COST AND PERFORMANCE REPORT

Pump and Treat and Containment of Contaminated Groundwater at the
Sylvester/Gilson Road Superfund Site
Nashua, New Hampshire

July 2005

EPA
Prepared by:
U.S. Environmental Protection Agency
Office of Superfund Remediation and Technology Innovation (OSRTI)

SITE INFORMATION

Identifying Information [2, 3, 8, 11]:

Sylvester/Gilson Road Superfund Site
Nashua, New Hampshire

CERCLIS #: NHD099363541

ROD Date(s): July 29, 1982 and September 22, 1983

ESD Date(s): July 10, 1990 and September 23, 2002

Treatment Application [1, 2]:

Type of Action: Remedial

Period of operation: December 1981 through December 1996 (1981 through 1986 for hydraulic control and 1986 through 1996 for remediation), followed by monitored natural attenuation. Performance data collected through December 1995.

Quantity of groundwater treated during application: 1.2 billion gallons

Background [2, 3, 5, 8, 10, 11, 12, 13]:

Historical Activity that Generated Contamination at the Site: Illegal waste disposal

Corresponding SIC Code: NA

Waste Management Practice That Contributed to Contamination: Waste disposal, drum burial, waste storage

Location: Nashua, New Hampshire

Facility Operations:

- The Sylvester/Gilson Road Superfund Site is a 28-acre site. Approximately six acres of the site was used as a sand borrow pit for an undetermined number of years. Illegal dumping was first discovered in 1970. A court injunction was issued in 1976, which required removal of all materials from the site. The operator of the site failed to comply with the injunction. In 1978, New Hampshire state personnel observed drums being stored at the site. A second court order was issued in 1979 prohibiting further disposal of hazardous wastes on the site.

- Although the total amount of hazardous waste disposed of at the site had not been determined, documents show that approximately 900,000 gallons of hazardous waste were discarded at the site during a 10-month period in 1979. It was estimated that the site was used for hazardous waste disposal for five years.

- During 1980, the state removed 1,314 drums of waste from the site and disposed of them off site.

- In 1981, initial remedial investigations by the State of New Hampshire showed high concentrations of heavy metals and organic compounds in the groundwater under the site. The contamination formed a plume in the groundwater, which was moving from the site toward Lyle Reed Brook. As the plume discharged to Lyle Reed Brook, hazardous compounds volatilized into the air at levels above acceptable public health limits.

- In December 1981, the EPA initiated an emergency containment action at the site that entailed installing a groundwater recirculation system. Four extraction wells were installed and pumped for containment only; no treatment was provided at this time. Contaminated groundwater was extracted and discharged to recharge trenches upgradient of the disposal area.

- A feasibility study was completed in May 1982 and a Record of Decision (ROD) was issued in July 1982. The ROD required a slurry wall to be installed around the 28-acre site and a synthetic cap to be placed over the area. The slurry wall and cap were designed to isolate the source area and provide containment of the groundwater plume. The containment system was installed by December 1982. The 1982 ROD also required groundwater extraction and treatment, but did not specify a treatment method for groundwater. However, pilot studies were underway to determine the appropriate treatment method. A groundwater recirculation system operated from 1981 until 1986. The groundwater treatment plant began operation in April 1986 to remove metals and organic compounds.

- A Supplemental ROD (SROD) concerning groundwater extraction and treatment was issued in September 1983. The SROD established cleanup goals for groundwater contaminants within the slurry wall containment area. The SROD cleanup goals were alternate concentrations limits (ACLs) based on levels that were determined to be protective of human health and the environment (see Table 4 of this report). The SROD identified a schedule for evaluating the progress of the pump and treat (P&T) system in meeting the ACLs, that would serve as the basis for EPA's decisions about whether to continue operating, modify, or shut down the P&T system.

- In July 1990, EPA determined that certain adjustments to the treatment remedy described in the SROD were necessary and issued an Explanation of Significant Differences (ESD). These major adjustments to the SROD included an extension of operation by five years, additional extraction wells, and measures to control a toluene contamination source. The source control measures included a soil vapor extraction (SVE) system and an additional source-area groundwater well.

- In September 1994, EPA issued the first five year review for the site. The five year review indicated that only two of the contaminants had met the cleanup goals. As required by the SROD, an evaluation of the P&T system was performed, and modifications were made to the system pumping rates to collect contaminated groundwater from stagnant locations within the containment area.

- The results of the 1994 Remedial Action Evaluation study indicated that all ACLs had been met, except for 1,1-Dichloroethane (1,1-DCA) and 1,1,2-Trichloroethane (1,1,2-TCA). The ACLs for these contaminants were close to or below the detection limits of the analytical equipment. EPA considered adjusting the ACLs for the contaminants based on the results of additional sampling and a determination that groundwater conditions were stable. The study's recommendations were to install an additional bedrock and overburden monitoring well downgradient of the plume.

- In December 1996, the P&T system was shut down. The system had removed 215 tons of contaminants, and the recovery rate of contaminants had declined to a point where continued operation of the system was not expected to further reduce contaminant concentrations. The

system was placed in a "ready" state pending the results of additional groundwater monitoring. Five additional rounds of groundwater sampling were conducted through the first half of 1999. Since the shutdown of the P&T system, the groundwater remedy has been monitored natural attenuation.

- In September 1999, EPA issued a second five year review for the site. Contaminant rebound was identified within and outside of the containment area. However, all ACLs outside the contaminant area were being met, with the exception of 1,1-DCA and 1,1,2-TCA. Recommendations included installing additional monitoring wells and continued site monitoring.

- In September 2002, EPA issued an ESD, which adjusted the ACL for 1,1-DCA from 1.5 ppb to 81 ppb (the New Hampshire Ambient Groundwater Quality Standard) and the ACL for 1,1,2-TCA from 1.7 ppb to 3 ppb (the current Safe Drinking Water MCLG [maximum contaminant level goal]). Following this adjustment, ACLs for all contaminants had been attained. EPA also determined that as of fall 2001, the groundwater conditions at the site had stabilized.

- As of spring 2004, ACLs continued to be met for all contaminants with the exception of chlorobenzene, which is expected to achieve its ACL in the near future.

- In September 2004, EPA issued a third five year review for the site, which indicated the current concern at the site is the presence of arsenic in site groundwater, surface water, and sediments. Arsenic was not an original contaminant of concern and was not part of the sampling strategy during P&T operation. The review recommended expanding the boundaries of existing institutional controls to encompass all areas where groundwater is contaminated with arsenic. Ecological risks due to elevated arsenic concentrations in sediments are being evaluated.

Regulatory Context:

- The ROD was signed on July 29, 1982, and the SROD was signed on September 22, 1983. ESDs were signed on July 10, 1990 and September 23, 2002.

- The State of New Hampshire and the U.S. EPA have entered into a cooperative agreement for remediating this site.

- Site activities are conducted under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) §121, and the National Contingency Plan (NCP), 40 CFR 300.

Groundwater Remedy Selection:

In the original ROD, the selected remedy included construction of a slurry wall and cap with treatment of groundwater within the slurry wall. The treatment method was not included in the original ROD language. The SROD specified groundwater extraction, treatment via chemical and biological processes, and discharge to the on-site aquifer.

Site Logistics/Contacts

Site Lead: State

Oversight: EPA

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* Indicates Primary Contact

MATRIX DESCRIPTION

Matrix Identification [1, 2]

Type of Matrix Processed Through the Treatment System: Groundwater

Contaminant Characterization [1, 2, 5, 6, 9]

Primary Contaminant Groups: Heavy metals and volatile organic compounds (VOCs)

- The reported initial maximum concentrations of organic contaminants found in the groundwater included: tetrahydrofuran (THF) at 1,000,000 : g/L, methylene chloride at 122,500 : g/L, methyl ethyl ketone (MEK) at 80,000 : g/L, toluene at 140,000 : g/L, and chloroform at 81,000 : g/L. Selenium was the primary heavy metal compound detected in the groundwater.

MATRIX DESCRIPTION (CONT.)

- Because toluene and 1,1-DCA concentrations in the groundwater remained high after several years of treatment, toluene was thought to be floating on the water table as a non-aqueous phase liquid (NAPL) at the southern end of the site. In 1988, the toluene concentration in this area was 140,000 : g/L, approximately 26 percent of the aqueous solubility of toluene. 1,1-DCA concentrations also remained persistently high. Based on similar concentration contours for toluene and 1,1-DCA and the low water solubility for both contaminants, 1,1-DCA appeared to be in solution with the toluene NAPL.

- Figure 1 illustrates the total VOC concentration contours of the plume as detected during a December 1980 sampling event. The outermost concentration contour marks the 1,000 : g/L levels; the innermost contour marks the 1,000,000 : g/L levels.

- The size of the plume in Figure 1 was estimated to be 669,000 square feet at the 1,000 : g/L contour. The plume volume was estimated at 59.9 million gallons based the areal extent, 40 feet of plume thickness, and a porosity of 30%.

Matrix Characteristics Affecting Treatment Costs or Performance

Hydrogeology:

The site is underlain by fractured bedrock mantled with 20 to 100 feet of unconsolidated sediments. These sediments consist of a thin low-permeability glacial till covered by a high-permeability sand and gravel outwash deposit.

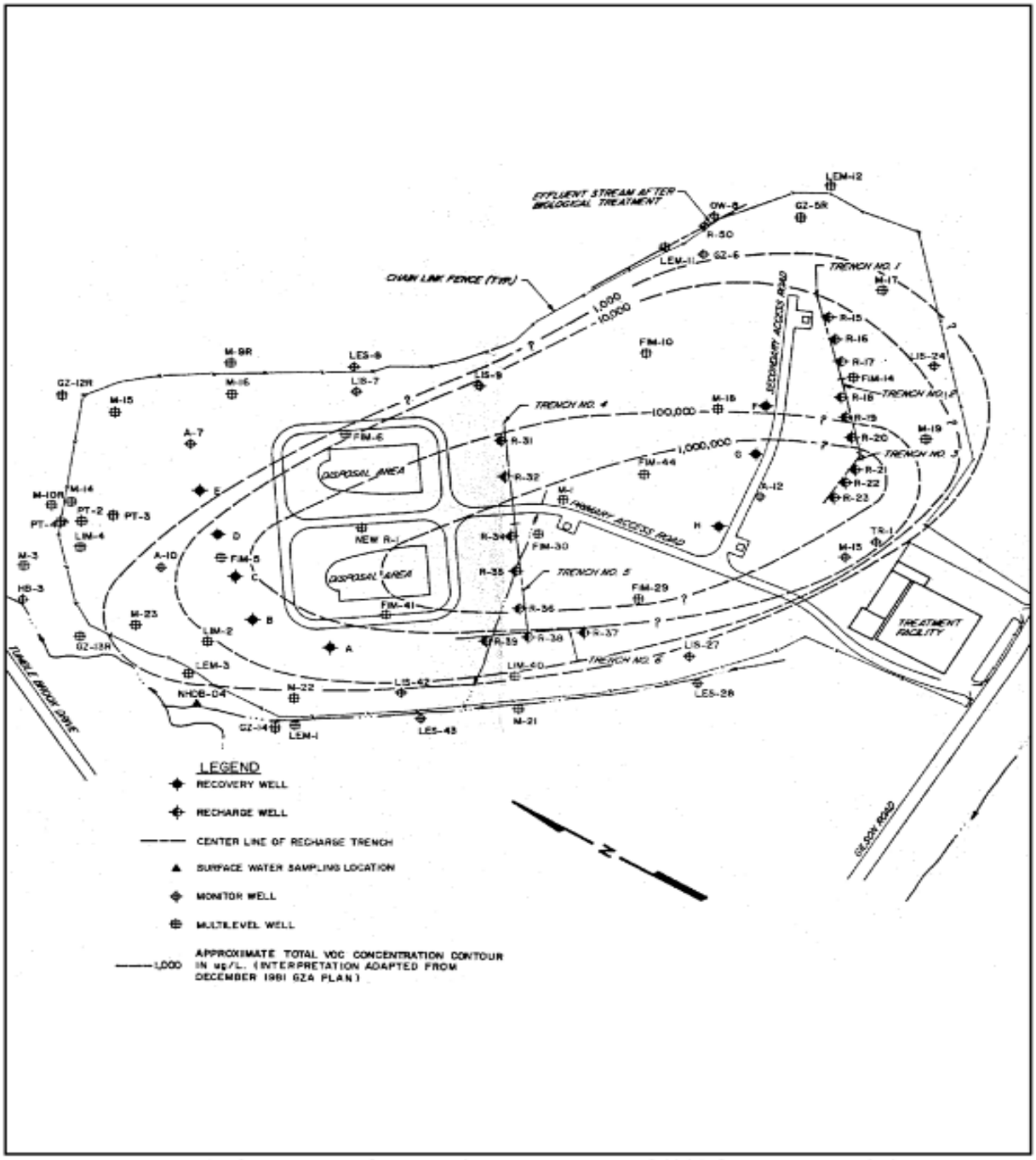
Unit 1	Stratified Drift	High permeability sand and gravel deposit. Groundwater encountered is under water table conditions.
Unit 2	Glacial Till	A discontinuous silt, sand, and gravel till layer with low permeability. This unit may act as a confining layer in some places.
Unit 3	Bedrock	A biotite schist of the Merrimack Group and igneous rocks. It is differentially weathered and fractured. The top of the bedrock surface is irregular, with variation in relief of more than 70 feet.

The site is located in the Lyle Reed Brook watershed. Lyle Reed Brook flows from the east to within 50 feet of the northern property boundary. Two major aquifers within this watershed underlie the site. One is a sand and gravel stratified drift aquifer, and the other is a fractured bedrock aquifer. A discontinuous till layer separates the two aquifers. In general, the till has a lower hydraulic conductivity than the overlying stratified drift, and may act as a confining layer in some places.

Groundwater in the stratified drift is under water table conditions, while groundwater within the fractured bedrock is under semiconfined conditions. Groundwater flows northwest through both aquifers and is encountered 10 to 20 feet below ground surface. The high-concentration area of the plume extended in a northwestern direction in an elliptical shape from the area of historical liquid waste disposal near the current location of Trench 3. Contamination has been detected in both aquifers.

MATRIX DESCRIPTION (CONT.)

Figure 1. Contaminant Contours (based on results of 1980 Sampling Event) [9]



MATRIX DESCRIPTION (CONT.)

Tables 1 and 2 present technical aquifer information and well data, respectively.

Table 1. Technical Aquifer Information

Unit Name	Thickness (ft)	Conductivity (ft/day)	Average Velocity (ft/day)	Flow Direction
Stratified Drift	20-80	30-50	0.15-0.25	Northwest
Glacial Till	0-20	5 (vertical)	NA	NA
Bedrock	>100	6,500 ft^2/day (transmissivity)	NA	Northwest

NA - not available
Source: [6]

Table 2. Extraction Well Data

Well Name	Unit Name	Depth (ft)	Yield (gal/min)
A	Stratified Drift	51	45
B	Stratified Drift	56	45
C	Stratified Drift	50	53
D	Stratified Drift	52	90
E	Stratified Drift	50	61
F	Stratified Drift	46	49
G	Stratified Drift	35	48
H	Stratified Drift	46	90
I	Stratified Drift	55	23
J	Stratified Drift	56	22
K	Stratified Drift	34	17
Ka	Bedrock	68	25
L	Stratified Drift	50	40
La	Bedrock	85	25

Note: The average extraction rate for the extraction system is 265 gpm.
Source: [1]

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

P&T with precipitation and high temperature air stripping.

Supplemental Treatment Technology

Biological treatment for polishing effluent from the groundwater treatment system prior to discharge to off-site recharge trenches.

System Description and Operation [1, 4, 12, 14]

System Description [1, 4]

- A 40-mil high-density polyethylene (HDPE) synthetic cap and containment wall were constructed to minimize infiltration and limit contaminant migration. The containment wall was constructed of bentonite slurry with a design hydraulic conductivity of 10^{-7} cm/sec. The slurry wall is approximately four feet wide, 4,000 feet in perimeter length, and 100 feet deep in some places. The bottom of the slurry wall is keyed into fractured bedrock. Approximately 20 acres is enclosed by the wall and covered by the cap.

- The remedial system includes 14 groundwater extraction wells (listed in Table 2) and seven recharge trenches. Groundwater is extracted, treated, then recharged through the trenches. The remedial system has been designed to isolate contaminated groundwater, recover and treat groundwater from within the slurry wall, and induce uniform flushing of the upper saturated zone.

- Four extraction wells (B, C, D, E) were installed in 1981 and 1982 as part of an emergency groundwater interception and recirculation system to halt the migration of contaminated groundwater. Wells A, F, and G were installed in 1986 as part of the construction of the site groundwater remedial system. Wells H, I, J, K, Ka, L, and La were installed in 1991 as part of the modification to the groundwater remedial system. Wells A, B, C, D, E, I, and J are located in the downgradient portion of the site. Wells F, G, and H are located in the area of original dumping and contamination. Wells K, Ka, L, and La are located in areas that EPA and NHDES determined to be areas of persistent contamination. All extraction wells are located inside the slurry wall.

- Pumping rates for each well were initially set by the design engineer. Wells A, B, C, D, E, I, and J were pumped at a rate to minimize leakage of groundwater from the containment area. Wells F, G, and H were pumped at a rate to maximize recovery of contaminated groundwater. Well L was pumped at a rate to depress the water table in the vicinity of the SVE system and recover contaminated groundwater. Well K was pumped to reduce a persistent “hot spot”. Bedrock wells Ka and La were pumped at very low rates and only as long as bedrock contamination was present.

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation [1, 4, 12, 14] (Cont.)

- The treatment system consisted of physical, chemical, biological, and thermal unit processes (Figure 2). Approximately 265 gpm of groundwater passed through a pH adjustment tank where pH was adjusted to approximately pH 11 using a lime slurry. Water then flowed to a flocculation tank where polymer was added and mixed using a variable speed mixer. After flocculation, groundwater passed through an inclined plate settler where metals in the form of suspended solids were removed. The groundwater was then neutralized to pH 7. Neutralized groundwater was pumped through four (series) mixed-media pressure filters to remove small particulate matter. Following filtration, the groundwater temperature was raised to 175° F. Heated groundwater then passed through a stripping column for removal of VOCs. Stripped vapors were introduced into a boiler/incinerator where No. 2 fuel oil was burned to create sufficient heat to destroy organic vapors.

- Stripped groundwater was pumped through a heat exchanger to transfer heat from treated groundwater to incoming groundwater. Stripped groundwater was then divided into two streams: one stream (215 gpm) was discharged to on-site recharge trenches while the other stream (50 gpm) flowed to biological treatment. Biological treatment consisted of extended aeration with an activated sludge and removed the remaining volatile organic compounds before discharge to off-site recharge trenches.

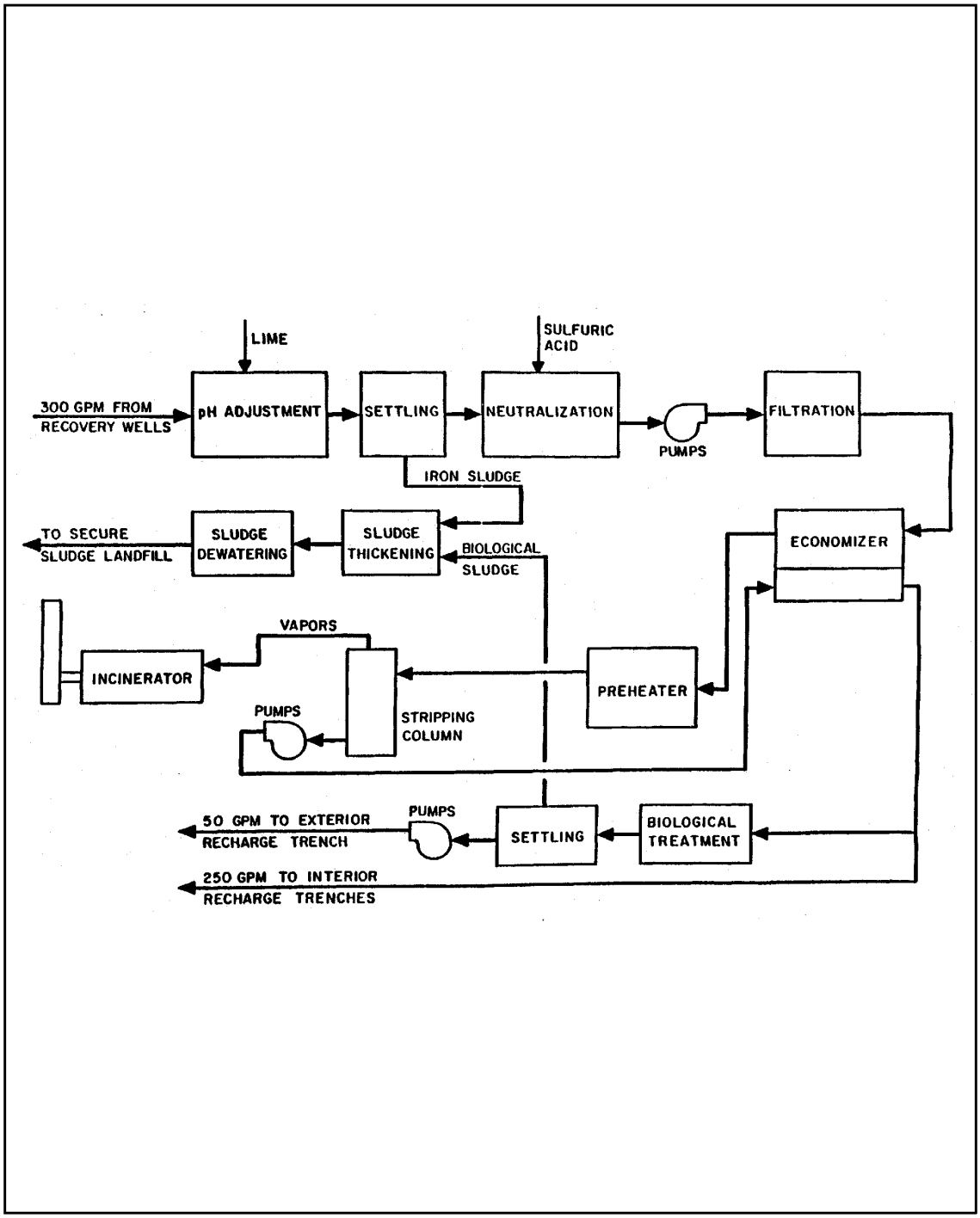
- The biological treatment effluent was discharged off site to remove water from the containment area, thereby inducing water to flow into the containment area through the fractured bedrock below and reducing leakage downward from the site. The stripping column used at this site was a 4-foot diameter, 40-foot tall stainless steel stripper with demister at the top and stripped water sump at the bottom. The effective stripping depth was about 20 feet. The packing used was Type 3Y Flexipack elements stacked to approximately 16 feet.

- Well L and the SVE system were installed to recover and remove toluene from the source area identified by a toluene NAPL floating on the groundwater surface. The SVE system, which operated for approximately three years, consisted of six headers with eleven extraction/injection wells on each header. A variable speed pump extracted soil gas, and pumped the vapors into the boiler/incinerator for destruction of VOCs.

- The groundwater monitoring system consisted of 73 monitoring wells. All wells were sampled quarterly. Because there were many contaminants in the groundwater, three indicator compounds were selected to monitor water quality: toluene, THF, and 1,1-DCA.

TREATMENT SYSTEM DESCRIPTION (CONT.)

Figure 2. Process Flow Diagram of the Sylvester Groundwater Extraction and Treatment System [4]



TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation [1, 4, 12, 14] (Cont.)

System Operation:

Table 3 presents the volume of groundwater pumped from the aquifer each year.

Table 3. Annual Groundwater Volumes Pumped

Year	Total Volume Pumped (gallons)	Unit Name
1986	80,666,000	1,3
1987	138,029,000	1,3
1988	130,086,000	1,3
1989	112,587,000	1,3
1990	125,437,000	1,3
1991	107,285,000	1,3
1992	125,040,000	1,3
1993	125,476,000	1,3
1994	124,395,000	1,3
1995	126,889,000	1,3

- The remedial system operated from mid- 1986 through December 1996, with the following exceptions. Incinerator repair in 1989 reduced operation for approximately one month. The treatment facility was off line for a portion of 1991 and 1992 to make modifications. According to the site contact, the system has operated an average of 88% of the time between 1986 and 1995. The treatment facility was designed to operate 24 hours per day, 365 days per year.

- The groundwater treatment facility started up in April 1986, and full-scale operation commenced in June 1986. The SROD estimated that cleanup levels inside the 20-acre containment area would be met within two years of treatment system initiation. After two years, the SROD required EPA and NHDES to evaluate the site to determine the degree to which treatment goals had been met. In March 1988, the evaluation was performed, and EPA and the NHDES concluded that several “hot spots,” or areas of elevated groundwater contamination, persisted. An ESD was issued in July 1990, which included adjustments to the remedy as a result of the 1988 evaluation.

- As required by the ESD, the groundwater treatment plant operated for an additional four years, six additional recovery wells were installed in areas of greatest residual contamination, and the location of an apparent toluene contamination source was investigated.

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation [1, 4, 12, 14] (Cont.)

- The total pump rate to the treatment facility did not increase substantially after the addition of six new extraction wells in 1991. The groundwater treatment facility was designed with a capacity of approximately 330 gpm, which could not be increased without decreasing contaminant removal efficiency. When new extraction wells were placed on line, the pumping rate from less contaminated existing wells was decreased.

- The original remedial design sought to optimize capture and treatment of contaminated groundwater while reducing leakage of groundwater from the site. Later optimization included increasing pumping rates at extraction wells with demonstrated greater groundwater contamination and using a MODFLOW model to maximize mass removal.

- The air stripper media and heat exchangers were acid washed quarterly to prevent clogging from iron fouling.

- High temperature air stripping was selected over conventional cold stripping because of the solubility of the organic compounds present and the desire to remove 90% of the VOCs on each pass through the stripper. While the removal efficiency was above expectations, the higher concentration of VOCs and greater total mass of pollutants resulted in a longer-than-expected treatment period to reduce groundwater concentrations to cleanup goals.

- Since groundwater treatment was terminated in December 1996, NHDES conducted groundwater monitoring semi-annually (in the spring and fall). However, in 2004, sampling was reduced from twice a year to once a year.

- After four years of verification monitoring, the P&T system was de-commissioned in 2001, which included removing all pumps, pipes, and devices associated with groundwater extraction. Only the treatment building remains.

Operating Parameters Affecting Treatment Cost or Performance [5, 11]

Table 4 presents parameters affecting performance for this technology.

Table 4. Performance Parameters

Parameter	Value
Average Pump Rate	265 gpm
Performance Standard (Effluent)	1. Same as remedial goals for effluent discharged to recharge trenches. 2. MCLs for effluent discharged outside the slurry wall.

Parameter	Value	
Remedial Goal (within the containment area)*	Vinyl Chloride	95 : g/L
	Benzene	340 : g/L
	Chloroform	1,505 : g/L
	1,1,2-Trichloroethane	3 : g/L**
	Methyl Ethyl Ketone	8,000 : g/L
	Chlorobenzene	110 : g/L
	Methylene Chloride	12,250 : g/L
	Toluene	2,900 : g/L
	1,1-Dichloroethane	81 : g/L**
	Trans-1,2-Dichloroethane	1,800 : g/L
	1,1,1-Trichloroethane	200 : g/L
	Methyl Methacrylate	350 : g/L
	Selenium	2.6 : g/L
	Phenols	400 : g/L

Source: [5, 11]
* Remedial goals within the containment area were ACLs
** In 2002, the ACL for 1,1,2-Trichloroethane was adjusted to 3 ppb and the ACL for 1,1-Dichloroethane was adjusted to 81 ppb.

Timeline [2, 3, 7, 11, 12]

Table 5 presents a timeline for this remedial project.

Table 5. Project Timeline

Start Date	End Date	Activity
7/29/82	---	Original ROD issued
9/22/83	---	SROD issued
10/83	3/84	Treatment facility designed
7/82	12/82	Slurry wall installed and synthetic cap placed over 20-acre area
4/84	4/86	Groundwater treatment facility constructed
6/86	---	Full-scale operations of groundwater treatment facility begin
7/90	---	ESD extending the operation of the treatment system, adding six new wells, and initiating toluene source removal actions issued

Start Date	End Date	Activity
9/91	3/92	Six additional extraction wells installed to enhance plume recovery
3/92	---	Soil vapor extraction system added to remove toluene NAPL on groundwater surface
---	12/96	Groundwater treatment system shut down and placed on standby
9/99	---	Five Year Review stating that all ACLs had been met, except for 1,1-DCA and 1,1,2-TCA. Two additional wells installed.
8/01	---	De-commissioning activities at the groundwater treatment plant completed
9/02	---	ESD adjusting the ACL for 1,1-DCA and 1,1,2-TCA and stating that all ACLs had been met.
9/04		Five Year Review stating monitored natural attenuation is currently protective, but institutional controls need to be expanded to address arsenic contamination in groundwater.

Source: [2, 3, 7, 11, 12, 13]

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards [8, 12]

The remedial goal for this site was to clean up groundwater to meet the ACLs, shown in Table 4, within the containment area. In 2002, EPA issued an ESD to revise the ACLs for 1,1-DCA and 1,1,2-TCA.

Additional Information on Goals [8, 13]

- Risk-based concentration levels were set for groundwater outside of the containment structure. Treated water discharged to infiltration trenches outside the slurry wall must meet maximum contaminant levels.
- Volatization from Lyle Reed Creek must be reduced to acceptable exposure levels.

Treatment Performance Goals [8]

- One performance goal of the remedial system was to prevent the contaminant plume from further migrating. The slurry wall was designed to eliminate horizontal flow of contaminants; the extraction/infiltration system was designed to hydraulically minimize downward leakage of contaminants to the bedrock aquifer below.
- Another goal of the treatment system was to reduce contaminant concentrations by 90% with each pass through the treatment train. It was envisioned that treating two pore volumes would reduce groundwater concentrations by 99%.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment [1, 4, 5, 7, 13]

P&T System Operation

- Performance data for the P&T system operation were available through December 1995. The P&T system was shut down and placed on stand by in December 1996.
- As of December 1996, ACLs had been met for all contaminants except 1,1-DCA and 1,1,2-TCA. Subsequent groundwater data indicated that contaminant rebound occurred within and outside the containment area, peaking within 1 to 2 years following shut down of the groundwater treatment system. In spite of the rebound, all ACLs continued to be met outside the slurry wall with the exception of 1,1-DCA and 1,1,2-TCA.
- A slurry wall and cap were installed to contain the contaminant plume and minimize groundwater flow into and through the site, which would have carried contaminants further downgradient. Eliminating infiltration reduced the downward migration of groundwater into the bedrock. The extraction system further reduced downward migration by extracting more groundwater than was injected thus maintaining a net inward flow into the containment structure.
- Figure 3 presents the removal of contaminants through the treatment system from 1986 through 1995. The mass flux data show that the mass of contaminant removed per day increased from 1986 to 1988 and reached a maximum of 512 pounds per day on average. The mass removed per day decreased in 1989 to 72 pounds and continued to decrease to less than 10 pounds per day in 1995. The total mass removed curve demonstrates that the mass of contaminants removed between 1986 and 1988 was 368,000 pounds, and between 1988 and 1995 was only 59,000 pounds.
- From 1986 through 1996, the P&T system removed approximately 430,000 pounds of contaminant mass from 1.2 billion gallons of groundwater treated.
- Most contaminant concentrations decreased after the treatment remedy was installed. However, two contaminants, toluene and 1,1-DCA, showed persistently high concentrations until a source control measure (SVE) aimed at removing a toluene NAPL was implemented.
- Figure 4 illustrates changes in total VOC concentrations in the groundwater since the remedial system was shut down. The total VOC measurement is the cumulative concentrations of contaminants detected in all monitoring wells. These data show that total concentrations are not rebounding.

Monitoring Results Post P&T Operation

- The P&T system was shut down and placed in standby in December 1996.
- Results of the five year review performed in 1999 (after shut down in 1996) indicated that all ACLs outside the contaminant area were being met, with the exception of 1,1-DCA and 1,1,2-TCA.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Figure 3. Mass Flux Rate and Cumulative Contaminant Removal (June 1986 - December 1995) [1]

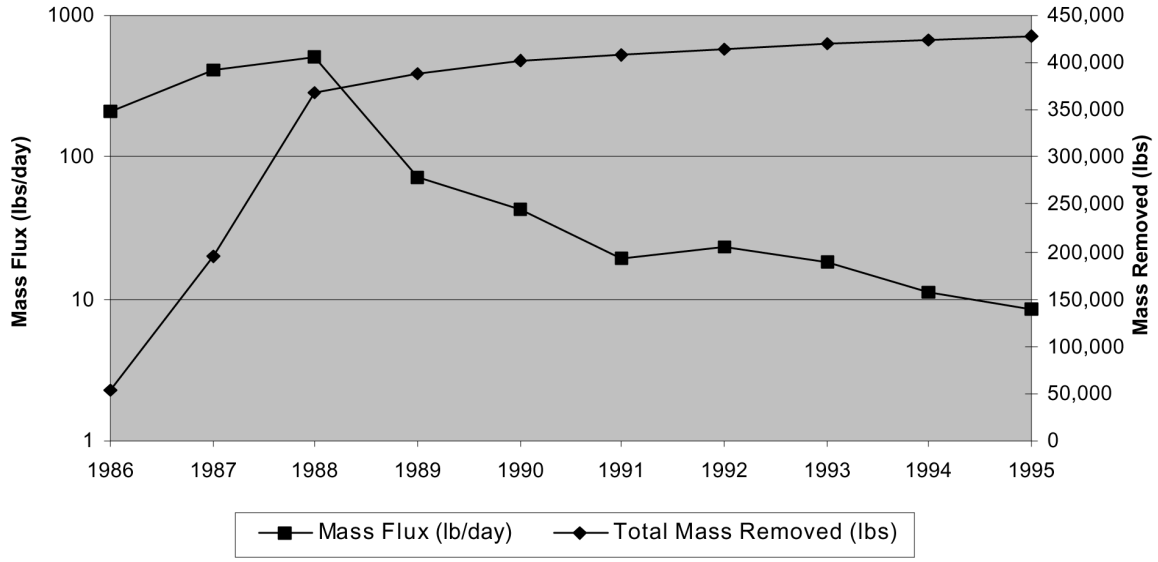
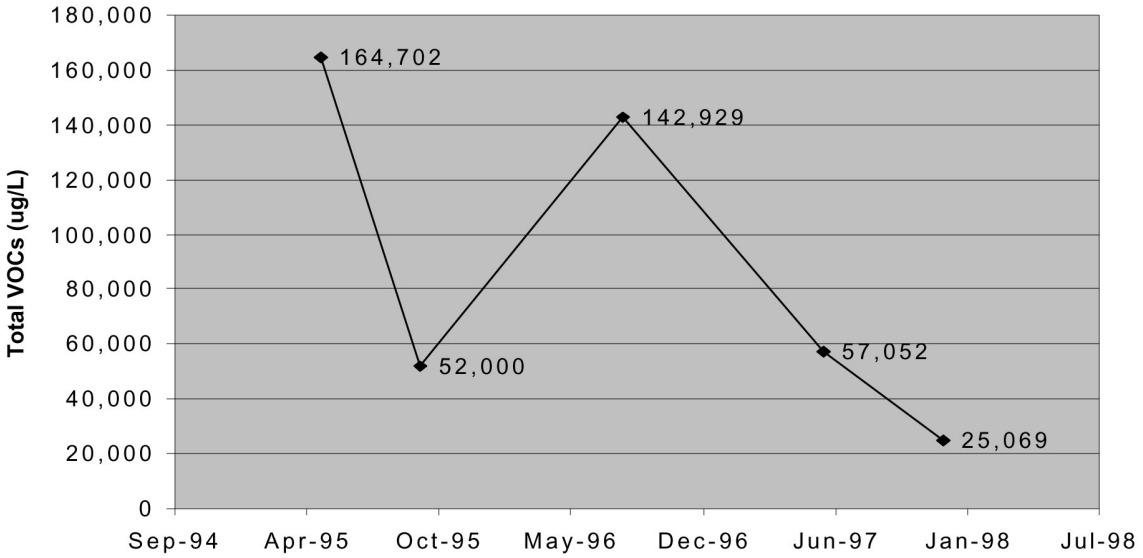


Figure 4. Total VOC vs. Time (1995 - 1997) Data Represents the Sum of All VOCs Detected [1]



TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment [1, 4, 5, 7, 13] (Cont.)

- In September 2002, EPA issued an ESD, which adjusted the ACL for 1,1-DCA from 1.5 ppb to 81 ppb and the ACL for 1,1,2-TCA from 1.7 ppb to 3 ppb. Following this adjustment, ACLs for all contaminants had been attained. EPA also determined that as of fall 2001, the groundwater conditions at the site had stabilized.

- In September 2004, the third five year review was issued and reported that ACLs for all contaminants continued to be met with the exception of chlorobenzene, which was expected to achieve its ACL in the near future. The report also stated that groundwater P&T, along with the current monitored natural attenuation remedy, are protective of human health and the environment in the short-term. EPA believes that for the groundwater remedy to be protective in the long-term, institutional controls will need to be expanded to include all areas where groundwater contaminated with arsenic exists.

Performance Data Completeness

- For the purpose of the analyses shown in Figure 3, annual flow rates, influent concentrations, mass removed data, and percent operational data were provided by the site contact.

- Quarterly data are available; however, an annual average was used in this report to present the data.

- The total VOCs data were taken from a common set of monitoring wells to demonstrate how contaminant concentrations are changing over the entire site.

- Contaminant mass removal was determined using analytical results from influent samples, along with flow rate data. Annual averages were used to calculate total mass removed and daily mass flux.

- Mass flux data was calculated with the following equation:

  mass flux = $(Q \times C_i) / \%$ operational, where:

  mass flux = pounds per day
  Q = total yearly flow in gallons per year
  C_i = average annual influent concentration in pounds per gallon
  % operational = days of operation per year

Performance Data Quality

The QA/QC program used throughout the remedial action met the EPA and the State of New Hampshire requirements. All monitoring was performed using EPA-approved methods, and the vendor did not note any exceptions to the QA/QC protocols.

TREATMENT SYSTEM COST

Procurement Process [1]

The NHDES is the lead for this site. Weston was the Remedial Action Contractor.

Cost Analysis [1]

- All costs through 1995 for design, construction and operation of the treatment system at this site were shared by the U.S. EPA (90%) and the State of New Hampshire (10%). As of 1996, all costs for the site have been borne by the State of New Hampshire.

Capital Costs [1]

Remedial Construction	
Slurry Wall & Cap	$2,200,000
Groundwater Extraction and Treatment Facility	$5,375,000
Change Order #1	$14,844
Change Order #2	$118,863
Change Order #3	$124,947
Groundwater Treatment Facility Modifications	$1,385,000
Change Order #1	Period of Performance Extension
Change Order #2	$39,179
Change Order #3	$31,329
Groundwater Treatment Facility Landfill Closure	$109,465
Total Site Construction	**$9,069,465**

Operating Costs [1, 14]

Operating and Maintenance Cost During P&T Operation

Year	Cost
1986	$1,142,411
1987	$1,615,500
1988	$1,590,169
1989	$1,574,255
1990	$1,908,630
1991	$1,896,018
1992	$1,981,405
1993	$1,961,017
1994	$1,940,022
1995	$2,116,624

TREATMENT SYSTEM COST (CONT.)

Operating and Maintenance Cost Following P&T Shut Down

1996	$375,385
1997	$366,170
1998	$405,108
1999	$426,402
2000	$417,322
2001	$583,839
2002	$146,114
2003	$92,863
1/1/04-9/30/04	$69,803
9/30/04-12/31/04	$11,250*
Total Operating Expenses**	**$20,620,307**

* Current maintenance costs range from $2,500 to $5,000 per month.
** Approximately $100,000 of total operating expenses were attributed to closure of the landfill cell.

Other Costs [1]

Remedial Design Cost	
Slurry Wall & Cap	$180,741
Groundwater Treatment Facility	$291,200
Groundwater Treatment Facility Modifications	$183,800
Remedial Action Evaluation and Closure Studies	
Remedial Action Investigation (1988)	$350,000
Remedial Action Evaluation and Closure Study (1994)	$810,000

Cost Data Quality

Actual cost data were provided by the NHDES site contact.

OBSERVATIONS AND LESSONS LEARNED

- The total construction and operating and maintenance (O&M) costs for the Sylvester/Gilson Road site were approximately $29.7 million (9.1 million in capital costs and $20.6 million in O&M costs) which corresponds to $69 per pound of contaminant removed and $25 per 1,000 gallons treated.
- Modifications were made to the system in 1991 to reflect changes required by the ESD and the site evaluation performed in 1988. These modifications resulted in a 15% increase in capital expenditures. The modifications included six new extraction wells and the installation of an SVE system for toluene source removal. (Listed as Groundwater Treatment Facility Modifications under Capital Costs.)

OBSERVATIONS AND LESSONS LEARNED (CONT.)

- O&M costs varied between approximately $1 and $2 million per year. The system was initially planned to operate for two years. As a result of higher than expected concentrations and overall mass of contaminants, the remedial system was required to operate for ten years.
- The high O&M costs at this site are attributed to the 300 gpm treatment system and number of staff required to operate it. For many years, the site was staffed with 15 full-time personnel who operated the site 24 hours per day.
- The slurry wall and cap contained the plume at the Sylvester/Gilson Road site. According to the site contact, this remedial action reduced the concentration of contaminants in Lyle Reed Brook while most groundwater contamination was being isolated and treated within the containment structure.
- Mass flux data from the Sylvester/Gilson Road site generally shows the typical asymptotic decline for mass removed using a P&T system. The mass flux slightly increased in 1992 to 23 lbs/day from 19 lbs/day in 1991. This increase was due to the addition of seven extraction wells installed in 1991.
- Based on persistent high toluene concentrations, additional investigations were performed and identified a toluene NAPL floating on the groundwater surface. As a result, a source removal action was initiated to remove the toluene NAPL after almost six years of P&T operation. After a SVE system was installed and removed the source area, groundwater concentrations were eventually reduced below cleanup goals.

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4. U.S. Environmental Protection Agency, Evaluation of Groundwater Extraction Remedies Phase II, February 1992.
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7. New Hampshire Department of Environmental Services, Annual Report (1996-1997) The Gilson Road Superfund Site, June 1997.

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8. U.S. Environmental Protection Agency, Supplemental Record of Decision, September 1983.

9. Plume map from: Remedial Program Evaluation Gilson Road Site, Nashua, NH, Weston, July 1989.

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13. U.S. Environmental Protection Agency, Five Year Review, Sylvester/Gilson Road Superfund Site, September 2004.

14. Data provided by state contact, Ken Kettenring via e-mail. November 2004.

ANALYSIS PREPARATION

This case study was prepared for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Eastern Research Group, Inc. and Tetra Tech EM, Inc. under EPA Contract No. 68-W-02-034.

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