravel). Consequently, there are no principal or primary bedrock or overburden aquifers underlying the Knolls Site for development as commercial or public water supplies.

The gray till is almost entirely impermeable except for the occasional lenses of fine sand, which are capable of transmitting small quantities of water. Based on drilling records, these lenses are small in both vertical and horizontal extent and are isolated from one another. Over most of the Knolls Site, the gray till aquaclude serves as the base of the unconfined hydrogeologic unit. Exceptions are portions of the Lower Level where the gray till is absent or thinned due to scour from the Mohawk River. The brown till is also relatively impermeable; however, water can percolate through the brown till, as indicated by perched water at the brown till/gray till contact. In the horizontal shales and sandstones of the Schenectady Formation, groundwater is found in the bedrock fractures, joints, and bedding planes and in the upper portions of the bedrock where it interfaces with the unconsolidated deposits. These shales and sandstones are characteristically nonporous and impermeable, and they form poor aquifers.

The overall sitewide direction of groundwater flow at the Knolls Site is generally northeast to the Mohawk River. Based on the relatively low permeability of the bedrock and till, groundwater movement is relatively slow. The movement of perched groundwater on the gray till mirrors the topography of the top of the till surface. The topography of the gray till is similar to the natural topography of the landscape where it has not been disturbed. In areas where gray till has been excavated for construction of site buildings, utilities, and other facilities, groundwater flow direction and velocities vary, with groundwater preferentially flowing into and along the less compact and more permeable backfill material.

3.2.3 Climate and Surface Water

The climate in the Knolls Site region is primarily continental in character but is subjected to some modification from the maritime climate that prevails in the extreme southeastern portion of New York State. Winters are usually cold and occasionally fairly severe. Maximum temperatures during colder winter months often are below freezing, and nighttime low temperatures frequently drop to 10 degrees Fahrenheit (°F) or lower. Subzero temperatures occur rather infrequently, about a dozen times a year. Snowfall in the area is quite variable, averaging approximately 65 inches a year. The mean annual precipitation for the region is approximately 36 inches per year, and winds are predominantly westerly to northwesterly.

The Knolls Site is adjacent to the Mohawk River, which serves as the main watercourse for the Mohawk River Drainage Basin. The river flows eastward to where it joins the Hudson River in Cohoes, New York. Three streams drain directly into the Mohawk River from the Knolls Site. The East Boundary Stream is located on the Knolls Site between the closed Knolls and Niskayuna Landfills and receives drainage from the southeastern portion of the Land Area. The Midline Stream drains the central area of the Knolls Site and receives only runoff from the Knolls Site property, including most of the Land Area. The West Boundary Stream, which is adjacent to the Knolls Site on General Electric Company Global Research Center property, receives some surface water runoff from the Knolls Site. Runoff from the southern and eastern area of the Upper Level SWMUs mostly enters onsite storm sewers for subsequent discharge to the Mohawk River. Runoff from the western and northern perimeter of the Upper Level flows over the bluff slope into drainage channels for discharge to the West Boundary Stream. Runoff from the Lower Level SWMUs/AOC also flows to the

Mohawk via storm sewers or, in the case of the northwestern parking lot, directly into the West Boundary Stream and the Mohawk River.

4. Upper Level SWMU Characterization

This section describes the characterization of the Upper Level SWMUs, including the characterization objectives, investigative approach, and previous investigation data used in the RFI evaluations. It describes the Upper Level geological and hydrogeological evaluations, the data gaps being resolved by the RFI, and the specific RFI results. Finally, this section describes the fate and transport potential for contaminants in the Upper Level.

4.1 Upper Level Characterization Objectives

An objective of the RFI was to characterize the environmental setting and the nature and extent of potential chemical releases at the Upper Level resulting from historical SPRU operations. To accomplish this objective, it was necessary to identify data gaps that remain from previous investigations, address specific comments from NYSDEC's technical review of the RFA SV (DOE/CH2M HILL, 2002), and collect the data required to evaluate corrective action alternatives.

Based on the results of the RFA SV, the extent of the VOC impact to groundwater at the Pipe Tunnel (SWMU-057) and the H2 Processing Facility (SWMU-030) required further evaluation to determine the source and extent of VOCs in the Pipe Tunnel and to confirm whether an additional release from the foundation of Building H2 had occurred. Potential transfer of metals (antimony) from soil to groundwater along the northwestern side of Building H2 also required further evaluation.

As indicated in the March 9, 2005, responses (DOE, 2005) to NYSDEC's technical review of the RFA SV Report, several comments recommended further evaluation as part of the groundwater RFI.

- Manganese, sodium, and iron are components of inorganic chemicals known to have been used at SPRU (e.g., manganese dioxide, manganese nitrate, sodium nitrate, sodium dichromate, sodium permanganate, ferric nitrate). Evaluation of these major ions in groundwater is necessary to determine if their distribution is caused by natural conditions or input from SPRU operations. Manganese, sodium, and iron results from groundwater analyzed during this groundwater RFI are evaluated with data obtained from the RFA SV and KAPL's ongoing environmental monitoring.

- Antimony results from groundwater in cased borings adjacent to Building H2 were considered suspect because of either analytical interference or well construction materials. Additional wells were installed to evaluate antimony levels together with groundwater flow around the northwestern portion of Building H2.
- Groundwater samples need to be analyzed for thallium at a detection limit of less than 0.5 μg/L.

As presented in the RFA SV Report, VOCs were detected in soil and groundwater along the western side of the Pipe Tunnel (SWMU-057) as shown in Figure 4-1 of that report (DOE/CH2M HILL, 2002). Groundwater monitoring well MW-SV1 (soil boring B5704) had concentrations of 1,1-DCE; total 1,2-DCE; 1,1-DCA; and TCE in soil. Groundwater monitoring well MW-SV3 (soil boring B5701) had concentrations of total 1,2-DCE and TCE in groundwater and soil. Neither the source nor the extent of these VOCs had been determined.

VOCs were also detected in soils at the H2 Processing Facility (SWMU-030). Soil boring B3003 had concentrations of TCE and total 1,2-DCE, and boring B3004 had concentrations of TCE. Soil borings B3003 and B3004 are inferred to be downgradient from wells MW-SV1 and MW-SV3. VOCs were identified in groundwater monitoring well B-15, which is southwest of Building H2. VOCs were also present in high concentrations in adjacent soils (e.g., soil boring SB-24) and groundwater at SB/MW-24. This area is being investigated by KAPL as part of the RFI for the Hillside Area (AOC-001). Data from KAPL's investigation are presented in Section 4.3.1.

The VOCs at Building H2 and the Pipe Tunnel may have resulted from releases from the G2/H2 Pipe Tunnel or Building H2 foundations. However, the VOC source in soil and potential impact of the VOCs on groundwater had not been determined nor fully investigated. There is a potential for the transport of VOCs along the fill/gray till contact from soils associated with the Hillside RFI toward the Pipe Tunnel and/or the southern perimeter of Building H2. The configuration of the fill/gray till contact is likely modified by utility excavations. An east-to-west sloping fire water line runs between the southern end of

Building H2 and the stormwater line between manhole catch basins (MCB) MCB-8 and MCB-7 at a similar elevation as groundwater (see Figure 4-1). The fire water line runs beneath the Pipe Tunnel before rising in elevation. A spur to the fire water line runs to the southern wall of Building H2, west of the Pipe Tunnel.

4.2 Investigative Approach

To meet the objectives summarized in the previous section, the following investigative approach was developed and completed. Note that the planned investigative activities were expanded to some extent as defined herein to address several developments encountered during the performance of the field investigations.

4.2.1 Data Gap 1—Source of VOCs in the Pipe Tunnel Footing Drains

This data gap from the SV relates to determining if the VOCs within the SV wells adjacent to the Pipe Tunnel originated from: (1) the VOCs detected near well B-15 and soil boring SB-24 (well MW-24) identified by KAPL as part of the Hillside Area RFI; (2) groundwater migration along the Building G2 footing drain; and/or (3) the loading dock in the northwest corner of Building G2.

To evaluate these potentials, additional soil borings and monitoring wells were completed in the Upper Level. Two soil borings (LA1401-3-W and LA1401-6-W) were installed in the Building G2 footing drain and were converted to monitoring wells (UW-3 and UW-4, respectively; see Figure 4-1 for soil boring and monitoring well locations). These borings were sampled to evaluate the foundation of Building G2 as a potential migration pathway for VOCs from the south side of G1, and to evaluate the area of the former loading dock for a source of VOCs in soils above and in groundwater. Monitoring well UW-4 was located along the Building G2 foundation wall, a few feet west of the Pipe Tunnel wall, to identify the potential groundwater migration pathway in the Building G2 foundation drain. The second well (UW-3) was installed adjacent to an existing well, SB/MW-22, in the Building G2 footing drain at a location outside of the abandoned borehole trace[1]. Shallow refusal resulted in lack of saturated conditions at the UW-4 location, so two additional soil

[1] KAPL determined during the Hillside RFI Investigation that well MW-22 was installed in gravel backfill remaining from abandonment of a previous boring or well. Since the gravel backfill did not allow isolation of groundwater at the till contact near the foundation drain invert elevation, a replacement groundwater monitoring well was required.

borings/temporary wells (UWT-2 and UWT-2A) were installed to evaluate the extent of VOCs along the western Building G2 footing drain and at the location of the former Building G2 scrubber stack. Select soil samples were collected and analyzed for Target Compound List (TCL) VOCs and remedial design parameters (RDPs) including total organic carbons (TOC), Atterberg Limits, and grain size distribution. Groundwater samples were collected and analyzed for TCL VOCs.

Three soil borings (LA-SO-UW-5, LA-SO-UW-6, and LA-SO-UW-7) were drilled west of the Pipe Tunnel between Buildings G2 and H2 to determine whether VOCs in soil and groundwater had migrated into the Pipe Tunnel and/or Building H2 footing drains. Only one boring (LA-SO-UW-6) was converted to a monitoring well (UW-6) because of shallow refusal and lack of saturated conditions. The boring/well positions were also selected to provide controls on the orientation of the till surface and to refine groundwater flow directions between Buildings G2 and H2.

4.2.2 Data Gap 2—Groundwater Flow and Chemistry at the Northwestern Perimeter of Building H2

The objective of the investigation of this SV data gap was to determine: (1) the potential impact to groundwater from metals, primarily antimony, along the northwestern portion of Building H2; and (2) if groundwater is flowing away from Building H2 within a construction excavation in the gray till.

Antimony was detected in soil at concentrations above the groundwater quality criteria at boring B3003 at the southwest portion of Building H2. It was also detected in groundwater at concentrations above the groundwater quality criteria in cased borings H-22 and H-28, near the northwestern corner of Building H2, and at lower concentrations in groundwater in other cased borings, along the west side of Building H2 (inferred to be downgradient of boring B3003). Groundwater flow around the foundation of Building H2 tends to stay within a few feet of the building because it is primarily contained and controlled by the limits of the building excavations (see discussion pertaining to the Historical Construction Photographs in Section 4.4.1). This is a result of the relatively higher permeability of the backfill material, as compared to the native gray till that surrounds it. One possible exception to this may be near the northwest corner of Building H2 where the construction excavation extended beyond the footer of the building, likely to provide vehicle access. This may have opened a potential pathway for groundwater to move beyond the building foundation in the event of a design or performance failure of the footing drains (i.e., plugged footing drains).

Additional sampling was required to investigate this possibility and also to determine whether groundwater is contained within the Building H2 foundation off the northwest corner of the building. To evaluate the potential transfer of antimony, and other metals or VOCs, from soil to groundwater, two additional soil borings/monitoring wells (UW-1 and UW-2) were completed at the northwest corner of Building H2.

Select soil samples were collected and analyzed for TCL VOCs, where saturated conditions were encountered, and Target Analyte List (TAL) metals. Soil samples were also collected during the field investigation for developing RDPs for soil. The samples were analyzed for TOC, Atterberg Limits, and grain size distribution. In addition, groundwater samples were collected and analyzed for TAL metals and TCL VOCs. The results of these analyses are summarized in Tables 4-1 through 4-4 (soils) and Tables 4-5 and 4-6 (groundwater). The analytical data summary is provided in Appendix I. Laboratory reports for RDPs are presented in Appendix D and summarized in Table 4-1. In situ hydraulic conductivity testing was performed on various soils at the KAPL facility, and the results are presented in Appendix H and summarized in Appendix A, Table A-13.

4.3 Previous Upper Level Investigations

KAPL and SPRU have conducted several other investigations at the Upper Level of the Knolls Site, including the KAPL Hillside RFI, KAPL sewer leak investigations, and the RFA SV. KAPL also conducts sitewide environmental monitoring, including groundwater, as part of the facility’s environmental monitoring program. Results are reported in annual Environmental Monitoring Reports. Data from these investigations were used in the Groundwater RFI evaluations and supplement the data collected during the RFI. The data from these investigations and monitoring programs that are relevant to the Groundwater RFI of the Upper Level are described in the following subsections.

4.3.1 KAPL Hillside RFI

In accordance with the NYSDEC-approved Hillside Area Task IV RFA SV Work Plan (KAPL, 2000b), KAPL has conducted an investigation to evaluate the nature and extent of organic contamination in soil and groundwater at AOC-001, the Hillside Area. The first phase of the field work, which was completed in November 2001, evaluated the distribution of VOCs associated with releases along the southern perimeter of Building G1 (south of Building G2) originating near groundwater monitoring well B-5. The work focused on three general areas: the area around well B-5, the area around well B-15 south of Building H2, and the general vicinity of the storm sewer system (see Figure 4-1). A second phase of field work, which was completed in October 2003, further evaluated soil and groundwater contamination between Buildings H2 and G2 in the area of well B-15.

The following summary discussion is based on characterization data presented in the RCRA Facility Investigation for the Knolls Site Hillside Area (KAPL, 2005). Data pertinent to the SPRU investigation are summarized from this report. A more thorough discussion of the Hillside Area RFI data is provided in KAPL (2005).

Soil Sampling South of Building H2

Eighteen soil borings (SB-1, -2, -3, -4, -4A, -5, -6, -21, -21A, -22, -23, -24, -25, -25A, -26, -27, -28, and -42) were sampled as part of the KAPL Hillside RFI in the area south of Building H2 (see Figure 4-1; SB-series soil borings are co-located with their corresponding well [MW-series] but are not specifically labeled on the figure). One or more of the following chlorinated VOCs were detected in one or more soil samples collected: TCE; chloroform; PCE; cis-1,2-DCE; carbon tetrachloride; , methylene chloride; carbon disulfide; 1,1,1-trichloroethane (1,1,1-TCA); 1,1-dichloroethane (1,1-DCA); vinyl chloride; trans-1,2-DCE; and 1,1-DCE. Only TCE and chloroform exceeded their respective NYSDEC soil cleanup objective.

The principal VOC detected in this area was TCE with maximum concentrations of 4,260 micrograms per kilogram (µg/kg) in the 17- to 18-foot-bgs interval from soil boring SB-6; 5,520 µg/kg at the 17-foot-bgs interval (at the gray till contact) from soil boring SB-23; and 91,500 µg/kg at 14.6 feet bgs at soil boring SB-24. At soil boring SB-23, TCE was not detected (10.8UJ µg/kg) in a sample taken approximately 1 foot into the gray till at 19 feet bgs, indicating minimal migration of VOCs into the gray till.

Chloroform was detected in soil borings SB-1, -2, -4A, -5, -6, -21, -21A, -22, -23, -24, -25, -26, -27, and -28) at concentrations ranging from 0.57 to 1,890 µg/kg. The highest and only chloroform concentration to exceed the NYSDEC soil cleanup objective of 300 µg/kg was from 14.6 feet bgs at soil boring SB-24. With the exception of the chloroform concentration of 112 J µg/kg from 10 feet bgs at soil boring SB-21A, most of the remaining detected chloroform concentrations are less than 10 µg/kg.

Carbon tetrachloride was detected in nine of the KAPL Hillside RFI soil borings south of Building H2 (SB-2, -4A, -6, -21A, -22, -23, -24, -27, and -28). Maximum concentrations were at 18 feet bgs from SB-6 (508 µg/kg, estimated concentration in diluted sample [DJ]) and at the 10-foot depth at SB-21A (19.4 µg/kg).

PCE was detected in 5 soil borings (SB-1, -21, -21A, -24, and -25) at concentrations ranging from 1.4 to 24.8 µg/kg; well below the NYSDEC soil cleanup objective of 1,400 µg/kg.

Soil Sampling South of Building G1

As part of the KAPL Hillside RFI, soil borings were drilled south of Building G1 (Building G1 is immediately south of Building G2) in the D4-G1 alleyway to evaluate historically elevated VOCs in groundwater from well B-5. One or more of the following chlorinated VOCs were detected in one or more of the soil samples: TCE; cis-1,2-DCE; trans-1,2-DCE; PCE, carbon tetrachloride; methylene chloride; chloroform; vinyl chloride; 1,1-DCE; and carbon disulfide.

The principal VOC detected was TCE found in 69 samples from 16 soil borings at concentrations ranging from 2 to 72,200 µg/kg. The highest TCE concentration was at the 8.8-foot depth at soil boring SB-13. Cis-1,2-DCE, a degradation product of TCE, was detected in 44 samples from 15 soil borings at concentrations ranging from 0.44 to 6,340 µg/kg, with most concentrations below 25 µg/kg. The highest cis-1,2-DCE concentration from the 13-foot depth at soil boring SB-18 was in conjunction with a TCE concentration of 35,200 µg/kg.

Trans-1,2-DCE was detected in 12 samples from 10 soil borings at concentrations ranging from 0.41 to 2,170 µg/kg, with most concentrations less than 10 µg/kg. PCE was detected in seven samples from 7 soil borings at concentrations ranging from 0.53 to 2.2 µg/kg. Carbon tetrachloride was detected in two samples at concentrations ranging from 0.34 to 6.2 µg/kg. In general, the highest VOC concentrations have been found at the water table or gray till contact, with concentrations typically decreasing to or approaching nondetect levels with depth.

Storm Sewer Backfill Soil Sampling

During the KAPL Phase I Hillside RFI investigation, eight soil samples were collected from two soil borings (SB-7 and SB-8) that were advanced in the storm sewer backfill material near the Hillside Area (see Figure 4-1). One or more of the following chlorinated VOCs were detected in one or more of the eight soil samples: PCE; cis-1,2-DCE; trans-1,2-DCE; chloroform; and TCE; 2-butanone; and vinyl chloride. At SB-8, PCE was the principal VOC detected at 4,040 µg/kg at 9 feet bgs.

During the Phase II Hillside RFI investigation, additional soil borings and wells were installed west of Building D3[2] to evaluate suspected sources of VOCs to the storm sewer. Samples collected from shallow soil borings between Building D3 and the storm sewer contained concentrations of PCE ranging from 1.2 to 27,900 µg/kg with the highest concentration at 10 feet bgs within soil boring SB-35A. This area appears to be the source area for the PCE detected in the adjacent storm sewer trench.

Footing Drain and Sump Sampling

Water samples were collected and analyzed for VOCs from MCB-8, MCB-9, MCB-29, and MCB-31 (in the stormwater line running along the northern and western sides of Building G2), and the Building G1 basement sump as part of the KAPL Hillside RFI (see Figure 4-1). PCE was detected at an estimated trace concentration of 0.67 micrograms per liter (µg/L) in one inlet to MCB-9. Bromodichloromethane (1.5 to 4.6 µg/L), dibromochloromethane (0.83J to 1.4 µg/L), and chloroform (0.17J to 8.2 µg/L) were also detected at inlets to MCB-9. Bromodichloromethane (1.7 µg/L), dibromochloromethane (0.8J to 0.86J µg/L), chloroform (2.6 to 3 µg/L), and TCE (0.32J to 0.4J µg/L) were detected in both inlets to MCB-8 near the VOC sources in the vicinity of B-15 and SB-24. Acetone (37.5 to 44.3 µg/L), TCE (2.8 to 3.1 µg/L), and cis-1,2-DCE (3.1 to 3.5 µg/L) were detected from multiple inlets and duplicate samples at MCB-31. The footing drain sampling originates to the west, encompassing an area of potential groundwater migration from well B-5 in the Building D4-G1 alleyway (south of Building G2). The presence of TCE and cis-1,2-DCE in the footing drain samples suggests the footing drains have intercepted groundwater and associated VOCs from the

[2] Building D3 is south of Building G1, which is immediately south of Building G2, and outside the SPRU Upper Level RFI area. These data are presented to indicate a potential VOC source south of Building G2.

area near B-5; however, potential migration along the storm sewer in this area is not toward the Building H2 area.

Groundwater Sampling

Groundwater samples were collected from the following 12 groundwater monitoring wells within the G2-H2 area during the KAPL Phase I Hillside RFI: MW-1, MW-2, MW-3, MW-4A, MW-6, MW-22, MW-24, MW-25, MW-26, MW-27, B-15, and WP-2 (see Figure 4-1). One or more of the following chlorinated VOCs were detected: PCE; TCE; cis-1,2-DCE; trans-1,2-DCE; 1,1-DCE; 1,1,1-trichloroethane (1,1,1-TCA); 1,1-DCA; 1,1,1,2-tetrachloroethane (1,1,1,2-PCA); chloroform; vinyl chloride; carbon tetrachloride; carbon disulfide; bromodichloromethane; and dibromomethane. TCE; cis-1,2-DCE, carbon tetrachloride; and chloroform are the primary VOCs detected in the G2-H2 area.

TCE was detected in six wells at concentrations ranging from 4.8 to 21,600 µg/L. The highest concentration was at groundwater monitoring well MW-24, with other elevated concentrations at MW-2 (7,530 µg/L), MW-6 (2,640 µg/L), and B-15 (97.1 µg/L).

Chloroform was detected in 6 groundwater monitoring wells at concentrations ranging from 0.37 to 4,690 µg/L. In addition to the maximum observed concentration in well MW-24, wells with elevated concentrations include MW-2 (946 µg/L) and MW-6 (464 µg/L).

Cis-1,2-DCE also was detected in six wells at concentrations ranging from 1.8 to 648 µg/L. The highest concentration was detected in MW-24, with the next two highest concentrations detected in MW-24 (438 µg/L) and MW-6 (357 µg/L).

Vinyl chloride was detected in three wells at concentrations ranging from 1.4 to 50.3 µg/L. The highest concentration was at MW-6 with the other detections at MW-2 and MW-24. Carbon disulfide was detected once at MW-24 at 22.6 µg/L. The primary VOCs in the G2-H2 area were all detected in groundwater monitoring wells MW-1, -2, -4A, -6, and -24 at concentrations exceeding the NYSDEC ambient water quality criteria. Groundwater monitoring wells MW-24, -2, and -6 contain the highest VOC concentrations. None of these compounds were detected in nearby well MW-25. VOCs were not detected in well point WP-2, located along the Building H2 hillside (WP-1 was not sampled due to lack of water).

VOCs were not detected in SW-10, located west of the D4-G1 alleyway, indicating that VOCs have not migrated to this location from the source areas south of Building G1 or west of Building G3 (both of which are south of Building G2).

4.3.2 KAPL Sewer Leak Investigations

In November 2003, KAPL performed a water pressure test of the storm sewer piping between MCB-7 and MCB-8 to determine the sewer line integrity because of periodic surcharging of the Hillside Sump during heavy precipitation. The test involved blanking off ancillary sewer lines to isolate the sewer line between MCB-7 and MCB-8. Water was added under pressure to the sewer line, and the pressure was monitored. The groundwater levels for monitoring wells MW-SV1, MW-SV2, MW-SV3, MW-24, and MW-25 were concurrently measured for depth to water level during the performance of the storm sewer pressure test. All of the wells are between the sewer line and Building H2 and mainly west of the Pipe Tunnel; MW-SV2 is the only well east of the Pipe Tunnel (see Figure 4-1). MW-SV3 is adjacent to the south side of Building H2 and immediately west of the main entrance.

The test resulted in the failure of the storm sewer piping to hold water pressure, indicating that the storm sewer piping integrity was compromised. During the water pressure test, the MW-SV3 water level increased by approximately 8 feet, and water was heard cascading into the well. Increased water level in the Hillside Sump was also observed. However, the water levels in the other four wells did not change. The increased water levels in MW-SV3 and the Hillside Sump suggest that a conduit for stormwater from the storm sewer piping between MCB-7 and MCB-8 exists that allows stormwater to enter the Pipe Tunnel and Building H2 footing drains.

To eliminate stormwater leakage to groundwater between Buildings G2 and H2, KAPL relined the stormwater lines between MCB-7, MCB-8 and MCB-9 in May 2005.

4.3.3 SPRU SV Investigations

The following sections summarize the findings of the SPRU SV investigations. Details of the SPRU SV investigation in the Upper Level are provided in Section 5 of the RFA SV Report (DOE/CH2M HILL, 2002).

VOCs in Upper Level Soils

A total of 21 soil samples and 2 duplicate samples were collected and analyzed for VOCs from 11 soil borings in the Upper Level (See Table 4-3). Eleven VOCs were detected in eight of the soil borings. Acetone, methylene chloride, chloroform, and carbon disulfide detections were attributed to laboratory contamination. VOC detections in the Upper Level SWMUs are summarized as follows.

H2 Processing Facility (SWMU-030). Toluene, TCE, and total 1,2-DCE were detected at B3003 (up to 4J µg/kg), in the southwest corner of Building H2, at 22 to 22.5 feet bgs (see Figure 4-1). TCE (9.1 µg/kg) was also detected along the western perimeter of Building H2 at B3004 (22.2 to 22.5 feet bgs).

H2 Tank Farm (SWMU-031). Low levels of carbon disulfide (1.4J µg/kg), ethylbenzene (0.41J µg/kg), and toluene (1J µg/kg) were detected at various depths in B3101 and B3103/B3103B, east and south of the Tank Farm, respectively.

Pipe Tunnel (SWMU-057). The highest concentrations of TCE (270 µg/kg) and total 1,2-DCE (150 µg/kg) were detected at B5704 (southwest of the Pipe Tunnel) at 12.5 to 13 feet bgs. TCE (7 µg/kg) was also detected at 6 to 6.3 feet bgs within B5704. Traces of 1,1-DCA (2J µg/kg); 1,1-DCE (5J µg/kg); and vinyl chloride (11J µg/kg) were also detected at 12.5 to 13 feet bgs within B5704. TCE and total 1,2-DCE were detected at B5701 (up to 11 µg/kg) at 22 to 22.5 feet bgs, north of B5704.

SVOCs in Upper Level Soils

A total of 41 soil samples and 2 duplicate samples were collected from various intervals in 11 soil borings and analyzed for SVOCs. Up to 16 PAHs (8.2J to 110,000 µg/kg) were detected in all 11 soil borings. Low levels of phenol, 2-chlorophenol, 4-chloro-3-methylphenol, and bis(2-ethylhexyl)phthalate (up to 142J µg/kg) were also detected in six of the soil borings.

The discontinuous nature of the elevated PAHs and phenols is indicative of materials containing SVOCs mixed in with the backfill excavations; these materials include surface asphalt and asphaltic water proofing on the exterior foundations of Building H2, the Tank Farm, and the Pipe Tunnel, and expansion joints in the Pipe Tunnel. Soil boring logs indicate traces (less than 10 percent) of cinders, slag-like material, dark anthropogenic material (typically less than 0.25-inch-diameter balls of hard carbon material with a charcoal streak), and organic material (leaves and roots) in fill material backfilling the Building H2, Tank Farm, and Pipe Tunnel construction excavations. Trace levels of detected phthalates, phenol, 2-chlorophenol, and 4-chloro-3-methylphenol are attributed to laboratory interferences because they were also detected in a limited number of blanks (i.e., equipment, trip, and method).

The location of elevated SVOCs does not correlate with detected VOCs. The RFA SV Report concluded that the presence of SVOCs in soil at the Upper Level SWMUs is from facility operations and not likely associated with a release.

Metals in Upper Level Soils

A total of 41 soil samples and 2 duplicate samples were collected from various intervals of 11 of the soil borings and analyzed for metals (see Table 4-2). Sixteen metals (aluminum, antimony, arsenic, barium, cadmium, calcium, total chromium, lead, magnesium, manganese, mercury, potassium, selenium, sodium, vanadium, and zinc) were detected at slightly elevated levels relative to their respective background values. A summary of elevated metals above SV background by SWMU area is provided below.

H2 Processing Facility (SWMU-030). The following metals were elevated in soil borings adjacent to the H2 Processing Facility.

- Arsenic exceeded NYSDEC soil cleanup objectives (25.2 mg/kg) along with other elevated levels of calcium (129,000J mg/kg) and magnesium (61,000 mg/kg) at soil boring B3002 (0 to 2 feet bgs) along the southwest side of Building H2. These metals attenuate with depth at the next deepest sample interval (14 to 16 feet bgs).
- Total chromium (19.2 mg/kg) exceeded the SPRU background value at B3002 (14 to 16 feet bgs) but was below the state soil criteria of 50 mg/kg.
- Slightly elevated antimony (0.78J mg/kg), mercury (0.14 mg/kg), and vanadium (56.7 mg/kg) and the highest concentrations of calcium (154,000J mg/kg) and magnesium (76,900 mg/kg) were detected in soil boring B3003 (0 to 2 feet bgs) along the southwest side of Building H2. Mercury and vanadium attenuate with depth at the next deepest sample interval (10 to 12 feet bgs). Antimony also exceeds background (0.46J mg/kg) at 22 to 22.9 feet bgs.

- Slightly elevated lead (21.5J mg/kg) and cadmium (0.39J mg/kg) were detected at B3004 (0.5 to 2 feet bgs). Lead attenuates with depth at the next deepest sample interval (10 to 12 feet bgs), and cadmium attenuates at 20 to 22 feet bgs.

Elevated levels of antimony, arsenic, and mercury exceed applicable background ranges at the southwest corner of Building H2 (B3002 and B3003), which likely indicates a hazardous constituent release from SPRU operations. However, the antimony levels may be suspect because of laboratory matrix interference.

H2 Tank Farm (SWMU-031). The following metals were elevated in soil borings adjacent to the H2 Tank Farm.

- Antimony (0.4J mg/kg) was slightly above the background value at the final depth of soil boring B3102 (8 to 8.83 feet bgs). However, antimony was not detected (<0.13J mg/kg) in the corresponding duplicate sample (FDD002) and therefore is likely a result of matrix interference and not a release indicator.

- Cadmium (0.75 mg/kg), lead (45.7 mg/kg), mercury (0.31 mg/kg), and zinc (357J mg/kg) were above background values in soil boring B3101 (1.33 to 2 feet bgs), immediately east of the Tank Farm. The mercury and zinc concentrations also exceed the state soil cleanup objective values. However, these metals attenuate with depth at the next sample interval (10 to 12 feet bgs) and are laterally bounded by lower concentrations in one direction (west) by soil boring B3102.

- Barium (up to 179 mg/kg), total chromium (up to 26.2 mg/kg), lead (20.7 mg/kg), mercury (0.15 mg/kg), selenium (up to 1.61 mg/kg), vanadium (up to 36.3J mg/kg), and zinc (97.1J mg/kg) were elevated in soil boring B3103 and its offset location B3103B, immediately south of the Tank Farm. With the exception of elevated levels of total chromium, selenium, and vanadium at 0.5 to 2 feet bgs, elevated concentrations are deeper than 10 feet bgs. Concentrations of barium (179 mg/kg), total chromium (26.2 mg/kg), selenium (0.772 mg/kg), and zinc (97.1J mg/kg) are elevated in the lowermost sampling interval (28.5 to 29 feet bgs) collected from backfill materials at the base of the tank vault wall, near its foundation. However, of the elements found deeper in the soil, only zinc exceeds the state cleanup criteria.

Elevated metals detected in the surface soil of B3101 (mercury, lead, cadmium, and zinc) and at deeper samples in B3103/B3103B (barium, chromium, selenium, and zinc) indicate a release of hazardous constituents from SPRU operations to the east and south portions of the Tank Farm, respectively. Some of these same metals are also associated with the tank vault residue and debris.

Pipe Tunnel (SWMU-057). The following metals are elevated in soil borings along the Pipe Tunnel.

- Antimony is slightly elevated (up to 0.38J mg/kg—above background) in the duplicate sample (FDD001) from borings B5701 (15 to 17 feet bgs), B5701 (18 to 20 feet bgs), and B5703 (5 to 7 feet bgs). Antimony attenuates at the next sample intervals within borings B5701 (22 to 24 feet bgs) and B5703 (10 to 12 feet bgs). Because antimony (0.17J mg/kg) was not elevated in the corresponding original sample from B5701 (15 to 17 feet bgs), variability of antimony is likely a result of matrix interference, and therefore elevated antimony is not a release indicator.

- Cadmium is above background (0.38 mg/kg) at B5701 (5 to 7 feet bgs) but is below the state cleanup criteria and within the background range of northeastern soils (0.001 to 1 mg/kg).

- Total chromium is slightly elevated above background (19.1 mg/kg) at B5701 (18 to 20 feet bgs).

- Lead is above background (15.9 mg/kg) at B5701 (5 to 7 feet bgs) but is less than the state cleanup criteria.

- Mercury is slightly elevated above background (0.11 mg/kg) at B5702 (5 to 5.6 feet bgs), near the northeast corner of the Pipe Tunnel.

- Selenium is slightly elevated (0.35 mg/kg) at B5701 (18 to 20 feet bgs) but is well below the state criteria.

Elevated levels of these metals (antimony, cadmium, total chromium, lead, mercury, and selenium) were all determined to be below other applicable background ranges or not confirmed in duplicate sample analyses. Therefore, they do not indicate a release of metal constituents from SPRU operations at the Pipe Tunnel.

VOCs in Upper Level Groundwater

A total of 14 groundwater samples (MW-SV8 was sampled twice) plus 2 duplicate groundwater samples were collected and analyzed for VOCs from four SV monitoring wells (MW-SV1, MW-SV2, MW-SV3, and MW-SV8), three existing 1952 monitoring wells (MW52-1, MW52-2, and MW52-4), and six 1973 cased borings (H-20, H-21, H-22, H-24, H-26, and H-28) (see Table 4-5 and Figure 4-1). Acetone, carbon disulfide, methyl ethyl ketone, and toluene were detected in trace concentrations (4.5J to 21 µg/L) that were not attributed to a release to the environment. Detected VOCs by SWMU are summarized below.

H2 Processing Facility (SWMU-030). A trace of carbon disulfide (5J µg/L) in groundwater from cased boring H-28 was the only VOC detected. No VOCs were detected in the other five cased borings.

H2 Tank Farm (SWMU-031). No VOCs were detected in monitoring wells MW52-1, MW52-2, and MW52-4. Low levels of acetone and traces of methyl ethyl ketone, and toluene detected in the sample (UPAGW21V2) collected from MW-SV8 using an inertial pump are most likely associated with laboratory or field handling of the samples.

Pipe Tunnel (SWMU-057). VOCs (i.e., TCE and 1,2-DCE) were detected at trace levels in two of the three SV monitoring wells (MW-SV1 and MW-SV3) along the west side of the Pipe Tunnel. A trace of carbon disulfide (1J µg/L) was also detected at MW-SV1. The highest concentrations of TCE (18 µg/L) and 1,2-DCE (7 µg/L) were detected in monitoring well MW-SV3, adjacent to Building H2. Trace levels of TCE (2J µg/L) and 1,2-DCE (1J µg/L) were detected in MW-SV1. TCE and 1,2-DCE were also routinely detected in monitoring well B-15, located approximately 75 feet west of the tunnel, during the KAPL Annual Environmental Monitoring Program (KAPL, 2004). No VOCs were detected in MW-SV2.

SVOCs in Upper Level Groundwater

A total of 21 groundwater samples plus 3 duplicate samples were collected and analyzed for SVOCs from the same wells/cased borings sampled for VOCs above, plus 8 existing monitoring wells (B-8, B-9, B-14, B-15, B-16, B-26, KH-15, and KH-16; see Figure 4-1). Up to 9 SVOCs were detected in 11 of the monitoring wells/cased borings. Trace levels (up to 0.8J µg/L) of 2-methylnaphthalene (MW-SV1), phenanthrene (MW-SV1), benzyl alcohol (H-22), and di-n-butylphalate (H-24, MW52-2, and B-26) were detected in 5 of the 20 monitoring wells/cased borings sampled for SVOCs. Traces of bis(2-ethylhexyl)phthalate (up to 13J µg/L) were also detected in six additional monitoring wells/cased borings (H-26, MW52-4, MW-SV8, B-8, B-14, and B-15). Trace levels (up to 0.7J µg/L) of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3,-c,d)pyrene were also detected in MW52-4.

Trace levels of PAHs detected in wells at the Tank Farm are indicative of materials (asphaltic water proofing on the exterior foundation) containing PAHs mixed in with backfill material. Trace levels of benzyl alcohol and phthalates detected in nine groundwater samples are attributed to laboratory interferences and, in the case of phthalates, are also detected in a limited number of blanks (i.e., equipment, trip, and method).

Overall, the locations of detected SVOCs do not correlate with detected VOCs. The presence of SVOCs in groundwater at the Upper Level SWMUs is not likely associated with a release from SPRU operations. However, SVOC analytical results from well MW52-4 were rejected during validation. No SVOCs were detected in the August 20, 2004, resample of well MW52-4.

Metals in Upper Level Groundwater

A total of 19 groundwater samples plus 3 duplicate samples were collected and analyzed for dissolved (filtered if turbidity exceeded 5 nephelometric turbidity unit [NTUs]) and total metals from four SV monitoring wells (MW-SV1, MW-SV2, MW-SV3, and MW-SV8), the three existing 1952 monitoring wells (MW52-1, MW52-2, and MW52-4), and the six 1973 cased borings (H-20, H-21, H-22, H-24, H-26, and H-28) (see Figure 4-1). Analytical results are discussed below and summarized in Table 5-8 of the RFA SV Report.

Elevated dissolved metal concentrations of magnesium, manganese, and/or sodium were detected in most of the wells. These nonhazardous metals were largely attributed to road salt application and backfill mineralogy. Other dissolved metals were detected below water quality criteria (NYSDEC, 1998b) except for the following.

- Dissolved iron was elevated in one monitoring well (860 µg/L in MW52-1).
- Estimated concentrations of dissolved antimony were slightly elevated in two cased borings adjacent to the northwest corner of Building H2 (H-28 at 4.3J µg/L and H-22 at 3.1J µg/L).

- A trace level of thallium was detected at 1 µg/L in a duplicate sample (FDGW11) of MW-SV3 but not from the associated corresponding normal sample. Neither sample was filtered since the groundwater turbidity was less than 5 NTUs.

Summary of SPRU SV Conclusions

The following sections summarize the conclusions regarding Upper Level SWMUs developed from the SV investigation. Section 8 of the RFA SV Report provides further detail.

H2 Processing Facility (SWMU-030). Surface soil near the southwest corner of Building H2 had elevated antimony, arsenic, and mercury concentrations. Antimony was also detected (although the analytical data were suspect because of matrix interference) above the NYSDEC ambient water quality criteria in dissolved groundwater samples collected along the northwest portion of Building H2. Groundwater along the southern perimeter of Building H2 contains VOCs (TCE and total 1,2-DCE) above the NYSDEC criteria.

H2 Tank Farm (SWMU-031). Mercury and zinc are elevated above background or NYSDEC recommended soil cleanup objectives in surface soil in the east-central portion of the H2 Tank Farm. Mercury is also elevated above background or NYSDEC soil cleanup objectives in soil at the base of the tank farm vault foundation. These metals are consistent with hazardous constituents managed by SPRU operations.

Pipe Tunnel (SWMU-057). VOCs below NYSDEC soil cleanup objectives were detected in soil along the western foundation of the Pipe Tunnel. Groundwater also contains traces of VOCs (1,1-DCA; 1,1-DCE; total 1,2-DCE; TCE; and vinyl chloride) west of the Pipe Tunnel. Only TCE exceeds the NYSDEC ambient water quality criteria in one well.

4.3.4 KAPL Sitewide Groundwater Monitoring

Groundwater throughout the Knolls Site is monitored annually, and the results are reported in annual Environmental Monitoring Reports. Data from annual reports through the Calendar Year 2003 report, KAPL-4851 (KAPL, 2004), have been used to summarize the sitewide groundwater monitoring results for the Knolls Site.

In 2003 the Knolls Site groundwater monitoring network consisted of 58 groundwater monitoring wells. Groundwater samples were collected from 38 of the 58 wells during the monitoring period.

The following KAPL groundwater monitoring wells are located within or downgradient of the Upper Level area between Buildings G2 and H2: B-15, B-16, B-26, and KH-15. These wells are sampled and analyzed annually for VOCs. VOC results for all monitoring wells are reported to be consistent with previous years, with VOCs only being detected in monitoring well B-15. As discussed in Section 4.3.1, more recent investigations of the Hillside Area have further defined the nature and extent of VOC contamination in its soil and groundwater.

4.4 Upper Level RFI

This section presents the results of the RFI evaluations for the Upper Level, including the geological, hydrogeological, and SWMU nature and extent evaluations. The fate and transport potential for the Upper Level is also described.

4.4.1 Upper Level Geological Evaluation

This section describes the geological conditions of the Upper Level, as identified through historical construction photographs; by previous subsurface evaluations of Building H2, the Tank Farm, and the Pipe Tunnel; and by recent subsurface evaluations as part of the Groundwater RFI and Outside Characterization. Based on these evaluations, the overall geologic conditions are presented and the top of till topography is described.

The geologic conditions within the Upper Level were evaluated based on extensive investigations completed by KAPL as part of the Hillside RFI, previous investigations completed by KAPL prior to the Hillside investigation, the RFA SV, the SPRU Outside Characterization (i.e., the radiological characterization conducted in conjunction with the Groundwater RFI as described in Section 1.2), and during this groundwater RFI. These investigations have involved the completion of various soil borings using a variety of drilling methods, and installation of numerous permanent and temporary groundwater monitoring wells. Soil borings and monitoring wells from previous investigations that are located in the SPRU Upper Level or, in the case of monitoring wells, are also immediately downstream of the Upper Level, were selected for inclusion in the RFI evaluations and conceptual model for the Upper Level. Subsurface geologic information and water levels from these wells and boreholes were used to develop an understanding of the hydrogeologic conditions in the Upper Level. Utility record drawings, construction photographs, and other related materials have also been reviewed in support of developing a conceptual model for the Upper Level.

The geologic conditions in the Upper Level were previously evaluated through:

- The completion of 11 soil borings (including redrills) and 5 monitoring well installations at the H2 Processing Facility, the H2 Tank Farm, and the Pipe Tunnel undertaken as part of the RFA SV
- Existing boring logs for other soil borings and monitoring wells previously completed in the Upper Level by KAPL for the Hillside RFI and sitewide groundwater monitoring and subsurface studies in relation to Building H2

This SPRU Groundwater RFI involved the completion of 14 soil borings (including redrills), 7 of which were converted to groundwater monitoring wells, as presented in Appendix A, Table A-1. The SPRU Outside Characterization involved the completion of 66 additional soil borings (including redrills), 11 of which were converted to either permanent or temporary groundwater monitoring wells, as presented in Appendix A, Table A-2. The SPRU Outside Characterization borings and monitoring wells were not sampled as a function of the Groundwater RFI but were used in the identification of Upper Level geologic characteristics. The soil boring and monitoring well locations are shown in Plate 4-1. Soil boring/ monitoring well logs and survey coordinates are provided in Appendixes E and F, respectively.

Historical Construction Photographs

As depicted in Figure 4-2, the foundations of Building H2 and the H2 Tank Farm were constructed within a deep excavation into the native brown and gray tills. The lowest portion of the building floor slab shown is believed to be the lowest level floor slab of Building H2. The vaults shown on the right in the photo are the SPRU tank vaults in the H2 Tank Farm. Concrete slabs were eventually installed immediately above the vaults as shown and covered with approximately 8 feet of fill to bring them up to finished ground surface elevation. The tops of the eastern and southern excavations, as shown in the photo, are believed to represent the approximate existing ground surface. The presence of the compact and dense glacial till allowed the establishment of the near vertical excavation walls on all sides of the building. Near vertical excavation walls are absent in the northwestern portion of the building, where it appears that an access/haul road was developed in support of the construction activity. The stockpile of soils shown in the background is believed to be the soils excavated for building location, which are referred to herein as till-derived fill, and used in part as foundation backfill. The Lower Level Access Road is shown on the left in the photo. The construction of the Pipe Tunnel, just below the midsection of the crane boom depicted in the foreground, does not appear to have been started yet.

The second photograph (Figure 4-3) depicts an advanced stage of construction at Building H2. The photo shows that the southern, eastern, and northern foundation walls have been backfilled up to the level of construction completed. The photograph does not depict the condition of the backfilling at the northwestern or western sides of the building but shows that the hillside slope was not established, so little backfilling of the western wall was completed at that time. Of notable mention is the coal fired boiler building on the north side of the building and adjacent to Building H1, the cooling tower, and the pile of coal just in front of the crane. This is a potential source of “slag” observed in some of the soil samples collected in the Upper Level and also a potential source of PAHs. Additionally, the Building H2 tank vaults have been covered, and the construction of the Pipe Tunnel in the foreground appears to be well underway. The pile of soil in the background appears to be smaller and reveals evidence that the pile is being actively worked, based on the absence of snow on the face of the pile.

The last photograph (Figure 4-4) shows the portion of Building H2 that was completed above grade. The southwestern corner and western wall of the building have been only partially backfilled, as the Lower Level Access Road can be seen through the open steel structural members. The photograph shows that the Hillside has not yet been fully established as it exists today. The top of the Pipe Tunnel is shown just below the main door at the southeastern side of the building. The pile of soil in the background, just to the right of the cooling tower, is nearly gone. Based on this observation, another source of fill was required to construct the hillside.

H2 Processing Building, H2 Tank Farm, and Pipe Tunnel Subsurface Evaluation

KAPL wells H-20, H-21, H-22, H-24, H-26, and H-28 were completed in 1973 along the western and northwestern sides of the exterior wall of Building H2 (see Figure 4-1). The wells are essentially standpipes installed in borings and were used to allow downhole radiological monitoring of the Building H2 foundation area (KAPL, 1974). They are referred to herein as cased borings. Well construction details are lacking, and it is not apparent that any well screens were installed. Groundwater enters the well casings presumably through leaks in the casing or casing seams. The cased borings were drilled to depths of up to 40 feet bgs, below the depth of the Building H2 foundation, typically at 22 to 23 feet bgs. The boring logs for these cased borings identify soils composed of silt, sand, gravel, and clay from grade to depths of 20 to 26 feet bgs. This soil was classified as fill and is likely to be till-derived fill. Gray till was present directly beneath the fill material, except at soil boring H-26, where a 3-foot layer of brown gravel was present beneath the fill, on top of the gray till, between the depths of 20 and 23 feet bgs.

KAPL monitoring wells MW52-1, MW52-2, MW52-3[3], and MW52-4 were advanced along the southern and northern ends of the H2 Tank Farm (Knapp, 1954) (see Figure 4-1). The boring logs for these wells provide little detail regarding the subsurface conditions encountered. The wells were constructed of 3-inch-inside-diameter, polyvinyl chloride (PVC) casing. "Windows" were cut into the casing to allow monitoring of the subsurface with downhole radiological monitoring equipment. Wells MW52-1, MW52-3, and MW52-4 were drilled to depths of about 40 feet bgs, with three windows cut into each well casing between 23 and 35 feet bgs. Well MW52-2 was drilled to a depth of about 196.5 feet bgs and encountered bedrock at 64.5 feet bgs (elevation of 266.6 feet amsl). MW52-2 is cased to a depth of 71.5 feet bgs, and the rest of the well consists of uncased and unscreened open hole in bedrock.

During the RFA SV, soil borings B5701 (well MW-SV3), B3103B (well MW-SV8), B5702, B3101, B3101A, B3103, B3001, B3002, B3003, B3004, B5703 (well MW-SV2), and B5704 (well MW-SV1) were completed along the southern, western, and northern sides of Building H2, and along the eastern and western sides of the Pipe Tunnel (see Plate 4-1). Samples from these borings indicate the presence of granular fill and till-derived fill around the perimeter of Building H2, and support the steepness and proximity of the excavation walls formed at the time Building H2 and the Pipe Tunnel were constructed. Three of the borings (B3001, B3004, and B3103B) confirmed the presence of granular fill at the base elevation of Building

[3] Well MW52-3 is no longer accessible. It was located along the eastern side of the Tank Farm 65.6 feet south of the northeast corner of the H2 Tank Farm (Knapp, 1954; Figure 5).

H2 or the Pipe Tunnel, lying on top of gray till. Otherwise, till-derived fill extends to the contact with undisturbed gray till, generally at the footing depth of the structures if the borings were completed close enough to the foundation walls. Additional details on these SV soil borings and monitoring wells are provided in the RFA SV Report.

Groundwater RFI and Outside Characterization Subsurface Evaluation

The monitoring wells (designated UW-xx) and soil borings (beginning with LA) completed around the immediate perimeter of Building H2 as part of the Groundwater RFI and SPRU Outside Characterization are UW-1 (LA1305-5-W1), UW-2 (LA1305-5-W2), UW-8 (LA1406-1-B), UW-8A (LA-SO-UW-8A), UW-9 (LA1303-7-B), UW-9A (LA-SO-UW-9A), UW-14 (LA-SO-UW-14), UW-14A (LA-SO-UW-14A), UW-17 (LA-SO-UW-17), UW-18 (LA-SO-UW-18), LA-SO-UW-19, LA1303-2-B2, and LA1303-3-B2 (see Plate 4-1). Other than UW-1 (LA1305-5-W1) and UW-2 (LA1305-5-W2), these borings/monitoring wells were installed to support the Outside Characterization efforts; UW-1 (LA1305-5-W1) and UW-2 (LA1305-5-W2) were installed to jointly support the Groundwater RFI and the Outside Characterization efforts.

Soil borings LA1305-5-W1 (well UW-1), LA1305-5-W2 (well UW-2), LA-SO-UW-14 (well UW-14), LA-SO-UW-14A (well UW-14A), and LA-SO-UW-19 were completed at the northwest corner of Building H2. At LA1305-5-W1 (well UW-1), till-derived fill was encountered below the surface materials to the top of gray till (307.8 feet amsl). Asphalt, wood, and plastic were noted at various depths within the till-derived fill. Crushed stone or sand and gravel were not found at the till-derived fill/gray till interface. At LA1305-5-W2 (well UW-2), similar subsurface conditions to LA1305-5-W1 (well UW-1) were encountered; however, a layer of sand and gravel was encountered from approximately 21 to 26.5 feet bgs. This sand and gravel layer was on top of the gray till at elevation 303.2 feet amsl. These findings are notable because:

1. LA1305-5-W1 (well UW-1) was completed closer to the wall of Building H2 than LA1305-5-W2 (well UW-2), and sand and gravel was not encountered at LA1305-5-W1 (well UW-1) as would be expected, but was encountered at LA1305-5-W2 (well UW-2).
2. Groundwater was not encountered at LA1305-5-W1 (well UW-1) but was found at LA1305-5-W2 (well UW-2).

As discussed in the section pertaining to the Historical Construction Photographs, an access road leading into the northwest corner of Building H2 was apparent in the historical construction photographs. Based on review of these photographs, the lowest portion of the northern wall of Building H2 may have been backfilled with till-derived fill to seal around the foundation footing drain, and the sand and gravel may represent the old construction roadbed running up to Building H2. LA-SO-UW-14 (well UW-14) and LA-SO-UW-14A (well UW-14A) were completed east of LA1305-5-W1 (well UW-1) and LA1305-5-W2 (well UW-2). LA-SO-UW-14 was completed closer to the northern wall of Building H2 than LA-SO-UW-14A. LA-SO-UW-14 was a blind Geoprobe push to the elevation 302.2 feet amsl to establish a monitoring well adjacent to the footing drain and as such, soils were not recovered for classification.

At LA-SO-UW-14A till-derived fill was encountered to a depth of 16.2 feet bgs (314.3 feet amsl) and contained a piece of rebar, slag, and wood fragments. Gray till was present directly beneath the till-derived fill (314.3 feet amsl). The shallow depth at which gray till was encountered suggests that this location was completed on the steep excavation wall formed at the time of building construction.

LA-SO-UW-19 was advanced east of LA1305-5-W2 (well UW-2) to further evaluate this condition and determine if the gray till was continuously impermeable in this area, and to confirm that sand strata within the gray till were not present that could be transporting groundwater with elevated radioactivity from the interior of the Building H2 foundation to intercept the H-28 cased boring below the Building H2 footing invert at 308 ft amsl and the bottom of the H-28 cased boring at approximately 293 feet amsl (KAPL, 1974). At this boring, sand and gravel were not encountered, and gray till was present at 22 feet bgs (308.1 feet amsl). These boring results suggest that the foundation backfilling activity was not completed with a specific type of backfill material, but rather a variety of materials, the majority of which were site-derived soils.

Soil borings LA1406-1-B (well UW-8), LA-SO-UW-8A (well UW-8A), LA-SO-UW-17 (well UW-17), and LA-SO-UW-18 (well UW-18) were advanced at the northeast corner of the H2 Tank Vault. At boring LA1406-1-B (well UW-8), till-derived fill was encountered to a depth of 22 feet bgs, where an approximate 2-foot layer of saturated sand and gravel was encountered on top of gray till (307.1 feet amsl). Portions of the upper till-derived fill were saturated such that a shallow (13-foot) monitoring well was installed at blind push boring LA-SO-UW-8A. Borings LA-SO-UW-17 and LA-SO-UW-18 were completed west of LA-1406-1-B and LA-SO-UW-8A. These borings were terminated above the building footing elevations and did not encounter gray till. The soils within these borings were predominantly gray and brown till-derived fill.

Soil borings LA1303-7-B (well UW-9) and LA-SO-UW-9A (well UW-9A) were completed at the southeast corner of the H2 Tank Vault. These borings/wells were installed during the radiological characterization to evaluate radiological conditions in a perched saturated zone associated with the top of the Tank Farm vault near SV monitoring well MW-SV8. These borings were blind push Geoprobe installations, so soils were not recovered for classification. LA1303-7-B was advanced to 5 feet bgs (307.8 feet amsl) with a monitoring well (UW-9) set at this elevation. LA-SO-UW-9A was advanced to 13 feet bgs (319.8 feet amsl) with a monitoring well (UW-9A) installed at this elevation.

Soil borings LA1303-2-B2 and LA1303-3-B2 were completed along the southern portions of Building H2. LA1303-3-B2 was completed at the southwestern corner of Building H2 and advanced to a total depth of 21.5 feet bgs. Gray and brown till-derived fill was present to a depth of 20 feet bgs. A sand and gravel layer with fragments of red drain pipe was present beneath the till-derived fill to a depth of 21.5 feet bgs, at which point spoon refusal was encountered. A monitoring well was not installed at this location. LA1303-2-B2 was a relatively shallow boring advanced to a depth of 4.0 feet bgs along the southern wall of Building H2 as part of the radiological characterization to evaluate a localized area of elevated radioactivity in shallow soils.

The remaining Groundwater RFI soil borings (and associated monitoring wells shown in parentheses, where applicable) are LA1401-3-W (UW-3), LA1401-6-Wc (UW-4), LA-SO-UW-5, LA-SO-UW-6 (UW-6), LA-SO-UW-7, LA-SO-UW-10 (well UW-10), LA1401-2-B (UWT-2), and LA1401-2-Ba (UWT-2A). Soil boring LA-SO-UW-10 (well UW-10) was installed as part of the SPRU Outside Characterization (radiological) investigation. These borings/monitoring wells focused on the western and northern perimeters of Building G2 and the open area between Buildings G2 and H2. Boring LA1401-3-W (well UW-3) was advanced at the northwest corner of G2, adjacent to SB/MW-22. Till-derived fill was encountered to 7 feet bgs, below which was brown till to the termination depth of the boring at 14 feet bgs. At boring LA-1401-6-Wc (well UW-4), several attempts were made to achieve the target depth; however, each attempt encountered obstructions, which resulted in drilling refusal at depths generally less than 8.3 feet bgs. An exception was at LA1401-6-We, where the boring was advanced to 11.3 feet bgs before encountering refusal. Monitoring well UW-4 was installed at boring LA1401-6-Wc. Borings LA1401-2-B (well UWT-2) and LA1401-2-Ba (well UWT-2A) were advanced along the western wall of Building G2, south of the northwest corner of the building. LA1401-2-B (well UWT-2) was advanced to a total depth of 12 feet bgs (321.8 feet amsl), at which point spoon refusal was encountered. Till-derived fill was present in the upper portions of the boring with granular fill below and a thin layer of till-derived fill at the base. Concrete fragments were noted in the upper fills, and a nail and clay pipe fragments were noted in the sample interval at 11 to 12 feet bgs.

Three soil borings (LA-SO-UW-5, LA-SO-UW-6, and LA-SO-UW-7) were completed in the area between Buildings G2 and H2. Each boring was terminated at depths between 7 and 8 feet bgs because of split-spoon refusal, probably the result of encountering native till. A monitoring well (UW-6) was installed at LA-SO-UW-6 but not at borings LA-SO-UW-5 or LA-SO-UW-7. Groundwater monitoring well UW-10 was installed east of the Pipe Tunnel, adjacent to the buried stormwater line. The well boring (LA-SO-UW-10) was advanced to a depth of 16.8 feet bgs (316.6 feet amsl), which is below the invert elevation of the stormwater line. Soils encountered from grade to the termination depth were composed primarily of granular fills with evidence of concrete fragments to approximately 13 feet bgs, and till-derived fill with evidence of nails, wood, and paper to 16.8 feet bgs.

Overall Upper Level Geology

The soils in the Upper Level are generally composed of fills consisting of granular sands and/or gravels, reworked native soils composed of brown or gray glacial till, and native undisturbed brown and gray till. The fill and reworked soil from other areas of the Knolls Site emplaced in the Upper Level are found to be associated predominantly with the buried subsurface improvements (i.e., utilities) and adjacent to the subsurface building structures (i.e., footing drains). Sand and gravel are associated primarily with the various building foundation wall footings and footing drains. The till-derived fill is found throughout the Upper Level to varying depths, particularly in abundance adjacent to the building foundation walls and above areas of buried utilities. Native brown and gray till are found at varying depths and represent the vertical limits of soil disturbance during construction of the Upper Level.

The Upper Level soil borings used to prepare geologic cross-sections A-A′, B-B′, C-C′, and D-D′ are shown in Figure 4-5. Figures 4-6 through 4-9 provide the geologic cross-sections for A-A′ running east to west, B-B′ running southwest to northeast, C-C′ running southwest to northeast, and D-D′ running east to west, respectively.

Soil borings LA-SO-UW-10 (well UW-10), B5703 (well MW-SV2), B5704 (well MW-SV1), SB-24 (well MW-24), SB-2 (well MW-2), SB-23, SB-6 (well MW-6), and SB-27 (well MW-27) were used to construct cross-section A-A′ (Figure 4-6), which crosses the Pipe Tunnel between Buildings H2 and G2. Beneath the asphalt pavement and sub-base sand and gravel is a granular fill composed of poorly sorted sands with varying percentages of silt, clay, and gravel. This fill material is generally underlain by till-derived fill that may be contiguous with the till-derived fill used as backfill around the Building H2 foundation wall. This reworked till lies directly above native gray till along this line, except at the western end of the cross-section, where the till-derived fill pinches out in the area of SB/MW-24, and native brown till lies in contact with the gray till. Along this cross-section, the gray till surface crests on the west side of the Pipe Tunnel, gently sloping downward to either side. The overall slope of the top of the gray till is from east to west, west of the Pipe Tunnel; and west to east, east of the Pipe Tunnel. At the center of the cross-section, soil boring B5703 (MW-SV2), on the east side of the Pipe Tunnel, reached a total depth of 18.2 feet bgs, with the till-derived fill extending from 0.6 to 15 feet bgs, where the native gray till was encountered. Soil boring B5704 (MW-SV1), on the west side of the Pipe Tunnel, reached a total depth of 16.2 feet bgs, with the till-derived fill extending from 0.6 to 13.1 feet bgs, where the native gray till was then encountered.

Soil borings SB-42, SB-21, LA-SO-UW-6 (well UW-6), B5701 (well MW-SV3), LA-SO-UW-17 (well UW-17), LA1406-2-B/-Ba, and LA-1406-3-B1 (well UWT-1) were used to construct cross-section B-B′ (Figure 4-7). This cross-section extends from the northwest corner of Building G2 to southeast corner of Building H1, crossing Building H2 and the Tank Farm. Asphalt pavement and sub-base sand and gravel are present at the southern and northern ends of this cross-section, while granular fill is present at grade along the central portion. The granular fill material is dominantly underlain by till-derived fill, which was used as backfill around the Building H2 foundation wall, except at the southern end where a thin layer of native brown till is present. Native gray till is present below the brown till and slopes downward, toward Building H2, where (based on historical site photographs and building construction drawings) the gray till surface likely descends steeply downward to the base of the foundation excavation along the southern wall of Building H2. Native brown till was encountered in soil boring LA-SO-UW-6 at a depth of approximately 8 feet, identifying a ridge of native brown till lying between Buildings G2 and H2. At the southern end of the cross-section, soil boring SB-42 reached a total depth of 19.5 feet bgs, with granular fill extending from 1 to 12 feet bgs, where 2 feet of native brown is present above native gray till at 14 feet bgs. Groundwater monitoring well MW-SV3 (boring B5701), at the southern wall of Building H2, reached a total depth of 25 feet bgs, with till-derived fill extending to 22.5 feet bgs, where native gray till was encountered.

Soil borings SB-26 (well MW-26), SB-23, SB-3 (well MW-3), B3003, and LA-SO-UW-14A (well UW-14A) were used to construct cross-section C-C′ (Figure 4-8), which extends from the fence west of Building G2 to the north side of Building H2, crossing Building H2. Asphalt pavement and sub-base sand and gravel are present in the area between Buildings G2 and H2, while granular fill is present at grade at the other locations. Subsurface conditions along C-C′ are similar to those along B-B′, with granular fill extending downward to till-derived fill. Native brown till is present at the southern end of the cross-section, above native gray till, which again slopes downward toward Building H2 and likely descends steeply downward to the base of the foundation excavation along the southern wall of Building H2. Near the southern end of the cross-section, soil boring SB-23 reached a total depth of 19.3 feet bgs, with granular fill extending from 1 to 8 feet bgs, encountering about 7.5 feet of till-derived fill, and then 1 foot of native brown till above native gray till at 17 feet bgs. Boring SB-3 (well MW-3) reached a total depth of 14.5 feet bgs, with granular fill extending to 11 feet bgs, where native brown till was encountered to 14 feet bgs, with 0.5 feet of native gray till at the bottom. Boring B3003, at the southern wall of Building H2, reached a total depth of 27.8 feet bgs, with 8 feet of granular fill at the top and till-derived fill extending from 8 to 24 feet bgs, where native gray till was encountered. The gray till contact slopes from a high at well MW-3 to the south toward well MW-26 and to the north toward the Building H2 excavation.

Soil borings LA1406-1-B (well UW-8), LA-SO-UW-17 (well UW-17), LA1305-2-B/-Ba (a shallow radiological characterization soil boring); cased borings H-28, H-26, H-24; and monitoring well KH-15 were used to construct cross-section D-D′ (Figure 4-9). This cross-section extends from the northeast corner of the Tank Farm, along the north side of Building H2, and down the hillside to the Lower Level Access Road. It is similar to the south side of Building H2, where a thin layer of granular fill (deeper at cased boring H-26) extends down from the surface to intercept till-derived fill. The till-derived fill was used as backfill material in the excavations for Building H2 and the Tank Farm, with native gray till below. Gravels were encountered at the base of soil boring LA1406-1-B at the northeast corner of the Tank Farm. The till-derived fill material comes up to grade at the top of the hillside. In general, along this cross-section line, the gray till follows topography. Boring LA1406-1-B, at the east end of the cross-section, reached a total depth of 24.6 feet bgs, with till-derived fill mixed with granular fill throughout the boring ; well UW-8 installed in boring LA1406-1-B was pushed to a depth of 27 feet to set the well. An approximately 2-foot-thick layer of poorly sorted gravel was encountered at the bottom of the reworked till. At soil boring LA-SO-UW-17, the till-derived fill begins near the surface at 0.7 feet bgs and is interbedded with granular fill to its total depth of 22.2 feet bgs. At cased boring H-26, the surficial granular fill is approximately 5 to 6 feet deeper than at any other location along the line. Reaching a total depth of 40 feet bgs, granular fill is present in cased boring H-26 from the surface to 7 feet bgs, where till-derived fill extends to 20 feet bgs. Granular fill is present from 20 to 23 feet bgs, and native gray till is present from 23 feet bgs to the bottom of the boring.

Top of Till Topography

Plate 4-2 provides the topography of the top of till surface in the Upper Level, particularly in the immediate area between Buildings G2 and H2. The top of till represents the elevation at which either undisturbed brown or gray till was encountered within the subsurface borings completed in the area. As shown, an east/west trending ridge of undisturbed till is present. The highest point of the ridge is found at UW-6 (323 feet amsl), but the ridge is generally present at an elevation of 318 to 319 feet amsl. The existence of the till ridge and its steep fall to the north are consistent with the construction of Building H2 in that a near vertical wall into the till was created to allow the construction of the southern foundation wall. The southern portion of the ridge, although not documented in photos, was likely created as a result of the installation of the fire-water lines and stormwater lines. As the Pipe Tunnel extends from the base elevation of Building G2 to the near-base elevation of Building H2, a trench excavated into the glacial till would have been required for its construction.

The till ridge on the east side of the Pipe Tunnel is more difficult to interpret because there are fewer borings there to define the till surface. The invert elevation of the outlet at MCB-8, off of the northwest corner of Building G2 where the stormwater line turns south, is at 318.7 feet amsl, and the invert elevation of the inlet of MCB-7, off the northeast corner of Building G2, is at 317.9 feet amsl; therefore, the stormwater line connecting the two basins required excavation into the till, passing beneath the Pipe Tunnel foundation. Similarly, the fire-water line passes beneath the Pipe Tunnel foundation. The stormwater line between MCB-8 and MCB-7 and the fire-water line running beneath the Pipe Tunnel are likely interconnected by the trenching/excavations required for installation.

Another ridge of till is also present west of Building G2, although not as pronounced as that adjacent to the southern wall of Building H2. This north-south trending ridge of till parallels the topography west of Building G2 and is the result of the natural hillside topography, with some modification likely along the western perimeter of Building G2 during its construction.

The existence of the till ridges, troughs, and the topography of the top of till are significant in terms of groundwater movement, as discussed in the following section.

4.4.2 Upper Level Hydrogeological Evaluation

This section describes groundwater movement in the Upper Level and presents water level contour maps based on water level data collected from site monitoring wells.

If the site were not in a developed state, natural groundwater movement would be expected to follow the topography of the native brown or gray tills. In the area of Buildings G2 and H2, natural groundwater movement would likely be from the southeast to the northwest.

Groundwater movement in the Upper Level soils, however, is influenced and controlled by manmade subsurface features related to building foundation systems, utility conduits, and the limits of earthwork during the construction of these features. Conditions influencing the movement of groundwater are:

1. Buildings that have been constructed into or above the underlying native gray till that have been backfilled with more permeable fill soils
2. Buried piping that has been installed either within trenches excavated into the native gray till or above the gray till and backfilled with more permeable fill soils
3. Areas where native soils were not removed in total in support of site construction and development

As presented in Section 4.3.2, the periodic leaking of the stormwater line between MCB-7 and MCB-8, generally running west to east between Buildings G2 and H2, during periods when the system was charged with stormwater may have resulted in isolated and infrequent groundwater movement variations.

Groundwater contour maps were prepared on the basis of water level data collected from the site monitoring wells. These monitoring wells are associated with KAPL investigations (KH, B, H, and MW52 series), the KAPL Hillside RFI (MW series), the RFA SV characterization (SV series), and the SPRU RCRA/radiological characterization (UW and UWT series). The groundwater level data from October 6, 2004, and February 9, 2005 (Appendix A, Table A-7) were used to prepare the water level contour maps, Figures 4-10 and 4-11, respectively.

As shown in these figures, the overall pattern of groundwater flow in the area of Buildings G2 and H2 is from the southeast to northwest; however, groundwater flow is significantly altered adjacent to each building and between the two buildings. The flow patterns on both measurement dates are similar, although October 6, 2004, data represent a period following relatively high precipitation, and February 9, 2005, data represent a period following the onset of a frost cap and little infiltration of precipitation.

As shown in both figures, a groundwater depression is present between Buildings G2 and H2, which is elongated in a west to east lineation. The deepest portion of the depression is centered around monitoring wells MW-2 and B-15. The western end of the depression is contained within the 325-foot groundwater contour. Although not delineated, the eastern end of the depression is believed to be controlled at some point by the 325-foot contour in this portion of the site. This is because the groundwater at UW-10 (east of the Pipe Tunnel) is at a higher elevation (320.48 feet amsl [2/9/05] to 320.72 feet amsl [10/6/04]) as compared to the groundwater elevation (319.41 feet amsl [2/9/05] and 319.28 feet amsl [10/6/05]) at MW-SV2, which is adjacent to the east wall of the Pipe Tunnel. Groundwater movement within the depression is from the Pipe Tunnel to the west.

The stormwater pipe was shown through KAPL testing to be leaking water while under hydraulic pressure before it was relined in May 2005. So it may also be an infiltration point for groundwater into the storm sewer, and it may have a role in the development and continued presence of the groundwater depression. Potential changes in groundwater flow directions resulting from the leak repair have not yet been determined.

The groundwater depression coincides well with the top of till contour map (Plate 4-2), as discussed in the section on Top of Till Topography in Section 4.4.1, and the gray till surface as shown in cross-section A-A′ (Figure 4-6).

Groundwater movement immediately west of Building G2 is easterly toward the building from the approximate top of the north/south trending Hillside ridge and the top of the till ridge, as depicted in Plate 4-2. Groundwater movement west of the Hillside and till ridges is westerly and away from Building G2. Groundwater movement at the north end of Building G2 appears to be northerly toward the groundwater depression that is between Buildings G2 and H2.

Groundwater movement west of the western wall of Building H2 flows easterly toward the building from the 325-feet-amsl groundwater contour that forms a groundwater ridge (flow divide), generally mirroring the top of the Hillside ridge. Groundwater movement on the north side of Building H2 is to the south toward the northern side of the building. This is apparent because the groundwater elevations at UW-14A and UW-2 are higher than at monitoring well UW-14 and cased boring H-24, which are closer to the foundation wall of Building H2. A groundwater ridge is located further north of Building H2 (325-feet-amsl contour) where groundwater flows in a northerly direction. Groundwater along the southern wall of Building H2 flows to the north, north of an east/west trending, 325-feet-amsl groundwater contour ridge and till ridge (Plate 4-2), and to the south, south of the 325-foot groundwater ridge, into the depressed groundwater area between Buildings G2 and H2.

On both water level contour maps, a high groundwater condition exists at SB/MW-24. This observation is evident in cross-section A-A′ (Figure 4-6), which shows that MW-24 was installed within a mound of brown till. The water elevation at MW-24 was at approximately 320 feet amsl on both dates of recording, which establishes the groundwater in the brown till. The elevated groundwater levels in MW-24 probably result from groundwater being retained in the less permeable brown till, causing a retarded drop in the groundwater table. The brown till is charged with groundwater during periods when the overall area groundwater levels rise, with leakage from stormwater lines near MW-24 during long-term precipitation events.

All of these variations of groundwater movement, except in SB/MW-24, reflect the more permeable soils (granular fill or till-derived fill) adjacent to the building foundation walls and around the buried utility lines. Foundation walls and utility lines intersect groundwater and are situated on gray till or within excavation troughs into the gray till. Flow directions are also controlled by topography of the native gray or brown till, as discussed in the section on Top of Till Topography in Section 4.4.1.

One bedrock monitoring well (MW52-2) is present in the Upper Level. The well is located about 7 feet north of the northern wall of the H2 Tank Farm and was installed in 1952 (Knapp, 1974). According to the well log for MW52-2, bedrock was encountered at a depth of approximately 65 feet bgs. The bedrock was then drilled out another 70 feet to a total depth of 135 feet bgs. The interval through the overlying clay and 4 feet into bedrock was cased off, leaving the rest of the well as an open hole through the shale bedrock. The water level in the well was recorded at approximately 95 feet bgs. Based on these data, the groundwater in the bedrock is separate from the groundwater found both perched and within the native tills in the Upper Level. Because there is only one bedrock well near Building H2, the direction of groundwater movement in the bedrock is not defined.

In December 2004 soil boring LA-SO-UW-19 was drilled 8 feet northwest of cased boring H-28 to evaluate the stratigraphy below the top of the gray till, which was not adequately described in the available soil boring logs (KAPL, 1974). The specific objectives were to determine whether the gray till was continuously impermeable in this area and to confirm that permeable strata were not present in the gray till. Other than an isolated inclusion of fractured shale bedrock between 300.1 and 298.1 feet amsl, the 40-foot-deep borehole contained low-permeability gray till from 306.1 to 290.1 feet amsl. The shale bedrock inclusion was not saturated, indicating that it was not a conduit for groundwater in the gray till sequence. No evidence of other water-bearing strata was identified in the gray till, indicating that at least the upper portion of the gray till serves as an effective aquaclude preventing downward flow from the native tills to bedrock.

4.4.3 Upper Level SWMU Nature and Extent Evaluation

This section describes the investigation and evaluation of two data gaps from the RFA SV pertaining to the Upper Level: the source of VOCs in the Pipe Tunnel footing drains, and the groundwater flow and chemistry at the northwestern perimeter of Building H2. This section presents the investigation results for VOCs, SVOCs, and metals in soil and groundwater. The following subsections evaluate detected VOCs, SVOCs, and metals in soil and groundwater within the Upper Level. The term "elevated" concentration is used throughout this report. Elevated concentrations in soil are those that exceed chemical-specific background conditions defined as follows:

- Detected VOC concentration not associated with laboratory or field sampling contamination
- Detected SVOC concentration not associated with interferences (i.e., asphalt, construction materials, and laboratory contamination)
- Detected TAL metal concentration above the calculated Upper Tolerance Limit statistic for the SV metals, which estimates site-specific background levels following the methodology discussed in Appendix G of the RFA SV Report

NYSDEC soil cleanup objectives (NYSDEC, 1994) are used for comparison purposes, where applicable. In addition, metals data were evaluated against published background ranges for the Albany area, New York State, and the northeastern and eastern United States (NYSDEC, 1988; USGS, 1984), where applicable.

Groundwater VOC and metals results that are not associated with laboratory or field contamination are compared to NYSDEC ambient water quality standards and guidance values for groundwater (NYSDEC, 1998b). Concentrations are considered elevated if they exceed their respective standard or guidance value. Turbid total (unfiltered) metal results are not representative of groundwater quality (established for the purposes of the RFI when particulate inclusion results in turbidity exceeding 5 NTUs [DOE/CH2M HILL, 2004a]). Therefore, the unfiltered (total) results, when the turbidity was less than 5 NTUs, and filtered (dissolved) results are compared to the NYSDEC criteria.

VOCs in Upper Level Soils

A total of 16 soil samples and 3 duplicates were collected and analyzed for TCL VOCs from 7 soil borings (including redrills) advanced during the RFI. Table A-1 of Appendix A summarizes all of the soil samples collected from the Upper Level and defines which samples were submitted for laboratory analysis; Table A-4 summarizes the analyses by location and sample. Table 4-3 summarizes the VOCs detected in the soil samples collected from the soil borings completed during the SV and this groundwater RFI. Six soil samples were also collected from four soil borings completed as part of the SPRU Outside Characterization and analyzed for VOCs because of photoionization detector (PID) readings greater than 2 parts per million (ppm) or evidence of petroleum odor; these results are also included in Table 4-3.

At the series of three soil borings (LA-SO-UW-5/LA1303-4-B, LA-SO-UW-6, and LA-SO-UW-7) in the area between Buildings G2 and H2 (see Figure 4-1), several VOCs were detected in soil. No VOCs were detected in the soil samples from LA-SO-UW-7 or its field duplicate (FD15). The only VOC detection that was not at an estimated low concentration was TCE (16 μg/kg) at LA-SO-UW-5 within the 3- to 5-foot sample depth interval. This concentration is well below the NYSDEC soil cleanup objective for TCE of 700 μg/kg. Several VOCs (TCE, chloroform, carbon tetrachloride, and methylene chloride) were detected in the soils from LA-SO-UW-5 and LA-SO-UW-6; however, none were at concentrations above their respective NYSDEC soil cleanup objectives. These detections may be the result of VOC vapors traveling along the surface of competent brown till through the till-derived fill and condensing on the soils nearer the surface, particularly during the colder seasons. They do not appear to be related to a surface release because the concentrations in surface soil are too low.

Soil boring LA1305-4-Ba was completed on the west side of Building H2 and was a designated Outside Characterization radiological soil boring. However, PID soil screen results for this boring revealed soil vapor readings above 2 ppm, which prompted the collection of soils for VOC analysis. Soil samples from 6 to 8 feet (4.4 ppm), 8 to 10 feet

(3.5 ppm), and 10 to 12 feet (3.3 ppm) bgs were collected and analyzed. The only VOCs detected in each of the sample intervals were toluene and TCE at very low, estimated concentrations below their respective NYSDEC soil cleanup objectives.

Two soil borings at the northwest corner of Building H2, LA1305-5-W1 (groundwater monitoring well UW-1) and LA1305-5-W2 (groundwater monitoring well UW-2), were to be sampled for VOCs if saturated conditions were encountered at the intervals specified in the Groundwater RFI Work Plan (DOE/CH2M HILL, 2004a). The only specified soil sample intervals where saturated conditions were encountered were within the 20.7- to 22.7-foot and 25.7- to 27.7-foot-bgs intervals at boring LA1305-5-W2 (well UW-2). The VOCs detected at this soil boring were chloroform (only VOC detected in the 20.7- to 22.7-foot-bgs sample), methylene chloride, PCE, and TCE. The concentrations are all estimated and well below their respective NYSDEC soil cleanup objectives.

Soil borings LA1401-3-W (well UW-3) and LA1401-6-Wc (well UW-4) were completed along the perimeter of Building G2. Three soil samples were collected from LA1401-3-W (well UW-3) and two from LA1401-6-Wc (well UW-4) at two different boring attempts because borings could not be advanced to their target depth due to buried obstructions at several attempted boring locations. Two VOCs (PCE and toluene) in the 0- to 2-foot-bgs interval and one VOC (TCE) in the 7- to 9-foot-bgs interval were detected above the method detection limit (MDL) at LA1401-3-W (well UW-3); all were below their respective NYSDEC soil cleanup objectives. Toluene was detected in the 12- to 14-foot-bgs interval at low estimated quantity. Several VOCs (carbon tetrachloride; cis-1,2-DCE; PCE; and TCE) were detected in the 0.6- to 2.6-foot-bgs soil sample from LA1401-6-Wc (well UW-4), all at concentrations below their respective NYSDEC soil cleanup objectives. TCE (29 µg/kg) was the only detected VOC that was not at an estimated concentration. TCE and cis-1,2-DCE were also detected in the field duplicate (FD01) at similar concentrations as the original sample.

Several VOCs (acetone, carbon tetrachloride, toluene, and TCE) were detected in the 7.5- to 9.5-foot-bgs interval from LA1401-6-We (well UW-4). The detected VOC concentrations were estimated, except for TCE, and all are below their respective NYSDEC soil cleanup objectives. TCE was detected at 320 µg/kg, below the NYSDEC soil cleanup objectives.

Acetone, toluene, and TCE were also detected in the field duplicate (FD20) at similar concentrations as the original sample.

Soil samples from Outside Characterization borings LA1407-1-B2 (2 to 4 feet bgs) northeast of Building H1, and LA1501-1-B (4.3 to 6.3 feet bgs) on the east side of the H2 Tank Farm, were also analyzed for VOCs because the first revealed PID soil screening results greater than 2 ppm, and the second exhibited a petroleum odor. There were no VOCs detected in the sample from LA1407-1-B2 above the MDL. A low-level estimated detection of methyl ethyl ketone (4.2J µg/kg) was identified in the sample from LA1501-1-B, which is well below its respective NYSDEC soil cleanup objective. The soil sample collected from LA1406-3-B1 (2 to 4 feet bgs) after an elevated PID reading (25.2 ppm) was analyzed for TCLP VOCs (due to laboratory error); no VOCs were detected by TCLP analysis.

SVOCs in Upper Level Soils

Due to the petroleum odor, the soil sample collected from LA1501-1-B (4.3 to 6.3 feet bgs) was also analyzed for SVOCs. As presented in Table 4-4, a few SVOCs were detected in the soil sample, which are consistent with levels of SVOCs identified during the RFA SV. These low levels of SVOCs were determined to be a product of facility operations and are not attributed to SPRU-related releases (see Section 5.4.3 of the RFA SV Report). All of the reported detections are well below NYSDEC soil cleanup objectives.

Metals in Upper Level Soils

A total of 10 soil samples and 1 duplicate sample were collected from the intervals specified in the Groundwater RFI Work Plan from soil borings LA1305-5-W1 (well UW-1) and LA1305-5-W2 (well UW-2) and analyzed for TAL metals (see Figure 4-1). Table 4-2 summarizes the metal results for the soil samples collected and analyzed from these soil borings, along with results for the soil samples collected and analyzed for metals during the SV. Seven metals (calcium, chromium, lead, magnesium, nickel, potassium, and sodium) were detected at slightly elevated levels relative to their respective SV background values (DOE/CH2M HILL, 2002), as discussed below. Of these metals, only chromium and nickel have applicable NYSDEC soil cleanup objectives.

Calcium was detected in two samples (up to 52,000 mg/kg), magnesium in four soil samples (up to 27,400 mg/kg), potassium in two soil samples (up to 1,940 mg/kg), and sodium in one soil sample (142J mg/kg), above SV background levels.

The three remaining metals detected above background concentrations are chromium, lead, and nickel at LA1305-5-W1 (well UW-1) only in the 25.6- to 27.6-foot-bgs sample, and nickel at LA1305-5-W2 (well UW-2) only in the 25.6- to 27.6-foot-bgs sample. The concentration of chromium was 21.7 mg/kg (compared with a background concentration of 18.8 mg/kg) but was below the NYSDEC criteria. The concentration of lead was 18.3 mg/kg (compared with a background concentration of 15.7 mg/kg). The concentrations of nickel were 37.5 mg/kg and 34.5 mg/kg (compared with a background concentration of 33.8 mg/kg) and greater than the NYSDEC soil cleanup objectives.

The laboratory MDL for a few metals was greater than the SV background level, including copper (one sample, MDL of 40.3 mg/kg versus SV background of 38.1 mg/kg); selenium (MDL of 0.301 mg/kg versus SV background of 0.21 mg/kg); and silver (MDL of 0.581 mg/kg versus SV background of 0.09 mg/kg).

Of notable mention, antimony, the primary driver for further evaluation of the northeast corner of Building H2 and Data Gap 2, was not detected above the laboratory MDL in all samples analyzed.

VOCs in Upper Level Groundwater

A total of 7 groundwater samples during Round 1, 10 groundwater samples during Round 2, and 1 duplicate groundwater sample during each event were collected and analyzed for TCL VOCs from three new RFI monitoring wells (UW-2, UW-3, and UWT-2A), four SV series monitoring wells (MW-SV1, MW-SV2, MW-SV3, and MW-SV8), two KAPL monitoring wells (B-15 and B-16), and the Hillside Sump (see Figure 4-1). Water from the Hillside Sump is considered to be a groundwater sample because it represents groundwater from the Building H2 footing drains. Samples were collected during two sampling events (when sufficient groundwater was available) in July/August 2004 and November/ December 2004. New monitoring wells UW-1, UW-3 (Round 1 only), UW-4, UW-6, UWT-2, and UWT-2A (Round 1 only) were not sampled because they did not yield groundwater. Subsequently, UW-6 produced sufficient groundwater for sampling on March 23, 2005. The RFI results are summarized in Table 4-5, along with the previous RFA SV results for comparison.

The concentrations of VOCs in the sampled monitoring wells were relatively low and only above NYSDEC ambient water quality criteria (NYSDEC, 1998b) at 2 of the 11 sampling locations, as summarized in Table 4-5. Consistent with data provided in the RFA SV Report, the two locations at which one or more VOCs were detected above NYSDEC ambient water quality criteria were B-15 and MW-SV3. These VOCs were TCE (39J μg/L and 31 μg/L at B-15, and 12 μg/L and 9.8J μg/L at MW-SV3) and cis-1,2-DCE (6J μg/L at MW-SV3 during Round 2 only).

The VOCs detected during either RFI sampling event in one or more of the groundwater samples (not including duplicates), and generally at estimated concentrations below the laboratory MDL, were:

- Chloroform (6 locations at 0.075J to 0.74J μg/L)
- 1,1-DCA (2 locations at 0.26J to 0.68J μg/L)
- 1,2-DCA (1 location at 0.49J μg/L)
- 1,2-Dichloropropane (1 location at 0.17J μg/L)
- Acetone (3 locations at 2.7J to 31 μg/L)
- Bromodichloromethane (2 locations at 0.3J to 0.53J μg/L)
- Carbon disulfide (2 locations at 1.2J to 11 μg/L)
- Carbon tetrachloride (1 location at 0.11J μg/L)
- Chloromethane (1 location at 0.22J μg/L)
- Cis-1,2-DCE (6 locations at 0.33J to 6.0J μg/L)
- Methyl ethyl ketone (1 location at 0.78J μg/L)
- PCE (1 location at 0.12J μg/L)
- TCE (6 locations at 0.19J to 39J μg/L)
- Trans-1,2-DCE (2 locations at 0.21J to 0.29J μg/L)
- Vinyl chloride (2 locations at 0.16J to 1.6J μg/L)

Trans-1,2-DCE was detected in the field duplicate but not the sample at MW-SV3 at 0.1J μg/L during the November 29, 2004, sampling event. Only TCE at monitoring wells B-15 and MW-SV3 and cis-1,2-DCE at monitoring well MW-SV3 exceeded their respective NYSDEC ambient water quality criteria of 5 μg/L each. As presented in Appendix B, acetone, carbon disulfide, and chloromethane were detected in laboratory blanks, so trace detections of these VOCs most likely result from laboratory contamination.

The analytical results for the Hillside Sump sample collected on August 11, 2004, indicate the presence of acetone and cis-1,2-DCE at estimated concentrations below their respective NYSDEC ambient water quality criteria. Low levels of PCE and TCE were detected at estimated concentrations in the sample collected on December 3, 2004, also below their respective NYSDEC criteria. No VOCs were detected in the sample collected from the Hillside Sump in January 2001 during the RFA SV.

Monitoring well B-16 located along the Lower Level Access Road and downgradient of the Hillside Sump was sampled on August 11, 2004, and November 30, 2004. There were no VOCs detected in the August groundwater sample. Chloromethane, cis-1,2-DCE, and trans-1,2-DCE were detected in the groundwater sample in November, each below its respective NYSDEC ambient water quality criteria. Groundwater well B-16 and upgradient well KH-15 along the Lower Level Access Road are sampled annually as part of KAPL's Environmental Monitoring Program. VOCs have not been previously detected in samples from these wells.

Metals in Upper Level Groundwater

A total of 7 groundwater samples during Round 1, 10 groundwater samples during Round 2, and 1 duplicate groundwater sample during each event were collected and analyzed for dissolved and/or total TAL metals from three new RFI monitoring wells (UW-2, UW-3, and UWT-2A), four SV series monitoring wells (MW-SV1, MW-SV2, MW-SV3, and MW-SV8), two KAPL monitoring wells (B-15 and B-16), and the Hillside Sump (see Figure 4-1). Water from the Hillside Sump is considered to be a groundwater sample because it represents groundwater from the Building H2 footing drains. Samples were collected during two sampling events (when sufficient groundwater was available) in July/August 2004 and November/December 2004. New monitoring wells UW-1, UW-3 (Round 1 only), UW-4, UW-6, UWT-2, and UWT-2A (Round 1 only) were not sampled because they did not yield groundwater. The RFI results are summarized in Table 4-6, along with the sample turbidity values and the previous SV results for comparison. As discussed in the following subsection, total metals results from turbid samples are elevated due to the inclusion of suspended solid particulates in the aqueous sample. Results from the dissolved fraction of groundwater samples for which turbidity exceeds 5 NTUs will be used as the primary indicator of compliance with ambient groundwater quality criteria.

Magnesium, manganese, and sodium were the most prevalent metals detected in the groundwater samples above the NYSDEC ambient water quality criteria. The total concentration values for magnesium and sodium were not, if at all, significantly reduced as a result of sample filtering when the turbidity exceeded 5 NTUs, which is attributed to the high solubility of these analytes in water. The dissolved and total concentrations (where turbidity was below 5 NTUs) of iron exceeded the NYSDEC criteria in only one sample at MW-SV1 (December 6, 2004, dissolved metals sample).

The secondary metal detections in groundwater in either the total or dissolved state at one or more locations were: aluminum, antimony, arsenic, barium, cadmium, calcium, cobalt, copper, total chromium, lead, mercury, nickel, potassium, silver, vanadium, and zinc. None of the dissolved and total concentrations (where turbidity was below 5 NTUs) of the secondary metal detections exceeded their NYSDEC ambient water quality criteria.

Thallium was not detected above the laboratory MDL. However, the laboratory MDLs for samples from some locations, primarily locations sampled during the SV, were above the NYSDEC ambient water quality criterion of 0.5 μg/L. Samples analyzed as part of the SV (sampled in 2000 or 2001) were analyzed for thallium using Environmental Protection Agency (EPA) SW-846 method 6010B, which has a high detection limit for thallium. The laboratory analyzed thallium only by EPA SW-846 method 6010B for the total and dissolved fractions from sample LA-GW-UW-2-1-1. Lack of thallium detection above the NYSDEC criterion is confirmed at monitoring well UW-2 by analysis of the samples from the second sampling round at a detection limit below the criterion.

Antimony was detected at cased boring H-28 during the SV in both the total and dissolved samples above its NYSDEC ambient water quality criterion. It was detected slightly above the criterion in both the total and dissolved samples from cased boring H-22. The only other detection of antimony above the criterion was at cased boring H-26 in the total sample, but not in the dissolved sample. With the exception of well UWT-2A, antimony was not detected in any groundwater sample collected during either sampling round of the Groundwater RFI. Although antimony was not detected above the laboratory MDL at well UW-2, the detection limit for the July 26, 2004, dissolved sample (4.8U μg/L) was above the NYSDEC criterion. This does not appear to be of significance because the total antimony concentration on that date was not detected above the laboratory MDL, which was well below the criterion for antimony. Antimony was detected at low levels below the NYSDEC criterion in the total (at 1.3 J μg/L) and dissolved (at 1.7 J μg/L) samples at well UWT-2A in November/December 2004. Antimony was not detected in any of the soil samples from soil borings LA1305-5-W1 (well UW-1) or LA1305-5-W2 (well UW-2).

Evaluation of Turbidity and Metals

Most of the wells installed during the SV and Groundwater RFI were completed in clay-rich glacial till or till-derived fill. High turbidity in groundwater results from suspension/inclusion of clay and other fines from the well bore in the groundwater sample and is not a function of particulate migration beyond the borehole wall. In many SPRU wells, groundwater yield was insufficient to sustain the lowest extraction possible with a peristaltic pump, which prevented sufficient removal of clay/fine materials to achieve sample turbidity below or near the 5 NTU criteria established in the Groundwater RFI Work Plan, Quality Assurance Project Plan (QAPP). This subsection evaluates the effect of sample turbidity on total (unfiltered) TAL metal concentrations by introducing metals associated with the suspended solid particulate mineralogy into the groundwater sample. The direct relationship between turbidity and total metal concentrations is evaluated together with the reduction in metal concentrations observed in dissolved (field filtered) samples.

Table 4-7 provides population descriptive statistics for detected TAL metal concentrations resulting from 75 total TAL metals analyses of samples collected from groundwater monitoring wells in both the Upper and Lower Levels. The statistics are reported for six groupings to cover the range of turbidity values observed in samples from both investigation areas and to provide a sufficient number of samples to allow meaningful statistical representation (see Table 4-7). The 33 samples that met the QAPP's turbidity goal of less than 5 NTUs, and therefore did not require collection of paired dissolved samples, were grouped together to allow comparison to higher turbidity samples.

The summary statistics show considerable variability in the relationship between groundwater sample turbidity and total metal concentrations. In many cases, central tendency average and median statistics are associated with high confidence intervals or a wide range of minimum and maximum values that are associated with either a low number of detections within the turbidity group or are skewed by low-frequency high values.

However, the following observations can be made regarding the relationship between total metals concentrations and turbidity in SPRU groundwater samples:

1. Average and median concentrations of aluminum, antimony, calcium, total chromium, cobalt, iron, magnesium, nickel, potassium, vanadium, and zinc are lowest in the samples with less than 5 NTU turbidity. The concentrations of these metals in total samples generally increase with the higher turbidity ranges, but not always in direct proportion.

2. Mean and median concentrations of arsenic, barium, and lead are generally higher in samples with turbidity exceeding 100 NTUs. However, the reduction in total concentrations of these metals in the sample group with less than 5 NTU turbidity, relative to the groups with 5 to 25 and 26 to 200 NTU, is not as pronounced as with the metals previously discussed.

3. Total beryllium, copper, manganese, and selenium concentrations are significantly elevated only in the offscale group of 551 NTU.

4. There is no clear relationship with total cadmium and sodium concentrations and groundwater turbidity.

5. There is an insufficient number of detections of mercury, silver, and thallium for evaluation.

Table 4-8 compares total and dissolved metal concentrations for samples where paired unfiltered and filtered fractions were analyzed, as required by the QAPP when sample turbidity exceeded 5 NTUs, and at least one of the paired values was detected. In most cases, the relative percent difference (RPD)[4] between the total and dissolved values is positive, indicating that the total value exceeds the dissolved value. Most negative RPDs are the result of estimated value variability when comparing values that are close to or at the detection limits.

TAL metals where the average RPD between total and dissolved values exceeds 100% (indicating that the average total values exceed the dissolved value by at least a factor of 3)

[4] The RPD is the difference between the total and dissolved value divided by the average of the two values. The maximum RPD of 200% occurs when one value is zero. The minimum value of 0% occurs when both values are the same. Positive values indicate that the total value exceeds the dissolved value; negative values indicate the dissolved value exceeds the total.

are: aluminum (193%), mercury (152%), iron (151%), cadmium (141%), total chromium (140%), copper (142%), vanadium (136%), zinc (133%), lead (126%), and nickel (101%).

TAL metals where the average RPD between total and dissolved values is positive but less than 100% (indicating that the average total values exceeds the dissolved value by less than a factor of 3) are: cobalt (93%), arsenic (94%), manganese (61%), barium (46%), magnesium (23%), silver (22%), calcium (21%), potassium (31%), and sodium (14%).

The relationships between total metal concentration and turbidity, together with the overall reduction in metal concentrations between the total and dissolved sample fractions, establish that concentrations of total metals are primarily controlled by sample turbidity. Samples with elevated turbidity are not representative of potable groundwater because groundwater supply wells capable of supporting domestic or industrial needs would either produce water with low turbidity or would be filtered. Therefore, the dissolved fraction of groundwater samples from which turbidity exceeded 5 NTUs will be used as the primary indicator of compliance with ambient groundwater quality criteria.

4.4.4 Upper Level Fate and Transport Potential

This section integrates the geologic and hydrogeologic conditions controlling the migration of VOCs near the SPRU facilities into a contaminant transport conceptual model. The conceptual models that represent the expected mode of contaminant fate and transport for the Upper Level SWMUs are also presented in this section and illustrated in Figure 4-12.

The subsurface conditions in the area between Buildings G2 and H2 are complicated as a result of building and utility construction in the Upper Level and the soil types that are present. The lower native brown and gray till forms an effective vertical barrier to groundwater movement and vertical contaminant migration. The surface topography of the native till in part controls the horizontal groundwater movement and contaminant migration. Groundwater and contaminant movement is also affected by the presence of buried structures (i.e., utilities and building foundations with more permeable backfill around them), which are positioned within or just above the groundwater surface. Groundwater and contaminant migration is also affected by the soil types above the native till and the elevation of the water table during certain external events (i.e., storms with significant runoff to the storm sewer systems).

Groundwater in the till-derived fill used as backfill around Building H2 and the Pipe Tunnel is largely contained laterally and vertically by the gray till in which the buildings and structures are constructed. Photographs taken during construction of these structures indicate that they were keyed into gray till and their foundations surrounded with nearly vertical cut walls, typically about 3 to 5 feet away from the poured concrete foundation walls. These relatively narrow channels provide an annulus around the building foundation that serves as a preferred pathway for groundwater migration because the till-derived fill is generally more permeable than the native gray till. They also provide a channel for surface water infiltration into the fill material building annulus at locations where the ground surface around the buildings is not covered with an impermeable surface cover (i.e., asphalt and concrete pavement sections).

The concentrations of VOCs in groundwater around and adjacent to the Pipe Tunnel and Building H2, and the backfill soil around the footings of the Pipe Tunnel and Building H2, have been found through the RFI and the SV to exist at low levels. The concentrations are consistent with residual contamination and may be related to minor releases of contaminated groundwater to the footing drainage system. However, as discussed in the following paragraphs, the distribution of VOCs in soil and groundwater, together with hydrogeologic data, support the interpretation that the source of VOCs in the foundations of the SPRU structures may be related to the area of high-level VOC contamination in soil and groundwater between Buildings G2 and H2 that was identified during the KAPL Hillside RFI.

The nature of the VOCs detected in the SV monitoring wells MW-SV1 through MW–SV3 is similar to that observed in the Hillside wells exhibiting the highest levels of VOCs (MW-24, MW-2, MW-6, and B-15) (see Figure 4-13). Detections of TCE; carbon disulfide; chloroform; cis-1,2-DCE; and vinyl chloride in wells MW-SV1, MW-SV2, and MW-SV3 are all represented in higher concentrations in wells MW-24, MW-2, MW-6, and B-15. Carbon tetrachloride is found in high concentration in well MW-24 (5,620 µg/L) and is not detected in the SV monitoring wells. However; this concentration attenuates in a very short distance from MW-24, as evident in the drop in concentration at MW-2 (79.6 µg/L), MW-6 (11.4 µg/L), and B-15 (0.11J µg/L). Carbon tetrachloride's lower solubility in water and high molecular weight relative to the other detected chlorinated hydrocarbons in the SV monitoring wells indicate that it is relatively immobile in groundwater and more likely to be confined to the source area near well MW-24.

VOCs are not likely migrating in groundwater around the footing of Building G2 to the Pipe Tunnel because the monitoring wells along the Building G2 wall (UW-3 and UWT-2A) were not significantly impacted by VOCs. At LA1401-6-Wc (UW-4), 320 µg/kg of TCE was detected in the soils at a depth of 7.5 to 9.5 feet bgs just above a buried obstruction that is believed to be a concrete slab. This may represent another source of TCE in groundwater at the Pipe Tunnel.

Based on the data developed to date, an east–to-west trending ridge of undisturbed till between the area of elevated VOCs near monitoring wells B-15 and MW-6 and the southern wall of Building H2 limits the migration of groundwater, and VOC contaminants therein, directly to the H2 footing drain. However, conditions exist that can allow contaminated groundwater migration from the area of B-15 and MW-6 to the footing drain of Building H2 in the backfill of the stormwater line, between MCB-8 and MCB-7. This line extends beneath the Pipe Tunnel and then follows the granular fill along the Pipe Tunnel footing to the Building H2 foundation, where it drains vertically downward along the H2 foundation wall until it intercepts the footing drain. This flow path may be enhanced along the underground fire-water line that runs parallel to the storm sewer.

Groundwater flow along the storm sewer lines is potentially driven by leaks in the storm sewer system, as documented in Section 4.3.2. Transport along this pathway is expected to be infrequent for the following reasons:

- There is a groundwater depression in the area of highest VOC impact in groundwater, and groundwater flows from the Pipe Tunnel to the lowest point of the depression around monitoring wells MW-2 and MW-3.
- Significant recharge would be required to raise the water table elevation in the depression and reverse the groundwater flow direction to the east, toward the Pipe Tunnel.
- The low levels and sporadic detections of VOCs in soil and groundwater around the Pipe Tunnel and Building H2 support infrequent groundwater charging to the footing drain systems.

As discussed in Section 4.3.2, the test performed by KAPL revealed leaks in the stormwater line between MCB-7 and MCB-8. During the test, the groundwater level in MW-SV3 (corner of the Pipe Tunnel and Building H2) rose approximately 8 feet, and field testing personnel noted that water was cascading into the well. This finding is significant because it represents a plausible mechanism by which groundwater levels rise, flow directions are reversed, and contaminated groundwater charges the foundations of the Pipe Tunnel and Building H2 during significant storm events. Additionally, the leaking stormwater pipe supports the presence of the groundwater depression between Buildings G2 and H2; if water flows out of the pipe, it has the ability to flow in.

The driving force for the contaminated groundwater to follow this flow path must be when the water table rises in elevation to reverse the groundwater flow gradient between the lowest point of the groundwater depression and the Pipe Tunnel. This occurs only during significant storm events, which charge the stormwater pipe with water to the point that the pipe leaks into the surrounding soil. The amount of contaminated groundwater that would move to the Pipe Tunnel would depend on the duration of the storm event.

The movement of groundwater perched on top of the gray till surface also depends, in part, on the slope of the surface, as it remained following the construction of Building H2, the Tank Farm, and the Pipe Tunnel. Based on groundwater levels observed during the SV and RFI, groundwater migrates in the backfill around the Pipe Tunnel and flows in a northerly direction toward the southern wall of Building H2. Upon intercepting the backfill around Building H2, the groundwater migrates to the west, to the southwest corner of Building H2. From this point, the groundwater migrates to the north along the western building wall to the northwest corner of Building H2. The groundwater drains into the footing drain that leads to a sump in the hillside to the west of the building. Trace levels of VOCs were detected in the Hillside Sump samples collected during this RFI.

The stormwater pipe was relined in May 2005 to repair the leak. To assess this condition, there is a need to either monitor water levels in many wells around the area during a significant storm event, or closely monitor the water levels following the repair for depression changes. If the stormwater line is accepting groundwater during nonstorm events, the water level in and around the depression may rise to 325 feet amsl, which appears to be the normal elevation of groundwater in areas that are not influenced by the drains. If there is no rise in water levels, the depressed water levels in the trough likely result from higher groundwater permeability in the backfill materials between Buildings G2 and H2. A rise in groundwater levels may result in more contaminated groundwater moving to either the Pipe Tunnel and Building H2, or it may cause more groundwater to move west over the Hillside ridge, in particular, through the trough feature in the native clay between MW-26 and MW-27. Inconsistencies in water level responses during the leak test will need to be evaluated by monitoring potential groundwater elevation changes.

At this time it has not been definitively established that the source of VOCs in the footing drains of the SPRU structures results directly from releases from the building structure or from other areas of VOC contamination. However, as further discussed in Section 6, the nature and extent of VOC contamination between Buildings G2 and H2, including the Pipe Tunnel, and throughout the Upper Level are established by the combined Hillside RFI, RFA SV, and Groundwater RFI investigations.

Relative to the requirements of Upper Level Data Gap 2, antimony was not detected in the soils from the base elevation of the Building H2 footer at UW-1 and UW-2, and it was not detected in the groundwater samples at these locations above the laboratory MDLs. Antimony is, therefore, no longer considered a contaminant of concern.

5. Lower Level SWMUs Characterization

This section describes the characterization of the Lower Level SWMUs and AOC, including the characterization objectives and previous investigation data used in the RFI evaluations. It describes the Lower Level geological and hydrogeological evaluations, the data gaps being resolved by the RFI, and the specific RFI results. Finally, this section describes the fate and transport potential for contaminants in the Lower Level and naturally occurring ions in groundwater.

5.1 Lower Level Characterization Objectives

The SPRU Lower Level SWMUs and AOC include the Former K6 Storage Pad (SWMU-036), the Former K7 Storage Pad (SWMU-037), the Railroad Staging Area (SWMU-038), the K5 Retention Basin (SWMU-040), and the Lower Level Parking Lot (AOC-003). The Former K6 and K7 Storage Pads were established as requiring no further action in the NYSDEC-approved RFA SV Report. The Railroad Staging Area, encompassing the Former K6 and K7 Storage Pads and the K5 Retention Basin but excluding the Lower Level Parking Lot, is generally characterized as a rectangular-shaped area approximately 1,200 feet long trending southeast/northwest and approximately 150 feet wide trending northeast/southwest. In the area of the K5 Retention Basin, this distance increases to approximately 200 feet.

The Lower Level Parking Lot area is contiguous to the northwestern end of the Railroad Staging Area, although physically separated by a chain-link fence. It is a rectangular-shaped area approximately 400 feet along its long axis, which trends south/north, and approximately 120 feet wide along its shorter, east/west-trending axis. Together, the Railroad Staging Area and Parking Lot comprise the Lower Level referred to throughout the remainder of this report.

An objective of the RFI is to characterize the environmental setting and the nature and extent of potential chemical releases at the Lower Level resulting from historical SPRU operations. To accomplish this objective, it was necessary to identify data gaps that remain from previous investigations, address specific comments from NYSDEC's technical review of the RFA SV (DOE/CH2M HILL, 2002), and collect the data required to evaluate corrective action alternatives. The NYSDEC-approved RFA SV Report established no further action or deferred investigation for the following chemical constituents in soil and groundwater.

- Because of current access limitations, the nature and extent of a trace level of TCE detected in soil at the northeast corner of the K5 Retention Basin will be evaluated following the D&D of the structure. The low concentration does not warrant immediate action, and there is no evidence of migration from the basin in two downgradient monitoring wells.
- PAH compounds and various metals (antimony, arsenic, copper, and lead) were detected in soil along the entire extent of the former railbed in the Railroad Staging Area. These PAHs and metals are attributed to railroad construction materials and operations, and not to SPRU or KAPL waste management. Also, traces of gasoline components were evident throughout the Railroad Staging Area and attributed to motor vehicle use. No further action is recommended for these constituents in soil and groundwater.
- Concentrations of chemical constituents in groundwater near the Former K6 Storage Pad and the K5 Retention Basin are consistent with natural conditions.

The RFA SV established that the extent of elevated metals, primarily mercury, in soil in the northern portion of the Railroad Staging Area and Parking Lot requires further evaluation. As described in Section 1.3.5, additional characterization of the extent of these metals will be addressed during remedial design. The scope of this RFI encompassed further characterization to establish the nature and extent of potential SPRU-related releases to the groundwater in areas affected by chemical releases to soil in the Railroad Staging Area and Parking Lot.

5.2 Investigative Approach

To meet the objectives summarized in the previous section, the following investigative approach was developed and completed. Note that the planned investigative activities were expanded to some extent as defined herein to address several developments encountered during the performance of the field investigation.

5.2.1 Data Gap 1—Impact to Groundwater in Areas of Elevated Metals and VOCs

This data gap relates to determining: (1) if there was a release to groundwater from metals and VOCs in the soil in the northern portion of the Railroad Staging Area, and (2) if there was a release to groundwater from elevated metals, VOCs, and SVOCs in the Lower Level Parking Lot fill materials.

To evaluate the Railroad Staging Area portion of this Lower Level data gap, three soil borings (LA-SO-RW-6, LA-SO-RW-7, and LA-SO-RW-8; see Figure 5-1) were completed in the northern portion of the area and converted to groundwater monitoring wells (RW-6, RW-7, and RW-8, respectively). One additional soil boring (LA-SO-RW-9) was installed north of and downgradient from the K5 Retention Basin and converted to a monitoring well (RW-9), but it did not yield water. Therefore, another groundwater well (PW-32)—installed north of the K5 Retention Basin as part of the SPRU radiological characterization—was sampled on March 23, 2005, for the Groundwater RFI because it produced water at that time and was near well RW-9. Groundwater samples were collected during two rounds (July/August 2004 and November 2004), which represent both wet and dry conditions, from the newly installed monitoring wells RW-6, RW-7, and RW-8, and existing SV monitoring wells MW-SV4, MW-SV5, MW-SV6, and MW-SV7. One duplicate sample was also collected per sampling event. The groundwater samples were analyzed in accordance with the Groundwater RFI Work Plan (DOE/CH2M HILL, 2004a) for TCL VOCs and TAL metals.

To evaluate the Parking Lot portion of the Lower Level:

- Two soil borings (LA-SO-RW-4 and LA-SO-RW-5) were completed in the northeastern portion of the Parking Lot, downgradient of the area of elevated metals, and converted to monitoring wells (RW-4 and RW-5, respectively).
- One soil boring (LA-SO-RW-2) was advanced in the area of SV boring B0311 to evaluate upgradient conditions.
- Existing KAPL well KH-18 was sampled to characterize background groundwater quality in the area.

Groundwater was not encountered at soil boring LA-SO-RW-2, so a monitoring well was not installed. Groundwater monitoring well RW-4 produced sufficient water for sampling in both sampling rounds, while RW-5 did not yield groundwater. The groundwater samples were analyzed in accordance with the Groundwater RFI Work Plan (DOE/CH2M HILL, 2004a) for TCL VOCs, TCL SVOCs, and TAL metals.

Radiological characterization wells PW-16 and PW-17 are downgradient of an area of radioactivity in soil identified during the radiological characterization program. In August 2005 these wells were sampled for metals and VOCs to determine if chemicals were present in groundwater due to a potential chemical release in the general area between wells PW-16, PW-17, RW-7, and RW-8.

5.2.2 Data Gap 2—Groundwater Below the K5 Retention Basin

This data gap relates to determining if there are elevated VOCs and metals in the soil and/or groundwater below the K5 Retention Basin. This data gap will be investigated following D&D of the K5 Retention Basin.

5.3 Previous Lower Level SPRU SV Investigation

During the RFA SV, the Lower Level was investigated through the completion of numerous soil borings and monitoring well installations. Soil and groundwater samples were collected for TCL VOCs, TCL SVOCs, and TAL metals analyses. The RFA SV investigation results are presented in Section 6.4 of RFA SV Report. Soil boring information and analytical results and water levels from additional sampling of these SV wells are incorporated into this RFI. The RFA SV investigative efforts and findings are summarized in the following subsections.

5.3.1 VOCs in Lower Level Soil

A total of 109 soil samples plus 14 duplicate samples were collected and analyzed for VOCs from 101 soil borings. Eleven VOCs (acetone, benzene, carbon disulfide, chlorobenzene, chloroform, methyl ethyl ketone, methylene chloride, TCE, PCE, toluene, and total xylenes) were detected in 59 soil borings (see RFA SV Report, Table 6-2). No VOC concentrations exceeded NYSDEC soil cleanup objectives.

5.3.2 SVOCs in Lower Level Soil

A total of 250 soil samples and 14 duplicate samples were collected from various intervals at 103 soil borings and analyzed for SVOCs (see RFA SV Report, Table 4-5). As many as 17 PAHs were detected at concentrations up to 12,000 µg/kg (see RFA SV Report, Tables 6-3 and 6-4). Other detected SVOCs were 1,2,4-trichlorobenzene, 4-methylphenol (p-cresol), benzyl butyl phthalate, bis(2-ethylhexyl) phthalate, di-n-butyl phthalate, di-n-octylphthalate, and phenol at concentrations up to 6,100 µg/kg. As previously reported, phthalate compounds were detected in field and laboratory blanks and, when reported, were not considered to be the result of hazardous constituent releases. SVOCs are widely occurring throughout the Lower Level and most likely result from railroad operations, vehicle emissions, or asphalt in the Lower Level, rather than hazardous constituent releases from SPRU operations.

5.3.3 Metals in Lower Level Soil

A total of 250 soil samples and 14 duplicate samples were collected from various intervals and analyzed for metals from 103 soil borings in the Lower Level area. In these 264 samples, all of the following 23 analyzed metals (in decreasing order of frequency) were elevated above their respective SV background values (see RFA SV Report, Appendix G and Tables 6-5 and 6-6): sodium (99), lead (87), selenium (57), arsenic (53), total chromium (51), vanadium (51), magnesium (42), cobalt (42), potassium (37), zinc (32), manganese (30), copper (31), calcium (29), thallium (28), mercury (26), antimony (25), barium (24), cadmium (23), nickel (21), iron (20), aluminum (19), silver (13), and beryllium (1).

Calcium (up to 120,000 mg/kg), magnesium (up to 56,500 mg/kg), manganese (up to 1,820 mg/kg), and sodium (up to 1,350 mg/kg) were detected in soil borings throughout the Lower Level. As further discussed in Section 5.5, these nonhazardous metals were largely attributed to road salt application and soil mineralogy.

5.3.4 VOCs in Lower Level Groundwater

VOC samples were collected from three wells (MW-SV4 to MW-SV6) installed at the Former K6 Storage Pad (SWMU-036) and K5 Retention Basin (SWMU-040). Carbon disulfide was detected in trace concentrations (1J to 2J µg/L) in samples from monitoring wells MW-SV4 and MW-SV6. Because carbon disulfide was detected in analytical and equipment blanks, laboratory or field contamination is the likely source of carbon disulfide. Chloromethane was detected (16 µg/L) in the duplicate sample from well MW-SV5. This detection was not confirmed by the corresponding original sample, and chloromethane was detected in analytical and equipment blanks; so laboratory or field contamination is the likely source of chloromethane. The RFA SV VOC results are described in further detail in Section 5.4.3.

5.3.5 SVOCs in Lower Level Groundwater

Eight groundwater samples and two duplicate samples were collected from eight groundwater monitoring wells and analyzed for SVOCs. Trace levels of phenol were detected in groundwater from MW-SV5 (2J µg/L) and KH-20 (8J µg/L). The phenol detection in MW-SV5 is also associated with a phenol detection (75J µg/kg) in a soil sample (B3602, 2 to 4 feet bgs) taken from this soil boring. This soil sampling interval from the MW-SV5 soil boring was below an interval of railroad ballast (0.8 to 2 feet bgs) containing dark, slag-like material and gray mottling, suggesting the presence of organic matter. The soil boring log for existing monitoring well KH-20 shows the presence of fill material with dark brown topsoil containing roots at a depth of 11.5 feet bgs. The presence of phenol in these wells and soil borings was concluded to be the result of natural degradation of organic matter or creosote associated with the railbed.

5.3.6 Metals in Lower Level Groundwater

Four groundwater samples and one duplicate sample were collected from four groundwater monitoring wells (MW-SV4, MW-SV5, MW-SV6, and MW–SV7) in the Lower Level, downgradient from the Former K6 Storage Area and the K5 Retention Basin. Iron, magnesium, manganese, and sodium are elevated above NYSDEC ambient water quality criteria in the soluble fraction of two or more of the four monitoring wells. The turbidity of the samples collected from this series of wells ranged from 3.78 NTUs at MW-SV4 to 262 NTUs at MW-SV7. No toxic metals in either total or filtered results are elevated or exceed NYSDEC ambient water quality standards.

5.3.7 Summary of SPRU SV Conclusions Regarding Groundwater

Overall, concentrations of chemical constituents in groundwater sampled near the K5 Retention Basin and the Former K6 Storage Pad are consistent with natural conditions. However, the extent of metals in soil in the Lower Level established during the RFA SV identified areas in the Railroad Staging Area and Parking Lot requiring further characterization for the potential transfer of metals and VOCs to groundwater.

5.4 Lower Level RFI

This section presents the results of the RFI evaluations for the Lower Level, including the geological, hydrogeological, and SWMU nature and extent evaluations. The fate and transport potential for the Lower Level is also described.

5.4.1 Lower Level Geological Evaluation

This discussion of the geological conditions of the Lower Level is based on previous subsurface investigations and recent subsurface evaluations as part of the Groundwater RFI and Outside Characterization. The overall Lower Level geologic conditions and the top of till topography are described. The subsurface conditions within the Lower Level were evaluated through:

- The completion of 96 soil borings (including redrills) as part of the SPRU Outside Characterization (see Appendix A, Table A-3) and 7 well borings (designated as LA-GW-RW-x), of which 6 were completed as RFI monitoring wells (see Appendix A, Table A-1)
- Existing boring logs for other soil borings and monitoring wells previously completed within the Lower Level, primarily through the SPRU RFI SV

Lower Level soil borings and monitoring wells from previous investigations, including the sitewide groundwater assessment performed in 1990 and 1991 (ERM, 1992), were selected for inclusion in the RFI evaluations and conceptual model for the Lower Level. The subsurface conditions of Lower Level SWMUs-036, -037, -038, and -040 were evaluated for the SV through the completion of 77 shallow and 16 deep soil borings. The following subsections present the results of these evaluations, including geologic cross-sections and a description of the top of till topography.

Overall Lower Level Geology

The soil boring and monitoring well locations throughout the Lower Level are shown in Plate 5-1 and Figure 5-1. Soil boring/monitoring well logs and survey coordinates are provided in Appendixes E and F, respectively. The Lower Level soil borings used to prepare geologic cross-sections A-A′, B-B′, C-C′, D-D′, E-E′, F-F′, and G-G′ are shown in Plate 5-3.

Three different types of fill materials were encountered at soil boring locations in the Lower Level:

- Railbed ballast—composed of darkly colored crushed stone, ash, cinders, and coal
- Structural/granular fill—composed primarily of sand and gravel with lower percentages of finer silt and clay components or crushed stone
- Till-derived fill—composed primarily of silt and clay with lesser percentages of sand and gravel, or silt and clay with nearly equal percentages of sand and gravel

Soil borings KH-21, LA-SO-PW-16 (well PW-16), LA-SO-PW-17 (well PW-17), LA1141-2-B, KH-20, LA-SO-PW-29 (well PW-29), and LA-SO-PW-30 (well PW-30) were used to construct cross-section A-A′ (Figure 5-2). This cross-section begins just outside the Lower Level security gate and runs southeast parallel to the road, ending near the steam lines at LA-SO-PW-30. Beneath the ground surface and/or asphalt pavement and sub-base sand/gravel, granular fill extends down to either till-derived fill or native brown till lying directly above bedrock at the northwest end of the cross-section, pinching out to the southeast. Both the ground surface and bedrock surface gently slope to the southeast, with a slight depression in the bedrock surface near the center of the cross-section. At the northwest end of the cross-section, soil boring KH-21 reaches a total depth of 34.5 feet bgs, with granular fill from the surface to 11 feet bgs, where the native brown till is encountered and extends to bedrock at 20.5 feet bgs. At LA-SO-PW-17 granular fill extends from 0.4 feet bgs, below asphalt and sub-base, to 1 foot bgs, with till-derived fill from 1 to 21 feet bgs, followed by 0.5 feet of native brown till to the boring total depth of 21.5 feet bgs. At KH-20 till-derived fill extends down to a weathered shale/bedrock layer at 14 feet bgs and then to competent shale bedrock at 15 feet bgs. No native till was found overlying shale bedrock.

Soil borings B0309, LA-SO-RW-2, KH-21, LA-SO-RW-6 (well RW-6), LA-SO-RW-7 (well RW-7), LA-SO-RW-8 (well RW-8), LA-SO-PW-18 (well PW-18), LA-SO-RW-9 (well RW-9), and LA-SO-PW-20 (well PW-20) were used to develop cross-section B-B′ (Figure 5-3). This cross-section begins at the northwest edge of the Lower Level Parking Lot and runs southeast parallel to the security fence through the former Railroad Staging Area, terminating near the northwest corner of the wastewater process facility (fenced area). Granular fill is present at or near the surface at most of the borings along this line, underlain by till-derived fill over the entire line, except for a pocket of granular fill below KH-21. Shale bedrock generally follows topography, with the exception of a ridge/high point at LA-SO-RW-8. A lens of fractured shale (shown as a lens of shale bedrock) is present at LA-SO-RW-8, while two lenses, one of railbed ballast and one of granular fill, were encountered at LA-SO-RW-9. At KH-21 granular fill extends from the ground surface to 11 feet bgs and is underlain by native brown till, which extends down to bedrock at 20.5 feet bgs. The till-derived fill layer that follows this cross-section encompasses a smaller lens of railbed ballast at LA-SO-RW-9 from 2.5 to 4 feet bgs, with the granular fill lens from 4.2 to 12.4 feet bgs.

Soil borings KH-23, LA-SO-PW-27 (well PW-27), LA-SO-PW-28 (well PW-28), B3602 (well MW-SV5), B4013 (well MW-SV6), B4014 (well MW-SV7), LA1112-1-B/Ba (LWT-1), B3845, and B3846 were used to develop cross-section C-C′ (Figure 5-4). Cross-section C-C′ begins at the southwest end of the Parking Lot and runs southeast parallel to the existing road through the Railroad Staging Area, in front of the Former K7 and K6 Storage Pads and the K5 Retention Basin, terminating at the wastewater process facility (in the fenced area). Along this line, granular fill extends from the ground surface, to shale bedrock at the western end, and to till-derived fill elsewhere. Railbed ballast is present at the surface at the southeastern end of the cross-section. Fractured/weathered shale was identified at the base of wells MW-SV5 and MW-SV6.

The soil boring at monitoring well KH-23 reached a total depth of 28 feet bgs; the upper 9.5 feet is granular fill with 1.5 feet of weathered bedrock, followed by competent shale bedrock at 11 feet bgs. At soil boring LA-SO-PW-27 (well PW-27), a total depth of 16.8 feet bgs was achieved, and the soil boring was composed almost entirely of till-derived fill. Boring B4013 (well MW-SV6) reached a total depth of 12.8 feet bgs; the upper 5.6 feet is granular fill with till-derived fill extending from 5.6 to 10 feet bgs, where native gray till was encountered above 1.8 feet of weathered shale. The extent of native gray till along cross-section C-C′ is discontinuous overlying shale bedrock.

Soil borings B4009, B4011, B4014 (well MW-SV7), LA-SO-PW-32 (well PW-32), and LA-SO-PW-30 (well PW-30) were used to develop cross-section D-D′ (Figure 5-5). This cross-section begins uphill of the K5 Retention Basin, running northeast through K5, across the road to LA-SO-PW-30. Granular fill thinly mantles till-derived fill, which is underlain by a layer of fractured/weathered shale that presumably tops shale bedrock, following the slope of the ground surface along this line. There is a lens of granular fill at the center of the section. Soil boring B4009 is shallow, reaching a total depth of only 3 feet bgs, with the upper 2 feet composed of granular fill, and the remainder of till-derived fill. At B4011 till-derived fill is present from the ground surface to 9 feet bgs, with weathered shale encountered from 9 feet bgs to the bottom of the boring at 10 feet bgs. A lens of granular fill begins at groundwater monitoring well MW-SV7, from 2.6 to 6 feet bgs, and continues to soil boring LA-SO-PW-32, where it is present from 12 to 14 feet bgs.

Soil borings B3604, B3602 (well MW-SV5), LA-SO-PW-18 (well PW-18), and KH-20 were used to develop cross-section E-E′ (Figure 5-6), which begins at the Former K6 Storage Pad and runs northeast, across the road to KH-20. Native brown till is present directly above fractured/weathered shale bedrock along the majority of the section line but is absent at LA-SO-PW-18 and KH-20, where a thin surficial granular fill layer above till-derived fill is present above bedrock. Soil boring B3604 reached a total depth of 12 feet bgs, with 1 foot of granular fill at the surface, till-derived fill from 1 to 6 feet bgs, and native brown till from 6 to 11 feet bgs, where shale was encountered. In the center of the cross-section line at LA-SO-PW-18, granular fill occupies the first 0.5 foot, while the remainder of the boring to 12.5 feet bgs is till-derived fill.

Soil borings B3866, LA1124-2-S/-Sa, LA-SO-PW-27 (well PW-27), B3827, and LA-SO-RW-6 (well RW-6) were used to develop cross-section F-F′ (Figure 5-7). This cross-section begins at the southeast corner of the former location of the L5 aboveground storage tank in the northwest portion of the Railroad Staging Area, running north-northeast to LA-SO-RW-6 near the security fence. Granular fill is present north of LA1124-2-S/-Sa, above till-derived fill, with native brown till present above fractured weathered shale at the north end of the cross section. At soil boring B3827, 2.1 feet of granular fill overlays till-derived fill to the total depth of 6 feet bgs.

Soil borings KH-23, LA-SO-RW-2, LA1702-2-S, LA-SO-RW-4 (well RW-4), and LA-SO-RW-5 (well RW-5) were used to develop cross-section G-G′ (Figure 5-8), which runs generally southwest to northeast across the Lower Level Parking Lot. Asphalt and sub-base material are present at the surface over much of this cross-section, with granular fill material extending down to shale bedrock at the southern end. Till-derived fill occupies much of the rest of the cross-section, with a layer of brown till extending southward from LA-SO-RW-5 to the vicinity of LA-SO-RW-4. At soil boring LA-SO-RW-4, granular fill is present below asphalt from 1 to 15 feet bgs, with wood present from 7 to 13.6 feet bgs. Additionally, a depression in the bedrock surface may exist under LA-SO-RW-4, although this surface is largely inferred between KH-23 and LA-SO-RW-5.

Top of Till Topography

Plate 5-2 provides the topography of the top of till surface in the Lower Level, particularly in the Railroad Staging Area near the K5 Retention Basin and the Former K6 Storage Pad. The top of till represents the elevation at which either undisturbed brown or gray till was encountered within the subsurface borings completed in the area. As shown, the surface generally dips to the north/northeast toward the Mohawk River, with a high point at KH-18 (273 feet amsl), and is generally present around 245 feet amsl in the Railroad Staging Area. Two till ridges/mounds extend downgradient, one northeast of the Former K6 Storage Area and the other near boring LA1116-3-S (across the road from the K5 Retention Basin), creating steep slopes to either side of each. Although it is difficult to fully define the extent of these ridges with the available data, their presence is consistent with the direction of groundwater movement, as measured on August 3, 2004, and February 10, 2005, shown in Figures 5-9 and 5-10, respectively. The till ridges correspond to mounds and steeper slopes in the groundwater surface. The top of till surface and till ridges/mounds are significant in terms of groundwater movement through the Lower Level, as discussed in the following subsection.

There are also four areas where glacial till is not present in the Lower Level. Two areas are found beneath the K5 Retention Basin and northeast of K5, one along the former railbed between wells RW-7 and PW-18, and one large area extending northward from well PW-27 into the southern portion of the Parking Lot.

5.4.2 Lower Level Hydrogeological Evaluation

This section describes groundwater movement in the Lower Level and presents water level contour maps. Groundwater contour maps were prepared based on water level data collected from the site monitoring wells. These monitoring wells are associated with KAPL (KH series), the RFA SV characterization (SV series), the SPRU Groundwater RFI and radiological characterization (RW series), and the SPRU radiological characterization (PW and LWT series) investigations. The groundwater level data from August 3, 2004, and

February 10, 2005 (Appendix A, Table A-8), were used to prepare the water level contour maps—Figures 5-9 and 5-10, respectively.

As depicted in Figure 5-9, overall groundwater movement is generally from the southwest to northeast with some deviation in the western portions of the study area. Within the area bounded by KH-21, KH-23, and the West Boundary Stream, groundwater movement is to the north, generally mirroring the topography of the landscape and surface water drainage patterns. In the central and northern portions of the Parking Lot, a groundwater flow divide is present, somewhat centered over monitoring well RW-4. Groundwater flow northwest of RW-4 is to the northwest toward the low-lying wet area bordering the northwestern edge of the paved parking lot. Groundwater flow east of RW-4 is to the east toward the Mohawk River.

In the central and southeastern portions of the Railroad Staging Area, there are two apparent groundwater mounds positioned over monitoring wells PW-17 and PW-18 (Figure 5-9). These mounds are formed in part by lower groundwater elevations at monitoring wells RW-8, KH-20, and RW-9. Groundwater movement between PW-17 and PW-18 converges into a troughlike feature. Groundwater movement on the outside margins of the mounds flows off to the north (from PW-17) and east (from PW-18).

The February 10, 2005 (Figure 5-10) contoured set of groundwater data reveals a similar groundwater flow pattern to the August 3, 2004, data. Several additional monitoring wells (LWT-1, LWT-2, PW-27, PW-28, PW-29, PW-30, and PW-32) were installed after August 3, 2004. A flow divide is apparent in the central and northern sections of the Lower Level Parking Lot, and groundwater mounds are positioned over monitoring wells PW-17, KH-20, and PW-29. A deeper groundwater trough is apparent between these two mounds, as created by the groundwater elevation at well PW-18.

Site utility mapping for the Lower Level shows that buried utilities are clustered near the overhead steam lines running in a southwest to northeast direction from the Upper Level and through the Lower Level, generally along the northern side of the K5 Retention Basin to monitoring well PW-29. These buried utility conduits are near monitoring wells KH-20, PW-29, and PW-30. A stormwater drain line between CB-4 and MCB-4 exists near the trough between the groundwater mounds associated with monitoring wells PW-17, KH-20, and PW-29. The stormwater utility runs and drains from southwest to northeast. The upgradient portion of the storm line is located near well PW-18, which forms the bottom of the groundwater trough. The significance of these utility features is that the buried utility conduit excavations may serve as a zone of preferential groundwater flow.

5.4.3 Lower Level SWMU Nature and Extent Evaluation

This subsection describes the investigation and evaluation of two data gaps from the RFA SV pertaining to the Lower Level: (1) the impact to groundwater in areas of elevated metals and VOCs, and (2) groundwater below the K5 Retention Basin. The investigation results for VOCs, SVOCs, and metals in groundwater are also presented.

Groundwater VOC and metals results that are not associated with laboratory or field contamination are compared to NYSDEC ambient water quality standards and guidance values for groundwater (NYSDEC, 1998b) and considered “elevated” if they exceed their respective criteria. Total (unfiltered) metal results may not be representative of groundwater quality when particulate inclusion results in turbidity significantly greater than 5 NTUs (see the turbidity discussion in Section 4.4.3).

Railroad Staging Area

As mentioned in Section 5.2.1, groundwater samples were collected during two rounds (July/August 2004 and November 2004) from the newly installed monitoring wells RW-6, RW-7, and RW-8, and existing SV monitoring wells MW-SV4, MW-SV5, MW-SV6, and MW-SV7. One duplicate sample was also collected per sampling event. A single round of groundwater samples was collected in August 2005 from radiological characterization wells PW-16 and PW-17 to further evaluate potential chemical releases. The groundwater samples were analyzed in accordance with the Groundwater RFI Work Plan (DOE/CH2M HILL, 2004a) for TCL VOCs and TAL metals. The results are summarized in Tables 5-1 to 5-3, respectively, along with the turbidity values (Table 5-3) and the previous SV results for comparison.

A soil sample collected during the SPRU radiological characterization from soil boring LA1119-1-B2 at the 0.5- to 2-foot-bgs interval exhibited a PID reading of 2.6 ppm and was also analyzed for VOCs. However, no VOCs were detected in the soil sample by laboratory analysis.

VOCs in Railroad Staging Area Groundwater. Two sets of groundwater samples were collected from well RW-6 (see Figure 5-1) on June 29 and November 16, 2004. No VOCs were detected in the groundwater samples from either date, except 0.24J µg/L of chloromethane in the June 29, 2004, sample. There is no NYSDEC ambient water quality criterion for chloromethane. Acetone, a common laboratory contaminant (see Appendix B), was detected in the June 29, 2004, sample and duplicate (FDGW03) at 1.7 J and 2.8J µg/L, respectively, both of which are well below the NYSDEC ambient water quality guidance value.

Two sets of groundwater samples were collected from well RW-7 (see Figure 5-1) on July 6 and November 16, 2004. No VOCs were detected in the groundwater samples from either date, except carbon disulfide at 0.45J µg/L in the July 6, 2004, sample, which is well below the respective NYSDEC water quality guidance value.

Two sets of groundwater samples were collected from well RW-8 (see Figure 5-1) on July 13 and November 17, 2004. The July 13th sample was collected to replace a sample collected on July 7th, which was rejected due to an elevated shipping cooler temperature upon receipt at the laboratory. No VOCs were detected in the July 13th and November 17th samples; although acetone and methyl ethyl ketone results were rejected during validation of the November 17th sample results.

Monitoring well MW-SV4 (see Figure 5-1) was sampled on January 2, 2001 (during the SV); July 7, 2004; and November 15, 2004. In the January 2, 2001, sample set, carbon disulfide was detected at a concentration of 2 µg/L but was not detected in the subsequent groundwater samples during the RFI. The low level carbon disulfide detection was below the NYSDEC ambient water quality criterion. During the data validation process, the July 7, 2004 sample results were rejected due to an elevated shipping cooler temperature upon receipt at the laboratory. No VOCs were detected in the November 15, 2004 sample, although acetone and methyl ethyl ketone results were rejected during validation of the November 15th sample results.

Monitoring well MW-SV5 (see Figure 5-1) was sampled on January 5, 2001 (during the SV); July 8, 2004; and November 15, 2004. The only VOC detected was chloromethane at 16 µg/L in the January 2001 duplicate sample. As noted previously, there is no NYSDEC ambient water quality criterion for chloromethane in groundwater. No VOCs were detected in the July 8, 2004, or November 15, 2004 samples.

Monitoring well MW-SV6 (see Figure 5-1) was sampled on January 4, 2001 (during the SV); July 9, 2004; November 15, 2004; and March 24, 2005. The July 9, 2004, samples were not analyzed by the laboratory due to a mistake. Therefore, the well was resampled on March 24, 2005. Only a trace of carbon disulfide (1J µg/L) was detected in the sample from January 4, 2001. Bromoform was the only VOC detected in the November 15, 2004, sample, at a trace concentration of 0.35J µg/L. Trace levels of styrene (0.13J µg/L) and total xylenes (0.36J µg/L) were detected only in the March 24, 2005, sample. All VOCs detected at MW-SV6 are well below NYSDEC ambient water quality criteria.

MW-SV7 was sampled on January 5, 2001 (during the SV); July 9, 2004; November 15, 2004; and March 24, 2005. The July 9, 2004, samples were not analyzed by the laboratory due to a mistake. Therefore, the well was resampled on March 24, 2005. No VOCs were detected in the January 5, 2001, and November 15, 2004, samples. Chloroform (0.2J µg/L), methylene chloride (1J µg/L), and toluene (0.15J µg/L) were detected in estimated trace levels in the normal sample collected on March 24, 2005. Chloroform was confirmed at a trace level (0.12J µg/L) in the duplicate groundwater sample collected on March 24, 2005. TCE and cis-1,2-DCE were also detected at estimated trace levels of 0.45J and 0.71J µg/L, respectively, in the duplicate March 24, 2005, sample. The only detections of TCE and its breakdown product, cis-1,2-DCE, in Lower Level groundwater were from this duplicate sample and were not confirmed in the corresponding normal sample.

Trace levels of bromomethane (0.31J and 0.24J µg/L from the normal and duplicate samples, respectively) and chloroform (0.076J µg/L from the normal sample only) were detected in the August 11, 2005 groundwater samples from well PW-17. A trace detection of carbon disulfide (0.53J µg/L) was detected in the August 11, 2005 sample from well PW-16.

Because acetone, chloromethane, bromomethane and carbon disulfide were all detected in analytical and equipment blanks (see Appendix B), these contaminants in groundwater are attributed to laboratory or field contamination. The trace xylene concentration is most likely related to the use and storage of gasoline in the Lower Level. Therefore, these sporadic and trace levels of VOCs in groundwater do not indicate a SPRU-related release to the environment.

Metals in Railroad Staging Area Groundwater. Iron, magnesium, manganese, and sodium were the most prevalent metals detected in the groundwater samples above the NYSDEC ambient water quality criteria. The total concentration values for magnesium and sodium were not significantly reduced, if at all, as a result of sample filtering when the turbidity was greater than 5 NTUs, which is attributed to the high solubility of these analytes in water.

The concentration of iron was significantly reduced between the total and dissolved results in all wells except well RW-6 (see Figure 5-1) on June 29, 2004. The total iron samples collected from well MW-SV4 for both 2004 sampling events and the November 2004 samples from wells MW-SV7, RW-7, and RW-8—all with turbidity of less than 5 NTUs—remained above the NYSDEC criterion. The total iron concentrations in both samples from well MW-SV5 were below the NYSDEC criterion, with turbidity of less than 5 NTUs for both samples.

Analytical results for sodium collected on March 24, 2005, are elevated about an order of magnitude above all previous sampling events at wells MW-SV6 (250,000 μg/L) and MW-SV7 (2,180,000 and 2,300,000 μg/L in the normal and duplicate samples, respectively). These well locations are situated hydraulically downgradient from the K5 Retention Basin, near the base of the Lower Level Hillside slope, and sample collection took place when spring snow melt and runoff are typically active. At this downgradient location from the K5 Retention Basin, there is a potential for increased runoff activity to mobilize sodium and other chemicals of concern (i.e., VOCs) associated with releases to the subsurface below the K5 Retention Basin. Analytical results for sodium were also elevated (1,100,000 to 1,230,000 μg/L) in total, dissolved, and duplicate samples collected in the August 2005 sample from well PW-17. Groundwater flow directions and sodium concentrations in well RW-8 (117,000 to 126,000 μg/L) between MW-SV6/MW-SV7 and PW-17 do not support sodium transport in groundwater from the K5 Retention Basin to PW-17. Sodium is not elevated in well PW-16, about 75 feet northwest of PW-17; however, PW-17 is completed in the upper portion of the till-derived fill (see Figure 5-2) and therefore may be impacted by surficial road salting operations in the Lower Level.

The remaining metals detected above the NYSDEC ambient water quality criteria in 2004 were total cadmium at MW-SV4 in the July 7 and November 15 samples; selenium at MW-SV4 in the July 7 sample; and beryllium at RW-8 in the July 7 sample. The turbidity of these samples was less than 5 NTUs. The July 9, 2004, samples from MW-SV6 and MW-SV7 were not analyzed by the laboratory due to a mistake. The data reported in Table 5-3 are from the March 24, 2005, resampling of these wells.

Lower Level Parking Lot

Groundwater samples were collected from newly installed monitoring well RW-4 existing well KH-18 (see Figure 5-1) and analyzed in June/August and November 2004 to evaluate seasonal variability. No samples were collected from newly installed monitoring well RW-5 because it was dry during both sampling rounds. The groundwater samples were analyzed in accordance with the Groundwater RFI Work Plan (DOE/CH2M HILL, 2004a) for TCL VOCs, TCL SVOCs, and TAL metals. The results are summarized in Tables 5-1 to 5-3, respectively, along with the turbidity values (Table 5-3) and the previous SV results for comparison.

VOCs in Lower Level Parking Lot Groundwater. The VOC groundwater analytical results for wells KH-18 and RW-4 (see Figure 5-1) are presented in Table 5-1. KH-18 was sampled to establish groundwater chemical quality upgradient of the Parking Lot.

As shown, bromomethane (0.36J µg/L), chloroform (0.57J µg/L), and toluene (2 µg/L) were detected above the laboratory MDL but below their NYSDEC ambient water quality criteria in the samples collected from KH-18 on November 17, 2004. No VOCs were detected in the sample or field duplicate (FDGW07) collected on August 2, 2004. Bromomethane, chloroform, and toluene were all detected in laboratory blanks (see Appendix B), so the low VOC detections in the November sample are attributed to laboratory contamination.

Groundwater samples were collected from RW-4 on June 24 and November 17, 2004. The June 24 results identified carbon disulfide (0.33J µg/L), ethylbenzene (0.49J µg/L), toluene (1.3J µg/L), and total xylenes (0.85J µg/L) at concentrations slightly above the laboratory MDLs but below their respective NYSDEC ambient water quality criteria. Only chloroform was detected in the November 17, 2004, sample at an estimated trace concentration (0.21J µg/L). The detections of ethylbenzene, toluene, and total xylenes are not representative of a hazardous material release and are likely related to petroleum hydrocarbons (fuels) from the Parking Lot.

SVOCs in Lower Level Parking Lot Groundwater. No SVOCs were detected in either the first or second round of groundwater samples collected from the Parking Lot well RW-4 or the upgradient well KH-18 (see Table 5-2).

Metals in Lower Level Parking Lot Groundwater. As shown in Table 5-3, iron, magnesium, manganese, and sodium were the primary metals detected above their respective NYSDEC ambient water quality criteria in the samples from well RW-4 and background well KH-18. RW-4 was sampled on June 24 and November 17, 2004, and KH-18 was sampled on August 2 and November 17, 2004. Iron, magnesium, manganese, and sodium were detected at RW-4 and KH-18 in both the total (where turbidity was less than 5 NTUs) and dissolved groundwater samples collected during both sampling events. The total concentration values for magnesium and sodium were not significantly reduced, if at all, as a result of sample filtering, which is attributed to the high solubility of these analytes in water. The concentration of iron was not reduced below the NYSDEC criterion in the November 17, 2004, groundwater sample from KH-18 as a result of filtering. This observation suggests that the natural iron concentration in bedrock at KH-18 is elevated and is not specifically related to sample turbidity.

No other metals were detected above their respective NYSDEC criteria at RW-4 and KH-18, except for antimony, thallium, and mercury. Antimony was detected at 3.2J µg/L, slightly above it NYSDEC criterion of 3 µg/L, in the total sample from KH-18 collected in November 2004. Antimony was not detected in the dissolved sample from KH-18 collected in November 2004 or the total sample collected in August 2004. Thallium was detected in the June 24, 2004, dissolved sample at RW-4 at 0.57J µg/L, slightly above its NYSDEC criterion of 0.5 µg/L. Although the sample result was a nondetect, the laboratory MDL for the total sample collected at KH-18 on August 2, 2004, was elevated (3.93 µg/L) and above the NYSDEC criterion for thallium. Mercury was detected in the June 24, 2004, total sample at RW-4 at 1 µg/L, slightly above its NYSDEC criterion of 0.7 µg/L. However, mercury was not detected in the associated dissolved sample collected on June 24, 2004, and was detected well below the NYSDEC criterion in the November 17, 2004 sample.

5.4.4 Lower Level Fate and Transport Potential

Conceptual models representing the expected mode of contaminant release and transport in groundwater for the Railroad Staging Area, Parking Lot, and K5 Retention Basin are summarized in this subsection.

Railroad Staging Area

The RFI has not identified any contaminants of concern in groundwater that are related to the VOCs, SVOCs, and metals identified during the SV or to the release of hazardous materials in the Railroad Staging Area.

Lower Level Parking Lot

The Lower Level Parking Lot is constructed of fill materials derived, at least in part, from soils in the Railroad Staging Area (see Section 2.2.4). Elevated concentrations of metals and organics were identified during the SV, primarily in the northern portion of the Parking Lot, corresponding to known areas of soil deposition from the Railroad Staging Area.

At the one monitoring well (RW-4) that produced groundwater, completed in the northern portion of the Parking Lot, carbon disulfide, ethylbenzene, toluene, and total xylenes were detected at concentrations below the NYSDEC ambient water quality criteria. These VOCs are not representative of a hazardous material release and are likely related to petroleum hydrocarbons (fuels) from the Parking Lot. No VOCs were detected in the groundwater samples from RW-4 at concentrations above the laboratory MDLs (i.e., the detections were estimated because the values were below the MDL). No non-naturally-occurring metals were detected above the laboratory MDLs and NYSDEC criteria in the groundwater samples collected from RW-4 and KH-18, except antimony, thallium, and mercury at estimated concentrations slightly above the NYSDEC criterion in one sample each.

There is an overall lack of saturated conditions beneath the Lower Level Parking Lot. Newly installed monitoring well RW-5 did not produce water for sampling. The soil boring for groundwater monitoring well RW-2 (LA-SO-RW-2) indicates only moist and damp conditions to its refusal depth of 9.5 feet. Additional well and soil sampling borings advanced during the SPRU radiological characterization (see Plate 5-1) were also unsaturated. Soil borings LA1702-3-B, LA1702-2-S, LA1702-1-S, LA1701-8-B2, LA1701-8-B1, LA1701-7-S, LA1701-7-B, and LA-SO-PW-25 (soil boring for planned radiological characterization well PW-25) were advanced to refusal in the Parking Lot fill. Depth to refusal ranged from 7.3 to 13.5 feet bgs. Soil in the borings was moist, but there was no indication of sufficient saturated conditions for well installation.

K5 Retention Basin

At the K5 Retention Basin, elevated sodium and trace levels of VOCs were identified in groundwater wells immediately downgradient of the retention basin (MW-SV6 and MW-SV7) sampled during March 2005. These detections likely coincide with increased groundwater flow, resulting from runoff and infiltration during the spring thaw, along the hillslope and beneath the K5 Retention Basin. Trace levels of toluene and TCE (2J µg/kg) were detected at soil boring B4005 (6 to 6.4 feet bgs) at the interface of structural fill and gray till along the southern wall of the K5 Retention Basin, which indicates that a source of VOCs may be present beneath the basin structure.

5.5 Naturally Occurring Ions in Groundwater

Sodium, iron, magnesium, and calcium were detected in both total and dissolved groundwater samples from the Lower and Upper Levels at concentrations exceeding NYSDEC ambient drinking water standards. Elevated concentrations of these metals in groundwater may be due to several sources, including natural mineralogy, road salting, and dissolution of SPRU-related chemicals. Pertinent examples of SPRU-related potential chemicals of concern include calcium hypochlorite, manganese dioxide, sodium hydroxide, ferric nitrate, and sodium salts used to soften water at the H1 cooling tower. Sodium is a component of the common road salt used at KAPL (sodium chloride) and is expected to be elevated because of winter application, particularly in the Upper Level.

The glacial tills in the New York State Capital Region typically contain black shale bedrock. Iron and manganese are commonly associated with water wells in shale bedrock and unconsolidated deposits comprising shale sediment. The City of Schenectady well field along the southern banks of the Mohawk River near the site produces groundwater with elevated manganese, which requires polyphosphate sequestration. Several high-yielding wells (over 2,000 gallons per minute) have been abandoned because of elevated manganese concentrations. The Clifton Park Water Authority Vischers Ferry Preserve wellfield along the northern banks of the Mohawk River near the site produces over 2,000 gallons per minute of groundwater daily that contain elevated concentrations of iron and manganese that are removed through treatment. Some of the early wells in this wellfield were abandoned because of high iron and manganese concentrations. The granular overburden within the Vischers Ferry Aquifer was reported to have been derived from the Niskayuna Gorge area (including KAPL).

Concentrations of naturally occurring ions in groundwater from monitoring wells across the Knolls Site were evaluated to determine if elevated levels were consistently associated with areas potentially impacted by SPRU operations. Three sources of available data for sodium, iron, magnesium, and calcium in groundwater were evaluated:

- Groundwater samples from across the Knolls Site reported by KAPL in annual environmental monitoring reports (1993 through 2002)
- Data reported in the SPRU RFA SV Report
- Additional data collected during this Groundwater RFI through March of 2005

The evaluated data are tabulated in Appendix G and summarized by well in Table 5-4. Figures 5-11 through 5-14 plot the minimum, maximum, and average values for iron, manganese, sodium, and calcium at monitoring wells across the Knolls Site.

Average iron concentrations exceeded the NYSDEC ambient water quality criterion (300 µg/L) in 20 of the 65 Knolls sitewide groundwater monitoring wells evaluated (Figure 5-11). Maximum average concentrations are associated with well RW-6 in the Railroad Staging Area. Overall, there is a generally consistent distribution of groundwater monitoring wells with average iron concentrations exceeding the NYSDEC criterion. These wells are in areas that could be hydrologically affected by iron releases in the Upper Level SPRU process buildings or waste management operations in the Lower Level (see Figure 5-15). Average iron levels are below the criterion in overburden monitoring wells in the center of the Knolls Site, upgradient of the SPRU facilities (KH-1S, KH-6, KH-9S, and KH-19); monitoring wells along the Lower Level Access Road (B-26, KH-15, and B-16); wells upgradient of Building G2 (B-5 and B-7); and Lower Level bedrock wells (KH-21 and KH-22). However, iron concentrations at monitoring well B-6 (average concentration of 424 µg/L), upgradient of SPRU Building G2, slightly exceed the criterion. The average iron concentration in the Hillside Sump (shown as HS on the figure) (36 µg/L), which receives drainage from Building H2 and the Tank Farm footing drains, is well below the criterion.

Manganese exceeded the NYSDEC ambient water quality criterion (300 µg/L) in 28 of the 65 Knolls sitewide groundwater monitoring wells evaluated (see Figure 5-12). The highest maximum average concentrations in the Lower Level are in wells RW-6, RW-4, and RW-8 (see Figure 5-16). Manganese is also elevated in Upper Level wells MW-SV1 and MW-SV5. Average manganese levels exceed the criterion in the Lower Level bedrock well KH-21 and well KH-18 completed in till on the hillside between the Upper and Lower Levels. Overall, manganese is elevated in groundwater monitoring wells adjacent to SPRU Buildings G2 and H2 and in most wells in the Railroad Staging Area and Parking Lot. The highest concentrations are in the Lower Level. Manganese is below the NYSDEC criterion in monitoring wells in the center of the Knolls Site, upgradient of the SPRU facilities (KH-1S, KH-6, KH-9S, and KH-19); wells along the Lower Level Access Road (B-26, KH-15, and B-16); and wells upgradient of Building G2 (B-5, B-6, and B-7). However, like iron, the average magnesium concentration was not elevated above the NYSDEC criterion in the Hillside Sump (1.46 µg/L).

Sodium was elevated above the NYSDEC ambient drinking water standard (20,000 µg/L) in 55 of the 66 Knolls sitewide groundwater monitoring wells evaluated (see Figure 5-13). As shown in Figure 5-17, the highest concentrations surround SPRU Process Buildings G2 and H2 and upgradient locations at wells B-5, B-6, and B-7). The sodium concentration in groundwater at MW-SV1 is significantly higher in the winter (1,890,000 and 2,870,000 µg/L in February 2001 and December 2004, respectively) than in the summer (465,000 µg/L in August 2004). However, there is no seasonal variation in sodium concentration in other Upper Levels wells, including B-5, MW-SV3, and B-15. Sodium concentrations above the criterion in groundwater in the Lower Level are generally less than those in the Upper Level, except in March 2005 at well MW-SV7 (2,300,000 µg/L). Elevated sodium in the Knolls Site interior monitoring wells (KH-6 and KH-9S) and the monitoring wells along the Lower Level Access Road (B-26, KH-15, and B-16) is likely due to road salt application. Sodium also exceeds the N YSDEC ambient water quality criterion in the Lower Level bedrock monitoring wells (KH-22 and KH-21).

No drinking water criteria are applicable for calcium. A value of 100,000 µg/L was selected to represent the upper 25 percent of the calcium concentrations, as presented in Figure 5-14. The distribution of calcium shows consistently elevated levels in the Upper Level, with the highest values associated with wells MW-SV1 and B-15 between Buildings H2 and G2 (see

Figure 5-18). The calcium concentration in groundwater at MW-SV1 is significantly higher in the winter (969,000 and 655,000 µg/L in February 2001 and December 2004, respectively) than in the summer (89,900 µg/L in August 2004). However, like sodium, there is no seasonal variation evident in other Upper Level wells. Calcium was also relatively elevated (647,000 µg/L) in the March 2005 sample from well MW-SV7 in conjunction with the elevated sodium.

The distribution of naturally occurring metals in groundwater across the Knolls Site cannot rule out impact from SPRU operations on sodium, manganese, and iron concentrations in groundwater; however, the data are somewhat contradictory. Concentrations of these metals are elevated between former SPRU process Buildings G2 and H2 and select locations in the Lower Level. However, elevated levels of sodium and iron associated with wells B-5, B-6, and B-7, upgradient of the SPRU facilities, indicate potential impacts from KAPL (non-SPRU) operations, including road salting. Sodium concentrations above the NYSDEC ambient water quality criterion in some wells away from SPRU operations (e.g., KH-9S), in the Knolls Site parking area (KH-6), and downgradient of the salt barn suggest salt application may also be a factor. Elevated manganese in the Lower Level is likely a result of the inclusion of shale in the overburden till because of the outcropping of the Schenectady Formation shale along the Lower Level Hillside. The absence of elevated concentrations of iron and manganese in the low-turbidity groundwater draining from the Building H2 footing drains into the Hillside Sump is likely the result of oxidation and precipitation from groundwater as it flows along the below-grade drainage pipe extending from the northwest corner of Building H2 to the Hillside Sump.

6. Conclusions

This section presents conclusions for each of the RFA SV data gaps that were addressed in this Groundwater RFI, as well as overall conclusions for the SWMUs and AOC in the SPRU Upper and Lower Levels. [1] In addition, this section explains the presence of naturally occurring metals in groundwater at the Knolls Site.

6.1 Upper Level Conclusions

The following sections present the conclusions for the two RFA SV groundwater data gaps investigated in the Upper Level and the overall conclusions from both the RFA and RFI of the Upper Level SWMUs.

6.1.1 Upper Level Data Gap 1—Source of VOCs in Pipe Tunnel (SWMU-057) Footing Drains

Upper Level Data Gap 1 required the determination of whether VOCs within the SV wells adjacent to the Pipe Tunnel originated from: (1) the VOCs detected near well B-15 and soil boring SB-24, identified during the KAPL Hillside Area RFI; (2) groundwater migration along the Building G2 footing drain; or (3) the loading dock in the northwest corner of Building G2.

Groundwater monitoring wells along the western side of Building G2 (UWT-2a and UW-3) did not contain VOCs in sufficient concentration to be the source of VOC levels in wells MW-SV1 and MW-SV3 (see Figure 4-1). Furthermore, water levels in wells along the western side of Building G2 do not indicate flow towards the northwest corner of Building G2 and subsequently towards the Pipe Tunnel. Therefore, transport of VOCs in groundwater is not evident along the western side of the Building G2 foundation.

A hydraulic condition has been identified that may allow groundwater containing VOCs from the area between Buildings H2 and G2, near wells B-15 and MW-24, to enter the Pipe

[1] The SPRU RFA SV also involved investigations of the Former Slurry Drum Storage Area (SWMU-035) within the SPRU Land Area, in the southeastern portion of the Knolls Site. The NYSDEC-approved RFA SV Report concluded that there was no release of SPRU-related chemicals in this SWMU and that no further action was necessary. The Former Slurry Drum Storage Area was, therefore, not carried forward into this RFI.

Tunnel footing drains. This interpretation is supported by the presence of common VOCs between wells B-15 and MW-24 and the monitoring wells installed around the Pipe Tunnel during the SPRU SV and Groundwater RFI. Although there is uncertainty in this evaluation, the overall nature and extent of VOC contamination between Buildings G2 and H2, including the Pipe Tunnel, and throughout the Upper Level are established by the Hillside RFI, SPRU SV, and RFI through the following observations.

1. The vertical extent of elevated VOC concentrations in soil borings in the area between Buildings G2 and H2 is bounded by the presence of impermeable gray till throughout the area as determined by soil borings terminated into the gray till and an exploratory soil boring that penetrated the gray till and confirmed that it is massive and without transmissive zones.
2. The subsurface conditions in the area between Buildings G2 and H2 are complicated as a result of building and utility construction in the Upper Level and the soil types that are present. However, groundwater flow directions around Buildings G2 and H2, the Pipe Tunnel, and the Tank Farm, together with the top of till configuration in the area between Buildings G2 and H2, confirm that groundwater flows into an east-west trending trough between the buildings. There it is discharged either to the Upper Level Hillside or into the Building H2 footing drain system that is keyed into impermeable gray till. Groundwater north of Building H2 is also contained within the footing drain system (see Section 6.1.2).
3. The lack of VOC detections in groundwater monitoring well UW-10 at the eastern end of a groundwater trough together with east-to-west groundwater flow directions, indicate that the VOCs in the trough between Buildings G2 and H2 are bounded to the east.
4. Lack of consistent VOC detections in groundwater monitoring wells located along the base of the H2 Hillside (B-16, B-26, and KH-15) indicate that there is not substantial migration of VOCs from the trough west towards the H2 Hillside.

6.1.2 Upper Level Data Gap 2—Groundwater Flow and Chemistry at the Northwestern Perimeter of the H2 Processing Facility (SWMU-030)

The objective of Upper Level Data Gap 2 investigation was to determine: (1) the potential impact to groundwater from metals, primarily antimony, along the northwestern portion of

Building H2; and (2) whether groundwater is flowing away from Building H2 along a construction excavation in the gray till.

Antimony was not detected in the soils from the base elevation of the Building H2 footer at UW-1 and UW-2, or in the groundwater samples from these locations, above the laboratory MDLs. Antimony is, therefore, no longer considered a potential contaminant of concern.

The absence of incised gray till beneath the northwestern portion of Building H2, together with the water levels observed in wells along the Building H2 perimeter and the Upper Level Hillside, result in the potential for groundwater flow from the northwestern corner of Building H2 beyond the containment of the Hillside Sump. Groundwater flow potentials along the northern portion of Building H2 are towards the building foundation, and there is no evidence of metal or target VOC contamination in wells located about 10 feet north of the Building H2 north wall (well UW-2). These observations confirm that the Building H2 footing drain system is operational and is draining the area immediately around the Building H2 perimeter. Trace levels of VOCs identified in one Hillside Sump sample indicate VOCs are captured by the sump from the Building H2 footer drain. Significant migration of VOCs beyond the extent of the Hillside Sump drainage system into the Upper Level Hillside has not been observed.

6.1.3 Overall Conclusions for Upper Level SWMUs

The following are overall conclusions for each Upper Level SWMU requiring further action following the RFA SV, including groundwater investigation conclusions achieved during this RFI and conclusions previously made regarding soil contamination in the SPRU RFA SV.

H2 Processing Facility (SWMU-030)

Antimony detections in dissolved groundwater samples collected along the northwest portion of Building H2 during the RFA SV were not confirmed in additional groundwater and soil sampling. Groundwater along the southern perimeter of Building H2 contains VOCs (TCE and total 1,2-DCE) above the NYSDEC ambient water quality criteria. However, this groundwater is contained in the Building H2 footing drain system. Surface soil near the southwest corner of Building H2 has elevated antimony, arsenic, and mercury concentrations.

H2 Tank Farm (SWMU-031)

Mercury and zinc are elevated above background or NYSDEC soil cleanup objectives in surface soil in the east-central portion of the H2 Tank Farm. Mercury is also elevated above background or NYSDEC objectives in soil at the base of the Tank Farm Vault foundation. These metals are consistent with chemical hazardous constituents managed by SPRU.

Pipe Tunnel (SWMU-057)

VOCs below NYSDEC soil cleanup objectives were detected in soil along the western foundation of the Pipe Tunnel. Groundwater also contains traces of VOCs (1,1-DCA; 1,1-DCE; total 1,2-DCE; TCE; and vinyl chloride) west of the Pipe Tunnel. Only TCE exceeds the NYSDEC ambient water quality criteria in one well. The source of the VOCs in groundwater in the Pipe Tunnel drains may be related to a separate source of VOCs in soil and groundwater between Buildings G2 and H2 or possibly releases from the Pipe Tunnel itself. The extent of VOCs in the area surrounding the Pipe Tunnel has been established.

6.2 Lower Level Conclusions

The following sections present the conclusions for the RFA SV groundwater data gap investigated in the Lower Level and the overall conclusions from both the RFA and RFI of the Lower Level SWMUs and AOC.

6.2.1 Lower Level Data Gap 1— Impact to Groundwater in Areas of Elevated Metals and VOCs

This Lower Level Data Gap 1 requires the determination of: (1) whether there has been a release to groundwater from metals and VOCs in the soil in the northern portion of the Lower Level Railroad Staging Area (SWMU-038); and (2) whether there has been a release to groundwater from elevated metals in the Lower Level Parking Lot (AOC-003) fill materials.

VOCs and metals in the Railroad Staging Area groundwater were not elevated. Detected VOCs in the Parking Lot groundwater monitoring well are likely the result of parked vehicles. One metal, thallium, was detected above NYSDEC ambient water quality criteria in the Parking Lot groundwater. Groundwater was found at only one drilling location in the Parking Lot, indicating a general lack of saturated conditions within the Parking Lot fill and low potential for the migration of this metal. No release of other hazardous chemicals from SPRU operations is evident in these investigation areas.

6.2.2 Overall Conclusions for Lower Level SWMUs and AOC

The following are overall conclusions for each Lower Level SWMU/AOC requiring further action following the RFA SV and include groundwater investigation conclusions achieved during this RFI and conclusions previously made regarding soil contamination in the SPRU RFA SV.

Railroad Staging Area (SWMU-038)

Concentrations of silver, mercury, total chromium, and thallium detected in shallow soil above background levels indicate hazardous chemical constituent releases in the southeastern, central, and northern portions of the Railroad Staging Area. These metals are also above the NYSDEC soil cleanup objectives. Traces of VOCs were detected below NYSDEC soil cleanup objectives in the northwestern and southeastern portions of the Railroad Staging Area. Concentrations of metals in groundwater in the central and northern portions of the Railroad Staging Area are below NYSDEC ambient water quality criteria, indicating a lack of significant transfer of metals from soil to groundwater in that area. VOCs were not detected in groundwater. Traces of gasoline constituents evident throughout the Railroad Staging Area are likely associated with motor vehicle use, not waste management or product spills from SPRU operations. Elevated metals and VOCs in the southeastern portion of the Railroad Staging Area may have resulted from operations at the former Sewage Treatment Plant that are not related to SPRU.

Antimony, copper, arsenic, lead, and PAH compounds are elevated throughout the former Railroad Staging Area. These PAHs and metals are attributed to railroad construction materials and operations, and not SPRU or KAPL waste management.

K5 Retention Basin (SWMU-040)[2]

A trace detection of TCE in soil at the northeast corner of the K5 Retention Basin suggests a potential release of VOCs from the building's foundation at a concentration well below the NYSDEC soil cleanup objective. Slightly elevated concentrations of copper and zinc in the soils surrounding the K5 Retention Basin are likely associated with soil mineralogy and/or

[2] The discussion in this section also corresponds to the Lower Level Data Gap 2 identified in the RFI Work Plan.

construction activity and, therefore, do not likely indicate a release from waste management or product spills from SPRU operations.

Because of access limitations, further evaluation of the VOCs along or beneath the building's foundation will be evaluated after D&D of the K5 Retention Basin. A trace detection of VOCs in a groundwater sample collected from a monitoring well downgradient of the K5 Retention Basin indicates the potential for transport of trace levels of VOCs (less than 1 μg/L) from the K5 Retention Basin, particularly during periods of high groundwater recharge. The levels are well below the NYSDEC ambient drinking water criteria. Groundwater at the Knolls Site is not consumed for any potable or industrial use, so this trace detection does not require accelerated characterization and potential remediation of VOCs at the K5 Retention Basin.

Lower Level Parking Lot (AOC-003)

Concentrations of antimony, arsenic, cadmium, copper, lead, mercury, and silver are above background or NYSDEC soil cleanup objectives in soil borings primarily in the northern portion of the Parking Lot. Concentrations of mercury (up to 6.9 mg/kg) significantly exceed the NYSDEC soil cleanup objective. Metal concentrations indicate a likely hazardous chemical constituent release from SPRU operations. However, traces of gasoline constituents in Parking Lot soil are likely associated with vehicle use, not waste management or product spills from SPRU operations.

Groundwater availability is limited in the Parking Lot fill. With the exception of thallium, chemicals are not elevated above NYSDEC ambient water quality criteria in the one well that produces groundwater in the Lower Level.

6.3 SPRU-Related Impact on Naturally Occurring Metals in Groundwater

Naturally occurring metals, including iron, magnesium, and sodium, are elevated in groundwater downgradient from SPRU operations in the Upper and Lower Levels. Although SPRU operations cannot be ruled out as a source of these metals, road salting and contributions from shale mineralogy are also likely sources of elevated levels of naturally occurring metals. Groundwater from shale bedrock and shale-bearing overburden groundwater production wells along the Mohawk River commonly has elevated levels of iron and magnesium. Because hazardous metals have been detected in only isolated occurrences in groundwater downgradient from SPRU SWMUs, there is no evidence to support a widespread release of hazardous chemicals to the environment from SPRU operations that could be inferred from the distribution of naturally occurring metals. Therefore, the distribution of naturally occurring metals downgradient of SPRU process areas and across the Knolls Site is interpreted to result from natural conditions.

7. Recommendations

Section 7 presents RFI recommendations for the SWMUs and AOC in the Upper and Lower Levels at the Knolls Site. The recommendations carry forward recommendations for additional evaluation made in the RFA SV Report together with recommendations arising from the groundwater characterization conducted in this RFI.

In general, previous recommendations made in the SPRU RFA SV Report (DOE/CH2M HILL, 2002) involving further characterization of soil for chemical releases are recommended to be addressed during remedial design to be performed in conjunction with the radiological remediation of SPRU facilities and environs. Radiological remediation will likely include a presumptive remedy of soil removal; however, the extent of soil to be removed is currently under evaluation. The need, if any, to further evaluate the extent of chemicals will be made when the extent of soil to be removed for radiological remediation is established.

7.1 Upper Level SWMUs

The Upper Level contains ten SWMUs, seven of which are aboveground tanks inside Building G2 (SWMU-058 through SWMU-064) designated for no further action based on the PR-VSI. The remaining three SWMUs were investigated in the RFA SV, with additional characterization to satisfy groundwater data gaps performed in this RFI. Recommendations for the three Upper Level SWMUs are presented in the following sections.

7.1.1 H2 Processing Facility (SWMU-030)

Building H2 was investigated during this RFI in response to Data Gap 2 in the Upper Level (see RFA SV Report). Analytical results confirm that antimony is not a contaminant of concern, and no further characterization is necessary to close this data gap. Groundwater at the northwest corner of Building H2 flows toward the building foundation, where it is intercepted by the footer drain to the Hillside Sump. No further characterization of this pathway is necessary. However, trace detections of VOCs in groundwater from monitoring well B-16 cannot rule out release of low concentrations of VOCs from this portion of Building H2. The extent of elevated metals in surface soil near the southwest corner of

Building H2 should be evaluated during RCRA corrective actions that will be implemented in association with radiological remediation of the SPRU facilities and surrounding grounds in the Upper Level.

7.1.2 H2 Tank Farm (SWMU-031)

The extent of metals in soil along the southern and eastern perimeter of the H2 Tank Farm should be evaluated during RCRA corrective actions that will be implemented in association with radiological remediation of SPRU facilities and surrounding grounds in the Upper Level.

7.1.3 Pipe Tunnel (SWMU-057)

The Pipe Tunnel was investigated during this RFI in response to Data Gap 1 in the Upper Level (see RFA SV Report). No additional characterization is recommended to resolve the origin of the VOCs at the Pipe Tunnel because the entire area is adequately characterized to support RCRA corrective actions that will be implemented in association with radiological remediation of SPRU facilities and surrounding grounds in the Upper Level.

7.2 Lower Level SWMUs and AOC

The Lower Level contains four SWMUs and one AOC. The SWMUs and AOC were initially investigated during the RFA SV and no further action was established for two SWMUs (Former K6 and K7 Storage Pads) in the NYSDEC-approved RFA SV Report. Additional characterization to satisfy groundwater data gaps was performed at one SWMU and AOC as part of this RFI. The following sections provide summary recommendations pertaining to the Lower Level SWMUs/AOC based on the SPRU RFA SV and Groundwater RFI.

7.2.1 Railroad Staging Area (SWMU-038)

The Railroad Staging Area was investigated during this RFI in response to Data Gap 1 in the Lower Level (see RFA SV Report). Based on the results of this RFI, no further action is recommended for groundwater in the Railroad Staging Area because transfer of hazardous chemicals from soil to groundwater is not evident. The extent of chemical releases to soil in the southeastern, central, and northern portions of the Railroad Staging Area should be evaluated during RCRA corrective actions that will be implemented in association with radiological remediation of SPRU environs in the Lower Level.

7.2.2 Lower Level Parking Lot (AOC-003)

The Parking Lot was investigated during this RFI in response to Data Gap 1 in the Lower Level (see RFA SV Report). Saturated conditions are lacking in the Parking Lot fill. Because of its physically limited extent, further characterization of the elevated thallium in groundwater is not required. Therefore, no further action is recommended for the Lower Level Parking Lot.

7.2.3 K5 Retention Basin (SWMU-040)

As recommended in the NYSDEC-approved RFA SV Report, the nature and extent of a trace level of TCE detected at the northeast corner of the K5 Retention Basin should be evaluated following D&D of the structure, because of access limitations present during the RFA SV and Groundwater RFI. The approved RFA SV Report also recommended sampling along the influent drain line to confirm the absence of a hazardous chemical constituent release following D&D of the structure because of access limitations present during the RFA SV and Groundwater RFI.

8. References

CH2M HILL. 2005. *Radiological Characterization Report for the SPRU Outside Areas, Separations Process Research Unit Project*. TSM-26. Revision 1. October, 2005.

Department of Energy (DOE). 1999a. SPRU Clean-Up Project, Phase 1 (Characterization) Request for Proposals, Attachment I, Appendix E, Supporting Information, Subsection 01: "Preliminary Evaluation of the Status of the Separations Process Research Unit (SPRU)." DE-RP03-99SF21767. July 22, 1999.

DOE. 1999b. *SPRU Clean-Up Project, Phase 1 (Characterization) Request for Proposals,* Attachment I, Appendix E, Supporting Information, Subsection 02: " Separations Process Research Unit (SPRU) History and Current Status." DE-RP03-99SF21767. July 22, 1999.

DOE. 2004. "RCRA Corrective Actions Part 373 Permit Application on the Solid Waste Management Units (SWMU) for the Separations Process Research Unit (SPRU)." DOE National Nuclear Security Administration, Albuquerque, N.M. to NYSDEC. September 30, 2004.

DOE. 2005. *Response to NYSDEC Comments on SPRU RFA-SV Comment Response Package of December, 2004.* March 7, 2005.

DOE/CH2M HILL. 2002. *RCRA Facility Assessment Sampling Visit Report, Separations Process Research Unit Project.* TSM-09. Revision 1. February 2002.

DOE/CH2M HILL. 2004a. *Task IV RCRA Facility Investigation Work Plan for Groundwater, Upper and Lower Level Areas, Separations Process Research Unit Project.* March 2004 (Revised March 2006; final).

DOE/CH2M HILL. 2004b. *SPRU SV Work Plan Amendment for SWMU-035*, TSM-23, Revision 2. (Revised May 11, 2005).

DOE/CH2M HILL. 2005. *RCRA Facility Assessment Sampling Visit Work Plan Amendment for SWMU-035: Amendment for Additional VOC Sampling*. TSM-23.1. Revision 1.

ERM Northeast Inc. (ERM). 1992. *Hydrogeologic Evaluation of the Knolls Atomic Power Laboratory – Knolls Site Final Report*.

KAPL. 1974. "Investigation of Soil Core Drillings; Knolls Site—Buildings H-2, G-2, and K5." J.P. Alexander, Radiological Engineering Operation. Under cover letter REO-7542-1216.

KAPL. 2000a. *Work Plan: RCRA Facility Assessment Sampling Visit for Separations Process Research Unit SWMUs/AOC.* Knolls Atomic Power Laboratory, Niskayuna, New York. April 2000.

KAPL. 2000b. *RCRA Facility Investigation for the Hillside Area (AOC-001), Knolls Atomic Power Laboratory, Niskayuna, New York, Task IV Facility Investigation Workplan (Including Task III Management Plans).* April 2000 (Revised September 2000).

KAPL. 2001. *RCRA Facility Investigation, Knolls Atomic Power Laboratory, Niskayuna, New York, Progress Report #26.* Topic: RFI activities and projected work for the Hillside Area (AOC-001) and J7 Scrap & Salvage (SWMU-024). October 2001.

KAPL. 2002. *RCRA Facility Investigation, Knolls Atomic Power Laboratory, Niskayuna, New York, Progress Report #27.* Topic: RFI activities and projected work for the Hillside Area (AOC-001) and J7 Scrap & Salvage (SWMU-024). January 2002.

KAPL. 2003a. *RCRA Facility Investigation, Knolls Atomic Power Laboratory, Niskayuna, New York, Progress Report #33.* Topic: RFI activities and projected work for the Hillside Area (AOC-001) and J7 Scrap & Salvage (SWMU-024). July 2003.

KAPL. 2003b. *RCRA Facility Investigation, Knolls Atomic Power Laboratory, Niskayuna, New York, Progress Report #34.* Topic: RFI activities and projected work for the Hillside Area (AOC-001) and J7 Scrap & Salvage (SWMU-024). October 2003.

KAPL. 2004. *Environmental Monitoring Report, Calendar Year 2003*. KAPL-4851.

KAPL. 2005. *RCRA Facility Investigation for the Knolls Site (AOC-001); Knolls Atomic Power Laboratory; Niskayuna, NY.* December 2005.

Knapp, B.F. 1954. *Summary and Evaluation of Building H Test Wells and Drainage Ditch Monitoring Findings.*

NYSDEC. 1988. *Background Concentrations of 20 Elements in Soils with Special Regard for New York State*. Wildlife Resources Center, E. Carol McGovern. April 1988.

NYSDEC. 1994. *Division Technical and Administrative Guidance Memorandum #4046: Determination of Soil Cleanup Objectives and Cleanup Levels*. January 1994 and Addendums, December 20, 2000, April 10, 2001, and July 10, 2001.

NYSDEC. 1997. *RCRA Facility Assessment, Preliminary Review – Visual Site Inspection Report, Knolls Atomic Power Laboratory, Niskayuna, New York, EPA I.D.# NY6890008992*. August 6, 1997 (revised July 20, 1998).

NYSDEC. 1998a. *NYSDEC 6 NYCRR Part 373 Hazardous Waste Management Permit for the U.S. Department of Energy Knolls Atomic Power Laboratory, Knolls Site, Niskayuna, New York 12309, EPA I.D. No. NY6890008992, DEC Permit Number: 4-4224-0024/00001*. July 20, 1998.

NYSDEC. 1998b. *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitation, Technical and Operational Guidance Series (TOGS) 1.1.1.* June 1998 and Addendums, April 2000 and June 2004.

NYSDEC. 2000. *6 NYCRR Part 373 Hazardous Waste Management Permit, Permit, #4-4224-00024/00001, RCRA Facility Assessment Sampling Visit Revised Work Plan, Separations Process Research Unit ("SPRU") SWMU/AOC, April 20, 2000*. May 18, 2000.

NYSDEC. 2006a. *Re: Response to NYSDEC, SPRU RCRA Facility Assessment Sampling Visit Report, SWMUs/AOC, February 2002; March 9, 2005.* February 1, 2006.

NYSDEC. 2006b. *Re: Task IV RCRA Facility Work Plan for Groundwater, Upper and Lower Level Areas, Separations Process Research Unit, TSM-20, April 2005; June 16, 2005.* February 1, 2006.

U.S. Geological Survey (USGS). 1984. *Elemental Concentrations in Soil and Other Surficial Materials of the Conterminous United States.* U.S. Geological Survey Professional Paper 1270.

Appendices to this document are available at the following location:

Niskayuna Branch
Schenectady County Public Library
2400 Nott Street East
Niskayuna, New York 12309
(518) 386-2249