REMEDIATION SYSTEM EVALUATION
HIGGINS FARM SUPERFUND SITE
Princeton, New Jersey


Report of the Remediation System Evaluation,
Site Visit Conducted at the Higgins Farm Superfund Site
21-22 August 2003

Prepared by US Army Corps of Engineers
Hazardous, Toxic, and Radioactive Waste Center of Expertise
For the US Environmental Protection Agency

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Executive Summary

The Higgins Farm Superfund Site is located in a rural portion of Franklin Township, Somerset County, New Jersey, approximately 4 miles northeast of Princeton, New Jersey. The site occupies approximately 75 acres southeast of New Jersey State Highway 518 and is largely used as pasture.

Though used as a farm and pasture land, the Higgins Farm Site was at times also used for the disposal of hazardous wastes, including hazardous substances. In December 1985, the Franklin Township Health Department reported to the New Jersey Department of Environmental Protection (NJDEP) that elevated levels of chlorobenzene existed in a potable well adjacent to the site. NJDEP and EPA later provided alternate drinking water supplies for homeowners with potentially impacted wells as part of the first Record of Decision (ROD) dated September 24, 1990. NJDEP also investigated and discovered multiple drum burial and disposal areas throughout the site.

Mr. Higgins attempted to remove drums from a portion of the property. During excavation activities, some of the containers, including drums were punctured and their contents spilled onto the ground. Liquids were pumped from the excavation pit to a holding tank and visibly contaminated soils were placed in roll-off containers.

NJDEP sampled residential wells near the site and discovered that three of ten residential wells and groundwater were contaminated with volatile organic compounds (VOCs). Later NJDEP personnel inspected Higgins Farm and collected soil samples from the site, including the excavation pit area. Analysis of these samples indicated the presence of volatile organic compounds, pesticides, metals, dioxins and furans in the soils at the site. The next year NJDEP requested the EPA assume the lead role in the cleanup. EPA has performed a number of activities between 1987 and 1992.

The Remedial Investigation (RI)/Feasibility Study (FS) was prepared in 1992 and a second ROD to address site ground water contamination was signed in September 1992. The selected alternative included the installation of extraction wells and construction of a treatment plant that would include metals treatment by precipitation and ion exchange and removal of volatile organic compounds by air stripping. A design was prepared in 1994 and construction began in 1995. The groundwater extraction system and treatment plant began operation in May 1998.

Ground water conditions have been characterized at two general depths; shallow (less than 20 feet depth), and deep (20- 200 feet depth). Shallow monitoring wells are constructed with casing and five to ten feet of well screen. Deep monitoring wells installed during the RI have a surface casing into competent bedrock and are completed as open holes to total depth. As such, the deep monitoring wells represent conditions over very long vertical intervals.

Ground water flow is primarily from the north-central part of the site to the south and southeast. Hydraulic gradients are typically around 0.015 ft/ft with steeper gradients near the extraction system and on the western part of the site. At times, the gradients in the central part of the site drop to as low as 0.005 ft/ft. Hydraulic conductivities are highly variable, particularly in the fractured rock ranging from 2E-3 to 3E-7 cm/sec. Higher conductivities were typically identified in the upper 70 feet of the deep wells.

The present operations staff has been doing a good job keeping the plant fully operational and in compliance with permit equivalency. The staff has been improving operations by routinely upgrading and adjusting equipment inside and outside the plant. Some examples include modifying the extraction well pump controls, increasing pipe and pump capacity within the plant to increase the hydraulic capacity. The influent contaminant concentrations have also decreased over the operational life of the plant. The reduction of metals concentrations to below discharge levels except for iron and manganese, and significant reduction in the VOC concentrations have made many of the current processes inefficient. More effective process operations were evaluated and recommendations made to replace the current metals removal system with a manganese greensand filter, and reduce the blower requirements for the air stripping system.

The Remediation System Evaluation (RSE) identified 9 of the 20 extraction wells as having met cleanup standards and recommends that pumping from those 9 wells be discontinued. Conversely, to enhance plume capture one additional well is proposed between existing wells 11 and 12. The RSE evaluated monitoring needs for the site, and proposed many suggestions to reduce sampling frequency and reporting based on the consistency of the last four sampling episodes.

A site exit strategy should be identified that sets goals for reduction in concentrations at specific locations based on the goals for human health and environmental protection. These goals may address achieving specific concentrations at specific locations, taking specific additional remedial actions if concentrations do not decline, or discontinuing extraction from certain wells or specific treatment processes if concentrations fall below a certain level. Example site exit strategy components are offered in section 6.4.2 as a starting point for discussions.

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1.0 INTRODUCTION

1.1 PURPOSE

In the OSWER Directive No. 9200.0-33, Transmittal of Final FY00 - FY01 Superfund Reforms Strategy, dated July 7, 2000, the Office of Solid Waste and Emergency Response outlined a commitment to optimize Fund-lead pump and treat systems. To fulfill this commitment, the U.S. Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI) and EPA Region 2 identified a need for an evaluation of the Higgins Farm Superfund Site, New Jersey.

As a matter of background, in fiscal year (FY) 2001, a nationwide effort identified all Fund-lead pump-and-treat systems in the EPA Regions, collected and reported baseline cost and performance data, and evaluated a total of 20 systems. The site evaluations were conducted by EPA contractors, GeoTrans, Inc. and the United States Army Corps of Engineers (USACE), using a process called a Remediation System Evaluation (RSE), which was developed by USACE and is documented on the following website:

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

In FY 2002 and 2003, additional RSEs were commissioned to address sites either recommended by a Region or selected by OSRTI.

A RSE involves a team of expert hydrogeologists and engineers, independent of the site team, 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, 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 with cost and cost savings estimates are provided in the following four categories:

- improvements in remedy effectiveness
- reductions in operation and maintenance costs
- technical improvements
- gaining site closeout

The recommendations are intended to help the site team identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, is required prior to implementation of the recommendation.

OSRTI and EPA Region 2 cooperatively selected the Higgins Farm Superfund Site. This site has high operation costs relative to the cost of an RSE and a long projected operating life. The RSE process described above was applied to the Higgins Farm Site. The EPA Region 2 RPM, Ms. Pamela J. Baxter, arranged for the site visit and facilitated the delivery of relevant documents to the RSE team. A site visit was made on 21-22 August 2003. This report provides a brief background on the site and current operations, a summary of the observations made during the 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:

Dave Becker, Geologist, USACE Hazardous, Toxic, and Radioactive Waste Center of Expertise (HTRW CX)

Lindsey Lien, Environmental Engineer, USACE HTRW CX

In addition, Matt Charsky, from HQ USEPA, participated in the first day of the RSE.

1.3 DOCUMENTS REVIEWED

The following documents and data were reviewed as part of the RSE:

- Record of Decision Higgins Farm - September 30, 1992
- Remedial Investigation, CH2M Hill - June, 1992
- Design Basis Report, CH2M Hill - December, 1993
- Summary of Field Activities, CH2M Hill - November 1996
- Operation and Maintenance Manual, Sevenson Environmental Services - June 3, 2002
- Final Plans, CH2M Hill - March, 1995
- Operation and Maintenance Reports Sevenson Environmental Services - December 2002, January 2003, February 2003, March 2003, and May, 2003
- Quarterly monitoring well sampling results, Sevenson Environmental Services - June 2001, March 2002, May 2002, September 2002, and March 2003
- Extraction well sampling results March 2002, June 2002, September 2002, and March 2003
- Quarterly Groundwater Monitoring Reports, Sevenson Environmental Services - November 2002, April 2003.

1.4 PERSONS CONTACTED

Pamela J. Baxter, Remedial Project Manager, EPA Region 2
Neal Ravensbergen, US Army Corps of Engineers, New York District
Jim Russell, Sevenson Environmental Services, Lead Operator
Barney Fite, Sevenson Environmental Services, Operator
Dawn Cermak, Sevenson Environmental Services, Project Manager
Jane Ten Eyck, New Jersey Department of Environmental Protection, Case Manager

1.5 SITE LOCATION, HISTORY, AND CHARACTERISTICS

1.5.1 SITE LOCATION

The Higgins Farm Superfund site is located in a rural portion of Franklin Township, Somerset County, New Jersey, approximately 4 miles northeast of Princeton, New Jersey. The site occupies approximately 75 acres southeast of New Jersey State Highway 518 and is largely used as pasture. The site is located at approximately 40^{o} 24.3' N latitude and 74^{o} 36.2'W longitude.

1.5.2 SITE HISTORY

The following site history was largely derived from the information contained in the 1992 Record of Decision. Though used as a farm and pasture land, the Higgins Farm Site was at times also used for the disposal of hazardous wastes, including hazardous substances. In December 1985, the Franklin Township Health Department reported to the New Jersey Department of Environmental Protection(NJDEP) that elevated levels of chlorobenzene existed in a potable well located at Route 518, Franklin Township, Somerset County, New Jersey. NJDEP investigated and discovered the presence of a drum burial dump at the site approximately forty yards from the contaminated well. Another disposal area, informally named the NJDEP fenced area, was discovered in the south-central portion of the site.

In April, 1986, the site owner, Mr. Higgins, employed O.H. Materials, to remove drums from a portion of the property, informally called the excavation pit area. Approximately fifty containers, including drums, were excavated. During excavation activities, some containers were punctured and their contents spilled onto the ground as the drums were excavated. Liquids were pumped from the excavation pit to a holding tank and visibly contaminated soils were placed in roll-off containers.

On April 26, 1986, NJDEP sampled ten residential wells in the vicinity of the site and discovered that three wells were contaminated with volatile organic compounds (VOCs). Nine of the ten residential wells were resampled by NJDEP in August 1986. The analysis confirmed the presence of volatile organic contamination in the ground water. On May 8, 1986, NJDEP personnel inspected Higgins Farm and collected soil samples from the site, including the excavation pit area. Analysis of these samples indicated the presence of volatile organic compounds, pesticides, metals, dioxins and furans in the soils at the site.

In March 1987, NJDEP formally requested that EPA assume the lead role in mitigating the Higgins Farm Site. On April 8, 1987, EPA initiated activities to stabilize the site and to control the release of hazardous substances into the environment. The following actions were undertaken: the construction of a barn to house contaminated material, including over-packed drums and roll-off containers; the excavation pit was drained, lined and backfilled; the pumped liquids were treated and stored in holding tanks; and the excavation pit area was fenced to prevent access by unauthorized persons. EPA conducted additional excavation of 94 drums in 1992 in the southwestern portion of the site.

In March 1987, EPA responded to the presence of contamination in drinking water wells neighboring the site by providing bottled water to potentially impacted area residents. At that time, EPA explained that it would provide bottled water as an interim solution until an alternate water supply could be arranged by NJDEP. Thereafter, NJDEP determined that the most appropriate method to supply potable water was to install individual carbon units at the potentially impacted homes. NJDEP installed the carbon filter units during the spring/summer of 1989, at which time bottled water delivery was discontinued.

The site was proposed for inclusion on the National Priorities List (NPL) in June 1988. In March 1989, the site was formally placed on the NPL, thus making it eligible for federal funds to investigate the extent of contamination and to clean up the site. In June 1990, EPA released a Focused Feasibility Study (FFS) report and EPA's Proposed Plan for the construction of a water line extension to provide the potentially affected residents with an alternate water supply. On September 24, 1990, EPA issued a first Record of Decision (ROD) that selected an interim remedy to connect the potentially affected residents to an existing water supply. The water supply was later installed for residents along State Highway 518.

Remedial investigation (RI) field work was conducted by EPA’s contractors in two phases: from March 1990 through January 1992, and from February 1992 through March 1992. Ground-water, surface and subsurface soil, surface-water, sediments and suspected source area (through test pit excavation) samples were collected and analyzed during Phase I of the RI. Phase II of the RI, which included the excavation of additional test pits and sampling, was conducted to investigate other potential sources of contamination. The RI effort also included a characterization of the site hydrogeology including water level measurements and slug, packer, and pump testing to determine hydraulic parameters. A risk assessment conducted in conjunction with the RI report indicated the site posed unacceptable risk to human health. A feasibility study of remedial alternatives was also prepared in 1992. Based on this RI and FS, a second ROD to address ground water contamination at the site was prepared in September 1992. The selected alternative included the installation of extraction wells and construction of a treatment plant that would include metals treatment by precipitation and ion exchange and removal of volatile organic compounds by air stripping. A remedial design was prepared in 1994 and construction activities began in 1995. A third removal action occurred in 1996 which included removal of drums, containers, and contaminated soil encountered during on-site road construction to the treatment plant. The plant began operating in May 1998.

1.5.3 SITE CHARACTERISTICS

1.5.3.1 HYDROGEOLOGY

The Higgins Farm Superfund Site is located in the Piedmont physiographic province and overlies rocks of the Newark Basin. The local bedrock is the Rocky Hill Diabase, a medium to dark gray rock composed of feldspar and pyroxenes, with lesser amounts of olivine, biotite, garnet, quartz, and hornblende and traces of other minerals. The Rocky Hill Diabase is part of a sill (sub-horizontal tabular intrusion) that underlies much of this area of New Jersey and is exposed along the Hudson River as the Palisades. The diabase is estimated to be over 1000 feet thick in southern Franklin Township. The upper portion of the diabase is weathered and fractured and is overlain by residual soils (primarily silty), fill, and traces of glacial deposits. Alluvial deposits are found near nearby streams. Overburden is generally less than 15 feet thick and in some places on site less than five feet thick.

The degree of fracturing in the diabase diminishes with depth. The unweathered rock is quite competent and has infrequent fracturing. Rock quality designation (RQD) values, which describe the degree of fracturing (higher values indicate larger fracture spacing), are very high. Continuous cores were obtained during drilling of the Westbay system monitoring wells. Very few sub-horizontal fractures were encountered, though some appeared to be open and often iron or manganese oxide coated. Others were filled with chlorite, pyrolusite, epidote, and less common minerals. Steeply dipping fractures that were encountered were largely completely healed by calcite, chlorite or other minerals. During coring, water loss was often negligible, though some zones were associated with significant water loss, indicating significant fracture permeability.

Though of high quality, the diabase is, however, offset by a significant fault zone in the large trap rock quarry just southwest of the site. The fault zone strikes N 15^{o} E and dips approximately 50 degrees to the southeast. Offset may be as large as 1700 feet (CH2M-Hill RI, 1992). Rock near this fault zone is more fractured and weathered. At least one possible fault zone was encountered while drilling at the site (at approximately 145-foot depth in MW-11) and slickensides were observed on fractures.

Ground water movement is believed to be restricted to the overburden and fractures within unweathered bedrock. Most flow is probably concentrated in a limited number of connecting open fractures. Not surprisingly, well yields at the site are low, and seepage into the nearby quarry was relatively small but noticeable during a site visit on August 16, 2003 by the EPA RPM and James May of the USACE Engineer Research and Development Laboratory located in Vicksburg, MS. Movement is controlled by the preferred orientation of the fractures.

1.5.3.2 SITE GROUND WATER CONDITIONS

Ground water conditions have been characterized at two general depths – shallow (less than 20 feet depth) and deep (20- 200 feet depth). Shallow monitoring wells are constructed with casing and five to ten feet of well screen. Deep monitoring wells installed during the RI have a surface casing into competent bedrock and are completed as open holes to total depth. As such, the deep monitoring wells represent conditions over very long vertical intervals. In 2000, additional monitoring points were installed around the perimeter of the site. These wells were completed as multi-port Westbay wells to depths of approximately 200 feet. Water levels are typically not taken from these ports, though they are sampled for chemical analyses.

Static water levels in monitoring points are typically less than 2 feet to over 25 feet below grade at the site. Piezometric levels are typically 275-235 feet above sea level. Ground water flow directions based on piezometric levels measured in the RI monitoring wells are comparable for the two depths. Ground water flow is primarily from the north-central part of the site to the south and southeast. Hydraulic gradients are typically around 0.015 ft/ft with steeper gradients near the extraction system and on the western part of the site. At times, the gradients in the central part of the site drop to as low as 0.005. Hydraulic conductivities are highly variable, particularly in the fractured rock. Slug testing on shallow wells conducted in the RI indicated hydraulic conductivities of 2E-3 to 3E-5 cm/sec. Packer testing on intervals in the deep open monitoring wells indicated hydraulic conductivities as high as 4E-3 cm/sec to many intervals (presumably essentially unfractured) displaying conductivities of less than 1E-7 cm/sec. Higher conductivities were typically identified in the upper 70 feet of the deep wells. Pump testing conducted at the site yielded an estimated transmissivity value of 112 ft^{2}/day. This value was used in the original basis for the extraction well layout. The Design Basis report recognized that additional wells may be needed to account for the uncertainty in the estimated transmissivity.

1.5.3.3 SITE CONTAMINATION

Contaminants at the site include, as would be expected given the nature of the release, a variety of organic compounds and some metals. The primary organic compounds found in ground water are tetrachloroethene (PCE), trichloroethene (TCE), with lesser amounts of 1,2-dichloroethane (1,2-DCA), cis-1,2-dichloroethene (1,2-DCE), chlorobenzene (CB), benzene, 1,1,2-trichloroethane (1,1,2-TCA), 1,1,2,2-tetrachloroethane (1,1,2,2-PCA), and trace amounts of vinyl chloride (VC). Other contaminants had been identified in soils at the site, including pesticides. Past removal actions by EPA and others have addressed the major source areas through the removal of drums and significant soil contamination.

Although characterization done during the RI identified widespread contamination at the site, ground water extraction has reduced the on-site extent of contamination. Whereas, the on-site plume was not initially well defined, now several individual plumes appear to emanate from specific past disposal sites. The largest mixed organic compound plume extends southeastward from the Excavation Area apparently beyond the Higgins property boundary and has a width of 750-800 feet. Another mixed organic compound plume extends southward from the NJDEP fenced area. This plume widens southward to over 1000 feet due to the source location on the slight ground water divide extending through the site. Finally, another plume, consisting primarily of 1,2-DCA with some 1,1,2-TCA extends westward from an indistinct source, perhaps near the Higgins residence. A geophysics survey in 1996 did not reveal drums in the area.

Given the presence of cis 1,2-DCE and trace amounts of VC, there is possibly some reductive dechlorination occurring at the site.

Ground water at the site is largely aerobic and dissolved oxygen levels are typically above 2 ppm, though there are some wells with DO concentrations as low as 1-2 ppm. Iron levels are variable, but elevated in some samples. Eh values are almost all positive relative to the reference electrode. Elevated turbidity is noted from some wells, including some evidence for suspended solids from certain extraction wells. Monitoring wells with elevated turbidity over 20 NTU (as of March 2003) include MW-2S, -2D, -3D, -6S, -6D, -8S, and -10S.

1.5.3.4 SITE AND NEARBY LAND USE

The region around the Higgins Farm Site is used for agricultural, rural residential, mining, and recreational purposes. There has been an increase in residential development in the area. The Higgins site is currently used as pasture for livestock. Portions of the Higgins property have been identified as wetlands. Wooded, undeveloped land lies to the south and southeast of the site almost to State Highway 27, though there is a law enforcement pistol range in the area. The Trap Rock Industries quarry uses land to the southwest. Areas to the north and east are used for a mix of agricultural and residential purposes. Most homes in the immediate vicinity of the site, with the exception of residences along State Highway 518, have domestic water wells. EPA provided a number of residences along highway 518 with municipal water in a 1990 interim remedial action.

2.0 SYSTEM DESCRIPTION

2.1 SYSTEM OVERVIEW

The groundwater remedy for the Higgins Farm Superfund Site includes the following items:

- groundwater extraction from 20 wells located on site;
- above ground treatment (equalization, coagulation and precipitation, filtration, ion exchange, air stripping, pH and alkalinity adjustment, solids handling, and discharge to a tributary to Carters Brook).

The groundwater treatment system operations began in May 1998. During the first year system commissioning phase, the system experienced hydraulic and process related problems. The secondary ion exchange system was not operating properly and taken off line due to short runs and inefficient operation. Metals of interest (iron, manganese, barium, zinc, barium, nickel, magnesium and copper) are generally below discharge levels following the weak acid ion exchange resin contactors. The plant was designed to have a maximum capacity of 100 gpm, although the surface water discharge standards in the permit equivalent are based on an average effluent flow rate of 75 gpm. Start up and shake down testing identified a maximum capacity of approximately 60 gpm. Additional problems associated with scaling down stream of the reaction tank and clarifier further exacerbated the problem. The capacity of the well field was slightly below the 60 gpm limitation of the plant, and the plant has been able to treat all the water extracted.

Plant operations transitioned to the current contractor Sevenson Environmental Services (SES) in 1999. The new operations contractor proceeded to diagnose hydraulic and operational system issues and reinforced the previous contractors finding that the chelating ion exchange system was not needed to meet metals discharge standards. SES revised the operation of the plant to include more chemical addition to the reaction tank to ensure the softening step which was used as a pretreatment step for the ion exchange units, maximize iron and calcium removal upstream of the ion exchange beds, resulting in longer filter runs and media life. Pump control wiring and iron fouling in the extraction pumps continue to consume a good deal of the operator’s time each day.

2.2 EXTRACTION AND INJECTION SYSTEM

The ground water extraction system includes 20 extraction wells, seventeen of which have been installed in a “U”-shaped configuration around the western, southern, and southeastern edge of the site. These wells are typically spaced approximately 150 to 400 feet apart. Three extraction wells have been installed just south and west of the excavation pit area. The extraction wells are all six inches in diameter and approximately 150 feet deep with a screen and filter pack extending from essentially the bottom of the borehole to within 5 feet of the surface. The 20 feet of screen in the interval of unconsolidated materials and weathered bedrock has a slot-size of 0.010-inch and is surrounded by filter sand (Morie 00N sand). The remainder of the screen set into competent rock had a slot size of 0.100-inch and was surrounded by pea gravel. Following drilling and prior to well construction, 16 of the 20 wells were hydraulically fractured to increase flow rates from the wells. Based on the report prepared by CH2M-Hill on the installation of the wells (CH2M-Hill, 1996), the hydraulic fracturing was only partially successful at increasing production from the extraction wells and resulted in an average increase of less than 1 gallon per minute.

The wells are equipped with Grundfos submersible pumps, with ¾ horsepower motors, that are nominally rated for flow at 5 gpm. The well flows from the western and southern portions of the site are conducted to the treatment plant through a combined 3-inch-diameter fiberglass-reinforced plastic (FRP) header pipe. Wells along the southeast edge of the site and the three wells near the excavation pit are connected to the treatment plant by separate 2-inch-diameter FRP pipe. Each well has a flow meter, sample port, solenoid-controlled valve, and pressure gauge. The wells are completed with a concrete vault with locking metal doors. These vaults do not have a drain or access ladder. A few vaults have sump pumps. Piping within vaults are heat-traced and insulated. A separate vault contains the electrical panel for the well or wells nearby. Electrical supply and control wiring are buried. In 2003, control wiring was replaced at several wells with radio communication equipment. Wiring for the remaining wells was completed in January 2004. The antennas need to be protected from damage caused by cattle present at the site.

2.3 TREATMENT SYSTEMS

The Higgins Farm groundwater treatment system was originally designed to operate at 100 gallons per minute (gpm). The actual flow rate varies between 35 and 60 gpm depending on water levels, number of pumps operating as well as other factors. The maximum design influent and discharge concentrations at the plant are shown in Table 3.

The treatment system consists of the following elements:

- duplex equalization tanks
- aerated chemical reaction tank/flocculation tank/clarifier
- duplex sand media pressure filters
- weak acid ion exchange system
- chelating ion exchange system
- duplex packed tower air strippers
- VOC off gas venting system to the atmosphere
- backwash holding tank
- chemical storage and feed
- effluent holding tank
- discharge to Carters Brook
- filter press system for solids handling

All treatment components with the exception of the bulk chemical (caustic, sulfuric acid) storage tanks are housed in the 100' wide x 120' long pre-engineered metal building.

2.4 MONITORING SYSTEM

The monitoring network for the extraction system consists of 21wells; 7 shallow monitoring wells, 8 deep monitoring wells, and six Westbay multiport wells. There are also a number of piezometers installed near the wetland areas at the site to determine impact of the ground water extraction on the wetlands. Standard monitoring wells were installed during the RI and are confined to the Higgins property. The Westbay wells were installed in 2000 and all are downgradient of the extraction system with exceptions of WB-11. All Westbay wells are located off the Higgins property with the exception of WB-11 and WB-14.

The shallow monitoring wells are typically screened at depths less than 20 feet. Deep monitoring wells are completed as open holes to depths of approximately 200 feet in competent bedrock. These deep wells isolate the unconsolidated materials and weathered bedrock with surface casing. The Westbay wells each have multiple sampling ports at various depths, as described in the Table 1.

Table 1: Monitoring Zones in Site Westbay Wells

Zone	Westbay Well Monitoring Zone Depths (total well depth in parentheses, units are in feet)					
	WB-11 (194')	WB-12 (160')	WB-13 (200')	WB-14 (200')	WB-15 (170')	WB-16 (172')
4	N/A	N/A	N/A	47.5'	N/A	N/A
3	47'	N/A	56'	112.5'	30'	33'
2	94'	45'	145'	154.5'	115'	115'
1	179'	145'	190'	189.5'	155'	157'

The conventional monitoring wells are sampled semi-annually using low-flow techniques and non-dedicated pumps. The Westbay wells are also sampled semi-annually, but samples are obtained using a MOSDAX sampler that is lowered inside the Westbay casing and attaches to a sampling port. The port is opened and a stainless steel sample chamber is filled. No purging is done. Samples are also collected semi-annually from the sample taps on the individual extraction wells. Samples are submitted for fixed lab analyses for volatile organic compounds by EPA method 8260B and metals by EPA methods 6010, 7041, 7421, and 7470. Analyses have also been conducted for dissolved gases methane, ethene, and ethane as well as chloride, nitrite, nitrate, and sulfate. Field analyses are conducted for dissolved sulfide, total iron, dissolved (ferrous) iron, pH, dissolved oxygen, turbidity, and alkalinity.

Table 2
Site Cleanup and Treatment Plant Discharge Criteria[1,2]

Parameter *	Cleanup Levels OU-2 ROD (μg/L) [2]	New Jersey Surface Water Quality Criteria (μg/L) [1]	New Jersey Maximum Contaminant Limit (μg/L) [1]	Federal Maximum Contaminant Limit (μg/L) [1]
Benzene	1	1	1	5
Carbon Tetrachloride	2	1 [6]	2	5
Chlorobenzene	4	1	4	100
Chloroform	100	1	-	100
1, 2 DCA	2	1 [6]	2	5
1, 1 DCE	2	1 [6]	2	7
cis-1, 2 DCE	10	1	10	70
1, 1, 2, 2 PCA	1	1 [6]	-	-
PCE	1	1 [6]	1	5
1, 1, 2 TCA	3	1 [6]	-	5
TCE	1	1	1	5
VC	2	1	2	2
bis(2-chloroethyl) ether	-	5	-	-
bis(2-ethylhexyl) phthalate	6	2.5 [625] [6]	-	6
Hexachlorobutadiene	-	1	-	-
Dieldrin	-	0.002 [608] [6]	-	-
Aluminum	-	100 [6]	-	-
Antimony	6	5	-	6
Arsenic	-	0.5 [200.9] [6]		
Barium	2000	28	-	2000
Beryllium	4	1 [6]	-	4
Cadmium	5	1 [6]	-	5
Chromium	100	5 [200.7] [6]	-	100
Cobalt	1300	10 [6]	-	-
Copper	-	5 [200.7] [6]	-	1300
Iron	-	300	-	-
Lead	15	0.3 [6]	-	15
Manganese	-	50	-	
Mercury	-	0.2 [245.1] [6]		
Nickel	100	13	-	100
Vanadium	-	14	-	-
Zinc	-	47	-	-
Cyanide	-	5.2		
*BOD_5	-	25		
*Dissolved Oxygen	-	5		
pH (units)	-	6.5 – 8.5		
*PetroHydrocarbons	-			
		15		
*TOC	-	50		
*TDS	-	500		
*TSS	-	40		

* all concentrations in μg/L except those identified by * are in mg/L

[1] NJDEP Permit Equivalent Table Outfall 001, Higgins Farm SF Site, August 4, 1994

[2] Table 16, Higgins Farm SF Site OU-2 ROD dated 30 September 1992

[6] Concentrations are "Discharge Reporting Levels" (DRL's) which corresponded to the detection limits using the published analytical method.

3.0 SYSTEM OBJECTIVES, PERFORMANCE AND CLOSURE CRITERIA

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

The groundwater extraction and treatment systems were installed as prescribed in the ROD for the second operable unit (OU) for the Higgins Farm Superfund Site. The Regional Administrator for the U.S. Environmental Protection Agency (EPA) Region II signed the Record of Decision for the Higgins Farm Superfund Site on September 30, 1992. The first operable unit provided for installation of a water line to supply area residents with an alternate water supply. The selected remedy for the second OU, as recommended in the FS, included the installation of ground water extraction wells, installation of an on-site groundwater treatment facility, and discharge of the water to the on-site pond that overflows into a branch of Carters Brook. The plant effluent is required to meet the stringent surface water quality criteria indicated in Table 3.

The following are the remedial action objectives set forth in the OU-2 ROD:

- capture and treat the contaminated ground water in an attempt to restore the aquifer to Federal and State drinking water standards
- control or limit the future off-site migration of the contaminated ground water
- minimize the potential for direct exposure of the populace to the contaminated ground water.

The duration of the final remedy as identified in the OU-2 ROD was estimated to be between 5 and 30 years based on design investigations.

3.2 TREATMENT PLANT OPERATION GOALS

The treatment plant goals are to maximize contaminant removal, minimize plant down time, and be consistent with the final discharge criteria specified in the ROD as identified in Table 2 and Table 3. The plant discharge is routed through a small wetlands area and discharged to a small pond that overflows into a branch of Carters Brook. The discharge criteria are extremely conservative, and in many cases exceed the aquifer clean up levels specified in the ROD. Table 3 identifies the design/actual/proposed influent concentrations, and Table 2 the effluent discharge criteria.

3.3 ACTION LEVELS

The action levels for the system are identified in Table 3 as specified in the ROD. Referring to Table 3 it is interesting to note these criteria are actually higher than the discharge standards identified for the above ground treatment facility discharge to Carters Brook.

Table 3: Site and Plant Discharge Criteria

Parameter	Discharge Criteria µg/L[8]	Influent Concentration GWTP µg/L Design [2]	Influent Concentration GWTP µg/L Actual [3]	Revised Concentration To GWTP Proposed [4] µg/L	Ecotoxicity Chronic Screening Levels [5] EPA Reg 4 (µg/L)	RBC's/PRG Levels [6] (µg/L) EPA Reg 3 (tap water)	RBC's/PRG Levels [6] (µg/L) EPA Reg 9 (tap water)	MCL [7] New Jersey (µg/L)
Benzene	1	1200	<1	<1	53	0.34c	0.34c	1
Chlorobenzene	1	1100	1.1 (1)	2	195	110nc	110nc	50
1, 2 DCA	1	320	<1	2	2000	0.12c	0.12c	2
1, 2 DCE	1	13	3.6(1)	4	1350	61nc cis 120nc trans	61nc 120nc	70 cis 100 trans
1, 1, 2, 2 PCA	1	7.5	2.3(1)	6	240	0.053c	0.055c	1
PCE	1	740	40(1)	67	84	0.10c	0.66c	1
1, 1, 2 TCA	1	1100	2(1)	5	940	0.19c	0.20c	3
TCE	1	220	15(1)	34	NA	0.026c	0.028c	1
Vinyl Chloride	1	86	<1	0.2	NA	0.015c	0.020c	2
Aluminum	100	304,000	<100	<100	87	37,000nc	36,000nc	200 (s)
Arsenic	8	<5	<8	<5	190	0.045c	0.045c	10
Barium	28	1890	30(21)	<21	NA	2,600nc	2,600nc	2000
Beryllium	1	25.7	<1	<1	0.53	73nc	73nc	4
Cadmium	1	4.1	<1	<1	0.66	18nc	18nc	5
Chromium	5	403	<10	<1	117	55,000nc	55,000nc	100
Copper	10	8750	<10	<1	6.54	1500nc	1500nc	1300(AL)
Iron	300	433,000	860(300)	1500	NA	11000nc	11000nc	300(s)
Lead	0.3	81.4	<3	<3	1.32	NA nc	0.0036nc	15 (AL)
Manganese	50	24,800	210 (80)	270	NA	730 nc	880nc	50(s)
Mercury	0.2	-	<0.2	<0.2	0.012	NA nc	11nc	2
Nickel	13	224	<20	<20	87.71	730nc	730nc	NA
Zinc	47	811	<20	<20	58.91	11000 nc	11000nc	5000(s)

Notes: All values are micrograms per liter (µg/L).

[1] The Risk-Based cleanup concentrations are identified in Table 2

[2] Table 5-1 Section 5, Design Basis Report, CH2M Hill, December, 1993.

[3] Calculated based on the average concentration of the last 4 sampling results for all wells

[4] Calculated based on the average concentration of the last 4 sampling results for wells to remain in service, 1, 2, 3A, 4, 5, 6, 8A, 9A, 13 and new well 11A.

[5] Region 4 Screening Values for select metals based on Hardness = 50 mg/L.

[6] Region 9 PRG's dated October 2002; Region 3 RBC's dated April 2003 both reflect HI = 0.1 or 10^{-6} Increased Cancer Risk

[7] Information obtained from NJDEP web site http://www.state.nj.us/dep/watersupply/standard.htm

[8] Compounds/analytes listed are those detected, a complete list is included in Table 2. See note 6, Table 2 concerning DRLs

MCL = Maximum Contaminant Level NA = Not applicable NC = Not calculated AL = Action Level
nc = non-carcinogenic risk c = carcinogenic risk

4.0 FINDINGS AND OBSERVATIONS FROM THE RSE SITE VISIT

4.1 Ground Water Extraction and Injection System

4.1.1 WELL CONDITION

Extraction well yields are highly variable, from a consistent 5 gpm to less than one gpm. Only extraction well RW-13 has an average capacity over 5 gpm and runs nearly continuously. The table below describes the recent average flow rates for the extraction wells. Most well pumps cycle on and off and are not throttled, with one well cycling 15-30 times per day. Wells require periodic rehabilitation due to fouling by iron bacteria. The operators perform their own rehabilitation by recirculating a mixture of 50 lbs of sulfamic acid and 55 gallons of hot water through the screened interval using the extraction pumps. Rehabilitation of each well is typically performed twice a year.

Table 4: Average Flow from Extraction Wells, Spring 2003

Extraction Well	Average Flow Rate (gpm)	Extraction Well	Average Flow Rate (gpm)
RW-1	1.7	RW-9	1.1
RW-2	0.29	RW-9A	0.71
RW-3	0.83	RW-10	0.5
RW-3A	0.76	RW-10A	3.5
RW-4	0.89	RW-11	3.4
RW-5	1.2	RW-12	4
RW-6	0.37	RW-13	6.5
RW-7	1.2	RW-14	2.1
RW-8	2.7	RW-15	1.4
RW-8A	2	RW-16	1.8

The extraction pumps require periodic maintenance due to fouling and wear. The operators perform much of the pump maintenance and periodically scavenge parts from other unusable pumps. Fouled pump bodies and impellers are cleaned using a sulfamic acid bath. Motors have a limited (roughly 2 year) life due to electrical failure, corrosion, or wear on the drive shaft. The operators have not noted corrosion of the drop pipe. A check valve in RW-10 failed at one point, allowing the reinjection of untreated water from other wells.

The heat tracing and insulation for piping in the well vaults have been successful at preventing freezing, though the heat tracing failed during the winter of 2002-2003 at wells RW-10 and RW-9A and piping there froze. Given the low flow rates, velocities in the piping from the wells to the plant are not high and there is a potential for build up of solids in the piping. The piping has not been pressure tested since it was installed. Even when a contractor punctured the piping while installing a fence, the piping was repaired but not pressure tested.

4.1.2 PLUME CAPTURE AND REMEDIATION

The objectives of the ground water extraction system at the Higgins Farm Site are to contain the plumes on-site and reduce on-site concentrations. To evaluate the system performance in this regard, the plumes must be adequately defined, the hydrogeology must be adequately characterized to assess probable flow paths and assess variability in ground water flow directions, water levels near the extraction system must be measured, and the flow rates for individual wells must be known. Flow rates are available for the individual extraction wells. Additional data regarding the other parameters would be quite useful.

The plumes are imprecisely defined on-site, though generally adequately defined relative to the placement of the extraction wells to assess probability of capture. Plume extent is defined largely with the extraction well concentrations near the site boundary. Additional monitoring wells are required to define the plumes on site. For example, the extent of elevated 1,2-DCA near extraction well RW-3 is defined only by extraction wells, the source of the plume is not certain. The northeastern edge of the main plume along the northern boundary of the site is only defined by recent low concentrations in RW-13 and the southwestern edge of that plume is not defined by monitoring wells within 500 feet. The very long open intervals in deep monitoring wells and extraction wells have made delineation of the vertical extent of the plumes problematic.

The fractured rock aquifer represents a very complex flow system. Given the highly discrete flow paths in fractured rock and limited number of fractures at depth at the site, there is a potential, though perhaps small, that some contaminant flow paths from the site are not intercepted by pumping of the extraction wells. In the area near RW-11 and RW-12, the wells are approximately 250 feet apart. These wells are in the core of the main plume and this spacing may not be adequate to capture all flow with a high degree of certainty. The orientation of the main plume in this area is similar to the strike of fractures observed in the nearby quarry and there may be a significant horizontal anisotropy to the flow paths. There may be significant permeable pathways perpendicular to the line of extraction wells near RW-11 and RW-12 inhibiting complete capture. Ground water flow directions are generally stable and predictable. The existing wells are generally located appropriately relative to the plumes' plan-view orientation. The extraction wells are quite deep with a long screened interval. Given the uncertainty in the vertical extent of the plumes, the use of such long interval extraction wells is of unknown benefit.

There are few monitoring points near the extraction wells to verify the piezometric surface and capture zone. It is not possible to draw flow lines based on the piezometric contours near the extraction well lines (and the fractured nature of the aquifer would make that an uncertain exercise, regardless of the available data).

Overall, a water budget approach, as documented in SAIC (2002), suggests the extraction rates are adequate to capture site ground water. Further analysis of the extraction conditions indicates that a significant number of extraction wells recover little contaminant mass. Six of the 20 extraction wells, RW-7, -8, -10A, -11, -14, and –16, account for approximately 95% of the extracted contaminant mass, based on the March 2003 sampling and flow rates. Another six wells, RW-1, -2, -3A, -5, -6, and –13, each extract less than 0.1% of the site mass and had essentially non-detectible levels of contaminants or levels below the ground water quality standards in March 2003.

The presence of contaminants in the Westbay wells downgradient of the extraction wells does raise the concern of additional contaminant extent outside the capture zone of the system. This issue is discussed further in section 5.1.

Table 5: Mass Removal by Extraction Well

Extr Well	Flow (gpm)	Total VOC[1]	Mass	Surrogate[2]
RW-1	1.7	0	0	0.0%
RW-2	0.29	1	0.29	0.0%
RW-3	0.83	22	18.26	0.8%
RW-3A	0.76	0.4	0.304	0.0%
RW-4	0.89	3	2.67	0.1%
RW-5	1.2	0.6	0.72	0.0%
RW-6	0.37	2	0.74	0.0%
RW-7	1.2	185	222	9.9%
RW-8	2.7	42	113.4	5.1%
RW-8A	2	4	8	0.4%
RW-9	1.1	33	36.3	1.6%
RW-9A	0.71	14	9.94	0.4%
RW-10	0.5	17	8.5	0.4%
RW-10A	3.5	54	189	8.4%
RW-11	3.4	270	918	40.9%
RW-12	4	5	20	0.9%
RW-13	6.5	0	0	0.0%
RW-14	2.1	33	69.3	3.1%
RW-15	1.4	10	14	0.6%
RW-16	1.8	340	612	27.3%
Total	**37**	**Total**	**2243.424**	

[1]Computed by summing VOCs above NJDWS

[2]Computed by multiplying gpm by total VOCs

4.1.3 NATURAL ATTENUATION CONDITIONS

The degradation of many chlorinated organic compounds occurs under anaerobic reducing conditions. Site ground water is largely aerobic and unfavorable for biodegradation, though reductive dechlorination products of trichloroethylene and tetrachloroethylene such as 1,2-DCE and VC are found at low concentrations. Petroleum hydrocarbons, including benzene, and other aerobically degradable organics such as acetone have been detected in some areas, and may represent localized carbon sources (in addition to other natural carbon in shallow soils) adequate to locally deplete electron acceptors such as oxygen, nitrate, and sulfate and allow reductive dechlorination. A few monitoring well locations have been shown to be periodically depleted in dissolved oxygen (see Table 6, below). In addition to degradation, dispersion and sorption are occurring at the site as these processes are common to all sites, though to different degrees. Flow in fractured rock would not likely be subject to significant sorption as there is little if any organic carbon in such settings. Sorption to weathering products, such as clays lining the fractures, may be significant. The aerobic degradation of the petroleum hydrocarbons and acetone is likely at this site and may be the cause of large declines in the concentrations of benzene and acetone in ground water. For example, according to the RI, benzene has been present at concentrations of over 1 mg/L in monitoring well MW-7D, but most recently has been measured at less than 1 µg/L, a decline of three orders of magnitude. In summary, the biodegradation of the predominant chlorinated organics (TCE, PCE) is not likely to be contributing significantly to declines in concentrations now or in the future, but is probably greatly remediating some of the degradable organics such as benzene. TCE and PCE are likely to migrate off-site if not captured.

Table 6: Selected Dissolved Oxygen (DO) Measurements, March 2003

Monitoring Well	DO Measurement (ppm)	Monitoring Well	DO Measurement (ppm)*
MW-1S	2.6	MW-6S	7.8
MW-1D	5.3	MW-6D	0.6*
MW-2S	2.1	MW-7D	7.8
MW-2D	0.48*	MW-8S	5.4
MW-3D	3.2	MW-8D	2.1
MW-4D	5.5	MW-9S	4.4
MW-5S	8.9	MW-10S	6.0
MW-5D	5.9	*Values indicative of dissolved oxygen depletion.	

4.2 TREATMENT EQUIPMENT

Groundwater is extracted from 20 wells through a system of 3 headers, which discharge to the groundwater treatment plant. Once the flow enters the plant it is metered and directed to one of the two16,000 gallon equalization tanks. Water is pumped from the equalization tank(s) to a small aerated reaction tank where chemicals are added to initiate the chemical reactions necessary to remove excess hardness that would reduce the effectiveness of the ion exchange units. Following the reaction tank water flows through a flocculation tank, and finally a clarifier where the resultant sludge settles out and is eventually dewatered by a plate and frame filter press system. Clarified effluent is pumped to a duplex pressure sand filter designed to remove any solids that might be carried over the clarifier weirs before undergoing treatment in the ion exchange units that follow the filters. The ion exchange system consists of 2 separate systems, a weak acid exchange system followed by a chelating ion exchange resin system. Following treatment in the ion exchange systems the water is passed through 2 packed tower air strippers operating in series. After VOC removal the pH and alkalinity is adjusted, and directed to an effluent holding tank and discharged to the on site pond.

The system currently operates in a batch mode at a flow rate of approximately 55 gpm. The original plant design was based on a continuous flow rate of 100 gpm. Because of hydraulic considerations and limited instrumentation, which makes it difficult to balance chemical feed, flows, and other critical parameters, the decision was made to operate the plant in a batch mode. Influent flow rate to the plant varies from 35 to 60 gpm depending on seasonal aquifer variations. Generally flow rates above 55 gpm are rare and short lived, but when they occur for extended periods, are managed by restricting flow from the well field.

4.2.1 EQUALIZATION TANKS

Flow equalization is accomplished by passing flow through one of the two 16,000 gallon units. Current operation is to use one as a standby unit available if the level in the operational unit reaches the interconnecting pipe between the two tanks. This may occur if the inflow to the facility exceeds 55 gpm, or if the treatment unit is down for a short period such as 6 – 12 hours. Flow is processed at a flow controlled target batch flow rate of 55 gallons per minute, which typically exceeds the plant influent flow rate by approximately 15 gpm. Flow is pumped from the equalization tank until it reaches the low level cut off elevation that shuts down the entire treatment process and restarts the plant when the equalization tank reaches an elevation of 13 feet. After activating the low level plant shut down elevation, the well field continues to operate, and generally takes 4 – 6 hours to fill the equalization tank to the 13’ level, the elevation which reenergizes the plant following a low level shut off. Pumps P-2-2-1 and P-2-2-2 transfer flow from the equalization tanks to the softening/metals removal process. Although the 55 gpm flow rate is below the 100 gpm design capacity of the plant, it is very close to its current hydraulic capacity of 60 gpm.

4.2.2 SOFTENING/METALS REMOVAL PACKAGE

The softening/metals removal package consists of three discreet components, the reaction tank, flocculation tank, and the clarifier/thickener. The 1500 gallon reaction tank is aerated at a rate of 1.5 scfm via a diffuser to convert any ferrous iron present into insoluble ferric iron. Samples taken September 29, 2003 identified ferrous iron concentrations were less than 0.1 mg/L. Addition of air and the presence of a slight vacuum present in all the gravity tanks upstream of the air strippers, also assist in the volatilization of the volatile solvents present in the tanks. Heavy metals are removed by adjusting the pH with a 50% caustic (sodium hydroxide) solution. A control loop that senses the pH in the reaction vessel adjusts the amount of caustic fed to the vessel based on a preset pH value of 10. Soda ash (30% concentration) is added to the reaction tank to aid in the softening process, in particular precipitation of non-carbonate hardness consisting of calcium and magnesium sulfates or chlorides. The soda ash feed is flow paced at a rate of 100 mg/L as is 2 ppm of anionic polymer. The reaction tank is equipped with a constant speed rapid mixer and has a detention time of 27 minutes at a flow rate of 55 gpm which far exceeds the detention time recommended for flash mix units.

Flow from the reaction tank flows by gravity to the flocculation tank, which was also sized at1500 gallons with a 27-minute detention time at a flow rate of 55 gpm. Detention times at or above 30 minutes are generally recommended for flocculation tanks, however given the design of the clarifier/thickener, which is actually combines the flocculation and clarification steps together, the total flocculation time between the two units exceed the recommended 30 minutes minimum. The operators pointed out 3 – 4 feet of sludge needs to be cleaned out of the flocculation tank every 3 months due to the extensive settling that occurs in the tank. Polymer may be added in the piping between the reaction tank and the flocculation tank, or directly into the flocculation tank, and is flow paced. The flocculation tank is equipped with a variable speed mixer that is intended to promote flocculation and particle growth as the water flows into the clarifier/thickener unit.

The clarifier/thickener unit consists of an approximately 40,000-gallon clarifier, with a 12-hour detention time. The clarifier is also provided with a motor driven rake arm assembly, which is supported by the walkway/truss, located on the top of the clarifier. The clarifier has a conical reaction or flocculation zone, which is also supported by the clarifier walkway/truss system. The 4" discharge pipe between the two tanks enters the above the clarifier rake and travels in about 3 feet, then angles upward horizontally for 5 more feet then up vertically for 5 feet allowing floc particles to enter the reaction well near the water surface and settle in the clarifier. The sludge density and sludge blanket depth are monitored remotely. A small volume of settled sludge is recycled to the reaction tank to act as seed sludge to enhance particle growth in the reaction and flocculation tanks. Sludge is withdrawn and dewatered through the plate and frame filter press, and clarified effluent is directed to the 1000-gallon filter feed tank.

4.2.3 FILTER SYSTEM

The filter system is intended to remove solids carry over from the clarifier/thickener and softening process prior to the ion exchange beds designed to remove trace metals. The 1000-gallon filter feed tank receives effluent from the clarifier and then directs the flow to the duplex pressure sand filter units. The filter feed pumps (P-5-2-1, P-5-2-2) that supply the media filters were designed to produce enough head to force the flow through the filter system and the weak acid ion exchange beds, chelating resin beds, and finally to the intermediate pH adjustment tank. The filter feed pumps were noted as having quite small diameter pump suction and discharge connections, both 1-inch in diameter. Fittings such as tee's, valves, and reducers in the fiberglass reinforced plastic resin piping cause added head loss. Scaling further reduces the cross sectional area in the pipes and fittings, particularly in the butterfly valves. The operators have identified the problems caused by scaling and replaced several 2" diameter pipe segments with 4' piping. In an effort to increase flow (65 gpm vs 55 gpm) from the existing pumps, the 7.5 HP motors were removed and replaced with 10 HP motors. Level switches in the filter feed tank control the filter pumps

Both filters operate in parallel, except when one filter is being backwashed, which occurs about 3 times per week per filter, which corresponds to about 105,000 gallons treated per filter unit backwashed. Head loss through the clean filter bed is 5 psi. A high level interlock between the filter feed tank and reaction tank feed pumps turns off the reaction tank feed pumps when the water level in the filter feed tank reaches the high-high level in the filter feed tank. This occurs during a backwash event when all flow is directed through one filter due to head requirements that exceed the pump flow-head capacity. Effluent from the filters is directed to the weak acid ion exchange units. Life expectancy for the sand media is only two years due to scaling that occurs.

4.2.4 ION EXCHANGE UNITS

The system was designed to remove metals such as iron, magnesium, manganese, aluminum, copper and nickel down to low ppb levels as listed in Table 2. The ion exchange resin system consists of two skids consisting of duplex resin exchangers operating in series. The first duplex resin bed is a weak acid exchange resin (WAR) system operated in series, piped such that either unit can operate in the lead position. The second system is a chelating resin system that operates in a manner similar to the WAR units. The chelating resin exchangers are off line and have been since 2000. The WAR units have been able to remove the cationic contaminants down to levels that meet discharge standards without using the chelating resin system. The head loss through the WAR beds is 23 psi, pH into the first bed is between 9 – 10, following the first bed the pH is roughly 7.5, and the pH following the second bed is between 5.5 and 6 at a residual pressure of around 8 psi. Effluent from the WAR beds discharge to the intermediate pH adjustment tank. Backwash for the resin is manually initiated and occurs approximately every 200,000 gallons. The regeneration cycle for the WAR (manufactured by Bayer) consists of the following sequence; backwash 1200 seconds, 200 seconds settle, 1200 seconds acid rinse with 5% $H_2 SO_4$, 300 seconds slow rinse, 600 seconds fast rinse. Since the backwash pumps have a maximum available flow of 55 gpm (which meets slow rinse criteria) the fast rinse sequence time is simply added onto the slow rinse cycle. The fast rinse flow rate identified by the manufacturer should be a minimum of 85 gpm. Regeneration rinse water is discharged to a regenerant waste storage tank where it is bled back into the reaction tank over approximately an 8-hour period. The low pH WAR effluent is adjusted by a modulating valve system that varies the chemical feed (sodium hydroxide) through a flow paced forward feeding loop based on the pH in the tank influent. The pH of the air stripper one influent is approximately 7 SU and following the stripping process rises to about 8.2.

4.2.5 AIR STRIPPING SYSTEM

The primary VOC removal system consists of two 30” diameter Delta packed tower air strippers with 25’ of 1-1/2” in diameter Jaeger tripack media. Pressure loss is 8 – 10 inches of water column, blowers are 25 HP Chicago Fan unit with a flow rate of 3200 scfm. A total of three blowers are provided, one per tower and a third as a standby unit. Flow is introduced into the first tower, and collected in the sump where it is then pumped to a second identical unit. Off gas is collected by an induced draft fan and discharged to the atmosphere through a stack approximately 90 feet above grade. After the second tower the flow is directed to the 1000-gallon final pH adjustment tank. These transfer pumps were designed to pump at a flow rate of 85 gpm.

4.2.6 pH ADJUSTMENT AND PLANT WATER SYSTEM

Following the air strippers, flow is directed to the 1000-gallon final pH adjustment tank. The pH is adjusted to neutral and using a pH probe and a feed forward control loop to adjust the necessary caustic or sulfuric acid dosage as needed. Lime is added at a rate of approximately 50 mg/L to increase the hardness as directed by the State of New Jersey to meet the whole effluent toxicity (WET) test criteria. After the pH adjust tank flow is directed to the 5000 gallon backwash/service water tank. Water from the backwash tank is used as service water, chemical makeup, dilution water, flushing lines, hose stations, backwash and rinse water for the filters and ion exchange units. Excess water is discharged to a small wetlands area that flows into a small surface pond located on the site and eventually to Carters Brook.

4.2.7 CHEMICAL FEED

The plant uses 93 percent sulfuric acid, lime, 50 percent sodium hydroxide, anionic polymer and 30 percent soda ash.

Sulfuric acid is used for the following:

pH adjustment for the intermediate pH adjustment tank following the WAR exchanger,
final pH adjustment following the air stippers,
regeneration of the WAR ion exchange units,
regeneration of the chelating ion exchange units (when operating).

Lime is used to add hardness to the finished water in an attempt to match the ambient hardness in the surface water.

50 percent sodium hydroxide solution is stored in an insulated and heated tank and is used for the following processes:

pH adjustment in the reaction tank,
pH adjustment for the intermediate pH adjustment tank following the WAR exchanger,
final pH adjustment following the air stippers,
regeneration of the chelating ion exchange units (when operating).

Polymer is used to enhance particle formation in the following units:

Flocculation tank,
Sludge storage tank.

30 percent soda ash is used in the reaction tank for chemical softening of the groundwater.

4.2.8 SLUDGE STORAGE AND DEWATERING SYSTEM

Sludge from the clarifier is transported to the sludge thickening tank where it is mixed and further thickened. Other sources such as the flocculation tank are also transferred to the sludge storage tank for eventual dewatering in the press. The softening process along with other miscellaneous processes produce enough sludge for a single sludge cycle per month, which is equivalent to approximately 2 cubic yards of 50 percent solids cake. The operators typically store an adequate volume of sludge in the thickener tank so they need only rent a dumpster for a single month twice yearly. Polymer is typically added to the thickener to assist in particle agglomeration resulting in a drier cake.

4.3 MONITORING SYSTEM AND PROGRAM

The subsurface monitoring program is evaluated for adequacy in space, time, sampling and analytical methodology, and data management and reporting. As discussed above, the monitoring system is somewhat sparse both on-site and off. This makes it difficult to define the extent of the main plume on site, capture near the extraction wells, and the small plume on the southwest side of the site. Additional monitoring would be useful as described in section 4.1.2. The long screened intervals for the deep wells do not allow adequate vertical characterization of the distribution of contaminants.

The most significant data gap lies off-site. Most of the off-site Westbay well ports are contaminated suggesting portions of the site plumes extend southeast and southwest of the site and extraction system. It should be noted that persistent high pH (pH>10) values have been noted in samples taken from the Westbay wells (over two years or more following construction). The cause of the elevated pH values is not clear. Grout was not used in the construction of the Westbay wells since these sampling systems were set in the open bedrock holes and used packers to isolate sampling zones. Grout was used for setting casing through the unconsolidated materials at the top of the Westbay boreholes, though the amounts were minor and there was ample flushing of the holes during the drilling into the bedrock. The range of pH observed in the extraction wells (6-7.5) most likely represents the natural ground water pH over similar depths.

Whatever the reason for the elevated pH values, the persistently high pH values in the Westbay wells suggest some of the ports were set in zones that do not conduct significant ground water flow. The degree to which the samples from these ports can be considered representative of true formation conditions is unclear. Westbay wells WB-12, WB-13, WB-14, WB-15, and WB-16 have elevated pH. Ports in Westbay well WB-11 have pH values similar to conventional wells. The elevated organic concentrations in various ports of the Westbay wells may not represent concentrations at the respective depths, but may be influenced by water communicated during/following drilling of the hole but before the packers were set in the well. Regardless, it is likely that contaminants exist off site and may be migrating downgradient toward Carters Brook and residential wells along Route 27 southeast of the site or toward the quarry.

The conventional monitoring wells are sampled semi-annually using low-flow techniques and non-dedicated pumps. The Westbay wells have, in the past year, been sampled quarterly, but samples are obtained using a MOSDAX sampler that is lowered inside the Westbay casing and attaches to a sampling port. The port is opened and a stainless steel sample chamber is filled. No purging is done. Given the historical data now available for these wells, quarterly sampling may no longer be needed from the Westbay wells. Samples are also collected quarterly from the sample taps on the individual extraction wells. This sampling is done using a low-flow-like sampling methods, though the reasons for this are not clear. Samples from active production wells are typically drawn by directly filling the bottles from a tap.

Samples are submitted for fixed lab analyses for volatile organic compounds by EPA method 8260B and metals by EPA methods 6010, 7041, 7421, and 7470. Analyses have also been routinely conducted for dissolved gases methane, ethene, and ethane as well as chloride, nitrite, nitrate, and sulfate. Dissolved methane, ethene, and ethane have been non-detectible using method RSK-175. Field analyses are conducted for dissolved sulfide, total iron, dissolved (ferrous) iron, and alkalinity.

Reports are generated to present results of each sampling round for whatever wells were sampled that quarter. The reports provide useful information including site background, maps of water levels and concentrations, tables of results for the wells with other recent sample results from the same wells and the range in all historical values. The plume maps in the reports have rough computer generated contour maps which honor the data, but do not consider site ground water flow. The analytical results are managed electronically in Excel format. Data are provided from the lab in hard copy and not electronically.

4.4 OTHER OBSERVATIONS

4.4.1 WATER DISCHARGE ALTERNATIVES

As part of the RSE analysis, the potential for alternative discharge locations for the treated (or untreated) water was considered. The potential to reinfiltrate the treated water into the subsurface was discounted given the low-permeability of the near-surface materials, the heterogeneous but low bedrock permeability, and the difficulties in maintaining injection wells in such conditions. The other alternative considered was discharge to a sewer line connected to a publicly owned treatment works (POTW). Sewers do not serve the Higgins Farm Site and the sanitary waste generated at the site must be removed from the site by truck (note that two different trucks must serve the two site trailers since the connections are different). There is also no sewer service along Routes 518 or 27.

Contacts were made with two municipal sewer departments that provide services within 1.5 miles of the site (Franklin Township Sewer Department and South Brunswick Sewer Department) and two regional treatment authorities (Stony Brook Regional Sewer Authority [SBRSA] and Middlesex County Utility Authority [MCUA]) to see what potential there may be for discharge to a POTW. The site lies within the service area of Franklin Township and, according to Mr. Bill Goodheat of Franklin Township, the nearest sewer connection to the site would be located near the intersection of Bunker Hill Rd. and Route 27, a distance of more than 1.5 miles. The sewage from Franklin Township is treated by the MCUA. In discussing the requirements for discharge of materials from the Higgins Farm Site with a representative of the MCUA, the authority would not accept ground water for a period of more than 5 years. Pretreatment requirements would be determined on a case-by-case basis, but she gave the impression that some treatment would be required before they would accept the water. There are some flow constraints faced by the MCUA treatment plant so they are trying to end discharge of ground water to the system. Costs for treatment were very high – $7.88/1000 gallons which translates into $165,000 per year for 40 gpm. Sewer construction costs would be $500,000 to the nearest sewer connection, based on an estimate prepared with the RACER estimating tool.

According to Mr. Bob Griggs of the South Brunswick Sewer Department, the nearest connection of adequate size in their system is in Kendall Park more than a mile east of the Higgins Farm Site. However, they have near-term plans to extend sewer service into the Little Rocky Hill area along Route 27. This would be less than 0.75 miles downhill from the site. The SBRSA was contacted and they would be interested in the water and would only charge $1.20/1000 gallons plus $1000/year. This translates to only about $27,000 per year at 40 gpm. Sewer construction south of the site to Route 27 would cost approximately $250,000 as per a RACER estimate. There are a substantial number of institutional issues that would need to be addressed before such a discharge could occur. Since the Higgins Farm site is not located within the South Brunswick sewer service area, the Franklin Township Board would have to approve the connection, as would the member municipalities sponsoring the SBRSA. In addition, the Waste Management Plan for the area would have to be modified and approved by NJDEP. Mr. Griggs did not sound optimistic that all necessary agreements could be achieved. Such a modification to the discharge of water would require substantial time and effort to coordinate with no guarantee of success.

4.4.2 SANITARY FACILITIES

Sewer lines do not serve the site and sanitary facilities are available only in the office trailers. Different contractors service each trailer due to incompatible connections with the septic trucks. The servicing of the septic systems is costly ($4300/year). There is a small sink in the treatment plant for hand washing, although larger basin would be useful for parts cleaning.

4.4.3 OTHER SUGGESTIONS FROM OPERATORS

The operators noted that an automatic restart on the air compressor would improve the operability of the system. A new PLC and computer would also reduce operation effort.

4.5 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

The system costs more than $900,000/year for the O & M contractor to operate and maintain. This includes labor, materials, sampling and analysis, residual disposal, utilities, and up to $100,000 in plant repairs and spare parts, but excludes U.S. Army Corps of Engineers and EPA oversight costs. The two operators spend essentially 100% of their time on this system and the project manager spends about 50% of her time at the site. Mr. Fite spends approximately 50% of his time on reporting and about 25% of his time sampling. Almost 25% of the operators time is spent in maintenance of the extraction wells and pumps. Mr. Russell had been spending about 50% of his time performing non-routine maintenance on the system to get it to run properly. The rest of the operator’s time is spent in routine maintenance of the wells and plant. Operations and maintenance costs approximately $210,000 per year including labor, travel, office space and supplies, equipment, and profit. Expendable materials including polymer, soda ash, caustic , acid, and limestone and office supplies and tools ($7,200) for a total annual cost of approximately $21,000 per year. Analyses of effluent, influent, and other plant samples (including toxicity testing) cost approximately $59,000 including G&A and profit. Sampling of monitoring wells and analyses of the samples for from monitoring wells cost approximately $161,000/year for labor (including travel and reporting), $38,000 in equipment and materials, approximately $150,000/year in analytical services, and $27,000 in hydrogeological review for a total of $376,000 or about 40% of the total project annual costs. Corrective repair materials are budgeted at $100,000 per year. Significant efforts have been made by the operator in the past year to improve the system to reduce this amount and it is likely that these costs will decline in the future. Disposal of spent materials, including protective equipment and filter cake, cost approximately $8,500 per year. The only utilities provided at the site are electricity, water, and phone services. Electricity accounts for most ($120,000) of the $130,000 annual cost. Phones for both USACE oversight and contractor use cost about $8,000/year. Water service costs about $1000/year. To summarize annual costs:

Operations:
- Labor and Travel: $182,000
- Equipment, Services: $28,000
- Total $210,000

Consumable Materials (for operations): $14,000
Subsurface Monitoring: $225,000
Chemical Analyses: $220,000
Utilities: $129,000
Disposal of Residuals: $8,500
Plant Repairs, Spare Parts, Well Maintenance, etc.: $100,000 (Budgeted)
Management: $24,000
Total: ~$930,000

The contract for operations considers the total flow through the treatment plant. The contractor is motivated to keep the plant running and to pump as much as possible from the subsurface, but is not motivated to optimize the subsurface performance. In the contract there is a budget for the operator to repair and replace items and these funds could be used for modifications to optimize the system, but there is no strong motivation to consider major changes to the plant. The operator has properly invested time and effort to improve the existing treatment system performance.

4.6 RECURRING PROBLEMS OR ISSUES

4.6.1 LIMITED HYDRAULIC CAPACITY

The plant design documents indicate the calculated plant capacity was set at approximately 100 gallons per minute (gpm). During the operation of the plant from 1998 to the present time, the maximum sustained flow rate through the system has been limited to approximately 55 gpm. While discussing the operation with the staff they identified several potential "hydraulic bottlenecks". The first area is the reaction tank, flocculation tank, and clarifier area. In particular the 4" gravity line between the flocculation tank and the clarifier. The elevation difference between the flocculation tank and clarifier water levels appears to be inadequate to provide enough driving force (head) to transfer 100 gpm through the 4" line interconnecting the two units. The problem is exacerbated by the number of direction changes that occur in the line as well as the scale and precipitate that coats the interior of the line reducing the cross sectional area, and eventually further reducing the flow capacity below 55 gpm. Various pumps throughout the plant appear to be unable to transfer the maximum design flow through the process units as designed. This hydraulic capacity deficiency results from several factors, small diameter pump discharge connections, undersized piping, numerous high head loss pipe fittings and valves installed in the discharge lines. The operators identified several of the pumps (7 of 15) as having inadequate capacity. Those pumps with sub standard capacity include; the filter feed pumps (P-5-2-1/P-5-2-2), the final pH adjustment feed pumps (P-10-1-1/P-10-1-2), and the ion exchange regenerant water pumps (P-10-6-1/P-10-6-2).

4.6.2 SLUDGE BUILD-UP IN THE FLOCCULATION UNIT

The operators have indicated the flocculation unit requires cleaning on a quarterly basis. The particulates resulting from the precipitation and flocculation processes do not make their way to the clarifier prior to settling out. Approximately 3 – 4 feet of sludge accumulates in the flocculent tank due to suspected hydraulic problems in the piping between the flocculent tank and clarifier. Also a potential issue is the quiescent conditions that occur when during periods when there is no flow through the plant allowing particulates to settle in the basin. The small diameter interconnecting pipe and numerous bends in the flow path to the clarifier may account for some of the sedimentation.

4.6.3 Poor Quality Backwash Water for Ion Exchange Units

Backwash water used to rinse the ion exchange units should be of high quality, in this case free of metals and cations that might use up valuable exchange sites on the resin. The current configuration at the Higgins Farm site requires the final conditioned water be used for the backwash/service water throughout the plant. Unfortunately as part of an agreement with the state of New Jersey, lime is added to increase the hardness of the water to match that of the receiving stream and improve the outcome of the whole effluent toxicity (WET) test. By adding lime, $Ca(OH)_2$ to the ion exchange rinse water, the actual process of regenerating the bed actually uses up metal adsorption exchange sites on the resin since it will remove Ca^{++} ions from the rinse solution. The easy solution would be addition of a separate tank downstream of the air strippers yet upstream of the lime addition. Removing the lime from the resin rinse solution could extend ion exchange bed regeneration intervals.

4.6.4 Sulfuric Acid Piping Leaks

The sulfuric acid piping was originally installed in the plant using 316 stainless steel threaded pipe and fittings rather than black steel which is compatible with 93 percent sulfuric acid. Such stainless will rapidly deteriorate if the moisture content of the acid rises such that it diluted to a concentration below 91 percent. The operators have had to replace sections of the piping with a more resistant stainless alloy (alloy “20” a high-nickel-content stainless steel). The operators discovered that the previous operators failed to change the desiccant on the tank vent which may have allowed condensation of moisture in the tank that would dilute the acid slightly. The operators now routinely check the desiccant that has a color indicator, and change the desiccant on 6 months intervals.

4.6.5 Caustic Pipe Plugging

Caustic is stored in a heated, insulated 9000-gallon tank. Caustic is fed to several points in the treatment plant from a recirculation loop. Chemical metering is done at each use point with a bleed valve. Excess caustic is sent back to the storage tank. When the plant is turned off, and the equalization tanks are in the fill mode, caustic trapped in the recirculation line adjacent to the tank is heated causing the water in the 50 percent slurry to evaporate out leaving the crystalline salt which scales out in the piping and fittings that eventually occludes flow through the pipe back into the caustic tank.

4.6.6 Extraction Well System Controls

The plant programmable logic controller controls the operation of the well pumps, based on transducer-measured water levels. Though the transducers have not had many problems, the communications between wells and plant have been highly unreliable. Significant expense in parts and labor are incurred in replacing link couplings (connecting the transducer leads to the communication cables). Parts of the cable system have failed entirely. Wells RW-6 and 7 were down at the time of the site visit due to communications problems. The cable was buried in the trench with the water piping at depths of over 5 feet. To date, the contractor has installed transceivers to replace the cable connections in three vaults controlling several wells. These have worked well and include automatic restart capabilities if the wells go down due to power loss. The USACE is negotiating for the replacement of the rest of the cables with transceivers at the time of the site visit. The RSE team supports the replacement of the cable-based control system as a means to reduce the maintenance load on the operators. Approximately 25% of the senior operators’ time and part of the other operator’s time is consumed in maintenance of the wells, communications, and pumps.

4.6.7 WELL FOULING AND PUMP FAILURE

The extraction wells require periodic rehabilitation due to iron bacteria fouling. The operators perform their own rehabilitation by recirculating a mixture of 50 lbs of sulfamic acid and 55 gallons of hot water through the screened interval using the dedicated pumps. Rehabilitation of each well is typically performed twice a year. The rehabilitation does not involve any surging or brushing of the well screen and there have not been any downhole camera surveys. Most wells cycle and are not throttled. The wells cycle up to 15-30 times per day.

The extraction well pumps require periodic maintenance due to fouling and wear. The operators perform much of the pump maintenance and periodically scavenge parts from other unusable pumps to replace others. Fouled pump bodies and impellers are cleaned using a sulfamic acid bath. Motors have a limited (roughly 2 year) life due to electrical failure, corrosion, or wear on the drive shaft. The operators have not found a more durable alternative.

4.7 REGULATORY COMPLIANCE

Discharge permit levels for the water are addressed in Table 2. Historically, test results have shown the plant is consistently reducing the volatile organic compounds and metals levels to below the discharge criteria. An analysis of the influent metals concentrations at the Treatment Plant indicate with the exception of iron and manganese, the levels are already below the discharge criteria. Clean up standards were compared to ecotoxicity and screening levels in Table 3. In all cases the calculated influent concentrations are below the ecotoxicity screening levels, except 1, 2 DCA, 1, 1, 2, 2 PCA, PCE, TCE and VC exceed the Region III RBC's, and Region IX PRG's. 1, 1, 2, 2 PCA, PCE, and TCE also exceeded MCL's. Many of the discharge limits were noted to be quite conservative and should perhaps be reevaluated.

No compliance issues related to plant operations were noted except difficulty in meeting whole effluent toxicity (WET) test parameters. Plant personnel coordinating with the state regulators have corrected the problem.

4.8 TREATMENT PROCESS EXCURSIONS AND UPSETS, ACCIDENTAL RELEASES

4.8.1 TREATMENT PROCESS EXCURSIONS AND UPSETS

As identified in section 1.5 Site Location, History and Characteristics, the plant was installed in 1997 and began operations in May 1998. During the initial 12 months of operation by the construction contractor the plant had several operational problems. Significant issues related to the operation of the softening, ion exchange systems, and general hydraulic capacity limitations. The current operations contractor has been systematically diagnosing and as funds allow correcting these chemical feed, and hydraulic deficiencies.

4.8.2 ACCIDENTAL CONTAMINANT RELEASES

There have been three accidental releases of extracted ground water that were not contained within the plant. In each case, the mass of contaminant released was determined to be below the reportable quantity. During installation of fencing at RW-14 in April 2001, a contractor punctured the piping. Though the pipe was subsequently repaired, it was not pressure tested. In July 2002, the equalization tank overflowed and allowed water to flow outside the building. The pump check valve on extraction well 10 stuck open on one occasion in June 2003, allowing water from the common discharge header to flow back into the well similar to an injection well and eventually overflowed the vault.

4.9 SAFETY RECORD

There have been no lost-time accidents reported during the plant operations. Housekeeping practices and general condition of the facilities, including the wells are commendable.

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

5.1 GROUND WATER

The protectiveness of the ground water extraction systems depends on the containment of the plume and the prevention of impacts to production wells or surface water. The extraction system is probably capturing the on-site plumes, though this is subject to some uncertainty as described in section 4.1.2. There are no known impacts to surface water or existing active water supply wells near the Higgins Farm Site, though there has been no recent offsite monitoring of surface water or domestic wells southeast of the site or of seeps at the nearby quarry. Though the extraction system is likely to be capturing the on-site plume, the current offsite extent of contaminants is unknown. As such, the protectiveness of the ground water remedies is unknown. The main portion of the plume extends in a direction toward an area with known active domestic wells and no current alternate water supply. Downgradient domestic wells are likely to be constructed to depths comparable to or possibly deeper than on-site extraction wells.

5.2 SURFACE WATER/WETLANDS AND SEDIMENTS

The EPA following consultation with a biologist has designated several areas of the site as wetlands. Though at least two of the wetlands were dry at the time of the site visit, these areas are seasonally wet. There is no indication of any site contaminant impacts to these areas, nor is there evidence of impacts due to ground water extraction at the site. The cattle at the site have substantially trampled the wetlands within the pastures used for grazing. The discharge of the treated ground water to a small pond appears to have enhanced wetland and aquatic habitat at the site. The discharge has also provided a consistent flow in Carters Brook, though this was not verified during the site visit. The plant has maintained compliance with the discharge requirements and should not be impacting surface water quality; however, the influent concentrations are substantially less than expected. There is a potential for contaminated ground water to discharge to surface water southeast and southwest of the site into the Carters Brook drainage and the nearby quarry, but there are no data to determine if these impacts are occurring.

5.3 AIR

The plant influent is treated using air strippers and no off gas treatment is provided. Influent volatile organic compound concentrations are approximately 100 µg/L and total extraction flow rates are around 40 gpm. This translates to less than 0.1 pound per day, primarily of TCE and PCE. Given the low mass loading on the atmosphere and the rural location, there is no significant impact on air quality.

6.0 RECOMMENDATIONS

6.1 RECOMMENDATIONS TO ENSURE EFFECTIVENESS

6.1.1 PLUME DEFINITION & POTENTIAL IMPACTS TO GROUND WATER USERS

The off-site extent of the contaminant plumes is unknown and there is a potential for impacts on ground water users, particularly southeast of the site. There is an urgent need for the evaluation of current ground water concentrations off-site and in domestic wells southeast of the site. A reconnaissance survey of domestic wells southeast of the site along Route 27, including well depth, pump rate, and water use, should be conducted and the sampling of selected wells based on the results should be implemented soon. The off-site extent of the plume should be further defined by a number of monitoring well clusters. In particular, wells are required southeast of Westbay wells WB-12, -13, and –14. For estimating purposes, three well clusters are recommended. Given the predominance of solvents in ground water, the sampling program should include a one-time evaluation of the presence or absence of 1,4 dioxane.

6.1.2 SURFACE WATER SAMPLING

Surface water sampling for VOCs in Carters Brook and any other tributary that may capture contaminated seepage is recommended. If possible, samples of the seepage into the northeast face of the Trap Rock quarry should also be obtained. If contamination is detected, the potential for human exposures and the degree of ecological impact should be determined. Assuming a two person team collects 4 samples over a one day period, the anticipated cost is approximately $2,500. (8 hours x $60/hr = $480, VOC analysis 5 x $250/sample = $1250, planning 10 hours x $60/hr = $600).

6.1.3 ON-SITE PLUME CAPTURE

Though it seems likely that the on-site plumes are being captured by the existing system, a new extraction well (RW-11A) between RW-11 and RW-12 is strongly recommended to assure the complete capture of the main plume. This location would fill a 250-foot-wide gap at the axis of the main plume and is likely to capture additional ground water contaminated with high concentration of VOCs at a reasonable flow rate, given the relatively high flow rates of the nearby wells. Costs are based on a RACER estimate of well design and construction. RACER is a parametric cost modeling system that uses a patented methodology for estimating costs. RACER cost technologies are based on generic engineering solutions for environmental projects, technologies, and processes. The generic engineering solutions were derived from historical project information, industry data, government laboratories, construction management agencies, vendors, contractors, and engineering analysis. RACER incorporates the most technologically up-to-date engineering practices and procedures to accurately reflect today's remediation processes and pricing. The new well would cost approximately $60,000 exclusive of oversight costs or contingencies. This assumes a new well similar in design to existing wells.

Additional monitoring points should be installed between, upgradient of, and downgradient of the extraction wells capturing the major site plumes to clarify the capture zone extent. At least eight additional monitoring points installed to approximately 20 feet into bedrock would be adequate. These should be installed near the main plume between RW-10A and RW-11, between the proposed RW-11A and RW-12, between RW-10 and RW-10A, downgradient of RW-11, and upgradient of the proposed RW-11A. There should also be additional monitoring points between RW-7 and RW-8, RW-8 and RW-9, and downgradient of RW-8. Downgradient wells should be placed approximately 75-100 feet downgradient of the extraction well line, based on a computed stagnation point assuming typical site parameters. Note that if additional investigations determine a significant off-site extent of the site plumes such that alternative remedial action objectives are considered, the installation of these monitoring points should be postponed until the utility of the current extraction system is verified. These monitoring points are estimated to cost approximately $55,000 based on a RACER estimate and a 10% design cost. No contingencies or oversight costs are included. These new wells would be sampled quarterly for the first year (32 samples at 2 person-hours per well). This would increase monitoring costs approximately $20,000 for the first year. During subsequent years, these wells would only need monitoring semi-annually.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 INVESTIGATE BYPASSING THE GROUNDWATER TREATMENT PLANT

Given the low influent concentrations of the contaminants of concern, both volatiles and metals, the groundwater treatment facility could likely be taken out of service and extracted groundwater discharged directly to a POTW. Analysis shows the total volatile organic compound concentration is in the 100 to 120 ppb range, consisting primarily of TCE and PCE, while the metals concentrations generally meet drinking water standards with the exception of iron and manganese. The anticipated flow rate would be approximately 30 gallons per minute. Flow would need to be pumped northwest of the existing plant to Washington Street (Route 518) and then flow by gravity northeast for approximately 1 mile to the intersection of Highway 27 where a second lift station would be required. The lift station would discharge to a manhole approximately 1000 feet away where the line will flow by gravity for another 2000 feet to a Middlesex County Utility Authority manhole at the intersection of Highway 27 and Bunker Hill Road. Costs associated with this option include O&M fees for treating the water prior to discharging to the authority of about $122,000 annually, and a one-time capital cost based on the RACER estimating tool of $500,000 for 2 lift stations, 3000 feet of force main, and 1.4 miles of 8-inch diameter gravity sewer. Significant cost reductions for operations, maintenance, sampling and analysis, chemicals, plant heating and power would be realized. Health and safety concerns would also be lessened due to elimination of chemical feeding and handling and confined space entry while cleaning tanks. The estimated total reduction in current contract operation and maintenance costs was estimated at 60 percent. Approximately $320,000 per year could be saved bypassing the Treatment Plant and discharging directly to the Middlesex County Utility Authority.

There are significant institutional hurdles to be overcome for discharge of site ground water to a POTW to occur. The Middlesex County Utility Authority has flow limitations and is only granting temporary permits for ground water discharge as proposed here. This alternative will only be appropriate for a maximum of 5 years, unless a permanent arrangement could be negotiated with the Authority. If water would be discharged to the South Brunswick Sewer and treated at the Stony Brook treatment plant, significant negotiations would be required with Franklin Township, the SBRSA, and the SBRSA member municipalities. Modifications to the waste management plan for the area would have to be developed and approved by the state. The costs for these negotiations would be substantial but have not been estimated. There is no guarantee that such negotiations would be successful. Capital cost for this option based on the RACER estimating tool is approximately $250,000. Annual fees would be approximately $27,000. Approximately $420,000 per year based on cost avoidance using current operations contract costs, could be saved bypassing the Treatment Plant and discharging directly South Brunswick Sewer and Stony Brook Treatment Plant.

6.2.2 EXTRACTION SYSTEM REVISIONS

A significant amount of time and effort is expended in maintaining the twenty on-site extraction wells. Since many of the wells produce very low to non-detectable concentrations of contaminants at low to moderate flow rates, a number of these wells could be eliminated from the system without sacrificing effectiveness of capture. Based on the concentrations, the cessation of pumping wells RW-1, -2 (if concentrations remain low), -3A, -4, -5, -6, -8A, -9A (if concentrations remain low), and –13 (if concentrations remain low) is recommended. This would reduce well electrical use by approximately 30% (about $150/month or $1,800/year), reduce well maintenance hours by 40% (reduce labor by approximately 10% of one operator's time = 0.10*2,000 hours/year * $56/hour with overhead and profit = ~$11,000), and reduce sampling costs for extraction wells (assume 8 wells * 4 times/year * $400/sample analytical = ~$13,000 year, neglecting sampling labor and equipment). The reduction of the flow into the plant would also reduce the cost of chemicals. The flow would be reduced by about 25% (assuming a new well is brought on line between wells RW-11 and RW-12) so materials and sludge disposal costs would be decreased by 25% or $5,500/year (based on cost avoidance using current operations contract costs). The total cost savings would be approximately $31,000/ year.

6.2.3 REDUCE THE SIZE OF THE AIR STRIPPING SYSTEM

Caveating our recommendations as identified in 6.2.1, analysis of the projected influent indicates the existing air stripping process consisting of 2-30" diameter packed towers each equipped with 25 HP blowers delivering 3200 cfm per tower, far exceeds the treatment requirements for removing relatively low concentrations of a variety of volatile organic carbon compounds. The primary VOC compounds present are: TCE, PCE, 1, 2 DCE, 1, 1, 1 TCA, 1, 1, 2 TCA, benzene, chlorobenzene, 1, 2 DCA, vinyl chloride, and 1, 1, 2, 2 PCA with concentrations of 34, 67, 4, 0, 5, 0.3, 2, 2, 0.2 and 6 ppb respectively. The most difficult compound to remove is the 1, 1, 2, 2 PCA.. Calculations based on generic and proprietary software indicates a single packed tower 24 inches in diameter containing 20 feet of 1.25" packing at a water flow rate of 35 gpm and air flow rate of 600 cfm will remove the VOC contaminants of concern to levels below the discharge criteria. A second option using a tray type air stripper would require a 900 cfm 7.5 HP blower and 6 trays. And finally a third option would involve taking one of the existing stripper units off line altogether and replacing the existing 25 HP, 3200 cfm blower in the other stripper with a smaller 1200 cfm, 10 HP blower. Approximate capital costs based on vendor quotes and typical installation costs are as follows: a new packed tower air stripper $40,000, a new tray type unit $25,000 and shut off one of the two strippers, and retrofit the remaining 30" diameter unit with a new blower $5000. Annual cost savings based on power savings alone (reduction of HP from the two strippers from 50 to 10) would be approximately $17,000.

6.2.4 EVALUATE ALTERNATIVE MANGANESE REMOVAL TECHNOLOGIES.

Notwithstanding our recommendations as identified in 6.2.1, a different iron and manganese removal process other than the current softening, filtration, and ion exchange system would be much simpler, compact, and economical. Data from the last year of operation identifies iron and manganese are the only metals of concern, which exceed the effluent criteria of 0.3 and 0.05 mg/L (the secondary drinking water standards) prior to discharge. Doing away with the current metals removal system that was intended to remove a variety of heavy metals will eliminate several processes, namely the reaction tank, flocculation tank, filter, and ion exchange systems, as well as all the chemical feed and hydraulic problems associated with them. The proposed system subjects the influent to a 3 - 5 ppm dose of potassium permanganate ($KMnO_4$) or other oxidant such as chlorine, which converts the iron and manganese to its insoluble oxidized forms. After iron and manganese is oxidized, the stream comes in contact with the specially treated media or a natural manganese greensand media that adsorbs the iron and manganese, and filters the water. The systems are designed to remove 3 – 5 times the iron and manganese concentrations present in the Higgins Farm influent stream and produce an effluent with iron and manganese concentrations below 0.3 and 0.05 mg/L respectively. The system would require backwashing about twice a week. The common water backwash should be supplemented with an air scour step that can be used in the event biosolids develop on the media. Backwash water would be directed to the existing clarifier, solids allowed to settle and water decanted back to the existing equalization tanks. Sludge volume generated would be small and could likely be removed periodically using a vacuum truck. The system could be installed near the air stripping system, bypassing the softening, filtration, and ion exchange processes. The pumps currently used to feed the reaction vessel may be suitable for use as the greensand filter feed pumps. Effluent from the greensand filter would discharge to the intermediate pH adjustment tank that feeds the air stripper. The cost for installation including control and piping modifications based on vendor quotes and typical installation costs would be approximately $50,000. Annual cost for oxidant addition would be less than $2,000. A one-week pilot test using small-scale equipment on site would cost between $6,000 and

$10,000. Annual cost savings based on cost avoidance using current operations contract costs, from bypassing the existing softening, ion exchange, and pH adjustment units would come from reductions in chemicals $11,200, sludge disposal $4,300, repairs $3,000 and reduction in plant labor by 40% or $66,500 respectively for a total savings of approximately $85,000 per year.

6.2.5 CHANGES IN MONITORING PROGRAM

The RSE team has evaluated the monitoring program and costs. The contract costs for the monitoring (both labor and analytical) appear approximately 40% high, based on conservative estimates of analytical costs and sampling time. The RSE team suggests obtaining competitive bids for acquiring monitoring well and extraction well samples from contractors located closer to the site. The team also recommends seeking a laboratory independent from the operations contractor to avoid a potential conflict.

Extraction Well Sampling. The quarterly sampling of the extraction wells is appropriate, provided the operations of the wells are adjusted based on the results. The sampling method applied to the extraction wells should be modified to just include sample collection from the tap with annual measurement of pH, temperature, conductivity, oxidation-reduction potential, dissolved iron, and dissolved oxygen using field kits and a flow-through cell and sensors. This will save labor, though the amount is not certain. Assuming 20 wells and a 1/3-hour labor savings per well, at $50/hour for sampling labor, this amounts to a savings of $330/round or approximately $1,300/year.

Monitoring Wells Sampling. The Westbay wells should be sampled only semi-annually at some point in the near future. Since drought conditions existed for some of the period following installation, this change can be implemented once the impact of the relatively recent return to more normal precipitation on contaminant concentrations, if any, is identified. Given the almost four-year history of sampling from these wells, the minimal observed rate of change in concentrations over time, and assuming no dramatic change is observed in the next six months due to a return to more normal precipitation, the ability to identify concentration trends would not be impacted by reducing the frequency to twice yearly. This would result in an immediate drop of 36 samples per year (20% reduction in the analytical costs for monitoring and 72 person-hours or 25% drop in labor). This may save as much as $56,000 per year, based on applying these percentages to the current costs for analytical and sampling labor. This savings would be offset during the first year by additional sampling of new monitoring points as described above. Based on the existing data on natural attenuation conditions at the site, the RSE team recommends the analysis for dissolved gases (methane, ethane, and ethene) and ions such as sulfate and chloride be terminated or reduced to biennial sampling. The representativeness of many of the Westbay sampling ports needs to be re-evaluated. Those wells/ports displaying persistent pH values over 7.5 should be re-purged to assure the interval actually yields water. Any port that is found to have very low yield should be dropped from the monitoring program. Costs or savings associated with this have not been estimated. Lastly, strings of diffusion bag samplers should be implemented in the deep conventional monitoring wells to determine the vertical distribution of contaminants. This would have a one-time cost of approximately $14,000 assuming 5 bags per each of the 8 deep wells at a cost of $300 per sample and 32 person-hours at $50/hour for acquisition and sampling. These costs are based on past experience with similar sites using comparable equipment. The results would clarify the site conceptual model and better focus low-flow sampling depths in these wells.

6.2.6 REDUCE SITE OVERSIGHT BY USACE

Additional cost savings are possible by reducing the level of effort of the on-site USACE representative from 50% time on-site to one day per week (20%). As the operators have improved the performance of the system, the level of needed oversight has diminished. There may be times when additional oversight is needed, especially if some of the recommendations of this RSE are to be implemented, but during routine operations, the oversight could be reduced. If the level of complexity of the treatment plant is significantly reduced as recommended above, the oversight could be reduced further. As a related item, during the next contract action for operations, an effort to critically evaluate the need for the large number of submittals should be made. Some should be eliminated, others combined to reduce level of effort in managing these submittals. Examples include: O&M Manual updates should be submitted when changes or adjustments occur, rather than submitting the document quarterly even if no changes are made; Quality Control Summary Report Information could be reported at monthly progress meetings and submitted bi-annually or as required instead of monthly; Part J Certified Payroll could be one submitted monthly with payments lagging one week rather than submitted weekly. These combined actions could reduce oversight costs by more than 50% and save approximately $35,000 annually (based on the fully burdened rate for a GS 12 step 5 engineer of approximately $80/hour).

6.2.7 REPLACE TRAILER WASTE HOLDING TANK PUMP OUT CONNECTION

Each of the on site trailers is equipped with a waste holding tank. Unfortunately they were installed with different pump out connections. These incompatible connections require a separate monthly trip from different contractors because the trucks do not come equipped with both fitting types. Changing the pump out connection fitting would reduce the number of contractors, and require only a single trip monthly to empty the contents of both waste-holding tanks. Estimated cost to change the connection would be approximately $500 and save approximately $1,000 per year (elimination of one contractor visiting the site monthly 12 x $115 less added cost growth for the second contractor to empty the tank). These costs are based on past experience with similar sites using comparable equipment.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

6.3.1 SUGGESTED CHANGES IN WELL MAINTENANCE METHODS

The extraction wells are currently rehabilitated about every six months. The operators mix a hot sulfamic acid solution and recirculate it through the well without agitation or brushing. The use of sulfamic acid is appropriate, but a combined effort using sulfamic or hydroxacetic acid with a dispersant and well swabbing is likely to be more successful in maintaining good flow for a longer period of time. There are commercially available pre-mixed products with these compounds. A downhole camera survey of a fouled well may help identify if the problem is localized within the screen or if the fouling is at or adjacent to pump. The project team is directed to the USACE guidance, EP 1110-1-27, on well maintenance (see http://www.usace.army.mil/inet/usace-docs/eng-pamphlets/ep1110-1-27/toc.htm). Additional guidance on well rehabilitation is provided in soon-to-be-issued USACE documents.

6.3.2 PIPING TESTING

Given the long piping runs and the past penetration of a portion of the piping during fence installation, a pressure test of segments of the piping may be appropriate to verify integrity. Pressure drops along the piping should be measured and compared to theoretical pressure drops as an indication of encrustation, fouling, or sedimentation. This may be appropriate given the low velocities due to low average well flow rates. No estimate of the cost of this activity is provided.

6.3.3 CONTROL SYSTEM MODIFICATIONS

The plant programmable logic controller controls the operation of the well pumps, based on transducer-measured water levels. Though the transducers have not had many problems, the communications between wells and plant have been highly unreliable. Significant expense in parts and labor are incurred in replacing link couplings (connecting the transducer leads to the communication cables). Parts of the cable system have failed entirely. Wells RW-6 and 7 were down at the time of the site visit due to communications problems. The cable was buried in the trench with the water piping at depths of over 5 feet. To date, the contractor has installed transceivers to replace the cable connections in three vaults controlling several wells. These have worked remarkably well and include automatic restart capabilities if the wells go down due to power loss. The RSE team supports the replacement of the cable-based control system as a means to reduce the maintenance load on the operators. Control system modifications should be coordinated with the findings in paragraph 6.2.2.

6.3.4 OTHER ISSUES

The operators recommended providing auto-restart capability for the plant air compressor and the installation of a larger sink in the plant to facilitate washing of parts, etc. The RSE team supports these recommendations as a means to improve operationally efficiency.

6.4 MODIFICATIONS INTENDED TO GAIN SITE CLOSEOUT

6.4.1 EVALUATION OF THE ADEQUACY OF PAST SOURCE REMOVAL

A key to achieving ground water quality standards on the Higgins Farm Site is the removal of contaminant sources. The regulatory agencies and the site owner have undertaken several removal operations. The degree to which these removal actions were able to remove all long-term sources, including any product that leaked from the drums and containers, was not clear in the information made available to the RSE team. The RSE team recommends a more thorough evaluation of the past actions to assess the effectiveness as a true source removal. If it appears there may still be significant contamination below the water table, consideration of additional efforts to reduce mass flux from these areas should be considered. It is encouraging that concentrations of some of the contaminants have declined substantially, especially benzene. If a substantial mass remained in the source areas, one may not expect such declines. In any event, it is likely on-site ground water concentrations will remain above the ground water quality standards for a significant time to come (perhaps several decades)**.**

6.4.2 SITE EXIT STRATEGY DEVELOPMENT

The 1992 ROD identifies remedial goals, as described in section 3.1, however the site does not have a detailed incremental exit strategy. There is not a process to compare site conditions to specific interim goals to quantitatively evaluate progress toward site closure goals, nor is there a process to evaluate the concentrations in water produced by specific extraction wells to determine the need for continued extraction from those wells. A site exit strategy should be identified that sets goals for reduction in concentrations at specific locations based on the goals for human health and environmental protection. These goals could be to achieve specific concentration reductions at specific locations. It may be that on-site concentrations may eventually fall due to current actions, additional actions to address sources (if appropriate) and natural processes to low levels such that natural processes alone could prevent downgradient exposure and no active remediation may be needed. Interim decision points could be developed that indicate when active extraction is no longer needed at specific locations within the extraction system, similar to the recommendations in section 6.2.3. Such reductions in flow may reduce future O&M costs. The interim decision points could also recommend more aggressive removal (e.g., additional wells, source removal) be attempted if concentration goals are not achieved or implement contingency actions if concentrations exceed a certain threshold at monitoring points upgradient of water supply wells. The exit strategy should include evaluation of the monitoring program to assure it is focused on gathering the data needed to make the decisions. Periodic independent reviews (and, of course, five-year reviews) are also part of the exit strategy. The exit strategy could be developed following the evaluation of off-gradient contaminant distribution.

Some examples of exit strategy points relevant to the Higgins Farm Site are discussed below. It is suggested that extraction wells be turned off when the extracted concentrations are below MCLs or when the extracted mass represents less than 1% of the extracted mass of the system. If the iron concentrations were to fall below some minimum value in the combined influent to the plant, the process for pre-treatment for iron should be discontinued in the plant. If influent concentrations decline to less than the discharge limits, the treatment plant should be bypassed entirely. The ground water extraction system should reduce concentrations in the plumes at some reasonable rate. Perhaps some exponential decline can be identified based on historical data and projected into the future for specific wells. If the future concentrations for wells such as MW-7D, MW-6S, and Westbay well 11 asymptotically approach a number more than 20%, as an example, above the projected trend, then some additional treatment of the higher concentrations remaining near the past disposal locations would be considered to promote further decline in concentrations in the plume. The addition of extraction wells may be considered if the concentrations in reliable downgradient Westbay monitoring points do not drop by (an assumed) 50% in the next two years since the lack of a significant decline suggests there is leakage past the existing wells. Finally, if sampling of off-site and downgradient supply wells indicates concentrations of site contaminants above 50% of the MCLs or other risk based numbers, some additional monitoring wells should be installed upgradient of the supply wells as sentinel wells and contingencies for additional extraction and/or treatment (e.g., well head treatment) considered. These are only suggestions offered as a starting point for the project team. The actual exit strategy must be determined through consensus building and may require modeling or other studies to actually develop trigger or target concentrations for the strategy.

6.5 SUGGESTED APPROACH TO IMPLEMENTATION OF RECOMMENDATIONS

The characterization of the off-site contamination needs to be pursued regardless of decisions about other changes. The decision for adding a new extraction well, RW-11A, and the installation of additional monitoring points near the existing extraction wells should not be made until the downgradient extent is clarified. The replacement of the existing metals treatment processes should be evaluated as other changes are considered. This recommendation should receive the most careful consideration due to the highly significant decrease in O&M cost even while maintaining effectiveness. Most of the other recommendations are independent of each other and can be evaluated as individual actions. These include development of an exit strategy, reduction in the number of active extraction wells, modifications to the monitoring program, reduction in the air stripping process, addition of a sink in the treatment plant, change in the well maintenance methods, change in the waste tank pump-out connections. Note that the reduction in the number of active extraction wells and influent flow rate may perpetuate the need for batch operation of the existing treatment processes. The upgrade of the communication and controls to the extraction wells should not be finalized until a decision is made as to the reduction in the number of extraction wells.

6.6 RECOMMENDATIONS FOR SITE MONITORING AND MONITORING REPORTS

The monitoring reports currently provided to USACE for the ground water extraction and treatment system at the site provide much useful information. The RSE team does not have many specific recommendations for the changes in the reports. Some evaluation of the well specific capacity as an indication of fouling problems should be provided on a quarterly or semi-annual basis. This would include indication of well average flow rates and extraction well dynamic water levels.

6.6.1 MONTHLY REPORTS

Currently, monthly reports are submitted to the USACE, though the reports could possibly submitted quarterly with a significant cost savings. Assuming 10% of Mr. Fite’s time and 5% of Ms. Cermac’s time are devoted to monthly reports, this may be about $7,000 per year (based on interviews and cost avoidance using current contract costs. At a minimum, the operational reports for the treatment plant should present (items apparently not currently reported are indicated by an asterisk*):

- Current operating status (operating at full capacity, limited capacity, or off)
- Operational time over the quarter (as percentage), descriptions of problems encountered (primarily those that resulted in shut down or exceedances in the effluent), and corrective actions taken.

- Brief description of major routine maintenance conducted during the month (e.g., carbon changes, filter backwashes, etc)
- Concentrations in effluent and influent, including results of sampling at intermediate points
- Average flow rates from each well over the time period along with total water extracted*
- Current draw (amperage) for each ground water pump as an indication of pump health*
- Water level measurements for each production well*
- Specific capacity estimates for each well*
- Water levels measured in prescribed monitoring points.* This data should be presented in a table and posted on a map of the well locations. No contours need be provided.
- If sampling of monitoring wells is conducted during the month, the results should be tabulated and key constituents posted on a map of the monitoring wells. This would include low-flow sampling parameters such as turbidity and DO. No contours need be provided.
- Descriptions of quantities consumable chemicals used
- Major maintenance items planned for the next quarter
- Appendices of lab reports, chain of custody forms, and field sampling records
- Recommendations for equipment replacement / repair, well maintenance or rehabilitation, process changes or optimization should be identified (approximate costs provided for major items)

6.6.2 MONITORING REPORTS

The monitoring report for the systems should be provided semi-annually and should include the above information along with a brief description of the site (history, hydrogeology, land use including any changes, short description of the extraction and treatment system) and a site conceptual model. Much of the monthly data water level information can be summarized, though if data is being reported for a month not covered by previous reports, the information should not be summarized. The results of the most recent monitoring well sampling should be compared to historical observations to determine trends or future problems. This is currently and nicely done in the tables, but could be provided for key wells and contaminants in graphical form. Any figures from monthly reports should be provided along with interpretive text (and contaminant and ground water contours). Graphs of flow rate and concentration, and mass removal rate, over time by extraction well are appropriate and should include historical data to show long-term trends. Similar graphs should be prepared for influent, effluent, and total system mass removal. A specific discussion comparing system performance to requirements (e.g., for effluent, plume capture, site closure) must be included.

7.0 SUMMARY

The observations and recommendations given below are not intended to imply a deficiency in the work of either the designers or operators, but are offered as constructive suggestions in the best interest of EPA and the public. These recommendations obviously have the benefit of the operational data unavailable to the original designers.

The RSE process is designed to help site operators and managers improve effectiveness, reduce operation costs, improve technical operation, and gain site closeout. In this report, several recommendations are made with respect to system effectiveness, cost reduction, and technical improvement. The report addresses potential ways to enhance remediation, improve reporting and data management.

The ground water extraction system is generally operating in a way that achieves containment of the contaminant plume although additional wells are recommended to verify plume capture. The groundwater extraction system has reduced the groundwater contaminant concentrations over the period of operation. Several wells have concentrations at or below cleanup levels and the RSE team recommends they be turned off, however one new extraction well is recommended along the property boundary between existing wells RW-11 and RW-12. The treatment plant is achieving treatment goals, but has experienced operational difficulties due to limited hydraulic capacity related to undersized piping and pumping systems. The plant was originally designed to treat a variety of metals, which have diminished in concentration below cleanup and discharge levels except for iron and manganese. The existing metals treatment system is much too complex than currently needed and should be replaced. Treated ground water currently discharges to Carters Brook but other options, namely discharge to a POTW should be investigated. Significant savings in monitoring frequency and analytical costs were also identified.

Table 7 summarizes recommendations for improvements in effectiveness, and cost reduction, which will also assist the customer gain site closeout.

Table 7. Cost Summary Table for Individual Recommendations

Recommendation	Reason	Estimated Change in Capital Costs	Estimated Change in Annual Costs	Estimated Change in Life-cycle Costs*
6.1.1 Plume Definition	Effectiveness	$95,000	$0	$95K
6.1.2 Surface Water Sampling	Effectiveness	$2,500	$0	$2,500
6.1.3 On-Site Plume Capture	Effectiveness	$115,000	$20,000 (first year) to $10,000	$325K
6.2.1 Bypass Treatment Plant to POTW	Cost Reduction	$500,000 to MCUA, or $250,000 to SBRSA	Savings ($320,000) (MCUA) ($420,000) (SBRSA)	($5.9M) ($8.1M)
6.2.2. Extraction System Revisions	Cost Reduction	$0	Savings ($31,000)	($620K)
6.2.3 Downsize Air Stripper Blower	Cost Reduction	$5,000	Savings ($17,000)	($100K)
6.2.4 Alternate Manganese Removal Technologies	Cost Reduction	$50,000 plus $7500 pilot test	Savings ($85,000)	($1.64M)
6.2.5 Changes in Monitoring Program	Cost Reduction	$14,000 for diffusion bag sampling one time	Savings ($56,000) (accounting for new mon. wells)	($1.12M)
6.2.6. Review Level of USACE Oversight	Cost Reduction	$0	($35,000)	($700K)
6.6.1 Reduce Monthly Reporting Frequency to Quarterly	Cost Reduction	$0	($7,000)	($140K)

Costs in parentheses imply cost reductions, refer to the paragraph cited for cost development information.
* assumes 20 years of operation at a discount rate of 0% (i.e., no discount).