# COST AND PERFORMANCE REPORT

## Pump and Treat and In Situ Bioventing at the Onalaska Municipal Landfill Superfund Site Onalaska, Wisconsin

April 2006

Prepared by:

EPA

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

# SITE INFORMATION

## IDENTIFYING INFORMATION [9]

**Site Name:** Onalaska Municipal Landfill Superfund Site

**Location:** Onalaska, Wisconsin

**CERCLIS #:** WID980821656

**ROD Date:** August 14, 1990

**ESD Date:** September 29, 2000; November 13, 2001

## TECHNOLOGY APPLICATION

**Type of Action:** Remedial

**Period of Operation:**

- Pump and Treat (P&T) (for groundwater) – June 1994 through November 2001
- In Situ Bioventing (for soil) – May 1994 to February 1997
- Monitored Natural Attenuation (MNA) (for groundwater) – November 2001 to present

**Quantity of Material Treated during Application:**

- 2.17 billion gallons of groundwater treated from 1994 through 2001
- Quantity of soil treated was not reported

## BACKGROUND [1,3]

**Waste Management Practice that Contributed to Contamination:** Disposal of municipal and chemical wastes in a landfill

**Facility Operations:**

- The Onalaska Municipal Landfill Superfund Site (Onalaska) is located in Onalaska, Wisconsin, about 10 miles north of La Crosse, Wisconsin. The 11-acre site is located 400 feet from the Black River and within 500 feet of several residences.

- The site was used as a sand and gravel quarry from the early to mid-1960s. In the mid-1960s, the Town of Onalaska began using the site as a landfill for both municipal and chemical wastes. In 1978, the Wisconsin Department of Natural Resources (WDNR) concluded that the landfill operation did not comply with state codes and ordered the landfill closed. Landfill operations stopped in September 1980, and the landfill was capped in June 1982.

- WDNR site investigations in September 1982 identified elevated levels of organic and inorganic contaminants in the aquifer beneath the landfill, which also served as the primary source of drinking water for the residents in the area. The site was placed on the National Priorities List in September 1984.

- Results of the remedial investigation (RI) conducted in 1988 and 1989 indicated that soils above the groundwater table and adjacent to the southwestern edge of the landfill were contaminated with petroleum solvents, including naphtha, at levels as high as 550 milligrams per kilogram (mg/kg). Groundwater was contaminated with (1) volatile organic compounds (VOCs), primarily toluene; 1,1-dichloroethane (1,1-DCA); and trichloroethene (TCE); and (2) metals, including barium and arsenic. The groundwater plume extended at least 800 feet from the southwestern edge of the landfill and discharged to nearby wetlands and the adjacent river. Figure 1 shows the extent of groundwater and nonaqueous phase liquid (NAPL) contamination at the site.

- Also during the RI, the U.S. Environmental Protection Agency (EPA) determined that the landfill cap installed in 1982 did not meet state closure requirements. The cap was found to be only 1 foot thick in some areas, and the soils encountered in the landfill cap did not satisfy the requirements for particle size or saturated hydraulic conductivity. It was also found that the landfill cap had deteriorated from surface runoff and frost damage. Erosion gullies and animal burrows were also discovered in some areas. Figure 2 shows the damaged areas of the landfill cap.

- A new landfill cap was constructed in 1993 and was designed to prevent storm water infiltration into the landfill. This landfill cap was installed in accordance with applicable federal and state requirements and consists of the following layers: grading, 2-foot clay (minimum), gravel drainage, frost-protective soil, and 6-inch topsoil. The cap also has a passive methane gas venting system.

**Regulatory Context:**

- A record of decision (ROD) was signed in August 1990. The ROD specified a P&T system for groundwater; bioventing for soils; monitoring for groundwater, surface water and sediments; and installing a landfill cap that met federal and state requirements.

- An explanation of significant difference (ESD) was signed in September 2000, which changed the cleanup goals specified in the ROD to updated state groundwater cleanup goals.

- A second ESD was signed in November 2001, allowing for the temporary shutdown of the groundwater P&T system to study the potential for natural attenuation to address remaining contamination in groundwater and to revise the monitoring program.

- The first 5-year review of the site was conducted in 1998.

- The second 5-year review of the site was conducted in 2003.

**Remedy Selection:**

- Groundwater – P&T followed by MNA
- Soil – in situ bioventing

**Figure 1. Extent of Groundwater and Non-Aqueous Phase Liquid Contamination [12]**

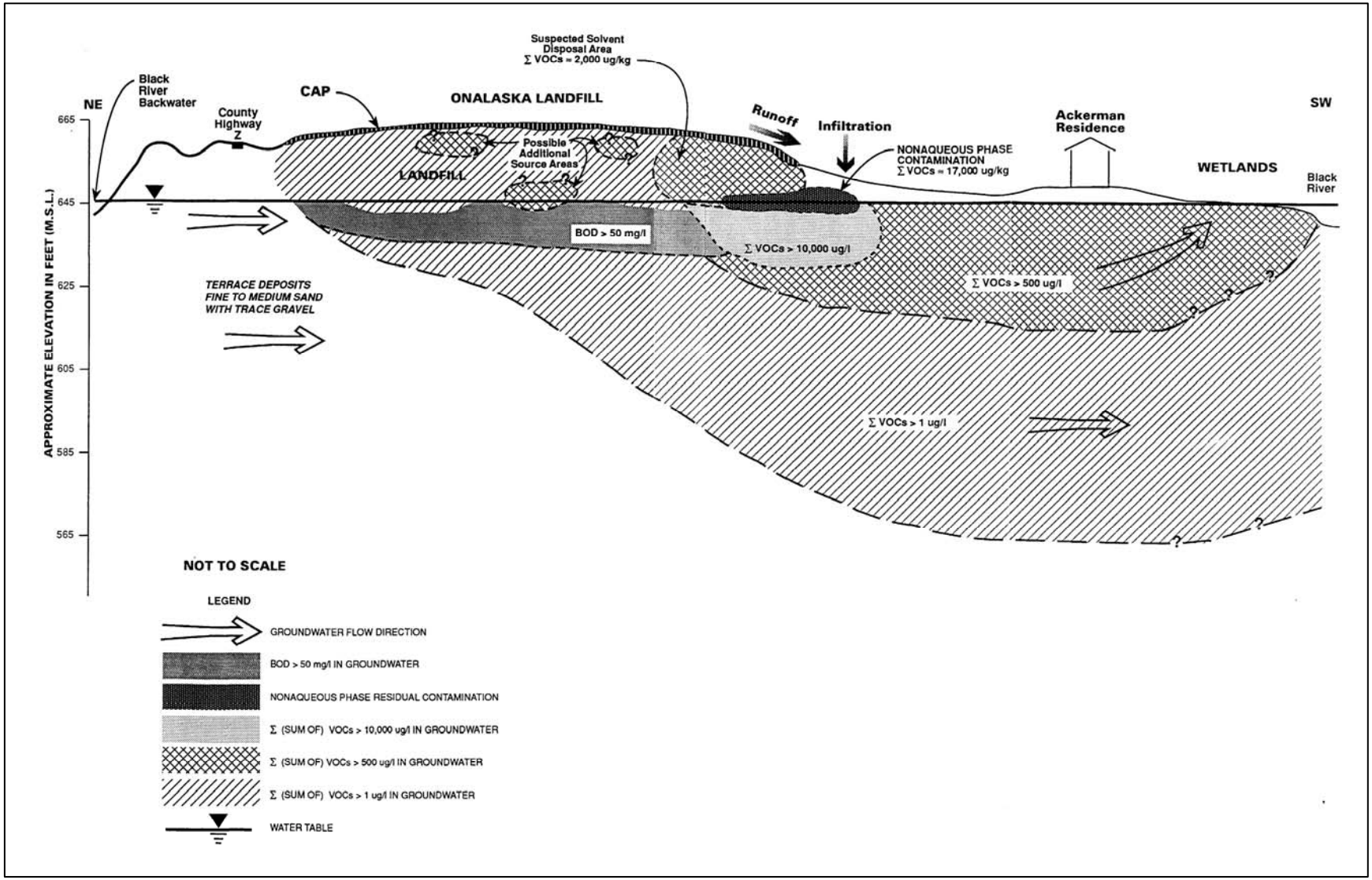
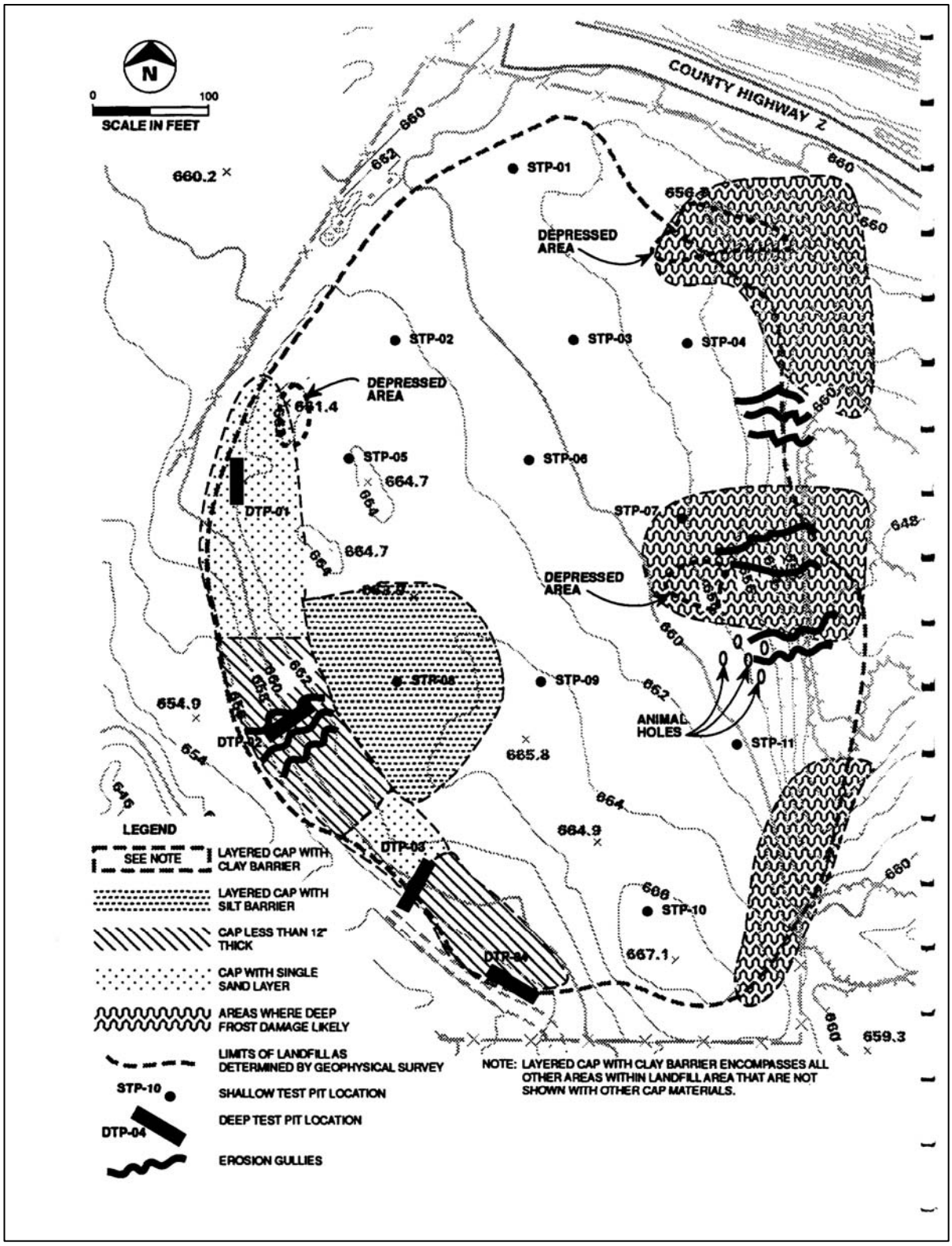


**Figure 2. Damaged Areas of the Landfill Cap [12]**



## SITE LOGISTICS/CONTACTS

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# MATRIX DESCRIPTION

## MATRIX IDENTIFICATION

Soil and Groundwater

## CONTAMINANT CHARACTERIZATION [1,2,3,9]

**Primary Contaminant Groups:**

VOCs, semivolatile organic compounds (SVOCs), metals

- The groundwater beneath the landfill was contaminated with VOCs, including TCE; 1,1-DCA; 1,1,1-trichloroethane (1,1,1-TCA); 1,1-dichloroethene (1,1-DCE); 1,2-dichlorethene (1,2-DCE); and benzene, toluene, ethylbenzene, and xylene (BTEX). During the RI, concentrations of chlorinated VOCs were as high as 800 micrograms per liter (µg/L) for 1,1-DCA, 27 µg/L for 1,2-DCE, and 8 µg/L for TCA (cleanup goals are shown in Table 4).

- The soil in the vadose zone immediately above the water table and downgradient of the landfill was contaminated with petroleum hydrocarbon solvents, primarily naphtha, at levels as high as 550 mg/kg.

- Metals of concern in groundwater included barium, arsenic, iron, manganese, and lead.

## MATRIX CHARACTERISTICS AFFECTING TREATMENT COSTS OR PERFORMANCE [1,2,6,9,11,12]

The table below provides matrix characteristics for each of the three remedial technologies. These values were based on baseline sampling or were observed during startup of each remedy.

**Matrix Characteristics Affecting Treatment Costs or Performance**

| Matrix Characteristic | Value |
|---|---|
| **Pump and Treat (Groundwater)** | |
| Thickness of zone of interest | 10 – 70 feet bgs |
| Presence of NAPLs | Yes |
| **In Situ Bioventing (Soil)** | |
| Depth bgs/thickness of zone of interest | 11 – 15 feet |
| Presence of NAPLs | Yes |
| Oxygen | 11.5% |
| Carbon dioxide | 5.5% |
| Methane | 1.3% |
| **Monitored Natural Attenuation (Groundwater)** | |
| pH | 5.2 – 7.2 |
| Thickness of zone of interest | 10 – 70 feet bgs |
| Total organic carbon | 4 mg/L |
| Oil & grease | 0.7 mg/L |
| Oxidation/reduction potential | 180 mV |

**Notes:**
bgs = Below ground surface
mg/L = Milligrams per liter
mV = Millivolts

## SITE HYDROGEOLOGY [1,5]

The upper groundwater aquifer consists primarily of sand and gravel and is 135 to 142 feet thick. This aquifer serves as a primary source of drinking water for local residents. The depth to the groundwater table is generally 15 feet below ground surface (bgs) but rises to 11 feet during the spring. Groundwater flow is generally to the south-southwest, toward the wetlands and the Black River, at a rate of 55 to 110 feet per year. Groundwater flow is to the south-southeast during high groundwater table conditions, which occur a few months a year.

# TREATMENT SYSTEM DESCRIPTION

## PRIMARY TREATMENT TECHNOLOGY

- Groundwater – P&T (treatment for metals using sodium hydroxide and polymer addition; air stripping for VOCs) followed by MNA
- Soil – in situ bioventing

## SYSTEM DESCRIPTION AND OPERATION [2,4,6,7,8,9,10]

### Groundwater P&T

- The groundwater P&T system consisted of five extraction wells located along the downgradient edge of the landfill, as shown in Figure 3. The design flow rate of the P&T system was 600 to 800 gallons per minute (gpm); the following describes the extraction well designs:

  - In spring 1991, a pump test was conducted to establish the number and location of wells and flowrates required to achieve the design capacity. Based on this testing, 5 extraction wells (EW-1 to -5) were identified to capture the plume and treat a total of 800 gpm. The wells were spaced 150 to 200 feet apart, with one well pumping at a rate of 100 gpm, two wells at 150 gpm, and the other two wells at 200 gpm.
  - EW-3 was designed with a 50-foot screen and a total depth of 85 feet bgs, while the other four extraction wells were each designed with a 45-foot screen and a total depth of 80 feet. All five extraction wells were 8 inches in diameter.
  - The depths specified were chosen because they contain the highest groundwater contaminant concentrations.

- The groundwater treatment system was designed to remove VOCs and iron. The system included aeration, clarification, and the addition of sodium hydroxide and polymer for iron removal. Air stripping was used to remove VOCs. The treated water was discharged to the river, and the clarifier sludge was dewatered and disposed in a landfill.

- The total volume of groundwater extracted and treated from 1994 through 2001 was more than 2 billion gallons. Table 1 provides information about the volume of groundwater treated by year, the average daily extraction rate, and the average pumping rate:

- Groundwater monitoring samples were collected from monitoring wells, extraction wells, and two residential wells. Baseline samples were collected in November 1993 (before system startup), then quarterly beginning in March 1995. In March 1997, the monitoring frequency was reduced to semi-annual.

- The system was operated from June 1994 to November 2001 and was operational about 80 percent of the time. The downtime was caused by equipment failures, maintenance, power outages, and automatic shutoffs.

- In November 2001, EPA issued an ESD allowing shutdown of the groundwater P&T system for a natural attenuation study. The system was shut down on November 26, 2001. Before the system was shut down, the groundwater monitoring program was revised to monitor plume behavior under non-pumping conditions and to allow for the natural attenuation study.

**Figure 3. Extraction Well and Groundwater Monitoring Network [4]**

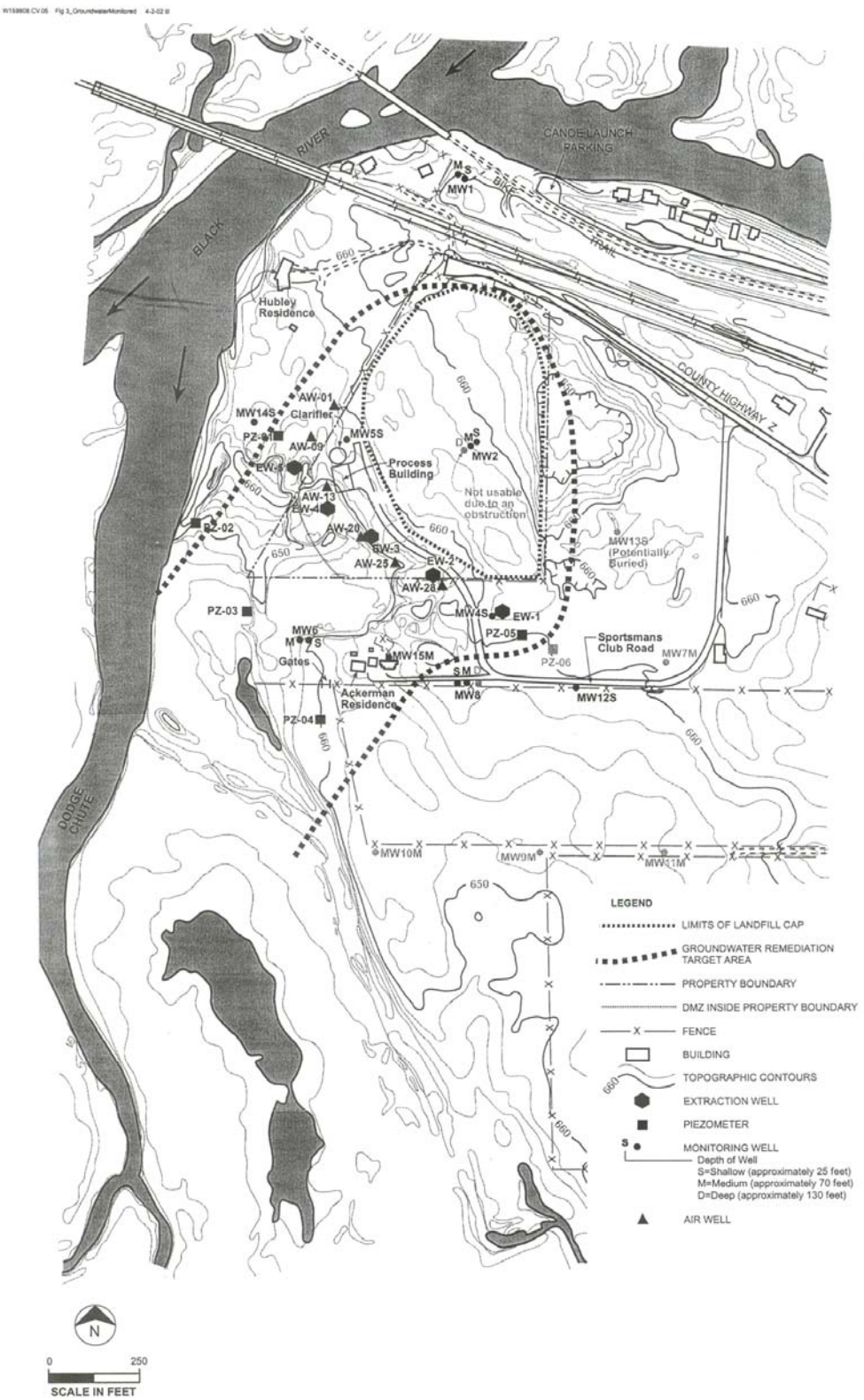


**Table 1. Groundwater Pumping Rates [9]**

| Year | Total Volume Extracted and Treated (gal) | Average Daily Extraction Rate (gal/day) | Average Pumping Rate (gpm) |
|---|---|---|---|
| 1994 | 176,247,120 | 855,568* | 594* |
| 1995 | 261,374,480 | 716,094 | 497 |
| 1996 | 247,556,080 | 678,236 | 471 |
| 1997 | 279,514,300 | 765,793 | 532 |
| 1998 | 257,877,450 | 706,514 | 491 |
| 1999 | 344,720,570 | 944,440 | 656 |
| 2000 | 365,955,490 | 1,002,618 | 696 |
| 2001 | 234,774,790 | 815,190* | 566* |
| **Total** | **2,168,020,280** | **810,557** | **563** |

**Notes:**
*Based on partial year due to startup in 1994 and shutdown in 2001.
gal = Gallons
gal/day = Gallons per day
gpm = Gallons per minute

### In Situ Bioventing

- In situ bioventing of soils consisted of injecting air into the area of petroleum NAPL contamination, to stimulate naturally occurring aerobic microbes and to promote biodegradation of the organic compounds. The area of NAPL contamination targeted for bioremediation was 2.5 acres downgradient of the landfill. The 3- to 5-foot NAPL layer was estimated to be at a depth of 8 to 12 feet bgs.

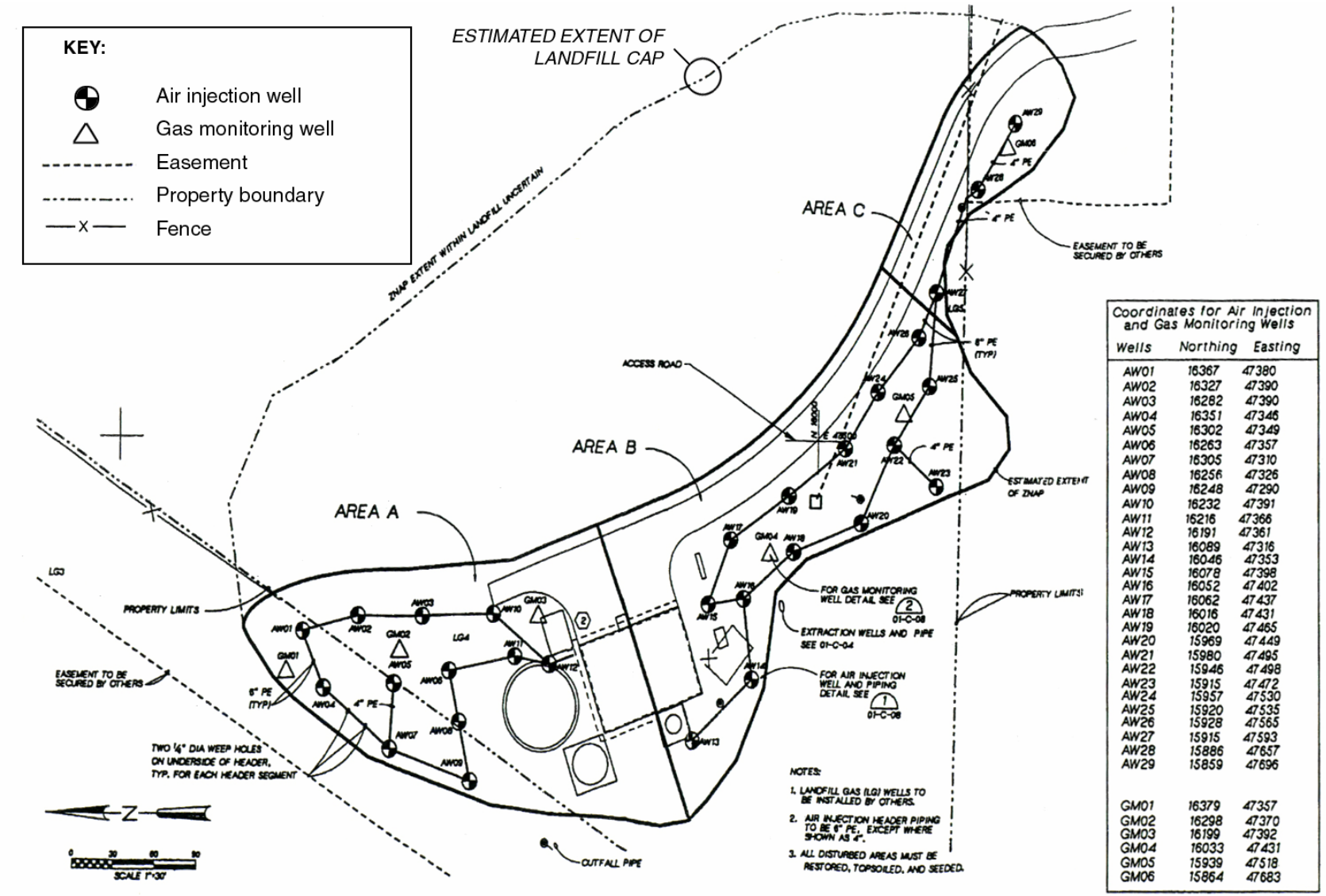
- In situ treatment to address contamination in the landfill was not considered technically feasible because of the potential for aerobic surface conditions to cause the landfill to smolder.

- The in situ remediation system, shown in Figure 4, consisted of 29 vertical air injection wells (AW-01 to AW-29), each 2 inches in diameter. The wells were installed on 40- to 50-foot centers, screened within the NAPL layer. The wells were connected by a header piping network to a single aeration well blower. The wells were equipped with valves used to modulate the air supply in response to the rate of oxygen consumption in each area. The system was designed to provide air at a rate of 100 to 420 standard cubic feet per minute (scfm). In addition, six soil gas probes were installed, with two probes per nest (one probe in the top and one in the bottom of the NAPL layer). The probes supported monitoring of subsurface conditions over time.

- Based on initial results for soil gas samples, the target NAPL area was divided into three subareas:

    - Area A – Oxygen conditions in Area A were low, but not depleted. Oxygen concentrations ranged from 9 to 19.1 percent; carbon dioxide concentrations were less than 7 percent; and methane was not detected above 1 percent. In general, soil in this area was less contaminated than in other subareas. There appeared to be ongoing microbial activity that was not limited by the availability of oxygen in soil gas.
    - Area B – Oxygen levels at Area B were significantly depleted (less than 2 percent). Carbon dioxide concentrations were as high as 17.5 percent. Methane concentrations were as high as 29 percent, although they generally measured less than 5 percent in most soils in this area. The area appeared to be the most contaminated, and microbial activity appeared to be limited by the low levels of oxygen.
    - Area C – Oxygen levels in Area C were similar to conditions in Area A. Although there was some oxygen depletion in the soil, oxygen levels were adequate to sustain microbial activity.

**Figure 4. In Situ Bioventing System – Vertical Air Injection Well Locations [2]**




*Coordinates for Air Injection and Gas Monitoring Wells*

| Wells | Northing | Easting |
|---|---|---|
| AW01 | 16367 | 47380 |
| AW02 | 16327 | 47390 |
| AW03 | 16282 | 47390 |
| AW04 | 16351 | 47346 |
| AW05 | 16302 | 47349 |
| AW06 | 16263 | 47357 |
| AW07 | 16305 | 47310 |
| AW08 | 16256 | 47326 |
| AW09 | 16248 | 47290 |
| AW10 | 16232 | 47391 |
| AW11 | 16216 | 47366 |
| AW12 | 16191 | 47361 |
| AW13 | 16089 | 47316 |
| AW14 | 16046 | 47353 |
| AW15 | 16078 | 47398 |
| AW16 | 16052 | 47402 |
| AW17 | 16062 | 47437 |
| AW18 | 16016 | 47431 |
| AW19 | 16020 | 47465 |
| AW20 | 15969 | 47449 |
| AW21 | 15980 | 47495 |
| AW22 | 15946 | 47498 |
| AW23 | 15915 | 47472 |
| AW24 | 15957 | 47530 |
| AW25 | 15920 | 47535 |
| AW26 | 15928 | 47565 |
| AW27 | 15915 | 47593 |
| AW28 | 15886 | 47657 |
| AW29 | 15859 | 47696 |
| GM01 | 16379 | 47357 |
| GM02 | 16298 | 47370 |
| GM03 | 16199 | 47392 |
| GM04 | 16033 | 47431 |
| GM05 | 15939 | 47518 |
| GM06 | 15864 | 47683 |

- The system operated from May 1994 to February 1997. The total system air flow ranged between 270 and 320 scfm.

- In 1998, as part of the first 5-year review, EPA concluded that bioventing was no longer affecting biodegradation, and the system was shut down. Based on confirmation of oxygen levels in soil gas, EPA determined that the bioremediation cleanup phase was completed.

**MNA**

- The ESD issued in November 2001 allowed for the temporary shutdown of the P&T system to evaluate the effectiveness of MNA, based on the long-term groundwater monitoring that was being conducted at the site. Previous monitoring results showed consistent, low levels of groundwater contaminants, with a few exceptions. In addition, none of the wells that were used as a primary source of drinking water were within the plume area. Because of the low levels of contamination and limited exposure pathways, it was determined that P&T was likely not more effective than less expensive remedies, such as MNA, to address remaining contamination.

- A final plan was prepared in December 2001 to study natural attenuation at the site. The monitoring network comprises 26 monitoring points, including 6 air injection wells, 5 piezometers, 13 monitoring wells, and 2 residential wells. Analytes include VOCs, metals, BTEX, naphthalene, and natural attenuation parameters such as oxidation-reduction potential, dissolved oxygen, pH, temperature, and specific conductance.

- The MNA study was expected to last for at least 2 years, and the P&T system was to be restarted if concentrations increased or if the plume started to migrate.

- Baseline monitoring of natural attenuation was performed in October 2001. The second and third monitoring events occurred in December 2002 and April 2003.

- In August 2002, WDNR assumed responsibility for managing the natural attenuation study and maintaining the idle groundwater P&T and in situ bioventing systems.

## OPERATING PARAMETERS THAT AFFECT TREATMENT COST OR PERFORMANCE [2,8,9]

Table 2 presents the operating parameters for each of the remedial technologies. These values were observed during operation of each remedy.

**Table 2. Operating Parameters Affecting Treatment Cost or Performance**

| Operating Parameter | Value |
|---|---|
| **Pump and Treat (Groundwater) [as of 2001]** | |
| pH | 5.2 – 7.2 |
| Pump rate | 563 gpm |
| **In Situ Bioventing (Soil) [based on data from 1994 through 1997]** | |
| Air flow rate | 270 – 320 scfm |
| Operating pressure/vacuum | 0.09 – 0.69 inches of water |
| Oxygen uptake rate | 1.08% (total average change) |
| Carbon dioxide evolution | Decreased to less than 1% |
| Biodegradation rate for organics | 0.55 – 1.05 mg/kg/day (3-year average) |
| Methane concentrations | Reduced to 0.1% |

| Operating Parameter | Value |
|---|---|
| **Monitored Natural Attenuation (Groundwater) [based on data from 2002 and 2003]** | |
| Temperature | 7.35 – 12.4 °C |
| Presence of breakdown products and levels of ethane, ethene, or methane | Methane: 0.58 – 2,200 µg/L |
| Conductivity | 0.209 – 0.709 mg/L |
| Alkalinity | 72 – 600 mg/L |
| Chloride | 1.8 – 16 mg/L |
| Redox conditions, dissolved oxygen levels, electron acceptors, electron donors | Oxidation/Reduction potential: 87 - 190mV,<br>Dissolved oxygen: 0.23 – 7.07 mg/L,<br>Nitrate (electron acceptor): <0.0076 – 2.2 mg/L<br>Sulfate (electron acceptor): <0.11 – 19.7 mg/L |
| Total Organic Carbon | 5 mg/L (approximate value) |

**Notes:**
gpm = Gallons per minute
µg/L = Micrograms per liter
mg/kg/day = Milligrams per kilogram per day
mg/L = Milligrams per liter
mV = Millivolts
ND = Not detected
scfm = Standard cubic feet per minute

## TIMELINE

Table 3 presents a timeline for remedial applications at this site.

**Table 3. Timeline for this Application**

| Activity | Timeline |
|---|---|
| Record of decision | August 14, 1990 |
| Groundwater pump and treat | June 8, 1994 to November 26, 2001 |
| In situ bioventing | May 1994 to February 1997 |
| First 5-year review | July 1998 |
| Explanation of significant difference to update groundwater goals | September 29, 2000 |
| Baseline monitoring for natural attenuation | October 2001 |
| Explanation of significant difference to allow temporary shutdown of pump and treat system and begin natural attenuation study | November 3, 2001 |
| Monitored natural attenuation monitoring and evaluation | Ongoing |
| Wisconsin Department of Natural Resources assumes responsibility for managing natural attenuation study and maintenance of idle pump and treat system and bioventing system | August 1, 2002 |
| Second 5-year review | July 2003 |

# TREATMENT SYSTEM PERFORMANCE

## CLEANUP GOALS/STANDARDS [1,3,10]

The ROD did not establish chemical-specific soil cleanup goals. The estimated cleanup goal was 80 to 95 percent reduction of the organic contaminant mass in the soil. Cleanup goals for groundwater were revised to the current state goals in the ESD in 2000. Table 4 shows the original and revised site cleanup goals.

**Table 4. State Groundwater Cleanup Goals for the Onalaska Municipal Landfill [1,3,10]**

| Compound | Original Cleanup Goal (µg/L) | Revised Cleanup Goal (µg/L) |
|---|---|---|
| 1,1-Dichloroethane | 0.04 | 85 |
| 1,1-Dichloroethene | 0.024 | 0.7 |
| 1,1,1-Trichloroethane | 40 | 40 |
| Trichloroethene | 0.18 | 0.5 |
| Benzene | 0.067 | 0.5 |
| 1,2,4- and 1,3,5- Trimethylbenzene* | NA | 96* |
| Toluene | 68.6 | 200 |
| Xylene | 124 | 1000 |
| Ethylbenzene | 272 | 140 |
| Lead | 5 | 1.5 |
| Arsenic | 5 | 5 |
| Barium | 200 | 400 |
| Manganese* | NA | 25 |
| Iron* | NA | 150 |

**Notes:**
*Not included in ROD list of contaminants
µg/L = Micrograms per liter
NA = Not applicable

The state cleanup goals for 1,1-DCA was revised to 85 µg/L based on a reclassification of 1,1-DCA from a type B-2 (probable human) carcinogen to a type C (possible human) carcinogen. State cleanup goals for benzene, TCE, and 1,1-DCE were revised because the original cleanup goals were below the standard laboratory detection limits for those compounds. In addition, state cleanup goals for ethylbenzene and lead have become more stringent. State cleanup goals for toluene, xylene, and barium were also revised.

Based on the original design of the P&T system, treated effluent was discharged to the Black River. This discharge was considered an on-site action, and therefore did not require a Wisconsin Pollutant Discharge Elimination System (WPDES) permit. However, the P&T system was required to meet the effluent standards listed in a WPDES permit, which included a daily maximum of 750 µg/L of BTEX. The state also mandated that effluent not be acutely toxic to test microorganisms.

## PERFORMANCE DATA ASSESSMENT [2,4,6,7,8,9]

### Groundwater P&T

- Performance data for the P&T system are available for May 2001 and for October and November 2001.

- By May 2001, concentrations for organic contaminants (except benzene and trimethylbenzene) had decreased to below cleanup goals, based on results for samples collected from 14 wells located on- and off-site. Trimethylbenzenes (1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene), although not included in the ROD list of contaminants, were monitored starting in early 2001. Arsenic, barium, iron, and manganese continued to be detected in groundwater at concentrations above the cleanup goals.

- As of October and November 2001, elevated concentrations of organic contaminants were present, primarily in well MW-5S. Trimethylbenzenes were present in wells MW-4S and MW-5S, with concentrations as high as 670 µg/L.

- As of November 2001, arsenic, barium, and manganese were present in several monitoring wells at levels as high as 14.9 µg/L arsenic; 997 µg/L barium; and 3,780 µg/L manganese. Iron was detected at concentrations below the cleanup goal, with the exception of well MW-14S, which had a concentration of 9,370 µg/L. According to the contractor, it is possible that the high concentration of iron was caused by a source other than the landfill. The concentration of iron in this downgradient well is higher than at monitoring points closer to the landfill.

**In Situ Bioventing**

- The in situ bioventing resulted in aerobic soil conditions, as evidenced by a steady increase in oxygen concentrations at the site, to levels as high as 21 percent. Carbon dioxide concentrations decreased from an average of 10 percent to less than 1 percent, and average methane concentrations decreased from 1.4 to 0.1 percent.

- The average hydrocarbon degradation rate was estimated to be 1 milligram per kilogram per day (mg/kg/day) in Areas A and B and 0.5 mg/kg/day in Area C.

- The average oxygen uptake in each of the three areas decreased to a level where it was concluded that active aeration was no longer needed to maintain aerobic conditions in the soil.

- The total mass of hydrocarbons removed was estimated to be 7,780 kilograms (kg) from Area A; 11,000 kg from Area B and 1,247 kg from Area C.

- EPA decided not to sample the affected soil layer to evaluate whether the ROD estimate of 80 to 95 percent destruction had occurred. This decision was made because of the large variation in initial VOC concentrations in soil over a small sampling area. EPA determined that no further remediation was required to protect human health and the environment because the groundwater P&T system was expected to capture residual contamination from the soil. The bioventing system was shut down in 1998.

**MNA**

- Monitoring of natural attenuation at the site is ongoing. Data are available for the baseline monitoring event (October 2001) and for two additional sampling events (December 2002 and April 2003).

- As of April 2003, two organic contaminants, trimethlybenzenes and methylene chloride, remained at concentrations above their respective cleanup goals. In addition, two inorganic compounds, iron and manganese, remain at concentrations above their respective cleanup goals.

- The results of the December 2002 and April 2003 sampling events showed the potential for natural attenuation at the site. According to the August 2003 MNA report, the "data indicates that natural attenuation may be an effective modification to the ROD." The data showed that the oxidation-reduction potential (ORP) ranged from 87 to 190 millivolts (mV), indicating that reductive dechlorination may be occurring. Concentrations of dissolved oxygen ranged from 0.23 to 7.07 milligrams per liter (mg/L), indicating aerobic conditions in the groundwater.

- The MNA report recommended continuing to monitor and evaluate natural attenuation to assess whether MNA can be effective at the site and achieve cleanup goals.

## TREATMENT SYSTEM COST

### COST INFORMATION [7]

Operation and maintenance (O&M) costs for the P&T system were provided in the second 5-year review report. O&M costs for 1998 through 2001, before the system was shut down, were about $200,000 per year including groundwater extraction, wastewater treatment plant O&M, sampling and monitoring, monitoring well maintenance, and reporting. After system shutdown, O&M costs were about $60,000 per year for 2002 and 2003.

## OBSERVATIONS AND LESSONS LEARNED

### PERFORMANCE OBSERVATIONS AND LESSONS LEARNED [2,7,9]

- The P&T system at the Onalaska Superfund Site reduced concentrations of contaminants in groundwater to below cleanup goals, with the exception of the organic contaminants trimethylbenzene, TCE, and benzene, and the metals arsenic, barium, iron, and manganese. Initial results from a MNA study suggest that natural attenuation at the site may be capable of addressing the remaining contaminants in groundwater to cleanup goals; however, further evaluation is needed and the MNA study is ongoing. In addition, the use of in situ bioventing reduced concentrations of contaminants in soil.

- During the remedial investigation of the site, trimethylbenzenes (1,2,4-trimethlbenzene and 1,3,5-trimethylbenzene) were not included in the original list of chemicals of concern and groundwater samples were not analyzed for these compounds. However, trimethylbenzenes were recently found as prominent chemicals in the groundwater at the site. Sampling for these chemical compounds began in 2001 and sampling data indicate that trimethylbenzenes exceed the state goal in 4 of the 26 wells sampled. Trimethylbenzenes were not evaluated in the original risk assessment; the toxicity data are still valid but may need to be modified to include the trimethylbenzenes.

## REFERENCES


1. U.S. Environmental Protection Agency (EPA). Record of Decision. Onalaska Municipal Landfill, Onalaska, WI. August 14, 1990.

2. CH2M Hill. In Situ Bioremediation Final Report. Onalaska Municipal Landfill. July 30, 1997.

3. EPA. Explanation of Significant Differences: Onalaska Municipal Landfill, Operable Unit (OU) 1, Onalaska, WI. September 29, 2000.

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5. EPA. Explanation of Significant Differences: Onalaska Municipal Landfill, OU1, Onalaska, WI. November 13, 2001.

6. EPA. Five-Year Review. Onalaska Municipal Landfill Site. 1998.

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## ANALYSIS PREPARATION

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