A Compilation of Field-Collected Cost and Treatment Effectiveness Data for the Removal of Dissolved Gasoline Components from Groundwater

HEALTH AND ENVIRONMENTAL SCIENCES DEPARTMENT
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EXECUTIVE SUMMARY

This study was conducted to document, summarize and evaluate cost and treatment effectiveness data for air stripping and carbon adsorption systems designed to remove dissolved petroleum hydrocarbons from groundwater. The compounds of primary interest were benzene, toluene, ethylbenzene and xylene isomers (BTEX) as well as the oxygenates methyl-tertiary-butyl-ether (MTBE) and isopropyl ether (IPE). The availability of comprehensive effectiveness and capital and operational maintenance costs for these treatment systems will assist API member companies in planning pump-and-treat remediation systems for removal of BTEX and oxygenates from groundwater.

Operating data were gathered from 57 field sites throughout the United States. Treatment system profiles including capital investment, operating and maintenance costs, influent and effluent contaminant concentrations, and operating parameters (e.g., flow rates, fouling characteristics) were generated for each site. While rigorous statistical analyses did not provide meaningful correlative data for system comparisons, a variety of summary statistics were useful for estimating costs and treatment effectiveness.

Median investment costs and operating and maintenance costs for air stripping systems operating at flow rates from 10 to 50 gallons per minute (gpm) were $1,627 per gpm and $2.80 per thousand gallons, respectively. Median costs for systems operating below 10 gpm were substantially greater. Median operating costs were approximately 40% greater than design costs, a difference at least partially attributable to operating flow rates that were lower than design flow rates.

The air stripping systems studied generally achieved benzene removal effectiveness of 99% or more. IPE removal effectiveness was similarly high (>98%; 3 sites), while MTBE removal effectiveness ranged from approximately 56% to 99% with a median removal effectiveness of greater than 91% (15 sites). Where design removal efficiencies were not met, biological or precipitated metal salt fouling were believed to be responsible. Fouling was found to be a common problem with air stripping systems, although fouling prevention and/or treatment efforts were generally successful.

Limited carbon adsorption system data indicated treatment costs similar to air stripping system costs operating at similarly low flow rates (<2 gpm). Carbon adsorption treatment effectiveness ranged from approximately 85% to 99.9% for benzene. Removal effectiveness for MTBE and IPE were 87% and 50%, respectively.

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APPENDICES

INTRODUCTION

Air stripping and liquid-phase activated carbon adsorption systems are two of the most commonly implemented water treatment technologies for removing dissolved gasoline components from groundwater. This study was undertaken to compile cost and treatment effectiveness data from installed and operating remediation systems throughout representative regions of the United States. The fuel components of particular interest included benzene, toluene, ethylbenzene and xylenes (BTEX) as well as the oxygenates methyl-tertiary-butyl-ether (MTBE) and isopropyl ether (IPE).

Relevant data were collected and analyzed from 57 anonymous remediation sites under the supervision of Groundwater Technology, Inc (GTI). Selected site visits were conducted in order to verify engineering descriptions and to gather influent and effluent water quality samples. Water quality and cost data were used to document actual treatment effectiveness and capital and operating/maintenance costs in comparison to design parameters.

Pertinent summary data are presented and discussed in the brief narrative section of this report. All relevant site-specific data and a variety of tabular summaries are provided in the various appendices.

METHODS AND DATA COMPILATION

Site Selection

GTI initially selected 50 sites from a list of 138 remediation sites that met at least three of the following criteria:

- sites contaminated with dissolved gasoline components,
- sites where air stripping or activated carbon adsorption systems were used for groundwater treatment,
- sites with systems achieving and/or designed to achieve less than one part per billion (1 ppb) effluent benzene,
- sites contaminated with dissolved fuel additives such as MTBE and IPE.

The list was expanded to 57 sites by the American Petroleum Institute (API) based on the following additional criteria:

- availability of system descriptions and cost data,
- a balanced regional geographic distribution of sites throughout the United States, and
- operating pretreatment systems. (Fouling of groundwater treatment equipment is a common remediation problem. Sites which satisfied other criteria and had antifouling systems were of special interest in this study.)

For the purposes of this study, each site was assigned a regional but otherwise anonymous identification number. The regions and site numbers representing the original 138 sites are presented here.

Region	Sites
Mid-Atlantic	MA-1 through MA-17
Midwest	MW-1 through MW-16
Northeast	NE-1 through NE-25
South Central	SC-1 through SC-5
Southeast	SE-1 through SE-36
West	W-1 through W-39

Operating data from each of the 57 final study sites are presented in Appendices B and C and arranged by technology (air stripping, carbon adsorption) and region (in alphabetical and numerical order). Three of the sites maintained multiple, independent systems treating groundwater from a single contaminant plume. In such cases, the site identification number included a treatment system number in parentheses (e.g., MA-10[1]; SE-33[2]). Of the 57 sites investigated, 62 individual treatment systems were studied.

Data Collection and Compilation

Site data were gathered during the site visits from project files and project personnel files. A thorough review of project files provided engineering design, capital and operating costs, and miscellaneous site-specific data. This information was reviewed for anomalies or data omissions. Data gaps and discrepancies were resolved through project personnel interviews, where possible. Site visits were conducted to verify data and to collect influent/effluent water samples for analysis.

For individual sites, the following data were gathered from project files through formal correspondence requests and during site visits:

Design Data:

Design tower height and diameter
Design packing type and height
Design water and air temperatures
Design water and air flow rates
Design tank size and retention time (for carbon adsorption systems)
Design & achieved rate of contaminant removal

Cost Data:

A. Capital Costs

(These costs are presented separately and as combined "Total Initial Cost" in Appendices B and C)
Engineering design cost
Permitting cost
Equipment cost
Piping cost
Site preparation cost
Electrical installation cost
Pretreatment system cost

B. Annual Operating and Maintenance Costs (O&M)

(These costs are presented separately and as combined "Total Annual Costs" in Appendices B and C)
Treatment system operating cost
Pretreatment system operating cost
Monitoring cost
Maintenance cost

Miscellaneous Data: Initial date of operation
Sampling frequency
Site-specific comments

Site visits were also used to verify the integrity of the data collected from project files and project staff. The variables to be verified for air stripping systems included: air flow rate, water flow rate, air temperature, water temperature, tower height, packing height and tower diameter. The packing type was noted. For carbon adsorption systems, the tank size and system configuration were noted. Air flow rates were measured using either a Dwyer Pitot Tube or a Kurz Air Velocity Meter, Model 443. Five replicate readings were obtained and an average was calculated. Similarly, water flow rates were measured with either a flow meter or on a timed basis using a retention tank. The water and air temperatures were measured with a scientific thermometer. Three replicate readings were taken and an average was calculated. The tower height, packing height and tower diameter were measured with a tape measure, and the packing was inspected to verify design specifications. Influent and effluent water samples were collected in duplicate from the air stripping towers or carbon tanks. The water samples were obtained from the sampling ports on the influent and effluent lines and collected in 40-ml sampling vials. These samples were then sent to Groundwater Technology Environmental Laboratories (GTEL) and analyzed for benzene, toluene, ethylbenzene, total xylenes, MTBE, and IPE. Results of these analyses can be found in Appendix D. Standard water sampling procedures for volatile organic compounds were used by GTI personnel. These procedures can be found in Appendix E, which also contains the GTEL QA/QC procedures for laboratory sampling and analysis.

Once the samples were received by the laboratory, the condition of each sample was carefully checked and recorded. Each container was inspected and any anomalies noted. The freight

bill and chain-of-custody documents were reviewed and matched to the labeled contents of each shipping container. Any labeling errors were noted and corrected once the project engineer had been notified of the error. All samples were logged in and assigned a number for ease of location throughout the process. The samples were maintained at $4^{o}C$ until analyzed.

Distilled water blanks were prepared in the same manner as water samples at each site. The standard procedure for the preparation of field blanks is described in Appendix E. Field blanks served as indicators of sample contamination throughout the entire sampling and sample transport process.

All influent samples were analyzed using EPA Method 624. Since effluent concentrations for benzene were likely to be less than 1 ppb, and the detection limit for benzene using EPA Method 624 is 1.7 ppb, it was decided that effluent samples would be analyzed by EPA Method 524.1, for which the benzene detection limit is 0.2 ppb. Detection limits for relevant contaminants for each of these EPA methods are presented in Appendix E.

Laboratory QA/QC procedures followed for this study dictated that GTEL analyze duplicate samples and matrix spiked samples at a rate of no less than 10% of those samples analyzed. Results and procedures used for these analyses are also included in Appendix E.

All site visits and sampling were completed within a 3-week period so that samples from this study could be analyzed at the laboratory at the same time. All laboratory analyses, along with QA/QC information, were mailed to the API Study Project Manager in a single package. Site visit data were also mailed from field engineers to the API Study Project Manager. All data were then tabulated for each site including file data, site visit data and laboratory analyses.

Appendices B and C contain the compiled data from each site with relevant information contained on two succeeding pages. The first page contains treatment system parameters, cost data and miscellaneous site-specific comments. The second page presents analytical data for the site. For each site, two sets of parametric and analytic information are presented, where available. The design data are comprised of values used in the design specifications for the individual systems. These data are important because capital costs and, to a lesser degree, operating costs are directly related to these values. The actual data include values measured onsite.

All cost data in Appendices B and C were compiled from project files. The costs listed and totaled as Total Initial Cost are considered capital costs. The Total Annual Cost represents annual operating and maintenance (O&M) costs, including monitoring. Cost calculation procedures are documented in Appendix A. Site-specific comments were collected from project files and site visit notes.

Appendix D contains the laboratory analytical data for influent and effluent water samples. These water quality data are also presented in tabular form in Appendices B and C with percent removal effectiveness calculations, number of transfer units (NTU) and height of transfer units (HTU). Transfer unit calculations were computed as follows:

1) Percent Removal

$$R = \frac{C-Ce}{C} \times 100$$

Where, R = Percent Removal
C = Influent Concentration
Ce = Effluent Concentration

2) Number of Transfer Units

$$NTU = \frac{R}{R-1} \ln \frac{(Ci/Ce)(R-1) + 1}{R}$$

Where, NTU = Number of Transfer Units

Ci = Influent Concentration

Ce = Effluent Concentration

$$R = \left(\frac{A}{W}\right)\left(\frac{\overline{dA}}{\overline{dw}}\right)\left(\frac{H}{P_T}\right)$$

Where: R = Stripping factor

A = air rate at average in-column conditions, m^3/min

W = water rate at average in-column conditions, m^3/min

$\overline{dA}$ = density of air at average in-column conditions, mol/m^3

$\overline{dw}$ = density of water at average in-column conditions, mol/m^3

H = Henry's Law Constant, atm/mol fraction

P_T = Total (ambient) pressure, atm

3) Height of Transfer for Unit

$$HTU = \frac{Z}{NTU}$$

Where, HTU = Height of Transfer Unit

Z = Packing Height

NTU = Number of Transfer Units

Percent removal, NTU and HTU are important performance and design parameters for air strippers. These parameters have specific mathematical relationships to many of the system parametric data collected in this study. A detailed explanation of the theory and mathematical development of these equations is beyond the scope of this study. Two excellent sources of this information are:

"Design of Aeration Towers to Strip Volatile Contaminants from Drinking Water," by Michael C. Kavanaugh and R. Rhodes Trussel, published in the Journal of the American Water Works Association, December, 1980.

Mass Transfer Operations, by R. E. Treybal, McGraw-Hill Book Company, of New York. 1968.

Appendix E contains quality control information relevant to this study. This information includes analytical results for duplicate samples, a table of detection limits relevant to this study and relevant excerpts from GTI's Standard Operating Procedures Manual and Laboratory QA/QC Program.

RESULTS AND DISCUSSION

Cost Information

Cost data developed during this study demonstrated substantial variability. Considering the diversity of treatment systems reviewed, such results were expected. Attempts to statistically correlate data in anything more than a general way did not prove to be useful. Indeed, even mathematical averages representing a variety of system parameters proved to be misleading. Median values proved to be more reliable predictors of system costs.

Tables I through IV provide summaries of the cost information for air stripping systems. Detailed cost data for individual systems are included in Appendices A through C. It is important to note that air stripping systems documented in this study did not include vapor phase treatment of hydrocarbons exhausted to the atmosphere.

Table II indicates that median operating and maintenance costs for air stripping were $2.80 per thousand gallons for flow rates in the range of 10 to 50 gpm. Median installed costs (Table III) were $1,627 per gpm for this 10 to 50 gpm flow range. Cost data for 11 sites are included.

For those 26 systems operating at less than 10 gpm, the costs per gallon treated were considerably higher. The median operating and maintenance cost was $6.40 per thousand gallons and the investment cost was $5,839 per gpm. At very low flow rates (1 gpm or less), the costs per gallon processed were considerably higher, as expected. For example, O&M costs at site W-39 at 0.8 gpm flow were $50 per thousand gallons. Investment cost was $29,125 per gpm.

At flow rates above 50 gpm, O&M costs were $.40 to $.60 per thousand gallons, with investment costs between $511 and $556 per gpm. Cost data for only two sites were available in this flow range.

Frequently there was a distinct difference between the costs per gallon estimated for the design of the systems and the costs actually experienced in the field. Table IV indicates that the median ratio of actual unit costs to those initially estimated for the design was approximately 1.4/1. The differences between design estimates and actual costs were partly due to operating at flow rates that were often considerably less than the rates for which the systems were designed.

Costs for carbon treatment are shown in Table V. There were only five sites where such cost data were available; therefore, no statistical analyses were attempted. Actual flow rates for these carbon adsorption systems were 2 gpm or less. At these low flow rates, the carbon treatment costs were comparable to air stripping costs at similar flow rates (Table I). Additional details are provided in Appendix C.

TABLE I. RAW COST DATA FOR AIR STRIPPING SYSTEMS

OBS NO.	SITE NO.	ACTUAL FLOW RATE (GPM)	ACTUAL CAPITAL COST ($/GPM)	ACTUAL O&M COST ($/1000 GAL)	DESIGN FLOW RATE (GPM)	DESIGN CAPITAL COST ($/GPM)	DESIGN O&M COST ($/1000 GAL)
1	MA-2	--	--	--	9.0	2000	1.1
2	MA-3	--	--	--	20.0	1018	0.8
3	MA-4	--	--	--	60.0	303	0.1
4	MA-5	--	--	--	11.0	1045	0.6
5	MA-8	--	--	--	5.0	2700	11.0
6	MA-9	--	--	--	50.0	640	1.8
7	MA-10(1)	15.00	1133	0.4	30.0	567	0.2
8	MA-10(2)	6.00	3083	0.9	30.0	617	0.2
9	MA-10(3)	8.00	2088	0.6	30.0	557	0.2
10	MA-10(4)	7.00	2386	0.7	30.0	557	0.2
11	MA-15	--	--	--	175.0	132	0.1
12	MA-16	--	--	--	175.0	149	0.1
13	MW-1	0.95	30,705	127.0	--	--	--
14	MW-6	1.20	19,443	130.0	0.5	46,664	313.0
15	MW-7	0.50	55,110	415.0	2.0	13,778	104.0
16	MW-10	2.50	12,724	87.0	2.0	15,905	109.0
17	MW-13	15.00	2210	9.6	15.0	2210	9.6
18	MW-16	--	--	--	40.0	574	3.0
19	NE-4	2.00	30,412	32.0	50.0	1216	1.3
20	NE-6	7.50	5427	6.4	10.0	4070	4.8
21	NE-9	5.20	4808	3.3	5.0	5000	3.4
22	NE-18	3.60	10,556	32.0	5.0	7600	23.0
23	NE-19	11.50	2113	2.8	25.0	972	1.3
24	NE-21	42.00	1085	1.2	40.0	1139	1.3
25	NE-22	3.75	4720	0.2	10.0	1770	0.1
26	SC-1	5.00	2822	0.4	3.5	4032	0.6
27	SC-2	4.50	3031	0.5	3.0	4546	0.7
28	SC-3	4.00	3584	2.5	3.0	4779	3.3
29	SC-4	3.80	2812	1.7	4.0	2671	1.6
30	SC-5	8.00	1497	0.2	7.0	1710	0.2
31	SE-7	32.40	739	1.2	28.0	855	1.4
32	SE-18	22.20	1483	2.6	22.0	1496	2.6
33	SE-22	3.00	6913	18.0	4.0	5184	13.0
34	SE-23	14.50	2559	4.0	16.0	2319	3.7
35	SE-29	30.00	683	1.9	30.0	683	1.9
36	SE-31	1.40	6250	5.0	5.0	1750	1.4
37	SE-32	14.30	2091	5.4	30.0	997	2.6
38	SE-33(1,2)	16.00	2331	3.7	20.0	1865	2.9
39	SE-35	9.50	3474	6.7	17.0	1941	3.7
40	SE-36	15.00	1627	3.9	50.0	488	1.2
41	W-1	0.80	30,865	135.0	10.0	2469	11.0
42	W-2	8.50	3835	4.2	60.0	543	0.6
43	W-4	8.50	6824	7.6	--	--	--
44	W-14	1.10	61,364	55.0	10.0	6750	6.0
45	W-17	--	--	--	5.0	1430	0.3
46	W-18	3.50	14,372	--	60.0	838	--
47	W-19	--	--	--	60.0	877	--
48	W-31(1,2)	270.00	511	0.4	--	--	--
49	W-38	52.20	556	0.6	30.0	967	1.0
50	W-39	0.80	29,125	50.0	15.0	1553	2.7

TABLE II. DOCUMENTED ANNUAL OPERATING AND MAINTENANCE COSTS FOR AIR STRIPPING SYSTEMS ($/1000 GALLONS)

FLOW FATE (GPM)	SAMPLE SIZE (N)	MEDIAN	AVERAGE	COST RANGE
<10	25	$6.40	$44.88	$0.20-$415.00
10-50	11	$2.80	$3.34	$0.40-$9.60
>50	2	$0.50	$0.50	$0.40-$0.60

TABLE III. DOCUMENTED CAPITAL COSTS FOR AIR STRIPPING SYSTEMS ($/GPM)

FLOW FATE (GPM)	SAMPLE SIZE (N)	MEDIAN	AVERAGE	COST RANGE
<10	26	$5839	$13,778	$1497-$61,364
10-50	11	$1627	$1641	$683-$2559
>50	2	$534	$534	$511-$556

TABLE IV. RATIOS OF ACTUAL VS. DESIGN PARAMETERS FOR AIR STRIPPING SYSTEMS

	COUNT (N)	MEDIAN OF RATIOS	AVERAGE OF RATIOS	RANGE OF RATIOS
FLOW RATE	36	0.74	0.73	0.04 - 2.40
CAPITAL COST	36	1.36	3.95	0.42 - 25.0
O&M COST	35	1.38	3.48	0.42 - 24.6

NOTE: For the capital and O&M costs, the average ratio may be a misleading estimate of the typical ratio because of the skewed distributions. The median is the preferred and recommended estimate.

TABLE V. RAW COST DATA FOR LIQUID-PHASE
ACTIVATED CARBON ADSORPTION SYSTEM

Site	ACTUAL			DESIGN		
	Flowrate (GPM)	Capital Cost ($/GPM)	O&M Cost($/1000 GAL)	Flowrate (GPM)	Capital Cost ($/GPM)	O&M Cost($/1000 GAL)
MW-5	0.75	2,8141	170	0.5	4,2212	255
MW-14	2	26,866	144	2	16,866	144
NE-7	2	7,160	13	20	716	1.3
NE-20	0.5	1,200	46	0.5	1,200	46
NE-23	0.17	176,471	604	1	30,000	103

Removal Effectiveness

As indicated in Table VI, most air stripping systems achieved significant reductions of dissolved volatile organic concentrations. Benzene reductions were generally greater than 99%.

Fifteen air stripping systems also provided data on MTBE removal effectiveness (Table VI). Percent removal ranged from 55.6% to 99.9% with a median value of approximately 91%. Removal effectiveness for IPE was documented at three sites and ranged from 97.8% to 99.9%.

The air stripping systems generally met their design requirements of 99% removal of dissolved volatile hydrocarbon contaminants. However, as shown in Table VII, there were six exceptions noted. In five of the six cases shown, the problem was fouling of the packing with either biological growth or precipitated metal salts (probably iron hydroxide).

Fouling was found to be a common problem with the air stripping systems. Of the 55 air stripping systems listed in Appendix B, fouling was noted in 30 of these systems. For 21 of these 30 systems where fouling was noted, some type of fouling prevention or treatment was used (either antifouling pretreatment or periodic cleaning).

The information in Appendix B indicates that the treatment for fouling was effective in all cases, with one possible exception. The information given in Appendix B for site NE-6 does not show how well the treatment for fouling worked. The only data provided in the Appendix for that site show that performance was seriously affected by fouling and that treatment for fouling was

started. Of eight other systems where fouling occurred and where there was no specified treatment, four failed to meet design performance requirements.

It is clear that fouling often occurs in air stripping columns. However, with proper cleaning or pretreatment, air stripping systems can operate acceptably in services that would otherwise significantly degrade system performance.

All five carbon adsorption systems where cost and performance data were available were small units (Table VIII). Actual flows ranged from 0.5 to 2 gpm. Benzene reductions ranged from 85.1% to 99.9%. One datum is documented for MtBE at 87.2% removal. This same system removed 50% of the IPE in the feed.

It is intuitive that at any given site, treatment to effluent concentrations below 1 ppb will be more expensive than treatment to some higher concentration. However, statistical analysis of actual cost data (ANOVA linear regression) did not demonstrate a significant difference between treatment to concentrations above versus below 1 ppb benzene.

Both within and between treatment systems, sample variances were very high. The sources of variance among sites included multiple factors: varying influent and effluent concentrations, overdesign (flow rates less than design), analytical sources of error, a wide range of flow rates, and the use of benzene as the single indicator contaminant in evaluating treatment. For example, benzene concentrations in the influent varied from nondetectable to 29,000 ppb, and in the effluent ranged from nondetectable to 1,900 ppb.

TABLE VI. PERFORMANCE, PARAMETERS FOR AIR STRIPPING SYSTEMS

Site	Water Temperature °F	Air Temperature °F	Air-to-Water Ratio CFM/GPM	Benzene %Removal	Additives %Removal
MA-10(1)	55.4	84.2	37.3:1	99.5	--
MA-10(2)	59.9	82.4	100:1	--	--
MA-10(3)	57.2	82.4	75:1	--	--
MA-10(4)	57.2	87.8	85.7:1	99.2	
MW-1	49.3	97.6	1,396:1	99.8	--
MW-6	53.3	95.0	233:1	>99.9	MtBE - 99.9
MW-7	49.0	91.7	2,478:1	99.9	
MW-10	55.0	85.0	11.2:1	***	--
MW-13	55.0	69.0	115:1	99.6	
NE-4	65.0	85.0	477:1	99.9	
NE-6	59.0	74.5	20.4:1	26.9	--
NE-9	54.7	80.8	33:1	99.7	
NE-18	62.3	77.2	29.4:1	>99.9	MtBE - >99.9, IPE - >99.9
NE-19	70.8	81.8	11:1	***	MtBE - 95.1
NE-21	57.5	87.0	5.5:1	96.1	MtBE - 62.0
NE-22	63.8	83.3	73.3:1	>99.9	MtBE - 76.0**
SC-1	81.1	78.0	40:1	>99.9	--
SC-2	73.0	89.0	43.5:1	>99.9	IPE - >99.9
SC-3	71.0	81.0	11:1	>99.9	IPE - 97.8
SC-4	70.0	87.0	52.6:1	***	MtBE - >99.9
SC-5	68.0	77.0	49.8:1	99.8	--

Note: * = No water quality data were available for MA-2, 3, 4, 5, 8, 9, 15, 16; MW-16
** = These values were calculated using one half of the appropriate detection limit
*** = No calculations performed

TABLE VI. (CONCLUDED)

Site	Water Temperature °F	Air Temperature °F	Air-to-Water Ratio CFM/GPM	Benzene %Removal	Additives %Removal
SE-7	81.2	95.6	21.4:1	***	--
SE-18	82.7	97.0	10.4:1	98.6	MtBE 84.9
SE-22	82.4	90.2	352.1	99.7**	MtBE 90.9
SE-23	81.5	86.0	11.1:1	99.8**	
SE-29	NA	NA	NA	***	--
SE-31	68.4	79.0	224:1	>99.9	MtBE >99.9
SE-32	81.5	93.8	60:1	99.6	MtBE 99.2**
SE-33(1)	78.8	79.1	35.4:1	>99.9	MTBE 99.8
SE-33(2)	78.8	97.1	37:1	***	MTBE 55.6
SE-35	82.4	86.0	47.8:1	>99.9	MTBE >99.9
SE-36	82.0	95.0	29.3:1	99.1	--
W-1	80.0	100.0	402.5:1	99.2	--
W-2	78.0	88.5	--	--	MtBE 78.6
W-4	76.5	93.8	18.9:1	--	
W-14	68.0	84.2	111.8:1	--	
W-18	68.0	75.0	100:1	***	
W-31(1)	64.4	86.0	7.3:1	***	--
W-31(2)	64.4	95.0	0.4:1	***	--
W-38	67.6	84.7	8.05:1	98.9	MtBE 72.7
W-39	73.2	74.1	380:1	--	--

Note: * = No water quality data were available for W-11, 17, 19, 32, 35
** = These values were calculated using one half of the appropriate detection limit
*** = No calculations performed
NA = Not available

TABLE VII. SITES NOT ACHIEVING DESIGN EFFICIENCY

SITE	DESIGN REMOVAL CRITERIA	ACTUAL REMOVAL ACHIEVED	COMMENTS
MA-10(3)	99% for petroleum hydrocarbons	88.17% Average* for BTEX	iron and/or biological fouling of packing
MA-10(4)	99% for petroleum hydrocarbons	>98.9% Average for BTEX	iron and/or biological fouling of packing
MW-7	100% for petroleum hydrocarbons to nondetectable levels	96.9% Average or 2 ppb average BTEX concentration	high target removal
NE-6	99% for petroleum hydrocarbons	32.6% Average for BTEX	biological fouling of air stripper
NE-9	99% for petroleum hydrocarbons	92.1 Average for BTEX	iron and/or biological fouling of air stripper
NE-19	99% for petroleum hydrocarbons	92.09% Average for BTEX	iron bacteria fouling of treatment system

NOTE: *unable to find how calculation was accomplished

TABLE VIII. PERFORMANCE PARAMETERS FOR CARBON ADSORPTION SYSTEMS*

Site	Water Temperature ^{o}F	Air Temperature ^{o}F	Rentention Time Min/Tank	Benzene %Removal	Additives %Removal
MW-5	55.0	85.0	73.3	>99.9[1]	
MW-14	63.0	90.0	27.5	99.9[1]	**
NE-7	82.0	96.0	27.5	99.9[1]	
NE-20	58.0	80.0	80.0	85.1[1] 99.1[2]	MtBE - 87.2[1], IPE - 50[1]
NE-23	74.0	78.0	323.0	**	--

Notes: 1 = These removal values are based on the first of two carbon tanks in series
2 = These removal values are based on the second of two carbon tanks in series
* = No water quality data were available for MW-9, MW-12
** = Removal rate data not calculated

We discourage the use of data from individual sites for predicting treatment costs. However, the median values for actual costs derived from this database provide reasonable values for estimating treatment costs. The wide ranges associated with these data imply that any estimates based on this information can be viewed only as rough approximations.

CONCLUSIONS

1. Median operating and maintenance costs for air stripping systems in the range of 10 to 50 gpm were $2.80 per thousand gallons. Median investment costs were $1,627 per gpm.

2. For those air stripping systems operating below 1 gpm, the median operating and maintenance cost was $6.40 per thousand gallons. The median investment cost was $5,839. At flow rates below 1 gpm, costs per gallon were substantially greater, as would be expected.

3. For the two air stripping systems operating at rates higher than 50 gpm, the operating and maintenance costs were $0.40 and $0.60 per thousand gallons. Investment costs were $511 and $556 per gpm.

4. There was a considerable difference between the costs per gallon estimated for the design of the air stripping systems and the costs per gallon actually obtained in the field. The actual costs per gallon appear to be about a factor of 1.4 higher than those originally estimated. Part of the reason for this is that actual flow rates were often much less than the design flow rates.

5. There were only five carbon treatment systems in this survey where data on treatment effectiveness were available. Consequently, there was no attempt to statistically analyze the data. Actual flow rates for all five of these carbon adsorption systems were 2 gpm or less. At these low flow rates, the carbon treatment costs are comparable to air stripping costs at similar flow rates.

6. Benzene reductions ranged from 85.1% to 99.9% in the five carbon adsorption systems where cost and performance data were available. One datum is documented for MtBE at 87.2% removal. This same system removed 50% of the IPE in the feed.

7. Almost all air stripping systems achieved a high degree of removal of the dissolved volatile hydrocarbons in the water. Benzene removals were normally 99% or more.

8. In five of the six cases where air stripping design contaminant removal requirements were not met, fouling was responsible. Fouling was caused by biological growth or precipitated metal salts (probably iron hydroxide).

9. Fouling was found to be a common problem with the air stripping systems. Of the 55 air stripping system studied, fouling was noted in 30 of these systems. For 21 of these 30 systems where fouling was noted, some type of fouling prevention or treatment was used. Such treatment was generally successful.

10. Many of the air stripping systems were operated at considerably lower water flow rates than those for which they were designed. Consequently, in such cases the systems were usually able to exceed their design requirements for contaminant removal.

11. MTBE removal ranged from 55.6% to 99.9% with a median of 91% in the 15 systems where MTBE was treated by air stripping.

12. There were three sites listed in Table VI where IPE was shown to be removed with the air stripping systems. Removal rates for IPE ranged from 97.8% to 99.9%.

13. The major sources of variation in the data among sites include multiple factors: varying influent and effluent concentrations, overdesign (flow rates less than design), anlytical sources of error, and a wide range of flow rates.

14. Because of the wide variability in the data, we discourage the use of data from individual sites for predicting treatment costs. However, the median values for actual costs derived from this data base provide reasonable values for estimating treatment costs.

APPENDIX A

UNIT COST CALCULATION PROCEDURES

AND

COST SUMMARY TABLES, AIR STRIPPING SYSTEMS

Various design cost data presented throughout this report were calculated as follows:

Unit Permitting Cost $Cp = \frac{Ctp}{Fd}$

where, Cp = Unit Permitting Cost
Fd = Design Flow Rate
Ctp = Total Permitting Cost from Appendices B or C

Unit Annual Operating and Maintenance Costs $Co = \frac{Cto}{Qd}$

where, Co = Unit Annual Operating Cost
Cto = Total O&M cost from Appendices B or C
Qd = Total annual flow rate in 1,000's of gallons.

Actual cost data were calculated as follows:

Unit Permitting Cost

$$Cp = \frac{Ctp}{Fa}$$

and,

Unit Operating Costs

$$Co = \frac{Cto}{Qa}$$

where,

Fa = Actual Flow rate
Qa = 1,000's gallons treated per year

Site summary Tables I(a) and I(b) present cost data for air stripping systems designed to achieve two different levels of treatment effectiveness (<1 ppb and >1 ppb). Summary Tables II(a) and II(b) contain similar data for air stripping systems actually achieving the two different levels of treatment effectiveness.

TABLE I(A). COSTS FOR AIR STRIPPING SYSTEMS
(Based on Design Flowrate)

Costs for Systems Designed to Achieve Less than 1 ppb Benzene in Effluent

Site	Design Flowrate	Design	Permitting	Equipment and Construction	Total Initial Capital	Annual O&M*	Initial Date of Operation
	GPM	$/GPM	$/GPM	$/GPM	$/GPM	$/1000 GAL	
MA-2	9	--	--	2000	2000	1.1	11/84
MA-9	50	40	120	480	640	1.8	10/86
MA-10(1)	30	--	67	500	567	0.2	1984
MA-10(2)	30	--	67	550	617	0.2	1984
MA-10(3)	30	--	67	4990	557	0.2	1984
MA-10(4)	30	--	67	490	557	0.2	1984
MW-6	0.5	3,504	4,800	38,360	46,664	313	Summer 1986
MW-7	2	876	1,200	11,702	13,778	104	2/87
MW-10	2	876	1,200	13,829	15,905	109	8/17/84
MW-13	15	117	224	1,870	2,210	9.6	8/86
NE-4	50	41	40	1,136	1,216	1.3	9/9/86
NE-18	5	100	300	7,200	7,600	23	6/30/86
SC-2	3	833	600	3,113	4,546	0.7	4/30/85
SC-3	3	667	600	3,512	4,779	3.3	7/24/85
SE-7	28	--	3.6	851	855	1.4	--
SE-18	22	--	--	1,496	1,496	2.6	8/86
SE-23	16	62	6.2	2,250	2,319	3.7	11/5/86
SE-29	30	30	7.0	646	683	1.9	--
SE-32	30	--	--	997	997	2.6	12/84
SE-35	17	118	--	1,824	1,941	3.7	9/6/85
W-1	10	319	200	1,950	2,469	11	4/87
W-2	60	--	--	543	543	0.6	9/86
W-14	10	1,350	700	4,700	6,750	6.0	4/87
W-38	30	--	67	900	967	1.0	2/87
W-39	15	--	100	1,453	1,553	2.7	2/87

TABLE I(B). COSTS FOR AIR STRIPPING SYSTEMS
(Based on Design Flowrate)

Costs for Systems Designed to Achieve Greater than 1 ppb Benzene in Effluent

Site	Design Flowrate	Design	Permitting	Equipment and Construction	Total Initial Capital	Annual O&M*	Initial Date of Operation
	GPM	$/GPM	$/GPM	$/GPM	$/GPM	$/1000 GAL	
MA-3	20	25	500	492	1,018	0.8	5/86
MA-4	60	8.3	100	195	303	0.1	3/87
MA-5	11	--	9	1,036	1,045	0.6	10/86
MA-8	5	--	400	2,300	2,700	11	10/86
MA-15	175	--	29	103	132	0.1	7/85
MA-16	175	--	34	115	149	0.1	6/84
MW-16	40	44	60	470	574	3.0	3/87
NE-6	10	200	300	3,570	4,070	4.8	4/85
NE-9	5	100	1,000	3,900	5,000	3.4	4/87
NE-19	25	32	100	840	972	1.3	4/86
NE-21	40	12	20	1,106	1,139	1.3	3/3/87
NE-22	10	75	150	1,545	1,770	0.1	1/87
SC-1	3.5	629	514	2,889	4,032	0.6	9/22/86
SC-4	4	550	450	1,671	2,671	1.6	1/85
SC-5	7	314	257	1,139	1,710	0.2	10/28/85
SE-22	4	--	--	5,184	5,184	13	9/86
SE-31	5	--	--	1,750	1,750	1.4	4/85
SE-33(1,2)	20	105	--	1,760	1,865	2.9	11/5/86
SE-36	50	36	--	452	488	1.2	4/15/87
W-17	5	--	--	1,430	1,430	0.3	5/19/86
W-18	60	54	101	683	838	--	3/86
W-19	60	--	--	877	877	--	1984

Notes: * = Operating and maintenance including monitoring
-- = Not available

TABLE II(A). COSTS FOR AIR STRIPPING SYSTEMS
(Based on Actual Flowrate)

Costs for Systems Actually Achieving Less than 1 ppb Benzene in Effluent

Site	Design Flowrate	Design	Permitting	Equipment and Construction	Total Initial Capital	Annual O&M*	Initial Date of Operation
	GPM	$/GPM	$/GPM	$/GPM	$/GPM	$/1000 GAL	
MA-10(1)	15	--	133	1,000	1,133	0.4	1984
MA-10(2)	6	--	333	2,750	3,083	0.9	1984
MA-10(3)	8	--	250	1,838	2,088	0.6	1984
MW-6	1.2	1,460	2,000	15,983	19,443	130	Summer 1986
MW-7	0.5	3,504	4,800	46,806	55,110	415	2/87
MW-10	2.5	701	960	11,063	12,724	87	8/17/84
NE-4	2	1,020	992	28,400	30,412	32	9/9/86
NE-19	11.5	70	217	1,826	2,113	2.8	4/86
NE-22	3.75	200	400	4,120	4,720	0.2	1/87
SC-2	4.5	556	400	2,075	3,031	0.5	4/30/85
SC-3	3	500	450	2,634	3,584	2.5	7/24/85
SC-4	3.8	579	474	1,759	2,812	1.7	1/85
SC-5	8	275	225	997	1,497	0.2	10/28/85
SE-7	32.4	--	3.1	735	739	1.2	--
SE-18	22.2	--	--	1,483	1,483	2.6	8/86
SE-22	3	--	--	6,913	6,913	18	9/86
SE-23	14.5	69	6.9	2,483	2,559	4.0	11/5/86
SE-29	30	30	7.0	646	683	1.9	--
SE-31	1.4	--	--	6,250	6,250	5.0	4/85
SE-32	14.3	--	--	2,091	2,091	5.4	12/84
SE-33(1,2)	16	131	--	2,200	2,331	3.7	11/5/86
SE-35	9.5	210	--	3,263	3,474	6.7	9/6/85
W-2	8.5	--	--	3,835	3,835	4.2	9/86
W-4	8.5	--	--	6,824	6,824	7.6	9/85
W-14	1.1	12,273	6,364	42,727	61,364	55	4/87
W-18	3.5	930	1,727	11,714	14,372	--	3/86
W-31(1,2)	270	--	--	511	511	0.4	5/84
W-39	0.8	--	1,875	27,250	29,125	50	2/87

TABLE II(B). COSTS FOR AIR STRIPPING SYSTEMS
(Based on Actual Flowrate)

Costs for Systems Achieving Greater than 1 ppb Benzene in Effluent

Site	Design Flowrate	Design	Permitting	Equipment and Construction	Total Initial Capital	Annual O&M*	Initial Date of Operation
	GPM	$/GPM	$/GPM	$/GPM	$/GPM	$/1000 GAL	
MA-10(4)	7	--	286	2,100	2,386	0.7	1984
MW-1	0.95	1,844	3,537	25,324	30,705	127	4/23/87
MW-13	15	117	224	1,870	2,210	9.6	8/86
NE-6	7.5	267	400	4,760	5,427	6.4	4/85
NE-9	5.2	96	962	3,750	4,808	3.3	4/87
NE-18	3.6	139	417	10,000	10,556	32	6/30/86
NE-21	42	12	19	1,054	1,085	1.2	3/3/87
SC-1	5	440	360	2,022	2,822	0.4	9/22/86
SE-36	15	120	--	1,507	1,627	3.9	4/15/87
W-1	0.8	3,990	2,500	24,375	30,865	135	4/87
W-38	52.2	--	38	517	556	0.6	2/87

Notes: * = Operating and Maintenance, including monitoring
-- = Not available

APPENDIX B

SYSTEM DESCRIPTIONS, COSTS AND REMOVAL EFFECTIVENESS

FOR AIR STRIPPING SYSTEMS

SITE IDENTIFICATION -- MA-2

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	
Packed Height	8.5'	
Tower Diameter	2.0'	
Packing Type	2" Tellerettes	
Water Temperature	55°F	
Air Temperature	Ambient	
Water Flow Rate	9 GPM	
Air Flow Rate	1000 CFM	
Air/Water Ratio	111:1 CFM/GPM	
Initial Date of Operation		11/84
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	
Equipment	$ 10,000
Piping	$ 5,000
Site Preparation	$ 2,000
Electrical	$ 1,000
Pretreatment System	
Total Initial Costs	$ 18,000

Treatment System Operation	
Pretreatment System Operation	
Monitoring	$ 3,600/year
Maintenance	$ 2,400/year
Total Annual Costs	$ 6,000/year

COMMENTS:

This site is an operating gasoline station in Pennsylvania.

MA -- 2

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0						
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons			95					
EDB								
MTBE								
IPE								

Notes: * = No site visit was completed at this site

SITE IDENTIFICATION -- MA-3

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	
Packed Height	14.0'	
Tower Diameter	1.0'	
Packing Type	#1/2 Tri-pack	
Water Temperature	55°F	
Air Temperature	Ambient	
Water Flow Rate	20 GPM	
Air Flow Rate	600 CFM	
Air/Water Ratio	30:1 CFM/GPM	
Initial Date of Operation		5/86
Sampling Frequency		Monthly

Costs

Engineering Design	$ 500
Permitting	$ 10,000
Equipment	$ 5,750
Piping	
Site Preparation	$ 600
Electrical	$ 3,500
Pretreatment System	
Total Initial Costs	$ 20,350
Treatment System Operation	$ 700/year
Pretreatment System Operation	
Monitoring/Maintenance	$ 7,200/year
Total Annual Costs	$ 7,900/year

COMMENTS:

This site is an operating gasoline service station in New Jersey. GTI is testing for lead in the water discharge.

MA -- 3

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene								
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons			99					
EDB								
MTBE								
IPE								

Notes: * = No site visit was completed at the site

SITE IDENTIFICATION -- MA-4

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	
Packed Height	8.5'	
Tower Diameter	2.0'	
Packing Type	#1 Jaeger Tri-pack	
Water Temperature	55°F	
Air Temperature	Ambient	
Water Flow Rate	60 GPM	
Air Flow Rate	600 CFM	
Air/Water Ratio	10:1 CFM/GPM	
Initial Date of Operation		3/87
Sampling Frequency		

Costs	
Engineering Design	$ 500
Permitting	$ 6,000
Equipment	$ 8,400
Piping	$ 300
Site Preparation	$ 3,000
Electrical	
Pretreatment System	
Total Initial Costs	$ 18,200
Treatment System Operation	$ 300/year
Pretreatment System Operation	
Monitoring/Maintenance	$ 2,040/year
Total Annual Costs	$ 2,340/year

COMMENTS:

This site is an operating gasoline station in Pennsylvania.

MA -- 4

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene								
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons			99					
EDB								
MTBE								
IPE								

Notes: No site visit was completed at this site

SITE IDENTIFICATION -- MA-5

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	
Packed Height	14.0'	
Tower Diameter	1.0'	
Packing Type	#1 Tri-pack	
Water Temperature	55°F	
Air Temperature	Ambient	
Water Flow Rate	11 GPM	
Air Flow Rate	400 CFM	
Air/Water Ratio	36:1 CFM/GPM	
Initial Date of Operation		10/86
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	$ 100
Equipment	$ 6,000
Piping	$ 400
Site Preparation	$ 3,000
Electrical	$ 2,000
Pretreatment System	
Total Initial Costs	$ 11,500

Treatment System Operation	
Pretreatment System Operation	
Monitoring	$ 2,400/year
Maintenance	$ 1,200/year
Total Annual Costs	$ 3,600/year

COMMENTS:

This site is an operating gasoline service station.

MA -- 5

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene								
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons			>99%					
EDB								
MTBE								
IPE								

Notes: * = No site visit was completed at this site

SITE IDENTIFICATION -- MA-8

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	
Packed Height	14.0'	
Tower Diameter	1.0'	
Packing Type	#1 Tri-pack	
Water Temperature	55°F	
Air Temperature	Ambient	
Water Flow Rate	5 GPM	
Air Flow Rate	600 CFM	
Air/Water Ratio	120:1 CFM/GPM	
Initial Date of Operation		10/86
Sampling Frequency		Monthly; Bi-monthly for December, January and February of 1986

Costs

Engineering Design	
Permitting	$ 2,000
Equipment	$ 6,000
Piping	$ 500
Site Preparation	$ 4,000
Electrical	$ 1,000
Pretreatment System	
Total Initial Cost	$ 13,500

Treatment System Operation	
Pretreatment System Operation	
Monitoring	
Maintenance	
Total Annual Cost	$ 30,000/year

COMMENTS:

This site is an operating gasoline station in Maryland. This job was initiated as an emergency response.

MA -- 8

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene								
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons			99%					
EDB								
MTBE								
IPE								

Notes: * = No site visit was completed at this site

SITE IDENTIFICATION -- MA-9

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	
Packed Height	8.0'	
Tower Diameter	2.0'	
Packing Type	1" Tellerettes	
Water Temperature	50°F	
Air Temperature	Ambient	
Water Flow Rate	50 GPM	
Air Flow Rate	1000 CFM	
Air/Water Ratio	20:1 CFM/GPM	
Initial Date of Operation		10/86
Sampling Frequency		Weekly

Costs

Engineering Design	$ 2,000
Permitting	$ 6,000
Equipment	$ 15,000
Piping	$ 1,000
Site Preparation	$ 2,000
Electrical	$ 5,000
Pretreatment System	$ 1,000
Total Initial Costs	$ 32,000

Treatment System Operation Pretreatment System Operation Monitoring System Maintenance	$ 36,000/year $ 12,000/year
Total Annual Costs	$ 48,000/year

COMMENTS:

This treatment system is located on the side of a highway in New Jersey. The source of contamination is a tank truck spill on the highway. A continuous chemical feed system pretreats the water at this site.

MA -- 9

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0	99					
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons								
EDB								
MTBE								
IPE								

Notes: No site visit was completed at this site

SITE IDENTIFICATION -- MA-10(1)

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	15.0'	15.0'
Packed Height	8.5'	8.8'
Tower Diameter	2.5'	2.5'
Packing Type	1" and 2" Tellarettes	1" and 2" Tellerettes
Water Temperature	55°F	55.4°F
Air Temperature	Ambient	84.2°F
Water Flow Rate	30 GPM	15 GPM
Air Flow Rate	600 CFM	560 CFM
Air/Water Ratio	20:1 CFM/GPM	37.3:1 CFM/GPM
Initial Date of Operation		1984
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	$ 2,000
Equipment	$ 12,000
Piping	$ 1,000
Site Preparation	$ 2,000
Electrical	
Pretreatment System	
Total Initial Cost	$ 17,000
Treatment System Operation	$ 500/year
Pretreatment System Operation	
Monitoring	$ 1,200/year
Maintenance	$ 1,500/year
Total Annual Cost	$ 3,200/year

COMMENTS:

The site is an operating pumping station for petroleum products in Pennsylvania. The spill occurred at bulk storage tank. Thin coat of brown film on the packing was evident during the site visit. Some bulk iron build up appeared to be in the middle of the tower.

MA -- 10(1)

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		83	0.4	99.5	1.6	5.4
Toluene				4.0	BDL	97.5	2.9	3.0
Ethylbenzene				BDL	ND	--	--	--
Total Xylenes				4.3	ND	--	--	--
Petroleum Hydrocarbons			99%					
EDB				ND	ND	--	--	--
MTBE				ND	ND	--	--	--
IPE				ND	ND	--	--	--

MA -- 10(2)

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		ND	ND	--	--	--
Toluene				5.5	ND	--	--	--
Ethylbenzene				BDL	ND	--	--	--
Total Xylenes				6.6	ND	--	--	--
Petroleum Hydrocarbons			99%					
EDB				ND	ND	--	--	--
MTBE				ND	ND	--	--	--
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- MA-10(3)

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	12.5'
Packed Height	8.5'	8.4'
Tower Diameter	2.0'	2.0'
Packing Type	1" and 2" Tellerettes	1" and 2" Tellerettes
Water Temperature	55°F	57.2°F
Air Temperature	Ambient	82.4°F
Water Flow Rate	30 GPM	8 GPM
Air Flow Rate	600 CFM	600 CFM
Air/Water Ratio	20:1 CFM/GPM	75:1 CFM/GPM
Initial Date of Operation		1984
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	$ 2,000
Equipment	$ 10,000
Piping	$ 2,000
Site Preparation	$ 2,000
Electrical	$ 700
Pretreatment System	
Total Initial Cost	$ 16,700

Treatment System Operation	
Pretreatment System Operation	
Monitoring	$ 1,200/year
Maintenance	$ 1,500/year
Total Annual Cost	$ 2,700/year

COMMENTS:

This site is an operating pumping station for petroleum products in Pennsylvania. The spill occurred at a bulk storage tank. Thin brown film was evident on the packing during the site visit.

MA -- 10(3)

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		10	ND	100	2.1	3.9
Toluene				4.4	ND	100	2.7	3.1
Ethylbenzene				ND	ND			
Total Xylenes				6.2	2.2	64.52	81.	1.0
Petroluem Hydrocarbons			99%					
EDB				ND	ND			
MTBE				ND	ND			
IPE				ND	ND			

SITE IDENTIFICATION -- MA-10(4)

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	12.5'
Packed Height	8.5'	8.9'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	55°F	57.2°F
Air Temperature	Ambient	87.8°F
Water Flow Rate	30 GPM	7 GPM
Air Flow Rate	600 CFM	600 CFM
Air/Water Ratio	20:1 CFM/GPM	85.7:1 CFM/GPM
Initial Date of Operation		1984
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	$ 2,000
Equipment	$ 10,000
Piping	$ 2,000
Site Preparation	$ 2,000
Electrical	$ 700
Pretreatment System	
Total Initial Cost	$ 16,700
Treatment System Operation	
Pretreatment System Operation	
Monitoring	$ 1,200/year
Maintenance	$ 1,500/year
Total Annual Cost	$ 2,700/year

COMMENTS:

This site is an operating pumping station for petroleum products in Pennsylvania. The spill occurred at the bulk storage tanks.

Water was naturally effervescent during site visit. Thin coat (1/32") of brown film was observed on the packing. Green patches were also noted on the packing. Exhaust gases from the stripper had a noticeable odor.

MA -- 10(4)

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		2300	18	99.2	1.8	4.9
Toluene				1000	9.3	99.1	1.9	4.7
Ethylbenzene				730	7.3	99.0	1.9	4.6
Total Xylenes				2170	30	98.6	2.1	4.3
Petroleum Hydrocarbons			99%					
EDB				BDL	BDL			
MTBE				ND	ND			
IPE				ND	ND			

SITE IDENTIFICATION -- MA-15

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	15.0'	
Packed Height	8.5'	
Tower Diameter	3.0'	
Packing Type	#1 Tri-pack	
Water Temperature	55°F	
Air Temperature	Ambient	
Water Flow Rate	175 GPM	
Air Flow Rate	600 CFM	
Air/Water Ratio	3.5:1 CFM/GPM	
Initial Date of Operation		7/85
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	$ 5,000
Equipment	$ 11,500
Piping	$ 4,000
Site Preparation	$ 600
Electrical	$ 2,000
Pretreatment System	
Total Initial Cost	**$ 23,100**
Treatment System Operation	$ 300/year
Pretreatment System Operation	(cost included in maintenance)
Monitoring/Maintenance	$ 8,400/year
Total Annual Cost	**$ 8,700/year**

COMMENTS:

This site used to be a service station in New York. It is presently a parking lot. The air stripper is cleaned quarterly due to iron and biological fouling.

MA -- 15

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene								
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons			99%					
EDB								
MTBE								
IPE								

Notes: No site visit was completed at this site

SITE IDENTIFICATION -- MA-16

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	15.0'	
Packed Height	8.5'	
Tower Diameter	3.0'	
Packing Type	#1 Tri-pack	
Water Temperature	55°F	
Air Temperature	Ambient	
Water Flow Rate	175 GPM	
Air Flow Rate	600 CFM	
Air/Water Ratio	3.5:1 CFM/GPM	
Initial Date of Operation		6/84
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	$ 6,000
Equipment	$ 11,500
Piping	$ 6,000
Site Preparation	$ 600
Electrical	$ 2,000
Pretreatment System	
Total Initial Cost	**$ 26,100**
Treatment System Operation	$ 300/year
Pretreatment System Operation	Cleaning cost included in maintenance
Monitoring	$ 6,000/year
Maintenance	$ 2,400/year
Total Annual Cost	**$ 8,700/year**

COMMENTS:

This site used to be a gasoline station in New York. It is now strictly a service station. The air stripper is cleaned quarterly due to iron and biological fouling.

MA -- 16

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene								
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons			99%					
EDB								
MTBE								
IPE								

Notes: No site visit was completed at this site

SITE IDENTIFICATION -- MW-1

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	14.0'	12.9'
Tower Diameter	1.0'	1.0'
Packing Type		#1 Tri Pack
Water Temperature		49.3°F
Air Temperature		97.6°F
Water Flow Rate		0.95 GPM
Air Flow Rate		1326 CFM
Air/Water Ratio	74.8 CFM/GPM	1396:1 CFM/GPM
Initial Date of Operation		4/23/87
Sampling Frequency		First three days (4/23,24,25/87) Next two weeks (5/7, 13/87) Last (5/29/87), Once/month for 3 months; then, every 3 months

Costs

Engineering Design	$ 1,752
Permitting	$ 3,360
Equipment	$ 13,595
Piping	$ 500
Site Preparation	$ 8,791
Electrical	$ 1,172
Pretreatment System	
Total Initial Cost	**$ 29,170**
Treatment System Operation	$ 21,099/year
Pretreatment System Operation	
Monitoring	$ 28,132/year
Maintenance	$ 14,065/year
Total Annual Cost	**$ 63,296/year**

COMMENTS:

This site is an operating gasoline service station and mini-market in Iowa.

MW -- 1

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene	2170	19.60	99.1	1700	2.3	99.86	2.0	6.6
Toluene				2800	7.2	99.74	2.2	6.0
Ethylbenzene				520	ND	100.0	1.6	7.9
Total Xylenes				3600	7.0	99.81	2.1	6.2
Petroleum Hydrocarbons								
EDB				ND	ND			
MTBE				780	ND	100	1.6	7.9
IPE				ND	ND			

SITE IDENTIFICATION -- MW-6

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	14.0'	12.8'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature		53.5°F
Air Temperature		95°F
Water Flow Rate	0.5 GPM	1.2 GPM
Air Flow Rate		280 CFM
Air/Water Ratio		233:1 CFM/GPM
Initial Date of Operation		Summer 1986
Sampling Frequency		Every 3 months

Costs

Engineering Design	$ 1,752
Permitting	$ 2,400
Equipment	$ 5,750
Piping	$ 500
Site Preparation	$ 11,409
Electrical	$ 1,521
Pretreatment System	
Total Initial Cost	**$ 23,332**

Treatment System Operation	$ 27,384/year
Pretreatment System Operation	
Monitoring	$ 36,510/year
Maintenance	$ 18,255/year
Total Annual Cost	**$ 82,149/year**

COMMENTS:

This site is an abandoned gasoline service station in Iowa. The tanks and pump islands have since been removed.

MW -- 6

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene	6500	140	97.9	8100	0.3	99.9+	1.2	10.2
Toluene				8500	0.7	99.9+	1.4	9.4
Ethylbenzene				1300	BDL	99.9+	1.4	8.8
Total Xylenes				5700	1.7	99.9+	1.6	8.1
Petroleum Hydrocarbons								
EDB				ND	ND	--	--	--
MTBE				9400	4.6	99.9	1.7	7.7
IPE				BDL	ND	--	--	--

SITE IDENTIFICATION -- MW-7

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	14.0'	13.8'
Tower Diameter	1.0'	1.0'
Packing Type		#1 Tri-pack
Water Temperature		49°F
Air Temperature		91.7°F
Water Flow Rate	2 GPM	0.5 GPM
Air Flow Rate		1239 CFM
Air/Water Ratio		2478:1 CFM/GPM
Initial Date of Operation		2/87
Sampling Frequency		

Costs

Engineering Design	$ 1,752
Permitting	$ 2,400
Equipment	$ 5,750
Piping	$ 500
Site Preparation	$ 15,135
Electrical	$ 2,018
Pretreatment System	
Total Initial Cost	**$ 27,555**

Treatment System Operation	$ 36,326/year
Pretreatment System Operation	
Monitoring	$ 48,435/year
Maintenance	$ 24,218/year
Total Annual Cost	**$108,979/year**

COMMENTS:

This site is an operating gasoline service station and mini-market in Iowa.

MW -- 7

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		360	0.4	99.9	2.0	6.8
Toluene				29	1.8	93.5	4.9	2.8
Ethylbenzene				37	ND			
Total Xylenes				100	5.9	94.1	4.9	2.8
Petroleum Hydrocarbons	2300	ND	100					
EDB				ND	ND	--	--	--
MTBE				BDL	0.3		4.9	2.8
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- MW-13

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	23.0'	23.0'
Packed Height	14.0'	17.0'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1/2 Tri-pack
Water Temperature	55°F	55°F
Air Temperature		69°F
Water Flow Rate	15 GPM	15 GPM
Air Flow Rate		1731 CFM
Air/Water Ratio		115:1 CFM/GPM
Initial Date of Operation		8/86
Sampling Frequency		Monthly

Costs

Engineering Design	$ 1,752
Permitting	$ 3,360
Equipment	$ 16,995
Piping	$ 500
Site Preparation	$ 10,550
Electrical	
Pretreatment System	
Total Initial Cost	**$ 33,157**
Treatment System Operation	$ 25,320/year
Pretreatment System Operation	
Monitoring	$ 33,760/year
Maintenance	$ 16,880/year
Total Annual Operation	**$ 75,960/year**

COMMENTS:

This site is an operating gasoline station in Minnesota.

MW -- 13

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene	<1.0			950	3.9	99.6	3.1	5.5
Toluene				3000	16	99.5	3.2	5.3
Ethylbenzene				440	2.9	99.3	3.4	5.0
Total Xylenes				2900	8.0	99.7	2.9	5.9
Petroleum Hydrocarbons	5700	45.0	99.2	1				
EDB				ND 2.5	ND			
MTBE				BDL	0.5		7.4	2.3
IPE				ND	ND			

SITE IDENTIFICATION -- MW-16

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.0'	
Packed Height	10.0'	
Tower Diameter	2.0'	
Packing Type	# 1/2 Tri-pack	
Water Temperature		
Air Temperature		
Water Flow Rate	40 GPM	
Air Flow Rate		
Air/Water Ratio		
Initial Date of Operation		3/87
Sampling Frequency		Every 3 months

Costs

Engineering Design	$ 1,752
Permitting	$ 2,400
Equipment	$ 8,450
Piping	$ 500
Site Preparation	$ 8,695
Electrical	$ 1,160
Pretreatment System	
Total Initial Cost	**$ 22,957**
Treatment System Operation	$ 20,868/year
Pretreatment System Operation	
Monitoring	$ 27,824/year
Maintenance	$ 13,912/year
Total Annual Costs	**$ 62,604/year**

COMMENTS:

This site is an operating gasoline service station and mini-market in Kansas.

MW -- 16

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene								
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons	1900	34	99.2					
EDB								
MTBE								
IPE								

Notes: No site visit was completed at this site

SITE IDENTIFICATION -- NE-4

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.0'	12.5'
Packed Height	10.0'	8.5'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	68°F	65°F
Air Temperature		85°F
Water Flow Rate	50 GPM	2 GPM
Air Flow Rate	500 CFM	954 CFM
Air/Water Ratio	10:1 CFM/GPM	477:1 CFM/GPM
Initial Date of Operation		9/9/86
Sampling Frequency		Monthly

Costs

Engineering Design	$ 2,040
Permitting	$ 1,985
Equipment	$ 26,525
Piping	$ 3,320
Site Preparation	$ 24,555
Electrical	$ 2,400
Pretreatment System	
Total Initial Cost	**$ 60,825**

Treatment System Operation	$ 900/year
Pretreatment System Operation	
Monitoring	$ 32,940/year
Maintenance	Included Above
Total Annual Cost	**$ 33,840/year**

COMMENTS:

This site is an operating gasoline station in Massachusetts. The air stripping tower packing is slightly fouled with iron bacteria.

NE -- 4

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		300	BDL	99.9+*	1.2	7.3
Toluene				6400	1.8	99.9+*	1.0	8.2
Ethylbenzene				1400	BDL	99.9+*	1.0	8.9
Total Xylenes				8400	4.7	99.9+	1.1	7.5
Petroleum Hydrocarbons	48.5	1.66	99.6					
EDB				ND	ND	--	--	--
MTBE				BDL	0.8		4.7	1.8
IPE				ND	ND	--	--	--

Notes: * = Refer to text for method of calculation

SITE IDENTIFICATION -- NE-6

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	12.0'
Packed Height	14.0'	9.1'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	68°F	59°F
Air Temperature	Ambient	74.5°F
Water Flow Rate	10 GPM	7.5 GPM
Air Flow Rate	250 CFM	153 CFM
Air/Water Ratio	25:1 CFM/GPM	20.4:1 CFM/GPM
Initial Date of Operation		4/85
Sampling Frequency		Weekly

Costs

Engineering Design	$ 2,000
Permitting	$ 3,000
Equipment	$ 25,000
Piping	$ 3,000
Site Preparation	$ 5,000
Electrical	$ 1,200
Pretreatment System	$ 1,500
Total Initial Cost	**$ 40,700**

Treatment System Operation	$ 1,200/year
Monitoring	$ 14,400/year
Maintenance	$ 9,600/year
Total Annual Cost	**$ 25,200/year**

COMMENTS:

This site is an operating gasoline station and mini-market in Massachusetts. The tanks have been replaced. Due to extensive biological fouling of the air stripper and reinjection gallery, a continuous chemical feed pretreatment system using citric acid and erythrobic acid has been implemented.

NE -- 6

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				2600	1900	26.9	30.3	0.3
Toluene				6800	4800	29.4	22.8	0.4
Ethylbenzene				540	320	40.7	18.2	0.5
Total Xylenes				13700	8700	36.5	18.2	0.5
Petroleum Hydrocarbons	24610	241	99					
EDB				ND	BDL	--	--	--
MTBE				BDL	190	--	--	--
IPE				ND	25	--	--	--

SITE IDENTIFICATION -- NE-9

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	27.0'	31.0'
Packed Height	24.0'	22.0'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	68°F	54.7°F
Air Temperature		80.8°F
Water Flow Rate	5 GPM	5.2 GPM
Air Flow Rate	175 CFM	172 CFM
Air/Water Ratio	35:1 CFM/GPM	33:1 CFM/GPM
Initial Date of Operation		4/87
Sampling Frequency		Monthly

Costs

Engineering Design	$ 500
Permitting	$ 5,000
Equipment	$ 14,000
Piping	$ 1,000
Site Preparation	$ 2,500
Electrical	$ 2,000
Pretreatment System	
Total Initial Cost	**$ 25,000**

Treatment System Operation	$ 1,800/year
Pretreatment System Operation	
Monitoring	$ 2,400/year
Maintenance	$ 4,800/year
Total Annual Cost	**$ 9,000/year**

COMMENTS:

This site is an operating gasoline service station in Massachusetts. The vapor phase discharge from the air stripper is treated with activated carbon at this site.

Iron bacteria were found to be present in the air stripper packing during the site visit.

NE -- 9

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				8700	24	99.7	3.7	6.0
Toluene				24000	460	98.1	5.5	4.0
Ethylbenzene				4200	640	84.8	11.6	1.9
Total Xylenes				19100	2700	85.9	11.0	2.0
Petroleum Hydrocarbons	106180	22.87	99					
EDB				ND	ND	--	--	--
MTBE				ND	ND	--	--	--
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- NE-18

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	27.0'	27.0'
Packed Height	24.0'	24.0'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	68°F	62.3°F
Air Temperature	Ambient	77.2°F
Water Flow Rate	5 GPM	3.6 GPM
Air Flow Rate	100 CFM	106 CFM
Air/Water Ratio	20:1 CFM/GPM	29.4:1 CFM/GPM
Initial Date of Operation		6/30/86
Sampling Frequency		Bi-monthly

Costs

Engineering Design	$ 500
Permitting	$ 1,500
Equipment	$ 10,000
Piping	$ 1,000
Site Preparation	$ 25,000
Electrical	N/A**
Pretreatment System	
Total Initial Cost	**$ 38,000**
Treatment System Operation	$ 960/year
Pretreatment System Operation	
Monitoring	$ 60,000/year
Maintenance	Included Above
Total Annual Cost	**$ 60,960/year**

COMMENTS:

This site is an operating gasoline service station in Massachusetts. Minimal tower fouling was apparent during the site visit.

NE -- 18

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		4200	1.8	99.9+	3.0	7.9
Toluene				13000	5.9	99.9+	3.1	7.8
Ethylbenzene				9900	0.7	99.9+	2.4	9.8
Total Xylenes				4400	3.0	99.9+	3.2	7.4
Petroleum Hydrocarbons	6900	6.2	99.9					
EDB				ND	ND	--	--	--
MTBE				16000	8.6	99.9+	2.8	8.4
IPE				1800	1.0	99.9+		

SITE IDENTIFICATION -- NE-19

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	22.5'	22.5'
Packed Height	20.0'	18.8'
Tower Diameter	2.0'	2.0'
Packing Type	#1 & #1/2 Tri-pack	#1 & #1/2 Tri-pack
Water Temperature	68°F	70.8°F
Air Temperature		81.8°F
Water Flow Rate	25 GPM	11.5 GPM
Air Flow Rate	750 CFM	125 CFM
Air/Water Ratio	30:1 CFM/GPM	11:1 CFM/GPM
Initial Date of Operation		4/86
Sampling Frequency		Weekly

Costs

Engineering Design	$ 800
Permitting	$ 2,500
Equipment	$ 14,000
Piping	$ 4,000
Site Preparation	$ 2,000
Electrical	$ 1,000
Pretreatment System	
Total Initial Cost	**$ 24,300**
Treatment System Operation	$ 1,200/year
Pretreatment System Operation	
Monitoring	$ 10,800/year
Maintenance	$ 4,800/year
Total Annual Cost	**$ 16,800/year**

COMMENTS:

This site is an operating gasoline service station in Massachusetts. Severe iron bacteria fouling was noted in the air stripper during the site visit.

NE -- 19

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				4800	ND	--	--	--
Toluene				24000	270	98.9	4.0	4.7
Ethylbenzene				2500	ND	--	--	--
Total Xylenes				19000	5800	69.5	15.7	1.2
Petroleum Hydrocarbons	43096	76.68	99					
EDB				ND	ND	--	--	--
MTBE				7800	380	95.1	4.8	3.9
IPE				BDL	ND	--	--	--

SITE IDENTIFICATION -- NE-21

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	12.5'
Packed Height	10.0'	8.3'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	50°F	57°F
Air Temperature	Ambient	87°F
Water Flow Rate	40 GPM	42 GPM
Air Flow Rate	400 CFM	231 CFM
Air/Water Ratio	10:1 CFM/GPM	5.5:1 CFM/GPM
Initial Date of Operation		3/3/87
Sampling Frequency		Monthly

Costs

Engineering Design	$ 500
Permitting	$ 800
Equipment	$ 31,500
Piping	$ 2,750
Site Preparation	$ 7,000
Electrical	$ 3,000
Pretreatment	
Total Initial Cost	**$ 45,550**

Treatment System Operation	$ 1,200/year
Pretreatment System Operation	$ 2,400/year
Monitoring	$ 6,000/year
Maintenance	$ 18,000/year
Total Annual Cost	**$ 27,600/year**

COMMENTS:

This site is an abandoned gasoline service station in Massachusetts. The tanks and pump islands have been removed. Due to iron and biological fouling, a continuous chemical feed system using citric acid and erythorbic acid has been implemented at this site.

NE -- 21

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				440	17	96.1	2.3	3.6
Toluene				400	16	96.0	2.4	3.5
Ethylbenzene				84	2.8	96.7	2.2	3.7
Total Xylenes				220	14.3	93.5	2.9	2.9
Petroleum Hydrocarbons	43000	100	99.8					
EDB				ND	ND	--	--	--
MTBE				710	270	62.0	6.4	1.3
IPE				ND	0.8	--	--	--

SITE IDENTIFICATION -- NE-22

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	14.0'	13.4'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	68oF	63.8oF
Air Temperature		83.3oF
Water Flow Rate	10 GPM	3.75 GPM
Air Flow Rate	250 CFM	275 CFM
Air/Water Ratio	25:1 CFM/GPM	73.3:1 CFM/GPM
Initial Date of Operation		1/87
Sampling Frequency		Monthly

Costs

Engineering Design	$ 750
Permitting	$ 1,500
Equipment	$ 12,000
Piping	Included above
Site Preparation	
Electrical	$ 3,450
Pretreatment	
Total Initial Cost	**$ 17,700**
Treatment System Operation	
Pretreatment System Operation	
Monitoring	$ 400/year
Maintenance	Included above
Total Annual Cost	**$ 400/year**

COMMENTS:

This site is an abandoned gasoline station in Massachusetts. The tanks and pump islands have been removed.

NE -- 22

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene	9210	12.3	99.9	340	BDL	99.9+*	1.8	7.5
Toluene				1900	0.6	99.9+*	1.6	8.1
Ethylbenzene				600	BDL	99.9+*	1.6	8.1
Total Xylenes				3300	1.2	99.9+	1.7	8.0
Petroleum Hydrocarbons	34200	66.1	99.8					
EDB				BDL	ND	--	--	--
MTBE				BDL	0.6		6.1	2.2
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- SC-1

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	27.0'	27.0'
Packed Height	24.0'	23.5'
Tower Diameter	1.0'	1.0'
Packing Type	# 1/2 Tri-pack	# 1/2 Tri-pack
Water Temperature	83°F	81°F
Air Temperature	90°F	78°F
Water Flow Rate	3.5 GPM	5 GPM
Air Flow Rate	155 CFM	200 CFM
Air/Water Ratio	44:1 CFM/GPM	40:1 CFM/GPM
Initial Date of Operation		9/22/86
Sampling Frequency		Quarterly

Costs

Engineering Design	$ 2,200
Permitting	$ 1,800
Equipment	$ 9,612
Piping	Included Above
Site Preparation	Included Above
Electrical	$ 500
Pretreatment	
Total Initial Cost	**$ 14,112**

Treatment System Operation	
Pretreatment System Operation	
Monitoring	$ 840/year
Maintenance	$ 320/year
Total Annual Cost	**$ 1,160/year**

COMMENTS:

This site is an operating gasoline station and mini-market in Louisiana. The spill contains ethanol as well as gasoline.

SC -- 1

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				29000	25	99.9+	3.3	7.2
Toluene				32000	30	99.9+	3.3	7.1
Ethylbenzene				3400	3.6	99.8	3.4	6.9
Total Xylenes				17800	20	99.8	3.4	6.9
Petroleum Hydrocarbons	68000	190	99.87					
EDB				ND	ND	--	--	--
MTBE				BDL	3.0	--	--	--
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- SC-2

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	14.0'	13.5'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature		73°F
Air Temperature		89°F
Water Flow Rate	3 GPM	4.5 GPM
Air Flow Rate	300 CFM	196 CFM
Air/Water Ratio	100:1 CFM/GPM	43.5:1 CFM/GPM
Initial Date of Operation		4/30/85
Sampling Frequency		Quarterly

Costs

Engineering Design	$ 2,500
Permitting	$ 1,800
Equipment	$ 8,989
Piping	Included Above
Site Preparation	Included Above
Electrical	$ 350
Pretreatment System	
Total Initial Cost	**$ 13,639**

Treatment System Operation	
Pretreatment System Operation	
Monitoring	$ 840/year
Maintenance	$ 240/year
Total Annual Cost	**$ 1,080/year**

COMMENTS:

This site is an operating gasoline station in Louisiana.

SC -- 2

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		520	BDL	99.9+	1.7	8.0
Toluene				4400	0.6	99.9+	1.2	11.4
Ethylbenzene				410	ND	--	--	--
Total Xylenes				2430	ND	--	--	--
Petroleum Hydrocarbons	34600	210	99.4					
EDB				ND	ND	--	--	--
MTBE				ND	ND	--	--	--
IPE				1700	0.7	99.9+	--	--

SITE IDENTIFICATION -- SC-3

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	14.0'	13.0'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature		71°F
Air Temperature		81°F
Water Flow Rate	3 GPM	4 GPM
Air Flow Rate	300 CFM	44 CFM
Air/Water Ratio	100:1 CFM/GPM	11:2 CFM/GPM
Initial Date of Operation		7/24/85
Sampling Frequency		Monthly

Costs

Engineering Design	$ 2,000
Permitting	$ 1,800
Equipment	$ 10,037
Piping	Included Above
Site Preparation	Included Above
Electrical	$ 500
Pretreatment System	
Total Initial Cost	**$ 14,337**

Treatment System Operation	
Pretreatment System Operation	
Monitoring	$ 2,400/year
Maintenance	$ 2,760/year
Total Annual Cost	**$ 5,160/year**

COMMENTS:

This site is an operating gasoline service station in Louisiana. Tower packed was observed to be fouled during site visit.

SC -- 3

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		2900	0.5	99.9+	1.4	9.2
Toluene				6400	1.0	99.9+	1.4	9.3
Ethylbenzene				990	0.2	99.9+	1.4	9.0
Total Xylenes				3330	1.7	99.9+	1.6	8.0
Petroleum Hydrocarbons	7300	60	99.2					
EDB				ND	ND	--	--	--
MTBE							6.8	1.9
IPE				600	13	97.8	--	--

SITE IDENTIFICATION -- SC-4

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	14.0'	13.5'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature		70°F
Air Temperature		87°F
Water Flow Rate	4 GPM	3.8 GPM
Air Flow Rate	400 CFM	200 CFM
Air/Water Ratio	100:1 CFM/GPM	52.6:1 CFM/GPM
Initial Date of Operation		1/85
Sampling Frequency		Monthly

Costs

Engineering Design	$ 2,200
Permitting	$ 1,800
Equipment	$ 5,750
Piping	Included Above
Site Preparation	Included Above
Electrical	$ 934
Pretreatment System	
Total Initial Cost	**$ 10,684**
Treatment System Operation	
Pretreatment System Operation	$ 900/year
Monitoring	$ 2,400/year
Maintenance	$ 110/year
Total Annual Cost	**$ 3,410/year**

COMMENTS:

This site is an operating gasoline station, mini-market and car wash in Louisiana. The packing in this air stripping tower accumulates inorganic precipitates.

SC -- 4

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				930	ND	--	--	--
Toluene				130	ND	--	--	--
Ethylbenzene				450	ND	--	--	--
Total Xylenes				930	ND	--	--	--
Petroleum Hydrocarbons	27400	331	98.8					
EDB				ND	ND	--	--	--
MTBE				3000	1.3	99.9+	1.6	8.2
IPE				ND	ND	--	--	-

SITE IDENTIFICATION -- SC-5

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	14.0'	13.5'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature		68°F
Air Temperature		77°F
Water Flow Rate	7 GPM	8 GPM
Air Flow Rate	300 CFM	398 CFM
Air/Water Ratio	43:1 CFM/GPM	49.8:1 CFM/GPM
Initial Date of Operation		10/28/85
Sampling Frequency		Not sampled on regular basis

Costs

Engineering Design	$ 2,200
Permitting	$ 1,800
Equipment	$ 6,273
Piping	Included Above
Site Preparation	Included Above
Electrical	$ 1,700
Pretreatment System	
Total Initial Cost	**$ 11,973**

Treatment System Operation	
Pretreatment System Operation	
Monitoring	
Maintenance	$ 720/year
Total Annual Cost	**$ 720/year**

COMMENTS:

This site is an operating gasoline station and car wash in Louisiana.

SC -- 5

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				340	0.7	99.8	2.2	6.3
Toluene				310	0.2	99.9+	1.8	7.4
Ethylbenzene				410	1.3	99.7	2.3	5.8
Total Xylenes				3000	11.5	99.6	2.4	5.6
Petroleum Hydrocarbons	59000	562	98.9					
EDB				ND	ND	--	--	--
MTBE				BDL	10			
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- SE-7

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	12.5'
Packed Height	10.0'	10.0'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature		81.2oF
Air Temperature		95.6oF
Water Flow Rate	28 GPM	32.4 GPM
Air Flow Rate		694 CFM
Air/Water Ratio		21.4:1 CFM/GPM
Initial Date of Operation		
Sampling Frequency		

Costs

Engineering Design	
Permitting	$ 101
Equipment	$ 14,500
Piping	
Site Preparation	$ 7,663
Electrical	$ 1,665
Pretreatment System	
Total Initial Cost	**$ 23,929**
Treatment System Operation	$ 2,700/year
Pretreatment System Operation	
Monitoring	$ 12,000/year
Maintenance	$ 6,000/year
Total Annual Cost	**$ 20,700/year**

COMMENTS:

This site is an operating gasoline station and mini-market in Florida.

SE -- 7

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		19	ND	--	--	--
Toluene				BDL	ND	--	--	--
Ethylbenzene				BDL	ND	--	--	--
Total Xylenes				5.9	ND	--	--	--
Petroleum Hydrocarbons	50	1.0	69					
EDB				ND	ND	--	--	--
MTBE				ND	ND	--	--	--
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- SE-18

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	18.0'	18.0'
Packed Height	15.5'	14.0'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature		82.7°F
Air Temperature		97°F
Water Flow Rate	22 GPM	22.2 GPM
Air Flow Rate		231 CFM
Air/Water Ratio		10.4:1 CFM/GPM
Initial Date of Operation		8/86
Sampling Frequency		

Costs

Engineering Design	
Permitting	
Equipment	$ 25,000
Piping	$ 137
Site Preparation	$ 7,776
Electrical	Included Above
Pretreatment System	
Total Initial Cost	**$ 32,913**
Operation	$ 6,000/year
Pretreatment	
Monitoring	$ 18,000/year
Maintenance	$ 6,000/year
Total Annual Cost	**$ 30,000/year**

COMMENTS:

This site is a water resources management company in Florida. Inclusive in the facility is a fueling facility from which the spill occurred.

SE -- 18

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		35	0.5	98.6	3.1	4.5
Toluene				10	ND	--	--	--
Ethylbenzene				BDL	ND	--	--	--
Total Xylenes				14.6	ND	--	--	--
Petroleum Hydrocarbons	804							
EDB				ND	ND	--	--	--
MTBE				8.6	1.3	84.9	6.1	2.3
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- SE-22

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	18.0'	18.0'
Packed Height	15.5'	14.0'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature		82.4oF
Air Temperature		90.2oF
Water Flow Rate	4 GPM	3 GPM
Air Flow Rate		1056 GPM
Air/Water Ratio		352:1 CFM/GPM
Initial Date of Operation		9/86
Sampling Frequency		

Costs

Engineering Design	
Permitting	
Equipment	$ 18,000
Piping	$ 138
Site Preparation	$ 580
Electrical	$ 2,020
Pretreatment System	
Total Initial Cost	**$ 20,738**

Treatment System Operation	$ 7,440/year
Pretreatment System Operation	
Monitoring	$ 14,400/year
Maintenance	$ 6,000/year
Total Annual Cost	**$ 27,840/year**

COMMENTS:

This site is an operating gasoline service station in Florida.

SE -- 22

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				36	BDL	99.7*	2.7	5.2
Toluene				14	0.3	97.8	3.6	3.8
Ethylbenzene				13	ND	--	--	--
Total Xylenes				53	ND	--	--	--
Petroleum Hydrocarbons	1400							
EDB				ND	ND	--	--	--
MTBE				7.7	0.7	90.9	5.8	2.4
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- NE-23

TECHNOLOGY -- ACTIVATED CARBON ADSORPTION

System Parameter	Design	Actual
Water Flow Rate	1 GPM	0.17 GPM
Water Temperature	50oF	74oF
Air Temperature	Ambient	78oF
Carbon Tank Size	55 gallon	55 gallon
Configuration	Two in series	Two in series
Retention Time	55 minutes/tank	323 minutes/tank
Initial Date of Operation		5/24/86
Sampling Frequency		Quarterly

Costs

Engineering Design	
Permitting	
Equipment	
Piping	
Site Preparation	
Electrical	
Pretreatment System Operation	
Total Initial Cost	**$ 30,000**
Treatment System Operation	
Pretreatment System Operation	
Monitoring	$ 54,000/year
Maintenance	Included Above
Total Annual Cost	**$ 54,000/year**

COMMENTS:

The site is a college in Massachusetts. Fuel oil tanks leaked in the boiler room. The soil beneath this building is not very permeable and recovery is difficult.

NE -- 23

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF* (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				BDL	ND	--	--	--
				ND	ND	--	--	--
Toluene				ND	ND	--	--	--
				ND	ND	--	--	--
Ethylbenzene				ND	MD	--	--	--
				ND	ND	--	--	--
Total Xylenes				15.3	ND	--	--	--
				ND	ND	--	--	--
Petroleum Hydrocarbons	69	ND	100					
EDB				ND	ND	--	--	--
				ND	ND	--	--	--
MTBE				ND	ND	--	--	--
				ND	ND	--	--	--
IPE				ND	ND	--	--	--
				ND	ND	--	--	--

* These values correspond to effluent from the first and second carbon tanks, respectively.

SITE IDENTIFICATION -- SE-29

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	22.5'	22.5'
Packed Height	20.0'	19.0'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature		
Air Temperature		
Water Flow Rate	30 GPM	30 GPM
Air Flow Rate		
Air/Water Ratio		
Initial Date of Operation		
Sampling Frequency		

Costs

Engineering Design	$ 888
Permitting	$ 211
Equipment	$ 16,524
Piping	
Site Preparation	$ 1,643
Electrical	$ 1,220
Pretreatment System	
Treatment System Operation	$ 12,000/year
Pretreatment System Operation	
Monitoring	$ 12,000/year
Maintenance	$ 6,000/year
Total Initial Cost	**$ 50,486/year**

COMMENTS:

This site is an operating gasoline station, mini-market and car wash in Florida.

SE -- 29

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		10	ND	--	--	--
Toluene				4	ND	--	--	--
Ethylbenzene				ND	ND	--	--	--
Total Xylenes				42	ND	--	--	--
Petroleum Hydrocarbons	590	50	91.5					
EDB								
MTBE								
IPE								

SITE IDENTIFICATION -- SE-31

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	14.0'	14.0'
Tower Diameter	1.0'	1.0'
Packing Type	# 1/2 Tri-pack	# 1/2 Tri-pack
Water Temperature	68.4°F	68.4°F
Air Temperature	80°F	79°F
Water Flow Rate	5 GPM	1.4 GPM
Air Flow Rate	100 CFM	214 CFM
Air/Water Ratio	20:1 CFM/GPM	224:1 CFM/GPM
Initial Date of Operation		4/85
Sampling Frequency		Quarterly

Costs

Engineering Design	
Permitting	
Equipment	$ 8,750
Piping	
Site Preparation	
Electrical	
Pretreatment System	
Total Initial Cost	**$ 8,750**
Treatment System Operation	$ 1,200/year
Pretreatment System Operation	
Monitoring	$ 1,400/year
Maintenance	$ 1,100/year
Total Annual Cost	**$ 3,700/year**

COMMENTS:

This site is an operating gasoline station in Florida. The packing in this tower is cleaned every six months.

SE -- 31

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				14000	0.9	>99.9	1.4	9.7
Toluene				12000	1.5	>99.9	1.6	9.0
Ethylbenzene				980	BDL	>99.9*	1.6	8.5
Total Xylenes				5000	0.7	>99.9	1.6	8.9
Petroleum Hydrocarbons	47000	<250	99.8					
EDB				BDL	BDL		--	--
MTBE				5200	4.7	>99.9	2.0	7.1
IPE				BDL	BDL		--	--

SITE IDENTIFICATION -- SE-32

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	12.5'
Packed Height	10.0'	10.0'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	75°F	81.5°F
Air Temperature		93.8°F
Water Flow Rate	30 GPM	14.3 GPM
Air Flow Rate		860 CFM
Air/Water Ratio		60:1 CFM/GPM
Initial Date of Operation		12/84
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	
Equipment	$ 21,500
Piping	
Site Preparation	$ 6,550
Electrical	$ 1,850
Pretreatment System	
Total Initial Cost	**$ 29,900**
Treatment System Operation	$ 9,696/year
Pretreatment System Operation	$ 7,200/year
Monitoring	$ 18,000/year
Maintenance	$ 6,000/year
Total Annual Cost	**$ 40,896/year**

COMMENTS:

This site is an operating gasoline station, mini-market, and car wash in Florida. A pretreatment system of continuous chemical feed has been on line since January 1987.

SE -- 32

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		27	BDL	99.6	2.0	5.0
Toluene				6.5	BDL	98.5	2.8	3.5
Ethylbenzene				37	ND	--	--	--
Total Xylenes				141	ND	--	--	--
Petroleum Hydrocarbons 5424								
EDB				ND	ND	--	--	--
MTBE				20	BDL	99.2*	2.3	4.4
IPE				0.4	ND	--	--	--

Notes: * = Refer to text for method of calculation.

SITE IDENTIFICATION -- SE-33(1)

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	22.5'	22.5'
Packed Height	20.0'	18.5'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	60°F	78.8°F
Air Temperature	70°F	97.1°F
Water Flow Rate	20 GPM	16 GPM
Air Flow Rate	200 CFM	567 CFM
Air/Water Ratio	10:1 CFM/GPM	35.4:1 CFM/GPM
Initial Date of Operation		11/5/86
Sampling Frequency		Quarterly

Costs

Engineering Design	$ 2,100
Permitting	
Equipment	$ 21,000
Piping	$ 2,500
Site Preparation	$ 8,000
Electrical	$ 3,700
Pretreatment System	
Total Initial Cost	**$ 37,300**

Treatment System Operation	
Pretreatment System Operation	$ 4,800/year
Monitoring	$ 8,000/year
Maintenance	$ 18,000/year
Total Annual Cost	**$ 30,800/year**

COMMENTS:

This site is an operating gasoline station in Florida. A continuous chemical feed system injects citric acid as a chelating agent.

SE -- 33(1)

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				990	BDL	99.9+*	2.2	8.6
Toluene				1300	BDL	99.9+*	2.1	8.9
Ethylbenzene				1100	ND	--	--	--
Total Xylenes				2800	BDL	99.9+*	2.0	9.3
Petroleum Hydrocarbons	3100		>99.9					
EDB				ND	ND	--	--	--
MTBE				540	0.9	99.8	2.6	7.0
IPE				ND	ND	--	--	--

Notes: * = Refer to text for method of calculation.

SITE IDENTIFICATION -- SE-33(2)

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	12.5'
Packed Height	8.5'	8.5'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	60°F	78.8°F
Air Temperature	70°F	97.1°F
Water Flow Rate	20 GPM	16 GPM
Air Flow Rate	200 CFM	532 CFM
Air/Water Ratio	10:1 CFM/GPM	33.2:1 CFM/GPM
Initial Date of Operation		11/5/86
Sampling Frequency		Quarterly

Costs

Engineering Design
Permitting
Equipment
Piping
Site Preparation
Electrical
Pretreatment System

Costs given for site SE.33 (1) include costs for site SE.33 (2)

Treatment System Operation
Pretreatment System Operation
Monitoring
Maintenance

COMMENTS:

This site is an operating gasoline station in Florida. This stripper is utilized in series with SE-33(1) as a polishing step.

SE -- 33(2)

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				BDL	ND	--	--	--
Toluene				BDL	BDL		--	--
Ethylbenzene				ND	ND	--	--	--
Total Xylenes				BDL	BDL		--	--
Petroleum Hydrocarbons			>99.9					
EDB				ND	ND	--	--	--
MTBE				0.9	0.4	55.6	10.6	0.8
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- SE-35

TECHNOLOGY -- AIR STRIPPER

System Parameter	Design	Actual
Tower Height	22.5'	22.5'
Packed Height	20.0'	18.5'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	60°F	82.4°F
Air Temperature	70°F	86.0°F
Water Flow Rate	17 GPM	9.5 GPM
Air Flow Rate	340 CFM	454 CFM
Air/Water Ratio	20:1 CFM/GPM	47.8:1 CFM/GPM
Initial Date of Operation		9/6/85
Sampling Frequency		Quarterly

Costs

Engineering Design	$ 2,000
Permitting	
Equipment	$ 25,000
Piping	
Site Preparation	$ 6,000
Electrical	
Pretreatment System	
Total Initial System	**$ 33,000**
Treatment System Operation	$ 2,500/year
Pretreatment System Operation	$ 4,800/year
Monitoring	$ 8,000/year
Maintenance	$ 18,000/year
Total Annual Cost	**$ 33,300/year**

COMMENTS:

This site is an operating gasoline station in Florida. A chlorine feed system pretreats the influent water to prevent biological fouling.

SE -- 35

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene	3700	<1.0	>99.9	520	0.2	>99.9	2.3	8.0
Toluene				2800	0.2	>99.9	1.9	9.7
Ethylbenzene				680	ND	--	--	--
Total Xylenes				5200	ND	--	--	--
Petroleum Hydrocarbons								
EDB				ND	ND	--	--	--
MTBE				150	BDL	>99.9*	2.8	6.6
IPE				ND	ND	--	--	--

Note: * Refer to text for method of calculation.

SITE IDENTIFICATION -- W-1

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	13.0'	13.0'
Tower Diameter	1.0'	1.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	65oF	80oF
Air Temperature	70oF	100oF
Water Flow Rate	10 GPM	0.8 GPM
Air Flow Rate	100 CFM	322 CFM
Air/Water Ratio	10:1 CFM/GPM	402.5:1 CFM/GPM
Initial Date of Operation		4/87
Sampling Frequency		Weekly

Costs

Engineering Design	$ 3,192
Permitting	$ 2,000
Equipment	$ 7,500
Piping	$ 1,000
Site Preparation	$ 9,000
Electrical	$ 2,000
Pretreatment System	
Total Initial Cost	**$ 24,692**
Treatment System Operation	$ 1,200/year
Pretreatment System Operation	$ 700/year
Monitoring	$ 55,000/year
Maintenance	Included Above
Total Annual Cost	**$ 56,900/year**

COMMENTS:

This site is a manufacturer of medical supplies in California. They have gasoline tanks on site for their vehicles. Pretreatment for iron precipitate is accomplished through harmonic fluid conditioning, an innovative alternative technology.

W -- 1

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene	9	0.7	92.22	440	3.7	99.2	2.7	4.8
Toluene				340	BDL	99.9+*	1.7	7.5
Ethylbenzene				180	ND	--	--	--
Total Xylenes				670	ND	--	--	--
Petroleum Hydrocarbons	10800	100	99.91					
EDB				ND	ND	--	--	--
MTBE				BDL	ND	--	--	--
IPE				ND	ND	--	--	--

Note: * = Refer to text for method of calculation.

SITE IDENTIFICATION -- MW-14

TECHNOLOGY -- ACTIVATED CARBON ADSORPTION

System Parameter	Design	Actual
Water Flow Rate	2 GPM	2 GPM
Water Temperature		63oF
Air Temperature		90oF
Carbon Tank Size	55 gallon	55 gallon
Configuration	Two in series	Two in series
Retention Time	27.5 minutes/tank	27.5 minutes/tank
Initial Date of Operation		6/86
Sampling Frequency		Monthly

Costs

Engineering Design	$ 1,752
Permitting	$ 2,400
Equipment	$ 5,280
Piping	$ 500
Site Preparation	$ 21,000
Electrical	$ 2,800
Pretreatment System	
Total Initial Cost	**$ 33,732**
Treatment System Operation	$ 50,411/year
Pretreatment System Operation	
Monitoring	$ 67,215/year
Maintenance	$ 33,607/year
Total Annual Cost	**$151,233/year**

COMMENTS:

This site is an operating gasoline station and mini-market in Illinois.

MW -- 14

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				1100	BDL	99.9+	--	--
Toluene				1800	BDL	99.9+	--	--
Ethylbenzene				890	0.5	99.9+	--	--
Total Xylenes				4500	3.1	99.9+	--	--
Petroleum Hydrocarbons			99					
EDB				ND	ND	--	--	--
MTBE				110	200			
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- W-2

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	12.5'
Packed Height	8.0'	8.0'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	65°F	78°F
Air Temperature	70°F	88.5°F
Water Flow Rate	60 GPM	8.5 GPM
Air Flow Rate	600 CFM	
Air/Water Ratio	10:1 CFM/GPM	
Initial Date of Operation		9/86
Sampling Frequency		Weekly

Costs

Engineering Design	
Permitting	
Equipment	$ 23,000
Piping	$ 7,400
Site Preparation	
Electrical	$ 2,200
Pretreatment	
Total Initial Cost	**$ 32,600**
Treatment System Operation	$ 17,000
Pretreatment System Operation	$ 1,700
Monitoring	Included Above
Maintenance	Included Above
Total Annual Cost	**$ 18,700/year**

COMMENTS:

This site is an operating gasoline station and mini-market in California. A harmonic fluid conditioning unit is pretreating for iron precipitate.

W -- 2

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		0.7		ND	BDL	--	--	--
Toluene				ND	4.7	--	--	--
Ethylbenzene				ND	ND	--	--	--
Total Xylenes				ND	ND	--	--	--
Petroleum Hydrocarbons		100	>99.5					
EDB				ND	ND	--	--	--
MTBE				1.4	0.3	78.6	--	--
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- W-4

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	27.0'	22.3'
Packed Height	22.0'	18.3'
Tower Diameter	1.0'	1.0'
Packing Type	Tri-pack	# 1/2 Tri-pack
Water Temperature	40 - 60°F	76.5°F
Air Temperature	40 - 60°F	93.8°F
Water Flow Rate	5 - 20 GPM	8.5 GPM
Air Flow Rate	100 CFM	160.7 CFM
Air/Water Ratio		18.9:1 CFM/GPM
Initial Date of Operation		9/85
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	
Equipment	$ 33,000
Piping	Included Above
Site Preparation	$ 21,800
Electrical	$ 3,200
Pretreatment System	
Total Initial Cost	**$ 58,000**
Treatment System Operation	$ 17,000/year
Pretreatment System Operation	
Monitoring	$ 17,130/year
Maintenance	Included Above
Total Annual Cost	**$ 34,130/year**

COMMENTS:

This site is an operating gasoline station in California.

W -- 4

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				9.2	ND	--	--	--
Toluene				2.3	ND	--	--	--
Ethylbenzene				BDL	ND	--	--	--
Total Xylenes				36	ND	--	--	--
Petroleum Hydrocarbons								
EDB				ND	ND	--	--	--
MTBE				BDL	1.0		10.2	1.8
IPE				5.0	ND	--	--	--

SITE IDENTIFICATION -- W-11

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	
Packed Height	13.0'	
Tower Diameter	1.0'	
Packing Type	#1/2 Tri-pack	
Water Temperature	40 - 60°F	
Air Temperature	40 - 60°F	
Water Flow Rate	5 - 20 GPM	
Air Flow Rate	1 - 100 CFM	
Air/Water Ratio		
Initial Date of Operation		9/86
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	
Equipment/Piping	$ 24,000
Site Preparation	$ 30,000
Electrical	
Pretreatment System	
Total Initial System	**$ 54,000**
Treatment System Operation	$ 24,400/year
Pretreatment System Operation	
Monitoring	$ 19,100/year
Maintenance	Included Above
Total Annual Cost	**$ 43,500/year**

COMMENTS:

This site is an operating service station in California.

W -- 11

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene								
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons								
EDB								
MTBE								
IPE								

Notes: No site visit was completed at this site

SITE IDENTIFICATION -- W-14

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	21.0'
Packed Height	14.0'	18.0'
Tower Diameter	1.0'	1.0'
Packing Type	#1/2 Tri-pack	#1/2 Tri-pack
Water Temperature	40 - 60°F	68°F
Air Temperature	40 - 60°F	84.2°F
Water Flow Rate	10 GPM	1.1 GPM
Air Flow Rate	100 CFM	123 GPM
Air/Water Ratio	20:1 CFM/GPM	111.8:1 CFM/GPM
Initial Date of Operation		4/87
Sampling Frequency		Monthly

Costs

Engineering Design	$ 13,500
Permitting	$ 7,000
Equipment	$ 9,400
Piping	$ 4,000
Site Preparation	$ 31,100
Electrical	$ 2,500
Pretreatment System	
Total Initial Cost	**$ 67,500**
Treatment System Operation	$ 18,500
Pretreatment	$ 3,000/year
Monitoring	$ 10,000/year
Maintenance	Included Above
Total Annual Cost	**$ 31,800/year**

COMMENTS:

This site used to be a gasoline station in California. It is now a police station. A harmonic fluid conditioning unit pretreats the influent to the air stripper due to high iron concentrations.

W -- 14

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		0.7		ND	BDL	--	--	--
Toluene				ND	ND	--	--	--
Ethylbenzene				BDL	ND	--	--	--
Total Xylenes				ND	ND	--	--	--
Petroleum Hydrocarbons	97000							
EDB				ND	ND	--	--	--
MTBE				BDL	BDL		--	--
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- W-17

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	
Packed Height	14.0'	
Tower Diameter	1.0'	
Packing Type	#1/2 Tri-pack	
Water Temperature	68 - 77oF	
Air Temperature	68 - 77oF	
Water Flow Rate	5 GPM	
Air Flow Rate	50 CFM	
Air/Water Ratio	10:1 CFM/GPM	
Initial Date of Operation		5/19/86
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	
Equipment	$ 6,000
Piping	
Site Preparation	
Electrical	
Pretreatment System	$ 1,150
Total Initial Cost	**$ 7,150**
Treatment System Operation	
Pretreatment System Operation	$ 700/year
Monitoring	
Maintenance	
Total Annual Cost	**$ 700/year**

COMMENTS:

This site is a chemical company in California. A continuous chemical for system feeds polyphosate sequesterin agent due to iron fouling.

W -- 17

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene	17000	15	99.9					
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons								
EDB								
MTBE								
IPE								

Notes: * = No site visit was completed at this site.

SITE IDENTIFICATION -- W-18

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	12.5'
Packed Height	8.0'	8.0'
Tower Diameter	2.0'	2.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	65°F	68°F
Air Temperature	70°F	75°F
Water Flow Rate	60 GPM	3.5 GPM
Air Flow Rate	600 CFM	350 CFM
Air/Water Ratio	10:1 CFM/GPM	100:1 CFM/GPM
Initial Date of Operation		3/86
Sampling Frequency		Monthly

Costs

Engineering Design	$ 3,256
Permitting	$ 6,046
Equipment	$ 41,000
Piping	Included Above
Site Preparation	Included Above
Electrical	Included Above
Pretreatement System	
Total Initial Cost	**$ 50,302**

Treatment System Operation	
Pretreatment System Operation	
Monitoring	
Maintenance	
Total Annual Cost	

COMMENTS:

This site used to be a gasoline service station in California. It is presently a fast-food restaurant.

W -- 18

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				410	ND	--	--	--
Toluene		7		25	ND	--	--	--
Ethylbenzene				4.8	ND	--	--	--
Total Xylenes				66.1	ND	--	--	--
Petroleum Hydrocarbons	200							
EDB				ND	ND	--	--	--
MTBE				BDL	ND	--	--	--
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- W-19

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	
Packed Height	8.0'	
Tower Diameter	2.0'	
Packing Type	#1 Tri-pack	
Water Temperature	60°F	
Air Temperature	70°F	
Water Flow Rate	60 GPM	
Air Flow Rate	600 CFM	
Air/Water Ratio	10:1 CFM/GPM	
Initial Date of Operation		1984
Sampling Frequency		Weekly

Costs

Engineering Design	Included Below
Permitting	Included Below
Equipment	$ 52,000
Piping	Included Above
Site Preparation	Included Above
Electrical	Included Above
Pretreatment System	$ 600
Total Initial Cost	**$ 52,600**

Treatment System Operation	
Pretreatment System Operation	$ 600
Monitoring	
Maintenance	
Total Annual Cost	

COMMENTS:

This site used to be a gasoline station in California. Their tanks were removed because of leaks. The service department is still operating. Pretreatment for iron fouling is accomplished in a harmonic fluid conditioning unit.

W -- 19

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		500						
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons		15000						
EDB								
MTBE								
IPE								

Notes: No site visit was completed at this site

SITE IDENTIFICATION -- W-31(1)

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	22.5'	20.0'
Packed Height	18.0'	16.0'
Tower Diameter	3.0'	3.5'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	40 - 60°F	64.4°F
Air Temperature	40 - 60°F	86°F
Water Flow Rate	30-175 GPM	135 GPM
Air Flow Rate	1 - 1000 CFM	982 CFM
Air/Water Ratio		7.3:1 CFM/GPM
Initial Date of Operation		5/84
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	
Equipment	$ 100,000
Piping	Included Above
Site Preparation	$ 10,000
Electrical	$ 28,000
Pretreatment System	
Total Initial Cost	**$ 138,000**
Operation	$ 35,000/year
Pretreatment	$ 10,000/year
Monitoring/Maintenance	$ 14,500/year
Total Annual Cost	**$ 59,500/year**

COMMENTS:

This site is an operating gasoline service station in California. Two towers operate in parallel at this site, with a polyphosphate feed pretreatment system.

W -- 31(1)

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				9.6	ND	--	--	--
Toluene				9.0	ND	--	--	--
Ethylbenzene				BDL	ND	--	--	--
Total Xylenes				6.5	ND	--	--	--
Petroleum Hydrocarbons								
EDB				ND	ND	--	--	--
MTBE				ND	ND	--	--	--
IPE				ND	0.4	--	--	--

SITE IDENTIFICATION -- W-31(2)

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	15.0'	16.0'
Packed Height	12.0'	13.0'
Tower Diameter	3.0'	3.0'
Packing Type	#1 Tri-pack	#1 Tri-pack
Water Temperature	40 - 60°F	64.6°F
Air Temperature	40 - 60°F	95°F
Water Flow Rate	30-175 GPM	135 GPM
Air Flow Rate	1 - 1000 CFM	54 CFM
Air/Water Ratio		0.4:1 CFM/GPM
Initial Date of Operation		5/84
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	
Equipment	
Piping	
Site Preparation	
Electrical	Costs given for site W.31 (1) include costs for site W.31 (2)
Pretreatment System	
Operation	
Pretreatment	
Monitoring/Maintenance	

COMMENTS:

This site is an operating gasoline service station in California. Two towers operate in parallel at this site, with a polyphosphate feed pretreatment system.

SE -- 31 (2)

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				23	ND	--	--	--
Toluene				23	ND	--	--	--
Ethylbenzene				BDL	ND	--	--	--
Total Xylenes				25	ND	--	--	--
Petroleum Hydrocarbons								
EDB				ND	ND	--	--	--
MTBE				ND	ND	--	--	--
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- W-32

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	
Packed Height	14.0'	
Tower Diameter	1.0'	
Packing Type	Tri-packs	
Water Temperature	40 - 60°F	
Air Temperature	40 - 60°F	
Water Flow Rate	5 - 20 GPM	
Air Flow Rate	1 - 100 CFM	
Air/Water Ratio		
Initial Date of Operation		1/87
Sampling Frequency		Monthly

Costs

Engineering Design	
Permitting	
Equipment	$ 14,000/year
Piping	Included Above
Site Preparation	$ 4,500
Electrical	$ 200
Pretreatment System	
Total Initial Cost	**$ 18,700**
Treatment System Operation	$ 9,000/year
Pretreatment System Operation	$ 3,900/year
Monitoring/Maintenance	$ 12,000/year
Total Annual Cost	**$ 24,900/year**

COMMENTS:

This site is an abandoned gasoline station in California. The tanks and pump islands have been removed. Pretreatment consists of a polyphosphate significant feed system.

W -- 32

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene								
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons								
EDB								
MTBE								
IPE								

Notes: No site visit was completed at this site

SITE IDENTIFICATION -- W-35

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	12.5'	
Packed Height	8.0'	
Tower Diameter	2.0'	
Packing Type	#1 Tri-pack	
Water Temperature	65°F	
Air Temperature	70°F	
Water Flow Rate		
Air Flow Rate		
Air/Water Ratio	10:1 CFM/GPM	
Initial Date of Operation		4/86
Sampling Frequency		Monthly

Costs

Engineering Design	$ 45,000
Permitting	
Equipment	
Piping	
Site Preparation	
Electrical	
Pretreatment System	
Total Initial Cost	**$ 45,000**

Treatment System Operation	
Pretreatment System Operation	
Monitoring	
Maintenance	
Total Annual Cost	

COMMENTS:

This site is an operating gasoline station and mini-market in California.

W -- 35

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene	700	7	99.0					
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons	10000	200	80.0					
EDB								
MTBE								
IPE								

Notes: No site visit was completed at this site

SITE IDENTIFICATION — W-38

Measured Variables (Based on Site Visit)

Air Flow Rate	420 CFM
Water Flow Rate	52.2 GPM
Air/Water Ratio	8.05 CFM/GPM
Air Temperature	84.7°F
Water Temperature	67.6°F
Tower Height	12.5'
Packing Height	8.8'
Packing Type	2.0'
Tower Diameter	# 1/2 Jaeger Tri-pack

Calculated Variables (Based on Site Visit Data)

Component	Influent Concentration (ppb)	Effluent Concentration (ppb)	Percent Removal (%)
Benzene	220	2.4	98.91
Toluene	32	0.5	98.30
Ethylbenzene	200	1.4	99.30
Total Xylenes	61.7	0.6	99.03
EDB	ND	ND	—
MTBE	220	60	72.73
IPE	ND	ND	—

SITE IDENTIFICATION -- W-39

TECHNOLOGY -- AIR STRIPPING

System Parameter	Design	Actual
Tower Height	17.0'	17.0'
Packed Height	12.0'	13.2'
Tower Diameter	1.0'	1.0'
Packing Type	#1/2 Tri-pack	#1/2 Tri-pack
Water Temperature	68°F	73.2°F
Air Temperature	77°F	74.1°F
Water Flow Rate	15 GPM	0.8 GPM
Air Flow Rate	500 CFM	304 CFM
Air/Water Ratio	10:1 CFM/GPM	380:1 CFM/GPM
Initial Date of Operation		2/87
Sampling Frequency		Twice monthly

Costs

Engineering Design	
Permitting	$ 1,500
Equipment	$ 18,000
Piping	$ 1,000
Site Preparation	$ 1,000
Electrical	$ 800
Pretreatment System	
Total Initial Cost	**$ 23,300**
Treatment System Operation	$ 10,000/year
Pretreatment System Operation	
Monitoring	$ 11,000/year
Maintenance	Included Above
Total Annual Cost	**$ 21,000/year**

COMMENTS:

This site is an operating gasoline station and mini-market in California.

W -- 39

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene	34000	<1.0	>99.9+	ND	ND	--	--	--
Toluene				BDL	2.5			
Ethylbenzene				ND	0.9	--	--	--
Total Xylenes				BDL	3.9			
Petroleum Hydrocarbons								
EDB				ND	ND	--	--	--
MTBE				BDL	ND	--	--	--
IPE				ND	ND	--	--	--

APPENDIX C

SYSTEM DESCRIPTIONS COSTS AND REMOVAL EFFECTIVENESS

FOR CARBON ADSORPTION SYSTEMS

SITE IDENTIFICATION -- MW-5

TECHNOLOGY -- ACTIVATED CARBON ADSORPTION

System Parameter	Design	Actual
Water Flow Rate	0.5 GPM	0.75 GPM
Water Temperature		55°F
Air Temperature		85°F
Carbon Tank Size	55 gallon	55 gallon
Configuration	Two in series	Two in series
Retention Time	110 minutes/tank	73.3 minutes/tank
Initial Date of Operation		11/13/86
Sampling Frequency		Monthly

Costs

Engineering Design	$ 1,752
Permitting	$ 2,400
Equipment	$ 5,910
Piping	$ 500
Site Preparation	$ 9,304
Electrical	$ 1,240
Pretreatment System	
Total Initial Cost	**$ 21,106**

Treatment System Operation	$ 22,330/year
Pretreatment System Operation	
Monitoring	$ 29,773/year
Maintenance	$ 14,886/year
Total Annual Cost	**$ 66,989/year**

COMMENTS:

This site is an operating gasoline service station and mini-market in Michigan.

MW -- 5

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene		<1.0		21000	BDL	>99.9	--	--
				BDL	ND	--	--	--
Toluene				21000	2.2	>99.9	--	--
				2.2	ND	--	--	--
Ethylbenzene				2200	ND	--	--	--
				ND	ND	--	--	--
Total Xylenes				14100	ND	--	--	--
				ND	ND	--	--	--
Petroleum Hydrocarbons	74000	ND	100					
EDB				ND	ND	--	--	--
				ND	ND	--	--	--
MTBE				BDL	ND	--	--	--
				ND	ND	--	--	--
IPE				ND	ND	--	--	--
				ND	ND	--	--	--

SITE IDENTIFICATION -- MW-9

TECHNOLOGY -- ACTIVATED CARBON ADSORPTION

System Parameter	Design	Actual
Water Flow Rate		
Water Temperature		
Air Temperature		
Carbon Tank Size	55 gallon	
Configuration	Two in series	
Initial Date of Operation		
Sampling Frequency		

Costs

Engineering Design	$ 1,752
Permitting	$ 2,400
Equipment	$ 5,820
Piping	$ 500
Site Preparation	$ 16,493
Electrical	$ 2,200
Pretreatment System	
Total Initial Cost	**$ 29,165**
Treatment System Operation	$ 39,585/year
Pretreatment System Operation	
Monitoring	$ 52,780/year
Maintenance	$ 26,390/year
Total Annual Cost	**$118.755/year**

COMMENTS:

This site is an operating gasoline service station in Indiana.

MW -- 9

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF* (ppb)	EFF* (ppb)	Removal* (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene-(First Unit)	14000	170	98.9					
-(Second Unit)	170	90	47.1					
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons			99%					
EDB								
MTBE								
IPE								

• These values correspond to the influent and effluent for the first and second carbon tanks, respectively.

* No site visit was completed at this site.

SITE IDENTIFICATION -- MW-12

TECHNOLOGY -- ACTIVATED CARBON ADSORPTION

System Parameter	Design	Actual
Water Flow Rate		
Water Temperature		
Air Temperature		
Carbon Tank Size	55 gallon	
Configuration	One carbon tank	
Initial Date of Operation		5/87
Sampling Frequency		Monthly

Costs

Engineering Design	$ 1,752
Permitting	$ 2,400
Equipment	$ 5,280
Piping	$ 500
Site Preparation	$ 11,700
Electrical	$ 1,560
Pretreatment System	$ 1,560
Total Initial Cost	**$ 24,752**

Treatment Sytem Operation	$ 28,084/year
Pretreatment System Operation	$ 1,560
Monitoring	$ 37,445/year
Maintenance	$ 18,723/year
Total Annual Cost	**$ 84,252/year**

COMMENTS:

This site is an abandoned gasoline station in Michigan. The treatment system has been removed and the job is now closed.

MW -- 12

Water Quality

CONSTITUTENT	DESIGN			ACTUAL*				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene								
Toluene								
Ethylbenzene								
Total Xylenes								
Petroleum Hydrocarbons			99.8					
EDB								
MTBE								
IPE								

Notes: * = No site visit was completed at this site

SITE IDENTIFICATION -- MW-14

TECHNOLOGY -- ACTIVATED CARBON ADSORPTION

System Parameter	Design	Actual
Water Flow Rate	2 GPM	2 GPM
Water Temperature		63°F
Air Temperature		90°F
Carbon Tank Size	55 gallon	55 gallon
Configuration	Two in series	Two in series
Retention Time	27.5 minutes/tank	27.5 minutes/tank
Initial Date of Operation		6/86
Sampling Frequency		Monthly

Costs

Engineering Design	$ 1,752
Permitting	$ 2,400
Equipment	$ 5,280
Piping	$ 500
Site Preparation	$ 21,000
Electrical	$ 2,800
Pretreatment System	
Total Initial Cost	**$ 33,732**
Treatment System Operation	$ 50,411/year
Pretreatment System Operation	
Monitoring	$ 67,215/year
Maintenance	$ 33,607/year
Total Annual Cost	**$151,233/year**

COMMENTS:

This site is an operating gasoline station and mini-market in Illinois.

MW -- 14

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				1100	BDL	99.9+	--	--
Toluene				1800	BDL	99.9+	--	--
Ethylbenzene				890	0.5	99.9+	--	--
Total Xylenes				4500	3.1	99.9+	--	--
Petroleum Hydrocarbons			99					
EDB				ND	ND	--	--	--
MTBE				110	200			
IPE				ND	ND	--	--	--

SITE IDENTIFICATION -- NE-7

TECHNOLOGY -- ACTIVATED CARBON ADSORPTION

System Description (Based on Original Design)

Water Flow Rate	20 GPM	2 GPM
Water Temperature	68°F	82°F
Air Temperature		96°F
Carbon Tank Size	55 gallon	55 gallon
Configuration	Two in series	Two in series
Retention Time	2.75 minutes/tank	27.5 minutes/tank
Initial Date of Operation		2/87
Sampling Frequency		Monthly

Costs

Engineering Design	$ 1,500
Permitting	$ 1,000
Equipment	$ 9,000
Piping	$ 500
Site Preparation	$ 1,000
Electrical	$ 1,320
Pretreatment System	
Total Initial Costs	**$ 14,320**

Treatment System Operation	$ 720/year
Pretreatment System Operation	
Monitoring	$ 13,200/year
Maintenance	Included Above
Total Annual Cost	**$ 13,920/year**

COMMENTS:

This site is an operating gasoline service station in Massachusetts.

NE -- 7

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF* (ppb)	Removal (%)	INF (ppb)	EFF* (ppb)	Removal (%)	*HTU (ft)	NTU
Benzene				2600	2.6	99.9		
				2.6	ND		--	--
Toluene				6000	1.3	99.9+	--	--
				1.3	1.3	0.0	--	--
Ethylbenzene				650	0.3	99.9+	--	--
				0.3	0.5		--	--
Total Xylenes				15700	2.6	99.9+	--	--
				2.6	5.2		--	--
Petroleum Hydrocarbons		14000	36.4					
	22000	0	100					
EDB				ND	ND	--	--	--
				ND	ND	--	--	--
MTBE				BDL	1.6		--	--
				1.6	BDL		--	--
IPE				BDL	ND	--	--	--
				BDL	ND	--	--	--

* These values correspond with effluent values from the first and second carbon tanks, respectively.

SITE IDENTIFICATION -- NE-20

TECHNOLOGY -- ACTIVATED CARBON ADSORPTION

System Parameter	Design	Actual
Water Flow Rate	0.5 GPM	0.5 GPM
Water Temperature		58°F
Air Temperature		80°F
Carbon Tank Size	20 gallon	20 gallon
Configuration	Two in series	Two in series
Retention Time	40 minutes/tank	40 minutes/tank
Initial Date of Operation		12/86
Sampling Frequency		Bi-monthly

Costs

Engineering Design	
Permitting	No permits as yet
Equipment	$ 600
Piping	
Site Preparation	
Electrical	
Pretreatment System	
Total Initial Cost	**$ 600**
Treatment System Operation	$ 3,600/year
Pretreatment System Operation	
Monitoring	$ 7,200/year
Maintenance	$ 1,200/year
Total Annual Cost	**$ 12,000/year**

COMMENTS:

This site is an operating gasoline service station in Massachusetts. They have had their tanks replaced and are currently treating their private water well for domestic use.

NE -- 20

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF* (ppb)	Removal (%)	*HTU (ft)	NTU
Benzene				370	55	85.1	--	--
				55	0.5	99.1	--	--
Toluene				770	2.2	99.7	--	--
				2.2	2.1	4.5	--	--
Ethylbenzene				59	1.3	97.8	--	--
				1.3	ND	--	--	--
Total Xylenes				480	2.9	99.4	--	--
				2.9	10.1	--	--	--
Petroleum Hydrocarbons	9580	100	99%					
EDB				ND	ND	--	--	--
				ND	ND	--	--	--
MTBE				370	860	--	--	--
				860	110	87.2	--	--
IPE				26	13	50.0	--	--
				13	ND	--	--	--

* These values correspond with effluent from the first and second carbon tank, respectively.

SITE IDENTIFICATION -- NE-23

TECHNOLOGY -- ACTIVATED CARBON ADSORPTION

System Parameter	Design	Actual
Water Flow Rate	1 GPM	0.17 GPM
Water Temperature	50°F	74°F
Air Temperature	Ambient	78°F
Carbon Tank Size	55 gallon	55 gallon
Configuration	Two in series	Two in series
Retention Time	55 minutes/tank	323 minutes/tank
Initial Date of Operation		5/24/86
Sampling Frequency		Quarterly

Costs

Engineering Design	
Permitting	
Equipment	
Piping	
Site Preparation	
Electrical	
Pretreatment System Operation	
Total Initial Cost	**$ 30,000**
Treatment System Operation	
Pretreatment System Operation	
Monitoring	$ 54,000/year
Maintenance	Included Above
Total Annual Cost	**$ 54,000/year**

COMMENTS:

The site is a college in Massachusetts. Fuel oil tanks leaked in the boiler room. The soil beneath this building is not very permeable and recovery is difficult.

NE -- 23

Water Quality

CONSTITUTENT	DESIGN			ACTUAL				
	INF (ppb)	EFF (ppb)	Removal (%)	INF (ppb)	EFF* (ppb)	Removal (%)	HTU (ft)	NTU
Benzene				BDL	ND	--	--	--
				ND	ND	--	--	--
Toluene				ND	ND	--	--	--
				ND	ND	--	--	--
Ethylbenzene				ND	MD	--	--	--
				ND	ND	--	--	--
Total Xylenes				15.3	ND	--	--	--
				ND	ND	--	--	--
Petroleum Hydrocarbons	69	ND	100					
EDB				ND	ND	--	--	--
				ND	ND	--	--	--
MTBE				ND	ND	--	--	--
				ND	ND	--	--	--
IPE				ND	ND	--	--	--
				ND	ND	--	--	--

* These values correspond to effluent from the first and second carbon tanks, respectively.

APPENDIX D

LABORATORY ANALYTICAL DATA

GT Environmental Laboratories
A division of Groundwater Technology, Inc.
Northeast Region 4 Mill Street, Greenville, NH 03048
(603) 878-2500 NE Area (800) 423-6153 In NH (800) 922-3422

Volatile Organics Analysis
Job I.D.: MA-10

Sample No.	50857	50858	50859	50860
Sample I.D.	INF (1)	EFF (1)	INF (2)	EFF (2)
Date Sampled	7-31-87	7-31-87	7-31-87	7-31-87
Date Analyzed	8-07-87	8-05-87	8-05-87	8-04-87
Parameter	Concentration ug/L			
Benzene	83	0.4	ND	ND
Ethylene Dibromide	ND	ND	ND	ND
Toluene	4.0	BDL	5.5	ND
Ethylbenzene	BDL	ND	BDL	ND
M-Xylene	ND	ND	BDL	ND
O&P-Xylene	4.3	ND	6.6	ND
MTBE	ND	ND	ND	ND
IPE	ND	ND	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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(603) 878-2500 NE Area (800) 423-6153 In NH (800) 922-3422

Volatile Organics Analysis
Job I.D.: MA-10

Sample No.	50861	50862	50863	50864
Sample I.D.	INF (3)	EFF (3)	INF (4)	EFF (4)
Date Sampled	7-31-87	7-31-87	7-31-87	7-31-87
Date Analyzed	8-07-87	8-04-87	8-07-87	8-04-87
Parameter	Concentration ug/L			
Benzene	10	ND	2300	18
Ethylene Dibromide	ND	ND	BDL	BDL
Toluene	4.4	ND	1000	9.3
Ethylbenzene	ND	ND	730	7.3
M-Xylene	BDL	0.9	870	11
O&P-Xylene	6.2	1.3	1300	19
MTBE	ND	ND	ND	ND
IPE	ND	ND	ND *5	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

*5 = Sample diluted; MDL times 10

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Northeast Region 4 Mill Street, Greenville, NH 03048
(603) 878-2500 NE Area (800) 423-6153 In NH (800) 922-3422

Volatile Organics Analysis
Job I.D.: MW-1

Sample No.	51083	51084
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	7-29-87	7-29-87
Date Analyzed	8-10-87	8-12-87
Parameter	Concentration	ug/L
Benzene	1700	2.3
Ethylene Dibromide	ND	ND
Toluene	2800	7.2
Ethylbenzene	520	ND
M-Xylene	1500	2.9
O&P-Xylene	2100	4.1
MTBE	780	ND
IPE	ND	ND
	*1	

Notes: ND = Not Detected

BDL = Below Detection Limit

*1 = Sample diluted; MDL times 100

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Volatile Organics Analysis
Job I.D.: MW-5

Sample No.	51383	51384
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-05-87	8-05-87
Date Analyzed	8-17-87	8-19-87
Parameter	Concentration	ug/L
Benzene	21000	BDL
Ethylene Dibromide	ND	ND
Toluene	21000	2.2
Ethylbenzene	2200	ND
M-Xylene	6800	ND
O&P-Xylene	7300	ND
MTBE	BDL	ND
IPE	ND	ND
	*4	

Notes: ND = Not Detected

BDL = Below Detection Limit

*4 = Sample diluted; MDL times 200

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Volatile Organics Analysis
Job I.D.: MW-6

Sample No.	51086	51087
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	7-29-87	7-29-87
Date Analyzed	8-11-87	8-12-87
Parameter	Concentration	ug/L
Benzene	8100	0.3
Ethylene Dibromide	ND	ND
Toluene	8500	0.7
Ethylbenzene	1300	BDL
M-Xylene	2700	0.7
O&P-Xylene	3000	1.0
MTBE	9400	4.6
IPE	BDL *1	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

*1 = Sample diluted; MDL times 100

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Volatile Organics Analysis
Job I.D.: MW-7

Sample No.	50759	50760
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	7-28-87	7-28-87
Date Analyzed	8-07-87	8-04-87

Parameter	Concentration	ug/L
Benzene	360	0.4
Ethylene Dibromide	ND	ND
Toluene	29	1.8
Ethylbenzene	37	ND
M-Xylene	BDL	3.2
O&P-Xylene	100	2.7
MTBE	BDL	0.3
IPE	ND	ND
	*6	

Notes: ND = Not Detected

BDL = Below Detection Limit

*6 = Sample diluted; MDL times 5

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Volatile Organics Analysis
Job I.D.: MW-10

Sample No.	51533	51534
Sample I.D.	EFFLUENT	INFLUENT
Date Sampled	8-07-87	8-07-87
Date Analyzed	8-21-87	8-17-87

Parameter	Concentration	ug/L
Benzene	ND	BDL
Ethylene Dibromide	ND	ND
Toluene	ND	0.4
Ethylbenzene	ND	BDL
M-Xylene	ND	0.9
O&P-Xylene	ND	0.7
MTBE	ND	BDL
IPE	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: MW-13

Sample No.	52228	52229
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-14-87	8-14-87
Date Analyzed	8-26-87	8-25-87

Parameter	Concentration	ug/L
Benzene	950	3.9
Ethylene Dibromide	ND	ND
Toluene	3000	16
Ethylbenzene	440	2.9
M-Xylene	1400	ND
O&P-Xylene	1500	8.0
MTBE	BDL	0.5
IPE	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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(603) 878-2500 NE Area (800) 423-6153 In NH (800) 922-3422

Volatile Organics Analysis
Job I.D.: MW-14

Sample No.	51436	51437
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-05-87	8-05-87
Date Analyzed	8-14-87	8-19-87

Parameter	Concentration	ug/L
Benzene	1100	BDL
Ethylene Dibromide	ND	ND
Toluene	1800	BDL
Ethylbenzene	890	0.50
M-Xylene	2000	1.4
O&P-Xylene	2500	1.7
MTBE	110	200
IPE	ND	ND
	*2	

Notes: ND = Not Detected

BDL = Below Detection Limit

*2 = Sample diluted; MDL times 20

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Volatile Organics Analysis
Job I.D.: NE-4

Sample No.	51558	51559
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-05-87	8-05-87
Date Analyzed	8-14-87	8-19-87

Parameter	Concentration	ug/L
Benzene	300	BDL
Ethylene Dibromide	ND	ND
Toluene	6400	1.8
Ethylbenzene	1400	BDL
M-Xylene	4000	1.5
O&P-Xylene	4400	3.2
MTBE	BDL	0.8
IPE	ND	ND
	*3	

Notes: ND = Not Detected .

BDL = Below Detection Limit

*3 = Sample diluted; MDL times 50

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Volatile Organics Analysis
Job I.D.: NE-6

Sample No.	50753	50754
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	7-29-87	7-29-87
Date Analyzed	8-05-87	8-05-87
Parameter	Concentration	ug/L
Benzene	2600	1900
Ethylene Dibromide	ND	BDL
Toluene	6800	4800
Ethylbenzene	540	320
M-Xylene	5000	3100
O&P-Xylene	8700	5600
MTBE	BDL	190
IPE	ND	25
	*1	*5

Notes: ND = Not Detected

BDL = Below Detection Limit

*1 = Sample diluted; MDL times 100

*5 = Sample diluted; MDL times 10

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Volatile Organics Analysis
Job I.D.: NE-7

Sample No.	50487	50488	50489
Sample I.D.	CT 1 INF	CT 2 EFF	CT 1 EFF
Date Sampled	7-24-87	7-24-87	7-24-87
Date Analyzed	8-05-87	8-04-87	8-04-87

Parameter	Concentration ug/L		
Benzene	2600	ND	2.6
Ethylene Dibromide	ND	ND	ND
Toluene	6000	1.3	1.3
Ethylbenzene	650	0.5	0.3
M-Xylene	5900	2.3	1.2
O&P-Xylene	9800	2.9	1.4
MTBE	BDL	ND	1.6
IPE	BDL *1	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

*1 = Sample diluted; MDL times 100

CT = Carb Tank

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Volatile Organics Analysis
Job I.D.: NE-9

Sample No.	50869	50870
Sample I.D.	EFFLUENT	INFLUENT
Date Sampled	7-28-87	7-28-87
Date Analyzed	8-04-87	8-07-87

Parameter	Concentration	ug/L
Benzene	24	8700
Ethylene Dibromide	ND	ND
Toluene	460	24000
Ethylbenzene	640	4200
M-Xylene	1300	9100
O&P-Xylene	1400	10000
MTBE	ND	ND
IPE	ND	ND
	*6	*4

Notes: ND = Not Detected

BDL = Below Detection Limit

*6 = Sample diluted; MDL times 5

*4 = Sample diluted; MDL times 200

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(603) 878-2500 NE Area (800) 423-6153 In NH (800) 922-3422

Volatile Organics Analysis
Job I.D.: NE-18

Sample No.	51005	51006
Sample I.D.	EFFLUENT	INFLUENT
Date Sampled	8-04-87	8-04-87
Date Analyzed	8-06-87	8-10-87

Parameter	Concentration	ug/L
Benzene	1.8	4200
Ethylene Dibromide	ND	ND
Toluene	5.9	13000
Ethylbenzene	0.7	9900
M-Xylene	1.4	1800
O&P-Xylene	1.6	2600
MTBE	8.6	16000
IPE	1.0	1800 *1

Notes: ND = Not Detected

BDL = Below Detection Limit

*1 = Sample diluted; MDL times 100

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(603) 878-2500 NE Area (800) 423-6153 In NH (800) 922-3422

Volatile Organics Analysis
Job I.D.: NE-19

Sample No.	50985	50984
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	7-28-87	7-28-87
Date Analyzed	8-05-87	8-07-87
Parameter	Concentration	ug/L
Benzene	4800	ND
Ethylene Dibromide	ND	ND
Toluene	24000	270
Ethylbenzene	2500	ND
M-Xylene	9000	1200
O&P-Xylene	10000	4600
MTBE	7800	380
IPE	BDL	ND
	*1	*1

Notes: ND = Not Detected

BDL = Below Detection Limit

*1 = Sample diluted; MDL times 100

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Volatile Organics Analysis
Job I.D.: NE-20

Sample No.	50756	50757	50758
Sample I.D.	INFLUENT	CT 1 EFF	CT 2 EFF
Date Sampled	7-29-87	7-29-87	7-29-87
Date Analyzed	8-07-87	8-05-87	8-04-87

Parameter	Concentration ug/L		
Benzene	370	55	0.5
Ethylene Dibromide	ND	ND	ND
Toluene	770	2.2	2.1
Ethylbenzene	59	1.3	ND
M-Xylene	240	0.9	3.7
O&P-Xylene	240	2.0	6.4
MTBE	370	860	110
IPE	26	13	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

CT = Carb Tank

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Volatile Organics Analysis
Job I.D.: NE-21

Sample No.	50564	50565
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	7-22-87	7-22-87
Date Analyzed	8-07-87	8-04-87

Parameter	Concentration	ug/L
Benzene	440	17
Ethylene Dibromide	ND	ND
Toluene	400	16
Ethylbenzene	84	2.8
M-Xylene	100	5.7
O&P-Xylene	120	8.6
MTBE	710	270
IPE	ND	0.8
	*2	

Notes: ND = Not Detected .

BDL = Below Detection Limit

*2 = Sample diluted; MDL times 20

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Volatile Organics Analysis
Job I.D.: NE-22

Sample No.	51398	51399
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-05-87	8-05-87
Date Analyzed	8-14-87	8-19-87

Parameter	Concentration	ug/L
Benzene	340	BDL
Ethylene Dibromide	BDL	ND
Toluene	1900	0.6
Ethylbenzene	600	BDL
M-Xylene	1400	0.5
O&P-Xylene	1900	0.7
MTBE	BDL	0.6
IPE	ND	ND
	*2	

Notes: ND = Not Detected

BDL = Below Detection Limit

*2 = Sample diluted; MDL times 20

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Volatile Organics Analysis
Job I.D.: NE-23

Sample No.	51597	51598	51599
Sample I.D.	INFLUENT	EFF. TANK 1	EFF.TANK 2
Date Sampled	8-06-87	8-06-87	8-06-87
Date Analyzed	8-18-87	8-19-87	8-19-87

Parameter	Concentration ug/L		
Benzene	BDL	ND	ND
Ethylene Dibromide	ND	ND	ND
Toluene	ND	ND	ND
Ethylbenzene	ND	ND	ND
M-Xylene	7.6	ND	ND
O&P-Xylene	7.7	ND	ND
MTBE	ND	ND	ND
IPE	ND	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: SC-1

Sample No.	51514	51515
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-07-87	8-07-87
Date Analyzed	8-14-87	8-13-87

Parameter	Concentration	ug/L
Benzene	29000	25
Ethylene Dibromide	ND	ND
Toluene	32000	30
Ethylbenzene	3400	3.6
M-Xylene	8100	9.0
O&P-Xylene	9700	11
MTBE	BDL	3.0
IPE	ND	ND
	*4	

Notes: ND = Not Detected

BDL = Below Detection Limit

*4 = Sample diluted; MDL times 200

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Volatile Organics Analysis
Job I.D.: SC-2

Sample No.	51511	51512
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-07-87	8-07-87
Date Analyzed	8-14-87	8-13-87

Parameter	Concentration	ug/L
Benzene	520	BDL
Ethylene Dibromide	ND	ND
Toluene	4400	0.6
Ethylbenzene	410	ND
M-Xylene	930	ND
O&P-Xylene	1500	ND
MTBE	ND	ND
IPE	1700	0.7
	*2	

Notes: ND = Not Detected

BDL = Below Detection Limit

*2 = Sample diluted; MDL times 20

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Volatile Organics Analysis
Job I.D.: SC-3

Sample No.	51490	51491
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-06-87	8-06-87
Date Analyzed	8-11-87	8-12-87
Parameter	Concentration	ug/L
Benzene	2900	0.5
Ethylene Dibromide	ND	ND
Toluene	6400	1.0
Ethylbenzene	990	0.2
M-Xylene	630	0.4
O&P-Xylene	2700	1.3
MTBE	BDL	1.0
IPE	600	13
	*3	

Notes: ND = Not Detected

BDL = Below Detection Limit

*3 = Sample diluted; MDL times 50

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Volatile Organics Analysis
Job I.D.: SC-4

Sample No.	51487	51488
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-06-87	8-06-87
Date Analyzed	8-10-87	8-13-87

Parameter	Concentration ug/L	
Benzene	930	ND
Ethylene Dibromide	ND	ND
Toluene	130	ND
Ethylbenzene	450	ND
M-Xylene	330	ND
O&P-Xylene	600	ND
MTBE	3000	1.3
IPE	ND	ND
	*3	

Notes: ND = Not Detected

BDL = Below Detection Limit

*3 = Sample diluted; MDL times 50

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Volatile Organics Analysis
Job I.D.: SC-5

Sample No.	51484	51485
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-06-87	8-06-87
Date Analyzed	8-11-87	8-13-87

Parameter	Concentration	ug/L
Benzene	340	0.7
Ethylene Dibromide	ND	ND
Toluene	310	0.2
Ethylbenzene	410	1.3
M-Xylene	1600	5.7
O&P-Xylene	1400	5.8
MTBE	BDL	10
IPE	ND	ND
	*1	

Notes: ND = Not Detected

BDL = Below Detection Limit

*1 = Sample diluted; MDL times 100

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Volatile Organics Analysis
Job I.D.: SE-7

Sample No.	52069	52070
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-13-87	8-13-87
Date Analyzed	8-20-87	8-19-87

Parameter	Concentration	ug/L
Benzene	19	ND
Ethylene Dibromide	ND	ND
Toluene	BDL	ND
Ethylbenzene	BDL	ND
M-Xylene	ND	ND
O&P-Xylene	5.9	ND
MTBE	ND	ND
IPE	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: SE-18

Sample No.	51646	51647
Sample I.D.	EFFLUENT	INFLUENT
Date Sampled	8-10-87	8-10-87
Date Analyzed	8-21-87	8-20-87

Parameter	Concentration	ug/L
Benzene	0.5	35
Ethylene Dibromide	ND	ND
Toluene	ND	10
Ethylbenzene	ND	BDL
M-Xylene	ND	7.5
O&P-Xylene	ND	7.1
MTBE	1.3	8.6
IPE	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: SE-22

Sample No.	52009	52013
Sample I.D.	EFFLUENT	INFLUENT
Date Sampled	8-13-87	8-13-87
Date Analyzed	8-25-87	8-26-87

Parameter	Concentration	ug/L
Benzene	BDL	36
Ethylene Dibromide	ND	ND
Toluene	0.3	14
Ethylbenzene	ND	13
M-Xylene	ND	26
O&P-Xylene	ND	27
MTBE	0.7	7.7
IPE	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: SE-23

Sample No.	52017	52018
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-13-87	8-13-87
Date Analyzed	8-25-87	8-25-87

Parameter	Concentration	ug/L
Benzene	48	BDL
Ethylene Dibromide	ND	ND
Toluene	400	0.5
Ethylbenzene	110	0.3
M-Xylene	400	0.8
O&P-Xylene	420	2.1
MTBE	BDL	1.6
IPE	ND	ND
	*2	

Notes: ND = Not Detected

BDL = Below Detection Limit

*2 = Sample diluted; MDL times 20

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Volatile Organics Analysis
Job I.D.: SE-31

Sample No.	52415	52416
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-19-87	8-19-87
Date Analyzed	8-26-87	8-25-87

Parameter	Concentration	ug/L
Benzene	14000	0.9
Ethylene Dibromide	BDL	BDL
Toluene	12000	1.5
Ethylbenzene	980	BDL
M-Xylene	2500	0.3
O&P-Xylene	2500	.4
MTBE	5200	4.7
IPE	BDL	BDL
	*1	

Notes: ND = Not Detected

BDL = Below Detection Limit

*1 = Sample diluted; MDL times 100

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Volatile Organics Analysis
Job I.D.: SE-32

Sample No.	51648	51649
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-10-87	8-10-87
Date Analyzed	8-21-87	8-20-87

Parameter	Concentration	ug/L
Benzene	27	BDL
Ethylene Dibromide	ND	ND
Toluene	6.5	BDL
Ethylbenzene	37	ND
M-Xylene	63	ND
O&P-Xylene	78	ND
MTBE	20	BDL
IPE	0.4	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: SE-33

Sample No.	51885	51823	51824
Sample I.D.	INF (1)	EFF (1)	EFF (2)
Date Sampled	8-12-87	8-12-87	8-12-87
Date Analyzed	8-19-87	8-26-87	8-26-87
Parameter	Concentration ug/L		
Benzene	990	BDL	ND
Ethylene Dibromide	ND	ND	ND
Toluene	1300	BDL	BDL
Ethylbenzene	1100	ND	ND
M-Xylene	1300	BDL	BDL
O&P-Xylene	1500	BDL	BDL
MTBE	540	0.9	0.4
IPE	ND	ND	ND
	*5		

Notes: ND = Not Detected

BDL = Below Detection Limit

*5 = Sample diluted; MDL times 10

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Volatile Organics Analysis
Job I.D.: SE-35

Sample No.	52015	52016
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-13-87	8-13-87
Date Analyzed	8-25-87	8-25-87

Parameter	Concentration	ug/L
Benzene	520	0.2
Ethylene Dibromide	ND	ND
Toluene	2800	0.2
Ethylbenzene	680	ND
M-Xylene	2100	ND
O&P-Xylene	3100	ND
MTBE	150	BDL
IPE	ND	ND
	*2	

Notes: ND = Not Detected

BDL = Below Detection Limit

*2 = Sample diluted; MDL times 20

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Volatile Organics Analysis
Job I.D.: SE-36

Sample No.	52702	52703
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-20-87	8-20-87
Date Analyzed	8-27-87	8-27-87

Parameter	Concentration	ug/L
Benzene	1200	9.5
Ethylene Dibromide	ND	ND
Toluene	780	8.1
Ethylbenzene	110	1.1
M-Xylene	300	3.1
O&P-Xylene	440	5.2
MTBE	BDL	ND
IPE	BDL	ND
	*5	

Notes: ND = Not Detected

BDL = Below Detection Limit

*5 = Sample diluted; MDL times 10

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Volatile Organics Analysis
Job I.D.: W-1

Sample No.	51552	51553
Sample I.D.	EFFLUENT	INFLUENT
Date Sampled	8-07-87	8-07-87
Date Analyzed	8-19-87	8-14-87

Parameter	Concentration	ug/L
Benzene	3.7	440
Ethylene Dibromide	ND	ND
Toluene	BDL	340
Ethylbenzene	ND	180
M-Xylene	ND	280
O&P-Xylene	ND	390
MTBE	ND	BDL
IPE	ND	ND
		*5

Notes: ND = Not Detected

BDL = Below Detection Limit

*5 = Sample diluted; MDL times 10

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Volatile Organics Analysis
Job I.D.: W-2

Sample No.	51529	51530
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-06-87	8-06-87
Date Analyzed	8-11-87	8-12-87

Parameter	Concentration	ug/L
Benzene	ND	BDL
Ethylene Dibromide	ND	ND
Toluene	ND	4.7
Ethylbenzene	ND	ND
M-Xylene	ND	ND
O&P-Xylene	ND	ND
MTBE	1.4	0.3
IPE	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: W-4

Sample No.	51519	51520
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-06-87	8-06-87
Date Analyzed	8-17-87	8-19-87

Parameter	Concentration	ug/L
Benzene	9.2	ND
Ethylene Dibromide	ND	ND
Toluene	2.3	ND
Ethylbenzene	BDL	ND
M-Xylene	BDL	ND
O&P-Xylene	36	ND
MTBE	BDL	1.0
IPE	5.0	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: W-14

Sample No.	51644	51645
Sample I.D.	EFFLUENT	INFLUENT
Date Sampled	8-10-87	8-10-87
Date Analyzed	8-24-87	8-20-87

Parameter	Concentration	ug/L
Benzene	BDL	ND
Ethylene Dibromide	ND	ND
Toluene	ND	ND
Ethylbenzene	ND	BDL
M-Xylene	ND	ND
O&P-Xylene	ND	ND
MTBE	BDL	BDL
IPE	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: W-18

Sample No.	51804	51807
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-07-87	8-07-87
Date Analyzed	8-18-87	8-19-87

Parameter	Concentration	ug/L
Benzene	410	ND
Ethylene Dibromide	ND	ND
Toluene	25	ND
Ethylbenzene	4.8	ND
M-Xylene	8.1	ND
O&P-Xylene	58	ND
MTBE	BDL	ND
IPE	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: W-31

Sample No.	51280	51281	51282	51283
Sample I.D.	INF (1)	EFF (1)	INF (2)	EFF (2)
Date Sampled	8-03-87	8-03-87	8-03-87	8-03-87
Date Analyzed	8-10-87	8-12-87	8-11-87	8-12-87
Parameter	Concentration ug/L			
Benzene	9.6	ND	23	ND
Ethylene Dibromide	ND	ND	ND	ND
Toluene	9.0	ND	23	ND
Ethylbenzene	BDL	ND	BDL	ND
M-Xylene	BDL	ND	10	ND
O&P-Xylene	6.5	ND	15	ND
MTBE	ND	ND	ND	ND
IPE	ND	0.4	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: W-38

Sample No.	51517	51518
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-05-87	8-05-87
Date Analyzed	8-21-87	8-19-87

Parameter	Concentration	ug/L
Benzene	220	2.4
Ethylene Dibromide	ND	ND
Toluene	32	0.5
Ethylbenzene	200	1.4
M-Xylene	6.7	ND
O&P-Xylene	55	0.6
MTBE	220	60
IPE	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

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Volatile Organics Analysis
Job I.D.: W-39

Sample No.	52134	52135
Sample I.D.	INFLUENT	EFFLUENT
Date Sampled	8-14-87	8-14-87
Date Analyzed	8-24-87	8-25-87

Parameter	Concentration	ug/L
Benzene	ND	ND
Ethylene Dibromide	ND	ND
Toluene	BDL	2.5
Ethylbenzene	ND	0.9
M-Xylene	BDL	1.8
O&P-Xylene	BDL	2.1
MTBE	BDL	ND
IPE	ND	ND

Notes: ND = Not Detected

BDL = Below Detection Limit

APPENDIX E

QA/QC INFORMATION

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Following is a table showing the detection limits for the compounds of interest by both EPA 524.1 and 624. Detection Limits are listed in ug/L (ppb.).

Parameter	Method	
	EPA 524.1	EPA 624
Benzene	0.2	1.7
Ethyl Dibromide	0.2	7.3
Toluene	0.2	2.1
Ethylbenzene	0.2	4.5
M-xylene	0.3	4.0
O & P xylene	0.3	4.0
MTBE	0.3	5.0
IPE	0.3	5.0

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9/16/87
Report No. 100-001-8219
Submitted to:

Lori Leo
Groundwater Technology
220 Norwood Park South
Norwood, MA 02062

Sample Identification:
The attached report covers water samples for the API project.

Method:
Analysis was performed for volatile organics by purge and trap GC/MS as per EPA Method 624 and 524.1. Detection limits are listed on the report. Samples are diluted in order to maintain the calibrated range of the instrument and so indicated by a footnote giving the factor by which the MDL is raised.

Sampling and sample handling and preservation are specified by this laboratory to be as per EPA Method 624 and 524.1.

Results:
Results are reported in ug/L (ppb.). All influent samples were analyzed by EPA 624 and effluent samples by EPA 524.1.

Prepared by:
Dave Reese

GC/MS Manager
DRR/CH

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Volatile Organic Duplicate Analysis

Job ID:	SE-23	W-18	MW-14
Sample No.	52018	51805	51436
Sample ID.	EFF. DUP.	INF. DUP.	INF. DUP.
Date Sampled:	8-13-87	8-7-87	8-5-87
Date Analyzed:	8-25-87	8-27-87	8-20-87

Parameter	Concentration ug/L		
Benzene	BDL	410	1200
Ethylene Dibromide	ND	ND	ND
Toluene	ND	32	1800
Ethylbenzene	0.6	BDL	710
M-Xylene	ND	15	1900
O&P-Xylene	BDL	63	2500
MTBE	0.6	BDL	100
IPE	ND	ND	ND
			*2

Notes: ND = Not Detected

BDL= Below Detection Limit

2 = Sample Diluted; MDL Times 20

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Volatile Organic Duplicate Analysis

Job ID:	SE-35	W-14
Sample No.	52016	52070
Sample ID.	EFF. DUP.	EFF. DUP.
Date Sampled:	8-13-87	8-13-87
Date Analyzed:	8-25-87	8-19-87

Parameter	Concentration ug/L	
Benzene	ND	ND
Ethylene Dibromide	ND	ND
Toluene	ND	ND
Ethylbenzene	ND	ND
M-Xylene	ND	ND
O&P-Xylene	ND	ND
MTBE	0.4	ND
IPE	ND	ND

Notes: ND = Not Detected

BDL= Below Detection Limit

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10/9/87
Report No. 100-001-8217-21
Submitted To: Lori Leo
Groundwater Technology
220 Norwood Park South
Norwood, MA 02062

Sample Identification:
The attached report covers water samples #51642-51643 taken by D.S., using 40 ml septum-capped glass vials at site #SE-29.

Method:
Analysis was performed for purgeable aromatic priority pollutants and xylenes by purge and trap gas chromatography with photo-ionization and flame ionization detection, as per a modified EPA Method 602. FID quantitation was performed on a very polar column which fractionates aliphatics (up to C12) away from volatile aromatics. Chromatographic conditions are referenced in GTL Method Code 2010. Hexane and orthoxylene are used as calibration standards for the aliphatic hydrocarbons and miscellaneous aromatics, respectively, if reported.

Samples diluted in order to maintain the calibration range are so indicated by a footnote giving the factor by which the MDL is raised.

Sampling, sample handling, and preservation are specified by this laboratory to be as per EPA Method 602. Any irregularities are referenced as notes to the analytical report.

Results:
Results are reported in ppb (ug/l).

Certification Status:
Category - Volatile Organics
Certifying Agency - Massachusetts Department of Public Health

Prepared By: Bob Edwards
GC Lab Manager

Analyst: E.A.

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Report No. 100-001-8219-21
Analytical Results
Hydrocarbons in Water ug/L (ppb)

Sample ID	Date Sampled	Date Run	Benzene	Toluene	Ethyl Benzene	Total Xylenes	Total BTEX
51642 INF	8/10/87	8/12/87	10	4	ND	42	56
51643 EFF	8/10/87	8/12/87	ND	ND	ND	ND	ND
REAGENT BLK	8/12/87	8/12/87	ND	ND	ND	ND	ND
DETECTION LIMITS			0.2	0.5	0.8	1.7	

ND = NONE DETECTED
BDL = BELOW DETECTION LIMIT

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Report No. 100-001-8219-21
Analytical Results
Hydrocarbons in Water ug/L (ppb)

Sample No.	ID	C4-C12 Aliphatic Hydrocarbons	C8-C10 Aromatic Hydrocarbons	Total
51642	INF	59	74	130
51643	EFF	BDL	BDL	BDL
REAGENT BLANK		BDL	ND	BDL
DETECTION LIMITS		15	10	

ND = NONE DETECTED
BDL = BELOW DETECTION LIMIT

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Quality Assurance Data
Purgeable Aromatics -- EPA Method 602
Aqueous Surrogate Compound Recovery
Report No. 100-001-8219-21

Sample	Amount Added ug/L	Surrogate Recovery %	*
51642	234	79	
51643	234	79	
reagent blank	234	82	
51643+MS	234	75	
51643+MSD	234	83	

ACCEPTABILITY LIMITS 65 - 133%

* = outside of acceptability range
MS = matrix spike
MSD = matrix spike duplicate

Comments:

EXCERPTS FROM GTI SOP MANUAL

The following section presents the standard operating procedure for water quality sampling from Groundwater Technology's SOP Manual. This excerpt sets procedure for water sampling and sample preservation. The procedure focuses on sampling from wells, but also applies to sampling influent and effluent water from treatment systems..

Procedure No. 14
Water Quality Sampling

Section No. 15
Revision No. 2
Date: May 1987
Page 1 of 8

Purpose

Water quality samples are taken to establish the water quality at each sampling point and to obtain bacteriological information as part of a bioremediation program. Special care must be taken to ensure that the sample taken from a well is representaitve of the water at that location and that the sample is not altered or contaminated by the sampling and handling procedure. The procedures for obtaining and handling water quality samples differ depending on the type of analysis required. Standard water quality analyses for volatile organic compounds (VOC) are EPA Analytical Methods 601, 602, amd 624. The standard analysis for semi-volatile organics is EPA Analytical Method 625. Bacterial analyses for a bioremediation program can be obtained by standard plating, membrane plating, and fermentation inoculum.

References

Driscoll, Fletcher G., Ph.D., 1986, "Groundwater and Wells", Second Edition, Johnson Division, St. Paul, Minnesota.

Scalf, Marion R., McNabb, James F., Dunlap, William J., Cosby, Roger L., Fryberger, John, 1981, " Manual of Ground-Water Sampling Procedures", Robert S. Kerr Enviornmental Research Laboratory, U.S. Enviornmental Protection Agency, Ada, Oklahoma.

U.S. EPA, 1977, " Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities", SW-611, U.S. EPA, Cincinnati, Ohio.

Procedure - General

* Water samples should not be taken from the stagnant water in the well.

* Water samples should be taken in duplicate.

* Remove 5 volumes of water in the well prior to sampling. The water may be removed by bailing, submersible pump, or purge system. Wells with a slow recovery period should be bailed dry and then sampled within 24 hours.

* Use only Teflon, stainless steel, or glass bailers to obtain the sample. Use Teflon, only, for sampling water containing chlorinated compounds and also for bacteriological samples. PVC bailers can be used for one-time sampling for other than EPA 624 analysis. Using a bailer for a one-time sampling reduces the possibility for cross- contamination.

* When sampling, avoid stirring up any sediments in the well.

* All sampling equipment must be cleaned following the appropriate procedure to avoid cross contamination from site to site and sample to sample. The sampling equipment should be cleaned before each well sampling, between each sampling, and at the end of each sampling round.

* Monitoring wells should be gauged prior to sampling.

* If possible, the monitoring wells should be sampled starting with the cleanest well and ending with the most contaminated well.

* Wells containing free-phase contaminants should not be sampled.

* When filling out the chain of custody form:
  a) enter the samples in the order in which they were collected
  b) make a note as to the cleaning fluid used to clean the sampling equipment
  c) attempt to identify which samples are the most contaminated
  d) complete all other requested information

* The laboratory sample identification label should be filled out with a waterproof pen and firmly afixed to each sample container. Typically, identificaton labels require that the following information be supplied:
  a) job name
  b) job number
  c) sampler's name
  d) date
  f) sample identification (ex: MW-1)
  g) date sampled (time is sometimes requested, too)
  h) analysis requested

* Acidificaton is required for samples that will by analyzed by the EPA 624 method. (see Acidification Procedure in this section)

* Acidification is recommended for EPA method 601 and 602 samples to preserve them and increase their holding life. (see Acidification Procedure in this section)

* Field blanks should be taken as part of each sampling round. A field blank consists of a sample of distilled water which has been collected by putting the distilled water into a sampling bailer after the bailer has been cleaned following the procedure used to clean that bailer during the sampling round. The field blank is stored with the samples. It is not analyzed unless requested by the Project Manager.

* CAUTIONS:

- Sample accuracy can be adversely affected by the entrainment of sediment in wells which have not been properly developed. Contaminants adhering to the sediments can be released when samples are acidified for preservation.

- Chemical changes can take place because the sample was oxidized during sampling. It is critical to avoid oxidation of samples when sampling for VOC.

- All samples should be properly and promptly preserved.

- All samples should be analyzed quickly; arrangments should be made with the testing laboratory to insure prompt analysis.

- Bailer strings should be replaced frequently to avoid contamination from a bailer string which has absorbed contamination. A good practice would be to replace the strings of both the evacuation and sampling bailers at the start of each sampling round. Caution: some bailer strings are treated with a fungicide which may be detected in priority pollutant analysis.

* Acidification Procedure

- at the start of each sampling round, the amount of acid required to lower a sampling container of water to be sampled to a pH of less than 2 should be determined

- after removing 5 well volumes from the first well to be sampled, put 5-10 drops of 50% HCL into a 40 ml sample vial (larger sampling containers will required more acid) and fill the vial with water from the well; determine the pH of the water in the vial with the pH paper; if the pH is too high, repeat the procedure using 15-20 drops of acid in the vial; repeat until the pH of the water in the sample vial is a pH of less than 2 on the pH paper; note the amount of acid required to lower the pH of the volume of water in the sampling vial

- discard the practice acidified sample

- once the amount of acid required to reach a pH of <2 is known, the acid can be routinely added to each sample container directly; the water to be analyzed is added to vial or container containing the appropriate amount of acid

- note that the amount of acid required is site specific and should be noted on the Chain of Custody form

- the procedure should be repeated at each site at the start of each sampling round

* EPA Analytical Methods 601, 602, and 624 Sampling Procedures

- equipment
  a) bailer or other means to remove 5 well volumes
  b) sampling bailer
  c) polyethylene squirt bottle of 50% hydrochloric (HCL) acid
  d) narrow range pH paper (1.0 - 2.5 pH range)
  e) paper towels
  f) waterproof pen
  g) laboratory sample identification labels
  h) cooler with ice
  i) chain of custody forms
  j) sample containers (usually 40 ml glass vials with teflon faced septums)
  k) alconox solution and/or methanol
  l) distilled water
  m) safety equipment
  n) dissolved oxygen meter (sometimes used in limited biorec projects in conjunction with bacteriological testing)

- all sampling equipment will be cleaned by washing thoroughly with alconox solution or methanol and rinsed with distilled water; this procedure should be repeated three times

- carefully remove five bailerfulls of water from the well using the sample bailer before retaining the sample from the fifth bailer; this thoroughly rinses the sample bailer with the water to be sampled helping to insure a representative sample and to reduce cross contamination

- thoroughly rinse the sample containers with the water to be sampled

- if the samples are to be acidified, add acid to the sample containers (EPA method 624 requires acidification)

- fill two sample containers with the contents of the sampling bailer

- BE CAREFUL not to touch the rim of the sample container or the sample container top with your fingers or with the bailer

- DO NOT pour the sample from the sample bailer over the bailer cord; do not allow the cord to touch the sample container

- avoid aeration of the sample during transfer of the water from the bailer to the sample

container in order to reduce the possibility of oxidation of the sample; gently and carefully pour the sample into the sample container in a steady stream

- the sample should contain no air; fill the sample container to the top so that a meniscus is formed; wait for any bubbles to rise to the surface; carefully and quickly slip the cap of the sampling container onto the container and tighten securely

- invert the sample and tap it gently against the heal of your hand; look for any air bubbles; if the sample contens air bubbles, discard the sample and repeat the sampling process with new sampling containers

- obtain a duplicate sample from the same well following the same procedure

- affix the laboratory sample identification labels

- place samples in cooler with ice

- complete the chain of custody form

* EPA Analytical Method 625

- the procedure for sampling for EPA 625 is the same as for EPA 601, 602, and 624

- the sample container size is a 1-liter glass sample container

- DO NOT acidify EPA 625 samples

* Bacteriological Sampling

- refer to " Handbook of Bioremediation " prepared by Groundwater Technology, Inc., Chadds Ford, PA

- sampling for an initial feasibility sampling should have the goal of assessing the total water ecology of the impacted area; the following parameters should be determined:
  - a) water temperature
  - c) dissolved oxygen
  - d) total dissolved solids (TDS)
  - e) pH
  - f) conductivity
  - g) inorganic chemistry
  - h) organic chemistry
  - i) microbiology

- it is extremely important to limit the possibility of contamination of samples collected for microbiological analysis

- potential sources of contamination are:
  a) bacteria colonizing the well casing
  b) sampling equipment
  c) air
  d) rain
  e) dust
  f) skin

- regular and complete well development along with periodic treatment of the well with non-polluting chemical disinfectants such as hydrogen peroxide can significantly reduce contamination due to bacteria colonizing the well casing

- utilizing dedicated sampling equipment is also an effective method of reducing the possibility of cross-contamination

- no more than 24 hours prior to sampling, purge wells to remove standing water in the wells; samples should be collected only after the well has been pumped or bailed sufficiently to insure that the sample represents the groundwater source

- in situations where it is necessary to obtain samples representative of the zone of contaminstion, the well should be pumped at a specified rate to achieve characteristic drawdown; the data defining pumping rates and drawdown characteristics should be recorded and kept for each well

- when it is not required to obtain samples representative of the zone of contamination, 5 well volumes of water should be removed from the well or the well should be purged until the water temperature and conductivity stabilize

- if surface samples are to be taken from the well casing, visual inspection of the water surface should be performed and floating debris should be removed prior to sampling

- the volume of the sample should be sufficient to carry out all required tests:
  a) 40 ml for standard plating
  b) 100 ml for membrane plating
  c) 1000 ml for fermentation inoculum

- follow the procedures outlined under the General heading to clean sampling equipment

- avoid collecting sediment, whenever possible

- keep the sampling container closed until it is time for it to be filled

- BE CAREFUL not to touch the rim or neck of the sample container with your fingers or with the bailer
- protect the cap from contamination
- swirl the sample container with wrist action to expel some water over the rim of the sample container thus flushing away contaminantion before the sample container is resealed
- leave ample air space (approximately 3 cm) to facilitate mixing by shaking preparatory to examinaton
- obtain a duplicate sample from the same well following the same procedure
- affix the laboratory sample identification labels
- complete the Cain of Custody form and attach it to the samples
- immediately refrigerate the samples or place samples on ice; storage of samples should be as close to 4 degrees centigrade as possible
- keep samples DRY!
- coordinate with the testing laboratory
- samples should be delivered to the testing laboratory within 24 HOURS ! the type(s) of bacteria present are metabolically active and in order to get a good representation of the conditions at the time of sampling rapid sample assay is essential
- after sampling, obtain dissolved oxygen reading from all wells sampled

EXCERPTS FROM GTEL QA/QC PLAN

The following section includes excerpts from the Groundwater Technology Environmental Laboratory Quality Assurance/Quality Control Plan. A complete version of this document is available upon request, but is to voluminous to be included in its entirety here. Certain relevent excerpts have been included in this appendix.

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GT ENVIRONMENTAL LABORATORIES

NORTHEAST REGION

QA/QC PLAN

Second Revision
October 1987

5.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA IN TERMS OF PRECISION, ACCURACY, COMPLETENESS, REPRESENTATIVENESS, AND COMPARABILITY.

5.1 GROUNDWATER TECHNOLOGY ENVIRONMENTAL LABORATORY

1. Groundwater Technology Evironmental Laboratory (GTEL) quality assurance objectives for precision, accuracy, completeness, representativeness, and comparability are as follows:

A. Precision: The laboratory objective for precision is to equal or exceed the precision demonstrated for these analytical methods on similar samples and to exceed precision data for these analyses published by the U.S. EPA. See Table 5.1. Precision is documented on the basis of replicate analyses.

B. Accuracy: The laboratory objective for accuracy is to equal or exceed the accuracy demonstrated for these analytical methods on similar samples and to exceed recovery data published by the U.S. EPA. See Table 5.1. Accuracy is documented on the basis of recovery of spiked reference materials introduced into the analytical system.

C. Completeness: The completeness objective of an analysis is to provide sufficient information to allow the data user to assess the quality of the results. The overall project

completeness objective is documented by the ratio of the number of acceptable data points compared to the total number of measurements attempted.

D. Representativeness: The representativeness of the data from the sampling sites depends on the sampling procedures. The laboratory expects to be able to assist the customer with enacting proper sampling methods. The representativeness of the analytical data is a function of the procedures used in processing the samples. The objective for representativeness is to provide data which is representative of the sampled medium. The representativeness can be documented by the difference between separately procured, but otherwise identical samples or sample aliquots.

E. Comparability: The objectives for comparability are: to demonstrate traceability of standards to NBS or EPA sources; to use standard methodology; to participate in interlaboratory studies to document laboratory performance; and to report results consistently in conventional untis of measure (see Table 5.2). Comparability of analytical results with those from other laboratories will be enhanced by these processes. See Table 5.3 for recent performance data.

Table 5.1 summarizes the precision, accuracy, and completeness objectives for the measurement parameters typically measured by GTEL. The values listed in Table 5.1 are based on EPA requirements published in the Federal Register (October 26, 1984), The EPA requirements in the Contract Laboratory Program, or if available statistical limits for GTEL performance (when an improvement over the EPA criteria).

The GTEL quality control program consists of appropriately placed blanks, duplicates, spikes, and QC check samples according to the method criteria (refer to Section 11).

7.0 SAMPLE CUSTODY

7.1 SAMPLE IDENTIFICATION

Each separate sample will be identified using the sample label shown in Figure 6.1. The sampler will complete all information, using a black waterproof pen, as follows:

A. The Sample ID Number will be the number assigned to the particular sampling station.

B. The job number will be the number assigned to the particular facility.

C. The Analysis Required will be indicated for each sample using either EPA 601, EPA 602, or EPA 624.

D. Date Taken will be the date the sample was collected, using the format MM-DD-YY.

Example: 08-15-86

E. Time will be the time the sample was collected, using military time.

Example: 1430

F. The sampler's name will be printed in the "Sampled By" section.

This sample label contains the authorative information for the sample. Inconsistencies with other documents will be settled in favor of the vial label unless otherwise corrected in writing from the client.

7.2 CHAIN OF CUSTODY

Some client samples analyzed by GTEL are of an evidentiary nature. The possession of samples must be traceable from the time samples are collected in the field until the analysis is completed and the data are entered as evidence. The tracing of the samples is accomplished by "chain-of-custody" procedures as follows:

A. A chain-of-custody record (Figure 7.2) will be completed for each set of samples. The sampler will sign the first "Relinquished By" line at the bottom of the chain of custody record, and will indicate the date and time of the custody transfer. Samples will not leave custody of the field investigator until relinquished to another party.

Custody is defined as:

1. In the actual physical possession of field personnel.
2. In the field personnel's view after being in physical possession.
3. In a locked area after being in physical possession.
4. In a designated, locked storage area.

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Section No. 7
Revision No. 2
Date 10/23/87
Page 3 of 7

FIGURE 7.2
CHAIN-OF-CUSTODY RECORD

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

PROJ. NO. | PROJECT NAME | SAMPLERS: (Signature)

CLIENT NAME/OFFICE LOCATION | PHONE NO. | PROJECT MANAGER

CHECK ANALYSIS TYPE REQUESTED

SAMPLE I.D. NUMBER	# OF CONTAINERS	WATER	SOIL	SED.	SOURCE OF SAMPLE	COMP.	GRAB	DATE	TIME	ACIDIFIED	ICED	REMARKS

GASOLINE HYDROCARBONS BY ☐ 602 ☐ HS
VOLATILE ORGANICS BY EPA ☐ 624 ☐ 601
☐ 624 + HSL ☐ 602
EXTRACTABLES BY EPA 625 ☐ ACIDS
☐ B/N ☐ B/N/A
METALS ☐ 13 PRIORITY POL
☐ RCRA ☐ EP TOX
OTHER

Relinquished by:	Date	Time	Received by:	Date	Time	Received by laboratory:	Date	Time

Transfer of samples to the analyzing laboratory by use of a common carrier will be documented on the COC form.

Upon arrival at the laboratory, the sample custodian at the lab is responsible for maintaining possession of the chain-of-custody samples and for maintaining all records documenting that possession. Upon receipt of samples, the sample custodian signs the shipping report accompanying each sample and records the date and time. A copy of this record becomes part of the report file. The custodian signs the COC "Received By" laboratory space. The samples are then secured under lock and key in refrigerated storage.

After each extraction or analysis of a sample fraction, the custody record (Figure 7.3) is signed by the analyst indicating the date and time of completion, which samples were used, and to which location they were returned. The latter goes in the "Reason" section.

FIGURE 7.3

LABORATORY LOGIN WORKSHEET

		Status		Acceptability	
Date:		Y	N	Y	N
Job Name:	Ice in Cooler:	—	—	—	—
Job Number:	Temperature: _____			—	—
Turn Around Requested:	Bubbles: If yes-list	—	—	—	—
Date Samples Received:					
Number of Samples:	Incorrect Septa: If yes-list	—	—	—	—
Analysis Code:					
Project Manager:	Package Security	—	—	—	—
Site Location: Outside Client Address: _____ _____ _____	Sample # Range: _____				

CUSTODY RECORD

Removed by:	Date/Time Removed:	Reason:	Date/Time Returned:
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

PROJECT LOG

_____

_____

_____

_____

_____

_____

_____

_____

By signing the custody record, the individual affirms that he was completely responsible for the sample fraction during the period of time it was not in the secure storage.

7.3 Sample tracking and management

GTEL maintains sample information records in a LIMS (Laboratory Information Management System) computer system. The sample receipt and data entry activity (called "login") is reflected in a daily report, Figure 7.3, which is immediately entered into the master logbook. This chronological file contains all samples.

Daily each laboratory manager gets a report of pertinent analyses not yet completed including the daily update from the login activity. The tracking continues until the LIMS registers the completion of report and invoice mailing.

GT ENVIRONMENTAL LABS

DAILY ENTRY LOGBOOK · PRODUCED ON PP/PP/PP AT QQ:QQ PAGE 1

REPORT#	PROJNAME	SAMPLE #	SAN.ID	STALOC	ANALYSIS	LOCATION	SAN.ENT
XXX-XXXX-YYY	Site Name	NNNNNNNNNN	Client Sample ID	Sampling Location	CODE	NAB	DD/DD/DD TT:TT:TT

KEY:

PP/PP/PP = Date Logbook sheet is printed
QQ:QQ = Time Logbook sheet is printed
XXX-XXXX = Project number
-YYY = Sequential report number
NNNNNNNNNN = GTEL unique sample identification number
CODE = GTEL analysis type code number
NAB = Sample storage location (N:refrigerator AB:shelf)
DD/DD/DD = Date log-in data are entered
TT:TT:TT = Time log-in data are entered

FIGURE 7.4

Daily sample entry logbook.

8.0 CALIBRATION PROCEDURES AND FREQUENCY

8.1 LABORATORY MEASUREMENTS

Groundwater Technology Environmental Laboratory will analyze water and soil samples for semi-volatile and volatile organics by gas chromatography and by gas chromatography/mass spectrometry. The calibration frequency required by these methods is dependent on the outcome of daily calibration checks made with QC standards. Reference materials are a minimum of 97% purity from Supelco Inc., (Supelco Park, Bellefonte, PA 16823), or Chem Service Inc. Spiked reference samples (spiked into reagent water) are introduced into the analytical system to determine recovery and to further validate calibrations at a frequency dependent on the matrix spike performance.

Metals will be analyzed by atomic absorption and inductively coupled plasma spectrophotometry. The calibration frequency required by these methods is daily with freshly made acidified aqueous standards. The standards are dilutions of stock 1000 ppm standards commercially available.

Petroleum hydrocarbons are analyzed by infrared spectrometry. The calibration frequency is daily with freshly made standards in freon.

11.0 INTERNAL QUALITY CONTROL CHECKS

The internal quality control checks to be routinely implemented by GTEL include the following:

A) Replicates - A minimum of 10% of all samples will be duplicated in the lab in the form of a spiked sample duplicate. Duplicate data will be used to determine analytical precision. The EPA Contract Lab Program criteria under which the GTEL GC/MS lab operates specifies a minimum of 5% duplicates.

B) Spikes - Spiked samples will be prepared in the lab and will be analyzed with the samples at a rate of 10% of all samples and at least one spiked sample per sample set. EPA Method 624 and EPA Contract Lab Program criteria under which the GTL GC/MS lab operates specify a minimum of 5% spikes. Soil samples will be spiked at a minimum rate of one spiked sample per sample set.

C) Blanks - Blanks will be analyzed at a minimum of one daily.

D) Quality Control Standards - Quality control standards traceable to the U.S. EPA or generated from concentrates prepared separately from concentration standards will be included at a rate dependent on sample matrix and lab performance. The minimum is one QC standard

per day to validate the calibration. EPA traceable standards will be run at least quarterly.

E) Quality Control Charts - Quality control charts for precision anc accuracy with statistically developed control limits will be prepared by GTEL and be updated for approximately every 20 data points.

Order No. 841-45250

1-1300—1/91-3756(2A)

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