A/M Area DNAPL Characterization Report for Cores Collected in 2Q99

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For

Cores Collected in 2Q99

August 1999

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Savannah River Site

Aiken, South Carolina 29808

Prepared for the United States Department of Energy under Contract No. DE-AC09-96-SR18500

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Summary

Drilling activities were conducted in 2Q99 in the A/M Area to further delineate the soil contamination and potential areas of dense non-aqueous phase liquids (DNAPL) below the water table emanating from the M-Basin. The purpose of the work was to further understand the subsurface contaminant distribution and to identify locations below the water table where aggressive DNAPL remediation technologies should be pursued. This work consisted of using roto-sonic drilling to complete three borings to the top of the Green Clay confining unit. Results of the drilling activities indicate a potential source of DNAPL beneath the M-Area Basin may be of sufficient quantity to support implementation of an aggressive groundwater remediation technology. Additional angle drilling beneath the basin and vertical drilling adjacent to the basin should be pursued to verify and quantify this initial finding. Tetrachloroethylene (PCE) and trichloroethylene (TCE) were found at concentrations ranging from below detection to 200 ppm and below detection to 23 ppm, respectively. The highest concentrations are located within a clay/sandy clay zone at elevations ranging from 215 ft msl to 270 ft msl (80 ft to 135 ft depth below ground surface).

Data collected at the M Area Settling Basin in FY99 provide additional evidence that contaminants are migrating toward the west/southwest from the basin along structural "depressions" on the surfaces of low permeability intervals. The concentrations measured in these cores indicate that the highest DNAPL source concentrations are present immediately adjacent to the source and do not indicate that a large volume of DNAPL is present at the locations further from the source. The data collected in FY99 corroborate the original data and indicate that a significant amount of PCE and TCE may still be located directly below the basin inlet.

Background

The A/M Area, a reactor fuel and target assembly area of the Savannah River Site, discharged approximately 3.5 million pounds of waste industrial solvents (primarily trichloroethylene, TCE, and tetrachloroethylene, PCE, with much lesser amounts of trichloroethane, TCA) from the 1950's to early 1980's. These discharges occurred at two locations – the A-014 Outfall and the M Area Settling Basin. Additional releases of solvent at the solvent storage tank were also documented during this period. Releases of large amounts of industrial solvent resulted in subsurface contamination present in an undissolved phase (NAPL) above and below the water table (Marine et al., 1984). This source DNAPL evaporates and dissolves, generating contaminated vapors/gas and a large dissolved plume. Presently, the dissolved phase and vadose zone are being addressed through a phased characterization/remediation program. Field activities specifically related to DNAPL characterization were initiated in 1991 (see Looney et al., 1992, Jackson et al., 1996, Jerome et al., 1998). Specific field activities related to the DNAPL remediation were initiated in FY97 with a demonstration of a remediation technology for destroying the DNAPL below the water table at a location of known DNAPL (Jerome et al., 1997).

FY99 DNAPL investigation activities centered around further identifying areas of pure phase DNAPL below the water table. Goals of this work were to further understand the subsurface contaminant distribution within the M-Area and to identify locations below the water table where aggressive DNAPL remediation technologies should be pursued. Areas examined in FY99 were beneath and adjacent to the M-Basin. Borings were completed using the roto-sonic drilling method and then grouted to surface. Two of the borings were drilled at an angle and one boring was drilled on the vertical. Core was collected continuously from surface to total depth for all borings. Total depth was to the top of the Green Clay confining unit (approximately 200 ft msl, depth of 155 ft).

Selection of Drilling Locations

Based on available information, residual DNAPL above the water table is within fine grained (silt and clay) layers. Residual DNAPL below the water table will migrate toward, and collect in, structural lows on top of fine grained layers. Gravitational movement of the DNAPL below the water table results in thin (but laterally extensive) layers of contaminant migration toward the accumulation areas. Locations selected below and adjacent to the M-Basin were to further investigate movement of DNAPL from beneath the basin, one of the key sources of solvent contamination within the A/M-Area.

Figure 1 identifies the resulting borings by location. Each location is identified and the basis for selection presented below. Drilling activities were centered adjacent to suspected sources of solvent discharge.

MRS26. This boring is located adjacent to the inlet of the M-Area Basin. This boring was drilled on a 45° angle. This area is a known source of DNAPL as spent solvents were disposed into this basin via a subsurface process sewer line. Because the basin has an approved RCRA cap in place the only acceptable way to investigate below the inlet of the basin was to drill at an angle.

MRS27. This boring is located on the opposite side of the M-Area Basin from the inlet line. This boring was drilled on a 45° angle to the center of the basin. As with boring MRS26, the purpose of this boring is to evaluate the migration of the spent solvents as they seeped through the bottom of the unlined basin.

MRS28. This boring is located between the M-Basin and the area where an in situ oxidation demonstration (Borings and/or Wells MOX 1 through 11) was conducted in 1997 (Jerome et al., 1997).

Soil Borings from 2Q99 to Support DNAPL
Characterization at the M-Area Basin.

**Figure 1: Location Map of FY99 Borings to Support Investigation of DNAPL
Sources in the A/M Area**

Field Activities

The above identified three soil borings were drilled using the rotosonic drilling technology for purposes of DNAPL characterization at the M-Area Basin. Drilling activities occurred in April and May 1999. The holes were drilled to total depths of approximately 155 ft., equivalent to the top of the Green Clay confining unit. Two of the borings (MRS26 and MRS27) were drilled on an angle of 45°. Table 1 is a list of all borings, surface northing, surface easting, surface elevation, total depth, total depth northing, total depth easting, total depth elevation.

Table 1: Location Data for 2Q99 Borings to Support Investigation of DNAPL Sources at the M-Area Basin

Boring ID	Surface Northing	Surface Easting	Surface Elevation (ft msl)	Total Depth (total footage)	Total Depth Northing	Total Depth Easting	Total Depth Elevation (ft msl)
MRS26*	102210.7	48646.1	357.4	157 (224)	102109.4	48525.3	200
MRS27*	101808.0	48534.4	351.2	149 (211)	101957.1	48534.4	202
MRS28	102268.4	48435.2	358.3	157 (157)	102268.4	48435.2	201.3

NOTE: * Indicates borings drilled on an angle.

Soil plug samples were collected from surface to total depth for each location and analyzed for TCE and PCE concentrations using a static (equilibrium) headspace method (Looney et al., 1993, EPA, 1995). Sampling intervals for each hole were determined based on distance from a source (e.g. M-Area Basin) and modified in the field based on field measurements with a photo-ionization detector (PID). Samples were collected at MRS 26 on 1 to 2 foot intervals along the length of the boring. This boring was positioned at the inlet to the basin, and PID measurements indicated volatile organic contaminants (VOCs) along its length. Samples were collected at MRS27 and MRS28 on 5 foot intervals to 114 and 121 foot depths, respectively, and then at 1 to 2 foot intervals to total depth.

Sediment samples were collected by taking a 2 cc plug sample from the center of the core using a modified plastic syringe. The plug was transferred to a 22 ml vial containing 5 ml of nano-pure water and the vial was sealed with a crimped septum top for later head space analysis. Duplicate samples were collected at each depth and all samples were stored at 4°C until analysis. Twenty percent (20%) of the duplicate samples were analyzed as a quality control check.

Each sample was weighed and then analyzed on a HP 5890 Series gas chromatograph (GC) equipped with flame ionization detector (FID) and electron capture detector (ECD). Equilibrated headspace gas was sub-sampled and transferred to the GC using an automated head space sampler. Equivalent water concentrations were calculated using the appropriate detector (ECD for low concentrations, FID for high concentrations). Mass soil concentrations (ppb, $\mu\text{g/kg}$) were calculated based on an equal head space volume from 7.5 ml of water standards and approximately 7.5 ml of water/soil matrix and were corrected for the mass difference between soil and water. The gas chromatograph was calibrated using certified solvent mixtures in methanol diluted to specific concentrations. Standard concentrations used were 3, 5, 10, 50, 250, 500, and 1000 ppb ($\mu\text{g/l}$). The standards were analyzed for vinyl chloride, freon-11, freon-113, 1,1-DCE, trans-DCE, cis-DCE, 1,1,1-TCA, CCl_4 , TCE, and PCE.

Results of Subsurface Investigations

Figures 2 through 4 are depth concentration profiles of TCE and PCE for each boring and the associated lithologic logs. Figure 5 provides the legend for Figures 2 through 4 and those presented in Appendix A. The bulk soil concentrations (x-axis of each figure) are graphed on different scales due to the wide range of concentrations between borings. Appendix A contains the same depth concentration profiles with field core descriptions incorporated on an expanded scale to allow a more detailed presentation. Also contained in Appendix A are depth/concentration tables for the three cores drilled.

A/M Area data collected from the early 1980's through the present supports a conceptual model that DNAPL is migrating from the M-Basin towards monitoring well MSB76 (westward) below the water table along the Green Clay confining unit or along an intermediate clay located above the Green Clay confining unit. There has been little evidence for migration to the east or north. The data collected from MRS 26, 27 and 28 characterization borings substantiates this hypothesis. Data collected from boring MRS 27, drilled on the eastern side of the basin angling toward the basin center, did not indicate the presence of DNAPL. The highest concentrations recorded in boring MRS 27 were 0.032 $\mu\text{g/g}$ of TCE and 0.017 $\mu\text{g/g}$ of PCE, at elevations of 204 ft msl and 229 ft msl, respectively. Data collected from boring MRS 26, drilled on the northern side of the basin angling beneath the basin's inlet pipe, indicated the presence of DNAPL. The highest concentrations recorded in boring MRS 26 were 22.1 $\mu\text{g/g}$ of TCE and 198.3 $\mu\text{g/g}$ of PCE, at elevations of 262 ft msl and 240 ft msl, respectively. Boring MRS 28, located on the western side of the basin indicated concentrations as high as 1.917 $\mu\text{g/g}$ TCE and 12.040 $\mu\text{g/g}$ PCE at elevations of 208 ft msl and 227 ft msl, respectively.

Figure 2. Depth Concentration Profile for Boring MRS 26, drilled at a 45° angle beneath inlet to M-Area Basin.

Figure 3. Depth Concentration Profile for Boring MRS 27, drilled at a 45° angle from southern side of M-Area Basin to center of basin.

Figure 4. Depth Concentration Profile for Boring MRS 28, vertical boring adjacent to northern side of M-Area Basin

Figure 5. Lithology Key for Depth Concentration Profiles and Lithology Profiles

Clay

Sand

Clayey Sand

Sandy Clay

Gravel

Silty Sand

No Recovery

Evaluation of Results

Evaluation of this data in relation to the simple estimate of DNAPL concentrations, indicate DNAPL below the inlet of the basin is primarily in the form of PCE. Looking at the vertical distribution of the contaminants in this boring indicates the contaminants are located in a zone ranging from elevations of 242 ft msl downward to 233 ft msl. This is a region of sandy material overlaying a sandy clay zone of approximately 3 ft thickness at a top elevation of 228 ft msl. This contaminated zone appears to be within a smear zone created from natural fluctuations in the water table. The water table at the basin is estimated to range from 119 ft depth to 125 ft depth (238 ft msl to 232 ft msl). Table 2 identifies the elevations at which DNAPL and suspect DNAPL concentrations were reported for the three borings drilled this year.

Boring MRS 28 data suggest that contaminants are moving through the area which is located between the M-Area Basin and monitoring well MSB 76. Concentrations of TCE and PCE were reported in boring MRS 28. However, none of the concentrations were above the 45 $\mu\text{g/g}$ calculated as a rule of thumb number for indication of DNAPL in the immediate area. This indicates that boring MRS 28 was drilled within an area of the dissolved plume, but not within the narrower area of the DNAPL transport zone.

Data from boring MRS 27 suggests DNAPL is not moving eastward from the basin. As this is the only boring available on the eastern side of the basin, an additional one or two borings along this edge of the basin is warranted to confirm or deny the findings of boring MRS 27.

Table 2. Identification of Elevations at which DNAPL and suspect DNAPL concentrations were reported for borings from the FY99 DNAPL investigations at the M-Area Basin.

Elevation	MRS26	MRS27	MRS28
263			
262	D		
261			
260			
259		nd	
258			
257			
256			
255			nd
254			
253			
252			
251			
250		nd	
249			
248			
247			
246			
245			
244	SD		nd
243		nd	
242	D		nd
241	D		nd
240 (~ water table)	D		nd
239			nd
238			nd
237			nd
236	D		nd
235			nd
234			nd
233	D		nd
232			nd
231			nd
230			
229			
228			
227			
226	SD		
225			

Elevation	MRS26	MRS27	MRS28
224			
223			
222			
221			
220			
219			
218			
217			
216			
215			
214			
213			
212			
211			
210			
209			
208			
207			
206		nd	
205			
204			
203			
202			
201			
200	nd		

D – DNAPL concentrations (45µg/g PCE or greater), SD – suspect DNAPL concentrations (between ½ the DNAPL concentration and the DNAPL concentration, 22.5 µg/g < x < 45 µg/g). nd – below detection limit of 0.001µg/g. Clear blocks indicate concentrations between suspect DNAPL and below detection. Shaded blocks indicate no samples collected at those elevations.

Future Work

The data presented in this report and in the FY98 report should be incorporated with the data collected near the M-Area Basin within the last 20 years. This data could be evaluated using three dimensional visualization techniques to determine if sufficient information is available to accurately delineate the DNAPL migration pathway from the M-Area Basin. This would include consolidating the recently completed mapping of the

structure and distribution of mud within the Steed Pond Aquifer and Vadose Zone beneath A/M Area (Parker, et al., June 1999) and concentration data from soil plug samples beneath and adjacent to the M-Area Basin.

Upon completion of this evaluation, data gaps should be filled to improve the delineation of the DNAPL migration pathway.

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Appendix A. Depth Concentration Information

Expanded Depth Concentration Profiles for Borings MRS 26, 27 and 28.

Depth Concentration Tables for Borings MRS 26, 27, and 28.

Boring name: MRS-26 M Area Seepage Basin Inlet logged by: Jay Noonkester			Drilling Method: Rotosonic Rig/ 45° angle Total Footage Drilled: 224ft. Total Depth Drilled: 157 ft. Surf. Elev.: 357.4 ft. T.D. Elev: 200 ft. (est.) Surface Coordinates: N102210.7 E48646.1 T. D. Coordinates: N102109.4 E48525.3			Environmental Restoration Technology Section
Elev.	Depth	TCE (ug/a) Soil conc.	PCE (ug/g) Soil conc.	Clay % <1/16mm	Lithology	Description	Sand Clay Silt
		0-----25	0-----200	1--100			

300							
						NO RECOVERY	
						SAND: grading into clayey sand, gray 5YR5/1 with red mottling, v. fine to med.	
						NO RECOVERY	
						NO RECOVERY	
						SANDY CLAY: brownish yellow 10YR6/8, med. to fine.	
						SAND: yellow 10YR7/8, med. to coarse.	
						NO RECOVERY	
						SAND: yellow 10YR7/8, fine to v. coarse.	
75						NO RECOVERY	
						NO RECOVERY	
						SAND: reddish yellow 7.5YR6/8, several v. thin lt. gray clay laminae.	
275						SANDY CLAY: reddish yellow 5YR6/8, v. fine to v. coarse with granules.	
						NO RECOVERY	
						SAND: yellow 10YR7/8, v. fine to coarse with granules, clay laminae present at 88'.	
						NO RECOVERY	
						CLAY: yellow 10YR7/8.	
						SAND: yellow 10YR7/8, black from 96' to 96.5', fine to coarse.	
100						NO RECOVERY	
						NO RECOVERY	
						CLAYEY SAND: brownish yellow 10YR6/8, med. to v. coarse with many granules.	
						SAND: yellow 10YR7/8, v. coarse, dry.	
250						NO RECOVERY	
						SAND: v. pale brn. 10YR7/4, coarse to granules,	

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Boring name: MRS-26 M Area Seepage Basin Inlet logged by: Jay Noonkester			Drilling Method: Rotasonic Rig/ 45° angle Total Footage Drilled: 224ft. Total Depth Drilled: 157 ft. Surf. Elev.: 357.4 ft. T.D. Elev.: 200 ft. (est.) Surface Coordinates: N102210.7 E48646.1 T. D. Coordinates: N102109.4 E48525.3			Environmental Restoration Technology Section
Elev.	Depth	TCE (ug/a) Soil conc.	PCE (ug/g) Soil conc.	Clay % <1/16mm	Lithology	Description	Sand Clay Silt
		0-----25	0-----200	1--100			
						coarsening down.	
						SAND: reddish yellow 7.5YR6/8, v. fine to fine, one thick gray clay laminae at 111.5'.	
						SAND: yellowish red 5YR4/6 to yellow 10YR7/8, v. fine to med. with occasional coarse, several zones of silty sand.	
						NO RECOVERY	
						SAND: reddish yellow 7.5YR6/3, fine to coarse.	
						NO RECOVERY	
						SANDY CLAY: multi-colors of reddish yellow, v. pale brn., reddish brn., v. fine to med.	
						SAND: reddish yellow 7.5YR7/8, med. to v. coarse with occasional granules.	
						NO RECOVERY	
						SAND: reddish yellow 7.5YR7/8, med. to coarse two thin gray laminae.	
						CLAY: reddish yellow, lt. gray, drk red, v. fine sand laminae throughout, thin fine grained cemented material at top.	
						SANDY CLAY: grading to clayey sand, reddish yellow with some drk. red and v. pale brn., med. to v. coarse.	
						SAND: yellow 10YR8/8, v. fine some cemented sands at top.	
						CLAYEY SAND: yellow 10YR7/8, med. to v. coarse.	
						NO RECOVERY	
						SAND: brownish yellow 10YR6/8, v. fine to fine, several thin light gray clay laminae throughout.	

Boring name: MRS-27 M Area Seepage Basin logged by: Jay Noonkester		Drilling Method: Rotasonic Rig/ 45° angle Total Footage Drilled: 214ft. Total Depth Drilled: 151 ft. Surf. Elev.: 351.6 ft. T.D.Elev: 200 ft. (est.) Surface Coordinates: N101807.95 E48534.44 T. D. Coordinates: N101957.1 E48534.44		Environmental Restoration Technology Section
Elev.	Depth	TCE (ug/a) Soil conc.	PCE (ug/g) Soil conc.	Clay % <1/16mm	Lithology	Description
	0	0-----1	0-----1	1--100		
350					SANDY CLAY: red 2.5YR4/6 with some yellow mottling, sand coarse to granules with occasional pebbles, hard to v. hard.	
					SANDY CLAY: red 2.5YR4/6 with some yellow mottling, sand med. to coarse, hard.	
					CLAYEY SAND: red 2.5YR4/6 with yellow, white and bluish gray mottling, fine to granules with abundant pebbles, hard.	
					SANDY CLAY: red 10R4/8 with some yellow mottling, sand fine to med., hard.	
					CLAYEY SAND: red 2.5YR5/8 with some white mottling, sand fine to coarse, occasional muscovite.	
25					CLAYEY SAND: reddish brn. 5YR5/4 with some bluish gray mottling, sand v. fine to med., muscovite present.	
325					SILTY SAND: mottled colors of yellowish red and gray, sandy clay laminae throughout, sand v. fine to v. coarse, firm, muscovite present.	
					SAND: yellow to reddish gray, sandy clay laminae throughout, sand v. fine to v. coarse.	
					CLAYEY SAND: drk. red 10R3/6, sand v. fine to med., firm.	
					NO RECOVERY	
					CLAYEY SAND: strong brn. 7.5YR5/8 with gray mottling, sand v. fine to med., soft.	
					CLAYEY SAND: brn. 7.5YR5/3 and strong brn. 7.5YR5/6, sand v. fine to med., soft.	
					NO RECOVERY	
					SANDY CLAY: weak red 10R5/3 with yellow mottling, sand v. fine to fine, firm.	
50					CLAYEY SAND: brownish yellow 10YR6/8, sand v. fine to v. coarse with granules and pebbles increasing down, clay + increasing down.	
300					CLAYEY SAND: brownish yellow 10YR6/8, sand v. fine to v. coarse with granules and pebbles.	

Boring name: MRS-27 M Area Seepage Basin logged by: Jay Noonkester			Drilling Method: Rotosonic Rig/ 45° angle Total Footage Drilled: 214ft. Total Depth Drilled: 151 ft. Surf. Elev.: 351.6 ft. T.D.Elev: 200 ft. (est.) Surface Coordinates: N101807.95 E48534.44 T. D. Coordinates: N101957.1 E48534.44			Environmental Restoration Technology Section
Elev.	Depth	TCE (ug/a) Soil conc.	PCE (ug/g) Soil conc.	Clay % <1/16mm	Lithology	Description	
0-----1	0-----1	0-----1	0-----1	1--100
					SAND: brownish yellow 10YR6/8, fine to coarse granules and pebbles at 54'.
					NO RECOVERY
					SAND: brownish yellow 10YR6/8, v. fine to med.
					NO RECOVERY
					SAND: yellowish brn 10YR7/8, fine to coarse with abundant pebbles from 71' to 72'.
					NO RECOVERY
					CLAYEY SAND: red 2.5YR4/6, fine to v. coarse with abundant granules and occasional pebbles.
					SAND: yellow 10YR7/8, v. fine to med.
					NO RECOVERY
					SAND: yellow 10YR7/8, v. fine to coarse with occasional v. coarse.
					NO RECOVERY
					SAND: strong brn. 7.5YR5/8, v. fine to coarse with abundant granules and pebbles.
					NO RECOVERY
					SAND: brownish yellow 10YR6/8, med. to coarse with granules and pebbles from 96' to 99'.
					CLAYEY SAND: brn. 7.5YR4/4 grading into reddish yellow to strong brn., med. to v. coarse with abundant granules and pebbles, hard dense.
					SAND: strong brn. 7.5YR5/8 to reddish yellow, v. fine to med., several silty sand layers v. clean sand, dry.
					SAND: drk. brn. 7.5YR3/3 to reddish yellow, med. to v. coarse with occasional granules, two thin clayey zones.	

A-7

August 1999

Revision 0

Boring name: MRS-28 M Area Seepage Basin logged by: Jay Noonkester			Drilling Method: Rotasonic Rig/ vertical Total Footage Drilled: 157ft. Total Depth Drilled: 157 ft. Surf. Elev.: 358.27 ft. T.D. Elev: 201.3 ft. Surface Coordinates: N102268.38 E48435.15 T. D. Coordinates: N102268.38 E48435.15			Environmental Restoration Technology Section
Elev.	Depth	TCE (ug/g)	PCE (ug/g)	Clay %	Lithology	Description
		Soil conc.	Soil conc.	<1/16mm			
		0-----15	0-----15	1--100			
	0					SANDY CLAY: red 2.5YR4/6, coarse to granules, hard.	
					X X X	NO RECOVERY	
						SANDY CLAY: red 2.5YR4/6, coarse to granules, with occasional pebbles, hard.	
						SANDY CLAY: red 2.5YR4/6 with yellow and bluish gray mottling throughout, med. to coarse, sand decreasing down, silt increasing down.	
						CLAYEY SAND: red 2.5YR4/6 grading into dusky red 10R3/4, med. to coarse, v. hard.	
						CLAYEY SAND: red 2.5YR4/8 grading into yellowish red 5YR4/6, fine to v. coarse, v. hard to firm.	
	25					SILTY SAND: reddish brn. 2.5YR4/4, some gray and black mottling, muscovite present, v. fine to v. coarse.	
					X X X	NO RECOVERY	
					X X X	NO RECOVERY	
						SILTY SAND: weak red 10R5/2, med. to v. coarse, several v. thin silty clayey laminae of yellow and gray.	
	325					SAND: banded colors of drk. red and pale red, v. fine to fine, some silty sand laminae present.	
						SILTY SAND: strong brn. 7.5YR5/8 changing to reddish brn. 5YR5/3 last 6", v. fine to fine, clay increasing down.	
					X X X	NO RECOVERY	
	50						

Boring name: MRS-28 M Area Seepage Basin logged by: Jay Noonkester			Drilling Method: Rotosonic Rig/ vertical Total Footage Drilled: 157ft. Total Depth Drilled: 157 ft. Surf. Elev.: 358.27 ft. T.D.Elev: 201.3 ft. Surface Coordinates: N102268.38 E48435.15 T. D. Coordinates: N102268.38 E48435.15			Environmental Restoration Technology Section
Elev.	Depth	TCE (ug/g) Soil conc.	PCE (ug/g) Soil conc.	Clay % <1/16mm	Lithology	Description	
		0-----15	0-----15	1--100			
					XXX	NO RECOVERY	
						SANDY CLAY: grading into a clayey sand, then back to sandy clay, weak red to yellow to weak red, v. fine to fine.	
						SAND: brownish yellow 10YR6/8, fine to med. with occasional v. coarse.	
					XXX	NO RECOVERY	
						SAND: brownish yellow 10YR5/8, fine to coarse.	
					XXX	NO RECOVERY	
						SAND: multi colors of brownish yellow, reddish yellow, red, and some white, fine to coarse.	
					XXX	NO RECOVERY	
						SILTY SAND: strong brn. 7.5YR5/8, v. fine to v. coarse with some granules and occasional pebbles, several v. thin clay laminae.	
						SAND: red 2.5YR4/8, v. fine to v. coarse, several sandy clay laminae present.	
						CLAYEY SAND: strong brown 7.5YR5/8, v. fine to coarse with many v. coarse and occasional granules, 2 thin brown clay laminae.	
						SAND: v. pale brn. 10YR 8/3, fine to v. coarse.	
						CLAYEY SAND: yellowish red 5YR 4/6, v. fine to v. coarse with granules and pebbles.	
					XXX	NO RECOVERY	
						SAND: strong brn. 7.5YR 5/8, med. to v. coarse.	
						CLAY: light gray with v. thin drk. brn. silty	

Boring name: MRS-28 M Area Seepage Basin logged by: Jay Noonkester			Drilling Method: Rotosonic Rig/ vertical Total Footage Drilled: 157ft. Total Depth Drilled: 157 ft. Surf. Elev.: 358.27 ft. T.D.Elev: 201.3 ft. Surface Coordinates: N102268.38 E48435.15 T. D. Coordinates: N102268.38 E48435.15			Environmental Restoration Technology Section
Elev.	Depth	TCE (ua/d)	PCE (ug/g)	Clay %	Lithology	Description	Sand Clay Silt
		Soil conc.	Soil conc.	<1/16mm			
		0-----15	0-----15	1--100			

Elev. Depth 125 225 150		sand laminae. SAND: strong brn. 7.5YR 5/8, v. fine to fine, v. thin light gray clay laminae near bottom.
		NO RECOVERY
		SAND: strong brn. 7.5YR 5/6, v. fine to coarse, several v. thin sandy clay laminae present.
		SILTY SAND: strong brn., v. fine to fine, hard, some indurated material. SAND: yellowish red 5YR 5/8, v. fine to medium with occasional granules, several zones of v. thin gray clay laminae.
		SAND: yellowish red 5YR 5/8, fine to medium with occasional granules.
		SILTY SAND: yellowish red 5YR5/8 with some drk. red and red streaks, v. fine to v. coarse. CLAY: banded colors of yellowish red, brn., and light brn.
		SAND: yellow 10YR7/8, with some pale brn. and red, two zones of clayed sand.
		SAND: yellow 10YR7/8, with some pale brn and red, v. fine to v. coarse, fining down, v. thin to thin purple clay laminae.
		CLAY: light gray, red, yellow, some silty sand laminae.

Table A-1. Depth Concentration Profile for Soil Boring MRS26. Drilled at a 45° angle from the north side of the M-Area Basin to below the inlet.

ID		Northing	Easting	Elevation	Soil Conc. (avg)			
		Surface: 102210.73	Surface: 48646.11	(ft msl)	TCE (ug/g)	PCE (ug/g)	TCA (ug/g)	CCl4 (ug/g)
MRS26	01	102206.6	48641.2	351	<0.001	0.005	<0.001	<0.001
MRS26	02	102204.4	48638.5	348	<0.001	<0.001	<0.001	<0.001
MRS26	03	102202.5	48636.4	345	<0.001	0.001	<0.001	<0.001
MRS26	04	102199.8	48633.1	340	<0.001	<0.001	<0.001	<0.001
MRS26	05	102198.0	48630.9	338	<0.001	0.002	<0.001	<0.001
MRS26	06	102195.3	48627.7	333	<0.001	0.003	<0.001	<0.001
MRS26	07	102193.5	48625.5	331	<0.001	0.005	<0.001	<0.001
MRS26	08	102191.6	48623.4	328	<0.001	0.004	<0.001	<0.001
MRS26	09	102189.8	48621.2	325	<0.001	0.005	<0.001	<0.001
MRS26	10	102188.9	48620.1	323	<0.001	<0.001	<0.001	<0.001
MRS26	11	102188.0	48619.0	322	<0.001	<0.001	<0.001	<0.001
MRS26	12	102187.1	48617.9	321	<0.001	0.006	<0.001	<0.001
MRS26	13	102183.5	48613.6	315	<0.001	0.027	<0.001	<0.001
MRS26	14	102181.6	48611.4	312	<0.001	0.235	<0.001	<0.001
MRS26	15	102179.4	48608.7	309	0.001	0.009	<0.001	<0.001
MRS26	16	102178.9	48608.2	308	0.003	0.020	<0.001	<0.001
MRS26	17	102178.0	48607.1	306	0.015	0.065	0.001	<0.001
MRS26	18	102175.7	48604.4	303	0.022	0.068	0.002	<0.001
MRS26	19	102174.8	48603.3	302	0.041	0.114	0.003	<0.001
MRS26	20	102174.4	48602.8	301	0.002	0.005	<0.001	<0.001
MRS26	21	102173.5	48601.7	299	0.035	0.050	0.001	<0.001
MRS26	22	102171.2	48599.0	296	0.063	0.066	<0.001	<0.001
MRS26	23	102170.7	48598.4	295	0.222	0.211	0.003	<0.001
MRS26	24	102170.3	48597.9	294	0.909	0.993	0.013	<0.001
MRS26	25	102165.7	48592.5	287	0.001	0.002	<0.001	<0.001
MRS26	26	102164.8	48591.4	286	0.005	0.005	<0.001	<0.001
MRS26	27	102161.2	48587.1	280	<0.001	<0.001	<0.001	<0.001
MRS26	28	102158.0	48583.3	275	<0.001	<0.001	<0.001	<0.001
MRS26	29	102157.1	48582.2	274	0.010	0.006	<0.001	<0.001
MRS26	30	102156.2	48581.1	273	0.160	1.369	<0.001	<0.001
MRS26	31	102155.3	48580.0	271	5.241	10.566	0.006	<0.001
MRS26	32	102153.9	48578.4	269	17.385	19.891	0.018	0.006
MRS26	33	102153.5	48577.9	268	0.212	0.179	<0.001	0.001
MRS26	34	102153.0	48577.3	268	0.226	0.180	<0.001	<0.001
MRS26	35	102152.6	48576.8	267	0.069	0.040	<0.001	<0.001

ID		Northing	Easting	Elevation	Soil Conc. (avg)			
		Surface: 102210.73	Surface: 48646.11	(ft msl)	TCE (ug/g)	PCE (ug/g)	TCA (ug/g)	CCl4 (ug/g)
MRS26	36	102152.1	48576.2	266	0.148	0.092	<0.001	<0.001
MRS26	37	102151.6	48575.7	265	0.015	0.007	<0.001	<0.001
MRS26	38	102149.4	48573.0	262	22.132	54.925	0.059	0.001
MRS26	39	102148.9	48572.4	261	0.019	0.074	<0.001	<0.001
MRS26	40	102148.5	48571.9	261	<0.001	0.002	<0.001	<0.001
MRS26	41	102148.0	48571.4	260	0.002	0.004	<0.001	<0.001
MRS26	42	102144.8	48567.6	255	0.379	8.493	<0.001	<0.001
MRS26	43	102144.4	48567.0	254	0.148	2.496	<0.001	<0.001
MRS26	44	102143.9	48566.5	253	0.111	0.452	<0.001	<0.001
MRS26	45	102143.5	48565.9	253	0.003	0.017	<0.001	<0.001
MRS26	46	102143.0	48565.4	252	0.002	0.010	<0.001	<0.001
MRS26	47	102142.6	48564.9	251	0.002	0.010	<0.001	<0.001
MRS26	48	102142.1	48564.3	251	0.003	0.012	<0.001	<0.001
MRS26	49	102141.6	48563.8	250	0.005	0.039	0.005	<0.001
MRS26	50	102140.3	48562.2	248	0.082	1.199	<0.001	<0.001
MRS26	51	102139.4	48561.1	246	0.158	1.431	<0.001	<0.001
MRS26	52	102138.5	48560.0	245	0.090	2.155	<0.001	<0.001
MRS26	53	102138.0	48559.4	244	0.052	3.779	0.005	<0.001
MRS26	54	102137.6	48558.9	244	0.041	23.575	0.004	<0.001
MRS26	55	102137.1	48558.4	243	0.004	8.656	0.020	0.004
MRS26	56	102136.6	48557.8	242	0.112	55.394	0.013	0.002
MRS26	57	102136.2	48557.3	241	0.006	1.298	<0.001	0.012
MRS26	58	102135.7	48556.7	241	0.480	49.306	0.025	0.015
MRS26	59	102135.3	48556.2	240	0.144	198.307	0.008	0.002
MRS26	60	102134.8	48555.7	239	<0.001	0.054	0.044	0.007
MRS26	61	102134.4	48555.1	239	<0.001	0.276	<0.001	0.006
MRS26	62	102133.9	48554.6	238	0.027	22.031	0.015	0.004
MRS26	63	102133.5	48554.0	237	<0.001	0.039	0.084	<0.001
MRS26	64	102133.0	48553.5	236	0.051	113.648	<0.001	<0.001
MRS26	65	102132.6	48552.9	236	0.006	0.946	0.716	<0.001
MRS26	66	102132.1	48552.4	235	0.040	20.802	<0.001	0.004
MRS26	67	102130.7	48550.8	233	0.132	47.146	<0.001	<0.001
MRS26	68	102130.3	48550.2	232	0.095	17.319	0.004	<0.001
MRS26	69	102129.8	48549.7	232	0.081	5.986	<0.001	<0.001
MRS26	70	102129.4	48549.2	231	0.038	2.022	<0.001	<0.001
MRS26	71	102128.9	48548.6	230	0.093	3.398	<0.001	<0.001
MRS26	72	102128.5	48548.1	229	0.142	6.796	<0.001	<0.001
MRS26	73	102128.0	48547.5	229	0.074	3.026	<0.001	<0.001
MRS26	74	102126.2	48545.4	226	1.639	36.763	<0.002	<0.001
MRS26	75	102125.3	48544.3	224	0.018	0.842	<0.001	<0.001
MRS26	76	102124.4	48543.2	223	0.010	1.894	<0.001	<0.001
MRS26	77	102122.1	48540.5	220	0.127	7.314	<0.001	<0.001

ID		Northing	Easting	Elevation	Soil Conc. (avg)			
		Surface: 102210.73	Surface: 48646.11	(ft msl)	TCE (ug/g)	PCE (ug/g)	TCA (ug/g)	CCl4 (ug/g)
MRS26	78	102121.6	48539.9	219	0.929	19.719	<0.001	<0.001
MRS26	79	102121.2	48539.4	218	1.016	18.469	<0.001	<0.001
MRS26	80	102120.7	48538.9	217	0.936	13.975	<0.001	<0.001
MRS26	81	102120.3	48538.3	217	0.174	1.420	<0.001	<0.001
MRS26	82	102119.8	48537.8	216	0.233	1.410	<0.001	<0.001
MRS26	83	102119.4	48537.2	215	0.689	1.639	<0.001	<0.001
MRS26	84	102118.9	48536.7	215	0.780	1.419	<0.001	<0.001
MRS26	85	102118.5	48536.1	214	0.728	2.228	<0.001	<0.001
MRS26	86	102118.0	48535.6	213	0.227	0.945	<0.001	<0.001
MRS26	87	102117.6	48535.1	212	0.064	0.102	<0.001	<0.001
MRS26	88	102116.6	48534.0	211	0.054	0.045	<0.001	<0.001
MRS26	89	102115.7	48532.9	210	0.132	0.571	<0.001	<0.001
MRS26	90	102114.8	48531.8	208	0.072	0.050	<0.001	<0.001
MRS26	91	102113.0	48529.6	205	0.016	0.008	<0.001	<0.001
MRS26	92	102112.1	48528.6	204	0.013	0.002	<0.001	<0.001
MRS26	93	102111.2	48527.5	203	0.003	0.035	<0.001	<0.001
MRS26	94	102110.3	48526.4	201	0.033	0.003	<0.001	<0.001
MRS26	95	102109.4	48525.3	200	0.023	<0.001	<0.001	<0.001

Table A-2. Depth Concentration Profile for Boring MRS27. Drilled at a 45° angle from the south side of the M-Area basin to the center.

ID		Northing	Easting	Elevation	Soil Conc. (avg)		
		Surface: 101807.95	Surface: 48534.44	(ft msl)	TCE (ug/g)	PCE (ug/g)	TCA (ug/g)
MRS27	01	101812.2	48534.44	347	<0.001	0.003	<0.001
MRS27	02	101817.8	48534.44	342	<0.001	<0.001	<0.001
MRS27	03	101824.9	48534.44	335	0.002	0.015	0.003
MRS27	04	101832.0	48534.44	328	0.002	0.011	0.002
MRS27	05	101839.1	48534.44	320	<0.001	<0.001	<0.001
MRS27	06	101844.7	48534.44	315	<0.001	<0.001	<0.001
MRS27	07	101851.1	48534.44	308	<0.001	<0.001	<0.001
MRS27	08	101860.3	48534.44	299	<0.001	<0.001	<0.001
MRS27	09	101863.1	48534.44	296	<0.001	<0.001	<0.001
MRS27	10	101870.2	48534.44	289	<0.001	<0.001	<0.001
MRS27	11	101880.1	48534.44	279	<0.001	0.003	<0.001
MRS27	12	101885.7	48534.44	274	0.001	0.002	<0.001
MRS27	13	101893.5	48534.44	266	<0.001	<0.001	<0.001
MRS27	14	101900.6	48534.44	259	<0.001	<0.001	<0.001
MRS27	15	101909.8	48534.44	250	<0.001	<0.001	<0.001
MRS27	16	101913.3	48534.44	246	<0.001	0.003	<0.001
MRS27	17	101916.8	48534.44	243	<0.001	<0.001	<0.001
MRS27	18	101923.9	48534.44	236	<0.001	0.002	<0.001
MRS27	19	101928.2	48534.44	231	0.001	0.007	0.002
MRS27	20	101931.0	48534.44	229	0.002	0.017	0.004
MRS27	21	101933.8	48534.44	226	0.002	0.003	<0.001
MRS27	22	101935.9	48534.44	224	0.004	0.015	0.003
MRS27	23	101938.1	48534.44	221	0.003	0.010	0.001
MRS27	24	101940.2	48534.44	219	0.002	0.011	0.002
MRS27	25	101943.0	48534.44	217	<0.001	0.001	<0.001
MRS27	26	101945.8	48534.44	214	<0.001	0.001	<0.001
MRS27	27	101947.3	48534.44	212	<0.001	0.001	<0.001
MRS27	28	101948.7	48534.44	211	0.002	0.010	0.002
MRS27	29	101950.8	48534.44	209	<0.001	0.005	0.001
MRS27	30	101951.5	48534.44	208	0.002	0.013	0.003
MRS27	31	101953.6	48534.44	206	<0.001	<0.001	<0.001
MRS27	32	101955.0	48534.44	205	0.013	0.003	<0.001
MRS27	33	101955.7	48534.44	204	0.032	0.007	0.001
MRS27	34	101956.4	48534.44	203	0.026	0.003	<0.001
MRS27	35	101957.1	48534.44	202	0.018	0.004	0.001

Table A-3. Depth Concentration Profile for Boring MRS28. Drilled vertically at a location between the M-Area Basin and the In Situ Oxidation Demonstration Location (MOX well series).

ID		Elevation	Soil Conc. (avg)		
		(ft msl)	TCE (ug/g)	PCE (ug/g)	TCA (ug/g)
MRS28	01	355	0.001	0.005	<0.001
MRS28	02	351	<0.001	0.001	<0.001
MRS28	03	346	<0.001	<0.001	<0.001
MRS28	04	341	<0.001	<0.001	<0.001
MRS28	05	335	<0.001	<0.001	<0.001
MRS28	06	327	<0.001	<0.001	<0.001
MRS28	07	311	<0.001	<0.001	<0.001
MRS28	08	304	<0.001	<0.001	<0.001
MRS28	09	295	<0.001	<0.001	<0.001
MRS28	10	285	<0.001	<0.001	<0.001
MRS28	11	274	<0.001	<0.001	<0.001
MRS28	12	261	0.004	0.001	<0.001
MRS28	13	255	<0.001	<0.001	<0.001
MRS28	14	244	<0.001	<0.001	<0.001
MRS28	15	242	<0.001	<0.001	<0.001
MRS28	16	241	<0.001	<0.001	<0.001
MRS28	17	240	<0.001	<0.001	<0.001
MRS28	18	239	<0.001	<0.001	<0.001
MRS28	19	238	<0.001	<0.001	<0.001
MRS28	20	237	<0.001	<0.001	<0.001
MRS28	21	236	<0.001	<0.001	<0.001
MRS28	22	235	<0.001	<0.001	<0.001
MRS28	23	234	<0.001	<0.001	<0.001
MRS28	24	233	<0.001	<0.001	<0.001
MRS28	25	232	<0.001	<0.001	<0.001
MRS28	26	231	<0.001	<0.001	<0.001
MRS28	27	230	0.002	0.010	<0.001
MRS28	28	229	0.004	0.049	<0.001
MRS28	29	228	0.126	1.291	<0.001
MRS28	30	227	1.705	12.040	<0.001
MRS28	31	226	1.154	11.440	<0.001
MRS28	32	225	0.770	2.589	<0.001
MRS28	33	224	1.672	10.852	0.002
MRS28	34	223	0.671	6.469	0.001
MRS28	35	222	0.279	2.826	<0.001
MRS28	36	221	0.142	1.159	<0.001

ID		Elevation	Soil Conc. (avg)		
		(ft msl)	TCE (ug/g)	PCE (ug/g)	TCA (ug/g)
MRS28	37	220	0.012	0.045	<0.001
MRS28	38	219	0.014	0.115	<0.001
MRS28	39	218	0.218	5.433	0.001
MRS28	40	217	0.141	2.539	<0.001
MRS28	41	216	0.264	3.535	<0.001
MRS28	42	215	0.434	3.331	0.001
MRS28	43	214	0.327	2.464	0.001
MRS28	44	213	0.145	1.617	<0.001
MRS28	45	212	1.293	6.056	<0.001
MRS28	46	211	0.728	5.913	<0.001
MRS28	47	210	1.704	9.376	<0.001
MRS28	48	209	1.806	7.178	<0.001
MRS28	49	208	1.917	7.551	<0.001
MRS28	50	207	0.633	2.185	<0.001
MRS28	51	206	0.194	0.352	<0.001
MRS28	52	205	0.052	0.121	<0.001
MRS28	53	204	0.093	0.121	<0.001
MRS28	54	203	0.051	0.031	<0.001
MRS28	55	202	0.019	0.007	<0.001
MRS28	56	201	0.041	0.015	<0.001