

# ADDENDUM

## Intrinsic Remediation Engineering Evaluation/Cost Analysis for the Former Car Care Center



**Bolling Air Force Base  
Washington, District of Columbia**

Prepared For

**Air Force Center for Environmental Excellence  
Technology Transfer Division  
Brooks Air Force Base  
San Antonio, Texas**

**20000830 020**

and

**11 CES/CEV  
Bolling Air Force Base  
Washington, DC**

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November 1997



**Walton, Norman**

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**Sent:** Tuesday, August 08, 2000 10:16 AM

**To:** 'nwalton@dtic.mil'

**Subject:** Distribution statement for AFCEE/ERT reports

Norman, This is a followup to our phone call. The eight boxes of reports you received from us are all for unlimited distribution. If you have any questions, you can contact me at DSN 240-4353.

08/08/2000

## 1.0 INTRODUCTION

This report was prepared for the Air Force Center for Environmental Excellence (AFCEE) by Parsons Engineering Science, Inc. (Parsons ES) as an addendum to the Final Intrinsic Remediation Engineering Evaluation/Cost Analysis (EE/CA) for the Former Car Care Center, Bolling Air Force Base (AFB), Washington, District of Columbia (DC) (Parsons ES, 1997a). The EE/CA was conducted to evaluate the use of natural attenuation (intrinsic remediation) with long-term monitoring (LTM) for remediation of fuel hydrocarbon contamination dissolved in groundwater at the Former Car Care Center. This addendum summarizes the results of the third sampling event performed as a part of the evaluation of natural attenuation at the site. This sampling was conducted in September 1997 by researchers from the US Environmental Protection Agency (USEPA) National Risk Management Research Laboratory (NRMRL) Subsurface Protection and Remediation Division. The original EE/CA sampling event was conducted in August 1994, and the first natural attenuation update sampling occurred in June 1996. The main emphasis of this summary is to evaluate changes in dissolved benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations, plume extent, and natural attenuation mechanisms through time. Results, calculations, and predictions presented in the EE/CA are used as the basis for comparison.

For the purposes of the work described herein, the Former Car Care Center Site at Building 41 (ST-04) includes the property of the Former Car Care Center and the adjacent properties that contain monitoring wells. This area includes Building 13, Building 503, Building 518, and the parking lot across Brookley Avenue (Figure 1). The Former Car Care Center served as an auto repair and fueling facility for Bolling AFB from 1936 to 1982. It ceased gasoline fueling operations in 1982 when the site's underground storage tanks (USTs) were taken out of service. Currently, Building 41 is used as a Hazardous Material Pharmacy to control the distribution of hazardous materials at the Base. Potential sources of contamination at the Former Car Care Center include two former 12,000-gallon gasoline USTs near the southeast corner of the Former Car Care Center facility, a single former 12,000-gallon gasoline UST near the northeast corner of the facility, four 275-gallon waste oil USTs, and the associated piping and dispensers. All seven USTs have been removed from the site. Additional site information, including site background, geology, and hydrogeology, is provided in the EE/CA (Parsons ES, 1997a).

The intrinsic remediation EE/CA concluded that, natural attenuation of BTEX compounds is occurring at the Former Car Care Center Site to the extent that the dissolved concentrations of these compounds in groundwater should be reduced to levels below current regulatory guidelines long before potential downgradient receptors could be adversely affected (i.e., the potential contamination migration pathway will not be completed for any of the potential receptors described in the EE/CA). However, the Air Force implemented a more aggressive remedial approach in order to reduce the remediation time frame and honor regulatory concerns in a cost-effective manner. Therefore, a pilot-scale treatability demonstration to test the effectiveness of SVE using an internal combustion engine (ICE) to extract and treat volatile fuel hydrocarbons operated at the site between November 15, 1996 and June 23, 1997, when the system was shut off to evaluate rebound of volatile fuel concentrations in soil vapors, and to determine if soil vapor total volatile hydrocarbon (TVH) concentrations

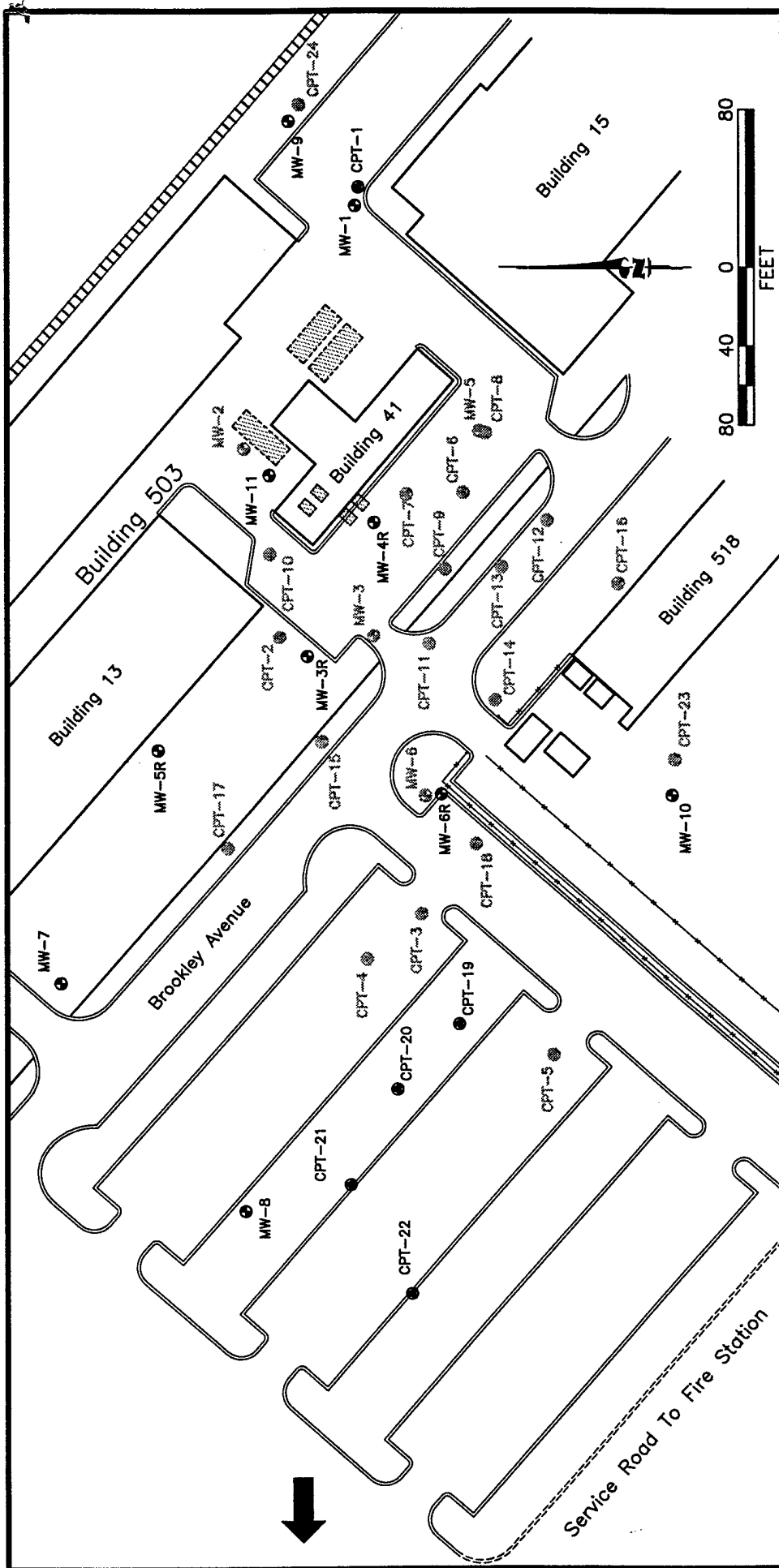


FIGURE 1







**SITE LAYOUT**

Former Car Care Center Site  
 Intrinsic Remediation Addendum  
 Bolling AFB, Washington DC

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Denver, Colorado

**LEGEND**

-  Former underground storage tanks (USTs).
-  MW-1 Monitoring well.
-  CPT-20 Piezometer and CPT test location installed by CPT rig.
-  MW-1 Abandoned/Destroyed Monitoring Well
-  CPT-20 Abandoned CPT Test Location
-  Approximate Groundwater Flow Direction

had been sufficiently reduced to allow air injection bioventing to be initiated without causing hazardous vapors to migrate into utilities or buildings. Due to concerns expressed by the DC Environmental Regulation Administration (DCERA) UST Management Branch, that termination of SVE at the site may be premature, continued SVE using a single-engine ICE unit to extract and treat vapors from site wells is occurring. The ICE unit began extracting and treating vapors from well MW-5R on October 2, 1997, and has been operating continuously as of the date of this document. To address mobile LNAPL recovery, passive LNAPL skimmers were installed in wells MW-3R, MW-4R, and MW-11 on September 19, 1997. The passive skimmers can be moved to other wells containing mobile LNAPL, as necessary.

## **2.0 RESULTS**

On September 9 and 10, 1997, researchers from the USEPA NRMRL collected groundwater samples from 9 groundwater monitoring wells (MW-1, -3R, -4R, -5R, -6R, -7, 8, -9, and -11) and 7 groundwater monitoring points (CPT-19S, -19D, -20S, -20D, -21S, -21D, and -22D) at the Former Car Care Center Site. Where sufficient groundwater volume was available, samples were analyzed in the field for dissolved oxygen (DO), temperature, carbon dioxide, alkalinity, pH, conductivity, oxidation/reduction potential (ORP), hydrogen sulfide, and ferrous iron. Additional sample volume was analyzed at the USEPA NRMRL in Ada, Oklahoma for BTEX, trimethylbenzenes (TMBs), fuel carbon, nitrate + nitrite, sulfate, chloride, methane, and total organic carbon (TOC). Analytical methods used are summarized in Table 1. Prior to purging and sampling each monitoring well, groundwater levels were measured.

### **2.1 Groundwater Flow Direction and Gradient**

Groundwater elevation data obtained during the August 1994 sampling event, as well as the shape of the dissolved BTEX plume, indicated that groundwater and dissolved contaminants generally migrate to the northwest at the Former Car Care Center Site. However, groundwater elevations measured in September 1997 and plotted on Figure 2 indicate more variable flow directions that are not consistent with data obtained during previous measurement events (August 1994 and June 1996, see Table 2). This inconsistency may be attributable to uncertainty regarding the top of casing elevations at wells MW-8 and MW-11, the inclusion of water level data from relatively new wells that were not measured during previous sampling events (e.g., MW-3R and MW-4R), and the relatively small amount and localized extent of groundwater elevation data obtained in September 1997 compared with previous sampling events. For these reasons, the accuracy of groundwater flow directions derived from the most recent data would be speculative, and a potentiometric surface map for September 1997 was not prepared.

### **2.2 Dissolved BTEX Contamination**

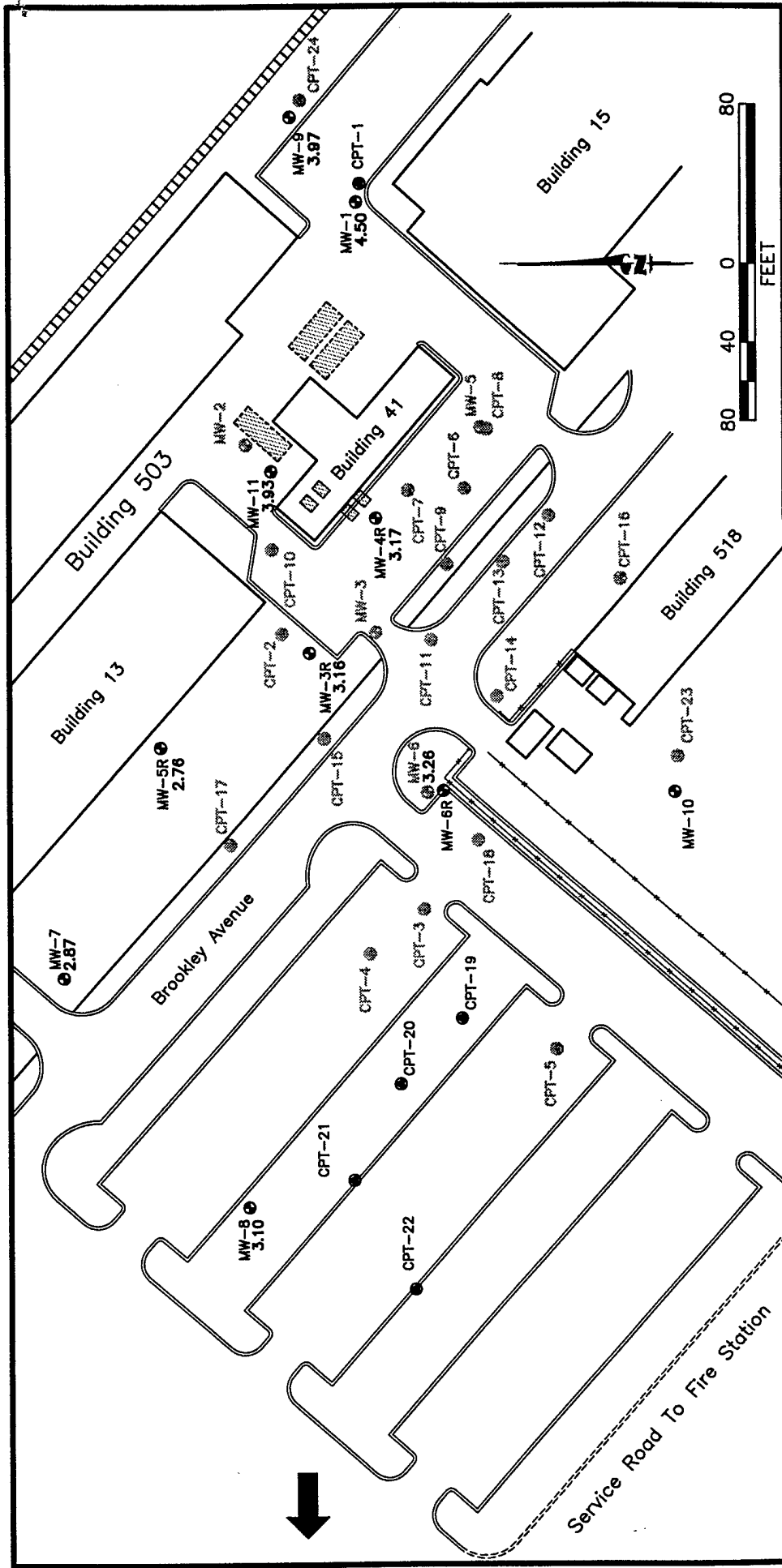
BTEX compounds were detected in groundwater samples collected from 10 of the 16 monitoring wells and points sampled in September 1997. Current and historical analytical results for these 16 sampling locations (as well as the other locations

**TABLE 1**  
**SUMMARY OF GROUNDWATER ANALYTICAL METHODS**  
**FORMER CAR CARE CENTER SITE**  
**INTRINSIC REMEDIATION ADDENDUM**  
**BOLLING AFB, DC**

Analyte	Method	Field (F) or Fixed-Base Laboratory (L)
Ferrous Iron (Fe <sup>2+</sup> )	Colorimetric, Hach Method 8146	F
Reduction/Oxidation Potential	Direct reading meter	F
Dissolved Oxygen	Direct reading meter	F
pH	Direct reading meter	F
Conductivity	Direct reading meter	F
Temperature	Direct reading meter	F
Carbon Dioxide	Titrimetric, Hach Method 1436-01	F
Alkalinity (Carbonate [CO <sub>3</sub> <sup>2-</sup> ] and Bicarbonate [HCO <sub>3</sub> <sup>-</sup> ])	Titrimetric, Hach Method 8221	F
Hydrogen Sulfide (H <sub>2</sub> S)	Colorimetric, Hach Method 8131	F
Nitrate + Nitrite	USEPA Method 353.1	L
Sulfate	Waters Capillary Electrophoresis Method N-601	L
Chloride	Waters Capillary Electrophoresis Method N-601	L
Methane, Ethane, & Ethene	RSKSOP-194/175 <sup>a/</sup>	L
Total Organic Carbon	RSKSOP-102	L
BTEX and TMBs <sup>b/</sup>	RSKSOP-133	L
Total Fuel Carbon	RSKSOP-133	L

<sup>a/</sup> RSKOP = Robert S. Kerr Laboratory (now known as NRMRL) standard operating procedure.

<sup>b/</sup> BTEX = benzene, toluene, ethylbenzene, and xylenes; TMBs = trimethylbenzenes.



**FIGURE 2**

**GROUNDWATER ELEVATIONS  
SEPTEMBER 1997**

Former Car Care Center Site  
Intrinsic Remediation Addendum  
Boiling AFB, Washington DC

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Denver, Colorado

**LEGEND**

- Former underground storage tanks (USTs).
- MW-1 ● Monitoring well.
- CPT-20 ● Piezometer and CPT test location installed by CPT rig.
- MW-1 ● Abandoned/Destroyed Monitoring Well
- CPT-20 ● Abandoned CPT Test Location
- 3.10 Groundwater Elevation (feet above mean sea level)
- Approximate Groundwater Flow Direction

**TABLE 2**  
**WATER LEVEL ELEVATION DATA**  
**FORMER CAR CARE CENTER SITE**  
**INTRINSIC REMEDIATION ADDENDUM**  
**BOLLING AFB, DC**

Measurement Location <sup>a/</sup>	Date	Easting (feet)	Northing (feet)	Datum Elevation <sup>b/</sup> (feet msl) <sup>c/</sup>	Total Depth (feet btoc) <sup>d/</sup>	Product Thickness (feet)	Water Depth (feet btoc)	Potentiometric Surface Elevation (feet msl)
Monitoring Points								
CPT-02S	8/94	796500	367430	22.26	23.2	0.00	19.61	2.65
CPT-02D	8/94	796500	367430	22.24	33.3	0.00	19.27	2.97
CPT-08S	8/94	796448	367290	21.49	23.2	0.00	18.25	3.24
CPT-08D	8/94	796448	367290	21.42	33.2	0.00	18.29	3.13
CPT-09S	8/94	796438	367362	20.97	23.2	0.00	17.92	3.05
CPT-09D	8/94	796438	367362	20.95	33.2	0.00	17.93	3.02
CPT-10S	8/94	796523	367394	21.17	23.2	0.00	18.13	3.04
CPT-10D	8/94	796523	367394	21.21	33.2	0.00	18.18	3.03
CPT-11S	8/94	796429	367400	20.77	23.2	0.00	17.85	2.92
CPT-11D	8/94	796429	367400	21.01	33.2	0.00	17.81	3.20
CPT-16S	8/94	796354	367330	20.40	23.2	0.00	17.42	2.98
CPT-16D	8/94	796354	367330	20.38	33.2	0.00	17.41	2.97
CPT-18S	8/94	796362	367483	21	23.2	NA <sup>e/</sup>	NA	NA
CPT-18D	8/94	796362	367483	21	33.2	NA	NA	NA
CPT-19S	8/94	796330	367571	24.97	27.2	0.00	21.24	3.73
	6/96					0.00	17.24	7.73
CPT-19D	8/94	796330	367571	24.96	37.2	0.00	22.16	2.80
	6/96					0.00	19.03	5.93
CPT-20S	8/94	796345	367615	24.80	27.2	0.00	20.83	3.97
	6/96					0.00	17.80	7.00
CPT-20D	8/94	796345	367615	24.79	37.2	0.00	21.99	2.80
	6/96					0.00	19.36	5.43
CPT-21S	8/94	796345	367670	22.25	23.2	0.00	18.50	3.75
	6/96					0.00	17.46	4.79
CPT-21D	8/94	796345	367670	22.08	33.2	0.00	19.56	2.52
	6/96					0.00	18.67	3.41
CPT-22S	8/94	796292	367707	21.97	23.2	0.00	20.80	1.17
	6/96					0.00	5.60	16.37
CPT-22D	8/94	796292	367707	22.07	33.2	0.00	19.21	2.86
	6/96					0.00	18.32	3.75

**TABLE 2 (Continued)**  
**WATER LEVEL ELEVATION DATA**  
**FORMER CAR CARE CENTER SITE**  
**INTRINSIC REMEDIATION ADDENDUM**  
**BOLLING AFB, DC**

Measurement Location <sup>a/</sup>	Date	Easting (feet)	Northing (feet)	Datum Elevation <sup>b/</sup> (feet msl) <sup>c/</sup>	Total Depth (feet btoc) <sup>d/</sup>	Product Thickness (feet)	Water Depth (feet btoc)	Potentiometric Surface Elevation (feet msl)
<b>Monitoring Wells</b>								
MW-1	8/94					0.00	18.33	3.35
	6/96	796559	367215	21.68	25	0.00	17.08	4.60
	9/97					NA	17.18	4.50
MW-2	8/94	796558	367351	21.68	25	0.15 <sup>fi</sup>	NA	NA
MW-3	8/94	796456	367409	21.14	25	0.32 <sup>g/</sup>	17.62	3.52
MW-3R	9/97	NA	NA	21.46	NA	NA	18.30	3.16
MW-4	8/94	796459	367356	21.27	25	0.00	18.08	3.19
MW-4R	9/97	NA	NA	21.67	NA	NA	18.50	3.17
MW-5	8/94	796452	367291	21.37	26	0.00	18.46	2.91
MW-5R	9/97	NA	NA	22.36	NA	NA	19.60	2.76
MW-6	8/94	796397	367471	21.55	26	0.00	18.62	2.93
MW-6R	9/97	NA	NA	22.04	NA	NA	18.78	3.26
MW-7	8/94					0.00	18.61	3.36
	6/96	796525	367639	21.97	29	0.00	17.97	4.00
	9/97					NA	19.10	2.87
MW-8	8/94					0.00	23.77	3.25
	6/96	796388	367706	27.02	27	0.00	22.95	4.07
	9/97					NA	23.92	3.10
MW-9	8/94					0.00	15.83	6.32
	6/96	796608	367191	22.15	30	0.00	15.04	7.11
	9/97					NA	18.18	3.97
MW-10	8/94	796282	367417	20.76	29	0.00	12.31	8.45
	6/96					0.00	11.71	9.05
MW-11	6/96	NA	NA	22.25	NA	0.47	17.50	4.75
	9/97					NA	18.32	3.93

<sup>a/</sup> See Figure 1 for measurement locations.

<sup>b/</sup> Datum elevation is top of well casing. Monitoring well elevations from Baker, 1997.

<sup>c/</sup> feet msl = feet above mean sea level.

<sup>d/</sup> feet btoc = feet below top of casing.

<sup>e/</sup> NA = not available

<sup>fi</sup> Measured product thickness on August 6, 1994. Monitoring well destroyed after this date.

<sup>g/</sup> Measured product thickness on August 9, 1994. Free product not present on August 11, 1994.

previously monitored as a part of the intrinsic remediation demonstration) are provided in Table 3. The areal distribution of total dissolved BTEX for September 1997 is presented on Figure 3. In order to evaluate trends in BTEX concentrations and distribution through time, the total dissolved BTEX isopleth maps derived from August 1994 and June 1996 data are provided on Figure 4.

In September 1997, the highest total BTEX concentration was detected in monitoring well MW-4R at a concentration of 63,030 micrograms per liter ( $\mu\text{g/L}$ ). Well MW-4R was installed west of Building 41 following damage to the original source area wells during site renovation, and is located within approximately 25 feet of former monitoring well MW-4. A mobile LNAPL thickness of approximately 0.28 feet was observed at this location in March 1997 (Parsons ES, 1997b); however, because mobile LNAPL observations were not recorded during the September 1997 sampling event, the current LNAPL thickness is unknown. During the August 1994 sampling event, dissolved BTEX concentrations in excess of 100,000  $\mu\text{g/L}$  were observed at the site; however, the monitoring well and monitoring point where these concentrations were observed (MW-2 and CPT-11S) no longer exist.

During the September 1997 sampling event, dissolved BTEX concentrations exceeded 30,000  $\mu\text{g/L}$  at monitoring wells MW-3R, MW-5R, and MW-11. These are the only other locations sampled in September 1997 where free product has historically been observed (Parsons ES 1997a and 1997b). Monitoring well MW-11 is the only source area well that was sampled as a part of previous intrinsic remediation sampling events. Between June 1996 and September 1997, dissolved BTEX concentrations in this well declined approximately 7.5 percent from 49,300  $\mu\text{g/L}$  to 45,570  $\mu\text{g/L}$ . Quarterly groundwater sampling results were available from December 1996 for well MW-3R (Baker, 1996). A decrease in dissolved BTEX concentrations of approximately 500  $\mu\text{g/L}$  (1.5 percent) was observed between the December 1996 and September 1997 sampling events. Other source area wells were not sampled in December 1996 because of the presence of mobile LNAPL (Baker, 1996). Although comparison of results from two sampling events at two wells does not conclusively document a trend, dissolved contaminant concentrations in the source area are expected to decrease as a result of ongoing source reduction activities (i.e., SVE).

A reduction in the mass of BTEX dissolving into the groundwater in the source area ultimately will contribute to declines in dissolved contaminant concentrations further downgradient. Nevertheless, because groundwater flow is not instantaneous, these effects are likely to be realized most rapidly at the nearest downgradient wells. A decrease in the dissolved BTEX concentration has been observed at MW-6R, the closest monitoring well downgradient from the source area. When sampled in December 1996, a total dissolved BTEX concentration of 28,700  $\mu\text{g/L}$  was measured in the sample from well MW-6R; in September 1997, the detected BTEX concentration was 13,749  $\mu\text{g/L}$ .

Further downgradient at monitoring point CPT-20D, the total dissolved BTEX concentration increased from 3,230  $\mu\text{g/L}$  in June 1996 to 19,090  $\mu\text{g/L}$  in September 1997. This trend suggests that source area remediation has not yet impacted the dissolved contaminant concentrations as far downgradient as CPT-20. Instead, the increase in the dissolved BTEX concentration at this location suggests that the plume

**TABLE 3**  
**FUEL HYDROCARBON COMPOUNDS DETECTED IN GROUNDWATER**  
**FORMER CAR CARE CENTER SITE**  
**INTRINSIC REMEDIATION ADDENDUM**  
**BOLLING AFB, DC**

Sample Location <sup>a/</sup>	Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylene (µg/L)	Total BTEX <sup>b/</sup> (µg/L)	1,3,5-Trimethylbenzene <sup>b/</sup> (µg/L)	1,2,4-Trimethylbenzene <sup>b/</sup> (µg/L)	1,2,3-Trimethylbenzene <sup>b/</sup> (µg/L)	Total Volatile Hydrocarbons <sup>c/</sup> (mg/L)
Monitoring Points										
CPT-2D	Aug-94	9.6	64	7.4	42	123	3.5	13	2	0.6
CPT-2S	Aug-94	21000	25000	1900	8400	56300	290	1100	200	76
CPT-8D	Aug-94	2.1	83	17	86	188.1	4.1	12	4.5	0.6
CPT-8S	Aug-94	1600	25000	1700	9000	37300	260	1100	210	82
CPT-9D	Aug-94	47	ND	31	95	173	0.6	26	4.3	0.7
CPT-9S	Aug-94	25000	29000	1600	8300	63900	230	960	180	200
CPT-10D	Aug-94	0.8	8.3	1.0	4.9	15	BLQ	0.6	1	BLQ
CPT-10S	Aug-94	7300	25000	1800	8700	42800	240	1000	190	61
CPT-11D	Aug-94	1600	170	410	870	3050	18	270	49	13
CPT-11S	Aug-94	44000	57000	1600	8400	111000	210	820	160	160
CPT-16D	Aug-94	56	300	520	918	1794	37	250	92	8
CPT-16S	Aug-94	400	21000	1100	6500	29000	280	720	170	124
CPT-18D	Aug-94	17000	2500	1600	5810	26910	180	920	210	89
CPT-18S	Aug-94	64	4800	1300	7000	13164	140	790	100	50
CPT-19D	Aug-94	750	370	980	3960	6060	160	690	130	49
	Jun-96	1400	700	1800	6000	9900	250	1100	340	31
	Sep-97	1580	518	561	1629	4288	81	571	76	6.1
CPT-19S	Jun-96	14	6.5	11	7.9	39.4	ND	0.5	ND	0.2
	Sep-97	ND	BLQ	ND	BLQ	BLQ	ND	ND	ND	BLQ
CPT-20D	Aug-94	2300	640	1600	4100	8640	240	970	200	46
	Jun-96	450	180	1900	700	3230	140	500	80	13
	Sep-97	4390	2540	2500	9660	19090	339	1480	429	28.3
CPT-20S	Jun-96	1.5	1	7.5	1	11	ND	ND	ND	0.1
	Sep-97	BLQ	BLQ	ND	BLQ	BLQ	ND	ND	ND	BLQ

**TABLE 3 (Continued)**  
**FORMER CAR CARE CENTER SITE**  
**INTRINSIC REMEDIATION ADDENDUM**  
**BOLLING AFB, DC**

Sample Location <sup>a/</sup>	Date	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylene (µg/L)	Total BTEX <sup>b/</sup> (µg/L)	1,3,5-Trimethylbenzene <sup>b/</sup> (µg/L)	1,2,4-Trimethylbenzene <sup>b/</sup> (µg/L)	1,2,3-Trimethylbenzene <sup>b/</sup> (µg/L)	Total Volatile Hydrocarbons <sup>c/</sup> (mg/L)
Monitoring Points (Continued)										
CPT-21D (Duplicate)	Aug-94	BLQ	ND	1.0	3.9	4.9	BLQ	BLQ	1.3	0.1
	Aug-94	BLQ	ND	1.0	4	5.0	BLQ	0.5	1.4	1.5
	Jun-96	430	7.6	4.9	0.9	443	ND	0.5	2.2	1.5
CPT-21S	Sep-97	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Jun-96	1.3	0.6	ND	0.5	2.4	ND	ND	ND	ND
	Sep-97	BLQ	BLQ	ND	BLQ	BLQ	ND	ND	ND	BLQ
CPT-22D (Duplicate)	Aug-94	0.6	72	15	92	179.6	7.5	35	7.6	0.5
	Jun-96	470	1.1	7	5.8	484	1	ND	2.3	2.3
	Sep-97	95.2	51.2	52.5	222.6	421.5	14	59.9	15.9	1.0
MW-1	Sep-97	94.9	55.3	58	246.4	455	15.5	66.9	17.8	1.1
	Monitoring Wells									
MW-2	Aug-94	3.5	J	BLQ	8	11.5	BLQ	BLQ	BLQ	1
	Jun-96	6.5	ND	0.8	0.5	7.8	ND	ND	0.6	0.2
	Sep-97	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-3	Aug-94	2900	31000	2600	68000	104500	670	2500	430	750
	Aug-94	14000	33000	3000	17800	67800	800	2700	630	56
	Sep-97	7690	12000	1600	10430	31720	682	2950	860	38.6
MW-4 (Duplicate)	Aug-94	21000	26000	2100	11300	60400	470	2000	360	130
	Aug-94	19000	23000	1800	10000	53800	400	1700	300	130
	Sep-97	23100	24300	2630	13000	63030	353	1530	527	65
MW-5	Aug-94	1500	3100	410	3800	8810	260	870	180	28
	Sep-97	5440	20300	2600	13630	41990	464	1960	569	49

**TABLE 3 (Continued)**  
**FUEL HYDROCARBON COMPOUNDS DETECTED IN GROUNDWATER**  
**FORMER CAR CARE CENTER SITE**  
**INTRINSIC REMEDIATION ADDENDUM**  
**BOLLING AFB, DC**

Sample Location <sup>a/</sup>	Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylene (µg/L)	Total BTEX <sup>b/</sup> (µg/L)	1,3,5-Trimethylbenzene <sup>b/</sup> (µg/L)	1,2,4-Trimethylbenzene <sup>b/</sup> (µg/L)	1,2,3-Trimethylbenzene <sup>b/</sup> (µg/L)	Total Volatile Hydrocarbons <sup>c/</sup> (mg/L)
Monitoring Wells (Continued)										
MW-6	Aug-94	2700	8000	460	2290	13450	60 J	230 J	50 J	53
(Duplicate)	Aug-94	2400	7200	450	2180	12230	49	250 J	30	39
MW-6R	Sep-97	949	3290	1890	7620	13749	334	1510	466	23.4
MW-7	Aug-94	0.8 J	ND	0.6 J	5.3	6.7	0.4 J	1.1 J	BLQ	BLQ
	Jun-96	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Sep-97	ND	BLQ	ND	4.8	4.8	ND	2.3	ND	0.02
MW-8	Aug-94	1.1 J	ND	0.8 J	8.2	10.1	0.5 J	1.4 J	0.4 J	BLQ
	Jun-96	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Sep-97	3.9	50.8	54.2	242.4	351	16.2	70.3	20.5	0.75
(Duplicate)	Sep-97	2.6	46.9	54.6	244.8	349	16.2	70.1	18.4	0.62
MW-9	Aug-94	BLQ	ND	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	0.2
	Jun-96	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Sep-97	ND	BLQ	ND	BLQ	BLQ	ND	1.8	ND	0.11
MW-10	Aug-94	BLQ	ND	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Jun-96	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Jun-96	9000	25000	2300	13000	49300	480	1600	530	110
	Sep-97	4300	22800	2660	15810	45570	402	1678	508	52

<sup>a/</sup> See Figure 1 for sample locations.

<sup>b/</sup> BTEX = benzene, toluene, ethylbenzene, and xylenes; quantified by EPA Method 602.

<sup>c/</sup> Quantified by EPA Method SW8015 modified.

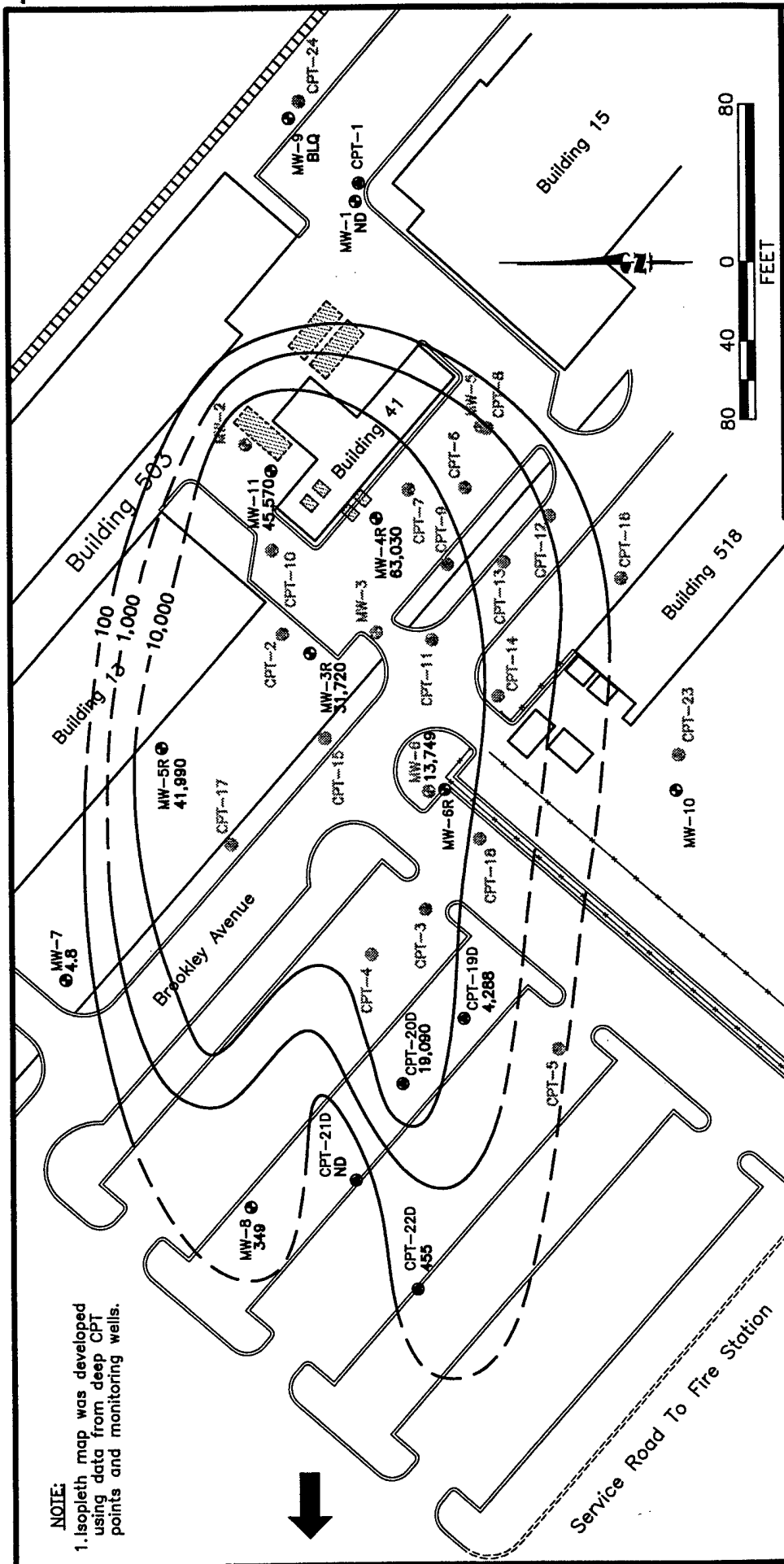
Qualifiers:

BLQ Compound concentration less than limit of quantitation.

J Indicates an estimated value when the compound is detected, but is below the Practical Quantitation Limit.

B Compound found in blank and sample.

ND Compound not detected.



**NOTE:**  
 1. Isopleth map was developed using data from deep CPT points and monitoring wells.

**LEGEND**

- Former underground storage tanks (USTs).
- MW-1 Monitoring well.
- CPT-20 Piezometer and CPT test location installed by CPT rig.
- MW-1 Abandoned/Destroyed Monitoring Well
- CPT-20 Abandoned CPT Test Location
- 100- Total BTEX Concentration (µg/L) Contour. Dashed Where Inferred
- 8,600 Total, Benzene, Toluene, Ethylbenzene and Xylene (BTEX) Concentration (µg/L)
- ND Not Detected
- BLQ Below Limit of Quantitation
- Approximate Groundwater Flow Direction

**FIGURE 3**

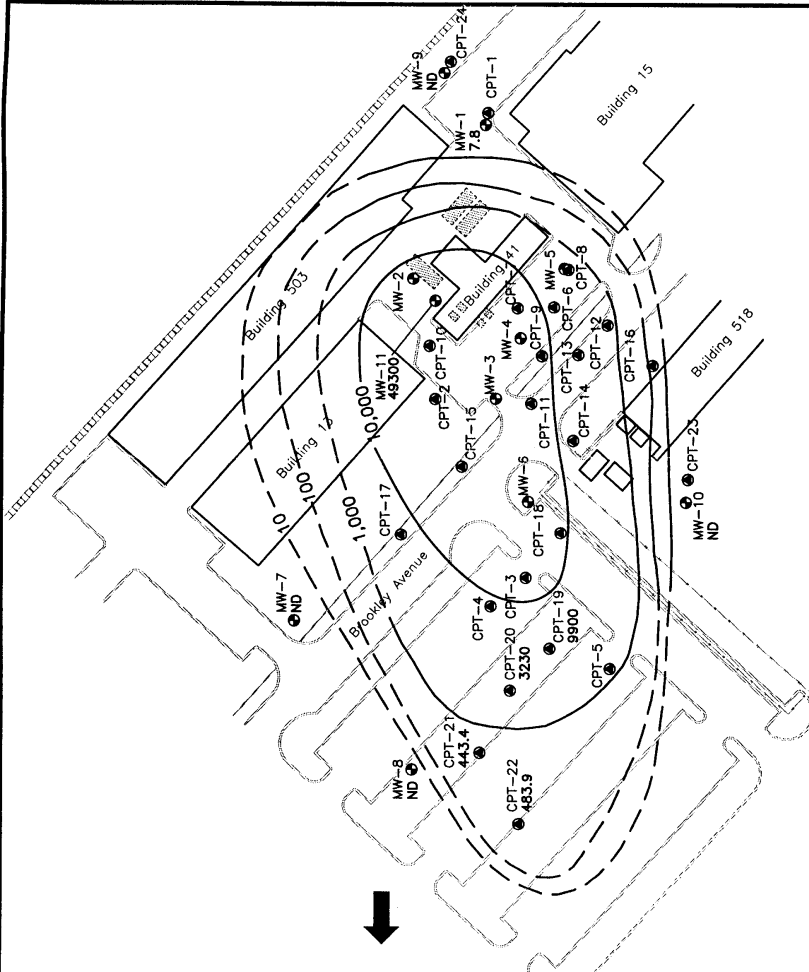
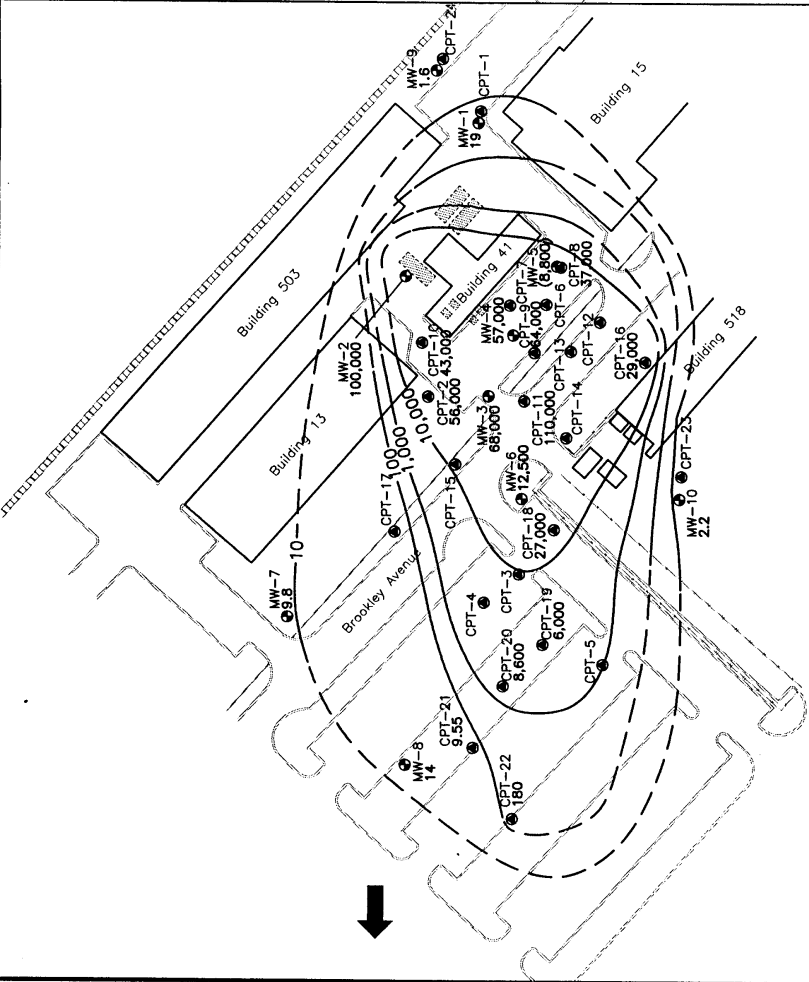
**TOTAL DISSOLVED BTEX ISOPLETH MAP SEPTEMBER 1997**

Former Car Center Site  
 Intrinsic Remediation Addendum  
 Bolling AFB, Washington DC






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




**AUGUST 1994**

**JUNE 1996**



**LEGEND**

-  Former underground storage tanks
-  MW-1
-  MW-20
-  CPT-20
- 8,600 Total benzene, toluene, ethylbenzene and xylene (BTEX) concentration (ug/L) by SW8020
- (8,800) Data not utilized to construct contours
- 100 Total BTEX concentration (ug/L) contour, dashed where inferred
-  Approximate groundwater flow direction

-  Former underground storage tanks
-  MW-1
-  MW-2
-  CPT-2
- 57,000 Total benzene, toluene, ethylbenzene and xylene (BTEX) concentration (ug/L) by SW8020
- (12,500) Data not utilized to construct contours
- 100 Total BTEX concentration (ug/L) contour, dashed where inferred
-  Approximate groundwater flow direction

**NOTE:**

1. Isopleth maps were developed using data from deep CPT points and monitoring wells.

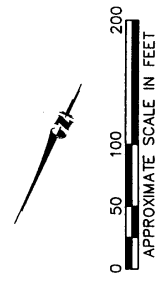
**FIGURE 4**

**TOTAL DISSOLVED BTEX ISOPLETH MAPS  
AUGUST 1994 AND JUNE 1996**

Former Car Care Center Site  
Intrinsic Remediation Addendum  
Bolling AFB, Washington DC

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Denver, Colorado



expansion predicted by the contaminant fate and transport model (Parsons ES, 1997a) may be occurring. Of the remaining downgradient and crossgradient sampling locations, however, only the concentration trend observed at MW-8 supports plume expansion. In September 1997, the total dissolved BTEX concentration at this well was 351 µg/L; in August 1994, June 1996, and December 1996 the total dissolved BTEX concentrations did not exceed 14 µg/L. September 1997 concentrations at the other four downgradient and crossgradient sampling locations do not clearly support plume expansion, and suggest a plume at or approaching equilibrium.

The numerical model developed for the Former Car Care Center as part of the 1994 intrinsic remediation demonstration predicted that the plume would expand approximately 30 feet downgradient between June 1996 and September 1997, and approximately 80 feet downgradient between August 1994 and September 1997. This rate of plume growth cannot be conclusively demonstrated over a span of 3 years given the sampling point spacing at the site and the lack of a contaminant-free downgradient monitoring location. Nevertheless, at the furthest downgradient monitoring points along the contaminant migration flowpath, CPT-20D and CPT-22D, dissolved BTEX concentrations have more than doubled since August 1994, suggesting expansion of the dissolved BTEX plume. Furthermore, as discussed in the previous paragraph, comparison of June 1996 with September 1997 results for CPT-20D and MW-8 also may indicate plume expansion.

#### **2.4 Inorganic Chemistry and Geochemical Indicators of Biodegradation**

As discussed in the EE/CA, microorganisms obtain energy for cell production and maintenance by facilitating thermodynamically advantageous oxidation/reduction reactions involving the transfer of electrons from electron donors to available electron acceptors. This results in the oxidation of the electron donor and the reduction of the electron acceptor. Electron donors at the Former Car Care Center Site are natural organic carbon and fuel hydrocarbon compounds. Fuel hydrocarbons are completely degraded or detoxified if they are used as the primary electron donor for microbial metabolism (Bouwer, 1992). Electron acceptors are elements or compounds that occur in relatively oxidized states and include oxygen, nitrate, ferrous iron, sulfate, and carbon dioxide. Microorganisms preferentially use electron acceptors while metabolizing fuel hydrocarbons (Bouwer, 1992). Dissolved oxygen is used first as the prime electron acceptor. After the DO is consumed, anaerobic microorganisms use electron acceptors in the following order of preference: nitrate, ferric iron, sulfate, and finally carbon dioxide. Anaerobic destruction of the BTEX compounds is associated with the accumulation of fatty acids, production of methane, solubilization of iron, and reduction of nitrate and sulfate (Cozzarelli *et al.*, 1990; Wilson *et al.*, 1990).

DO concentrations were measured at 12 of the 16 groundwater sampling locations monitored in September 1997. DO concentrations could not be obtained at 4 of the monitoring points (CPT-19S, CPT-19D, CPT-20S, and CPT-21S) because of insufficient groundwater yield, most likely due to the presence of low-permeability sediments in the screened intervals. Table 4 summarizes DO concentrations measured at the Former Car Care Center Site from 1994 to 1997. The September 1997 DO results presented on Figure 5 illustrate that DO is depleted throughout the site,

**TABLE 4  
GROUNDWATER GEOCHEMICAL DATA  
FORMER CAR CARE CENTER SITE  
INTRINSIC REMEDIATION ADDENDUM  
BOLLING AFB, DC**

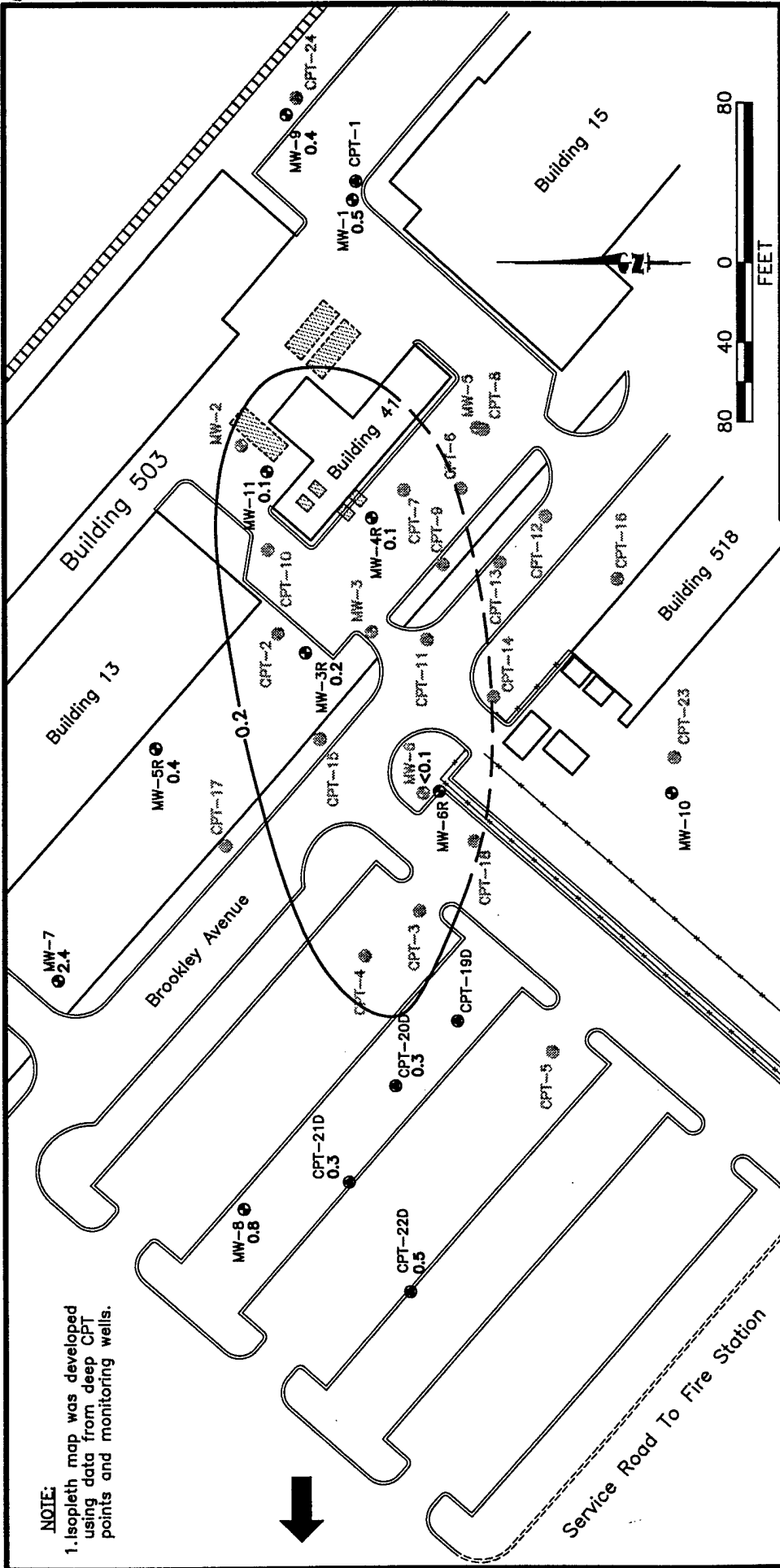
Sample Location <sup>u</sup>	Water			Dissolved		Redox		Total		Hydrogen				Ferroous		Methane (mg/L)	Mn <sup>2+</sup> <sup>v</sup> (mg/L)	CO <sub>2</sub> <sup>v</sup> (mg/L)	Chloride (mg/L)	TOC <sup>v</sup> (mg/L)
	Date	Temp. (C) <sup>v</sup>	pH	Conductivity (µmhos/cm) <sup>v</sup>	Oxygen (mg/L) <sup>d</sup>	Potential (mV) <sup>d</sup>	Alkalinity (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	Iron (mg/L)	Sulfate (mg/L)	Iron (mg/L)	Iron (mg/L)					
CPT-02S	Aug-94	21.5	6.03	58	0.9	-112	28	ND <sup>v</sup>	0.008	41	ND	7.2	NA <sup>v</sup>	NA	NA	NA	NA	NA	NA	
CPT-02D	Aug-94	21.2	6.60	24	0.7	-92	NS <sup>u</sup>	0.35	0.025	46	ND	2.9	NA	NA	NA	NA	NA	NA	NA	
CPT-08S	Aug-94	22.6	6.32	9	0.6	-413	132	ND	ND	28	ND	6.4	NA	NA	NA	NA	NA	NA	NA	
CPT-08D	Aug-94	22.2	4.88	89	2.2	-215	266	2.4	0.006	65	ND	0.025	NA	NA	NA	NA	NA	NA	NA	
CPT-09S	Aug-94	22.6	4.48	109	0.3	-414	69	ND	0.002	55	ND	0.61	NA	NA	NA	NA	NA	NA	NA	
CPT-09D	Aug-94	22.4	6.05	25	0.3	-296	9.0	2.6	0.016	41	ND	5.4	NA	NA	NA	NA	NA	NA	NA	
CPT-10S	Aug-94	23.0	6.11	22	0.4	-477	124	ND	ND	0.90	ND	0.6	NA	NA	NA	NA	NA	NA	NA	
CPT-10D	Aug-94	22.3	5.26	70	2.1	-60	7.0	4.7	0.025	56	ND	3.4	NA	NA	NA	NA	NA	NA	NA	
CPT-11S	Aug-94	21.6	4.75	95	0.3	-328	108	ND	ND	72	ND	2.8	NA	NA	NA	NA	NA	NA	NA	
CPT-11D	Aug-94	21.9	6.29	11	0.2	-189	< 5.00	1.1	0.002	31	ND	8.1	NA	NA	NA	NA	NA	NA	NA	
CPT-16S	Aug-94	24.0	5.04	106	0.8	-243	18	ND	0.092	44	ND	0.04	NA	NA	NA	NA	NA	NA	NA	
CPT-16D	Aug-94	24.6	6.59	24	0.4	-177	122	0.70	ND	25	ND	8.4	NA	NA	NA	NA	NA	NA	NA	
CPT-18S	Aug-94	24.0	4.46	140	0.3	-258	23	1.2	0.016	16	ND	0.44	NA	NA	NA	NA	NA	NA	NA	
CPT-18D	Aug-94	23.1	6.62	18	0.3	-58	18	ND	0.003	30	ND	NA	NA	NA	NA	NA	NA	NA	NA	
CPT-19S	Jun-96	19.9	5.00	NA	5.5	120	50	8.6	ND	44	NA	ND	ND	ND	20	NA	NA	NA	NA	
	Sep-97	NA	6.33	1570	NA	121	71	NA	NA	NA	ND	ND	ND/ND	NA	114	NA	NA	NA	1.3	
CPT-19D	Aug-94	23.6	6.12	31	0.9	-108	106	ND	ND	14	ND	12	0.31 <sup>v</sup>	NA	NA	NA	NA	NA	NA	
	Jun-96	19.6	6.00	NA	2.8	-110	140	0.11	ND	0.88	NA	16	0.7	4.2	170	NA	NA	NA	NA	
	Sep-97	NA	6.38	679	NA	-99	178	ND	ND	ND	ND	66	2.91	NA	NA	NA	NA	115	7.9/7.7	
CPT-20S	Jun-96	18.8	5.00	NA	7.1	138	25	5.5	ND	35	NA	0.08	0.003	ND	NA	NA	NA	NA	NA	
	Sep-97	NA	6.33	878	NA	126	31	7.1 <sup>v</sup>	NA	50	ND	0.30	<0.001	NA	60	193	0.60	NA	0.60	
CPT-20D	Aug-94	22.7	6.44	13	0.4	-266	94	ND	ND	36	ND	5.8	NA	NA	NA	NA	NA	NA	NA	
	Jun-96	18.9	6.00	NA	2.8	-154	150	0.07	ND	0.95	NA	20	9.1	5.8	170	NA	NA	NA	NA	
	Sep-97	20.0	6.63	866	0.3	-116	208	ND	ND	ND	ND	58	11	NA	NA	NA	153	8.5	8.5	
CPT-21S	Jun-96	20.4	5.00	NA	1.5	88	60	0.08	ND	9.6	NA	10	0.021	0.6	70	NA	NA	NA	NA	
	Sep-97	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.046	NA	NA	NA	NA	NA	0.44	
CPT-21D	Aug-94	21.6	5.33	7	0.4	-352	5.2/165	0.60	0.025	62	ND	0.09	NA	NA	NA	NA	NA	NA	NA	
	Jun-96	19.2	7.70	NA	0.1	165	100	ND	ND	36	NA	0.2	2.1	14	70	NA	NA	NA	NA	
	Sep-97	20.4	6.55	612	0.3	48	128	ND/ND	ND	29/29	NA	0.7	1.6/1.53	NA	116	91/90	2.9	NA	2.9	
CPT-22S	Jun-96	18.3	NA	NA	6.24	116	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Aug-94	21.0	6.21	25	0.8	-189	109	2.9	0.12	48	ND	0.055	<0.001 <sup>v</sup>	NA	NA	NA	NA	NA	NA	
	Jun-96	19.6	NA	NA	0.1	191	60	0.33	0.21	36	NA	0.3	4	8.8	100	NA	NA	NA	NA	
	Sep-97	20.5	6.07	402	0.5	105	48	ND	ND	38	ND	0.51	2.1/2.0	NA	144	71	0.97	NA	0.97	

**TABLE 4 (Continued)**  
**GROUNDWATER GEOCHEMICAL DATA**  
**FORMER CAR CARE CENTER SITE**  
**INTRINSIC REMEDIATION ADDENDUM**  
**BOLLING AFB, DC**

Sample Location <sup>v</sup>	Water				Dissolved				Redox		Total				Hydrogen				Ferrous		Chloride (mg/L)	TOC <sup>w</sup> (mg/L)	
	Date	Temp. (°C) <sup>v</sup>	pH	Conductivity (µmhos/cm) <sup>d</sup>	Oxygen (mg/L) <sup>d</sup>	Potential (mV) <sup>d</sup>	Alkalinity (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	Iron (mg/L)	Methane (mg/L)	Mn <sup>2+</sup> <sup>v</sup> (mg/L)	CO <sub>2</sub> <sup>v</sup> (mg/L)	Iron (mg/L)	Methane (mg/L)	Mn <sup>2+</sup> <sup>v</sup> (mg/L)	CO <sub>2</sub> <sup>v</sup> (mg/L)	Iron (mg/L)			Methane (mg/L)
MW-1	Aug-94	25.6	6.46	33	1.2	57	18	ND	ND	11	ND	3.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jun-96	21.9	5.50	NA	2.0	-81	1100	0.06	ND	2.1	NA	16	0.171	2.5	250	NA	NA	NA	NA	NA	NA	NA	NA
	Sep-97	23.1	6.27	527	0.5	202	64	1.3 <sup>v</sup>	NA	68	NA	ND	<0.001	NA	90	NA	NA	NA	NA	NA	NA	60	ND
MW-2	Aug-94	NA	NA	NA	NA	NA	< 5.00	0.50	NA	12	ND	8.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-3	Aug-94	20.0	5.33	90	0.9	32	165	0.50	ND	38	NS	6.6	1.37 <sup>v</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-3R	Sep-97	19.9	5.92	525	0.2	-36	53	ND	21	21	ND	21.3	18.7	NA	NA	NA	NA	NA	NA	NA	111	36	NA
MW-4	Aug-94	23.4	6.12	49	1.4	-110	68	1.4	0.027	0.40	ND	6.1	0.005 <sup>v</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-4R	Sep-97	21.0	6.72	729	0.1	-123	236	ND	ND	ND	ND	30.3	6.64	NA	NA	NA	NA	NA	NA	NA	84	24	NA
MW-5	Aug-94	NA	NA	NA	NA	NA	167	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-5R	Sep-97	20.5	6.06	185	0.4	-102	78	ND	14	14	1.0	13.8	1.61	NA	NA	NA	NA	NA	NA	NA	4.6	20	NA
MW-6	Aug-94	25.0	6.14	50	0.3	112	215/47	2.0	0.55	44	ND	0.48	<0.001 <sup>v</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-6R	Sep-97	20.3	6.09	1890	<0.1	-128	121	ND/ND	ND	381/379	2.0	14.5	0.67/0.62	NA	NA	NA	NA	NA	NA	NA	347/338	10	NA
MW-7	Aug-94	21.9	4.63	115	1.0	234	49	18	0.026	91	NS	0.10	<0.001 <sup>v</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jun-96	18.6	4.50	NA	4.4	167	10	12	ND	83	NA	ND	ND	4.3	70	NA	NA	NA	NA	NA	NA	NA	NA
	Sep-97	19.0	5.20	725	2.4	219	7	12 <sup>v</sup>	NA	67	ND	ND	ND	NA	120	NA	NA	NA	NA	NA	140	ND	NA
MW-8	Aug-94	20.9	5.43	90	0.9	175	< 5.00	0.60	0.010	25	ND	4.7	0.003 <sup>v</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jun-96	18.9	4.50	NA	3.4	165	NA	0.76	ND	38	NA	4.2	0.003	1.6	80	NA	NA	NA	NA	NA	NA	NA	NA
	Sep-97	19.1	5.27	242	0.8	194	5	1.6 <sup>v</sup>	NA	38	ND	3.3	0.009	NA	160	NA	NA	NA	NA	NA	35	ND	NA
MW-9	Aug-94	25.4	6.33	39	5.2	270	< 5.00	2.0	0.021	54	ND	0.05	<0.001 <sup>v</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jun-96	18.4	5.50	NA	7.5	176	70	5.2	ND	73	NA	ND	ND	0.1	100	NA	NA	NA	NA	NA	NA	NA	NA
	Sep-97	21.9	6.38	683	0.4	-44	157	ND	ND	ND	ND	18	0.205	NA	NA	NA	NA	NA	NA	NA	108	1.2	NA
MW-10	Aug-94	24.1	4.64	114	4.8	285	142	13	0.004	53	ND	0.10	<0.001 <sup>v</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jun-96	20.9	4.50	NA	4.0	137	20	17 <sup>v</sup>	ND	54	NA	0.01	ND	1.1	100	NA	NA	NA	NA	NA	NA	NA	NA
MW-11	Jun-96	19.0	6.00	NA	1.3	-94	700	0.14	ND	0.97	NA	11	2.5	7.9	120	NA	NA	NA	NA	NA	NA	NA	NA
	Sep-97	22.2	6.55	728	0.1	-115	237	ND	ND	ND	0.1	54	11.6	NA	NA	NA	NA	NA	NA	NA	85	33	NA

Monitoring Wells

<sup>d</sup> mV = millivolts.  
<sup>e</sup> °C = degree Centigrade.  
<sup>f</sup> µmhos/cm = micromhos per centimeter.  
<sup>g</sup> mg/L = milligrams per liter.  
<sup>v</sup> See Figure 1 for sample locations.  
<sup>w</sup> ND = Not Detected.  
<sup>x</sup> Mn<sup>2+</sup> = manganese.  
<sup>y</sup> CO<sub>2</sub> = carbon dioxide.  
<sup>z</sup> TOC = total organic carbon  
<sup>aa</sup> Data collected on January 26, 1995. Quantified by Kerr Research Laboratories Method RSKSOP-175.  
<sup>ab</sup> Nitrate + Nitrite (as nitrogen).



**NOTE:**

1. Isopleth map was developed using data from deep CPT points and monitoring wells.

**LEGEND**

- Former underground storage tanks (USTs).
- MW-1 Monitoring well.
- CPT-20 Piezometer and CPT test location installed by CPT rig.
- MW-1 Abandoned/Destroyed Monitoring Well
- CPT-20 Abandoned CPT Test Location
- 0.2- Total Dissolved Oxygen Concentration (mg/L) Contour.
- Dashed Where Inferred
- 0.5 Dissolved Oxygen Concentration (mg/L)
- Approximate Groundwater Flow Direction

**FIGURE 5**

**DISSOLVED OXYGEN ISOPLETH MAP  
SEPTEMBER 1997**

Former Car Care Center Site  
Intrinsic Remediation Addendum  
Boiling AFB, Washington DC

**PARSONS ENGINEERING SCIENCE, INC.**

Denver, Colorado

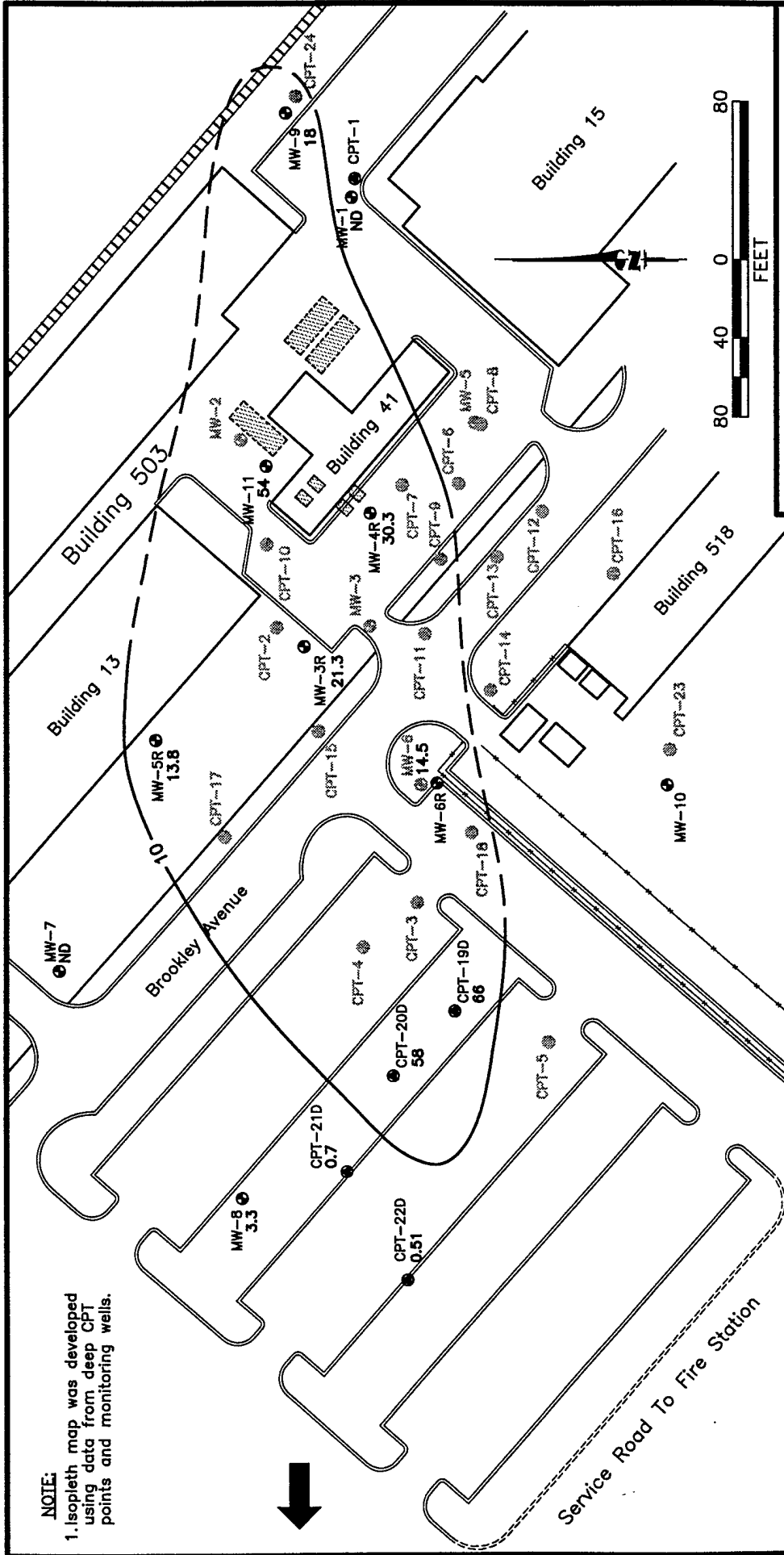
including background locations. Only MW-7, with a DO concentration of 2.4 milligrams per liter (mg/L), exceeded the anaerobic threshold of 1 mg/L. It is possible that the groundwater at the background locations has been impacted by activities associated with an adjacent railroad line; therefore, data from crossgradient well MW-7 may be more representative of regional DO concentrations. Despite low DO concentrations throughout the plume, the lowest concentrations are present within and immediately downgradient from the source area. Monitoring wells MW-3R, MW-4R, MW-6R, and MW-11 all had DO concentrations of 0.2 mg/L or less. Of the wells where mobile LNAPL has been identified historically, only well MW-5R had a DO concentration in excess of 0.2 mg/L. This well is outside the core source area. During ICE operation in May and June 1997, a vent/sparge tube was installed in well MW-5R to enhance volatilization of VOCs from mobile LNAPL present in the well. The area of low DO has remained relatively stable throughout all three intrinsic remediation sampling events. The primary difference between the current sampling event and the two previous sampling events is that background DO concentrations were much higher historically. The correlation between depleted DO and elevated BTEX concentrations is a strong indication that aerobic biodegradation of the BTEX compounds is occurring at the site. The most significant aerobic activity is expected to occur along the margins of the dissolved BTEX plume, because this is the area where BTEX-contaminated groundwater interacts with groundwater containing the highest concentrations of DO.

Concentrations of nitrate + nitrite (as nitrogen) were measured at 14 of the 16 locations sampled in September 1997. Nitrate + nitrite concentrations could not be obtained at 2 of the monitoring points because of insufficient groundwater yield. Nitrate + nitrite results measured at the Former Car Care Center Site between 1994 and 1997 are presented on Table 4. Nitrate concentrations were below detection limits at all but three locations on the periphery of the dissolved BTEX plume. Monitoring well MW-7, which had the highest DO concentration, also had the highest concentration of nitrate + nitrite at 12 mg/L. In addition, the second highest nitrate + nitrite concentration (1.6 mg/L) was detected at monitoring well MW-8 where the second highest DO concentration (0.8 mg/L) was detected. Although the nitrate + nitrite concentrations were on average lower during the September 1997 sampling event than during the two previous events, the relationship of depleted nitrate concentrations to depleted DO and elevated dissolved BTEX remained consistent. An expanding zone of depleted nitrate + nitrite concentrations that coincides with the dissolved BTEX plume provides strong evidence that anaerobic biodegradation of the BTEX compounds continues to occur at the site through the microbially mediated process of denitrification.

Ferrous iron concentrations were measured at all but 1 of the 16 locations sampled in September 1997. The unsampled monitoring point produced an insufficient quantity of water to analyze for all parameters. Table 4 lists ferrous iron concentrations measured at all sampled Former Car Care Center Site locations from 1994 to 1997. Figure 6 is an isopleth map showing the distribution of ferrous iron in groundwater in September 1997. Throughout the majority of the dissolved BTEX plume, ferrous iron concentrations exceed 10 mg/L. Although concentrations throughout this area are as high as 66 mg/L, a consistent relationship between the magnitudes of the dissolved BTEX and ferrous iron concentrations is not evident.

**NOTE:**

1. Isopleth map was developed using data from deep CPT points and monitoring wells.



**LEGEND**

- Former underground storage tanks (USTs).
- Monitoring well.
- Piezometer and CPT test location installed by CPT rig.
- Abandoned/Destroyed Monitoring Well
- Abandoned CPT Test Location
- Total Ferrous Iron Concentration (mg/L) Contour.
- Dashed Where Inferred
- Ferrous Iron Concentration (mg/L)
- ND Not Detected
- Approximate Groundwater Flow Direction

**FIGURE 6**

**DISSOLVED FERROUS IRON ISOPLETH MAP  
SEPTEMBER 1997**

Former Car Care Center Site  
Intrinsic Remediation Addendum  
Boiling AFB, Washington DC

**PARSONS  
ENGINEERING SCIENCE, INC.**

Denver, Colorado

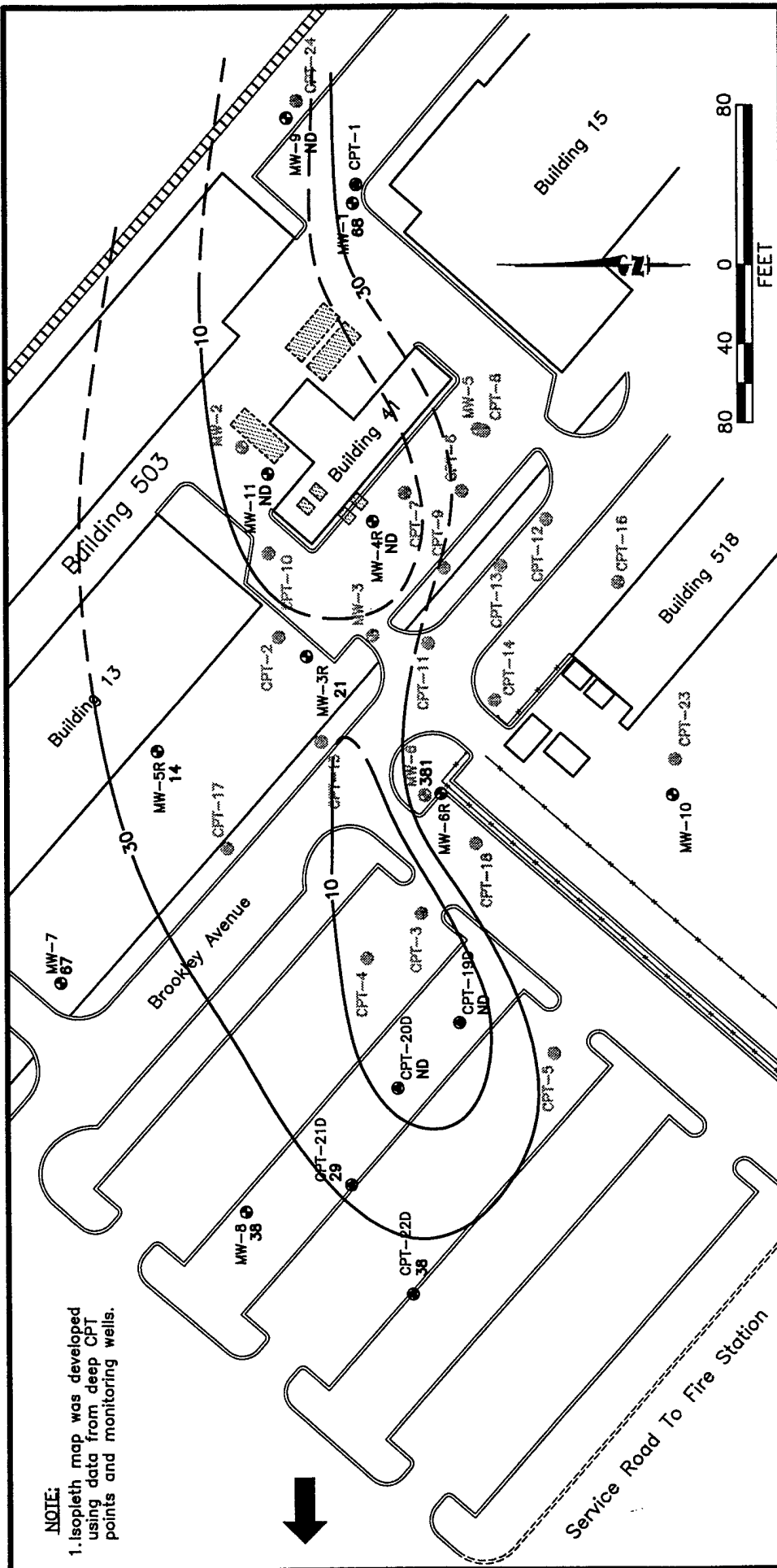
Along the plume's leading edge (MW-8, CPT-21D, and CPT-22D) ferrous iron concentrations are less than 5 mg/L. Ferrous iron was not detected at MW-7, which also had the highest DO and nitrate + nitrite concentrations. In September 1997, the areal extent of elevated ferrous iron concentrations is comparable to the August 1994 and June 1996 sampling events; however, on average ferrous iron concentrations have been increasing since the first intrinsic remediation sampling event in August 1994. Recent evidence suggests that the reduction of ferric iron to ferrous iron cannot proceed without microbial mediation (Lovley and Phillips, 1988; Lovley *et al.*, 1991; Chapelle, 1993); therefore, the presence of ferrous iron strongly suggests that ferric iron is being used as an electron acceptor at the site. Furthermore, the coincident ferrous iron and BTEX plumes and increasing ferrous iron concentrations suggests that the reduction of ferric iron to ferrous iron continues to occur at the site during biodegradation of BTEX compounds.

Sulfate concentrations were measured at 14 of the 16 locations sampled in September 1997. Sulfate concentrations could not be obtained at 2 of the monitoring points because of insufficient groundwater yield. Results for sulfate analyses performed at all sampled Former Car Care Center Site locations between 1994 and 1997 are summarized on Table 4, and Figure 7 is an isopleth map showing the distribution of sulfate in groundwater in September 1997. Sulfate was not detected at 4 of the 7 sampling locations where the total dissolved BTEX concentration exceeded 1,000 µg/L. Conversely, six of the seven monitoring wells/points along the plume periphery or upgradient had sulfate concentrations of 29 mg/L to 68 mg/L. Generally, the distribution of sulfate concentrations measured in September 1997 is similar to that measured during the June 1996 sampling event. For both of these sampling events, the area of depleted sulfate is somewhat larger and the sulfate concentrations are generally lower than measured during the August 1994 sampling event. The general correlation of depleted sulfate concentrations with the highest BTEX concentrations provides strong evidence that anaerobic biodegradation of the BTEX compounds is occurring at the site through the microbially mediated process of sulfate reduction. Since 1994, the areal extent of depleted sulfate concentrations has increased at a faster rate than the extent of the dissolved BTEX plume. This may indicate an increasing importance of sulfate reduction in plume degradation as the BTEX plume matures and uses available electron acceptors with higher oxidizing potentials.

Methane concentrations measured in September 1997 are presented on Figure 8. Methane concentrations measured at the Former Car Care Center between 1994 and 1997 are presented in Table 4. All sampling locations with total dissolved BTEX concentrations exceeding 10 µg/L also have detectable concentrations of methane. Half of the sampling locations with total dissolved BTEX concentrations below 10 µg/L did not have methane concentrations detected above the 0.001 mg/L detection limit. The highest methane concentrations (>10 mg/L) extend from the former tank pit near monitoring well MW-11 to downgradient monitoring point CPT-20D. The presence of concomitant methane and BTEX plumes at the site is a strong indication that anaerobic biodegradation of the BTEX compounds is occurring at the site through the microbially mediated process of methanogenesis. As observed for depleted sulfate concentrations, the areal extent of elevated methane concentrations also has increased faster than the extent of the BTEX plume in recent years. This suggests that methanogenesis, like sulfate reduction, may have become a more important BTEX-degrading mechanism as the BTEX plume has matured between August 1994 and September 1997.

**NOTE:**

1. Isopleth map was developed using data from deep CPT points and monitoring wells.



**LEGEND**

- Former underground storage tanks (USTs).
- MW-1 Monitoring well.
- CPT-20 Piezometer and CPT test location installed by CPT rig.
- MW-1 Abandoned/Destroyed Monitoring Well
- CPT-20 Abandoned CPT Test Location
- Sulfate Concentration (mg/L) Contour. Dashed Where Inferred
- Sulfate Concentration (mg/L)
- ND Not Detected
- Approximate Groundwater Flow Direction

**FIGURE 7**

**SULFATE ISOPLETH  
MAP FOR GROUNDWATER  
SEPTEMBER 1997**

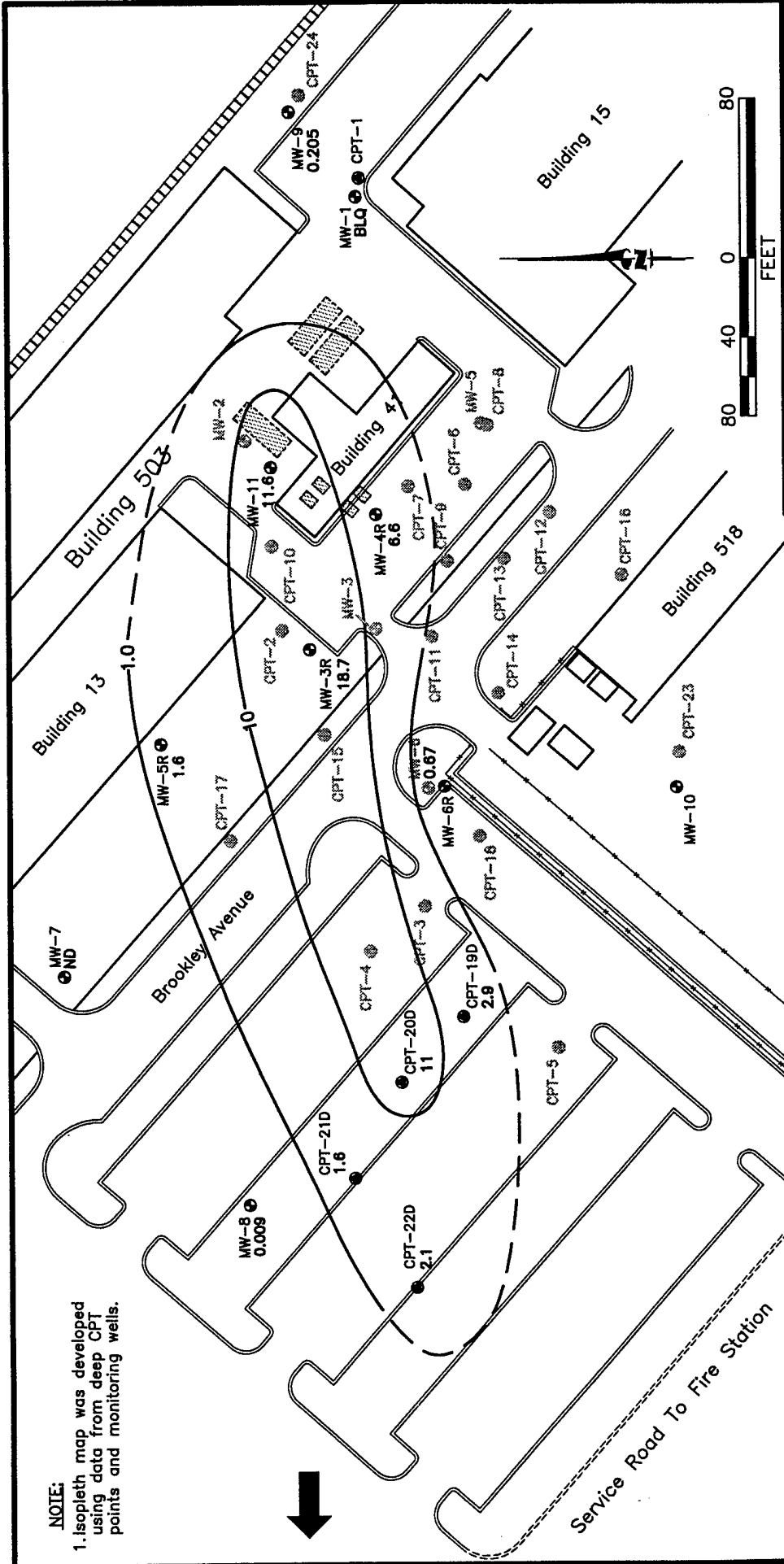
Former Car Care Center Site  
Intrinsic Remediation Addendum  
Bolling AFB, Washington DC

**PARSONS  
ENGINEERING SCIENCE, INC.**

Denver, Colorado

**NOTE:**

1. Isopleth map was developed using data from deep CPT points and monitoring wells.



**LEGEND**

- Former underground storage tanks (USTs).
- MW-1 Monitoring well.
- CPT-20 Piezometer and CPT test location installed by CPT rig.
- MW-1 Abandoned/Destroyed Monitoring Well
- CPT-20 Abandoned CPT Test Location
- 10 --- Methane Concentration (mg/L) Contour.  
Dashed Where Inferred
- 2.1 Methane Concentration (mg/L)  
Not Detected
- ND Not Detected
- BLQ Below Limit of Quatiation
- Approximate Groundwater Flow Direction

**FIGURE 8**

**DISSOLVED METHANE ISOPLETH MAP  
SEPTEMBER 1997**

Former Car Care Center Site  
Intrinsic Remediation Addendum  
Boiling AFB, Washington DC

**PARSONS ENGINEERING SCIENCE, INC.**  
Denver, Colorado

ORP, a measure of the relative tendency of a solution to accept or transfer electrons, was measured at all but one of the 16 locations sampled in September 1997. Site ORPs are summarized in Table 4 and presented on Figure 9. The September 1997 ORPs at the Former Car Care Center range from 219 millivolts (mV) to -128 mV. Areas with low ORPs coincide with areas characterized by high BTEX contamination; low DO, nitrate, and sulfate concentrations; and elevated ferrous iron and methane concentrations. This suggests that dissolved BTEX at the site may be subjected to a variety of biodegradation processes, including aerobic respiration, denitrification, iron reduction, sulfate reduction, and methanogenesis. The same relationships between ORP and electron acceptor/metabolic byproduct concentrations were noted in the August 1994 and June 1996 data presented in the EE/CA (Parsons ES, 1997a). However, many authors have noted that field ORP data alone cannot be used to reliably predict the electron acceptors that may be operating at a site, because the platinum electrode probes are not sensitive to some redox couples (e.g., sulfate/sulfide) (Stumm and Morgan, 1981; Godsey, 1994; Lovley *et al.*, 1994).

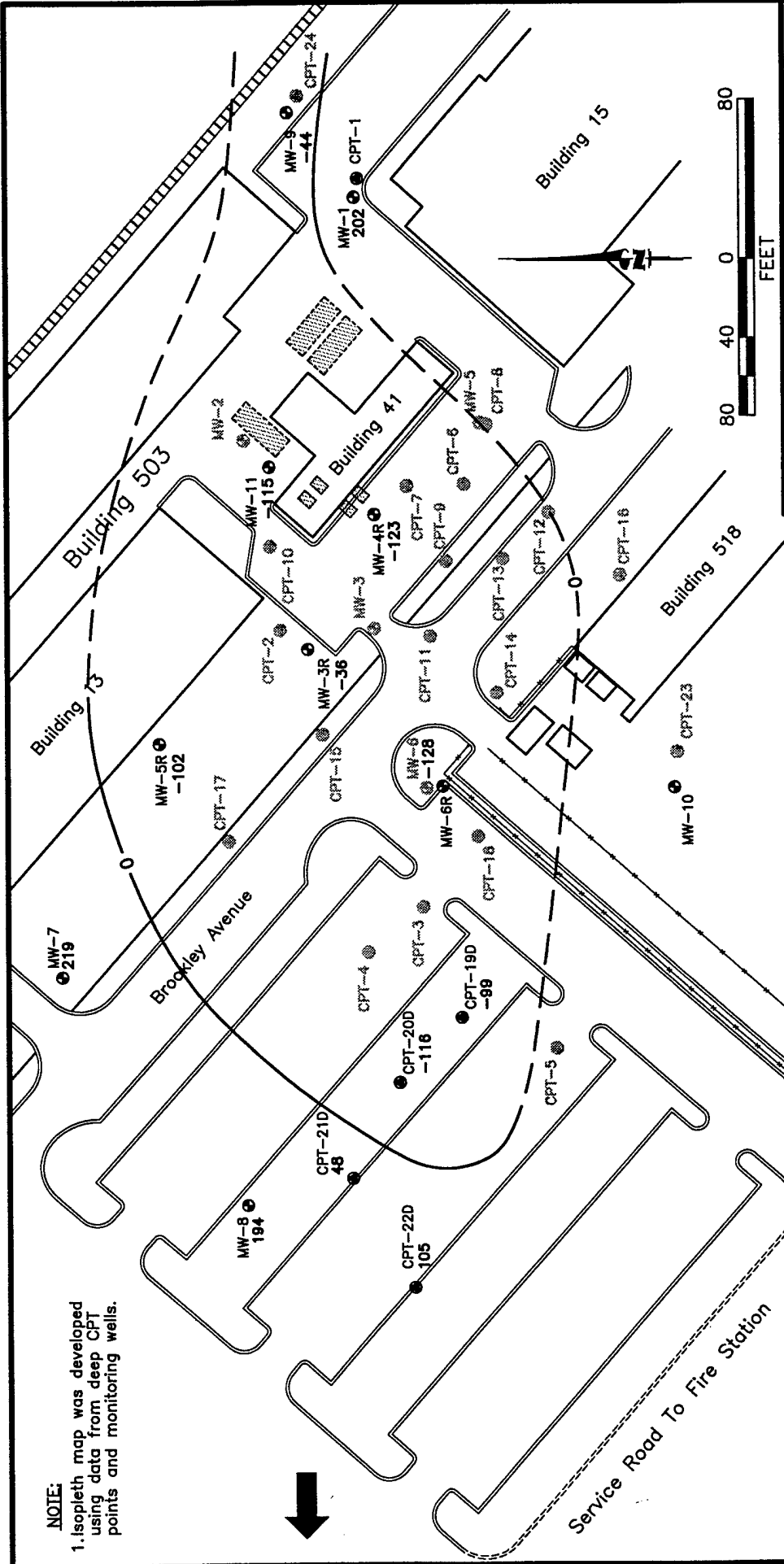
Alkalinity is a measure of the ability for groundwater to buffer changes in pH caused by the addition of biologically generated acids. An increase in alkalinity in an area with BTEX concentrations elevated over background conditions can often be observed in areas of active intrinsic bioremediation. Total groundwater alkalinity (as calcium carbonate) measured in September 1997 is presented on Figure 10 and in Table 4. Total alkalinity in excess of 100 milligrams calcium carbonate per liter (mg CaCO<sub>3</sub>/L) was observed throughout most of the dissolved BTEX plume, with the highest concentrations in excess of 200 mg/L. Along the fringes of the BTEX plume, groundwater alkalinity was as low as 5 mg/L. The range of total alkalinity detected in August 1994 (<5 to 266 mg/L) is similar to the September 1997 range of 5 to 237 mg/L. June 1996 alkalinity results also are comparable to the other two sampling rounds with the exception of two anomalously high alkalinities. It is unclear why alkalinity levels of 1,100 mg/L and 700 mg/L were measured at monitoring wells MW-1 and MW-11, respectively, in June 1996.

### 3.0 CONCLUSIONS

Results from the long-term groundwater monitoring conducted during September 1997 continue to support the occurrence of intrinsic bioremediation at the Former Car Care Center Site. Because source remediation is likely responsible for a possible decrease in dissolved contaminant concentrations observed in the source area, the primary line of evidence supporting the occurrence of biodegradation of dissolved BTEX compounds is the distribution of electron acceptors/metabolic byproducts that are involved in biologically mediated redox reactions. This is further supported by the observed increase in the zones of depleted electron acceptors and elevated degradation byproducts between August 1994 and September 1997. In addition, the rates of plume expansion for the elevated ferrous iron, depleted sulfate, and elevated methane concentrations appears to be higher than for the BTEX plume or other geochemical parameters. This could indicate that these three biodegradation processes (iron reduction, sulfate reduction, and methanogenesis) are becoming more advantageous as the BTEX plume matures and electron acceptors involved in more thermodynamically favorable redox reactions decrease in abundance within the site groundwater, making site redox conditions favor these processes.

**NOTE:**

1. Isoleth map was developed using data from deep CPT points and monitoring wells.



**LEGEND**

- ▨ Former underground storage tanks (USTs).
- MW-1 ● Monitoring well.
- CPT-20 ● Piezometer and CPT test location installed by CPT rig.
- MW-1 ● Abandoned/Destroyed Monitoring Well
- CPT-20 ● Abandoned CPT Test Location
- 0 — Redox Potential (mv) Contour.
- - - Dashed Where Inferred
- 102 Redox Potential (mv)
- ➔ Approximate Groundwater Flow Direction

**FIGURE 9**

**OXIDATION/REDUCTION POTENTIAL MAP**

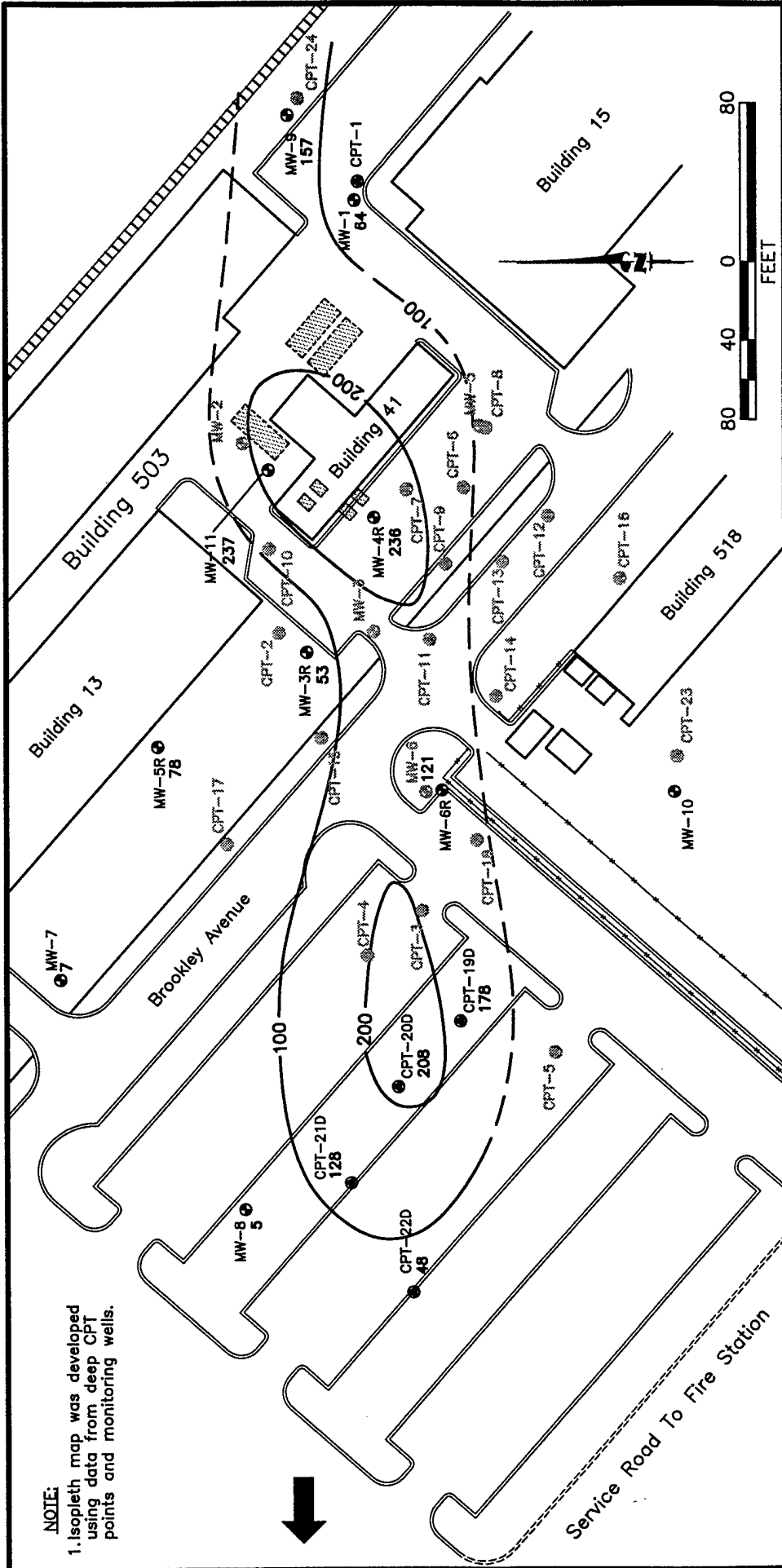
**SEPTEMBER 1997**

Former Car Care Center Site  
 Intrinsic Remediation Addendum  
 Bolling AFB, Washington DC

**PARSONS ENGINEERING SCIENCE, INC.**  
 Denver, Colorado

**NOTE:**

1. Isoleth map was developed using data from deep CPT points and monitoring wells.



**FIGURE 10**

**TOTAL ALKALINITY ISOPLETH MAP FOR GROUNDWATER SEPTEMBER 1997**

Former Car Care Center Site  
 Intrinsic Remediation Addendum  
 Bolling AFB, Washington DC

**PARSONS ENGINEERING SCIENCE, INC.**

Denver, Colorado

**LEGEND**

- Former underground storage tanks (USTs). —100— Total Alkalinity (mg CaCO<sub>3</sub>/L)  
 Dashed Where Inferred
- MW-1 Monitoring well. 78 Total Alkalinity (mg CaCO<sub>3</sub>/L)
- CPT-20 Piezometer and CPT test location installed by CPT rig. Approximate Groundwater Flow Direction
- MW-1 Abandoned/Destroyed Monitoring Well
- CPT-20 Abandoned CPT Test Location

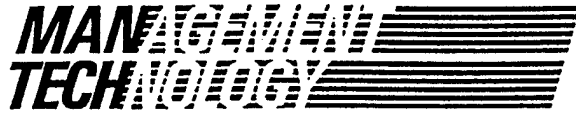
As predicted by the Bioplume II models included in the EE/CA and suggested by analytical results, the leading edge of the total dissolved BTEX plume may be continuing to migrate downgradient. However, given the slow rate of migration, the monitoring network spacing, and a monitoring span of only 3 years, an observed rate of migration could not be determined for comparison to the model-predicted rate of 80 feet in 3 years. Future LTM, including installation of additional LTM wells, will help to establish whether Bioplume II model predictions match observed plume fate and transport. The LTM program is described in Parsons ES (1997c), and will be implemented under Air Mobility Command (AMC) Contract No. F11623-94-D0024, Delivery Order RL49.

Because the furthest downgradient dissolved BTEX concentration (CPT-22D) has increased to 421 µg/L, consideration should be given to relocating the permanent LTM well proposed for installation adjacent to CPT-22D further downgradient (e.g., across the grassy median approximately 50 feet northwest of CPT-22D). In this way, the new LTM well would allow better definition of the location of the plume toe. The LTM well proposed for installation approximately 120 feet downgradient from CPT-22D (see Parsons ES, 1997c) also could be moved further downgradient a similar distance to ensure that this well would function as an interim sentry well.

#### 4.0 REFERENCES

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- Cozzarelli, I.M., Eganhouse, R.P., and Baedecker, M.J., 1990, Transformation of Monoaromatic Hydrocarbons to Organic Acids in Anoxic Ground Water Environment. *Environmental and Geological Water Science*, 16.
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- Parsons Engineering Science, Inc., 1997a, *Final Intrinsic Remediation Engineering Evaluation/Cost Analysis, Former Car Care Center*, Bolling Air Force Base, Washington DC. Prepared for Air Force Center for Environmental Excellence, Technology Transfer Division, Brooks AFB, Texas, US Air Force Contract F41624-92-D-8036, March.
- Parson Engineering Science, Inc., 1997b, *Draft Site-Specific Evaluation Report and Corrective Action Plan for Building 41, Former Car Care Center*, Bolling Air Force Base, Washington DC. Prepared for Air Force Center for Environmental Excellence, Technology Transfer Division, Brooks AFB, Texas, April.
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- Stumm, W. and Morgan, J.J., 1981, *Aquatic Chemistry*. John Wiley & Sons, New York.
- Wilson, B.H., Wilson, J.T., Kampbell, D.H., Bledsoe, B.E., and Armstrong, J.M., 1990, Biotransformation of Monoaromatic and Chlorinated Hydrocarbons at an Aviation Gasoline Spill Site. *Geomicrobiology Journal*, 8:225-240.



Ref: 97-TH25/vg

September 25, 1997

Dr. Don Kampbell  
National Risk Management Research Laboratory  
Subsurface Protection & Remediation Division  
U.S. Environmental Protection Agency  
P.O. Box 1198  
Ada, OK 74820

THRU: S.A. Vandegrift *SV*

Dear Don:

Attached are the results of 14 Bolling AFB samples submitted to MERSC as part of Service Request #SF-3-379. The samples were received September 12, 1997 and analyzed immediately. The methods used for analysis were EPA Method 353.1 for NO<sub>2</sub> and NO<sub>3</sub> and Waters capillary electrophoresis Method N-601 for Cl and SO<sub>4</sub>. Quality assurance measures performed on this set of samples included spikes, duplicates, known AQC samples and blanks.

If you have any questions concerning these results, please feel free to contact me.

Sincerely,

A handwritten signature in cursive script that reads "Tim Hensley".

Tim Hensley

xc: R.L. Cosby  
G.B. Smith  
J.L. Seeley *JL*

ManTech Environmental Research Services Corporation

---

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive  
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

<u>Sample</u>	<u>mg/L Cl<sup>-</sup></u>	<u>mg/L SO<sub>4</sub><sup>=</sup></u>	<u>mg/L NO<sub>2</sub> + NO<sub>3</sub>(N)</u>
MW-1	59.9	67.7	1.30
MW-3R	111	21.4	<.05
MW-4R	84.4	<.1	<.05
MW-5R	4.64	14.4	<.05
MW-6R	347	381	<.05
MW-6R Dup	338	379	<.05
MW-7	140	67.1	12.2
MW-8	35.2	38.0	1.55
MW-9	108	<.1	<.05
MW-11	84.5	<.1	<.05
CPT 19D	115	<.1	<.05
CPT 20S	193	49.7	7.08
CPT 20D	153	<.1	<.05
CPT 21D	90.6	29.2	<.05
CPT 21D Dup	90.0	29.2	<.05
CPT 22D	71.4	38.4	<.05
Blank	<.5	<.5	<.05
AQC	35.0	42.7	.62
AQC T.V.	34.8	44.0	.62
Spike Rec.	104%	106%	100%



Ref: 97-LH53

September 16, 1997

Dr. Don Campbell  
National Risk Management Research Laboratory  
Subsurface Protection and Remediation Division  
U.S. Environmental Protection Agency  
P.O. Box 1198  
Ada, OK 74820

THRU: S.A. Vandegrift *SV*

Dear Don:

As requested in Service Request #SF-3-279, gas analysis was performed for methane, ethylene, and ethane on samples from Bolling AFB, D.C. The samples were received on September 11, 1997. The analyses were performed on September 12, 1997. These analyses were performed as per RSKSOP-194, and the calculations were done as per RSKSOP-175.

If you should have any questions, please feel free to contact me.

Sincerely,

A handwritten signature in black ink that reads "Lisa C. Hopkins". The signature is fluid and cursive, with a long horizontal stroke at the beginning.

Lisa Hopkins

xc: R.L. Cosby  
J.T. Wilson  
G.B. Smith  
J.L. Seeley *JS*

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive  
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Sample	Methane	Ethylene	Ethane
100ppm CH4	101.3	**	**
100ppm C2H4	**	112.8	**
100ppm C2H6	**	**	109.6
HPHe	**	**	**
Lab Blank	**	**	**
MW-1	*	**	**
MW-3R	18.7	0.003	0.008
MW-4R	6.64	0.015	0.026
MW-5R	1.61	*	0.002
MW-6R	0.671	*	0.002
MW-6R	0.619	*	0.002
Lab Dup			
MW-7	**	**	**
MW-8	0.009	**	**
MW-9	0.205	**	**
MW-11	11.6	*	0.015
CPT-19S	**	**	**
CPT-19S	**	**	**
Field Dup			
10ppm CH4	9.7	**	**
CPT-19D	2.91	*	0.007
CPT-20S	*	**	**
CPT-20D	11.0	0.005	0.017
CPT-21S	0.046	**	**
CPT-21D	1.61	**	0.002
CPT-21D	1.53	**	0.002
Lab Dup			
CPT-22D	2.06	**	0.003
CPT-22D	2.00	**	0.003
Field Dup			
100ppm CH4	104.2	**	**
100ppm C2H4	**	112.0	**
100ppm C2H6	**	**	111.1

## Lower Limit of Quantitation

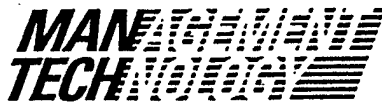
0.001	0.003	0.002
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Units for the samples are mg/L dissolved in water.

Units for the standards are parts per million.

\*\* denotes None Detected.

\* denotes Below Limit of Quantitation.



Ref: 97-SH64

September 17, 1997

Dr. Don Kampbell  
National Risk Management Research Laboratory  
Subsurface Protection & Remediation Division  
U.S. Environmental Protection Agency  
P.O. Box 1198  
Ada, OK 74820

THRU: S.A. Vandegrift *SV*

Dear Don:

Attached are TOC results for 16 Bolling liquids submitted September 16, 1997 under Service Request #SF-3-279. Sample analysis was begun September 16, 1997 and completed September 16, 1997 using RSKSOP-102.

Blanks, duplicates, and AQC samples were analyzed along with your samples, as appropriate, for quality control. If you have any questions concerning this data, please feel free to ask me.

Sincerely,

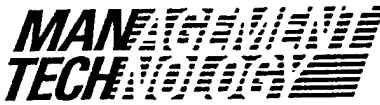
Sharon Hightower

xc: R.L. Cosby  
G.B. Smith  
J.L. Seeley *JL*

KAMPBELL BOLLING LIQUIDS SF-3-279

SAMPLE	MG/L TOC
MW-1	<.4
MW-3R	35.5
MW-4R	24.1
MW-5R	19.9
MW-6R	10.1
MW-7	<.4
MW-8	<.4
MW-9	1.20
MW-11	33.4
CPT-19D	7.93
DUP	7.74
CPT-19S	1.26
CPT-20D	8.46
CPT-20S	.598
CPT-21D	2.91
CPT-21S	.440
CPT-22D	.968
WP37	56.3

WP37 std. t.v.=60.0



Ref: 97-LB65  
September 18, 1997

Dr. Don Kampbell  
National Risk Management Research Laboratory  
Subsurface Protection and Remediation Division  
U.S. Environmental Protection Agency  
P.O. Box 1198  
Ada, OK 74820

THRU: Steve Vandegrift <sup>SV</sup>

Dear Don:

Please find attached the analytical results for the Bolling AFB service request SF-3-279 requesting the analysis of monitoring well samples to be analyzed for benzene, toluene, ethylbenzene, p-, m-, and o-xylene, 1,3,5-, 1,2,4-, and 1,2,3-trimethylbenzene and total fuel carbon. We received your 16 samples, in duplicate, September 11, 1997 in capped, lead lined 40 mL VOA vials. The samples were analyzed on September 15-17, 1997. All samples were acquired and processed using the Millennium data system. A 6 point (1-1000 ppb) external calibration curve was used to determine the concentration for all compounds.

RSKSOP-133 "Simultaneous Analysis of Aromatics and Total Fuel Carbon by Dual Column/Dual Detector Gas Chromatography in Ground Water Samples" was used for these analyses. Autosampling was performed using a Dynatech-Precision autosampler in-line with a Tekmar LSC 2000 sample concentrator.

Sincerely,

  
Lisa R. Black

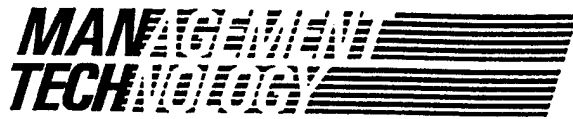
xc: R.L. Cosby  
G.B. Smith  
J.T. Wilson  
J.L. Seeley <sup>JS</sup>

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive  
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

SampleName	BENZENE	TOLUENE	ETHYLBENZENE	p-XYLENE	m-XYLENE	o-XYLENE	1,3,5-TMB	1,2,4-TMB	1,2,3-TMB	Fuel Carbon
QC, OBSERVED, PPB	18.5	18.3	17.4	18.8	18.1	19.1	18.6	19.0	17.2	N/A
QC, TRUE VALUE, PPB	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	N/A
100 PPB	96.6	97.2	95.8	96.1	95.4	97.1	95.0	96.1	97.1	N/A
MW-1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-3R	7690	12000	1600	1930	4960	3540	682	2950	860	38600
MW-4R	23100	24300	2630	2530	6320	4150	353	1530	527	65000
MW-5R	5440	20300	2600	2770	7140	3740	464	1960	569	49000
MW-6R	949	3230	1890	1910	4670	1040	334	1510	466	23400
MW-7	ND	BLQ	ND	1.5	2.0	1.3	ND	2.3	ND	15.4
MW-8	3.9	50.8	54.2	65.5	145	31.9	16.2	70.3	20.5	750
MW-8 Duplicate	2.6	46.9	54.6	66.1	146	32.7	16.2	70.1	18.4	622
MW-9	ND	BLQ	ND	ND	BLQ	ND	ND	1.8	ND	106
MW-11	4300	22800	2660	3080	7600	5150	402	1678	508	52000
CPT-19S	ND	BLQ	ND	ND	BLQ	ND	ND	ND	ND	BLQ
10 PPB	9.6	9.5	9.9	9.9	9.8	9.9	9.9	9.9	10.0	N/A
CPT-19D	1580	518	561	497	837	295	81.0	371	76.0	6075
CPT-20S	BLQ	BLQ	ND	ND	BLQ	ND	ND	ND	ND	BLQ
CPT-20D	4390	2540	2500	2480	5880	1300	339	1480	429	28300
CPT-21S	BLQ	BLQ	ND	ND	BLQ	ND	ND	ND	ND	BLQ
CPT-21D	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CPT-22D	95.2	51.2	52.5	56.7	133	30.9	14.0	59.9	15.9	1010
CPT-22D Duplicate	94.9	55.3	58.0	65.1	147	34.3	15.5	66.9	17.8	1070
500 PPB	530	544	555	551	549	548	551	552	553	N/A

ND = None Detected; BLQ = Below Limit of Quantitation, 1 ppb; N/A = Not Analyzed



Ref: 97-LP90/vg

September 24, 1997

Dr. Don Kampbell  
National Risk Management Research Laboratory  
Subsurface Protection & Remediation Division  
U.S. Environmental Protection Agency  
P.O. Box 1198  
Ada, OK 74820

THRU: S.A. Vandegrift *SV*

Dear Don:

Attached are the results of time-sensitive parameters determined on field samples from Bolling AFB, Washington, DC and Dover AFB, Dover, DE. The analyses were performed between September 9 and 13 to satisfy Service Requests #SFTA-3-136 and SFTA-3-137.

The analyses were done using various Hach kits and meters provided on-site by Mr. Mike Cook. Please note that many samples had high levels of ferrous iron that interfered with CO<sub>2</sub> titrations; therefore, CO<sub>2</sub> was not determined for those samples.

Quality control data is reported for each day analyses were performed.

If you have any questions concerning this data, please feel free to contact me.

Sincerely,

*Lynda Pennington*  
Lynda Pennington

xc: R.L. Cosby  
G.B. Smith  
J.L. Seeley *JL*

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive  
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Bolling AFB, Washington, DC  
September 9 and 10, 1997

<u>Sample</u>	<u>pH</u>	<u>mV Redox</u>	<u>Conductivity</u> $\mu\text{S/cm}$	<u>Alkalinity</u> mg/L (as $\text{CaCO}_3$ )	<u>Ferrous Iron</u> mg/L	<u>mg/L <math>\text{H}_2\text{S}</math></u>	<u>ppm <math>\text{CO}_2</math></u>
MW-1	6.27	+202	527	64	<.05	NA	90
MW-9	6.38	-43.8	683	157	18.0	<.01	NA
MW-11	6.55	-115	728	237	53.8	0.1	NA
MW-7	5.20	+219	725	7	<.05	<.01	120
MW-3R	5.92	-35.9	525	53	21.3	<.01	NA
MW-4R	6.72	-123	729	236	30.3	<.01	NA
MW-5R	6.06	-102	185	78	13.8	1.0	NA
MW-6R	6.09	-128	1890	121	14.5	2.0	NA
CPT-20D	6.63	-116	866	208	57.5	<.01	NA
MW-8	5.27	+194	242	5	3.25	<.01	160
CPT-19D	6.38	-99.0	679	178	65.8	<.01	NA
CPT-22D	6.07	+105	402	48	0.51	<.01	144
CPT-19S	6.33	+121	1570	71	<.05	<.01	114
CPT-20S	6.33	+126	878	31	0.30	<.01	60
CPT-21D	6.55	+48.0	612	128	0.72	NA	116

NA= Not Analyzed

9-9-97 Quality Control

1413 Std.		1428	
7.00 Buffer	7.00		1.91
2.0 mg/L Std.			
Redox A		230	
Redox B		295	

<u>Sample</u>	<u>pH</u>	<u>mV Redox</u>	<u>Conductivity</u> $\mu\text{S/cm}$	<u>mg/L</u> <u>(as CaCO<sub>3</sub>)</u>	<u>mg/L</u> <u>Ferrous Iron</u>	<u>mg/L H<sub>2</sub>S</u>	<u>ppm CO<sub>2</sub></u>
<u>9-10-97 Quality Control</u>							
1413 Cond. Std.			1420				
7.00 pH Buffer	7.00						
Redox A		226					
Redox B		293					
2.0 mg/L Fe <sup>++</sup> Std.					2.04		
Fe <sup>++</sup> Blank					0.00		
Alk. Std.				247			

Dover AFB, Dover, DE  
September 11-13, 1997

<u>Sample</u>	<u>pH</u>	<u>mV Redox</u>	<u>Conductivity</u> $\mu\text{S/cm}$	<u>mg/L</u> <u>(as CaCO<sub>3</sub>)</u>	<u>mg/L</u> <u>Ferrous Iron</u>	<u>mg/L H<sub>2</sub>S</u>	<u>ppm CO<sub>2</sub></u>
DM 343-S	5.75	-44.3	313	103	25.8	0.1	NA
DM 343-D	5.53	+107	259	45	22.8	<0.1	NA
DM-16S		----- FUEL ONLY		---	NO WATER RECOVERED	-----	
DM-16D	6.54	-34.8	384	213	19.8	<0.1	NA
DM-342S	6.01	+273	56	<1	0.06	NA	36
DM-342D	5.72	+261	57	12	0.06	NA	76
DM-344S	6.45	-58.0	456	236	4.50	1.0	NA
DM-344D	5.87	+129	113	32	5.25	NA	164
CPT-9	6.34	-133	755	397	15.5	0.3	NA
CPT-27D	5.33	+218	148	10	3.70	NA	370
CPT-27S	5.13	+275	195	<1	0.12	NA	160

<u>Sample</u>	<u>pH</u>	<u>mV Redox</u>	<u>Conductivity</u> $\mu\text{S/cm}$	<u>mg/L</u> (as $\text{CaCO}_3$ ) <u>Alkalinity</u>	<u>mg/L</u> <u>Ferrous Iron</u>	<u>mg/L <math>\text{H}_2\text{S}</math></u>	<u>ppm <math>\text{CO}_2</math></u>
DM-349D	5.27	+241	133	6	<0.05	NA	100
DM-349S	5.53	+240	130	5	0.07	NA	106
CPT-NW	5.45	+222	86	16	0.24	NA	234
CPT-NW Dup	5.44	+224	87	19	0.21	NA	230

NA = Not Analyzed

9-11-97 Quality Control

7.00 Buffer	7.00						
1413 Cond. Std.			1441				
Redox A		232					
Redox B		295					

9-12-97 Quality Control

7.00 Buffer	6.99						
1413 Cond. Std.			1436				
Redox A		235					
Redox B		299					
Alk. Std.				247			

9-13-97 Quality Control

7.00 Buffer	7.00						
1413 Cond. Std.			1437				
Redox A		242					
Redox B		305					
D.I. $\text{H}_2\text{O}$ Alk.				0			
Alk. Std.				252			
2.0 mg/L $\text{Fe}^{++}$ Std.					2.02		

Groundwater Sampling Record  
Monitoring Well No. MW 1

~~9-9-97~~ 9-9-97  
~~Ballung AFB~~  
Ballung AFB

5 [ ] SAMPLE EXTRACTION METHOD:

- Bailer made of: \_\_\_\_\_
- Pump, type: \_\_\_\_\_
- Other, describe: \_\_\_\_\_

Sample obtained is  GRAB;  COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	1:40 P	1:50 P	1:55 P	2:00 P	Measured with
Temp (°C)	24.1	23.3	23.9	23.1	
pH					
Cond (µS/cm)					
DO (mg/L)	2.1	0.2	0.6	0.5	
Redox (mV)					
Salinity					

7 [ ] SAMPLE CONTAINERS (material, number, size): \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH \_\_\_\_\_  
Items Cleaned (List): \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

2 [ ] PRODUCT DEPTH \_\_\_\_\_ FT. BELOW DATUM  
Measured with: \_\_\_\_\_

WATER DEPTH 17.12 (TOC) \_\_\_\_\_ FT. BELOW DATUM  
Measured with: \_\_\_\_\_

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):  
Color: \_\_\_\_\_  
Turbidity: \_\_\_\_\_  
Odor: \_\_\_\_\_  
Other Comments: \_\_\_\_\_

4 [ ] WELL EVACUATION:  
Method: \_\_\_\_\_  
Volume Removed: \_\_\_\_\_  
Observations: Turbidity (clear      slightly cloudy      very cloudy)  
Water level (rose    fell    no change)  
Water odors: \_\_\_\_\_  
Other comments: \_\_\_\_\_

Groundwater Sampling Record  
Monitoring Well No. 3R

*Balling AFB*

5 [ ] SAMPLE EXTRACTION METHOD:

- [ ] Bailer made of: \_\_\_\_\_  
 Pump type: Cole Parmer (Peristaltic)  
 [ ] Other, describe: \_\_\_\_\_

Sample obtained is  GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	15:20	15:30	15:40		Measured with
Temp (°C)	20.3	19.9	19.9		Orion O <sub>2</sub>
pH					
Cond (µS/cm)	0				
DO (mg/L)	0.5	0.2	0.2		Orion O <sub>2</sub>
Redox (mV)					
Salinity					

7 [ ] SAMPLE CONTAINERS (material, number, size): \_\_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH \_\_\_\_\_  
 Items Cleaned (List): \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

2 [ ] PRODUCT DEPTH: \_\_\_\_\_ FT. BELOW DATUM  
 Measured with: \_\_\_\_\_

WATER DEPTH: 18.3 (TOC) FT. BELOW DATUM  
 Measured with: \_\_\_\_\_

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):  
 Color: \_\_\_\_\_  
 Turbidity: \_\_\_\_\_  
 Odor: \_\_\_\_\_  
 Other Comments: \_\_\_\_\_

4 [ ] WELL EVACUATION:  
 Method: \_\_\_\_\_  
 Volume Removed: Le sol.  
 Observations: Turbidity (clear) slightly cloudy very cloudy  
 Water level (rose fell no change)  
 Water odors: ~~Strong~~ Petroleum (Moderate)  
 Other comments: \_\_\_\_\_

Groundwater Sampling Record  
Monitoring Well No. MW-4R

9-9-97  
Ballin AFB

5 [ ] SAMPLE EXTRACTION METHOD:

- Bailer made of: \_\_\_\_\_
- Pump, type: \_\_\_\_\_
- Other, describe: \_\_\_\_\_

Sample obtained is  GRAB;  COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	4:20	4:30	4:40		Measured with
Temp (°C)	21.2	21.0	21.0		
pH					
Cond (µS/cm)					
DO (mg/L)	0.2	0.1	0.1		
Redox (mV)					
Salinity					

7 [ ] SAMPLE CONTAINERS (material, number, size): \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH \_\_\_\_\_  
Items Cleaned (List): \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

2 [ ] PRODUCT DEPTH: \_\_\_\_\_ FT. BELOW DATUM  
Measured with: \_\_\_\_\_

WATER DEPTH: 18.50 TOC FT. BELOW DATUM  
Measured with: \_\_\_\_\_

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):  
Color: \_\_\_\_\_  
Turbidity: \_\_\_\_\_  
Odor: \_\_\_\_\_  
Other Comments: \_\_\_\_\_

4 [ ] WELL EVACUATION:  
Method: \_\_\_\_\_  
Volume Removed: \_\_\_\_\_  
Observations: Turbidity (clear      slightly cloudy      very cloudy)  
Water level (rose    fell    no change)  
Water odors: \_\_\_\_\_  
Other comments: \_\_\_\_\_

Groundwater Sampling Record  
Monitoring Well No. 5R

Balling AFB

5 [ ] SAMPLE EXTRACTION METHOD:

- [ ] Bailer made of: \_\_\_\_\_  
 Pump type: Cole-Parmer (Peristaltic)  
 [ ] Other, describe: \_\_\_\_\_

Sample obtained is [X] GRAB;  SAMPLE **SAMPLE**

6 [ ] ON-SITE MEASUREMENTS:

Time	8:10	8:20	8:30		Measured with
Temp (°C)	20.0	20.5	20.5		Omnion O <sub>2</sub>
pH					
Cond (µS/cm)					
DO (mg/L)	0.9	0.4	0.4		Omnion O <sub>2</sub>
Redox (mV)					
Salinity					

7 [ ] SAMPLE CONTAINERS (material, number, size): \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH \_\_\_\_\_  
 Items Cleaned (List): \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

2 [ ] PRODUCT DEPTH \_\_\_\_\_ FT. BELOW DATUM  
 Measured with: \_\_\_\_\_

WATER DEPTH 19.4 FT. BELOW DATUM  
 Measured with: \_\_\_\_\_

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):  
 Color: \_\_\_\_\_  
 Turbidity: \_\_\_\_\_  
 Odor: \_\_\_\_\_  
 Other Comments: \_\_\_\_\_

4 [ ] WELL EVACUATION:  
 Method: \_\_\_\_\_  
 Volume Removed: 6 gal  
 Observations: Turbidity clear slightly cloudy very cloudy  
 Water level (rose fell no change)  
 Water odors: Petroleum (Moderate)  
 Other comments: \_\_\_\_\_



**Groundwater Sampling Record**  
Monitoring Well No. 7

*Bolling AFB*

5 [ ] **SAMPLE EXTRACTION METHOD:**

- Bailer made of: \_\_\_\_\_
- Pump, type: Cole Parmer (Peristaltic)
- Other, describe: \_\_\_\_\_

Sample obtained is  GRAB;  **COMPOSITE SAMPLE**

6 [ ] **ON-SITE MEASUREMENTS:**

Time	14:20	14:30			Measured with
Temp (°C)	19.5	19.0	19.0		Omnice
pH					
Cond (µS/cm)					
DO (mg/L)	2.8	2.4	2.4		Omnice
Redox (mV)					
Salinity					

7 [ ] **SAMPLE CONTAINERS (material, number, size):**  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Check-off**

1 [ ] **EQUIPMENT CLEANED BEFORE USE WITH** \_\_\_\_\_  
Items Cleaned (List): \_\_\_\_\_  
\_\_\_\_\_

2 [ ] **PRODUCT DEPTH** \_\_\_\_\_ **FT. BELOW DATUM**  
Measured with: \_\_\_\_\_

**WATER DEPTH** 19.1 (TOC) **FT. BELOW DATUM**  
Measured with: \_\_\_\_\_

3 [ ] **WATER-CONDITION BEFORE WELL EVACUATION (Describe):**  
Color: \_\_\_\_\_  
Turbidity: \_\_\_\_\_  
Odor: \_\_\_\_\_  
Other Comments: \_\_\_\_\_

4 [ ] **WELL EVACUATION:**  
Method: \_\_\_\_\_  
Volume Removed: 5 gal  
Observations: Turbidity (clear slightly cloudy very cloudy)  
Water level (rose, fell, no change)  
Water odors: None  
Other comments: \_\_\_\_\_



Groundwater Sampling Record  
Monitoring Well No. 9

9-9-97  
Balling AFB

5 [ ] SAMPLE EXTRACTION METHOD:

- [ ] Bailer made of: \_\_\_\_\_  
 [ ] Pump, type: Cole Parmer (Peristaltic)  
 [ ] Other, describe: \_\_\_\_\_

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	13:00	13:15	13:20		Measured with
Temp (°C)	22.1	21.9	21.9		
pH					
Cond (µS/cm)					
DO (mg/L)	0.8	0.5	0.4		Orion
Redox (mV)					
Salinity					

7 [ ] SAMPLE CONTAINERS (material, number, size): \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH \_\_\_\_\_  
 Items Cleaned (List): \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

2 [ ] PRODUCT DEPTH \_\_\_\_\_ FT. BELOW DATUM  
 Measured with: \_\_\_\_\_

WATER DEPTH 18.18 FT. BELOW DATUM  
 Measured with: \_\_\_\_\_

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):  
 Color: \_\_\_\_\_  
 Turbidity: \_\_\_\_\_  
 Odor: \_\_\_\_\_  
 Other Comments: \_\_\_\_\_

4 [ ] WELL EVACUATION:  
 Method: \_\_\_\_\_

Volume Removed: 16 gal

Observations: Turbidity (clear) slightly cloudy very cloudy

Water level (rose fell no change)

Water odors: petroleum odor (moderate)

Other comments: pumped dry, then sampled after recharge

36  
185

**Groundwater Sampling Record**  
Monitoring Well No. MW-11

9-9-97

Bailey AFB

5 [ ] **SAMPLE EXTRACTION METHOD:**

- Bailor made of: \_\_\_\_\_
- Pump, type: \_\_\_\_\_
- Other, describe: \_\_\_\_\_

Sample obtained is  GRAB;  ~~COMPOSITE SAMPLE~~

6 [ ] **ON-SITE MEASUREMENTS:**

Time	2:10p	2:20	2:30		Measured with
Temp (°C)	22.2	22.2	22.2		
pH					
Cond (µS/cm)					
DO (mg/L)	0.1	0.1	0.1		
Redox (mV)					
Salinity					

7 [ ] **SAMPLE CONTAINERS (material, number, size):** \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**Check-off**

1 [ ] **EQUIPMENT CLEANED BEFORE USE WITH** \_\_\_\_\_  
 Items Cleaned (List): \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

2 [ ] **PRODUCT DEPTH** \_\_\_\_\_ **FT. BELOW DATUM**  
 Measured with: \_\_\_\_\_  
**WATER DEPTH** 18.32' 70C **FT. BELOW DATUM**  
 Measured with: \_\_\_\_\_

3 [ ] **WATER-CONDITION BEFORE WELL EVACUATION (Describe):**  
 Color: \_\_\_\_\_  
 Turbidity: \_\_\_\_\_  
 Odor: \_\_\_\_\_  
 Other Comments: \_\_\_\_\_

4 [ ] **WELL EVACUATION:**  
 Method: \_\_\_\_\_  
 Volume Removed: \_\_\_\_\_  
 Observations: Turbidity (clear      slightly cloudy      very cloudy)  
 Water level (rose    fell    no change)  
 Water odors: \_\_\_\_\_  
 Other comments: \_\_\_\_\_

**Groundwater Sampling Record**  
Monitoring Well No. CPT-20

*Bolling AFB*

5 [ ] **SAMPLE EXTRACTION METHOD:**

- [ ] Bailor made of: \_\_\_\_\_  
 Pump, type: Colo-Panner (Per)  
 [ ] Other, describe: \_\_\_\_\_

Sample obtained is  GRAB; [ ] COMPOSITE SAMPLE

6 [ ] **ON-SITE MEASUREMENTS:**

Time	9:45	9:55	10:05		Measured with
Temp (°C)	20.1	20.0	20.0		Omin O <sub>2</sub>
pH					
Cond (µS/cm)					
DO (mg/L)	1.6	0.5	0.3		Omin O <sub>2</sub>
Redox (mV)					
Salinity					

7 [ ] **SAMPLE CONTAINERS (material, number, size):**  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**Check-off**

1 [ ] **EQUIPMENT CLEANED BEFORE USE WITH**  
 Items Cleaned (List): \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

2 [ ] **PRODUCT DEPTH** \_\_\_\_\_ **FT. BELOW DATUM**  
 Measured with: \_\_\_\_\_  
**WATER DEPTH** \_\_\_\_\_ **FT. BELOW DATUM**  
 Measured with: \_\_\_\_\_

3 [ ] **WATER-CONDITION BEFORE WELL EVACUATION (Describe):**  
 Color: \_\_\_\_\_  
 Turbidity: \_\_\_\_\_  
 Odor: \_\_\_\_\_  
 Other Comments: \_\_\_\_\_

4 [ ] **WELL EVACUATION:**  
 Method: \_\_\_\_\_  
 Volume Removed: \_\_\_\_\_  
 Observations: Turbidity (Clear slightly cloudy very cloudy)  
 Water level (rose fell no change)  
 Water odors: \_\_\_\_\_  
 Other comments: \_\_\_\_\_

Groundwater Sampling Record  
Monitoring Well No. 210

Ballou AFB

5 [ ] SAMPLE EXTRACTION METHOD:

- [ ] Bailer made of: \_\_\_\_\_  
 Pump, type: Cole-Parmer (Peristaltic)  
 [ ] Other, describe: \_\_\_\_\_

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Time	12:50	13:00	13:10		Measured with
Temp (°C)	21.2	20.6	20.4		Orion 02
pH					
Cond (µS/cm)					
DO (mg/L)	0.6	0.3	0.3		Orion 02
Redox (mV)					
Salinity					

7 [ ] SAMPLE CONTAINERS (material, number, size): \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH \_\_\_\_\_  
 Items Cleaned (List): \_\_\_\_\_  
 \_\_\_\_\_

2 [ ] PRODUCT DEPTH \_\_\_\_\_ FT. BELOW DATUM  
 Measured with: \_\_\_\_\_

WATER DEPTH \_\_\_\_\_ FT. BELOW DATUM  
 Measured with: \_\_\_\_\_

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):  
 Color: \_\_\_\_\_  
 Turbidity: \_\_\_\_\_  
 Odor: \_\_\_\_\_  
 Other Comments: \_\_\_\_\_

4 [ ] WELL EVACUATION:  
 Method: \_\_\_\_\_  
 Volume Removed: \_\_\_\_\_  
 Observations: Turbidity (clear slightly cloudy very cloudy)  
 Water level (rose fall no change)  
 Water odors: \_\_\_\_\_  
 Other comments: \_\_\_\_\_

