REMEDIATION SYSTEM EVALUATION

FORMER HONEYWELL FACILITY
FORT WASHINGTON, PENNSYLVANIA

Report of the Remediation System Evaluation,
Site Visit Conducted at the Former Honeywell Facility, Fort Washington, Pennsylvania
January 30, 2003

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Office of Solid Waste
and Emergency Response
(5102G)

EPA 542-F-04-025
July 2003
www.epa.gov/tio
clu-in.org/optimization

Remediation System Evaluation
Former Honeywell Facility
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NOTICE AND DISCLAIMER

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This report has undergone review by the EPA site managers and EPA headquarters staff. For more infomation about this project, contact: Mike Fitzpatrick (703-308-8411 or fitzpatrick.mike@epa.gov) or Kathy Yager (617-918-8362 or yager.kathleen@epa.gov).

EXECUTIVE SUMMARY

A Remediation System Evaluation (RSE) involves a team of expert hydrogeologists and engineers, independent of the site, conducting a third-party evaluation of site operations. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, effectiveness in protecting human health and the environment, and site exit strategy. The evaluation includes reviewing site documents, visiting the site for up to 1.5 days, and compiling a report that includes recommendations to improve the system. Recommendations, including estimates of resulting net cost impacts, are provided in the following four categories:

- improvements in remedy effectiveness in protecting human health and the environment
- reductions in operation and maintenance costs
- technical improvements
- gaining site closeout

The recommendations are intended to help the site team (the responsible party and the regulators) identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, might be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation by the RSE team, and represent the opinions of the RSE team. These recommendations do not constitute requirements for future action, but rather are provided for the consideration of all site stakeholders.

The Honeywell facility is located at 1100 Virginia Drive in Upper Dublin Township, Montgomery County, Pennsylvania in the Fort Washington Industrial Park. The property is approximately 67 acres and is owned by 1100 Virginia Drive Associates. The main building is 861,000 square feet. The facility was built in 1964 and was primarily used for the manufacturing of electronic controls and mechanical valve assemblies. In 1986, Honeywell sold the property but continues to lease office space. A portion of the main building (approximately 103,000 square feet) is also used by the DeVry University. Soil sampling related to a tank excavation in 1986 provided the first documented presence of subsurface contamination. Further investigations revealed ground water concentrations of trichloroethene (TCE) exceeding 10,000 ug/L. A pump and treat (P&T) system operates at the facility as a final remedy, which is the focus of this RSE.

The RSE team observed an extremely well-managed remedy. Honeywell, their contractors, and EPA all have an excellent understanding of the site conditions, the remedy, and potential risks. Continuing efforts have been made by the site team as a whole to improve system operation and protect human health and the environment. The observations and recommendations contained in this report are not intended to imply a deficiency in the work of either the system designers or operators but are offered as constructive suggestions in the best interest of the EPA, the public, and the facility. These recommendations have the obvious benefit of being formulated based upon operational data unavailable to the original designers.

Recommendations are provided in all four categories: effectiveness, cost reduction, technical improvement, and site closeout. The recommendations to improve effectiveness include the following:

- Further evaluate the potential for vapor intrusion into the main building occupied by DeVry University.

- Consider the installation of two monitoring wells to assist in the evaluation of plume capture.

- Modify the interpretation of plume capture by correcting the water levels in the extraction wells for well losses and adding three existing offsite wells to the sampling program.

- Consider institutional controls.

Recommendations for cost reduction include the following:

- Consider replacing the currently used UVOX system with an air stripper and off-gas treatment with vapor phase granular activated carbon (GAC). If implemented, this recommendation might require up to $100,000 in capital costs but might save $27,500 per year in annual O&M costs. Implementing this recommendation is contingent upon decisions made regarding implementation of the site-closeout recommendations.

- Consider revising the ground water monitoring program by reducing the sampling frequency at select wells. The sampling and analysis frequency is discussed and a potential revised monitoring program is provided. If implemented, this recommendation should not require any capital costs and might save $16,000 per year in annual sampling and analysis costs.

The remaining recommendations pertain to technical improvement and site closeout. Notable recommendations include considering alternative remedial approaches to address persistently elevated contaminant concentrations in a localized area and modifying the remedy based on the results from implementing those approaches.

A table summarizing the recommendations, including estimated costs and/or savings associated with those recommendations, is presented in Section 7.0 of this report.

PREFACE

This report was prepared as part of a pilot project conducted by the United States Environmental Protection Agency (USEPA) Office of Solid Waste (OSW) and Technology Innovation Office (TIO). The objective of this project is to conduct Remediation System Evaluations (RSEs) of pump and treat systems under the Resource Conservation and Recovery Act. The following organizations are implementing this project.

Organization	Key Contact	Contact Information
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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000, 2001, and 2002 Remediation System Evaluations (RSEs) were conducted at 24 Fund-lead pump and treat (P&T) sites (i.e., those sites with pump and treat systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, EPA TIO and OSW are performing a pilot study of conducting RSEs at RCRA sites. During fiscal year 2003, RSEs at up to 5 RCRA sites are planned in an effort to evaluate the effectiveness of this optimization tool for this class of sites. GeoTrans, Inc., an EPA contractor, is conducting these evaluations, and representatives from EPA OSW and TIO are attending the RSEs as observers.

The Remediation System Evaluation (RSE) process was developed by the US Army Corps of Engineers (USACE) and is documented on the following website:

http://www.environmental.usace.army.mil/library/guide/rsechk/rsechk.html

A RSE involves a team of expert hydrogeologists and engineers, independent of the site, conducting a third-party evaluation of site operations. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, effectiveness in protecting human health and the environment, and site exit strategy. The evaluation includes reviewing site documents, visiting the site for 1 to 1.5 days, and compiling a report that includes recommendations to improve the system. Recommendations with cost and cost savings estimates are provided in the following four categories:

- improvements in remedy effectiveness in protecting human health and the environment
- reductions in operation and maintenance costs
- technical improvements
- gaining site closeout

The recommendations are intended to help the site team (the responsible party and the regulators) identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, might be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation by the RSE team, and represent the opinions of the RSE team. These recommendations do not constitute requirements for future action, but rather are provided for the consideration of all site stakeholders.

The Honeywell Fort Washington facility was selected by EPA OSW based on progress made toward Environmental Indicators and comments from the EPA project manager for the site . This report provides a brief background on the site and current operations, a summary of the observations made during a site visit, and recommendations for changes and additional studies. The cost impacts of the recommendations are also discussed.

1.2 TEAM COMPOSITION

The team conducting the RSE consisted of the following individuals:

Rob Greenwald, Hydrogeologist, GeoTrans, Inc.
Peter Rich, Civil and Environmental Engineer, GeoTrans, Inc.
Doug Sutton, Water Resources Engineer, GeoTrans, Inc.

The RSE team was also accompanied by Bob Maxey from EPA OSW, who served as an observer of the RSE process.

1.3 DOCUMENTS REVIEWED

Author	Date	Title
EEC Environmental, Inc.	2/1992	Interim Measures Design
Harding Lawson Assoc.	12/15/1993	Draft Results of the RCRA Facility Investigation
Harding Lawson Assoc.	7/14/1994	Results of Bedrock Investigation
Harding Lawson Assoc.	8/4/1994	Draft Results of Risk Assessment Activities
US EPA	8/24/1994	Statement of Basis
US EPA	12/16/1994	Final Decision and Response to Comments
US EPA	8/18/1995	Final Administrative Order on Consent
Harding Lawson Assoc.	11/9/1995	Draft Results of Aquifer Performance Test and UV/Peroxide Oxidation Treatability Study
Harding Lawson Assoc.	2/13/1996	Quarterly Progress Report November 1995 through January 1996
Harding Lawson Assoc.	5/21/1996	Quarterly Progress Report February through April 1996
Harding Lawson Assoc.	8/12/1996	Quarterly Progress Report May through July 1996
Harding Lawson Assoc.	11/8/1996	Quarterly Progress Report August through October 1996
Harding Lawson Assoc.	5/21/1996	Groundwater Extraction and Treatment System
Harding Lawson Assoc.	5/21/1996	Results of Groundwater Flow Modeling
US EPA	6/19/1996	Letter to James Platt to provide comments on flow modeling and 30% design report
US EPA	1/23/1997	Letter to James Platt to clarify statement in 1/8/1997 letter

Author	Date	Title
Harding Lawson Assoc.	11/15/1996	Responses to EPA Comments on Pre-final Design
Harding Lawson Assoc.	2/12/1998	Quarterly and Annual Progress Report Period Ending January 1998
Hydro-Geo Services, Inc.	1/3/2002	Final Report Act 2 Land Recycling Program Site Characterization for 1070 Virginia Drive
Harding ESE	5/10/2002	Quarterly Progress Report Period Ending April 2002
Harding ESE	6/19/2002	Draft Five-Year Review Report Corrective Measures Implementation (CMI) Report Period 7/97 through 6/02
Harding ESE	7/10/2002	Vapor Intrustion Evaluation
US EPA	7/24/2002	Letter providing comments on vapor intrusion evaluation
Harding ESE	8/12/2002	Letter responding to EPA comments on vapor intrusion evaluation
Harding ESE	8/9/2002	Quarterly Progress Report Period Ending July 2002
MACTEC	11/13/2002	Quarterly Progress Report Period Ending October 2002

1.4 PERSONS CONTACTED

The following individuals associated with the site were present for the visit:

Joel Hennessy, EPA Region 3
Mike Cramer, EPA Region 3, Environmental Scientist
Darius Ostrauskas, EPA Region 3, EPA Project Manager for Honeywell Fort Washington Site

Emil Walerko, Honeywell, Project Leader, Health Safety, Environment and Remediation
James Platt, Honeywell, Manager, Facilities and Services - East

Randy Talbot, P.E., Harding ESE, Infrastructure Manager
J. Vincent Saleski, MACTEC, Senior Hydrologist

1.5 SITE LOCATION, HISTORY, AND CHARACTERISTICS

1.5.1 LOCATION

The Honeywell facility is located at 1100 Virginia Drive in Upper Dublin Township, Montgomery County, Pennsylvania in the Fort Washington Industrial Park. The property is approximately 67 acres and owned by 1100 Virginia Drive Associates. The main building is 861,000 square feet. The remainder of the property is an asphalt parking lot and grass. The site is bordered by Virginia Drive and then the Pennsylvania Turnpike to the south. Camp Hill Road and a residential area borders the site on the north. Undeveloped property is located immediately to the west. Commercial and industrial area is located further to the west and also borders the site to the east. Figure 1-1 provides a map of the site and the surrounding area.

The facility was built in 1964, and at the time, was the largest manufacturing facility east of the Mississippi River. The facility was primarily used for the manufacturing of electronic controls and mechanical valve assemblies. In 1986, Honeywell sold the property but continues to lease office space. A portion of the main building (approximately 103,000 square feet) is also used by the DeVry University.

Soil sampling related to a tank excavation in 1986 provided the first documented presence of subsurface contamination. Further investigations revealed ground water concentrations of trichloroethene (TCE) exceeding 10,000 ug/L. A pump and treat (P&T) system operates at the facility as a final remedy, which is the focus of this RSE. A brief site chronology is provided below:

1964	-	Facility is constructed and manufacturing begins
1986	-	Honeywell sells property but continues to lease office space
1986 - 1991	-	Nine phases of environmental investigations are performed, indicating ground water and soil vapor are contaminated with TCE. Former UST 8 is identified as the likely source of TCE. Approximately 22 monitoring wells/piezometers are installed in either the overburden or bedrock as part of these investigations.
1992	-	Ground water sampling identifies TCE in MW-9D exceeding 85,000 ug/L
1993	-	Surface water sampling identified TCE at concentrations below the Maximum Contaminant Levels (MCLs) and consistent with background levels.
	-	An Ecological Assessment identifies Pine Run Creek as the only potential ecological receptor of contaminated ground water and that short-term and future impacts were likely minimal.
	-	Interim remedial measures includes extraction of ground water at a total rate of 0.5 gpm from RW-1 and RW-2 and treatment via granular activated carbon (GAC). Operation of this system continues through July 1997 when construction of the final remedy is completed.
1994	-	USEPA Final Decision and Response to Comments specifies that the Corrective Measures Objectives are to restore ground water to MCLs.
	-	Honeywell contractors complete a Bedrock Investigation.
	-	Honeywell submits a Draft Results of Risk Assessment Activities and Corrective Measures Study.
	-	Honeywell contractors performs an Aquifer Performance Test and UV Oxidation (UVOX) Treatability Study.

1996	-	EPA approves of decommissioning MW-11 due to its location within the Fort Washington Expo Center.
	-	Honeywell contractors conduct ground water flow modeling in conjunction with final remedy design.
	-	Honeywell submits the final design for the final remedy P&T system.
1997	-	Final remedy begins operation. Active remediation includes ground water extraction and treatment of ground water at a total rate of approximately 10 gpm.
1999	-	EPA approves removing benzene from the list of compounds of interest (COI) due to benzene concentrations below the MCLs for three consecutive sampling events.
	-	EPA approves of discontinuing analysis for inorganics and to reduce treatment plant influent sampling from monthly to quarterly.
2000	-	EPA approves of reducing the sampling frequency of residences along Camp Hill Road from annual to biannual.
2001	-	EPA approves of decommissioning MW-12 due to its potential for disrupting security and activities within the building for a different tenant.
2002	-	EPA approves decommissioning of MW-8 and RW-2. A replacement well for MW-8 is installed.
	-	Honeywell submits a Vapor Intrusion Study of the main building at the site using the Johnson and Ettinger (J&E) model. Results of the study suggest risks are considered negligible. Further evaluation suggests that the building is under positive pressure thereby preventing the influx of contaminant vapors into the building from the subsurface. EPA suggests the need for further evaluation.
2003	-	DeVry University begins classes in the main building.

1.5.2 Potential Sources

The original source of contamination is assumed to be former UST 8 due to its location relative to ground water contamination and its use for storing TCE. Although UST 8 has been removed and releases are not continuing, ground water concentrations of TCE are indicative of dense non-aqueous phase liquid (DNAPL) in the vicinity of former UST 8. MW-9D is located adjacent to the location of former UST 8 and dissolved TCE concentrations in this well have exceeded 15,000 ug/L since 1997 despite continuous pumping from nearby RW-3. Solubility of TCE in water is approximately 1,100,000 ug/L at 20 C (Groundwater Chemicals Desk Reference, 1991). Therefore, TCE concentrations have consistently exceeded 1% of the reported solubility for over 5 years.

As DNAPL continues to dissolve in the ground water, it serves as a continuing source of dissolved ground water contamination. Although DNAPL has not been directly observed at the site, its presence (perhaps in the residual form) might explain the persistent elevated concentrations at MW-9D.

1.5.3 HYDROGEOLOGIC SETTING

The site elevation is approximately 190 feet above mean sea level (MSL) and slopes gently to the south from the source area to Pine Run Creek. A steep rise in elevation to approximately 220 feet is present from the source to Camp Hill Road to the north. A northwest/southeast geological cross-section (along strike) from the 1993 *RCRA Facility Investigation* (RFI) report is presented in Figure 1-2. The upper portion of the subsurface, referred to as Zone A in the RFI report, consists of unconsolidated materials, predominantly fill and alluvial sediments. The thickness of Zone A ranges from approximately 20 feet near the southern property boundary to approximately 4 feet near the source area to no appreciable thickness near the northern property boundary.

Beneath Zone A is bedrock consisting of alternating layers of silstone/shale, sandstone, and shale. Regional dip of these layers is to the northwest at approximately 11 degrees from horizontal. The RFI report categorizes bedrock into two zones (not distinguished in Figure 1-2):

- Zone B consists of weathered, highly fractured bedrock that is hydraulically connected to Zone A. The thickness of Zone B varies across the site, and its vertical extent has been observed to an approximate depth of 60 feet below ground surface (bgs) near MW-1D/MW-2D. It is unclear from the available data and from discussions during the site visit if Zone B is horizontally superimposed over the dipping layers or if Zone B dips with the formation.

- Zone C is the deeper, fractured portion of the bedrock underlying Zone B. An aquiclude has been found between Zones B and C, but pumping conducted during the bedrock investigation suggests that the aquiclude is not continuous across the entire site. For example, the *Bedrock Investigation Report* suggests that the aquiclude might not be present near MW-4D.

Another prominent geologic feature at the site that influences ground water flow is a diabase dike located beneath Camp Hill Road. Geophysical and pumping data presented in the RFI suggests that this dike serves as an impermeable barrier to ground water flow to the north.

The depth to water at the site varies with time, but the RFI report suggests that ground water elevation ranges across the site from approximately 2 feet bgs near former UST 8 to 7 feet bgs at the southern property boundary.

In Zone A, ground water flows to the south but is intercepted by the former bed of Pine Run Creek (the creek was moved further south to its current location prior to facility construction). The former creek bed runs east-west, and ground water turns to the west along this buried feature.

Ground water flow in Zones B and C is more complicated. For example, the RFI suggests that ground water flow is influenced by a downward flow component that is deflected in the direction of bedding dips and along fractures. Principal fracture directions are reportedly along strike (northeast to southwest) and perpendicular to strike (northwest to southeast). The hydraulic conductivity in Zone B is several orders of magnitude higher than in Zone C.

1.5.4 POTENTIAL RECEPTORS

The current potential receptors in the area are as follows:

- Residences using ground water to the north of the property on the other side of Camp Hill Drive are potential receptors for ground water contamination.

- The DeVry University building on site is a potential receptor for contaminant vapors.

- Pine Run Creek, which flows along the southern border of the site and off to the west, is a potential receptor for ground water contamination.

Each of the potential exposure pathways to these potential receptors are discussed further in Section 5.0 of this report. Potential receptors also include potential future users of impacted ground water and occupants of potential future buildings on the neighboring property at 1070 Virginia Drive.

1.5.5 DESCRIPTION OF GROUND WATER PLUME

The ground water plume in Zone A (unconsolidated material) extends to the south/southwest from the source area and onto the neighboring undeveloped property at 1070 Virginia Drive as evidenced by sampling from HGS-1, HGS-2, HGS-3 and grab samples taken during soil borings in 2001. The maximum sampled TCE concentrations for HGS-1, HGS-2, and HGS-3 are 270 ug/L, 18 ug/L, and 48 ug/L, respectively. Concentrations in Zone A at the facility and immediately downgradient of the source zone are typically on the order of 1,000 ug/L.

In Zones B and C, TCE concentrations are generally above 100 ug/L. The plume in these zones appears to extend from the source area to the northwest toward MW-4D (a pumping well) and to the north (upgradient but down dip) toward MW-27. The greatest TCE concentrations are repeatedly measured in MW-9D and RW-3 (a pumping well). Concentrations in MW-9D are persistently above 16,000 ug/L. Concentrations in RW-3 have decreased from 30,000 ug/L but appear to be asymptotically approaching a value of 5,000 ug/L or higher.

Figure 1-3 depicts the extent of contamination by presenting ground water sampling and analysis results from October 2002. The 2001 sampling results from the site characterization of 1070 Virginia Drive are also included.

2.0 SYSTEM DESCRIPTION

2.1 SYSTEM OVERVIEW

The P&T system extracts ground water from two recovery wells, treats the extracted water with UV/oxidation (UVOX) and polishing with GAC, and then discharges treated water to the POTW.

2.2 EXTRACTION SYSTEM

The extraction system consists of 2 recovery wells, RW-3 and MW-4D equipped with transducers and 0.75 HP electric submersible Grundfos pumps. The extraction wells are located 200 feet (RW-3) and 500 feet (MW-4D) from the former UST source area. MW-4D is completed with open hole from 47 to 57 feet bgs. RW-3 has a stainless steel screen from 10 to 50 feet bgs. The pumping rate at each well is throttled (a throttling valve is present at each well head) so that a continuous flow is maintained to the extent possible while the water level is between the high and low transducer set points. Ground water is routed separately from each well underground to the treatment building through double containment (1.5-inch diameter polypropylene carrier pipe with 3-inch diameter PVC containment pipe). The flow rate from the two wells combined is about 9 gpm, but the flow rate from each well might vary from month to month. The lines from each well enter the treatment building and include individual Y-strainers, sampling ports, check and globe valves and flow meters prior to being combined in a 2-inch diameter polypropylene line to enter the equalization tank.

The extraction well and blended treatment plant influent parameters are summarized in the following table.

Extraction Well	Formation Screened	Extraction Rate (gpm)	TCE Conc. (ug/L)	TCE Pounds Per Day (lbs/day)	% of mass Extracted
RW-3	Zone B/C	4.5*	6,900	0.37	96%
MW-4D	Zone B/C	4.5*	300	0.016	4%
	Plant Influent	**9.0**	**3,600**	**0.386**	**100%**

Extraction rates and concentrations taken from October 2002 Progress Report
Influent values are calculated based on extraction well data.
** The extraction rate in each well might vary from month to month, but the 4.5 gpm for each well from the October 2002 Progress report is representative*

2.3 TREATMENT SYSTEM

The treatment system is housed in 25-foot by 28-foot concrete block building with a roll-up door and two 10 KW heaters. The treatment system has an autodialer and a modem that allows remote viewing of water levels in wells, the EQ tank, and alarm conditions to be viewed remotely.

The treatment system is designed to treat an average flowrate of 10 gpm and a maximum of 30 gpm. The design influent concentrations are as follows:

- 100,000 ug/L trichloroethene (TCE)
- 100 ug/L 1,2-dichloroethene (1,2-DCE)
- 880 ug/L 1,1-dichloroethene (1,1-DCE)
- 20 ug/l 1,1-dichloroethane (1,1-DCA)
- 3 ug/l 1,2-dichloroethane (1,2-DCA)

Therefore, the design mass removal rate is approximately 12 to 36 pounds per day of TCE (and approximately 0.1 pounds per day of other constituents), compared to the current mass removal rate of 0.39 pounds per day of TCE. The treatment consists of the following components:

Equalization Tank: This is a 1,625 gallon flat bottom polyethylene tank. It receives water from the 2 extraction wells, the building sump and purge water from monitoring well sampling. Water is transferred from the tank by a 2 HP centrifugal process feed pump that operates based on level controls in the EQ tank.

Bag Filters: Water is routed form the EQ tank through 2 parallel bag filters, Rosedale PolyPro 8 models. The bag filters are equipped with a differential pressure alarm to notify the operator when the filter bags require changing. Ten micron bags are used in the filters.

UVOX System: After the bag filters hydrogen peroxide is added to the process water at a rate of about 28 ml/minute and mixed with a static mixer prior to the water entering the oxidation unit. It is a 30 KW Calgon oxidation unit with 6 UV bulbs and a hydrogen peroxide storage tank with metering pumps and a 2HP air compressor. The unit operates on a batch basis. It is activated when flow from the process transfer pump starts. A minimum of about 10 gpm and an average rate of about 15 gpm is maintained through the unit.

Liquid GAC Units: Following the UVOX system water is routed to two liquid GAC units operated in series. Each of these units contains 1,000 pounds of GAC. Following the GAC units the process water is discharged to the POTW.

2.4 MONITORING PROGRAM

The POTW requires monthly effluent sampling from each of the GAC units. Other process monitoring is conducted quarterly in conjunction with the ground water monitoring. Quarterly samples are collected from the following process locations:

- the RW-3 extraction well influent
- the MW-4D extraction well influent
- the blended influent to the UVOX system (before the hydrogen peroxide addition)
- the UVOX effluent
- effluent from the first GAC unit
- effluent from the second GAC unit

Analyses of all samples are provided on a three-week turnaround with the exception of the effluent from the first GAC unit, which is provided on a one-week turnaround. If the analysis shows no detection, then the sample of the effluent from the second GAC unit is discarded. It should also be noted that samples are occasionally collected and analyzed after the process water flows through four of the six UVOX chambers to determine the UVOX effectiveness. Effluent from the UVOX system is analyzed on-site for hydrogen peroxide with a Hach test kit.

In addition to quarterly monitoring of the extraction wells, the ground water monitoring program consists of both quarterly and semi-annual monitoring as presented in the following table.

Quarterly (13 Monitoring Wells)		**Semi-annually (2 Monitoring wells)**
MW-01	MW-17	MW-9D
MW-02D	MW-19	MW-25
MW-03D	MW-20	
MW-05	MW-26	
MW-07D	MW-27	
MW-08D	MW-28	
MW-16		

Samples are analyzed with EPA SW846 Method 8021b ("8021b"). Four surface water samples are collected from Pine Run Creek semi-annually and samples from four residences across Camp Hill Road are sampled bi-annually (once every two years).

Ground water elevations are collected quarterly and potentiometric surface maps are prepared and included with the quarterly progress reports.

3.0 SYSTEM OBJECTIVES, PERFORMANCE AND CLOSURE CRITERIA

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

The 1994 Statement of Basis indicates that the only medium requiring corrective measures is ground water. The stated goal of the corrective measures is to restore the ground water to its beneficial use, which would be drinking water. EPA has established the cleanup standards as the MCLs, which are listed below. Although benzene was originally considered a contaminant of concern, EPA approved of removing it as a contaminant of concern in 1999 because it had been absent in three consecutive monitoring events.

Compound	MCL
1,1-DCE	7 ug/L
PCE	5 ug/L
TCE	5 ug/L
Vinyl chloride	2 ug/L

Points of compliance are established as MW-1, MW-9D, and MW-25.

3.2 TREATMENT PLANT OPERATION STANDARDS

Treated water is discharged to the POTW, which limits the system discharge rate to 15 gpm. The POTW limits are MCLs which are similar to the expected surface water discharge limits. Honeywell indicated at the site visit that they chose the POTW discharge mainly to avoid potential liability issues associated with discharge to surface water.

4.0 FINDINGS AND OBSERVATIONS FROM THE RSE SITE VISIT

4.1 FINDINGS

The RSE team observed an extremely well-managed remedy. Honeywell, their contractors, and EPA all have an excellent understanding of the site conditions, the remedy, and potential risks. Continuing efforts have been made by the site team as a whole to improve system operation and protect human health and the environment. The observations provided below are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions in the best interest of the EPA and the public. These observations obviously have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of ground water remediation have changed over time.

4.2 SUBSURFACE PERFORMANCE AND RESPONSE

4.2.1 WATER LEVELS

Water table elevations collected both prior to and after pumping are depicted in Figures 4-1 and 4-2. In general, only the overburden wells are used in generating the potetiometric surface maps. Therefore, these potentiometric surfaces do not necessarily indicate ground water flow in Zones B and C. Shallow ground water, in the absence of pumping, flows to the south. In the presence of pumping, drawdown in the two extraction wells appears to be approximately 15 feet relative to other nearby monitoring points. Including the water levels from these pumping wells in the development of the potentiomentric surface maps might over estimate the degree of drawdown in the surrounding aquifer. The use of nearby monitoring (non-pumping) wells in developing potentiometric surface maps is generally preferred over pumping wells because pumping wells might be subject to well losses and generally are not representative of surrounding aquifer. If such wells are not available, including an adjustment for well losses to the extraction well water levels is often appropriate.

Analysis of the water levels in the non-pumping deeper wells (MW-1D through MW-3D and MW-5D through MW-8D) also indicate hydraulic gradients to the south. For example, in October 2002, MW-3D to the north had a water level of 188.44 feet MSL and MW-8D to the south had a water level of 174.84 feet MSL. The other deep wells also consistently indicated hydraulic gradients to the south.

Hydraulic gradients at this site do not necessarily indicate the direction of ground water flow and contaminant transport because fractures run down dip or along strike. For example, TCE is present in both MW-9D and MW-27, which are upgradient of the source with respect to the regional gradient but are down dip. Contaminant transport down dip might be due to ground water flow directed through preferential flow paths that are aligned in that direction or might be indicative of either past or present NAPL migration.

4.2.2 CAPTURE ZONES

The P&T capture zone in hydrogeologic Zones A and B is evaluated in the June 2002 *Draft Five-Year Review*. Two lines of evidence are used to analyze the capture zone:

- the potentiometric surface

- the concentration trends in monitoring wells located downgradient of the extraction wells

In addition, ground water modeling and particle tracking were used to evaluate capture during system design. This modeling (summarized in the May 1996 modeling report) indicates that pumping rates similar to those sustained by RW-3 and MW-4D would be sufficient for capture. It does not appear that the performance of the ground water model has been evaluated based on actual system operation and response.

Potentiometric surface maps show an influence due to pumping, but as stated in Section 4.2.1, their development includes the use of water levels from operating pumping wells. As a result, the degree of drawdown and capture might be overestimated when using these potentiometric surface maps. Furthermore, as the *Draft Five-Year Review* indicates, the presence of complex geology with dipping beds and fracture orientations in three directions complicates analyses of ground water flow directions, particularly in Zone B.

The *Draft Five-Year Review* discusses the concentration trends in MW-1, MW-16, MW-17, MW-19, MW-20, MW-25, MW-27, and MW-28 as part of a capture zone analysis. The RSE team provides the following observations on capture based on concentration trends in monitoring (non-pumping) wells.

- TCE concentrations in MW-1 and MW-28 appear to have decreased since pumping began. The concentrations in MW-1 have decreased from over 1,000 ug/L to under 50 ug/L and the concentrations in MW-28 have decreased from over 10,000 ug/L to approximately 1,000 ug/L. These decreases might indicate that either 1) these wells are within the capture zone and the TCE is diluted by entrainment of cleaner water or 2) they are located downgradient of the capture zone and less TCE contamination is able to migrate to these wells from the upgradient portion of the plume. It is also possible that MW-28 is within the capture zone and that MW-1 is downgradient of the capture zone. If this is the case, then the following would be expected:

    - MW-28 would continue to have elevated TCE concentrations as long as TCE is present in the source area.

    - MW-1 would be expected to cleanup over time, even if contamination remains in the source area, as long as capture is complete.

    The potentiometric surface maps appear to suggest that MW-28 is within the capture zone and MW-1 is downgradient of it, but insufficient water level data are available for a conclusive determination.

- Due to the relatively large distance between the pumping wells and monitoring wells MW-7D, MW-8D, MW-16, MW-17, MW-19, and MW-20 it is relatively safe to assume that these wells are downgradient of the capture zone. As such, if capture is complete, the TCE concentrations in these wells should remain at or decrease to undetectable levels over time. Because ground water flow is generally slow, achieving undetectable concentrations might take years to observe. The following trends in these wells have been observed:

    - TCE concentrations in MW-8D and MW-16 were undetectable before pumping and have remained undetectable.

- TCE concentrations in MW-7D and MW-17 were detectable near the MCLs before pumping and have remained at this level. No detectable trend is present.

- TCE concentrations in MW-19 were present at concentrations above 100 ug/L prior to 1999, but have not exceeded that level in 16 consecutive monitoring events. A discernible decrease is not readily observable from visual inspection, but the data show that concentrations are not increasing.

- TCE concentrations at MW-20 have remained at or below the MCLs, no discernible trend is evident from visual inspection.

These six downgradient monitoring wells do not show that capture is compromised. Continued monitoring at these four locations and MW-1 will likely help determine the extent of capture over time. Given that substantial decreases have been evident in MW-1 and MW-28, decreasing trends in MW-16, MW-17, MW-19, and MW-20 will likely occur in the future. If concentrations at these four wells and MW-1 continue to decrease or remain below MCLs, capture is likely sufficient to the south.

Other downgradient wells include HGS-1, HGS-2, HGS-3 and MW-15. These wells were sampled during characterization of the neighboring property at 1070 Virginia Drive but are not sampled as part of the ground water monitoring program for the Honeywell site. In 2001 all four wells had detectable concentrations of TCE, and HGS-1 and MW-15 had TCE concentrations over 100 ug/L. This contamination could have been present before the system began operation, and because limited sampling has been conducted, long-term trends cannot be established and used for a capture zone evaluation.

No such sentinel wells are available to the west beyond (i.e., to the west of MW-4D or MW-1). Therefore, a similar evaluation of capture with trend analyses in this area is not feasible. Site characterization activities of 1070 Virginia Drive showed undetectable TCE contaminated ground water samples from direct-push borings S-4 and S-10, which are immediately west of MW-4D. These samples are limited to the overburden and demonstrate that contamination has not migrated west of MW-4D in Zone A. Data are not available to confirm that migration has not occurred in Zone B of this area.

The above analyses do not consider the potential for DNAPL migration in Zone C along the bedding planes. TCE concentrations at MW-9D and MW-27 indicate that contamination has migrated down dip to the northwest. This might be due to ground water flow or to DNAPL migration, and it is unclear if such migration continues. TCE concentrations at MW-9D have remained above 16,000 ug/L but have not increased over time. TCE concentrations at MW-27 have generally remained above 200 ug/L and at times have increased to over 1,000 ug/L, but a consistent increasing or decreasing trend is not readily apparent from visual inspection. MW-25, which is further downgradient of MW-27, has undetectable TCE concentrations, but site records indicate that this monitoring well is not screened in the same fracture zone as MW-9D and MW-27. Therefore, it is difficult to determine the extent of or the potential for the migration of TCE contamination along the MW-9D fracture zone. The hydrogeologic conceptual model suggests that contamination is contained by the diabase dike and the decreasing permeability with depth. Continued undetectable TCE concentrations over time at the three residences along Camp Hill Road and TCE below MCLs at the fourth residence could help confirm that the diabase dike prevents further contaminant migration to the northwest. It should be noted, however, that increases in TCE concentrations at these wells could also be due to an offsite source.

4.2.3 CONTAMINANT LEVELS

Contaminant concentrations in the two recovery wells (RW-3 and MW-4D) and MW-1, MW-9D, and MW-28 can be evaluated to indicate progress toward restoration. The RSE team provides the following observations of concentrations in these five wells. The RSE team also provides its conclusions/opinions as to what these concentration trends imply for the P&T remedy.

- In RW-3, TCE concentrations have decreased from 30,000 ug/L prior to pumping to approximately 5,000 ug/L. Although this represents a substantial decrease in concentrations over a 5-year period, the TCE concentrations in RW-3 appear to have stabilized above 5,000 ug/L. The *Draft Five-Year Review* fits a power model to this concentration trend that, when extrapolated, suggests cleanup in that well will be reached in approximately 35 years. This estimate from a statistical model only takes into account the trend in the data and does not fully represent the hydrogeology and contaminant transport. In addition, the model does not fit the trend exactly and may not provide accurate estimates through extrapolation. As a result, this estimate should be taken with caution.

- In MW-4D, TCE concentrations have decreased from over 1,000 ug/L prior to pumping to approximately 200 ug/L. This also represents a substantial decrease in contamination over a 5-year period. Concentrations appear to have stabilized above 200 ug/L. The Draft Five-Year Review fits a power model to this concentration trend that, when extrapolated, suggests cleanup in that well will occur in approximately 10 to 15 years. As with the estimate from the statistical model used for RW-3, this estimate should be taken with caution.

- As stated in Section 4.2.2, the concentrations in MW-1 and MW-28 have decreased. These wells are either within the capture zone or are downgradient of the capture zone. As of yet, the TCE concentrations in these two wells have not dropped below cleanup standards. If they are located within the capture zone, then concentrations will likely remain above standards until the TCE in the source area is removed. If they are located downgradient of the capture zone, and capture is complete, then these wells will likely reach cleanup standards even if TCE remains in the source area, but this may take many years to occur.

- In MW9D, concentrations remain above 16,000 ug/L and show no discernible or consistent decrease since pumping began. Therefore, with the current remedy and a goal of restoring the aquifer to MCLs, it is reasonable to assume that pumping and treating will continue indefinitely.

4.3 COMPONENT PERFORMANCE

4.3.1 EXTRACTION SYSTEM WELLS AND PUMPS

The average pumping rates from RW-3 and MW-4D vary on a weekly basis. For example, between May and July 2002, the RW-3 extraction rate varied from 4.5 gpm to 6.3 gpm when the pump was operating. During the same time period, the MW-4D extraction rate varied from 3.5 gpm to 4.4 gpm. These variations are likely due, in part, to variation in the regional water table but also due to fouling or corrosion. The pump in RW-3 has been replaced or repaired at least five times since 1998, and the MW-4D pump was cleaned in October 2002 due to heavy build up of ferric hydroxide. The pump columns were also replaced with stainless steel 316 to reduce the potential for corrosion.

4.3.2 FILTERS

Changeouts of the bag filters are infrequent, less than monthly. This indicates that the water has minimal suspended solids and iron. Corrosion of one filter housing resulted in a leak and corrosion of the other housing was also observed. Both housings were replaced in the second quarter of 2002. It is reasonable to expect that such replacements might be required every 5 years.

4.3.3 UVOX SYSTEM

According to the *Draft Five-Year Review*, the UVOX system has required non-routine service on three separate occasions between 1998 and June 2001. Problems included a faulty circuit breaker, a malfunctioning feed pump controller, and the internal computer program. All issues were addressed and down time from these problems totaled approximately 87 days. Other system shutdowns have occurred because of a low flow rate condition (i.e., when the flow rate to the UVOX system drops below the required 15 gpm). When the UVOX system performs as expected, it has a removal efficiency of greater than 99%.

4.3.4 GAC

On average, one of the 1,000-pound GAC units is changed out once per year. The GAC in the lead unit is changed and the two units are rearranged so that the secondary unit becomes the lead unit and the unit with the replaced GAC becomes the new secondary unit. This frequency for GAC changeouts (i.e., 1,000 pounds per year) is approximately double what would be expected based on mass loading to the GAC units (assuming 99% removal of contaminants by the UVOX system) and their expected chemical loading capacity. The site contractor states that increased frequency in changeouts is due to channeling in the GAC units caused by a buildup of air pressure. Since the RSE site visit, the installation of a pressure-relief valve has increased the efficiency of the GAC units and will likely reduce the changeout frequency.

4.4 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF MONTHLY COSTS

The facility specifies that the treatment system operating budget is $220,000 for 2003. This includes labor, utilities, materials, analytical costs, and disposal costs. An approximate breakdown of these costs is presented in the following table based on estimates provided by the facility and estimates prepared by the RSE team based on the remedy scope of work. The assumptions and estimates made in generating the table are discussed in the following subsections.

Item Description	Estimated Cost	% of Total Costs
Labor (project management, reporting, monitoring, maintenance, etc.)	$130,000	59%
Utilities: Electricity	$30,000	14%
Non-utility consumables (GAC, chemicals, other materials or parts)	$16,000	7%
Chemical Analysis	$20,000	9%
Discharge fees and waste disposal	$24,000	11%
Total Estimated Cost	**$220,000**	**100%**

4.4.1 UTILITIES

The primary power draw for the system is the UVOX system, which utilizes 30 KW for the UV bulbs. Assuming 100% uptime, this translates to over 250,000 kWh (kilowatt hours) per year. Assuming $0.10 per kWh, this translates to approximately $25,000 per year in electrical costs. Space heaters (two 10 KW heaters used part-time during the winter), extraction pumps, and transfer pumps would also contribute to the power draw of the remedy. Therefore, it is reasonable to assume that electrical costs are approximately $30,000 per year and are primarily due to the UVOX system.

4.4.2 NON-UTILITY CONSUMABLES AND DISPOSAL COSTS

Materials include hydrogen peroxide, GAC, and replacement bulbs and parts for the UVOX system. The facility estimates that the hydrogen peroxide costs approximately $4,500 per year, the GAC costs $5,000 per year, and the UVOX bulbs cost $6,000 per year. This translates to a cost of approximately $16,000 per year in non-utility consumables.

The facility has not recently been invoiced by the POTW; therefore, an actual cost cannot be determined for the past year. However, the POTW charges a reported $0.005/gallon and the average discharge rate is approximately 9 gpm. Assuming 100% uptime, this translates to an annual cost of approximately $24,000 per year.

4.4.3 LABOR

Labor at the site includes project management, reporting, ground water sampling, and P&T system maintenance. A facility employee checks the system twice per week, and the labor associated with those checks is not included in the $220,000 budget. The facility estimates that the labor costs are approximately 60% of the total budgeted costs, or approximately $130,000 per year.

4.4.4 CHEMICAL ANALYSIS

The facility estimates that a total of 30 samples are analyzed using 8021b each quarter for process and ground water monitoring combined. In addition, 4 surface water samples are analyzed twice a year and 4 residential well samples are analyzed once every two years. The POTW requires monthly effluent sampling. Therefore, including field blanks and other quality assurance samples, approximately 160 samples per year are analyzed, and the large majority of these samples are analyzed with 8021b.

The unit cost for 8021b at this facility is approximately $85; therefore, according to these assumptions, analytical costs are approximately $14,000 per year. The facility estimated that the analytical costs were approximately 16% of the total budget, which would suggest an annual cost of $35,000. The value provided in the table is a compromise between the RSE and facility estimates. The value is closer to the RSE estimate because the facility estimate might be based on a review of past costs that might not be indicative of current or future costs.

4.5 RECURRING PROBLEMS OR ISSUES

The majority of system downtime or reduced performance is due to upsets to either the UVOX system or the pump in RW-3. RW-3 appears susceptible to corrosion that has resulted in replacement or repair on five separate occasions (an average of one replacement per year). The UVOX system has had three separate instances of non-routine repair, all due to different causes.

4.6 REGULATORY COMPLIANCE

The treatment system regularly meets the POTW discharge requirements.

4.7 TREATMENT PROCESS EXCURSIONS AND UPSETS, ACCIDENTAL CONTAMINANT/REAGENT RELEASES

Minor leaks have been reported but have been contained by secondary containment. One reported leak was due to corrosion in one of the bag filter housings. A small drip prior to the UVOX system was noted during the RSE site visit, and it was understood that the drip would be corrected immediately.

4.8 SAFETY RECORD

The facility has no reported health and safety incidents.

5.0 EFFECTIVENESS OF THE SYSTEM TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT

5.1 GROUND WATER

Contaminated ground water has the potential to impact Pine Run Creek to the south and west (hydraulically downgradient) and residential supply wells screened in bedrock to the north (hydraulically upgradient but down dip). The *Draft Five-Year Review* reports that surface water samples are collected semi-annually. Four locations along the stream are sampled, and the highest TCE concentration is repeatedly detected in the sample collected upstream from the site in the east corner of the property (SW-4). Therefore, the *Draft Five-Year Review* concludes that site-related contamination is likely not adversely impacting the stream, and an upgradient source of TCE might exist. In the opinion of the RSE team, these appear to be reasonable conclusions.

No compounds of interest have been detected in three of the four sampled residential wells. The fourth well (at 1200 Camp Hill Road) has TCE below MCLs and the RFI identifies several lines of evidence to suggest why the TCE detected in that well is not related to the former Honeywell facility. These lines of evidence are summarized below:

- 1200 Camp Hill Road is hydraulically upgradient from the facility.

- 1200 Camp Hill Road is located on the opposite side of the diabase dike, which site data indicate is a barrier to ground water flow.

- Chloroform has been identified in the well at 1200 Camp Hill Road but has not been detected in MW-25, which is the closest on-site monitoring well, and has only sporadically been detected on site. (A review of the historical ground water monitoring data indicates that chloroform has been detected 5 times in on-site monitoring wells in all of the long-term monitoring samples collected since 1997 and reported in the October 2002 progress report. The highest concentration was 0.9 ug/L in MW5 in 1998. Chloroform is also a common laboratory contaminant, which might be the cause of the sporadic detections in both the on-site and residential samples.)

- Napthalene has been identified in the well at 1200 Camp Hill Road but is not a site compound of interest or a breakdown product of a compound of interest.

- TCE has been detected numerous times in samples collected from background well MW3D, suggesting that there is an upgradient source of TCE.

In the opinion of the RSE team, these lines of evidence are relatively convincing and the RSE team generally agrees that the impacts at 1200 Camp Hill Road are likely due to another source. The following issues, however, should be noted:

- Although 1200 Camp Hill Road is hydraulically upgradient, it is down dip from the facility and TCE has been found in down dip locations such as MW-27.

- Although MW-25 is the closest on-site well to 1200 Camp Hill Road, it is not completed in the same fracture zone as MW-27. Therefore, TCE contamination might be present at the location of MW-25 or beyond but not at the elevation screened by MW-25.

With respect to potential future ground water users, institutional controls could help prevent or control use of ground water in or in the vicinity of the plume until it is restored. However, such controls are not part of the current remedy and otherwise not known to be in place.

5.2 SURFACE WATER

As stated in Section 5.1, surface water shows that contaminated ground water from the site is not likely impacting Pine Creek Run.

5.3 AIR

A vapor intrusion evaluation for the site main building is currently underway by the facility contractors. The evaluation to date has included a preliminary screening analysis conducted with the Johnson and Ettinger model and a review of the building HVAC information. The HVAC information suggests that the building (at least the DeVry portion of the building) is maintained at a higher pressure (2.46 Pascals) than ambient. The Johnson and Ettinger model is not applicable when the building pressure is higher than the ambient pressure. So the facility has conducted the model simulations with a nominal negative pressure differential of 0.01 $g/cm\text{-}s^2$ (or 0.001 Pascals). The facility also used many of the default parameters for the model, including the default soil vapor permeability of 10^{-8} cm^2 for sand. The results of these model simulations suggest that in order to exceed a 10^{-5} incremental risk, the TCE ground water concentration would need to be over 2,000,000 ug/L, which is above the water solubility of TCE and two orders of magnitude higher than the highest ground water TCE concentrations found on site. The model also calculates that to exceed an incremental risk of over 10^{-6}, a TCE ground water concentration of over 300,000 ug/L would be required.

If the model is run with the same parameters, but with a pressure differential of 0.1 $gm/cm\text{-}s^2$ and the upper limit of soil vapor permeability for a medium sand (10^{-6} cm^2 as stated in the Johnson and Ettinger model user's guide), then the model suggests that a ground water TCE concentration of approximately 16,000 ug/L would result in a 10^{-5} incremental risk. The model also suggests that a ground water TCE concentration of approximately 1,600 ug/L would result in a 10^{-6} incremental risk. The highest TCE ground water concentration found on site is approximately 18,000 ug/L at MW-9D.

Because the model cannot use a positive pressure differential, the model is likely not appropriate for the vapor evaluation at this site. Using nominally low pressure differentials could provide misleading results. Rather, a more appropriate vapor evaluation would likely rely on data that confirm that the positive pressure differential is maintained throughout the building and/or vapor sampling within the building. As of the RSE site visit, actual pressure differentials between the building and ambient conditions had not been measured and vapor sampling within the building had not been conducted.

Vapor intrusion could potentially become an issue at 1070 Virginia Drive if buildings on that property are constructed and occupied. An evaluation of this potential exposure would require more information about the current and future TCE concentrations in the subsurface of 1070 Virginia Drive as well as the building construction and HVAC parameters.

5.4 SOILS

With respect to direct exposure, soils on site do not pose a human health risk. The site is covered by asphalt or by buildings such that contaminated soils, if any remain, are out of reach of human contact. If subsurface construction or utility work were to occur on-site, soil vapors might pose a potential health risk. It is unclear to the RSE team if any deed restrictions are in place to specify the health and safety practices to be considered if such work is performed.

5.5 WETLANDS AND SEDIMENTS

The only wetlands or sediments that would potentially be impacted by site-related contamination are associated with Pine Run Creek. Wetlands and sediments were not evaluated as part of the RSE.

6.0 RECOMMENDATIONS

Cost estimates provided herein have levels of certainty comparable to those done for CERCLA Feasibility Studies (-30/+50%), and these cost estimates have been prepared in a manner consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July 2000.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS IN PROTECTING HUMAN HEALTH AND THE ENVIRONMENT

The primary recommendation in this category is to more fully evaluate the potential for vapor intrusion into the on-site main building (Recommendation 6.1.1). Otherwise, site data suggest that ground water contamination from the site is not adversely impacting Pine Run Creek or the residential wells along Camp Hill Road. Therefore, the RSE team has limited suggestions (Recommendation 6.1.2) for improving the protectiveness of this remedy with respect to contaminant transport in ground water.

6.1.1 FURTHER EVALUATE POTENTIAL FOR VAPOR INTRUSION

The highest TCE ground water concentrations based on ground water monitoring data are outside of but adjacent to the building footprint. TCE in ground water has also been detected beneath the building footprint. MW-21 was historically sampled twice with TCE concentrations of 270 ug/L in July 2000 and 250 ug/L in October 2000. TCE was historically detected in MW-12 (with concentrations ranging from 1,900 ug/L in July 1997 to160 ug/L in October 2000). Although these concentrations in MW-12 and MW-21 are relatively low compared to the concentrations in MW-9D and RW-3, the majority of the property is covered with an asphalt parking lot that might limit the exchange of air in the subsurface and minimize venting of TCE vapors. As a result, TCE vapors might accumulate in the subsurface and vent through preferential flow paths that could potentially include cracks in the building floor.

If the building is maintained at a higher pressure relative to the vadose zone, then vapor intrusion into the building is not likely a concern. The RSE team was told during the site visit that the HVAC information suggests positive pressure is maintained within the building, but that this has not been confirmed by measurements of actual conditions. In the opinion of the RSE team, the building should be further evaluated to confirm that a positive pressure, relative to ambient, is maintained throughout the building. Alternatively (or potentially additionally), indoor air sampling at multiple locations within the building could be conducted for confirmation that vapor intrusion is not a human health concern. The nature of any additional vapor intrusion evaluation work should consider pertinent EPA and Pennsylvania Department of Environmental Protection guidance. The potential exists that other VOCs or ionizable gases are used within the building and that PID screening would not be able to distinguish between the subsurface TCE contamination and these currently used VOCs. The RSE team, therefore, believes that if sampling is to occur, sampling with Summa canisters and laboratory analysis would be more effective.

Including a work plan, sampling, analysis, and reporting, the RSE team estimates that sampling and analysis can be conducted for under $10,000. This would include more than 10 TO-14/TO-15 samples from within the building. Measurements of pressure throughout the building relative to the soil or atmosphere would likely be significantly less.

6.1.2 CONSIDER THE INSTALLATION OF TWO MONITORING WELLS

The hydrogeology at the site is complex, and this complicates the evaluation of plume capture. Evaluation of potentiometric surfaces accompanied by trend analyses in downgradient monitoring wells provides sufficient data to evaluate plume capture to the southeast, south, and southwest. As noted in Section 4.2, however, data for plume delineation and evaluation of capture to the west and to north could be augmented.

To the West

Ground water samples from borings (S-4 and S-10), conducted as part of the site characterization of the neighboring property (1070 Virginia Drive), showed no detectable TCE concentrations in the overburden to the west of MW-4D and MW-1. These results suggest limited (if any) contaminant migration to west of MW-4D or MW-1 in the overburden and that capture need not be evaluated in this area. However, this area is along strike in the bedrock (Zones B/C) and these borings were only completed to a depth of 10.5 feet. Therefore, it is unclear if contaminant migration has and/or continues to migrate through Zones B/C in this area. Site documents suggest that MW-10D was originally proposed in this area but not installed. If deemed necessary by the site stakeholders, installation of this well could help determine if contamination extends to this area. If contamination is present, then a decreasing trend in the concentration would indicate that capture is sufficient in this direction.

If the site team agrees that installation is merited, the well should be placed sufficiently far downgradient of the suspected capture zone and completed within Zone B so that it can be used as a sentinel well to evaluate contaminant migration in this direction. If the well is located within the capture zone, its TCE concentrations could increase over time, even if capture is sufficient. For there to be adequate capture to the west of MW-4D, this well should likely have and maintain TCE concentrations below MCLs or should have TCE concentrations that are declining and eventually fall below MCLs.

To the North

Elevated TCE concentrations at MW-27 suggest the potential for TCE to migrate regionally upgradient but “down dip” within the MW-9D fracture zone. TCE concentrations in MW-27 exceed 200 ug/L and the extent of this contamination and the potential for further migration is unknown. MW-25 is located further to the north/northwest; however, it is not completed within the same fracture zone as MW-9D and MW-27 and therefore might not intercept an important preferential pathway for contaminant transport in this direction. An additional well could be installed further down dip of and in the same fracture zone as MW-27 to better delineate the plume and to provide concentration trends that might be used for evaluating plume capture within this fracture zone. A preliminary analysis suggests that this well might be located adjacent to MW-25 but might only be 120 feet deep rather than 190 feet deep.

It is hoped that this additional well would have and would maintain TCE concentrations below MCLs. This would provide more conclusive evidence that TCE migration is not occurring in this direction. Installation of this additional well would also provide another location for water level measurements within the same fracture zone that could be used to better determine if flow in this fracture zone is toward the extraction at RW-3. In the opinion of the RSE team, this proposed well provides additional useful information, although other information is available to help evaluate capture in this area and might be considered prior to installing the well:

- The concentration trend in MW-27 can be analyzed to determine if it is increasing or decreasing. If it is consistently decreasing and continues to decrease, then at least partial capture is likely provided. A preliminary analysis by the RSE team shows no detectable trends in MW-27.

- The hydraulic gradient between MW-27 and MW-9D can be determined to demonstrate if ground water flow is toward or away from the extraction at RW-3. If consistent capture is provided, then ground water flow should be directed toward RW-3. Water level records to date show that ground water flow between MW-27 and MW-9D alternates between flowing toward and away from RW-3.

- A tracer could be injected into MW-27 to determine what fraction (if any) is recovered by extraction at RW-3. A different tracer could be injected in MW-9D for a similar evaluation. Prior to the test, the site team should agree on criteria that would indicate successful capture.

- Continued sampling at the residential wells along Camp Hill Road will indicate if site-related contamination reaches these wells. According to the site conceptual model, however, these wells would not be impacted due to the hydraulic barrier provided by the diabase dike. Therefore, even if contamination is migrating in this direction, it might not appear in these wells.

The RSE team estimates that installing the two wells should cost less than $25,000. Monitoring these wells would increase the annual costs for monitoring, and this increase is considered in Section 6.2.2, which discusses potential modifications to the ground water monitoring program. Conducting a tracer test with chloride or bromide tracers (including permitting, development of the test objectives and metrics, and the final reporting) could likely be done for approximately $10,000. Trend analysis and monitoring of ground water flow directions should require no additional cost.

6.1.3 MODIFY APPROACH TO EVALUATING PLUME CAPTURE

As is currently the practice, the RSE team recommends interpreting the extent of plume capture by analyzing potentiometric surface maps and trends in ground water sampling data. However, the RSE team recommends modifications in developing potentiometric surface maps and including the HGS monitoring wells in the sampling program. Sampling from the HGS wells would require an access agreement.

Water levels should continue to be collected from all wells during sampling events, and potentiometric surface maps should continue to be developed. However, as stated in Section 4.2.1, the water levels from the operating wells should not be used when developing the potentiometric surfaces. Ideally, piezometers would be located near the extraction wells to provide a representative water level for the aquifer in those areas. Alternatively, the water levels from the extraction wells could be used if they are adjusted for well losses and the interpretation accounts for the likelihood that the drawdown is likely focused near the well (i.e., linear interpolation between the water level at the extraction well and other monitoring points is not necessarily a reasonable assumption). For this site, it is the opinion of the RSE team, that using corrected water levels from extraction wells is appropriate.

Sampling conducted in 2001 from the HGS wells, which are located on the 1070 Virginia Drive property, indicate that site-related contamination has migrated offsite. However, it cannot be determined from these limited data if the contamination detected in these wells migrated offsite before or after implementation of the P&T system. If it has migrated offsite while the P&T system has operated, capture is incomplete and additional pumping might be required prevent the plume from growing. The RSE team, however, believes that the contamination likely migrated offsite prior to system operation. To monitor this offsite contamination and confirm that additional contamination is not migrating offsite, the RSE team recommends that sampling and gauging of the HGS wells be added to the Honeywell ground water monitoring program. Because these wells are likely downgradient of the capture zone, the RSE team expects that the TCE concentrations in the HGS wells will slowly decrease over time to background concentrations. The contaminant transport history at the site provides an approximate indication of the time to see a decrease in these wells. The TCE contamination at the site first occurred in 1986 at the latest and the TCE concentration in HGS-1 was 270 ug/L in 2001 (15 years later). As a result, it may take an additional 5 to 10 years to see a substantial decline in the TCE concentrations in HGS-1, HGS-2, and HGS-3. If TCE concentrations consistently increase or do not consistently decrease over this time period, it would indicate that the plume may be growing.

If the modified potentiometric surface maps do not provide sufficient resolution to evaluate capture to the degree desired by the site team, and the concentrations in the HGS wells do not show a consistent decrease in TCE concentration over the course of a 5 year period, the RSE team would recommend that the site team establish a target capture zone, update the ground water flow model, and use the model to evaluate capture with respect to the target capture zone. The target capture zone would be the area or volume of the contaminant plume (as highlighted on a site map) that the site team agrees should be contained by the P&T system. Updating the model would primarily involve calibrating it with respect to water levels that are measured during the current pumping conditions. The cost of the initial update might be $20,000, and the use of the model to evaluate capture might cost an additional $5,000. The results of the simulations could be included in a progress report to minimize the additional cost of reporting. The costs associated with the modeling are not included in Table 7-1 with the other RSE cost estimates, because it is probable that the modeling work will not be necessary based on the updated potentiometric surface maps and monitoring from the HGS wells.

6.1.4 CONSIDER INSTITUTIONAL CONTROLS

If deemed necessary based on future land use plans and ground water monitoring, institutional controls (perhaps in the form of a notice) should be considered at the 1070 Virginia Drive property to notify the current and future property owners of the VOC contaminated ground water. The RSE team estimates that the cost of developing such institutional controls would be less than $5,000.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 CONSIDER REPLACING UVOX SYSTEM WITH AIR STRIPPER AND VAPOR PHASE GAC

The current treatment plant was designed to remove at least 12 pounds of contaminants per day, with an influent concentration of 100,000 ug/L TCE. However, over the past five years it has only needed to treat up to 1 pound per day and generally less than 0.5 pounds per day. As of October 2002, the mass removal rate for TCE was approximately 0.4 pounds per day. Although UVOX might have been cost effective at the design mass removal rate, air stripping with off-gas treatment would be more cost effective given the current and expected conditions. Treatment with GAC only is another option, but Honeywell is limited to using the existing building, and using a larger GAC vessel (that is more economical to changeout) is not feasible. Therefore, air stripping with off-gas treatment is the only option discussed here. A cost comparison for operating the UVOX system and an air stripping system is provided on the following page.

UVOX System		Air Stripping with Off-gas Treatment	
Item	**Annual Cost**	**Item**	**Annual Cost**
Maintenance labor	$10,000*	Maintenance labor (cleaning trays annually)	$2,000
Materials • bulbs, tubes, etc. • hydrogen peroxide	 $6,000 $4,500	Vapor GAC (6 pounds per day at $5 per pound)**	$11,000
Electricity (assumes $0.10/kWh) (30 KW for lamps)	$25,000	Electricity (assumes $0.10/kWh) (5 HP blower, 75% efficiency)	$4,500
Total	**$45,500**	**Total**	**$17,500**

** estimated cost excluding system checks by facility staff*
*** assumes the following mass loading rates and GAC efficiencies*

- *0.39 lbs/day TCE with 8% GAC efficiency = 4.875 lbs/day*
- *0.003 lbs/day DCE with 0.5% GAC efficiency= 0.6 lbs/day*

Replacing the UVOX system with an air stripper and off-gas treatment would require capital expenses. A tray stripper, 5 HP blower, and 1,000-pound vapor GAC unit could be purchased and installed in the same treatment building for under $100,000. The liquid phase GAC could be left in place as a polishing step but could be removed in the future if the stripper consistently meets the discharge criteria. Given the above comparison, the capital expenses would be recovered in approximately 4 years (without discounting) and savings would be realized in future years. A present-worth cost analysis of this recommendation is provided in Table 7-1 at the end of this report. If influent concentrations and mass loading to the treatment system decreases, the UVOX costs would remain similar but the costs for air stripping with off-gas treatment would decrease because less vapor phase carbon will be required. Therefore, cost savings would increase in the out years.

Replacing the UVOX system with an air stripper and off-gas treatment would be more cost-effective, but implementing this recommendation has other advantages and disadvantages the site team might wish to consider.

<u>*Advantages*</u>

- Less downtime would be expected with the air stripper.

- The air stripper could operate continuously and would not have low-flow shutdowns like the UVOX system.

- The lower energy consumption of the air stripper provides a hedge against potential future increases in energy costs and provides a "greener" or more environmentally friendly remedy in terms of energy consumption.

<u>*Disadvantages*</u>

- Recovered contamination would not be destroyed on-site.

- If additional pumping or mass removal is expected, the annual cost savings would decrease.

In the RSE team's opinion, destroying contamination on-site does not generally provide a substantial benefit, but the facility might have reasons for this preference. Additional pumping is discussed in Section 6.4.1. Evaluation of the treatment system modifications should be postponed until after the potential for additional pumping is evaluated. Given the current conditions and historical trends in RW-3 and MW-9D, P&T may continue at the site for decades. Therefore, replacing the system could be cost-effective over the life-time of the remedy.

6.2.2 CONSIDER REVISIONS TO GROUND WATER MONITORING PROGRAM

Ground water is currently sampled and analyzed from 13 monitoring wells on a quarterly basis, two monitoring wells on a semi-annual basis, and two extraction wells on a quarterly basis. In Section 6.1.2, the RSE team suggested the site team consider installing two additional wells and adding them to the monitoring program. Quarterly monitoring has demonstrated consistent results, and monitoring associated with the remedy is expected to continue for many years, possibly decades. Therefore, the RSE team suggests that decreases in the monitoring frequency be considered. In the opinion of the RSE team, the following monitoring program is reasonable for demonstrating that site goals are being achieved.

- Semi-annual sampling and analysis from the following 11 wells should be sufficient for trend analyses for evaluating capture to the southeast, south, southwest, west, and north/northwest: MW-1, MW-7D, MW-17, MW-19, MW-20, MW-27, HGS-1, HGS-2, HGS-3, the proposed well to the west, and the proposed well to the north.

- MW-2D is theoretically below the aquiclude, however, historical data suggests it has TCE concentrations that vary from undetectable to over 50 ug/L. Semi-annual sampling and trend analysis of the concentrations from this well should help evaluate capture in the vertical or across the bedding plane. If the concentrations fall below MCLs or shows a consistent decrease, then capture is likely adequate.

The following wells appear to be used for the following purposes and can be sampled on an annual basis:

- MW-8D and MW-16 are also pertinent for capture evaluation to the south, but TCE has not been detected in either well; therefore, the sampling frequency at these locations could potentially be reduced to annual.

- MW-5, MW-28, and MW-26 are likely within the capture zone and therefore will not likely help evaluate capture. Annual sampling should be sufficient to help document progress toward cleanup.

- MW-1D and MW-9D might also be in the capture zone and do not appear to be providing useful information to evaluate capture. Therefore, annual sampling at these well should be sufficient to track the progress of the remedy. It should be noted that a potential increase in the MW-1D concentrations might be apparent in a trend analysis. A potential explanation for this is that MW-1D is within the capture zone and that contaminated water, on its way to RW-3, is passing by MW-1D.

- MW-25 has shown minimal and sporadic detections of TCE. It is screened below the primary fracture zone screened by MW-9D and MW-27. If the northern recommended well is installed, MW-25 could be removed from the monitoring program. If the northern recommended well is not installed, MW-25 could remain in the sampling program with an annual sampling frequency. Removing MW-25 from the monitoring program might be complicated due to its designation as a compliance point.

- MW-3D is a background well. It has effectively established a background condition, and does not provide useful information with regard to evaluating capture or the progress toward cleanup. It is, however, useful to determine background conditions. For these reasons, an annual sampling frequency at this location should be sufficient.

- The extraction wells, RW-3 and MW-4D, are known to have elevated VOC concentrations, and it is likely that these concentrations will remain elevated for a number of years or even decades. As a result, the sampling of the extraction wells RW-3 and MW-4D could also be reduced to annual. The blended influent concentration at the treatment plant is monitored quarterly, so information pertaining to the treatment plant performance would not be lost from reducing the monitoring frequency in these two extraction wells.

The current ground water sampling program includes 15 wells sampled on a quarterly basis and two wells sampled on a semi-annual basis, or a total of 64 samples per year. These suggested modifications have the potential to reduce sampling to 11 wells on a semi-annual basis and 8 wells on an annual basis for a total of 30 samples per year. The RSE team estimates that the current ground water monitoring program costs (for labor and analysis) approximately $32,000 per year and that implementation of this recommendation could save as much as 50% (i.e., $16,000 per year).

Process monitoring should continue quarterly.

6.3 MODIFICATIONS INTENDED FOR TECHNICAL IMPROVEMENT

6.3.1 USE HDPE FOR RW-3 DROP TUBE IF/WHEN IT REQUIRES REPLACEMENT

Given that the pump in RW-3 has failed five times, it might be worth using HDPE for the drop tube if the current stainless steel drop tube requires replacement. HDPE is resistant to corrosion. It is also lighter than stainless steel and will facilitate pump removal and maintenance. The cost of implementing this recommendation is under $1,000.

6.4 CONSIDERATIONS FOR GAINING SITE CLOSE OUT

6.4.1 CONSIDER ALTERNATIVE REMEDIAL APPROACHES TO AUGMENT P&T SYSTEM

The persistent concentrations in MW-9D suggest that achieving MCLs in a reasonable time frame is unlikely with the current remedy. Furthermore, the persistent contamination in this area might be the cause of the lower but persistent concentrations in RW-3. Additional remedial efforts could be attempted in the area of MW-9D to help determine if it is practicable to achieve MCLs. The RSE team envisions two primary options for augmenting the existing P&T system: pumping from MW-9D or injecting agents to enhance in-situ degradation. Implementing either or both of these options could potentially provide one or more of the following benefits:

- shorten the operating life time of the P&T system, thereby reducing life-cycle costs

- reduce concentrations to allow for monitored natural attenuation as a component of a modified remedy

- demonstrate the presence of a technical impracticability zone and limit the remedy goal for that zone to containment rather than restoration

It should be noted that substantial life-cycle costs savings will likely occur only if the duration of the P&T system operation is decreased. If aggressive remediation at MW-9D reduces the influent concentrations to the P&T system, less contaminant mass will need to be removed from the extracted water, but the decrease in annual O&M costs would not be substantial.

Pumping from MW-9D

Pumping from MW-9D would utilize the existing treatment system and would target mass removal at MW-9D where concentrations have stabilized above 16,000 ug/L. It would also enhance hydraulic capture of the contaminant plume, and more specifically, provide a degree of control for the source zone. The treatment system and POTW permit has the capacity for an additional 5 gpm on average and the 1995 *Aquifer Performance Test* demonstrated that the yield at MW-9D is sufficient to provide this rate. Consideration of replacing the UVOX system with the air stripper should be delayed until after this recommendation is evaluated due to the potential for additional mass removal requirements. The UVOX would be more appropriate for addressing the increased mass removal.

Converting MW-9D into an extraction well and piping the water to the treatment system would be unusually expensive at this site due to the surface finish requirements and local labor costs. However, piping from MW-9D could be connected with the 1.5-inch diameter piping between RW-3 and the treatment plant to reduce trenching costs and to avoid trenching across the DeVry parking lot. The RW-3 piping could easily accommodate a combined flow rate of 10 gpm (5 gpm from RW-3 and 5 gpm from MW-9D). Because MW-9D is located in front of the loading dock, work would likely need to be coordinated with DeVry to avoid disruption to deliveries. The RSE team estimates the cost to install and connect the well would be between $60,000 and $100,000. This cost assumes over $35,000 for the wellhead-vault, pump, drop tube (HDPE), transducer, regrading, valving, and finishing the surface. It also assumes 150 feet of trenching at $200 per foot with double-contained pipe, power, and control cable/conduit.

Prior to proceeding with this approach, the site team might want to consider temporary pumping from MW-9D to confirm the yield of MW-9D, to determine the expected mass removal rate, and to evaluate the influence on pumping from RW-3. The 1995 *Aquifer Pump Test* demonstrated that a yield of 6 gpm to 10 gpm is feasible. Sampling and analysis during this 1995 test also showed an increase in concentration over the course of pumping. Conditions have changed after 5 years of an operating P&T system; therefore, an additional test might be beneficial before installing a permanent system.

Pumping could consist of a pump test that is 48 hours in duration. Because MW-9D is located in front of the loading dock, pumping would likely need to be coordinated with DeVry to avoid disruption to deliveries. For example, pumping could be accomplished on the weekend in which 10,000 to 15,000 gallons of ground water is extracted from MW-9D and treated with the UVOX system. The site team might determine the optimal approach for this temporary pumping and treating. It might involve establishing a temporary line from the extraction well to the treatment system equalization tank or it might involve pumping water to a temporary tank and then transferring the contents of the tank to the treatment system equalization tank at a prescribed rate. Because of the high expected TCE concentrations in the extracted water, if a temporary line is set up directly from the extraction well to the treatment system, steps should be taken to ensure any leaks would be properly contained. For reference, at an extraction rate of 5 gpm, 10,000 gallons could be extracted in less than 35 hours. Also for reference, the treatment system has up to 5 gpm of additional capacity, so treatment of 10,000 gallons could be accomplished in 35 hours. Multiple events could be conducted to more accurately represent extended pumping, but the cost of the pilot should be kept small relative to the cost of installing and connecting the well. Sampling and analysis at MW-9D before and after each event would reveal whether or not concentrations were increasing, decreasing, or remaining unchanged. Potential concentration and water level changes in RW-3 could also be monitored.

Prior to implementing this pilot test, specific conditions should be set by the site team to help evaluate the appropriate course of action. Possible courses of action might include the following:

- installing an extraction well at MW-9D to allow permanent and continuous pumping for both mass removal and source control

- conducting quarterly pump events (similar to those noted above) for mass removal for a predetermined amount of time or until a specific set of conditions is achieved

- no additional pumping at MW-9D in favor of an alternative approach to remediation

If the site team opts for conducting a pump test, it would need to determine the appropriate conditions and courses of action to be taken based on the results. The RSE team estimates that each pumping event could cost $10,000 but would depend on the test protocols. Planning, interpreting, and reporting the pump test could cost an additional $10,000. Therefore, the pilot program might cost $20,000 or more. This cost for a test should be weighed against the cost of installing and connecting the well.

Injection for Enhanced In-Situ Degradation

This approach has the added advantage that remediation occurs underground with limited involvement or disturbance to surface activities. This is particularly applicable to this site where the responsible party does not own property and current tenants have ongoing activities near MW-9D. However, this approach does not enhance plume capture or provide hydraulic control of the source area. The RSE team suggests two potential options for enhancing in-situ degradation: bioaugmentation and nano-scale zero-valent iron injection. The two options are discussed below.

Bioaugmentation

Bioaugmentation refers to the injection of both nutrients and microorganisms to enhance the in-situ degradation of site contaminants. In some cases, bioaugmentation simply supplies the nutrients for an existing population of microorganisms, and in other cases, biougmentation supplies both the nutrients and microorganism cultures. Because specific microbe populations can be introduced, degradation from TCE to harmless products (i.e., ethene) is possible in locations where natural degradation generally leads to only DCE or vinyl chloride. Bioaugmentation has shown the ability to reduce concentrations to below MCLs by degrading TCE to ethene. The microbes are also rather robust and have been shown to survive in ground water with dissolved concentrations that are indicative of DNAPL.

The first step in assessing bioaugmentation is a technical evaluation of site-specific conditions including hydrogeology and geochemistry. The potential to create a reducing environment is evaluated and the expected radius of influence of potential injection points is estimated. The RSE team estimates the cost for this step at $1,500.

The second step is to conduct laboratory genetic analyses and bench testing. Ground water is analyzed to determine the presence of halorespiring bacteria using genetic tests, to determine which microbes (if any) need to be introduced to the subsurface, and to estimate the amount of nutrients that would be required to maintain the reducing environment. The RSE team estimates the cost for this step at $2,500 to $5,000.

The third step is a field test. For this facility, the field test might include injecting microbes and nutrients into MW-9D and monitoring changes in concentrations in MW-5, MW-9D, MW-27, and RW-3 over a period of three to six months and possibly longer to determine the potential for rebound. The RSE team estimates the cost for this step at $50,000 to $100,000.

As with other technologies, specific criteria to evaluate the success of bioaugmentation should be established prior to the test. Hypothetical outcomes of the test might include the following:

- If degradation is still occurring at or above a pre-determined acceptable rate, continue nutrient injection in MW-9D for an additional 6 months to maintain the existing microbe population and further enhance degradation. Reevaluate success of bioaugmentation relative to expectations after this additional 6 months. Consider conducting bioaugmentation at other injection points.

- If degradation occurs, but is below a pre-determined acceptable rate, consider one to two adjustments that can be made to further enhance the process. Retest for another six months and reevaluate.

- If degradation occurs well be low a pre-determined acceptable rate, discontinue bioaugmentation in favor of another remedial approach or potentially technical impracticabilty.

Other pre-set conditions and courses of action might be established to account for contaminant rebound, in case it occurs. Other than the reduction in TCE concentrations, other factors to consider in evaluating the success or failure of a pilot test might include the estimated cost of full-scale application and the potential for fouling of the P&T system.

Nano-Scale Zero-Valent Iron

The facility is already familiar with this technology, which involves the injection of zero-valent iron powder, carried by nitrogen gas, into the subsurface. The corrosion of the zero-valent iron to ferrous iron yields hydrogen gas that then combines with a chlorinated compound and results in the dechlorination of the contaminant. This technology is marketed by ARS Technologies (**www.arstechnologies.com**) under the trade name FEROX. Other vendors might be available but could not be located by the RSE team. Bedrock applications are considered ideal for this application because the iron can be injected efficiently. A typical radius of influence in bedrock might be 20 to 40 feet. Implementing this technology would likely be similar to implementing bioaugmentation. An evaluation, bench test, and pilot test are generally recommended, and the RSE team recommends setting specific parameters and conditions to evaluate the success of the pilot test. Example conditions are provided in the discussion on bioaugmentation. As with bioaugmentation the potential for iron injection to foul the P&T system should be considered.

Based on discussions with ARS, the RSE team estimates that the cost for a pilot test of this technology at the facility might range from $60,000 to $125,000.

6.4.2 CONSIDER MODIFYING THE REMEDY

Following a pilot test for aggressive remediation at MW-9D, the RSE team recommends that the site team consider modifying the remedy and/or remedy goals. The remedy goal currently states that operation of the P&T system continue until MCLs are reached in the compliance wells. The results of the pilot test will likely have one of the two following outcomes:

- Reaching MCLs is practicable with a modified remedy

- Reaching MCLs is technically impracticable

If the pilot test suggests that reaching MCLs is practicable, the remedy goal should likely be modified to include the current P&T system and the additional remediation might occur at MW-9D (or other locations). Consideration should also be given to including monitored natural attenuation (MNA) as a component of the final remedy.

If the pilot test suggests that reaching MCLs is technically impracticable, the site team should consider altering the remedy goals to containment in the area that is technically impracticable to restore but continue to pursue aquifer restoration in the remaining portion of the aquifer. In this case, consideration should be given to including MNA as a component of the final remedy, e.g., for the portion of the plume amenable to MNA per EPA guidance.

6.5 SUGGESTED APPROACH TO IMPLEMENTATION

The RSE team places a higher priority on evaluating the recommendations in Section 6.1 relative to evaluating the other recommendations. These recommendations are to further evaluate the potential for vapor intrusion, to consider the installation of two monitoring wells, to modify the approach for evaluating plume capture, and to consider institutional controls.

Recommendation 6.2.2 (consider modifications to the monitoring program) are given the next highest priority by the RSE team, but could be done concurrently if they do not interfere with considering/implementing the Section 6.1 recommendations.

The next level of priority could be reserved for consideration of alternative/supplemental remedial technologies (6.4.1). Once these are evaluated, the site team can evaluate Recommendation 6.2.1 (consider replacing the UVOX system with air stripping and vapor phase GAC) and Recommendation 6.4.2 (consider modifying the remedy goal).

Recommendation 6.3.1, which entails replacing the RW-3 drop tube with HDPE, can be evaluated if/when the tube or pump requires replacement.

7.0 SUMMARY

The RSE team observed an extremely well-managed remedy. Honeywell, their contractors, and EPA all have an excellent understanding of the site conditions, the remedy, and potential risks. Continuing efforts have been made by the site team as a whole to improve system operation and protect human health and the environment. The observations and recommendations contained in this report are not intended to imply a deficiency in the work of either the system designers or operators but are offered as constructive suggestions in the best interest of the EPA and the public. These recommendations have the obvious benefit of being formulated based upon operational data unavailable to the original designers.

Recommendations are provided in all four categories: effectiveness, cost reduction, technical improvement, and site closeout. Recommendations for effectiveness include further evaluating the potential for vapor intrusion, consideration of two additional monitoring wells, suggestions for improving the capture zone analysis, and consideration of institutional controls. Recommendations for cost reduction include considering modifying the treatment system to use air stripping instead of UV/oxidation and optimizing the ground water monitoring program. Replacement of an extraction well drop tube with HDPE (when/if necessary) is the only technical improvement recommendation. Recommendations for site closeout consist of considering the use of alternative technologies to address persistently elevated contaminant concentrations near MW-9D and modifying the remedy goals based on the performance of the alternative technologies. When considering these alternative technologies and potential pilot tests, the RSE team highly suggests developing specific criteria with which to evaluate the success or failure of pilot tests.

Table 7-1 summarizes the costs and cost savings associated with each recommendation in Sections 6.1 through 6.4. Both capital and annual costs are presented. Also presented is the expected change in life-cycle costs over a 30-year period for each recommendation both with discounting (i.e., net present value) and without it.

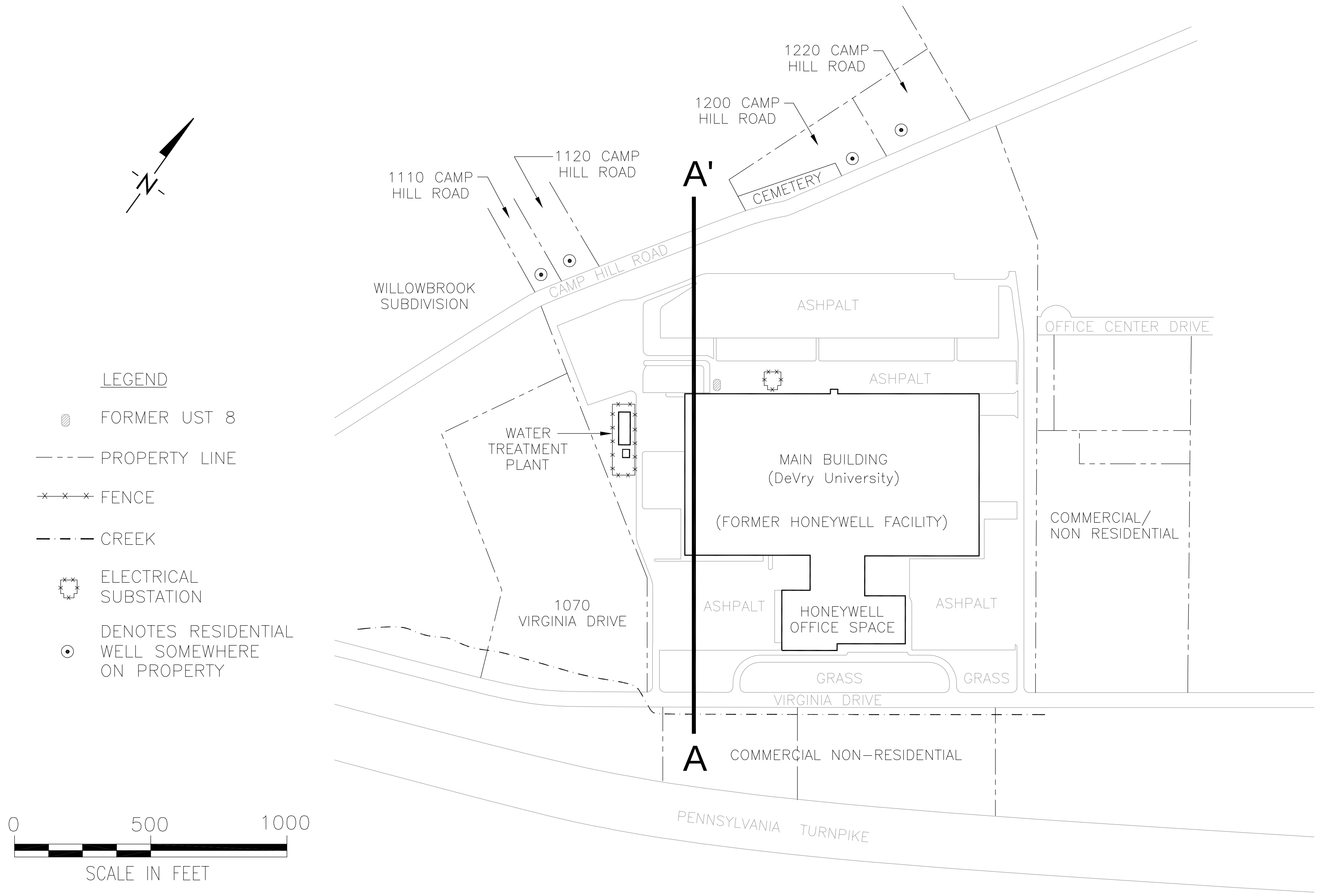
Table 7-1. Cost Summary Table

Recommendation	Reason	Additional Capital Costs ($)	Estimated Change in Annual Costs ($/yr)	Estimated Change In Life-cycle Costs ($) [1]	Estimated Change In Life-cycle Costs ($) [2]
6.1.1 Further Evaluate Potential for Vapor Intrusion	Effectiveness	$10,000	$0	$10,000	$10,000
6.1.2 Consider the Installation of Two Monitoring Wells	Effectiveness	$25,000	$0[3]	$25,000	$25,000
6.1.3 Modify Approach to Evaluating Plume Capture	Effectiveness	$0	$0	$0	$0
6.1.4 Consider Institutional Controls	Effectiveness	$5,000	$0	$0	$0
6.2.1 Consider Replacing UVOX System with Air Stripper and Vapor Phase GAC	Cost Reduction	$100,000	($27,500)	($725,000)	($344,000)
6.2.2 Consider Revisions to Ground Water Monitoring Program	Cost Reduction	$0	($16,000)	($480,000)	($260,000)
6.3.1 Use HDPE for RW-3 Drop Tube if/when it Requires Replacement	Technical Improvement	<$1,000	$0	<$1,000	<$1,000
6.4.1 Consider Alternative Remedial Approaches to Augment P&T System	Site Closeout	$54,000 to $125,000	potential savings[4]	potential savings[4]	potential savings[4]
6.4.2 Consider Modifying the Remedy	Site Closeout	not provided	not provided	not provided	not provided

Costs in parentheses imply cost reductions.
[1] assumes 30 years of operation with a discount rate of 0% (i.e., no discounting)
[2] assumes 30 years of operation with a discount rate of 5% and no discounting in the first year
[3] annual costs for monitoring these wells are considered in Recommendation 6.2.2.
[4] potential savings might result from a decrease in mass loading to the treatment system or to a reduced remedy duration

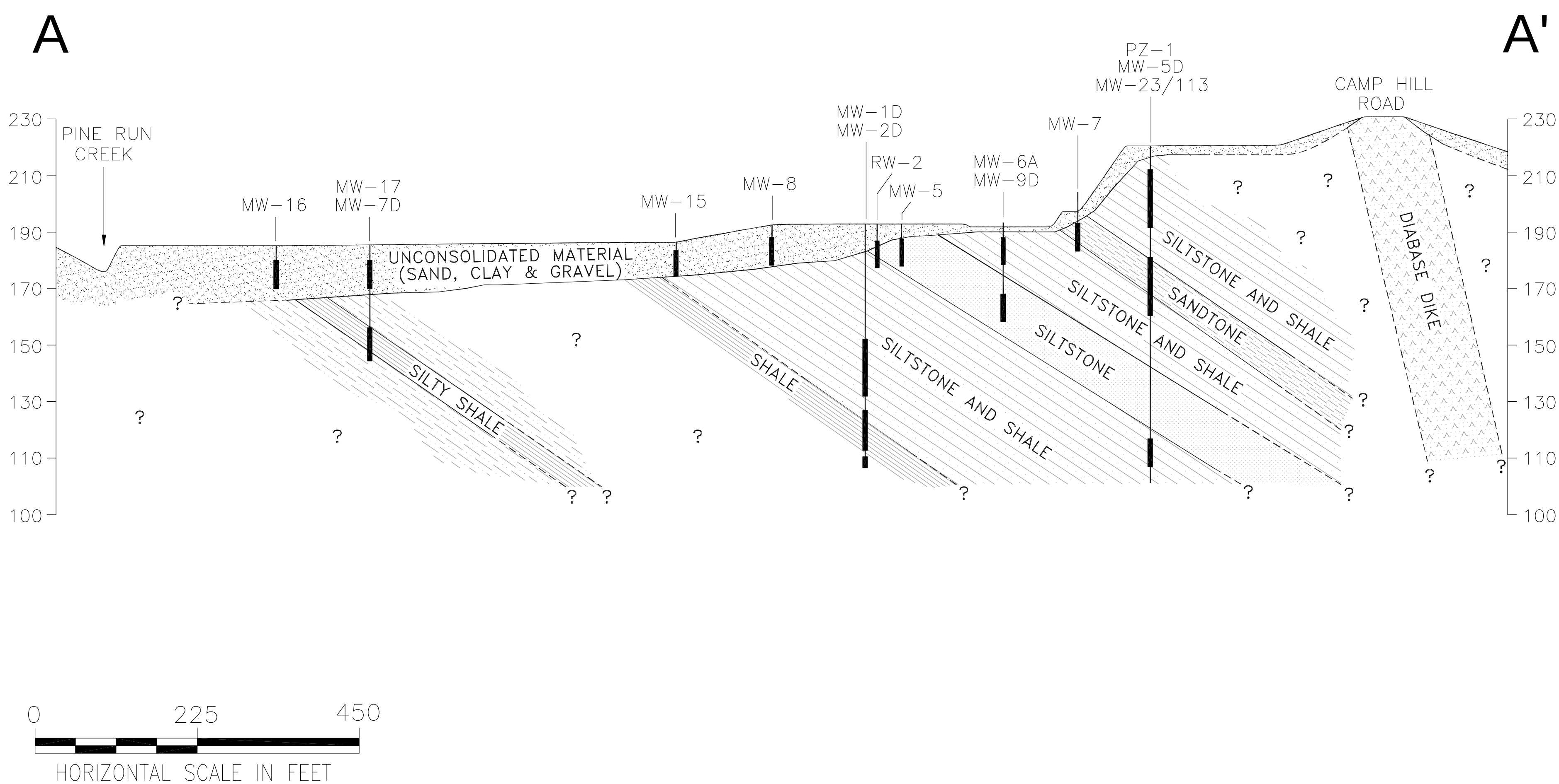
FIGURES

FIGURE 1-1. THE HONEYWELL FACILITY, SURROUNDING AREA, AND LOCATION OF THE CROSS-SECTION SHOWN IN FIGURE 1-2



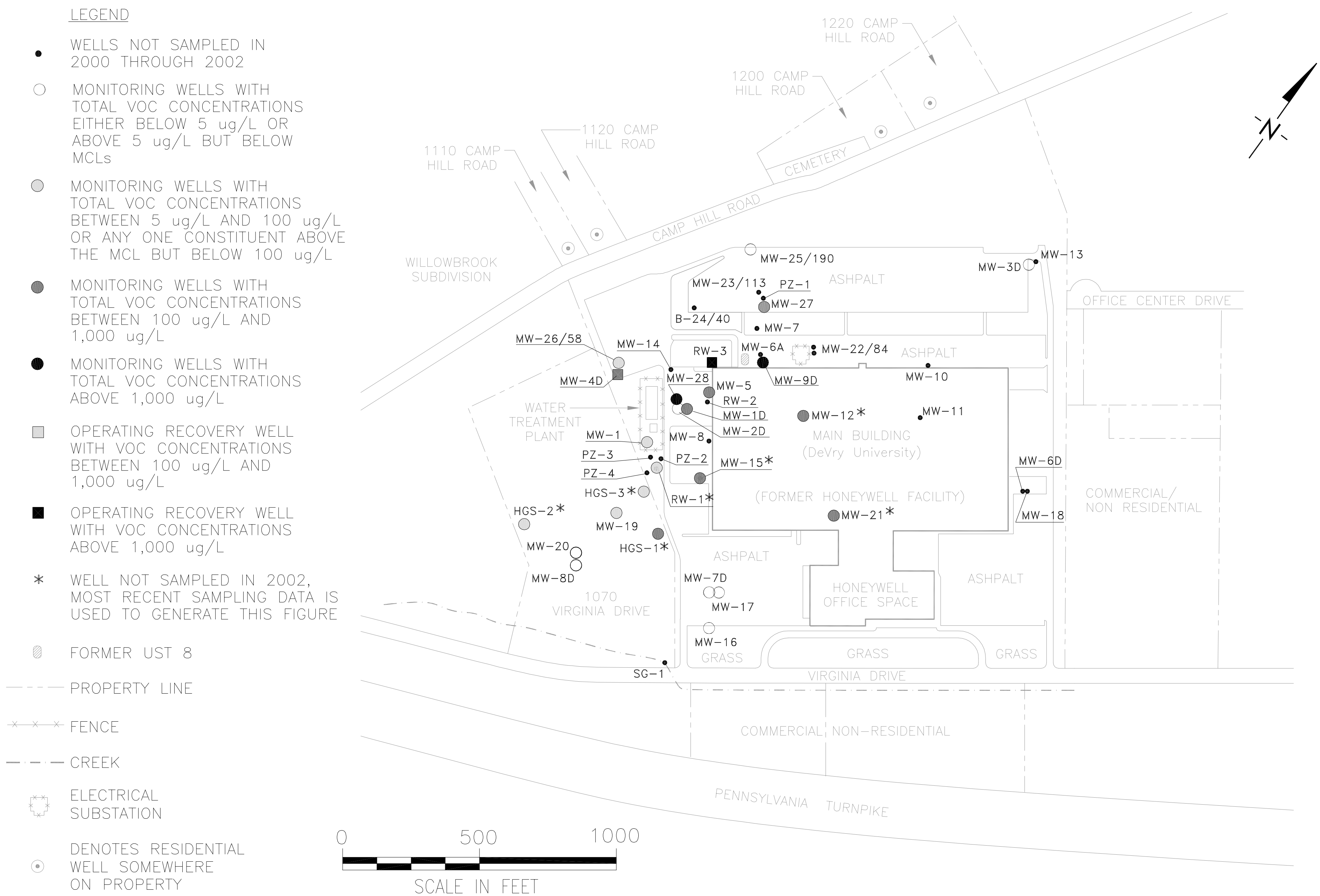
(Note: This figure is based on figures in site documents prepared by Harding Lawson Associates.)

FIGURE 1-2. NORTHWEST/SOUTHEAST GEOLOGIC CROSS-SECTION AS DEPICTED IN FIGURE 1-1.



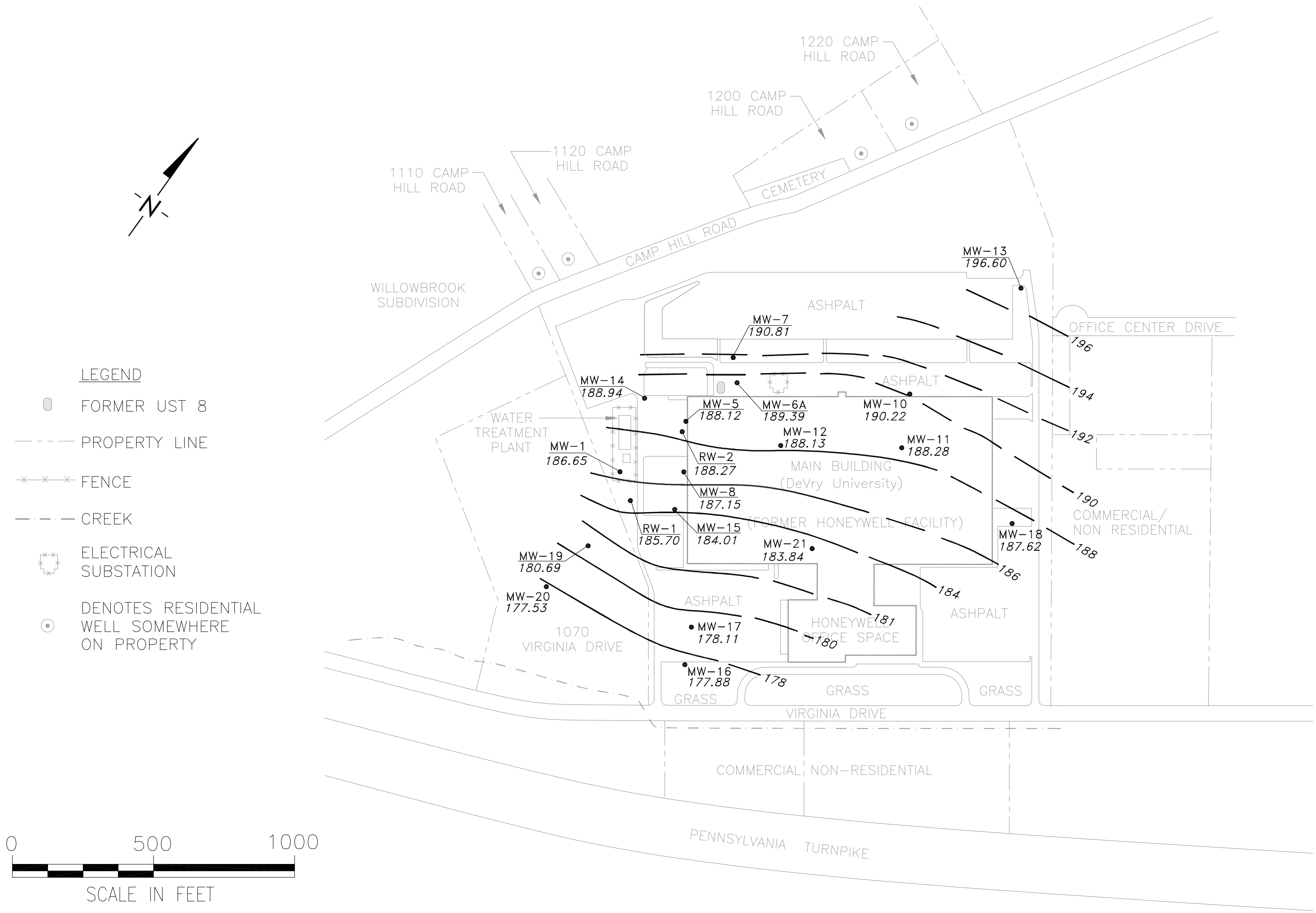
(Note: This figure is a re-creation of Figure 33 from the RCRA Facility Invesitgation Report, Harding Lawson Associates, December 1993. The cross-section runs directly from the top to the bottom of the Figure 1-1 of this report along the southeastern edge of the main building.)

FIGURE 1-3. EXTENT OF VOC CONTAMINATION BASED ON JULY 2002 SAMPLING EVENT.



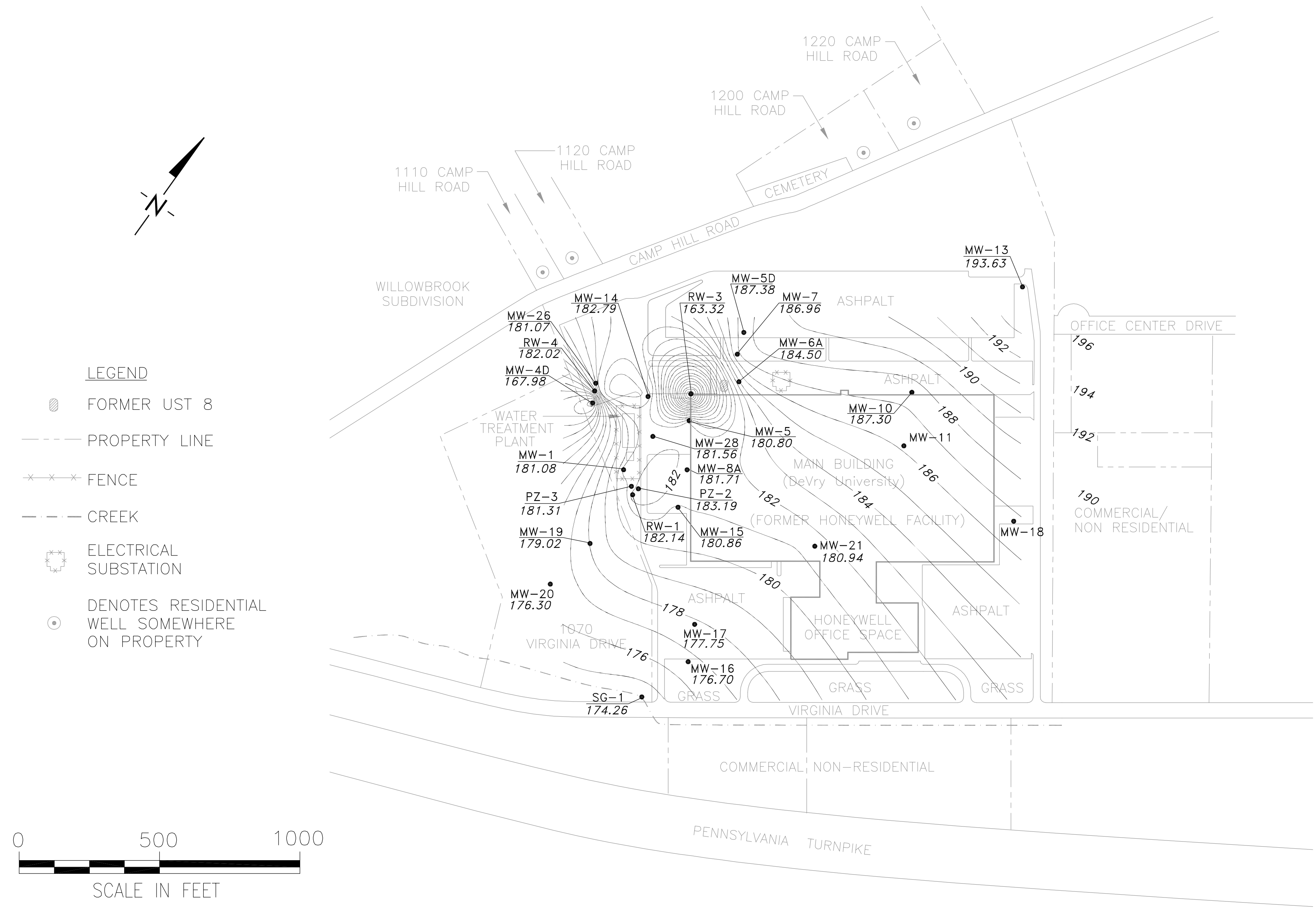
(Note: Base features taken from figures generated by Harding Lawson Associates. Sampling data obtained from July 2002 sampling event unless otherwise noted.)

FIGURE 4-1. POTENTIOMETRIC SURFACE MAP DEPICTING PRE-PUMPING CONDITIONS (1993).



(Note: This figure is a re-creation of Figure 7 from the RCRA Facility Investigation, Harding Lawson Associates, December 1993.)

FIGURE 4-2. POTENTIOMETRIC SURFACE MAP DEPICTING PUMPING CONDITIONS (1993).



(Note: This figure is a re-creation of Figure 1 from 3rd Quarter Progress Report, Harding ESE, October 2002.)