COST AND PERFORMANCE REPORT

Pump and Treat of Contaminated Groundwater
at the Ott/Story/Cordova Superfund Site,
North Muskegon, Michigan

November 2000

EPA

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

November 2000

SITE INFORMATION

IDENTIFYING INFORMATION

Site Name: Ott/Story/Cordova Superfund Site

Location: North Muskegon, Michigan

Operable Unit: OU1 and OU2

CERCLIS #: MID060174240

ROD Date: September 29, 1989 (OU1); September 29, 1990 (OU2)

TREATMENT APPLICATION [15,16]

Type of Action: Remedial

Period of Operation: February 1996 - Ongoing (concentration data available through December 1999, data on quantity treated available through October 2000)

Quantity of material treated during application: 1.1 billion gallons of groundwater through October 2000

BACKGROUND

Historical Activity that Generated Contamination at the Site: Specialty organic chemical production

Waste Management Practice That Contributed to Contamination: Disposal of industrial wastewaters and residuals from chemical production in unlined seepage lagoons

Facility Operations [9,10,25]:

- From 1958 to 1985, a variety of organic chemicals were manufactured at the site. Ott Chemical manufactured synthetic organic chemicals at the facility from 1958 until 1972 when it was purchased by Story Chemical Company. Story Chemical Company was subsequently purchased by Cordova Chemical Company in 1977, and operated until 1985 when the facility closed.

- In the early 1960s, soil and groundwater contamination were discovered at the site, including volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs). In 1978, 10,000 55-gallon drums of waste material and 8,000 cubic yards of buried sludges and contaminated soil were removed from the site under a Michigan Department of Natural Resources order. Residential wells near the facility were found to be contaminated, and in November 1982 a permanent water supply alternative was installed for homes near the groundwater plume.

- The site was listed on the National Priorities List (NPL) in September 1983, and a Remedial Investigation (RI) was conducted from January 1988 through May 1988. More than 90 contaminants were identified in the groundwater, including benzene, toluene, chlorobenzene, methylene chloride, chloroform, 1,1-dichloroethane (DCA), 1,2-DCA, vinyl chloride, and tetrachloroethene (PCE), PCBs, heptachlor epoxide, zinc, copper, and nickel.

Regulatory Context [11,12,13,14]:

- Three Records of Decision (RODs) were issued for this site - OU1 addressing plume containment was signed September 29, 1989; OU2 addressing aquifer restoration was signed September 29, 1990; and OU3 addressing soil remediation was signed on September 27, 1993 and amended on February 26, 1998. This case study addresses the remediation of OU1 and OU2.

Groundwater Remedy Selection: The selected groundwater remedy for the site is pumping and treating of contaminated groundwater with direct discharge of the treated groundwater in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit.

SITE LOGISTICS/CONTACTS [8]

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*Indicates primary contact

MATRIX DESCRIPTION

MATRIX IDENTIFICATION

Type of Matrix Processed Through the Treatment System: Groundwater

CONTAMINANT CHARACTERIZATION [4,10,13,16]

Primary Contaminant Groups: Halogenated and non-halogenated VOCs, PCBs, pesticides, and metals

- Maximum concentrations of contaminants detected in groundwater during the RI included 1,2-DCA (110,000 ug/L), 1,1-dichloroethene (DCE) (7,900 ug/L), benzene (3,800 ug/L), PCE (24,000 ug/L), toluene (38,000 ug/L), and vinyl chloride (50,000 ug/L).

- Concentrations of contaminants such as PCE, 1,2-DCA, and vinyl chloride at the site are greater than one percent of the contaminant solubility. However, dense non-aqueous phase liquids (DNAPLs) have not been observed at the site.

MATRIX CHARACTERISTICS AFFECTING TREATMENT COSTS OR PERFORMANCE

Hydrogeology [10,13]:

Two aquifers were identified at the site - an unconfined upper aquifer containing an upper and lower unit, and a lower aquifer. The unconfined aquifer extends to a depth of approximately 65 feet below ground surface (bgs). Between 65 and 85 feet bgs, layers of silts and clays tend to form a barrier separating the unconfined aquifer from the lower aquifer, which is present at 85 feet bgs. Groundwater flow is generally to the southeast in the upper unconfined aquifer and to the east in the lower aquifer. Table 1 summarizes information about the two units. Leakage from the lower aquifer up through the barrier and into the unconfined aquifer is suspected based on the interbedded nature of the barrier separating the upper and lower aquifers and the pressure difference of the groundwater between the two units (the lower aquifer is under a higher pressure than the upper unconfined aquifer).

The estimated volume of groundwater treated through October 2000 is 1.1 billion gallons.

Figures 1, 2, and 3 illustrate the contaminant plume for total organic compounds (TOC) in January 1996 in the upper unconfined aquifer, lower unconfined aquifer, and lower (confined) aquifer, respectively.

Table 1. Technical Aquifer Information [10,13]

Unit Name	Thickness (ft)	Conductivity (ft/day)	Velocity (ft/day)	Flow Direction
Unconfined aquifer	65	2.7-37	0.05-1.1	Southeast
Lower aquifer	50	0.065-0.076	0.0001-0.0003	East

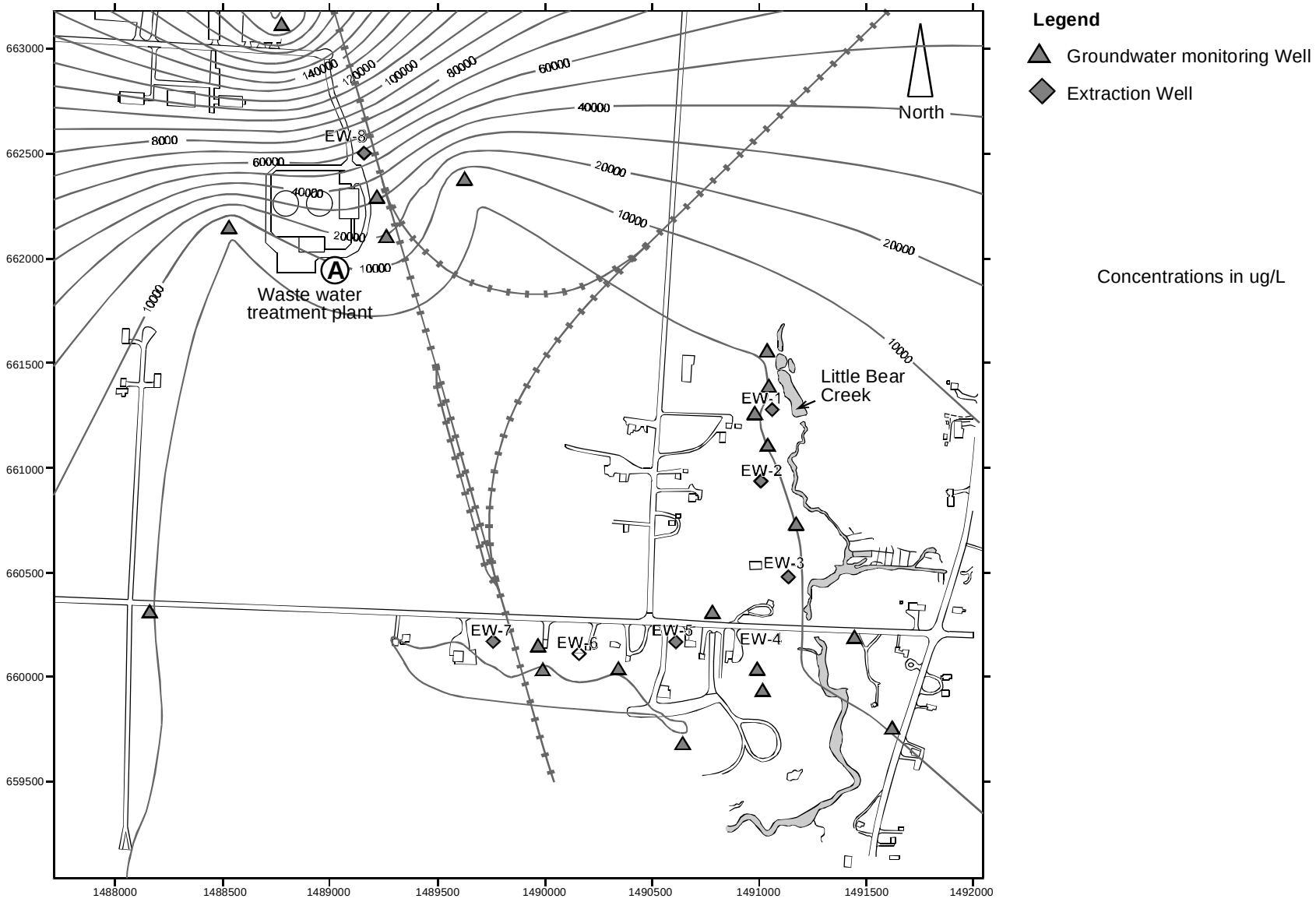
TREATMENT SYSTEM DESCRIPTION

PRIMARY TREATMENT TECHNOLOGY [22]

Pump and treat (P&T) using diffused air stripping, sand filtration, and powdered activated carbon treatment (PACT)

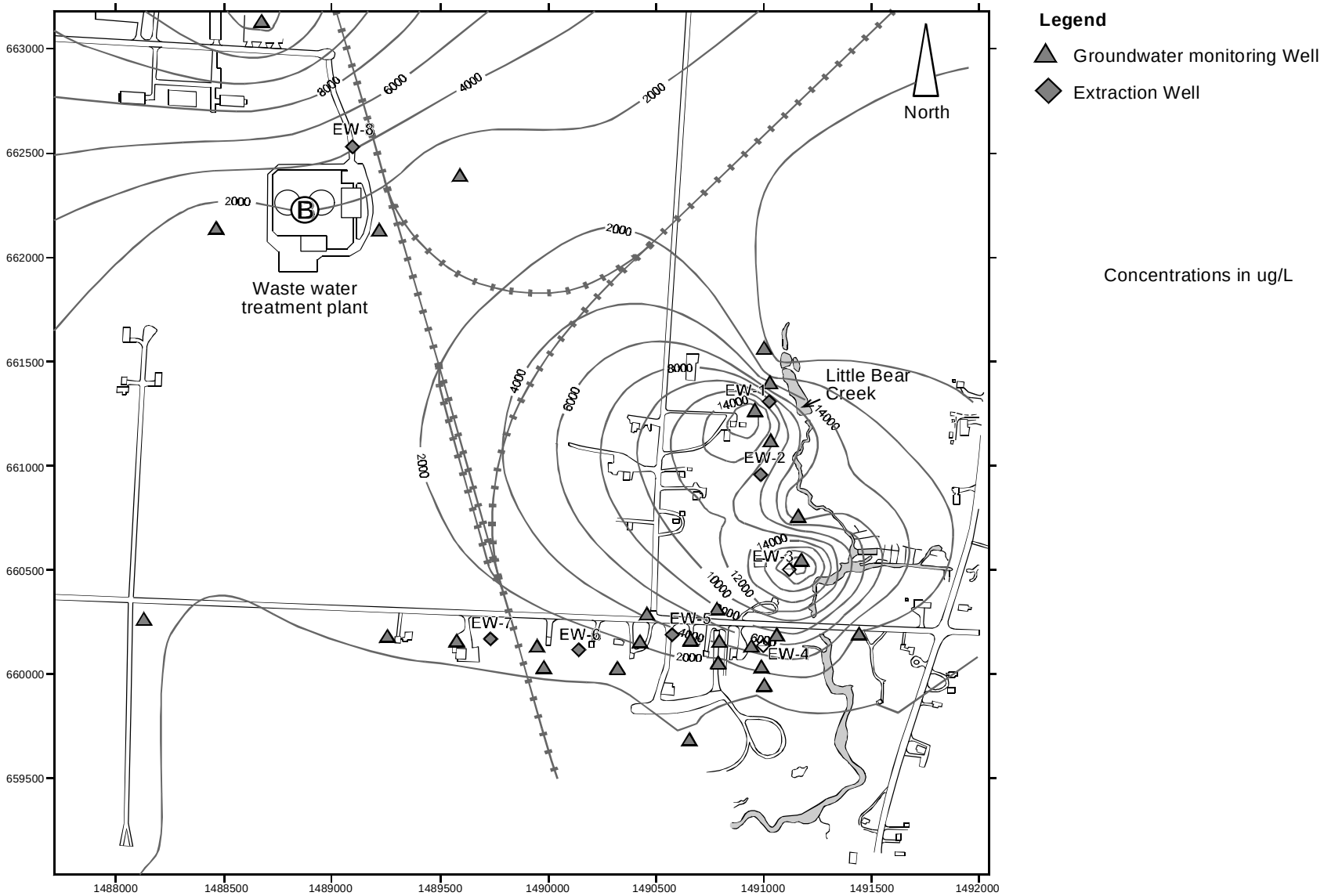
SUPPLEMENTARY TREATMENT TECHNOLOGY [22]

Thermal oxidation to treat off-gases; filter presses to dewater sludge



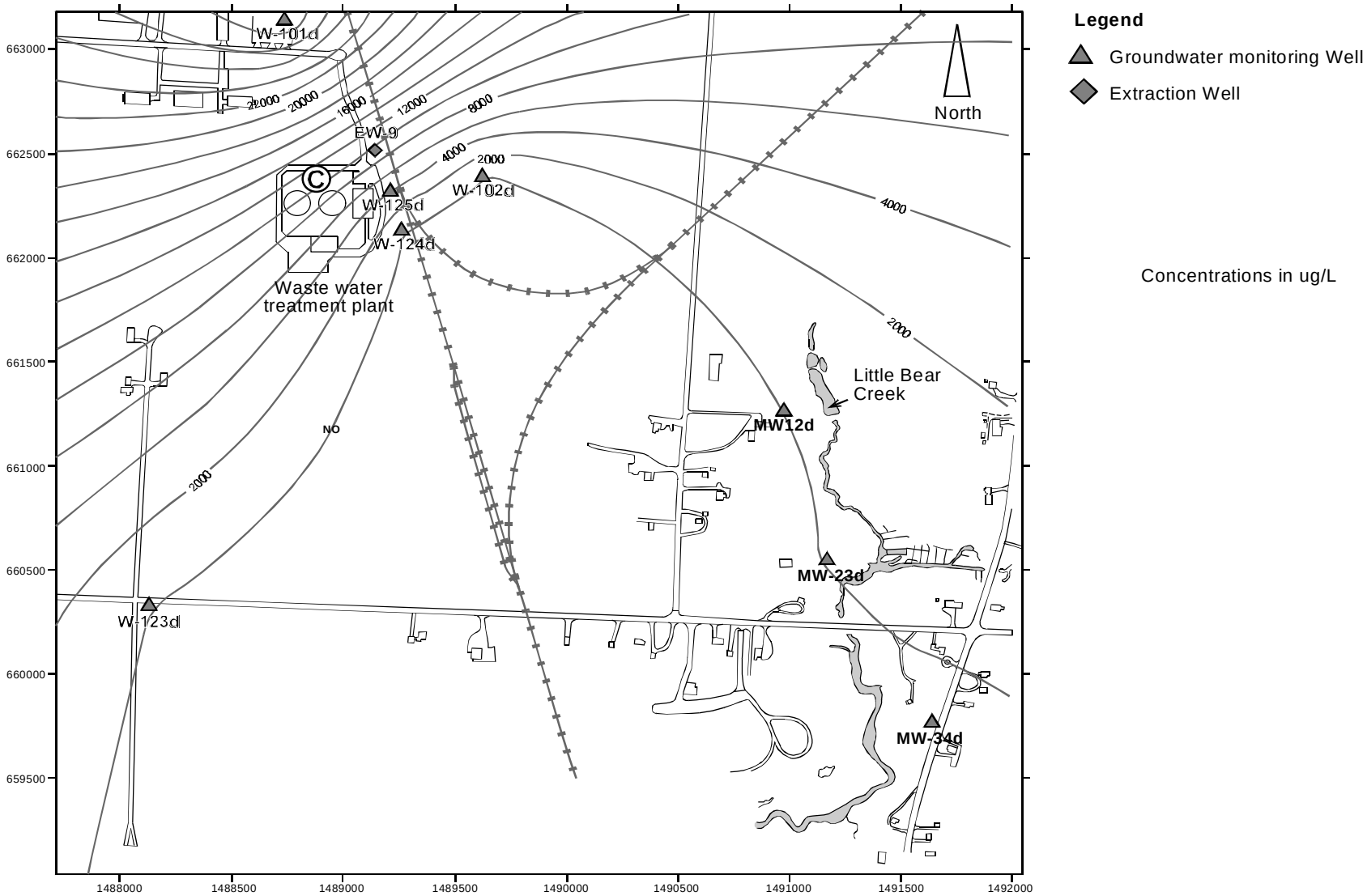
Source: Modified from Black and Veatch Special Projects Corp. *Ott/Story/Cordova Operable Units 1 and 2 Groundwater Summary Report-- Quarters 14.* October 1996

Figure 1. TOC Concentrations in the Upper Unconfined System (January 1996)



Source: Modified from Black and Veatch Special Projects Corp. Ott/Story/Cordova Operable Units 1 and 2. Groundwater Summary Report-- Quarters 1 and 2. October 1996

Figure 2. TOC Concentrations in the Lower Unconfined System (January 1996)



Source: Modified from Black and Veatch Special Projects Corp. Ott/Story/Cordova Operable Units 1 and 2. Groundwater Summary Report-- Quarters 1 and 2. October 1996

Figure 3. TOC Concentrations in the Confined System (January 1996)

SYSTEM DESCRIPTION AND OPERATION [1,2,4,5,7,8,15,16,19,20,22,23]

System Description:

- As shown in Figure 4, the groundwater treatment system at the Ott/Story/Cordova site includes extraction wells; diffused air strippers (DAS), PACT, sand filters, and granular activated carbon to treat extracted groundwater prior to discharge to the Muskegon River; a thermal oxidation unit to treat vapors from the air stripper; and filter presses to dewater sludges (from the PACT unit) prior to offsite disposal.

- The extraction system, shown in Figure 5, includes 10 extraction wells (EW-1 through EW-10), installed in the upper and lower aquifers, as shown in Table 2. Wells EW-1 through EW-9 have been operating since January 1996; well EW-10 has been operating since November 1999. EPA and MDEQ project managers requested that well EW-10 be installed in a highly contaminated area to better use the excess organic treatment capacity of the system and to reduce overall cleanup time for the site.

Table 2. Extraction Well Data [16,22]

Well Name	Unit Name (Confirm well designations)	Screen Depth (ft)	Pump Intake Depth (ft)	Well Depth (ft)	Design Yield (gal/min)
EW-1	Upper	23.5-83.5	79.5	85.5	100
EW-2	Upper	26.5-84.5	80.5	86.5	100
EW-3	Upper	28.0-93.0	89.0	95.0	100
EW-4	Upper	24.0-97.5	93.5	99.5	100
EW-5	Upper	25.0-93.0	89.0	95.0	75
EW-6	Upper	22.0-83.5	79.5	85.5	75
EW-7	Upper	19.5-88.5	84.5	90.5	75
EW-8	Upper	13.0-73.5	69.5	75.5	135
EW-9	Lower	85.0-148.0	144.0	150	40
EW-10	Upper	40.0-70.0	25.0	75.0	40

- Extracted groundwater is pumped to the DAS system to remove volatile contaminants. The system includes two tanks and a blower which injects compressed air into the groundwater near the bottom of the tanks. Off-gases from the top of the DAS tanks are drawn under vacuum into the thermal oxidation unit to treat residual organics prior to release to the atmosphere.

- After treatment in the DAS system, the groundwater is pumped to a two-stage PACT system to remove semivolatile organic compounds and other substances such as ammonia, metals, cyanide, and oxygen-depleting chemicals as measured by biological oxygen demand (BOD) and chemical oxygen demand (COD). Sludge generated during PACT system treatment is dewatered in filter presses prior to offsite disposal.

- Groundwater from the PACT system is sent through a series of three tertiary sand filters to remove suspended solids, then through a granulated activated carbon system for final polishing. The treated groundwater is discharged under an NPDES permit to the Muskegon River.

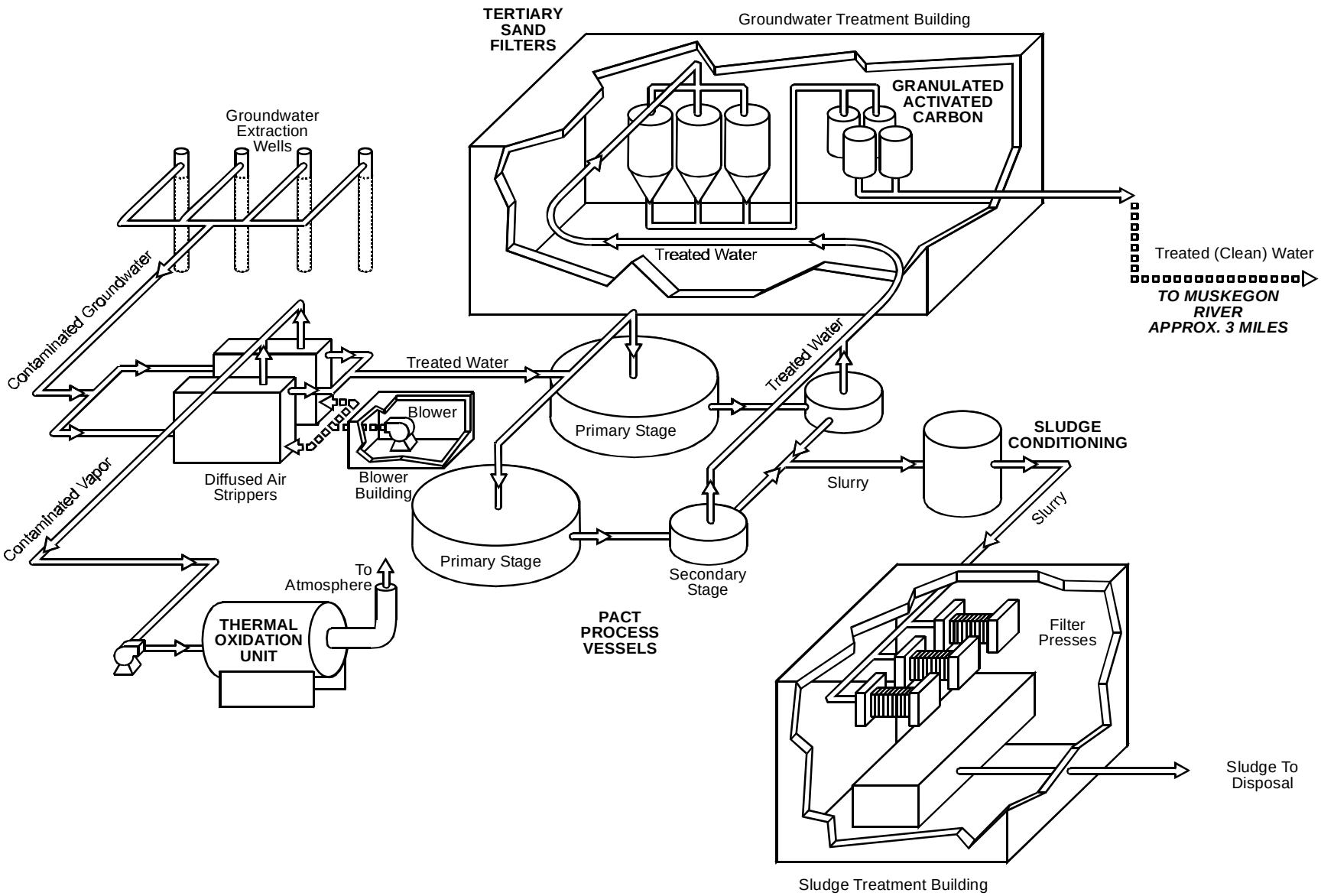
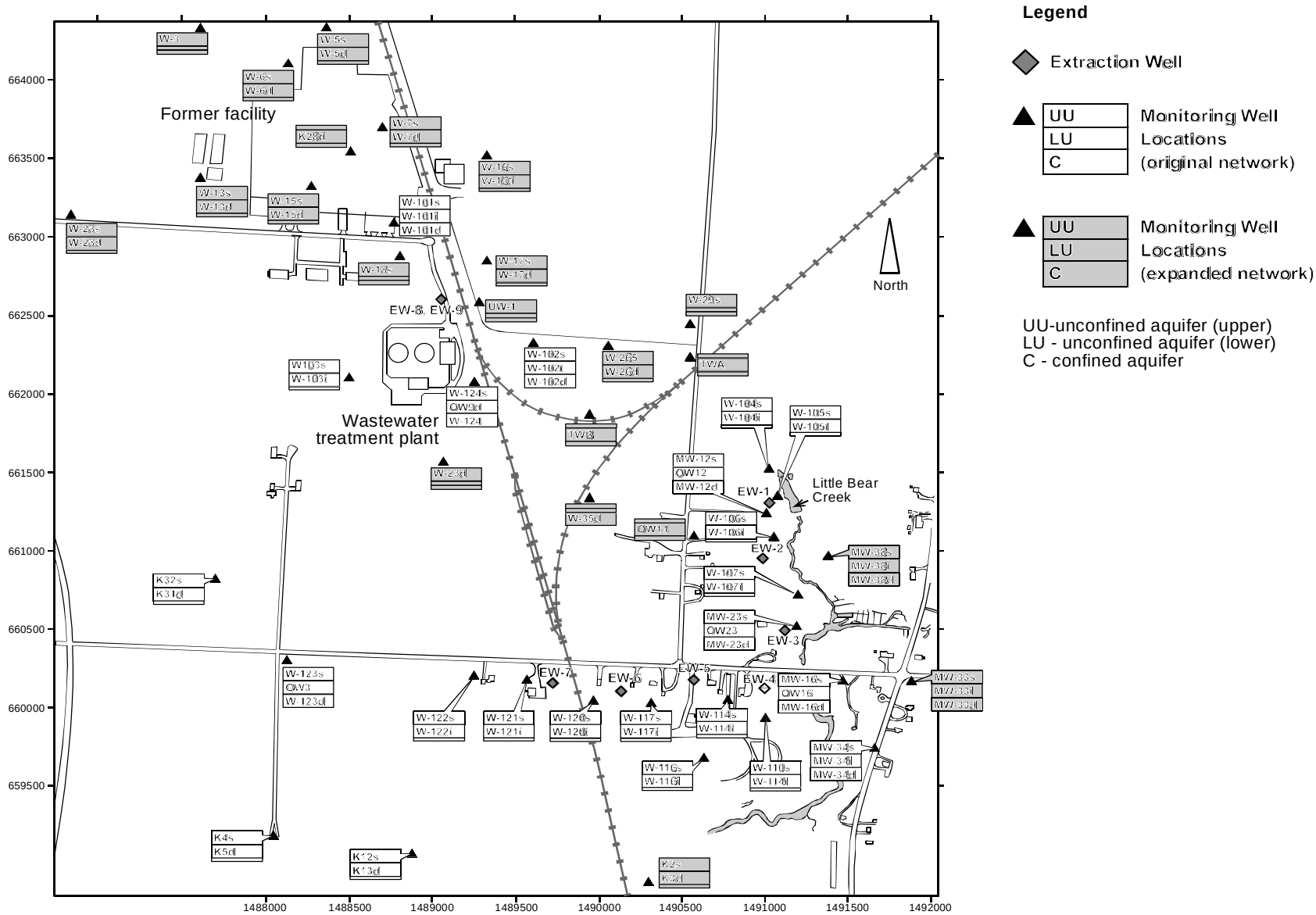


Figure 4. Groundwater Treatment System [8, 22]



Source: Modified from Black and Veatch Special Projects Corp. Ott/Story/Cordova Operable Units 1 and 2. Groundwater Summary Report-- Quarter 14. August 1999

Figure 5. Locations of Extraction and Monitoring Wells

- The monitoring well system, shown in Figure 5, includes 90 wells. The initial monitoring network of 54 wells was installed during the 1970s and 1980s, with the bulk of these wells installed in 1988 as part of the RI. Between November 1994 and May 1995, the network was expanded, adding 36 monitoring wells, to more fully evaluate the contaminant plume in the following three areas: (1) upgradient of the original monitoring network; (2) between the groundwater treatment facility area and extraction wells near Little Bear Creek and River Road; and (3) downgradient of the containment system and Little Bear Creek. Groundwater monitoring is performed quarterly with data collected from selected monitoring wells during each sampling event. In addition, data are collected from the ten extraction wells. Groundwater samples are analyzed for volatile and semivolatile organics using SW-846 Methods 8260B and 8270C, respectively.

System Operation:

- The system began operating in January 1996 and operations are ongoing at the site. The system is operated seven days per week, 24 hours per day. According to the RPM, since startup, the system has been operational 97 percent of the time.

- The groundwater treatment facility discharge pipe was determined to be undersized for the volume of groundwater that needed treatment. In March 1998, after performing an analysis and considering alternatives to alleviate the groundwater treatment facility flow problem, a decision was made to construct a larger treated water effluent pipe. Start-up of the new pipe line began in August 1999.

- The average extraction rate for the system between February 1996 through July 1999 was estimated by the RPM to be approximately 500 gpm. In August 1999, the new larger treated water effluent pipe became operational. Therefore, between August 1999 and October 2000, the average extraction rate was estimated by the RPM to be approximately 800 gpm. According to the RPM, the average fluctuates month to month as the number of wells on-line varies with maintenance of the wells.

- In June 1997, reduced extraction well flows and pump cyclings indicated that biofouling of the extraction wells was occurring, resulting in reduced groundwater flow to the treatment system. To address the problem, a program for extraction well preventative maintenance, cleaning, and repair was initiated.

- According to the RPM, future plans for system operation include repair of well EW-6, addition of well EW-11, and testing of different operating scenarios to identify alternatives that may result in a cost savings.

OPERATING PARAMETERS AFFECTING TREATMENT COST OR PERFORMANCE

Table 3 presents the major operating parameters affecting cost or performance for this technology.

Table 3. Performance Parameters [13,18,23]

Parameter	Value
Average Extraction Rate	500 gpm (2/96 through 2/99) 800 gpm (3/99 through 10/00)
Performance Standard (effluent) (ug/L)	NPDES Effluent Limitations Purgeable halocarbons - 5 Purgeable aromatics - 5 Heptachlor Epoxide - 0.003 4,4'-DDD - 0.0002 Total Phosphorus - 500 (7 lbs/day) Total Mercury - 0.0013

Table 3. Performance Parameters [13,18,23] (continued)

Parameter	Value
Remedial Goal (Aquifer) (ug/L)	Benzene - 5 Chlorobenzene - 60 Chloroform - 0.19 1,2-Dichlorobenzene - 600 1,4-Dichlorobenzene - 75 1,2-Dichloroethane - 0.4 1,1-Dichloroethene - 0.06 cis-1,2-Dichloroethene - 70 trans-1,2-Dichloroethene - 100 Ethylbenzene - 74 Heptachlor - 0.0004 Heptachlor Epoxide - 0.0002 n-Nitroso-diphenylamine - 7 Tetrachloroethene - 5 Toluene - 790 1,1,1-Trichloroethane - 200 Trichloroethene - 3 Vinyl Chloride - 0.015 Xylenes - 280

Timeline

Table 4 presents a timeline for the major events performed during this remedial project.

Table 4. Project Timeline [15,16]

Start Date	End Date	Activity
9/82	---	Ott/Story/Cordova added to the National Priorities List (NPL)
9/89	---	RI/FS completed
9/89	---	ROD for OU # 1 signed
9/90	---	ROD for OU # 2 signed
10/93	---	Original groundwater treatment facility construction started
4/95	9/95	Extraction well installation and development
2/96	Ongoing	Groundwater extraction, treatment, and quarterly monitoring
6/97	---	Initiation of extraction well preventative maintenance, cleaning, and repair program
6/98	Ongoing	Quarterly monitoring in an expanded network of monitoring wells
3/99	8/99	Construction of new, larger 3-mile treated water effluent pipe
11/99	---	Start-up of new extraction well, EW-10

TREATMENT SYSTEM PERFORMANCE

CLEANUP GOALS/STANDARDS [13,15]

Table 3 lists the specific aquifer cleanup goals for 19 contaminants. The goals were based on the following three sources: maximum contaminant levels (MCLs) under the Safe Drinking Water Act, Part 201 of the Michigan Natural Resources and Environmental Protection Act, and concentrations intended to restore levels of risk to potential users of the aquifer to 10^{-6} for a given carcinogen, such that the cumulative risk is below 10^{-4}. For each contaminant, the source with the lowest concentration was used as the basis for the cleanup goal.

TREATMENT PERFORMANCE GOALS [13]

Treated groundwater must meet discharge criteria included in the NPDES permit. Specific criteria are included in Table 3.

PERFORMANCE DATA ASSESSMENT [4,5,7,13,16,21,23]

- Quarterly data are available from January 1996 through June 1999 for total organic carbon (TOC), selected by EPA as an indicator compound for organic contaminants at the site, including VOCs and semivolatile organic compounds. Data on concentrations of individual constituents are available for a sampling event conducted in December 1999.

- Figure 6 shows TOC concentrations in monitoring wells W-103s and W-103i located just west of the groundwater treatment system. Figure 7 shows TOC concentrations in wells W-101s, W-101i, and W-101d located at the southeast corner of the former facility. Well 101s was one of the most contaminated wells at the site. As of March 1999, TOC concentrations were 356,656 ug/L in well W-101s; 23,966 ug/L in well W-101d; 6,231 ug/L in well W-101i; 1,292 ug/L in well W-103i; and 667 ug/L in well W-103s. The greatest fluctuation in TOC concentrations has been observed in wells W-101s and W-103i.

- In addition, isoconcentration contours maps are available for January 1996 (start of treatment) and June 1999 (most recent isoconcentration data available) for the upper unconfined aquifer (upper and lower units) and for the lower aquifer. The maps for January 1996 are presented in Figures 1 though 3. The maps for June 1999 are presented in Figures 8 through 10. As shown in Figures 1 and 8, the concentrations of TOC in the unconfined aquifer (upper unit) just south of the treatment system (at Point A) have decreased from 10,000 ug/L in January 1996 to 1,000 ug/L in June 1999. The concentration of TOC in the unconfined aquifer (lower unit) near the treatment system (at Point B), shown in Figures 2 and 9, has remained constant at about 2,000 ug/L. As shown in Figures 3 and 10, the concentration of TOC in the lower aquifer near the treatment system (at Point C) has decreased from 10,000 ug/L in January 1996 to 1,000 ug/L in June 1999. Concentrations at points A, B, and C were selected for comparison because these locations are amongst the most contaminated areas at the site.

- As of the time of this report, the plume had not been completely delineated. The groundwater monitoring network, expanded in June 1998, is intended to provide additional data to define the plume.

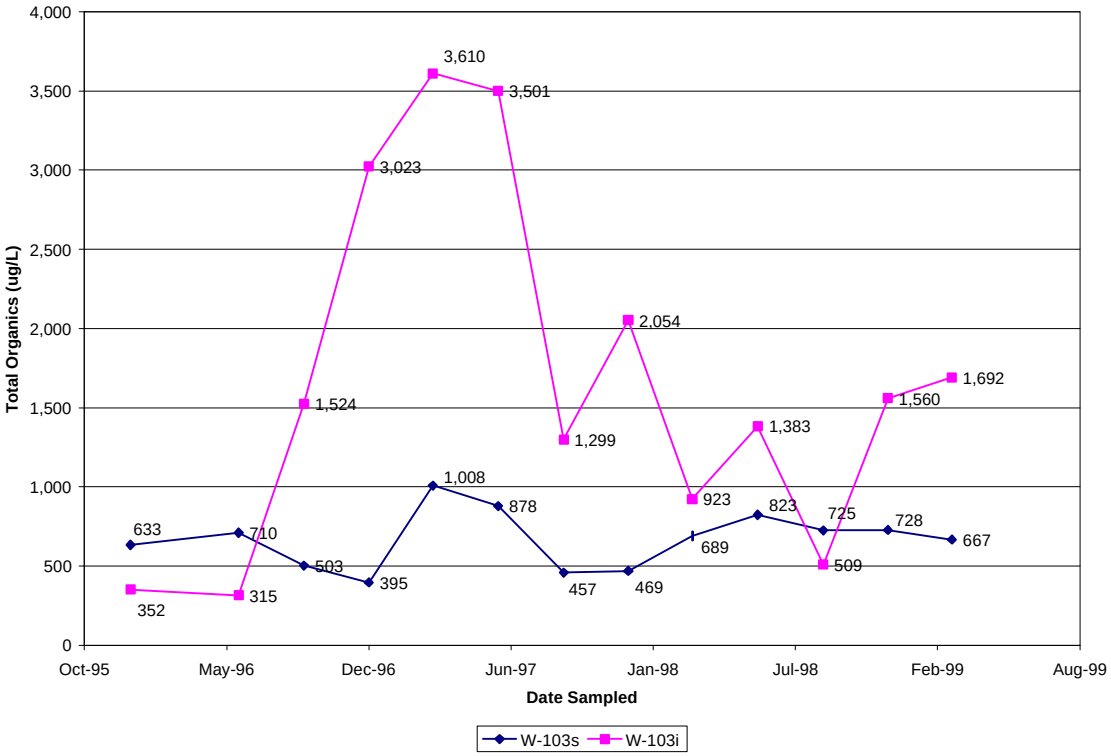


Figure 6. TOC Concentrations in Monitoring Wells W-103s and W-103i [4]

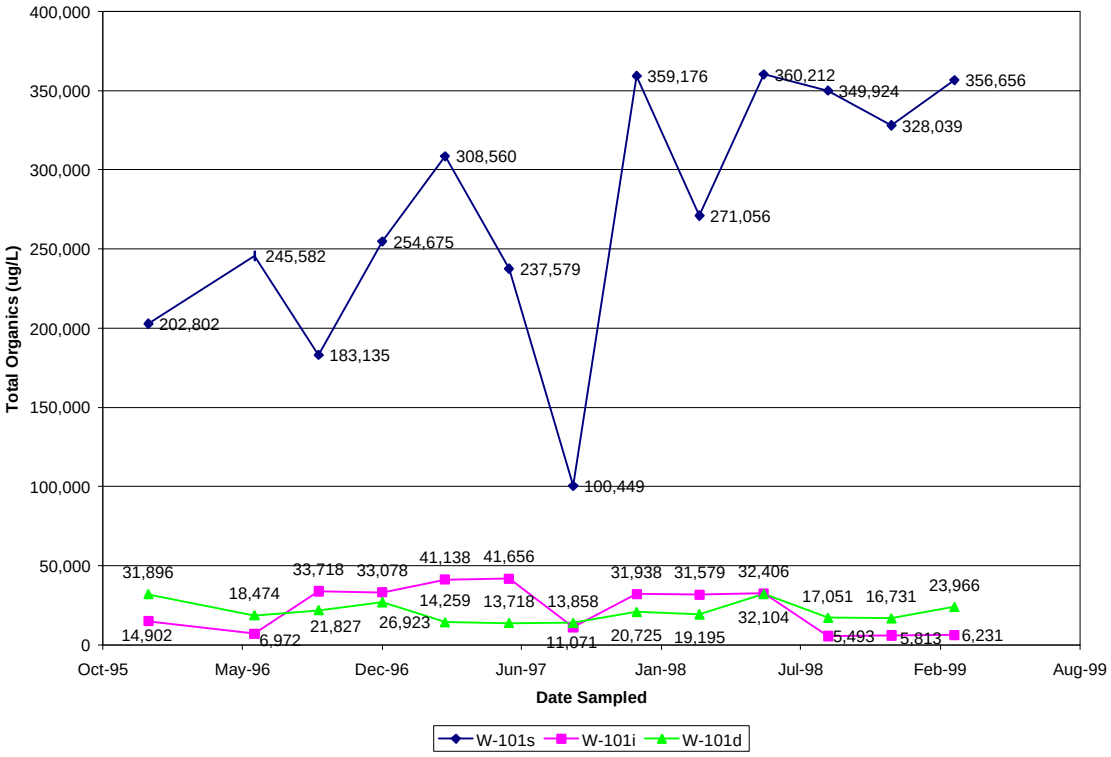
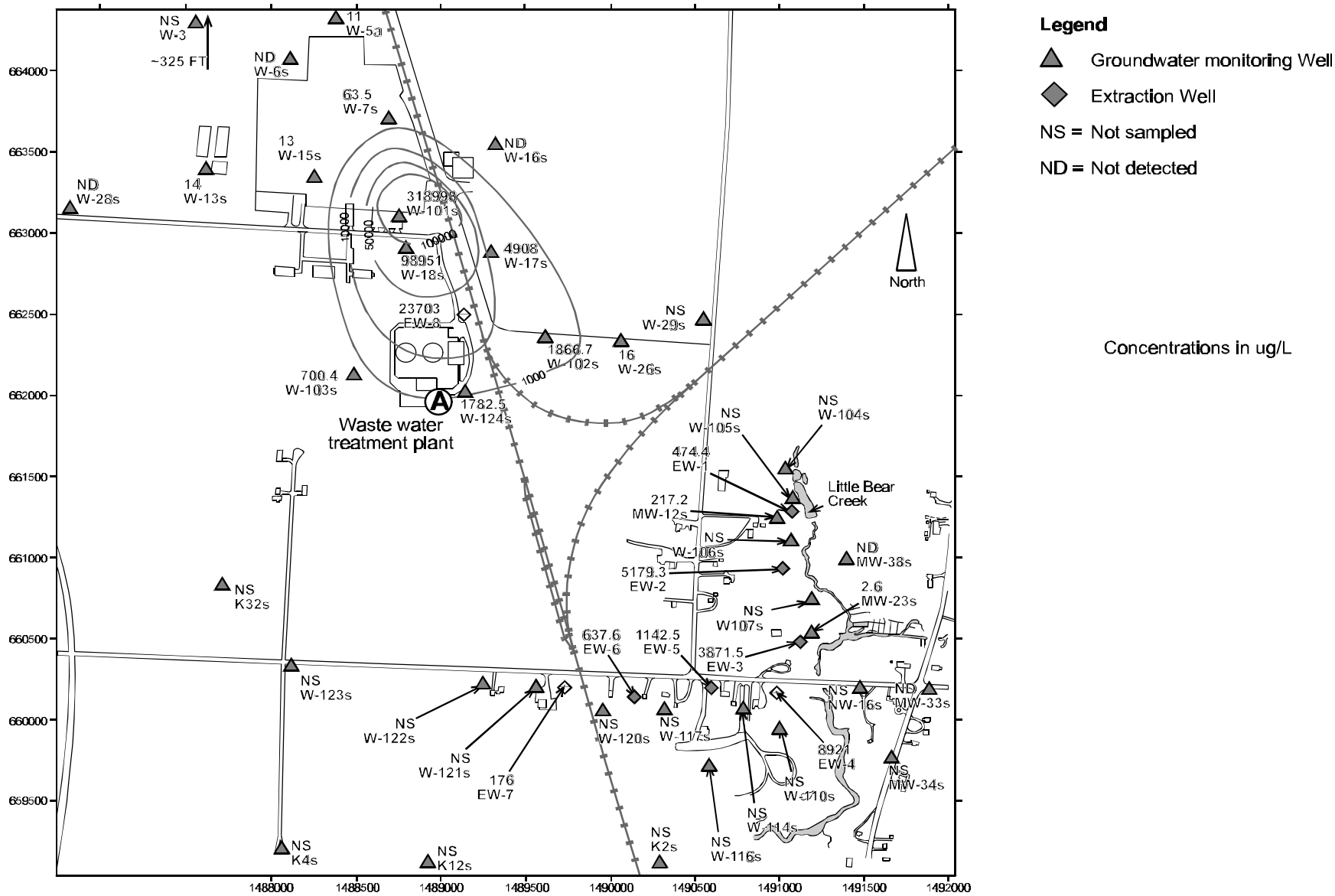
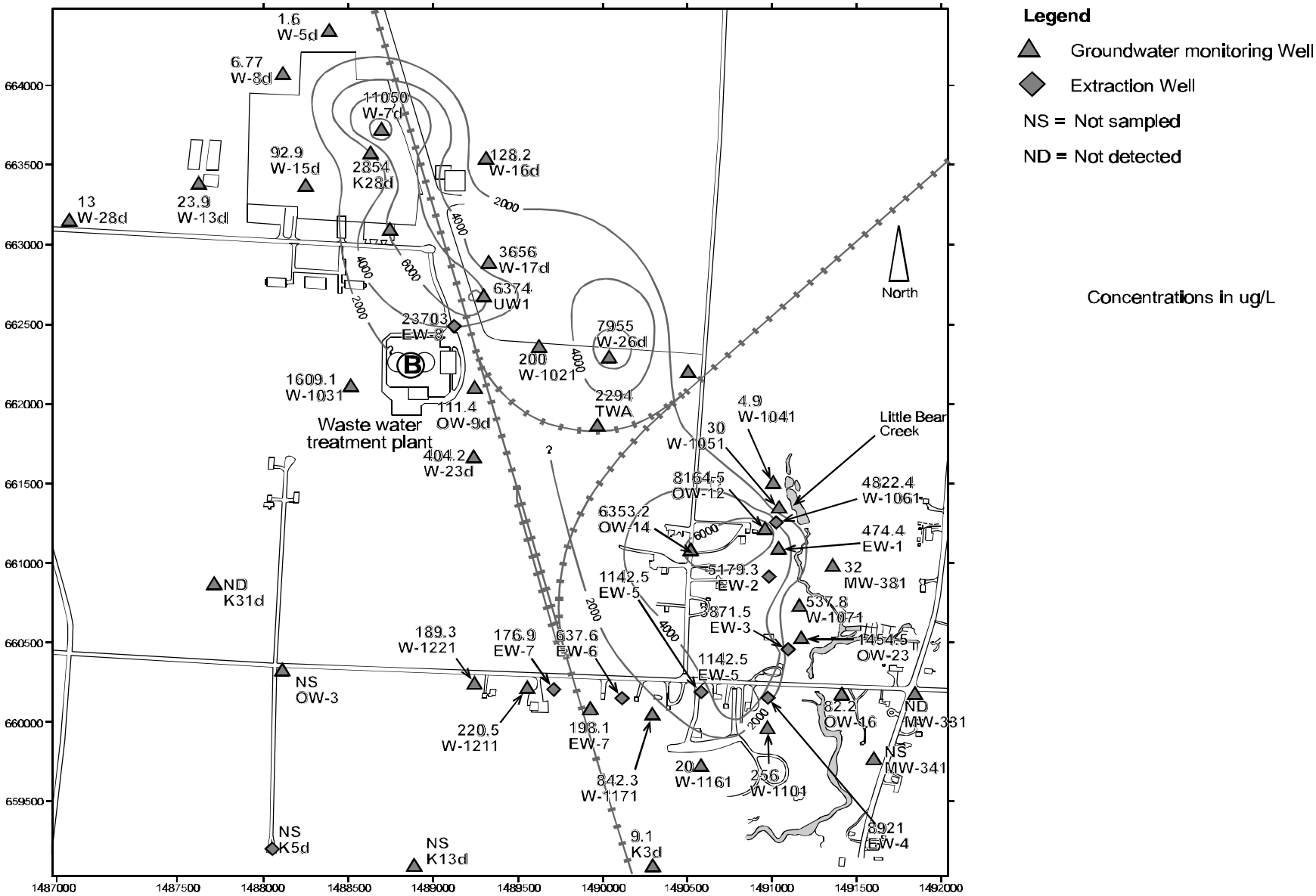


Figure 7. TOC Concentrations in Monitoring Wells W-101s, W-101i, and W-101d [4]



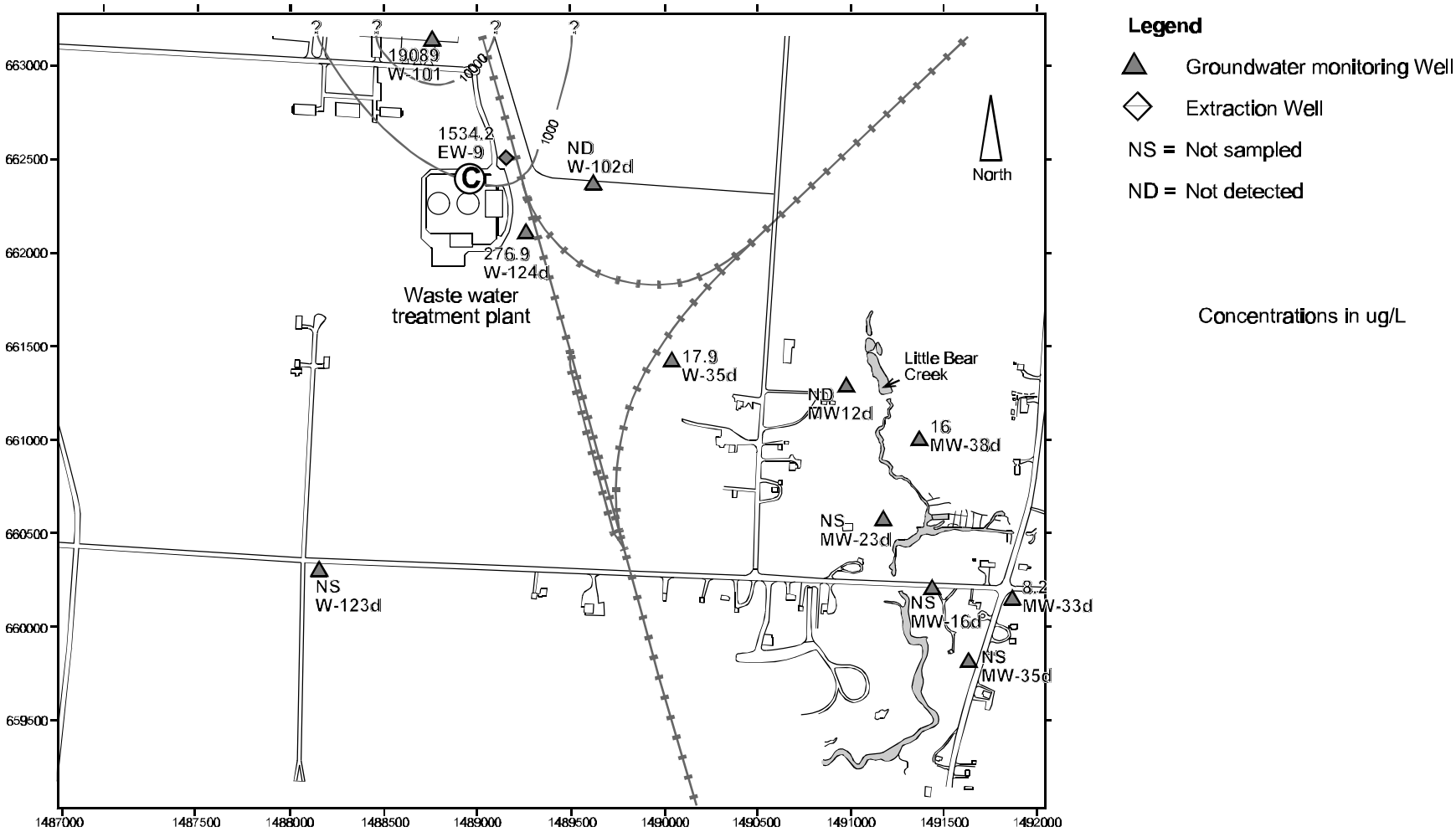
Source: Modified from Black and Veatch Special Projects Corp. Ott/Story/Cordova Operable Units 1 and 2. Groundwater Summary Report-- Quarter 14. August, 1999.

Figure 8. TOC Concentrations in the Upper Unconfined System (June 1999)



Source: Modified from Black and Veatch Special Projects Corp. *Ott/Story/Cordova Operable Units 1 and 2 Groundwater Summary Report-- Quarter 14.* August 1999

Figure 9. TOC Concentrations in the Lower Unconfined System (June 1999)



Source: Modified from Black and Veatch Special Projects Corp. *Ott/Story/Cordova Operable Units 1 and 2 Groundwater Summary Report-- Quarter 14*. August 1999

Figure 10. TOC Concentrations in the Confined System (June 1999)

- In December 1999, more detailed analyses were performed for the groundwater samples to evaluate progress towards the specific cleanup goals in the upper aquifer (upper and lower units) and in the lower aquifer. Contaminant concentrations were compared with cleanup goals for 13 of the 19 constituents for which cleanup goals have been established, as shown in Table 5. The contaminant concentrations for four of the remaining constituents (chloroform, 1,2-DCA, 1,1-DCE, and vinyl chloride) were not detected in December 1999 and the detection limit is greater than the cleanup goals established for the constituents. The remaining two constituents (heptachlor and heptachlor epoxide) were not analyzed in December 1999 because they consistently have concentrations below detection limits. As with chloroform, 1,2-DCA, 1,1-DCE, and vinyl chloride, the detection limit is greater than the cleanup goals established for heptachlor and heptachlor epoxide. Therefore, a comparison of contaminant concentration and cleanup goals could not be made for chloroform, 1,2-DCA, 1,1-DCE, vinyl chloride, heptachlor, and heptachlor epoxide.

Table 5. December 1999 Results [4,5,13,16,21,23]

Upper aquifer - upper unit
- Cleanup goals were met for all 13 contaminants in eight of the 14 wells sampled, and for the majority of contaminants in five of the remaining wells (above cleanup goal for 2 to 3 contaminants) - One well had concentrations above the cleanup levels for a majority of the contaminants (9 of 13) - The wells with contaminant concentrations above the cleanup goals were all located downgradient of the facility - There was variation among wells in terms of which contaminant was above the cleanup goal, though chlorobenzene, benzene, and 1,4-dichlorobenzene were most frequently detected above the cleanup goals in the sampled wells - Trans-1,2-DCE was below the cleanup goal in all 14 wells
Upper aquifer - lower unit
- Cleanup goals were met for all 13 contaminants in 16 of the 33 wells sampled, and for the majority of contaminants in the remaining 17 wells (above cleanup goal for 1 to 2 contaminants) - For the 17 wells - 16 showed contaminant concentrations above the cleanup goal for one compound; one well showed contaminant concentrations above the cleanup goal for two compounds - Similar to the upper unit, there was variation among wells in terms of which contaminant was above the cleanup goal; benzene was most frequently detected above the cleanup goals in the sampled wells - Nine contaminants (chlorobenzene, TCE, cis-1,2-DCE, trans 1,2-DCE, 1,1,1-TCA, toluene, ethylbenzene, total xylenes, and n-nitrosodiphenylamine) were below their respective cleanup goals in all 33 wells
Lower aquifer
- Cleanup goals were met for all 13 contaminants in 3 of the 5 wells, and for the majority of contaminants in the remaining 2 wells (above cleanup goal for 1 to 5 constituents) - Both wells with levels above cleanup goals were located downgradient - Seven contaminants (chlorobenzene, trans 1,2-DCE, 1,1,1-TCA, toluene, ethylbenzene, total xylenes, and n-nitrosodiphenylamine) were below their respective cleanup goals in all 5 wells

- According to the RPM, quarterly monitoring data through June 2000 show trends in contaminant concentrations that are similar to those observed through June 1999.

- Data on mass of contaminants removed from the groundwater were not available.

- Table 6 presents a summary of data on the performance of the groundwater treatment system from September 1999 through December 1999. The data show that the treatment system is meeting the NPDES permit limits for discharge to the river.

- During Fiscal Year 2001, EPA plans to determine the overall contaminant reduction rate using groundwater modeling and historical data. EPA also plans to perform additional contaminant characterization to determine if contamination (including possibly DNAPL) has migrated below Little Bear Creek to the east.

Table 6. Groundwater Treatment System Performance [21]

Contaminant	NPDES Permit Limit	Effluent Concentrations			
		September 1999	October 1999	November 1999	December 1999
Purgeable halocarbons	5 ug/L	0 ug/L	0 ug/L	0 ug/L	2.9 ug/L
Purgeable aromatics	5 ug/L	0 ug/L	0 ug/L	0 ug/L	0 ug/L
Heptachlor Epoxide	0.003 ug/L	0 ug/L	0 ug/L	0 ug/L	0 ug/L
4,4'-DDD	0.0002 ug/L	0 ug/L	0 ug/L	0 ug/L	0 ug/L
Total Phosphorus	0.5 mg/L	0 mg/L	0.052 mg/L	0.042 mg/L	0.084 mg/L
	7 lbs/day	0 lbs/day	0.39 lbs/day	0.35 lbs/day	0.77 lbs/day
Total Mercury	0.0013 ug/L	0 ug/L	0 ug/L	0 ug/L	0 ug/L

PERFORMANCE DATA COMPLETENESS [4,16,20,21]

Performance data were available on a quarterly basis through June 1999 and for a sampling event in December 1999. Data on quantity of groundwater treated was available through October 2000.

PERFORMANCE DATA QUALITY [16,20]

The QA/QC program used throughout the remedial action met EPA, State of Michigan, and United States Army Corps of Engineers (USACE) requirements. All monitoring was performed using EPA-approved methods. No deviations to the QA/QC protocols were noted in the available references.

TREATMENT SYSTEM COST

PROCUREMENT PROCESS [7,15]

EPA hired the USACE to design/construct/operate the remedial system at the site. The USACE contracted the design work to Black and Veatch Special Projects Corp. The USACE contracted the construction and operation of the remedial system to Jacobs Engineering Group (formerly Sverdrup Environmental) and the operation and maintenance of the remedial system to Fishbeck, Thompson, Carr, and Huber.

COST ANALYSIS [3,6,7,15,23,24]

Data on the costs of the technology application at the Ott/Story/Cordova site were provided by the RPM and USACE. As presented in Table 7, capital costs include costs through August 1999 and are taken from construction contract documents. Annual operating costs are based on operating costs incurred

from February 1996 through August 1999, and are noted. Annual operating cost breakdown is based on the current O&M contract allowances.

Since startup, 1.1 billion gallons of groundwater have been treated by the remedial system which cost a total (capital plus operating) of $32,123,500, which is equivalent to $30 per 1,000 gallons of groundwater treated.

Table 7. Remediation Costs [3,6,15,23,24]

Capital Costs	
Initial Installation of Extraction and Monitoring Wells (1994)	$ 1,650,000
Groundwater Treatment Facility (GWTF) (includes facility buildings, indoor and outdoor process equipment only, site work (earthwork / disposal, including some extraction well areas) (September 1994 to February 1996)	$ 20,715,000
Startup period (costs incurred during the first year of the startup period includes all labor, equipment, personnel, utilities, analytical work for GWTF operations, and treatment chemicals) (February 1996 to August 1996)	$ 610,000
Installation of New Effluent Pipeline (1999)	$ 692,000
Total Capital Cost	**$ 23,667,000**
Operating Costs	
Annual Operating Costs (August 1996 to August 1997)	$ 2,342,000
Annual Operating Costs (August 1997 to August 1998)	$ 1,788,500
Annual Operating Costs (August 1998 to August 1999)	$ 1,913,500
Operating Costs (August 1999 to October 2000)	$ 2,412,500
Total Operating Cost Through October 2000	**$ 8,456,500**
Remedial System Cost-Total	**$ 32,123,500**
Other Costs	
GWTF Remedial Design (1994)	$ 1,600,000
Administration cost of USACE to U.S. EPA (1992 to 1997)	$ 2,065,000
Ongoing Remedial Action Support - independent sampling and off-site analysis of groundwater (1994 to 1997)	$ 843,750
Ongoing Remedial Action Support - independent sampling and off-site analysis of groundwater (1997 to 2000)	$ 750,000

OBSERVATIONS AND LESSONS LEARNED

- In general, the groundwater monitoring data show that progress is being made towards meeting the cleanup goals for the site. In an analysis of thirteen contaminants, cleanup goals were met for all

contaminants in 27 of the 52 wells sampled. In 24 of the remaining 25 wells, cleanup goals were met for the majority of the 13 contaminants). One well had concentrations above the cleanup levels for a majority for the 13 contaminants.

- A comparison of isoconcentration contour maps from January 1996 and December 1999 show that TOC concentrations near the facility (the area of highest contamination) have decreased in the upper unconfined aquifer (upper unit) and in the lower aquifer. TOC concentrations have remained relatively constant in the upper unconfined aquifer (lower unit).

- Since startup, 1.1 billion gallons of groundwater have been treated by the remedial system which cost a total (capital plus operating) of $32,123,500, which is equivalent to $30 per thousand gallons of groundwater treated.

- In June 1997, reduced extraction well flows and pump cyclings indicated that biofouling of the extraction wells was occurring, resulting in reduced groundwater flow to the treatment system. To address the problem, an extraction well preventative maintenance, cleaning, and repair program was initiated.

- According to the RPM [23]:

  - There is no longer a visible sheen on Little Bear Creek at locations where groundwater flows into the creek

  - All of the monitoring and extraction wells that are sampled and analyzed quarterly have shown some decrease in concentrations of contaminants

  - The groundwater treatment facility has successfully achieved NPDES discharge permit limitations throughout its operation.

- During Fiscal Year 2001, EPA plans to determine the overall contaminant reduction rate using groundwater modeling and historical data. EPA also plans to perform additional contaminant characterization to determine if contamination (including possibly DNAPL) has migrated below Little Bear Creek to the east.

REFERENCES

1. Black and Veatch. *Description of PACT System That Will Replace Biological Treatment*. February 4, 1994.

2. Black and Veatch. *Evaluation of the Report on the PACT Demonstration Project*. December 21, 1993.

3. Black and Veatch. *Final Design Estimate for Ott/Story/Cordova (OU # 1 and OU # 2), Groundwater Treatment System, North Muskegon, Michigan*. August 6, 1992.

4. Black and Veatch. *Groundwater Summary Reports*. January and June 1996, March 1997, August 1997, February 1998, August 1998, May 1999, September 1999.

5. Black and Veatch. *Summary of Quarterly Groundwater Monitoring*. November 10, 1998.

6. EPA. *Actual GWTF Construction and Operating Costs for OU # 1 and OU # 2*. November 1995.

7. EPA. EPA and USACE Comments on Draft Cost and Performance Report on Pump and Treat of Contaminated Groundwater at the Ott/Story/Cordova Superfund Site. August 7, 2000.
8. EPA. *Groundwater Treatment Process Flow Diagram*. August 24, 1999.

9. EPA. *NPL Fact Sheets for Ott/Story/Cordova Chemical Company*. February 1998 and July 1999.

10. EPA. *Remedial Investigation Report, Ott/Story/Cordova Site*. February 28, 1989.

11. EPA. *ROD Amendment for Ott/Story/Cordova Site, OU # 3*. February 26, 1998.

12. EPA. *ROD for Ott/Story/Cordova Site, OU # 1*. September 29, 1989.

13. EPA. *ROD for Ott/Story/Cordova Site, OU # 2*. September 29, 1990.

14. EPA. *ROD for Ott/Story/Cordova Site, OU # 3*. September 27, 1993.

15. EPA. *Superfund Preliminary Closeout Report: Ott/Story/Cordova Superfund Site*. September 30, 1999.

16. Jacobs Engineering Group. *Groundwater Monitoring Report*. December 1999.

17. Merck and Company, Inc. *The Merck Index, Eleventh Edition.* 1989.

18. Michigan Department of Environmental Quality. *Part 201 Cleanup Criteria and Screening Levels*. <http://www.deq/state/mi.us/erd/critguide>. January 1999.

19. MDNR. *Location Map of Existing Wells*. March 1992.

20. Sverdrup Environmental. *Groundwater Monitoring Report*. September 1999.

21. Sverdrup Environmental (Jacobs Engineering Group for October 1999 Through December 1999 Reports). *Influent and Effluent Monitoring Data*. March 1996 - December 1999.

22. Sverdrup Environmental, Inc. *Operation and Maintenance Manual for the Groundwater Extraction and Treatment Systems at the Ott/Story/Cordova Superfund Site*. August 1998.

23. Tetra Tech EM Inc. *Correspondence Between Tetra Tech EM Inc. and EPA*. August 24, 1999; February 2, 2000; February 16, 2000; February 22, 2000; March 28, 2000; and October 16, 2000.

24. USACE. *Actual Annual Operating Costs for Base Year*. August 14, 1999.

25. United States Department of the Interior. *Preliminary Natural Resources Survey, Ott/Story/Cordova Chemical Company Site*. December 11, 1987.

ANALYSIS PREPARATION

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