REMEDIAL ACTION PLAN
THE UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
AIRPORT ROAD WASTE DISPOSAL AREA
CHAPEL HILL, NORTH CAROLINA

Volume II

February 1997

Prepared for:

The University of North Carolina at Chapel Hill
Chapel Hill, North Carolina

Prepared by:

GERAGHTY & MILLER, INC.
Environment and Infrastructure
and
GMCE, INC.
2840 Plaza Place, Suite 350
Raleigh, North Carolina 27612
(919) 571-1662

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Prepared by Geraghty & Miller, Inc.

Michael T. Ray
Regional Manager

357
ANTHONY J.

Tony Gogel, L.G.
Vice President/Project Officer

and
GMCE, Inc.

Nanjundeswar V. Shetty, P.E.
Vice President

FCR

J. Lawrence Hosmer, P.E.
President

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1.0 INTRODUCTION

The University of North Carolina at Chapel Hill (the University or UNC) retained Geraghty & Miller, Inc., (Geraghty & Miller) to perform a Remedial Investigation (RI) of groundwater conditions at the Airport Road Waste Disposal Area (site). The RI was performed voluntarily by the University. The RI report (Geraghty & Miller, 1996) prepared in November 1996 describes the scope of the investigation and the findings at the site.

The next step in the remedial action process is to prepare a Remedial Action Plan (RAP) report. The purpose of this RAP is to identify appropriate remedial action alternatives for source control and groundwater remediation and to present a conceptual design of the proposed system. This RAP is prepared in accordance with Section 6.0, Subsection 4 of the Inactive Hazardous Sites Program Guidelines (Guidelines) prepared by the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR), Division of Solid Waste Management, Superfund Section (NCDEHNR, 1996).

1.1 BACKGROUND INFORMATION

The following sections briefly discuss the site location and site history.

1.1.1 Site Location/Surrounding Land Use

The site is located near Highway 86 (Airport Road) in Chapel Hill, Orange County, North Carolina (Figure 1-1). 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 0.5-acre wooded parcel of University property that includes part of the entrance road to the former Airport Road UNC Old Sanitary Landfill. Approximately 0.2 acre of this tract was used from 1973 through 1978, with the approval of the

State of North Carolina, to dispose of chemical waste from University facilities in 16 separate burials (see Section 1.2, Summary of Waste Activities). An adjacent 0.3-acre expansion was proposed and approved by the State of North Carolina for use when the original area was full. However, only two burials were made in 1979 in this expanded area. Access to the site is restricted by an 8-foot-high locked fence erected by the University in early 1994 and by several warning signs.

Town of Chapel Hill municipal facilities are located near the site on a parcel of land leased from the University since 1979. This parcel is located east and southeast of the site. The municipal facilities include paved roadways, parking lots, a street and bus maintenance facility, and an animal shelter. The Horace Williams Airport is south and southwest of the site, and the former UNC Old Sanitary Landfill (closed in 1973), which was operated by the Town of Chapel Hill, is to the west. Wooded land and Crow Branch Creek are present north of the site. A small residential area, accessible from Airport Road, is located one-quarter to one-half mile north of the site. The majority of the east side of Airport Road is also developed for residential use (NCDEHNR, 1993).

The site is generally flat, sloping toward Crow Branch Creek to the north. The site is covered by a thicket of 20-foot-tall evergreen trees with an apparently undisturbed ground surface.

1.1.2 Site History/Operation

The site was used from 1973 to 1979 by the University to dispose of chemical wastes from the University's teaching, research, and hospital laboratories. A total of 18 burials in trenches were made at the site between 1973 and 1979 (NCDEHNR, 1993). A sketch showing the locations of the burials is included in Appendix A. A list of laboratory chemicals potentially disposed of at the site (North Carolina Department of Human Resources [DHR], 1984) also is included in this appendix.

The University installed five monitor wells 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., (1991) completed a Phase II Screening Site Investigation (SSI) for the NCDEHNR Superfund Section at the UNC Old Sanitary Landfill. However, SSI focused primarily on the Airport Road Waste Disposal Area. 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.

1.2 SUMMARY OF REMEDIAL INVESTIGATION REPORT

The RI report (Geraghty & Miller, 1996) described three phases of field activities conducted at the site. 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). The monitor well locations are presented in Figure 1-2. 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 consisted of bedrock coring (core holes CH-1, CH-2, and CH-3). In addition, 10 monitor wells (MW-14, MW-15, MW-16, MW-17, MW-18, MW-19, MW-20, MW-21, MW-22, and MW-23) were installed. Monitor Wells MW-14 and MW-23 were installed in coreholes CH-1 and CH-3, respectively. These 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 RI consisted of the installation of four monitor wells (MW-25, MW-24, MW-26, and MW-28), groundwater sampling, four shallow geotechnical soil borings, and five Geoprobe^{TM} borings at the site. The soil boring and Geoprobe^{TM} soil sample locations are presented in Figure 1-3. 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 Geoprobe^{TM} borings were analyzed for VOCs, SVOCs, and inorganic parameters.

To confirm the horizontal and vertical extent of impacted groundwater at the site, additional Monitor Wells MW-29, MW-30, MW-31, MW-32, and MW-33 were installed in November 1996. Groundwater from these wells were 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 Geraghty & Miller's Well Installation and Sampling Report (Geraghty & Miller, 1997a) and Groundwater Sampling Report (Geraghty & Miller, 1997b).

The RI report includes a detailed discussion of the investigation procedure and results of soil and groundwater investigations, geotechnical assessment, and surface emission flux sampling. A summary of monitor well construction details can be found in Table 1-1. The results of hydrogeological investigation, soil sampling, surface-water sampling, and groundwater sampling are summarized in subsequent sections of this report.

1.3 SUMMARY OF SITE HYDROGEOLOGIC CONDITIONS

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 saprolite unit varies in lithology from sandy clay to clayey sand, with a variable thickness ranging from approximately 5 to 20 feet. Competent granodiorite bedrock underlies the saprolite. 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).

Water level measurements collected from the 30 site monitor wells on December 11, 1996, indicate that the depth to water in the shallow aquifer monitor wells ranged from 1.34 feet below top of casing (ft btoc) in Well MW-5 to 11.72 ft btoc in Well MW-2 (see Table 1-2). A water level elevation contour map for the shallow aquifer was prepared using the water level elevation data collected on December 11, 1996, and is presented in Figure 1-4. The information presented on Figure 1-4 indicates that the groundwater flow direction in the shallow aquifer south of Crow Branch Creek is generally to the north-northwest, toward Crow Branch Creek. A south/southeast groundwater flow direction is indicated for the shallow aquifer on the north side of Crow Branch Creek.

The depth to water in the bedrock aquifer monitor wells ranged from land surface in Well MW-23, which is a flowing artesian well, to 15.30 ft btoc in Well MW-11. A water level elevation contour map for the bedrock aquifer was prepared using the water level elevation data collected on December 11, 1996, and is presented in Figure 1-5. The groundwater flow direction in the bedrock aquifer is generally similar to that of the shallow aquifer, with a slightly more north-northeasterly component at the southeastern portion of the site. A southeast groundwater flow direction is indicated for the bedrock aquifer on the north side of Crow Branch Creek.

Upward vertical hydraulic gradients were measured at the site in five downgradient well clusters on December 11, 1996. The upward vertical hydraulic gradients measured on December 11, 1996, were: MW-6/MW-7 (0.067 feet per foot [ft/ft]), MW-12/MW-15 (0.104 ft/ft), MW-25/MW-26 (0.005 ft/ft), MW-30/MW-31 (0.010 ft/ft), and MW-32/MW-33 (0.005 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 0.035 ft/ft and 0.016 ft/ft were measured at upgradient well clusters MW-2/MW-14 and MW-28/MW-29, respectively. A downward vertical hydraulic gradient at these well cluster locations is consistent with the hydrogeologic interpretation that the wells are located close to a groundwater flow divide along a topographic high (ridge line).

The in-situ hydraulic conductivity of the saturated sediments were 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 dummy 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 Geraghty & Miller's AQTESOLV software, which utilizes the Bouwer and Rice Method (1976). 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} for 1.45×10^{-2} cm/sec, with an average K of 4.26×10^{-3} cm/sec. Aquifer test results are presented in the RI report. Using average hydraulic conductivity values and hydraulic gradients of 0.04 ft/ft for the shallow aquifer and 0.05 ft/ft for the bedrock aquifer, the average groundwater flow velocities for the surficial and bedrock aquifers in the vicinity of the site were estimated to be 0.3 and 6.04 feet/day, respectively. While the velocity of groundwater in bedrock is relatively high, it is emphasized that the rate represents flow through a fracture as opposed to flow through porous medium.

1.4 NATURE AND EXTENT OF CONTAMINATION

The following sections discuss the nature and extent of contamination in soil and groundwater at the site, and results of surface water sampling.

1.4.1 Soils

The analytical results of soil samples collected in close proximity to the disposal area (see Figure 1-3) are summarized in Table 1-3. Two of the five samples had detections of VOCs. Sample SB-1 contained 8 parts per billion (ppb) chloroform. Sample SB-2 contained 20 ppb of chloroform and 10 ppb of methylene chloride. Inorganic constituents detected in the five soil samples, with a few minor exceptions, are below background levels of a soil sample obtained from east-central North Carolina (USGS, 1984).

1.4.2 Groundwater

The analytical results of groundwater samples collected during the RI activities are summarized in Appendix B. Contaminated groundwater was identified extending from the vicinity of the disposal area to the northwest, terminating in the vicinity of Crow Branch Creek. The primary VOCs detected at the site are benzene, chloroform, diethyl ether, and methylene chloride. The RI report summarizes the concentrations of SVOCs detected in groundwater samples collected from site monitor wells and these include dichlorobenzene, phthalates, phenols, and benzoic acid (see Appendix B for a summary of analytical results). Iron and manganese were detected in groundwater samples at concentrations above groundwater standards. However, due to the presence of turbidity in the samples, it is likely the dissolved metals are naturally occurring in the groundwater.

The analytical results for the groundwater samples collected in December 1996 are summarized in Table 1-4. Contaminants isoconcentration contour maps (horizontal extent of contamination) for total VOCs for the shallow unconsolidated aquifer and the bedrock aquifer are presented as Figures 1-6 and 1-7, respectively. Based on the results of the November and December 1996 sampling events, the mass transport of VOC constituents which exists in the shallow unconsolidated aquifer and the bedrock aquifer are interpreted to terminate in the vicinity of Crow Branch Creek. It is noted that chloroform and acetone were both detected at a concentration of 15 ppb in the groundwater samples collected from Corehole CH-3 which was completed as Monitor Well MW-23. However, no VOCs were detected in groundwater samples collected from Well MW-23 during three subsequent sampling events. The presence of chloroform and acetone in the corehole water samples may be attributed to the introduction of water from a municipal water supply during the coring process and/or cross contamination of the borehole packer equipment and/or sampling equipment. Also, acetone was detected in samples collected from Wells MW-32 and MW-33 in November 1996 at concentrations of 66 ppb and 6 ppb, respectively. However, acetone was not detected in the groundwater sample collected from Well MW-32 in December 1996 (MW-33 was not resampled). In addition, acetone was detected in the rinsate sample from the December 1996 sampling event. The presence of acetone in the groundwater samples collected from Wells MW-32 and MW-33 is attributed to the fact that isopropyl alcohol, from which acetone is a degradation product, has been used in the decontamination process for the monitor well sampling equipment. In any event, the concentration of acetone detected in samples from Wells MW-32 and MW-33 were well below the North Carolina Groundwater Standard (NCGWS) of 700 ppb. A contaminant plume map for individual contaminants and detailed discussions on the findings can be found in the Groundwater Sampling Report (Geraghty & Miller, 1997b).

Vertical definition of the plume has, in practical terms, been established near the downgradient edge of the plume at Monitor Well MW-24, which is in a well cluster with Wells MW-12 and MW-15 (Geraghty & Miller, 1996). Monitor Well MW-24 is screened from 175 to 195 feet below land surface (ft bls) into bedrock. The detected contaminants in the groundwater samples collected in February 1996 from the Well MW-24 were benzene (2 ppb), chloroform (12 ppb), methylene chloride (8 ppb), and acetone (60 ppb). These concentrations are three orders of magnitude lower than the concentrations detected in groundwater samples collected in July 1995 from Well MW-15, which is screened in a fractured bedrock zone at 50 to 60 ft bls. In addition, phenol was detected in the groundwater sample collected in February 1996 from Well MW-2 at 3400 ppb. However, contaminant concentrations increased with depth near the source in corehole CH-1 (MW-14). This may be due to the potential for dense non-aqueous phase liquids (DNAPLs) to exist in the vicinity. However, no visible evidence of DNAPLs was found in groundwater samples from the monitor wells. Corehole CH-1(MW-14) was drilled to 175 feet.

1.4.3 Surface Water

Six rounds of surface-water samples were collected between June 1995 and October 1996 from Crow Branch Creek at locations shown on Figure 1-2. VOCs were detected at sampling locations SW-01 and SW-03 from the January 26, 1996, sampling event. Diethyl ether was detected at 10 ppb in SW-03 from the August 7, 1996, sampling event. In addition, dietheyl ether was detected at 10 ppb in SW-05 from the October 28, 1996 sampling event. VOCs were not detected at any of the other sampling locations or during other sampling events in the samples collected from the locations SW-01 or SW-03. Location SW-01 is upstream from the likely zone of plume discharge from the site to Crow Branch Creek (near the former UNC Old Sanitary Landfill). The detection of tetrachloroethene at 5 ppb at SW-03 on January 26, 1996, was at the method detection limit and may represent discharge from the waste area plume or another upstream source.

1.5 REMEDIAL ACTION OBJECTIVES

The Remedial Action Objectives (RAOs) are statements that specify site remediation goals and identify which constituents of concern, media, and exposure pathways will be addressed by remedial actions. The media of concern at the site include source material (including soils and containers) and contaminated groundwater. The RAOs are used in screening technologies and in the evaluation and comparison of remedial alternatives.

The primary RAO for the site is to protect human health and the environment. Specific RAOs for the site are based on the media of concern and are listed as follows:

- Minimize further degradation of the groundwater quality by providing source control/remediation;
- Reduce further migration of dissolved constituents of concern in groundwater;
- Minimize contaminated groundwater from impacting the receptors; and
- Meet the requirements of Inactive Hazardous Site Voluntary Cleanup Program as outlined in the Guidelines.

2.0 EVALUATION OF REMEDIES

This section identifies potential regulatory requirements for various activities to remediate primary source (waste), secondary source (saturated soils/contamination), and contaminated groundwater. In addition, this section describes the general response actions to accomplish the RAOs as well as remedial technologies available to achieve these objectives consistent with Section 5.0 of the Guidelines. The technologies frequently implemented for remedial action at similar sites are considered for remediation at this site. The technologies are initially screened and selected for forming remedial alternatives. The remedial alternatives are then evaluated using a set of criteria and compared to each other prior to selecting a remedial alternative for implementation at the site.

2.1 COMPLIANCE WITH REGULATORY REQUIREMENTS

This section identifies the state and federal (if applicable) laws and regulations which are potentially applicable for the remedial actions identified for the site. These regulations/laws are to be complied with during remedial action implementation to meet the cleanup objectives. Table 2-1 identifies the potential regulatory requirements for the remediation of the site. Table 2-2 provides a summary of North Carolina Groundwater Standards, Federal Drinking Water Standard Maximum Contaminant Limits, Remediation Goals (adopted from Appendix C-1 of the Guidelines), and maximum observed concentrations of constituents in groundwater at the site. Soil Remediation Goals for the organic compounds at the site are listed in Table 2-3.

2.2 TECHNOLOGY SCREENING

Remedial technologies for both source control and groundwater remediation at the site are categorized in terms of the following general response actions:

- No Action
- Limited Action
- Source Control

- Collection, Treatment, and Disposal
- In-Situ Treatment

The identification of remedial technologies and process options was based on: (1) the ability of a given technology and/or process option to meet the RAOs; (2) the ability to meet the regulatory requirements; (3) technology effectiveness; (4) implementability; and (5) relative costs. The technologies under consideration in this section have been screened to identify and select representative process options within each technology. Although specific processes were selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology. In general, one or more process options were retained for use in formulating remedial measures and remedial alternatives.

Tables C-1 and C-2 (Appendix C) present identification and screening of source control and groundwater remedial technologies, respectively. These tables identify technology types, process options, a brief description, technology applications and limitations, and selection status.

2.2.1 Screening of Source Control Technologies

Table C-1 (Appendix C) presents the source control technologies that were identified and screened. The screening process was based on effectiveness, limitations, implementability, and relative costs. After screening, technologies retained are combined to form remedial alternatives which are evaluated in Section 2.3.1. Following is a brief discussion on screening of each potential response action.

No Action

The no action option will be used as a baseline against which other options may be compared. Under no action, no additional cleanup would be undertaken, and the site would be left as it now exists, except for deed/access restriction and monitoring.

Institutional Controls

Institutional controls (fencing and deed restrictions) typically are used for restricting access or exposure to waste material. Institutional actions were retained as a result of the initial screening process and may be used in conjunction with other technologies to meet the RAOs. To continue to streamline the alternatives evaluation/comparison process, institutional controls will remain but will not be discussed specifically in the remaining sections.

Containment

Containment is a source control response category in which physical barriers are used to prevent infiltration of storm water and direct precipitation into the contaminated subsurface soils and/or to divert groundwater from the contaminated area. Based on available water level information, portions of the primary source material appear to be below the groundwater. Therefore, a combination of containment technologies would be required to contain the primary source. Implementation of multiple containment technologies would be uneconomical and is also technically ineffective. Therefore, the containment response action was eliminated from further consideration (see Table C-1 in Appendix C).

Source Removal

Excavation and removal of contaminated material for treatment or off-site land disposal is technically feasible and is very effective; therefore, this technology was retained for further consideration. For source remediation, excavated material can be transported off-site to a permitted waste treatment and disposal facility.

Ex-situ Treatment

One ex-situ on-site treatment technology, soil washing, was screened. However, this technology was not selected since the percentage of fine-grained material in the site soils is high, making this technology costly. In addition, the volume of soils to be treated is low which makes this technology uneconomical. The off-site treatment (incineration) and disposal of excavated material was retained for formation of alternatives (Section 2.3.1).

In-situ Treatment

In-situ treatment systems for degrading or detoxifying waste in place typically reduce the need for soil excavation and transportation to an off-site facility for treatment and disposal. The in-situ technology (in-situ volatilization/solidification), has been retained for further evaluation. This technology can be used to remediate sites with volatile organics by mixing soil with a large-diameter auger/mixer with hot air or steam injection. Following mixing, solidification occurs by direct injection of reagents and additives into the subsurface soil using specialized machinery with injection augers and rotary-type mixers for blending. This process has the potential to reduce the mobility of inorganic contaminants.

Miscellaneous Technologies

Additional technology, such as cosolvent flushing, is innovative but has not been fully demonstrated to be effective at sites similar to UNC Airport Road Waste Disposal Area. Therefore, these methods are retained for further consideration as supplemental technologies for future use. In addition, phytoremediation also was considered for source control, but it is not effective based on site water-table conditions.

2.2.2 Screening of Groundwater Remediation Technologies

The groundwater remediation technologies were identified and screened in Table C-2 (Appendix C). The screening process was based on effectiveness, limitations/implementability, and costs. The technologies retained in the screening process are combined to form alternatives which are then evaluated using a set of criteria in Section 2.3.2. Following is a brief discussion on the response actions.

Due to the limited extent of groundwater impacts and, based on screening of a variety of technologies and process options, a limited number of technologies/options were retained for groundwater remediation. Institutional actions were retained for future use and to support other process options.

No Action

The no action option will be used as a baseline against which other options may be compared. Under no action, no groundwater cleanup would be undertaken, and the site would be left as it now exists with minimum monitoring. No action response action will be used as a baseline for comparison with other options.

Natural attenuation of contaminants in groundwater is a process option that is applicable for remediating dissolved organic compounds in groundwater due to its cost effectiveness and innovativeness. This option has potential for future use when the groundwater is remediated to levels which can be naturally attenuated before reaching the receptor. Therefore, this option was retained for future implementation.

Extraction Technologies

Groundwater extraction (controls) using conventional recovery wells and vacuum enhanced recovery were retained as representative process options. These technologies are commonly used for the containment and remediation of contaminated groundwater.

Treatment Technologies

Based on the constituents of concern in groundwater, physical/chemical treatment process options such as precipitation/flocculation, filtration, air stripping, carbon adsorption, and ultraviolet treatment were considered. Air stripping was the most preferable alternative for treatment of VOCs (see Table C-2 of Appendix C) and was retained for further evaluation. An activated carbon system may be required as a polishing step, if the treated effluent is discharged to a surface water body. Process options such as precipitation/flocculation, filtration, and sedimentation (clarification) were retained as support or optional technologies.

Discharge Options

Infiltration of treated groundwater onsite is a potentially applicable technology. However, the application of this technology can be limited due to the presence of clay/silt in the subsurface.

While retained for further considerations, this technology can be used only if the groundwater extraction rates are low or in combination with other discharge options. Sanitary sewers are present in the vicinity of the site. Orange County Water and Sewer Authority (OWASA) may accept treated groundwater through a certified waste hauler, but not by direct connection. However, the University may negotiate for a direct connection with OWASA. Therefore, this option is retained for future use. Discharge of treated water to a surface-water body (Crow Branch Creek) under a National Pollutant Discharge Elimination System (NPDES) permit is a viable option. Therefore, this option may be used as a major discharge option.

In-Situ Treatment

In-situ treatment process options for groundwater were considered in the screening process. Reactive wall/zones and air sparging curtain were two treatment technologies considered as a potentially applicable options and were retained. In addition, in-situ chemical oxidation is becoming a more popular and powerful remediation tool. Therefore, this option also was retained as a potential groundwater remediation technology. Some of the in-situ processes, such as anaerobic bioremediation, reductive dehalogenation using zero-valent iron metal, etc., are innovative and their applications have not been fully demonstrated in the field. These technologies will be retained for future consideration as supplementary technologies. Phytoremediation also was considered for controlling groundwater. However, this technology is not effective in remediating contaminants at depths below the water table. Therefore, this option was eliminated.

2.2.3 Summary of Technologies Retained for Further Consideration

The remedial technologies retained in Section 2.2 for the formulation of alternatives are listed below.

2.2.3.1 Source Control Technologies

- No Action

- Institutional Controls: Deed Restriction and Access Restriction
- Excavation
- Off-Site Disposal
- Incineration
- In-Situ Volatilization (Mixing)
- In-Situ Solidification (Encapsulation)
- Other In-Situ Technologies (Cosolvent Flushing)

2.2.3.2 Groundwater Remediation Technologies

- No Action
- Natural Attenuation
- Institutional Controls: Deed Restriction and Access Restrictions
- Extraction Wells
- Vacuum Enhanced Recovery
- Filtration (Support Technology)
- Precipitation/Flocculation
- Air Stripping
- Activated Carbon
- Sedimentation/Clarification
- In-Situ Chemical Oxidation

- Infiltration Gallery
- Surface-Water Disposal
- Discharge to a Sanitary Sewer
- Miscellaneous In-Situ Technologies (Reductive Dehalogenation)

The technologies retained in Section 2.2.3 following the screening process are used to develop alternatives in Section 2.3 for remediating the site.

2.3 EVALUATION OF REMEDIAL ALTERNATIVES

In the previous sections of this report, general response actions and the related remedial technologies and process options were identified. Remedial technologies and process options were screened in Section 2.2 to narrow the list of process options under consideration for remedial action at the site. The technologies screened in Section 2.2 are combined to form alternatives. This section includes evaluation and comparison of alternatives with a set of criteria listed in the Guidelines. These criteria are listed below:

- Overall protection of human health and the environment, including attainment of remediation goals;
- Compliance with applicable Federal, State and local regulations;
- Long-term effectiveness and permanence;
- Reduction in toxicity, mobility, or volume;
- Short-term effectiveness: effectiveness at minimizing the impact of the site remediation on the environment and the local community;
- Implementability: technical and logistical feasibility;
- Cost; and
- Community acceptance.

These criteria are defined further by factors and sub-criteria which are discussed briefly in Appendix D.

2.3.1 Evaluation of Source Control Alternatives

Source control alternatives (SCA) developed using technologies retained in the screening process, are listed below:

SCA-1:	No Action
SCA-2:	Excavation of Primary and Secondary Sources, Off-Site Treatment, and Off-Site Disposal
SCA-3:	Excavation of Primary Source, Off-Site Treatment/Disposal, and In-Situ Volatilization of Secondary Source
SCA-4:	In-Situ Volatilization and Solidification of Primary and Secondary Sources

The following sections describe and evaluate the above listed alternatives using the eight criteria.

2.3.1.1 SCA-1: No Action

The no action alternative is included to serve as a baseline against which other alternatives are compared. Currently, the waste material has approximately 4 to 5 feet of soil cover. The site is currently covered with mostly pine trees, and a locked fence is in place with warning signs. The no action alternative applies to both primary (actual waste/material) and secondary sources (contaminated soils - saturated zone). Since no active source control measures are involved in this option, the potential for continued impacts to the environment are high. This option potentially would require deed restrictions and monitoring.

A detailed evaluation of the no action alternative against the eight evaluation criteria is listed in Table 2-4. An opinion of probable costs for the implementation of this alternative is presented as Table 2-5. The present worth of opinion of total costs was estimated using a 7 percent discount factor for 30 years of annual inspections/repairs and monitoring.

2.3.1.2 SCA-2: Excavation of Primary and Secondary Sources, Off-Site Treatment, and Off-Site Disposal

Excavation, treatment, and disposal of primary (soil/waste material) and secondary sources (contaminated soils/saturated) are expected to address and eliminate the continued sources of groundwater contamination. This alternative includes excavation of buried waste material and contaminated soil underneath the waste to the top of the bedrock. The excavated waste/soils (primary source) will be screened initially for separation of soil and containers. The screened soils will be conveyed using a belt conveyor to a truck/roll-off box. The containers will be screened for chemical compatibility and grouped together for lab/over packing for proper disposal. Similarly, the secondary source (soil) beneath the primary source will be excavated and stored in roll-off boxes for treatment and disposal. Figure 2-1 presents a conceptual process flow schematic of this alternative.

The excavated waste material/soils will be transported to a Resource Conservation and Recovery Act (RCRA)-permitted Subtitle C treatment (incineration) and disposal facility. The disposal facility will be required to treat the material to Land Disposal Restrictions (LDR) Treatment Standards. Since the excavation will exceed 5 feet and is expected to encounter the shallow water table, shoring/sheet piling and dewatering will be required. The extracted water will require treatment prior to disposal. To prevent odors/vapors/gases, a temporary pre-fabricated roofing/building with a ventilation system to collect air pollutants will be required. The extracted air will be treated using a scrubber and a vapor phase activated carbon system.

As required by the Guidelines, soils samples (post-remediation) will be collected to verify the cleanup process upon removing the sources.

Table 2-4 presents detailed evaluation of this alternative with eight criteria. An opinion of probable costs for excavation of primary and secondary sources and off-site treatment/disposal is presented in Table 2-6.

2.3.1.3 SCA-3: Excavation of Primary Source and Off-Site Treatment/Disposal and In-Situ Volatilization of Secondary Source

The scope of this alternative includes excavation of the primary source (soil and waste material/containers) and treatment/disposal at a permitted RCRA facility. However, the secondary source (potentially contaminated/saturated soils beneath the waste site) will be treated in-place using in-situ volatilization technology. This technology involves mixing of the soil column using a mobile equipment setup with a rotary mixing tool capable of injecting hot air/steam at high pressures. The volatilized contaminants are recovered by applying vacuum on the shroud at ground surface where the soil column is being mixed. The contaminated soils are treated in place by mixing (volatilizing) contaminants in a series of overlapping columns to ensure proper treatment of VOCs. Figure 2-2 presents a conceptual process flow schematic for this alternative.

Table 2-4 presents the detailed evaluation of this alternative with respect to the eight criteria. Table 2-7 presents details of the opinion of probable costs for this option.

2.3.1.4 SCA-4: In-Situ Volatilization and Solidification of Primary and Secondary Sources

The scope of this alternative includes treatment of primary and secondary sources in-place using in-situ volatilization/mixing and solidification technology. This process consists of two steps: (1) volatilization/mixing; and (2) solidification. Figure 2-3 presents a conceptual process flow schematic of this alternative. In the first step, contaminated soil columns are mixed using a mobile equipment setup with a rotary mixing tool capable of injecting high pressure hot air/steam. Initially, the VOCs and some SVOCs in the soil/waste matrix are volatilized by mixing and injecting hot air/steam. According to vendors of this technology, this process is expected to remediate greater than 90% of contamination in the subsurface. The volatilized contaminants are recovered by applying a vacuum on a shroud covering the ground surface where the soil column is being mixed. The recovered vapors during the mixing process are treated and discharged into the atmosphere. Depending on the design, hot air or steam is injected through openings on the auger blades. A series of overlapping columns of mixing will ensure proper treatment. Upon completion of the volatilizing/mixing process, the solidification process is implemented by injecting a cement-based solidification agent (second step).

The solidification process will ensure non-volatile or inorganic compounds are bound/microencapsulated in-place by the solidifying agent. Depending upon the volume and depth of treatment, the soil column can vary in diameter from 6 feet to 18 feet. The solidification process will be used for treatment of both primary and secondary source materials/contaminated soils. Bulking of stabilized soil is expected to occur due to injection of cement during the in-situ solidification phase. Depending on the amount of bulking, the stabilized material will either be transported to an off-site facility for disposal or regraded on site. If the solidified material is regraded at the site, a final cover will be installed and seeded for protection and erosion control.

A detailed evaluation of this alternative is presented in Table 2-4, and the opinion of probable present worth costs is presented in Table 2-8.

2.3.2 Evaluation of Groundwater Remediation Alternatives

The groundwater remediation alternatives (GWA) selected for the shallow (unconsolidated) groundwater hot spots and dissolved contamination in the bedrock aquifer at the site are as follows:

GWA-1:	No Action
GWA-2:	Vacuum-Enhanced Recovery of Shallow Groundwater (Hot Spot), and Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal
GWA-3:	Funnel and Gate for Shallow Hot Spot Groundwater Remediation, and Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal
GWA-4:	In-Situ Chemical Treatment of Shallow and Deep Hot Spot Groundwater, Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal.

The following sections describe and evaluate the above listed alternatives using the eight criteria.

2.3.2.1 GWA-1: No Action

This alternative will not involve any remediation of contaminated groundwater. However, groundwater samples from the representative monitor wells will be collected and analyzed on an annual basis to evaluate the effectiveness of this alternative. These samples will be analyzed for VOCs. The fate and transport of contaminants in the groundwater will depend on the natural processes.

A detailed evaluation of this alternative is presented in Table 2-9, and Table 2-10 presents the opinion of probable costs for implementation of the no action alternative.

2.3.2.2 GWA-2: Vacuum-Enhanced Recovery of Shallow Groundwater (Hot Spot) and Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal

The scope of this alternative includes groundwater extraction in the shallow aquifer (overburden) using the vacuum-enhanced recovery (VER) technique. This technology enhances recovery of contaminated groundwater from low-permeability soils such as those present at the site. Figure 2-4 presents a conceptual process flow schematic of this alternative. The contaminated groundwater in the bedrock aquifer will be recovered using conventional pumping techniques. The recovered water from both shallow and bedrock aquifers will be treated aboveground prior to disposal. An air stripper and an activated carbon polishing system will be required to treat the VOCs. It is assumed that a portion of the treated water will be discharged via an infiltration gallery upgradient of the shallow VER wells and the remaining water will be discharged into Crow Branch Creek. It is assumed that the concentrations of dissolved organics in the recovered groundwater will be relatively lower; therefore, emissions from the air stripper or vacuum extraction will not require vapor phase treatment.

For the purpose of evaluating alternatives, five shallow (overburden) VER wells and four deep bedrock recovery wells are assumed. The exact number and locations of the shallow and bedrock extraction wells can be optimized by modeling capture zones using data from a bedrock aquifer test (pumping test) and a shallow aquifer VER pilot test. The shallow wells will be located downgradient of the source area (downgradient of Monitor Well MW-1). The bedrock recovery wells will be installed in the downgradient direction and south of Crow Branch Creek to function as containment wells. The extraction wells will be piped to a central treatment system. For the purposes of this evaluation, it is estimated that shallow wells will operate for approximately 5 years and deep extraction wells will operate for approximately 30 years.

A detailed evaluation of this alternative is presented in Table 2-9. Table 2-11 presents the opinion of probable costs for implementation of this alternative.

2.3.2.3 GWA-3: Funnel and Gate for Shallow Hot Spot Groundwater Remediation and Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal

The scope of this alternative includes a funnel and gate technology to achieve passive remediation of shallow groundwater in the overburden aquifer and conventional extraction of bedrock groundwater. An air stripper with a carbon polishing system will be used for groundwater treatment, and treated effluent will be discharged to Crow Branch Creek. Figure 2-5 presents a process flow schematic of this alternative.

The funnel and gate system will be constructed of low permeability wall using sheet piles. The gate will be constructed of permeable backfill with air sparging and vapor extraction points. The purpose of constructing a funnel is to convey shallow groundwater through the gate. As groundwater containing VOCs passes through the gate, it is volatilized by the air sparging system and the vapors are removed by a vapor extraction system. The funnel and gate system will be installed downgradient of Monitor Well MW-1 (hot spot) for the treatment of high concentration VOCs in the overburden aquifer. The conventional recovery wells for the bedrock aquifer will be constructed near the creek as in Alternative GWA-2.

A detailed evaluation of this alternative is presented in Table 2-9, and the present worth of capital and operation, maintenance, and monitoring (OMM) costs are presented in Table 2-12.

2.3.2.4 GWA-4: In-Situ Chemical Treatment of Shallow and Deep Hot Spot Groundwater, Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal

In-situ chemical oxidation of organic compounds can be achieved by injecting chemicals (acetic acid, ferrous sulfate, and hydrogen peroxide) in a sequence into injection/monitor wells. Injection of these chemicals will produce hydroxyl radicals which can oxidize organic compounds in-place. This process is patented by CleanOX® Environmental Services, Inc., Houston, Texas. Hydroxyl radicals are very powerful oxidizing agents which will oxidize organic compounds to carbon dioxide and water. Production of hydroxyl radicals will involve conversion from liquid to vapor state with a consequent large volume expansion. CleanOX® claims that this process has been applied at several sites with various saturated zone matrices (sands, silts and clays, and fractured bedrock).

This alternative consists of using the CleanOX® method for remediation of dissolved contaminants in both shallow (overburden) and deep bedrock hot spots. It is assumed that existing deep monitor wells, in addition to a set of shallow injection wells, will be required to implement this process for groundwater remediation. This scenario involves the use of the CleanOX® process to remediate in the shallow hot spots (around Monitor Well MW-1) and bedrock hot spots (around MW-14). However, a conventional groundwater recovery, treatment, and disposal will be required to contain remaining contaminants from reaching the nearby creek. As indicated in GWA-2, approximately four bedrock recovery wells are assumed to be sufficient to contain the bedrock contamination.

A detailed evaluation of this alternative is presented in Table 2-9, and the present worth of capital costs and OMM are presented in Table 2-13.

2.4 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section compares the relative performance of each alternative. Alternatives for source control and groundwater remediation are compared separately. The comparison is based on eight criteria used in evaluating alternatives (Section 2.3).

2.4.1 Comparison of Source Control Alternatives

The four source control alternatives evaluated in Section 2.3.1 are: SCA-1: No Action; SCA-2: Excavation of Primary and Secondary Sources, Off-Site Treatment, and Off-Site Disposal; SCA-3: Excavation of Primary Source and Off-Site Treatment/Disposal, and In-Situ Volatilization of Secondary Source; and SCA-4: In-Situ Volatilization and Solidification of Primary and Secondary Sources. These alternatives are compared with each other in Table 2-14 using the eight evaluation criteria.

2.4.2 Comparison of Groundwater Remedial Alternatives

The four groundwater remediation alternatives evaluated in Section 2.4.1 are: GWA-1: No Action; GWA-2: Vacuum Enhanced Recovery of Shallow Groundwater (Hot Spot) and Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal; GWA-3: Funnel and Gate for Shallow Hot Spot Groundwater Remediation and Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal; and GWA-4: In-Situ Chemical Treatment of Shallow and Bedrock Hot Spot Groundwater, Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal. These alternatives are compared with each other in Table 2-15 using the eight evaluation criteria.

2.5 SELECTION OF REMEDIAL ALTERNATIVES

The following sections briefly describe the selection of source control and groundwater remediation alternatives.

2.5.1 Selection of the Source Control Alternative

Based on the evaluation and comparison of alternatives in Sections 2.3.1 and 2.4.1, the no action alternative (SCA-1) is not expected to meet RAOs. Alternatives SCA-2, SCA-3, and SCA-4 are expected to meet RAOs. Excavation and off-site treatment/disposal is expected to be a very slow process compared to the in-situ volatilization/solidification process. In addition, impacts on the local community from the operation of equipment and vehicles for transporting waste/soil transport are high. The excavation process can be effective in removing source material with minimum or no residual contamination, whereas the in-situ treatment process may leave some residuals in-place. The residual contamination associated with in-situ treatment is expected to be minimal and will not adversely impact the environment. Exposure to contamination during implementation of Alternatives SCA-2, SCA-3, and SCA-4 can be minimized by proper monitoring and use of personnel protective equipment (PPE). Alternatives SCA-2, SCA-3, and SCA-4 are readily implementable with careful planning and are expected to be effective. Among Alternatives SCA-2, SCA-3, and SCA-4, Alternative SCA-4 is the least expensive alternative capable of meeting RAOs. Based on the factors discussed above, Alternative SCA-4 (in-situ volatilization and solidification) appears to be the most desirable option. Therefore, the University selected Alternative SCA-4 for implementation at the site.

2.5.2 Selection of Groundwater Remediation Alternative

As in source control, the no action alternative (GWA-1) will not meet all RAOs. Based on the evaluation and comparison of alternatives in Section 2.4.2, Alternatives GWA-2, GWA-3, and GWA-4 are expected to meet all RAOs. Due to remediation of hot spots and containment of the groundwater plume, Alternatives GWA-2, GWA-3, and GWA-4 are expected to be protective of human health and the environment. The in-situ chemical oxidation process in Alternative GWA-4 is an innovative method, but its field application at similar sites is limited. Alternative GWA-3 involves a passive method for containment and treatment (funnel and gate) of shallow hot spots, whereas Alternative GWA-2 involves active remediation of shallow hot spots using a VER technique. The VER system in Alternative GWA-2 is expected to have a shorter project life compared to that of the reactive wall (sparge curtain) in Alternative GWA-3. Alternative GWA-2 and GWA-3 are easily implementable. Remediation of the bedrock aquifer using either of Alternatives GWA-2, GWA-3, and GWA-4 is expected to be a long-term process and will produce similar long-term results. Finally, the opinion of probable costs indicates that Alternative GWA-2 is less expensive (not including Alternative GWA-1). Based on these factors, Alternative GWA-2 (VER for shallow hot spot remediation and conventional extraction of bedrock groundwater, treatment and disposal) appears to be the most desirable groundwater remediation alternative. Therefore, the University selected this alternative for implementation at the site.

3.0 PROPOSED REMEDY

This section presents the description and conceptual design of the proposed source control and groundwater remediation alternatives for Airport Road Waste Disposal Area in Chapel Hill, North Carolina. In addition, various plans required for implementing the proposed alternatives also are identified in this section.

3.1 DESCRIPTION OF THE PROPOSED REMEDY

The following sections describe the proposed source control and groundwater remedies for the site.

3.1.1 Source Control

The source control alternative selected is in-situ volatilization and solidification of primary and secondary sources. In the volatilization step, contaminated soil columns are mixed using a mobile equipment setup with a rotary mixing tool capable of injecting high pressure hot air/steam. Air injection rates and injection temperatures are site specific. Mixing soil within a column is accomplished by advancing and retracting a rotating auger into the soil to a desired treatment depth. During advancement and retraction of the auger, compressed air and/or steam are injected through the ports on the auger into the soil column while the auger is simultaneously breaking up and mixing the soil. VOCs and some SVOCs in the soil/waste matrix are volatilized. The volatilized contaminants are recovered by applying a vacuum on a shroud covering the ground surface where the soil column is being mixed. These recovered vapors can be treated and discharged into the atmosphere. The effectiveness of the volatilization process for the removal of VOCs depends on several parameters, including soil type, contaminant physical properties (Henry's Law Constant, solubility, and vapor pressure), temperature, and soil moisture content.

Upon completion of the volatilizing process, a cement-based solidification agent can be injected into the soil columns. The stabilization/solidification process will ensure non-volatile organic and inorganic compounds are bound/microencapsulated in-place by the solidifying agent. Depending upon the volume and depth of treatment, the soil column can vary in diameter from 6 feet to 18 feet. This method can be potentially used for treatment and solidification of both primary and secondary source materials/contaminated soils.

Bulking of stabilized soil will occur due to injection of cement during the solidification phase. Depending on the amount of bulking, the stabilized material can be either transported to an off-site facility or regraded on site. A final cover can be placed and seeded if solidified material is regraded on-site.

3.1.2 Groundwater Remediation

The proposed groundwater remediation alternative will include groundwater extraction in the shallow aquifer using the VER technique. Groundwater in the bedrock aquifer will be recovered using a conventional pumping technique. The recovered water from both shallow and bedrock aquifers will be treated aboveground prior to disposal. Based on existing information, primary contaminants are VOCs. Therefore, air stripping with activated carbon polishing appears to be the most applicable technique to treat the VOCs in the groundwater at the site. The need for a granular-activated carbon system will be based on the selected discharge route. To replenish groundwater in the shallow overburden, a portion of treated groundwater will be discharged into an infiltration gallery upgradient of the VER wells (near source area), and the remaining portion is expected to be discharged to Crow Branch Creek under an NPDES permit. Additionally, the effluent disposal to a local POTW will be further evaluated during the remedial design phase.

In the shallow aquifer, VER was selected to enhance recovery of contaminated groundwater due to the presence of low-permeability soils. Vacuum-enhanced pumping offers a considerable advantage over conventional pumping by increasing the effective gradient to the well, allowing an increased pumping rate and capture zone beyond that achieved by pumping alone. It is assumed that the concentrations of dissolved organics in the recovered groundwater will be relatively lower; therefore, emissions from the air stripper and vacuum extraction will not require vapor phase treatment.

It is assumed that the shallow wells (VER) will be located downgradient of the source area. The bedrock recovery wells are assumed to be installed in the downgradient direction, south of Crow Branch Creek, to act as containment wells.

3.2 CONCEPTUAL DESIGN OF THE PROPOSED REMEDY

The following sections discuss the conceptual design of the proposed source control and groundwater remedies.

3.2.1 Source Control: In-Situ Mixing/Solidification

The following sections identify the necessary steps for collecting the design data and present a conceptual design of the in-situ volatilization/solidification process.

3.2.1.1 Treatability Study

Prior to designing a full-scale system, a treatability study should be performed to evaluate the effectiveness of in-situ volatilization/solidification processes. This treatability study is expected to provide information necessary to design the pilot-scale/full-scale implementation. Soil/waste samples will be collected from four locations in the disposal area. The existing soil cover (4 to 5 feet thick) will be uncovered, and soil/waste samples will be collected from the primary source areas. A 5 gallon bucket of soil/waste will be collected at each sampling location. The collected samples will be shipped to a treatability laboratory for field testing.

An in-situ volatilization treatability study is expected to provide information such as removal rates, auger rotational speed, the rate of auger advance, the air/steam agent injection rate, mixing (cycle) time in the soil column, and number of mixing cycles.

The objective of the solidification treatability study is to determine the most effective reagent mixture for in-situ solidification of the soils and waste at the site. The addition of a reagent will initiate physical and/or chemical changes within the soil/waste matrix, thereby decreasing the solubility and/or mobility of hazardous constituents in the treated soil/waste.

Contaminants will become mechanically locked within the solidified matrix through a phenomenon called microencapsulation. Bench-scale testing will be conducted with a variety of mixtures of reagents and soil/waste. Subsequent testing will be conducted utilizing procedures which mimic, to the greatest extent possible, in-situ solidification procedures to be employed in pilot test/full-scale operations at the site.

The effectiveness of the reagents will be evaluated by observing the remolded compressive strength of the treated soil/waste matrix, the reduction of leachability in the constituents of concern as determined by the Toxicity Characteristic Leaching Procedure (TCLP) test, and the geotechnical properties (i.e., index properties, bulking factors, compressive strength permeability, and durability) of the treated soil/waste/matrix. However, the most important data to be derived are the residual concentrations of constituents after laboratory processing.

3.2.1.2 Full-Scale Design/Implementation

Based on the results from the bench-scale treatability study, a full-scale in-situ volatilization and solidification process will be designed for application at the site. For the volatilization process, the treatment time, auger advance/retraction rate, and air/steam injection rate will be determined based on the results from the treatability study. Similarly, for the solidification process, the mix ratios (i.e., percentage of soil/waste versus reagent) will be based on the results of the treatability study and will be designed to achieve the established physical and chemical treatment criteria for on-site disposal. In addition, the design will also include quality control and quality assurance requirements.

A pilot-scale in-situ volatilization/solidification test will be conducted as a part of the full-scale implementation process. Design parameters will be carefully monitored during this test. Data from this test will serve as verification of the design parameters and will be used to finalize or adjust the full-scale implementation in the field.

In the volatilization step, the auger will be advanced down to the top of the bedrock while injecting hot air/steam and mixing in-place. Typically, the zone of mixing and injection is approximately 18 inches thick. During advancement and retraction of the auger, the injected hot air/steam will heat the soil and groundwater surrounding the auger, and VOCs and some SVOCs will vaporize and migrate upward. This process may involve a number of cycles to be determined in the field. As presented in Figure 3-1, a series of overlapping columns of mixing will ensure proper treatment. The diameter of the auger to be used can vary between 8 to 16 feet and will be determined based on economical considerations.

During the volatilization process, air/steam injection pressure, air/steam injection rate, air temperature, soil temperature in the column, the off-gas flow rate, off-gas temperature, and concentration of organic compounds in the off-gas will be monitored periodically and recorded. In addition, auger advance rate, number of cycles, and augering sequence also will be monitored and recorded. The volatilization process will be followed by soil sampling and analysis. The soil samples will be collected using a direct-push technology. The locations and depths of the samples will be determined during the design phase and adjusted in the field during implementation.

The next step is solidification of the treatment area. The solidification process is anticipated for implementation by constructing the solidified periphery of the treatment area. As presented in Figure 3-1, a series of overlapping columns will be solidified to ensure proper treatment. Appropriate quality control/quality assurance protocols will be implemented to evaluate the effectiveness of the solidified material. The strength and leachability of the solidified material will be used as evaluating criteria and will be determined by the TCLP analysis and the geotechnical properties (i.e., index properties compressive strength, bulking factors, permeability, and durability) tests.

3.2.1.3 Permitting Requirements

It is assumed that emission control devices will be used during the implementation of a full-scale in-situ volatilization/solidification system. The 15A NCAC, 2Q, Air Permit Procedures, specifically require air permits for certain activities, including the installation of air emission control devices. An exemption to this requirement is available for remedial activities where less than five (5) tons per year of emissions result. However, it is anticipated that this threshold will be less than the significant emissions threshold associated with the new source review requirements (40 Code of Federal Regulations 51-52). This provision will be further evaluated during the design phase. If required, a permit application will be prepared and submitted to NCDEHNR Division of Air Quality (DAQ) for approval.

Additionally, an erosion and sediment control plan will be prepared, but no permit will be required since the area to be disturbed will be less than 1 acre. Local permits covering electrical service connection will be obtained by the contractor at the time of implementation.

3.2.1.4 Construction Drawings and Technical Specifications

In-situ volatilization/solidification procedures will be defined in a design report and contract document package, including construction drawings and technical specifications, depicting the general site conditions and requirements, staging areas, construction sequencing, mixture ratios, grading plans, stormwater management plan, final cover system, and appropriate supporting sections, profiles and details, and presented in a package suitable for construction bidding. A final cover system, potentially consisting of a soil cover with surface vegetative growth, will be designed over the solidified mass to prevent direct human and environmental contact with the treated soils and to minimize erosion from surface-water runoff. The construction drawings and technical specifications, which will be part of the contract document package, will be prepared in a manner that clearly portrays the intended remedial requirements and which assists in the contractor bidding process. A list of planned drawings is included in Appendix E-1.

Specifications for field testing the volatilization process and selected reagent mixtures will be defined in the contract document package to verify the results of the treatability study under full-scale site conditions. The contractor will perform this test at the outset of the full-scale in-situ volatilization/solidification process activities, prior to production, to permit scale-up, equipment, and procedural factors to be considered. If the defined performance criteria are not satisfied, refinement of the process procedures and reagent mix will be conducted by the contractor until the criteria are achieved. A list of planned specifications is included in Appendix E-1.

3.2.2 Groundwater Remediation: Pump-and-Treat

The following sections identify the necessary steps for collecting the design data and present a conceptual design of the groundwater remediation alternative. These steps will be completed as part of the final engineering design report.

3.2.2.1 Proposed Tests

Prior to designing a groundwater remediation system, aquifer properties should be determined. For the bedrock aquifer, a constant head pump test is proposed. Similarly, a VER pilot test is proposed for the shallow aquifer. In addition, an infiltration test is proposed to evaluate the infiltration potential of the subsurface. The following subsections briefly describe the proposed tests.

3.2.2.1.1 VER Pilot Test

A VER pumping test will be conducted to provide site-specific information for use in the design of a full-scale remedial system. The VER (shallow recovery) well will be installed to the top of bedrock (approximately 25 ft bls) and constructed of 4-inch-diameter stainless steel with 15 feet of screen. In addition, three additional 2-inch-diameter polyvinyl chloride (PVC) observation wells will be installed in close proximity to the recovery well for utilization during the VER pump test to monitor water levels and vacuum influence.

The VER test will be performed by connecting a high vacuum, liquid ring pump to the proposed 4-inch-diameter stainless steel VER well. Groundwater will be pumped from the VER well and discharged into an on-site tank. The effective radius of influence of the pumping well will be measured by collecting depth-to-water and vacuum readings from the proposed observation wells at regular intervals. Measurements may also be collected from other existing monitor wells on a periodic basis. The water flow rate at the discharge point also will be recorded at regular intervals. The vacuum pressure applied by the liquid ring pump will remain constant throughout the test, and the air flow velocity will be monitored. This test will be performed for approximately 8 hours. Additionally, groundwater and vapor samples will be collected and submitted for analysis. The groundwater samples will be analyzed for VOCs and other inorganic parameters necessary for designing a treatment system. The vapor samples will be analyzed for VOCs only. The drill cuttings, development water, and pump test water will be properly stored and disposed of to meet all regulatory requirements.

3.2.2.1.2 Bedrock Aquifer Test

A deep (bedrock) aquifer pumping test will be conducted to collect data for evaluating the aquifer properties required to design a bedrock recovery system. A bedrock recovery well will be constructed using a 6-inch-diameter steel surface casing to approximately 20 ft bls and drilling a 6-inch-diameter open borehole to approximately 80 ft bls. Three 4-inch-diameter open borehole observation wells will be installed in close proximity to the recovery well for utilization during the deep aquifer pump test. The 4-inch-diameter open borehole wells also will be constructed by installing a 4-inch-diameter steel surface casing to approximately 20 ft bls and drilling a 4-inch-diameter open borehole to approximately 80 ft bls.

A short-term step-drawdown test (approximately 6 hours) will be performed prior to the actual aquifer test to accurately calculate the pumping rate for the main test. The aquifer test will consist of a 24-hour drawdown test followed by an 8-hour recovery period.

During these tests, water-level data will be collected using data loggers and pressure transducers from the proposed observation wells and the pumping well. The depth-to-water information recorded by the data logger will be checked periodically with the use of an electronic water-level meter. Water levels also will be collected from other nearby deep bedrock monitor wells on a periodic basis using an electronic water-level meter. The water flow rate at the discharge point will be checked and recorded at regular intervals to ensure that a constant pumping rate is maintained. Groundwater samples will be collected for VOC analyses and other inorganic parameters. The drill cuttings, development water, and pump test water will be containerized, analyzed, and disposed of properly. Data obtained from the pump test will be reduced and aquifer properties, such as transmissivity and hydraulic conductivity, will be estimated.

3.2.2.1.3 Infiltration Test

A constant head permeameter test is proposed to evaluate the feasibility of infiltrating treated groundwater. This will involve setting a permeameter at the specified location (potential location of the infiltration gallery) and conducting a constant head test. This method is used to determine the saturated hydraulic conductivity of the unsaturated zone which is necessary information to allow design of an infiltration gallery. Results of this test also will be used to prepare a non-discharge permit application.

3.2.2.2 Groundwater Modeling

Computer modeling will be used to support decisions relating to selection of various alternative remedial strategies. The groundwater modeling will serve as a quantitative tool to characterize the complex groundwater flow system and to conceptually design and evaluate a groundwater pumping system to recover groundwater and dissolved phase constituents. Public domain MODFLOW (McDonald and Harbaugh, 1988) code will be used to simulate groundwater flow. MODFLOW is widely used in the industry, familiar to regulators, and has the flexibility to handle the boundary conditions found at the site. MODFLOW will be used in conjunction with MODPATH (Pollock, 1989) for capture zone analysis of both VER and bedrock recovery systems.

3.2.2.3 Process Design

The process design will include design of both shallow and bedrock recovery systems, a groundwater treatment system, and equipment specifications.

3.2.2.3.1 Recovery System Design

The number of recovery wells incorporated into the conceptual design in this RAP is based on past experience at sites similar to the UNC Airport Road Waste Disposal Area and best engineering judgment. The groundwater extraction system is expected to consist of approximately five shallow (overburden) extraction wells and four deep bedrock recovery wells. Figure 3-2 presents the preliminary proposed recovery well locations. However, the actual number and location of VER and bedrock recovery wells will be based on groundwater modeling results. Data from the bedrock aquifer test (to be performed) and VER pilot test will be used for modeling the capture zones in the remedial design phase.

The recovery well screens and gravel pack will be properly sized to prevent the aquifer material (fines) from entering the wells. Data gathered during the pilot test (recovery wells installation) will be used to select the screen and packing. The shallow recovery wells will be constructed of 4-inch-diameter stainless steel screen and casing and will be screened from approximately 5 to 25 ft bls. The deep recovery wells will be constructed using 6-inch-diameter steel surface casing to approximately 20 ft bls. A 6-inch-diameter open borehole will then be drilled to approximately 80 ft bls. Figures 3-3 and 3-4 present the construction details of a typical VER and groundwater recovery well, respectively.

Recovery piping will be designed to convey extracted groundwater from the bedrock recovery and VER wells to a centralized treatment system. Typically, this piping will be schedule 40 PVC or polyethylene, installed in a trench below the freeze line (approximately 2 feet deep). The trench will be backfilled and compacted after installation of piping. Pumps will be appropriately sized based on the total design head and flow rate. It is anticipated that liquid-ring pumps with drop tubes will be utilized for the VER wells, and electric submersible pumps will be utilized for the bedrock recovery wells. Extracted water from the recovery system will be conveyed to the treatment system. Figure 3-2 presents a preliminary layout of the proposed recovery wells, piping, treatment, and disposal locations.

3.2.2.3.2 Treatment System Design

The contaminated water from the recovery wells will be conveyed into an air stripper. Based on past experience at similar sites, a low-profile air stripper provides more efficient performance and requires less maintenance. The unit size, number of trays, and air-to-water ratio required to achieve required discharge criteria of the air stripper will be based on flow rates and influent contaminant concentrations which will be estimated based on the results from the aquifer tests.

A low-profile air stripper process uses forced draft, countercurrent air routed through baffled aeration trays to remove VOCs from the groundwater. Influent groundwater is allowed to flow into the inlet chamber over a distribution weir and along the baffled aeration trays. Clean air is blown up through the perforated aeration tray, forming a froth of bubbles which creates a large mass transfer surface area to volatilize VOCs. The treated water then flows into the next phase of treatment, and the contaminated air will be discharged directly into the atmosphere.

The treated groundwater from the air stripper sump will be pumped through a set of activated carbon vessels using a transfer pump. The activated carbon will function as a polishing unit to remove untreated organic contaminants from the air stripper. A portion of the treated effluent will gravity flow into an infiltration gallery. The remaining water will be gravity discharged into Crow Branch Creek. The spent carbon will be shipped to an off-site permitted facility for regeneration or disposal, and a fresh carbon vessel will be placed in its location. Figure 3-5 presents a preliminary process flow diagram. The treatment system is designed to operate continuously and will be provided with safety features to prevent accidental releases of untreated water.

Figure 3-6 presents the preliminary layout of the proposed treatment system. A concrete pad will be constructed to provide a level surface for the treatment equipment. The equipment pad will be enclosed inside a building to protect it from vandalism and weather.

3.2.2.4 Permitting

Permits/notifications will be required to implement the remedial action. The following permit applications/notifications will be filed with appropriate regulatory agencies:

1. NPDES permit application for disposal of treated effluent will be filed with the DWQ;
2. Non-Discharge permit application for disposal of treated effluent via infiltration gallery will be filed with the DWQ;
3. Recovery well construction permits will be obtained from the DWQ;
4. Notification will be provided to the DAQ.

3.2.2.5 Construction Plans and Specifications

A set of construction drawings will be prepared to assist in constructing the groundwater remediation system. The proposed construction drawings will include site layout, piping and instrumentation diagram, equipment layout, electrical details, and mechanical details. A list of potential drawings is included in Appendix E-2.

Technical specifications will accompany the construction drawings. These specifications will conform to Construction Specification Institute (CSI) format. A list of technical specification sections is included in Appendix E-2.

3.3 PROPOSED REMEDIAL ACTIVITIES

The major remedial activities necessary to implement the proposed remedy will include the preparation of construction plans and technical specifications. A site remediation contract document package will include:

- construction plans,
- technical specifications,

- bidding information, and
- proposed contract/agreement.

Bid documents will be submitted to qualified contractors. All bidding activities will be coordinated with UNC Facility Planning Department and will be in accordance with State of North Carolina Guidelines and Laws. After providing an opportunity for the contractors to review the documents, a pre-bid meeting will be held at the site to familiarize contractors with site conditions. Any questions and concerns regarding the remedial system construction will be addressed in this meeting. Any minor changes in the design that may be required to improve the constructability of the remedial system or clarifications recognized during the pre-bid meeting will be addressed as an addendum to the bid-package. This addendum will be submitted to all qualified contractors who received the bid package.

Upon receipt of the bids from the qualified contractors, an appropriate contractor will be selected to construct the remedial system. Separate contractors will be selected for implementing in-situ volatilization/stabilization and groundwater pump-and-treat systems. Generally, the contractors will be selected on the merits of the plan, the price, and qualifications, including previous similar experience. Subsequent to the award of the contract, the selected contractor will be required to submit site-specific pre-construction work plans which will include, at a minimum, a schedule of activities, equipment/material procurement, a Contractor's Site Safety Plan (CSSP), a commitment regarding the personnel and equipment availability, and a list of all subcontractors and their qualifications.

The selected contractor will be responsible for constructing the component systems in conformance with the project design plans and specifications as economically and efficiently as possible without disruption to on-site or off-site activities.

3.4 HEALTH AND SAFETY PLAN

A health and safety plan (HASP) was prepared for the remedial action implementation at the site, and is presented in Appendix F.

3.5 POST-REMEDIAL ACTIVITIES

Post-remedial activities will include regular inspection and monitoring to ensure proper operation of the proposed remedial system. The following sections describe the proposed inspection/monitoring program.

3.5.1 Source Control: In-Situ Volatilization/Solidification

Post-remedial activities will involve site inspection to ensure that no erosion of the cover has occurred. Based on the site inspections, suitable corrective actions will be implemented. The site inspections will be conducted on a quarterly basis during the first year, and semi-annually for the next 4 years. Upon completion of 5 years, the need for further site inspections will be evaluated.

3.5.2 Groundwater Remediation: Pump-and-Treat

An environmental monitoring program is required to monitor the progress of remediation and ensure that remedial efforts meet the design objectives. Based on the monitoring data, the groundwater recovery system can be optimized by making appropriate field alterations.

3.5.2.1 Operation and Maintenance

Operation and maintenance (O&M) of the remediation system will be performed on a periodic basis. O&M tasks will consist of an inspection of the recovery system, the air stripper, the activated carbon system, and infiltration gallery. A system check will be performed to ensure that the recovery pumps are operating properly. In addition to this inspection, the following tasks will be conducted:

- Inspect air stripper blower flow switch and all tank high-level switches for proper operation;
- Inspect air stripper for fouling;

- Measure and record vapors and groundwater flow rates;
- Measure and record vacuum readings on all VER and nearby monitor wells;
- Measure and record pressure reading on the carbon vessels;
- Measure and record water levels from all site monitor wells;
- Inspect and cleanup totalizers, if fouled; and
- Inspect pressure gauges located on the aqueous phase activated carbon canisters.

3.5.3 Groundwater Monitoring

Water levels in the monitor wells and recovery wells will be measured on a monthly basis during the first year of operation, quarterly for the next 3 years, and semi-annually thereafter. This data will be used to construct groundwater elevation maps and to evaluate the groundwater recovery system's effectiveness in containing and remediating the dissolved contaminant plume.

The combined header of VER recovery wells will be sampled initially at startup and quarterly thereafter. The measurement frequency may change based on sampling results and reduction of contaminant concentrations. In addition, individual VER wells may be sampled to support the system shutdown. Similarly, the bedrock recovery wells will be sampled individually during startup, quarterly during first year of operation, and annually thereafter.

Combined influent to the treatment system (air stripper) will be sampled once weekly during the first month of system operation, quarterly during the first year, and semi-annually thereafter. These samples will be analyzed for VOCs using U.S. Environmental Protection Agency (USEPA) Method 8260. Effluent from the treatment system will be sampled and analyzed according to the requirements of the non-discharge and NPDES permits. Groundwater samples will be collected from the air stripper effluent on an as-needed basis to evaluate the contaminant load to the carbon system and to determine the need to change out the carbon vessels. The pumping rates and recovery system operation will be re-evaluated if analytical data indicate that the groundwater recovery system is producing groundwater with higher than anticipated VOC concentrations.

The proposed monitoring program also will include semi-annual sampling of selected monitor wells during the first year of implementation and annually the second year. These samples will be analyzed for VOCs using USEPA Method 8260. This monitoring plan will be adjusted after the second year. The monitor wells to be sampled will be selected in the design phase.

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