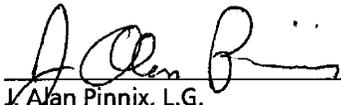


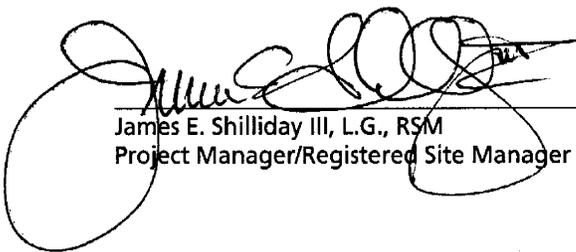
REMEDIAL INVESTIGATION REPORT

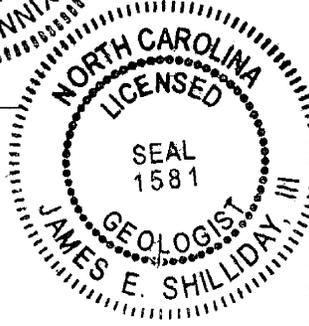
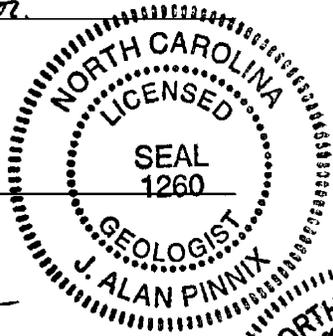
UNC Chapel Hill, Airport Road Waste
Disposal Area, Chapel Hill, North
Carolina

October 2004


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Remedial Investigation Report

UNC Chapel Hill, Airport Road
Waste Disposal Area, Chapel
Hill, North Carolina

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The University of North Carolina at
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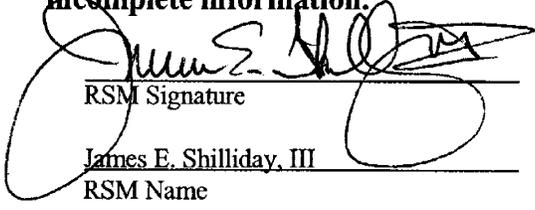
Date:
October 2004

North Carolina Department of Environment
and Natural Resources
Division of Waste Management
Superfund Section
Inactive Hazardous Sites Branch

REMEDIAL INVESTIGATION COMPLETION CERTIFICATION
15A NCAC 13C.0306(b)(5)(B)

Site Name UNC Airport Road Waste Disposal Area Street Address Municipal Drive
County Orange Chapel Hill, North Carolina
Site ID No. NCD980557623

The remedial investigation, which is the subject of this certification has, to the best of my knowledge, been completed in compliance with the Inactive Hazardous Sites Response Act G.S. 130A-310, et seq. and the voluntary remedial action program Rules 15A NCAC 13C .0300, and The University of North Carolina at Chapel Hill is in compliance with Rules .0305(b)(2) and .0305(b)(3), of this section. I am aware that there are significant penalties for willfully submitting false, inaccurate or incomplete information.


RSM Signature
James E. Shilliday, III
RSM Name

10/26/04
Date

ARCADIS G&M of North Carolina, Inc.
REC Name
00021
REC No.

801 Corporate Center Drive, Suite 300
Mailing Address
Raleigh, North Carolina 27607
City, State, ZIP

North Carolina
WAKE COUNTY

I, Greta Leigh Muschlitz, a Notary Public of said County and State, do hereby certify that James E. Shilliday III did personally appear and sign before me this the 26th day of October,

Greta Leigh Muschlitz
Notary Public (signature)



My commission expires: 11/02/2008

Remediating Party Certification Statement (.0306(b)(2)):

"I certify under penalty of law that I have personally examined and am familiar with the information contained in this submittal, including any and all documents accompanying this certification, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, the material and information contained herein is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for willfully submitting false, inaccurate or incomplete information."

Peter A. Reinhardt – Director, Environment, Health & Safety
(Name of Remediating Party Official)

Peter A. Reinhardt
(Signature of Remediating Party Official)

10/25/09
Date

North Carolina

ORANGE COUNTY

I, *Shelley D. Kuhra*, a Notary Public of said County and State, do hereby certify that *Peter A. Reinhardt* did personally appear and sign before me this the 25 day of Oct., 2004.

Shelley D. Kuhra
Notary Public (signature)

(OFFICIAL SEAL)

My commission expires: 5-29-2008

Registered Site Manager Certification Statement (.0306(b)(1)):

"I certify under penalty of law that I am personally familiar with the information contained in this submittal, including any and all supporting documents accompanying this certification, and that the material and information contained herein is, to the best of my knowledge and belief, true, accurate and complete and complies with the Inactive Hazardous Sites Response Act G.S. 130A-3 10, et seq, and the voluntary remedial action program Rules 1 5A NCAC 1 3C .0300. I am aware that there are significant penalties for willfully submitting false, inaccurate or incomplete information."

James E. Shilliday III, L.G., RSM
(Name of Registered Site Manager)

James E. Shilliday III
(Signature of Registered Site Manager)

10/26/04
Date

North Carolina

WAKE COUNTY

I, *Greta Leigh Muschlitz*, a Notary Public of said County and State, do hereby certify that *James E. Shilliday III* did personally appear and sign before me this the 26th day of October, 2004.

Greta Leigh Muschlitz
Notary Public (signature)

(OFFICIAL SEAL)

My commission expires: 11/02/2008

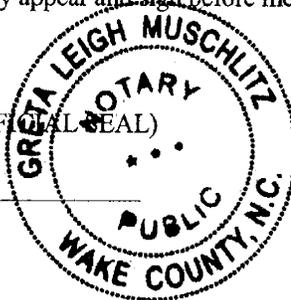


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1 Introduction

This Remedial Investigation (RI) Report was prepared for the University of North Carolina at Chapel Hill (the University) Airport Road Waste Disposal Area. The contents of this document were prepared following the requirements specified in the August 2004 guidelines of the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Waste Management, Superfund Section, Inactive Hazardous Sites Branch, Registered Environmental Consultant (REC) Program. This RI Report is a required document as outlined in the administrative agreement between the University and the NCDENR dated January 9, 2004. The steps to complete this RI were outlined in the May 28, 2004 RI Work Plan.

The objective of performing this RI was to delineate impacted media sufficiently to allow for remedial action. The current and historic data indicates that the extent of the impacted media at this site is well understood and there continues to be no known impact to off-site receptors. As this objective is now complete, the next phase of this project will involve the preparation of a REC compliant remedial action plan (RAP).

2 Physical Setting

2.1 Site Location

The site is located near North Carolina Highway 86 (Airport Road) in northern Chapel Hill, Orange County, North Carolina (Figure 2-1). The site latitude is 35° 56' 18.0" N, and the longitude is 79° 03' 22.0" W (NCDEHNR 1993). The site consists of a 0.489-acre wooded parcel of University property that is located adjacent to the entrance road to the Airport Road Inactive Sanitary Landfill (Figure 2-2). Photographs of the site, the fence surrounding the site, and the signs posted at the site are presented in Appendix A.

Approximately 0.2 acres of this tract was used from 1973 through 1978, with the approval of the State of North Carolina, to dispose of chemical waste from the University's facilities in 16 separate burial trenches. An additional 0.289 acres adjacent to the 0.2-acre area was proposed for use when the original area was full. However, only two burials were made in this expanded area, both in 1979. All references to "site or waste disposal area" in this work plan include the original 0.2-acre area (16 burials) and that portion of the expanded area used for two burials in 1979. Access to the site is restricted by an 8-foot-high locked fence erected by the University in early 1994. Several warning signs surround the site.

Municipal facilities for the Town of Chapel Hill are to the east and south of the site on a parcel leased from the University since 1979. The municipal facilities include but are not limited to paved roadways, parking lots, a street and bus maintenance facility, and an animal shelter. The Horace Williams Airport is south of the site, and the Airport Road Inactive Sanitary Landfill, formerly used by the Town of Chapel Hill, is to the west. The area north of the site is heavily wooded. Crow Branch Creek is located north/northwest of the site in the wooded area. A small residential area accessible from Airport Road is located approximately 1,200 feet north of the site. Most of the property east of Airport Road is also developed for residential use (NCDEHNR 1993).

2.2 Topographic Information

The site and surrounding property are relatively flat, sloping gently to the north/northwest in the general direction of Crow Branch Creek. Surface elevations in the vicinity of the site are approximately 485 feet above mean sea level (ft msl) and slope to approximately 460 ft msl in the vicinity of Crow Branch Creek. The site

Remedial Investigation Report

Physical Setting

location is depicted on a portion of the Chapel Hill 1967 (photorevised 1988) 7.5-minute United States Geologic Survey Topographic map which is included as Figure 2-1.

3 Previous Environmental Investigations

3.1 Summary of Previous Investigation Activities

The University installed five monitor wells (MW-1 through MW-5) in the vicinity of the site after waste disposal activities ceased in 1979. The NCDEHNR Superfund Section completed a Preliminary Assessment (PA) on March 19, 1984, and a Site Inspection (SI) on June 19, 1984. The SI revealed that volatile organic compounds (VOCs), including benzene, chloroform, and methylene chloride, were detected in groundwater samples collected from monitor wells MW-1 and MW-2.

In June 1991, Greenhorne & O'Mara, Inc. at the request of the NCDENR, completed a Phase II Screening Site Investigation (SSI) for the UNC Old Sanitary Landfill (Greenhorne & O'Mara, 1991). The SSI focused primarily on the Airport Road Old Sanitary Landfill and not the chemical waste disposal site. Groundwater, surface soil, surface-water, and sediment samples were collected during the SSI. Groundwater samples collected from monitor wells MW-1, MW-2, and MW-3 contained benzene, chloroform, trimethylhydrazine, trichlorofluoromethane, phenol, dimethylphthalate, and isophorone. Some metals and inorganic compounds also were sporadically detected in these groundwater samples. Details of the sampling activities and results can be found in the SSI report (Greenhorne & O'Mara, 1991).

Three phases of field activities conducted at the site by Geraghty & Miller, Inc. were described in a RI report dated November 1996 (Geraghty & Miller, 1996). The 1996 RI report was transmitted to DENR by UNC with a letter dated March 3, 1997; however it was not completed in accordance with the requirements of the REC program. Phase I consisted of the installation and sampling of six monitor wells (MW-6, MW-7, MW-9, MW-11, MW-12, and MW-13). These wells, in addition to existing monitor wells MW-1, MW-2, and MW-3, were sampled for VOCs, semi-volatile organic compounds (SVOCs), and inorganic parameters.

Phase II of the 1996 RI consisted of bedrock coring (core holes CH-1, CH-2, and CH-3) and installation of 10 monitor wells (MW-14, MW-15, MW-16, MW-17, MW-18, MW-19, MW-20, MW-21, MW-22, and MW-23). Monitor wells MW-14 and MW-23 were installed in coreholes CH-1 and CH-3, respectively. The new wells were sampled for VOCs, SVOCs, and inorganic parameters. Surface-water samples also were collected and analyzed for VOCs (including tentatively identified compounds) and some inorganic compounds.

Phase III of the 1996 RI consisted of the installation of four monitor wells (MW-24, MW-25, MW-26, and MW-28), groundwater sampling, four shallow geotechnical soil borings, and five direct push technology (DPT) borings at the site. In addition, groundwater samples and surface emission flux samples were also collected. Groundwater samples from the Phase III monitor wells and surface emission flux samples were analyzed for VOCs. Soil samples from DPT borings were analyzed for VOCs, SVOCs, and inorganic parameters.

The 1996 RI Report included a detailed discussion of the investigation procedures and results of the soil and groundwater assessment activities, geotechnical assessment, and surface emission flux sampling. The 1996 RI indicated that groundwater was impacted with both VOCs and SVOCs, but the primary constituents of concern (COCs) in groundwater were volatile organics (benzene, chloroform, diethyl ether and methylene chloride). The soil data collected during the RI assessment indicated very limited impacts outside the fenced disposal area. Surface water samples also indicated very low impacts, as low levels of tetrachloroethene and diethyl ether were the only constituents above reporting limits in one of six surface water samples collected.

To further evaluate the horizontal and vertical extent of impacted groundwater at the site, five additional monitor wells (MW-29, MW-30, MW-31, MW-32, and MW-33) were installed in November 1996. Groundwater from these wells was sampled and analyzed for VOCs. In addition, shallow monitor wells MW-1, MW-3, MW-12, MW-22, MW-25, and bedrock aquifer monitor wells MW-14, MW-15, MW-23, MW-31, and MW-32 were sampled in December 1996, and a complete round of water levels was measured. The groundwater samples were analyzed for VOCs, SVOCs, and eight regulated metals. Details of well installation and sampling can be found in the Well Installation and Sampling Report (Geraghty & Miller 1997a) and Groundwater Sampling Report (Geraghty & Miller 1997b). The Well Installation and Sampling Report and the results of the 1996 sampling event were transmitted to DENR by UNC on May 27, 2004.

A Remedial Action Plan (RAP) prepared for the site in 1997 (Geraghty & Miller 1997c) outlined various options for addressing both the source area (buried waste) and dissolved groundwater plume north of the burial area. The RAP was transmitted to DENR by UNC with a letter dated March 3, 1997; however, it was not completed in accordance with the requirements of the REC program. The 1997 RAP was followed by aquifer and vacuum enhanced recovery testing in 1998 that further evaluated remedial options for the site (ARCADIS Geraghty & Miller 1998). No source area or groundwater remedy has been implemented to date.

Groundwater monitoring events were conducted at the site in May 1998 (ARCADIS Geraghty & Miller 1999), November 2000 (ARCADIS Geraghty & Miller 2001), and October 2002 (ARCADIS 2003). These three events consisted of a site-wide collection of groundwater elevation data and groundwater sampling for volatile organics to evaluate the primary COCs. Results of the 1998, 2000, and 2002 groundwater monitoring events were transmitted to DENR by UNC on May 27, 2004.

In December 2003, resampling of select monitor wells MW-12, MW-15, MW-24, MW-32 and MW-33 was conducted. Monitor wells MW-12, MW-15 and MW-24 were sampled to create a vertical profile of groundwater conditions downgradient of the source area. Monitor wells MW-32 and MW-33 were sampled to confirm the presence of diethyl ether reported in these wells in the October 2002 sampling event.

3.2 Nature and Extent of Impacted Media

The following sections describe the extent of impacted media at the site based on data generated between 1996 and December 2003.

3.2.1 Soil

Soil samples were collected from the area immediately outside of the fence surrounding the waste burial pits as part of the RI conducted in 1996 (Geraghty & Miller 1996). The soil sample collection locations are depicted on Figure 3-1. All soil samples were collected from the periphery of the waste disposal area. No samples were collected from the waste pits or within the fenced area of the site, due to safety concerns.

The 1996 analytical results indicated trace concentrations of volatile organics in two soil samples which were collected from borings located within 5 feet of the fence surrounding the waste burial area (see Table 3-1 and Figure 3-1). Low concentrations of metals, attributed to background concentrations were reported in all samples. The data suggest that impacted soils do not extend outside the source area. Therefore, no additional soil samples were collected as part of the 2004 RI activities.

It is presumed that impacted soils are present within, beneath and adjacent to the individual waste burial pits. However this will be addressed as part of the source remedy.

3.2.2 Groundwater

The site-wide groundwater sampling event conducted in 2002 included samples from 10 shallow aquifer monitor wells and 17 bedrock aquifer monitor wells. The groundwater samples were analyzed for VOCs using USEPA Method 8260. Additional data was collected in December 2003 for confirmation of water quality in 5 shallow and bedrock aquifer monitor wells (MW-12, MW-15, MW-24, MW-32 and MW-33).

In 2002, constituents were detected at concentrations above the 15A NCAC 2L Groundwater Standards in the samples from wells MW-1, MW-2, MW-6, MW-7, MW-9, MW-11, MW-12, MW-13, MW-14, MW-15, MW-16, MW-17, MW-22, MW-28, MW-29, MW-30, MW-31, MW-32, and MW-33. Based on the results of the October 2002 sampling event, the VOC contaminant plume in the shallow, unconsolidated aquifer was interpreted to terminate in the vicinity of Crow Branch Creek. However, the analytical data from two bedrock aquifer monitor wells (MW-32 and MW-33) suggested that VOCs were present in the bedrock aquifer north of the creek. Diethyl ether was the only VOC constituent reported above method detection limits in bedrock monitor wells MW-32 and MW-33 in 2002. This differed from the previous sampling events, when no targeted VOCs were present above method detection limits in the samples collected from bedrock monitor wells north of the creek (MW-21, MW-23, MW-32, and MW-33). The December 2003 resampling data confirmed the presence of diethyl ether in bedrock monitor well MW-33, but not in MW-32.

It should be noted that the VOC concentrations in the most impacted bedrock aquifer monitor well (MW-15) were orders of magnitude lower than the VOC concentrations detected in the most impacted shallow aquifer wells (MW-1 and MW-2).

Overall, the October 2002 sampling data suggested that the groundwater plume was well defined by the existing monitor well network with one minor exception. The confirmed presence of diethyl ether in monitor well MW-33 required additional delineation be performed to the north and east of this well. The additional groundwater delineation activities were performed as part of this July 2004 RI and the results are presented in Section 6.1.

3.2.3 Surface Water

During the 1996 RI (Geraghty & Miller, 1996), surface water samples were collected at 6 locations from Crow Branch Creek on five separate occasions. Sporadic detections of tetrachloroethene and diethyl ether were reported in the surface water samples. Diethyl ether was also sporadically detected at low concentrations in samples collected by the University at the same locations dating back to 1995. As a result, surface water sampling was included as part of the 2004 RI activities. Details regarding the results of surface water sampling are provided in Section 6.2.

4 Remedial Investigation Program

The following sections discuss the field activities performed during the July 2004 RI program. The field activities were designed to complete the delineation of the horizontal and vertical extent of the impacted groundwater plume and included installation of additional monitor wells, collection of groundwater samples from all existing and new monitor wells, and collection of surface water samples from Crow Branch Creek. The locations of existing and new monitor wells are shown on Figure 4-1 and the construction details for the site monitor wells are summarized in Table 4-1.

4.1 Site Investigative Procedures

4.1.1 Drilling and Monitor Well Installation

Four competent bedrock monitor wells (MW-34, MW-35, MW-36 and MW-37) were installed to further delineate the extent of site-related constituents in the groundwater. Existing monitor well MW-33 is screened at an elevation of approximately 391 to 376 feet above mean sea level (ft msl). Monitor wells MW-34, MW-35 and MW-36 were installed to provide downgradient (east/northeast) delineation of this same interval. Monitor well MW-37 was installed adjacent to existing monitor wells MW-32 and MW-33 for the purposes of vertical delineation. The construction details for the new wells are listed on Table 4-1 and well construction logs for the new wells are included in Appendix B.

Drilling and well-installation activities were conducted by Geologic Exploration, a North Carolina-licensed well driller from Statesville, North Carolina. All drilling activities were performed under the supervision of an ARCADIS geologist and in accordance with well construction standards provided in North Carolina Administrative Code 15A Subchapter 2C Section .0100. Soil cuttings were collected from all borings for field screening and lithologic characterization.

Monitor wells MW-34, MW-35, and MW-36 were constructed by advancing a nominal 6-inch-diameter borehole using the air-rotary drilling technique to depths of 85 feet below land surface (ft bls), 75 ft bls, and 85 ft bls, respectively. The new wells were constructed in the borehole with 2-inch-diameter, Schedule 40 PVC riser and 10 to 15 feet of 0.010 slot screen. After the screen and riser were installed within the borehole,

a silica sand filter pack was placed in the annular space between the well screen and borehole wall, from the base of the boring to approximately 2 feet above the top of the screen. Bentonite pellets were then placed on top of the filter pack to form a seal approximately 4 feet thick. After hydration of the bentonite pellets, the well was grouted to within a few inches of the ground surface.

Monitor well MW-37 was constructed by first advancing a nominal 10-inch-diameter borehole to a depth of 100 ft bbs using the air-rotary drilling technique and installing and grouting a 6-inch-diameter galvanized steel outer casing. Once the grout cured for approximately 96 hours, a nominal 6-inch-diameter borehole was advanced using air-rotary techniques through the outer casing to a depth of 125 ft bbs. The inner casing consisted of Schedule 40 PVC riser and 10 feet of 0.010 slot screen. The well was completed with a silica sand filter pack extending two feet above the top of the screen, a four-foot thick bentonite seal, and grout to the ground surface.

A watertight, locking expansion cap was installed on top of the 2-inch diameter casing of each well. All new monitor wells were completed at the surface with a steel, stick-up protective casing and a 2-foot by 2-foot concrete pad.

4.1.2 Monitor Well Development

Residual clay, silt, and fine sands that collected in the silica sand filter pack and bottom of each monitor well were removed by development. Prior to well installation, all new boreholes were initially developed by flushing the open borehole with air from the drill rig. Following installation, monitor wells were further developed using disposable polyethylene bailers until the purge water was relatively clear or until the well went dry.

4.1.3 Monitor Well Surveying

Philip Post and Associates, a North Carolina registered surveyor, surveyed the horizontal and vertical locations of the four new monitor wells and the six historic surface water sampling locations. The surface water sampling locations were marked with a metal stake that was driven into the center of the stream bed. New well locations and the surface water locations were surveyed in reference to the existing monitor well network. Measuring point elevations (top-of-casing for the monitor wells and top-of-stake for surface water points) were determined to within ± 0.01 ft. Top-of-casing elevations are presented in Table 4-1.

4.1.4 Water-Level Measurement Collection

ARCADIS measured water levels in new and existing monitor wells. The water-level measurements were collected with an electronic water-level probe, which was decontaminated with a dilute soap/water solution prior to insertion into each well. Static water levels were measured in site monitor wells on July 19 and 22, 2004 and converted to water-level elevations using the well survey data. Due to difficulty locating monitor wells MW-9 and MW-16 and insects in the protective cover of MW-1, water level measurements could not be collected for these wells until July 22, 2004. A portion of the stick-up cover for monitor well MW-19 was under water and it could not be gauged. The surface water locations were gauged on July 20, 2004 by measuring the distance from the top of the metal stake to the stream surface. Groundwater flow direction and hydraulic gradients are discussed in Section 5.5.

4.1.5 Groundwater and Surface Water Sampling

ARCADIS collected groundwater samples from 33 monitor wells on July 19 through July 22, 2004. Prior to sampling, monitor wells were purged using a stainless-steel submersible pump or a peristaltic pump and disposable polyethylene tubing. Field parameters including pH, temperature, conductivity, dissolved oxygen (DO), and oxidation-reduction potential (redox) were measured using a YSI 600xl multi-parameter meter and a flow-through cell prior to obtaining samples for laboratory analysis. ARCADIS personnel calibrated the multi-parameter probe daily in accordance with the manufacturer's specifications. The monitor wells were considered adequately purged when field parameters stabilized and/or a minimum of three well volumes of groundwater had been removed and/or the well went dry. Groundwater samples were collected in laboratory supplied containers and placed on ice in coolers.

ARCADIS collected surface water samples on July 20, 2004 from six locations along Crow Branch Creek both upstream and downstream of the site. The locations were consistent with the previous surface water sampling locations identified in the 1996 RI Report and were confirmed by UNC during a site visit on July 19, 2004. Surface water samples were collected by direct immersion of laboratory-provided containers, taking care not to lose sample preservatives, and were placed on ice in coolers.

Groundwater and surface water samples were submitted to STL Savannah Laboratories in Savannah, Georgia, for analysis of VOCs by USEPA Method 8260. The

groundwater sample analytical results are discussed in Section 6.1 and the surface water results are discussed in Section 6.2.

4.1.6 Investigative Derived Waste (IDW)

Investigation-derived waste (IDW) consisting of purge water from monitor wells MW-1, MW-6, MW-7, MW-11, MW-12, MW-14, MW-15, and MW-31 was containerized in four 55-gallon drums. The drums were properly labeled and stored on wooden pallets within the fenced and padlocked area of the site. Following receipt of laboratory analyses, the drums were transported offsite for proper disposal. The decision to contain purge water from select wells was based on several factors including constituent concentrations from past events, proximity to surface water, and screen interval of the well (i.e. purge water from a bedrock aquifer having higher concentrations than the overlying shallow aquifer).

4.2 Quality Assurance and Quality Control

The overall quality assurance objective was to ensure that laboratory analytical data of known and acceptable quality was produced. Data was calculated and reported in units consistent with those of other agencies and organizations to allow comparability of databases. The laboratory analytical data package included Modified Level II reportable data quality objectives.

4.2.1 Laboratory Quality Control

To assess whether the laboratory analytical data met the quality assurance objectives, it was necessary to compare both descriptive and numerical quality control (QC) information generated by the laboratory with the quality control (QC) criteria established by the level of data. Five components of QC criteria include precision, accuracy, completeness, comparability, and representativeness. For the purposes of this report, precision and accuracy for the field QC and laboratory QC samples are discussed in the following sections.

Precision

The first component, precision, measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared with their average value. For the purposes of this project, precision was evaluated using the relative percent difference (RPD). The overall precision of measurement data is a function of sampling and analytical factors.

Analytical precision is much easier to control and quantify than sampling precision. Numerical estimates for the analytical precision were provided by matrix spike/matrix spike duplicate (MS/MSD) analysis and method blank analysis.

Accuracy

Accuracy measures the bias in a measurement system; it is difficult to measure for the entire data collection activity. Sampling accuracy may be assessed by evaluating the results of field/trip blanks, while analytical accuracy may be assessed through use of known QC samples (laboratory control samples, or LCS) and/or sample-specific matrix spike (MS) samples. The laboratory provided numerical estimates for the analytical accuracy for MS/MSD analysis and method blank analysis.

4.2.2 Field Quality Control Samples

The types of field quality control samples that were collected during this investigation are:

Duplicate Samples: Duplicate samples were collected from MW-33 (DUP-1), MW-14 (DUP-2), and MW-1 (DUP-3). Duplicate samples were collected by splitting equal portions of a groundwater sample from a specific monitor well. The field split and the primary sample were collected at the same time, in the same container type, preserved in the same fashion, and shipped in the same cooler. Duplicate samples were collected at a frequency of one sample per field day.

The results of the sample and field split duplicate were compared using the RPD. All three duplicate samples were within control criteria for the duplicate samples.

Equipment Rinsate Blanks: Three equipment rinsate blanks (EB-1, EB-2, and EB-3) were collected during the investigation. The equipment blanks were collected by pouring distilled water over the outside of the submersible pump which was used for purging and sampling the monitor wells and collecting the rinsate water off of the pump in a laboratory supplied container. Equipment blank samples were collected in the same type of sample container as the other samples, preserved in the same manner (using the exact preservative source), transported to the laboratory with the samples, and analyzed for the same parameters. Equipment blanks were collected at a frequency of one sample per field day.

VOCs were not detected in the equipment blank samples with the exception of EB-2. Benzene, chloroform, and diethyl ether were detected in EB-2 at

concentrations of 2.0 micrograms per liter ($\mu\text{g/L}$), 9.6 $\mu\text{g/L}$, and 8.6 $\mu\text{g/L}$, respectively. Since these compounds were also detected at low concentrations in associated samples (e.g. MW-3 , MW-7, and MW-22), detections were qualified as U^B , which indicates that the compound is considered non-detect due to blank contamination.

Trip Blanks: Three trip blanks (TB-1, TB-2, and TB-3) were submitted for analysis of VOCs. The trip blanks were filled with organic-free water by the laboratory and traveled unopened with the VOC sample containers to the site. The trip blanks then traveled back to the laboratory along with the groundwater and surface water samples collected in the field. A trip blank was included in every cooler sent to the laboratory.

No VOCs were detected in any of the trip blank samples.

4.3 Decontamination Procedures

Sampling equipment and drilling equipment were thoroughly decontaminated prior to fieldwork, between wells, and at the conclusion of sampling to prevent cross-contamination. All drilling equipment was decontaminated using a steam cleaner. Groundwater sampling was conducted using a stainless steel, submersible pump or peristaltic pump with disposable polyethylene tubing. New disposable polyethylene tubing was used for each monitor well. Cleaning the submersible pump consisted of a distilled water rinse, scrub with laboratory grade soap/water solution, a final distilled water rinse and air drying.

5 Hydrogeology

5.1 Regional Geology

Chapel Hill and Orange County lie within the eastern Piedmont physiographic province. Chapel Hill, located in the southeastern corner of Orange County, lies within the easternmost portion of the Carolina Slate Belt. This northeast/southwest trending geologic belt consists primarily of metamorphosed granitic rocks and volcanic rocks. Immediately east of Chapel Hill is the boundary between the Carolina Slate Belt and the northeast/southwest trending Durham Triassic Basin. The rocks in the vicinity of Chapel Hill consist primarily of intrusive igneous rocks having a variable composition ranging from granites, monzonites, granodiorites, quartz diorites, diorites, and gabbros (Allen and Wilson, 1968). Allen and Wilson (1968) also reported that north/south trending Triassic basaltic and diabase dikes are present approximately 2 miles west and 1 mile east of Chapel Hill. Structurally, several small faults and shear zones are found throughout the county, with the majority trending strongly northeast/southwest. Measured foliations also exhibit strong northeast/southwest orientations.

Bedrock underlying the saprolite at the site is mapped as intrusive igneous rocks of middle to upper Paleozoic age. The igneous complex intrudes surrounding metamorphosed igneous rock and reportedly varies in mineral composition, grading in lithology from granite to diorite to gabbro (NCDENHR, 1993).

5.2 Regional Hydrogeology

The hydrogeologic systems of the Piedmont province possess unique features in comparison to most other groundwater regions. According to Heath (1980) and LeGrand (1988), these unique characteristics control the principal groundwater directions, flow volumes, and the location of system boundaries including recharge and discharge areas. The unique features of the Piedmont system are as follows:

- (1) The gneissic metamorphic rocks have been folded, faulted and interstratified with granite or diorite intrusions, resulting in little or no lateral or vertical continuity of hydraulic properties for the igneous rock units.
- (2) The active groundwater flow within these rocks is limited to fracture flow. The aerial and vertical distribution and interconnection of these fractures is limited. For instance, fractures in crystalline rocks typically decrease both in width of opening and in frequency with depth. As a result, active groundwater circulation or flow within fractured igneous rocks is relatively shallow, primarily limited to

the upper 250 feet of bedrock. In addition, the igneous rocks have very low storage capacity for groundwater.

- (3) Most of the water flowing in these fractures is derived from vertical leakage from the saprolitic soils and the “unfractured” matrix rock. The regolith or saprolite overlying the bedrock forms a shallow aquifer system which is the principal storage reservoir and provides a very local source for domestic drinking water. Groundwater movement within this shallow aquifer reservoir is predominantly vertical, intergranular flow.
- (4) The groundwater basins developed in this Piedmont system exhibit shallow flow paths and are not aerially extensive. These basins mimic surface water basins. That is, topographic high points such as ridges and hilltops form drainage basin boundaries and divides which groundwater does not typically flow across. The topographic highs, located on upland ridges, act as the principal area of groundwater recharge. Perennial stream beds represent another basin boundary, as they represent discharge areas where groundwater flows to the surface as diffuse seepage or springs. Shallow, local groundwater flow paths develop, efficiently moving recharge from hilltops to close-by permanent streams, marshes, and wetlands.

The interaction of these unique features within the Piedmont develops a series of shallow, aerially small, flow systems which are almost congruent with the surface-water drainage basins. Each groundwater basin, like the surface-water drainage basin, is separated from adjacent basins. The water table develops in the saprolite in response to precipitation recharge and forms a subdued expression of the local topography (LeGrand, 1988).

5.3 Site Specific Geology

Previous intrusive investigative activities (bedrock core holes and soil borings) revealed a relatively thin layer of residual soils and weathered rock (saprolite) overlying competent bedrock. The surficial aquifer/saprolite unit varies in lithology from sandy clay to clayey sand, and extends from land surface to approximately 5 to 20 ft bls. Competent granodiorite bedrock underlies the saprolite. Lithologic information gathered at the site indicated that the competent granodiorite unit occurs at depths ranging from 10 to 25 ft bls and extends to a depth of at least 195 ft bls. The equigranular granodiorite contains abundant high-angle fractures commonly filled with pyrite, calcium carbonate, and chlorite. Occasional brecciated zones were noted at

various depths during coring, and no evidence of diabase dikes was observed (Geraghty & Miller 1996).

The subsurface site geology is depicted on north to south and east to west geologic cross sections, which are included as Figures 5-1 and 5-2, respectively. The north to south cross section begins at monitor well MW-29, passes beneath the waste disposal area and crosses Crow Branch Creek before terminating at monitor well MW-34. The east to west cross section begins at monitor well MW-18 and terminates at monitor well MW-36. This cross section roughly parallels Crow Branch Creek.

5.4 Site Specific Hydrogeology

In-situ hydraulic conductivity of the saturated sediments has been calculated from slug-test data obtained from selected monitor wells (Geraghty & Miller 1996). The slug tests typically were performed using a 5-foot long cylindrical stainless steel tube to displace the water in the wells while recording the water-level response with a pressure transducer and data logger. Hydraulic conductivities were calculated using AQTESOLV software, which utilizes the Bouwer and Rice Method. Calculated hydraulic conductivity (K) values for the surficial aquifer range from 4.52×10^{-6} to 2.31×10^{-3} centimeters per second (cm/sec), with an average K of 5.32×10^{-4} cm/sec. Similarly, calculated K values for the bedrock aquifer range from 3.44×10^{-4} to 1.45×10^{-2} cm/sec, with an average K of 4.26×10^{-3} cm/sec.

A full scale aquifer test was performed on May 6 and 7, 1998 (ARCADIS Geraghty & Miller 1998). Newly installed bedrock aquifer recovery well RW-1, which has an open borehole from 20 to 80 ft bls, was pumped for a total of 24 hours, followed by a 17.5 hour recovery period. Water levels were recorded at a total of 17 observation wells. Approximately 42 ft of drawdown was observed in recovery well RW-1 and observation wells MW-15, OW-5 and OW-6, which are located 20 ft from RW-1. The large amount of drawdown observed in observation wells MW-15, OW-5, and OW-6 indicates that the boreholes for these wells and the borehole for recovery well RW-1 are highly interconnected possibly through northwest-southeast trending fracture zones in the bedrock aquifer. In addition, the drawdown data indicated that pumping RW-1 at 5 gallons per minute created a drawdown of 8.46 ft in well MW-14 located approximately 270 feet upgradient and a drawdown of 1.35 ft in well MW-23 located approximately 350 feet downgradient of the pumping well. The elliptical cone of depression created by pumping recovery well RW-1 provides additional evidence to support the existence of a northwest-southeast trending fracture zone in the bedrock aquifer. The Recovery Well Installation and Aquifer Test Report were transmitted to DENR by UNC on May 27, 1998.

5.5 Groundwater Flow System

Water-level measurements were collected from 33 site monitor wells and 6 surface water staff gauges and converted to water-level elevations using survey data (Table 5-1). The water-level elevations in the shallow aquifer ranged from 449.87 ft msl in downgradient well MW-5 to 478.04 ft msl in upgradient well MW-3. A water-level elevation contour map for the shallow aquifer was prepared using the water-level elevation data collected in July 2004 and is presented in Figure 5-3.

The water-level elevations in the bedrock aquifer ranged from 388.27 ft msl in downgradient well MW-35 to 473.22 ft msl in upgradient well MW-28. It should be noted that the elevation of groundwater in monitor well MW-35 is approximately 50 feet lower than that of adjacent surrounding comparable screened monitor wells (MW-33, MW-34 and MW-36). The difference in elevation in this well has been attributed to minimally fractured bedrock at this location.

A water-level elevation contour map for the bedrock aquifer was prepared using the water-level elevation data collected in July 2004 and is presented in Figure 5-4.

5.5.1 Groundwater Flow Direction

The information presented in Figure 5-3 indicates that the groundwater flow direction in the shallow aquifer south of Crow Branch Creek is generally to the north, toward Crow Branch Creek. The groundwater flow direction for the shallow aquifer on the north side of Crow Branch Creek appears to be to the east/southeast convergent on Crow Branch Creek. The information presented in Figure 5-4 indicates that the groundwater flow direction in the bedrock aquifer is generally to the north/northeast.

The groundwater flow patterns indicated in Figures 5-3 and 5-4 are consistent with the flow patterns observed during previous water-level measurement events conducted in May 1998, November 2000, and October 2002.

5.5.2 Hydraulic Gradients

Upward vertical hydraulic gradients were measured at the site in five well clusters downgradient of the source area on July 19, 2004. The upward vertical hydraulic gradients were as follows: MW-6/MW-7 (0.118 feet per foot [ft/ft]), MW-12/MW-15 (0.153 ft/ft), MW-25/MW-26 (0.003 ft/ft), MW-30/MW-31 (0.012 ft/ft), and MW-32/MW-33 (0.035 ft/ft). Upward flow gradients in well clusters located near the stream support the interpretation that the stream is a discharge point for groundwater.

Downward vertical hydraulic gradients of 0.033 ft/ft and 0.025 ft/ft were measured at well clusters MW-2/MW-14 and MW-28/MW-29, respectively, which are adjacent to, or upgradient of, the source area. A downward vertical hydraulic gradient at these well cluster locations is consistent with the hydrogeologic interpretation that these wells are located close to a groundwater flow divide along a topographic high (ridge line). The vertical hydraulic gradients measured during July 2004 are generally consistent with historical gradients measured in May 1998, November 2000, and October 2002.

Horizontal hydraulic gradients were calculated for the surficial and bedrock aquifers using groundwater data collected in July 2004. The horizontal hydraulic gradient for the upgradient portion of the surficial aquifer near the waste disposal area was estimated to be 0.06 ft/ft which was steeper than the horizontal hydraulic gradient for the downgradient portion of the site near Crow Branch Creek which was estimated to be 0.03 ft/ft. The horizontal hydraulic gradients in the bedrock aquifer varied from 0.02 ft/ft in the upgradient portion of the site to 0.04 ft/ft in the downgradient portion of the site.

5.5.3 Groundwater Flow Velocity

Groundwater in the surficial hydrogeologic unit at the site, as determined from water-level elevation data collected in July 2004, is estimated to flow to the north and southeast convergent on Crow Branch Creek. A representative average hydraulic conductivity of 5.32×10^{-4} cm/sec (1.51 ft/day) was calculated based on previous aquifer tests as discussed in Section 5.4. An average hydraulic gradient in the surficial aquifer was determined to be 0.04. Average interstitial groundwater flow velocity for the surficial hydrogeologic unit was determined using a form of the Darcy equation as follows:

$$V = \frac{K}{Ne} \left(\frac{dh}{dl} \right)$$

Where:

V = groundwater flow velocity

K = hydraulic conductivity

$\frac{dh}{dl}$ = groundwater gradient

Ne = effective porosity (assumed to be 20 percent for the surficial aquifer)

Substituting values determined by ARCADIS as follows:

$$K = 1.51 \text{ ft/day (for wells in the surficial aquifer)}$$

$$\frac{dh}{dl} = 0.04 \text{ ft/ft}$$

$$dl$$

$$\text{then, } V = \frac{1.51 \text{ ft/day} (0.04 \text{ ft/ft})}{0.20}$$

$$V = 0.30 \text{ ft/day} = 110 \text{ feet per year (ft/year)}$$

This value is a calculated average velocity. Inhomogenities in the surficial aquifer could lead to higher or lower localized rates of flow.

6 Remedial Investigation Results

The sampling event was conducted from July 19, 2004 through July 22, 2004 and included the collection of water samples from surface water locations and site monitor wells. The water samples collected during the sampling event were analyzed for VOCs using USEPA Method 8260. The results of the groundwater field parameter measurements collected in July 2004 are summarized in Table 6-1, analytical results from the July 2004 groundwater sampling event are summarized in Table 6-2 and a historical summary of groundwater sample analytical results is presented in Table 6-3. The results of the July 2004 surface water sampling event are summarized in Table 6-4, and a historical summary of surface water sample analytical results for diethyl ether is presented in Table 6-5. Laboratory analytical data reports associated with the July 2004 groundwater and surface water sampling events are presented in Appendix C.

Groundwater sample concentrations were compared with the Title 15A North Carolina Administrative Code (NCAC) 2L Groundwater Standards. Reported concentrations that exceed the established groundwater standards are indicated in tables by a green, shaded enclosed box. For those compounds for which a groundwater standard has not been established (e.g. diethyl ether and 1,1,2,2-tetrachloroethane), sample concentrations were compared to the United States Environmental Protection Agency (USEPA) Region IX Preliminary Remediation Goals (PRGs) for tap water/drinking water. North Carolina is located within USEPA Region IV, which accepts the PRGs published by USEPA Region IX. The PRGs were developed in similar manner to the North Carolina groundwater standards using a conservative health-based approach. The PRGs are drinking water standards based on human health exposure via ingestion. PRGs of 1,200 µg/L and 0.05 µg/L were established by the USEPA Region IX office for drinking water impacted by diethyl ether and 1,1,2,2-tetrachloroethane, respectively (USEPA 2002).

6.1 Groundwater Analytical Results

The groundwater sampling event included the collection of groundwater samples from 11 shallow aquifer monitor wells and 22 bedrock aquifer monitor wells. The water samples collected during the sampling event were analyzed for VOCs using USEPA Method 8260.

6.1.1 Groundwater Field Parameters

Groundwater field parameter measurements for temperature, pH, specific conductance, dissolved oxygen, and oxidation-reduction potential were recorded for samples collected from each of the 33 monitor wells sampled during the July 2004 sampling event. The last set of measurements, which were recorded prior to sampling each well, are presented in Table 6-1. The temperature measurements ranged from 15.2 to 20.0 degrees Celsius, the pH measurements ranged from 5.7 to 11.1, the specific conductance measurements ranged from 86 to 3,891 umhos/cm, dissolved oxygen measurements ranged from 0.3 to 6.4 mg/L, and oxidation-reduction potentials ranged from -381.8 to +250.0 mV. The field measurements collected in July 2004 are consistent with the measurements collected in May 1998, November 2000, and October 2002.

6.1.2 Shallow Aquifer

Constituents were detected at concentrations above established groundwater standards in the groundwater samples collected from 5 of the 11 shallow site monitor wells (MW-1, MW-2, MW-6, MW-12, and MW-22) (see Table 6-2). Ten compounds (acetone, benzene, chloroform, 1,2-dichloroethane [1,2-DCA], diethyl ether, ethylbenzene, methylene chloride, 1,1,2,2-tetrachloroethane [1,1,2,2-TCA], trichloroethene [TCE], and total xylenes) exceeded their respective groundwater standards in shallow wells. Contaminant isoconcentration contour maps for benzene, chloroform, methylene chloride, and diethyl ether are provided for the shallow unconsolidated aquifer (Figures 6-1, 6-2, 6-3, and 6-4 respectively). The isoconcentration contour maps for the shallow aquifer were generated using analytical data from the 11 shallow aquifer monitor wells sampled during the July 2004 sampling event (MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, MW-12, MW-18, MW-20, MW-22, and MW-25) and knowledge of the analytical results from previous groundwater sampling events.

The diethyl ether, benzene, chloroform and methylene chloride isoconcentration contour maps indicate that the most laterally extensive groundwater plume in the shallow aquifer is diethyl ether, followed by benzene. Methylene chloride and chloroform groundwater plumes are similar in lateral extent.

The relative lateral extent of these four constituents in groundwater can be explained by an evaluation of the water solubility and density of each compound. Compounds with high water solubilities will have greater potential for dispersion and generally

spread out through an aquifer more readily than compounds with low water solubilities. Compounds with densities greater than water (greater than 1.0) will have a tendency to sink in the aquifer which may reduce the extent of lateral migration for that compound within the aquifer. Compounds that have densities less than water (less than 1.0) will have a tendency to float in the upper portions of an aquifer which will likely enhance that compound's ability to migrate laterally within the aquifer. The most soluble and least dense of the four compounds is diethyl ether, and as such, this compound is expected to be the most laterally extensive constituent of concern. Diethyl ether has a water solubility of 60,400 mg/L and a density of 0.7134. By comparison, benzene has a water solubility of 1,790 mg/L and a density of 0.8787. Methylene chloride has a higher water solubility than benzene at 13,000 mg/L, but also a higher density at 1.3255. Chloroform has a water solubility of 7,710 mg/L with a density of 1.4835. As a result, methylene chloride and chloroform may be more soluble than benzene, but due to the higher density, may not travel quite as readily in the subsurface. Water solubility and density values were obtained from the Hazardous Substances Databank (HSDB) of the National Library of Medicine TOXNET System (HSDB, 2004).

Based on the results of the July 2004 sampling event, the VOC contaminant plume which exceeds groundwater standards in the shallow unconsolidated aquifer extends from the waste disposal area approximately 600 ft downgradient to Crow Branch Creek and terminates in the vicinity of Crow Branch Creek. In addition, the VOC contaminant plume which exceeds groundwater standards in the shallow aquifer is approximately 500 ft wide at its widest point. The VOC contaminant plume geometry in the shallow aquifer is consistent with the previously described site hydrogeology with shallow groundwater flow converging from the north and south into Crow Branch Creek.

The extent of the dissolved phase plumes for most VOC compounds (i.e. benzene, chloroform, and methylene chloride) in the shallow aquifer appear to be relatively consistent with past sampling events in May 1998, November 2000, and October 2002. In comparison with past events, diethyl ether concentrations increased in some downgradient shallow wells and new detections were reported in shallow monitor wells MW-5, MW-18, and MW-25.

A comparison of the July 2004 sampling event analytical data with data from the May 1998, November 2000, and October 2002 sampling events indicated that concentrations of detected compounds fluctuated significantly in several wells between the four sampling events. Analytical data from shallow aquifer wells

MW-1, MW-2 and MW-6, which are located near the source area, indicate that many VOC constituents increased significantly in concentration between May 1998 and November 2000, decreased in concentration between November 2000 and October 2002, and increased again between October 2002 and July 2004. For example, benzene concentrations in monitor well MW-1 increased from 69,000 µg/L (May 1998) to 142,000 µg/L (November 2000) followed by a decrease to 32,000 µg/L (October 2002) and another increase to 100,000 µg/L. Other VOC compounds including chloroform, diethyl ether, methylene chloride, and TCE displayed similar trends in monitor wells MW-1, MW-2, and MW-6. It is possible that the fluctuations in VOC concentrations are related to changes in the groundwater table elevation. Data for the last four sampling events indicate that a positive correlation may exist between VOC concentrations and groundwater elevations. Future sampling events will provide additional evidence about the possible correlation between VOC concentrations and groundwater elevations.

VOC concentrations in shallow aquifer wells MW-12 and MW-22 have generally decreased or remained stable since the May 1998 sampling. Declining concentrations of benzene (160 µg/L to 1.2 µg/L), diethyl ether (2,600 µg/L to 470 µg/L), and TCE (8.9 µg/L to 1.4 µg/L) were observed in monitor well MW-22 between May 1998 and July 2004 while chlorobenzene concentrations have remained relatively stable. In monitor well MW-12, concentrations of benzene (1,300 µg/L to 470 µg/L), chloroform (10,000 µg/L to 21 µg/L), and methylene chloride (5,700 µg/L to less than 100 µg/L) also decreased between the May 1998 and July 2004 sampling events while chlorobenzene, diethyl ether, and TCE concentrations have remained relatively stable.

Diethyl ether was also detected in monitor wells MW-3 (16 µg/L), MW-5 (3 µg/L), MW-18 (49 µg/L), and MW-25 (45 µg/L). These monitor wells have had few (MW-3 and MW-18) to no (MW-5 and MW-25) detections of VOC compounds in the last four sampling events and no detections of diethyl ether in the most recent past event in October 2002. The presence of diethyl ether in MW-5, MW-18 and MW-25 indicates the continued migration of the dissolved phase diethyl ether plume. The majority of the diethyl ether concentrations detected in July 2004 are relatively low with the exception of the source area wells.

No VOCs were detected above reportable limits in shallow aquifer wells MW-4 and MW-20.

6.1.3 Bedrock Aquifer

Constituents were detected at concentrations above established groundwater standards in the groundwater samples from 8 of the 22 bedrock site monitor wells (MW-7, MW-9, MW-11, MW-13, MW-14, MW-15, MW-17, and MW-31) (see Table 6-2). Seven compounds (acetone, benzene, chloroform, 1,2-DCA, diethyl ether, TCE, and vinyl chloride) exceeded their respective groundwater standards in bedrock wells.

Contaminant isoconcentration contour maps for benzene, chloroform, methylene chloride, and diethyl ether are provided for the bedrock aquifer (Figures 6-5, 6-6, 6-7, and 6-8, respectively). The isoconcentration contour maps for the bedrock aquifer were generated using analytical data from the 22 bedrock aquifer monitor wells sampled during the July 2004 sampling event (MW-7, MW-9, MW-11, MW-13, MW-14, MW-15, MW-16, MW-17, MW-21, MW-23, MW-24, MW-26, MW-28, MW-29, MW-30, MW-31, MW-32, and MW-33, MW-34, MW-35, MW-36, and MW-37) and knowledge of the analytical results from previous groundwater sampling events.

Based on the results of the July 2004 sampling event, and as depicted in Figures 6-5 through 6-8, the VOC contaminant plume which exceeds groundwater standards in the bedrock aquifer extends approximately 600 feet downgradient of the waste disposal area and is approximately 900 feet wide at its widest point. While the dissolved phase plume in the shallow aquifer is interpreted to terminate in the vicinity of Crow Branch Creek, the impacted groundwater in the bedrock aquifer extends slightly north of the creek. Downgradient bedrock monitor wells MW-32 and MW-33, both of which are located on the north side of Crow Branch Creek, did not contain any VOC constituents during the May 1998 and November 2000 sampling events. However, diethyl ether was reported in both MW-32 and MW-33 in October 2002 at concentrations of 15 µg/L and 13 µg/L, respectively. An additional small scale sampling event was conducted in December 2003 to confirm the presence of diethyl ether north of the creek. Diethyl ether was detected again in monitor well MW-33 at a concentration of 18 µg/L and was below detectable limits (<2.0 µg/L) in MW-32.

The results of the July 2004 sampling event confirmed the results of December 2003 event with diethyl ether being below reportable limits in MW-32 (<2.0 µg/L) and detected in MW-33 at a concentration of 30 µg/L. Three additional bedrock wells were installed in July 2004 north of the creek to further delineate diethyl ether.

Diethyl ether was not detected in wells MW-34 and MW-35, which are located downgradient of MW-33. Monitor well MW-37 was installed adjacent to MW-32 and MW-33 with a screen interval 30 feet below that of MW-33. Diethyl ether was not detected in MW-37 during the July 2004 sampling event. No VOC constituents other than diethyl ether were detected in July 2004 north of the creek.

Diethyl ether was the most widespread VOC constituent detected south of the creek in July 2004 with reportable concentrations in monitor wells MW-7 (2,300 µg/L), MW-9 (140 µg/L), MW-11 (3,100 µg/L), MW-13 (4,200 µg/L), MW-14 (1,800 µg/L), MW-15 (14,000 µg/L), MW-16 (3.5 µg/L), MW-17 (110 µg/L), MW-24 (6 µg/L), and MW-31 (2,000 µg/L). In a comparison of the last four sampling events from May 1998 to July 2004, concentrations of diethyl ether have generally increased in bedrock monitor wells MW-7, MW-11, MW-17, and MW-31 while concentrations have remained relatively stable in MW-9, MW-13, MW-14, MW-15, MW-16, and MW-24.

Benzene was detected above the groundwater standard in bedrock monitor wells MW-7 (2.7 µg/L), MW-13 (22 µg/L), MW-14 (190 µg/L), MW-15 (930 µg/L), and MW-31 (1.3 µg/L). Benzene concentrations have generally remained stable or decreased with some minor fluctuations over the last four sampling events in bedrock monitor wells MW-7, MW-13, MW-14, and MW-15.

Chloroform was also detected above the groundwater standard in bedrock monitor wells MW-7 (6.9 µg/L), MW-14 (53 µg/L), MW-15 (180 µg/L), and MW-31 (2.1 µg/L). Chloroform concentrations have generally decreased over the last four sampling events in monitor wells MW-7 and MW-15 and remained stable in MW-14 and MW-31.

It should be noted that the VOC concentrations in the most impacted bedrock aquifer monitor well (MW-15) are orders of magnitude lower than the VOC concentrations detected in the most impacted shallow aquifer monitor wells (MW-1 and MW-2).

No VOCs were detected above reportable limits in bedrock aquifer monitor wells MW-21, MW-23, MW-26, MW-28, MW-29, MW-30, MW-32, MW-34, MW-35, MW-36, and MW-37.

6.1.4 Isoconcentration Contour Cross Sections

Isoconcentration contour cross sections (C-C') were created across a profile extending from southeast of the waste burial area to the northwest, extending across Crow Branch Creek. The profile includes shallow aquifer monitor wells MW-1, MW-3 and MW-12 and bedrock aquifer monitor wells MW-14, MW-15, MW-21, MW-24, MW-28 and MW-29. These wells were selected because they are aligned down the axis of the impacted groundwater plume, are directly downgradient of the waste burial area and some of these wells have historically exhibited the greatest concentrations of targeted compounds.

Data from the July 2004 groundwater monitoring event for diethyl ether and benzene are depicted in cross sectional view on Figures 6-9 and 6-10, respectively. These two constituents were selected as they are two of the most laterally and vertically extensive constituents at the site.

The dissolved diethyl ether plume, as depicted on Figure 6-9, has migrated from the waste burial area to the northwest extending slightly beyond Crow Branch Creek. Although present in deep bedrock monitor well MW-14 (1,800 µg/L) and at trace concentrations in deep bedrock monitor well MW-24 (6 µg/L), the predominant mass appears to travel in the shallow aquifer and the upper 50 feet of the bedrock aquifer. This is demonstrated by the concentrations in monitor wells MW-1 (290,000 µg/L), MW-12 (13,000 µg/L) and MW-15 (14,000 µg/L). The concentrations of diethyl ether detected in the shallow aquifer and bedrock aquifer monitor wells are consistent with groundwater flow directions and vertical gradients seen in the shallow and bedrock aquifers.

The dissolved benzene plume, as depicted on Figure 6-10, follows a very similar travel pathway to diethyl ether in the subsurface. The greatest concentrations are seen in the shallow aquifer and upper bedrock aquifer and decrease rapidly to the northwest away from the burial area. Both the diethyl ether and benzene plumes have similar geometry and both appear to terminate in the vicinity of Crow Branch Creek.

6.2 Surface Water Analytical Results

Surface water samples were collected from six surface water sampling locations for analysis of VOCs via USEPA method 8260 during the July 2004 sampling event. The analytical results for the July 2004 surface water sampling event are summarized in Table 6-4, and the sample collection locations are depicted in Figure 2-2. Diethyl ether

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was the only VOC constituent that was detected during the July 2004 sampling event. Diethyl ether was detected at concentrations of 4.2 µg/L, 4.0 µg/L, and 2.4 µg/L in surface water samples SW-3, SW-4, and SW-5, respectively. No surface water standard exists for diethyl ether; however, the sample concentrations were significantly less than the USEPA Region IX PRG of 1,200 µg/L, which is a drinking water standard based on human health exposure via ingestion. The detection of diethyl ether in Crow Branch Creek likely represents the discharge of the impacted groundwater plume originating from the waste disposal area.

It should be noted that no VOCs were detected in surface water sample SW-6 which is the furthest downgradient surface water sampling point.

7 Principal Findings and Future Site Activities

ARCADIS conducted a final phase of field investigation activities at the University of North Carolina at Chapel Hill Airport Road Waste Disposal Area in July 2004 to complete the RI process. Field activities included monitor well installation, monitor well gauging, and collection of surface water and groundwater samples. The principle findings of the remedial investigation and planned future activities are summarized in this section.

7.1 Principal Findings

- Soil samples were collected from the area immediately outside of the fence surrounding the waste burial pits as part of the RI conducted in 1996. All soil samples were collected from the periphery of the waste disposal area. No samples were collected from the waste pits or within the fenced area of the site, due to safety concerns. The 1996 analytical results indicated trace concentrations of volatile organics in two soil samples which were collected from borings located within 5 feet of the fence surrounding the waste burial area. The data suggest that impacted soils do not extend outside the source area; however, it is presumed that impacted soils are present within, beneath and adjacent to the individual waste burial pits. Based on the results of the soil investigation activities conducted in 1996, it was determined that the extent of impacted soils was adequately defined and no additional soil sampling activities were necessary.
- Depth to water measurements were collected from site monitor wells and six surface water locations in July 2004 and converted to water elevation data. A water-level elevation contour map was prepared for both the shallow aquifer and the deeper bedrock aquifer. The water-level elevation data indicate that groundwater flow in the shallow aquifer, south of Crow Branch Creek, is generally to the north and in the general direction toward Crow Branch Creek. The groundwater flow direction for the shallow aquifer on the north side of Crow Branch Creek is generally toward the east/southeast convergent on Crow Branch Creek. The water-level elevation data for the deeper bedrock aquifer monitor wells indicate that groundwater flow in the bedrock aquifer is similar to that of the shallow aquifer. The groundwater flow pattern indicated by the July 2004 water level elevation data is similar to the groundwater flow patterns observed at the site in May 1998, November 2000, and October 2002.
- The calculated vertical gradients for the July 2004 water-level measurement event were upward in five well clusters located downgradient of the disposal area

(MW-6/MW-7, MW-12/MW-15, MW-25/MW-26, MW-30/MW-31, and MW-32/MW-33). Well clusters located near the ridge line (MW-2/MW-14 and MW-28/MW-29) exhibited a downward vertical gradient. The vertical gradients indicate that groundwater is moving vertically downward in the area of the ridge (a recharge area) and upward in the general area of Crow Branch Creek (a discharge area), suggesting that the creek may be recharged from the shallow and deeper aquifers.

- VOC constituents were detected in the shallow aquifer at concentrations above the established groundwater standards in 5 of the 11 shallow site monitor wells (MW-1, MW-2, MW-6, MW-12, and MW-22). Ten compounds (acetone, benzene, chloroform, 1,2-DCA, diethyl ether, ethylbenzene, methylene chloride, 1,1,2,2-TCA, TCE, and total xylenes) exceeded their respective groundwater standards in shallow wells. Diethyl ether is the most widespread of the constituents. Analytical data from source area wells (i.e., MW-1, MW-2 and MW-6) indicate that a positive correlation may exist between VOC concentrations and groundwater elevation. In general VOC concentrations detected in shallow aquifer monitor wells increase following a period when water level elevations increased. Future sampling events will provide additional evidence about the possible correlation between VOC concentrations and groundwater elevation.
- VOC constituents were detected in the bedrock aquifer at concentrations above the established groundwater standards in groundwater samples collected from 8 of the 22 bedrock aquifer monitor wells (MW-7, MW-9, MW-11, MW-13, MW-14, MW-15, MW-17, and MW-31). Seven compounds (acetone, benzene, chloroform, 1,2-DCA, diethyl ether, TCE, and vinyl chloride) exceeded their respective established groundwater standards in bedrock wells. Diethyl ether was the most widespread constituent and was the only VOC compound detected on the north side of the creek.
- Four competent bedrock monitor wells (MW-34, MW-35, MW-36 and MW-37) were installed to further delineate the extent of site-related constituents in the groundwater in the northern portion of the site. Monitor wells MW-34, MW-35 and MW-36 were installed with screen elevations comparable to MW-33 to provide downgradient (east/northeast) delineation. Monitor well MW-37 was installed adjacent to existing monitor wells MW-32 and MW-33 for the purposes of vertical delineation. Diethyl ether was not detected in the new monitor wells (MW-34, MW-35, MW-36 and MW-37).

- The analytical data from the July 2004 shallow aquifer and bedrock aquifer monitor well sampling event indicate that the horizontal and vertical extent of the VOC impacted groundwater plume is defined by the existing monitor well network.
- Surface water samples were collected from six surface water sampling locations for analysis of VOCs. Diethyl ether was detected in samples collected at SW-3, SW-4, and SW-5, respectively. The detection of diethyl ether in Crow Branch Creek likely represents the discharge to the creek of the VOC impacted groundwater plume originating from the waste disposal area. It should be noted that no VOCs were detected in surface water sample SW-6 which is the furthest downgradient surface water sampling point on the UNC property.

7.2 Future Activities

The current and historic data presented in this RI Report indicates that the extent of the impacted media is well understood and has been sufficiently delineated to allow for remedial action. The next phase of this project will involve the preparation of a REC compliant Remedial Action Plan (RAP).

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