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OPTIMIZATION STUDY REPORT

FOR SITE 26, OPERABLE UNIT 3 (OU-3), EXPLOSIVE "D" WASHOUT AREA NEAR BUILDING GB-1 LOCATED AT NAVAL WEAPONS STATION (NWS) EARLE, COLTS NECK, NEW JERSEY

Prepared for

Engineering Field Activity Northeast
Naval Facilities Engineering Command
10 Industrial Highway
Lester, PA 19113-2090

Prepared by

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June 18, 2004

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Engineering Field Activity Northeast
Naval Facilities Engineering Command
10 Industrial Highway
Lester, Pennsylvania 19113-2090

Attention: Ms. Michele DiGeambeardino

Dear Ms. DiGeambeardino:

Contract No. N62472-00-D-1300/D.O. 008
Draft Optimization Study Report for Site 26,
Naval Weapons Station Earle, Colts Neck, New Jersey

Battelle was contracted by Engineering Field Activity Northeast (EFANE) Naval Facilities Engineering Command to perform an initial evaluation and provide recommendations to optimize the remediation systems in operation at Site 26, Operable Unit 3 (OU-3), Explosive "D" Washout Area Near Building GB-1 located at Naval Weapons Station (NWS) Earle, Colts Neck, New Jersey. Based on comments on the Final Draft Report provided by EFANE on June 3, 2004, we have finalized the *Optimization Report for Site 26* (Final Report). In addition, the Final Report incorporates supplemental information provided by Battelle to EFANE on May 28, 2004. As requested, we have enclosed fifteen (15) copies of the Final Report for distribution.

We appreciate the opportunity to participate in this optimization study and make these recommendations. Please call Mark Nielsen at (215) 579-2330 or Steve Rosansky at (614) 424-7289 should you have any questions.

Sincerely,

Jeff Oxenham /FOR

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EXECUTIVE SUMMARY

Project Objectives

The objectives of this optimization project are to assess the existing remedial actions at Site 16F and Site 26, and provide recommendations to the Navy that help the systems achieve remedial action (RA) objectives and ultimate site closure while optimizing life-cycle costs. This report follows the seven-step optimization guidance presented in NAVFAC *Guidance for Optimizing Remedial Action Operation Special Report* SR-2101-ENV (Radian, 2001):

Step 1: Review and Evaluate Remedial Action Objectives
Step 2: Evaluate Remediation Effectiveness
Step 3: Evaluate Cost Efficiency
Step 4: Identify Remediation Alternatives
Step 5: Develop and Prioritize Optimization Strategy
Step 6: Prepare Optimization Report
Step 7: Implement Optimization Strategy.

Where appropriate, specific recommendations are included based on the results of the document review and observations made during the site visit. These recommendations are intended to provide the first assessment in the optimization process. As specified in Battelle's *Technical Proposal for Optimization Studies for Sites 16 and 26 at NWS Earle, Colts Neck, NJ*, this optimization report includes the results of the first five of the seven-step guidance procedure; therefore, the recommendations presented in this report are not necessarily all-encompassing. The optimization process should be refined as additional data become available resulting from the implementation of the recommended optimization process.

Site Investigation and Remediation Activities

Site 26 (Operable Unit [OU]-3) is defined as the area surrounding Building GB-1, which is located within the Ordnance Area on the Mainside portion of NWS Earle. Building GB-1 reportedly was used for the reconditioning of munitions casings and shells. Spent solvents and wash waters associated with this operation apparently were discarded into an on-site sanitary waste system located on the northwest side of Building GB-1, consisting of a grease trap and cesspool-type leach tank measuring approximately 10 ft by 10 ft, and 6 ft deep. Building GB-1 is no longer used for processing activities; the facility currently is being used for housing groundwater remediation equipment, warehousing, and storage. Currently, there are no active Navy operations in Building GB-1 or the surrounding area. In addition, no operations are currently planned for this area of NWS Earle; once active remediation is completed in this area, the Navy plans to demolish Building GB-1.

The area surrounding the operational area associated with Building GB-1 is wooded upland areas. The nearest wetlands are located approximately 300 yards northwest of the operational area. The east branch of Mingamahone Brook is located 300 yards southwest of Site 26. On-site borings encountered light yellowish-brown sand and gravel and brownish-yellow, brown and gray, fine- to medium- to coarse-grained sands to a depth of approximately 25 ft bgs in this area. Groundwater was encountered in this shallow sand zone at a depth of approximately 10 ft bgs. Flow in this shallow groundwater zone has been determined to be toward the southwest. Beneath this shallow sand zone, a silty clay and clayey silt layer was encountered from approximately 25 to 45 ft bgs. Sand is present beneath the clay-silt layer from approximately 45 to 70 ft. Based on drilling at one location, this deeper sand zone is underlain by a clayey silt layer having a thickness of at least 7 ft.

Remedial investigations at Site 26 detected elevated concentrations of volatile organic compounds (VOCs) (primarily trichloroethene [TCE] and *cis*-1,2-dichloroethene [*cis*-1,2-DCE]) in the shallow groundwater zone, with the highest concentrations detected immediately downgradient of the former leach tank location. Vertical profile sampling within the shallow zone determined that the highest VOC concentrations were present in the lower portion of the shallow groundwater zone. A second overlapping plume apparently resulting from a separate source and consisting primarily of tetrachloroethene (PCE) was also identified. These overlapping groundwater contaminant plumes extend from the Building GB-1 area to the southwest toward Mingamahone Brook.

Based on data collected during the remedial investigation (RI) and RI Addendum, risk estimates for hypothetical future residential and industrial receptors exposed to soil and shallow groundwater (assuming groundwater is used as a drinking water source, which it is not currently or reasonably expected to be in the future) at Site 26 were calculated. This risk characterization determined that:

- Reasonable maximum hypothetical residential exposures to soil and groundwater exceed the acceptable cancer risk range of 10^{-6} to 10^{-4} and/or a noncancer hazard index of 1.

- Reasonable maximum hypothetical industrial worker exposures to soil are within the acceptable cancer risk range and below the noncancer hazard index of 1. However, reasonable maximum exposures of an industrial worker to contaminants in site groundwater exceed the acceptable cancer risk range of 10^{-6} to 10^{-4} and a noncancer hazard index of 1.

Based on these results, remedial actions to address groundwater contamination were determined to be warranted.

A Record of Decision (ROD) was issued in September 1998 which documented the remedial method for groundwater at the site as air sparging and soil vapor extraction (AS/SVE), institutional controls, and long-term monitoring. The objective for the AS/SVE system is to remediate groundwater in the shallow aquifer that has been impacted by chlorinated hydrocarbons (primarily TCE and *cis*-1,2-DCE). The system was designed to inject air (air sparging) into the groundwater and extract (SVE) the volatilized contaminants in the vapor phase from the vadose zone. The Site 26 AS/SVE system will continue to operate (at least intermittently) until extracted VOCs reach asymptotic levels with no significant rebound effects and groundwater concentrations are below New Jersey Groundwater Quality Standards (GWQS). If concentrations in groundwater are still above GWQS at that time, and it is no longer cost-effective to operate the AS/SVE system, fate and transport modeling are to be conducted to evaluate the potential for the remainder of the contaminant plume to naturally attenuate before reaching any downgradient receptors. In this case, the Navy may propose a revised ROD for monitored natural attenuation (MNA) of the residual compounds.

In May 1999, a pilot process study was completed, and the information obtained from the pilot system operation formed the basis of design for the full-scale AS/SVE system. The full-scale AS/SVE system was installed in late winter of 1999 and early spring of 2000, and system operation began on January 4, 2001. The system has remained operational since, operating up to forty (40) hours per week.

Remediation System Performance

The overall performance of the AS/SVE system during eight quarters of operation is summarized below:

- Through eight quarters of operation of the AS/SVE system, concentrations of TCE and DCE in the shallow groundwater have declined.

- TCE was detected during the RI at concentrations up to 9,300 μg/L. The latest groundwater sampling detected TCE above the New Jersey GWQS of 1 μg/L in five wells, with concentrations ranging up to 56 μg/L; the MCL set under the Safe Drinking Water Act (5 μg/L) was exceeded in only three wells.
- PCE was detected during the RI at concentrations up to 56 μg/L. PCE was detected in the latest groundwater sampling at only one well at a concentration equal to the New Jersey GWQS (1 μg/L) and below the MCL (5 μg/L).
- *cis*-1,2-DCE was detected during the RI at concentrations up to 2,000 μg/L. *cis*-1,2-DCE was detected in the latest groundwater sampling at two wells ranging up to 200 μg/L; the current interim specific GWQS and the MCL set under the Safe Drinking Water Act (both 70 μg/L) were exceeded in only one well.

- A total of 1.08 lb of TCE and 0.59 lb of *cis*-1,2-DCE (total of 1.7 lb) has been removed. The rate of mass recovery has dropped significantly since the initial start-up. Based on monitoring conducted during the 8th Quarter of operation, zero mass recovery was measured.

- Based on the quarterly mass extraction rates and the quarterly operations costs, it is estimated that the cost per pound of VOC mass extracted has increased from approximately $45K/lb in the 2nd Quarter to approximately $3,500K/lb in the 7th Quarter. Labor costs account for approximately 75% of the monthly operations and monitoring costs.

Recommendations

Based on the available monitoring and cost data for the Site 26 remediation program, operation of the AS/SVE system no longer represents the most cost-effective method for achieving further reductions in groundwater concentrations necessary to achieve the remedial action objectives for Site 26. In particular, the latest available monitoring report indicates that VOC mass recovery is no longer measurable and the cost per pound of VOC mass recovered has increased significantly. In addition, groundwater monitoring data indicate that concentrations are generally reaching asymptotic levels. It is therefore recommended that an alternative approach be pursued. Specifically, as specified in the ROD for the selected remedy, the Navy may propose MNA for the portion of the contaminant plume remaining above GWQS once extracted VOCs reach asymptotic levels.

The following steps are recommended to further develop the optimization plan and alternate remedy for Site 26:

1. Shut down AS/SVE system and allow groundwater mounding caused by AS operation to subside and groundwater flow conditions to return to unstressed conditions.

2. Confirm steady-state groundwater flow pattern.

3. Identify key existing monitoring wells and locations for new monitoring wells, if any, to fill data gaps based on unstressed groundwater flow patterns.

4. Monitor groundwater quality quarterly in key monitoring wells for evidence of rebound or attenuation. Data collection should include parameters for assessing in situ anaerobic degradation potential (e.g., dissolved oxygen, redox potential, sulfate, nitrate, oxygen, iron, manganese) (DON, 1998).

5. Based on four quarters of post-shutdown monitoring, demonstrate plume stability.

6. Apply for a New Jersey groundwater classification exception area (see Attachment B for New Jersey Department of Environmental Restoration [NJDEP] requirements).

7. Develop a contingency action plan in the event that post-shutdown monitoring does not show continued reductions in VOC concentrations. Consideration should be given to including enhanced biotechnology as part of this contingency plan (see Attachment C for a preliminary evaluation of the HRC technology for Site 26).

1.0 BACKGROUND

1.1 Site History

NWS Earle is located in Monmouth County, NJ, approximately 47 miles south of New York City. The station consists of two areas, the 10,248-acre Main Base (Mainside area), located inland, and the 706-acre Waterfront area (Figure 1). The two areas are connected by a Navy-controlled right-of-way. The Facility was commissioned in 1943, and its primary mission is to supply ammunition to the naval fleet. An estimated 2,500 people either work or live at the NWS Earle (U.S. EPA, 1998b).

The Mainside area is located approximately 10 miles inland from the Atlantic Ocean at Sandy Hook Bay in Colts Neck Township, which has a population of approximately 6,500 people. The surrounding area includes agricultural land, vacant land, and low-density housing. The Mainside area consists of a large, undeveloped portion associated with ordnance operations, production, and storage. Other land use in the Mainside area consists of residences, offices, workshops, warehouses, recreational space, open space, and undeveloped land. The Waterfront area is located adjacent to Sandy Hook Bay in Middletown Township, which has a population of approximately 68,200 people. The Mainside and Waterfront areas are connected by a narrow strip of land that serves as a government-controlled right-of-way containing a road and railroad.

Site 26 (OU-3) is defined as the area surrounding Building GB-1, which is located within the Ordnance Area on the Mainside portion of NWS Earle, at the intersection of Macassor and Midway roads (see Figure 2). Building GB-1 reportedly was used for the reconditioning of munitions casings and shells. Spent solvents and wash waters associated with this operation apparently were discarded into an on-site sanitary waste system located on the northwest side of Building GB-1, consisting of a grease trap and cesspool-type leach tank constructed of cement block masonry and measuring approximately 10 ft by 10 ft, and 6 ft deep. Building GB-1 is no longer used for processing activities and the facility currently is being used for housing groundwater remediation equipment, warehousing, and storage.

All facilities located in the Mainside Administration area are connected to a public water supply operated by the New Jersey American Water Company (U.S. EPA, 1998b). Building GB-1 is connected to the public water supply. Water for the public supply network comes from surface water intakes, reservoirs, and deep wells. No public water supply wells or surface water intakes are located on the NWS Earle Facility. A combination of private wells and public water supply from the New Jersey American Water Company serves businesses and residences in areas surrounding the Mainside facilities. A number of private wells are located within a 1-mile radius of NWS Earle and several are located within the NWS Earle boundaries. The majority of these wells are used for potable supplies; previous testing for drinking water parameters indicates these wells have not been adversely impacted (U.S. EPA, 1998b).

1.2 Site Investigation

Potential hazardous substance releases at Site 26 were addressed in an Initial Assessment Study (IAS) in 1982, and a Site Inspection (SI) Study in 1986. These were preliminary investigations to determine the number of sources, compile histories of waste-handling and disposal practices at the Facility, and acquire data on the types of contaminants present and potential human health and/or environmental receptors. In 1990, NWS Earle was placed on the National Priorities List (NPL).

According to the *Remedial Investigation Report for Naval Weapons Station Earle* (Brown and Root Environmental, 1996), during site investigations conducted in 1993, four monitoring wells were installed. Trichloroethene (TCE) was detected in the monitoring well located nearest the leach tank (well MW26-01)

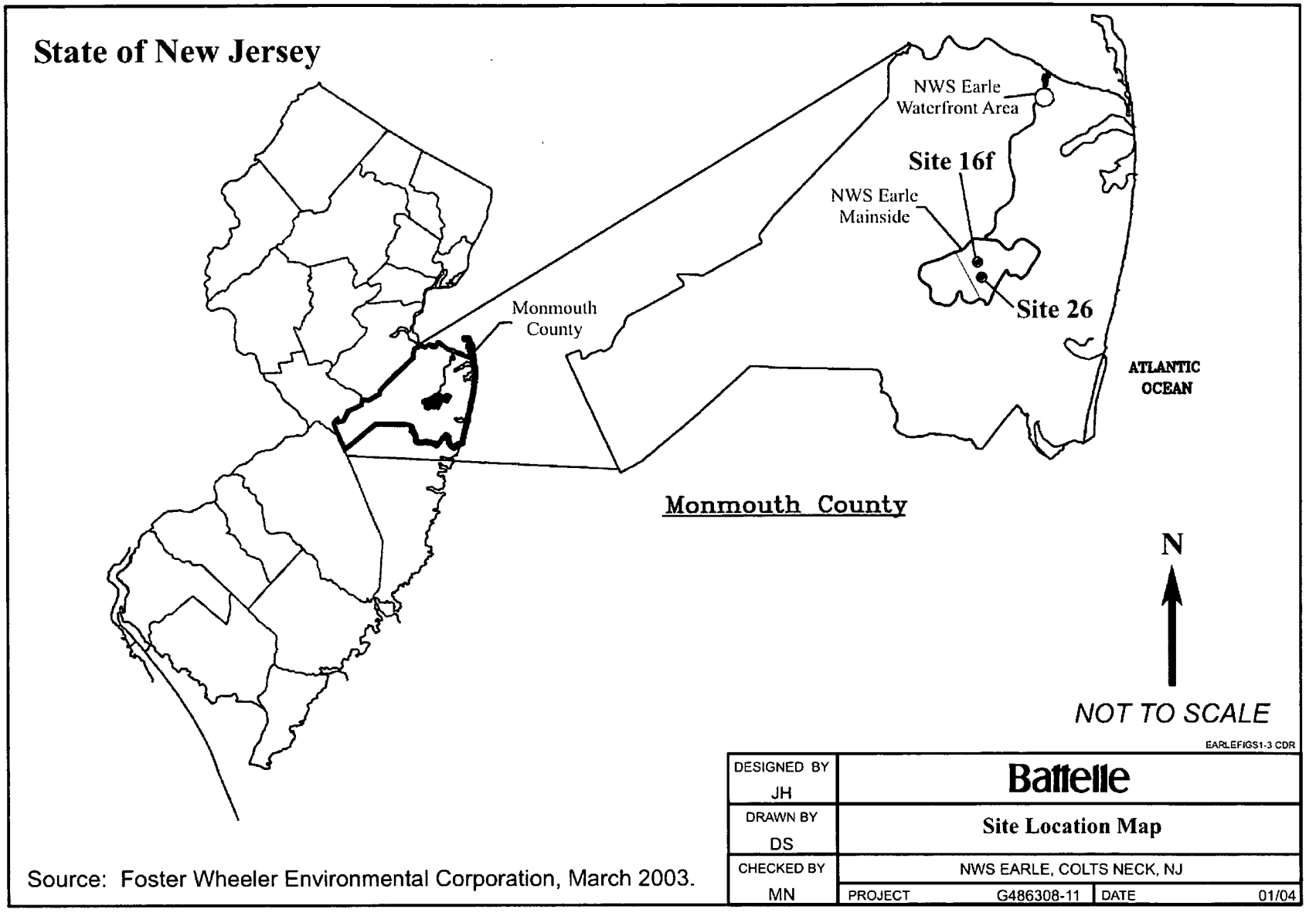

Figure 1. Site Location Map

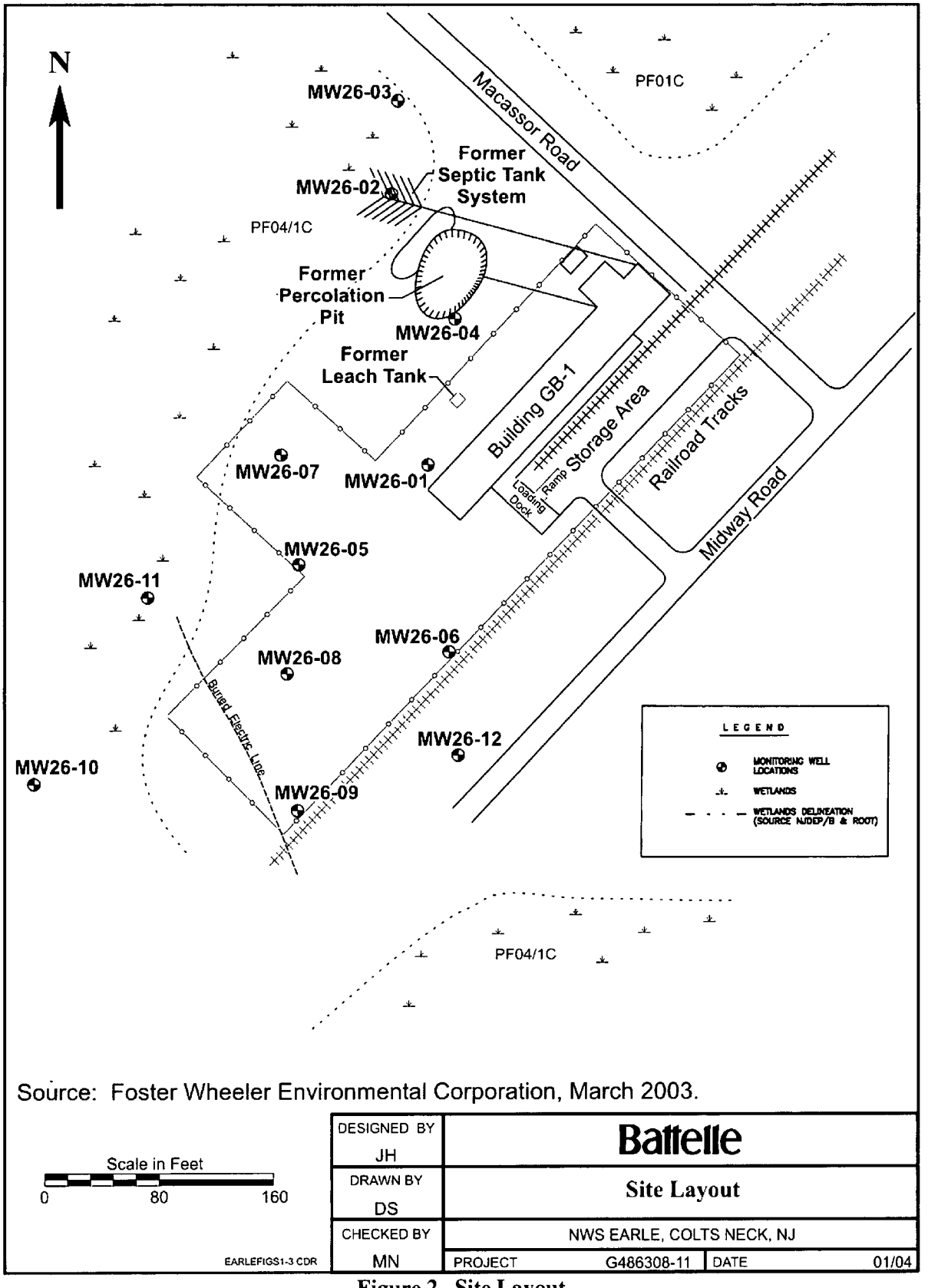

Figure 2. Site Layout

at a concentration of 660 μg/L. Other volatile organic compounds (VOCs), including dichloroethanes related to TCE impurities or breakdown products, also were detected. Based on this information, a remedial investigation (RI) was conducted in 1995 that consisted of the following field activities:

- **Soil-Gas Survey.** A soil gas survey was conducted in the area southwest and northwest of Building GB-1. Samples were collected at 25-ft grid spacing at depths between 7 and 8 ft below ground surface (bgs), at approximately 1 ft above the water table. In general, this survey indicated a potential source of TCE near well MW26-01.

- **Soil Sampling.** Soil sampling took place from six soil borings, including four installed adjacent to the leach tank. Saturated conditions were encountered at approximately 7 to 10 ft bgs. Low concentrations of TCE were detected in two samples collected next to the leach tank.

- **Monitoring Well Installation.** Two additional monitoring wells were installed downgradient of the leach tank to further evaluate potential groundwater impacts associated with this tank. The wells were installed to a depth of approximately 8 ft below the water table, and completed with a 10-ft screened interval.

- **Groundwater Sampling for Target Compound List (TCL) VOCs and Target Analyte List (TAL) Metals.** TCE was detected at concentrations up to 1,700 μg/L, 1,1-dichloroethene (DCE) was detected at 3 μg/L, 1,2-DCE was detected at 2,000 μg/L, chloroform was detected at 1 μg/L, and tetrachloroethene (PCE) was detected at 1 μg/L. The highest concentrations were detected at well MW26-01.

- **Groundwater Elevation Survey.** Static water level measurements were collected from six monitoring wells in August and October 1995. Depth to water ranged from approximately 11 to 14 ft bgs in August and 13 to 16 ft bgs in October. Groundwater flow was determined to be toward the southwest.

At the conclusion of the RI, additional data collection was recommended at Site 26 to further characterize the source area (i.e., the process leach tank) and the horizontal and vertical extent of VOC contamination in groundwater. According to the *Remedial Investigation Addendum Report for Naval Weapons Station Earle* (Brown and Root Environmental, 1997), the RI Addendum was implemented in 1996 and consisted of the following:

- **Lithologic Profiling at 8 Locations.** Deeper on-site borings encountered a silty clay and clayey silt layer beneath the shallow upper water bearing zone, from approximately 25 to 45 ft bgs. Sand is present beneath this clay-silt layer from approximately 45 to 70 ft. Based on drilling at one location, this deeper sand zone is underlain by a clayey silt layer having a thickness of at least 7 ft.

- **Groundwater Sampling at Wells MW26-01 and MW26-06.** Trace levels of VOCs (TCE, PCE, and chloroform) were detected in well MW26-06. Results for sampling at MW26-01 indicated elevated VOC concentrations (1,2-DCE: 300 μg/L; TCE: 9,100 μg/L; and PCE: 3 μg/L).

- **Multi-Depth Groundwater Sampling.** Samples (64 samples and one duplicate sample) were collected from 28 locations using direct-push sampling techniques. VOCs were detected with TCE concentrations ranging from 0.06 to 4,800 μg/L. At a given sampling location, the VOC concentrations tended to be higher in the deeper sampling interval (i.e.,

18 to 25 ft bgs) within the shallow water bearing zone, than in the shallower sampling interval (i.e., less than 17 ft bgs). The maximum TCE concentration was detected at a sampling point approximately 280 ft southwest of Building GB-1 (sampling point 26HP-22 at a depth of 18 to 25 ft). The highest concentration of PCE (56 μg/L) was detected approximately 100 ft downgradient of 26HP-22 at location 26HP-24. Low concentrations of VOCs also were detected in the lower sand zone (45 to 79 ft bgs); TCE was detected up to 7 μg/L and 1,2-DCE was detected up to 0.2 μg/L.

Based on data collected during the RI and RI Addendum, risk estimates for hypothetical future residential and industrial receptors exposed to soil and shallow groundwater (assuming groundwater is used as a drinking water source) at Site 26 were calculated. This risk characterization determined that:

- Reasonable maximum hypothetical residential exposures to soil and groundwater exceed the acceptable cancer risk range of 10^{-6} to 10^{-4} and/or a noncancer hazard index of 1.

- Reasonable maximum hypothetical industrial worker exposures to soil are within the acceptable cancer risk range and below the noncancer hazard index of 1. However, reasonable maximum exposures of an industrial worker to contaminants in site groundwater exceed the acceptable cancer risk range of 10^{-6} to 10^{-4} and a noncancer hazard index of 1.

1.3 Site Remediation

A Proposed Plan was announced in December 1997 for remediation of the site using AS/SVE. A removal action was conducted in February 1998 to remove the leach tank system and associated sludge immediately northwest of Building GB-1 (FWEC, 2003c). A Record of Decision (ROD) was issued in September 1998 which documented the remedial method for groundwater at this site as AS/SVE, institutional controls, and long-term monitoring (U.S. EPA, 1998b). The overall objective for the remedy at OU-3 is to protect human health and the environment. The RA Objective to protect human health is to prevent human exposure to contaminated groundwater. The RA Objective for protection of the environment is to mitigate VOC contaminants in the groundwater. According to the ROD (U.S. EPA, 1998b), by using air sparging with soil vapor extraction, active removal of contaminants from the soil and groundwater would be achieved. Also, according to the ROD, residual VOCs remaining after AS/SVE treatment reaches its physically limiting endpoint would be permitted to naturally attenuate under anaerobic conditions in situ (U.S. EPA, 1998b). Removal of the suspected source area would eliminate the potential for direct exposure.

Additional investigation activities were conducted as part of the predesign studies necessary to implement the ROD. These investigations included (TTN, 2003):

- Characterization of soil conditions at a septic tank associated with former Building GB-2 located southwest of Building GB-1 (this tank was suspected of having been used for similar disposal activities as the Building GB-1 leach tank). All samples were nondetect for VOCs of concern. In addition, an aqueous sample collected from this tank was nondetect for VOCs.

- Surface water and sediment sampling in Mingamahone Brook, upstream, within, and downstream of the projected path of groundwater migrating from Site 26. No VOCs were detected in these samples.

- Groundwater sampling from four monitoring wells and 72 direct-push (i.e., Hydropunch™) temporary well locations. The temporary wells were located within the known area of the

groundwater plume, and in the area between the known plume limits and the western banks of Mingamahone Brook. VOCs were detected in well MW26-01 as high as 9,300 μg/L for TCE (consistent with the RI data), and 3,800 μg/L for 1,2-DCE. Sampling at the temporary well points detected TCE up to 2,000 μg/L, 1,2-DCE up to 1,700 μg/L and PCE up to 77 μg/L. Sampling in temporary wells installed near Mingamahone Brook reported TCE concentrations from nondetect to one detection of 8.3 μg/L; PCE concentrations from nondetect to 29 μg/L, with detections at multiple locations; and 1,2-DCE concentrations from nondetect levels to 0.5 μg/L (J) at one location. This characterization also delineated a portion of the plume containing only PCE.

- Installation of 12 additional monitoring wells to monitor the interior of the plume and the plume limits (as sentry wells).

In May 1999, a pilot process study was completed; the information obtained from the pilot system operation formed the basis of design for the full-scale AS/SVE system. The full-scale system was completed in the fall of 1999 with installation of the system in late winter of 1999 and early spring of the year 2000. The full-scale AS/SVE system consists of 72 sparge wells, 8 horizontal SVE wells, and 4 vertical SVE wells connected in an aboveground piping network. The AS system consists of two rotary lobe blowers, which are capable of being operated individually or in parallel. Both blowers are connected to the AS piping manifold network to facilitate operational flexibility. Similarly, the SVE system also consists of two rotary lobe blowers, which are capable of being operated individually or in parallel. Both blowers are connected to the SVE piping manifold network to facilitate operational flexibility. The extracted soil vapors are directed from the SVE piping manifold network, and divided into two streams. Each stream passes through a moisture separator, inlet filter/silencer, blower, outlet silencer, and then on to the off-gas control system. The processed vapor stream is recombined after the outlet of the two blowers before proceeding to the off-gas control system.

System operation began on January 4, 2001. Groundwater measurements obtained in January 2001 indicated that a significant amount of groundwater mounding was occurring within the area of the AS influence. Measures taken to reduce the groundwater mounding included opening of the AS blower bleed valve and the closing of individual AS well valves to lower the airflow to the AS wells. The belts, sheaves, and pulley for the AS blower were also replaced to decrease the airflow and minimize the groundwater mounding effect. On January 25, 2001, operation of the AS/SVE system ceased as directed by the Navy. The system was shut down while more information was provided to the New Jersey Department of Environmental Protection (NJDEP) on the SVE air discharge permit application. System operation resumed on February 6, 2001, as directed by the Navy. Because groundwater mounding continued to be problematic, a second attempt to reduce sparging airflow was made on March 7, 2001. The proposed remedy for the situation was to replace the 1-inch sparge blower bleed valve with a 2-inch bleed valve. This allowed for the injection of a lower volume of sparge air to the subsurface and for more of the air volume produced by the blower to be "bled" off. Bleeding off additional air through the 2-inch diameter air bleed valve was successful in eliminating the groundwater mounding problem. Normal operation of the AS/SVE system continued via remote startup and shutdown through April 2003. After eight (8) quarters of operation, approximately 1.7 lb of TCE and DCE mass has been removed.

As indicated above, site investigations determined that significant concentrations of TCE were present just above a clay layer located 25 ft bgs. The plume was approximately 350 ft long and 130 ft wide. In addition, there is a continuation of this plume that has shown only PCE contamination. U.S. EPA has stated that they believe the PCE contamination is the result of a separate source.

1.4 Performance Review

In 2003, a performance review was conducted of the Site 26 remediation program. This review included the evaluation of the following:

- Whether the PCE component of the site's VOC plume warrants regulatory administration as a separate OU; and
- Whether all impacted groundwater can be managed through a single or common classification exception area (CEA).

The findings of the review are contained in the *Technical Memorandum: Extent of Groundwater Contamination at Site 26, Operable Unit 3 (OU3)* (TTN, 2003). In summary, it was concluded that:

- The TCE and PCE components of the VOC plume appear to emanate from different source locations, but generally overlap at most locations within the plume. The PCE component of the plume has a greater lateral extent to the south due to the more southerly location of the likely PCE source location. The downgradient extents of the TCE and PCE plumes are identical. A separate operable unit (OU-7) is not required for the regulatory administration of the PCE component of the VOC plume. This conclusion is supported by the observations that the PCE and TCE components of the VOC plume overlap throughout much of its area, and that the existing AS/SVE system is already remediating the source areas for both of these plume components.
- Theoretically, the dissolved-phase plume emanating from these sources should attenuate or retract as the source concentrations are reduced. Very limited available data suggest that this attenuation is occurring, although this attenuation cannot be confirmed without additional data.
- Additional permanent monitoring wells should be installed within the dissolved-phase plume (as defined by the screening well data) downgradient of the TCE and PCE source areas in order to acquire the analytical data needed to prove that the plume is attenuating. The installation of an additional sentry monitoring well to the north of existing monitoring well MW26-18 is also suggested. This sentry well would define the northern boundary of the plume in the mid-gradient position.
- The Mingamahone Creek and its tributary should be sampled periodically to ensure that the plume is not discharging to surface water and migrating beyond the site through the surface water pathway.

Based on a review of the existing data, the Navy concluded that the generally overlapping nature of the TCE and PCE components of the VOC plume indicate that a single CEA is needed for the total VOC plume. The existing sentry wells are in favorable locations to both define the outer boundary of the CEA and to indicate if the plume should migrate beyond the CEA, although the existing data indicate that it is very unlikely that the plume will migrate to that extent.

2.0 SITE CONCEPTUAL MODEL

Based on the findings of the RI and RI Addendum, the following conceptual model was developed for Site 26.

2.1 Setting

Site 26 comprises a relatively small area approximately 200 ft by 200 ft behind Building GB-1. The area immediately northwest and southwest of Building GB-1 consists of pavement and a gravel/dirt storage area (see Figure 3). The surrounding area is turfgrass. This area is expected to provide little ecological habitat.

Figure 3. Site 26 Aerial Photograph

The area surrounding the operational area associated with Building GB-1 is wooded upland areas. The nearest wetlands are located approximately 300 yards northwest of the operational area. The east branch of Mingamahone Brook is located 300 yards southwest of Site 26. Currently, there are no active Navy operations in Building GB-1 or the surrounding area. In addition, no operations currently are planned for this area of NWS Earle.

2.2 Geology and Hydrogeology

On-site borings encountered light yellowish-brown sand and gravel and brownish-yellow, brown and gray, fine- to medium- to coarse-grained sands to a depth of approximately 25 ft bgs. These deposits likely represent upland gravel and an outcrop area of the Kirkwood Formation. The hydraulic conductivity of this formation is on the order of 10^{-3} cm/sec.

Beneath the upland gravel and Kirkwood sand, a silty clay and clayey silt layer was encountered from approximately 25 to 45 ft bgs. Sand is present beneath the clay-silt layer from approximately 45 to 70 ft. Based on drilling at one location, this deeper sand zone is underlain by a clayey silt layer having a thickness of at least 7 ft (see Figures 4 and 5).

Groundwater in the shallow water table aquifer occurs under unconfined conditions. The water table in this zone is encountered at a depth of approximately 10 ft bgs. This water bearing zone is underlain by a confining layer comprised of approximately 20 ft of silt and clay. Shallow groundwater flows from the area of Building GB-1 to the southwest, so groundwater from the site could eventually discharge to surface water in Mingamahone Brook. Figure 6 depicts the groundwater flow pattern based on the Eighth Quarter monitoring results.

2.3 Exposure Pathways

Based on the prior site investigations and the site visit conducted in November 2003, the assessment of potential exposures to contaminants detected at Site 26 determined that:

- There is no current or reasonably likely future use of groundwater.
- There is no current or reasonably likely future operational use of Building GB-1 or the Site 26 area.
- There is little ecological habitat associated with Site 26, although ecological receptors may be present in the surrounding wooded upland areas.

The primary migration pathway for contamination detected at Site 26 is via shallow groundwater flow, with the potential for discharge into Mingamahone Brook. To date, VOCs have not been detected in surface water in Mingamahone Brook.

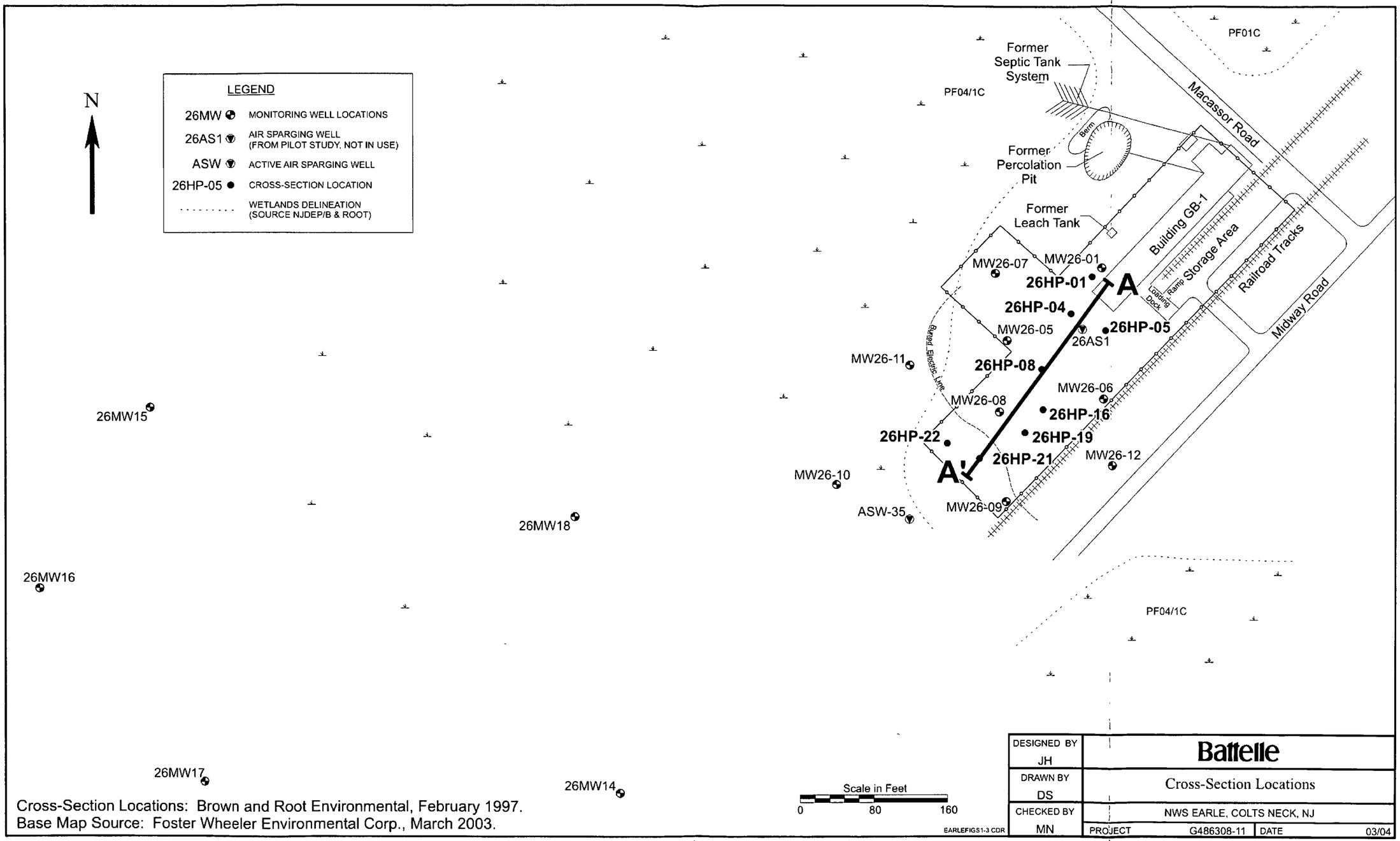

Figure 4. Cross-Section Locations at Site 26

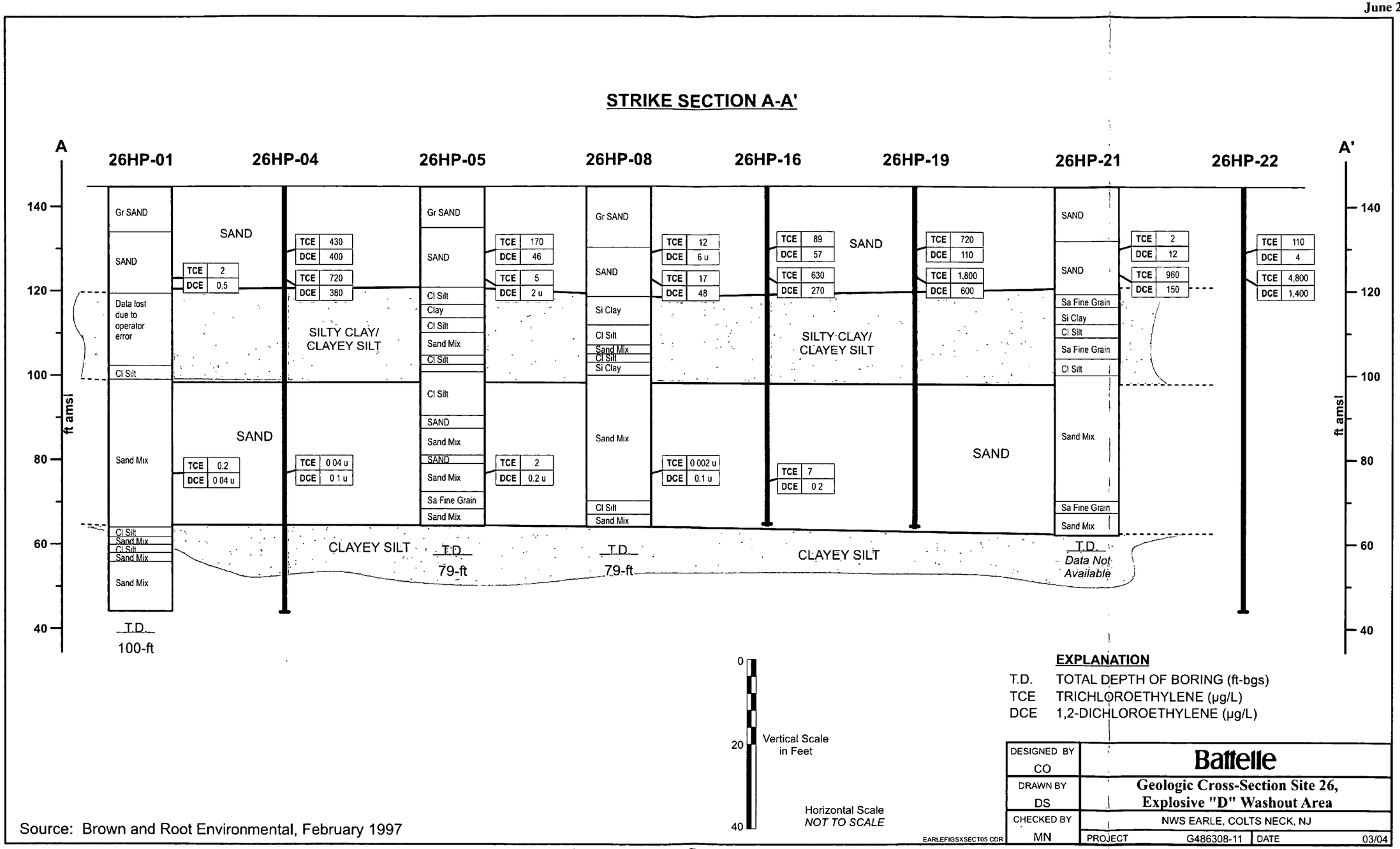

Figure 5. Geologic Cross-Section at Site 26

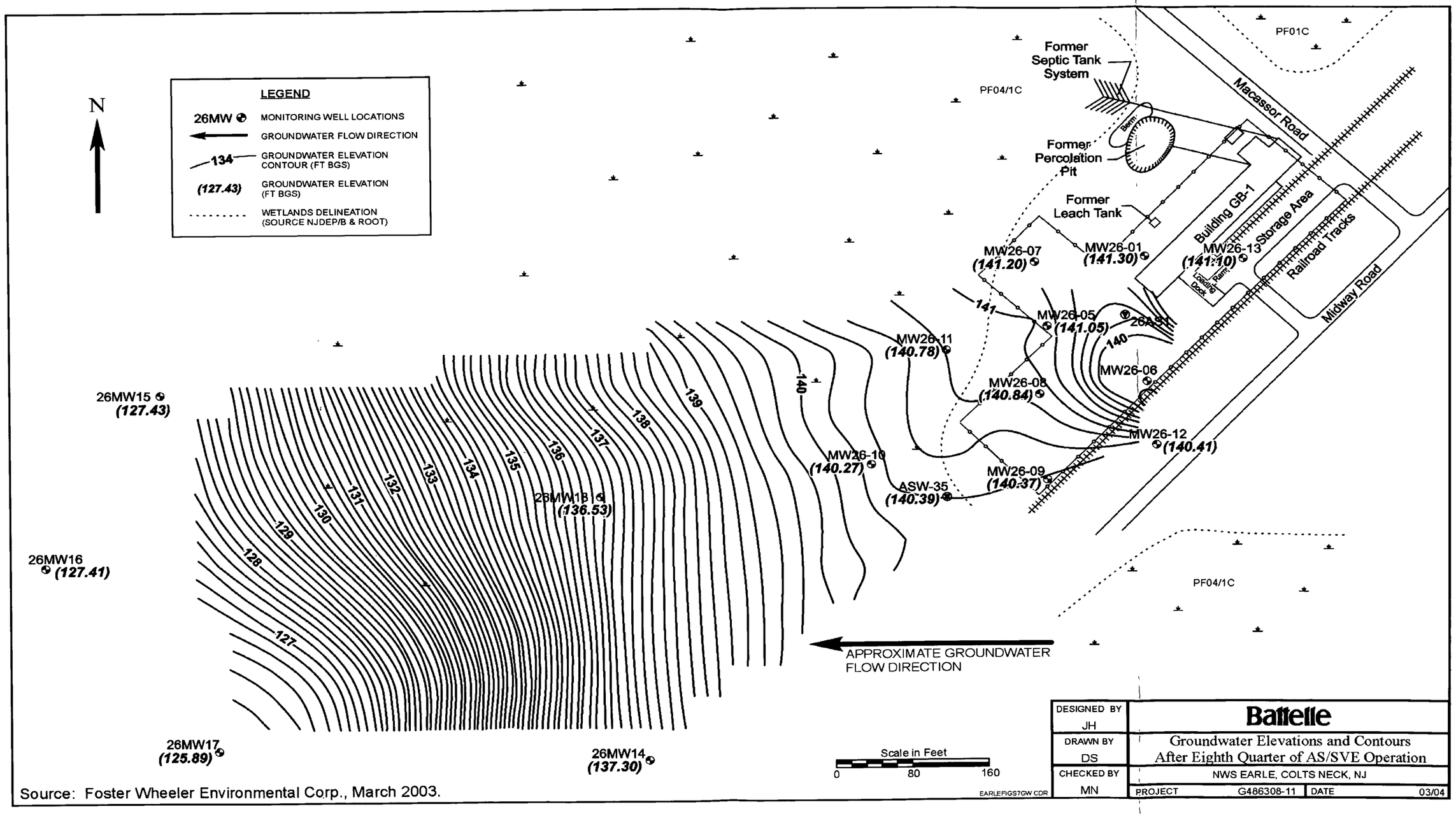

Figure 6. Groundwater Flow Pattern Based on Eighth Quarter Monitoring Results

3.0 SITE VISIT

On November 21, 2003, a site visit was conducted to gather information regarding remedial operations being conducted at Sites 16F and 26, and to observe current conditions at these two locations.

Several items were discussed during the visit regarding the remedial program at Site 26, including:

Primary Source Area: The primary source area of VOCs (primarily TCE and DCE) identified in groundwater at Site 26 is the former leach field located on the northwest side of Building GB-1. A separate source for PCE observed in this same area has not been identified.

Contaminant Distribution: The results of concentration profiling conducted using Hydropunch™ sampling indicate that VOC concentrations are higher in the lower portion of the shallow saturated zone (see Figure 5, which depicts VOC concentrations with depth along a representative cross section through the groundwater plume based on RI sampling data), and that concentrations reported for permanent monitoring wells having 10-ft-long screened intervals are generally lower than the Hydropunch™ concentrations.

Mass Recovery Rates: Very little mass recovery by the AS/SVE system has been reported in the recent quarterly performance reports.

Five-Year Review: On March 21, 2003, findings and recommendations were issued as part of the five-year project review.

4.0 OPTIMIZATION STRATEGY

The remainder of this report uses steps from the seven-step optimization approach to organize recommendations for optimizing the remedial activities at Site 26. Where appropriate, specific recommendations are included based on the results of the document review and observations made during the site visit.

4.1 Review and Evaluate Remedial Action Objectives

Groundwater sampling in the vicinity of Building GB-1 revealed an elongated plume of chlorinated compounds in shallow groundwater immediately southwest of Building GB-1. This contaminant plume extends from Building GB-1 to Mingamahone Brook and is confined to an upper sand aquifer which extends to a depth of approximately 25 ft bgs. This upper sand aquifer is underlain by approximately 20 ft of low-permeability silts and clays.

As discussed above, based on the findings of the RI and RI Addendum, a Proposed Plan was announced in December 1997 for remediation of Site 26 using air sparging and soil vapor extraction. A removal action was conducted in February 1998 to remove the leach tank. The ROD issued in September 1998 specified that the remedial method for this site include AS/SVE. The objective for the AS/SVE system is to remediate groundwater in the shallow aquifer that has been impacted by chlorinated hydrocarbons (primarily TCE and *cis*-1,2-DCE). Remediation will be accomplished by sparged (injected) air volatilizing VOCs in the saturated zone, and capture of volatilized VOCs using soil vapor extraction. Residual VOCs remaining after AS/SVE treatment reaches its physically limiting endpoint would be permitted to naturally attenuate in situ under anaerobic conditions. Removal of the suspected source area would eliminate the potential for direct exposure.

According to the quarterly System Operation Reports, the cleanup goal for Site 26 is to reduce the TCE/DCE concentrations to New Jersey Groundwater Quality Standards (GWQS); the GWQS cited for TCE and *cis*-1,2-DCE in the quarterly reports is 1 μg/L and 10 μg/L, respectively (FWEC, 2003c).[1] Contaminant concentrations in groundwater are to be monitored and reported quarterly during active operation of the AS/SVE system. As extracted VOCs reach asymptotic levels, the AS/SVE system may be operated more intermittently, while the plume is monitored for rebound.[2] Intermittent operation of the system, and/or operating it at varying flowrates, is expected to minimize the magnitude and duration of any rebound effects (FWEC, 2003c). The Site 26 AS/SVE system will continue to operate (at least intermittently) until extracted VOCs reach asymptotic levels with no significant rebound effects and groundwater concentrations are below GWQS. If concentrations in groundwater are still above GWQS at that time, and it is no longer cost-effective to operate the AS/SVE system, fate and transport modeling is to be conducted to evaluate the potential for the remainder of the contaminant plume to naturally attenuate before reaching any downgradient receptors. In this case, the Navy may propose monitored natural attenuation (MNA) of the residual compounds.

Based on a review of the site conceptual model, RA Objectives and remedial strategy, Battelle has not identified a need to change the RA Objectives or remediation strategy, and specifically that natural

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[1] The ROD for Site 26 establishes the remediation goal for *cis*-1,2-DCE as 70 μg/L, rather than the value of 10 μg/L indicated in the quarterly reports. This ROD-specified remediation goal is consistent with the interim specific criterion published by NJDEP in 1997, which supercedes the 10 μg/L GWQS that was published in N.J.A.C. 7:9-6 (NJDEP specifies that when the Department believes that existing GWQS are no longer appropriate in light of current scientific information, interim specific criteria may be developed to replace the existing criteria).

[2] Rebound refers to situations where contaminant concentrations in groundwater (and/or the extracted vapors) increase after the remedial system has been inactive (i.e., shut down) for an extended period of time. Rebound occurs due to diffusion-limited reactions, and the presence of residual (immobile) contaminant and stagnation zones.

attenuation be considered as a follow-up remedial technology when VOC extraction rates reach asymptotic levels but groundwater concentrations remain above GWQS.

4.2 Evaluate Remedial Action Effectiveness

In accordance with postconstruction submittal requirements, quarterly System Operation Reports are prepared to summarize system operation activities, system performance monitoring results and groundwater sampling results. As part of this task, EFANE provided the following System Operation Reports for review:

- ***System Operation Report for Air Sparging/Soil Vapor Extraction Second Quarter of Operation July through October 2001.*** This report discusses the operation of the system for the second full quarter from July 20 to October 31, 2001 (FWEC, 2002a).

- ***System Operation Report for Air Sparging/Soil Vapor Extraction November 2001 through January 2002.*** This report discusses the operation of the system for the third full quarter from November 1, 2001 to January 31, 2002 (FWEC, 2002b).

- ***System Operation Report for Air Sparging/Soil Vapor Extraction February 2002 through April 2002.*** This report discusses the operation of the system for the fourth full quarter from February 1 to April 30, 2002 (FWEC, 2002c).

- ***System Operation Report for Air Sparging/Soil Vapor Extraction May 2002 through July 2002.*** This report discusses the operation of the system for the fifth full quarter from May 1 to July 31, 2002 (FWEC, 2002d).

- ***System Operation Report for Air Sparging/Soil Vapor Extraction August 2002 through October 2002.*** This report discusses the operation of the system for the sixth full quarter from August 1 to October 31, 2002 (FWEC, 2003a).

- ***System Operation Report for Air Sparging/Soil Vapor Extraction November 2002 through January 2003.*** This report discusses the operation of the system for the seventh full quarter from November 1, 2002 through January 31, 2003 (FWEC, 2003b).

- ***System Operation Report for Air Sparging/Soil Vapor Extraction February 2003 through April 2003.*** This report discusses the operation of the system for the eighth full quarter from February 1 through April 30, 2003 (FWEC, 2003c).

Mass Recovery – According to the System Operation Reports, during the operation of the AS/SVE system, influent and effluent air samples are collected and analyzed for VOCs to evaluate the extraction of TCE and DCE from the groundwater and the loading of VOCs on the vapor-phase granular activated carbon (GAC) units. The estimated TCE and DCE mass recovery rates over the eight quarters of operation, as reported in the above System Operation Reports, is summarized below. These calculations indicate that a total of 1.08 lb of TCE and 0.59 lb of DCE (total of 1.7 lb) has been removed since the start of treatment.

As indicated on Figure 7, the contaminant mass recovery rate has dropped significantly since initial AS/SVE system startup. In fact, the mass extraction rate reported for the Eighth Quarter was zero (FWEC, 2003c). However, the *System Operation Report for Air Sparging/Soil Vapor Extraction February 2003 through April 2003* (FWEC, 2003c) indicates that the influent air is diluted with soil gas from the cleaner areas, and this reported extraction rate does not mean that the AS/SVE system is not effective in remediating the VOCs from the groundwater; the concentrations of soil gas extracted from the

SVE wells in more concentrated areas is diluted by soil gas throughout the system prior to obtaining the precarbon air sample (FWEC, 2003c).

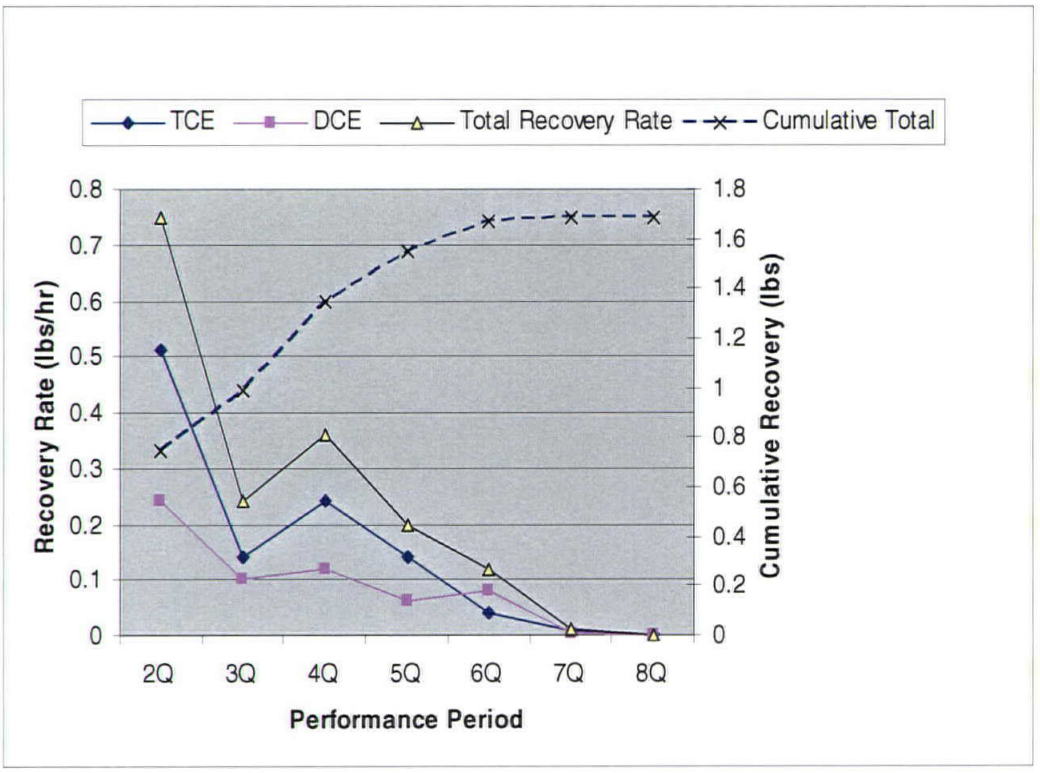


Figure 7. Site 26 – VOC Mass Recovery Rate

Reduction in Groundwater Concentrations – According to the Eighth Quarterly Systems Operation Report, the Eighth Quarter data indicated that both TCE and DCE concentrations still show a decreasing trend since the start of treatment (FWEC, 2003c). The Eighth Quarter data indicated that some well samples exhibited concentrations of TCE and DCE above the GWQS. The majority of these wells were shown to have exceeded the GWQS for TCE and/or DCE during past sampling events, and the Eighth Quarter data indicates that TCE and DCE concentrations appear to be within the range of concentrations that have been exhibited during the previous quarterly performance sampling event. Further, the majority of concentrations are below the concentrations that were detected during earlier sampling events.

- During the Eighth Quarter, TCE was detected at concentrations above the GWQS of 1 µg/L in five wells (MW26-05, -06, -08, -13, and 26AS-01). The current TCE exceedances ranged from 1.1 to 56 µg/L. The Seventh Quarter TCE exceedances were of similar magnitude and ranged from 1.9 to 48 µg/L. At well MW26-01, where the highest TCE concentrations had been historically detected, TCE was not detected during the Eighth Quarter event.

- *Cis*-1,2-DCE was detected at only one well (26AS-01) at a concentration above the current interim specific GWQS of 70 µg/L. The concentration at this well was 200 µg/L. PCE was only detected in well MW26-18. There appears to be minor fluctuation in the PCE concentrations detected in MW26-18 over the sampling history. A consistent trend of increase or decrease has not been established with the limited data; however, the data indicate that the PCE plume may be relatively stable in the area of MW26-18. Based upon the analytical results of the groundwater samples obtained from the PCE plume sentinel wells (MW26-14 through MW26-17), the PCE plume does not appear to be migrating.

- Data from the downgradient wells (southwest of MW26-10) indicate that the TCE and DCE contamination has not migrated past the downgradient boundary of the original plume.

It also was noted that the groundwater analytical results from the Sixth Quarter (October 2002) indicated a significant increase in the concentrations of TCE and DCE. The most significant increase in TCE and DCE concentrations from the Fourth Quarter to the Sixth Quarter was detected in 26AS-1. The Sixth Quarter results of samples collected from 26AS-1 indicated elevated concentrations of both TCE (1,500 µg/L) and DCE (1,200 µg/L), which are higher than the concentrations reported at the start of remediation. Data from Fourth Quarter analysis indicated concentrations of TCE at 65 µg/L and DCE at 53 µg/L in well 26AS-1. Well 26AS-1 was originally installed as an air sparging well during the pilot study. Well 26AS-1 appears to be downgradient of the suspected TCE and DCE source. The cause of the increase was not determined, although it was postulated that rebounding of groundwater levels combined with a significant amount of rainfall during the Sixth Quarter may have had a "rinsing" effect on the contaminated soil under the southern portion of Building GB-01; this groundwater rinsing effect on the contaminated soil would act to liberate contamination trapped in the soil at or near the source (FWEC, 2003a). The downgradient migration of this groundwater may have resulted in creating the rebound of TCE and DCE concentrations near well 26AS-1. A similar, although delayed, spike in concentration was observed at well MW26-01, which is also immediately downgradient of the former source location.

The results of the quarterly groundwater monitoring at key plume monitoring wells discussed above are presented on Figures 8 through 12. As indicated on these figures, with the exception of well 26AS-1, the concentrations of VOCs in wells where certain VOCs have been detected at levels exceeding GWQS have generally declined since the start of active remediation. Figure 13 presents the approximate concentration profile along the center of the plume (1) during the predesign study, and (2) after eight quarters of remediation. As indicated in Figure 12, there has been a significant decrease in TCE concentrations within the core plume area (which extends approximately 350 ft downgradient of the source) where AS/SVE was conducted.

In addition, Figures 14 and 15 present the areal extent and concentrations for key constituents in the early stage of remediation (end of First Quarter) and at the end of the latest quarter of operations (Eighth Quarter), respectively. The plume limits are defined based on concentrations above the New Jersey GWQS for TCE, PCE and *cis*-1,2-DCE. To remain consistent with existing figures and information reported in the quarterly system operation reports, Figures 14 and 15 also include the limits of the *cis*-1,2-DCE plume based on the original New Jersey GWQS of 10 µg/L. A comparison of the plume limits presented on each of these figures highlights the reduction in the size of the plume and plume concentrations over the remedial action operation period.

4.3 Evaluate Cost Efficiency

A review of the system operations costs (Tetra Tech FW, 2004) was also conducted as part of this task. The information provided included the following monthly cost elements for the period of January 2002 to January 2004 (a copy of this cost summary is provided in Attachment A):

- Direct Costs (combined costs between Site 16F and Site 26)
  - Labor
  - Equipment
  - ODCs (e.g., temporary utilities, office supplies, phones, etc.)
  - Materials (e.g., PPE, filters, sampling supplies, etc.)

- Subcontract Costs
  - Quarterly groundwater analysis

- Monthly air analysis
- Vapor-phase carbon supply/disposal.

Over the period of operation that the cost information was provided, the monthly operations and monitoring cost for the Site 26 AS/SVE system, assuming that the direct costs are split evenly between the Site 16F and Site 26 operations, is approximately $11,300. The primary contributor to the monthly cost is labor, which represents approximately 75% of the monthly costs.

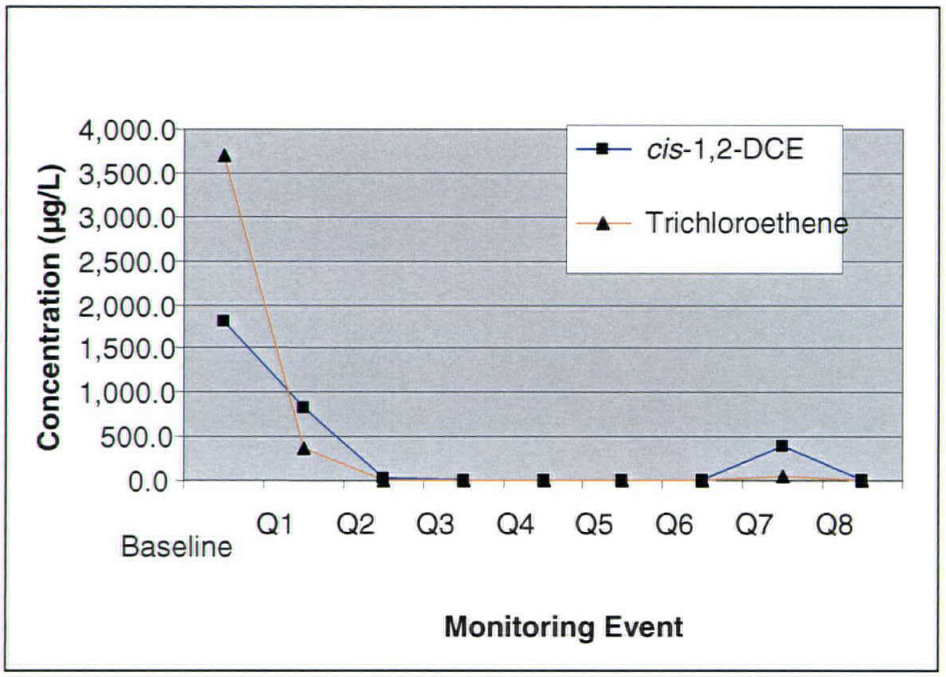


Figure 8. VOC Concentrations in Well MW26-01

(Note that during RI activities, TCE in well MW26-01 was detected at concentrations up to 9,300 µg/L. The change in concentration between the RI/predesign studies and the baseline event is likely a result of the leach tank (source) removal.)

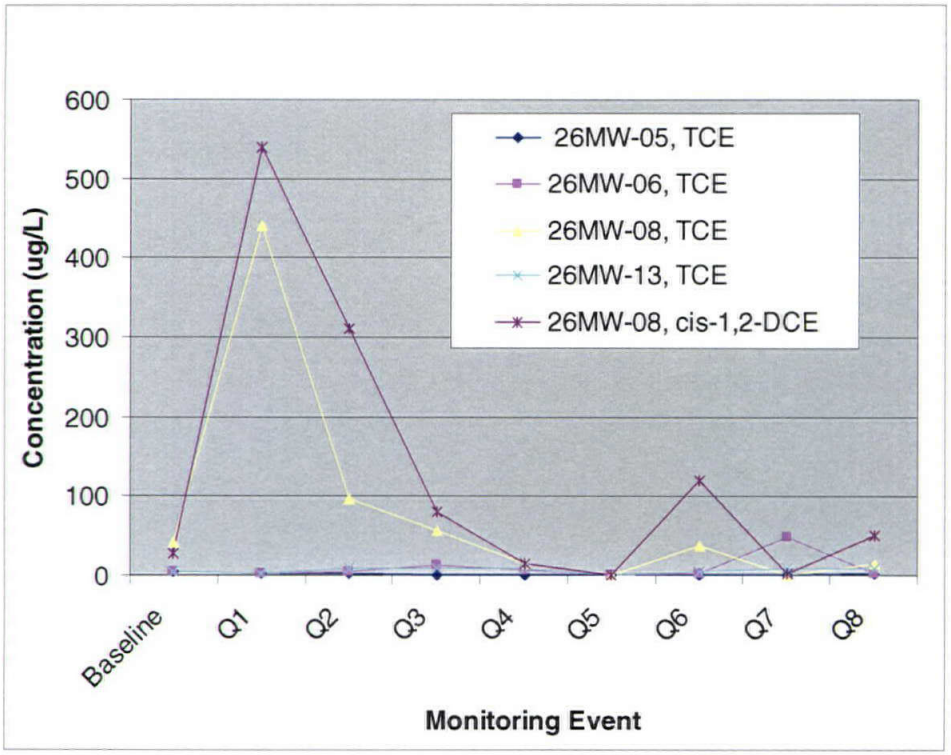


Figure 9. Monitoring Wells Having TCE and *cis*-1,2-DCE Concentrations Exceeding GWQS (1 µg/L and 10 µg/L, respectively) during 8th Quarter Monitoring

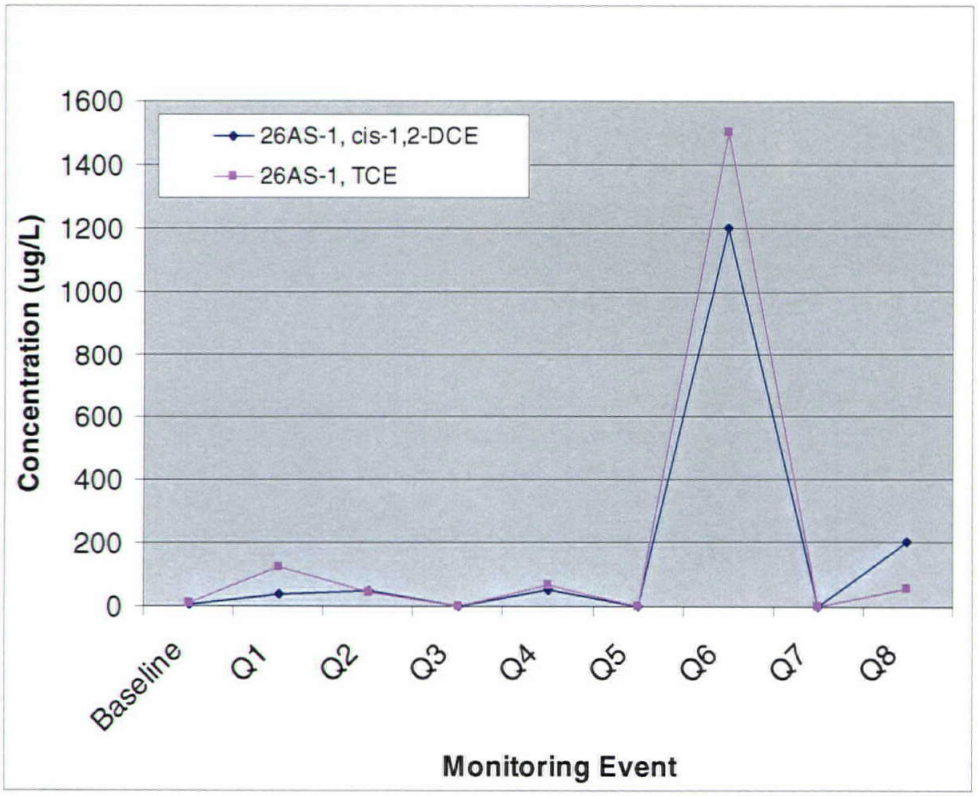


Figure 10. TCE and *cis*-1,2-DCE Concentrations Exceeding GWQS in Well 26AS-1

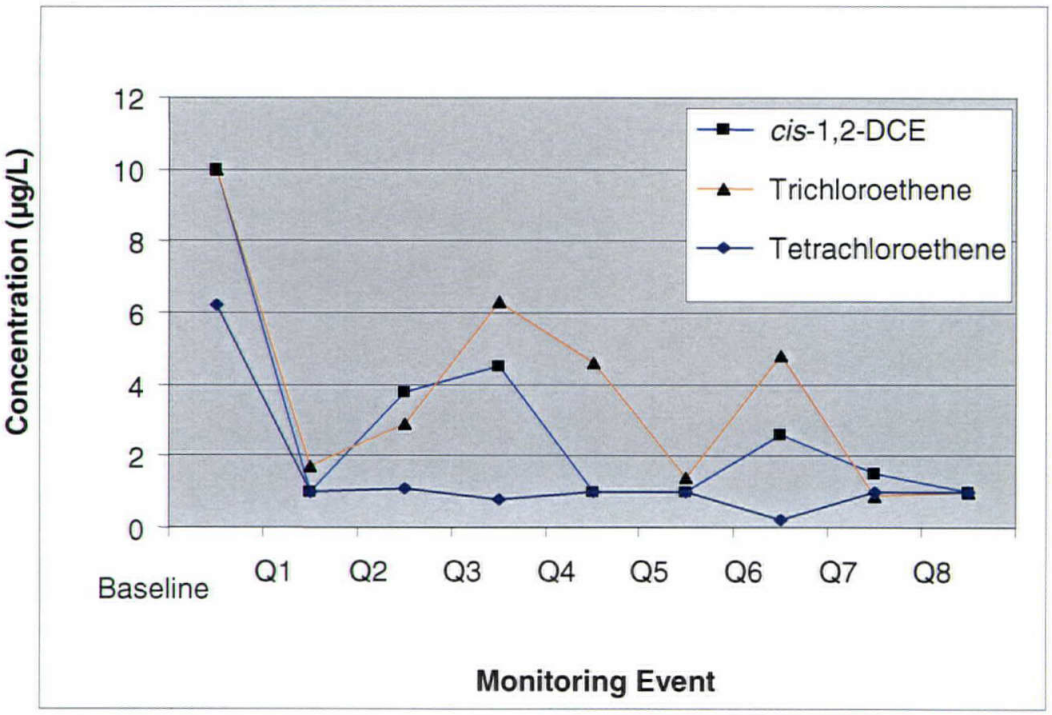


Figure 11. VOC Concentrations in Downgradient Well MW26-10

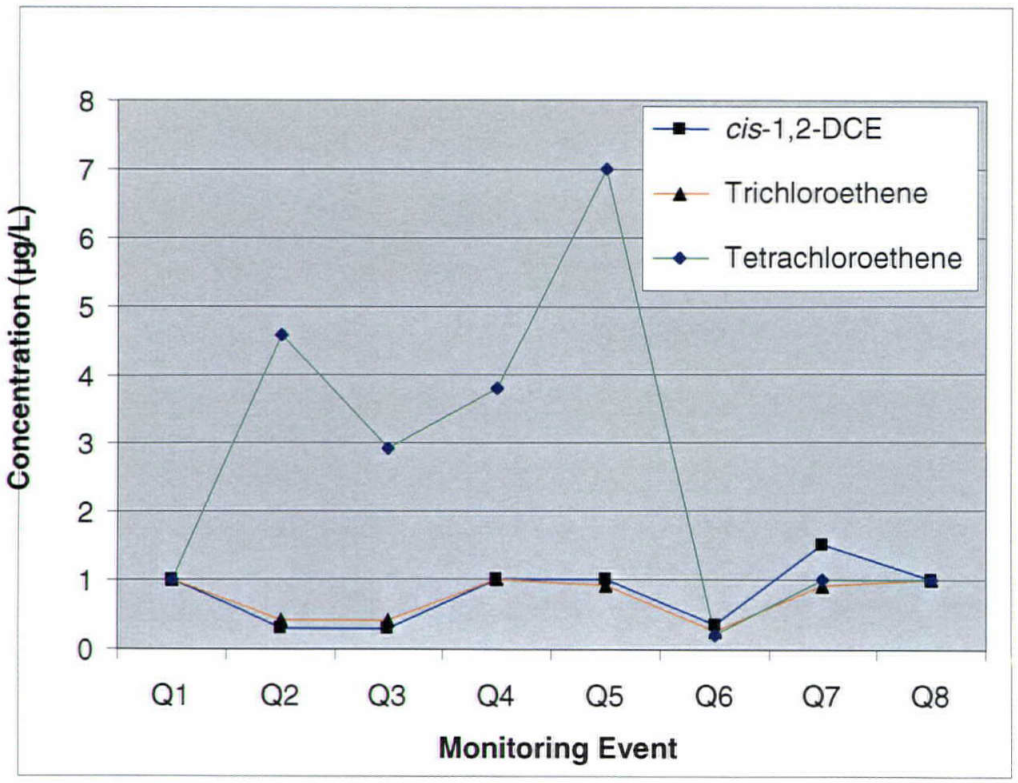


Figure 12. VOC Concentrations in Well MW26-18

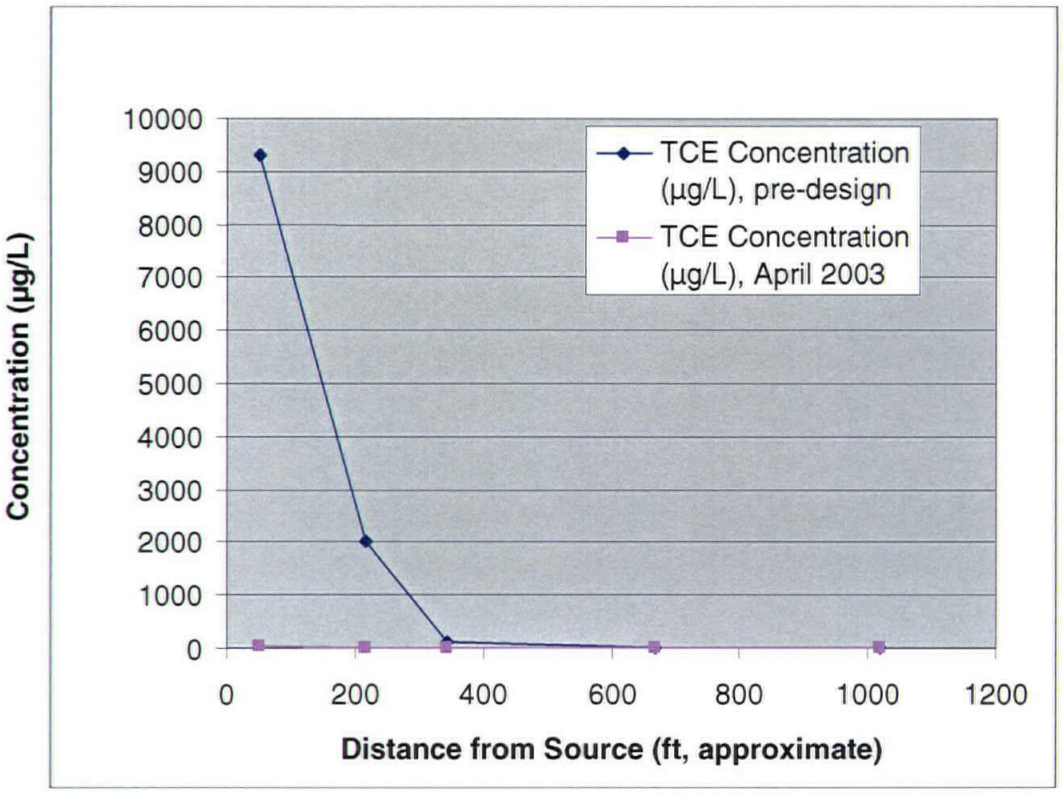


Figure 13. TCE Concentration with Distance from Source

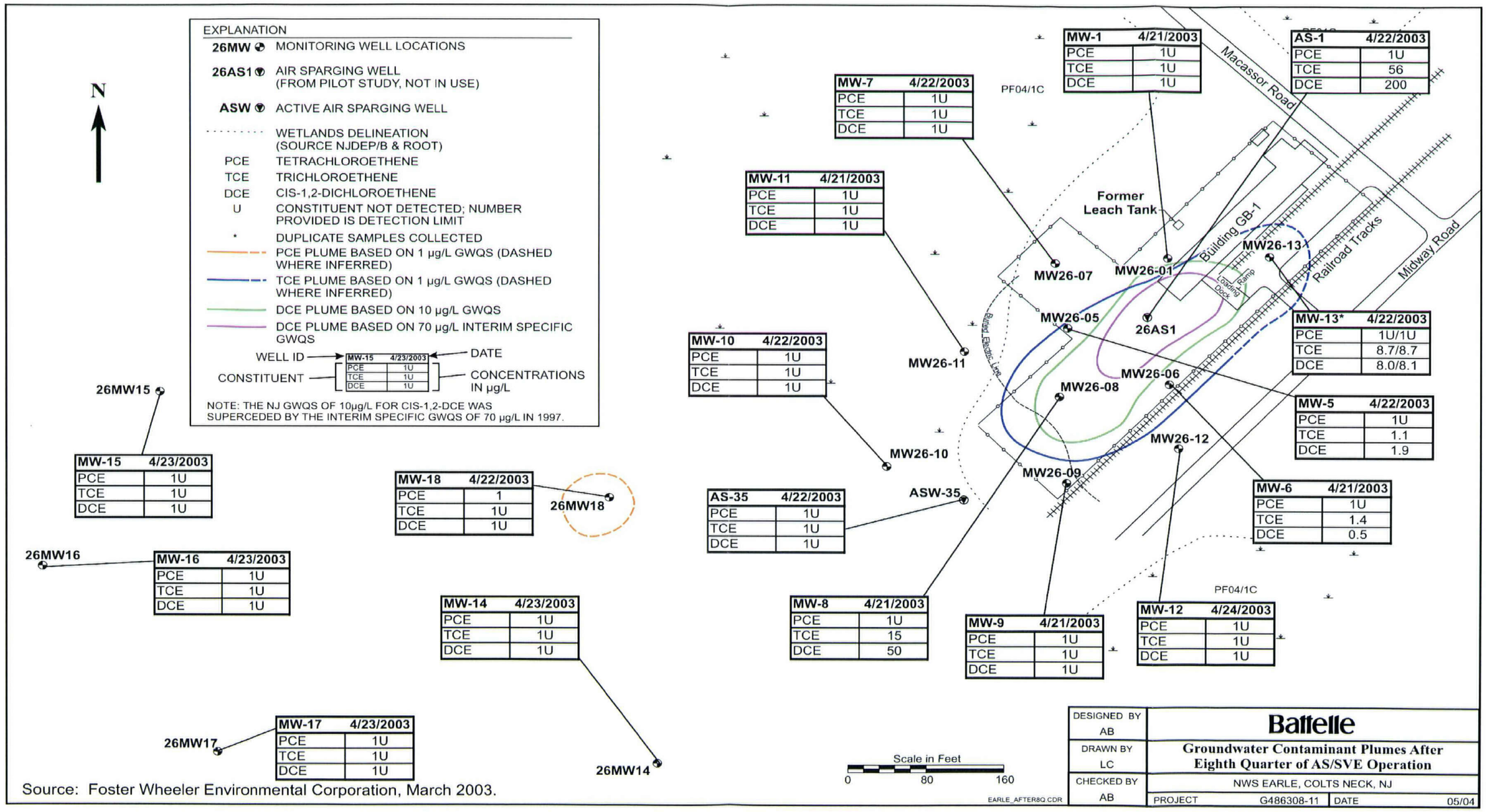
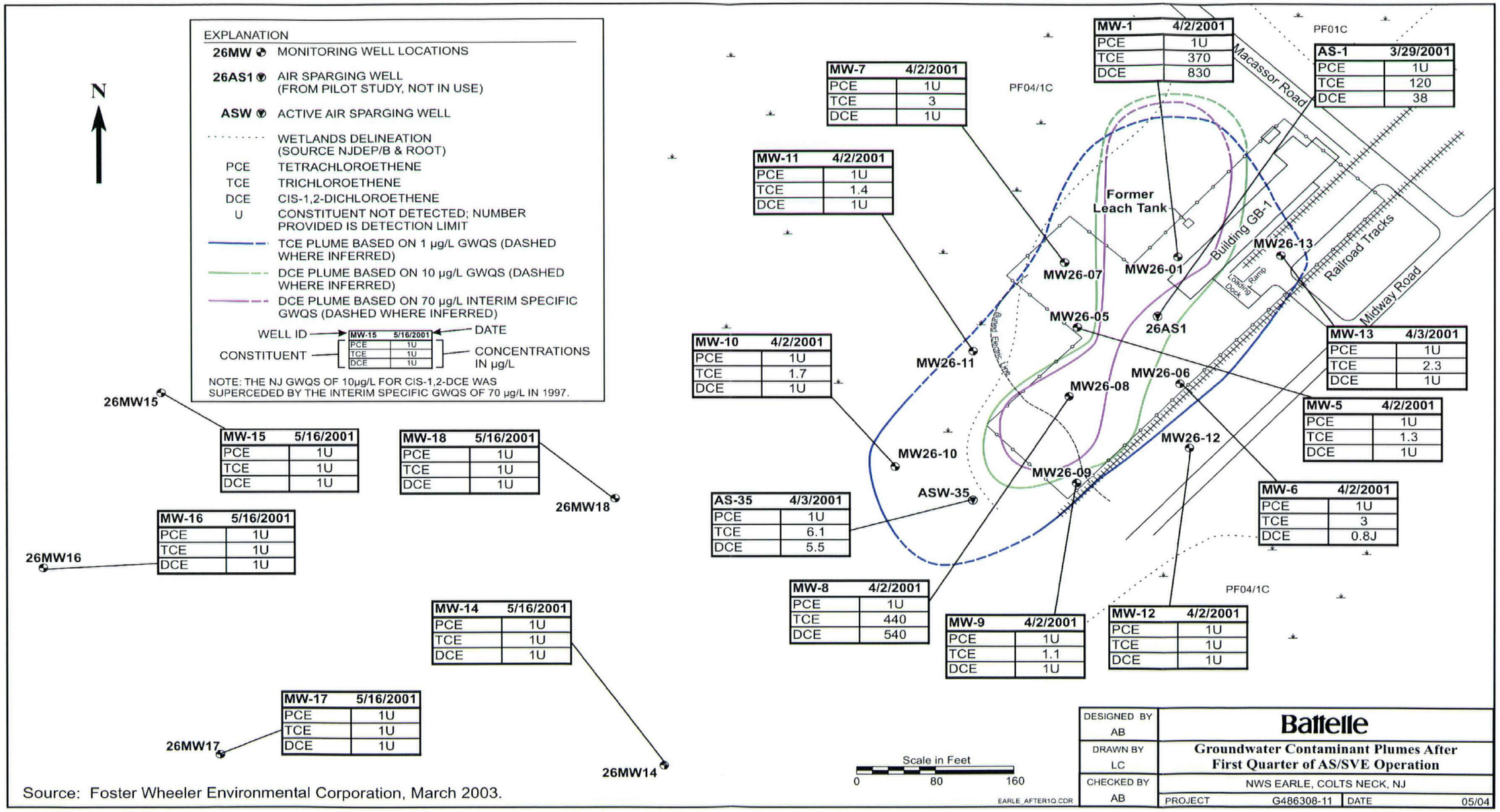


Figure 14. Groundwater Contaminant Plumes After First Quarter of AS/SVE Operation



Source: Foster Wheeler Environmental Corporation, March 2003.

Figure 15. Groundwater Contaminant Plumes After Eighth Quarter of AS/SVE System Operation

Cost and VOC mass extraction data are both available for the period of February 2002 through April 2003 (i.e., Fourth Quarter of operations to the Eighth Quarter). The quarterly mass extraction rate and operation costs are presented on Figure 16 (for the Second and Third Quarters the average monthly costs were assumed to represent the costs during these two operating periods). As indicated on Figure 16, the operational cost has remained relatively constant over the eight quarters of operation, whereas the mass extraction rate has declined.

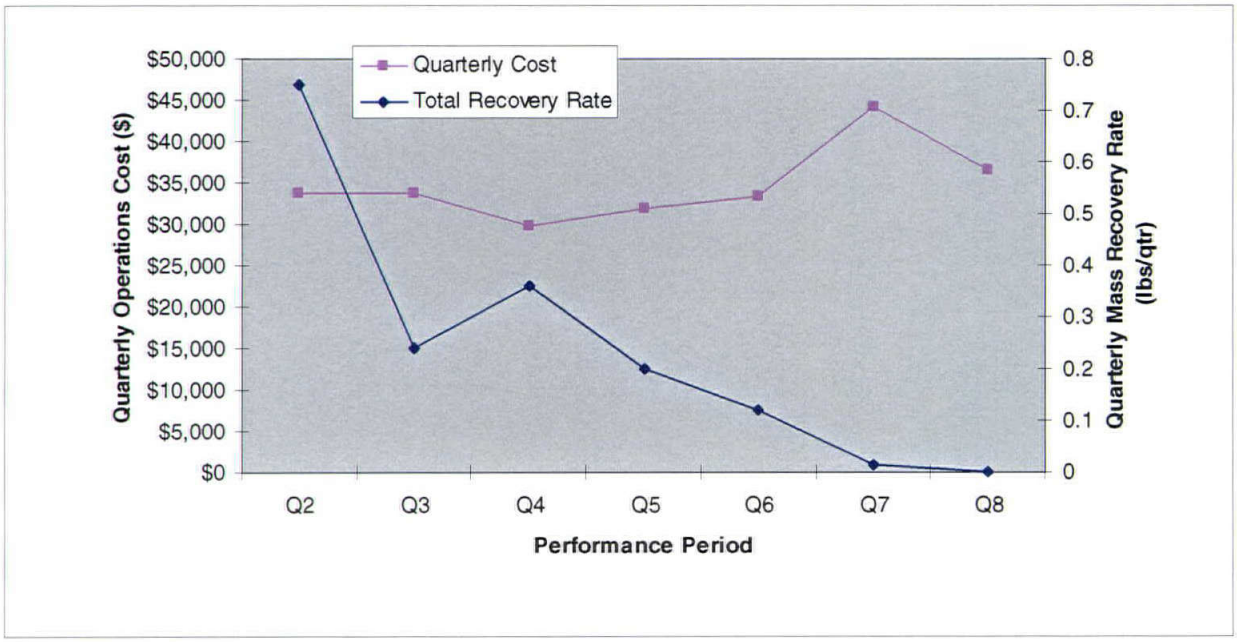


Figure 16. Approximate Quarterly Costs versus Quarterly Mass Recovery Rates

Based on the quarterly mass extraction rates discussed above (see Figure 7) and the quarterly operations costs, it is estimated that the cost per pound of VOC mass extracted has increased by a factor of over 80 between the Second Quarter and Eighth Quarter of operation (from approximately $45K/lb in the Second Quarter to approximately $3,500K/lb in the Seventh Quarter; mass recovery was not measurable in the Eighth Quarter).

The cumulative costs incurred versus cumulative mass removed during the Second through Eighth Quarter of operation are presented on Figure 17. The near vertical portion of the curve presented on Figure 17 illustrates that, based on the cost and mass recovery data provided for this operational period, the cost-effectiveness of the system has declined significantly due to lower mass removal rates at a relatively constant operating cost.

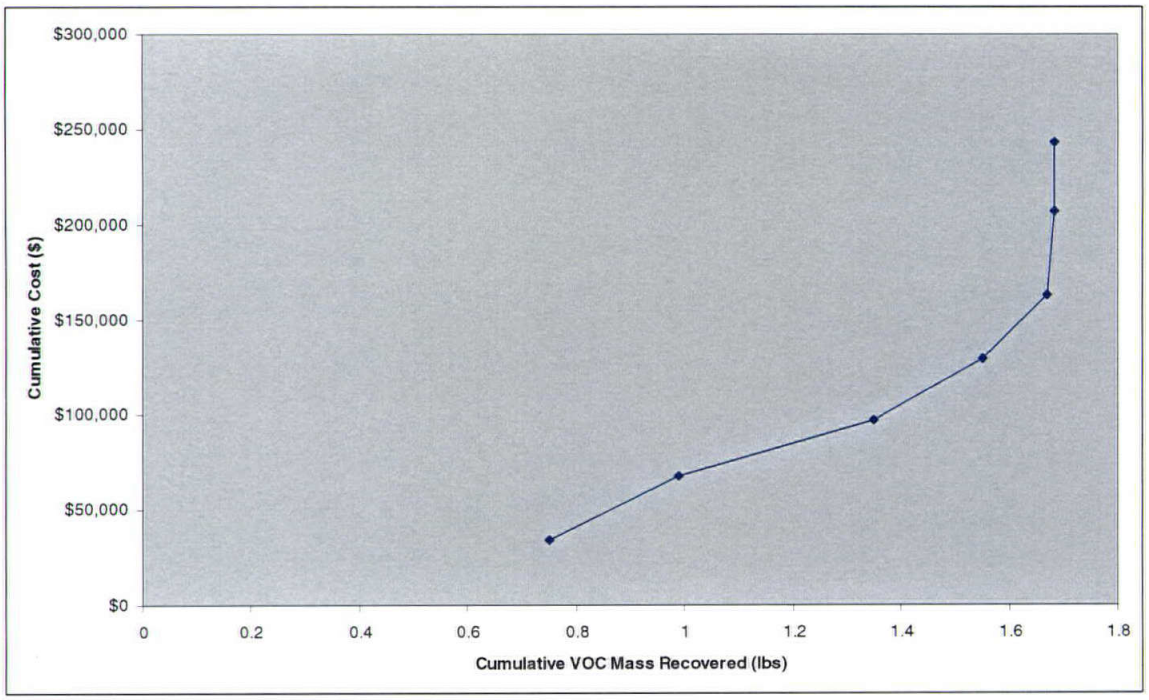


Figure 17. Cumulative Costs versus Cumulative Mass Recovered, Second Quarter through Eighth Quarter

5.0 CONCLUSIONS AND RECOMMENDATIONS

Source removal and operation of the AS/SVE system has been successful in significantly reducing VOC concentrations in groundwater in the source area:

- The latest groundwater sampling detected TCE above the GWQS of 1 μg/L in five wells; the MCL set under the Safe Drinking Water Act (5 μg/L) was exceeded in only three wells.

- PCE was detected in the latest groundwater sampling at only one well at a concentration equal to the GWQS (1 μg/L).

- *cis*-1,2-DCE was detected above the current interim GWQS and the MCL set under the Safe Drinking Water Act (both 70 μg/L) in only one well.

Based on the available monitoring and cost data for the Site 26 remediation program, operation of the AS/SVE system no longer represents the most cost-effective method for achieving further reductions in groundwater concentrations necessary to achieve the RA Objectives for Site 26 in a reasonable time frame. In particular, the latest available monitoring report indicates that VOC mass recovery is no longer measurable and the cost per pound of VOC mass recovered has increased significantly. In addition, groundwater monitoring data indicate that concentrations are generally reaching asymptotic levels. Therefore, an alternative approach should be pursued. Specifically, as specified as part of the remedial alternative selected in the ROD, the Navy may propose MNA for the remainder of the contaminant plume remaining above GWQS once extracted VOCs reach asymptotic levels.

This conclusion and recommendation is based on the following observations:

- As indicated in the latest mass extraction estimates (see Figure 7), mass removal by the AS/SVE system has reached an asymptotic level; because the latest monitoring indicates that no mass recovery was measured, the current system operations are no longer effective at removing measurable VOC mass.

- Based on data for the Second through Eighth Quarters of operation, the cost-effectiveness of the system has declined significantly due to lower mass removal rates at a relatively constant operating cost (see Figures 16 and 17). Between January 2001 and April 2003, the cost per pound of mass extracted has increased by a factor of over 80.

- Shallow groundwater at Site 26 is not currently used as a source of water, and it is not reasonably likely to be used for a water source in the future. The primary pathway for potential exposure to VOCs in shallow groundwater would be via transport and discharge to Mingamahone Brook. Prior sampling did not detect VOCs in Mingamahone Brook. Therefore, passive remedial measures (i.e., MNA) are appropriate to complete the remedial action for groundwater at Site 26.

The following steps are recommended to further develop the optimization plan for Site 26:

1. Shut down AS/SVE system and allow groundwater mounding caused by AS operation to subside and groundwater flow conditions to return to unstressed conditions.

2. Confirm steady-state groundwater flow pattern.

3. Identify key existing monitoring wells and locations for new monitoring wells, if any, to fill data gaps based on unstressed groundwater flow patterns.

4. Monitor groundwater quality quarterly in key monitoring wells for evidence of rebound or attenuation. Data collection should include parameters for assessing in situ anaerobic degradation potential (e.g., dissolved oxygen, redox potential, sulfate, nitrate, oxygen, iron, manganese) (DON, 1998).

5. Based on four quarters of post-shutdown monitoring, demonstrate plume stability.

6. Apply for a New Jersey groundwater classification exception area (see Attachment B for NJDEP requirements).

7. Develop a contingency action plan in the event that post-shutdown monitoring does not show continued reductions in VOC concentrations. Consideration should be given to including enhanced biotechnology as part of this contingency plan (see Attachment C for a preliminary evaluation of the HRC® technology for Site 26).

In summary, the operation of the AS/SVE system no longer represents the most cost-effective method for achieving further reductions in groundwater concentrations at Site 26 in a timely manner. An alternative approach should be considered based on data collected after the AS/SVE system has been shut down and the aquifer has returned to unstressed conditions. With the estimated labor costs currently contributing approximately 75% of the monthly system operations cost, an alternative requiring lower labor requirements should be considered to reduce the overall operations cost for Site 26. If it is determined that rebound does not occur, then in accordance with the remedial strategy specified in the ROD, monitored natural attenuation should be pursued as the primary alternative approach, in conjunction with a CEA. In the event that rebound does occur, or extended MNA monitoring does not demonstrate continued reduction in VOC concentrations, then MNA may be enhanced by the injection of HRC® or similar substrate. Both the MNA and enhanced MNA alternatives would eliminate the need for labor associated with AS/SVE system operations; O&M costs for these alternatives would be primarily associated with sample collection, analytical and reporting activities. Further reduction in long-term monitoring costs may also be achieved by the use of diffusion samplers for groundwater sample collection for VOC analysis.

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ATTACHMENT A

Site 16F and Site 26 O&M Costs
January 2002 through January 2004

CTO 49 Spreadsheet for Bioslurper & AS/SVE Monthly Operating Costs

	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02
Labor	$14,135.43	$12,246.66	$21,403.11	$10,939.21	$18,133.61	$16,007.24	$7,419.74	$11,464.94	$23,163.48
Equip.	$0.00	$2,620.86	$373.65	$1,013 43	$384.25	$373.65	$0.00	$0.00	$185.50
Includes air monitors, misc. tools, Geoguard eqip., etc.									
ODCs	$1,574.22	$937.60	$3,204.34	$1,326.53	$1,269.31	$1,149 97	$937.97	$908.23	$1,271.56
Includes temporary utilities, office supplies, postage, reproduction, phones, etc.									
Material	$0.00	$989.80	$0.00	$0.00	$396 45	$80.06	$5.15	$50.05	$590 36
Includes PPE, filters, sampling supplies, etc.									
Subcontracts									
Environmental Chemical Corp.									
Site 16F - Monthly water analysis	$0.00	$4,050.00	$1,405.00	$0.00	$0.00	$0.00	$0.00	$580.00	$0.00
Chem-Trade									
Site 16F - Vapor-phase carbon supply/disposal	$1,775 00	$1,345.00	$0.00	$1,345.00	$1,345.00	$1,345.00	$1,345.00	$1,345.00	$2,690.00
*** Apollo Analytical**									
Site 16F - monthly air analysis	$955 30	$722.00	$640.00	$0.00	$0.00	$3,060.00	$0.00	$0.00	$0.00
Site 26 - monthly air analysis	$955.30	$722.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Lorco Petroleum									
Site 16F - Oil & oily water recycle/disposal	$0 00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$276.25
ChemTech									
Site 26 - Quarterly groundwater analysis	$0.00	$0.00	$0 00	$0.00	$1,800 00	$2,067.50	$0.00	$0.00	$1,710.00
Barnebey Sutcliff									
Site 16F - Carbon & clay supply/disposal	$0.00	$0.00	$0.00	$4,684.00	$0.00	$0.00	$3,406.00	$0.00	$0.00
Site 26 - Vapor-phase carbon supply/disposal	$0.00	$0.00	$0 00	$0 00	$0.00	$0.00	$2,754.00	$0.00	$0.00
*** Air Toxics**									
Site 16F - Monthly air analysis	$0.00	$0.00	$2,265.00	$2,265.00	$2,261.25	$2,261.25	$1,665.00	$1,665.00	$1,665 00
Site 26 - Monthly air analysis	$0.00	$0.00	$720.00	$720.00	$720.00	$720.00	$720.00	$720.00	$720.00
Simalabs									
Site 16F - Monthly water analysis	$0.00	$0.00	$0.00	$0.00	$2,810.00	$1,240.00	$0.00	$0.00	$1,985.00
Danka Office Imaging									
Site 16F - Copier rental	$0.00	$0.00	$0.00	$340.10	$0 00	$0.00	$0 00	$0 00	$0.00
Analytical Labs									
Site 16F - Monthly water analysis	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0 00	$0.00
Subcontract Total	$3,685.60	$6,839.00	$5,030.00	$9,354.10	$8,936.25	$10,693.75	$9,890.00	$4,310.00	$9,046.25
Totals	$19,395.25	$23,633.92	$30,011.10	$22,633.27	$29,119 87	$28,304.67	$18,252.86	$16,733.22	$34,257.15

* Costs per month are approximate for Site 16F and Site 26. Costs were actually invoiced on a quarterly basis.

CTO 49 Spreadsheet for Bioslurper & AS/SVE Monthly Operating Costs

	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03
Labor	$19,482.26	$16,685.57	$22,033.80	$23,876.77	$15,525.55	$26,025.77	$14,640.97	$11,650.09	$18,481.48	$13,127 27
Equip.	$0.00	$1,408 25	$2,570 98	$848.00	$0.00	$0.00	$1,196.25	$777.08	$0.00	$1,152 75
Includes air monitors, misc. tools, Geoguard eqip., etc.										
ODCs	$725.68	$1,127.85	$1,666.50	$2,771.92	$2,315.83	$3,522.90	$1,944.82	$1,677.92	$1,526.25	$1,664.74
Includes temporary utilities, office supplies, postage, reproduction, phones, etc.										
Material	$1,240.72	$786.23	$6,786.02	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0 00
Includes PPE, filters, sampling supplies, etc.										
Subcontracts										
Environmental Chemical Corp.										
Site 16F - Monthly water analysis	$0.00	$0.00	$0.00	$0.00	$0 00	$0.00	$0 00	$0.00	$0.00	$0.00
Chem-Trade										
Site 16F - Vapor-phase carbon supply/disposal	$0.00	$1,345.00	$0.00	$0.00	$1,447.24	$0.00	$1,447.24	$0.00	$0.00	$2,894.48
*** Apollo Analytical**										
Site 16F - monthly air analysis	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0 00	$0.00	$0.00	$0.00
Site 26 - monthly air analysis	$0.00	$0 00	$0.00	$0.00	$0.00	$0 00	$0.00	$0.00	$0.00	$0 00
Lorco Petroleum										
Site 16F - Oil & oily water recycle/disposal	$0.00	$0 00	$0.00	$0.00	$0.00	$1,089.65	$0.00	$0.00	$0 00	$0.00
ChemTech										
Site 26 - Quarterly groundwater analysis	$0.00	$0 00	$1,800 00	$0.00	$0.00	$1,710 00	$0.00	$1,710.00	$0.00	$0.00
Barnebey Sutcliff										
Site 16F - Carbon & clay supply/disposal	$4,394.00	$3,833.00	$0.00	$4,109.00	$0 00	$2,343.00	$3,822.00	$0.00	$0.00	$3,406.00
Site 26 - Vapor-phase carbon supply/disposal	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0 00	$0.00
*** Air Toxics**										
Site 16F - Monthly air analysis	$1,665.00	$2,025.00	$2,025.00	$2,025.00	$2,535.00	$2,535.00	$2,025.00	$2,025.00	$1,560.00	$645.00
Site 26 - Monthly air analysis	$720.00	$720.00	$720.00	$720.00	$720.00	$720.00	$720.00	$720.00	$720.00	$0.00
Simalabs										
Site 16F - Monthly water analysis	$0.00	$580.00	$0.00	$0 00	$0.00	$0.00	$0.00	$0 00	$0.00	$0.00
Danka Office Imaging										
Site 16F - Copier rental	$0.00	$0.00	$0.00	$0.00	$0 00	$0.00	$0.00	$0.00	$0.00	$0.00
Analytical Labs										
Site 16F - Monthly water analysis	$0.00	$680.00	$260.00	$260.00	$260.00	$0 00	$260.00	$470.00	$0 00	$260.00
Subcontract Total	$6,779 00	$9,183.00	$4,805 00	$7,114.00	$4,962.24	$8,397.65	$8,274.24	$4,925 00	$2,280.00	$7,205.48
Totals	$28,227.66	$29,190.90	$37,862.30	$34,610.69	$22,803 62	$37,946.32	$26,056.28	$19,030.09	$22,287.73	$23,150.24

* Costs per month are approximate for Site 16F and Site 26. Costs were actually invoiced on a quarterly basis.

CTO 49 Spreadsheet for Bioslurper & AS/SVE Monthly Operating Costs

	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03	Jan-04	
Labor	$15,965.17	$12,858.28	$20,184 62	$15,820.46	$16,117 67	$21,808 55	
Equip. Includes air monitors, misc. tools, Geoguard eqip., etc.	$0 00	$0.00	$0.00	$0.00	$1,537 00	$0.00	
ODCs Includes temporary utilities, office supplies, postage, reproduction, phones, etc.	$1,896.01	$1,967.95	$1,773 74	$1,937.50	$1,879.42	$2,251.66	
Material Includes PPE, filters, sampling supplies, etc.	$0.00	$0.00	$0 00	$0.00	$532 50	$0 00	
Subcontracts							
Environmental Chemical Corp.							
Site 16F - Monthly water analysis	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Chem-Trade							
Site 16F - Vapor-phase carbon supply/disposal	$1,447.24	$1,447.24	$1,447 24	$1,447.24	$0.00	$0.00	
*** Apollo Analytical**							
Site 16F - monthly air analysis	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Site 26 - monthly air analysis	$0.00	$0.00	$0.00	$0.00	$0.00	$0 00	
Lorco Petroleum							
Site 16F - Oil & oily water recycle/disposal	$0.00	$0.00	$0.00	$0 00	$0.00	$0.00	
ChemTech							
Site 26 - Quarterly groundwater analysis	$0.00	$720.00	$0.00	$0.00	$1,710.00	$0 00	
Barnebey Sutcliff							
Site 16F - Carbon & clay supply/disposal	$0.00	$0.00	$0.00	$0.00	$0.00	$3,385.00	
Site 26 - Vapor-phase carbon supply/disposal	$0 00	$0.00	$0.00	$0.00	$0.00	$5,539.56	Inv. Received but not paid yet
*** Air Toxics**							
Site 16F - Monthly air analysis	$1,665.00	$1,665.00	$1,665.00	$2,025.00	$1,800.00	$0.00	
Site 26 - Monthly air analysis	$720.00	$720.00	$720.00	$720.00	$0.00	$0 00	
Simalabs							
Site 16F - Monthly water analysis	$0.00	$0 00	$0.00	$0.00	$0.00	$0 00	
Danka Office Imaging							
Site 16F - Copier rental	$0 00	$0.00	$0.00	$0.00	$0.00	$0.00	
Analytical Labs							
Site 16F - Monthly water analysis	$260.00	$835.00	$470.00	$0.00	$130.00	$0.00	
Subcontract Total	$4,092.24	$5,387.24	$4,302.24	$4,192.24	$3,640.00	$8,924.56	
Totals	$21,953.42	$20,213.47	$26,260.60	$21,950.20	$23,706 59	$32,984.77	

* Costs per month are approximate for Site 16F and Site 26 Costs were actually invoiced on a quarterly basis.

ATTACHMENT B

New Jersey Department of Environmental Protection Regulations for Classification Exception Area

NJAC 7:26E-8.3 GROUND WATER CLASSIFICATION EXCEPTION AREAS

(a) A ground water classification exception area serves as an institutional control by providing notice that there is ground water pollution in a localized area caused by a discharge at a contaminated site. The area and depth of ground water pollution will be determined based on actual ground water contamination, as well as, fate and transport modeling. The Department will establish a ground water classification exception area as part of a remedial action for ground water at a contaminated site when the ground water does not meet the ground water quality standards, pursuant to N.J.A.C. 7:9-6.

(b) The person responsible for conducting the remediation shall submit the following information to the Department as part of the remedial action workplan pursuant to N.J.A.C. 7:26E-6.2:

1. For each ground water sampling point, a list of all contaminants and their concentrations, that do not meet the groundwater quality standards, from the most recent 24 months of ground water sampling;

2. A description of the fate and transport of the contaminant plume, using the most mobile and persistent contaminants present that exceed the ground water quality standards, including:

   i. The horizontal and vertical distances that the contaminated ground water plume is expected to travel before contaminant concentrations decrease to or below the applicable ground water quality standards;

   ii. A proposed expiration date for the classification exception area; and

   iii. All other information required by Appendix F (included below);

3. The following maps consistent with the requirements of N.J.A.C. 7:26E-8.2(d)2;

   i. A USGS Quadrangle map (paper copy only), indicating the location of the site;

   ii. A map, in paper and electronic formats, indicating the predicted extent of the ground water contaminant plume; and

   iii. A map (paper copy only) showing all properties, according to tax block and lot with a reference to the year of the referenced tax map, under which the contaminant plume is located and is expected to migrate;

4. Information regarding current and projected use of the ground water in the aquifer(s) in which the ground water classification exception area is located, as follows:

   i. The current ground water use based on the most recent well search conducted pursuant to this chapter; and

   ii. The future ground water use for a 25-year planning horizon based on the following, without limitation:

      (1) The New Jersey Water Supply Master Plan;

      (2) Department of Environmental Protection, Bureau of Water Allocation;

(3) Municipal master plans;
(4) Zoning plans;

(5) Local water purveyor plans and planning data pertaining to the existence of water lines and proposed future installation of water lines;

(6) Local planning officials;

(7) County and local boards of health; and

(8) Local and/or county ordinances restricting installation of potable wells.

5. Copies of the certified letters, return receipt requested, notifying the following persons of the need to establish the ground water classification exception area:

i. The municipal and county clerks for each municipality and county in which the ground water classification exception area will be located;

ii. The local, county and regional health department for each municipality and county in which the ground water classification exception area will be located;

iii. The designated County Environmental Health Act agency for each county in which the ground water classification exception area will be located;

iv. The county planning board for each county in which the ground water classification exception area will be located;

v. The Pinelands Commission if the ground water classification exception area will be located within the jurisdiction of that Commission;

vi. New Jersey Department of Environmental Protection, Water Supply Administration:

(1) Bureau of Safe Drinking Water; and

(2) Bureau of Water Allocation; and

vii. If the ground water classification exception area is located in a ground water use area, each owner of any real property within the ground water classification exception area.

(c) The Department will establish a ground water classification exception area based upon the projected area of the contaminant plume in the ground water, pursuant to (b), above.

(d) The Department may revise or reestablish a ground water classification exception area at any time to more accurately reflect ground water conditions using any relevant data, including any data submitted along with the certification required by N.J.A.C. 7:26E-8.6.

(e) The Department will remove a ground water classification exception area based upon ground water data, collected pursuant to N.J.A.C. 7:26E-8.6(a)7, that indicate that the contaminant concentrations in the ground water meet all of the applicable ground water quality standards.

APPENDIX F (of Attachment B)

Ground Water Classification Exception Area Fact Sheet

A. SITE INFORMATION

1. Program's Site Identification Number: _____
2. Program Interest Number (Preferred ID): _____
3. Program Interest Name: _____
4. Street address: _____
5. City: _____
6. County: _____
7. Block and Lots of the site (duplicate if the site is located in more than one municipality):
   a. Name of the municipality in which the site is located: _____
   b. Block and Lots: _____
   c. Year of tax map: _____
8. United States Geological Survey Quadrangle map, indicating the location of the site, presented as Exhibit A.
9. Site Contact:
   a. Name of contact person: _____
   b. Company name: _____
   c. Mailing address: _____
   d. Phone number: (__ __ __) __ __ __ - __ __ __ __

B. PROPOSED CLASSIFICATION EXCEPTION AREA INFORMATION

1. Narrative description of proposed classification exception area:
2. Location of proposed classification exception area (duplicate if the site is located in more than one municipality):
   a. Name of the municipality in which the site is located: _____
   b. Block and Lots: _____

c. Year of tax map: _____

3. Affected aquifer(s):

Aquifer Name	Vertical Depth	Ground Water Classification

4. Contaminant concentrations:

Contaminant	Concentration[1]	GWQS[2]	SWQS[3]

5. Proposed classification exception area boundaries:

Horizontal: Scaled map indicating projected areal extent of proposed classification exception area, as well as location of site, presented as Exhibit B.

Vertical: As stated in B.3., above.

Locational coordinates of boundary of proposed classification exception area as New Jersey State Plane Coordinates. A minimum of four coordinates shall be submitted, in a format compatible with Department's geographic information system:

Northing Easting (New Jersey State Plane Coordinates)

Latitude Longitude

6. Estimated size of the proposed ground water classification exception area:

_____

7. Projected duration and expiration date of the proposed classification exception area:

a. Duration (in years and or days): _____

b. Expiration date (as calendar date): _____

1 Maximum concentration detected at the time Classification Exception Area information submitted to the Department.
2 New Jersey Ground Water Quality Standards, N.J.A.C. 7:9-6.
3 New Jersey Surface Water Quality Standards, N.J.A.C. 7:9B.

ATTACHMENT C

Preliminary Evaluation of Enhanced Natural Attenuation Using Hydrogen Release Compound (HRC®)

Process Overview

Hydrogen Release Compound (HRC®) is an innovative and unique product developed by Regenesis Bioremediation Products (Regenesis) to stimulate rapid biological degradation of chlorinated solvent contaminants often found in ground water and soil. It has been applied to treat compounds such as tetrachloroethene (PCE) and trichloroethene (TCE) at sites across the United States and has demonstrated effective results. HRC® has been shown to achieve rapid in-situ degradation of target contamination without the costs and disruption associated with complex engineered remediation systems.

HRC® is a proprietary, environmentally safe, food-grade quality, polylactate ester specially formulated for slow release of lactic acid upon hydration. The HRC® is applied to the subsurface via push-point injection or within dedicated wells. The HRC® is then left in place where it passively acts to stimulate rapid contaminant degradation.

The process by which HRC® operates is a series of chemical and biologically mediated reactions. Initially, when in contact with subsurface moisture, the HRC® slowly releases lactic acid. Indigenous anaerobic microbes (such as acetogens) metabolize the lactic acid producing consistent low concentrations of dissolved hydrogen. The resulting hydrogen is then used by other subsurface microbes (reductive dehalogenators) to strip the solvent molecules of their chlorine atoms and allow for further biological degradation. When in the subsurface, HRC® continues to operate in this fashion for a period of approximately one year's time, cost-effectively degrading a wide range of chlorinated aliphatic hydrocarbons (CAHs) including common ground water pollutants such as PCE, TCE, and 1,1,1-trichloroethane (TCA), as well as their daughter products.

Contaminant degradation with HRC® presents a cost-effective solution to CAH remediation and has been certified by the NJDEP as a technology with demonstrated effectiveness for treating ground water contaminated with anaerobically degradable compounds such PCE and TCE. When compared to other remediation approaches, HRC® technology presents the following advantages:

1. Low Capital Cost: HRC® application requires low capital costs as the product is relatively inexpensive and is generally applied to the subsurface through push-point type applications;

2. Low Operation and Maintenance Cost: The use of HRC® requires no continuous mechanical operation, therefore operating and maintenance costs are eliminated;

3. Minimal Site Disturbance: Treatment with HRC® is in-situ, and thus, above-ground disturbance is minimized;

4. Rapid Treatment: By supplying a consistent, low level of hydrogen over time, the rate of dechlorination in the subsurface is stimulated to increase by orders of magnitude. This stimulation results in a very rapid removal of the CAH contamination;

5. Energy Efficient: The passive HRC® process results in significant reductions in energy use over other current proven technologies, resulting in lower carbon dioxide air emissions.

Field Operations Overview

There are two main design methods for the use of HRC® injection to treat dissolved phase contamination; the grid design and the barrier design. In the grid application, the HRC® is injected directly into the aquifer matrix in a grid pattern over the aerial extent and across the vertical zone of the contaminant plume. In the event that the plume is very large and an HRC® injection grid is not cost-effective, an alternative approach is to use a series of HRC® barriers. These HRC® barriers are installed perpendicular to the ground water flow direction at regular intervals throughout the length of the plume. In this design approach, a unit volume of contaminated ground water moving in the plume is subject to sequential doses of hydrogen to fuel the reductive dechlorination reactions.

The preferred method for delivering HRC® into the subsurface is to inject the material through direct push rods using hydraulic equipment. This approach increases the spreading and mixing of HRC® into the aquifer. The installation of HRC® can span either a portion of or the entire vertical thickness of the aquifer. One advantage of the barrier method particularly applicable to the CLTL site is the ability to target thin zones of contamination over large areas.

The initial impact of HRC® is the reduction of redox potential and DO levels as lactic acid is released from HRC®. Over time, pyruvic and acetic acid concentrations increase as the lactic acid undergoes metabolism by indigenous microorganisms. At the same time, electron acceptors (nitrate and sulfate) are reduced as indicated by VOC concentration decreases. These initial processes are collectively called "driving" the aquifer anaerobic.

Once the aquifer is driven to a reduced, anaerobic state, reductive dechlorination of the CAHs begins occurring. The reduction of CAHs can begin to occur within a few weeks to a few months of injection, depending on the initial aquifer conditions. Aquifers with higher redox potential, measurable DO levels, and higher levels of competing electron acceptors will require a longer time period to become anaerobic. According to the U.S. EPA screening protocol for natural attenuation of chlorinated solvents (U.S. EPA, 1998a), the current aquifer conditions within the intermediate zone (the pilot test target zone) are favorable for anaerobic biodegration (i.e., low dissolved oxygen concentrations, negative redox potential, and the presence of biodegradation daughter products).

Conceptual Plan for Site 26

Based on the information provided for the Site 26 hydrogeology and contaminant distribution, it is assumed that HRC® would be applied to the deeper portion of the shallow water bearing aquifer above the clay layer, at a depth of approximately 15 to 25 ft (i.e., a target treatment zone having a 10 ft vertical thickness).

Based on input from Regenesis, the suggested HRC® dosage is 4.9 lb/ft; to be conservative, a dosage of 6 lb/ft is assumed. Injection of HRC® would be performed over a grid area (targeting the source area(s)) or as a treatment wall at the downgradient edge of the source area(s). It is assumed that approximately 20 to 50 points would be used to inject HRC® over a grid or as a treatment wall. Injection may be performed using direct push methods; it is assumed that 10 points a day can be completed. Based on these preliminary assumptions, the estimated cost for implementation of enhanced bioremediation using HRC® injected using direct push methods would be approximately $45,000.

As an alternative, it may be possible to use the existing air sparge wells for the injection of HRC® over a grid. Assuming 42 sparge wells could be used for HRC® injection at a rate of 60 lb/well, the estimated

cost for this approach is approximately $35,000. However, the construction of the sparge wells would need to be reviewed to determine the viability of this approach.

To further assess the viability of HRC® as an alternative remedy for Site 26, the following information should be evaluated:

1. Design information for the sparge well construction.

2. Ground water quality data such as sulfate, nitrate, oxygen, iron, manganese, etc., which are competitive electron acceptors with the chlorinated compounds for the HRC®. This might affect the dosage rate required.

3. A portion of the plume containing only PCE may be resulting from a source than the TCE plume. Additional injection points in the southwest portion of the plume may be necessary to address the PCE concerns.