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# Sampling and Analysis Plan for Post-Groundwater Modeling Parameter Confirmation

EPA United States Environmental Protection Agency

## Popile, Inc. Superfund Site

**September 1999**

**El Dorado, Arkansas**

**Total Environmental Restoration Contract**
**Contract No. DACA56-94-D-0021**


***Prepared by:***
**Morrison Knudsen Corporation**
**Littleton, Colorado**

***Prepared for:***
**U.S. Army Corps of Engineers**
**New Orleans District**
**New Orleans, Louisiana**


MORRISON KNUDSEN CORPORATION

# SAMPLING AND ANALYSIS PLAN
# FOR
# POST-GROUNDWATER MODELING
# PARAMETER CONFIRMATION

## POPILE, INC. SUPERFUND SITE
## El Dorado, Arkansas

**Prepared For:**

**U.S. Army Corps of Engineers,**
**New Orleans District**
**New Orleans, Louisiana**

**Prepared By:**

**Morrison Knudsen Corporation**
**Littleton, Colorado**

**Under Contract to:**

**U.S. Army Corps of Engineers**
**Tulsa District**
**Tulsa, Oklahoma**

**TOTAL ENVIRONMENTAL RESTORATION CONTRACT**
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**September 1999**

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### Appendices

## Acronym List

| | |
|---|---|
| ADEQ | Arkansas Department of Environmental Quality |
| ADPCE | Arkansas Department of Pollution Control and Ecology |
| ASTM | American Society of Testing and Materials |
| BTEX | Benzene, toluene, ethylbenzene, and xylene |
| CDM | Camp, Dresser & McKee |
| COCs | Contaminants of Concern |
| DQO | Data Quality Objective |
| FSP | Field Sampling Plan |
| LIF | Laser-Induced Fluorescence |
| MK | Morrison Knudsen Corporation |
| MNA | Monitored Natural Attenuation |
| MSL | Mean Sea Level |
| NAPL | Non-aqueous Phase Liquid |
| PAHs | Polynuclear Aromatic Hydrocarbons |
| PCP | Pentachlorophenol |
| QA | Quality Assurance |
| QC | Quality Control |
| RA | Removal Action |
| RCRA | Resource Conservation and Recovery Act |
| RD | Remedial Design |
| RI/FS | Remedial Investigation/Feasibility Study |
| ROD | Record of Decision |
| SAP | Sampling and Analysis Plan |
| SCAPS | Site Characterization and Analysis Penetrometer System |
| SOP | Standard Operating Procedure |
| SSHP | Site Safety and Health Plan |
| USACE | United States Army Corps of Engineers |
| USEPA | United States Environmental Protection Agency |

## 1.0 Introduction

This Sampling and Analysis Plan (SAP) outlines post-groundwater modeling investigations to be implemented at the discretion of the U.S. Environmental Protection Agency (USEPA) at the Popile, Inc. Superfund site (the Popile site). Data to be collected under the SAP will be to confirm processes proven important to the groundwater modeling efforts but not completely documented, and to establish a temporal monitoring program to expand on previous multi-phase field sampling efforts for characterizing the Popile site.

Remedial Design (RD) has been conducted at the site since the issuance of the Record of Decision (ROD), which outlined a proposed remedy for source control and groundwater containment. Sampling efforts on behalf of the RD include Phase I investigations, which focused on locating areas of residual sources (i.e. contaminated soil) and defining subsurface stratigraphy utilizing the Site Characterization and Analysis Penetrometer System (SCAPS) technology. Phase I results (and results from earlier studies) were evaluated and used to design the Phase II field investigation. Phase II sampling collected data to support the groundwater investigation and modeling efforts for the RD activities at the site. Data from these studies were used to evaluate the contaminant loading, present and future, to the nearby Bayou de Loutre.

Results from the MK Phase II RD investigation and numerical modeling of groundwater fate and transport concluded that groundwater contamination is not entering Bayou de Loutre or other off-site receptors now, nor will it affect these entities in the future. Actual monitoring well data have demonstrated that the dissolved-phase groundwater contamination is limited to a 185-ft travel distance within the immediate area of the former process ponds used in wood treating, and is not impacting Bayou de Loutre or other off-site receptors. As the treating operations date to the 1940's, the plume has had decades to migrate from the source area. Despite this opportunity, only a limited aerial impact has been observed and measured, indicating a steady-state condition.

Groundwater modeling and calibration efforts have predicted that the plumes currently reside in a steady-state condition, i.e. stable. This means that the release of contaminants of concern (COCs) from the residual sources is balanced by (1) sorption within the Cockfield sands; and, (2) their destruction by biodegradation. As a result, dissolved pentachlorophenol (PCP) and naphthalene will continue to be restrained to an area approximately 185 ft beyond the remaining source areas. Other polynuclear aromatic hydrocarbon (PAH) COCs will remain stable.

Monitored natural attenuation (MNA) is therefore a viable option to closing the site, provided control of the source areas against human contact or consumption of groundwater is addressed. This SAP outlines a five-year sampling program that will provide on-going plume monitoring to confirm the predictions of the groundwater model and calibration, namely, a stable plume. Confirmation of a stable or shrinking plume is referred to in the literature as a primary line of evidence for natural attenuation (see Section 1.2.6). This SAP also details sampling that will produce data to show aquifer conditions conducive to natural attenuation processes, indirect evidence which is considered a secondary line of evidence. Sampling will also be performed to obtain micro-organism data that is a tertiary line of evidence for natural attenuation.

## 1.1 Site Background

The Popile site is located approximately 1/4 mile south of the intersection of Southfield Road and U.S. Highway 82 in El Dorado, Union County, Arkansas. The following overview of the historical use of the property and previous investigations at the site is condensed and modified from the Remedial Investigation/Feasibility Study [(RI/FS), Camp, Dresser & McKee (CDM) Federal Programs, Corp. (CDM 1992)], the ROD (USEPA 1993), and work by the U.S. Army Corps of Engineers (USACE 1997) and Morrison Knudsen Corporation (MK 1999a), from 1997 through 1999.

### 1.1.1 History of Operations

Figure 1 shows the layout of the Popile site. The Popile site is an inactive wood treatment/ preserving facility that utilized creosote, PCP, and petroleum distillates (such as diesel) in its processes. Wood-preserving operations using creosote began in 1947. In 1958, wood preserving operations at the site included the use of PCP as well as creosote.

A small impoundment (No. 1) was initially constructed at the Popile site to store process wastewater and sludge from the early operations. By 1964, Impoundment No. 1 had grown considerably in size and a sludge pit was apparently added. In a 1964 aerial photo, significant surface contamination apparently existed across the northern portion of the site due to overflow and/or discharge from Impoundment No. 1. It appears from this photo that surface contamination had entered the adjoining Bayou as well. By 1969, two additional process impoundments were constructed near Impoundment No. 1. Wastewater treatment using these three impoundments began in 1976. Wood preserving operations continued for several years at the site, and ceased on July 1, 1982.

In a 1984 photo, a small surface impoundment (No. 4; unknown operation) existed south of the three major process impoundments in the former lumber storage yard. Resource Conservation and

Recovery Act (RCRA) closure activities for the three major process impoundments at the site were completed by Popile, Inc. in October 1984 under the administration of the Arkansas Department of Pollution Control and Ecology [ADPCE, now Arkansas Department of Environmental Quality (ADEQ)]. Detailed descriptions of the Popile site history appear in previous MK documents (MK 1999a, 1999b).

### 1.1.2 History of Investigations and Remedial Activities

From 1988 through 1990, the USEPA conducted preliminary inspections and assessments at the site in response to reported leakage of contamination from the closed impoundments. In September 1990, the USEPA performed a Removal Action (RA) at the site. This consisted of excavating a soil cell and debris cell in the impoundment area, former facilities area, and northern parts of the site (Ecology and Environment, Inc. 1991). The excavated material, estimated to be 30,000 cubic yards of sludges and contaminated soils, was then stabilized using rice hulls and fly ash and placed into a large clay-lined holding cell constructed on the southern portion of the site.

The RI/FS for the site was prepared for the USEPA by CDM in June 1992, leading to the Record of Decision (ROD) for the site in February of the following year. CDM collected supplemental data on the site in the summer and fall of 1993 (CDM 1994). This additional information was acquired to aid in the design of the selected remedy and to assist in other RD activities.

In 1997, the USACE used Site Characterization and Analysis Penetrometer System (SCAPS) technology to determine the extent of residually-contaminated soils beneath the excavated process ponds that pose an ongoing threat to groundwater.

In 1998 and 1999, MK performed subsurface soils and groundwater investigations to confirm the extent of residual sources, investigate the extent of dissolved phase groundwater contamination, and provide data for groundwater modeling. The investigation included installation of eight boreholes, twenty-one monitoring wells, and two pump/observation well pairs to augment the monitoring systems in place from prior studies. MK investigations provided substantial amounts of data regarding subsurface soils and groundwater as to water quality, rate of flow, and sorption and biodegradation characteristics.

Groundwater modeling results demonstrated that the plumes are in a steady-state condition, will remain that way, and will only impact groundwater to a travel distance of approximately 185 ft beyond the remaining source areas.

## 1.2 Site Status

### 1.2.1 Physical Features

The Popile site comprises about 41 acres, bordered on the west by Southfield Road, the Ouachita Railroad (also known as the East Camden & Highland Railroad) on the east, and Bayou de Loutre on the north (Figure 1). Land surface elevations across the site range from 220 to 185 ft above mean sea level (MSL). The most pronounced topographic features on the site consist of the capped holding cells in the southern portion of the site. The surface of the larger of the two cells is raised 15 to 20 ft above the natural grade.

The Popile site is surrounded by wooded areas. Stands of trees exist in the northwest portion of the site and are scattered across the southern portion. Surface water drainage in the northern half of the site (including the old impoundment and facility areas) is northward toward Bayou de Loutre. In the southern half of the site, surface water drains radially off the holding cell caps.

### 1.2.2 Residual Source Materials

Contaminated soils (residual source) are still in place at the Popile site. These soils, as defined by the SCAPS laser-induced fluorescence (LIF) probe and RD drilling, exist beneath most of the clean backfill of the RA excavation and in some areas outside the excavation. The thickest sections of contaminated soils occur beneath the former impoundments, sludge pit, and facilities area. Thin zones of mildly-contaminated soils do exist off-site to the northeast, but are limited in thickness (MK 1999a).

Relevant to this SAP, the residual soil sources, consisting of non-aqueous phase liquid, or NAPL, are immobile. Groundwater in contact with the NAPL has very high concentrations of contaminants, probably creating a toxic environment to microorganisms (MK 1999a). However, outside of residual source areas, groundwater concentration quickly decrease to the point where biodegradation may be occurring under anaerobic or anaerobic conditions.

Overflow and discharge from impoundment No. 1 occurred through time, resulting in surface and shallow subsurface contamination across the northern portion of the site. This may serve as a secondary source of contamination to groundwater. Surface water monitoring indicates no impacts to the Bayou, despite some sediments bearing site contaminants, and no further surface water monitoring is proposed in this plan.

### 1.2.3 Site Groundwater Flow

The fluvial deposits overlying the Cook Mountain Formation, the Cockfield Formation and Quaternary alluvium, are referred to as the alluvial aquifer. Information on groundwater conditions within this aquifer was obtained in the RI (March 1992), and during the RD program (MK 1999a). Groundwater within the aquifer appears to be generally under confined to semi-confined conditions, but locally may be unconfined. Groundwater flow is east to northeast through the process pond area. MK (1999a) summarizes site groundwater flow conditions.

### 1.2.4 Dissolved-Phase Contamination

According to the ROD (USEPA 1993), the contaminants of concern (COCs) at this site consist of PCP and the following polynuclear aromatic hydrocarbons (PAHs): benzo(a)pyrene, dibenz(a,h)anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene. However, MK(1999a; 1999b) demonstrated that PCP and Naphthalene are the most mobile of the contaminants and representative or worst case contaminant movement. These constituents are proposed for further monitoring in this SAP.

The dissolved PCP plume is shown by the isoconcentration lines in Figure 2. The figure shows that the concentrations are localized to the area around the former impoundments, facilities area, and sludge pit, which correlate well with the area of existing residual soil contamination.

Given the plume condition of Figure 2, existing monitoring wells may be used at the site to further characterize portions of the site relative to the plume, depending on their location:

- Upgradient and downgradient areas
- Plume core and plume periphery, and unaffected areas

Upgradient and downgradient areas are unaffected by contamination. They are outside the plume boundary and represent background conditions for the biogeochemical environment. Wells spread over a wide upgradient and downgradient area also allow, through water level measurements, definition of the direction of groundwater flow. "Leading edge" wells separate the plume from unaffected areas in the direction of flow, and lie within the downgradient area.

The plume boundary contains (1) a core area, which is a subset of the entire plume area; and (2) the remaining area of the plume (outside the core), which is the plume periphery. Wells within the core may lie within an anaerobic biogeochemical environment. Within the plume periphery, zones of aerobic and anaerobic biodegradation may exist. Wells generally in the core area and extending some

unknown distance beyond will aid in determining if and where there is a change in the degradation process from anaerobic to aerobic.

### 1.2.5 Monitoring Well Inventory

The RI/FS and Supplemental Investigation, plus RD investigations including Phase I SCAPS and Phase II (MK Groundwater Investigation), resulted in a present configuration of 44 monitoring wells and 12 piezometers at the Popile site (MK 1999a). Other wells existed at times in the past, but have since been abandoned. Table 2 shows the current monitoring wells at the site.

The wells (Figure 1) are appropriately configured to monitor and investigate the nature and extent of the contamination. The existing well configuration covers areas important to monitoring at any site, including upgradient area, plume core and plume periphery, downgradient, and leading edge areas.

### 1.2.6 Remediation by Monitored Natural Attenuation

Natural attenuation is the reduction in mass, concentration, or mobility of a COC with distance and time due to naturally occurring processes in the groundwater system, such as physical, sorption, and biodegradation. Physical and sorption processes result in the reduction of the concentration and/or mobility of a chemical, but not its total mass. As a result, these processes are referred to as "non-destructive" mechanisms. In contrast, chemical and biological reactions serve to reduce the total mass in the aquifer and are referred to as "destructive" mechanisms.

MNA is a remedial option that can be used by itself or combined with other remedial approaches (USEPA 1997a). It is not, however, a "presumptive" or "default" remedy; rather, it is one alternative that may be evaluated along with other applicable remedies. USEPA does not consider monitored natural attenuation to be a "no action" or "walk-away" approach. Instead, MNA is considered to be one of multiple viable options that may be potentially appropriate for a limited set of site circumstances where using MNA meets the applicable statutory and regulatory requirements.

The use of MNA, in combination with other remedial activities at a site, is subject to demonstration that certain activities are taking place. These activities have been grouped, for regulatory evaluation purposes, into three lines of evidence: primary, secondary, and tertiary. Primary lines of evidence rely on historical data to determine if contaminant plumes are shrinking or stable. Secondary lines of evidence include data that indirectly demonstrate that natural attenuation processes are active at the site, such as monitoring indicator compounds (oxygen, nitrate, sulfate, iron, etc.) methane, and

contaminant daughter products. Tertiary lines of evidence are the results of laboratory "microcosm" or field studies that demonstrate microbial activity in the soil or aquifer material (USEPA 1997b).

Previous studies at the Popile site support, to varying degrees, each of the three lines of evidence (Table 1). However, these studies have not tested for the existence of anaerobic organisms that may be destructively reducing the mass of COCs. The existence of anaerobic organisms capable of biodegrading the site COCs would provide further tertiary evidence that would be useful in determining the appropriateness of MNA at the Popile site. This SAP is designed in part to further evaluate the potential for anaerobic activity at the Popile site.

### 1.2.7 Data Gaps

The current data gaps are as follows:

- Confirmation of anaerobic activity in the aquifer
- Confirmation of a stable plume through monitoring of COCs on a regular basis
- Confirmation of redox conditions and the extent of the aerobic zone
- Confirmation of alternate/ultimate breakdown products of biodegradation: chloride and carbon dioxide

Previous studies have identified COC-tolerant aerobic organisms in the Popile soils and groundwater. However, the existence of anaerobic organisms at the site has not been demonstrated. This sampling plan details sampling that addresses the data gap regarding whether such anaerobic organisms exist at the site, and to what extent they may be contributing to biodegradation.

Data from previous studies have not been able to identify a good aerobic zone within the aquifer. This is the result, in part, of certain data readings that were considered to be unreliable for redox conditions (dissolved oxygen, etc.). This sampling plan will outline additional sampling to fill the data gaps surrounding redox and aerobic zone definition.

This SAP details a temporally-phased water quality sampling program that will assist in contaminant plume monitoring. These plume monitoring samples will serve to confirm or refute the predictions of the groundwater model, wherein the contaminant plume has been judged to be stable.

**Table 1**

**Summary of Evidence Supporting Natural Attenuation at Popile**

| Lines of Evidence /Prior Investigation | Primary Lines of Evidence: Stable or Shrinking Plume | Secondary Lines of Evidence: Biogeochemical Environments | Tertiary Lines of Evidence: Microbial Assays |
|---|---|---|---|
| **RI and Supplemental Data Reports (CDM)** | Initial monitoring network showed no widespread contamination, but by definition, could not establish any change from earlier conditions. | | |
| **Meso-Scale Bio-attenuation Study (WES)** | | 168 day study of biodegradation in cultivated soils cells showed peak $CO_2$ production corresponding to oxygen depletion. | Results showed a trend in total PAH reduction and an increase in microbial activity as measured by respiration and biomass. PCP appeared to be recalcitrant, with no significant reduction in concentration during the meso scale study. |
| **Phase II RD Data Collection (MK 1999a)** | East of the process ponds, contamination is absent within a travel distance of 185 feet after 50 years of potential movement. Large amount of time between CDM and MK work, and non-comparable well networks, again preclude direct temporal comparisons.<br><br>Apparently stable plume. | **Aerobic Environments** - Noticeable features among four zones sampled (upgradient, source, source periphery and down gradient were depressed oxygen levels and low microbial numbers in the source area. In addition, whereas one out of four measurements in the up gradient zone showed a $CO_2$ concentration greater than 100 mg/L, three out of eight measurements in the source and source periphery zones showed elevated $CO_2$ concentrations. Although not accompanied by significant increases in microbial populations, the elevated $CO_2$ concentrations may be indicative of zones of aerobic metabolism.<br><br>**Anaerobic Environments** - In anaerobic respiration, microbes use a chemical other than oxygen as an electron acceptor to oxidize the organic contaminant. Common electron acceptors in anaerobic respiration are nitrate ($NO_3^-$), sulfate ($SO_4^{2-}$), ferric iron ($Fe^{3+}$), or manganese ($Mn^{4+}$). Major byproducts are nitrogen gas ($N_2$), hydrogen sulfide ($H_2S$), reduced forms of metals, and methane ($CH_4$), depending on the electron acceptor. Data did not indicate overall trends in the levels of the anaerobic electron acceptors, although some localized effects were seen. Source area well MW-18 contained 47 mg/L nitrite, which appears significant when compared with the non-detectable levels in the other wells. However, there was no detectable nitrite in any of the other samples from source area wells.<br><br>Total iron and dissolved iron concentrations appeared elevated in the source area. All total iron measurements exceeded background levels, but concentrations were highest within the source area. Concentrations of $Fe^{3+}$ and manganese were also higher in source area wells, possibly indicating the presence of a reductive pathway. Chloride levels appeared to be elevated in all wells, with the highest concentrations occurring within the source and source periphery areas, possibly the result of reductive dechlorination of chlorinated organic compounds (USEPA, 1997). | Laboratory enumerations on soil did not identify PCP- or BaP-degrading organisms. None of the plates containing PCP or BaP as a sole carbon source supported any visible growth. Colonies were identified that could grow in the presence of PCP and BaP; these were identified as contaminant-tolerant populations. This would seem to indicate that indigenous organisms are acclimated to certain concentrations of site contaminants but there are no significant populations present that utilize PCP or BaP for growth.<br><br>Contaminant-tolerant populations in some groundwater samples were characterized as BaP-tolerant, but not PCP-tolerant. The results were consistent with a model that assumes contaminant-tolerant populations will become acclimated in areas where the concentration of dissolved contaminant can support, but is not toxic to, a degrading population.<br><br>Dissolved oxygen level measurements and total heterotrophic plate counts show sufficient oxygen and aerobic organisms present in most of the samples to validate the assumption that any biodegradation of PCP that might be occurring is an aerobic process. It is also most likely true that anaerobic degradation is occurring in zones where the dissolved oxygen levels are very low.<br><br>Weight of evidence supports the assumption that biological activity is occurring but do not indicate that biodegradation is a dominant mechanism for contaminant transformation or destruction. |

**Table 1 (cont.)**
**Summary of Evidence Supporting Natural Attenuation at Popile**

| Lines of Evidence /Prior *Investigation* | Primary Lines of Evidence: Stable or *Shrinking Plume* | Secondary Lines of Evidence: Biogeochemical Environments | Tertiary Lines of Evidence: Microbial Assays |
|---|---|---|---|
| **Model Study (MK 1999b)** | Biodegradation is a necessary condition for stabilizing the contaminants, and is the sole mechanism responsible for retracting the low (single to tens of $\mu$g/L) dissolved phase contamination from where they would have traveled with sorption and dispersion acting alone. | Basic input on biodegradation rates resulted in depressed dissolved oxygen from model output very similar to the depressed pattern and range observed in the field. | |

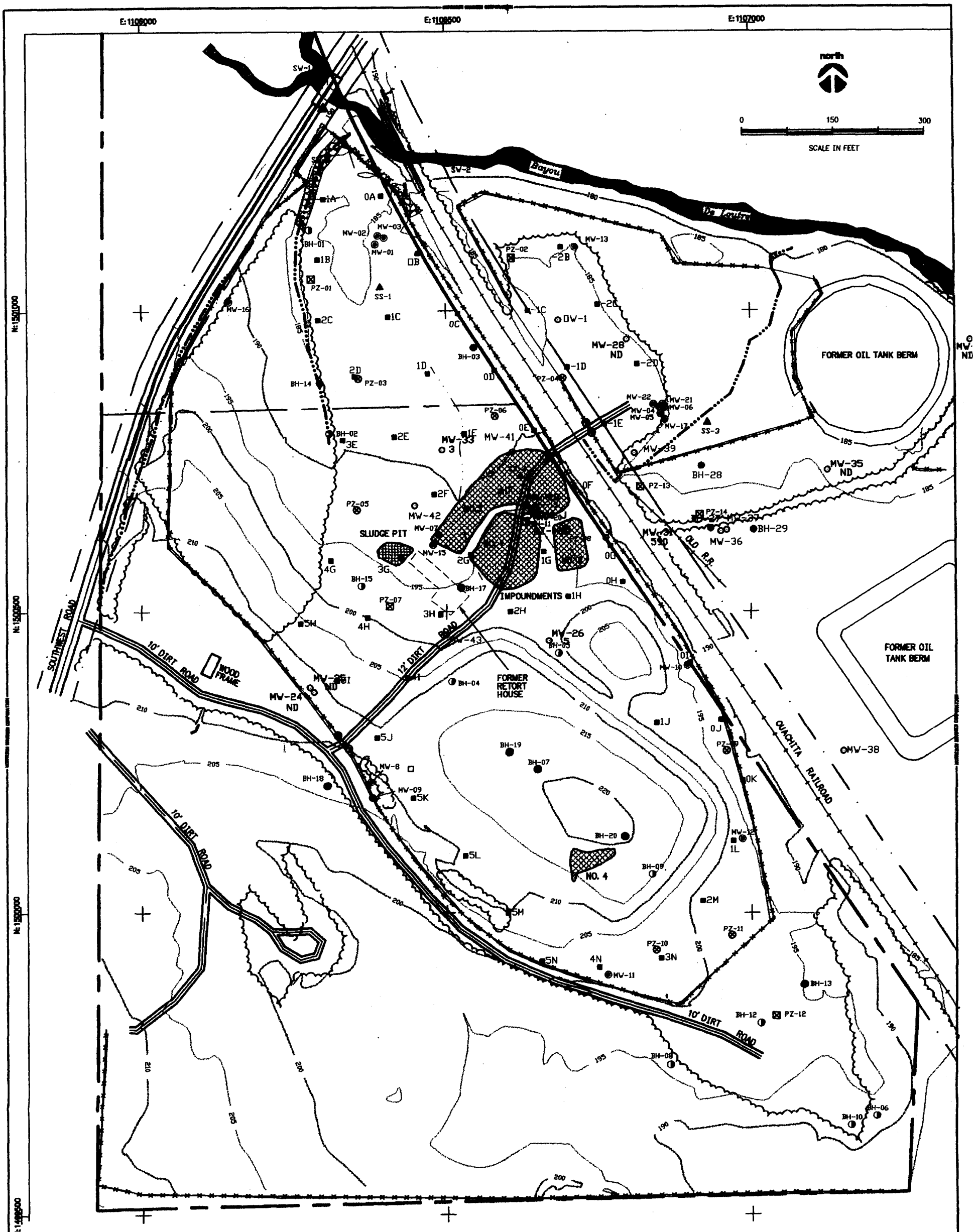
**TABLE 2**
**MONITORING WELL INVENTORY**

| Monitoring Well or Piezometer | Top of Casing Elevation (ft, MSL) | Screened Interval (ft, bgs) |
|---|---|---|
| MW-01 | 187.99 | 5.0 - 10.0 |
| MW-02 | 188.05 | 14.0 - 24.0 |
| MW-03 | 187.22 | 28.5 - 38.5 |
| MW-04 | 186.76 | 5.0 - 10.0 |
| MW-05 | 188.19 | 14.0 - 24.0 |
| MW-06 | 186.81 | 9.0 - 29.0 |
| MW-08 | 208.59 | 9.0 - 14.0 |
| MW-09 | 207.98 | 41.0 - 51.0 |
| MW-10 | 194.82 | 7.0 - 17.0 |
| MW-12 | 199.55 | 7.0 - 17.0 |
| MW-13 | 187.36 | 4.0 - 14.0 |
| MW-15 | 195.37 | 35.0 - 45.0 |
| MW-18 | 198.42 | 10.0 - 20.0 |
| MW-24 | 213.31 | 20.0 - 30.0 |
| MW-25 | 213.52 | 56.0 - 66.0 |
| MW-26 | 200.40 | 18.0 - 28.0 |
| MW-27 | 190.36 | 23.0 - 28.0 |
| MW-28 | 188.33 | 25.0 - 35.0 |
| MW-31 | 194.33 | 29.5 - 32.0 |
| MW-32 | 187.24 | 20.0 - 30.0 |
| MW-33 | 191.66 | 23.0 - 33.0 |
| MW-34 | 186.32 | 20.0 - 30.0 |
| MW-35 | 188.64 | 20.0 - 30.0 |
| MW-36 | 189.63 | 40.0 - 50.0 |
| MW-37 | 189.76 | 20.0 - 30.0 |
| MW-38 | 190.67 | 9.0 - 19.0 |
| MW-39 | 190.38 | 20.0 - 30.0 |
| MW-40 | 191.47 | 20.0 - 30.0 |
| MW-41 | 192.48 | 20.0 - 30.0 |

**TABLE 2 (cont.)**
**MONITORING WELL INVENTORY**

| Monitoring Well or Piezometer | Top of Casing Elevation (ft, MSL) | Screened Interval (ft, bgs) |
|---|---|---|
| MW-42 | 195.01 | 20.0 - 30.0 |
| MW-43 | 200.98 | 20.0 - 30.0 |
| PZ-02 | 186.64 | 12.5 - 15.0 |
| PZ-03 | 189.11 | 12.0 - 14.5 |
| PZ-04 | 188.37 | 12.5 - 15.0 |
| PZ-08 | 196.19 | 12.5 - 15.0 |
| PZ-09 | 194.14 | 12.5 - 15.0 |
| OW-1 | 188.54 | 30.0 - 35.0 |

Note: All listed wells and piezometers to have water level measurements taken for all sampling events.




## LEGEND - EXISTING ITEMS

| | | | |
|---|---|---|---|
| ▲ | TEMP. VERT. BENCH MARK | | TREELINE |
| ◑ | BOREHOLE (BH) (UNSURVEYED) | | FENCE (WIRE STRAND) |
| ● | BOREHOLE (BH) | | RAILROAD |
| ◉ | MONITORING WELL (MW-) | | EDGE OF ROAD |
| ⊗ | PIEZOMETER (PZ) | | PROPERTY BOUNDARY LINE |
| ⊠ | PIEZOMETER (PZ-) (UNSURVEYED) | R.O.W. | RIGHT OF WAY (ROW) |
| ▲ | SURFACE SOIL LOCATION (SS-) | | BUILDING |
| △ | SURFACE WATER/SEDIMENT LOCATION (SW-) | | RIPRAP |
| ■-2C | SCAP LOCATIONS | | FORMER IMPOUNDMENTS AND PITS |

<CPD: 07/08/99 [TIME: 2:06 PM]>

**POPILE, INC. SUPERFUND SITE**
EL DORADO, ARKANSAS
POST GROUNDWATER MODELING SAMPLING
USACE TULSA DISTRICT

Figure 1

**SITE MAP - SHOWING PREVIOUS SAMPLING LOCATIONS AND SITE FEATURES**

MORRISON KNUDSEN CORPORATION
10822 W. TOLLER DR., LITTLETON CO 80127 Tel (303) 948-4000

| | | | |
|---|---|---|---|
| SCALE: 1"=150' | DATE: | WORK ORDER NUMBER: 4423-0180 | 11 of 17 |
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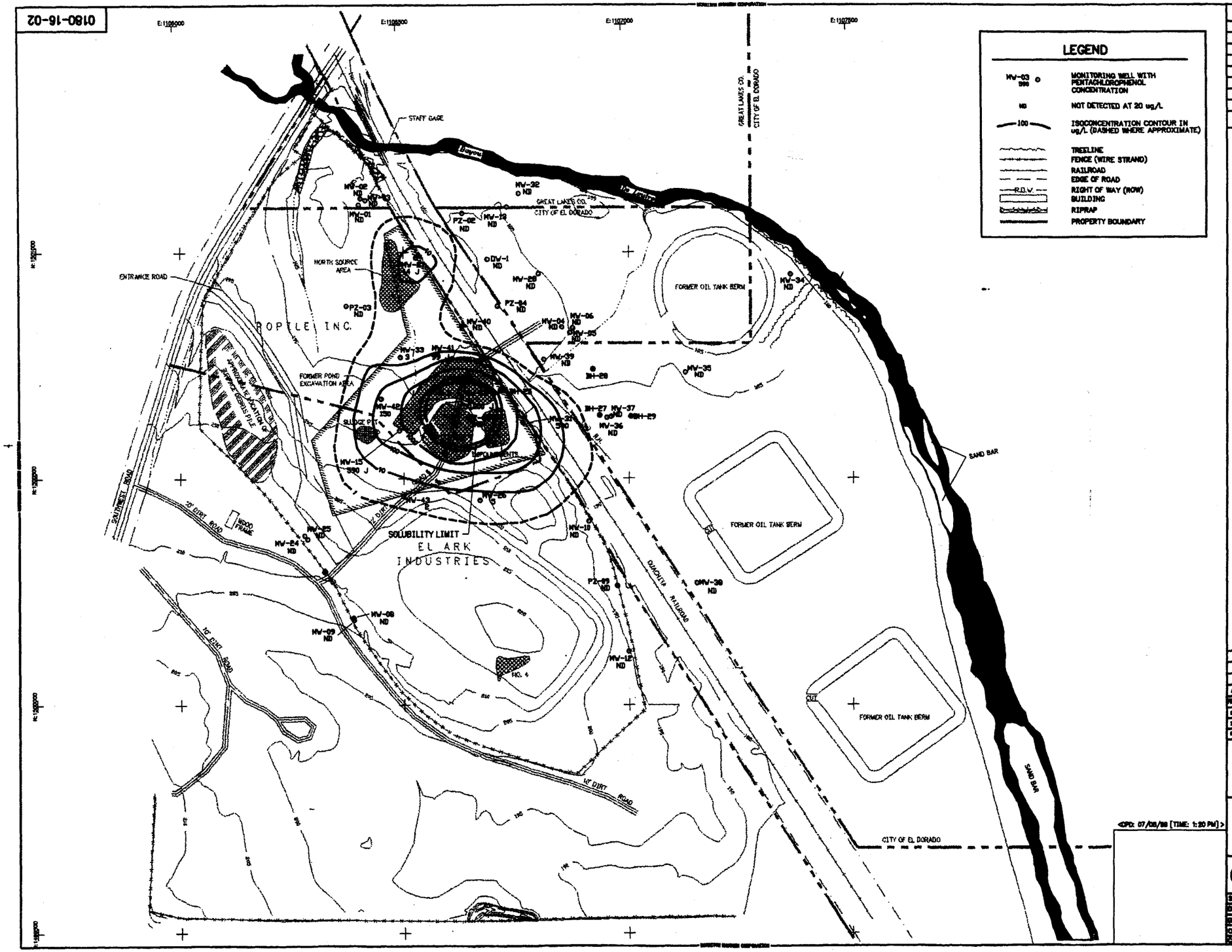


## LEGEND

- MW-03 990 — MONITORING WELL WITH PENTACHLOROPHENOL CONCENTRATION
- ND — NOT DETECTED AT 20 ug/L
- 100 — ISOCONCENTRATION CONTOUR IN ug/L (DASHED WHERE APPROXIMATE)
- TREELINE
- FENCE (WIRE STRAND)
- RAILROAD
- EDGE OF ROAD
- R.O.W. — RIGHT OF WAY (ROW)
- BUILDING
- RIPRAP
- PROPERTY BOUNDARY

## REFERENCE DRAWINGS

| DRAWING NO. | TITLE |
|---|---|
| | |
| | |
| | |
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| | |
| | |
| | |

## NOTES

100 50 0 100 200 FT.
SCALE IN FEET

| REV | DATE | BY | CHKD | DESCRIPTION |
|---|---|---|---|---|
| A | 07/08/98 | JS | JM | ISSUED FOR REVIEW AND COMMENT |

POPILE, INC. SUPERFUND SITE
EL DORADO, ARKANSAS
POST GROUNDWATER MODELING SAMPLING
USACE TULSA DISTRICT

Figure 2
DISSOLVED PENTACHLOROPHENOL CONCENTRATIONS IN GROUND WATER OF UPPER COCKFIELD SANDS

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MORRISON KNUDSEN CORPORATION
10982 W. TOLLER DR., LITTLETON, CO 80127 Tel (303) 948-4000

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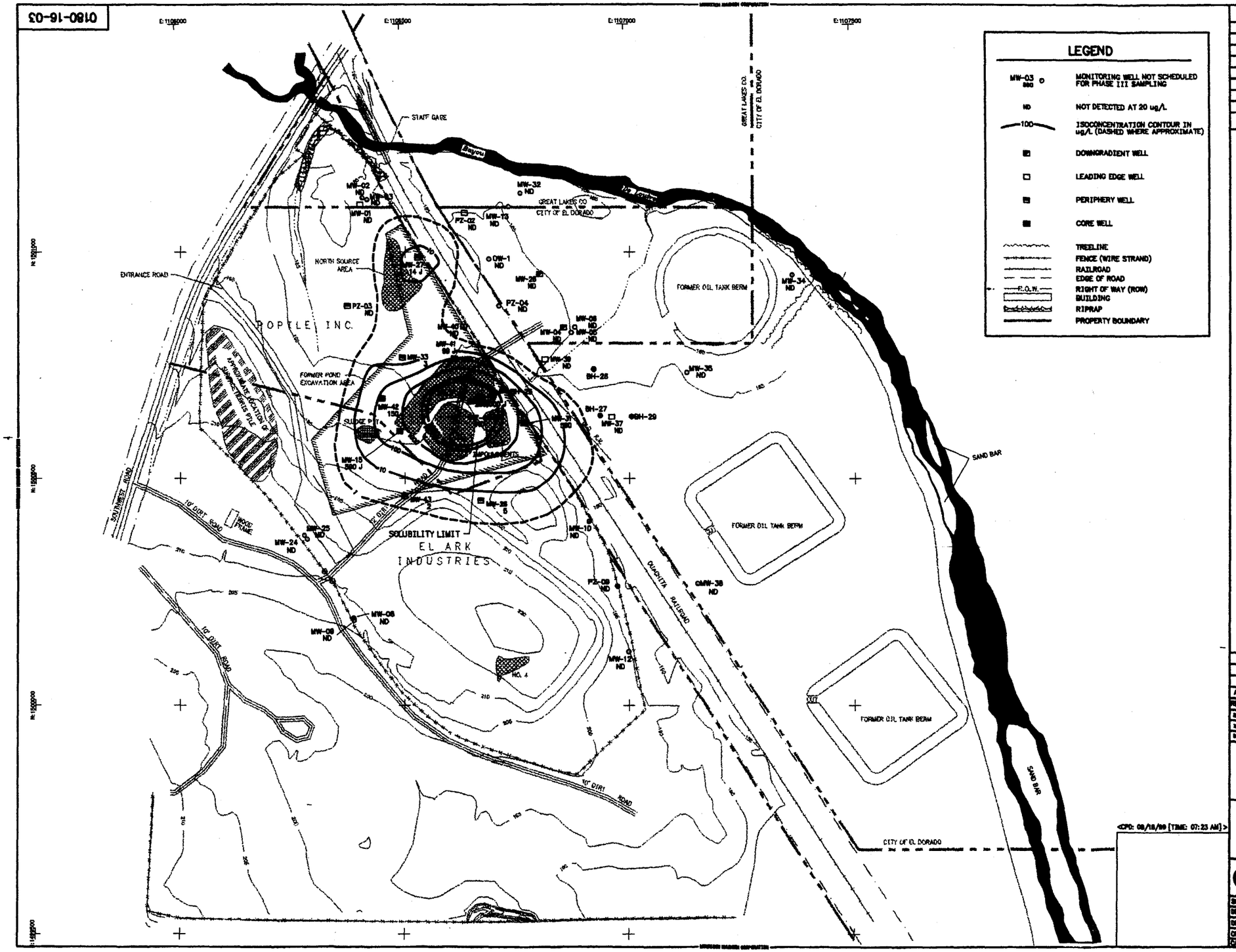


## LEGEND

- MW-03 880 — MONITORING WELL NOT SCHEDULED FOR PHASE III SAMPLING
- ND — NOT DETECTED AT 20 ug/L
- 100 — ISOCONCENTRATION CONTOUR IN ug/L (DASHED WHERE APPROXIMATE)
- DOWNGRADIENT WELL
- LEADING EDGE WELL
- PERIPHERY WELL
- CORE WELL
- TREELINE
- FENCE (WIRE STRAND)
- RAILROAD
- EDGE OF ROAD
- R.O.W. — RIGHT OF WAY (ROW)
- BUILDING
- RIPRAP
- PROPERTY BOUNDARY

## REFERENCE DRAWINGS

| DRAWING NO. | TITLE |
|---|---|
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## NOTES

north

100 50 0 100 200 FT.
SCALE IN FEET

| REV | DATE | BY | CK | DESCRIPTION |
|---|---|---|---|---|
| A | 08/18/99 | JS | JM | ISSUED FOR REVIEW AND COMMENT |

POPILE, INC. SUPERFUND SITE
EL DORADO, ARKANSAS
POST GROUNDWATER MODELING SAMPLING
USACE TULSA DISTRICT

Figure 3
GROUND WATER CHEMICAL SAMPLING LOCATIONS

<CPD: 08/18/99 [TIME: 07:23 AM]>

MORRISON KNUDSEN CORPORATION
10822 W. TOLLER DR., LITTLETON, CO 80127 Tel (303) 948-4000

| | | | |
|---|---|---|---|
| SCALE: 1"=200' | DATE | WORK ORDER NUMBER | 11 of 17 |
| DRAWN: J. STEWART | 08/18/99 | 4423-0180 | |
| DESIGNED: J. MYERS | 08/18/99 | DRAWING NUMBER | REV |
| CHECKED: J. SIEBEL | 08/18/99 | 0180-16-03 | A |
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001673

# 2.0 Phase III Investigation and Sampling Program Overview

## 2.1 Field Program Objectives

This proposed post-groundwater modeling five-year monitoring program is herein designated the Phase III investigation program of the RD activities. The Phase III investigation and sampling program will have three main objectives:

- To prove the primary line of evidence of a stable or shrinking plume by providing a five-year, temporally-phased groundwater monitoring program to test the predictions of the groundwater model and calibration, and to better understand the redox conditions within the aquifer.

- To confirm a secondary line of evidence for natural attenuation by measuring and confirming redox conditions within the aquifer and to identify the extent of the aerobic zone and confirm aerobic breakdown products.

- To test the tertiary line of evidence by testing for anaerobic organisms in Popile groundwater that may contribute to the destructive biodegradation of COCs. Previous sampling and groundwater modeling studies have shown that anaerobic degradation is most likely occurring in zones where the dissolved oxygen levels are very low. However, specific anaerobic bacteria capable of biodegrading the site COCs have not been investigated in previous work. This study will attempt to identify anaerobic organisms that are contributing to the natural attenuation process at the Popile site in an attempt to augment tertiary evidence for MNA. Identification of such organisms will be performed by means of laboratory DNA identification and lipid analysis.

Each objective will require collection of data on various parameters. Section 3 summarizes the parameters to be measured for each objective.

## 2.2 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements which specify the quality and quantity of the data required to support decisions during remedial response activities (USEPA 1994). The DQO process is a step-by-step planning tool developed by the U.S. Environmental Protection Agency's (USEPA) Quality Assurance Division that, when implemented, is intended to result in specification of the optimum sampling plan that will accomplish the objective. This process will be used to identify:

- The number and locations for samples to investigate the existence of anaerobic organisms that may be contributing to the biodegradation of COCs at the Popile site.
- The number and locations of samples to define more accurately the aerobic zone in the aquifer and to understand better the redox conditions within the aquifer.

The current monitoring wells are appropriately configured to monitor and investigate the parameters of interest (MK 1999b). Given this situation of ample site coverage, no additional wells need to be installed to accomplish the goals of this sampling plan.

### 2.2.1 DQOs for Anaerobic Organism Investigation

- Step 1: State the Problem

  The problem is to determine if anaerobic organisms exist in the groundwater at the Popile site that can contribute to the biodegradation and natural attenuation of the COCs present at the site.

- Step 2: Identify the Decision

  The decision will be whether to add anaerobic organisms to the tertiary evidence category, for natural attenuation at the site.

- Step 3: Identify the Inputs to the Decision

  The inputs to the decision will be the new data collected under this sampling plan (Table 3). These data will consist of groundwater samples to be analyzed by a laboratory. Specifically, DNA identification and lipid testing will be performed to determine which anaerobic organisms are present that may contribute to biodegradation and natural attenuation at the Popile site.

- Step 4: Define the Study Boundaries:

  The study boundaries will be the Popile site, specifically the groundwater aquifer beneath the site. The time frame for assessing anaerobic organisms is once only to test for their presence.

- Step 5: Develop a Decision Rule:

  If specific organisms contributing to anaerobic biodegradation are identified by laboratory DNA testing, then these findings will be added as tertiary line of evidence of natural attenuation at the site. If no such organisms are found, then no additional evidence will be contributed for the tertiary line of evidence for biodegradation.

- Step 6: Specify Limits on Decision Errors
  Limits on decision errors will correspond to laboratory errors for the analytical processes used for the DNA identification and lipid analysis testing. Statistically-based limits will not be imposed. One source of environmental laboratory testing for DNA identification and lipid analyses is Microbial Insights, Inc. of Rockford, Tennessee.

- Step 7: Optimize the Design
  The sampling is capable of being performed in a single field mobilization.

### 2.2.2 DQOs for Redox Condition Investigation and Plume Monitoring

- Step 1: State the Problem
  The problem is to confirm the redox conditions found during previous sampling in the aquifer and to define the extent of the aerobic zone, and to confirm that the groundwater plume is stable and not migrating towards Bayou de Loutre.

- Step 2: Identify the Decision
  The decision will be whether to recalibrate the groundwater model and rerun the numerical model.

- Step 3: Identify the Inputs to the Decision
  The inputs to the decision will be the new data collected under this sampling plan (Table 2). These data will include groundwater samples from the aquifer at predefined temporal intervals.

- Step 4: Define the Study Boundaries:
  The spatial study boundaries will be the Popile site, including the groundwater aquifer beneath. The time frame for the study and duration of the measurements will be five years to allow for the detection of potential changes in the groundwater flow and contamination patterns.

- Step 5: Develop a Decision Rule:
  If COCs do not appear in the nearest and as-yet unimpacted leading edge monitoring wells (MW-01, PZ-02, MW-28, MW-04, MW-37, MW-39, and MW-40), then MNA can be considered. If COC concentrations appear or increase in those monitoring wells, then the remedial approach of MNA will be reassessed to determine if continuation of the approach is justifiable.

- Step 6: Specify Limits on Decision Errors
  Limits on decision errors will correspond to laboratory and measurement errors for the various parameters to be monitored (water levels, dissolved oxygen, chloride, carbon dioxide, Eh, pH). Statistically-based limits will not be imposed.

- Step 7: Optimize the Design
  The sampling will be performed at predefined temporal intervals to limit field mobilizations and analytical costs.

**TABLE 3**

**POPILE, INC. SUPERFUND SITE**

**POST-GROUNDWATER MODELING SAMPLING PARAMETERS, LOCATIONS, AND FREQUENCY**

| Location | Well or Piezometer | Screened Interval (ft. bgs) | Contaminant Monitoring (Semi-Volatiles, Phenols) | Water Quality Parameters ($Cl^-$, $CO_2$, $NO_3$, $SO_4$, $Fe^{+2}$, $Fe^{+3}$, DO, Eh, pH, $CH_4$, Nitrite) | Anaerobic Organisms (DNA Testing and Lipid Analysis) | Comments |
|---|---|---|---|---|---|---|
| Plume Core | MW-15 | 35.0 45.0 | X | X | X | - Annually after first four quarters for contaminants<br>- MW-18 one time only for contaminants |
| | MW-18 | 10.0 - 20.0 | X | X | X | |
| | MW-31 | 8.0 - 13.0 | X | X | X | |
| | MW-41 | 20.0 - 30.0 | X | X | X | |
| | MW-42 | 20.0 - 30.0 | X | X | X | |
| Plume Periphery | MW-26 | 18.0 - 28.0 | X | X | X | |
| | MW-27 | 23.0 - 28.0 | X | X | X | |
| | MW-43 | 20.0 - 30.0 | X | X | X | |
| | PZ-03 | 12.0 - 14.5 | X | X | | |
| | MW-33 | 23.0 - 33.0 | X | X | X | |
| Leading Edge | MW-01 | 5.0 - 10.0 | X | X | | |
| | PZ-02 | 12.5 - 15.0 | X | X | | |
| | MW-40 | 20.0 - 30.0 | X | X | | |
| | MW-37 | 20.0 - 30.0 | X | X | | |
| | MW-39 | 20.0 - 30.0 | X | X | | |

**TABLE 3 (cont.)**
**POPILE, INC. SUPERFUND SITE**
**POST-GROUNDWATER MODELING SAMPLING PARAMETERS, LOCATIONS, AND FREQUENCY**

| Location | Well or Piezometer | Screened Interval (ft. bgs) | Contaminant Monitoring (Semi-Volatiles, Phenols) | Water Quality Parameters ($Cl^-$, $CO_2$, $NO_3$, $SO_4$, $Fe^{+2}$, $Fe^{+3}$, DO, Eh, pH, $CH_4$, Nitrite) | Anaerobic Organisms (DNA Testing and Lipid Analysis) | Comments |
|---|---|---|---|---|---|---|
| Downgradient | MW-04 | 5.0 - 10.0 | X | X | | - One time only for all tests |
| | MW-28 | 25.0 - 35.0 | X | X | | |

**Sampling Frequency (unless otherwise restricted by comments)**

- Water Levels: quarterly for two years; annually thereafter (years 3 through 5)
- Contaminants: quarterly for two years; annually thereafter (years 3 through 5)
- Water Quality Monitoring: quarterly for one year, semi-annually during year two; annually thereafter (years 3 through 5)
  Note: $CH_4$ monitored quarterly for one year only
- Anaerobic Organisms: one-time event

# 3.0 Redox Investigation Sampling and Plume Monitoring Plan

## 3.1 Scope of This Plan

The following text states the media to be sampled, which locations will be sampled, which parameters will be analyzed, and when those samples will be collected as part of a five-year sampling and monitoring schedule. In that regard, it relies on Standard Operating Procedures (SOPs) previously developed (MK 1998) for the sampling protocols. However, parameters that are particularly sensitive to exposure to the atmosphere (pH, temperature, Eh, DO, and alkalinity) should be measured with flow-through measuring systems. Appendix A provides product literature on such devices. Figure 3 (Section 1) shows the monitor well locations.

Samples will be collected and analyzed by both off-site laboratory methods and field methods. The analytical methods and field procedures, including sample handling, chain-of-custody procedures, field sample custodian, sample numbering, sample labels, chain-of-custody record sheets, custody seals, sample shipment, laboratory custody procedures, and off-site laboratory analytical procedures (including PAHs, phenols, water quality parameters, and microbial counts), and field analyses can follow previously established practices and protocols (MK 1998), or similar SOPs.

One parameter to be measured in this sampling is dissolved hydrogen. This is a specialized test which will follow Microseeps' (Pittsburgh, Pennsylvania) field operating procedures and fixed-base laboratory methods. Appendix B contains product literature describing Microseeps' gas stripping cell. Microseeps should be contacted at (412) 826-5245 before undertaking the sampling.

Other field and project procedures such as decontamination of field equipment, waste management and investigation derived wastes (IDW), health and safety, documentation (field log book, field forms, scheduled reporting, etc.) can be performed in accordance with established procedures and protocols (MK 1998), or similar SOPs.

## 3.2 Classification of Wells

The following wells are grouped to suit different data needs:

- Leading edge wells (MW-01, MW-37, MW-39, PZ-02, and MW-40) provide a basis for confirming that the plume is not expanding to impact additional areas, and will be sampled for contaminant monitoring parameters, and water quality (biogeochemical environment) parameters.

- Downgradient wells (MW-04 and MW-28) will be sampled once in the event that initial sampling shows a detection in leading edge wells.

- Plume periphery wells (MW-26, MW-27, MW-33, MW-43, and PZ-03), typically in the single and low-double digit microgram per liter ($\mu$g/l) concentration range for PCP, will be monitored to determine if contaminant concentrations and the biogeochemical environment are stable over time, and will be sampled for contaminant monitoring parameters and water quality (biogeochemical environment) parameters. However, water quality parameters will be measured on a less regular basis, as their intent is to confirm depressed dissolved oxygen that has already been documented.

- Plume core wells (MW-15, MW-18, MW-31, MW-41, and MW-42), generally with a greater than a 100 $\mu$g/l dissolved concentration for PCP, will be monitored for source area concentrations over time, and will be sampled for contaminant monitoring parameters, water quality (biogeochemical environment) parameters, and anaerobic organisms. However, contaminants will not be measured regularly in highest-concentration well MW-18, as its concentration is near the solubility limit for PCP, is situated in contact with residual NAPL, and has a concentration that is not likely to change with time.

### 3.3 Water Levels

Water levels will be measured in all accessible wells and piezometers (on-site and off-site). Water levels can be measured per SOP 10-GW-01 (MK 1998), or equivalent SOP. Water levels will be measured quarterly for two years to ensure that seasonal fluctuations are observed. After two years, water levels will be measured on an annual basis until five years of monitoring has been completed. Table 2 (Section 1) indicates the complete well inventory at the site.

### 3.4 Groundwater Sampling

Overall, groundwater sampling from selected wells will be conducted quarterly for two years and yearly thereafter until five years' data have been collected. As indicated on Table 3, target suites of analytes may include, depending on the well classification, semi-volatile organic compounds (SVOCs), phenols, and/or water quality parameters. Table 3 also indicates the times when specific types of analyses should be performed. The following subsections indicate the analytical suites, laboratory methods, and field procedures groundwater sampling.

#### 3.4.1 Contaminant Monitoring Parameters

Analytical methods and field procedures for testing the contaminants at the site are listed in Table 4. Contaminant monitoring locations are limited to plume wells (core and periphery) where

concentrations are not affected by the presence of NAPL, and leading edge wells for detection of contaminant movement in the direction of groundwater flow. Background wells need not be sampled for site contaminants. Target analytes for the plume monitoring will be SVOCs, and phenols.

Note that on Figure 3, wells MW-26 and MW-43 are situated near the toe of the soil cell. This distinction should be recognized in the event that their contaminant concentrations increase to a greater degree than other peripheral wells, as the soil cell could be a potential source of contamination.

### 3.4.2 Biogeochemical Parameters

Analytical methods and field procedures for testing the biogeochemical environments are listed in Table 5. Laboratory and field objectives for analyte sensitivity and precision are presented in Table 6.

Target analytes for the plume monitoring will be chloride, carbon dioxide, nitrate, nitrite, iron, manganese, sodium, dissolved oxygen, Eh, pH, temperature, alkalinity, conductivity, hydrogen, and methane.

## 3.5 Anaerobic Organism Investigation

Table 7 shows the analytical methods and field procedures for anaerobic organism testing. Sampling for anaerobic organisms that assist in biodegradation will be performed a single time coinciding with the first quarterly water level sampling event.

**TABLE 4**

**CONTAMINANT GROUNDWATER MONITORING PARAMETERS AND METHODS**

| Matrix | Analyte | Method/ Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|---|
| Water | Phenols | Modified EPA Method 8270 | Gas chromatography; GC/MS | Monitoring of groundwater plume advancement | Year 1: Quarterly<br>Year 2: Semi-annually<br>Years 3-5: Annually | Two one-L amber glass containers with teflon lids; Cool to 4° C | Fixed-base |
| Water | SVOCs | EPA Method 8270/GC-MS | | | | Two one-L amber glass containers with teflon lids; Cool to 4° C | Fixed-base |

**TABLE 5**
**BIOGEOCHEMICAL GROUNDWATER PARAMETERS AND METHODS**

| Analyte | Method/ Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|
| Chloride ($Cl^-$) | Mercuric nitrate titration A4500-$Cl^-C$ | Ion Chromatography Method E300; Method SW9050 may also be used | Final product of chlorinated solvent reduction; can be used to estimate dilution in calculation of rate constant | Year 1: Quarterly<br><br>Year 2: Semi-annually | Collect 250 mL of water in a glass container | Fixed-base |
| $CO_2$ | HACH Method CA-23 | Colorimetric method | Indicator of bioactivity | | Collect up to 40 mL of water in a glass or plastic container; | Field |
| $NO_3$<br>Nitrite | Iron chromatography Method 353.2/353.3 | | Substrate for microbial respiration if oxygen is depleted | | Collect one 250 mL of water in a glass or plastic container; add $H_2SO_4$ to pH less than 2; cool to 4° C | Fixed-base |
| $SO_4$ | Iron chromatography | Method E300 is a handbook method. HACH Method 8051 is a colorimetric method; use one or the other | Substrate for anaerobic microbial respiration | | Collect up to 40 mL of water in a glass or plastic container; cool to 4° C | Fixed-base |
| $Fe^{+2}$<br>$Fe^{+3}$ | HACH Method IR-18A | Colorimetric method | Electron acceptor for anaerobic respiration | | Collect up to 40 mL of water in a glass or plastic container | Field |
| Dissolved Oxygen (DO) | DO meter | Refer to Method A4500 for a comparable laboratory procedure | Concentrations less than 1 mg/L generally indicate an anaerobic pathway | | Measure DO on site using a flow-through cell | Field |

**TABLE 5 (cont.)**
**BIOGEOCHEMICAL GROUNDWATER PARAMETERS AND METHODS**

| Analyte | Method/ Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|
| Eh | Field probe with direct reading meter | | Aerobic and anaerobic process are pH sensitive | Year 1: Quarterly<br><br>Year 2: Semi-annually | Flow-through cell. | Field |
| pH | Field probe with direct reading meter | Field | Aerobic and anaerobic process are pH sensitive | | Flow-through cell. | Field |
| $H_2$ | Microseeps Gas Stripping Cell | Specialized analysis | To determine the terminal electron accepting process; predicts the possibility for reductive dechlorination | | Sampling at well head requires the production of 100 mL per minute of water 30 minutes | Field |
| $CH_4$ | Kampbell et al. or SW3810, modified | Method published by EPA researchers | The presence of $CH_4$ suggests biodegradation of organic carbon via methanogenesis | | Collect water samples in 50 mL glass serum bottles with butyl fray/Teflon-lined caps; add $H_2SO_4$ to pH less than 2; cool to 4° C | Field mobile lab is recommended |
| Mn | SW6010 | | Monitor anaerobic activity | | Collect 500 mL in a plastic container; add $HNO_3$ to pH <2; cool to 4° C | Fixed-base |
| Na | | | Serves as a control or check on anthropogenic or alternative sources of $Cl^-$ | | | Fixed-base |

**TABLE 5 (cont.)**
**BIOGEOCHEMICAL GROUNDWATER PARAMETERS AND METHODS**

| Analyte | Method/ Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|
| Alkalinity | HACH alkalinity test kit Model AL AP MG-L | Phenolphthalein method | Water quality parameter used to measure the buffering capacity of ground water; can be used to estimate the amount of $CO_2$ produced during biodegradation | | Collect 100mL of water in a glass container | Field |
| Conductivity | E120.1/SW9050, direct reading meter | Protocols/Handbook methods | Water quality parameter used as a marder to verify that site samples are obtained from the same groundwater system | | Collect 100 to 250 mL of water in a glass or plastic container | Field |
| Temperature | Field probe with direct-reading meter | Field only | Well development | | Not applicable | Field |

**TABLE 6**
**OBJECTIVES FOR ANALYTE SENSITIVITY AND PRECISION**

| Matrix | Analyte | Method/ Reference | Minimum Limit of Quantification | Precision | Availability | Potential Data Quality Problems |
|---|---|---|---|---|---|---|
| Water | Chloride ($Cl^-$) | Mercuric nitrate titration A4500-Cl⁻C | 1 mg/L | Coefficient of Variation of 20 percent | Common laboratory analysis | ------ |
| Water | $CO_2$ | HACH Method CA-23 | 1 ppm | Coefficient of Variation of 20 percent | Readily available field instrument | Instrument must be properly calibrated |
| Water | $NO_3$ | EPA Method 353.2/353.3 | 0.1 mg/L | Standard deviation of 0.1 mg/L | Common laboratory analysis | Must be preserved; short holding times |
| Water | Nitrite | | | | | |
| Water | $SO_4$ | Iron chromatography | 5 mg/L | Coefficient of Variation of 20 percent | Common laboratory analysis | Fixed-base |
| Water | $Fe^{+2}$ | HACH Method IR-18A | 0.5 mg/L | Coefficient of Variation of 20 percent | Common field analysis | Possible interference from turbidity (must filter if turbid). Keep out of sunlight and analyze within minutes of collection. |
| Water | $Fe^{+3}$ | HACH Method IR-18C | | Coefficient of Variation of 40 percent | | |
| Water | Dissolved Oxygen (DO) | DO meter | 0.2 mg/L | Standard deviation of 0.2 mg/L | Common field instrument | Improperly calibrated electrodes, or bubbles behind the membrane, or a fouled membrane, or introduction of atmospheric oxygen during sampling |
| Water | Eh | Field probe with direct reading meter | NA | ± 2 millivolts | Common field meter | Instrument must be properly calibrated |

**TABLE 6 (cont.)**
**OBJECTIVES FOR ANALYTE SENSITIVITY AND PRECISION**

| Matrix | Analyte | Method/ Reference | Minimum Limit of Quantification | Precision | Availability | Potential Data Quality Problems |
|---|---|---|---|---|---|---|
| Water | pH | Field probe with direct reading meter | 0.1 standard units | 0.1 standard units | Common field meter | Improperly calibrated instrument; time sensitive |
| Water | $H_2$ | Microseeps Gas Stripping Cell | 0.1 nM | Standard deviation of 0.1 nM | Specialized analysis | Numerous |
| Water | $CH_4$ | Kampbell et al. or SW3810, modified | 1 $\mu$g/L | Coefficient of Variation of 20 percent | Specialized laboratory analysis | Sample must be preserved against biodegradation and collected without headspace (to minimize volatilization). |
| Water | Mn | SW6010 | 1 mg/L | Coefficient of Variation of 20 percent | Common laboratory analysis | Possible colloidal interferences |
| Water | Na | | | | | |
| Water | Alkalinity | HACH alkalinity test kit Model AL AP MG-L | 50 mg/L | Standard deviation of 20 mg/L | Common field analysis | Analyze sample within one hour of collection |
| Water | Conductivity | E120.1/SW9050 direct-reading meter | 50 $\mu S/cm^2$ | Standard deviation of 50 $\mu S/cm^2$ | Common field probe | Improperly calibrated instrument |
| Water | Temperature | Field probe with direct reading | 0 degrees Celsius | Standard deviation of 1 degree Celsius | Common field probe | Improperly calibrated instrument; time sensitive |

**TABLE 7**
**GROUNDWATER MICROBIAL PARAMETERS AND METHODS**

| Location[1] | Analyte | Method/ Reference | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|
| MW-15<br>MW-18<br>MW-31<br>MW-41<br>MW-42 | DNA Testing | Microbial Insights Sphingomonas (4.8) | To determine presence or absence of anaerobic organisms in groundwater | Single Sampling Event | - 1 to 2L of water required (2L required if water crystal clear)<br>- Clean jar, plastic container, or whirl-pack bag<br>- Place samples on ice (4° C) and ship via overnight service<br>- Samples preserved with 10 mls formaldehyde for each liter of water | Fixed-Base |
| | Lipid Analysis | Microbial Insights PLFA | | | | Fixed-Base |

## 4.0 References


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USEPA, 1997b. *Issues Associated With Natural Attenuation.* D.S. Tulis, USEPA. http://www.epa.gov/swerust/rbdm/issues.htm.

# Appendix A

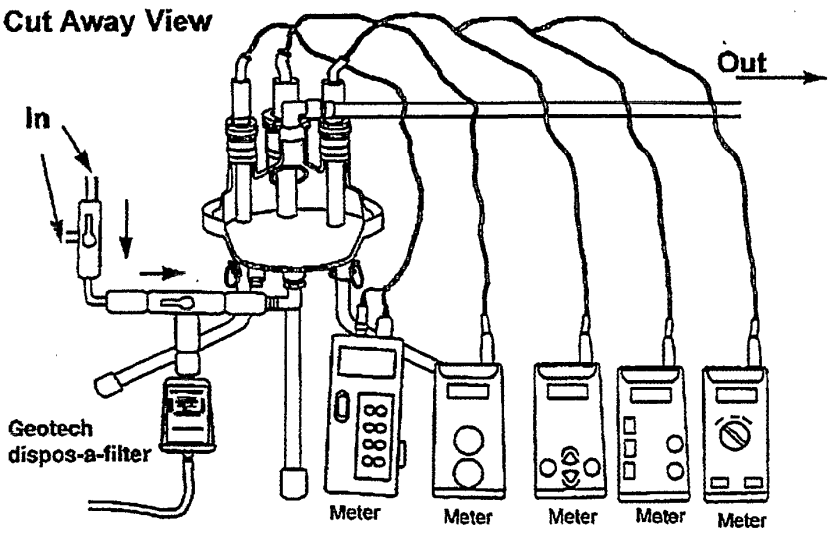
# Flow-Through Cell Product Literature

# Multiprobe Sampling System

geotech

## *flow-through analysis*

**pH • Temperature • Conductivity**
**ORP (redox) • Dissolved Oxygen • TDS**




The **U.S. Environmental Protection Agency** recommends that specific measurements be documented at the field site when samples are taken for further analysis. Prior to the development of the **Multiprobe Sampling System Flowcell**, there has been no simple, accurate way of doing this especially in the often difficult conditions of field sampling.

The **Geotech** System is a uniquely designed product which enables the user to utilize various probes (up to five at exactly the same time on exactly the same sample). As the water enters through the bottom, the flow is directed in a circular path to fill the chamber with minimal sample agitation and exits through the top. As the water flows through the chamber, the pH, Temperature, Conductivity, etc. can be monitored. When the readings stabilize, they can be documented and a representative sample collected. There is no need to buy an all-new expensive system, since the ports will accommodate any round probes with diameters ranging from 1/8" to 1". When replacement or new meters and probes are necessary, we recommend ORION products. Oakton meters are also available if desired.

These units can be used directly in-line with a ground water monitoring pump such as the Geotech Bladder Pump, Redi-flo2 or Geotech Peristaltic Pumps. Other manufacturers' pumps will also work with our system. The sample should be collected by the way of a two-way valve prior to passing through the chamber. Geotech **dispos-a-filters** are easily incorporated into this system and are the cleanest, most efficient, certified groundwater sampling filters available.

Geotech manufactures two types of flowcells:

The #930 which has a chamber volume of 1350cc and is used when purging 1 gpm to 3 gpm.

The #940 has a chamber volume of 250cc and is best when millipurging 100 milliliters to 1 gpm.

A choice of meters and sensors provides maximum economy and flexibility. The system can be conveniently carried when purchased with the rugged carrying case designed to hold all of the necessary equipment.

Geotech Environmental Equipment, Inc.
8035 East 40th Avenue
Denver, Colorado 80207
(303)320-4764 • (800) 833-7958 • FAX (303) 322-7242
email: geotech@ix.netcom.com• website: www.geotechenv.com

flyflocl 061298

# Multiprobe Sampling System

geotech

## *specifications*

### Materials

| | |
|---|---|
| Chamber top piece | medical grade polycarbonate |
| Chamber bottom piece (high capacity) | medical grade polycarbonate |
| Chamber bottom piece (low flow) | machined acrylic |
| O-ring | medical grade silicone |
| Clamp | stainless steel |
| Grommets | medical grade silicone |
| Gasket | medical grade silicone |
| Pressure relief valve | medical grade silicone |
| Legs | anodized aluminum |
| Leg end covers | red neoprene |

### Dimensions

| | |
|---|---|
| Inlet | 3/8" |
| Outlet | 1/2" |
| Flow cell leg length | 12" |
| Width with clamp | 8" |
| Grommets included accommodate | .125 to .250", .250 to .375", .375 to .500", .500 to .675", .750 to .875" |
| Grommet also available | .875 to 1.00" |
| Parts kit includes grommet sizes | .500 to .675", .375 to .500", .875 to 1.00 |

### High capacity

| | |
|---|---|
| Volume | 1350 cc (cubic centimeters) |
| Flow rate | 1 to 3 gpm (gallons per minute) |
| Height with fittings | 9 inches |
| Weight | 2 lbs |
| Height with legs | 18 inches |

### Milli-purge chamber

| | |
|---|---|
| Volume of low flow chamber | 250 cc |
| Flow rate | 100 milliliters per minute to 1 gpm |
| Height with fittings | 7 inches |
| Weight | 4 lbs |
| Height with legs | 16 inches |

### Carrying case

| | |
|---|---|
| Material | PVC |
| Handles | locking |
| Weight | 4 lbs |
| Depth | 12" |
| Width | 15" |
| Length | 19.5" |
| Foam cut inserts | specific to model |

Geotech Environmental Equipment, Inc.
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email: geotech@ix.netcom.com • website: www.geotechenv.com

# Multi-Parameter Meter

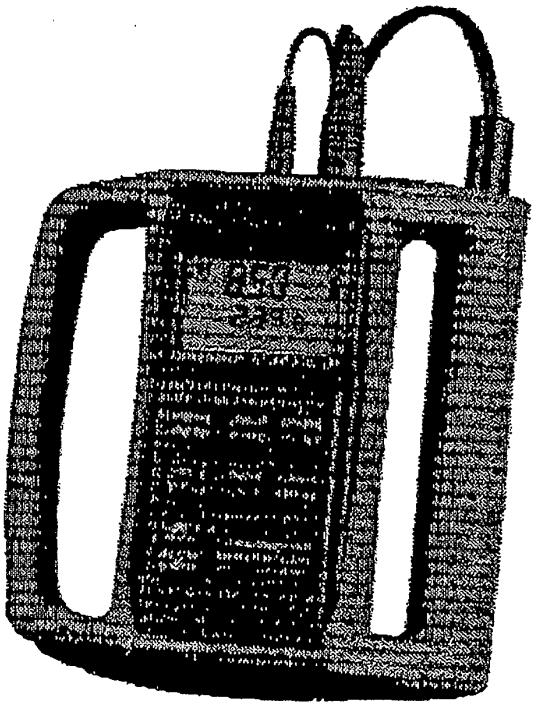
geotech

***pH • Conductivity • Dissolved Oxygen***

**Geotech Multi-Parameter Meter**
**pH/mV/°C/ORP/Conductivity/Salinity/D.O.**

- Built-in memory for 120 data sets
- AutoRead function for high reproducibility
- Continuous operation with plug-in AC power suply
- Automatic temperature compensation
- Automatic sensor recognition
- Automatic calibration of all sensors
- Impact-resistant antistatic ABS plastic housing
- Time controlled measurement over periods of up to 5 days

**Handles are optional**



The Geotech Multi-parameter meter is both splash-proof (IP66) and submersible (IP67), with AC power or rechargeable batteries, perfect for use in the field, laboratories or production sites. It offers simultaneous measurement of pH, ORP. Dissolved Oxygen, conductivity, salinity and temperature. You can control data output at 8 fixed intervals: 5s / 30s / 1min / 5min / 10min / 30 min / 60min. The datalogging function allows measurements to be recorded over a long period of time.

You can store up to 120 points. It has a built-in memory for 120 data sets each with 3 measured values, date, time and identification number.

The meter is available as a complete kit or in a meter package. The meter package includes the Multiparameter meter, plug-in AC power supply, calibration and maintenance supplies, and operating instructions. It can operate for 150-800 hours with rechargeable batteries.

The complete kit includes Multiparameter meter, professional case with built-in workstation, set up, two probe stands, two beakers, rubber field case and carrying strap with two sleeves, plug-in AC power supply, calibration and maintenance supplies, electrodes and operating instructions.

All our Geotech Waterproof meters are compatible with the Geotech Multiprobe Sampling System. The probes fit securely into the flow cell allowing simultaneous readings from samples directly in-line with your pumping system! This helps to avoid the bias associated with exposure of samples to ambient air, and stagnant conditions. Using the Geotech Multiprobe Sampling System with two Geotech Multiparameter Meters will give you direct, in-line simultaneous readings for pH, Dissolved Oxygen, Conductivity, ORP, Temperature, Date, and time. Datalog the results to avoid human error in the field! Store all components in the durable field carrying case for complete convenience and portability. We'll be happy to help you set up a system that meets the requirements of your work site.

## WE WANT YOUR BUSINESS !!

Geotech Environmental Equipment, Inc.
8035 East 40th Avenue
Denver, Colorado 80207
(303)320-4764 • (800) 833-7958 • FAX (303) 322-7242
email: geotech@ix.netcom.com • website: www.geotechenv.com

# Multi-Parameter Meter

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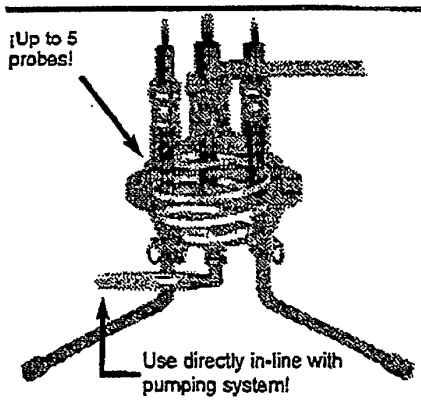
***pH • Conductivity • Dissolved Oxygen***

## Specifications

| Specifications | pH/mV | Temperature | D.O. | Conductivity/Salinity |
|---|---|---|---|---|
| Range/resolution | pH-2.00 to+16.00/ mV:-1250 to+1250 | -5.0 to 99.99°C/ 0.1 | O2 concentration: 0.00 to 19.99 0.0 to 90.0 mg/ O2 saturation: 0.00 to 19.99% 0.0 to 600% | 1µs/cm to 500 mS/cm in 4 measuring ranges / 0.0 to 70.0ppt |
| Accuracy (± 1 digit) | pH: ± 0.01/ ±1 mV | N/A | ±0.5% of value | ±1% of value /±0.1,0.0 to42.0 at 5 to 25°C |
| Temperature Comp. | automatic-5 to+99.9°C (manual -20 to 130°C) 0 to + 40°C / NA | N/A | automatic via IMT compensation from | linear and non-linear functions for ultrapure and natural waters / nLF natural waters |
| Display | LCD display 60 x 35mm visible area, simultaneous display of measurement, temperature, special characters. | | | |
| Sensor evaluation | depends on calibration results, shown on display. | | | |
| Calibration alarm | 1 to 999 days, adjustable. | | | |
| AutoRead | for pH, O2 and conductivity. | | | |
| Calibration | automatic calibration. | | | |
| Data memory | 120 data sets. | | | |
| Data output | via display or interface. | | | |
| Interface | serial RS 232 interface, baud rate adjustable, bi-directional. | | | |
| Certified to | CE, TUV/GS, UL, CUL. | | | |
| Warranty | 3 years. | | | |




**The Geotech Multiprobe Sampling System,** enables the operator to use up to five probes of varying sizes at exactly the same time on exactly the same sample in-line with the sampling system! As the water flows through the chamber, the various parameter readings can be monitored simultaneously. When the readings stabilize, they can be manually documented or data-logged and a representative sample taken immediately. These units can be used directly in-line with a groundwater monitoring pump such as the Geotech Bladder Pump, Redi-Flo2 or the Geopump Peristaltic Pump. The Multiprobe Sampling System is available in the standard or low flow model.

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# geotech

***** Facsimile Transmission *****

Date : August 18, 1999

Pages : 5

To

Fax Phone : 303-948-4010

From : Greg Wooldridge

Subject : Flow Cells.

Here is the pricing information that you requested. When you are ready to order please call Geotech at 1-800-833-7958!

| Quantity | Item/Description | Price | Extended Price |
|---|---|---|---|
| 1 | #82200001 High Volume Flow Cell | $ 595.00 | each |
| 1 | #82200002 Low Volume Flow Cell | $ 895.00 | each |
| 1 | #82200003 Flow Cell Case | $ 125.00 | each |
| 1 | #72105000 Multi-Parameter Meter Kit | $1,810.00 | kit |
| 1 | #12105001 ORP (eH) Probe | $ 113.00 | each |
| 1 | #12105002 3 Meter Cable For ORP | $ 29.00 | each |

These are in stock and available for immediate delivery. This pricing is good per this quote for the next 30 days. If you need to delay your order beyond 30 days, please call Geotech to confirm exact pricing.

I am including product information for your convenience.

You may reach me at 1-800-833-7958 to place your order.

And remember..."we want your business!"™

Thanks,
Greg Wooldridge

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# Rental Equipment

geotech

| Item Description | Prices Weekly | Daily | Each |
|---|---|---|---|
| **PUMPS - Electric, Submersible and Peristaltic** | | | |
| •Redi-Flo2 pump on reel w/converter | $400.00 | $175.00 | |
| •Redi-Flo2 pump only, (choice of reels) | $200.00 | $85.00 | |
| •Redi-Flo2 Converter only, 115VAC or 230VAC | $250.00 | $95.00 | |
| •Generator, Honda 3500SX | $200.00 | $75.00 | |
| •Peristaltic Pump, Geopump™ | $85.00 | $35.00 | |
| •Easy Load Pump Head | $10.00 | $5.00 | |
| •Rechargeable Battery and Charger | $15.00 | $5.00cs | |
| **ANALYTICAL EQUIPMENT - pH, Cond., Temp., DO, Turbidity, PID** | | | |
| •PID, MiniRAE | $225.00 | $75.00 | |
| •Turbidity Meter, Hach 2100P | $95.00 | $35.00 | |
| •PHA-100, In-Situ Hydrocarbon Analyzer | $650.00 | $200.00 | |
| •pH Meter, Oakton or Orion | $85.00 | $35.00 | |
| •pH Meter w/ORP, Oakton or Orion | $95.00 | $40.00 | |
| •Conductivity Meter, Oakton or Orion | $75.00 | $30.00 | |
| •Dissolved Oxygen Meter, Orion (Includes 1 membrane cap) | $135.00 | $80.00 | |
| •Extra Membrane Caps | | | $35.00 |
| •Multi-Probe monitoring Chamber (flow cell) (Includes grommet set & O Ring) | $155.00 | $55.00 | |
| **WATER / INTERFACE METERS** | | | |
| •Water Level Meter, 200 feet | $95.00 | $40.00 | |
| •Water Level Meter, 500 feet | $115.00 | $50.00 | |
| •Interface Meter, 150 feet | $200.00 | $80.00 | |
| •Interface Meter, 300 feet | $250.00 | $95.00 | |

Daily price after the first week, reverts to Weekly price divided by 5.

**ALL EQUIPMENT LISTED IS ALSO AVAILABLE FOR PURCHASE**

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# Appendix B

# Microseeps Product Literature

# Microseeps Gas Stripping Cell Instructions

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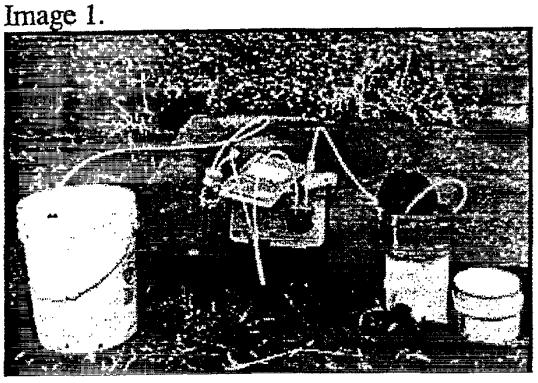
## INSTALLATION AND OPERATION

To place the gas stripping cell into service:

Image 1.



1. Remove one of the cell assemblies from the packing carton. See Figure 1.

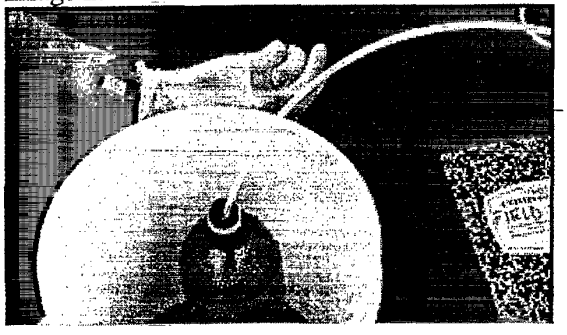
2. **Image 1.** Connect the inlet tube of the cell to the outlet of your pump. The inlet tube is designed to connect to 1/4 O.D. hard tubing. Secure the connection using binder clips or cable ties.

3. Insert the drain tube of the cell into a waste container, keeping the end of the tube at the bottom of the container. Any waste container of suitable size may be used. A 2-Liter soda pop bottle may be placed in the waste container to determine pumping flow rate.

4. Secure the cell assembly so that the housing cover (stopper) is above the glass housing (i.e. upright). A ring stand and clamp are recommended for this purpose.

5. Turn the pump on and check for leaks. If any leaks are found, seal them before proceeding.

Image 2.



6. **Image 2.** Measure, in mL per minute, the flow rate of the pump. If a 2-Liter soda pop bottle is used, the flow rate can be determined by measuring how many minutes it takes to fill the bottle and substituting the measured time into the following equation:

Flow = 2000 mL/Time to fill (in minutes)

Consult Table 1 to determine the equilibrium time needed to bubble strip at this flow rate.

**Note:** Use a flow rate between 100 mL/min. and 500 mL/min. **Do not turn off the pump.**

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Image 3.

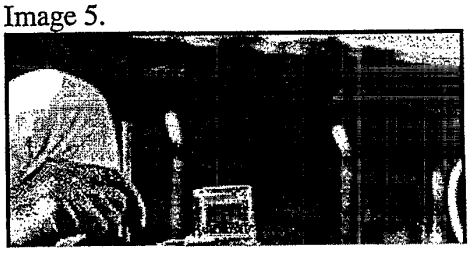
7. **Image 3.** Unclamp the cell assembly, invert it, and re-secure the assembly in the inverted position. Make sure the drain tube is still in the waste container and the end of the drain tube is near the bottom of the bottle.

Image 4.

8. **Image 4.** Connect the stopcock to the syringe and the needle to the stopcock (zoom in on image). Place the stopcock in the open position (so that the stopcock handle is in-line with the syringe). Draw the plunger back on the syringe to the 20.0 mL mark pulling ambient air into the syringe.

9. **Image 5.** Keeping the cell in the inverted position, insert the needle into the needle guide. Pierce the septum and inject the air into the cell creating the bubble. Withdraw the needle from the assembly and carefully place the needle into the cover. Do not discard the syringe apparatus.

Image 5.



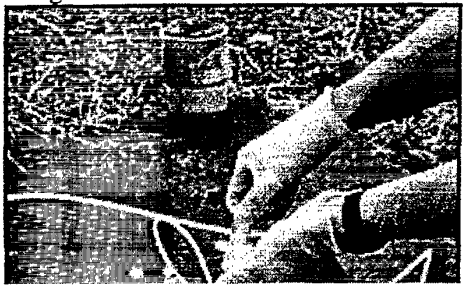
10. Start timing and let the groundwater pump through the cell for time specified in Table 1 for your particular pumping speed. Meanwhile, be sure that the sample vial is properly labeled and that the flow rate and any other relevant field data are recorded in the field log.

**Note:** Be sure to keep the end of the drain tube at the bottom of the waste container. This will insure that outside air is not drawn into the cell. **Failure to do this will invalidate the sample.**

11. When equilibration time is up, **turn off the pump,** unclamp the cell, and re-clamp it in its upright position. See Image 1. Verify that the plunger of the syringe is pushed all the way in and that the stopcock is in the open position.

12. **Image 6.** Insert the needle into the needle guide and pierce the septum. Withdraw 1 mL of gas by pulling back on the syringe plunger while holding the syringe body in place. Remove the syringe from the cell and expel the sample.

Image 6.

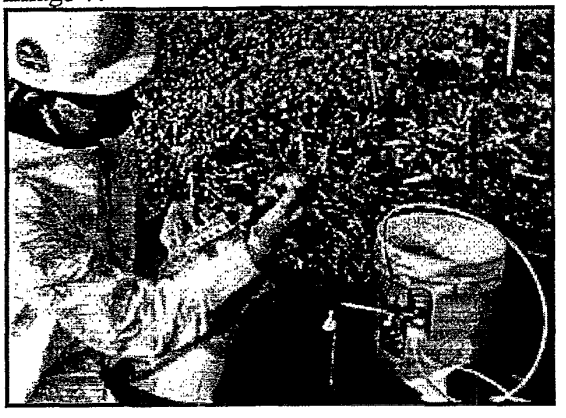


13. Immediately re-insert the

needle into the needle guide and pierce the septum. Withdraw a 15 mL sample of gas (being careful not to pull any water into the syringe). With the needle still through the septum, close the stopcock and withdraw the needle from the septum.

14. **Image 7.** Immediately insert the needle through the septum on the sample vial. Keeping the syringe and vial "in line", open the stopcock and completely depress the syringe plunger injecting the entire sample into the vial.

Image 7.



15. **Image 8.** Keeping the plunger depressed, quickly remove the vial from the needle. Your sample is now ready to be packaged and shipped back to Microseeps for analysis. Do not cool the samples.

Image 8.

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**Decontamination/Cleaning**

Pump at least 1 liter of potable water through the cell. The cell assembly is now ready for re-use.

**The only expendable part of the cell is the sampling septum (part 7). Normally, each septum may be used for the collection of up to 5 samples. If bubbles are seen rising up from the septum when the cell is inverted the septum MUST be replaced. Instructions for replacing the septum are provided below.**

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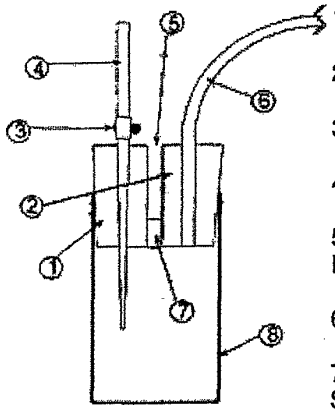
**SAMPLING QUESTIONS?**

CALL MICROSEEPS AT **1-412-826-5245**

MON.- FRI. 7:30 AM TO 6 PM EST

**Figure 1.** Cross section of Microseeps Gas Stripping Cell




1. Housing Cover
2. Jet Spray Nozzle
3. Nylon Tie
4. Inlet Tube
5. Needle Guide Port
6. Drain Tube
7. Replaceable Septum
8. Glass Housing

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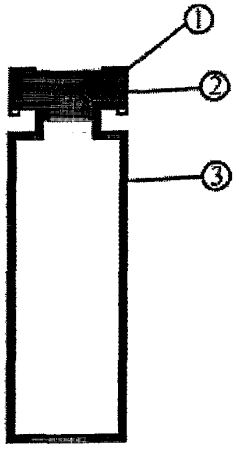


**Figure 2.** Cross section of septum bottle

1. Septum
2. Metal Closure
3. Glass vial

**Replacing the Sampling Port Septum**

***All part numbers refer to Figure 1.***

1. Remove the housing cover (part 1) from the glass housing (part 8).

2. Use a handy, blunt tipped object to push the replaceable septum (part 7) out of the housing cover. The cover to a needle works well for this purpose, but be sure that the needle is **NOT** in the cover. Discard the old septum.

4. Take a new septum and wet both the new septum and the housing cover with potable water.

5. Carefully using the same blunt instrument used in step three above, slide the new septum into the hole from which the old septum was removed. The bottom of the new septum must be flush with the narrow end of the housing cover.

6. If the housing cover is not still wet, wet it again with potable water. Place the bottom end of the housing cover into the glass housing and push it in until less than 3/8" are above the rim of the glass housing. This may require some force.

7. Follow the cleaning procedures described above to prepare the cell for a return to service.

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**Table 1.**

| Flow rate (ml/min) | Sampling time (min) |
|---|---|
| 100-120 | 30 |
| 130-150 | 25 |
| 160-200 | 20 |
| 210-300 | 15 |
| >300 | 10 |

Return to Step 6

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