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# FINAL MONTHLY ACTIVITIES REPORT MOBILE ENHANCED MULTI-PHASE EXTRACTION MILLINGTON SUPPACT TN

6/4/1999

BAT ASSOCIATES, INC.

# MONTHLY ACTIVITIES REPORT

# MOBILE ENHANCED MULTI-PHASE EXTRACTION (MEME) AT THE NAVAL EXCHANGE SERVICE STATION; NAVAL SUPPORT ACTIVITY MID-SOUTH, MILLINGTON, TENNESSEE

# FACILITY I.D. No. 0-791718

**FINAL June 4, 1999**

Prepared by:

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Prepared for:

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Under Contract No. N62467-98-D-0938
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BAT PROJECT NO. 983019

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# 1.0 PROJECT DESCRIPTION AND BACKGROUND

## 1.1 Project Description

BAT Associates, Inc. (BAT), under contract number N62467-98-D-0938, has been tasked by the Department of the Navy, Southern Division Engineering Facilities Command to perform mobile enhanced multi-phase extraction (MEME) technology at the Naval Exchange Service Station at the Naval Support Activity (NSA) MID-South, Millington, Tennessee (Facility I.D. No. 0-791718).

The application of the MEME events are intended to be an abatement initiative to reduce the levels of dissolved benzene, toluene, ethyl benzene, and xylene (BTEX), and total petroleum hydrocarbons (TPH) constituents in groundwater. This report summarizes data obtained from the MEME performed May 17, 1999. Field activities were conducted in accordance with BAT's approved final Plan of Action and the Tennessee Department of Environment and Conservation's (TDEC) Technical Guidance Document (TGD)-016.

## 1.2 Project Background

The Naval Exchange Service Station is located in the northwestern quadrant of NSA Memphis. The site encompasses approximately three acres, is flat, drains surfacially to the west, and is covered with asphalt pavement.

A loss of gasoline was discovered in February 1986 by Exchange Service Station personnel. The initial release was reported to TDEC in March 1986. A preliminary investigation of this leak by Navy personnel revealed that a pipe joint on the regular unleaded gasoline fuel line was leaking. As part of former site assessments, twenty-two (22) groundwater monitoring wells were installed.

Several groundwater monitoring events performed between 1987 and 1998 indicate that the contaminated groundwater has not moved from the immediate vicinity of the fuel line leak. TDEC has established that cleanup levels for groundwater for the "non-drinking water" classification is 0.070 ppm for benzene and 1.0 ppm for TPH. TPH and Benzene concentrations in the groundwater did exceed TDEC action levels for a non-drinking aquifer in ten (10) monitoring wells (MEM-757-1 through -3, MEM-757-6 through -8, MEM-757-12 through -14, and MEM-757-B3. Therefore, only these ten (10) wells were used for this MEME event. Location of the wells is shown on Figure 1-1.

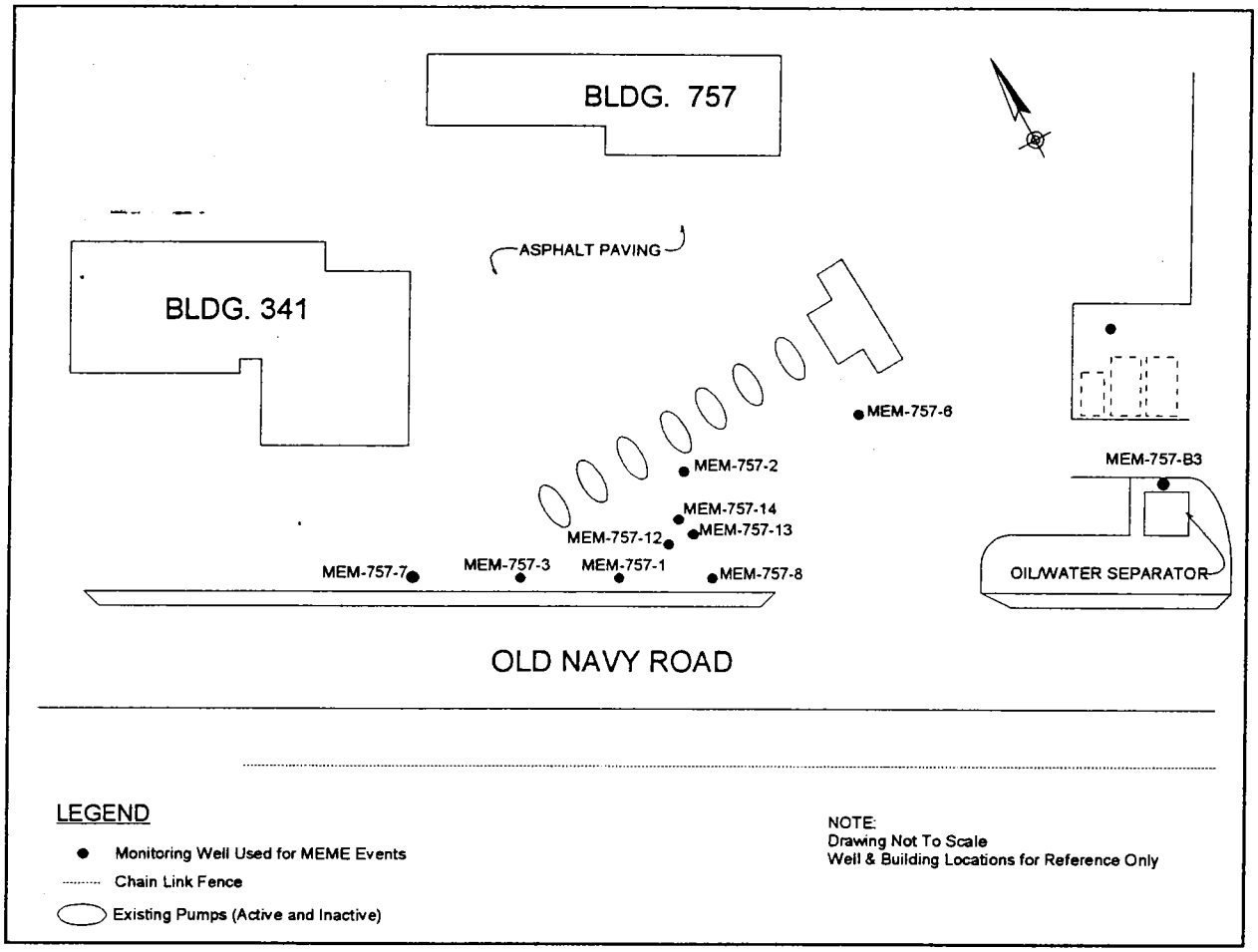


Figure 1-1 Site Map and Monitoring Well Locations

## 1.3 MEME Technology Employed

BAT utilized Enhanced Fluid Recovery (EFR™), a mobile variation of what is commonly referred to as multi-phase extraction, dual-phase extraction, and vacuum enhanced recovery. This technology is a remediation method that utilizes high vacuum pressures and flow rates to remove multiple phase (i.e. vapor, absorbed, dissolved, and free phase) volatile organic compounds (VOCs) from the subsurface. It utilizes high vacuum and high flow rates simultaneously connected to monitoring or recovery wells.

The MEME simultaneously removes vapors, free product, and groundwater from the subsurface. It volatizes adsorbed and free phase VOCs through a process similar to soil vapor extraction, but with much higher vacuum and radius of influence. MEME can also treat adsorbed phase VOCs existing in the "smear zone" (i.e. the zone of seasonal or climatic groundwater fluctuation) that act as a source for dissolved phase VOCs. MEME dewaters and exposes the smear zone to the effects of 'high rate" soil vapor extraction. MEME also introduces oxygen to the vadose zone and saturated zones, thereby enhancing aerobic biodegradation.

## 2.0 SUMMARY OF RESULTS

This MEME is the seventh event that has been conducted at this site. Five previous events were conducted January 15-16, 1998 (initial event), January 29-30, 1998 (second event), January 19, 1999 (third event), February 10, 1999 (fourth event), March 15, 1999 (fifth event), and April 15, 1999 (sixth event).

Separate phase hydrocarbons (SPH) were not detected prior to, or upon completion of, conducting the May 17, MEME event. SPH has also not been detected during the previous six MEME events. This MEME event was performed for a duration of eight hours at ten extraction points, consisting of the initial three hours at monitoring wells MEM-2, MEM-8, MEM-13, and MEM-14, the ensuing three hours at MEM-1, MEM-3, MEM-7, and MEM-12, and the final two hours at MEM-6 and B-3.

The first and second events were conducted over two days consisting of eight hours at wells MEM-1, MEM-2, MEM-3, MEM-7, MEM-8, MEM-12, MEM-13, and MEM-14 on the first day, and eight hours at wells MEM-6 and B3 on the second day. The third event was conducted for eight hours consisting of the initial six hours at monitoring well MEM-1, MEM-2, MEM-3, MEM-7, MEM-8, MEM-12, MEM-13, and MEM-14 and the final two hours at MEM-6 and B-3. The fourth, fifth, and sixth events were conducted in the same configuration and for the same duration as this seventh event.

### 2.1 Petroleum Hydrocarbons Removed

A calculated total of 407 pounds of carbon (approximately equivalent to 687 pounds of petroleum hydrocarbons - 113 equivalent gallons of gasoline) were removed during this MEME event. This recovered mass/volume of petroleum hydrocarbons represents an increase from the removal achieved during the sixth event (i.e. a calculated total of 499 pounds of petroleum hydrocarbons - approximately 82 equivalent gallons of gasoline), and is within the range of removals achieved during previous events (i.e. calculated total of 581 to 3,704 pounds of petroleum hydrocarbons - approximately 95 to 611 equivalent gallons of gasoline). A combined total of 9,522 pounds of petroleum hydrocarbons (approximately 1,570 gallons of gasoline) have been recovered during the seven MEME events conducted at this site.

A summary of petroleum hydrocarbons removed to date is shown in Table 1.

**TABLE 1**
**Summary of Petroleum Hydrocarbons Removed**

| MEME Event Number | MEME Event Date | Petroleum Hydrocarbons Removed (lbs.) | Equivalent Gasoline Removed (gal.) |
|---|---|---|---|
| 1* | January 15 and 16, 1998 | 905 | 149 |
| 2* | January 29 and 30, 1998 | 581 | 95 |
| 3 | January 19, 1999 | 3,704 | 611 |
| 4 | February 10, 1999 | 1,307 | 216 |
| 5 | March 15, 1999 | 1,839 | 304 |
| 6 | April 15, 1999 | 499 | 82 |
| 7 | May 17, 1999 | 687 | 113 |
| | **Total Removed To Date** | **9,522** | **1,570** |

*Performed by others

The carbon removal rate ranged from 1.7 to 113 pounds per hour during this MEME event. The removal rate increased from 50 to 103 pounds per hour during the initial one hour of extraction from wells MEM-2, MEM-8, MEM-13, and MEM-14 and decreased to 46 pounds during the ensuing two hours. Upon commencement of extraction from wells MEM-1, MEM-3, MEM-7, and MEM-12, the carbon removal rate initially increased to 113 pounds per hour and generally decreased to 44 pph during the ensuing three hours of extraction. Upon commencement of extraction from MEM-6 and B-3, the carbon removal rate increased from 1.7 to 2.2 pounds per hour during the initial 1 hour and decreased to 1.9 pounds per hour during the final one hour of this event. These removal rates are within the lower range of those achieved during the sixth event (i.e. 0.7 to 258 pounds per hour) and during previous events (i.e. 1.7 to 1,192 pounds per hour).

## 2.2 Offgas Concentrations

Offgas concentrations ranged from 640 to 40,000 ppm during this MEME event. Offgas concentrations increased from 4,000 to 38,000 ppm during the initial one hour of extraction from MEM-2, MEM-8, MEM-13, and MEM-14 and decreased to 14,000 ppm during the ensuing two hours. Upon commencement of extraction from MEM-1, MEM-3, MEM-7, and MEM-12, offgas concentrations generally decreased from 40,000 to 14,000 ppm during the ensuing three hours of extraction. Upon commencement of extraction from wells MEM-6 and B-3, the offgas concentrations increased from 640 to 1,000 ppm during the initial 0.5 hour and decreased to 740 ppm during the final 1.5 hours of this event. These offgas concentrations are within the range of those

recorded during the sixth event (i.e. 120 to 60,000 ppm) and during previous events (i.e. 620 to >100,000 ppm).

## 2.3 Flow Rates

Flow rates attained during this MEME event ranged from 293 to 440 CFM (174 to 274 DSCFM), of which 0 to approximately 16 CFM was attributed to atmospheric air inflow at MEM-6 breather ports. Breather ports are sometimes used to enhance the removal of petroleum hydrocarbons and/or groundwater. The flow rates recorded during the initial 0.5 hours of this event (1,174 to 1,210 CFM) were the result of the valve on the auxiliary pump being left open; therefore, these flow rates were not utilized in the comparisons between previous events. The flow rate increased from 367 to 403 CFM during the ensuing one hour of extraction from MEM-2, MEM-8, MEM-13, and MEM-14 and remained stable at 403 CFM during the final one hour. During the ensuing three hours of extraction from MEM-1, MEM-3, MEM-7, and MEM-12, the flow rates ranged from 403 to 440 CFM. Upon commencement of extraction from MEM-6 and B-3, the flow rates increased from 293 to 330 CFM during the final two hours of this event. These flow rates ranged lower than those recorded during the sixth event (i.e. 403 to 734 CFM) and are within the lower range of those recorded during previous events (i.e. 236 to 1,100 CFM).

## 2.4 Extraction Wellhead Vacuum Readings

The range of vacuum readings recorded at the extraction wells during this MEME event are detailed in the field data sheets (Appendix A) and are summarized in Table 2 below.

**TABLE 2**
**Summary of Sixth Event Vacuum Readings**

| Extraction Well Location | Vacuum Reading (in. of mercury) |
|---|---|
| MEM-1 | 6 to 7 |
| MEM-2 | 15 to 18 |
| MEM-3 | 17 |
| MEM-6 | 17 to 19 |
| MEM-7 | 6 to 7 |
| MEM-8 | 10 |
| MEM-12 | 15 |
| MEM-13 | 15 to 17 |
| MEM-14 | 14 to 16 |
| B-3 | 7 to 13 |

The vacuum readings recorded at extraction well MEM-6 may have been biased by atmospheric air inflow at the wellhead breather port.

Differential pressures were recorded during this event to assess the vacuum induced by MEME in the vadose zone. Vacuum influence was not detected during this event as detailed in Appendix A.

Groundwater levels were recorded during this event to determine drawdown of the aquifer during the MEME and is detailed below.

| Monitoring Well | Maximum Change | Nearest Extraction Well (Approx. Distance) |
|---|---|---|
| MEM-11 | -0.28 feet | MEM-8 (37 feet) |
| B-4 | +0.04 feet | B-3 (54 feet) |
| MEM-16 | -0.01 feet | B-3 (75 feet) |

## 2.5 Groundwater Disposal

Approximately 1,378 gallons of liquid (SPH was not detected in the vacuum truck tank upon conclusion of MEME activities) were removed during this MEME and off loaded to an on-base oil/water separator at the direction of the NSA environmental personnel.

# APPENDIX A

# MEME FIELD DATA SHEETS

# EFR® FIELD DATA SHEET

Client: BAT Env. | Facility Name: NEX (Navy Exchange) Auto Part/Fuel Lock | Facility ID#: 0-791718 | Event #: 7

Facility Address: 757 Old Navy Road, Millington, Tennessee | Technician: Lewis | Date: 5/17/99

| Extraction Well(s) | Start Time (hh:mm) | End Time (hh:mm) | Interval Time (min) | Extraction Well-head Vacuum (in. Hg) | | | | | | | | | | | Offgas Velocity (ft/min) | Total Flow (CFM) | Stack Gas Temp. (° F) | Total Flow (DSCFM) | Offgas Concentrations | | | Rate of Carbon Removal (lbs/hour) | Total Carbon Removed (pounds) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Inlet | MEM-1 | MEM-2 | MEM-3 | MEM-6 | MEM-7 | MEM-8 | MEM-12 | MEM-13 | MEM-14 | B-3 | | | | | Initial $PPM_V$ | Ending $PPM_V$ | Average $PPM_V$ | | |
| MEM-2,8,13,14 | 7:30 | 7:45 | 15 | 21 | - | 18 | - | - | - | 10 | - | 17 | 16 | - | 6,400 | 1,174 | 100 | 1098 | 4,000 | 4,200 | 4,100 | 50 | 13 |
| " | 7:45 | 8:00 | 15 | 21 | - | 18 | - | - | - | 10 | - | 17 | 16 | - | 6,600 | 1,210 | 130 | 1027 | 4,200 | 4,800 | 4,500 | 52 | 13 |
| " | 8:00 | 8:15 | 15 | 18 | - | 15 | - | - | - | 10 | - | 15 | 15 | - | 2,000 | 367 | 150 | 274 | 4,800 | 36,000 | 20,400 | 63 | 16 |
| " | 8:15 | 8:30 | 15 | 18 | - | 15 | - | - | - | 10 | - | 15 | 15 | - | 2,000 | 367 | 160 | 248 | 36,000 | 38,000 | 37,000 | 103 | 26 |
| " | 8:30 | 9:00 | 30 | 18 | - | 15 | - | - | - | 10 | - | 15 | 14 | - | 2,200 | 403 | 170 | 239 | 38,000 | 29,000 | 33,500 | 90 | 45 |
| " | 9:00 | 9:30 | 30 | 18 | - | 15 | - | - | - | 10 | - | 15 | 14 | - | 2,200 | 403 | 170 | 239 | 29,000 | 24,000 | 26,500 | 71 | 35 |
| " | 9:30 | 10:00 | 30 | 19 | - | 15 | - | - | - | 10 | - | 15 | 14 | - | 2,200 | 403 | 160 | 273 | 24,000 | 20,000 | 22,000 | 67 | 34 |
| " | 10:00 | 10:30 | 30 | 18 | - | 15 | - | - | - | 10 | - | 15 | 14 | - | 2,200 | 403 | 170 | 239 | 20,000 | 14,000 | 17,000 | 46 | 23 |
| MEM-1,3,7,12 | 10:30 | 10:45 | 15 | 18 | 6 | - | 17 | - | 6 | - | 15 | - | - | - | 2,200 | 403 | 160 | 273 | 34,000 | 40,000 | 37,000 | 113 | 28 |
| " | 10:45 | 11:00 | 15 | 18 | 6 | - | 17 | - | 6 | - | 15 | - | - | - | 2,200 | 403 | 170 | 239 | 40,000 | 32,000 | 36,000 | 96 | 24 |
| " | 11:00 | 11:30 | 30 | 18 | 6 | - | 17 | - | 6 | - | 15 | - | - | - | 2,200 | 403 | 170 | 239 | 32,000 | 26,000 | 29,000 | 78 | 39 |
| " | 11:30 | 12:00 | 30 | 18 | 7 | - | 17 | - | 7 | - | 15 | - | - | - | 2,400 | 440 | 170 | 260 | 26,000 | 22,000 | 24,000 | 70 | 35 |
| " | 12:00 | 12:30 | 30 | 18 | 7 | - | 17 | - | 7 | - | 15 | - | - | - | 2,400 | 440 | 170 | 260 | 22,000 | 18,000 | 20,000 | 58 | 29 |
| " | 12:30 | 13:00 | 30 | 18 | 7 | - | 17 | - | 7 | - | 15 | - | - | - | 2,200 | 403 | 170 | 239 | 18,000 | 14,000 | 16,000 | 43 | 21 |
| " | 13:00 | 13:30 | 30 | 18 | 7 | - | 17 | - | 7 | - | 15 | - | - | - | 2,400 | 440 | 170 | 260 | 14,000 | 16,000 | 15,000 | 44 | 22 |
| MEM-6;B-3 | 13:30 | 13:45 | 15 | 19 | - | - | - | 19 | - | - | - | - | - | 7 | 1,600 | 293 | 160 | 199 | 640 | 880 | 760 | 1.7 | 0.4 |
| " | 13:45 | 14:00 | 15 | 19 | - | - | - | 19 | - | - | - | - | - | 10 | 1,600 | 293 | 170 | 174 | 880 | 1,000 | 940 | 1.8 | 0.5 |
| " | 14:00 | 14:30 | 30 | 18 | - | - | - | 18 | - | - | - | - | - | 12 | 1,800 | 330 | 170 | 195 | 1,000 | 1,000 | 1,000 | 2.2 | 1.1 |
| " | 14:30 | 15:00 | 30 | 17 | - | - | - | 17 | - | - | - | - | - | 13 | 1,800 | 330 | 170 | 195 | 1,000 | 1,000 | 1,000 | 2.2 | 1.1 |
| " | 15:00 | 15:30 | 30 | 17 | - | - | - | 17 | - | - | - | - | - | 13 | 1,800 | 330 | 170 | 195 | 1,000 | 740 | 870 | 1.9 | 1.0 |

**Vacuum Truck Information**

| | |
|---|---|
| Subcontractor: | NB Env. |
| Invoice No.: | |
| Truck Operator: | Lowe |
| Truck No.: | KingVac VK-39 |
| Vacuum Pump Type: | Liquid Ring |
| Tank Capacity: | 2,561 |
| Stack I.D. (inches): | 5.8 |
| Calibration Gas: | 500 ppm Hexane |
| Molecular Weight: | 75 g/mole |

| Well No. | Breather Port (CFM) | Stinger Depth (feet) |
|---|---|---|
| MEM-1 | 0 (closed) | 10 |
| MEM-2 | 0 (closed) | 10 |
| MEM-3 | 0 (closed) | 10 |
| MEM-6 | 16 | 10 |
| MEM-7 | 0 (closed) | 10 |
| MEM-8 | 0 (closed) | 10 |
| MEM-12 | 0 (closed) | 10 |
| MEM-13 | 0 (closed) | 10 |
| MEM-14 | 0 (closed) | 10 |
| B-3 | 0 (closed) | 10 |

**Recovery/Disposal Information**

| | |
|---|---|
| Total Gal. of Liquid: | 1,378 |
| Disposal Facility: | * |
| Manifest No.: | * |
| Total Lbs. of Carbon (Offgas): | 407 |
| Cum. Lbs. Carbon Removed: | 6,771 |
| Lbs. Hydrocarbons Removed: | 687 |
| Cum. Lbs. Hydrocarbons: | 9,522 |
| Equiv. Gal. Removed: | 113 |
| Cum. Equiv. Gal. Removed: | 1,570 |

ECOVAC SERVICES

Comments: * Offloaded extracted liquid to an on-site oil/water separator

** Auxiliary pump valve left open during the initial 0.5 hour of EFR® - reflected in the offgas velocity.

# EFR® EVENT GAUGING DATA

| Client: BAT Env. | Facility Name: NEX (Navy Exchange) Auto Part/Fuel Lock | Facility ID#: 0-791718 | Event #: 7 |
|---|---|---|---|
| Facility Address: 757 Old Navy Road, Millington, Tennessee | | Technician: Lewis | Date: 5/17/99 |

| Well Designation | Well Diameter (inches) | Total Depth (feet) | Before EFR® Event | | | After EFR® Event | | | Depth to Liquid Change (feet) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Depth to SPH (feet) | Depth to Water (feet) | SPH Thickness (feet) | Depth to SPH (feet) | Depth to Water (feet) | SPH Thickness (feet) | |
| MEM-1 | 4 | | - | 4.60 | 0.00 | - | 10.00 | 0.00 | -5.40 |
| MEM-2 | 4 | | - | 3.29 | 0.00 | - | 10.10 | 0.00 | -6.81 |
| MEM-3 | 4 | | - | 4.87 | 0.00 | - | 9.50 | 0.00 | -4.63 |
| MEM-6 | 4 | | - | 3.65 | 0.00 | - | 9.90 | 0.00 | -6.25 |
| MEM-7 | 4 | | - | 4.26 | 0.00 | - | 9.90 | 0.00 | -5.64 |
| MEM-8 | 4 | | - | 4.90 | 0.00 | - | 10.00 | 0.00 | -5.10 |
| MEM-11 | 4 | | - | 5.15 | 0.00 | - | 5.43 | 0.00 | -0.28 |
| MEM-12 | 4 | | - | 4.93 | 0.00 | - | 11.20 | 0.00 | -6.27 |
| MEM-13 | 4 | | - | 4.30 | 0.00 | - | 10.40 | 0.00 | -6.10 |
| MEM-14 | 6 | | - | 4.13 | 0.00 | - | 10.30 | 0.00 | -6.17 |
| MEM-16 | 6 | | - | 4.94 | 0.00 | - | 4.95 | 0.00 | -0.01 |
| B-3 | 4 | | - | 4.67 | 0.00 | - | 9.80 | 0.00 | -5.13 |
| B-4 | 4 | | - | 5.02 | 0.00 | - | 4.98 | 0.00 | 0.04 |

ECOVAC SERVICES

Comments:

Differential Pressure and Groundwater Drawdown Data Recorded During EFR®
Event No. 7 (May 17, 1999)
NEX (Navy Exchange) Auto Part/Fuel Lock
757 Old Navy Road
Millington, Tennessee

## DIFFERENTIAL PRESSURE DATA

| | | Well Designation: | |
|---|---|---|---|
| | | MEM-3 | MEM-6 |
| Nearest Extraction Well: | | MEM-14 | MEM-2 |
| (Approx. Distance): | | (50 feet) | (75 feet) |
| Time | Elapsed Time | Differential Pressure Readings (inches of water): | |
| 8:00 | 0.5 hr. | >0.00 | >0.00 |
| 8:30 | 1.0 hr. | >0.00 | 0.00 |
| 9:00 | 1.5 hrs. | 0.00 | 0.00 |
| 9:30 | 2.0 hrs. | 0.00 | 0.00 |
| 10:30 | 3.0 hrs. | 0.00 | 0.00 |
| 11:30 | 4.0 hrs. | 0.00 | - |
| 12:30 | 5.0 hrs. | 0.00 | - |
| 13:30 | 6.0 hrs. | 0.00 | - |
| Maximum Change: | | 0.00 | 0.00 |

## GROUNDWATER DRAWDOWN DATA

| | | Well Designation: | | |
|---|---|---|---|---|
| | | MEM-11 | B-4 | MEM-16 |
| Nearest Extraction Well: | | MEM-8 | B-3 | B-3 |
| (Approx. Distance): | | (37 feet) | (54 feet) | (75 feet) |
| Time | Elapsed Time | Depth to Liquid (feet below top of casing): | | |
| Prior to EFR® | | 5.15 | 5.02 | 4.94 |
| 14:30 | 7.0 hrs. | 5.43 | 4.98 | 4.95 |
| Maximum Change: | | -0.28 | +0.04 | -0.01 |