4.0 RFI-Phase II RFI RESULTS

This section presents the contamination assessments of SWMUs 3, 5, 8, 9, 30, and 31. Each contamination assessment is formulated using three steps. First, the historical and physical characteristics of each SWMU are identified. Second, the nature and extent of the contamination in soil, groundwater, surface water (at SWMU 31 only), and air is determined for each SWMU using the chemical analytical results. Third, contaminant fate and transport mechanisms are identified for each SWMU. Once compiled, the information provided in the contamination assessments is used to support the evaluation of potential risk to human and ecological receptors from contamination at each SWMU (see Sections 5 and 6, respectively).

4.1 SWMU 3

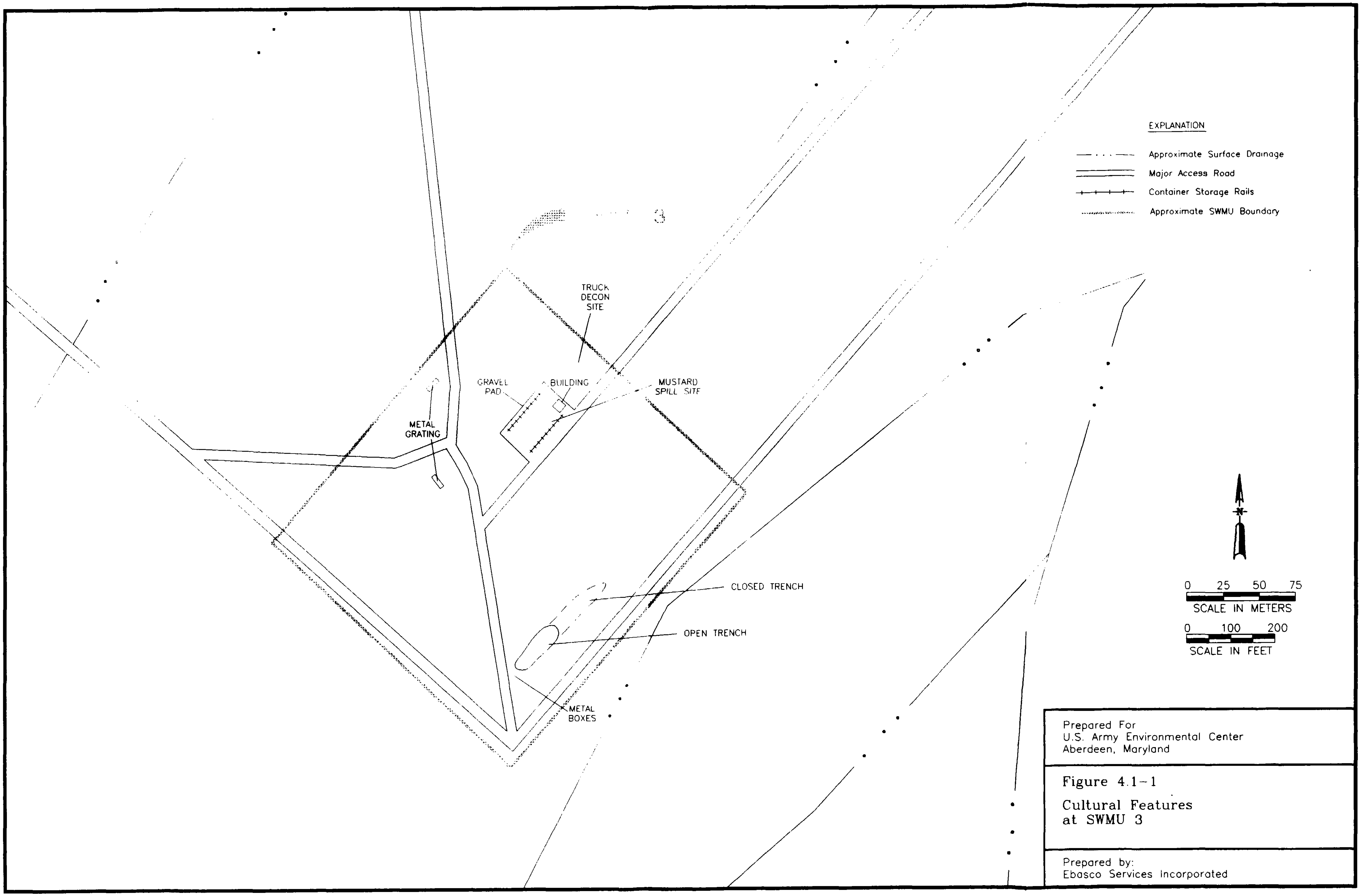
4.1.1 Background

This section presents information on SWMU 3 site history and cultural features, geology and soil, and hydrology.

4.1.1.1 Site History and Description of SWMU 3: Impounding Bay/Disposal Pit (Southeast of Area 2)

SWMU 3 is referred to as the "Disposal Pit" in the corrective action module; however, the SWMU name was revised for the purposes of this report to reflect the increased significance of the gravel pad in the unit and to include the facility name for the gravel pad.

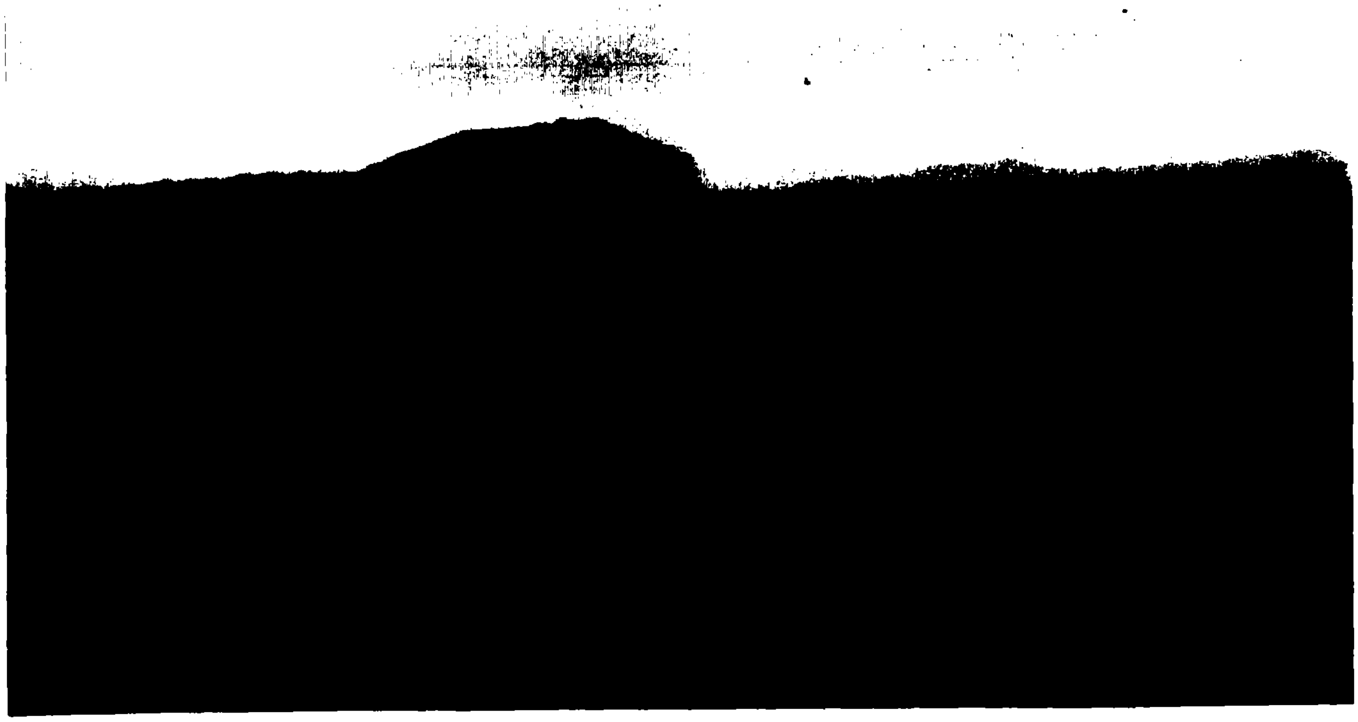
SWMU 3 is located in the southeastern portion of TEAD-S. The site includes an elevated gravel pad with an open-sided wood and sheet-metal building and a nearby disposal trench (Figure 4.1-1). According to Norris (1993b), leaking 1-ton chemical agent containers were decontaminated and leaking valves were repaired at the gravel pad, which was referred to by name as the Impounding Bay. Prior to 1968, the containers were transported from the open storage portion of Area 2 in SWMU 9 to the site in dump trucks and placed on railroad ties while awaiting maintenance; after 1968 the containers were placed on the rails. The dump trucks were decontaminated off the north side of the gravel pad (Figure 4.1-2). The containers were decontaminated on the rails or ties on the gravel pad using Decontaminating Agent, Non-Corrosive (DANC), sodium hydroxide, sodium hypochlorite, sodium carbonate, DS2, or super tropical bleach (STB). DANC, which was used to neutralize blister agents, was composed of a 6.25% solution of RH-195 (1,3-dichloro-5,5-dimethydantoin) in acetylene tetrachloride. According to Barnes (1992), DANC was no longer used on site by the late 1960s. The valves on the containers were replaced while the containers were on the ties or rails and the containers returned to storage at SWMU 9. According to Norris (1993b), mustard containers leaked onto the pad at the north end of the eastern rail in the late 1960s (Figure 4.1-3).



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-1
Cultural Features
at SWMU 3

Prepared by:
Ebasco Services Incorporated

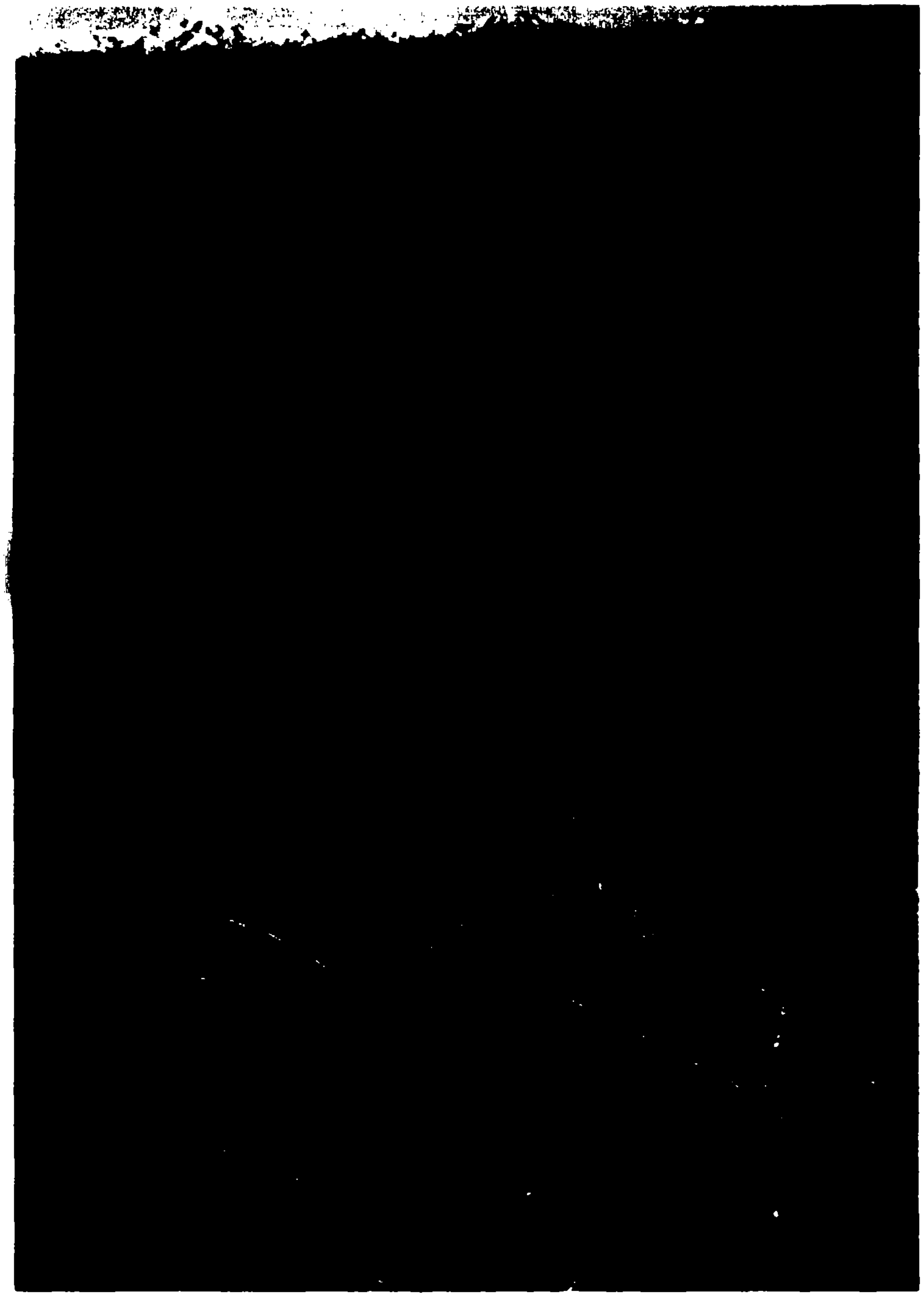


Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-2

Truck Decontamination Site (Bare Area) at SWMU 3.

Prepared by:
Ebasco Services Incorporated



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-3

Mustard Leak Site (3-BLD-2) at SWMU 3.

Prepared by:
Ebasco Services Incorporated

The wood and sheet-metal building is open on three sides; the one wall faces the rails. The building frame is constructed of 2 x 6 lumber, while the flooring is built of 4 x 6 timber laid in a crossed pattern to provide added strength. The exact function of the building is unknown (Norris 1993b). During the RFI-Phase I field program, a sign was found on the ground near the building stating "Groups (special hazard) ammunition or agent" and "Contains agent." The remainder was illegible due to rusting (EBASCO 1993a). The unit was reportedly used to repair agent containers until about 1970. The startup date for the unit is not known, although all the structural features were extant in 1967 (Norris 1993b).

Stacks of metal grating are located west and south of the gravel pad (Figure 4.1-4). According to Norris (1993a, b), the grating was used at SWMU 3 to provide support for the vehicles when road conditions became impassable. Previously the grating had been used to store smoke pots above the floor in the warehouses at Area 2. The grating may have been moved from SWMU 9 to SWMU 3 because it was contaminated (Niskala 1992). Similar grating was also observed within Old Area 2 at SWMU 9, where it was used for road stabilization.

The disposal trench is partially backfilled and remains open at the southern end (Figure 4.1-5). NUS (1987) noted that the open trench was approximately 80 ft long, 15 ft wide, and 6 ft deep. In the open end, drums and cans can be observed; some of the cans are marked DANC. Some of the drums have heavy ribs, indicating that they probably contained chemical agent rather than decontaminating solutions. TEAD-S employees stated that past employees had indicated that the site contained "a little bit of everything," and that people had been warned not to enter the area (USATHAMA 1979). Construction debris and packing material have also been observed in the trench. Charring of some of the trench contents indicated that an attempt at some point was made to burn the contents (NUS 1987). The contents of the covered portion of the trench (Figure 4.1-6), which is approximately 120 ft long, are presently unknown.

The general area of SWMU 3 has also been identified as the potential site of an unconfirmed 1960s nerve agent spill. According to the Installation Assessment (IA), a VX (nerve agent) spill was reported in the southeast corner of SWMU 9 (Old Area 2) at an area called the Impounding Bay where mustard spills also occurred (USATHAMA 1979). The location of the spill in Figure 8 in the IA (USATHAMA 1979) indicates that the spill may have occurred on the road from Area 2 to SWMU 3 or on the gravel pad at SWMU 3. According to Norris (1993b), the only incident at SWMU 3 involving VX concerned a VX spray tank. After dripping was heard, the tank was reportedly examined by the Army TEU in the building at SWMU 3 to determine whether agent had been released. However, only water condensation was found.

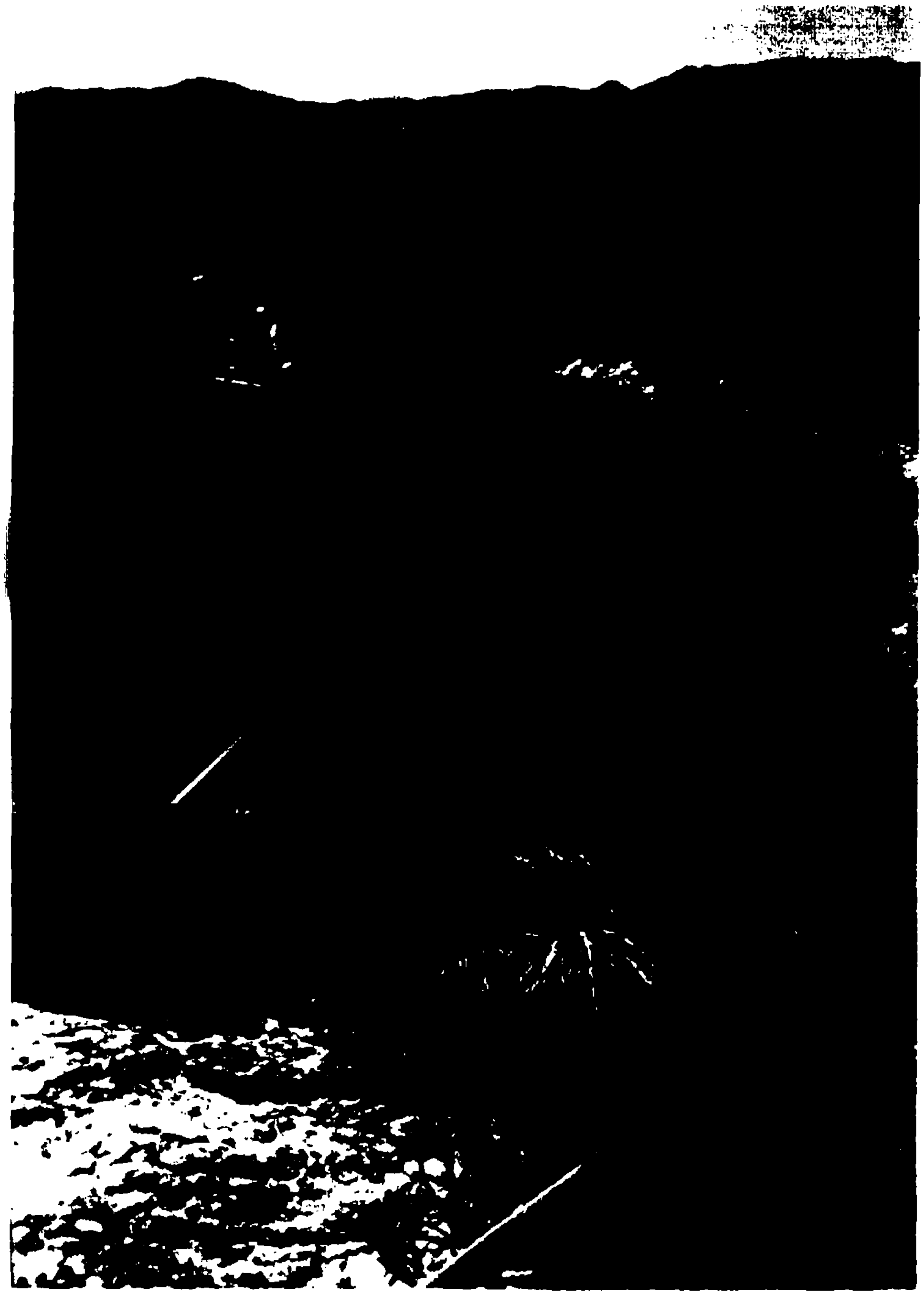
Although no fences exist at this site to indicate the exact area of any waste handling or disposal, it is likely that the trail south of the stacks of metal grating and the disposal trench was used to transport agent containers and decontamination solutions to the unit from Area 2.

Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-4

Metal Grating Stacks
at SWMU 3.

Prepared by:
Ebasco Services Incorporated



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-5

Open Section of Disposal Trench at SWMU 3.

Prepared by:
Ebasco Services Incorporated

Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1–6

Covered Section of Disposal Trench at SWMU 3.

Prepared by:
Ebasco Services Incorporated

4.1.1.2 Geology and Soil at SWMU 3

SWMU 3 is located at the distal end of the Mercur Creek alluvial fan (Figure 2.1-3). Mercur Creek cuts through the highly mineralized Great Blue limestone, which contains significant deposits of arsenic and mercury minerals, along with gold (Burger, 1983). These minerals should be present in the alluvial fan material at higher concentrations than in downgradient lacustrine deposits.

The geology and soil at SWMU 3 were characterized using a total of 17 surficial samples and shallow borings. Surficial samples were collected from the 0- to 0.2-ft interval; soil borings were collected to a maximum depth of 3 ft (Figure 3.7-1).

The overall geology of the upper 3 ft of soil in SWMU 3 consists of fine-grained lacustrine deposits. These deposits, silty clay or clayey silt, classified as CL and ML, respectively, according to the USCS. The total thickness of these deposits is unknown. In the area surrounding the wood and sheet-metal building, soil sample results (3-BLD-1, 3-BLD-2, 3-BLD-3, 3-BLD-4, 3-BLD-6, and 3-BLD-7) indicate that the 0- to 1.2-ft interval consists of a fill material that consists of silty and clayey gravel (GM, GC). Below this fill material, CL or ML soil is found.

The relative moisture conditions observed for the samples ranged from damp to moist since rain was falling during much of the soil sampling at this SWMU. The silty clay or clayey silt soil is unconsolidated and fissile. Detailed boring logs can be found in Appendix A1.

Based on geotechnical testing, soil from the two background samples is classified as CH and CL. These soil types are consistent with those described on the boring logs and are slightly alkaline, (pH values of 7.8 to 8.7). The measured moisture content of these samples was very low, ranging from 5.8 to 8.5 percent, indicating damp conditions. A coefficient of permeability was determined for each background sample location: 2.4 x 10^{-4} centimeters per second (cm/sec) for the CL soil, and 9.7 x 10^{-6} cm/sec for the CH soil. Only one sample (3-BK-1) underwent analysis for effective porosity, exhibiting a value of 24.5 percent. The bulk density was nearly identical for both sample locations at 92 to 93 pounds per cubic ft (pcf). Geochemical results of total organic carbon (TOC) and the cation-exchange capacity (CEC) were also very similar in range: 0.21 to 0.27 percent TOC and 18 to 27 meq/100 g CEC. Detailed geotechnical and geochemical data can be found in Appendix A3.

Unpublished information on soil types at TEAD-S was obtained from SCS in 1993 (SCS, no date). Only one soil type was mapped at SWMU 3, which is the Tooele fine sandy loam. This soil is slightly saline and moderately alkaline at the surface, with these conditions increasing with depth. The suitable uses for the Tooele loam are wildlife habitat and very limited pasture crop production. The suitability of this soil for livestock grazing is only fair, since the soil only produces limited amounts of forage.

4.1.1.3 Hydrology at SWMU 3

SWMU 3 is located on a gently southwest-sloping topographic surface. Surface water may occur in the area as runoff after major storms. This runoff flows to the southwest in a broad system of shallow, braided gullies that pass through the SWMU and just to the east of the disposal trench. Other shallow gullies have eroded into an old roadbed leading directly to the site from the north. These gullies are part of the Mercur Creek alluvial fan (Figure 2.1-3). Since the mid-1980s, surface water that once flowed onto TEAD-S from Mercur Creek to the northeast has now been diverted around the east side of the site (Feuerbach 1994); therefore, the amount of flow in these channels may be small. Prior to that time, including the time during which the site was actively used, surface runoff flowed through the site. Even under current conditions the open pit creates the potential for local runoff to collect and leach contaminants into the subsurface at this site.

Groundwater quality and groundwater level data were collected during the RFI-Phase II field investigation from the three existing monitoring wells in SWMU 3. These data are tabulated in Table 3.10-1; groundwater flow at SWMU 3, which is generally to the south-southwest, is presented in Figures 3.10-1 and 3.10-2.

4.1.2 Nature and Extent of Contamination

This section describes the nature and extent of contamination in soil, groundwater, and air at SWMU 3. It should be noted that in the assessments of soil and groundwater contamination only those COCs of potential risk to human or ecological receptors are described in detail. Human health COC selection for SWMU 3 is detailed in Section 5.2.1. Ecological COC selection for all Group 2 SWMUs are discussed in Section 6.3.

4.1.2.1 Soil Contamination Assessment

This section summarizes the chemical analytical results of the RFI-Phase II field sampling program, as well as those programs conducted previously, at SWMU 3. The RFI-Phase II sample results and evaluations are grouped by analyte, with significant detections discussed by location within the SWMU. The sample locations are shown on the individual contaminant maps. The complete chemical data for the RFI-Phase II soil samples can be found in Appendix F1.

Although this section presents an evaluation of all of the analytical data collected, the discussion of the RFI-Phase II results focuses on the detections of the human health and ecological COCs at SWMU 3 that are being evaluated in the risk assessments. The COCs for SWMU 3 include one organic compound (methylphosphonic acid, an agent breakdown product) and six metals (arsenic, chromium, copper, lead, mercury, and zinc).

Previous Investigations

Prior to the RFI-Phase II, no soil sampling was conducted at SWMU 3 because there was a potential for chemical agent contamination in the open portion of the trench, where soil samples were to be collected. Army TEU personnel, who are required to collect these soil samples, were unavailable during the RFI-Phase I, so the collection of samples from the trench was rescheduled for the RFI-Phase II program.

S.E.R.

unavailable during the RFI-Phase I, so the collection of samples from the trench was rescheduled for the RFI-Phase II program.

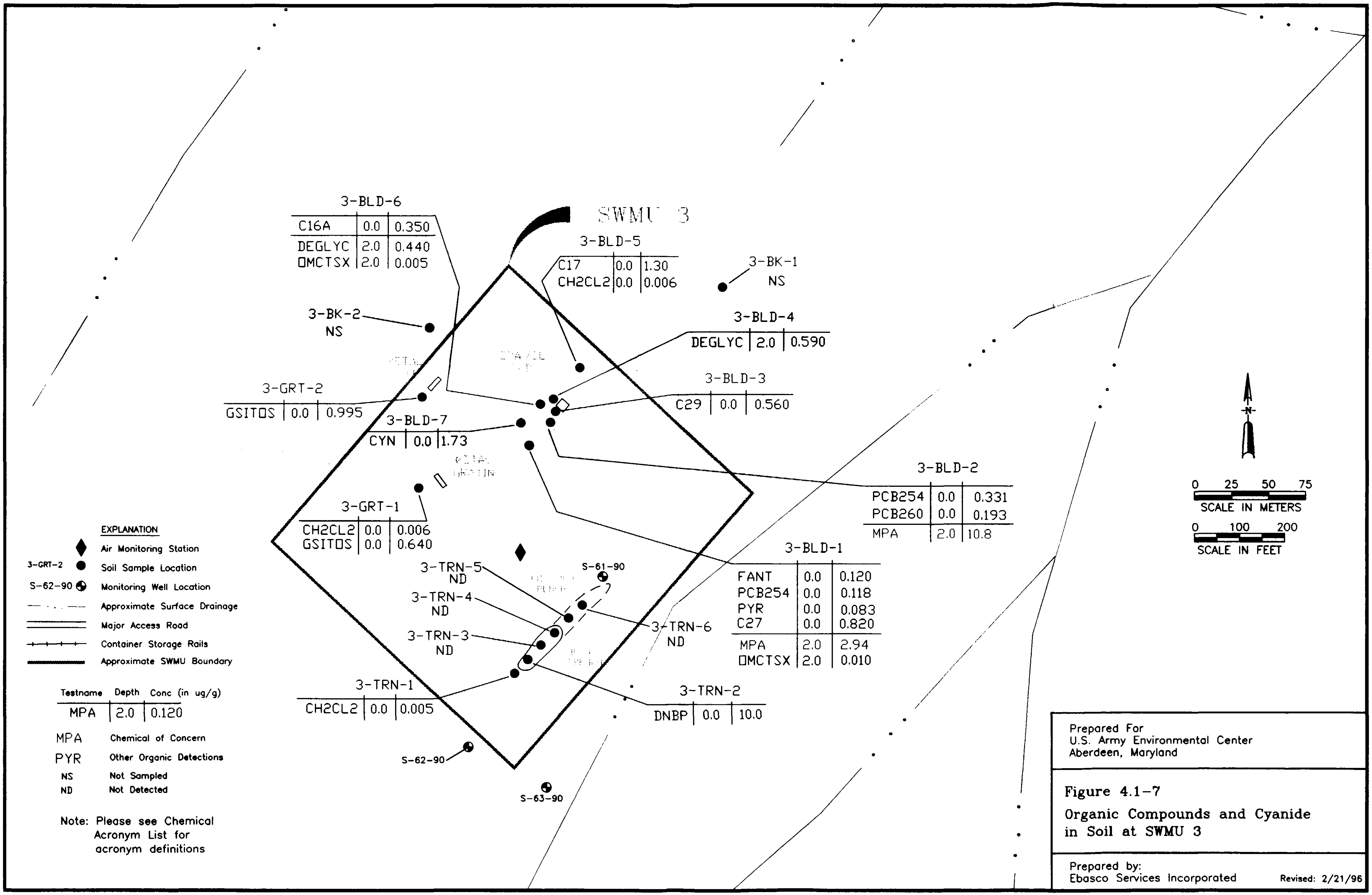
RFI-Phase II Results
A total of 24 surficial and subsurface soil samples were collected in SWMU 3. Soil borings were collected to a maximum depth of 3 ft. Of the samples, 14 were collected near the building in the SWMU, including 12 from the gravel pad. Four additional samples were collected near the two piles of metal grating and six surficial samples were collected from within and near the open trench. All samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), explosives, agent breakdown products, and metals.

Organic Compounds and Cyanide
Thirteen organic compounds were detected in soil samples at SWMU 3, (Figure 4.1-7). The target analytes were fluoranthene (FANT), methylphosphonic acid (MPA), methylene chloride (CH2CL2), pyrene (PYR), PCB 1254 (PCB254) and PCB 1260 (PCB260). Non-target analytes were clionasterol (GSITOS), diethylene glycol (DEGLYC), octamethylcyclotetrasiloxane (OMCTSX), hexadecanoic acid (C16A), heptadecane (C17), heptacosane (C27), and nonacosane (C29). **MPA is the only organic human health COC at SWMU 3; there are no organic ecological COCs at this SWMU.**

MPA was detected at two sampling locations on the gravel pad, both of which are both adjacent to the eastern rail. Both samples were collected from 2 ft below ground surface (bgs). The highest concentration of MPA (10.8 μg/g) was detected at 3-BLD-2, where mustard (blister agent) containers reportedly leaked onto the ground at the northern end of the rail in the late 1960s. However, MPA is a breakdown product of nerve agent (e.g., GB or VX), not blister agent. Although no confirmed nerve agent spills are known to have occurred on the gravel pad, it is likely that a VX spill in the 1960s, which reportedly occurred at the Impounding Bay in SWMU 9 may actually have occurred at the gravel pad in SWMU 3. The presence of MPA at the gravel pad may indicate that the VX spill occurred or that GB containers were repaired at that site. Because of the lack of toxicity data on MPA, this compound could not be quantitatively addressed in the SWMU-wide risk assessment. The presence of MPA at the gravel pad, however, indicates that MPA is a location-specific COC at SWMU 3.

Cyanide was detected in a single surface soil sample from the west side of the pad. The detected concentration was 1.73 μg/g, approximately two times the method detection limit.

Metals
Thirteen metals exceeded background concentrations at SWMU 3. These metals included beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), lead (Pb), antimony (Sb), thallium (Th), and zinc (Zn). The human health risk assessment for SWMU 3 determined that four metals (Cr, Cu, Pb, and Zn,) are COCs in this area. Only lead (Pb) is considered to be COCs on a SWMU-wide basis,



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-7
Organic Compounds and Cyanide in Soil at SWMU 3

Prepared by:
Ebasco Services Incorporated

Revised: 2/21/96

F:\PROJECTS\TOOELE\ARCAD\SWMU3\SWMU-3.DWG whereas Cr, Cu, and Zn are considered to be COCs specific to a certain area or sample location within the SWMU. The ecological risk assessment determined that seven metals (Ag, As, Cd, Cu, Hg, Pb, and Zn) are facility-wide COCs at TEAD-S. Silver (Ag) was not detected at SWMU 3, and three of these metals (Cu, Pb, and Zn) are already human health COCs at this SWMU. Only metal COCs are discussed below in detail and their distribution shown within the SWMU.

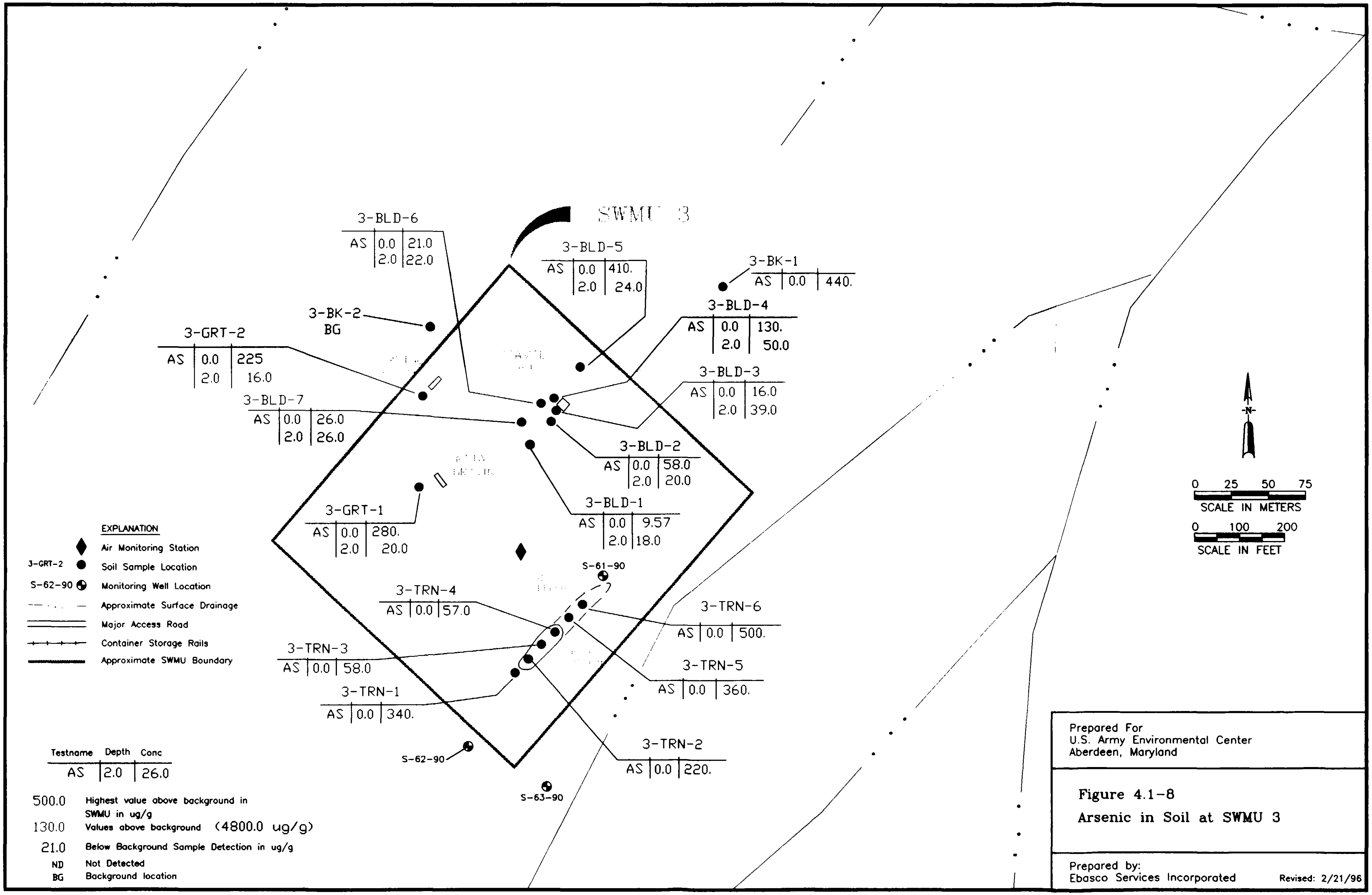
Arsenic (As), an ecological COC, was detected at concentrations above the background level established for the other Group 2 SWMUs, but was within the levels later measured in supplemental background samples collected upslope from SWMU 3 in the Mercur Creek alluvial channels, which pass through this area (see Section 2.3.1 and Figures 2.1-3 and 2.3-2). The maximum concentration of arsenic detected in SWMU 3 samples (500 μg/g in the surficial sample at 3-TRN-6) was well within the range of arsenic concentrations measured in the supplemental background samples (23 μg/g to 4,820 μg/g). Therefore, the elevated arsenic concentrations are caused by the presence of Mercur Creek sediments rather than any activities at SWMU 3, and all arsenic detections at the SWMU are below the background level for the area of TEAD-S whre the unit is located (Figure 4.1-8).

Cadmium (Cd), an ecological COC, was detected above background (0.98 μg/g) in only two locations at SWMU 3 (Figure 4.1-9). The maximum concentration (2.00 μg/g) was detected at 3-TRN-1 in the surficial sample collected near the metal boxes at the southern end of the trench. The other detection of Cd above background occurred on the gravel pad between the building and the east rail.

Chromium (Cr), a human health COC, was detected at a maximum concentration (117.0 μg/g) at 3-TRN-1 in the surficial sample collected near the metal boxes at the south end of the trench (Figure 4.1-10). All other detections of chromium at SWMU 3 were below background (48.5 μg/g). Chromium is, therefore, considered a COC specific to the area near the metal boxes.

The only detection (61.2 μg/g) of copper (Cu), a human health and ecological COC, at a concentration above background (27.6 μg/g) occurred in the surficial sample at 3-TRN-1, taken near the metal boxes at the south end of the trench (Figure 4.1-11). Copper is considered a COC only for the area near the metal boxes.

Lead (Pb), a human and ecological COC, was detected in concentrations above background (35.0 μg/g) in six samples at SWMU 3 (Figure 4.1-12). The highest concentration of lead (170.0 μg/g) was detected in the surficial sample at 3-BLD-2, the mustard spill site on the gravel pad. At another location on the south end of the gravel pad, lead was detected above background in the surficial sample. Another detection of lead above background occurred in the surficial sample at the truck decontamination site. Lead was also detected above background in the surficial sample at the southern pile of metal grating. In addition, lead was detected at above-background concentrations in two surficial samples from the southern end of the trench, one near the metal boxes and the other in the southern end of the open trench. Because of its wide areal distribution and its toxicity, lead is considered a SWMU-wide COC. The sources of Pb contamination at SWMU 3 may include leaded gasoline and particulate lead from solid waste, as well as natural

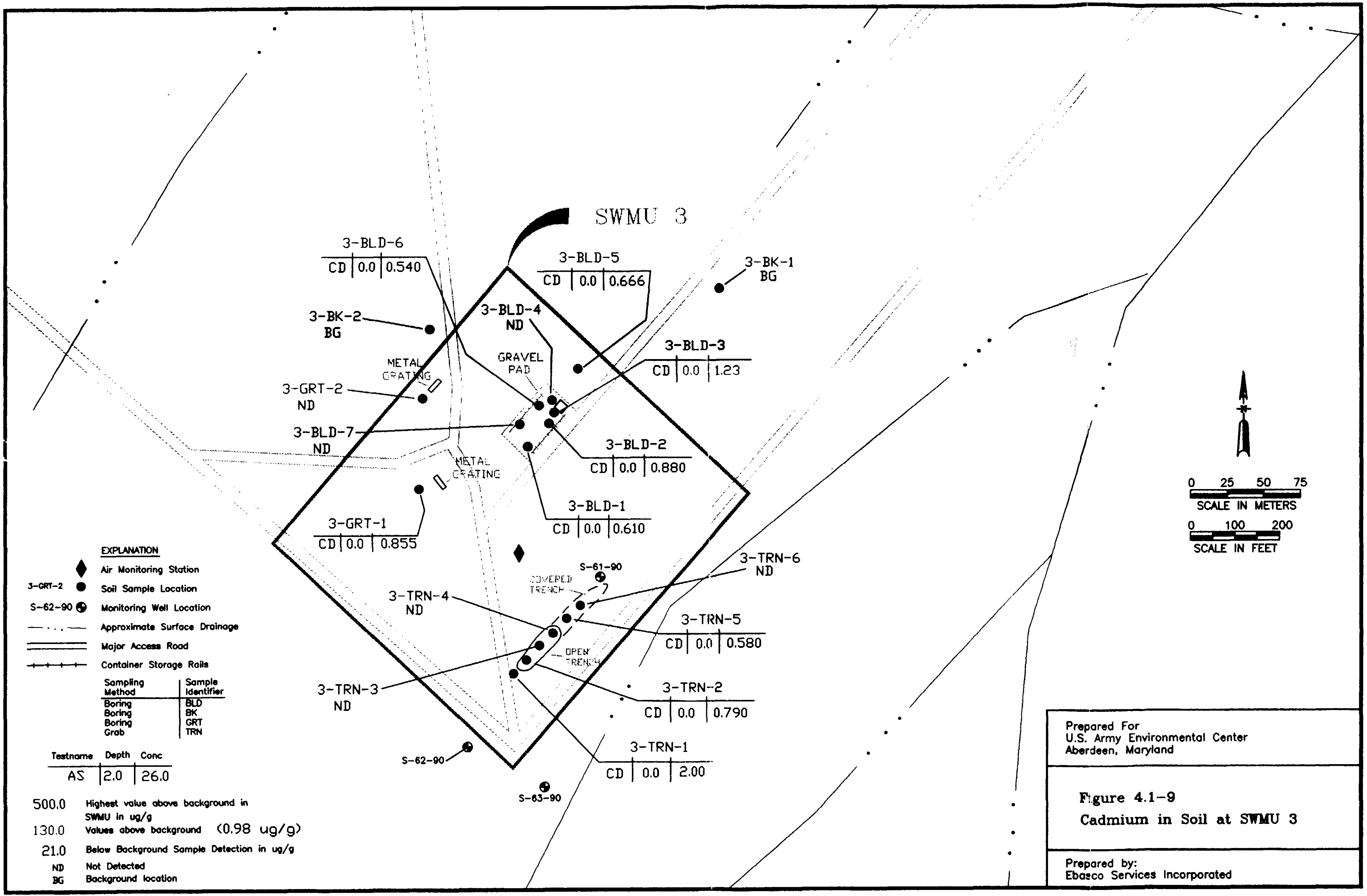


Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-8
Arsenic in Soil at SWMU 3

Prepared by:
Ebasco Services Incorporated

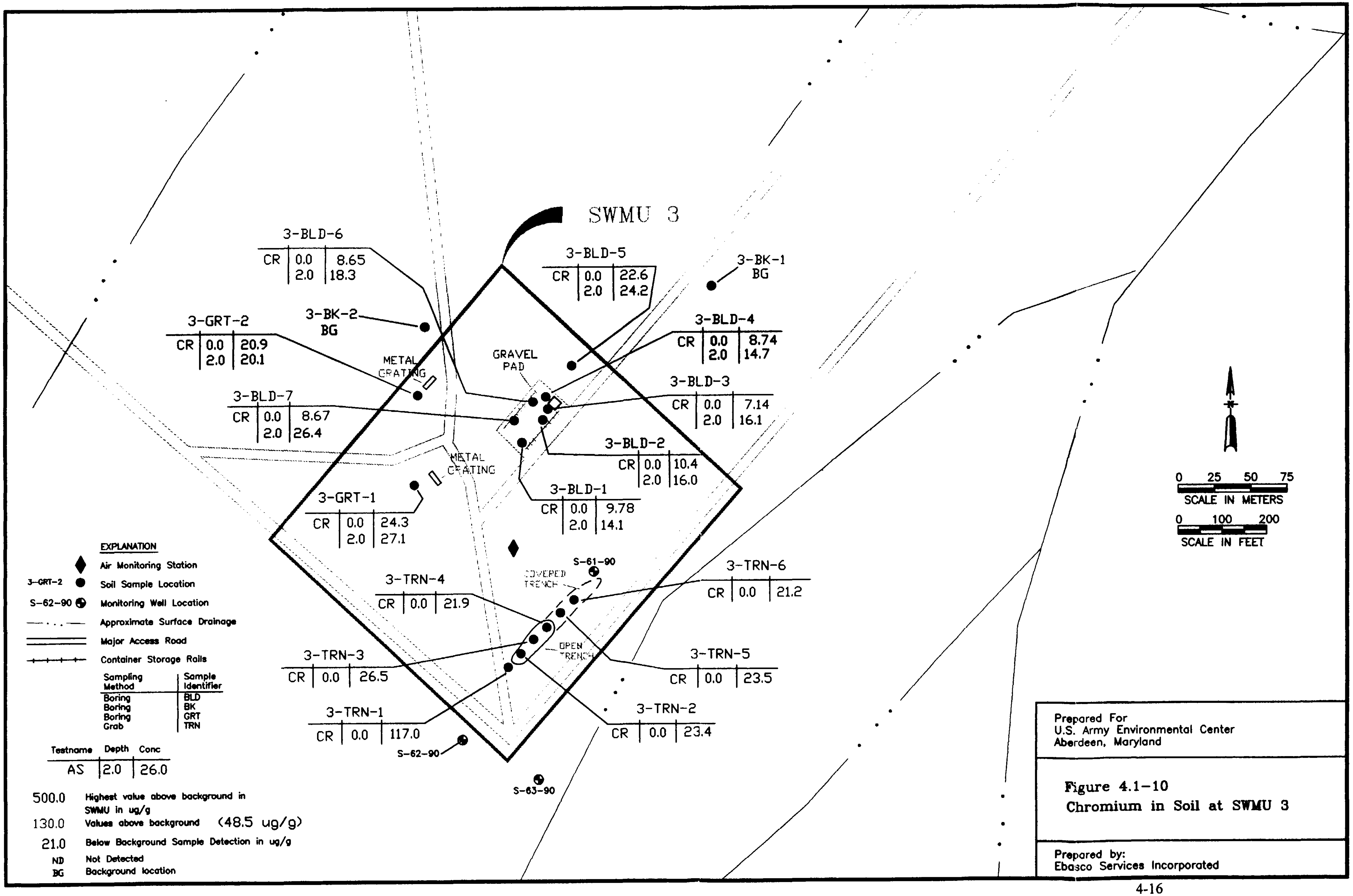
Revised: 2/21/96



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-9
Cadmium in Soil at SWMU 3

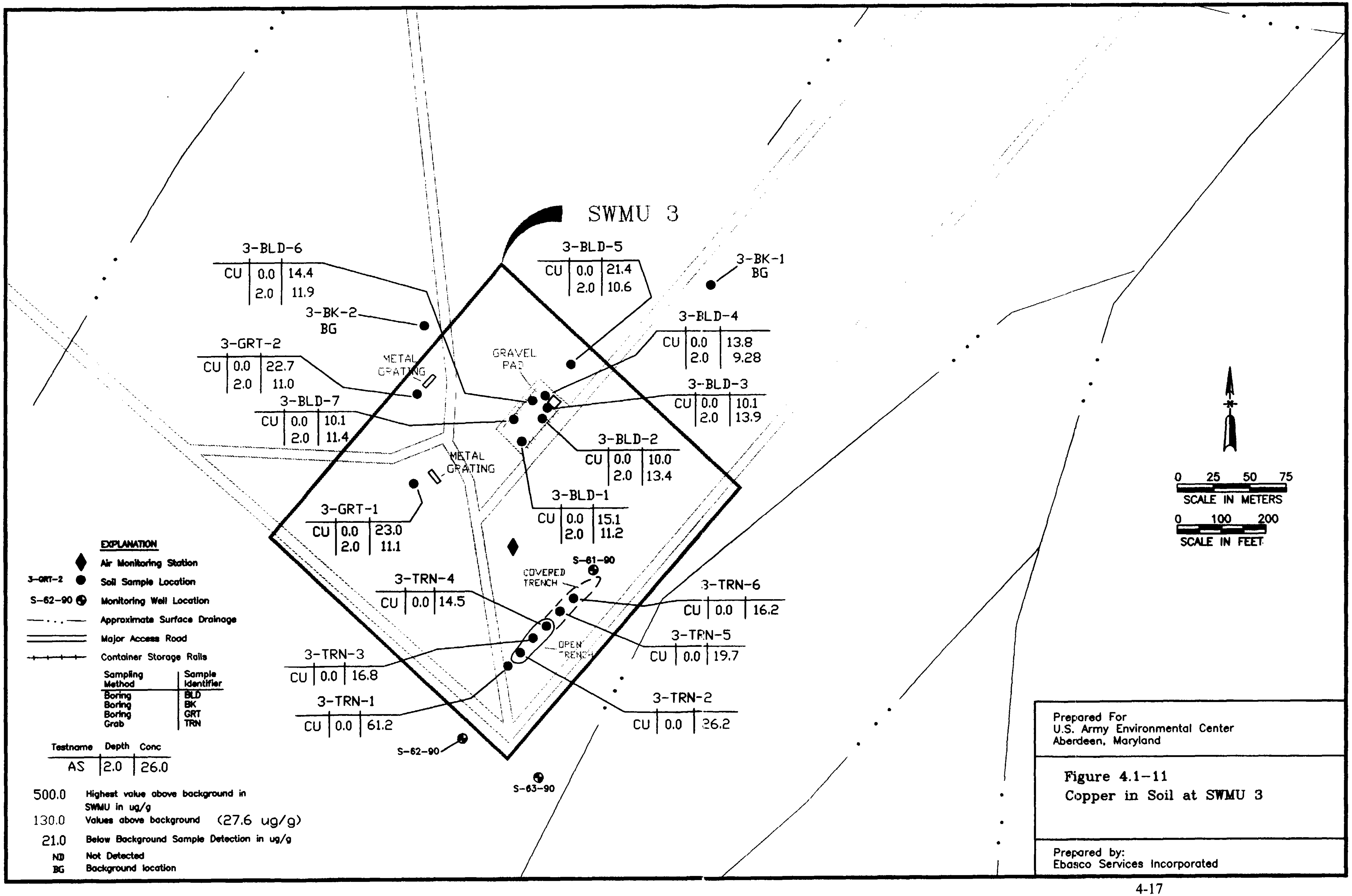
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-10
Chromium in Soil at SWMU 3

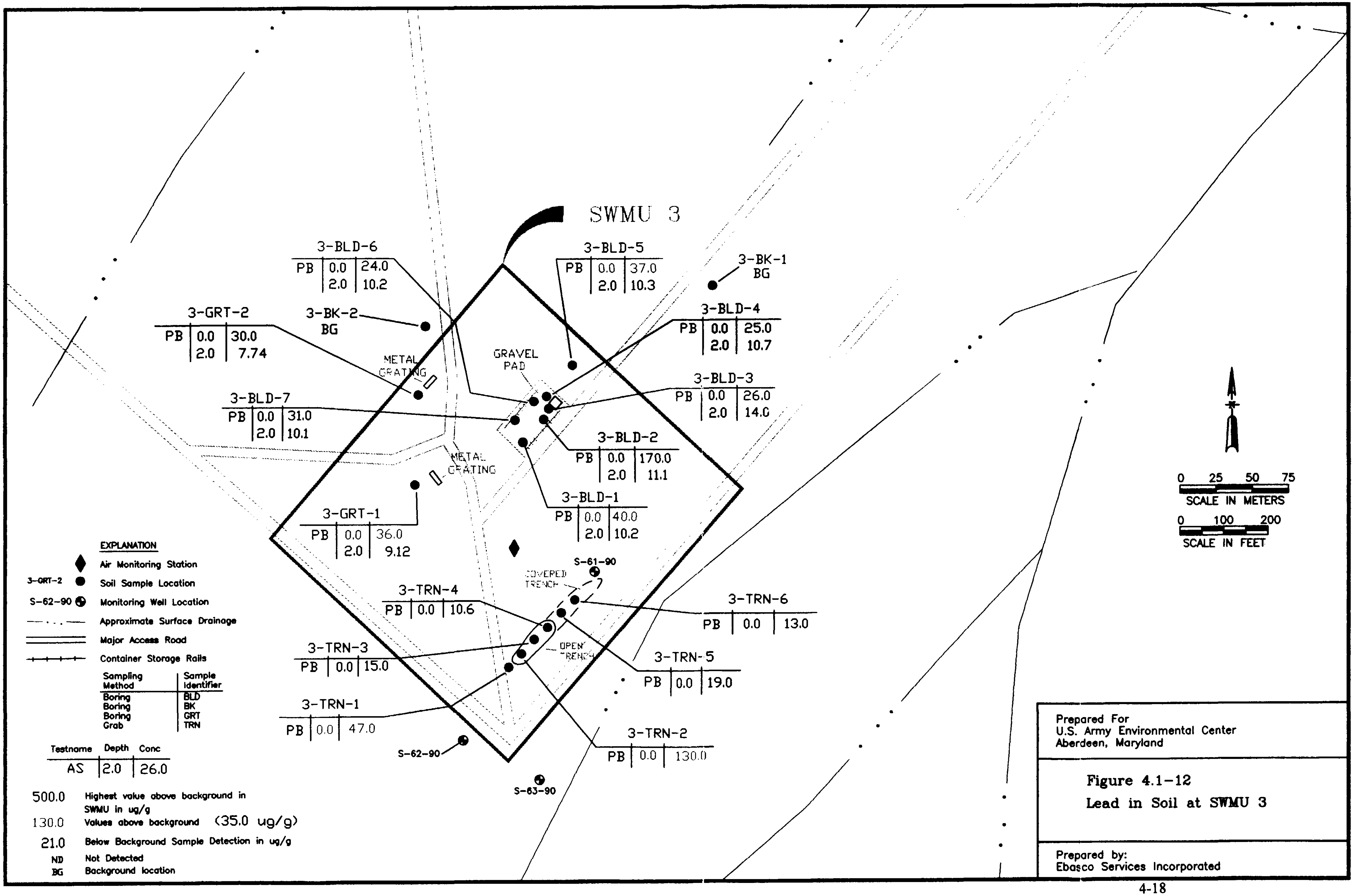
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-11
Copper in Soil at SWMU 3

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-12
Lead in Soil at SWMU 3

Prepared by:
Ebasco Services Incorporated

occurrences of the mineral in the soil.

Mercury (Hg), an ecological COC, was detected at concentrations above the background level established for the other Group 2 SWMUs, but was within the levels later measured in supplemental background samples collected upslope from SWMU 3 in the Mercur Creek alluvial channels, which pass through this area (see Section 2.3-1 and Figures 2.1-3 and 2.3-2). The maximum concentration of mercury detected in SWMU 3 samples (2.8 µg/g in the surficial sample at 3-BLD-5) was well within the range of mercury concentrations measured in the supplemental background samples (0.047 µg/g to 22.1 µg/g). Therefore, the elevated mercury concentrations are caused by the presence of Mercur Creek sediments rather than any activities at SWMU 3, and all mercury detections at the SWMU are below the background level for the area of TEAD-S where the unit is located (Figure 4.1-13).

Silver (Ag), an ecological COC, was not detected in soil samples at SWMU 3.

Zinc (Zn), a human health and ecological COC, was detected in all 24 samples collected at SWMU 3; however, concentrations above-background (144.0 µg/g) were detected in only two samples (Figure 4.1-14). The highest concentration of Zn (820.0 µg/g) was detected in the surficial sample in the southern end of the open trench at 3-TRN-2. The other sample with an above-background concentration was collected from surficial soil at the metal boxes south of the trench (3-TRN-1). Since Zn is a common element in the surficial soil at TEAD-S, it is considered a COC only at the southern end of the trench where above-background concentrations were detected.

Detections above background in SWMU 3 soils are shown in Table 4.1-1.

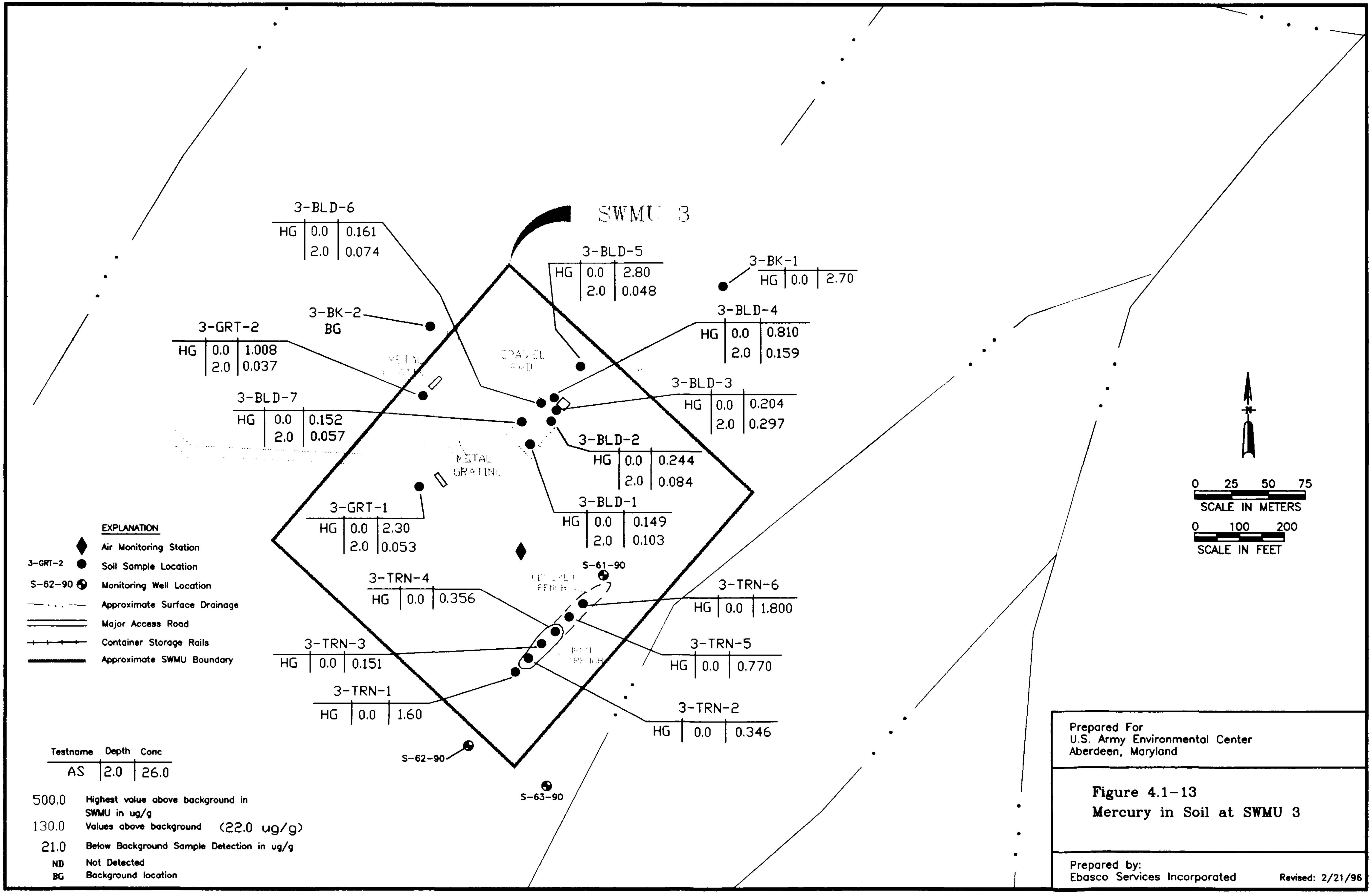
4.1.2.2 Groundwater Contamination Assessment

This section presents the chemical analytical results of the groundwater sampling program at SWMU 3. Although this section evaluates all of the analytical data collected, the discussion of the RFI-Phase II results focuses on the detections of the human health and ecological COCs at SWMU 3 that are being considered by the risk assessment (seven metals and one organic compound).

Previous Investigations

During the RFI-Phase I investigation of SWMU 3, three monitoring wells were installed in the vicinity of the trench to detect possible contaminant releases from the trench contents to the underlying groundwater (EBASCO 1993a). One monitoring well was installed upgradient and two monitoring wells were installed downgradient of the trench. Groundwater samples were analyzed for VOCs, SVOCs, agent breakdown products, explosives, metals, anions, and radiological parameters.

Results from RFI-Phase I sampling showed detections of methylene chloride in the upgradient well (S-61-90) and one downgradient well (S-62-90) at concentrations of 5.9 µg/L and 6.2 µg/L,



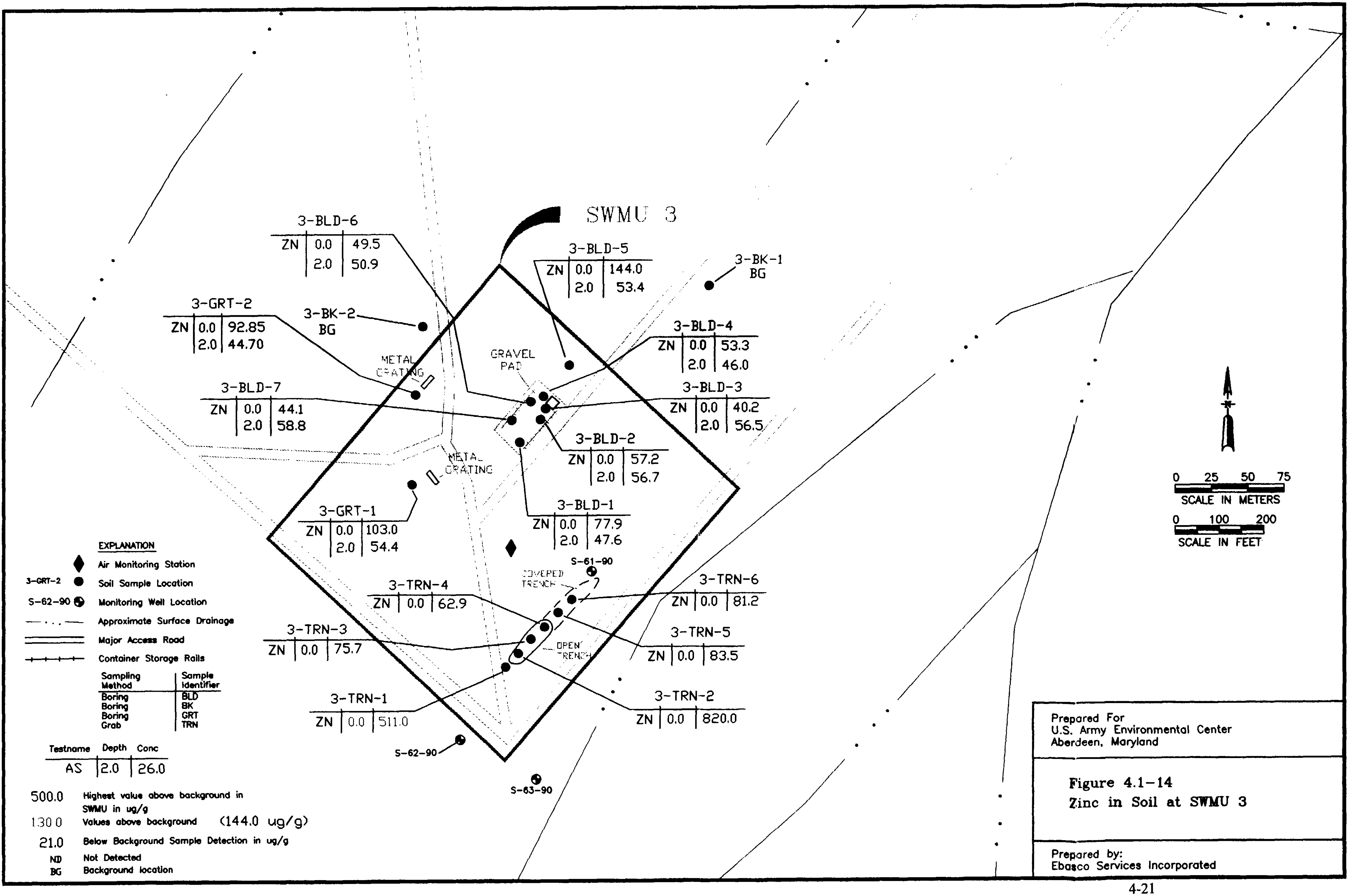
Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-13
Mercury in Soil at SWMU 3

Prepared by:
Ebasco Services Incorporated

Revised: 2/21/96

F:\PROJECTS\TOOLE\ARCAD\SWMU3\SWMU-3.DWG



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-14
Zinc in Soil at SWMU 3

Prepared by:
Ebasco Services Incorporated

Table 4.1-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 3

Page 1 of 1

Location	Analyte	Depth (ft)	Value (µg/g)	Units	Location	Analyte	Depth (ft)	Value (µg/g)	Units
3-GRT-1	AL	0.000	21,400	UGG	3-GRT-1	K	0.000	10,100	UGG
3-GRT-2	AL	0.000	17,900	UGG	3-GRT-2	K	0.000	8,115	UGG
3-TRN-3	AL	0.000	18,500	UGG	3-BLD-1	MG	0.000	16,900	UGG
3-TRN-4	AL	0.000	18,000	UGG	3-BLD-2	MG	0.000	18,700	UGG
3-TRN-5	AL	0.000	18,700	UGG	3-BLD-3	MG	0.000	23,500	UGG
3-BLD-5	BE	0.000	1.20	UGG	3-BLD-6	MG	0.000	16,600	UGG
3-GRT-1	BE	0.000	1.22	UGG	3-GRT-1	MG	0.000	16,700	UGG
3-TRN-3	BE	0.000	0.916	UGG	3-BLD-2	MN	2.000	561	UGG
3-BLD-6	C16A	0.000	0.350	UGG	3-BLD-5	MN	2.000	669	UGG
3-BLD-5	C17	0.000	1.30	UGG	3-GRT-1	MN	0.000	737	UGG
3-BLD-1	C27	0.000	0.820	UGG	3-TRN-1	MN	0.000	673	UGG
3-BLD-3	C29	0.000	0.560	UGG	3-BLD-1	MPA	2.000	2.94	UGG
3-BLD-1	CA	0.000	160,000	UGG	3-BLD-2	MPA	2.000	10.8	UGG
3-BLD-2	CA	0.000	170,000	UGG	3-BLD-5	NA	0.000	2,240	UGG
3-BLD-3	CA	0.000	180,000	UGG	3-GRT-1	NA	0.000	1,760	UGG
3-BLD-3	CD	0.000	1.23	UGG	3-TRN-3	NA	0.000	2,310	UGG
3-TRN-1	CD	0.000	2.00	UGG	3-BLD-5	NI	0.000	22.3	UGG
3-BLD-5	CH2CL2	0.000	0.006	UGG	3-GRT-1	NI	0.000	22.3	UGG
3-GRT-1	CH2CL2	0.000	0.006	UGG	3-TRN-1	NI	0.000	27.4	UGG
3-TRN-1	CH2CL2	0.000	0.005	UGG	3-BLD-1	OMCTSX	2.000	0.010	UGG
3-GRT-1	CO	0.000	7.17	UGG	3-BLD-6	OMCTSX	2.000	0.005	UGG
3-GRT-2	CO	0.000	6.96	UGG	3-BLD-1	PB	0.000	40.0	UGG
3-TRN-1	CO	0.000	8.89	UGG	3-BLD-2	PB	0.000	170	UGG
3-TRN-3	CO	0.000	7.60	UGG	3-BLD-5	PB	0.000	37.0	UGG
3-TRN-4	CO	0.000	6.97	UGG	3-GRT-1	PB	0.000	36.0	UGG
3-TRN-5	CO	0.000	6.98	UGG	3-TRN-1	PB	0.000	47.0	UGG
3-TRN-6	CO	0.000	7.13	UGG	3-TRN-2	PB	0.000	130	UGG
3-TRN-1	CR	0.000	117	UGG	3-BLD-1	PCB254	0.000	0.118	UGG
3-TRN-3	CR	0.000	26.5	UGG	3-BLD-2	PCB254	0.000	0.331	UGG
3-TRN-1	CU	0.000	61.2	UGG	3-BLD-2	PCB260	0.000	0.193	UGG
3-TRN-2	CU	0.000	26.2	UGG	3-BLD-1	PYR	0.000	0.083	UGG
3-BLD-7	CYN	0.000	1.73	UGG	3-BLD-5	SB	0.000	15.3	UGG
3-BLD-4	DEGLYC	2.000	0.590	UGG	3-TRN-1	SB	0.000	10.7	UGG
3-BLD-6	DEGLYC	2.000	0.440	UGG	3-TRN-1	TL	0.000	54.9	UGG
3-TRN-2	DNBP	0.000	10.0	UGG	3-GRT-1	V	0.000	32.5	UGG
3-BLD-1	FANT	0.000	0.120	UGG	3-GRT-2	V	0.000	28.35	UGG
3-BLD-5	FE	0.000	19,800	UGG	3-TRN-3	V	0.000	33.6	UGG
3-GRT-1	FE	0.000	20,600	UGG	3-TRN-4	V	0.000	33.5	UGG
3-GRT-2	FE	0.000	18,100	UGG	3-TRN-5	V	0.000	35.3	UGG
3-TRN-1	FE	0.000	30,800	UGG	3-TRN-6	V	0.000	31.5	UGG
3-TRN-2	FE	0.000	20,800	UGG	3-BLD-5	ZN	0.000	144	UGG
3-TRN-3	FE	0.000	18,300	UGG	3-TRN-1	ZN	0.000	511	UGG
3-GRT-1	GSITOS	0.000	0.640	UGG	3-TRN-2	ZN	0.000	820	UGG
3-GRT-2	GSITOS	0.000	0.995	UGG					

µg/g micrograms per gram
Note: Analyte names are defined in the chemical acronym list.

respectively. The presence of methylene chloride was attributed to laboratory contamination in the RFI-Phase I report (EBASCO 1993a). However, the possibility that it is a degradation or decomposition product of mustard agent was also recognized. No inorganic analytes were detected at elevated levels during the RFI-Phase I program, when filtered groundwater samples were collected for metals analyses.

RFI-Phase II Results

To further evaluate detections of contaminants encountered in groundwater during previous investigations at SWMU 3, sampling of the existing monitoring wells was performed as part of the RFI-Phase II program. The complete analytical results of the RFI-Phase II sampling can be found in Appendix F2.

Organic Compounds

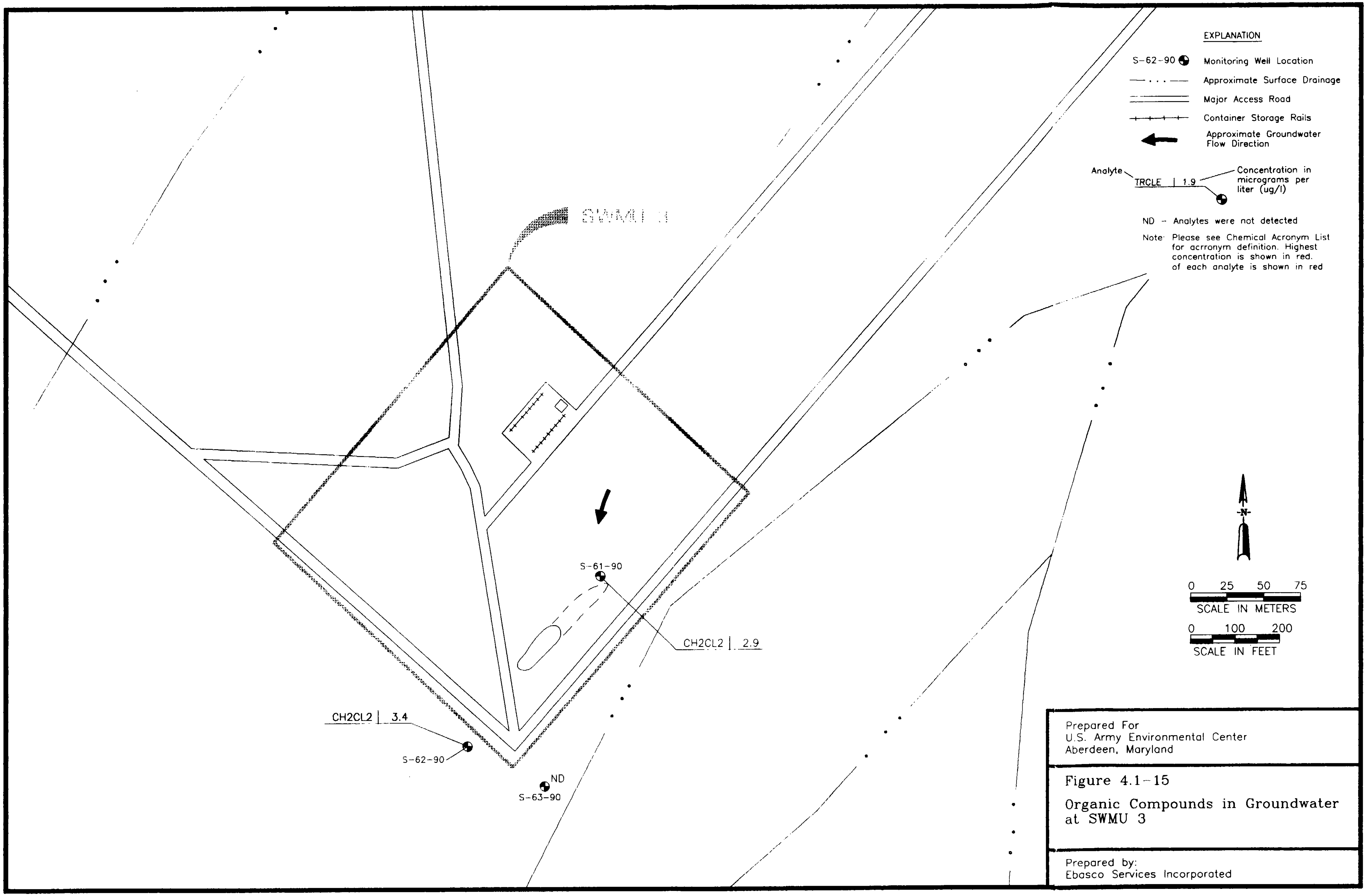
Figure 4.1-15 shows the analytical results for organic compounds detected in groundwater samples taken from wells at SWMU 3.

As in previous sampling, methylene chloride was the only organic compound detected in groundwater at SWMU 3; it was found in both the upgradient and the same downgradient well as during the RFI-Phase I program. The upgradient well (S-61-90) had a methylene chloride concentration of 2.9 µg/L, and the downgradient well (S-62-90) had a methylene chloride concentration of 3.4 µg/L. These concentrations are approximately half the concentrations detected during the RFI-Phase I program.

Methylene chloride can be used as a degreaser, paint stripper, or cleaning solvent (Hazardous Substance Database [HSDB] 1994), can result from incomplete combustion of distilled mustard (HD) (Department of the Army 1988), or occurs as a common laboratory contaminant and cleaning solvent (HSDB 1994; EPA 1989b). As munitions containing mustard may have been burned and disposed of at SWMU 3, detections of methylene chloride may indicate a release of mustard decomposition products from the trench. However, since other combustion or degradation products of mustard (such as thiodiglycol) were not detected in groundwater, it is likely that the low concentrations of methylene chloride in the upgradient and downgradient wells were caused by laboratory contamination of the samples.

Metals

During the RFI-Phase II, unfiltered groundwater samples were collected at SWMU 3 and analyzed for aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Results of these analyses are shown in Figure 4.1-16. Metal concentrations for the RFI-Phase II were compared to TEAD-S background levels for unfiltered samples to determine the potential for groundwater contamination at SWMU 3. Background levels for metals were discussed previously in Section 2.3.2.

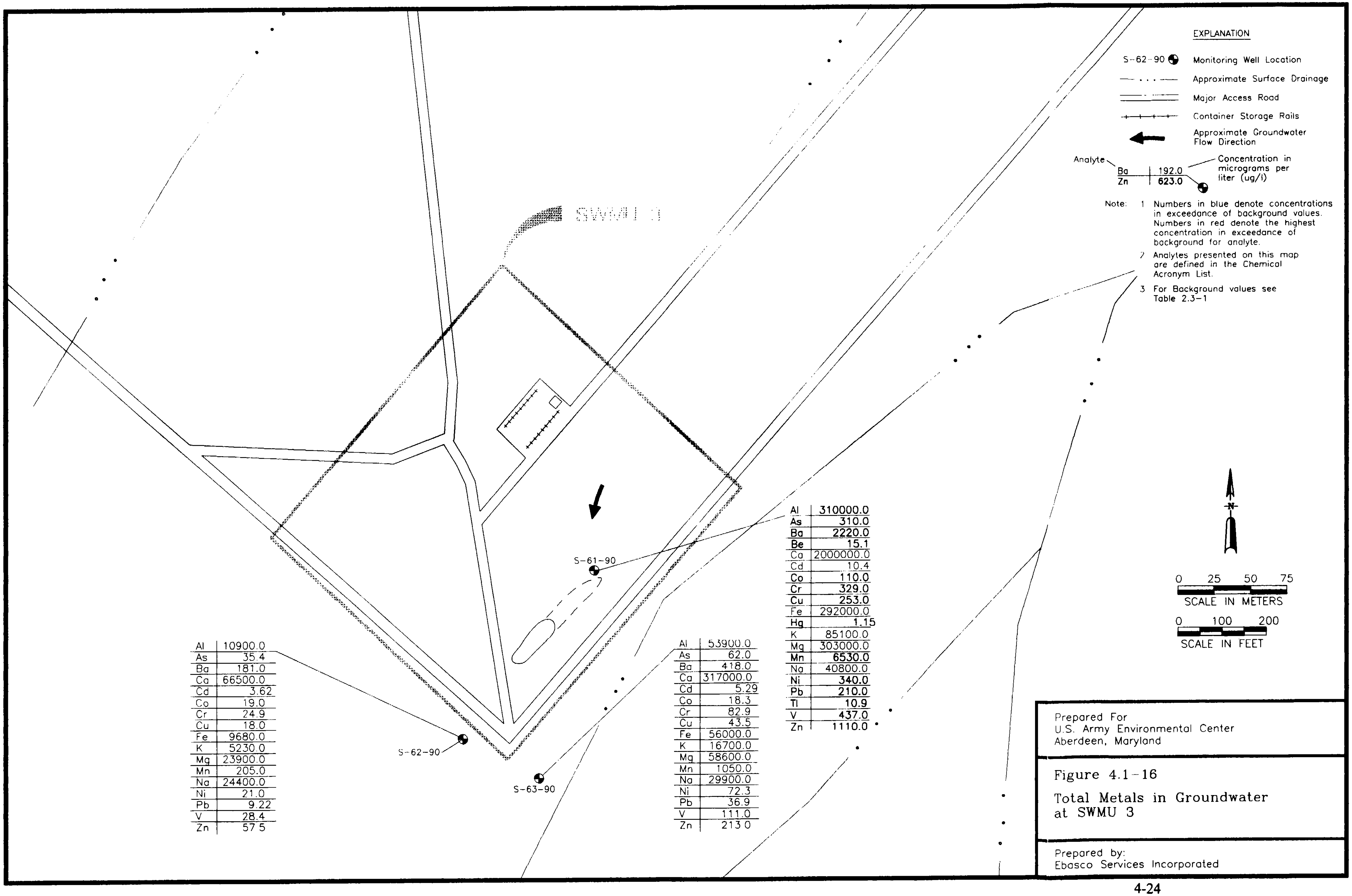


Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-15

Organic Compounds in Groundwater at SWMU 3

Prepared by:
Ebasco Services Incorporated



Note: 1 Numbers in blue denote concentrations in exceedance of background values. Numbers in red denote the highest concentration in exceedance of background for analyte.
2 Analytes presented on this map are defined in the Chemical Acronym List.
3 For Background values see Table 2.3-1

Al	10900.0
As	35.4
Ba	181.0
Ca	66500.0
Cd	3.62
Co	19.0
Cr	24.9
Cu	18.0
Fe	9680.0
K	5230.0
Mg	23900.0
Mn	205.0
Na	24400.0
Ni	21.0
Pb	9.22
V	28.4
Zn	57 5

Al	53900.0
As	62.0
Ba	418.0
Ca	317000.0
Cd	5.29
Co	18.3
Cr	82.9
Cu	43.5
Fe	56000.0
K	16700.0
Mg	58600.0
Mn	1050.0
Na	29900.0
Ni	72.3
Pb	36.9
V	111.0
Zn	213 0

Al	**310000.0**
As	**310.0**
Ba	**2220.0**
Be	**15.1**
Ca	2000000.0
Cd	10.4
Co	**110.0**
Cr	**329.0**
Cu	**253.0**
Fe	292000.0
Hg	**1.15**
K	85100.0
Mg	303000.0
Mn	**6530.0**
Na	40800.0
Ni	**340.0**
Pb	**210.0**
Tl	**10.9**
V	**437.0**
Zn	1110.0

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-16

Total Metals in Groundwater at SWMU 3

Prepared by:
Ebasco Services Incorporated

Of the 18 metals analyzed during the RFI-Phase II, 14 occurred above background at SWMU 3, primarily in the upgradient well (S-61-90). These metals include aluminum, arsenic, barium, beryllium, chromium, cobalt, copper, manganese, mercury, nickel, lead, thallium, vanadium, and zinc. Of these metals, eight occur above background in well S-63-90 and three occur above background in well S-62-90.

Elevated levels of metals in well S-61-90 may be the result of high suspended solids observed in this well. Water quality field data logs (summarized in Table 4.1-2 and located in Appendix A2) indicate well S-61-90 had turbidity readings of greater than 200 nephelometric turbidity units (NTU) and exhibited a "muddy" appearance at the time of sampling. This well is screened in silty clay and fine sand. The analytical laboratory confirmed that the groundwater sample from

Table 4.1-2 Water Quality Characteristics of Groundwater at SWMU 3

Well	Conductivity (μmhos)	pH	Turbidity (NTU)	Appearance	Calculated TDS(mg/L)*	Temp°F
S-61-90	360	7.76	>200	"muddy"	302 ± 53	50.1
S-62-90	380	8.71	>200	"sl: cloudy"	243 ± 42	54.9
S-63-90	330	8.39	>200	"brown, cloudy"	281 ± 48	47.3

* Total Dissolved Solids (TDS) content was determined by taking the reported anions in mg/L, converting mg/L to equivalents per mole (epm), and then balancing the anion content with the appropriate equivalent number of cations as calcium, magnesium, potassium, and sodium.

well S-61-90 was turbid. Well S-63-90 also had elevated turbidity readings (>200 NTU) and a "brown, cloudy" appearance at the time of sampling, but had consistently lower turbidity readings than well S-61-90 during the pre-sampling purge phase. This well had six fewer metals above background than well S-61-90, and these metals occurred at significantly lower concentrations. Like well S-61-90, well S-63-90 is screened in fine sand and silty clay. The sample from well S-62-90, which had only one metal detected above background, also had turbidity readings greater than 200 NTU and a slightly cloudy appearance at the time of sampling. This well is screened in silty clay.

It is apparent from this data that levels of total (unfiltered) metals may be a function of the turbidity, or suspended solids, of the groundwater and may not be indicative of SWMU-derived metals contamination. The presence of suspended solids and associated turbid water may in part be the consequence of using a standard filter pack (10-20 silica sand) and screen slot size (0.01) for each well, regardless of the grain size of the screened interval. This well construction may allow the aquifer to contribute mobile particulates and colloids to the groundwater samples, resulting in elevated levels of metals.

Anions

Groundwater sampling at SWMU 3 included analyses for the following eight anions: bicarbonate, bromide, chloride, cyanide, fluoride, nitrate/nitrite, phosphate, and sulfate. Results of detections of these analytes are depicted on Figure 4.1-17. All results reflect unfiltered concentrations.

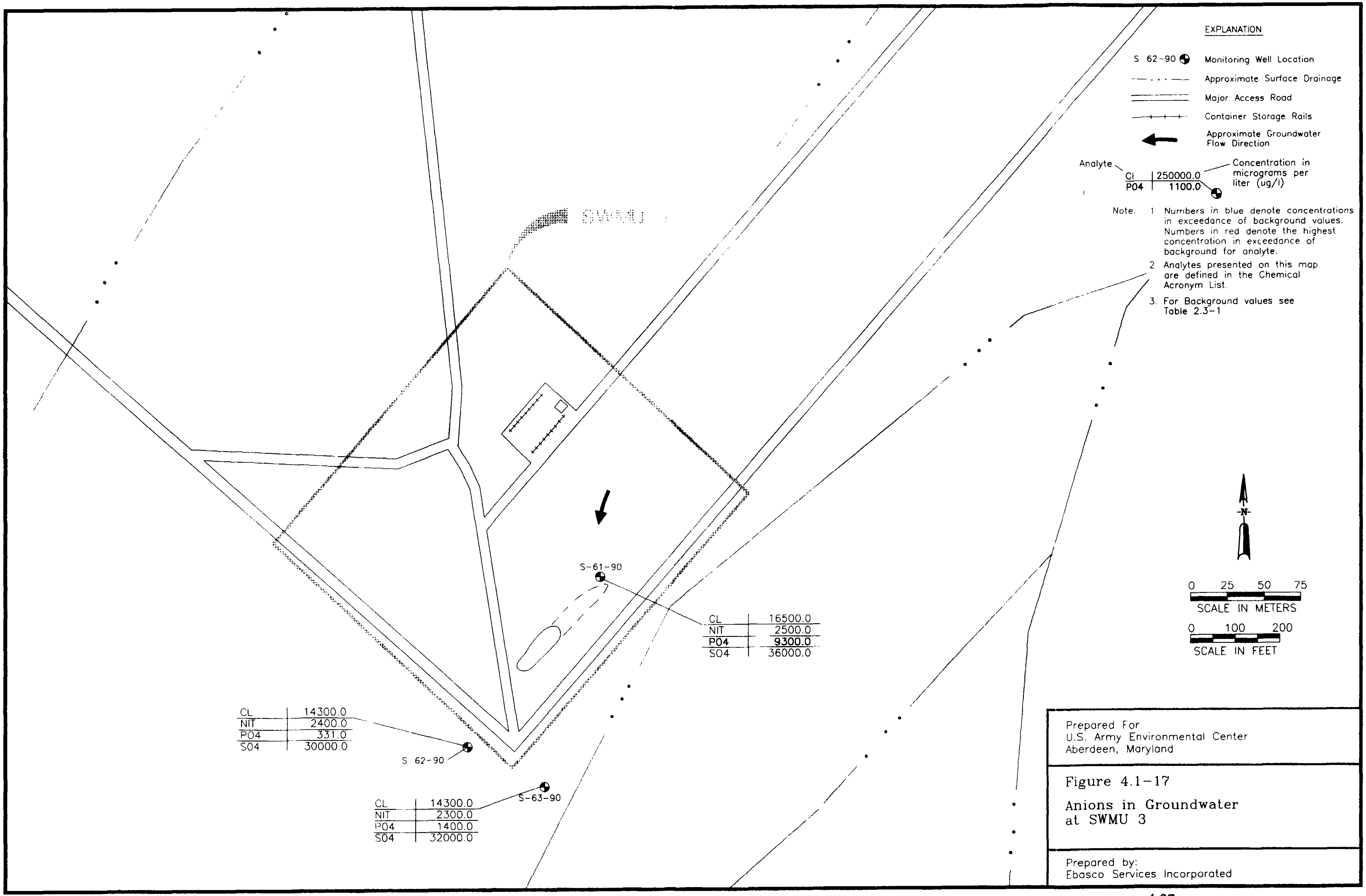
Concentrations of anions detected in SWMU 3 wells were compared to TEAD-S background levels to identify groundwater contamination. As depicted on Figure 4.1-17, only phosphate exceeded TEAD-S background levels in groundwater. Phosphate exceeded background (1,200 µg/L) in two of three wells at SWMU 3. Phosphate levels exceeding background include 9,300 µg/L in the upgradient well (S-61-90), and 1,400 µg/L in well S-63-90. Phosphates in groundwater at SWMU 3 may represent either the residual products of compounds known to contain phosphorus (e.g., VX, MPA, or IMPA) or variations in natural phosphate levels. Because neither agent nor agent breakdown products were detected in groundwater at SWMU 3, it is probable that the elevated phosphorus is naturally occurring.

Detections above background in SWMU 3 groundwater are shown in Table 4.1-3.

4.1.2.3 Air Contamination Assessment

Ambient air sampling was performed at a station located in the west-central portion of SWMU 3. Samples were analyzed from six 24-hour events collected during the period of September 21, 1993 to October 1, 1993.

Various volatile organic compounds were measured at SWMU 3 throughout the sampling program. Methylene chloride was detected in four out of six samples with an average concentration of 0.33 parts per billion volume. Tetrachloroethene was detected in three samples at an average concentration of 0.64 ppbv. Chloroform was measured on two sample



Note. 1 Numbers in blue denote concentrations in exceedance of background values. Numbers in red denote the highest concentration in exceedance of background for analyte.

2 Analytes presented on this map are defined in the Chemical Acronym List.

3. For Background values see Table 2.3-1

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.1-17

Anions in Groundwater at SWMU 3

Prepared by:
Ebasco Services Incorporated

Table 4.1-3 Chemical Analytical Detections Above Background in Groundwater from SWMU 3

Page 1 of 1

Location	Analyte	Value (µg/l)	Units	Location	Analyte	Value (µg/l)	Units
S-61-90	AL	310,000	UGL	S-61-90	MG	303,000	UGL
S-62-90	AL	10,900	UGL	S-62-90	MG	23,900	UGL
S-63-90	AL	53,900	UGL	S-63-90	MG	58,600	UGL
S-61-90	AS	310	UGL	S-61-90	MN	6,530	UGL
S-62-90	AS	35.4	UGL	S-62-90	MN	205	UGL
S-63-90	AS	62.0	UGL	S-63-90	MN	1,050	UGL
S-61-90	BA	2,220	UGL	S-61-90	NA	40,800	UGL
S-63-90	BA	418	UGL	S-62-90	NA	24,400	UGL
S-61-90	BE	15.1	UGL	S-63-90	NA	29,900	UGL
S-61-90	CA	2,000,000	UGL	S-61-90	NI	340	UGL
S-62-90	CA	66,500	UGL	S-63-90	NI	72.3	UGL
S-63-90	CA	317,000	UGL	S-61-90	NIT	2,500	UGL
S-61-90	CH2CL2	2.90	UGL	S-62-90	NIT	2,400	UGL
S-62-90	CH2CL2	3.40	UGL	S-63-90	NIT	2,300	UGL
S-61-90	CO	110	UGL	S-61-90	PB	210	UGL
S-62-90	CO	19.0	UGL	S-61-90	PO4	9,300	UGL
S-63-90	CO	18.3	UGL	S-62-90	PO4	331	UGL
S-61-90	CR	329	UGL	S-63-90	PO4	1,400	UGL
S-63-90	CR	82.9	UGL	S-61-90	SO4	36,000	UGL
S-61-90	CU	253	UGL	S-62-90	SO4	30,000	UGL
S-61-90	FE	292,000	UGL	S-63-90	SO4	32,000	UGL
S-62-90	FE	9,680	UGL	S-61-90	TL	10.9	UGL
S-63-90	FE	56,000	UGL	S-61-90	V	437	UGL
S-61-90	HG	1.15	UGL	S-62-90	V	28.4	UGL
S-61-90	K	85,100	UGL	S-63-90	V	111	UGL
S-62-90	K	5,230	UGL	S-61-90	ZN	1,110	UGL
S-63-90	K	16,700	UGL				

µg/l micrograms per liter
Note: Analyte names are defined in the chemical acronym list.

days with a maximum concentration of 6.70 ppbv. Trichloroethene was detected once (1.30 ppbv). Local ambient air concentrations for all four of these analytes appear related to SWMU 3 source impacts.

Low levels (0.10 - 0.60 ppbv) of numerous other volatile organic compounds were regularly detected at SWMU 3 and at the other sampling stations located around TEAD-S, including the background station located on the northeast perimeter. The list of detected analytes includes 1,1,1-trichloroethane, carbon tetrachloride, benzene, methyl isobutyl ketone, toluene, ethyl benzene, and total xylenes. The levels measured at SWMU 3 are similar to those recorded at the other sampling stations including the background station and most likely represent the composition of the background airshed.

Several semivolatile organic compounds were detected in the field samples including naphthalene, di-n-butylphthalate, butylbenzylphthalate, and bis(2-ethylhexyl) phthalate. However, all these analytes were measured at comparable levels in the nonaerated blank samples and thus, are most likely indicators of laboratory contamination.

There were no detections of cyanide, mercury, or PCBs at SWMU 3 during the sampling program. The total suspended particulate and metal results were not used due to laboratory and media problems. It was determined during subsequent laboratory analysis that the sample filters supplied to the field team were contaminated with high background levels of the target elements. This prevented the identification and quantification of metals in the ambient air. To offset this missing data, conservative assumptions were used in the human health risk assessment to estimate ambient concentrations of soil COCs resuspended in airborne particulates. Appendix I contains a complete listing of all air monitoring data.

4.1.3 Contaminant Fate and Migration

This section discusses the probable contaminant fate and transport processes and migration pathways operating at SWMU 3 based on SWMU history, site physical characteristics, contaminant chemical and physical properties, and the nature and extent of contamination in soil and groundwater.

As outlined in Section 4.1.2, releases of organic and inorganic chemicals from past activities at SWMU 3 have resulted in the contamination of soil and groundwater. While several compounds were identified as potential contaminants at SWMU 3, only the compounds identified as COCs in the baseline human health risk assessment for SWMU 3 (Section 5.2) are assessed here. These include MPA, arsenic, chromium, copper, lead, mercury, and zinc in soil, and methylene chloride, aluminum, arsenic, barium, beryllium, chromium, copper, lead, mercury, nickel, thallium, and vanadium in groundwater. The physical and chemical properties of the organic compounds are listed in Table 4.1-4.

Table 4.1-4 Physical and Chemical Properties of Organic Contaminants of Concern in Soil and Groundwater at SWMU 3 Page 1 of 1

Compound	CAS No.	Formula	Molecular Weight (g/mol)	Physical State	Density (g/ml)	Aqueous Solubility (mg/l)	Vapor Pressure (mm Hg)	Henry's Law Constant (atm-m^3/mol)	Kow	K_{oc}	Soil Half-Life*	Groundwater Half-Life*	Surface Water Half-Life*	Air (Photolysis or Photooxidation) Half-Life*
Volatile Organics														
Methylene chloride (G)	75-09-2	CH_2Cl_2	84.9	liquid	1.33	20000	362	0.00203	20	8.8	1-4wk	2-8wk	1-4wk	19-191 days
Semi-Volatile Organics														
Methylphosphonic acid	ND	ND	299	liquid	ND	miscible	1×10^{-7}	ND	ND	170-1300	ND	ND	ND	Not significant

---

(G) Groundwater contaminant

(S) Soil contaminant

* Half-life data primarily from "Handbook of Environmental Degradation Rates" (Howard et al. 1991), and secondarily from Hazardous Substance Data Base - Tommes Data Base (Micromedex, Inc. 1994). Physical and chemical properties from "Handbook of Environmental Fate and Exposure Data, Vols. I and II" (Howard 1989, 1990), "Groundwater Chemicals Desk Reference, Vols. 1 and 2 (Montgomery and Welkom, 1989; Montgomery, 1991), and the Hazardous Substance Data Base - Tomes Data Base (Micromedex, Inc. 1994)

ND - No data

Soil

Seven compounds were identified as COCs in soil. Of the seven, four were sample- or area-specific COCs for which elevated concentrations were detected in localized areas within the SWMU. These compounds include chromium, copper, and zinc, which were detected in samples collected at the disposal trench, and MPA, which was detected in two samples at the gravel pad. Three compounds were identified as SWMU-wide COCs in soil: arsenic, lead, and mercury. Metals exhibit a strong tendency to partition to soil organic carbon and soil mineral matter, especially the clay- and silt-sized particle fraction. At SWMU 3, therefore, the primary migration process is likely to involve the resuspension and transport of the metal COCs as fugitive dusts; secondary migration is likely to involve surface water runoff caused by episodic rainfall or flash floods. However, due to the hardpan-like nature of the surficial soil at SWMU 3, these migration processes may be limited in magnitude and extent. Vertical transport of metal COCs to the water table is not expected to be significant, due to the partitioning of metals to the fine-grained mineral fraction of site soil, the low soil moisture content, and the limited recharge to groundwater by surficial water sources at this site. Furthermore, some SWMU-wide COCs, such as arsenic and mercury, have not been conclusively linked to SWMU activities and may be naturally occurring.

The potential fate and migration of the single organic COC identified in soil at SWMU 3, MPA, is relatively uncertain due to the lack of information available for this compound. However, based on the information that is available for MPA (see Table 4.1-2), the following fate and transport scenario is presented. MPA was detected at concentrations of 10.80 µg/g and 2.940 µg/g in two soil samples collected 2 ft bgs at the gravel pad. Because MPA is miscible in water, it is likely to become dissolved in any seasonal rainwater or snowmelt that enters the soil at this location. However, MPA is expected to remain in near-surface soil because MPA tends to partition from water to soil and because the recharge to groundwater from infiltrating rainwater is extremely limited at TEAD-S due to the semiarid climate. Soil-water partition coefficients (K_{oc}) for this compound range from 170 to 1,300. The higher value is expected to be more representative at SWMU 3 due to the fine-grained soil and the presence of organic carbon in near-surface soil there. Moreover, due to the high solubility of this compound, biodegradation is expected to be a significant fate process, especially in near-surface soil where microbial communities may be abundant.

Groundwater

COCs in groundwater at SWMU 3 include 1 organic compound (methylene chloride) and 11 inorganic compounds. Of these COCs, seven compounds, including methylene chloride, were conservatively selected as COCs, even though there is no evidence that their presence is due to activities at SWMU 3. In fact, the detection of methylene chloride may be due to laboratory contamination.

The fate and transport of methylene chloride in groundwater is controlled primarily by the high solubility (20,000 mg/L) of this compound, and the short degradation half-life in groundwater (2 to 8 weeks). The soil-water partition coefficients (see values for K_{ow} and K_{oc} in Table 4.1-2) of methylene chloride are very low as a result of its high solubility. As a result, methylene chloride is expected to be mobile in groundwater and migrate as a result of advective flow in the subsurface. However, the residence time of methylene chloride in groundwater is expected to be short due to the susceptibility of this compound to degradation by microorganisms in groundwater.

Given this, detections of methylene chloride in Phase I and Phase II RFI's at TEAD-S may be due to several factors, including:

- Conditions in the aquifer may not be favorable for degradation processes to effectively remove methylene chloride, i.e., the aquifer is aerobic and methylene chloride requires anaerobic conditions for degradation, and/or the aquifer does not yet have the required population of acclimated microbes to effectively degrade methylene chloride, but given time the situation will reverse itself as resident microbes adapt to utilizing methylene chloride as an energy source.

- Detections of methylene chloride in groundwater may be due to the presence of previously adsorbed methylene chloride, that has desorbed to solution in response to decreases in the dissolved fraction as a result of effective biodegradation.

- There may be isolated "pockets" of residual methylene chloride in the aquifer that are slowly being released to solution over time by diffusion or in response to purging and pumping of the monitor wells.

- Detections may actually represent laboratory contamination.

The identification of metal COCs in groundwater at SWMU 3 may be due to the very turbid nature of the groundwater and the contribution of colloids and suspended solids to the unfiltered metals content. Because the metal COCs in groundwater most likely exist as particulates, they are not expected to be mobile in groundwater due to sorption to the aquifer matrix.

4.2 SWMU 5

4.2.1 Background

This section presents information on the site history and cultural features, geology and soil, and hydrology of SWMU 5.

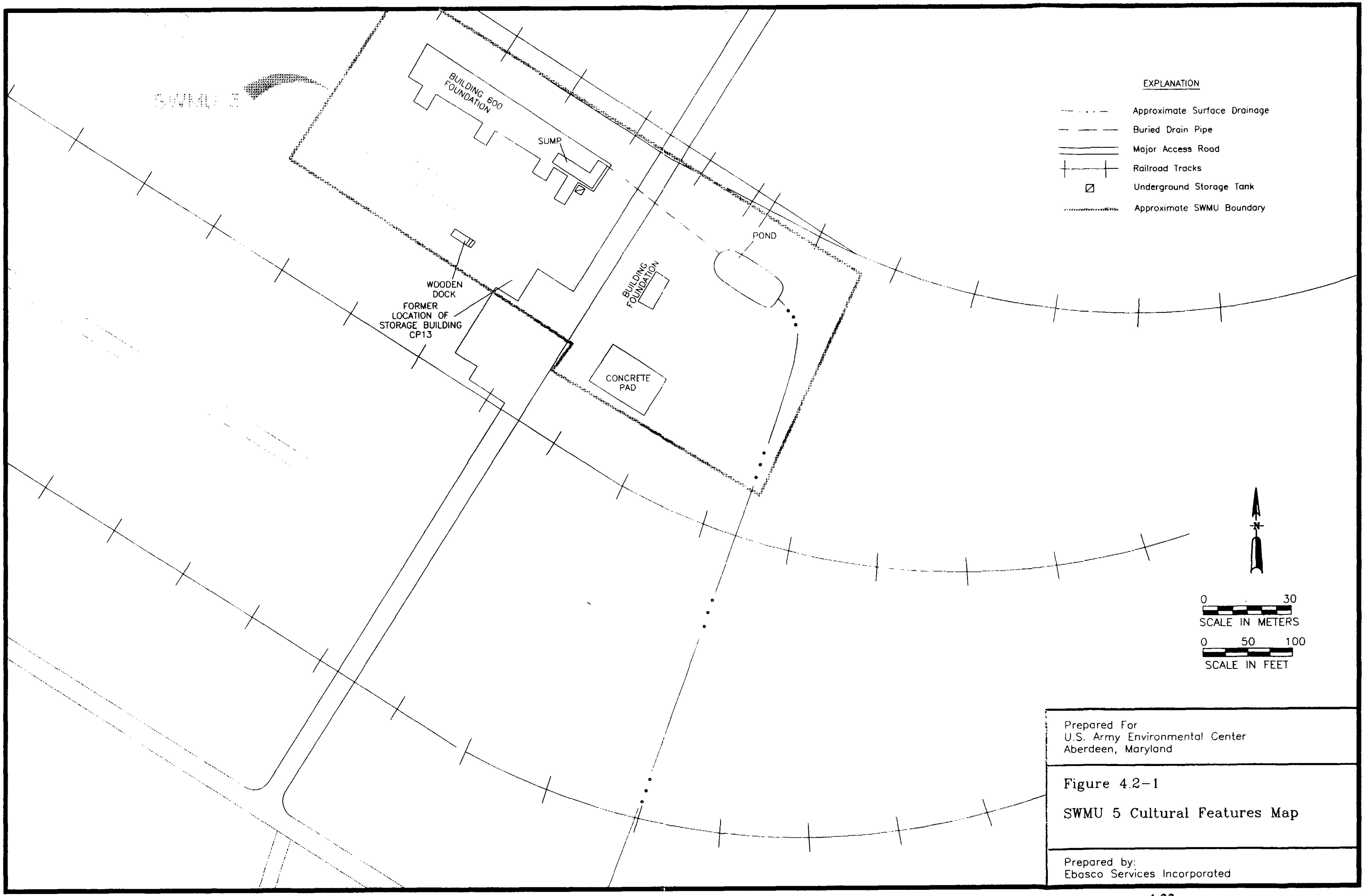
4.2.1.1 Site History and Description of SWMU 5: Building 600 Foundation, Drainage Pond, and Ditch

SWMU 5 is referred to as Building 600 Drainage Pond, Foundation, and Leaching Pit in the corrective action module; however, the SWMU name was revised for the purposes of this report to reflect the actual site features.

SWMU 5 consists of the Building 600 foundation, an unlined earthen drainage pond, an unlined ditch (which has previously been called a leaching pit), and several peripheral structures (Figure 4.2-1). The Building 600 foundation, which is made of concrete, is located on the west side of Cross Street; the drainage pond and ditch are located to the east of this street. A drainage pipe crosses under the street and connects the northeast corner of the large L-shaped sump in the Building 600 foundation to the drainage pond. The drainage pond, which is approximately 10 ft deep, empties into the ditch, which is approximately 4 ft deep. The ditch leads south and eventually empties onto the surrounding land. South of the Building 600 foundation is a service road, across which is located a wooden loading dock and an asphalt pad. East of Cross Street, but west of the drainage pond, lies a small building foundation, a concrete pad, and a standpipe.

In the IA (USATHAMA 1979) it is stated that chemical munitions, including white phosphorous (WP) grenades, were renovated in Building 600. It is also reported that high-explosive (HE) cluster bombs were washed out here in the late 1940s and early 1950s. Mustard projectiles, M15 WP grenades, and M4-A2 smoke pots were also reportedly renovated in this building (USATHAMA 1979), although the dates of these operations were not provided. According to Norris (1993b), Building 600 was used for renovation of less-than-carload (LCL) quantities of smoke pots and WP grenades in the early 1960s and for testing of BZ, an incapacitating agent, in the mid-1960s. Norris (1993b) recalls that numerous fire bombs (i.e., napalm) and German nerve gas bombs were stored on the rails around Building 600. Munitions renovation was also resumed at Building 600 in the late 1960s. During munitions renovation, the west end of Building 600 was used to remove fuses and bursters from smoke pots and WP grenades (Figure 4.2-2). The munitions, with the WP or smoke intact, were then taken to acid baths at the east end of the building (Figure 4.2-3), where rust was removed and the fuses and bursters replaced. The munitions were then repainted in spray booths located in the center of the building (also shown in Figure 4.2-2). In the mid-1970s, the L-shaped sump (Figure 4.2-4) and other modifications were constructed at the east end of Building 600 for retort operations. The unlined drainage pond (Figure 4.2-5) and drainage ditch (Figure 4.2-6) was also constructed at this time to manage effluent from retort operations. Peripheral structures attached to Building 600 include an office, a large aid station, and two coal-fired furnaces. The drainage pipe from the sump to the drainage pond was constructed of 8-inch diameter cast iron, with an interior 1-inch-thick coating of grout or cement. Such an internal coating may indicate that the pipe was used to manage the flow of corrosive liquids, either acidic or caustic. In addition to chemical agents, the IA lists paint constituents and chromic acid as potential contaminants. ERTEC (1982) lists Composition B, RDX, and TNT (all explosives) as potential contaminants at the site, but the source of this information was not recorded.

According to Barnes (1992), an employee who worked at TEAD-S for 33 years beginning in 1956, sandblasting and repainting operations were also conducted at this building from the late 1950s to early 1960s. Barnes remembered spray paint operations, sand blasting, and general munitions renovations, but no munitions washout. This information confirms that washout may have ended there in the early 1950s, as is stated in the IA (USATHAMA 1979). However,

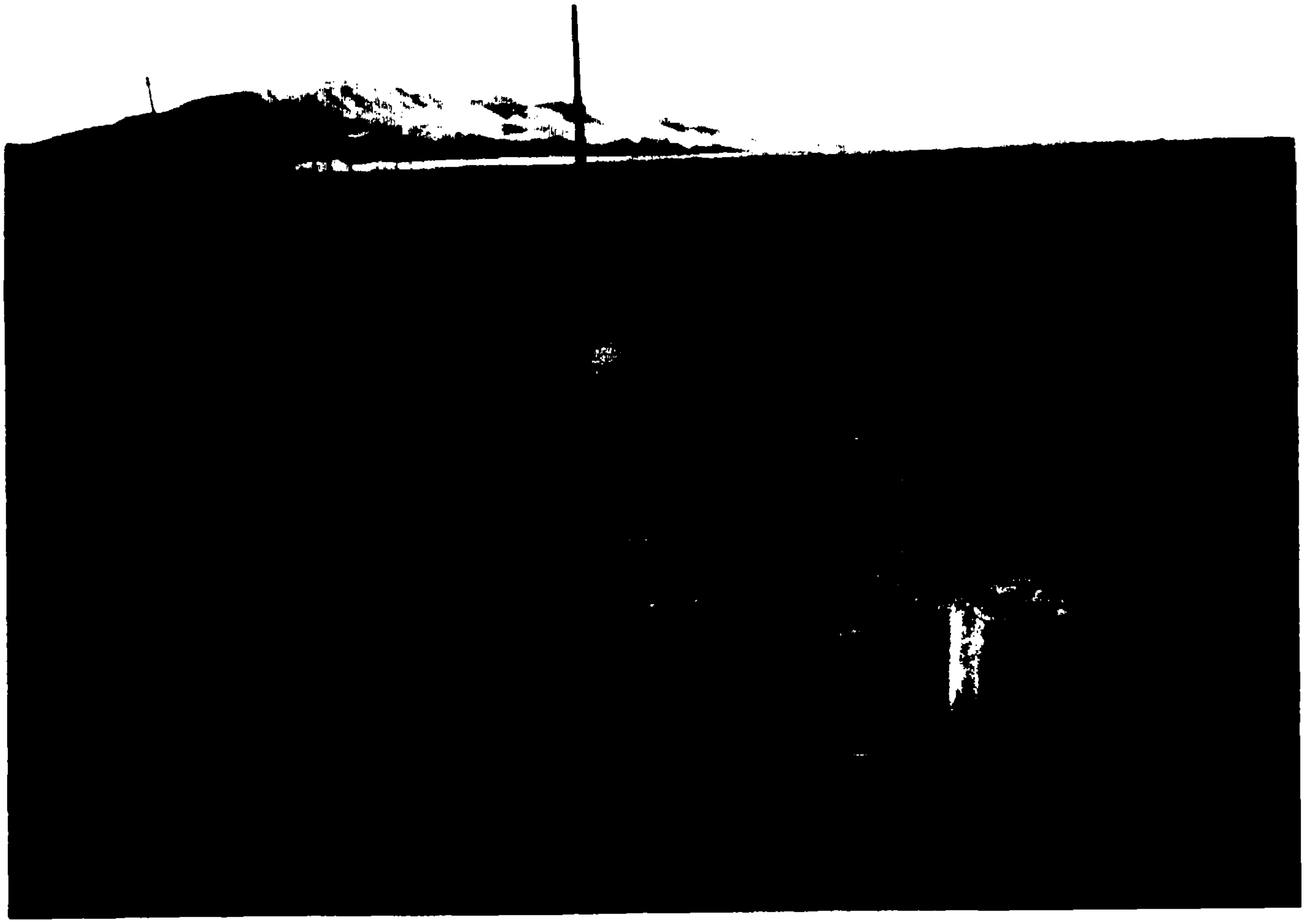


Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-1

SWMU 5 Cultural Features Map

Prepared by:
Ebasco Services Incorporated

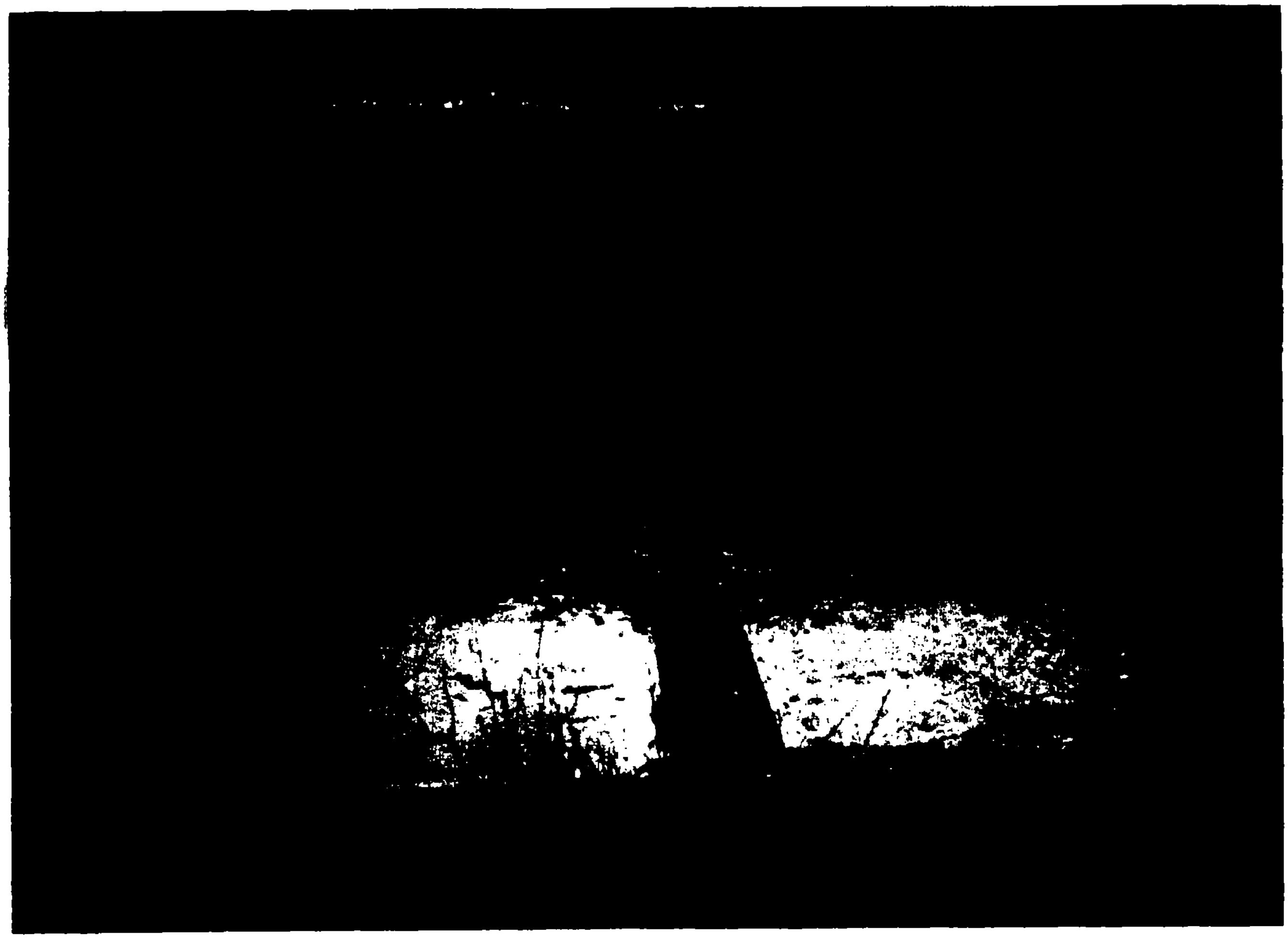


Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-2

Location of Paint Spray Booths (foreground) and Fuse/Burster Removal Area (background) in Building 600 at SWMU 5.

Prepared by:
Ebasco Services Incorporated

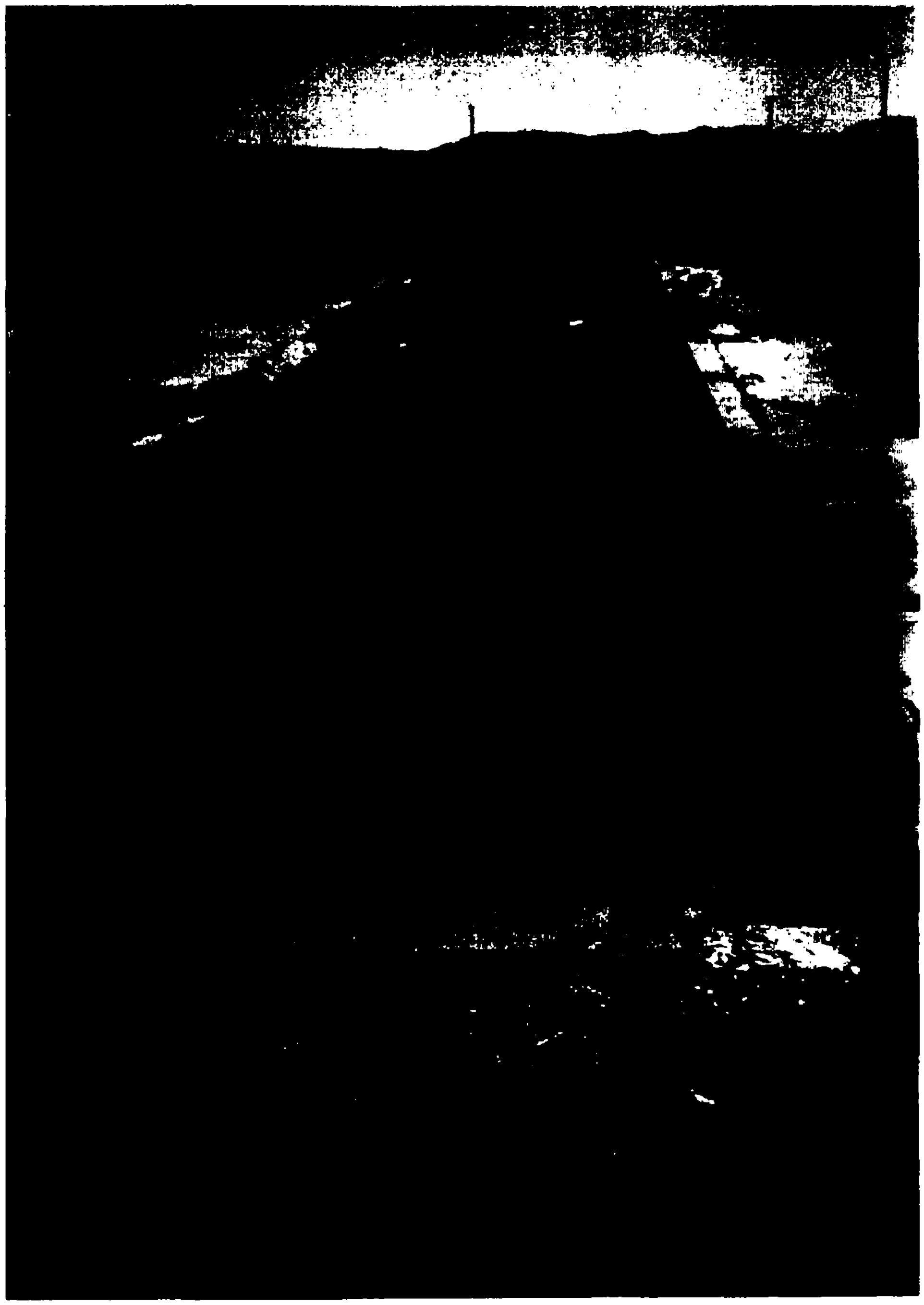


Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-3

Location of Acid Bath Tank
in Building 600 at SWMU 5.

Prepared by:
Ebasco Services Incorporated

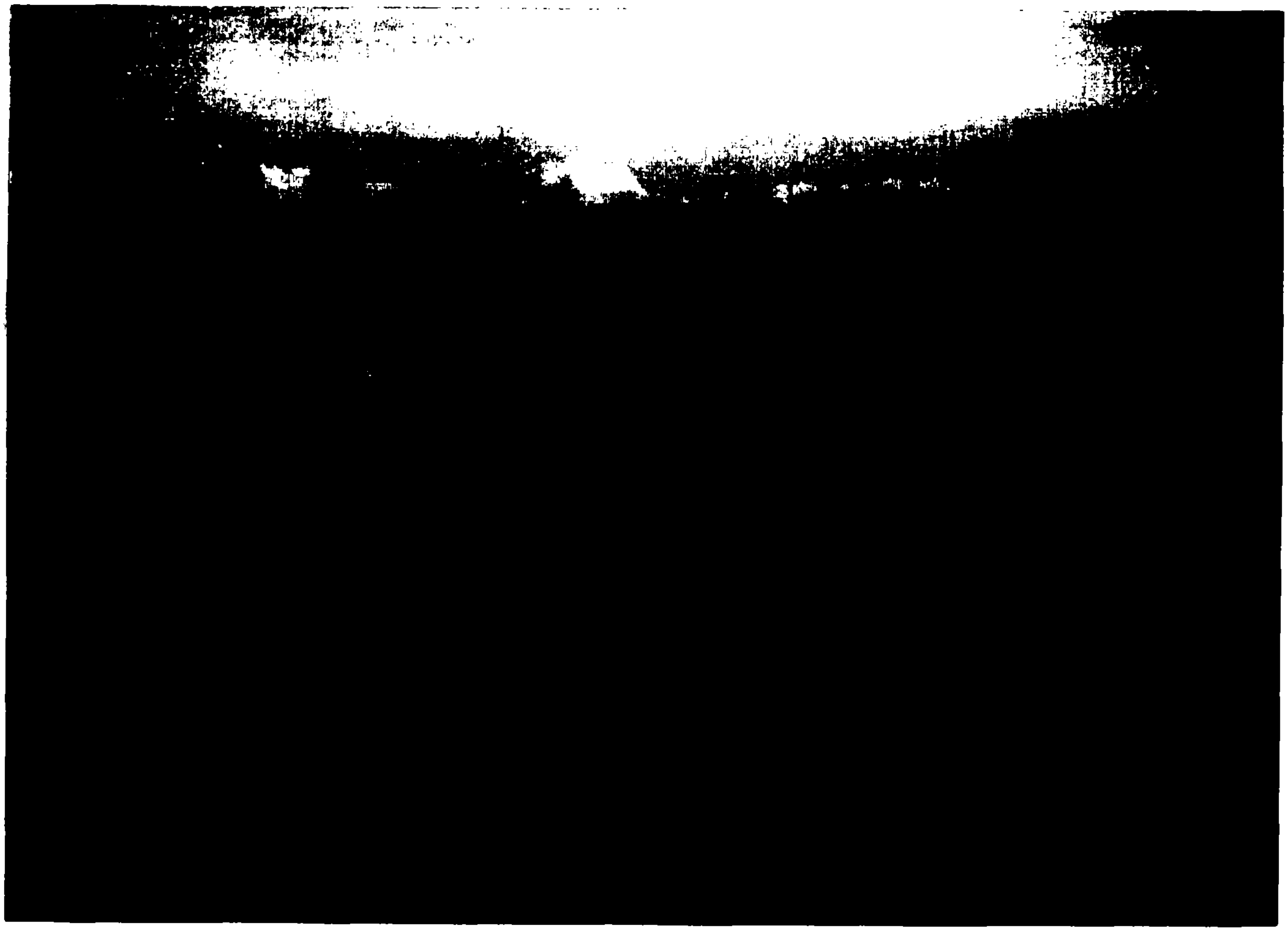


Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-4

L-Shaped Sump
in Building 600 at SWMU 5.

Prepared by:
Ebasco Services Incorporated

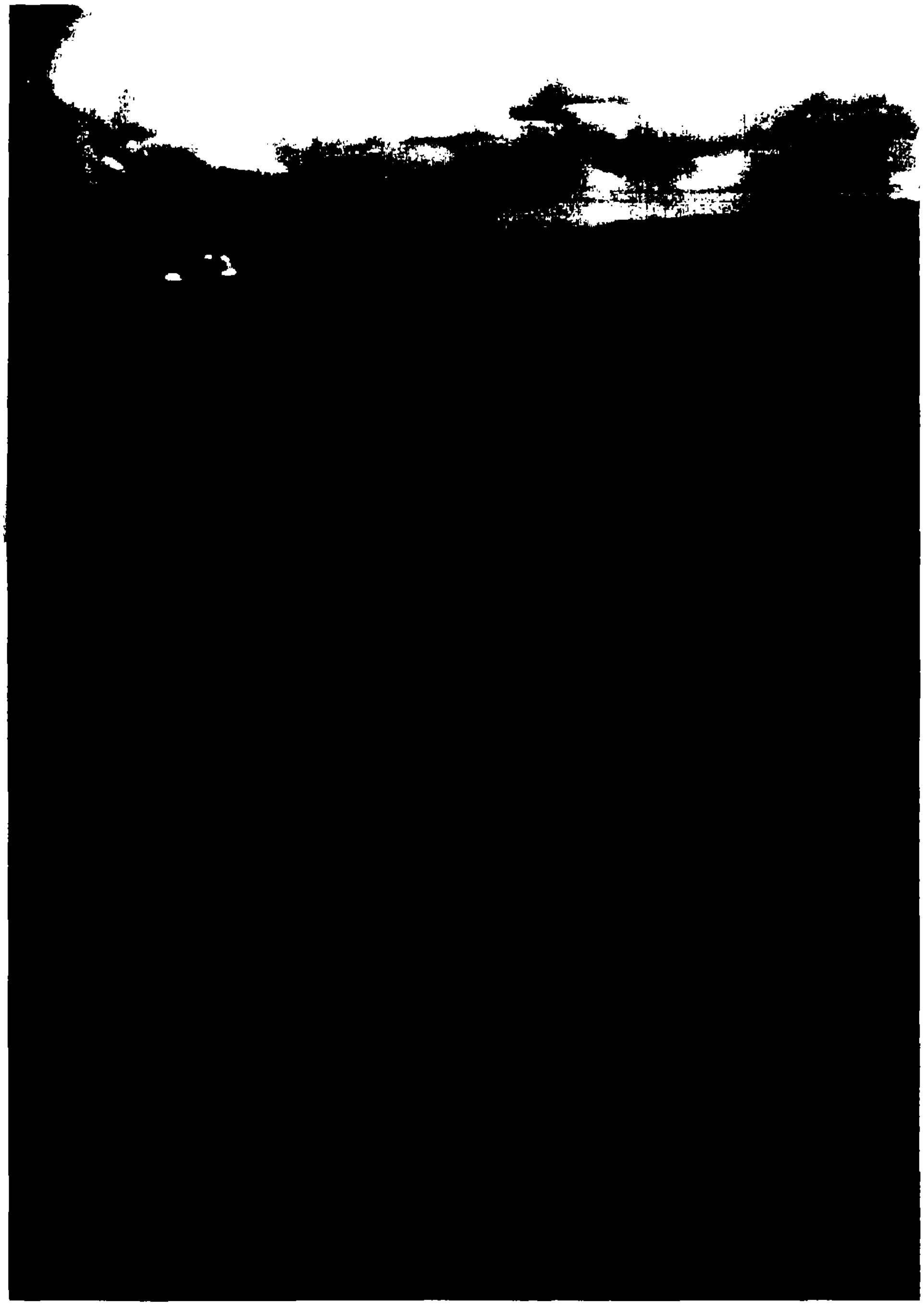


Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-5

Drainage Pond at SWMU 5.

Prepared by:
Ebasco Services Incorporated



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-6

North-South Section of Drainage Ditch at SWMU 5. Note Detonation at SWMU 31 in Left Background.

Prepared by:
Ebasco Services Incorporated

according to Norris (1993b), who worked at the unit in the early 1960s hot water was used for washout operations.

Trucks moving leaking, agent-filled munitions from SWMU 9 to SWMU 1 for disposal were decontaminated with DANC and washed off outside the buildings an indeterminate number of times at an unknown location area at SWMU 5 according to Norris (1993b). The wash water was directed into the drainage pond and ditch. Barnes (1992) also states that DANC was commonly used at this SWMU, and that it was commonly discharged to the pond and ditch.

During the RFI-Phase I (EBASCO 1993a), a vent or standpipe south of the Building 600 foundation was investigated and found to be connected to a UST that appeared to contain fuel oil. This UST was still in place at the completion of the RFI-Phase II field program.

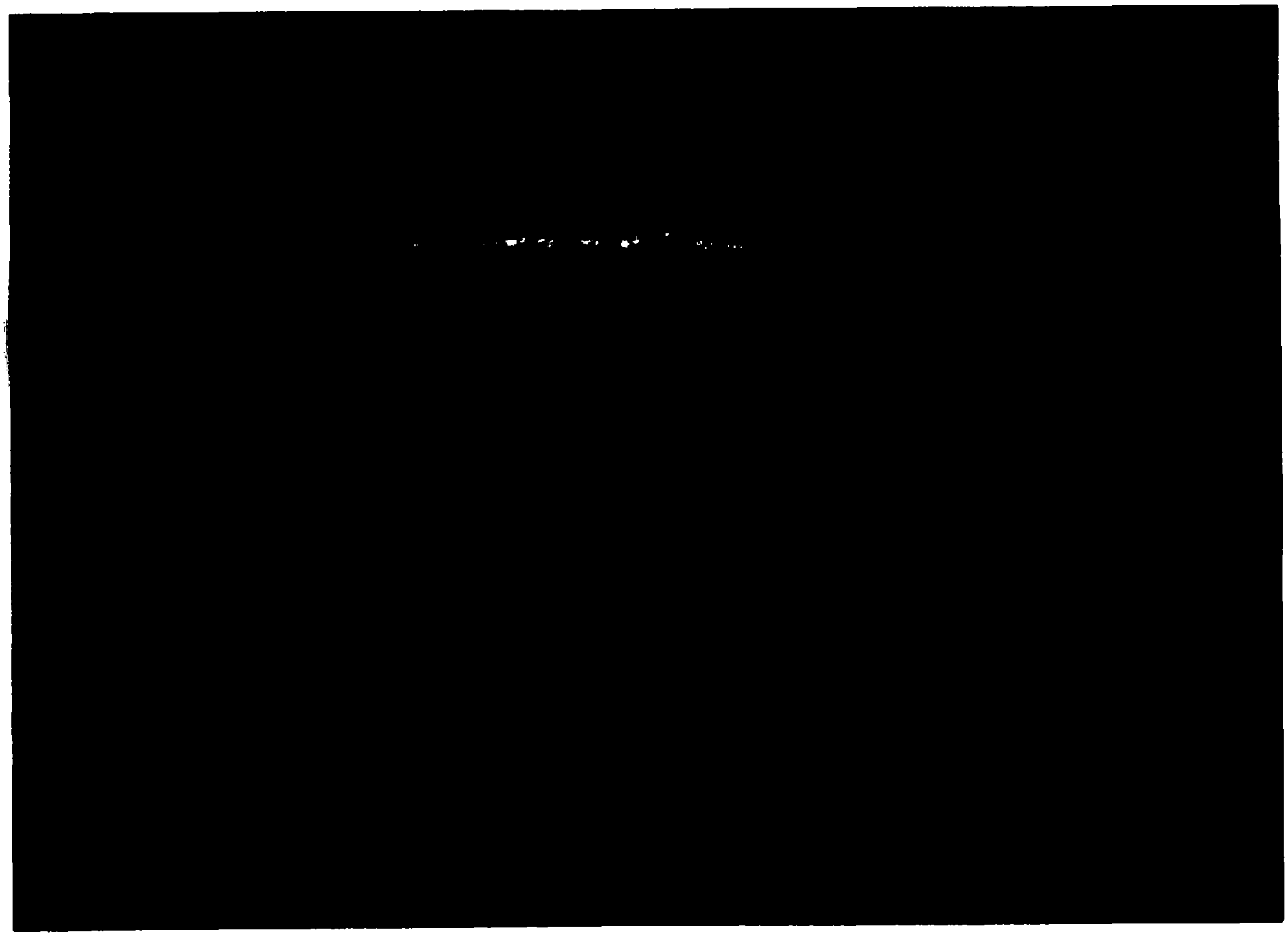
Peripheral structures at SWMU 5 include a small building foundation located east of Cross Street and south of the drainage pond. The building, which contains floor drains and fire brick, was reportedly used as a break room and shower facility. A standpipe is located east of this building, but the results of the nonintrusive geophysical survey did not indicate the presence of another UST. In this instance, the standpipe may have been attached to an aboveground tank. The remains of what appears to have been wooden planks is evident in an area east of the standpipe. The decayed wood covers an area approximately 60 ft by 20 ft in size and is of unknown function. A concrete pad of unknown function is located south of the break room building on the east side of Cross Street.

A small metal building designated as CP13, which was located south of Building 600 on the west side of Cross Street, was reportedly used for storage of riot control agents, including CN, CS, and DM, as well as paints, glues, and solvents. Norris (1993a, b) states that Building CP13, which is no longer extant, was located at the northwest corner of the asphalt pad on Cross Street (1993b), and that a wooden loading dock (Figure 4.2-7) west of the building may have been used to load LCL quantities of conventional munitions into trucks for shipment.

4.2.1.2 Geology and Soil at SWMU 5

The geology and soil at SWMU 5 are characterized from a total of 36 surficial samples and shallow borings. Surficial samples were collected from 0- to 0.2-ft depth interval; soil borings were collected to a maximum depth of 15.5 near the two UST investigation sites. In addition, two new monitoring wells (S-108-93 and S-109-93) were installed south of well S-53-90 in the eastern portion of the SWMU (Figure 3.7-2).

The overall geology and soil present in SWMU 5, as encountered during this investigation, consist of fine-grained lacustrine deposits that are classified as silty clay (CL) or clayey silt (ML) according to the USCS. In the northern and eastern portions of the SWMU, varying quantities of fine- to coarse-grained sand, with occasional small amounts of gravel, are present. In the central portion of the site near the Building 600 foundation, the upper soil was identified as fill



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-7

Wooden Dock South of
Building 600 at SWMU 5.

Prepared by:
Ebasco Services Incorporated

to a maximum observed depth of 1.8 ft (5-BLD-16). It is composed of the same soil types detected in other areas of the SWMU, but was reworked or disturbed through human activities such as building construction. A common observation in many of the samples, predominantly in the former pond area, was the presence of calcium carbonate as veining, seams, or cement.

The relative moisture conditions for all of these samples ranged from dry to moist. No groundwater was encountered during the sampling of the shallow borings. The relative consistency of the soil was quite variable, (i.e., from unconsolidated to more cemented). Detailed information on these characteristics can be found on the boring logs located in Appendix A1.

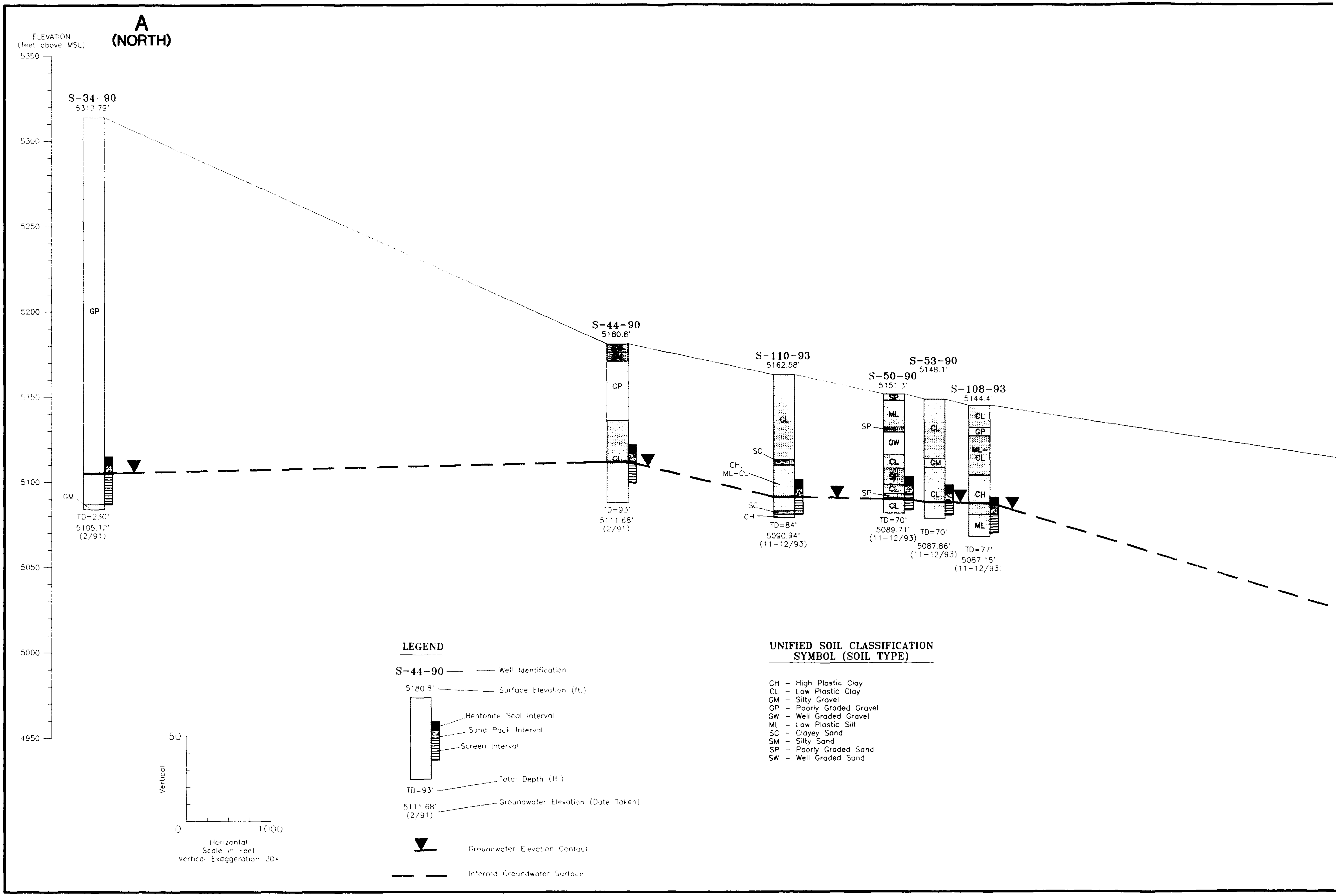
Results from the geotechnical testing of shallow soil came from the two background sample locations (5-BK-1 and 5-BK-2) and the one building sample location (5-BLD-17). The USCS symbols (CL, ML, and ML-CL) correspond to the soil types observed by the field geologists. The measured moisture contents ranged from 13.8 to 20.1 for damp to moist conditions. The soil was moderately alkaline, with a pH range of 8.73 to 9.61. The coefficient of permeability was determined for each sample and showed a decrease in permeability with increasing clay content (values of 5.3 x 10^{-4} cm/sec in the ML, 2.0 x 10^{-5} cm/sec in the ML-CL, and 6.9 x 10^{-6} cm/sec in the CL). Only the two background samples were evaluated for effective porosity, with values of 26.9 and 27.6 percent, respectively. Bulk density measurements were performed on all samples and ranged from 79 to 98 pcf. The only geochemical testing performed was for TOC on material collected from depths more than 1.5 ft bgs. The TOC values ranged from 0.33 to 0.48 percent. Additional geotechnical and geochemical details are found in Appendix A4.

Information on soil types present at SWMU 5 was also obtained from SCS (no date). Only one soil type was mapped at SWMU 5, which is the Tooele fine sandy loam. This soil is slightly saline and moderately alkaline at the surface, with these conditions increasing with depth. The suitable uses for the Tooele loam are wildlife habitat and very limited pasture crop production. The suitability of the soil for livestock grazing is only fair since the soil produces only limited amounts of forage.

4.2.1.3 Hydrology at SWMU 5

SWMU 5 is located on a gently southwest-sloping topographic surface. No significant runoff is likely to enter the area near SWMU 5 because railroad tracks upslope to the north obstruct surface water flow. However, the ditch that use to receive flow from the drainage pond extends from the pond under several sets of railroad tracks to a valley south of the SWMU. This ditch is capable of carrying runoff out of the eastern portion of SWMU 5.

As part of the RFI-Phase II program, two new monitoring wells (S-108-93 and S-109-93) were installed in the vicinity of SWMU 5. Construction details of these wells are provided in Table 3.9-1. In November and December 1993, the depth to groundwater ranged from 59 ft bgs at well S-51-90 to 66 ft bgs at well S-109-93. In April 1994, depths to groundwater were similar. Figure 4.2-8 is a stratigraphic cross section of SWMU 5 that shows the lithologic variability of

ELEVATION
(feet above MSL)
A
(NORTH)
5350
5300
5250
5200
5150
5100
5050
5000
4950
S-34-90
5313.79'
GP
GM
TD=230'
5105.12'
(2/91)
S-44-90
5180.8'
GP
CL
TD=93'
5111.68'
(2/91)
S-110-93
5162.58'
CL
SC
CH,
ML-CL
SC
CH
TD=84'
5090.94'
(11-12/93)
S-50-90
5151.3'
SP
ML
SP
GW
CL
SP
CL
SP
CL
TD=70'
5089.71'
(11-12/93)
S-53-90
5148.1'
CL
GM
CL
TD=70'
5087.86'
(11-12/93)
S-108-93
5144.4'
CL
GP
ML-CL
CH
ML
TD=77'
5087.15'
(11-12/93)
50
Vertical
0
1000
Horizontal
Scale in Feet
Vertical Exaggeration 20x
LEGEND
S-44-90 — Well Identification
5180.8' — Surface Elevation (ft.)
Bentonite Seal Interval
Sand Pack Interval
Screen Interval
TD=93' — Total Depth (ft.)
5111.68' (2/91) — Groundwater Elevation (Date Taken)
Groundwater Elevation Contact
Inferred Groundwater Surface
UNIFIED SOIL CLASSIFICATION SYMBOL (SOIL TYPE)
CH - High Plastic Clay
CL - Low Plastic Clay
GM - Silty Gravel
GP - Poorly Graded Gravel
GW - Well Graded Gravel
ML - Low Plastic Silt
SC - Clayey Sand
SM - Silty Sand
SP - Poorly Graded Sand
SW - Well Graded Sand

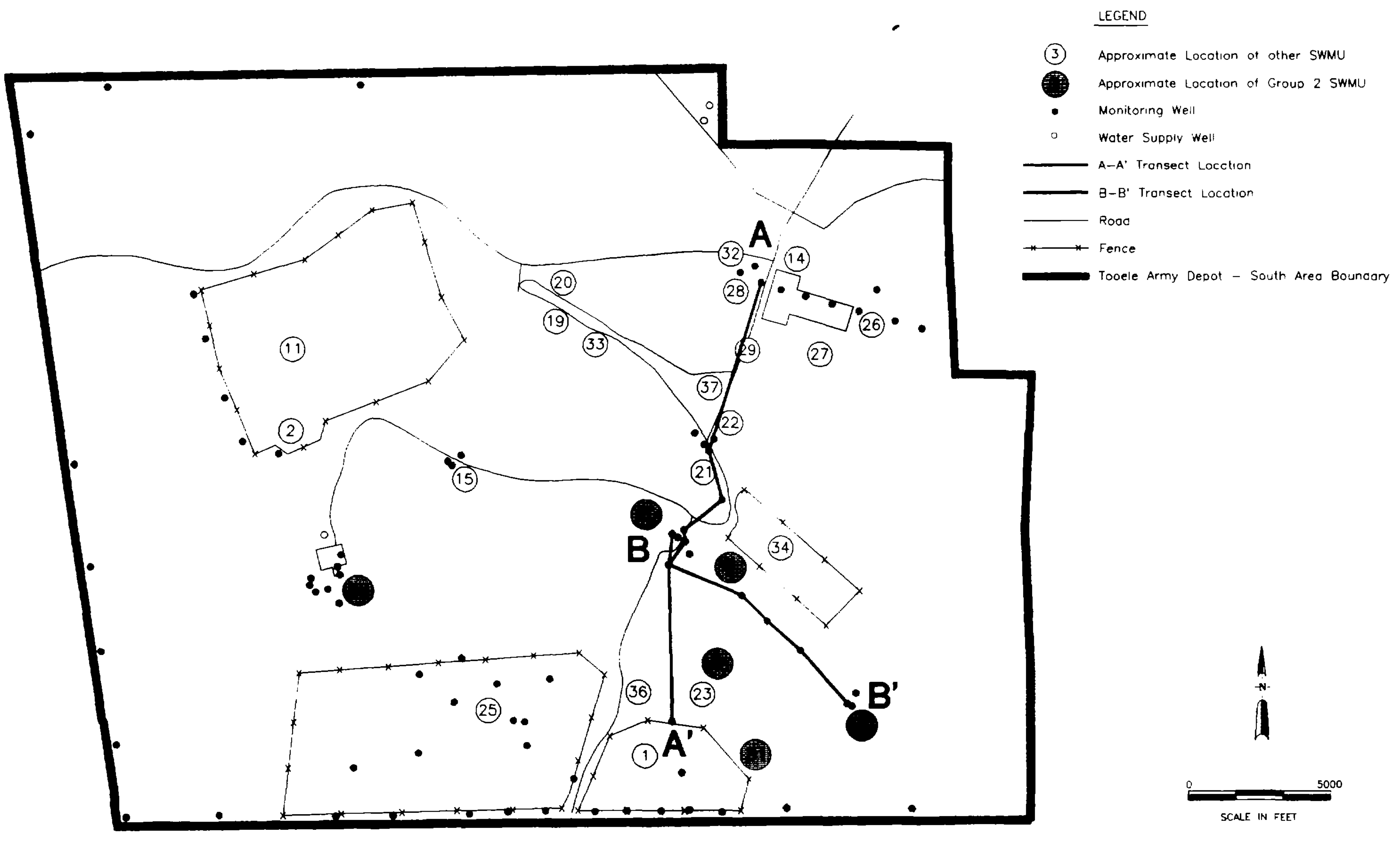
the water-bearing zone across the SWMU. The location of this cross section is shown in Figure 4.2-9.

Groundwater flow in this area is affected by a groundwater high that appears to extend along Montgomery Road from SWMUs 14, 28, and 32 and past SWMUs 21 and 22 to the SWMU 5 area. This groundwater recharge area may result either from leakage of a water main that follows Montgomery Road or from building discharge in and near SWMUs 5 and 22 (see Figures 3.10-1 and 3.10-2). At SWMU 5, this recharge results in an eastern component to groundwater flow near the drainage pond and a western component near the building foundation. Downgradient from the SWMU groundwater flow is generally southward. Water level measurements collected during the RFI-Phase II still indicated that well S-50-90 is upgradient of the drainage pond and the remaining wells (S-2, S-51-90, S-53-90, S-108-93, and S-109-93) are downgradient of the Building 600 foundation. In April 1994, groundwater elevations were slightly higher in well S-2 than in well S-50-90. Groundwater elevations in November and December 1993 varied from 5,084 ft above mean sea level (msl) at well S-109-93 to 5,090 ft msl at well S-50-90.

The average horizontal hydraulic gradient for this area is 0.0040. The gradient is calculated on a line through well S-50-90 south between the 5,085- and 5090-ft contours on Figure 3.10-1. There are no well clusters in the area, so a vertical hydraulic gradient cannot be calculated.

Slug tests were conducted in the two new wells to estimate the hydraulic conductivity of the water-bearing zone in the vicinity of each well. These hydraulic conductivity (K) values were obtained using rising head test data analyzed by the Bouwer and Rice method (1976). The calculated hydraulic conductivity values are 1.08×10^{-4} ft per minute (ft/min) and 3.93×10^{-4} ft/min for wells S-108-93 and S-109-93, respectively. According to Freeze and Cherry (1979), these results are typical of clay, silt, and silty fine-grained sand, such as are found in the water-bearing zones in these wells.

A seepage velocity was calculated along the flow path used to calculate the hydraulic gradient through well S-50-90. Seepage velocity is the average velocity at which groundwater flows for a given gradient and aquifer permeability. Using the average hydraulic conductivity of the two wells (0.36 ft/day), a hydraulic gradient of 0.0040, and effective porosities of 2 and 10 percent, seepage velocities of 0.014 ft/day and 0.072 ft/day were obtained. Given these velocities, it would take several thousand years for groundwater contamination from SWMU 5 to reach the southern boundary of TEAD-S.



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-9
Locations of
Geologic Cross Sections

Prepared by:
Ebasco Services Incorporated

4.2.2 Nature and Extent of Contamination

This section describes soil, groundwater, and air contamination assessments at SWMU 5. It should be noted that in the assessments of soil and groundwater contamination only those COCs of potential risk to human or ecological receptors are described in detail. Human health COC selection for SWMU 5 is detailed in Section 5.3.1. Ecological COC selection for all Group 2 SWMUs are discussed in Section 6.3.

4.2.2.1 Soil Contamination Assessment

This section summarizes the chemical analytical results of the RFI-Phase II sampling program, as well as those programs conducted previously, at SWMU 5. The RFI-Phase II results and evaluations are grouped by analyte, with significant detections discussed by location within the SWMU. The sample locations are shown on the individual contaminant maps. The complete chemical data for the RFI-Phase II soil samples can be found in Appendix F1.

Although this section presents an evaluation of all the analytical data collected, the discussion focuses on the results for the human health and ecological COCs at SWMU 5 that are being evaluated in the risk assessments. The COCs for SWMU 5 include one organic compound (1,1,2-trichloro-1,2,2-trifluoromethane, or TCLTFE) and 11 metals (antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, vanadium, and zinc).

Previous Investigations

Prior to the RFI-Phase I, five soil samples had been collected at SWMU 5: four samples from the drainage pond and one soil sample collected during the installation of monitoring well S-2. Soil samples were analyzed for VOCs, SVOCs, metals, and anions. Nitrates were detected in two of the four samples collected from the drainage pond; sodium, chloride and nitrates were detected in the soil sample from well S-2.

The RFI-Phase I program at SWMU 5 included the collection of four additional soil samples. Two of the four soil samples were collected from the drainage pond, one was collected from the drainage ditch, and one was collected from an area northwest of the drainage pond to provide background metal concentrations. The soil samples were analyzed for SVOCs, agent breakdown products, explosives, and metals to detect releases of chlorinated solvents, explosives, and mustard agent and its decomposition products from truck decontamination, and munitions washout and painting activities. Results of the RFI-Phase I soil sampling indicated detections above background of chromium in the drainage pond and ditch samples. Arsenic, copper, lead, mercury, nickel, silver, and zinc were also detected above background levels in the drainage pond samples. No organic compounds (VOCs, SVOCs, agent breakdown products, or explosives) were detected in these samples.

RFI-Phase II Results

There were a total of 74 soil samples collected in SWMU 5. Samples were collected from locations in the drainage pond, the drainage ditch, around building foundations, and two suspected USTs. The samples were collected from the surface and at various depths to a maximum of 15 ft near the suspected USTs. Samples collected from the pond and drainage ditch were analyzed for metals only. Samples from the building foundations and UST locations were analyzed for VOCs, SVOCS, and metals.

Organic Compounds and Cyanide

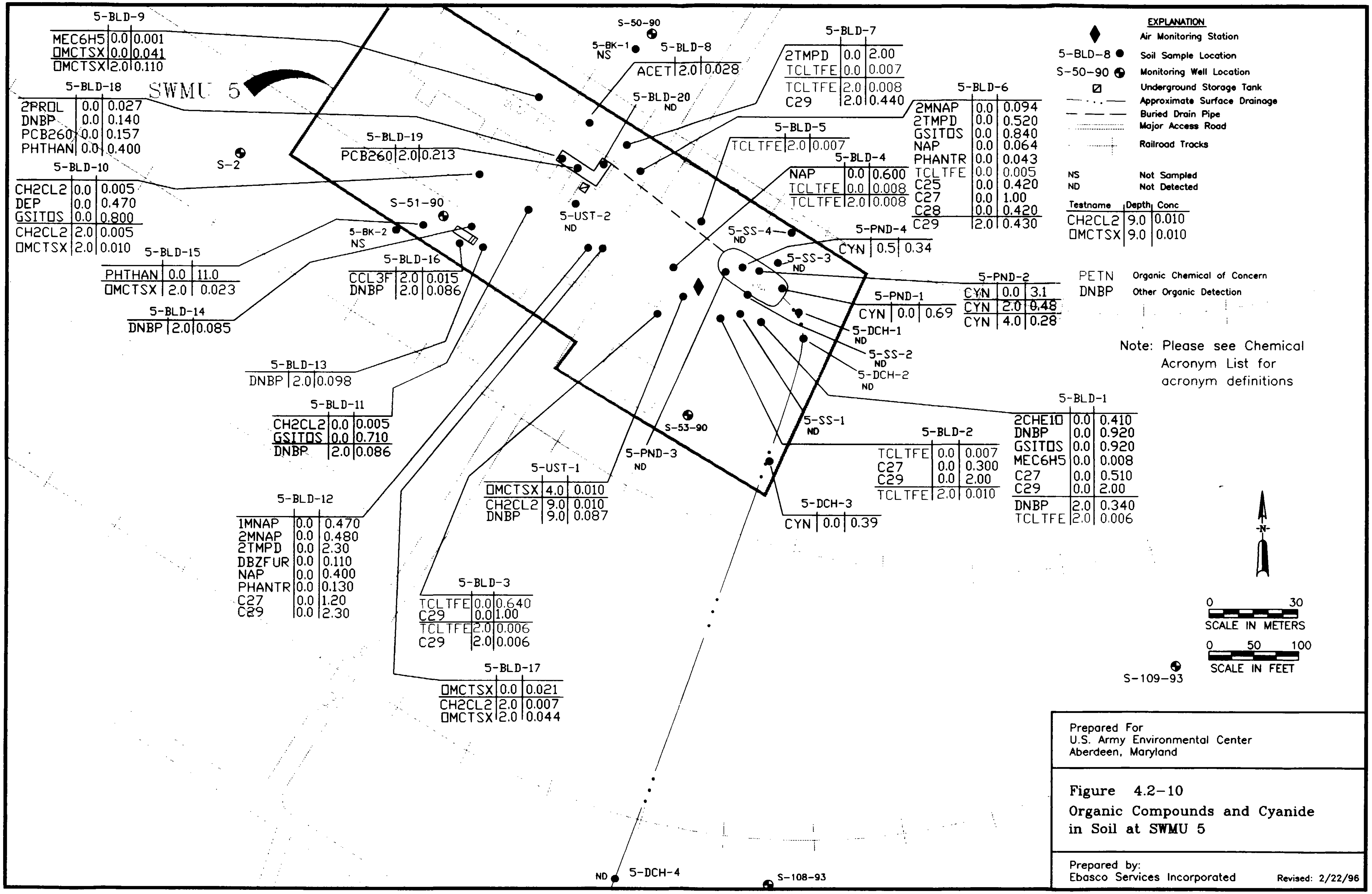
A total of 21 organic compounds were detected at various locations around the SWMU (Figure 4.2-10). The target analytes were dibenzofuran (DBZFUR), diethylphthalate (DEP), di-n-butylphthalate (DNBP), methylene chloride (CH2CL2), 2-methylnaphthalene (2MNAP), naphthalene (NAP), phenanthrene (PHANTR), PCB 1260 (PCB260), and toluene (MEC6H5). Non-target analytes detected were clionasterol (GSITOS), 1-methylnaphthalene (1MNAP), octamethylcyclotetrasiloxane (OMCTSX), phthalic anhydride (PHTHAN), 2-propanol (2PROL), 2,6,10,14-tetramethylpentadecane (2TMPD), trichlorofluoromethane (CCL3F), 1,1,2-trichloro-1,2,2-trifluoroethane (TCLTFE) pentacosane (C25), heptacosane (C27), octacosane (C28), and nonacosane (C29). TCLTFE is the only human health COC at SWMU 5; there are no organic ecological COCs at this SWMU.

1,1,2-trichloro-1,2,2-trifluoroethane (TCLTFE) was detected in 11 of 74 samples collected at SWMU 5. TCLTFE was detected in surficial and 2-ft samples at 7 locations, which were primarily located east of Cross Street. The only detections of TCLTFE west of Cross Street were low concentrations (0.007 to 0.008 µg/L) in the surficial and 2-ft samples at a location north of the Building 600 foundation, and in the surficial sample adjacent to the buried drain pipe connecting the L-shaped sump to the drainage pond. TCLTFE was detected at 2 ft bgs adjacent to the drain pipe on the east side of Cross Street, and in several locations south and west of the drainage pond. The highest concentration (0.640 µg/L) was detected at 2 ft bgs at the south end of the shower building (5-BLD-3). Because of its toxicity, areal distribution, and frequency of detection in 15% of the soil samples, TCLTFE is a SWMU-wide COC at SWMU 5.

Cyanide (CYN) was detected at low concentrations in five soil samples collected in the drainage pond and ditch (Figure 4.2-10). The highest concentration of cyanide (0.69 µg/g) was detected in surficial soil at 5-PND-1.

Metals

Eighteen metals, (Ag, Al, As, Be, Cd, Co, Cr, Cu, Fe, Hg, Mg, Mn, Ni, Pb, Sb, Se, V, and Zn), and cyanide were detected in concentrations above background levels at various locations around SWMU 5. The human health risk assessment for SWMU 5 identified Cd, Cr, Cu, Pb, and Zn as SWMU-wide COCs and Sb, Hg, Ni, Ag, and V as sample- or area-specific COCs. Arsenic, an ecological COC, was generally detected at levels below background.



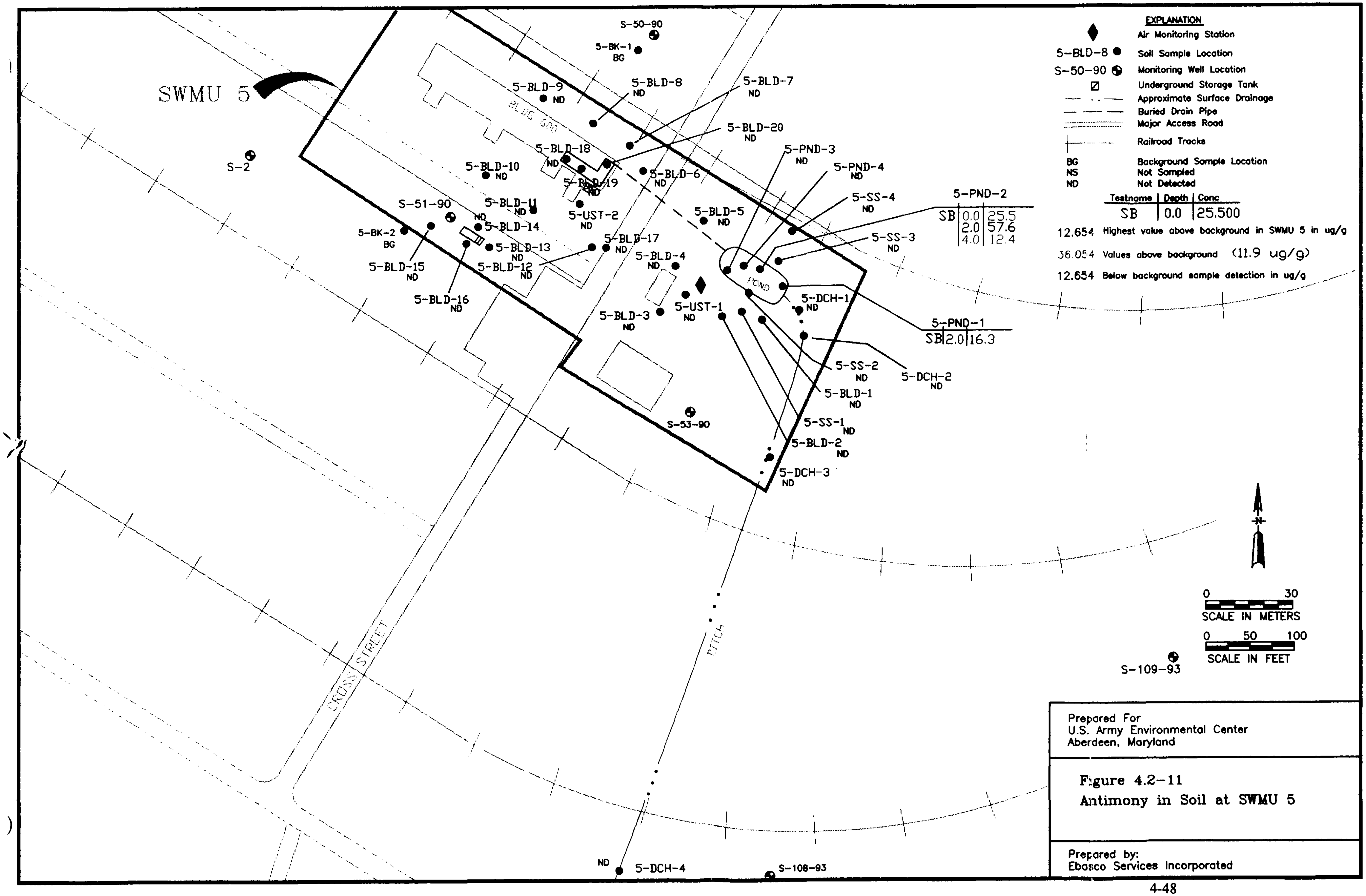
Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-10
Organic Compounds and Cyanide in Soil at SWMU 5

Prepared by:
Ebasco Services Incorporated

Revised: 2/22/96

F:\PROJECTS\TOOELE\ARCAD\SWMUS\SWMU-5.DWG



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-11
Antimony in Soil at SWMU 5

Prepared by:
Ebasco Services Incorporated

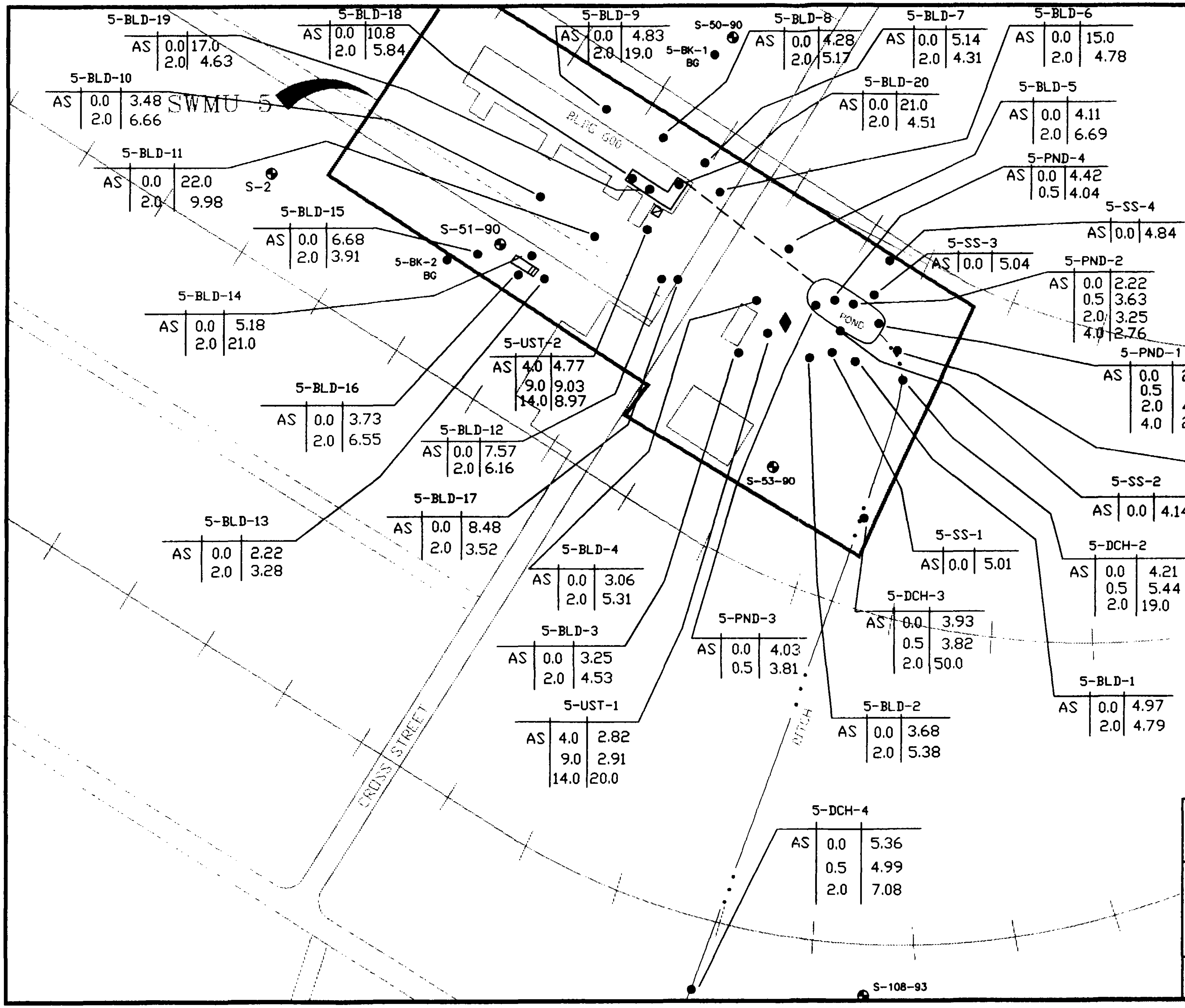
Antimony (Sb), a human health COC, was detected in only four soil samples collected at two locations in the drainage pond (Figure 4.2-11). It was detected three times at one location: in the surficial sample, at 2 ft bgs and 4 ft bgs. At another location, it was detected at 2 ft bgs only. The highest concentration of antimony (57.6 µg/g) in SWMU 5 was detected 2-ft bgs at 5-PND-2. All four detections were above background (11.9 µg/g). Antimony is therefore a potential COC for the pond area only.

Arsenic (As), a facility-wide ecological COC, was detected above background (40.0 µg/g) at 2 ft bgs at only one sample location (5-DCH-3), a downgradient location in the drainage ditch. The concentration in this sample was 50.0 µg/g. All other detections of arsenic at SWMU 5 were below background. The concentrations of arsenic at all SWMU 5 sampling locations are shown in Figure 4.2-12.

Cadmium (Cd), a human health and ecological COC, was detected in 26 samples at concentrations above background (0.98 µg/g). It is therefore considered a SWMU-wide COC (Figure 4.2-13). The highest concentration (22.5 µg/g) was detected in the surficial sample at one of the pond sampling locations (5-PND-2). Cadmium was detected in all the sampling locations in the pond, both surficial and subsurface. Cadmium was detected in only one sample (0.5 ft bgs) collected from the ditch; the concentration was above background. Also on the east side of Cross Street, cadmium was detected above background in the surficial sample taken on the south side of the shower building foundation, in the surficial sample taken between the pond and Cross Street, and in the 9-ft bgs sample in the boring near the stand pipe on the east side of Cross Street. On the west side of Cross Street, cadmium was detected at concentrations above background from seven surficial samples collected around the Building 600 foundation and the wooden dock.

Chromium (Cr), a human health COC, which was detected in 15 of 74 samples, is considered to be a SWMU-wide COC because of its frequency of detection at SWMU 5 (Figure 4.2-14). The highest concentrations of chromium at SWMU 5 were detected in samples collected from the pond, with the highest concentration (1,680 µg/g) occurring 2 ft bgs at sample location 5-PND-2. Chromium was detected above background at one depth in all four sample locations in the pond, and it was detected in three pond locations above background (48.5 µg/g) at various depths up to 5 ft bgs. Chromium was also detected above background in a sample at 0.5 bgs in the ditch south of the pond. On the west side of Cross Street, chromium was detected at two sample locations: once in the surficial sample collected in the sump of the Building 600 foundation (which was actually obtained beneath the concrete sump bottom); and south of well S-51-90 in the surficial sample and the subsurface sample (2 ft bgs).

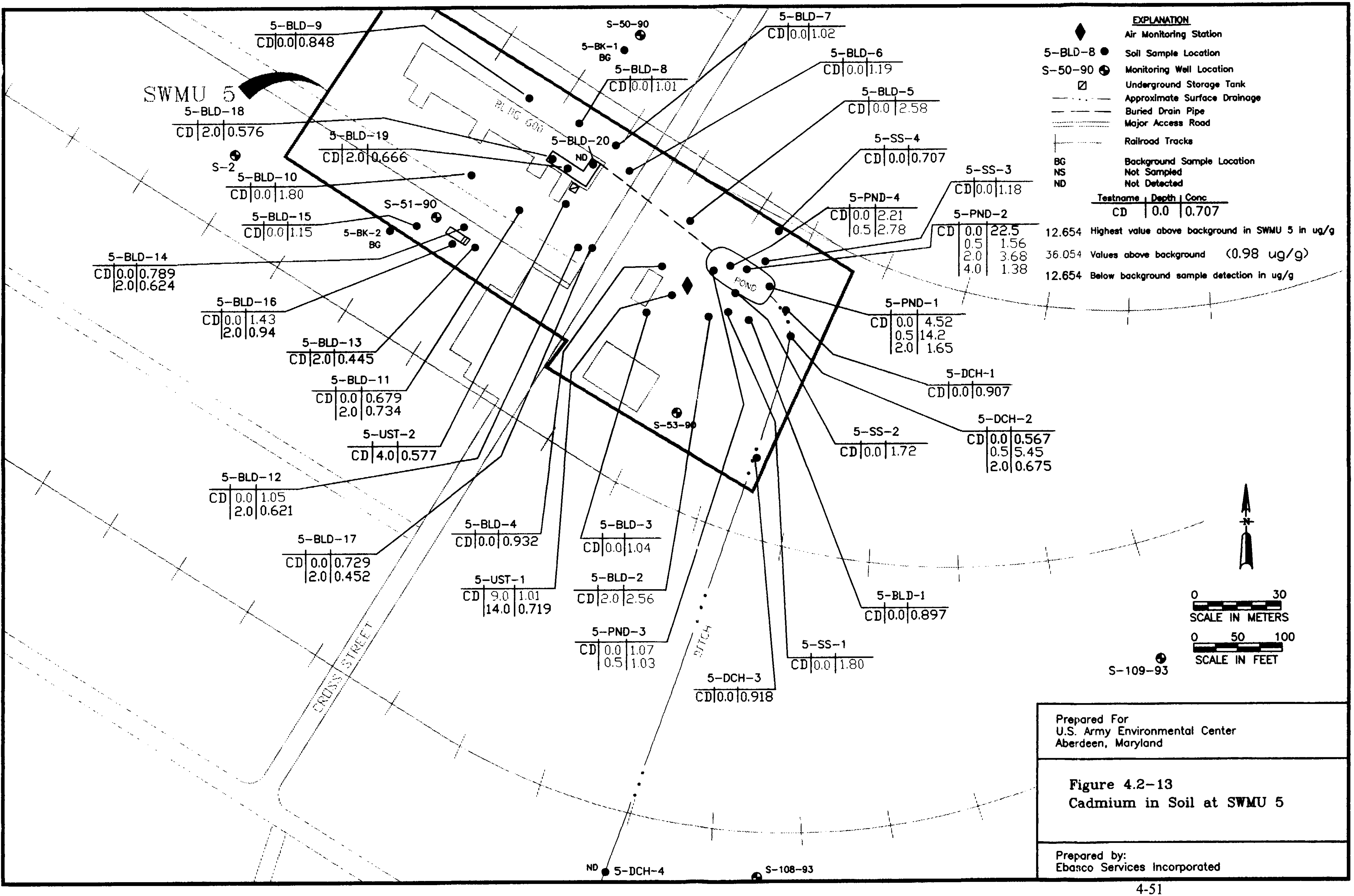
Copper (Cu), a human health and ecological COC, was detected in all soil samples collected at SWMU 5 and is therefore considered a SWMU-wide COC (Figure 4.2-15). Copper was detected at concentrations above background (27.6 µg/g) in 9 samples. West of Cross Street, copper was detected above background in two surficial soil samples collected below the sump and around the Building 600 foundation. East of Cross Street, copper was detected above background at three sample locations in the drainage pond and ditch: once at 0.5 bgs, once at both the surface and at 0.5 bgs, and once in the ditch at both the surface and at 2 ft bgs. The highest concentration of copper (170.0 µg/g) was detected in the surficial sample at 5-PND-2. At one location in the



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-12
Arsenic in Soil at SWMU 5

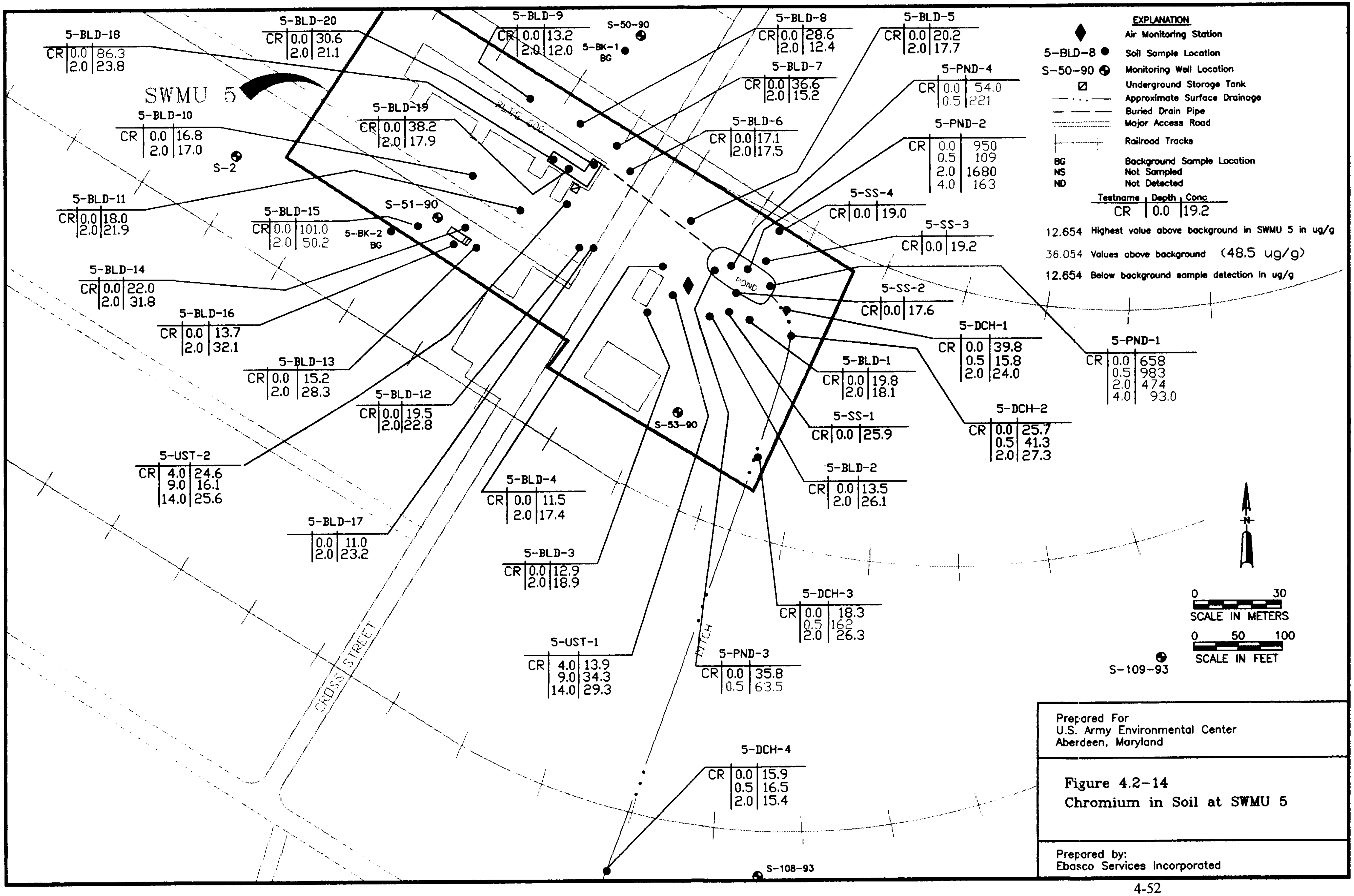
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-13
Cadmium in Soil at SWMU 5

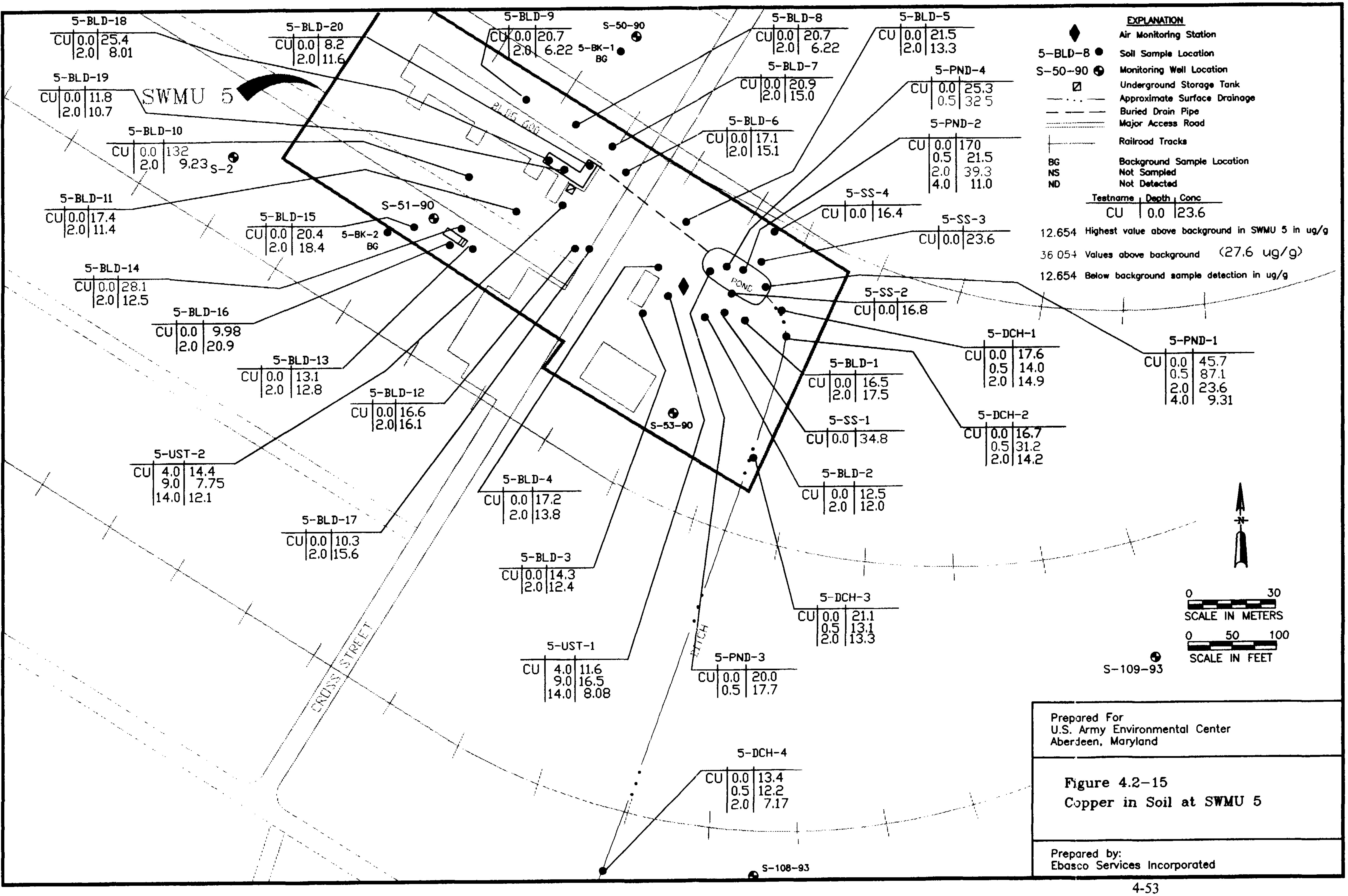
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-14
Chromium in Soil at SWMU 5

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-15
Copper in Soil at SWMU 5

Prepared by:
Ebasco Services Incorporated

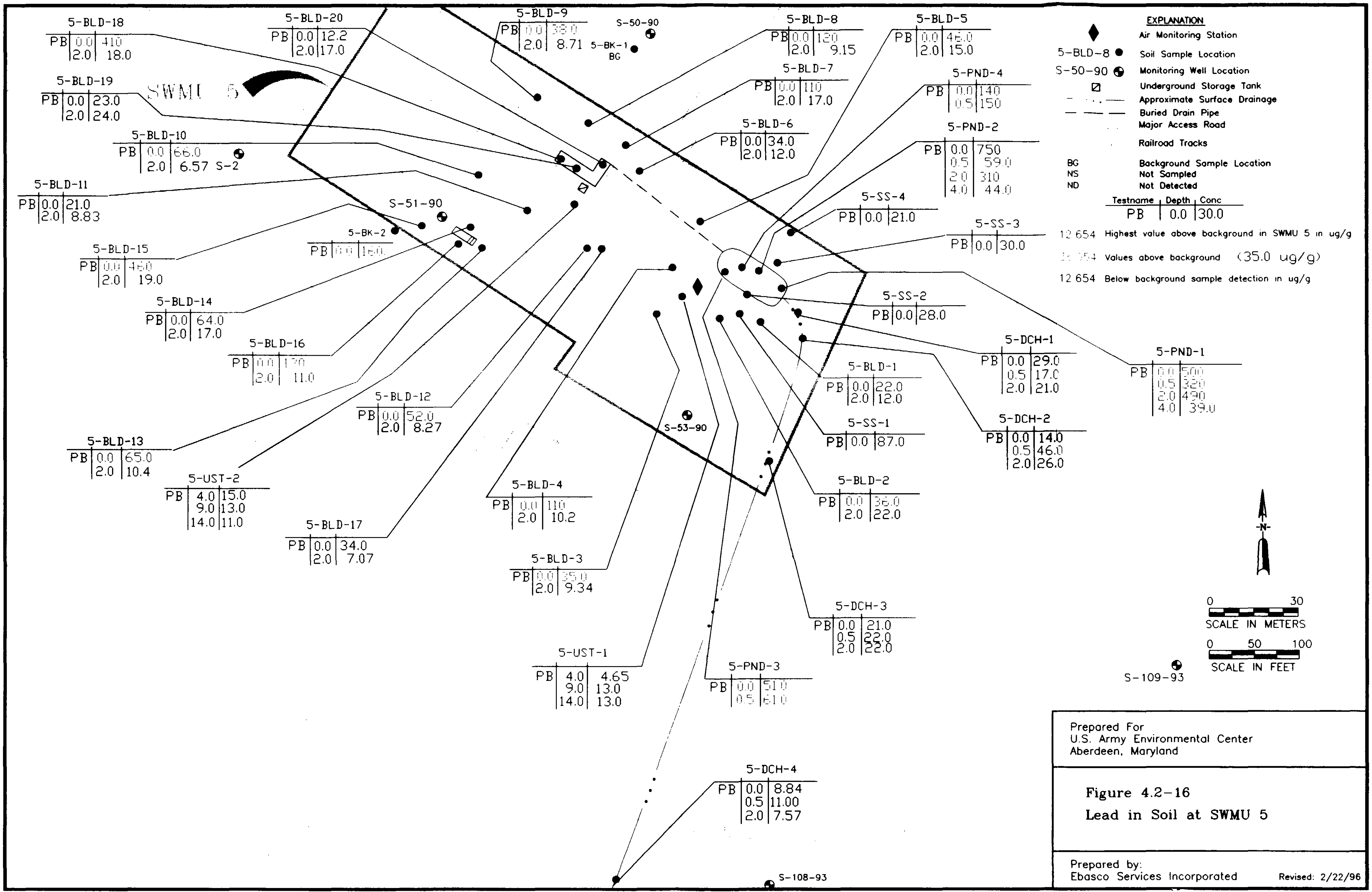
ditch south of the pond Cu was detected in the sample collected 0.5 ft bgs. Copper was also detected in a surficial soil sample taken south of the pond.

Lead (Pb), a human health and ecological COC, was detected in all 74 soil samples collected at SWMU 5, and above background (35.0 µg/g) in 26 samples (Figure 4.2-16). Because of the frequency of detection, lead is considered a SWMU-wide COC at SWMU 5. The highest concentration of lead (750.0 µg/g) was detected in the surficial sample at 5-PND-2 in the drainage pond. Lead was detected above background at various depths at each of the four locations in the pond. South of the pond, lead was detected at concentrations above background in one sample from the ditch and one surficial soil sample. Lead was also detected at above background concentrations in a surficial soil sample near the shower building foundation and in another surficial sample between the pond and Cross Street. On the west side of Cross Street, lead was detected in the surficial soil samples taken at 10 locations around the Building 600 foundation and the wooden dock.

Mercury (Hg), a human health and ecological COC, was detected above background (0.143 µg/g) in only four samples at SWMU 5; however, only the maximum value (1.80 µg/g) is significantly above background. The maximum concentration was detected in the surficial soil sample at 5-BLD-10 south of the Building 600 foundation (Figure 4.2-17). Because mercury is a common element in TEAD-S soil, this metal is considered to be a potential COC only at sample location 5-BLD-10.

Nickel (Ni), a human health COC, was detected at concentrations above background (27.9 µg/g) in 11 samples taken from the four sample locations in the drainage pond (Figure 4.2-18). At two of the four pond locations, nickel was detected above background in both the surficial samples and the subsurface samples (0.5 ft bgs). At another location, nickel was detected above background in the surficial sample and two subsurface samples (2 ft and 4 ft bgs). At the fourth location, nickel was detected above background at all four depths sampled (surface and 0.5 ft, 2 ft, and 4 ft bgs). The highest concentration of nickel at SWMU 5 (172 µg/g) was detected 2 ft bgs in 5-PND-2. Nickel is considered to be a potential COC in the pond area, but is not considered a SWMU-wide COC.

Silver (Ag), a facility-wide ecological COC, was detected in eight samples from a total of four sampling locations in the pond and drainage ditch (Figure 4.2-19). All detections were above background (0.435 µg/g). At the sampling location in the ditch, a detection occurred in the sample collected 0.5 ft bgs. At two of three sample locations in the pond, silver was detected above background in both the surficial sample and the 0.5 ft bgs sample. At the third sample location in the pond, silver was detected in the surficial sample and two subsurface samples (0.5 ft and 4 ft bgs). The highest silver concentration at SWMU 5 (78.0 µg/g) was detected in the surficial sample at 5-PND-2. Because Ag was only detected in one general area, it is a COC for the area around the pond and ditch, but not for the entire SWMU.

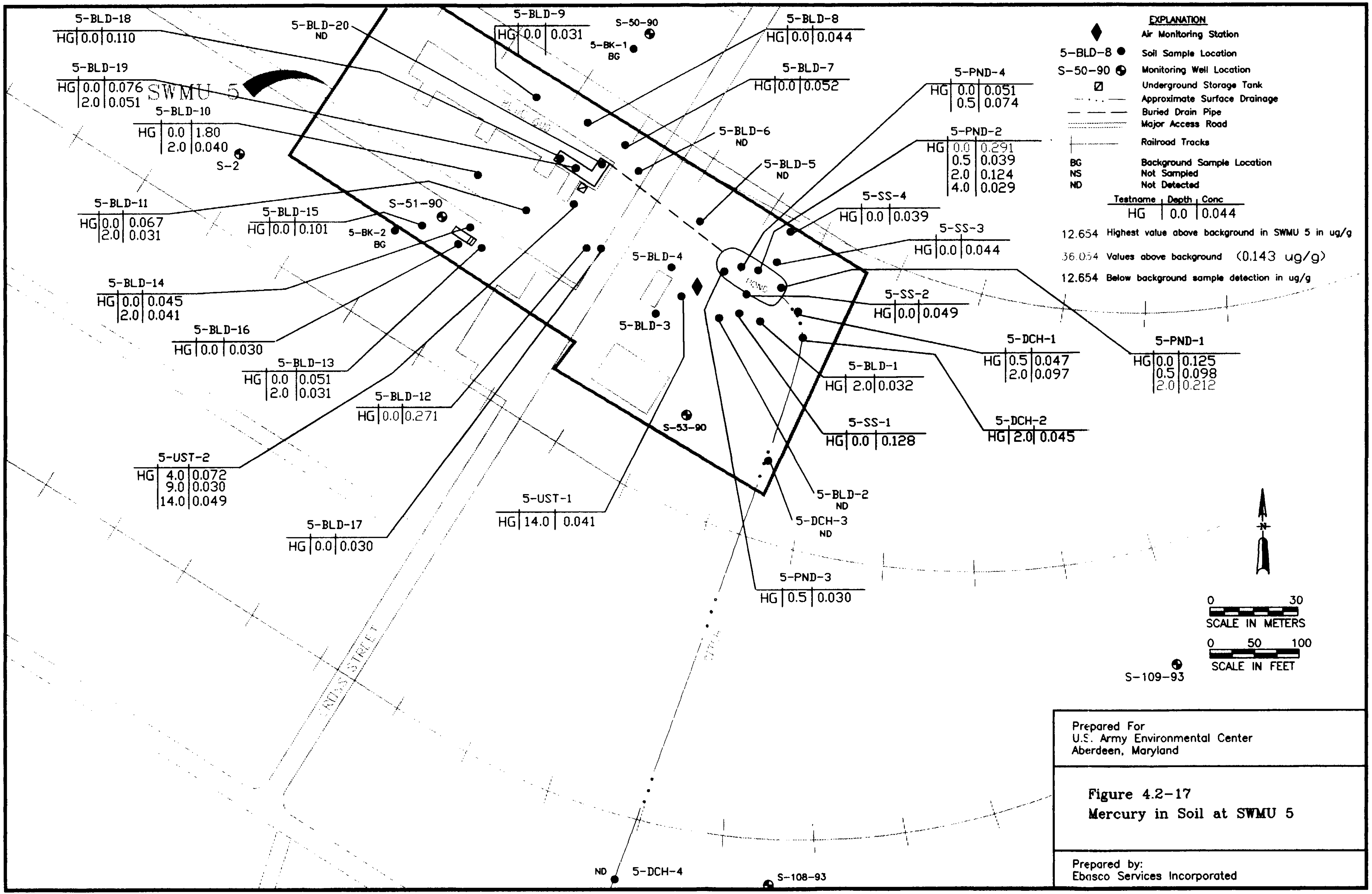


Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-16
Lead in Soil at SWMU 5

Prepared by:
Ebasco Services Incorporated
Revised: 2/22/96

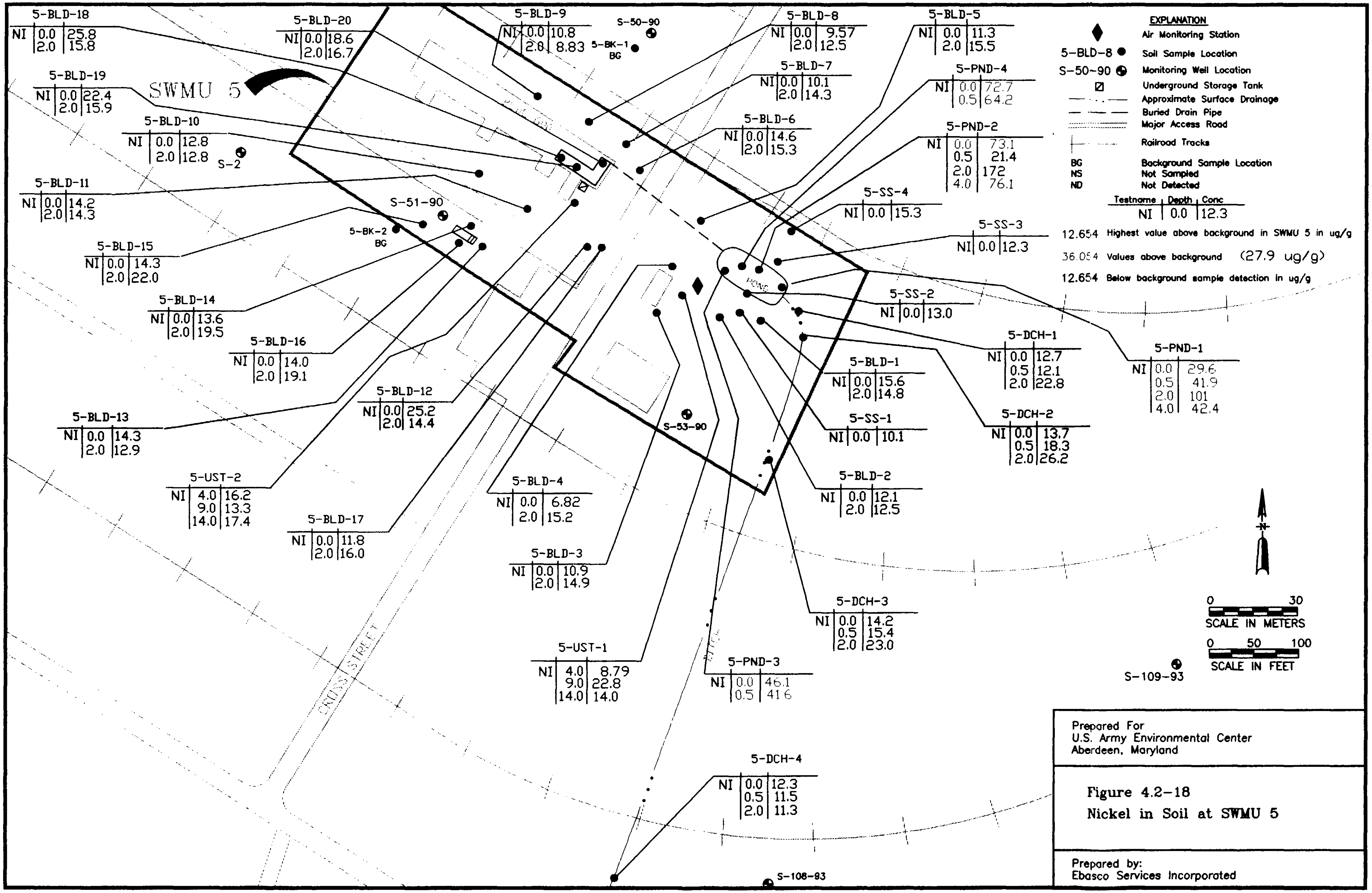
F:\PROJECTS\TOOELE\ARCAD\SWMU5\SWMU-5.DWG



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-17
Mercury in Soil at SWMU 5

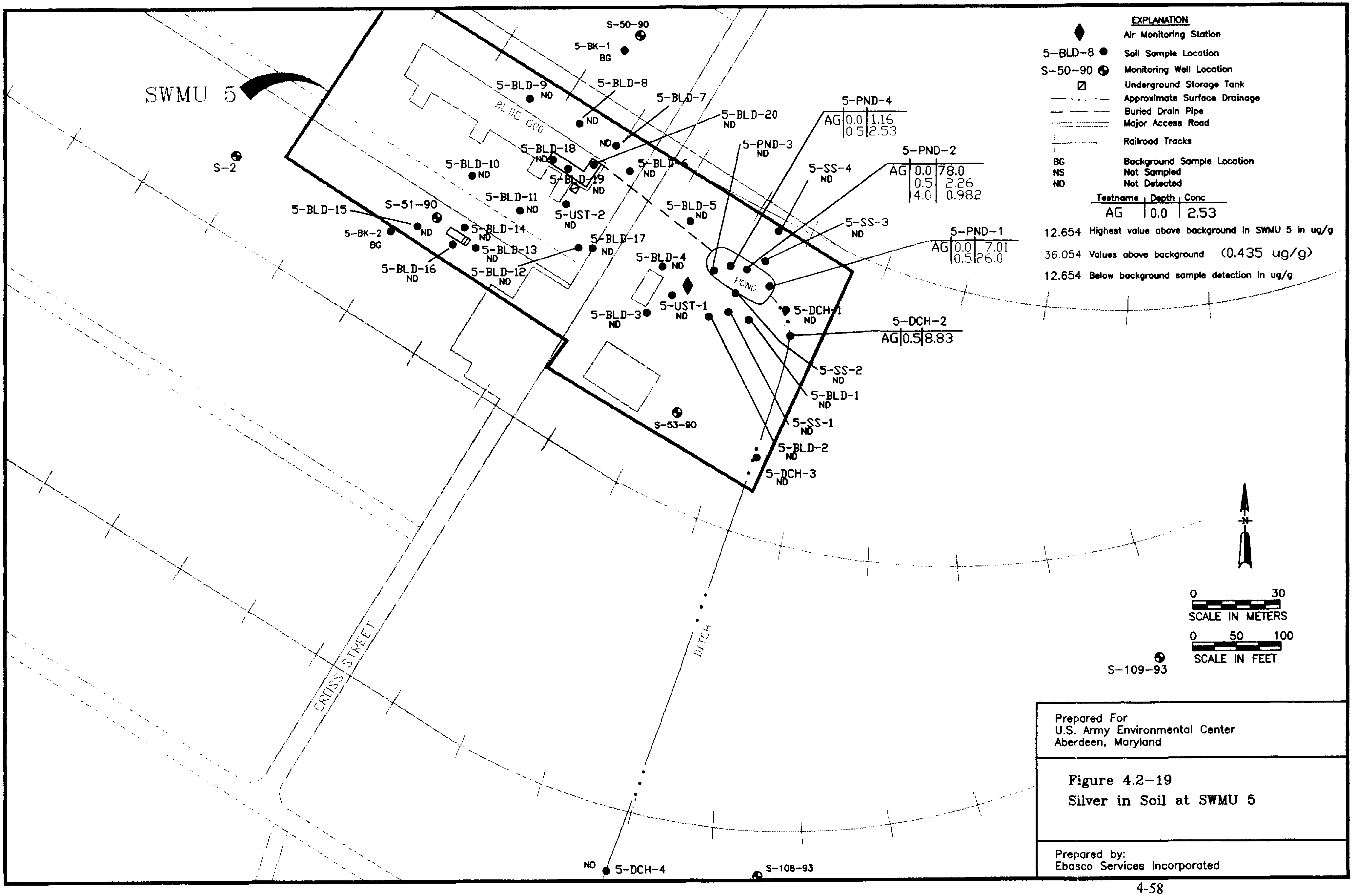
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-18
Nickel in Soil at SWMU 5

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-19
Silver in Soil at SWMU 5

Prepared by:
Ebasco Services Incorporated

Vanadium (V), a human health COC, was detected in concentrations above background (62.6 µg/g) in 4 of the 74 soil samples (Figure 4.2-20). The risk assessment determined that only the two highest concentrations (from two sample locations near the wooden dock) were of concern. These concentrations occurred in the samples collected 2 ft bgs. The maximum concentration of vanadium at SWMU 5 (103.0 µg/g) occurred at 5-BLD-14, on the north side of the wooden dock. Vanadium is a COC that is specific to the area near this structure.

Zinc (Zn), a human health and ecological COC, was detected in all soil samples taken from SWMU 5 (Figure 4.2-21). Concentrations of zinc exceeded background (144 µg/g) in 18 of the 74 soil samples; and zinc is, therefore, is considered to be a SWMU-wide COC. The highest concentrations of zinc occurred in samples collected in the pond. Zinc was detected above background in at least one sample at all pond sampling locations. The highest zinc concentration (2,950 µg/g) was detected in the surficial sample at 5-PND-2. Zinc was also detected above background in two samples taken from the drainage ditch at locations closest to the pond. In addition, zinc was detected above background in one surficial soil sample south of the pond. On the west side of Cross Street, zinc was detected in five surficial soil samples at above-background concentrations: one was located beneath the sump in the Building 600 foundation; one was north of the Building 600 foundation; two were near the wooden dock; and one was south of well S-51-90.

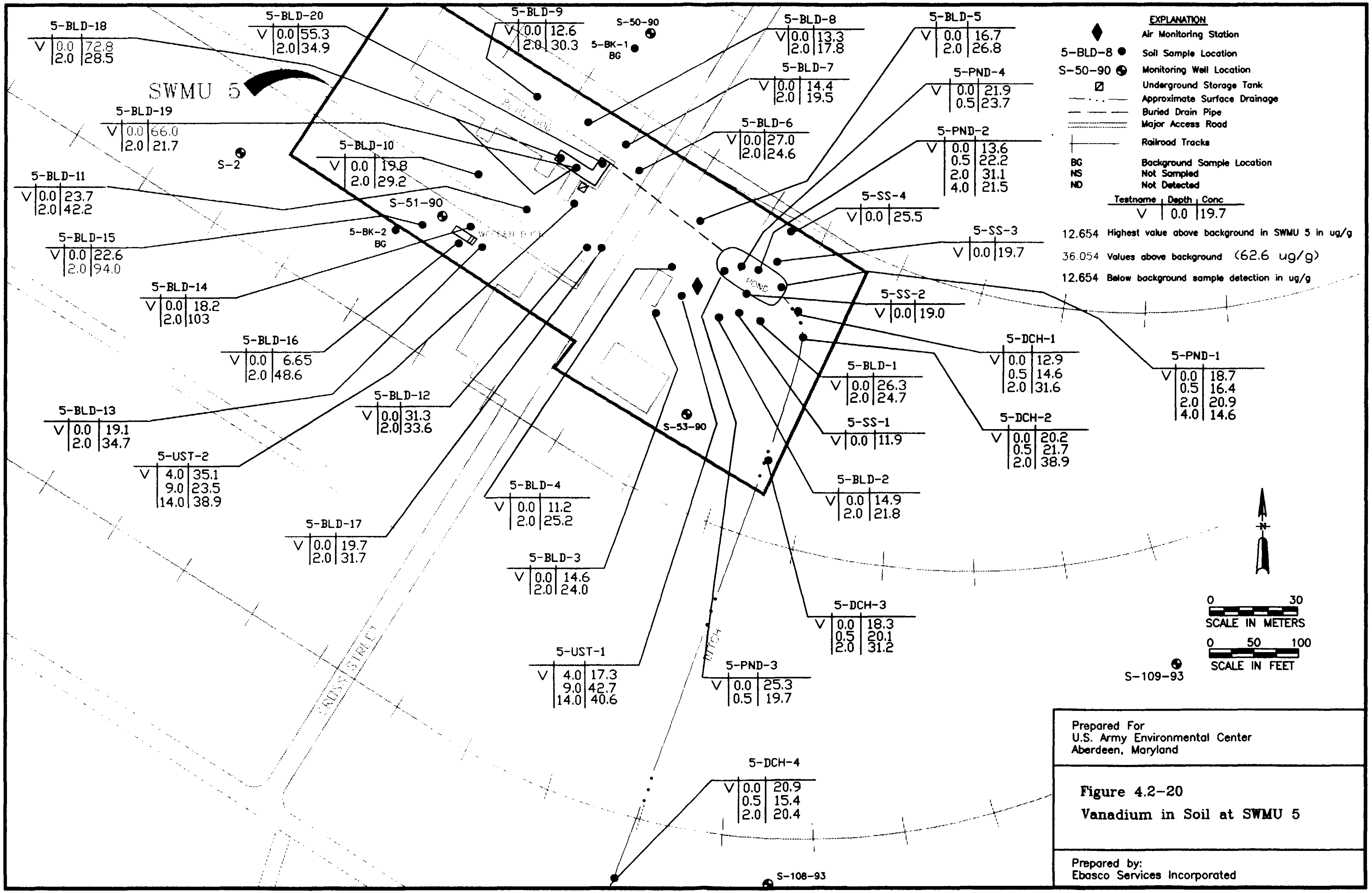
Detections above background in SWMU 5 soils are shown in Table 4.2-1.

Soil Gas Analysis

A soil gas survey was conducted at 58 locations around the Building 600 foundation and peripheral structures within SWMU 5. Trichloroethylene (TCE) was present at elevated levels in many of the sample locations (Figure 4.2-22). The TCE detections are centered around the shower building foundation located on the east side of Cross Street and west of the drainage pond (Figure 4.2-23). Sample locations to the north of the pond show no indication of TCE, and only minor detections were measured on the southeastern side of the pond, indicating that the pond is not the source of TCE contamination. Given that the highest TCE concentration occurs between the pond and the building foundation, and given that the concentration levels decrease in all directions away from that sample location, it is reasonable to consider the maximum TCE detection indicates a single hot spot of contamination with some potential for migration away from the hot spot. The occurrence of TCE cannot be tied to the historical use of the shower building and drainage pond. Toluene also appears to be present at several locations around the Building 600 foundation (Figure 4.2-24). These detections are near the analytical detection limit and, due to matrix interference, are not necessarily an indication of toluene contamination. More information on soil gas sampling procedures and results can be found in Appendix L.

4.2.2.2 Groundwater Contamination Assessment

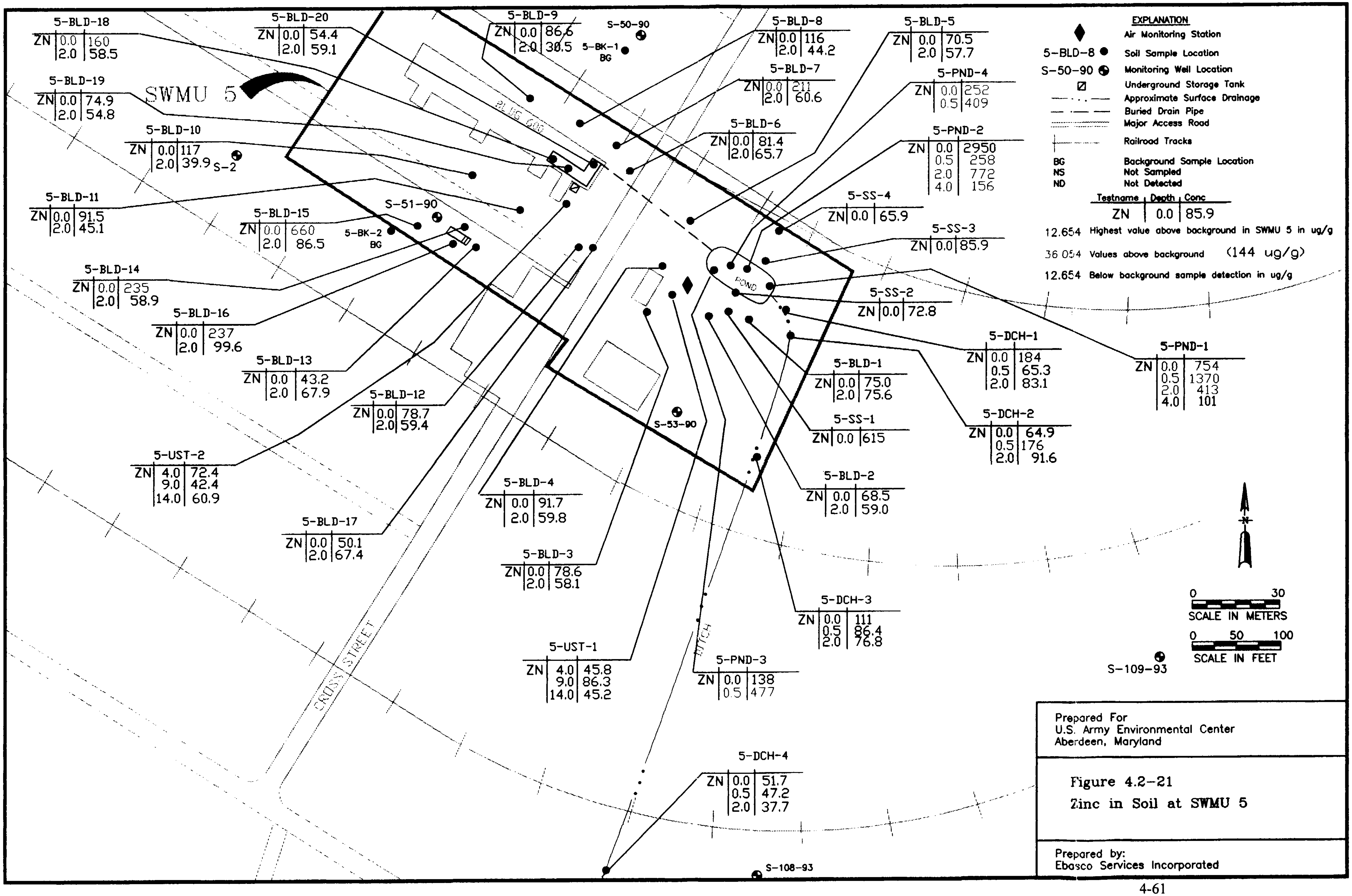
This section presents the chemical analytical results of the groundwater sampling program at SWMU 5. Although this section evaluates all of the analytical data collected, it focuses on the results for 1 organic compound and 11 metals that are being considered by the risk assessment.



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-20
Vanadium in Soil at SWMU 5

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-21
Zinc in Soil at SWMU 5

Prepared by:
Ebasco Services Incorporated

Table 4.2-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 5

Page 1 of 3

Location	Analyte	Depth (ft)	Value (μg/g)	Units	Location	Analyte	Depth (ft)	Value (μg/g)	Units
5-BLD-12	1MNAP	0.000	0.470	UGG	5-BLD-10	CD	0.000	1.80	UGG
5-BLD-1	2CHE1O	0.000	0.410	UGG	5-BLD-11	CD	2.000	0.734	UGG
5-BLD-12	2MNAP	0.000	0.480	UGG	5-BLD-12	CD	0.000	1.05	UGG
5-BLD-6	2MNAP	0.000	0.094	UGG	5-BLD-12	CD	2.000	0.621	UGG
5-BLD-18	2PROL	0.000	0.027	UGG	5-BLD-14	CD	2.000	0.624	UGG
5-BLD-12	2TMPD	0.000	2.30	UGG	5-BLD-15	CD	0.000	1.15	UGG
5-BLD-6	2TMPD	0.000	0.520	UGG	5-BLD-16	CD	0.000	1.43	UGG
5-BLD-7	2TMPD	0.000	2.00	UGG	5-BLD-16	CD	2.000	0.940	UGG
5-BLD-8	ACET	2.000	0.028	UGG	5-BLD-19	CD	2.000	0.666	UGG
5-DCH-2	AG	0.500	8.83	UGG	5-BLD-2	CD	2.000	2.56	UGG
5-PND-1	AG	0.000	7.01	UGG	5-BLD-3	CD	0.000	1.04	UGG
5-PND-1	AG	0.500	26.0	UGG	5-BLD-5	CD	0.000	2.58	UGG
5-PND-2	AG	0.000	78.0	UGG	5-BLD-6	CD	0.000	1.19	UGG
5-PND-2	AG	0.500	2.26	UGG	5-BLD-7	CD	0.000	1.02	UGG
5-PND-2	AG	4.000	0.982	UGG	5-BLD-8	CD	0.000	1.01	UGG
5-PND-4	AG	0.000	1.16	UGG	5-DCH-2	CD	0.500	5.45	UGG
5-PND-4	AG	0.500	2.53	UGG	5-DCH-2	CD	2.000	0.675	UGG
5-BLD-15	AL	2.000	27,700	UGG	5-PND-1	CD	0.000	4.52	UGG
5-BLD-18	AL	0.000	24,300	UGG	5-PND-1	CD	0.500	14.2	UGG
5-BLD-19	AL	0.000	21,700	UGG	5-PND-1	CD	2.000	1.65	UGG
5-DCH-3	AS	2.000	50.0	UGG	5-PND-2	CD	0.000	22.5	UGG
5-PND-1	BA	0.500	511	UGG	5-PND-2	CD	0.500	1.56	UGG
5-BLD-14	BE	2.000	1.63	UGG	5-PND-2	CD	2.000	3.68	UGG
5-BLD-15	BE	2.000	1.74	UGG	5-PND-2	CD	4.000	1.38	UGG
5-BLD-18	BE	0.000	1.17	UGG	5-PND-3	CD	0.000	1.07	UGG
5-BLD-19	BE	0.000	1.11	UGG	5-PND-3	CD	0.500	1.03	UGG
5-PND-2	BE	2.000	1.22	UGG	5-PND-4	CD	0.000	2.21	UGG
5-PND-3	BE	0.000	1.40	UGG	5-PND-4	CD	0.500	2.78	UGG
5-PND-4	BE	0.000	1.07	UGG	5-SS-1	CD	0.000	1.80	UGG
5-BLD-6	C25	0.000	0.420	UGG	5-SS-2	CD	0.000	1.72	UGG
5-BLD-1	C27	0.000	0.510	UGG	5-SS-3	CD	0.000	1.18	UGG
5-BLD-12	C27	0.000	1.20	UGG	5-UST-1	CD	9.000	1.01	UGG
5-BLD-2	C27	0.000	0.300	UGG	5-UST-1	CD	14.000	0.719	UGG
5-BLD-6	C27	0.000	1.00	UGG	5-BLD-10	CH2CL2	0.000	0.005	UGG
5-BLD-6	C28	0.000	0.420	UGG	5-BLD-10	CH2CL2	2.000	0.005	UGG
5-BLD-1	C29	0.000	2.00	UGG	5-BLD-11	CH2CL2	0.000	0.005	UGG
5-BLD-12	C29	0.000	2.30	UGG	5-BLD-17	CH2CL2	2.000	0.007	UGG
5-BLD-2	C29	0.000	2.00	UGG	5-UST-1	CH2CL2	9.000	0.010	UGG
5-BLD-3	C29	0.000	1.00	UGG	5-BLD-18	CO	0.000	10.4	UGG
5-BLD-3	C29	2.000	0.640	UGG	5-BLD-19	CO	0.000	10.2	UGG
5-BLD-6	C29	2.000	0.430	UGG	5-BLD-20	CO	0.000	6.67	UGG
5-BLD-7	C29	2.000	0.440	UGG	5-PND-2	CO	0.000	12.2	UGG
5-BLD-13	CA	0.000	160,000	UGG	5-BLD-15	CR	0.000	101	UGG
5-BLD-16	CA	0.000	220,000	UGG	5-BLD-15	CR	2.000	50.2	UGG
5-BLD-17	CA	0.000	170,000	UGG	5-BLD-18	CR	0.000	86.3	UGG
5-BLD-3	CA	0.000	170,000	UGG	5-BLD-19	CR	0.000	38.2	UGG
5-BLD-4	CA	0.000	160,000	UGG	5-BLD-20	CR	0.000	30.6	UGG
5-BLD-9	CA	0.000	160,000	UGG	5-BLD-7	CR	0.000	36.6	UGG
5-PND-1	CA	0.000	160,000	UGG	5-BLD-8	CR	0.000	28.6	UGG
5-BLD-16	CCL3F	2.000	0.015	UGG	5-DCH-1	CR	0.000	39.8	UGG

Table 4.2-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 5

Location	Analyte	Depth (ft)	Value (µg/g)	Units	Location	Analyte	Depth (ft)	Value (µg/g)	Units
5-DCH-2	CR	0.000	25.7	UGG	5-BLD-1	GSITOS	0.000	0.920	UGG
5-DCH-3	CR	0.500	162	UGG	5-BLD-10	GSITOS	0.000	0.800	UGG
5-PND-1	CR	0.000	658	UGG	5-BLD-11	GSITOS	0.000	0.710	UGG
5-PND-1	CR	0.500	983	UGG	5-BLD-6	GSITOS	0.000	0.840	UGG
5-PND-1	CR	2.000	474	UGG	5-BLD-10	HG	0.000	1.80	UGG
5-PND-1	CR	4.000	93.0	UGG	5-BLD-12	HG	0.000	0.271	UGG
5-PND-2	CR	0.000	950	UGG	5-BLD-15	HG	0.000	0.101	UGG
5-PND-2	CR	0.500	109	UGG	5-BLD-18	HG	0.000	0.110	UGG
5-PND-2	CR	2.000	1,680	UGG	5-PND-1	HG	0.000	0.125	UGG
5-PND-2	CR	4.000	163	UGG	5-PND-1	HG	2.000	0.212	UGG
5-PND-3	CR	0.000	35.8	UGG	5-PND-2	HG	0.000	0.291	UGG
5-PND-3	CR	0.500	63.5	UGG	5-SS-1	HG	0.000	0.128	UGG
5-PND-4	CR	0.000	54.0	UGG	5-BLD-1	K	2.000	4,870	UGG
5-PND-4	CR	0.500	221	UGG	5-BLD-12	K	2.000	5,060	UGG
5-SS-1	CR	0.000	25.9	UGG	5-BLD-17	K	2.000	7,280	UGG
5-BLD-10	CU	0.000	132	UGG	5-BLD-4	K	2.000	5,360	UGG
5-BLD-14	CU	0.000	28.1	UGG	5-BLD-5	K	2.000	5,480	UGG
5-BLD-18	CU	0.000	25.4	UGG	5-BLD-6	K	2.000	6,600	UGG
5-BLD-8	CU	0.000	35.4	UGG	5-PND-2	K	0.500	5,620	UGG
5-DCH-2	CU	0.500	31.2	UGG	5-UST-1	K	9.000	5,900	UGG
5-PND-1	CU	0.000	45.7	UGG	5-UST-2	K	4.000	5,450	UGG
5-PND-1	CU	0.500	87.1	UGG	5-BLD-1	MEC6H5	0.000	0.008	UGG
5-PND-2	CU	0.000	170	UGG	5-BLD-9	MEC6H5	0.000	0.001	UGG
5-PND-2	CU	2.000	39.3	UGG	5-BLD-17	MG	2.000	16,100	UGG
5-PND-4	CU	0.000	25.3	UGG	5-BLD-2	MG	2.000	18,500	UGG
5-PND-4	CU	0.500	32.5	UGG	5-BLD-4	MG	0.000	32,200	UGG
5-SS-1	CU	0.000	34.8	UGG	5-BLD-7	MG	0.000	17,200	UGG
5-DCH-3	CYN	0.000	0.385	UGG	5-DCH-3	MG	0.500	15,400	UGG
5-PND-1	CYN	0.000	0.686	UGG	5-DCH-4	MG	0.000	20,100	UGG
5-PND-2	CYN	0.000	3.13	UGG	5-DCH-4	MG	0.500	19,500	UGG
5-PND-2	CYN	2.000	0.476	UGG	5-UST-1	MG	9.000	19,200	UGG
5-PND-2	CYN	4.000	0.279	UGG	5-BLD-10	MN	2.000	542	UGG
5-PND-4	CYN	0.500	0.342	UGG	5-BLD-19	MN	0.000	663	UGG
5-BLD-12	DBZFUR	0.000	0.110	UGG	5-BLD-20	MN	0.000	744	UGG
5-BLD-10	DEP	0.000	0.470	UGG	5-BLD-4	MN	2.000	594	UGG
5-BLD-1	DNBP	0.000	0.920	UGG	5-BLD-5	MN	2.000	531	UGG
5-BLD-1	DNBP	2.000	0.340	UGG	5-BLD-6	MN	2.000	513	UGG
5-BLD-11	DNBP	2.000	0.086	UGG	5-DCH-2	MN	2.000	605	UGG
5-BLD-13	DNBP	2.000	0.098	UGG	5-DCH-3	MN	2.000	1,160	UGG
5-BLD-14	DNBP	2.000	0.085	UGG	5-BLD-13	NA	0.000	1,570	UGG
5-BLD-16	DNBP	2.000	0.086	UGG	5-BLD-12	NAP	0.000	0.400	UGG
5-BLD-18	DNBP	0.000	0.140	UGG	5-BLD-4	NAP	0.000	0.600	UGG
5-UST-1	DNBP	9.000	0.087	UGG	5-BLD-6	NAP	0.000	0.064	UGG
5-BLD-15	FE	2.000	25,800	UGG	5-BLD-12	NI	0.000	25.2	UGG
5-BLD-18	FE	0.000	21,800	UGG	5-BLD-18	NI	0.000	25.8	UGG
5-BLD-19	FE	0.000	20,400	UGG	5-BLD-19	NI	0.000	22.4	UGG
5-PND-1	FE	0.000	20,500	UGG	5-PND-1	NI	0.000	29.6	UGG
5-PND-1	FE	0.500	28,600	UGG	5-PND-1	NI	0.500	41.9	UGG
5-PND-2	FE	0.000	73,200	UGG	5-PND-1	NI	2.000	101	UGG
5-PND-2	FE	2.000	30,100	UGG	5-PND-1	NI	4.000	42.4	UGG

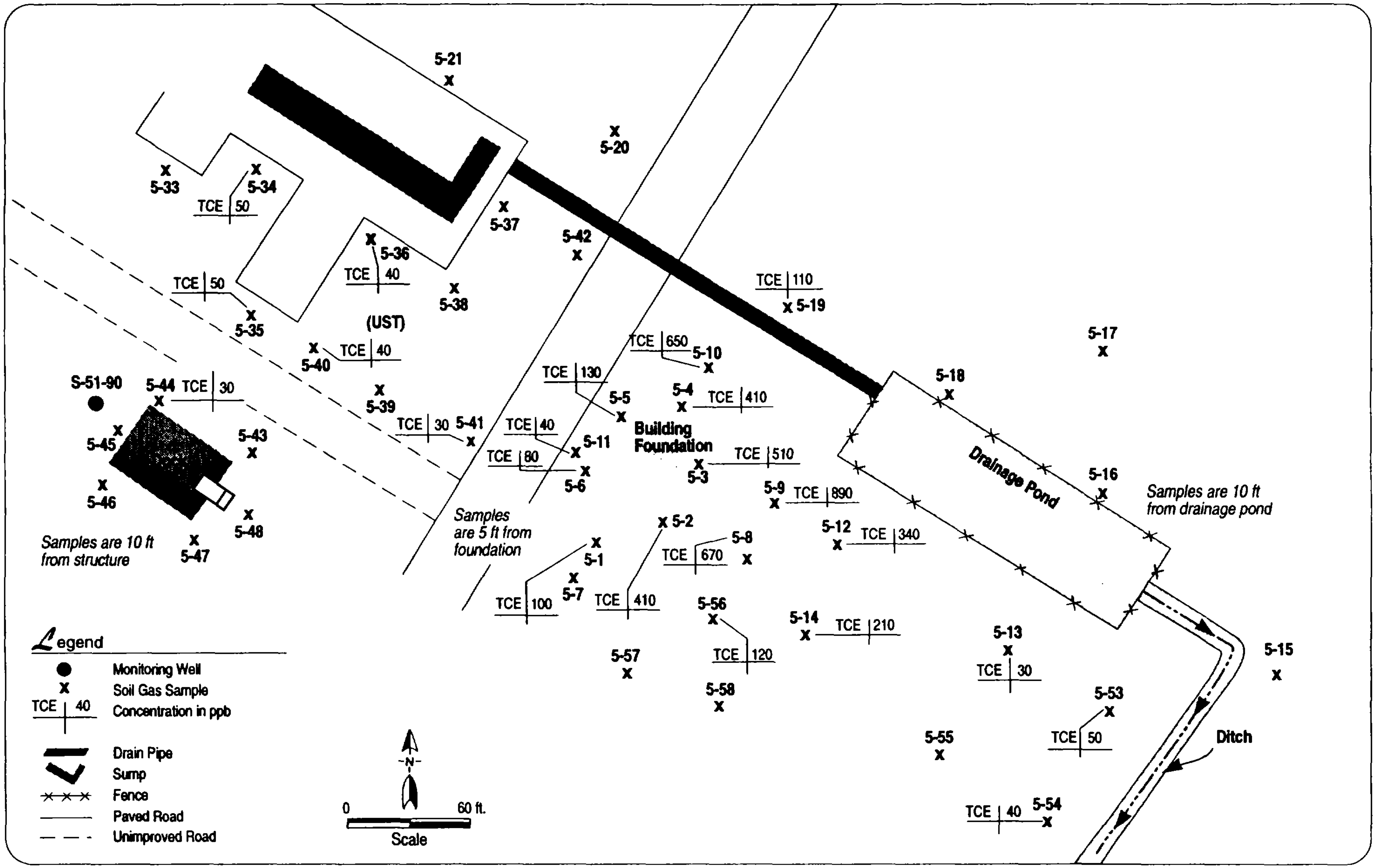
Table 4.2-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 5

Page 3 of 3

Location	Analyte	Depth (ft)	Value (µg/g)	Units	Location	Analyte	Depth (ft)	Value (µg/g)	Units
5-PND-2	NI	0.000	73.1	UGG	5-BLD-19	PCB260	2.000	0.213	UGG
5-PND-2	NI	2.000	172	UGG	5-BLD-12	PHANTR	0.000	0.130	UGG
5-PND-2	NI	4.000	76.1	UGG	5-BLD-6	PHANTR	0.000	0.043	UGG
5-PND-3	NI	0.000	46.1	UGG	5-BLD-15	PHTHAN	0.000	11.0	UGG
5-PND-3	NI	0.500	41.6	UGG	5-BLD-18	PHTHAN	0.000	0.400	UGG
5-PND-4	NI	0.000	72.7	UGG	5-PND-1	SB	2.000	16.3	UGG
5-PND-4	NI	0.500	64.2	UGG	5-PND-2	SB	0.000	25.5	UGG
5-BLD-10	OMCTSX	2.000	0.010	UGG	5-PND-2	SB	2.000	57.6	UGG
5-BLD-15	OMCTSX	2.000	0.023	UGG	5-PND-2	SB	4.000	12.4	UGG
5-BLD-17	OMCTSX	0.000	0.021	UGG	5-PND-1	SE	0.000	0.355	UGG
5-BLD-17	OMCTSX	2.000	0.044	UGG	5-SS-1	SE	0.000	0.324	UGG
5-BLD-9	OMCTSX	0.000	0.041	UGG	5-BLD-1	TCLTFE	2.000	0.006	UGG
5-BLD-9	OMCTSX	2.000	0.110	UGG	5-BLD-2	TCLTFE	0.000	0.007	UGG
5-UST-1	OMCTSX	4.000	0.010	UGG	5-BLD-2	TCLTFE	2.000	0.010	UGG
5-BK-2	PB	0.000	160	UGG	5-BLD-3	TCLTFE	0.000	0.006	UGG
5-BLD-10	PB	0.000	66.0	UGG	5-BLD-3	TCLTFE	2.000	0.006	UGG
5-BLD-12	PB	0.000	52.0	UGG	5-BLD-4	TCLTFE	0.000	0.008	UGG
5-BLD-13	PB	0.000	65.0	UGG	5-BLD-4	TCLTFE	2.000	0.008	UGG
5-BLD-14	PB	0.000	64.0	UGG	5-BLD-5	TCLTFE	2.000	0.007	UGG
5-BLD-15	PB	0.000	460	UGG	5-BLD-6	TCLTFE	0.000	0.005	UGG
5-BLD-15	PB	2.000	19.0	UGG	5-BLD-7	TCLTFE	0.000	0.007	UGG
5-BLD-16	PB	0.000	130	UGG	5-BLD-7	TCLTFE	2.000	0.008	UGG
5-BLD-18	PB	0.000	410	UGG	5-BLD-12	V	0.000	31.3	UGG
5-BLD-19	PB	2.000	24.0	UGG	5-BLD-14	V	2.000	103	UGG
5-BLD-2	PB	0.000	36.0	UGG	5-BLD-15	V	2.000	94.0	UGG
5-BLD-2	PB	2.000	22.0	UGG	5-BLD-18	V	0.000	72.8	UGG
5-BLD-4	PB	0.000	110	UGG	5-BLD-19	V	0.000	66.0	UGG
5-BLD-5	PB	0.000	46.0	UGG	5-BLD-20	V	0.000	55.3	UGG
5-BLD-7	PB	0.000	110	UGG	5-BLD-10	ZN	0.000	117	UGG
5-BLD-8	PB	0.000	120	UGG	5-BLD-14	ZN	0.000	235	UGG
5-BLD-9	PB	0.000	38.0	UGG	5-BLD-15	ZN	0.000	660	UGG
5-DCH-1	PB	2.000	21.0	UGG	5-BLD-16	ZN	0.000	237	UGG
5-DCH-2	PB	0.500	46.0	UGG	5-BLD-18	ZN	0.000	160	UGG
5-DCH-2	PB	2.000	26.0	UGG	5-BLD-7	ZN	0.000	211	UGG
5-DCH-3	PB	0.500	22.0	UGG	5-BLD-8	ZN	0.000	116	UGG
5-DCH-3	PB	2.000	22.0	UGG	5-DCH-1	ZN	0.000	184	UGG
5-PND-1	PB	0.000	500	UGG	5-DCH-2	ZN	0.500	176	UGG
5-PND-1	PB	0.500	320	UGG	5-DCH-3	ZN	0.000	111	UGG
5-PND-1	PB	2.000	490	UGG	5-PND-1	ZN	0.000	754	UGG
5-PND-1	PB	4.000	39.0	UGG	5-PND-1	ZN	0.500	1,370	UGG
5-PND-2	PB	0.000	750	UGG	5-PND-1	ZN	2.000	413	UGG
5-PND-2	PB	0.500	59.0	UGG	5-PND-2	ZN	0.000	2,950	UGG
5-PND-2	PB	2.000	310	UGG	5-PND-2	ZN	0.500	258	UGG
5-PND-2	PB	4.000	44.0	UGG	5-PND-2	ZN	2.000	772	UGG
5-PND-3	PB	0.000	51.0	UGG	5-PND-2	ZN	4.000	156	UGG
5-PND-3	PB	0.500	61.0	UGG	5-PND-3	ZN	0.000	138	UGG
5-PND-4	PB	0.000	140	UGG	5-PND-3	ZN	0.500	477	UGG
5-PND-4	PB	0.500	150	UGG	5-PND-4	ZN	0.000	252	UGG
5-SS-1	PB	0.000	87.0	UGG	5-PND-4	ZN	0.500	409	UGG
5-BLD-18	PCB260	0.000	0.157	UGG	5-SS-1	ZN	0.000	615	UGG

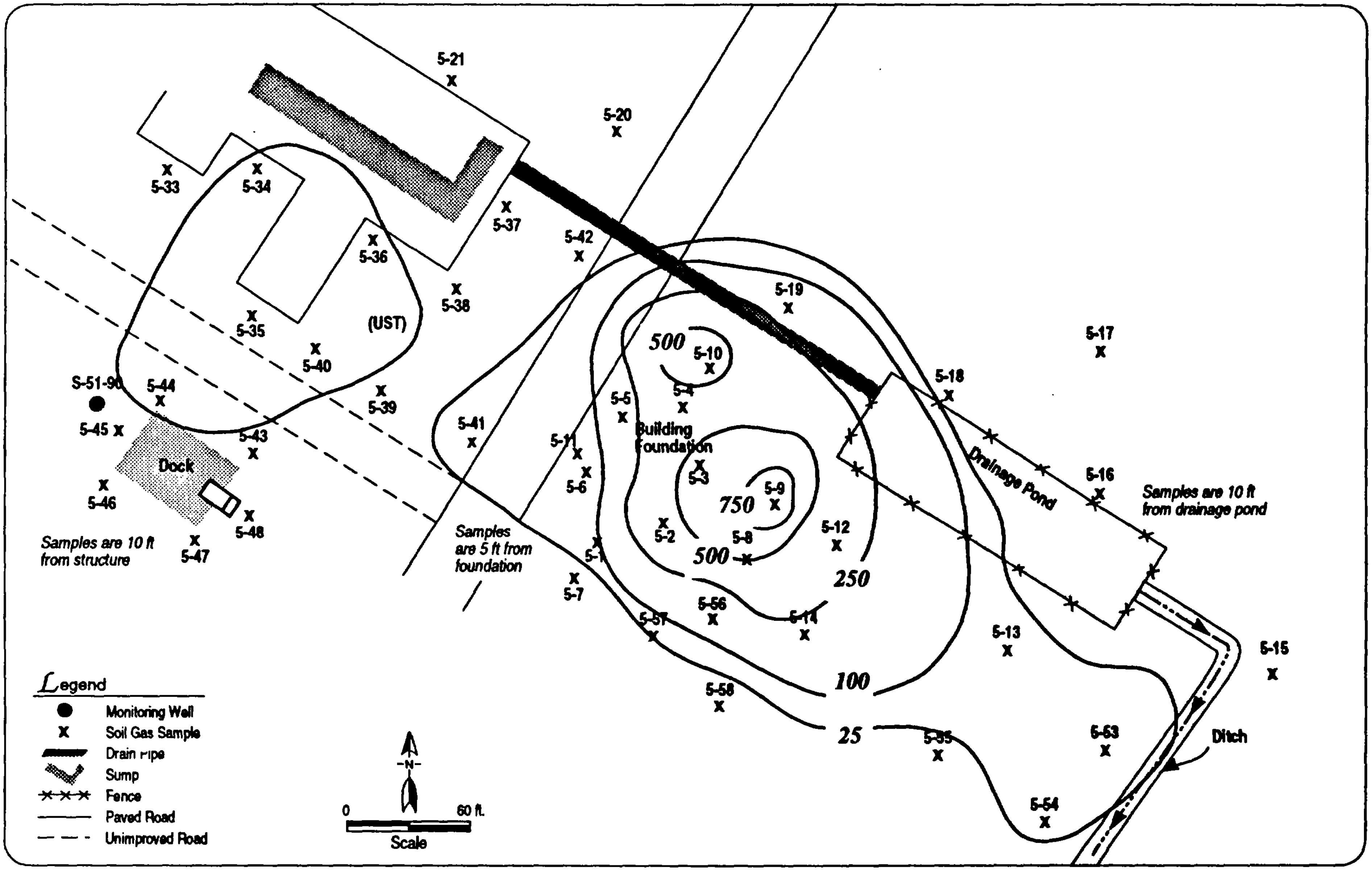
µg/g micrograms per gram

Note: Analyte names are defined in the chemical acronym list.



T3G2 2.29.96 jb

Figure 4.2-22
Soil Gas Survey Results at SWMU 5
Drainage Pond Enlargement
Tooele Army Depot - South Area
Prepared by: Ebasco Services Incorporated

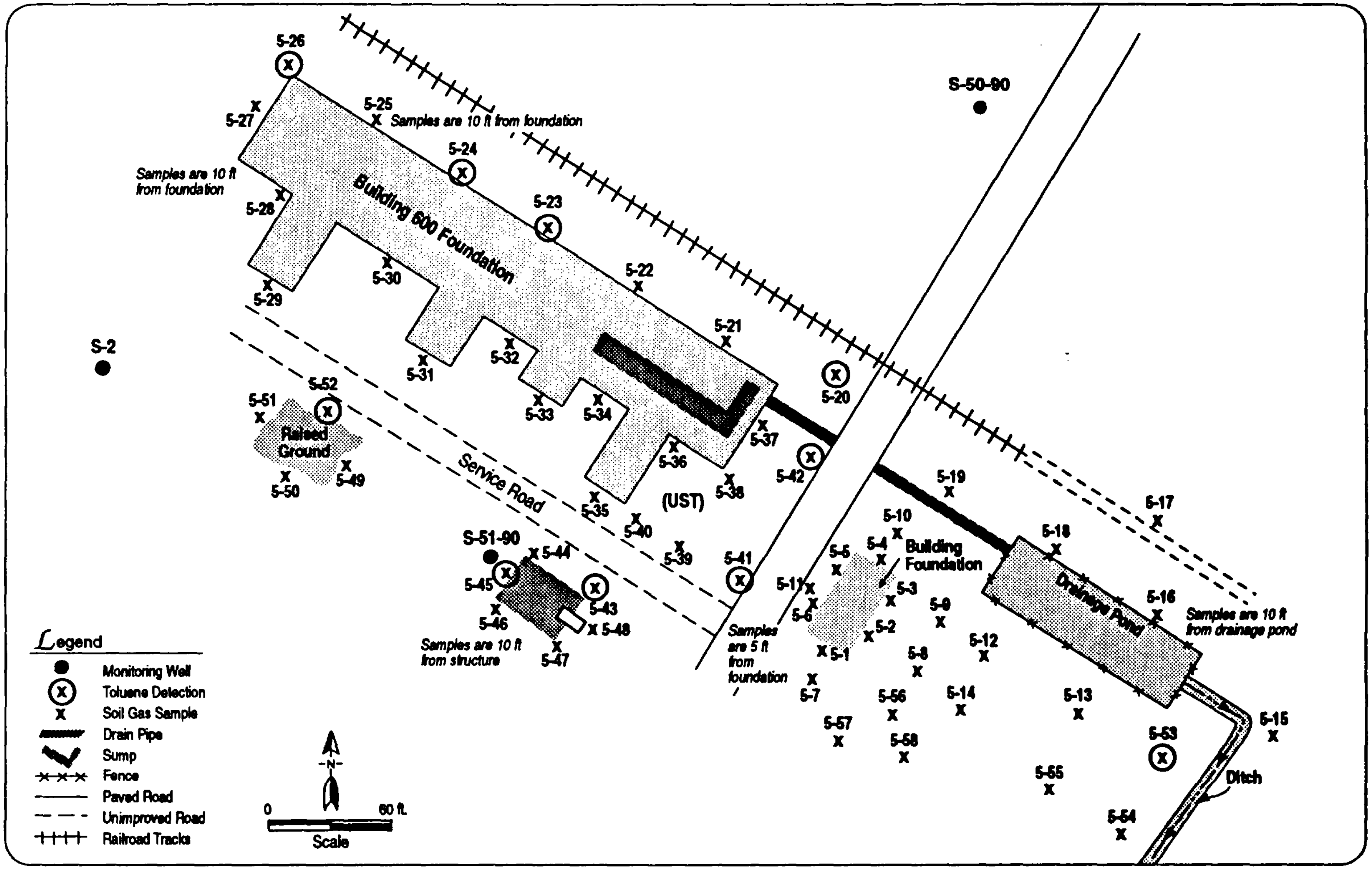


T3G2 8.31.94.jb

Figure 4.2-23
Soil Gas Survey at SWMU 5
Isoconcentration Map - Trichloroethylene

Tooele Army Depot - South Area
Prepared by: Ebasco Services Incorporated

EBASCO



T3G2 8.31.94.jb

Figure 4.2-24
Soil Gas Survey at SWMU 5 -
Toluene Detections

Tooele Army Depot - South Area
Prepared by: Ebasco Services Ir ated

EBASCO

Previous Investigations

Prior to the RFI-Phase I, well S-2 was installed west of the Building 600 foundation. Groundwater sampling in well S-2 occurred in 1987, 1988, and 1990. These samples were analyzed for VOCs, SVOCs, explosives, agent breakdown products, metals, anions, and radiological parameters. Results indicated low-level detections of toluene and butylbenzyl phthalate in 1987, and low levels of chloromethane and unknown SVOCs in 1990.

As part of the RFI-Phase I program, three monitoring wells were installed at SWMU 5: one upgradient on the north side of the SWMU (S-50-90) and two to the south of Building 600 (S-51-90) and the drainage pond (S-53-90). Sampling of RFI-Phase I wells in 1990 showed organic detections in well S-53-90 that included chloroform, methylene chloride, and trichloroethylene. The detection of toluene in S-2 and trichlorethylene in S-53-90 may indicate groundwater contamination from paint or solvent releases. The detections of chloroform and chloromethane may be attributable to recharge of the aquifer by chlorinated water, which can form these compounds through reaction with naturally-occurring organic compounds. Methylene chloride is commonly associated with laboratory contamination of samples.

Inorganic analyses performed on groundwater from these wells showed elevated levels of chromium, lead, sodium, and zinc relative to the background levels established for groundwater quality zone I. Previous investigations reported elevated concentrations of sodium and zinc in well S-2. These results were not confirmed during the RFI-Phase I groundwater sampling, but there were slight detections of chromium in well S-2 and lead in well S-53-90. However, it could not be established whether these detections were related to sandblasting or painting activities at SWMU 5 or to natural variations of the groundwater quality (EBASCO 1993a).

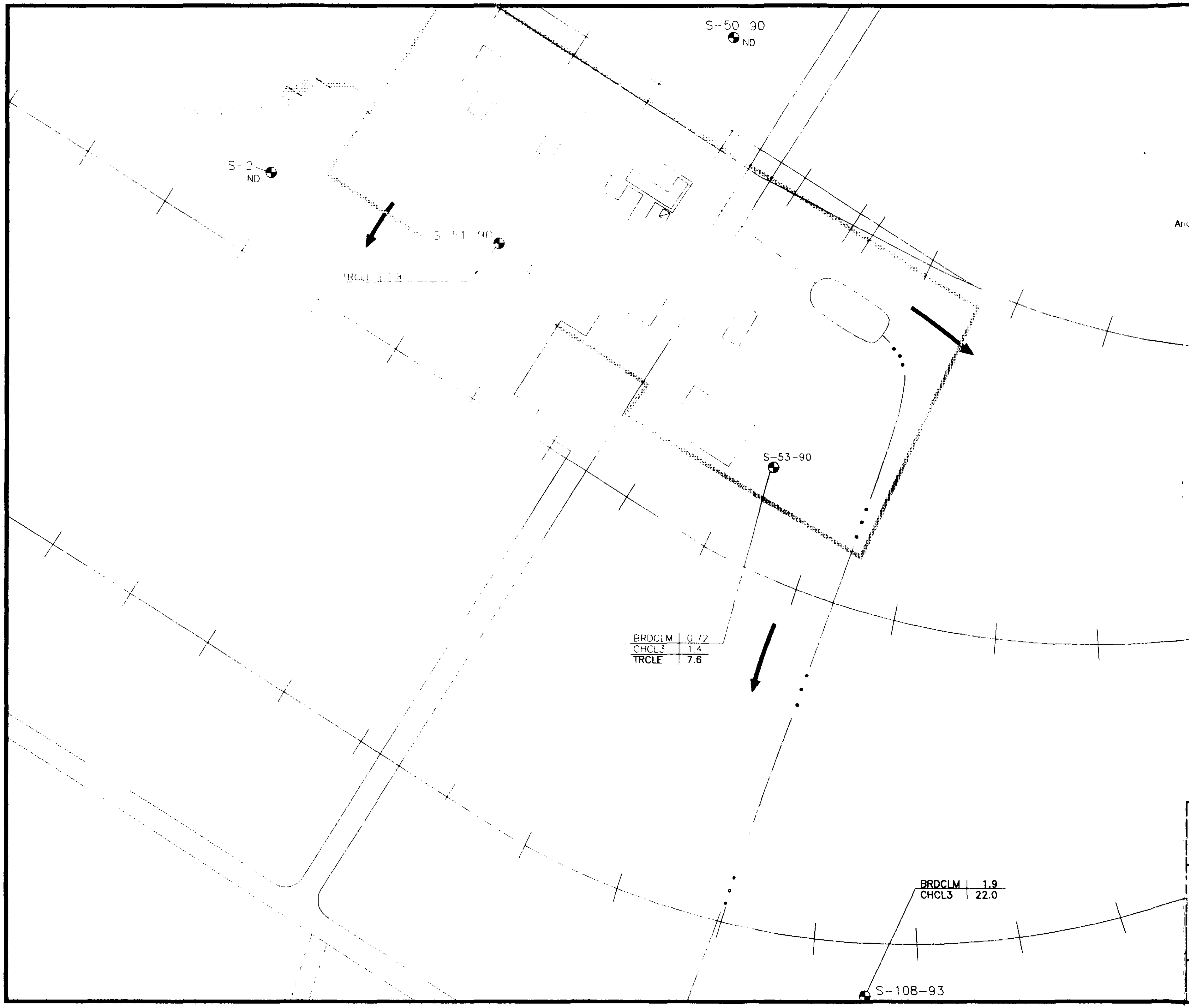
RFI-Phase II Results

To further evaluate detections of contaminants encountered in groundwater during previous investigations at SWMU 5, sampling of existing monitoring wells, as well as the new wells, was performed as part of the RFI-Phase II program. The complete analytical results of this groundwater sampling can be found in Appendix F2.

Organic Compounds

Figure 4.2-25 shows the analytical results for organic compounds detected in groundwater samples taken from wells at SWMU 5.

Organic compounds were detected in three of six wells at SWMU 5. These compounds included trichloroethylene (TRCLE), bromodichloromethane (BRDCLM), and chloroform (CHCL3). Trichloroethylene was detected in wells S-51-90 and S-53-90, and bromodichloromethane and chloroform were detected in wells S-53-90 and S-108-93. Wells S-108-93 and S-109-93 are located downgradient of the SWMU 5 drainage pond. Concentrations of organic compounds in all wells, measured in µg/L, were in the low part-per-billion range.



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-25

Organic Compounds in Groundwater at SWMU 5

Prepared by:
Ebasco Services Incorporated

Upgradient wells S-2 and S-50-90 were free of organic compounds during RFI-Phase II sampling.

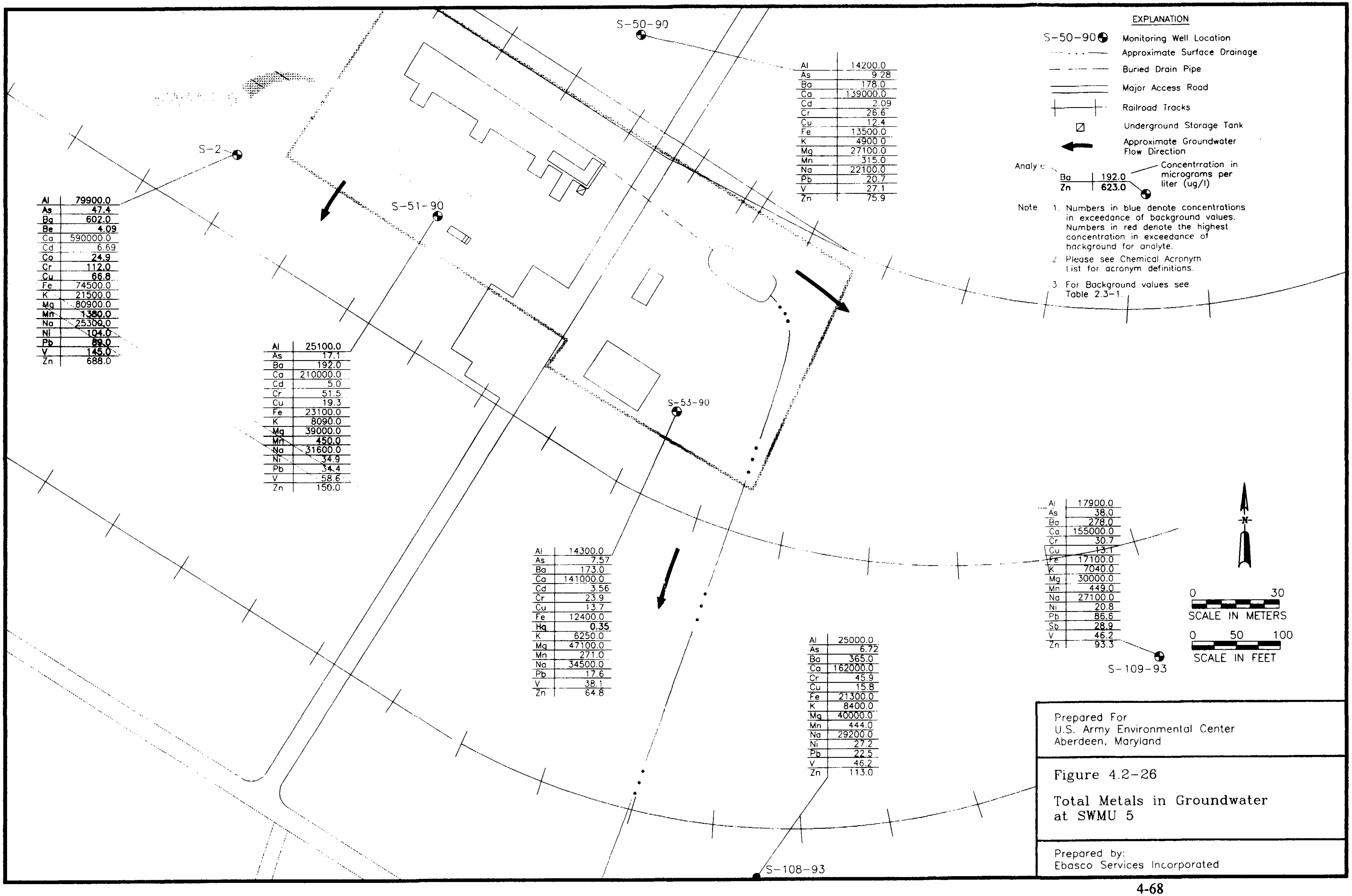
Concentrations of chloroform and trichloroethylene detected in S-53-90 during RFI-Phase II sampling confirm previous detections of these compounds in this well during 1990. However, chloroform is a common laboratory contaminant. Bromodichloromethane was detected in S-53-90 during RFI-Phase II, but was not present in RFI-Phase I sampling. Lower detection limits for trichloroethylene in well S-51-90 during the RFI-Phase II program showed concentrations of 1.9 μg/L in contrast to RFI-Phase I sampling, which showed a nondetection (with the detection limit of 7.0 μg/L). Detections of chloromethane in well S-2 during RFI-Phase I sampling were not repeated during RFI-Phase II sampling. Based on the observed concentrations and frequency of detections of organic compounds in wells at SWMU 5, it appears that organic contamination of groundwater is at a very low level and is limited in extent.

Metals

During the RFI-Phase II, unfiltered groundwater samples were collected at SWMU 5 and analyzed for aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Results for these analyses are illustrated in Figure 4.2-26. Metal concentrations for the RFI-Phase II were compared to TEAD-S background levels for unfiltered samples to determine the potential for groundwater contamination at SWMU 5. Background levels for metals were discussed previously in Section 2.3.2.

Of the 18 metals analyzed during the RFI-Phase II, 12 occurred at levels above background: arsenic, antimony, barium, beryllium, chromium, cobalt, copper, lead, manganese, mercury, nickel, and vanadium. The majority of metals that were detected above background levels occur in upgradient well S-2. Water quality field data logs (summarized in Table 4.2-2 and located in Appendix A2) indicate groundwater from well S-2 and well S-109-93 exhibited a "muddy" appearance at the time of sampling. However, all wells at SWMU 5 have at least one metal above background. Two analytes occurring above background at SWMU 5 are barium and vanadium. However, the potential that these metals represent contamination is difficult to assess, since background values for these analytes are incomplete. For example, historical data from background wells give a maximum value of >200 mg/L for barium. Vanadium was not an analyte in background wells at TEAD-S. Other metals at levels above background (such as mercury, chromium, and antimony) are really separated and apparently not attributable to historic activities at the SWMU.

Several metals exceeded background, but by less than a factor of 2, suggesting that these levels may be due to natural variability or to the high turbidity encountered during sampling. Because turbidity readings in all SWMU 5 wells were greater than 200 NTU, it is impossible to determine the effect turbidity may have had on metal values for these wells. However, based on field borehole logs and well construction logs of RFI-Phase II wells, it is probable that the elevated



Ba	192.0
Zn	**623.0**

Note 1. Numbers in blue denote concentrations in exceedance of background values. Numbers in red denote the highest concentration in exceedance of background for analyte.

2. Please see Chemical Acronym List for acronym definitions.

3. For Background values see Table 2.3-1.

S-2

Al	**79900.0**
As	**47.4**
Ba	**602.0**
Be	**4.09**
Ca	590000.0
Cd	6.69
Co	**24.9**
Cr	**112.0**
Cu	**66.8**
Fe	74500.0
K	21500.0
Mg	80900.0
Mn	**1380.0**
Na	25300.0
Ni	**104.0**
Pb	**89.0**
V	**145.0**
Zn	688.0

S-51-90

Al	25100.0
As	17.1
Ba	192.0
Ca	210000.0
Cd	5.0
Cr	51.5
Cu	19.3
Fe	23100.0
K	8090.0
Mg	39000.0
Mn	**450.0**
Na	31600.0
Ni	34.9
Pb	34.4
V	58.6
Zn	150.0

S-50-90

Al	14200.0
As	9 28
Ba	178.0
Ca	139000.0
Cd	2.09
Cr	26.6
Cu	12.4
Fe	13500.0
K	4900 0
Mg	27100.0
Mn	315.0
Na	22100.0
Pb	20.7
V	27.1
Zn	75.9

S-53-90

Al	14300.0
As	7.57
Ba	173.0
Ca	141000.0
Cd	3.56
Cr	23.9
Cu	13.7
Fe	12400.0
Hg	**0.35**
K	6250.0
Mg	47100.0
Mn	271.0
Na	34500.0
Pb	17.6
V	38.1
Zn	64.8

S-109-93

Al	17900.0
As	38.0
Ba	278.0
Ca	155000.0
Cr	30.7
Cu	13.1
Fe	17100.0
K	7040.0
Mg	30000.0
Mn	449.0
Na	27100.0
Ni	20.8
Pb	86.6
Sb	28.9
V	46.2
Zn	93.3

S-108-93

Al	25000.0
As	6.72
Ba	365.0
Ca	162000.0
Cr	45.9
Cu	15.8
Fe	21300.0
K	8400.0
Mg	40000.0
Mn	444.0
Na	29200.0
Ni	27.2
Pb	22.5
V	46.2
Zn	113.0

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-26

Total Metals in Groundwater at SWMU 5

Prepared by:
Ebasco Services Incorporated

Table 4.2-2 Water Quality Characteristics of Groundwater at SWMU 5

Page 1 of 1

Well	Conductivity (µmhos)	pH	Turbidity (NTU)	Appearance	Calculated TDS(mg/L)*	Temp°F
S-2	780	8.09	> 200	"muddy"	350 ± 60	47.9
S-50-90	786	8.19	> 200	"murky"	470 ± 90	47.7
S-51-90	760	7.97	> 200	"cloudy-brown"	440 ± 85	48.2
S-53-90	1,250	8.37	> 200	"cloudy-brown"	630 ± 130	46.4
S-108-93	630	8.26	> 200	"cloudy-brown"	596 ± 60	45.4
S-109-93	410	8.14	> 200	"muddy"	780 ± 130	42.2

* Total Dissolved Solids (TDS) content was determined by taking the reported anions in mg/L, converting mg/L to equivalents per mole (epm), and then balancing the anion content with the appropriate equivalent number of cations as calcium, magnesium, potassium, and sodium.

turbidity is due to the fine-grained nature of the screened interval and the comparatively large slot size (0.10) and sand pack (10-20) in these wells.

Anions

Groundwater sampling at SWMU 5 included analyses for the following eight anions: bicarbonate, bromide, chloride, cyanide, fluoride, nitrate/nitrite, phosphate, and sulfate. Results of detections of these analyses are depicted on Figure 4.2-27. All results reflect unfiltered concentrations.

Concentrations of anions detected in SWMU 5 wells were compared to TEAD-S background levels for unfiltered samples to identify groundwater contamination. As depicted on Figure 4.2-26, only phosphate and nitrate exceeded TEAD-S background levels in groundwater. Phosphate exceeded background (1,200 µg/g) in four of the six wells at SWMU 5 and equaled background in another well. Phosphate levels exceeding background range from 1,300 µg/L to 6,300 µg/L. The highest detection of phosphate occurred in one downgradient well (S-109-93). Phosphates in groundwater at SWMU 5 may represent the residual products of compounds known to contain phosphorus (e.g., VX, MPA, or IMPA), or may reflect variations in natural background phosphate levels. Because neither agent nor agent breakdown products were detected in soil or groundwater at SWMU 5, it is probable that the elevated phosphorus is naturally occurring.

Nitrate exceeded background (6,100 µg/g) in only one well (S-53-90). Nitrates in groundwater may represent the breakdown products of explosives. However, given that the detected level of nitrate in well S-53-90 is only 2,400 µg/L above background, and given that no explosive compounds were detected in soil or groundwater at SWMU 5, these levels probably reflect naturally-occurring nitrate.

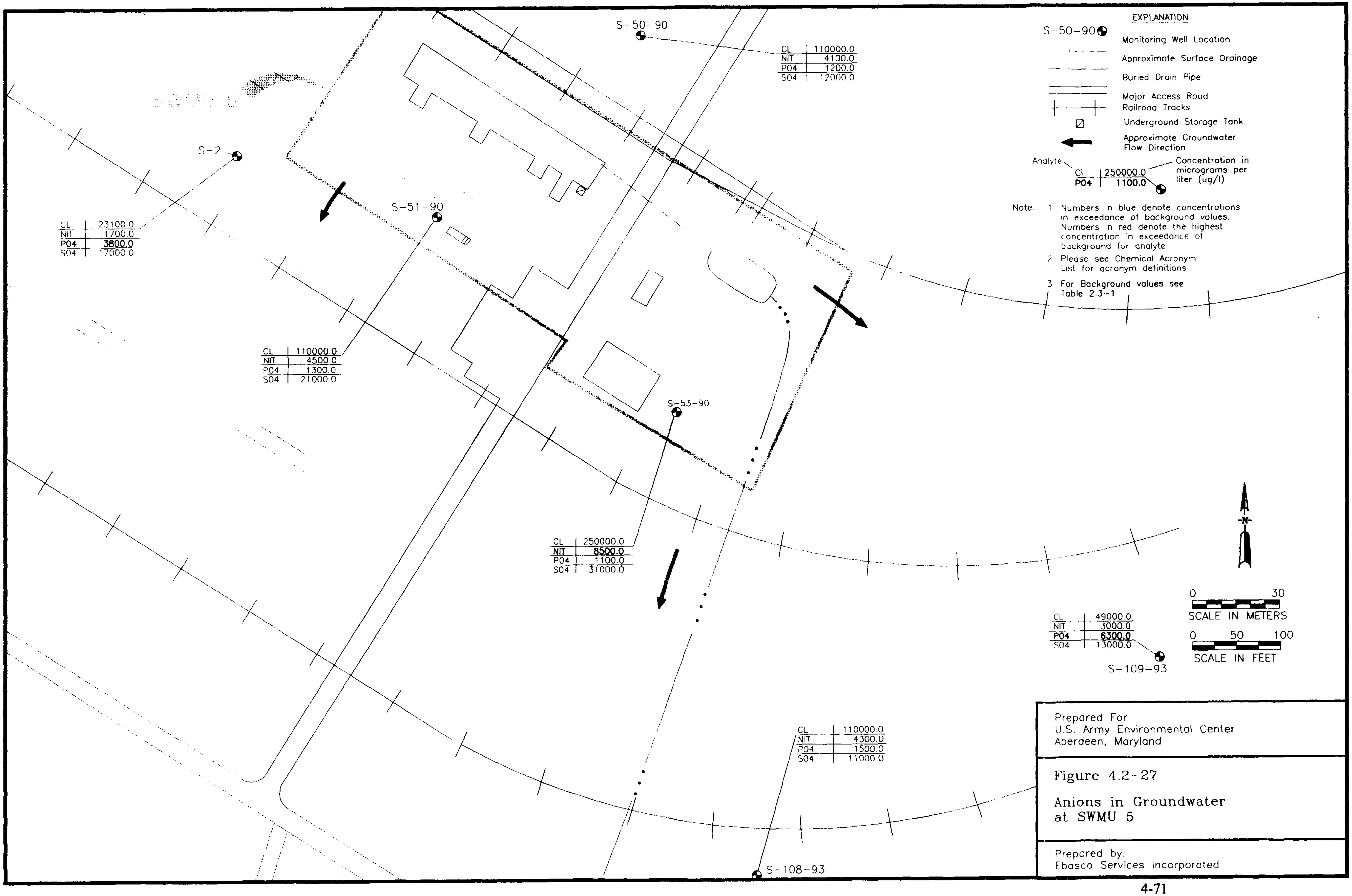
Detections above background in SWMU 5 groundwater are shown in Table 4.2-3.

4.2.2.3 Air Contamination Assessment

Ambient air sampling was performed at SWMU 5 at a station located approximately 165 ft north of the drainage poind and 250 ft northeast of the Building 600 foundation. Six 24-hour sampling events from September 221, 1993 to October 1, 1993 were chosen for laboratory analysis.

Methylene chloride was detected in two samples with a maximum concentration of 0.47 ppbv. Chloroform was detected once at concentration of 0.028. This concentration is slightly above the method detection limit of 0.025 ppbv. Local ambient air concentrations for both of these analytes appear potentially related to SWMU 5 source impacts.

Low levels (0.10 – 0.30 ppbv) of various other volatile organic compounds were detected at SWMU 5, as well as at the other sampling stations located around TEAD-S, including the background station located on the northeast perimeter of the Depot. The list of analytes detected at SWMU 5 as well as the other sampling locations includes 1,1,1-trichloromethane, carbon tetrachloride, benzene, methyl isobutyl ketone, toluene, and total xylenes. The low levels measured at SWMU 5 are comparable to those recorded elsewhere and most likely represent the composition of the background airshed.



Note. 1 Numbers in blue denote concentrations in exceedance of background values. Numbers in red denote the highest concentration in exceedance of background for analyte.

2 Please see Chemical Acronym List for acronym definitions

3 For Background values see Table 2.3-1

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.2-27

Anions in Groundwater
at SWMU 5

Prepared by:
Ebasco Services Incorporated

Table 4.2-3 Chemical Analytical Detections Above Background in Groundwater from SWMU 5

Page 1 of 2

Location	Analyte	Value (μg/l)	Units	Location	Analyte	Value (μg/l)	Units
S-108-93	AL	25,000	UGL	S-53-90	FE	12,400	UGL
S-109-93	AL	17,900	UGL	S-53-90	HG	0.350	UGL
S-2	AL	79,900	UGL	S-108-93	K	8,400	UGL
S-50-90	AL	14,200	UGL	S-109-93	K	7,040	UGL
S-51-90	AL	25,100	UGL	S-2	K	21,500	UGL
S-53-90	AL	14,300	UGL	S-50-90	K	4,900	UGL
S-109-93	ALKBIC	480,000	UGL	S-51-90	K	8,090	UGL
S-108-93	AS	6.72	UGL	S-53-90	K	6,250	UGL
S-109-93	AS	38.0	UGL	S-108-93	MG	40,000	UGL
S-2	AS	47.4	UGL	S-109-93	MG	30,000	UGL
S-50-90	AS	9.28	UGL	S-2	MG	80,900	UGL
S-51-90	AS	17.1	UGL	S-50-90	MG	27,100	UGL
S-53-90	AS	7.57	UGL	S-51-90	MG	39,000	UGL
S-108-93	BA	365	UGL	S-53-90	MG	47,100	UGL
S-109-93	BA	278	UGL	S-108-93	MN	444	UGL
S-2	BA	602	UGL	S-109-93	MN	449	UGL
S-2	BE	4.09	UGL	S-2	MN	1,380	UGL
S-53-90	BRDCLM	0.720	UGL	S-50-90	MN	315	UGL
S-108-93	CA	162,000	UGL	S-51-90	MN	450	UGL
S-109-93	CA	155,000	UGL	S-53-90	MN	271	UGL
S-2	CA	590,000	UGL	S-108-93	NA	29,200	UGL
S-50-90	CA	139,000	UGL	S-109-93	NA	27,100	UGL
S-51-90	CA	210,000	UGL	S-2	NA	25,300	UGL
S-53-90	CA	141,000	UGL	S-50-90	NA	22,100	UGL
S-53-90	CHCL3	1.40	UGL	S-51-90	NA	31,600	UGL
S-2	CO	24.9	UGL	S-53-90	NA	34,500	UGL
S-108-93	CR	45.9	UGL	S-2	NI	104	UGL
S-2	CR	112	UGL	S-108-93	NIT	4,300	UGL
S-51-90	CR	51.5	UGL	S-109-93	NIT	3,000	UGL
S-2	CU	66.8	UGL	S-2	NIT	1,700	UGL
S-108-93	FE	21,300	UGL	S-50-90	NIT	4,100	UGL
S-109-93	FE	17,100	UGL	S-51-90	NIT	4,500	UGL
S-2	FE	74,500	UGL	S-53-90	NIT	8,500	UGL
S-50-90	FE	13,500	UGL	S-109-93	PB	86.6	UGL
S-51-90	FE	23,100	UGL	S-2	PB	89.0	UGL

Table 4.2-3 Chemical Analytical Detections Above Background in Groundwater from SWMU 5

Page 2 of 2

Location	Analyte	Value (μg/l)	Units	Location	Analyte	Value (μg/l)	Units
S-108-93	PO4	1,500	UGL	S-53-90	SO4	31,000	UGL
S-109-93	PO4	6,300	UGL	S-51-90	TRCLE	1.90	UGL
S-2	PO4	3,800	UGL	S-53-90	TRCLE	7.60	UGL
S-50-90	PO4	1,200	UGL	S-108-93	V	46.2	UGL
S-51-90	PO4	1,300	UGL	S-109-93	V	46.2	UGL
S-53-90	PO4	1,100	UGL	S-2	V	145	UGL
S-109-93	SB	28.9	UGL	S-50-90	V	27.1	UGL
S-108-93	SO4	11,000	UGL	S-51-90	V	58.6	UGL
S-109-93	SO4	13,000	UGL	S-53-90	V	38.1	UGL
S-2	SO4	17,000	UGL				

μg/l micrograms per liter

Note: Analyte names are defined in the chemical acronym list.

Several semivolatile organic compounds were detected in the field samples including naphthalene, di-n-butylphtalate, butylbenzylphthalte, and bix(2-ethylhexyl) phthalate. However, all these analytes were measured at comparable levels in the non aerated blank samples and thus, are most likely indicators of laboratory contamination.

There were no detections of cyanide, mercury, or PCBs at SWMU 5 during the sampling program. The total suspended particulate and metal results were not used due to laboratory and media problems. It was determined during subsequent laboratory analysis that the sample filters supplied to the field team were contaminated with high background levels of the target elements. This prevented the identification and quantification of metals in the ambient air. To offset this missing data, conservative assumptions were used in the human health risk assessment to estimate ambient concentrations of metal soil COCs resuspended in airborne particulates.

Recent particulate matter less than 10 microns (PM-10) data collected near SWMU 5 at site MS-1 by the Tooele Army Depot Met Team indicates that ambient levels of respirable particulates are generally low (approximately 11 μg/m3 for the period of 1989-1992) and quite typical of rural settings. Appendix I contains a complete listing of all air monitoring data.

4.2.3 Contaminant Fate and Transport

This section discusses the probable contaminant fate and transport processes and migration pathways that are operating at SWMU 5 based on SWMU history, site physical characteristics, contaminant chemical, and physical properties, and the nature and extent of contamination in soil and groundwater.

As outlined in Section 4.2.2, the release of organic and inorganic compounds at SWMU 5 has resulted in the contamination of soil and groundwater at the SWMU. While several compounds were identified as potential contaminants at SWMU 5, only those compounds identified as COCs in the human health risk assessment for SWMU 5 (Section 5.3.1) are described here.

SWMU-wide soil COCs include 1,1,2-trichloro-1,2,2-trifluoroethane, cadmium, chromium, copper, lead, and zinc; area-specific soil COCs include antimony, mercury, nickel, silver, and vanadium. Groundwater COCs include bromodichloromethane, chloroform, trichloroethylene, aluminum, antimony, barium, beryllium, chromium, lead, mercury, nickel, and vanadium.

4.2.3.1 Soil

The only organic compound identified as a COC in soil at SWMU 5 is 1,1,2-trichloro-1,2,2-trifluoroethane (TCLTFE), also known as Freon 113. Freon 113 was detected in seven locations, all within the upper 3 ft of soil, at concentrations ranging from 0.005 μg/g to 0.64 μg/g. This compound may have been released to the environment as emissions from its use as a foaming agent, refrigerant, or solvent, or from the disposal of compounds containing the compound. Freon 113 has an aqueous solubility of 170 mg/L and a vapor pressure of 362 mm Hg. Its high vapor pressure is also reflected in its high Henry's law constant of 0.53 atm-m^3/mole. Freon 113 has an octanol-water partition coefficient of 1,445, and an organic-carbon partition coefficient ranging from 191 to 259. Data concerning rates of biodegradation could not be found.

Due to its high vapor pressure and Henry's law constant, volatilization from soil and water is expected to be rapid following its release. Therefore, the presence of Freon 113 in near-surface soil at the site suggests that it exists in residual amounts adsorbed primarily to soil organic matter, and secondarily to the silt- and clay-sized mineral fraction. Slow desorption of this compound from soil will likely result in trace amounts of Freon 113 reaching the atmosphere by volatilization. Similarly, trace amounts will desorb and become dissolved in infiltrating rainwater to be transported to the subsurface. The susceptibility of Freon 113 to biodegradation is poorly known, but is not expected to be significant in the aerobic soil environment at SWMU 5 due to the presence of chlorine and bromine. Degradation of Freon 113 by abiotic reactions (hydrolysis, oxidation, photolysis) is not a significant because it is, in general, chemically inert.

Metal COCs in soil have been detected in widely separated sample locations (SWMU-wide COCs) and in localized areas (sample-specific COCs). The majority of metal COCs have been detected in surface or near-surface samples. The mobility of metal COCs at SWMU 5 by desorption and leaching from near-surface soil to deeper soil and the water table is expected to be very low for several reasons. First, these metals readily form solids (oxides and hydroxides) of low solubility that restrict their movement even in the presence of water. Second, these metals sorb strongly to soil organic matter and the silt- and clay-sized mineral fraction of soils which are abundant at TEAD-S. Third, the alkaline pH of the soil at TEAD-S greatly reduces the potential for dissolution of the metals by rainwater or snowmelt and prevents the leaching of these metals to the subsurface. These conditions act in concert to keep metal COCs stable in the solid phase. However, for these same reasons, transport of metal COCs as fugitive dust or by particulate erosion from surface water runoff thereby increases as a potentially significant migration mechanism.

4.2.3.2 Groundwater

COCs identified in groundwater at SWMU 5 include bromodichloromethane, chloroform, trichloroethylene, and nine metals (Al, Sb, Ba, Be, Cr, Pb, Hg, Ni, and V). Bromodichloromethane was detected in downgradient wells S-53-90 and S-108-93 at concentrations of 0.72 µg/L and 1.9 µg/L, respectively. Chloroform was also detected in wells S-53-90 and S-108-93 at concentrations of 1.4 µg/L and 2.0 µg/L, respectively. Trichloroethylene was detected in two wells (S-51-90 and S-53-90) at concentrations of 1.9 µg/L and 7.6 µg/L, respectively. All three of organic COCs in groundwater are halogenated hydrocarbons that share similar chemistry and environmental behaviors.

Bromodichloromethane has an aqueous solubility of 4,700 mg/L, a vapor pressure of 50 mm Hg, and a Henry's law constant of 1.6 x 10^{-3} atm-m^3/mole, which indicates its rapid volatilization from water. It is moderately to highly mobile in soil, as indicated by its octanol-water partition coefficient (126) and organic-carbon partition coefficient (53 to 251). Biodegradation data is scarce; the degradation half-life of bromodichloromethane in anaerobic tests using methanogenic bacteria is approximately 1 week, whereas degradation half-lives under sterile controls were on the order of 6 weeks. Direct photolysis of bromodichloromethane does not occur; however, reaction with photochemically produced hydroxyl radicals in the atmosphere results in a half-life of almost 4 years. Because this compound is not widely distributed for commercial use, the predominant anthropogenic source of bromodichloromethane in the environment is its inadvertent formation during the chlorination of water. When released to groundwater, biodegradation may be a significant attenuation mechanism when conditions are reducing (anaerobic), but less effective when groundwater is well oxygenated due to the presence of halogen species (bromine and chlorine). Due to its high solubility (4,700 mg/L) and relatively low octanol-water partition coefficient (126), bromodichloromethane is expected to be moderately to highly mobile in groundwater (Howard, et al. 1990).

Chloroform is commonly used as a solvent and chemical intermediate; it is also inadvertently introduced to the environment during the chlorination of water. Chloroform has a solubility of 7,950 mg/L and an octanol-water partition coefficient of 93.3, which indicates that it should be mobile in groundwater. Because it has three chlorine atoms in its structure, chloroform is susceptible to biodegradation only under anaerobic conditions. It is not expected to undergo hydrolysis, or other abiotic degradation reactions in groundwater (Howard et al. 1990).

Trichloroethylene (TRCLE) is a chlorinated solvent used primarily for the vapor degreasing of metal surfaces and as a solvent in metal finishing; it is secondarily used as a component in the formation of paints. It has a solubility of 1,100 mg/L and an octanol-water partition coefficient of 263. Based on these properties, TRCLE is expected to be moderately to highly mobile in groundwater. TRCLE is not susceptible to hydrolysis or oxidation reactions in groundwater. Due to the presence of chlorine atoms in its structure, biodegradation is only significant in anaerobic environments where reductive dehalogenation reactions can occur. It sorbs poorly to soil organic carbon and clay-sized minerals.

Given that site groundwater exhibited high turbidity during well development and sampling, and given that samples were not filtered prior to analysis, metal COCs in groundwater probably exist as primary and secondary minerals and as adsorbed complexes on colloids, particulates, and suspended solids. As a result, migration of these COCs is limited to advective flow in groundwater and retardation of these metals relative to groundwater flow by natural filtration and adsorption mechanisms in the aquifer matrix. As such, it is highly unlikely that metal COCs in groundwater at SWMU 5 represent true contamination.

In summary, the potential migration pathways that may be significant at SWMU 5 include the transport of metal COCs in surface and near-surface soil by wind erosion and surface water runoff and by migration of organic COCs in groundwater by advective flow. The fate of 1,1,2-trichloro-1,2,2-trifluoroethane in soil is likely to be restricted to slow desorption and volatilization to the atmosphere and to slow desorption and leaching to the subsurface by infiltrating rainwater.

In general, the small concentrations of organic COCs in soil and groundwater indicate that migration of these compounds will not result in any significant redistribution of contaminants at the site.

4.3 SWMU 8

4.3.1 Background

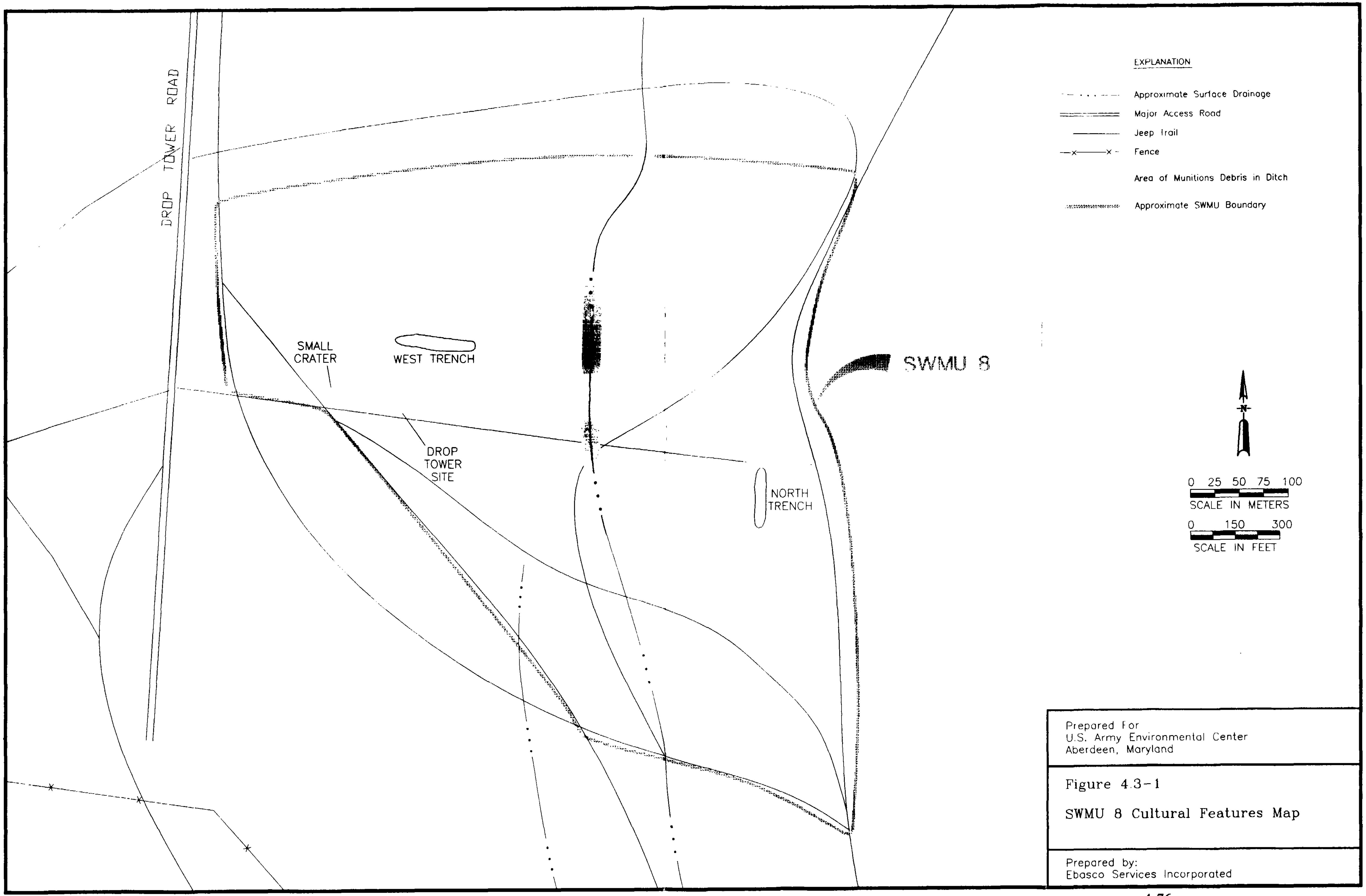
This section presents information on the site history and cultural features, geology and soil, and hydrology of SWMU 8.

4.3.1.1 Site History and Description of SWMU 8: Surveillance Test Site

SWMU 8 was reportedly a munitions testing area located adjacent to the active SWMU 31 Demilitarization Area (Figure 4.3-1). The area is referred to as the Surveillance Test Site in the corrective action module. Employees remembered a wooden drop tower on an elevated pad where munitions were tested. According to the IA (USATHAMA 1979), functional surveillance testing included dropping munitions from a 30-ft-high tower near Building T-3251. The IA states that a pendulum-functioning facility for testing M69 and M79 bombs from the M19 cluster bomb was located near Building T-3150 at SWMU 8. In addition, the IA reports that smoke pots, M15 WP grenades, and smoke grenades were tested approximately 450 ft north of Building T-3250. The munitions included thermate bombs and M19 cluster bombs (M69 napalm and WP bombs clustered with M79 incendiary bombs). According to Norris (1993b), the munitions were dropped down a metal tube onto a tilted concrete pad covered with a metal plate (Figure 4.3-2). The munitions then rolled away from the base of the tower and detonated. There were metal tubes on the east and west side of the drop tower down which the munitions were dropped. Munitions tested at this site were representative of every lot of munitions stored at TEAD-S. Several thousand munitions were tested at the unit, with each lot of munitions being tested for approximately 1 month (Norris 1993b). No chemical munitions were tested at the unit. During the RFI-Phase II field program extensive metal debris including handles and pins from grenades, was observed on the ground surrounding the Drop Tower (Figure 4.3-3).

During the initial site visit in 1989 (RFI-Phase I), two open pits in the same general area were observed to contain rusted scrap metal, smoke canisters, small empty drums, smoke pots, smoke grenades, caustic soda drums, CS grenades and canisters, and cans labeled as thickener (napalm). These pits are now covered. According to Norris (1993b), test residue from the drop tower was reportedly placed in the trenches.

Large pieces of munitions debris are also scattered on the ground throughout the SWMU due to the unit's proximity to SWMU 31. Several ground scars within SWMU 8 indicate other areas where munitions testing or disposal may have occurred (Figure 4.3-4) USAEC personnel also observed piles of munitions debris in the drainage ditch that crosses the eastern part of SWMU 8 (Figure 4.3-5). This ditch drains from Area 2 in SWMU 9 into SWMU 8.

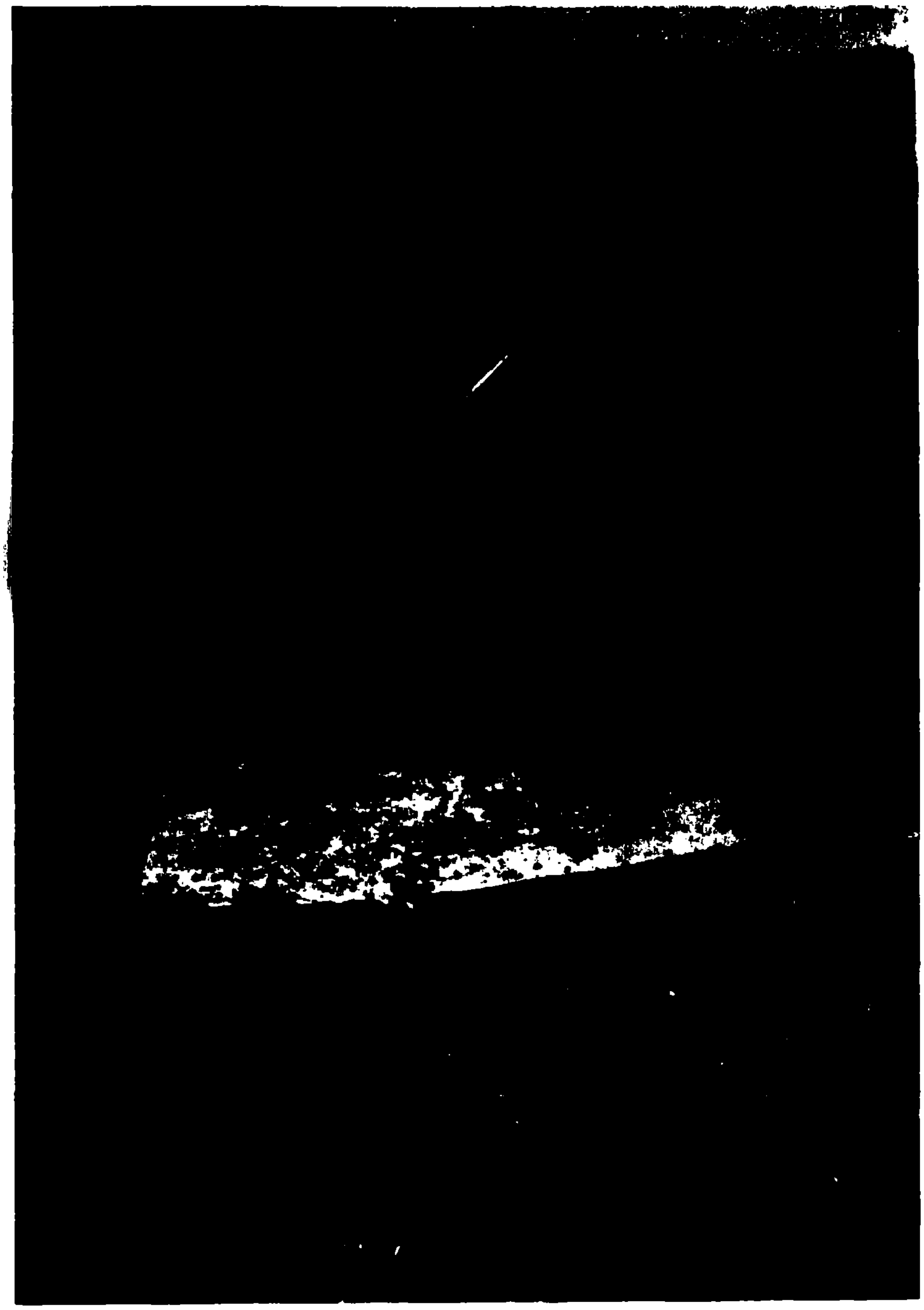


Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-1

SWMU 8 Cultural Features Map

Prepared by:
Ebasco Services Incorporated



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-2

Concrete Pad on East Side of Drop Tower Site in SWMU 8.

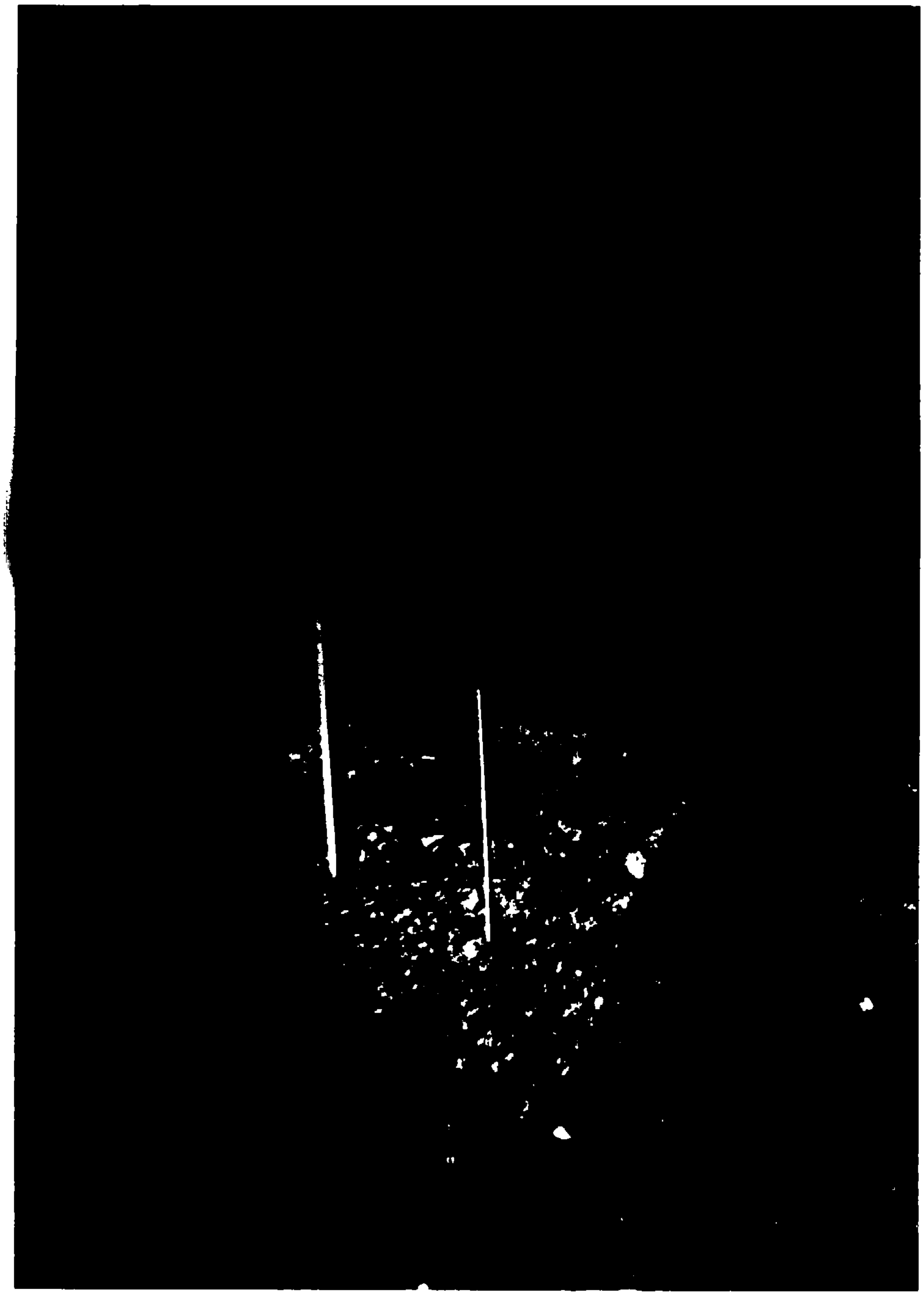
Prepared by:
Ebasco Services Incorporated

Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-3

Munitions Debris on Ground East of Drop Tower Site in SWMU 8

Prepared by:
Ebasco Services Incorporated

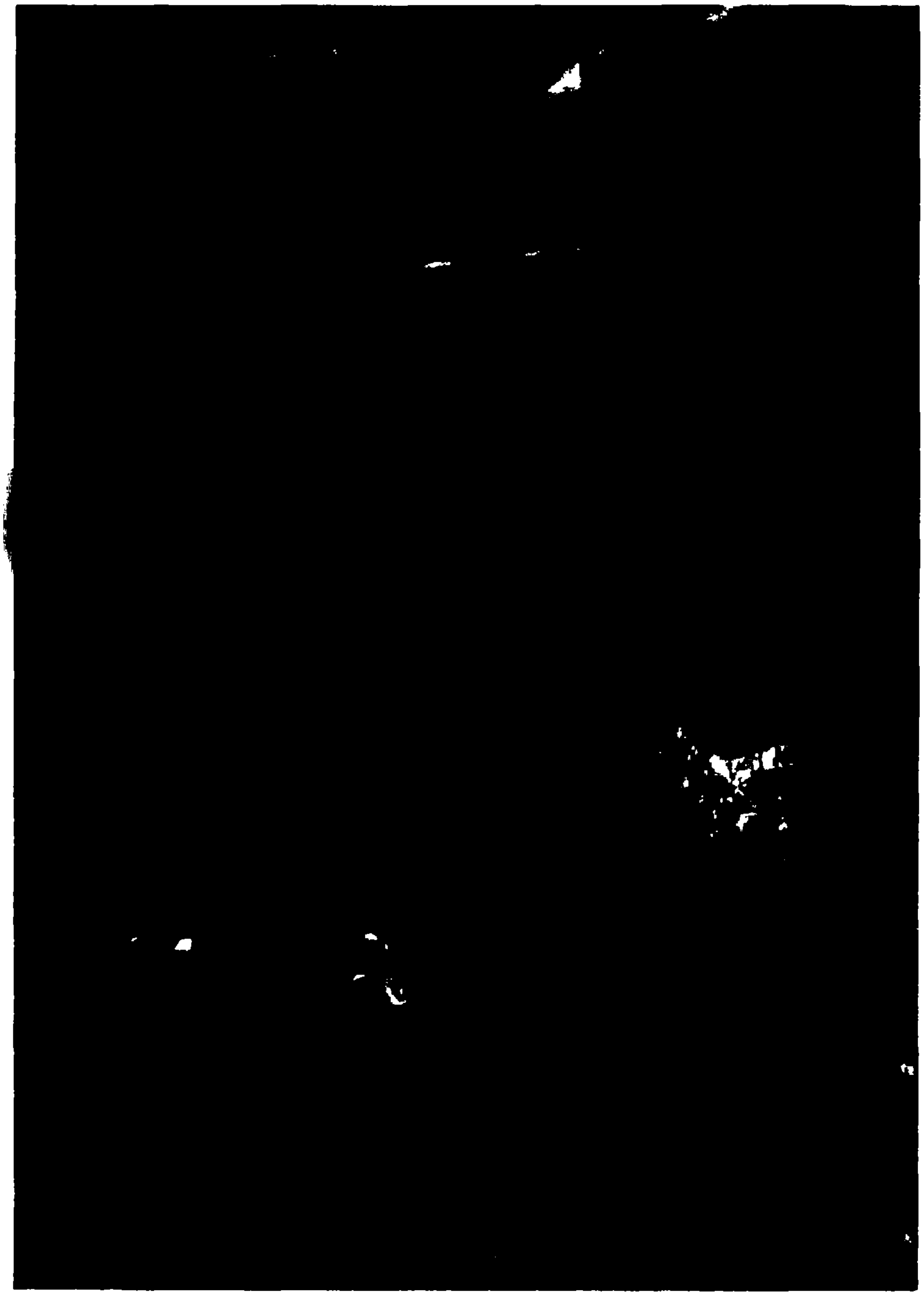


Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-4

Incendiary Bomblet Debris at Ground Scar in SWMU 8

Prepared by:
Ebasco Services Incorporated



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-5

Incendiary Munitions Debris in Drainage Ditch through SWMU 8

Prepared by:
Ebasco Services Incorporated

4.3.1.2 Geology and Soil at SWMU 8

The geology and soil at SWMU 8 were characterized using a total of 16 shallow borings and test pit excavations (Figure 3.7-3). Samples were collected to a maximum depth of 10 ft.

The soil encountered at SWMU 8 is predominantly a fine-grained lacustrine deposit that is classified as a clayey silt (ML). Very often significant amounts of sand, up to 40 percent, are contained within the silty soil. Small quantities of gravel were also observed in the silt, but generally only in the shallow surface zone, which extends to about 1.5 ft bgs. However, only three widely separated locations (8-NTR-1, 8-DCH-2, and 8-GS-4) contained small coarse-grained layers of silty sands (SM) or silty gravels (GM). In two locations on the elevated pad at the former drop tower site (8-GS-2 and 8-GS-3), the upper 1 ft of soil was identified as a fill consisting mainly of silty gravel.

All of the soil materials encountered were relatively low in moisture content, with conditions ranging from dry to moist. The consistency and density of these materials covered the range of conditions from soft to hard in the cohesive-type soils or loose to very dense in the granular soils. More specific information for each location can be found in the boring logs in Appendix A1.

Geotechnical testing, performed on the two background samples (8-BK-1 and 8-BK-2), identified the soil as moderately alkaline (pH of 9.15 to 9.34). The USCS classification of the soil is CL. The moisture content observed ranged from 9.1 to 10.1 percent, which indicates damp conditions. The range in the coefficient of permeability was 2.6 x 10^{-5} cm/sec to 1.1 x 10^{-6} cm/sec. Only one sample (8-BK-1) received effective porosity and CEC testing, with resultant values of 13.2 percent and 15 meq/100g, respectively. Bulk density values were between 83 and 91 pcf. The TOC results were relatively low for both locations (0.14 and 0.19 percent). Detailed geotechnical and geochemical data can be found in Appendix A3.

Information on soil types present at SWMU 8 was also obtained from the SCS (no date). Only one soil type, the Tooele fine sandy loam, was mapped at SWMU 8. This soil is slightly saline and moderately alkaline at the surface, with these conditions increasing with depth. The suitable uses for the Tooele loam are wildlife habitat and very limited pasture crop production. The suitability of the soil for livestock grazing is only fair since the soil only produces limited amounts of forage.

4.3.1.3 Hydrology at SWMU 8

SWMU 8 is located on a gently southward-sloping topographic surface. The intermittent drainage ditch that extends south from SWMU 9 enters the eastern part of SWMU 8. Downslope from SWMU 8, this drainage passes through SWMU 31, but is disrupted by roads (EPIC 1986). No new hydrologic or hydrogeologic information was collected during this phase.

There are no monitoring wells at SWMU 8 due to its proximity to SWMU 31, where explosive detonations could damage the structural integrity of nearby wells, including both casing and grout.

The depth to groundwater in November and December 1993 was estimated between 75 and 85 ft bgs. The resulting estimated groundwater elevation is approximately 5,020 to 5,030 ft above msl. Groundwater flow is mostly to the south based on data from surrounding monitoring wells.

4.3.2 Nature and Extent of Contamination

This section describes the nature and extent of contamination in SWMU 8. No assessment of groundwater contamination was performed for SWMU 8 because there are no monitoring wells at SWMU 8. Only those soil COCs of potential risk to human or ecological receptors are described in detail. Human health COC selection for SWMU 8 is detailed in Section 5.4.1. Ecological COC selection for all Group 2 SWMUs is discussed in Section 6.3.

4.3.2.1 Soil Contamination Assessment

This section summarizes the chemical analytical results of the RFI-Phase II sampling program, as well as those conducted previously, at SWMU 8. The RFI-Phase II results and evaluations are grouped by analyte, with significant detections discussed by location within the SWMU. The sample locations are shown on the individual contaminant maps. The complete chemical data for the RFI-Phase II soil samples is found in Appendix F1.

Although this section presents an evaluation of all of the analytical data collected, the discussion focuses on the results for the human health and ecological COCs at SWMU 8 that are being evaluated in the risk assessments. The COCs for SWMU 8 include one organic compounds (trichlorofluoromethane, or CCL3F) and eight metals (cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc).

Previous Investigations

No soil sampling was performed at SWMU 8 prior to the RFI-Phase I. During the RFI-Phase I, two soil samples were collected from the firing range area, in the northwestern section of the SWMU which was thought at the time to be the former drop tower location, and one background soil sample was collected approximately 100 ft south of the western edge of the southern berm of the firing range. The two soil samples from the firing range were analyzed for SVOCs, total petroleum hydrocarbons, explosives, and metals. The samples to be analyzed for SVOCs exceeded their holding times, and poor Tetryl recoveries indicated inaccuracy in the explosives method. These samples were not replaced, since further aerial photograph interpretation indicated a different location for the drop tower. The background soil sample was analyzed for metals only. Only sodium (Na) was detected at the background sample location.

During the RFI-Phase I program two open debris-filled trenches were observed at SWMU 8. Survey monuments were installed at the trenches so that these features could be found again if covered. One monument was installed at the west end of the east-west trench which is north of the drop tower site and was named 8-W-TRNCH. The other monument was installed at the north end of the north-south trench and named 8-N-TRNCH. For convenience, the trenches are now given the names of these monuments, although the outlying north-south trench, marked by 8-N-TRNCH, is not actually north of the other trench.

RFI-Phase II Results

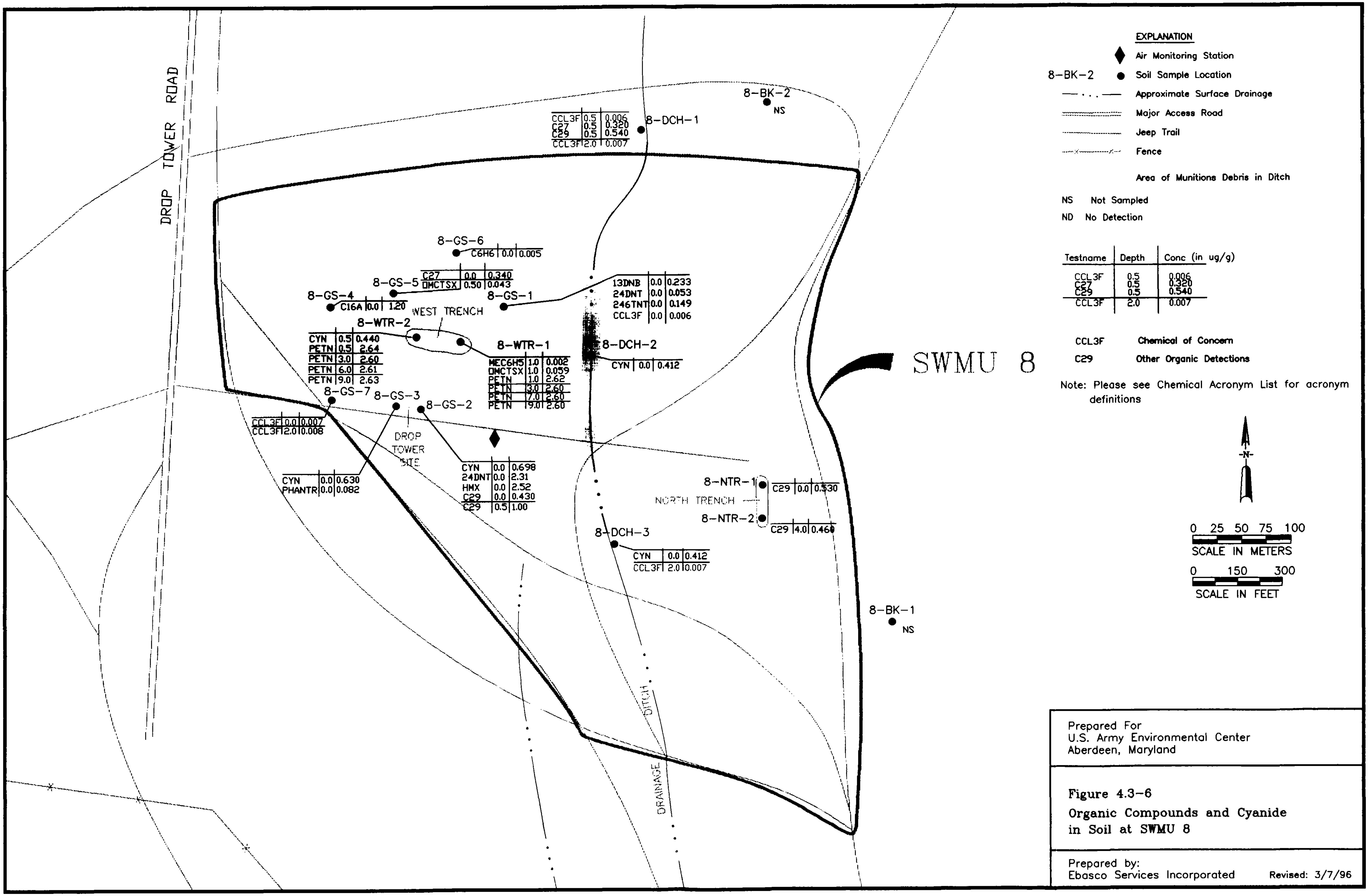
A total of 40 soil samples were collected at SWMU 8 during the RFI-Phase II program. All samples were obtained using a backhoe since there was extensive UXO and metal debris in the SWMU caused primarily by open detonation in the adjacent SWMU 31. Of the seven ground scars sampled, six were sampled at the surface, and at 0.5 and 2 ft bgs. The seventh ground scar was sampled at the surface and at 2 ft bgs. A streambed extending from north to south across the SWMU was sampled in three locations at the surface and at 2 ft bgs. Four samples each from two locations in the west trench were collected from depths ranging from 0.5 to 9 ft bgs. The north trench was sampled at two locations at the surface and at 0.5 and 2 ft bgs. The samples were all analyzed for VOCs, SVOCS, explosives, agent breakdown products, and metals.

Organic Compounds and Cyanide

Twelve organic compounds were detected in samples from SWMU 8 (Figure 4.3-6). Target analyte compounds were benzene (C6H6), toluene (MEC6H5), phenanthrene (PHANTR), 1,3-dinitrobenzene (13DNB), 2,4-dinitrotoluene (24DNT), 2,4,6-trinitrotoluene (246TNT), and cyclotetramethylenetetranitramine (HMX). Non-target analytes detected were trichlorofluoromethane (CCL3F), octamethylcyclotetrasiloxane (OMCTSX), tetranitrate, heptacosane (C27), and nonacosane (C29). Only CCL3F is considered a SWMU-wide human health COC. There are no ecological organic COCs at this SWMU.

There were six detections of CCL3F in the SWMU. The maximum concentration (0.008 µg/g) occurred in a sample collected 2 ft bgs from a small crater (8-GS-7) on the west side of the SWMU. CCL3F was also detected in the surficial sample at this location. Another detection occurred in the surficial sample collected from a ground scar north of the west trench that is a possible burn or disposal pit. The remaining three detections occurred in samples taken from the streambed at depths ranging from 0.5 to 2 ft bgs. The detection frequency (greater than 5 percent) and the potential toxicity of CCL3F suggest that the compound should be considered a SWMU-wide COC. However, because the concentration is low and the range narrow (0.006 to 0.008 µg/g), the selection of CCL3F as a COC is conservative.

Cyanide was detected at less than 1 µg/g in soil samples at four locations at SWMU 8 (Figure 4.3-6). The two highest concentrations (0.630 µg/g and 0.698 µg/g) were detected in surficial soil near the former drop tower site (iin 8-GS-3 and 8-GS-2, respectively).



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-6
Organic Compounds and Cyanide in Soil at SWMU 8

Prepared by:
Ebasco Services Incorporated
Revised: 3/7/96

F:\PROJECTS\TOOELE\ARCAD\SWMU8\SWMU-8L_O.DWG

Metals

Above background concentrations of 11 metals including silver (Ag), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), magnesium (Mg), sodium (Na), nickel (Ni), lead (Pb), antimony (Sb), and zinc (Zn), were detected in samples throughout the SWMU. The risk assessment for SWMU 8 has identified eight metals (Ag, Cd, Cr, Cu, Pb, Hg, Ni, and Zn) as COCs.

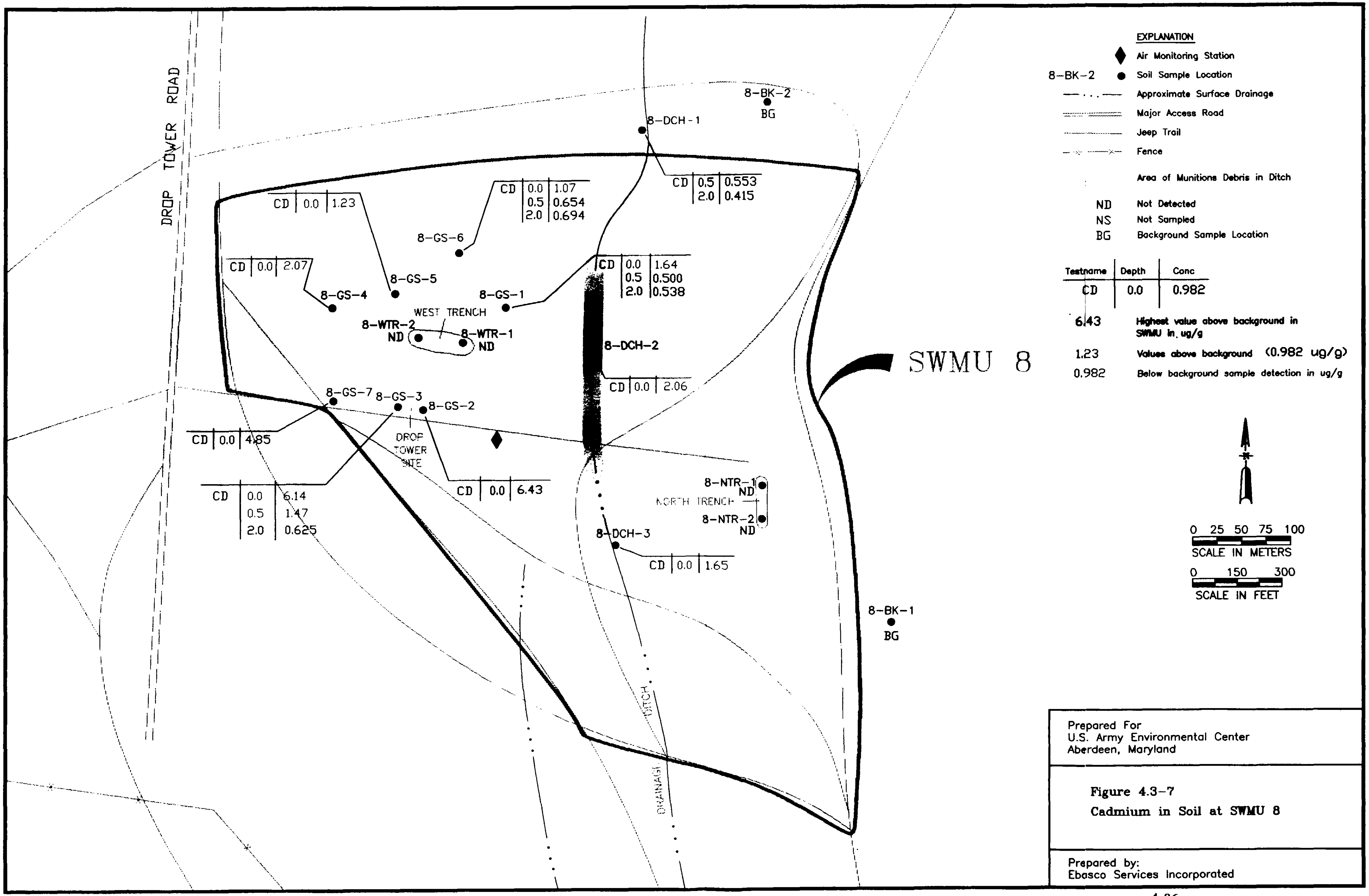
Arsenic (As), a facility-wide ecological COC, was detected only at concentrations below background (40 µg/g) at SWMU 8. Therefore, no figure showing the distribution of arsenic detections at the SWMU is included.

Cadmium (Cd), a human health and ecological COC, was detected in concentrations above background in 10 of 40 samples (Figure 4.3-7). All of the detections, except one, were in surficial samples at various ground scar locations and in the drainage ditch. At the drop tower site, cadmium was detected both in the surficial sample and the subsurface sample (0.5-ft bgs) at 8-GS-3. **The maximum concentration (6.43 µg/g) was detected in the surficial sample collected from the east side of the drop tower site (8-GS-2). Cadmium is considered a SWMU-wide COC for SWMU 8 because of the potential toxicity of the element and because the concentrations exceed background in 25 percent of the soil samples.**

Chromium (Cr), a human health COC, was detected in all 40 samples collected at SWMU 8. However, concentrations above background (48.5 µg/g) occurred in only two samples (Figure 4.3-8), so chromium is considered a COC specific to these sampling locations. The two above-background concentrations occurred in one subsurface sample (0.5 bgs) collected from the west trench (8-WTR-2), where the maximum concentration (75.8 µg/g) was detected, and in the surficial sample collected east of the drop tower site.

Copper (Cu), a human health and ecological COC, was also detected in all 40 soil samples collected at SWMU 8. Concentrations above background (27.6 µg/g) occurred in 12 samples (Figure 4.3-9). Copper was detected in above-background concentrations in the surficial samples collected at all seven of the ground scar locations. Additionally, an above-background concentration was detected in a subsurface sample (0.5 ft bgs) east of the drop tower site. Copper was detected above background in two surficial samples collected from two ditch locations and in two subsurface samples (0.5 and 1 ft bgs) collected from two locations at the west trench. The maximum concentration (557.0 µg/g) of copper was detected in a subsurface sample (0.5 ft bgs) in the west trench (8-WTR-2). Because of the potential toxicity of Cu and because the concentration exceeds background in 30 percent of the samples, it is considered to be a SWMU-wide COC.

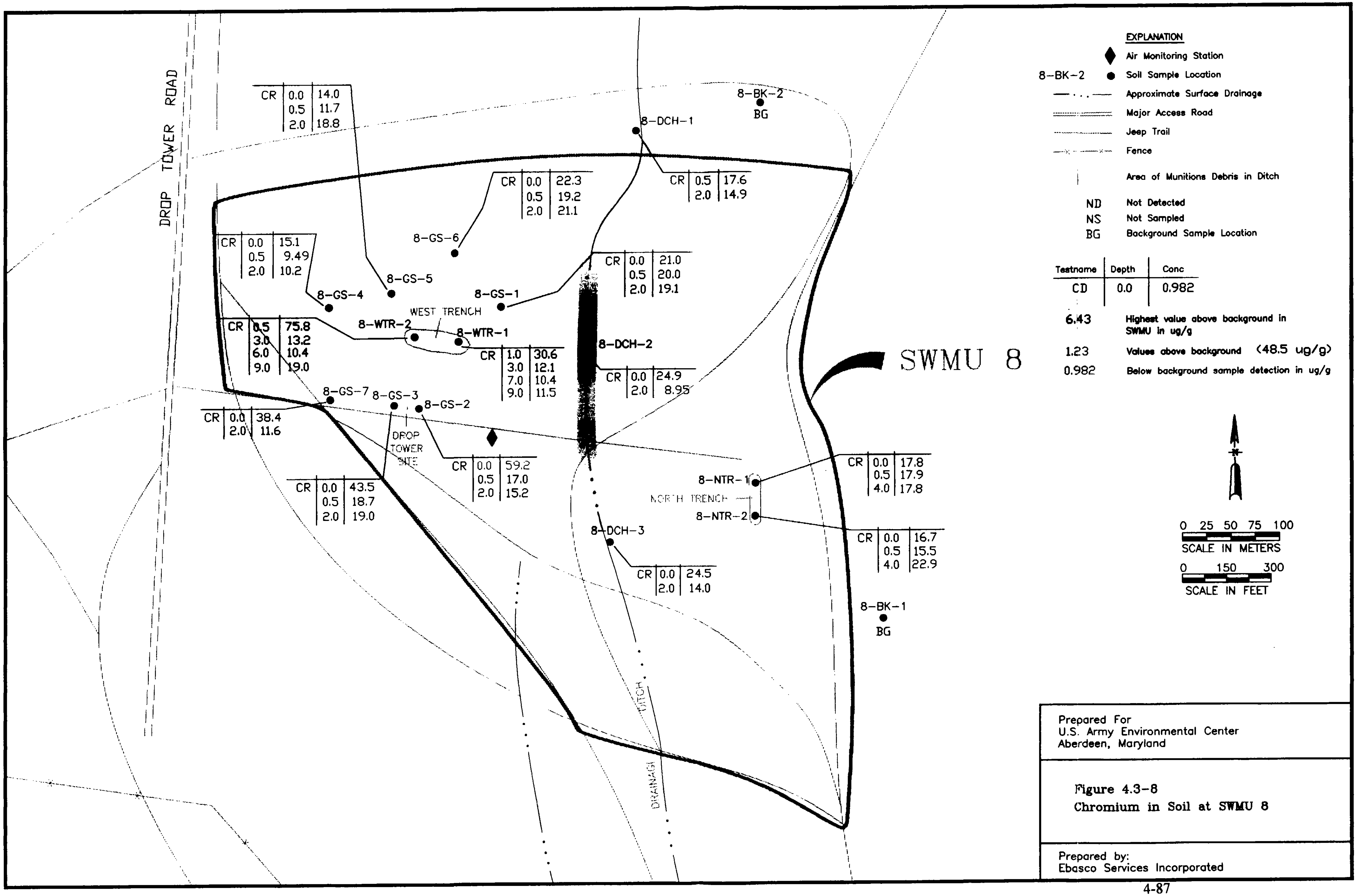
Lead (Pb), a human health and ecological COC, was detected in all 40 of the soil samples, but concentrations above background (35.0 µg/g) occurred in only 6 of the samples (Figure 4.3-10). The above-background detections included the surficial sample collected in one of the drainage



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-7
Cadmium in Soil at SWMU 8

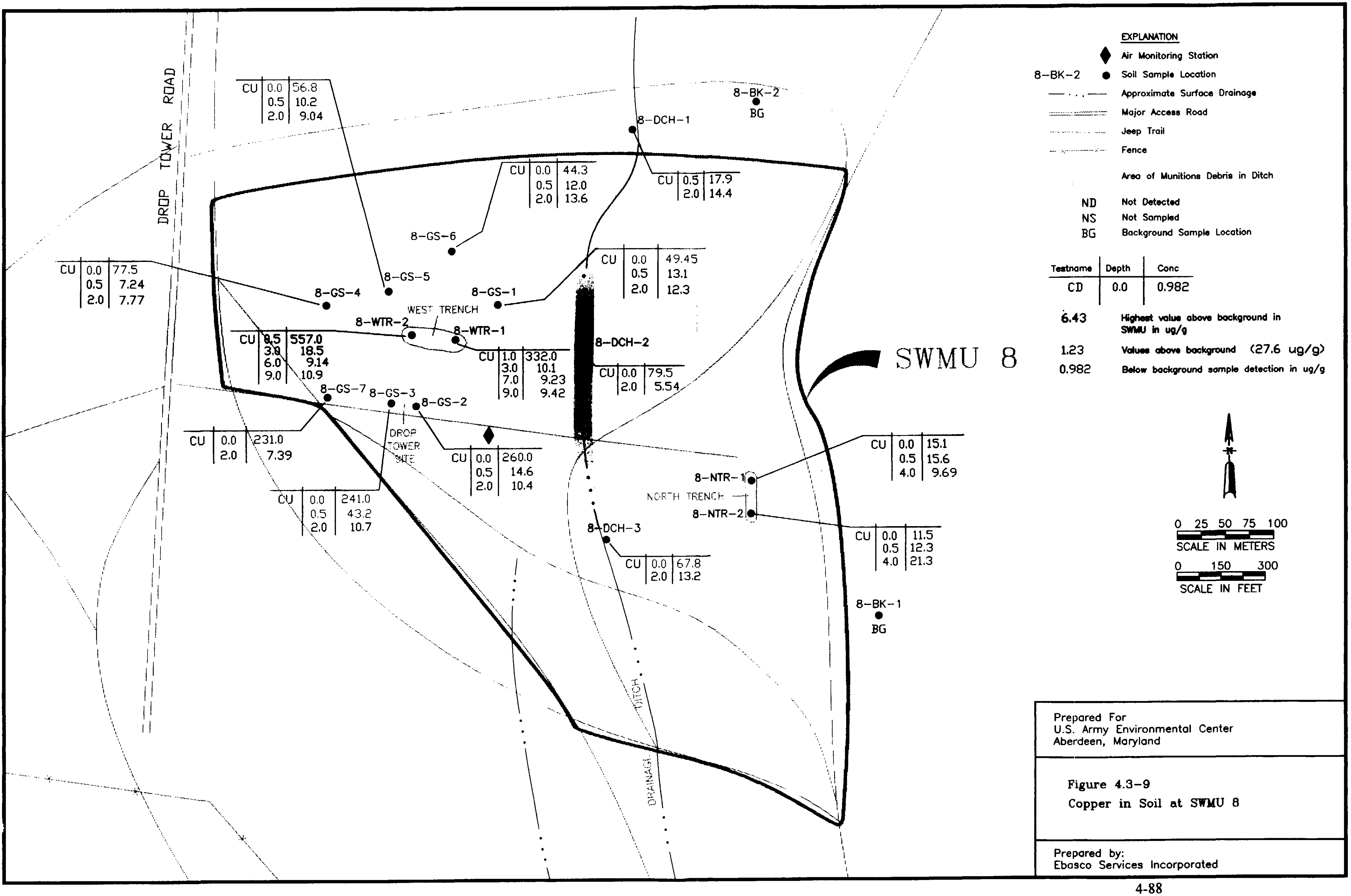
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-8
Chromium in Soil at SWMU 8

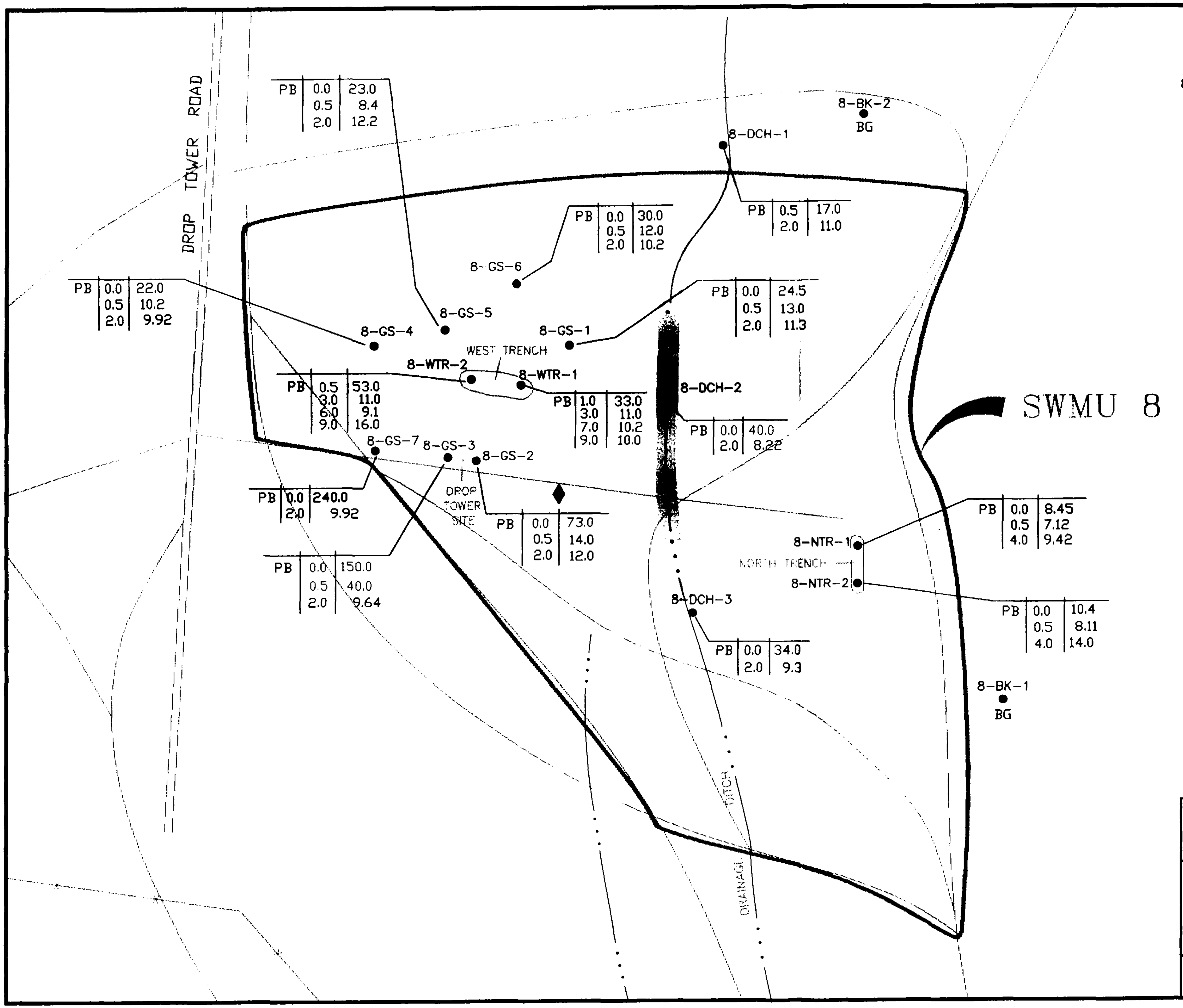
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-9
Copper in Soil at SWMU 8

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-10
Lead in Soil at SWMU 8

Prepared by:
Ebasco Services Incorporated

ditch locations, the surficial sample at the ground scar east of the drop tower site, the surficial sample and subsurface sample (0.5 ft bgs) collected west of the drop tower site, the surficial sample at the small crater, and the subsurface sample (0.5 ft bgs) collected at one sampling location in the west trench. The highest concentration of Pb (240 µg/g) was detected in the surficial sample at the small crater site (8-GS-7). Lead is considered to be a SWMU-wide COC because of the frequency of above-background detections (15 percent) and because of its potential toxicity.

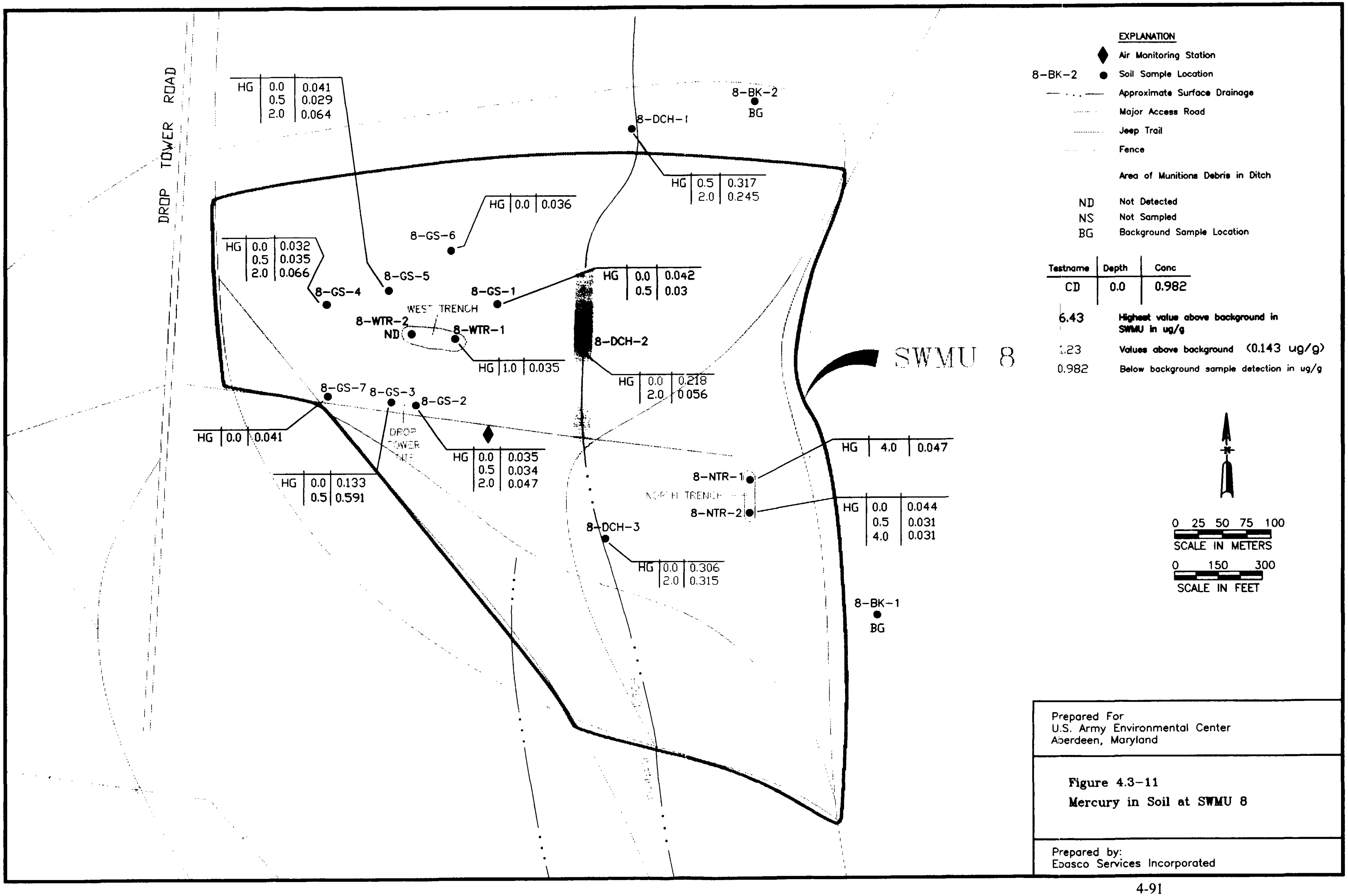
Mercury (Hg), a human health and ecological COC, was detected above-background (0.143 µg/g) in six samples (Figure 4.3-11). Five of the samples with above-background detections were collected from sample locations within the drainage ditch. The sixth detection occurred in a subsurface sample (0.5 ft bgs) collected on the west side of the drop tower site (8-GS-3), where the highest concentration (0.591 µg/g) was detected. Like lead, mercury is considered to be a SWMU-wide COC.

Nickel (Ni), a human health COC, was detected in all 40 soil samples collected at SWMU 8 (Figure 4.3-12), but was above background (27.9 µg/g) in only two samples. One of these above- background detections occurred in the surficial sample collected from the east side of the drop tower site (8-GS-2). The other detection, which was the maximum (57.9 µg/g), occurred in a subsurface sample (0.5 ft bgs) collected at one of the west trench locations (8-WTR-2). Because of its limited distribution above background, Ni is a potential COC only at the west trench and the east side of the drop tower site, not throughout the SWMU.

Silver (Ag), a facility-wide ecological COC, was detected at above-background concentrations (0.435 µg/g) in only three surficial samples at SWMU 8 (Figure 4.3-13). These samples were collected from both sides of the drop tower site and from the small crater west of the drop tower site. The maximum concentration (0.837 µg/g) was detected in the surficial sample at the small crater (8-GS-7). Because of its limited areal distribution, Ag is a potential ecological COC only at the drop tower site and the small crater.

Zinc (Zn) was detected in all 40 soil samples collected from SWMU 8 (Figure 4.3-14), but only 10 samples had concentrations above background (144 µg/g). The above-background detections occurred at two ditch locations (surficial), at two of the possible burn or disposal pits (surficial), at one west trench location (0.5 bgs), at the small crater location (surficial), and at the two drop tower locations (surficial and 0.5 bgs). The highest concentration (2,820 µg/g) was detected in the surface sample from the west side of the drop tower site (8-GS-3). Zinc concentrations may be the result of leaching from munitions debris scattered throughout the SWMU or the testing of M5 smoke pots at the drop tower. Zinc oxide is a component of these smoke pots. However, the selection of zinc as a COC may be conservative, since it is naturally abundant in the ore-producing areas in the Oquirrh Mountains.

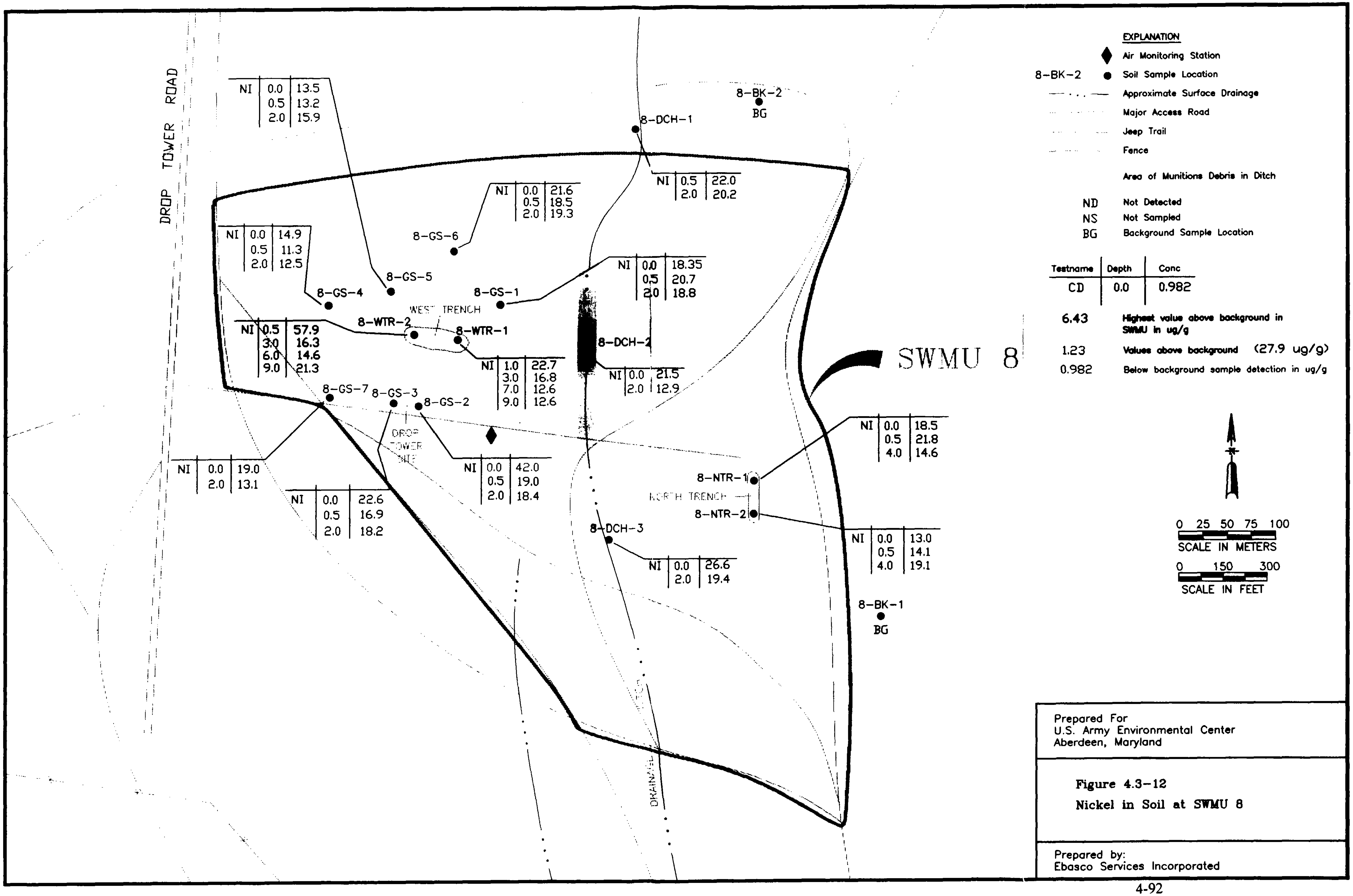
Detections above background in SWMU 8 soils are shown in Table 4.3-1.



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-11
Mercury in Soil at SWMU 8

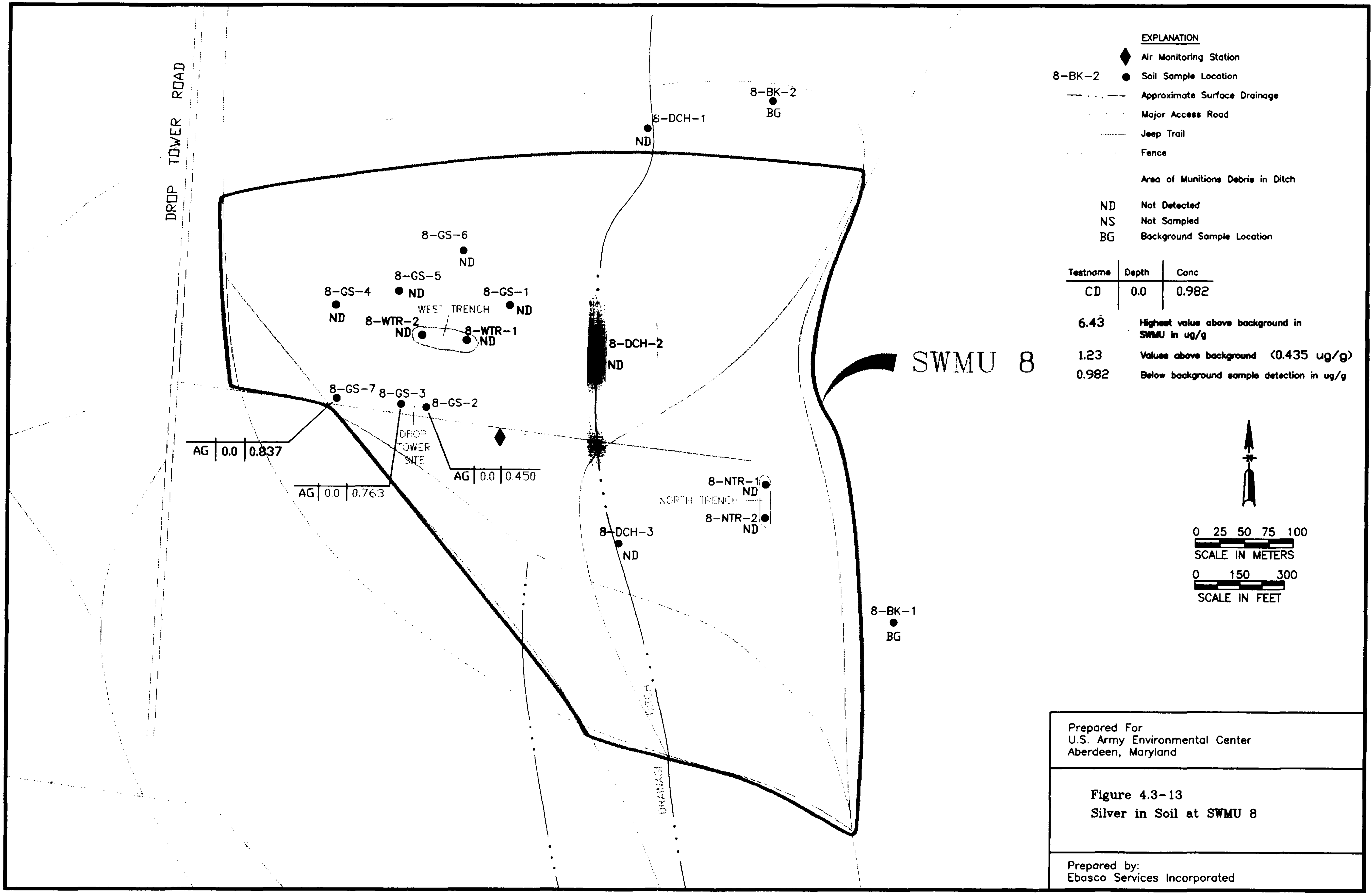
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-12
Nickel in Soil at SWMU 8

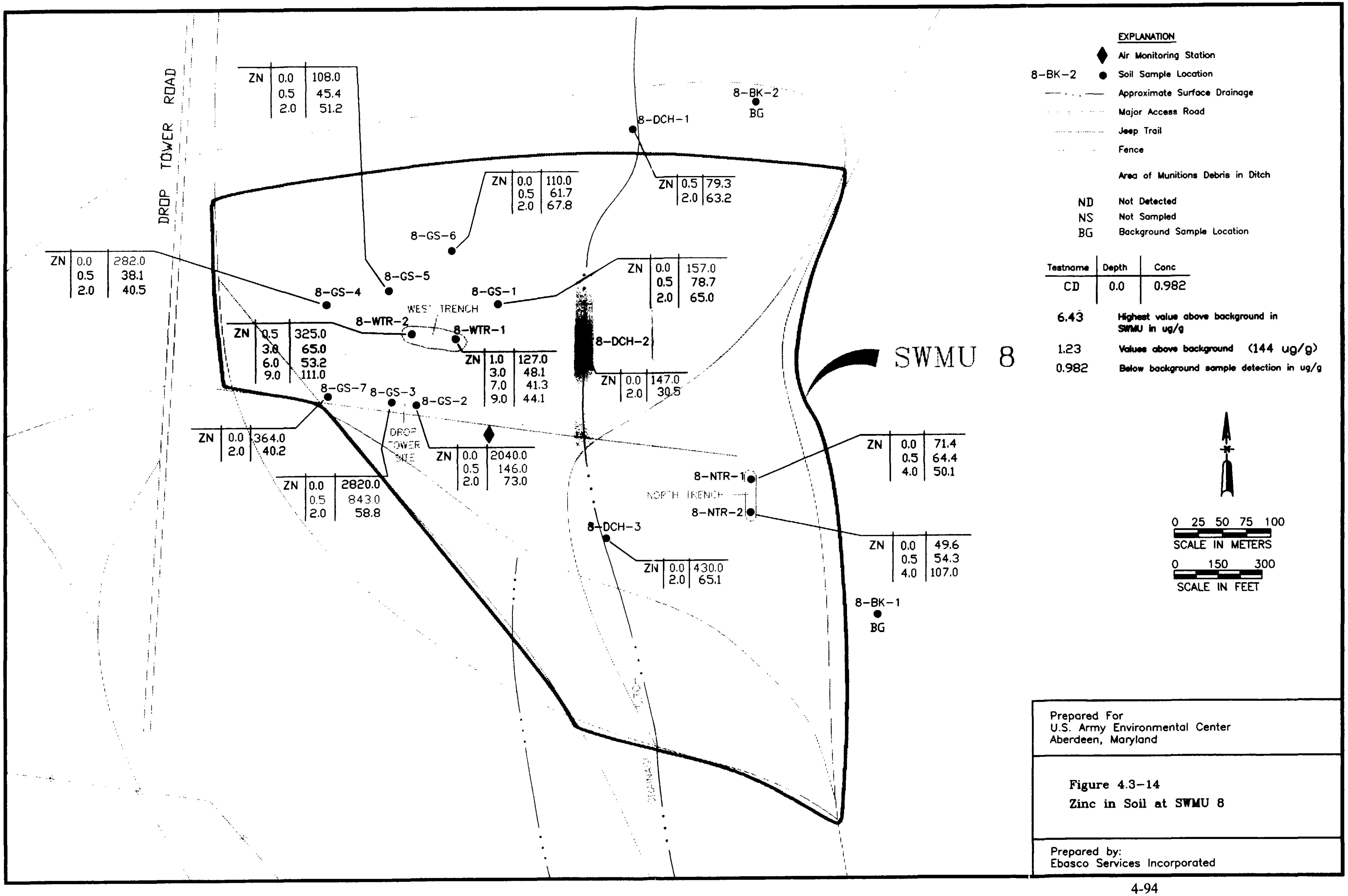
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-13
Silver in Soil at SWMU 8

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.3-14
Zinc in Soil at SWMU 8

Prepared by:
Ebasco Services Incorporated

Table 4.3-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 8

Page 1 of 2

Location	Analyte	Depth (ft)	Value (μg/g)	Units	Location	Analyte	Depth (ft)	Value (μg/g)	Units
8-GS-1	13DNB	0.000	0.233	UGG	8-GS-5	CU	0.000	56.8	UGG
8-GS-1	24DNT	0.000	0.053	UGG	8-GS-6	CU	0.000	44.3	UGG
8-GS-2	24DNT	0.000	2.31	UGG	8-GS-7	CU	0.000	231	UGG
8-GS-1	246TNT	0.000	0.456	UGG	8-WTR-1	CU	1.000	332	UGG
8-GS-2	AG	0.000	0.450	UGG	8-WTR-2	CU	0.500	557	UGG
8-GS-3	AG	0.000	0.763	UGG	8-DCH-2	CYN	0.000	0.412	UGG
8-GS-7	AG	0.000	0.837	UGG	8-GS-2	CYN	0.000	0.698	UGG
8-WTR-1	BA	1.000	1,550	UGG	8-GS-3	CYN	0.000	0.630	UGG
8-WTR-2	BA	0.500	4,300	UGG	8-WTR-2	CYN	0.500	0.440	UGG
8-GS-4	C16A	0.000	1.20	UGG	8-DCH-3	FE	0.000	17,900	UGG
8-DCH-1	C27	0.500	0.320	UGG	8-GS-6	FE	0.000	20,400	UGG
8-GS-5	C27	0.000	0.340	UGG	8-DCH-1	HG	0.500	0.317	UGG
8-DCH-1	C29	0.500	0.540	UGG	8-DCH-1	HG	2.000	0.245	UGG
8-GS-2	C29	0.000	1.00	UGG	8-DCH-2	HG	0.000	0.218	UGG
8-GS-2	C29	0.500	0.430	UGG	8-DCH-3	HG	0.000	0.306	UGG
8-NTR-1	C29	0.000	0.530	UGG	8-DCH-3	HG	2.000	0.315	UGG
8-NTR-2	C29	4.000	0.460	UGG	8-GS-3	HG	0.000	0.133	UGG
8-GS-6	C6H6	0.000	0.005	UGG	8-GS-3	HG	0.500	0.591	UGG
8-DCH-1	CCL3F	0.500	0.006	UGG	8-GS-2	HMX	0.000	2.52	UGG
8-DCH-1	CCL3F	2.000	0.007	UGG	8-GS-1	K	0.500	5,580	UGG
8-DCH-3	CCL3F	2.000	0.007	UGG	8-GS-3	K	0.500	5,250	UGG
8-GS-1	CCL3F	0.000	0.006	UGG	8-NTR-2	K	4.000	6,400	UGG
8-GS-7	CCL3F	0.000	0.007	UGG	8-WTR-1	MEC6H5	1.000	0.002	UGG
8-GS-7	CCL3F	2.000	0.008	UGG	8-GS-1	MG	0.000	19,000	UGG
8-DCH-2	CD	0.000	2.06	UGG	8-GS-1	MG	0.500	17,400	UGG
8-DCH-3	CD	0.000	1.65	UGG	8-GS-1	MG	2.000	17,000	UGG
8-GS-1	CD	0.000	1.635	UGG	8-GS-2	MG	0.000	16,700	UGG
8-GS-2	CD	0.000	6.43	UGG	8-GS-2	MG	0.500	16,700	UGG
8-GS-3	CD	0.000	6.14	UGG	8-GS-3	MG	0.500	15,900	UGG
8-GS-3	CD	0.500	1.47	UGG	8-GS-5	MG	2.000	18,900	UGG
8-GS-3	CD	2.000	0.625	UGG	8-GS-6	MG	0.000	19,100	UGG
8-GS-4	CD	0.000	2.07	UGG	8-GS-6	MG	0.500	16,500	UGG
8-GS-5	CD	0.000	1.23	UGG	8-GS-6	MG	2.000	17,300	UGG
8-GS-6	CD	0.000	1.07	UGG	8-GS-7	MG	0.000	17,800	UGG
8-GS-6	CD	0.500	0.654	UGG	8-WTR-1	MG	1.000	28,800	UGG
8-GS-6	CD	2.000	0.694	UGG	8-WTR-1	MG	7.000	17,200	UGG
8-GS-7	CD	0.000	4.85	UGG	8-WTR-1	MG	9.000	17,300	UGG
8-DCH-3	CO	0.000	7.89	UGG	8-WTR-2	MG	0.500	58,000	UGG
8-NTR-1	CO	0.000	7.01	UGG	8-WTR-2	MG	6.000	17,700	UGG
8-GS-2	CR	0.000	59.2	UGG	8-WTR-2	MG	9.000	19,400	UGG
8-GS-3	CR	0.000	43.5	UGG	8-DCH-1	MN	0.500	578	UGG
8-GS-7	CR	0.000	38.4	UGG	8-DCH-1	MN	2.000	572	UGG
8-WTR-2	CR	0.500	75.8	UGG	8-DCH-3	MN	2.000	481	UGG
8-DCH-2	CU	0.000	79.5	UGG	8-GS-5	MN	2.000	523	UGG
8-DCH-3	CU	0.000	67.8	UGG	8-NTR-2	MN	4.000	577	UGG
8-GS-1	CU	0.000	49.45	UGG	8-WTR-1	MN	1.000	496	UGG
8-GS-2	CU	0.000	260	UGG	8-NTR-2	NA	0.000	2,880	UGG
8-GS-3	CU	0.000	241	UGG	8-NTR-2	NA	4.000	5,730	UGG
8-GS-3	CU	0.500	43.2	UGG	8-DCH-2	NI	0.000	21.5	UGG
8-GS-4	CU	0.000	77.5	UGG	8-DCH-3	NI	0.000	26.6	UGG

Table 4.3-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 8

Page 2 of 2

Location	Analyte	Depth (ft)	Value (μg/g)	Units	Location	Analyte	Depth (ft)	Value (μg/g)	Units
8-GS-2	NI	0.000	42.0	UGG	8-GS-5	TL	2.000	34.3	UGG
8-GS-3	NI	0.000	22.6	UGG	8-WTR-2	TL	6.000	35.2	UGG
8-GS-6	NI	0.000	21.6	UGG	8-NTR-2	V	0.000	27.8	UGG
8-WTR-2	NI	0.500	57.9	UGG	8-DCH-2	ZN	0.000	147	UGG
8-GS-5	OMCTSX	0.500	0.043	UGG	8-DCH-3	ZN	0.000	430	UGG
8-WTR-1	OMCTSX	1.000	0.059	UGG	8-GS-1	ZN	0.000	157	UGG
8-DCH-2	PB	0.000	40.0	UGG	8-GS-2	ZN	0.000	2,040	UGG
8-GS-2	PB	0.000	73.0	UGG	8-GS-2	ZN	0.500	146	UGG
8-GS-3	PB	0.000	150	UGG	8-GS-3	ZN	0.000	2,820	UGG
8-GS-3	PB	0.500	40.0	UGG	8-GS-3	ZN	0.500	843	UGG
8-GS-7	PB	0.000	240	UGG	8-GS-4	ZN	0.000	282	UGG
8-WTR-1	PB	1.000	33.0	UGG	8-GS-5	ZN	0.000	108	UGG
8-WTR-2	PB	0.500	53.0	UGG	8-GS-6	ZN	0.000	110	UGG
8-GS-3	PHANTR	0.000	0.082	UGG	8-GS-7	ZN	0.000	364	UGG
8-GS-3	SB	0.000	25.5	UGG	8-WTR-2	ZN	0.500	325	UGG

μg/g microgrāms per gram
Note: Analyte names are defined in the chemical acronym list.

4.3.2.2 Air Contamination Assessment

Ambient air sampling was conducted at a station centrally located within SWMU 8 east of the drop tower site. Samples were analyzed from six 24-hour sampling events collected during the period of September 21, 1993 to October 1, 1993.

Low levels of methylene chloride were measured in two samples with a maximum concentration of 0.24 ppbv. Chloroform was also detected in two samples with a maximum concentration of 0.035 ppbv. This concentration is slightly above the method detection limit of 0.025 ppbv. Ambient concentrations of both of these analytes might be related to SWMU 8 source impacts.

Low levels (0.10 -0.75 ppbv) of various other volatile organic compounds were detected at SWMU 8, as well as at the other sampling stations located around TEAD-S, including the background station located on the northeast perimeter of the Depot. These analytes include 1,1,1-trichloroethane, carbon tetrachloride, benzene, methyl isobutyl ketone, toluene, ethyl benzene, and total xylenes. The low levels measured at SWMU 8 are similar to those recorded elsewhere and most likely represent the composition of the background airshed.

Several semivolatile organic compounds were detected in the field samples including naphthalene, di-n-butylphthalate, butylbenzylphthalate, and bis(2-ethylhexyl) phthalate. However, all these analytes were measured at comparable levels in the non aerated blank samples and thus, are most likely indicators of laboratory contamination.

Cyanide was detected once at a concentration of 0.73 µg/m3. Winds were northerly during the sample period and indicate that SWMU 8 may be a local source of cyanide. There were no detections of mercury or PCBs at SWMU 8 throughout the sampling program.

The total suspended particulate and metal results were not used due to laboratory and media problems. It was determined during subsequent laboratory analysis that the sample filters supplied to the field team were contaminated with high background levels of the target elements. This prevented the identification and quantification of metals in the ambient air. To offset this missing data, conservative assumptions were used in the human health risk assessment to estimate ambient concentrations of metal soil COCs resuspended in airborne particulates. Appendix I contains a complete listing of all air monitoring data.

4.3.3 Contaminant Fate and Transport

This section discusses the probable contaminant fate and transport processes and migration pathways that are operating at SWMU 8 based on site physical characteristics, contaminant chemical and physical characteristics, and the nature and extent of contamination in soil.

As outlined in Section 4.3.2, the release of organic and inorganic compounds at SWMU 8 has resulted in the contamination of site soil. While several compounds were identified as potential contaminants at SWMU 8, only those compounds identified as COCs in the risk assessment for SWMU 8 (Section 5.4-1) are described here. These include trichlorofluoromethane, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

4.3.3.1 Organic Compounds

Pentaerythritol tetranitrate (PETN) is a military munitions pollutant that exists in the pure form as crystalline prisms. It has a chemical formula of $C_5H_8N_4O_{12}$, and a molecular weight of 316.15. It has an aqueous solubility of 43 mg/L, making it slightly soluble in water. PETN has a vapor pressure of 1.0 x 10^{-10} mm Hg, and a Henry's law constant of 1.2 x 10^{-11} atm-m^3/mole. The octanol-water partition coefficient (K_{ow}) is estimated to be approximately 41; and the organic-carbon partition coefficient (K_{oc}) ranges from 179 to 1720. No data was located concerning biodegradation rates; however, the low octanol-water partition coefficient and moderate water solubility suggest that it does not bioconcentrate and therefore should be relatively degradable by soil and groundwater microorganisms.

PETN was released to the environment at SWMU 8 as a munitions waste product and has been detected in surface and subsurface soil at this site. Given the estimated range of K_{oc} values of 179 to 1,720, PETN will exhibit low to moderate mobility in soil depending on the organic carbon and clay content of the soil. The high clay content in the soils at SWMU 8 indicate probably low mobility is expected to occur due to the extended depth to the water table (approximately 75 to 85 ft bgs), and the low rate of precipitation and high evaporation at the site. However, if some PETN does leach to groundwater, stepwise hydrolysis to pentaerythritol and nitrate may be a possible fate process. In addition, given a solubility of 43 mg/L, and the low K_{ow} value of 41, there should be some biodegradation of this compound in groundwater.

Volatilization of PETN from soil to the atmosphere will not be an important fate process based on the extremely low vapor pressure of this compound. The small amount of PETN that may volatilize to the atmosphere will be expected to exist in the particulate form and be rapidly degraded by reaction with photochemically-produced hydroxyl ions brought into solution during periods of rainfall or seasonal snowmelt will not be expected to volatilize from water to the atmosphere due to PETN's extremely low Henry's law constant. In summary, given the chemical and physical properties of PETN and the geologic conditions at the site, PETN is not expected to be very mobile or extremely persistent; however, there may be some redistribution of PETN to deeper soil horizons given the right conditions and its persistence in soil will depend on the activity of microorganisms to cause degradation.

Trichlorofluoromethane (CCL3F), also known as Freon 11, is primarily used as a refrigerant, a foaming agent for polyurethane foams, and a solvent and degreaser. It has a water solubility of 1,080 mg/L and a vapor pressure of 803 mm Hg. The high vapor pressure indicates that Freon 11 is extremely volatile and exists in the vapor phase when released to the atmosphere. The Henry's law constant for this compound is 0.097 atm-m^3/mole, indicating rapid volatilization from water to air. The octanol-water partition coefficient is 339, and the organic carbon partition coefficient is 147, indicating moderate affinity for soil mineral and organic matter.

Based on these characteristics, it is expected that when Freon 11 is released to soil, a large portion of its mass will rapidly evaporate to the atmosphere because of its high vapor pressure. That fraction that does not evaporate will infiltrate the soil. Because of its high water solubility, moderate octanol-water partition coefficient, and low organic-carbon partition coefficient, Freon 11 is expected to be moderately to highly mobile in soil. A small fraction is expected to remain behind in soil organic matter and be sorbed to the clay-sized fraction. Biodegradation in soil is not expected to be significant, nor is degradation by photolysis or hydrolysis. It is therefore anticipated that the Freon 11 detected in SWMU 8 soils exists adsorbed to soil organic matter and to clay minerals. Accordingly, the likely migration pathways for Freon 11 appear to be restricted to transport as fugitive dust in surface soil and to slow desorption and volatilization to soil gas in subsurface soil.

4.3.3.2 Inorganic Compounds

Inorganic COCs at SWMU 8 consist of cadmium, chromium, copper, lead, mercury, nickel, and zinc. Cadmium, copper, lead, mercury, and zinc were found in sample locations across several areas of SWMU 8; chromium and nickel were found mainly in the west trench and drop tower areas. Detections of these compounds above site background were found primarily within the surficial and shallow subsurface (0.5 bgs) samples.

Because these COCs have negligible vapor pressures and do not biodegrade, their fate is determined primarily by their solubilities. Their inorganic solubilities determine whether they remain in soil in the solid phase (either as adsorbed complexes or solid precipitates) or dissolve under the influence of surface water and leach to subsurface soil. Based on site conditions at SWMU 8, it is anticipated that the mobility of these COCs by desorption, dissolution, and leaching will be very low for several reasons. First, these metals readily form solids (oxides, hydroxides, and carbonates) of low solubility, which reduce their mobility, even in the presence of water for extended periods of time. Second, these metals sorb strongly to soil organic matter and the silt- and clay-sized mineral fractions of soil that are abundant at TEAD-S. Third, the alkaline pH of soil at TEAD-S greatly reduces the potential for dissolution of the metals by rainwater or snowmelt and prevents the leaching of these metals to the subsurface. These conditions act in concert to keep site inorganic COCs stable in the solid phase. However, for these same reasons, the migration and redistribution of these COCs as fugitive dust or by particulate erosion from surface water runoff becomes a potentially significant migration pathway.

As a result, the fate of inorganic COCs in soil at SWMU 8 appear to be limited to particulate transport in surface soil.

4.4 SWMU 9

4.4.1 Background

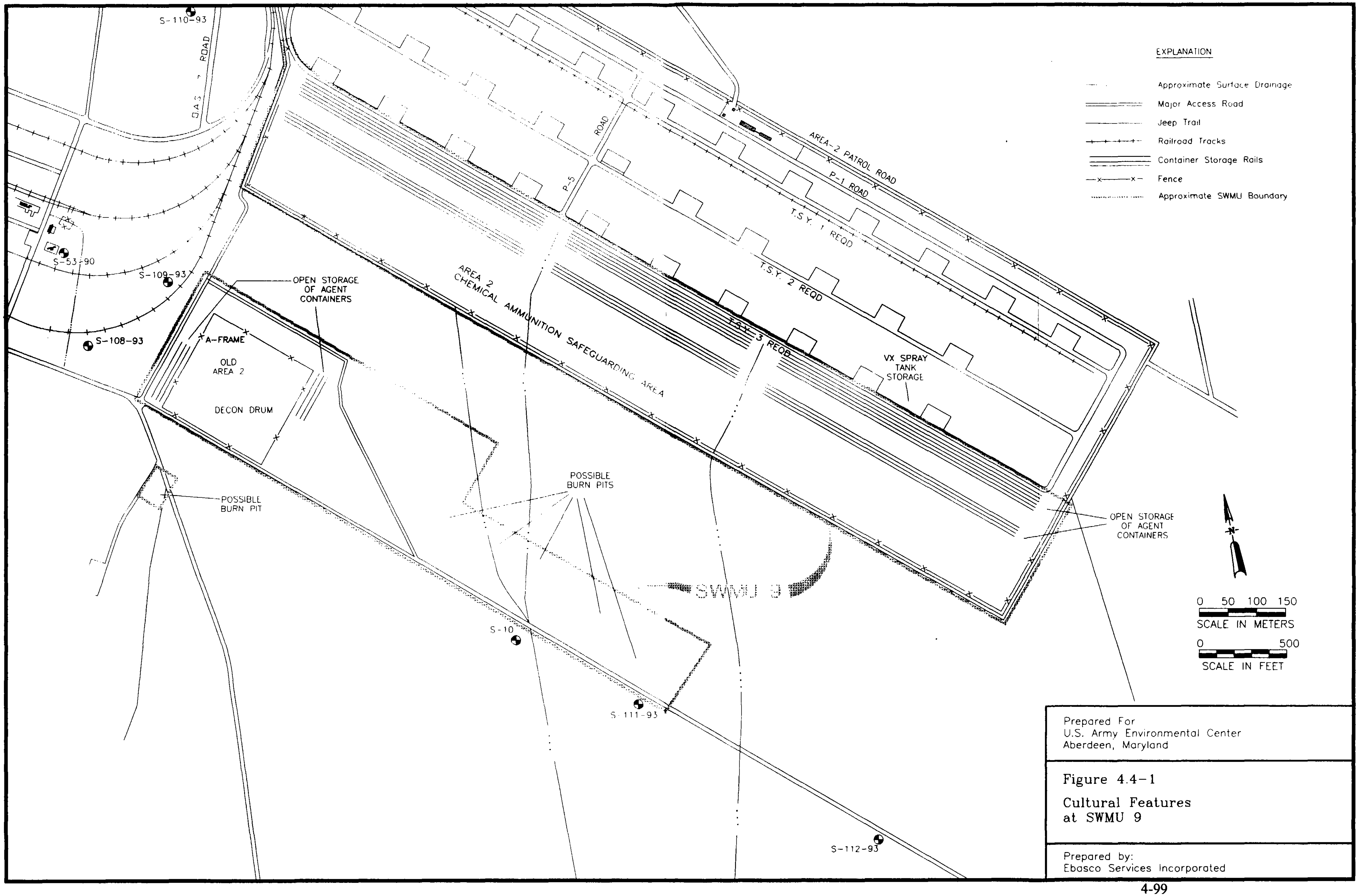
This section presents information on the site history and cultural features, geology and soil, and hydrology of SWMU 9.

4.4.1.1 Site History and Description of SWMU 9: Area 2 (Including Mustard Holding and Pit Areas)

SWMU 9 includes the former open-storage portion of the Area 2 chemical munitions safeguarding area and Old Area 2 located to the southwest of Area 2. The SWMU also includes an area southeast of Old Area 2 that reportedly contained burn pits (Figure 4.4-1). SWMU 9 is no longer used for agent storage.

Ertec (1982) indicated that Sarin (GB), incendiary powder, and WP were stored at the former mustard holding area within SWMU 9, but it is unclear whether this storage was in Old Area 2 or Area 2. According to the IA (USATHAMA 1979), Area 2 was used to store munitions containing mustard, possibly V and VX (nerve agents), chemical agent identification sets, and war gas identification sets. Weston (1991) described Area 2 as 23 chemical munitions storage buildings and an open area where 1-ton containers of mustard, GB, and VX were stored on rails (Figure 4.4-2). According to former TEAD-S employees (Norris 1993b), the rails were emplaced in 1967 to hold canisters from Area 10 at TEAD-S as well as from Rocky Mountain Arsenal. VX spray tanks were reportedly stored on ties between the buildings in Area 2, while the GB and mustard containers were stored on 10 pairs of rails south of the buildings in an area that was approximately 0.75 mi long. Signs beside the rails indicated that phosgene (CG) and mustard (H) were stored in this area. Open storage continued in Area 2 until 1974, when the containers were transferred back to Area 10 and to newly constructed bunkers in Area 9. Former TEAD-S employees stated that GB containers leaked the most, although leaking mustard containers were taken to SWMU 3 for renovation in the late 1960s or to SWMU 1 for disposal (Norris 1993b).

Old Area 2 is located southwest of Area 2 and was used to store M70 bombs, mustard, chemical agent identification sets, and a limited number of 1-ton containers of mustard and lewisite prior to 1967. According to Norris (1993b), there were two or three sheds at the south end of Old Area 2 that contained 1-ton containers of mustard and CG. Metal grating was used for road stabilization for trucks transporting containers to and from the buildings (Figure 4.4-3). Norris (1993b) states that several of the mustard containers leaked onto the ground by the sheds. EPIC (1982) described Site 27 (Old Area 2) in a 1974 aerial photograph as a storage or disposal area consisting of many shallow trenches or linear, revetted storage sites with storage racks and small containers or objects. By 1981, aerial photographs indicated that some of the stored or discarded objects had been removed. By 1986, aerial photographs showed that all of the stored containers had been removed. According to the 1A (USATHAMA 1979), Old Area 2 contained leaking mustard munitions that were disposed of by burning. The locations where leaks occurred were decontaminated with bleach and sodium hydroxide and the area was disced to mix the soil and



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-1
Cultural Features at SWMU 9

Prepared by:
Ebasco Services Incorporated

Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-2

Protective Equipment Sign in open storage portion of Area 2 in SWMU 9.

Prepared by:
Ebasco Services Incorporated

Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-3

Partially Buried Metal Grating in Old Area 2 within SWMU 9.

Prepared by:
Ebasco Services Incorporated

decontamination solutions. The entire area was fenced with wooden posts and signs was posted that warned of the presence of toxic chemicals (USATHAMA 1979). The IA (USATHAMA 1979) states that surveillance testing of CK (cyanogen chloride, a blood agent) and CG occurred at Old Area 2; however, this testing only involved sampling the CK-filled bombs and sending the samples to the chemical laboratory at Building 541 or checking the CG-filled bombs for leaks. In addition, CK bombs were reportedly frozen in a freezer in Old Area 2 to immobilize the agent and allow valves in the bombs to be changed (Norris 1993b). The bombs were reportedly held during the valve replacement using a steel frame that is still present in Old Area 2 (Figure 4.4-4) (Norris 1993a).

The presence of trenches indicated to the east of the fenced portion of Old Area 2 in a 1974 aerial photograph (EPIC 1982). Weston (1991) identified the trenches to the east of Old Area 2 as burn trenches; however, it is not known whether the leaking mustard munitions mentioned in the IA were burned in these trenches or at another location.

During the RFI-Phase II program a different perspective of the area was obtained a non-intrusive on-intrusive EMI geophysical survey did not detect any evidence of trenches or burn pits in the suspected burn trench area. Field reconnaissance of the area indicated that it may have been used for additional open storage of containers instead of for burning wastes. Elevated pads with some remnants of railroad ties were found along with stacks of sheet metal and railroad rail sections driven into the ground for apparent use as tie-downs for buildings.

The VX spill reported in the IA (USATHAMA 1979) at the Impounding Bay in the southeast corner of former Storage Area 2 (Area 2) is believed to have actually occurred in SWMU 3. An additional pit where dunnage was reportedly burned (Figure 4.4-5) was located by former TEAD-S employees slightly south of Old Area 2 (Norris 1993b).

4.4.1.2 Geology and Soil at SWMU 9

The geology and soil at SWMU 9 were characterized using a total of 30 shallow borings 10 test pit excavations, and deep borings for three monitoring wells. The depth for the test pits ranged from 3 ft to 10 ft; soil borings were all drilled to a maximum depth of 3 ft. In addition, two new monitoring wells (S-111-93, S-112-93) were installed along the southern SWMU 9 boundary. A third monitoring well (S-110-93) was installed upgradient of Area 2 to aid evaluation of groundwater conditions at SWMU 9. These well borings extended from depths of 83.6 ft to 85.0 ft (S-112-93). The soil sample and monitoring well locations are shown in Figure 3.7-5.

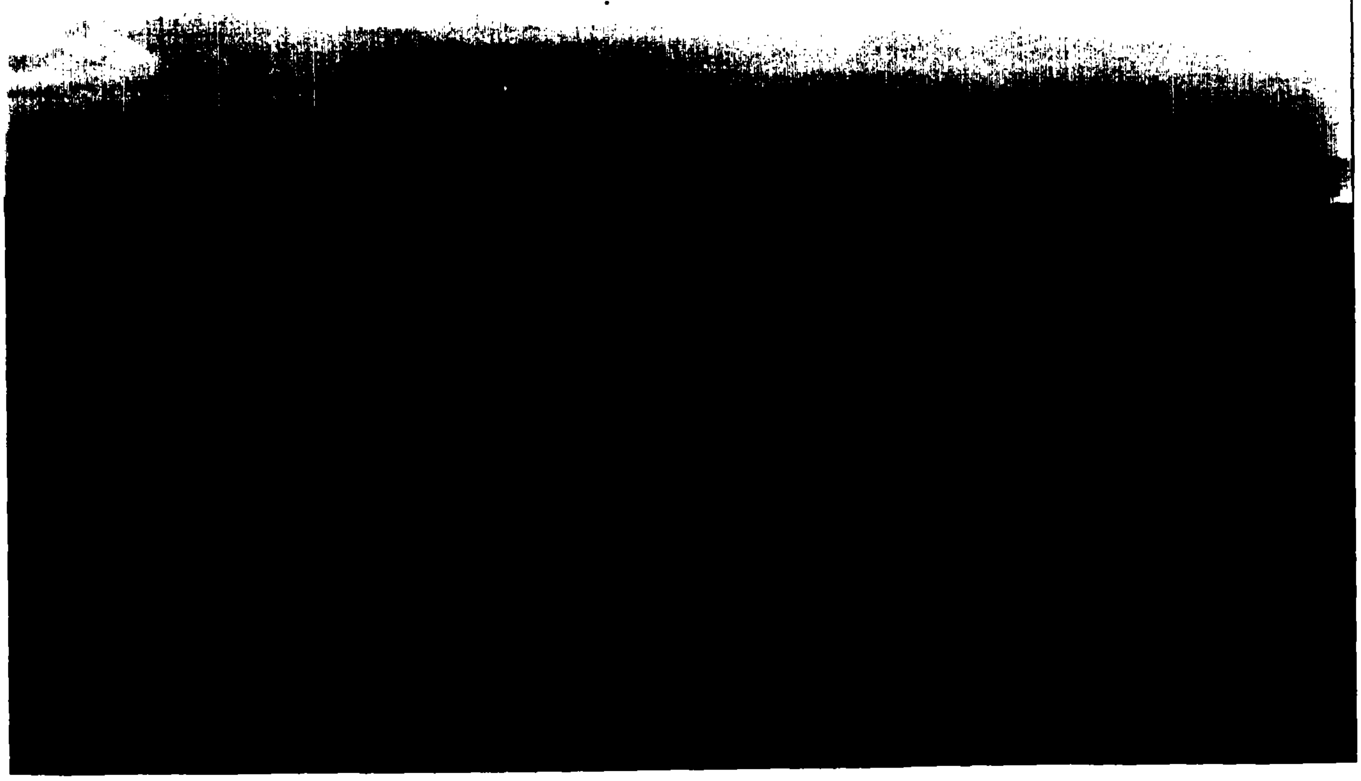
The overall geology of the upper 10 ft of soil in SWMU 9 is that of lacustrine material composed of very fine-grained material, classified as silty clay (CL) and clayey silt (ML). Varying amounts of fine- to coarse-grained sand are usually observed in these materials and may occur at any location within SWMU 9. In localized areas, in fact, sand may be the dominant soil type. In these instances, the sand is mixed with silt or clay for a few ft. These layers may be seen at or below the ground surface.

Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-4

Steel Frame used to hold CK-Filled Bombs in Old Area 2 within SWMU 9.

Prepared by:
Ebasco Services Incorporated



Prepared For:

U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-5

Suspected Dunnage Burn Pit Location
South of Old Area 2 in SWMU 9.

Prepared by:
Ebasco Services Incorporated

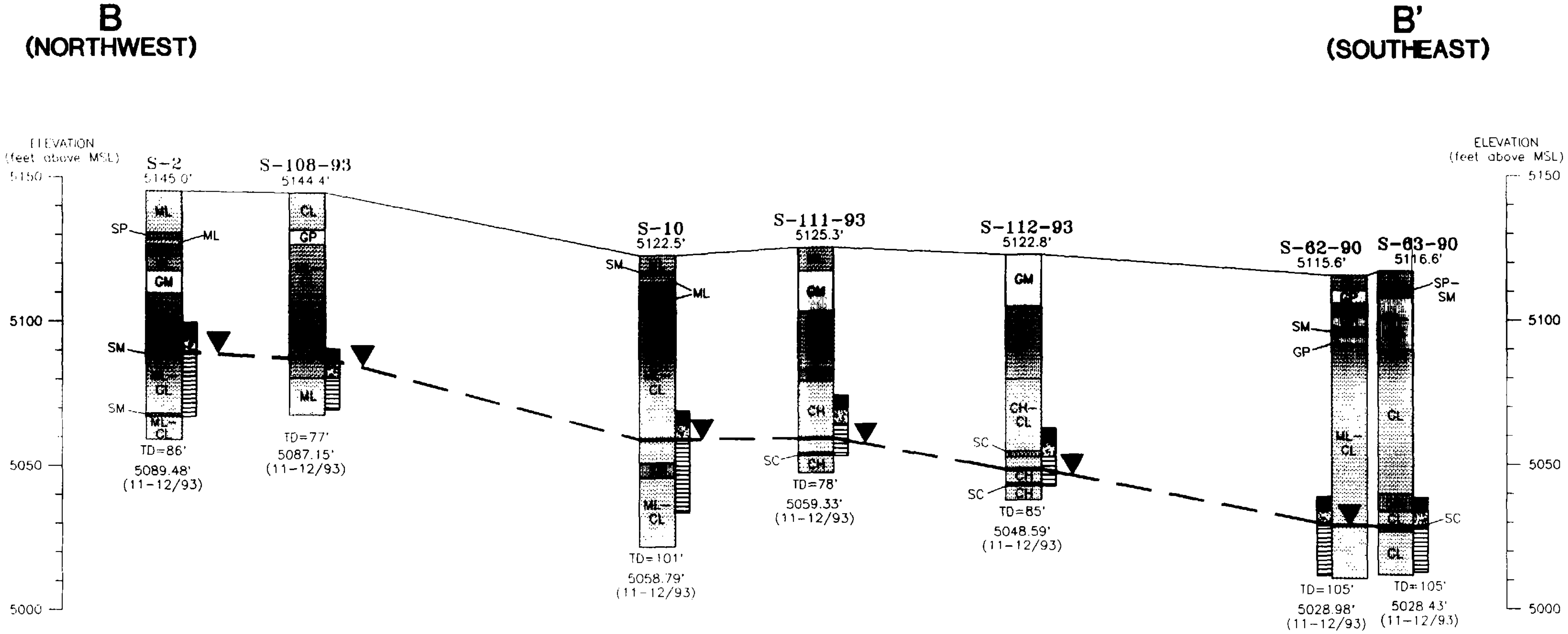
Thin gravel layers typically occur with the silt and clay in Area 2 along the northern portion of SWMU 9. Much of the gravel in the upper 0.5 ft most likely results from human activities, such as the use of gravel in the creation of the adjacent gravel road or as a stabilizer for the rails in the open storage area. In addition, gravels become more common at depth further east and south. In the background borings and wells S-111-93 and S-112-93, thin gravel layers or lenses are present.

The moisture content for the soil was relatively low, with conditions varying from dry to moist. The silty clay or clayey silt soil is unconsolidated and fissile. Detailed boring logs can be found in Appendix A1.

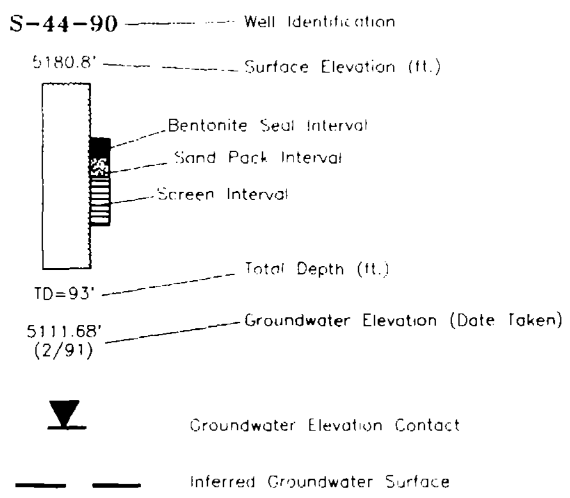
A summary of the new monitoring well bore logs indicates an upper fine-grained silty clay (CL) to clayey silt (ML) that extends to a depth of 13.0 ft in three locations (S-108-93, S-109-93, and S-111-93). Outside the northwest boundary of SWMU 9, the entire 83-ft length of the S-110-93 boring consists of similar silty clay (CL) and clayey silt (ML). The only notable changes in lithology at this location are trace amounts of gravel found in the 8.0- to 22.0-ft section and one 2-ft layer of clayey sand (SC) approximately 50 ft bgs. The upper material at monitoring well location S-112-93, which extends from 0 to 17.0 ft, is a silty gravel (GM), rather than a finer-grained CL or ML. This gravel zone varies from being silty to more sandy, and may be a distinct layer that thickens from 5.5 ft in the west (S-108-93) to 17 ft (S-112-93) in the southeast along the southern edge of SWMU 9. This layer also appears to thicken to the northeast, where it is approximately 15 ft thick in well S-109-93. Below this gravel layer, the remaining soil is either silty clay or clayey silt of varying degrees of low to high plasticity (i.e., CH, CL, or ML). Occasionally a small layer or lens of silty sand (SM) is encountered. The largest such zone is approximately 4 ft thick in well S-111-93. However, it is not traceable to the other locations. No sandy zones are observed in the fine-grained material in well S-108-93. Figure 4.4-6 is a stratigraphic cross section from SWMU 5 to SWMU 3 that shows the lateral variability of the sediment, including the water-bearing zones, across SWMUs 3, 5, and 9. The location of this cross section is shown in Figure 4.2-9 (p. 4-44).

The moisture conditions in the well borings were mostly damp to moist, except in the water-bearing zones, which were typically found in ML soils at approximate depths of 65 to 75 ft bgs. The borings were advanced to material below the water-bearing zones, at which point the material again became damp to moist. The consistency/density of this soil also extended over a large range of conditions from soft to hard and loose to very dense. Detailed boring logs can be found in Appendix A1.

The geotechnical testing for SWMU 9 was performed on samples from the two background locations. In addition, samples from the saturated zone in two monitoring wells (S-110-93, and S-111-93) were submitted for selected geotechnical and geochemical analyses. The results of the aquifer characterization are discussed later in this section.



LEGEND

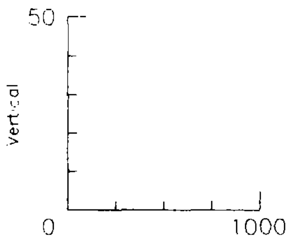


▼ Groundwater Elevation Contact

— — Inferred Groundwater Surface

UNIFIED SOIL CLASSIFICATION SYMBOL (SOIL TYPE)

CH – High Plastic Clay
CL – Low Plastic Clay
GM – Silty Gravel
GP – Poorly Graded Gravel
GW – Well Graded Gravel
ML – Low Plastic Silt
SC – Clayey Sand
SM – Silty Sand
SP – Poorly Graded Sand



Horizontal
Scale in Feet
Vertical Exaggeration 20X

Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-6

Geologic Cross Section B-B'

Prepared by:
Ebasco Services Incorporated

Background sample 9-BK-1 was identified as a moist SM-SC soil (12.7 percent moisture content). The coefficient of permeability (7.4 x 10^{-5} cm/sec) and effective porosity, (9.7 percent) reflect the significance of the clay content and the water present. A bulk density of 85 pcf was obtained. Both background samples (9-BK-2 and 9-BK-1) were slightly alkaline, with pH values of 7.78 and 8.43, respectively. The geochemical results for TOC vary from 0.29 to 0.81 percent. The higher value came from a sample that was a composite of 0 to 2.0 ft from 9-BK-2. A single CEC analysis was performed on 9-BK-1 with a result of 18 meq/100 g.

The four well borehole soil samples were obtained over a continuous 1.5- to 4.0-ft interval at or above the screened interval. Portions of the interval were analyzed for only one characteristic, as some of the analyses required undisturbed samples. No porosity or permeability tests were performed because insufficient undisturbed samples were recovered for these tests. All the samples were classified as CL according to the USCS, and the moisture contents were generally high (20.7 to 46.6 percent). The bulk density of these samples ranged from 76 to 103 pcf; with the 76-pcf sample being the most saturated. Generally, the higher the observed moisture content, the lower the bulk density. Each sample exhibited slightly to moderately alkaline conditions, with pH values ranging from 7.92 to 8.94. TOC values were very low (0.052 to 0.07 percent). CEC values were typical, ranging from 14 to 24 meq/100g. Full details on the these characteristics can be found in Appendix A4.

Unpublished information on soil types at SWMU 9 indicated two units are present. These units are the Taylorsflat loam and the Tooele fine sandy loam. The Tooele loam exhibits moderately rapid permeability, while the Taylorsflat soil exhibits moderately low permeability. Both soil types are slightly saline and moderately alkaline at the surface, with an increase in both characteristics with depth. The potential uses for each soil include wildlife habitat and livestock grazing and rangeland seeding in the Taylorsflat, while possibly a few types of irrigated crops may be viable in the Tooele loam. These soil types are both susceptible to wind and water erosion.

4.4.1.3 Site Hydrogeology

SWMU 9 is located on a southwest- to south-southwest sloping topographic surface. Surface runoff may be channeled into the drainage ditches that run south out of Area 2, or may occur as sheet-flow across the surface of the clayey soil in the area.

RFI-Phase II included installation of five new monitoring wells in the SWMU 9 area, including two downgradient from SWMU 5. Well construction details for these wells are provided in Table 3.9-1. The saturated zone for the new wells correlates with the saturated interval encountered in the previously installed wells. Groundwater levels were obtained for all wells during two rounds of water-level measurements (see Table 3.10-1). Using this data, as well as information from the prior investigations, generalized groundwater elevation maps of this area were created (see Figures 3.10-1 and 3.10-2). The groundwater elevations from the northern SWMU 5 area to the southern-most wells at SWMU 3 ranged from approximately, 090 ft to 5,030 ft above msl. The depth to water in the Group 2 SWMU areas, excluding SWMU 30, ranges from 60 to 90 ft below ground surface.

Groundwater flow is primarily to the south-southeast (see Figures 3.10-1 and 3.10-2). The average horizontal hydraulic gradient for this SWMU is 0.0075. The gradient is calculated on a line through monitoring wells S-10 and S-110-93.

Slug tests were conducted in the three new monitoring wells at SWMU 9 to estimate the hydraulic conductivity of the water-bearing zone in the vicinity of each new well. These hydraulic conductivity (K) values were obtained using rising head test data analyzed by the Bouwer and Rice method (1976). The calculated hydraulic conductivity values are 2.02×10^{-4} ft/min, 1.49×10^{-3} ft/min, and 2.99×10^{-5} ft/min for wells S-110-93, S-111-93, and S-112-93, respectively. These results are typical of clay, silt, and silty fine-grained sand (Freeze and Cherry 1979), such as were encountered in the SWMU 9 wells.

A seepage velocity was calculated along a flow path across SWMU 9 from well S-110-93 to well S-10. Seepage velocity is the average velocity at which groundwater flows for a given gradient and aquifer permeability. Using the average hydraulic conductivity of the three wells (0.83 ft/day), a hydraulic gradient of 0.0075, and effective porosities of 2 and 10 percent, seepage velocities of 0.062 ft/day and 0.311 ft/day were obtained. Given these velocities, it would take several thousand years for groundwater contamination from SWMU 9 to reach the southern boundary of TEAD-S.

4.4.2 Nature and Extent of Contamination

This section describes the nature and extent of contamination at SWMU 9. It should be noted that in the assessments of soil and groundwater contamination only those COCs of potential risk to human or ecological receptors are described in detail. Human health COC selection for SWMU 9 is detailed in Sections 5.5.1. Ecological COC selection for all Group 2 SWMUs is discussed in Section 6.3.

4.4.2.1 Soil Contamination Assessment

This section summarizes the chemical analytical results of the RFI-Phase II field sampling programs as well as those conducted previously at SWMU 9. The RFI-Phase II results and evaluations are grouped by analyte, with significant detections discussed by location within the SWMU. The sample locations are shown on individual contaminant maps (Figures 4.4-7 though 4.4-13). The complete chemical data for the RFI-Phase II soil samples can be found in Appendix F1.

Although this section presents an evaluation of all of the analytical data collected, the discussion focuses on the results for the human health and ecological COCs at SWMU 9 that are being evaluated in the risk assessments. The COCs for SWMU 9 include three organic compounds (di-n-butylphthalate, or DNBP, toluene, or MEC6H5, and trichlorofluoromethane, or CCL3F) and six metals: arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), and zinc (Zn).

Previous Investigations

Prior to the RFI-Phase I, sampling of SWMU 9 included the collection of soil samples from Old Area 2 and sediment samples from the drainage ditches.

Soil and sediment samples collected prior to the RFI-Phase I from SWMU 9 included 11 from the area of mustard spills in Old Area 2 and 3 from drainages southeast of Old Area 2. The spill area soil samples were collected from 1 to 3 ft bgs, and the stream sediment samples were collected at a depth of 1 to 1.5 ft bgs. These samples were analyzed for metals, SVOCs, and agent breakdown products. Chromium, copper, and nickel were detected above background at all sample locations. Silver was also detected above background at one location in Old Area 2.

During the RFI-Phase I, one background soil sample was collected near well S-10. No metals were detected above background in this sample.

RFI-Phase II Results

Sampling locations were selected in three distinct areas of SWMU 9: the open container storage area within the chemical ammunition safeguarding area (Area 2), the mustard holding area (Old Area 2), and several possible burn pit locations. There were a total of 131 soil samples collected at SWMU 9.

In Area 2, 62 soil samples were collected from 18 locations. Four sample locations were in drainage ditches and ranged in depth from surficial to 2 ft bgs. Samples were collected at the remaining 14 locations in the open storage area within Area 2 from the surface to 4 ft bgs. Samples collected from Area 2 locations were analyzed for VOCs, SVOCs, agent breakdown products, and metals. The ditch samples were also analyzed for explosives.

In Old Area 2, 48 surficial and subsurface soil samples were collected from 12 locations within and around the fenced area. Subsurface samples were collected at depths of 0.5, 2, and 4 ft bgs. The samples were analyzed for VOCs, SVOCs, agent breakdown products, and metals.

Six possible burn pit locations were trenched and samples collected from depths ranging from 0 to 9 ft bgs. These samples were analyzed for VOCs, SVOCs, explosives, agent breakdown products, and metals. In addition, four of the samples were analyzed for dioxins and furans.

The risk assessment for SWMU 9 has identified six metals (As, Cd, Cu, Pb, Hg, and Zn) as human health and ecological COCs. Di-n-butyl phthalate, toluene, and trichlorofluoromethane have also been identified as human health COCs for SWMU 9.

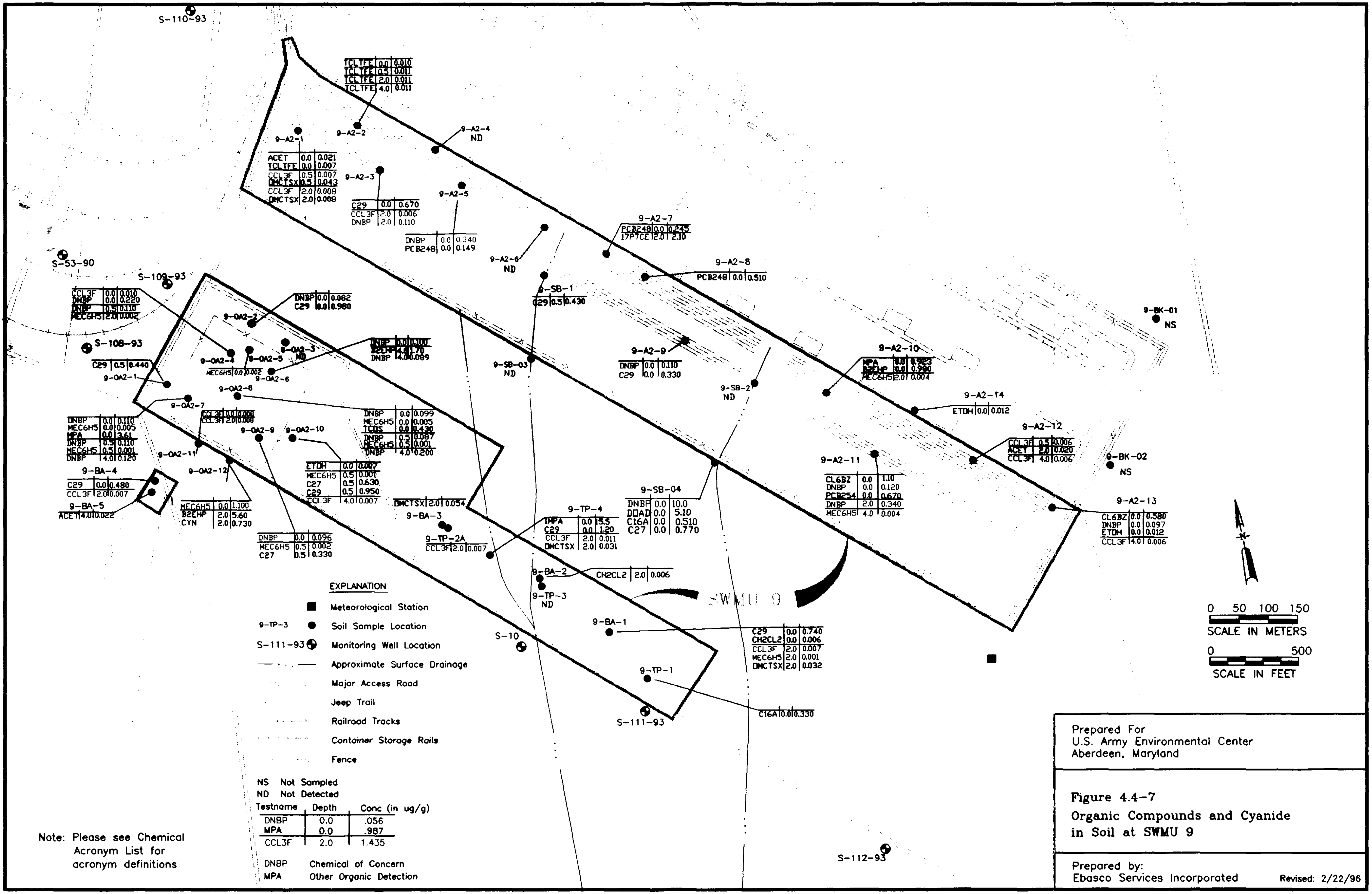
Organic Compounds and Cyanide

Different organic compounds were detected in the three areas at SWMU 9. In Area 2, sixteen organic compounds were detected. Target analytes organic compounds detected were bis (2-ethylhexyl) phthalate (B2EHP), hexachlorobenzene (CL6BZ), di-n-butylphthalate (DNBP), toluene (MEC6H5), methylphosphonic acid (MPA), polychlorinated biphenyls (PCBs), and acetone (ACET). Non-target organic compounds detected in Area 2 were trichlorofluoromethane (CCL3F) 1,1,2-trichloro-1,2,2-trifluoroethane (TCLTFE), octamethylcyclotetrasiloxane (OMCTSX), 1,7-pentatriacontene (17PTCE), ethanol (ETOH), dioctyl adipate (DOAD), hexadecanoic acid (C16A), and heptacosane (C27). Seven of these organic compounds (B2EHP, CCL3F, C27, DNBP, ETOH, MEC6H5, and MPA) were also detected in Old Area 2, along with the non-target analytes tetracosane (TCOS), and nonacosane (C29). Isopropyl methylphosphonic acid (IMPA), methylene chloride (CH2CL2), CCL3F, MEC6H5, OMCTSX, DNBP, MPA, B2EHP, ACET, C16A, and C29 were detected in the burn pit area. However, no dioxin or furan detections occurred in the four samples collected at the burn pit locations. Of these compounds, only DNBP, MEC6H5, and CCL3F were identified as human health COCs at SWMU 9. There were no organic ecological COCs at SWMU 9.

The results of the analyses indicate a varied distribution of the different compounds. There were 19 detections of DNBP in SWMU 9 (Figure 4.4-7). However, it was not detected at any of the potential burn pit locations, and the maximum concentration of DNBP (10.0 µg/g) in SWMU 9 occurred in a surficial sample collected in the drainage ditch on the south edge of Area 2 (9-SB-4). Within Area 2 there were six detections of DNBP. Four of these detections occurred in surficial samples, and two occurred in subsurface samples (2 ft bgs). There is no apparent pattern to the distribution of DNBP at Area 2. At Old Area 2, there were 12 detections of DNBP. They occur at depths ranging from 0 to 4 ft bgs and are concentrated within the fenced area. There was only one detection of DNBP outside the fence on the north side; this detection occurred in the surficial sample.

There were 12 detections of toluene (MEC6H5) at SWMU 9 (Figure 4.4-7). One of these detections occurred in a subsurface sample (2 ft bgs) at a burn pit location. No other detections occurred in the potential burn pit areas. At Area 2, two toluene detections occurred in subsurface samples (2 and 4 ft bgs) at two different sample locations on the eastern side of Area 2. Seven toluene detections occurred within the fence at Old Area 2 in both surficial and subsurface (0.5 bgs) samples. Outside the fence, it was detected in a subsurface sample (0.5 bgs) at a sample location on the east side of the fenced area. The highest concentration of toluene (1.1 µg/g) was detected in a surficial sample located to the south of the fenced area at Old Area 2 (9-OA-12).

Fourteen detections of CCL3F were measured at SWMU 9 (Figure 4.4-7). The highest concentration (0.011 µg/g) occurred in a subsurface sample (2 ft bgs) collected from a probable burn pit location (9-TP-4). Three other detections of CCL3F occurred in three possible burn pit sample locations in subsurface samples (2 ft bgs). At Old Area 2, CCL3F was detected in one sample location (surficial) inside the fenced area and at another sample location on the south side



Note: Please see Chemical Acronym List for acronym definitions

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-7
Organic Compounds and Cyanide in Soil at SWMU 9

Prepared by:
Ebasco Services Incorporated

Revised: 2/22/96

F:\PROJECTS\TOOELE\ARCAD\SWMU9\SWMU_9G.DWG of the fence area (both surficial and 2 ft bgs). On the east side of the fenced area in Old Area 2, CCL3F was detected at one location in a subsurface sample (4 ft bgs). At Area 2, three detections in subsurface samples occurred at two locations on the western edge of the area (one at 0.5 bgs and two at 2 ft bgs), and three detections occurred at two locations on the eastern edge of the area (one at 0.5 bgs and two at 4 ft bgs).

Cyanide was detected in only one soil sample at SWMU 9 (Figure 4.4-7). It was detected at 0.731 µg/g on the south side of Old Area 2 in 9-OA-12 at a depth of 2 ft.

Metals

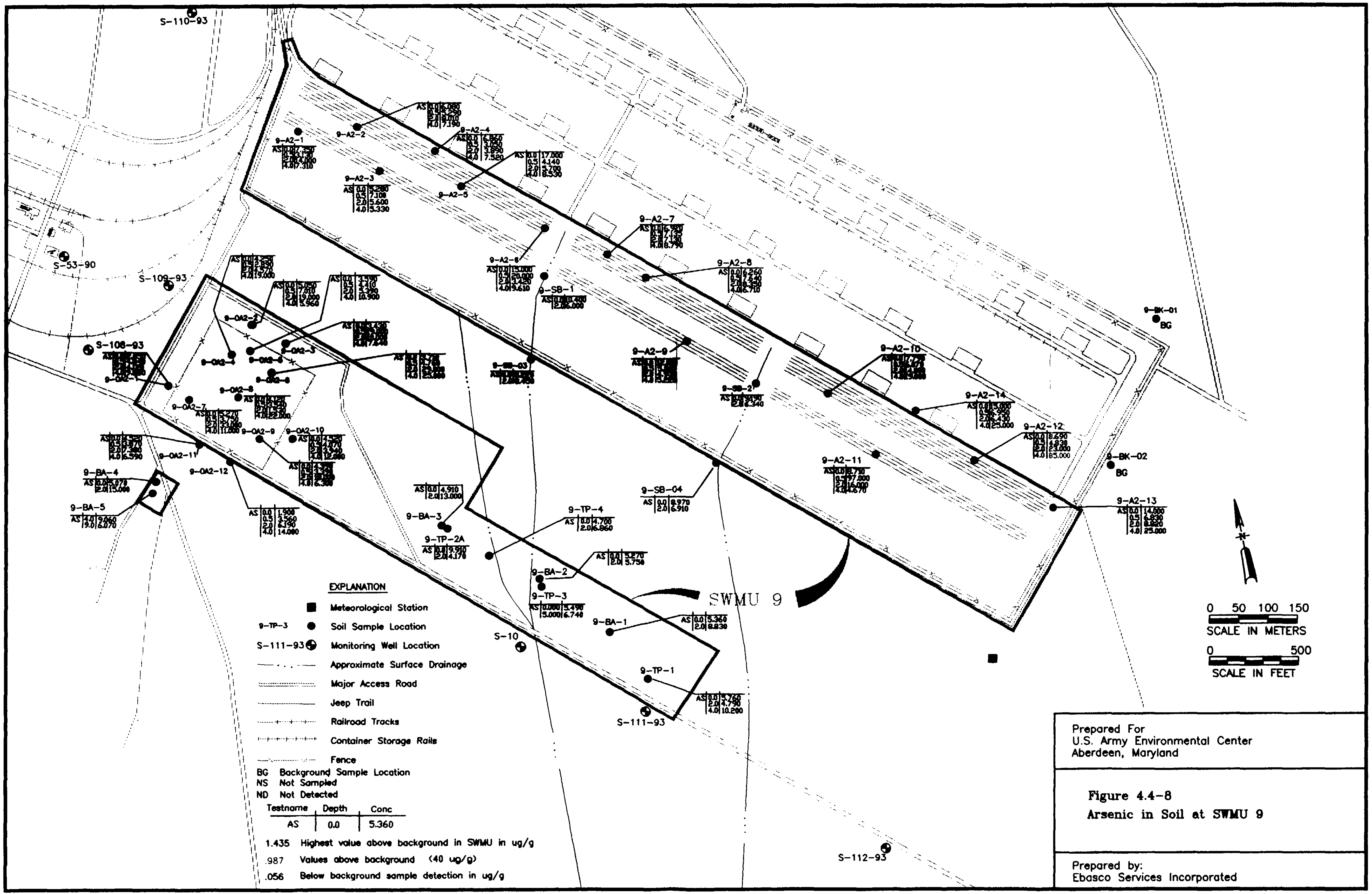
Like organic compounds, the distribution of metals varied among the three areas within SWMU 9. In Area 2 eight metals were detected: antimony (Sb), arsenic (As), beryllium (Be), cadmium (Cd), cobalt (Co), lead (Pb), magnesium (Mg), and mercury (Hg). In Old Area 2, five of these metals (Be, Cd, Mg, Pb, and Sb) were detected, along with potassium (K) and manganese (Mn). In the burn pit area, two of these metals (Mg and Mn) were detected along with copper (Cu) and zinc (Zn). Neither chromium (Cr) nor nickel (Ni), which were detected during the remedial investigation (Weston 1991), were detected above background levels at Old Area 2 during the RFI-Phase II sampling. Based on the risk assessments, six metals (As, Cd, Cu, Hg, Pb, and Zn) were selected as COCs at SWMU 9.

Arsenic (As), a human health and ecological COC, was detected above background (40.0 µg/g) in only two sample locations at SWMU 9 (Figure 4.4-8). Both of the locations are in the eastern portion of Area 2. The maximum concentration (97.0 µg/g) occurred in a subsurface sample (0.5 bgs) at sample location 9-A2-11. Arsenic is not considered a SWMU-wide COC, but is a potential COC for the eastern portion of Area 2.

Cadmium (Cd), a facility-wide ecological COC, was detected above background (0.98 µg/g) at only three locations in SWMU 9 (Figure 4.4-9). It was detected in a surficial sample at one location in Old Area 2 and in a subsurface sample (4 ft bgs) at another location. The maximum concentration (3.39 µg/g) was detected in a surficial sample in Area 2 (9-A2-14). This sampling location was near a reported VX spray tank storage site.

Copper (Cu) is a human health and ecological COC that was detected above background (27.6 µg/g) only in the burn pit area (Figure 4.4-10). There were three detections of copper in this area: two of the detections occurred in surficial samples; and one in a subsurface sample (2 ft bgs). The highest concentration of Cu (966 µg/g) was detected in the surficial sample at sample location 9-BA-1. Copper is considered a COC for that sample location only.

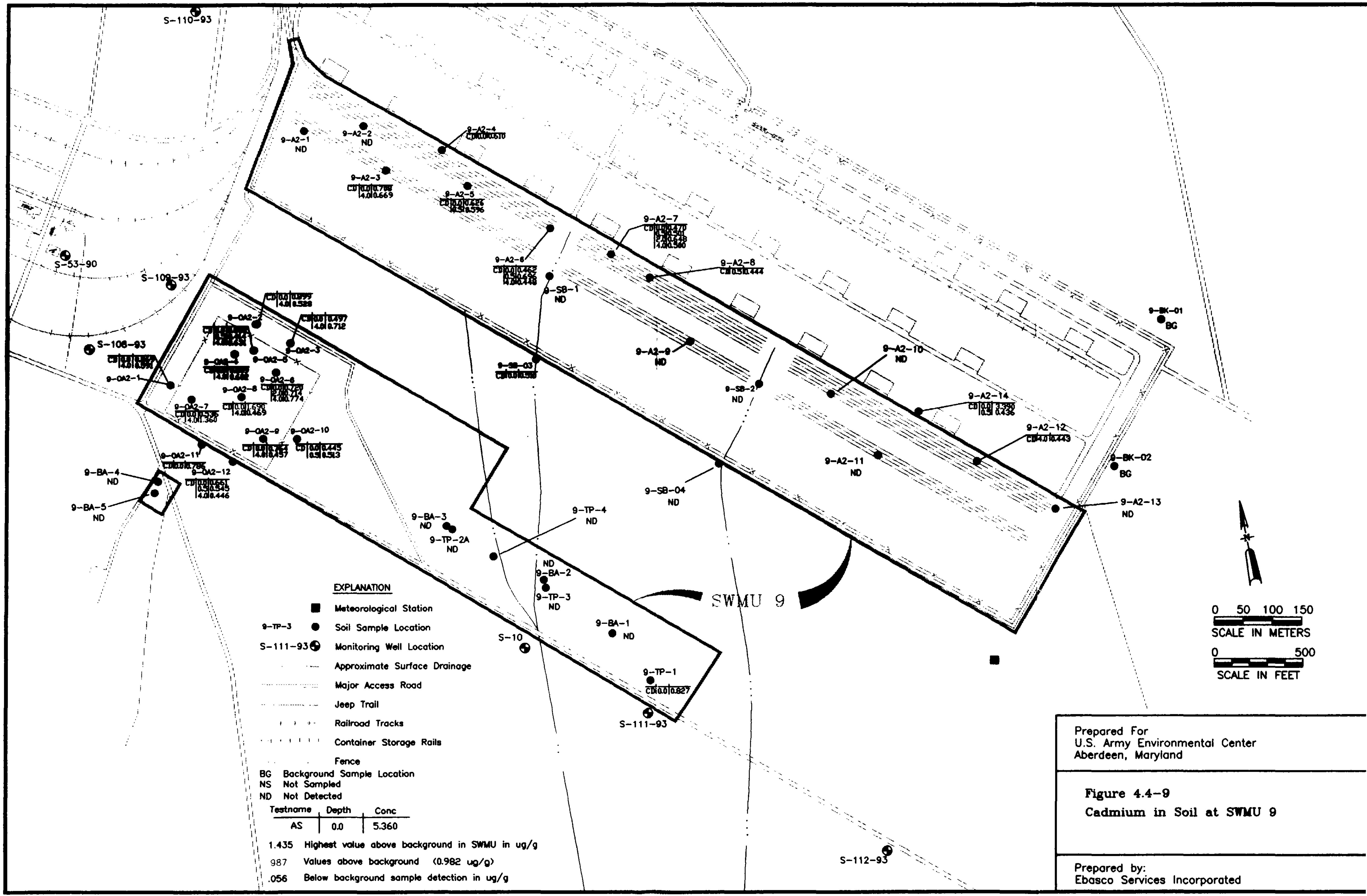
Lead (Pb), a human health and ecological COC, was detected above background (35.0 µg/g) in surficial samples from eight sampling locations (Figure 4.4-11). Five of these locations are in Area 2, scattered through the northern half of the open storage area. It is here that the highest lead concentration (210 µg/g) was measured (9-A2-12). Two detections above background were also measured in samples from within the fenced area at Old Area 2. The eighth location is outside the fence on the east side of Old Area 2. Lead was selected as a SWMU-wide COC due to its toxicity and distribution.



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-8
Arsenic in Soil at SWMU 9

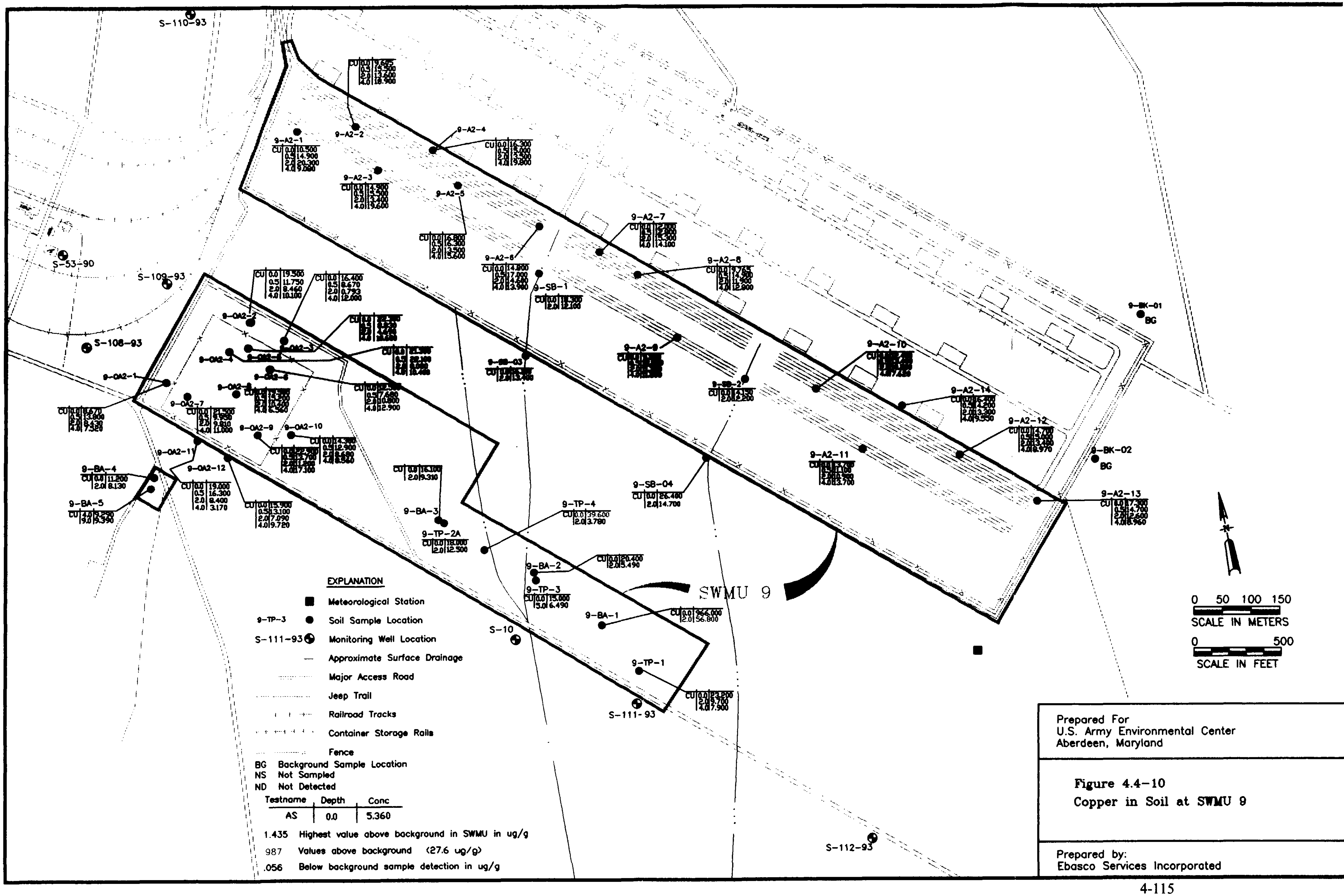
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-9
Cadmium in Soil at SWMU 9

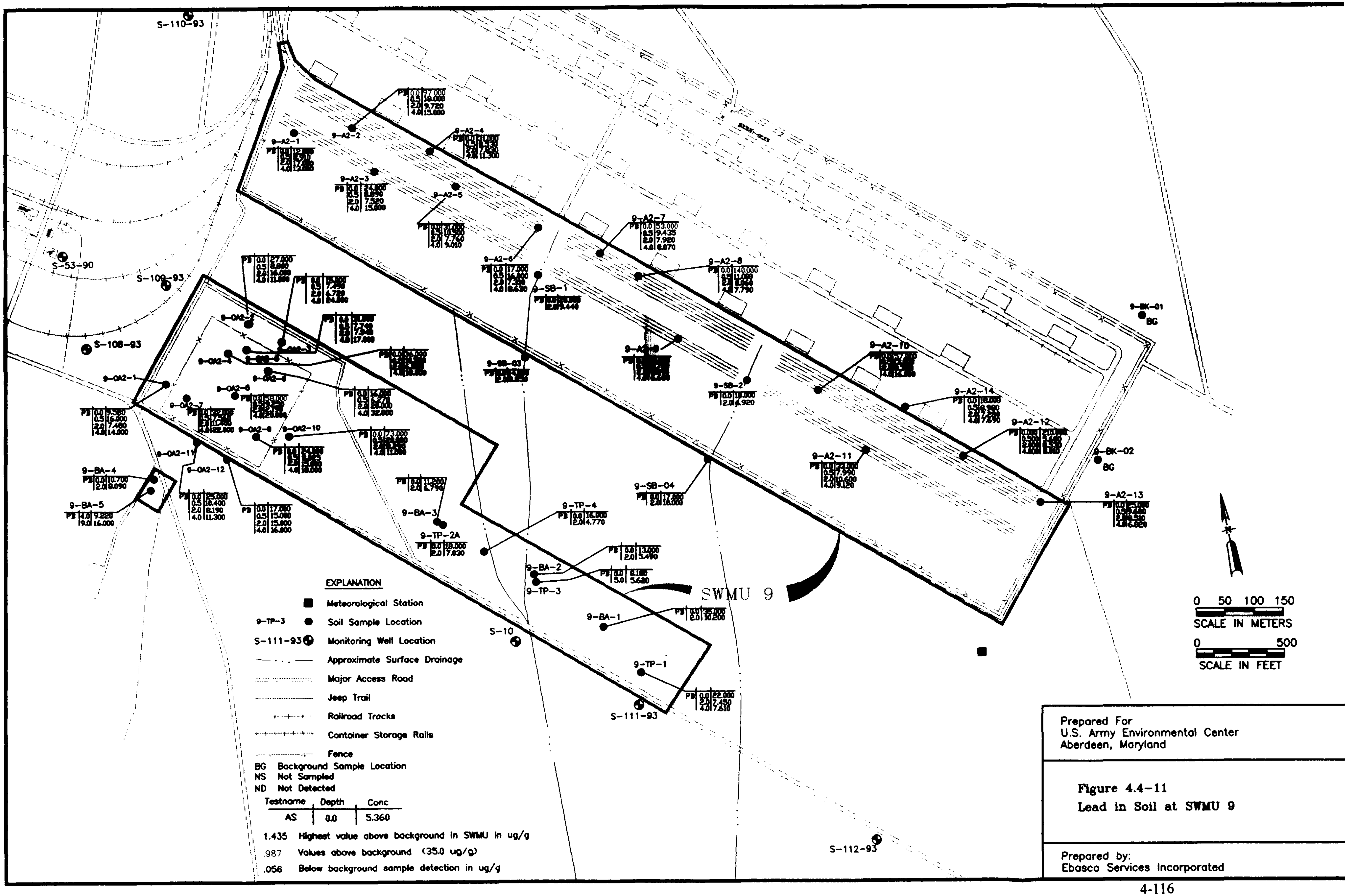
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-10
Copper in Soil at SWMU 9

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-11
Lead in Soil at SWMU 9

Prepared by:
Ebasco Services Incorporated

Mercury (Hg), a human health and ecological COC, was detected above background (0.143 µg/g) at only one location (9-A2-6) in Area 2 (Figure 4.4-12), where signs indicated mustard containers were stored. Mercury was detected in both the surficial sample and a subsurface sample (0.5 bgs). The highest concentration (0.361 µg/g) was detected in the subsurface sample at 9-A2-6. Mercury is considered a COC only for that sample location.

Silver (Ag), a facility-wide ecological COC, was not detected in any of the three areas within SWMU 9.

Zinc (Zn), a human health and ecological COC, was detected above background (144 µg/g) in only one sample (9-BA-1) in the burn pit area (Figure 4.4-13). The highest concentration (366 µg/g) was detected in the surficial sample at this location. Zinc is considered a COC only at this location, not throughout the SWMU. Results of three organic compounds and six metals that are being considered in the risk.

Detections above background in SWMU 9 soils are shown in Table 4.4-1.

4.4.2.2 Groundwater Contamination Assessment

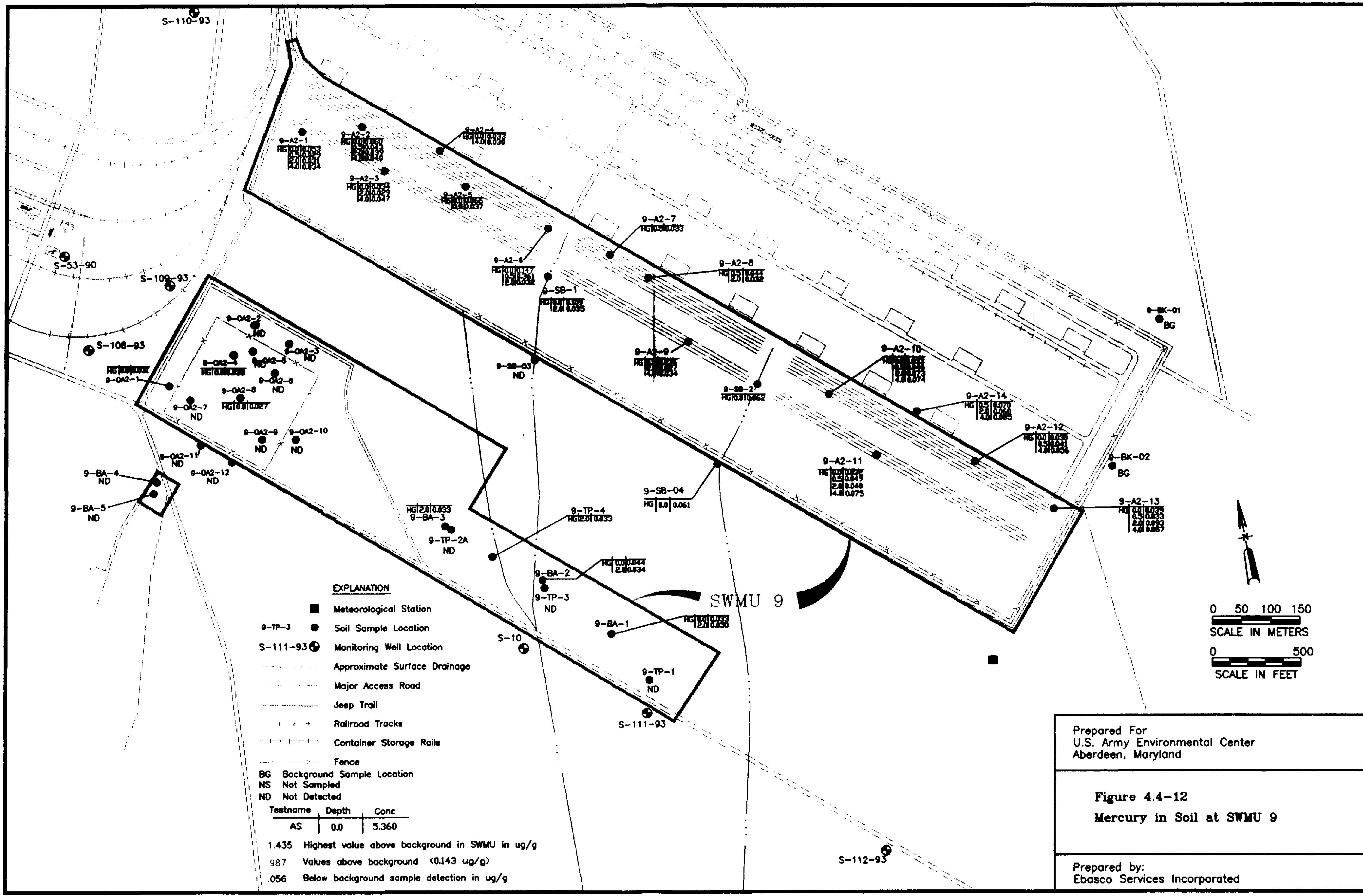
This section presents the chemical analytical results of the groundwater sampling program at SWMU 9. Although this section evaluates all of the analytical data collected, it focuses on the assessment. The complete chemical data can be found in Appendix F2.

Previous Investigations

Previous groundwater sampling at SWMU 9 was limited to the sampling of well S-10, which is located approximately 1,800 ft to the southeast of Old Area 2. Sampling of well S-10 was performed during 1982, 1987, 1988, and 1993 (RFI-Phase I). Groundwater samples collected prior to the RFI-Phase I investigation were analyzed for SVOCs, agent breakdown products, metals, anions, and radiological parameters. RFI-Phase I samples were analyzed for a full suite of analytes, including VOCs.

Previous sampling results for well S-10 indicated the presence of four organic compounds in groundwater. Three compounds (benzyl alcohol, bis (2-ethylhexyl) phthalate [B2EHP], and butylbenzyl phthalate) were detected at low part-per-billion concentrations. IMPA, an agent breakdown product, was detected at high concentrations (3,700 µg/L) during the 1988 sampling. However, organic compounds were not detected in well S-10 during RFI-Phase I sampling.

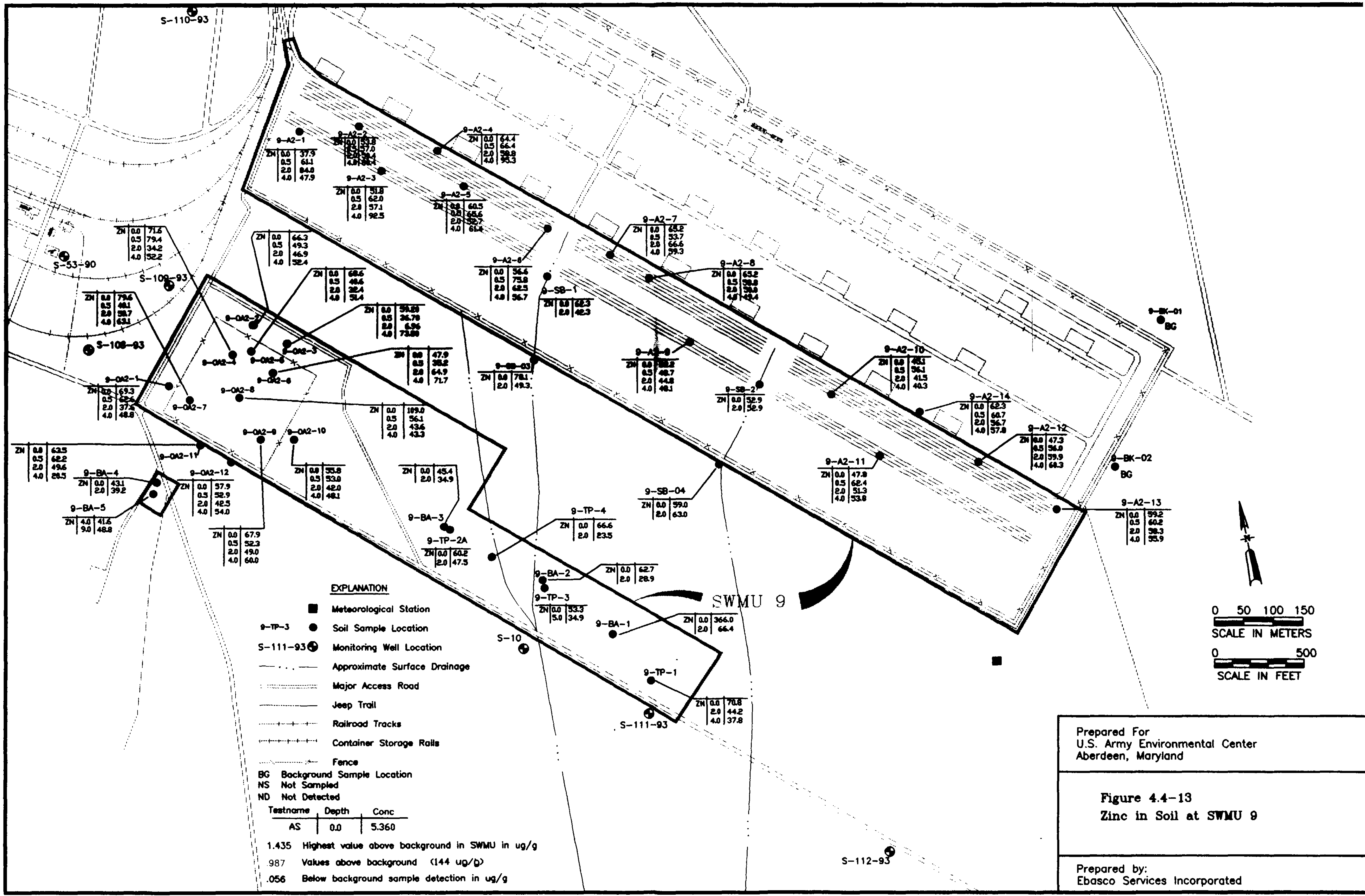
Pre-RFI Phase I sampling detected arsenic (As), barium (Ba), beryllium (Be), chromium (Cr), copper (Cu), lead (Pb), nickel (Ni), silver (Ag), sodium (Na), thallium (Th), and zinc (Zn) in groundwater. Of these, four metals (beryllium, chromium, copper, and nickel) were above background, but they were detected at levels that appear to be the result of variations in natural groundwater chemistry as opposed to SWMU-derived contamination. RFI-Phase I results detected arsenic, chromium, and zinc at levels below background.



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-12
Mercury in Soil at SWMU 9

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-13
Zinc in Soil at SWMU 9

Prepared by:
Ebasco Services Incorporated

Table 4.4-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 9

Page 1 of 3

Location	Analyte	Depth (ft)	Value (µg/g)	Units	Location	Analyte	Depth (ft)	Value (µg/g)	Units
9-A2-7	17PTCE	2.000	2.10	UGG	9-OA2-1	CA	0.000	190,000	UGG
9-A2-1	ACET	0.000	0.021	UGG	9-A2-1	CCL3F	0.500	0.007	UGG
9-A2-12	ACET	2.000	0.020	UGG	9-A2-1	CCL3F	2.000	0.008	UGG
9-BA-5	ACET	4.000	0.022	UGG	9-A2-12	CCL3F	0.500	0.006	UGG
9-BA-5	AG	4.000	8.05	UGG	9-A2-12	CCL3F	4.000	0.006	UGG
9-BA-5	AG	4.000	7.94	UGG	9-A2-13	CCL3F	4.000	0.006	UGG
9-BA-1	AL	0.000	50,400	UGG	9-A2-3	CCL3F	2.000	0.006	UGG
9-A2-11	AS	0.500	97.0	UGG	9-BA-1	CCL3F	2.000	0.007	UGG
9-A2-12	AS	4.000	85.0	UGG	9-BA-4	CCL3F	2.000	0.007	UGG
9-A2-10	B2EHP	0.000	0.980	UGG	9-OA2-10	CCL3F	4.000	0.007	UGG
9-OA2-12	B2EHP	2.000	5.60	UGG	9-OA2-11	CCL3F	0.000	0.008	UGG
9-OA2-6	B2EHP	4.000	1.70	UGG	9-OA2-11	CCL3F	2.000	0.008	UGG
9-OA2-12	BA	2.000	467	UGG	9-OA2-4	CCL3F	0.000	0.010	UGG
9-A2-3	BE	4.000	1.26	UGG	9-TP-2A	CCL3F	2.000	0.007	UGG
9-BA-5	BE	4.000	54.4	UGG	9-TP-4	CCL3F	2.000	0.011	UGG
9-BA-5	BE	4.000	54.2	UGG	9-A2-14	CD	0.000	3.39	UGG
9-OA2-10	BE	0.000	1.67	UGG	9-A2-3	CD	4.000	0.669	UGG
9-OA2-10	BE	0.500	1.35	UGG	9-A2-6	CD	0.500	0.596	UGG
9-OA2-10	BE	2.000	1.28	UGG	9-A2-7	CD	2.000	0.648	UGG
9-OA2-10	BE	4.000	1.34	UGG	9-BA-5	CD	4.000	57.3	UGG
9-OA2-11	BE	0.000	1.39	UGG	9-BA-5	CD	4.000	56.5	UGG
9-OA2-7	BE	0.000	1.22	UGG	9-OA2-3	CD	4.000	0.712	UGG
9-OA2-7	BE	0.500	1.33	UGG	9-OA2-4	CD	4.000	0.602	UGG
9-OA2-7	BE	2.000	1.38	UGG	9-OA2-5	CD	4.000	0.631	UGG
9-OA2-7	BE	4.000	1.33	UGG	9-OA2-6	CD	2.000	0.714	UGG
9-OA2-8	BE	0.000	1.10	UGG	9-OA2-6	CD	4.000	0.774	UGG
9-OA2-8	BE	0.500	1.43	UGG	9-OA2-7	CD	0.000	1.36	UGG
9-OA2-8	BE	2.000	1.33	UGG	9-OA2-8	CD	0.000	1.69	UGG
9-OA2-9	BE	0.000	1.46	UGG	9-BA-2	CH2CL2	2.000	0.006	UGG
9-OA2-9	BE	0.500	1.545	UGG	9-A2-11	CL6BZ	0.000	1.10	UGG
9-OA2-9	BE	2.000	1.32	UGG	9-A2-13	CL6BZ	0.000	0.580	UGG
9-OA2-9	BE	4.000	1.50	UGG	9-A2-3	CO	4.000	8.87	UGG
9-SB-4	C16A	0.000	0.510	UGG	9-BA-5	CO	4.000	110	UGG
9-TP-1	C16A	0.000	0.330	UGG	9-BA-5	CO	4.000	109	UGG
9-OA2-10	C27	0.500	0.630	UGG	9-SB-3	CO	0.000	6.77	UGG
9-OA2-9	C27	0.500	0.330	UGG	9-TP-2A	CO	0.000	6.82	UGG
9-SB-4	C27	0.000	0.770	UGG	9-BA-1	CR	0.000	29.2	UGG
9-A2-3	C29	0.000	0.670	UGG	9-BA-5	CR	4.000	113	UGG
9-A2-6	C29	0.500	0.430	UGG	9-BA-5	CR	4.000	116	UGG
9-A2-9	C29	0.000	0.330	UGG	9-BA-1	CU	0.000	966	UGG
9-BA-1	C29	0.000	0.740	UGG	9-BA-1	CU	2.000	56.8	UGG
9-BA-4	C29	0.000	0.480	UGG	9-BA-5	CU	4.000	55.8	UGG
9-OA2-1	C29	0.500	0.440	UGG	9-BA-5	CU	4.000	55.5	UGG
9-OA2-10	C29	0.500	0.950	UGG	9-SB-4	CU	0.000	26.4	UGG
9-OA2-2	C29	0.000	0.980	UGG	9-TP-4	CU	0.000	39.6	UGG
9-TP-4	C29	0.000	1.20	UGG	9-OA2-12	CYN	2.000	0.731	UGG
9-A2-1	CA	0.000	200,000	UGG	9-A2-11	DNBP	0.000	0.120	UGG
9-A2-10	CA	0.000	160,000	UGG	9-A2-11	DNBP	2.000	0.340	UGG
9-A2-7	CA	0.000	190,000	UGG	9-A2-13	DNBP	0.000	0.097	UGG
9-A2-9	CA	0.000	180,000	UGG	9-A2-3	DNBP	2.000	0.110	UGG

Table 4.4-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 9

Page 2 of 3

Location	Analyte	Depth (ft)	Value (µg/g)	Units	Location	Analyte	Depth (ft)	Value (µg/g)	Units
9-A2-5	DNBP	0.000	0.340	UGG	9-OA2-9	K	4.000	5,030	UGG
9-A2-9	DNBP	0.000	0.110	UGG	9-SB-4	K	2.000	4,950	UGG
9-OA2-2	DNBP	0.000	0.082	UGG	9-A2-10	MEC6H5	2.000	0.004	UGG
9-OA2-4	DNBP	0.000	0.220	UGG	9-A2-11	MEC6H5	4.000	0.004	UGG
9-OA2-4	DNBP	0.500	0.110	UGG	9-BA-1	MEC6H5	2.000	0.001	UGG
9-OA2-6	DNBP	0.000	0.100	UGG	9-OA2-10	MEC6H5	0.500	0.001	UGG
9-OA2-6	DNBP	4.000	0.089	UGG	9-OA2-12	MEC6H5	0.000	1.10	UGG
9-OA2-7	DNBP	0.000	0.110	UGG	9-OA2-4	MEC6H5	2.000	0.002	UGG
9-OA2-7	DNBP	0.500	0.110	UGG	9-OA2-5	MEC6H5	0.000	0.002	UGG
9-OA2-7	DNBP	4.000	0.120	UGG	9-OA2-7	MEC6H5	0.000	0.005	UGG
9-OA2-8	DNBP	0.000	0.099	UGG	9-OA2-7	MEC6H5	0.500	0.001	UGG
9-OA2-8	DNBP	0.500	0.087	UGG	9-OA2-8	MEC6H5	0.000	0.005	UGG
9-OA2-8	DNBP	4.000	0.200	UGG	9-OA2-8	MEC6H5	0.500	0.001	UGG
9-OA2-9	DNBP	0.000	0.096	UGG	9-OA2-9	MEC6H5	0.500	0.002	UGG
9-SB-4	DNBP	0.000	10.0	UGG	9-A2-9	MG	0.000	19,200	UGG
9-SB-4	DOAD	0.000	5.10	UGG	9-BA-3	MG	2.000	17,400	UGG
9-A2-13	ETOH	0.000	0.012	UGG	9-BA-4	MG	2.000	19,400	UGG
9-A2-14	ETOH	0.000	0.012	UGG	9-BA-5	MG	9.000	24,400	UGG
9-OA2-10	ETOH	0.000	0.007	UGG	9-OA2-1	MG	0.500	20,000	UGG
9-A2-6	HG	0.000	0.147	UGG	9-OA2-1	MG	2.000	18,200	UGG
9-A2-6	HG	0.500	0.361	UGG	9-OA2-1	MG	4.000	18,000	UGG
9-SB-1	HG	0.000	0.109	UGG	9-OA2-10	MG	4.000	16,100	UGG
9-TP-4	IMPA	0.000	15.5	UGG	9-OA2-11	MG	0.500	19,100	UGG
9-A2-1	K	0.500	6,550	UGG	9-OA2-11	MG	2.000	19,300	UGG
9-A2-1	K	2.000	5,350	UGG	9-OA2-12	MG	0.500	16,000	UGG
9-A2-10	K	0.500	5,430	UGG	9-OA2-12	MG	2.000	19,600	UGG
9-A2-11	K	4.000	5,610	UGG	9-OA2-12	MG	4.000	17,300	UGG
9-A2-12	K	0.500	5,930	UGG	9-OA2-2	MG	4.000	16,300	UGG
9-A2-13	K	0.500	6,480	UGG	9-OA2-4	MG	0.500	18,200	UGG
9-A2-13	K	2.000	5,440	UGG	9-OA2-4	MG	2.000	15,800	UGG
9-A2-14	K	0.500	6,340	UGG	9-OA2-4	MG	4.000	16,000	UGG
9-A2-2	K	0.500	5,520	UGG	9-OA2-6	MG	2.000	16,100	UGG
9-A2-2	K	4.000	5,050	UGG	9-OA2-7	MG	0.000	16,200	UGG
9-A2-3	K	0.500	6,490	UGG	9-OA2-7	MG	0.500	19,300	UGG
9-A2-3	K	4.000	5,210	UGG	9-OA2-7	MG	2.000	16,900	UGG
9-A2-4	K	0.500	4,980	UGG	9-OA2-7	MG	4.000	20,200	UGG
9-A2-5	K	0.500	5,670	UGG	9-OA2-8	MG	0.500	17,600	UGG
9-A2-6	K	0.500	4,960	UGG	9-OA2-8	MG	2.000	15,600	UGG
9-A2-6	K	2.000	5,520	UGG	9-OA2-8	MG	4.000	15,800	UGG
9-A2-7	K	2.000	5,270	UGG	9-OA2-9	MG	0.500	15,850	UGG
9-A2-8	K	0.500	5,100	UGG	9-OA2-9	MG	2.000	16,400	UGG
9-BA-5	K	4.000	5,590	UGG	9-OA2-9	MG	4.000	15,800	UGG
9-BA-5	K	4.000	5,810	UGG	9-TP-2A	MG	2.000	18,200	UGG
9-OA2-1	K	0.500	5,420	UGG	9-A2-1	MN	0.500	510	UGG
9-OA2-10	K	0.500	5,440	UGG	9-A2-14	MN	0.500	499	UGG
9-OA2-11	K	0.500	5,410	UGG	9-A2-2	MN	0.500	581	UGG
9-OA2-12	K	0.500	5,450	UGG	9-A2-2	MN	4.000	512	UGG
9-OA2-4	K	0.500	8,650	UGG	9-A2-3	MN	4.000	491	UGG
9-OA2-8	K	0.500	5,540	UGG	9-A2-4	MN	0.500	506	UGG
9-OA2-9	K	0.500	5,735	UGG	9-A2-5	MN	0.500	585	UGG

Table 4.4-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 9

Page 3 of 3

Location	Analyte	Depth (ft)	Value (µg/g)	Units	Location	Analyte	Depth (ft)	Value (µg/g)	Units
9-A2-6	MN	2.000	497	UGG	9-A2-7	PB	0.000	53.0	UGG
9-A2-8	MN	0.500	557	UGG	9-A2-8	PB	0.000	140	UGG
9-BA-2	MN	0.000	673	UGG	9-OA2-10	PB	0.000	73.0	UGG
9-OA2-1	MN	0.500	504	UGG	9-OA2-10	PB	0.500	20.0	UGG
9-OA2-10	MN	0.500	483	UGG	9-OA2-3	PB	4.000	24.0	UGG
9-OA2-11	MN	0.500	478	UGG	9-OA2-4	PB	0.000	36.0	UGG
9-OA2-2	MN	0.000	663	UGG	9-OA2-6	PB	2.000	20.0	UGG
9-OA2-4	MN	0.500	641	UGG	9-OA2-6	PB	4.000	32.0	UGG
9-OA2-6	MN	2.000	615	UGG	9-OA2-7	PB	4.000	22.0	UGG
9-OA2-6	MN	4.000	485	UGG	9-OA2-8	PB	0.000	58.0	UGG
9-OA2-7	MN	4.000	511	UGG	9-OA2-8	PB	4.000	20.0	UGG
9-OA2-9	MN	2.000	679	UGG	9-A2-5	PCB248	0.000	0.149	UGG
9-OA2-9	MN	4.000	641	UGG	9-A2-7	PCB248	0.000	0.245	UGG
9-SB-4	MN	2.000	487	UGG	9-A2-8	PCB248	0.000	0.510	UGG
9-TP-1	MN	0.000	670	UGG	9-A2-11	PCB254	0.000	0.670	UGG
9-TP-2A	MN	0.000	686	UGG	9-A2-13	SB	0.000	13.1	UGG
9-A2-10	MPA	0.000	0.923	UGG	9-BA-5	SB	4.000	42.2	UGG
9-OA2-7	MPA	0.000	3.61	UGG	9-BA-5	SB	4.000	42.6	UGG
9-BA-1	NA	0.000	1,610	UGG	9-OA2-10	SB	4.000	12.1	UGG
9-BA-5	NA	4.000	5,800	UGG	9-OA2-11	SB	0.000	8.85	UGG
9-BA-5	NA	4.000	5,890	UGG	9-OA2-9	SB	0.000	9.99	UGG
9-TP-3	NA	0.000	1990	UGG	9-A2-1	SE	2.000	0.262	UGG
9-BA-1	NI	0.000	25.7	UGG	9-A2-11	SE	2.000	0.247	UGG
9-BA-5	NI	4.000	56.6	UGG	9-A2-1	TCLTFE	0.000	0.007	UGG
9-BA-5	NI	4.000	56.5	UGG	9-A2-2	TCLTFE	0.000	0.010	UGG
9-A2-1	OMCTSX	0.500	0.043	UGG	9-A2-2	TCLTFE	0.500	0.011	UGG
9-A2-1	OMCTSX	2.000	0.008	UGG	9-A2-2	TCLTFE	2.000	0.011	UGG
9-BA-1	OMCTSX	2.000	0.032	UGG	9-A2-2	TCLTFE	4.000	0.011	UGG
9-BA-3	OMCTSX	2.000	0.054	UGG	9-OA2-8	TCOS	0.000	0.430	UGG
9-TP-4	OMCTSX	2.000	0.031	UGG	9-BA-5	TL	4.000	116	UGG
9-A2-10	PB	0.000	57.0	UGG	9-BA-5	TL	4.000	115	UGG
9-A2-12	PB	0.000	210	UGG	9-BA-1	ZN	0.000	366	UGG
9-A2-2	PB	0.000	97.0	UGG	9-OA2-8	ZN	0.000	109	UGG

µg/g microgram per gram
Note: Analyte names are defined in the chemical acronym list.

RFI-Phase II Results

To further evaluate detections of contaminants encountered in groundwater during previous investigations at SWMU 9, additional sampling of monitoring well S-10 was performed as part of the RFI-Phase II program. In addition, three new monitoring wells were installed to further characterize the groundwater environment at SWMU 9. Two wells (S-111-93 and S-112-93) were installed to the southeast of well S-10 and downgradient of SWMU 9. The third well (S-110-93) was installed northwest and upgradient of SWMU 9. RFI-Phase II groundwater samples were analyzed for VOCs, SVOCs (including PCBs and dioxins/furans), metals, anions, explosives, and agent breakdown products. Radiological parameters were not included in the RFI-Phase II sampling program. The complete analytical results of this sampling can be found in Appendix F2.

Organic Compounds

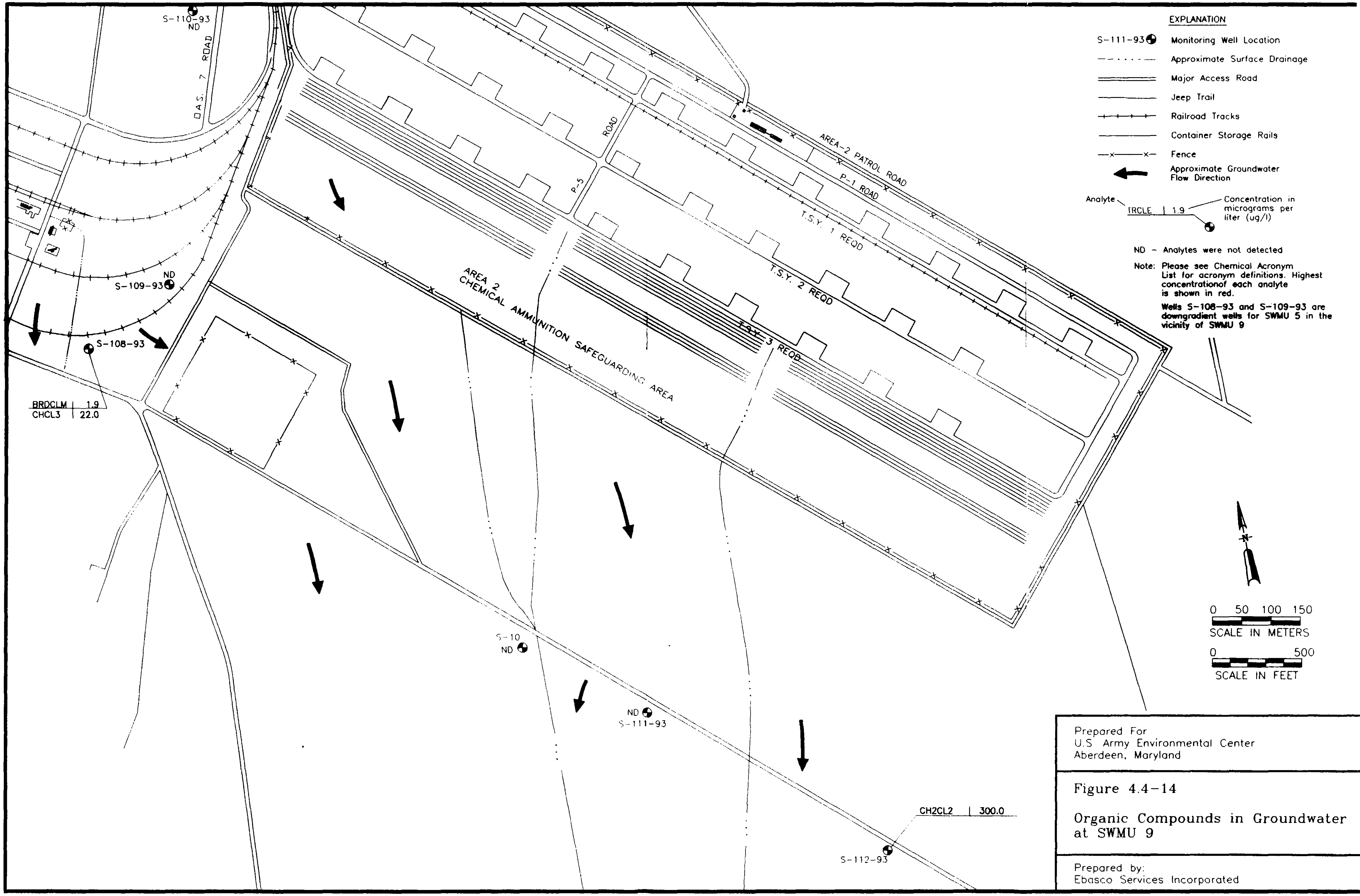
Figure 4.4-14 shows the analytical results for organic compounds detected in groundwater samples taken from wells at and near SWMU 9. Bromodichloromethane (BRDCLM) and chloroform (CHCL3) were detected in well S-108-93, which is upgradient to Old Area 2, but is a downgradient well at SWMU 5.

Methylene chloride was detected in the most downgradient well at a concentration of 300 µg/L, a level greater than ten times the concentration detected in the method blank (7.4 µg/L). Methylene chloride was also detected in the other new wells at SWMU 9 (S-110-93 and S-111-93) at concentrations ranging from 10 µg/L to 14 µg/L. These levels only slightly exceed the concentrations detected in the associated method blank and therefore are not considered valid detections. There were also no organic compounds detected in well S-10, which confirms results obtained during the RFI-Phase I program.

Metals

During the RFI-Phase II program, unfiltered groundwater samples were collected at SWMU 9 and analyzed for aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Ca), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag), thallium (Th), vanadium (V), and zinc (Zn). Results for these analyses are illustrated in Figure 4.4-15. Metal concentrations for the RFI-Phase II were compared to TEAD-S background levels for unfiltered samples to determine the potential for groundwater contamination at SWMU 9. Background levels for metals were discussed previously in Section 2.3.2.

Of the 18 metals analyzed during the RFI-Phase II at SWMU 9, ten occurred above background (antimony, beryllium, chromium, lead, aluminum, barium, cobalt, manganese, vanadium, and nickel). The majority of the metals above background occur in upgradient well S-110-93; however, all wells at SWMU 9 have at least one of the 10 metals above background. Water quality field data logs (summarized in Table 4.4-2 and located in Appendix A2) indicate that groundwater from well S-112-93 exhibited a "muddy" appearance at the time of sampling, while groundwater from the other three wells was "cloudy" or "murky" in appearance. Well S-10 had the fewest metals exceeding background (barium and vanadium). Metals previously occurring above background in this well (beryllium, chromium, copper, and nickel) did not exceed background levels during RFI-Phase II sampling.



Note: Please see Chemical Acronym List for acronym definitions. Highest concentrationof each analyte is shown in red.

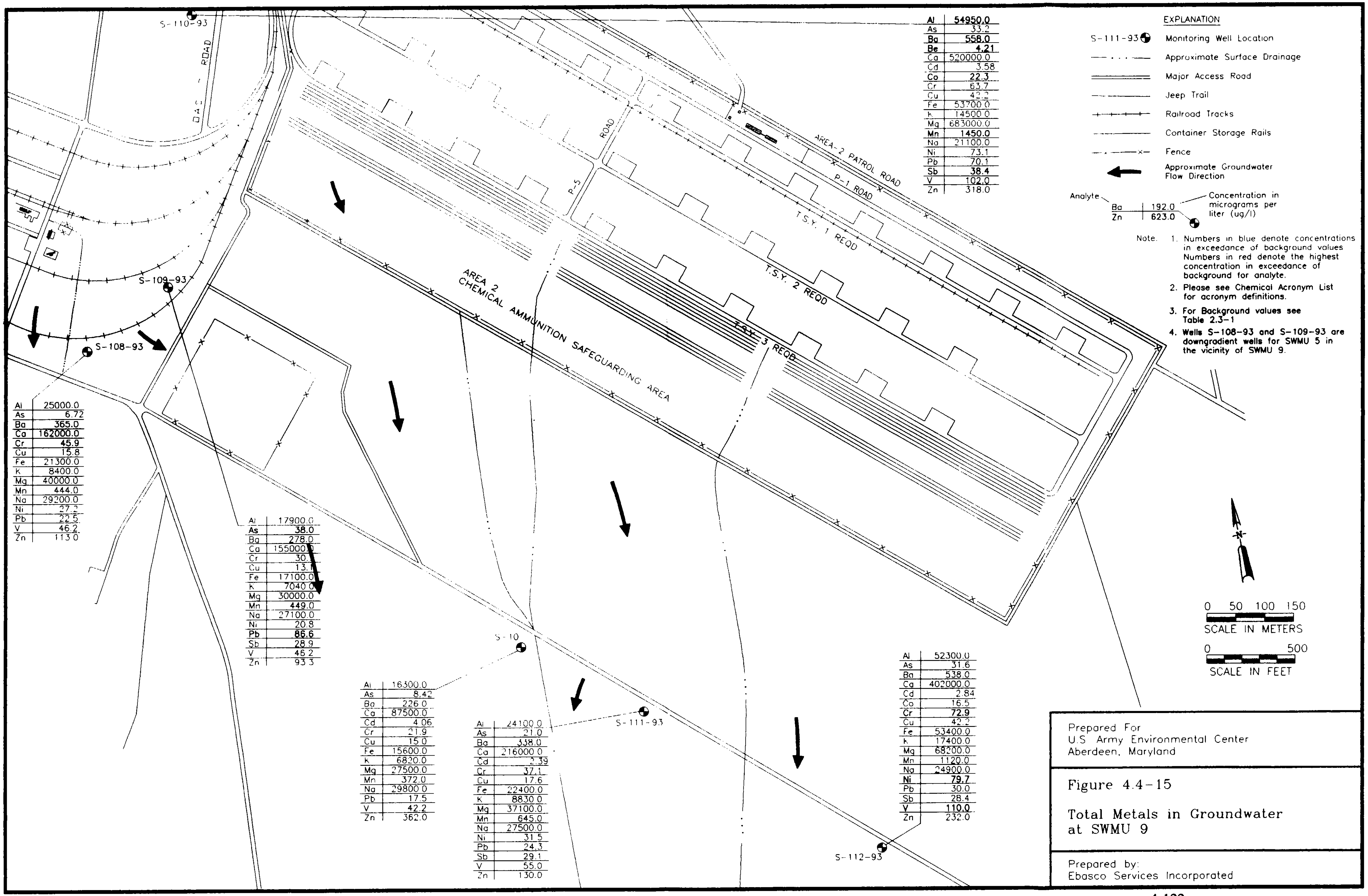
Wells S-108-93 and S-109-93 are downgradient wells for SWMU 5 in the vicinity of SWMU 9

Prepared For
U.S Army Environmental Center
Aberdeen, Maryland

Figure 4.4-14

Organic Compounds in Groundwater at SWMU 9

Prepared by:
Ebasco Services Incorporated



EXPLANATION

Note.
1. Numbers in blue denote concentrations in exceedance of background values Numbers in red denote the highest concentration in exceedance of background for analyte.
2. **Please see Chemical Acronym List for acronym definitions.**
3. **For Background values see Table 2.3-1**
4. **Wells S-108-93 and S-109-93 are downgradient wells for SWMU 5 in the vicinity of SWMU 9.**

Al	**54950.0**
As	33.2
Ba	**558.0**
Be	**4.21**
Ca	520000.0
Cd	3.58
Co	**22.3**
Cr	63.7
Cu	42.2
Fe	53700 0
K	14500 0
Mg	683000.0
Mn	**1450.0**
Na	21100.0
Ni	73.1
Pb	70.1
Sb	**38.4**
V	102.0
Zn	318.0

Al	25000.0
As	6.72
Ba	365.0
Ca	162000.0
Cr	45.9
Cu	15.8
Fe	21300.0
K	8400.0
Mg	40000.0
Mn	444.0
Na	29200.0
Ni	27.2
Pb	22.5
V	46.2
Zn	113.0

Al	17900.0
As	**38.0**
Ba	278.0
Ca	155000.0
Cr	30.
Cu	13.1
Fe	17100.0
K	7040.0
Mg	30000.0
Mn	449.0
Na	27100.0
Ni	20.8
Pb	**86.6**
Sb	28.9
V	46 2
Zn	93 3

Al	16300.0
As	8.42
Ba	226 0
Ca	87500.0
Cd	4 06
Cr	21.9
Cu	15 0
Fe	15600.0
K	6820.0
Mg	27500.0
Mn	372.0
Na	29800 0
Pb	17.5
V	42.2
Zn	362.0

Al	24100 0
As	21.0
Ba	338.0
Ca	216000 0
Cd	2.39
Cr	37.1
Cu	17.6
Fe	22400.0
K	8830 0
Mg	37100.0
Mn	645.0
Na	27500.0
Ni	31 5
Pb	24.3
Sb	29.1
V	55.0
Zn	130.0

Al	52300.0
As	31.6
Ba	538.0
Ca	402000.0
Cd	2.84
Co	16.5
Cr	**72.9**
Cu	42.2
Fe	53400.0
K	17400.0
Mg	68200.0
Mn	1120.0
Na	24900.0
Ni	**79.7**
Pb	30.0
Sb	28.4
V	**110.0**
Zn	232.0

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-15

Total Metals in Groundwater at SWMU 9

Prepared by:
Ebasco Services Incorporated

Table 4.4-2 Water Quality Characteristics of Groundwater at SWMU 9 Page 1 of 1

Well	Conductivity (μmhos)	pH	Turbidity (NTU)	Appearance	Calculated TDS(mg/L)*	Temp°F
S-10	710	8.35	>200	"cloudy"	283 ± 50	50.0
S-110-93	480	8.09	>200	"cloudy-brown"	700 ± 124	40.2
S-111-93	480	8.03	>200	"lt. brown-murky"	446 ± 78	40.6
S-112-93	530	8.59	>200	"muddy"	479 ± 84	44.1

* Total Dissolved Solids (TDS) content was determined by taking the reported anions in mg/L, converting mg/L to equivalents per mole (epm), and then balancing the anion content with the appropriate equivalent number of cations as calcium, magnesium, potassium, and sodium.

Aluminum, barium, cobalt, and vanadium were also detected in groundwater; however, the potential that these metals represent contamination is difficult to assess, since background values for these analytes have not been established. Most of the metals occurring above background in SWMU 9 wells exceed background by less than a factor of two, suggesting that these levels may be due to natural variability or to the high turbidity of the groundwater encountered during sampling. Based on field borehole logs and well construction logs of the RFI-Phase II wells, it is probable that the elevated turbidity is due to the fine-grained nature of the screened interval and the comparatively large slot (0.10) and coarser-grained (10–20 sand) filter pack in these wells.

Anions

Groundwater sampling at SWMU 9 included analyses for the following eight anions: bicarbonate, bromide, chloride, cyanide, fluoride, nitrate/nitrite, phosphate, and sulfate. Results of detections of these analyses are depicted in Figure 4.4-16. All results reflect unfiltered concentrations.

Concentrations of anions detected in SWMU 9 wells were compared to TEAD-S background levels to identify groundwater contamination. As depicted in Figure 4.4-16, only phosphate exceeded the TEAD-S background levels. Phosphate exceeded background (1,200 µg/L) in three of the four wells at SWMU 9. Phosphate levels exceeding background ranged from 1,500 µg/L to 3,600 µg/L. The highest detection of phosphate occurred in upgradient well S-110-93. Phosphates in groundwater at SWMU 9 may represent the residual products of compounds known to contain phosphorus (e.g., VX, MPA, or IMPA), or may reflect variations in natural background phosphate levels. Because MPA was only detected in soil at one location (9-A2-10) in SWMU 9, and neither agent nor agent breakdown products were detected in or groundwater at SWMU 9, it is probable that the elevated phosphorus is naturally occurring.

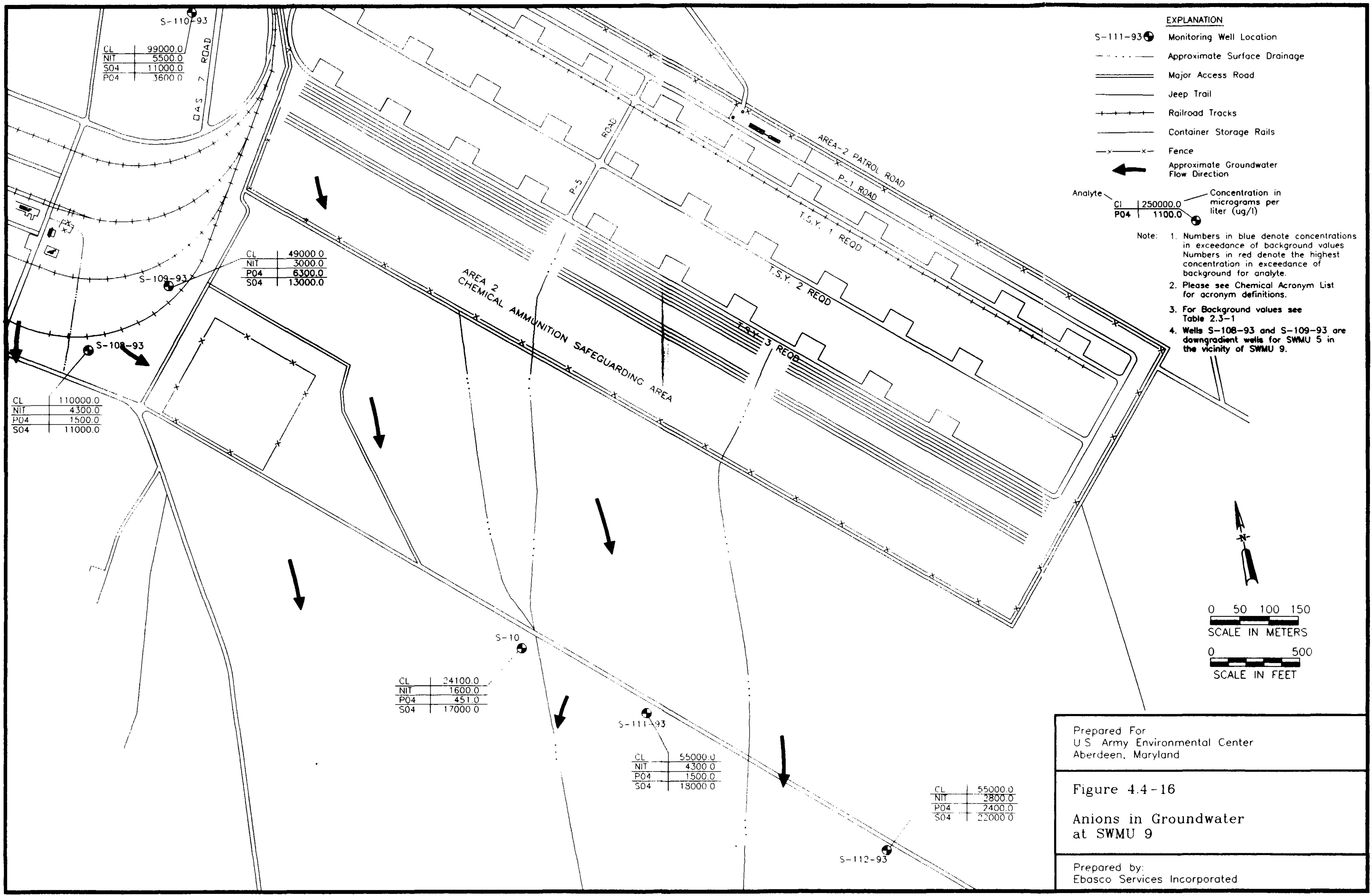
Detections above background in SWMU 9 groundwater are shown in Table 4.4-3.

4.4.2.3 Air Contamination Assessment

Ambient air sampling was performed at a station centrally located adjacent to the burn trenches and south of the Mustard Storage Area in SWMU 9. Meteorological monitoring was conducted utilizing a tower sited approximately 350 meters northeast of the air monitoring station. Samples were analyzed from six 24-hour events (volatile organic compounds were analyzed from only 5 events), collected during the period of September 21, 1993 to October 1, 1993.

Various volatile organic compounds were detected at SWMU 9 during the sampling program. Toluene was detected in all five samples with average and maximum concentrations of 2.23 and 9.30 ppbv, respectively. Methylene chloride was detected in three out of five samples with an average concentration of 0.41 ppbv. Moderate levels of total xylenes were measured in three samples with an average concentration of 0.92 ppbv and a maximum concentration of 3.80 ppbv. Tetrachloroethene was detected once (0.66 ppbv). Local ambient concentrations for all four of these analytes appear potentially related to SWMU 9 source impacts.

Trichloroethene was detected in three out of five samples and ethyl benzene was recorded in two samples. However, ambient concentrations for both of these analytes at SWMU 9 are similar to



Note:
1. Numbers in blue denote concentrations in exceedance of background values Numbers in red denote the highest concentration in exceedance of background for analyte.
2. Please see Chemical Acronym List for acronym definitions.
3. **For Background values see Table 2.3-1**
4. **Wells S-108-93 and S-109-93 are downgradient wells for SWMU 5 in the vicinity of SWMU 9.**

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.4-16

Anions in Groundwater at SWMU 9

Prepared by:
Ebasco Services Incorporated

Table 4.4-3 Chemical Analytical Detections Above Background in Groundwater from SWMU 9

Page 1 of 1

Location	Analyte	Value (μg/l)	Units	Location	Analyte	Value (μg/l)	Units
S-10	AL	16,300	UGL	S-111-93	MG	37,100	UGL
S-110-93	AL	54,950	UGL	S-112-93	MG	68,200	UGL
S-111-93	AL	24,100	UGL	S-10	MN	372	UGL
S-112-93	AL	52,300	UGL	S-110-93	MN	1,445	UGL
S-10	AS	8.42	UGL	S-111-93	MN	645	UGL
S-110-93	AS	33.2	UGL	S-112-93	MN	1,120	UGL
S-111-93	AS	21.0	UGL	S-10	NA	29,800	UGL
S-112-93	AS	31.6	UGL	S-110-93	NA	21,100	UGL
S-10	BA	226	UGL	S-111-93	NA	27,500	UGL
S-110-93	BA	558	UGL	S-112-93	NA	24,900	UGL
S-111-93	BA	338	UGL	S-110-93	NI	73.1	UGL
S-112-93	BA	538	UGL	S-112-93	NI	79.7	UGL
S-110-93	BE	4.21	UGL	S-10	NIT	1,600	UGL
S-10	CA	87,500	UGL	S-110-93	NIT	5,500	UGL
S-110-93	CA	510,500	UGL	S-111-93	NIT	4,300	UGL
S-111-93	CA	216,000	UGL	S-112-93	NIT	2,800	UGL
S-112-93	CA	402,000	UGL	S-110-93	PB	70.1	UGL
S-112-93	CH2CL2	300	UGL	S-10	PO4	451	UGL
S-110-93	CO	22.3	UGL	S-110-93	PO4	3,600	UGL
S-112-93	CO	16.5	UGL	S-111-93	PO4	1,500	UGL
S-110-93	CR	63.7	UGL	S-112-93	PO4	2,400	UGL
S-111-93	CR	37.1	UGL	S-110-93	SB	38.4	UGL
S-112-93	CR	72.9	UGL	S-111-93	SB	29.1	UGL
S-10	FE	15,600	UGL	S-112-93	SB	28.4	UGL
S-110-93	FE	53,650	UGL	S-10	SO4	17,000	UGL
S-111-93	FE	22,400	UGL	S-110-93	SO4	11,000	UGL
S-112-93	FE	53,400	UGL	S-111-93	SO4	18,000	UGL
S-10	K	6,820	UGL	S-112-93	SO4	22,000	UGL
S-110-93	K	14,500	UGL	S-10	V	42.2	UGL
S-111-93	K	8,830	UGL	S-110-93	V	102	UGL
S-112-93	K	17,400	UGL	S-111-93	V	55.0	UGL
S-10	MG	27,500	UGL	S-112-93	V	110	UGL
S-110-93	MG	68,250	UGL				

μg/l   micrograms per liter
Note: Analyte names are defined in the chemical acronym list.

those measured at the background air monitoring station located on the northeast perimeter of the Depot. Low levels (0.10 - 0.50 ppbv) of various other volatile organic compounds were regularly detected at SWMU 9 and at the other sampling stations located around TEAD-S, including the background station. The list of detected analytes includes 1,1,1-trichloroethane, carbon tetrachloride, benzene, and methyl isobutyl ketone. The levels measured at SWMU 9 are similar to those recorded at the other sampling stations including the background station and most likely represent the composition of the background airshed.

Several semivolatile organic compounds were detected in the field samples including naphthalene, di-n-butylphthalate, butylbenzylphthalate, and bis(2-ethylhexyl) phthalate. However, all these analytes were measured at comparable levels in the non aerated blank samples and thus, are most likely indicators of laboratory contamination.

There were no detections of cyanide, mercury, or PCBs at SWMU 9 during the sampling program. The total suspended particulate results and metal results were not used due to laboratory and media problems. It was determined during subsequent laboratory analysis that the sample filters supplied to the field team were contaminated with high background levels of the target elements. This prevented the identification and quantification of metals in the ambient air. To offset this missing data, conservative assumptions were used in the human health risk assessment to estimate ambient concentrations of metal soil COCs resuspended in airborne particulates. Appendix I contains a complete listing of all air monitoring data.

4.4.3 Contaminant Fate and Transport

This section discusses the probable contaminant fate and transport processes and migration pathways that are operating at SWMU 9 based on site physical characteristics, contaminant physical and chemical characteristics, and the nature and extent of contamination in soils and groundwater.

As outlined in Section 4.4.2, the release of organic and inorganic compounds at SWMU 9 has resulted in the contamination of site soil and groundwater. While several compounds were identified as potential contaminants at SWMU 9, only those compounds identified as COCs in the human health risk assessment for SWMU 9 (Section 5.5.1) are described here. These include di-n-butyl phthalate (DNBP), toluene, trichlorofluoromethane, arsenic, copper, and lead in soil; and methylene chloride, aluminum, antimony, barium, beryllium, chromium, lead, mercury, and vanadium in groundwater.

4.4.3.1 Soil

Organic SWMU-wide COCs in soil are di-n-butyl phthalate (DNBP), toluene, and trichlorofluoromethane (CCL3F). These compounds were detected in numerous and widely scattered sample locations, primarily within the upper 2 ft of soil. Most detections of DNBP were less than 0.34 µg/g, indicating that trace amounts of this compound were present. DNBP is a ubiquitous pollutant and common plasticizer, which suggests that its presence in soil may be an artifact of the sampling or analysis procedure. Detections of toluene and trichlorofluoromethane were in the low part-per-billion range, and may also be an artifact of laboratory contamination.

DNBP is a ubiquitous pollutant as a result of its use as a plasticizer. It has a chemical formula of $C_{16}H_{22}O_4$ and a molecular weight of 278.34. It is an oily liquid at normal temperatures and pressures, with a density of 1.05 g/ml, and an aqueous solubility of 11.2 mg/L. It has a low vapor pressure (1.4×10^{-5} mm Hg) and a very low Henry's law constant (4.6×10^{-7} atm-m^3/mole). DNBP has a very high octanol-water partition coefficient (79.433), but exhibits a wide range of organic-carbon partition coefficients (2 to 6,400). DNBP is rapidly degraded in soil, water, and air, with half-lives in these media on the order of days to weeks.

Based on these characteristics, it is expected to remain in shallow soils and rapidly degrade. Its virtual absence in soil samples deeper than about 2 ft suggests that adsorption of DNBP to soil organic matter and clay-sized particles has fixed this compound to the near-surface horizon only. Because of its low solubility, DNBP is not expected to desorb and leach during periods of infiltration from rainfall or snowmelt. Because it adsorbs ultraviolet (UV) radiation in the range of 274 to 290 nanometers (nm), it is susceptible to photolysis. Therefore, DNBP residing in surface soil may be subject to both biotic and abiotic degradation processes. Potential migration pathways for DNBP appear to be limited to surface migration processes as a result of its low solubility and soil partitioning characteristics. Potential migration pathways would include transport as fugitive dust and by surface water runoff. Given the low concentrations of DNBP found at SWMU 9, the potential for migration of this compound does not appear significant.

Toluene is a volatile aromatic hydrocarbon that is typically released to the environment from the volatilization of petroleum fuels, toluene-based thinners and solvents, and from motor vehicle exhausts. Toluene has an aqueous solubility of 535 mg/L, a vapor pressure of 28.4 mm Hg, and a Henry's law constant of 5.9×10^{-3} atm-m^3/mole. The octanol-water partition coefficient of toluene is 537, and the organic carbon partition coefficient ranges from 37 to 178. Toluene is very susceptible to biological degradation, with degradation half-lives in soil and water on the order of days or weeks. Toluene does not absorb UV radiation, but it will react with photochemically-produced hydroxyl radicals in the atmosphere.

Based on these characteristics, it is expected that when toluene is released to soil a portion of its mass will rapidly evaporate to the atmosphere, with the remainder entering the soil. The moderate octanol-water partition coefficient and low organic carbon partition coefficient values indicate that toluene is moderately mobile in soil, partitioning strongly to soil solid matter only when the soil is dry. The high vapor pressure of toluene indicates that volatilization to soil pore-gas is a significant process. Given that toluene was detected in low concentrations in surface and near-surface soil only indicates that most toluene exists adsorbed to soil mineral and organic matter. The probable migration pathways of toluene in soil are therefore limited to slow desorption and volatilization to the atmosphere and transport by wind as fugitive dust and surface water runoff. Trace amounts of toluene may migrate to the subsurface by dissolution and leaching by infiltrating water and snowmelt, but this is probably an insignificant process. Most toluene in soil will likely be eliminated by biodegradation.

Trichlorofluoromethane, also known as Freon 11, is primarily used as a refrigerant, a foaming agent for polyurethane foams, and a solvent and degreaser. It has a water solubility of 1,080 mg/L and a vapor pressure of 803 mm Hg. The Henry's law constant for this compound is 0.097 atm-m^3/mole, the octanol-water partition coefficient is 339, and the organic carbon partition coefficient is 147. This compound is relatively resistant to biological and abiotic degradation processes. Typical degradation half-lives in soil and water are on the order of months to years, indicating a high persistence in the environment.

Based on these characteristics, it is expected that when Freon 11 is released to soil a large portion of its mass will rapidly evaporate to the atmosphere because of its high vapor pressure. That fraction that does not evaporate will infiltrate the soil. Because of its high water solubility, moderate octanol-water partition coefficient, and low organic carbon partition coefficient value, Freon 11 is expected to be moderately to highly mobile in soil. A small fraction is expected to remain behind in soil organic matter and sorbed to the clay-sized fraction. Biodegradation in soil is not expected to be significant, nor is degradation by photolysis or hydrolysis. It is, therefore, anticipated that the Freon 11 detected in SWMU 9 soil exists adsorbed to soil organic matter and to clay minerals. Accordingly, the likely migration pathways for Freon 11 appear to be restricted to transport as fugitive dust in surface soil or slow desorption and volatilization to soil gas in subsurface soil.

Inorganic COCs in soil at SWMU 9 consist of arsenic, copper, and lead. These COCs are most susceptible to transport and migration by the mechanical transport of soil particles in which they reside. This is due to the strong tendency of metals to partition to soil organic carbon and soil mineral matter, especially the clay- and silt-sized particle fractions that are abundant at this site. The primary migration process is likely to involve the resuspension and transport as fugitive dust by wind; the secondary migration process is likely to involve by surface water runoff that results from episodic rainfall or flash-flooding. However, due to the hard-pan nature of the surface soils at SWMU 9, these migration processes may be limited in magnitude and extent.

Vertical transport of metal COCs to the water table is not expected to be significant, due to the partitioning of metals to the fine-grained mineral fraction of site soils, the low soil moisture content, and the limited recharge to groundwater by surface water sources at this site. Because these inorganic compounds do not have appreciable vapor pressures or Henry's law constants, and because they are not biodegradable, the concentrations will not change appreciably with time, except by mechanical relocation processes.

4.4.3.2 Groundwater

The fate of methylene chloride in groundwater is controlled primarily by the chemical and physical characteristics of this compound. Methylene chloride is a liquid compound that has a high aqueous solubility (20,000 mg/L), and a high vapor pressure (362 mm Hg). The relatively high Henry's law constant (0.002 atm-m^3/mole) indicates that methylene chloride volatilizes rapidly from water to air. The values of the octanol-water partition coefficient and organic-carbon partition coefficient of 20 and 8.8, respectively, are considered low and result from its high aqueous solubility. Therefore, methylene chloride is not expected to sorb significantly to soil solid matter. The degradation half-life of methylene chloride in groundwater ranges from 2 to 8 weeks. The lower value reflects degradation under anaerobic conditions, where reductive dehalogenation can occur, and the higher value is reflective of aerobic groundwater conditions.

Migration pathways of methylene chloride at SWMU 9 appear to be limited to transport by advective groundwater movement and volatilization from groundwater to soil pore gas in the zone immediately above the water table. Groundwater at SWMU 9 flows to the south at a rate of 0.062 to 0.311 ft per day. However, the migration of methylene chloride from SWMU 9 by advective flow appears to be limited, due to the susceptibility of this compound to degradation by microorganisms in groundwater, and the very low concentrations found in wells at the site. The portion of methylene chloride that sorbs to aquifer solids is small, so the migration of this compound is limited by the rate of groundwater flow.

Inorganic COCs in groundwater include Al, As, Ba, Be, Cr, Hg, Pb, Sb, and V. The presence of inorganics above background levels in groundwater at SWMU 9 is probably due to the very turbid nature of the groundwater samples and the subsequent contribution of metals by colloids and suspended solids to the unfiltered metals content. Because the inorganic COCs in groundwater most likely exist as particulates, they are not expected to be mobile in groundwater due to sorption of the inorganic to the aquifer matrix. Aquifer sediments at SWMU 9 are rich in silt- and clay-sized particles which, in combination with organic carbon and iron and manganese oxides, act to retard the movement of inorganic compounds relative to the flow of groundwater.

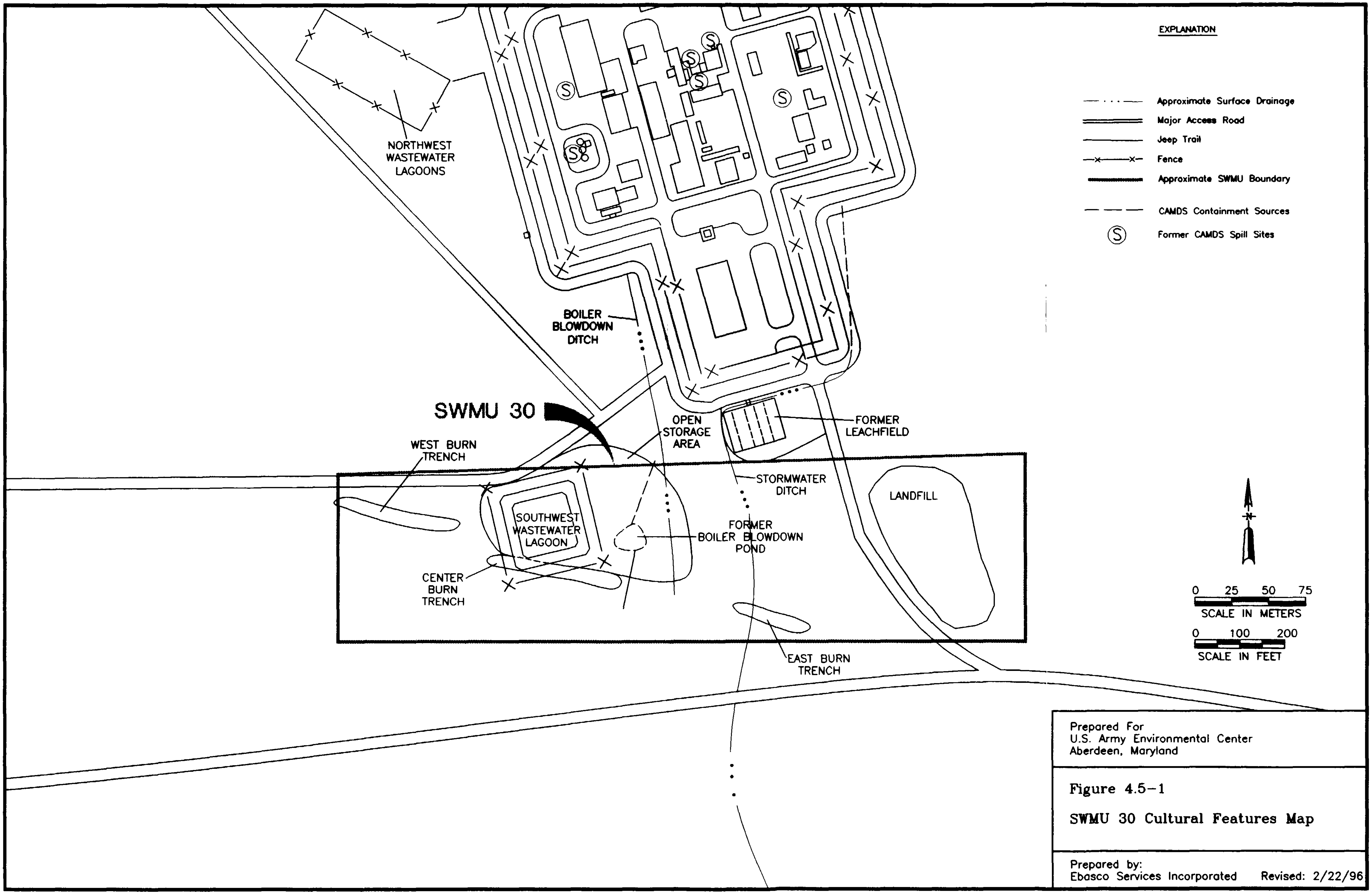
4.5 SWMU 30

4.5.1 Background

This section presents information on the site history and cultural features, geology and soil, and hydrology of SWMU 30.

4.5.1.1 Site History and Description of SWMU 30: CAMDS Landfill

SWMU 30 is located in the southwestern portion of TEAD-S, south of SWMU 13 (CAMDS) (Figure 4.5-1). The unit includes covered burn trenches and a landfill. Three trenches were used from 1956 to the early 1970s to burn wood and dispose of dunnage that originated from igloos in Old Area 8 above the Area 10 chemical safeguarding area (USAEHA 1986). The nontoxic waste was brought to the unit by truck or rail. According to Norris (1993a), fuel oil was used



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-1

SWMU 30 Cultural Features Map

Prepared by:
Ebasco Services Incorporated Revised: 2/22/96

to ignite waste in the trenches. After the trenches were no longer used, they were covered with native soil. The current waste water lagoon for CAMDS was built over the site of the central burn trench. The landfill east of the former trenches currently receives road-renovation waste such as soil, asphalt, and PVC pipe. The waste is placed in discrete, east-west trending piles. The piles are 4 to 5 ft high and cover an area measuring approximately 500 ft by 500 ft.

The dunnage burn area in SWMU 30 is visible in aerial photographs from 1959 and 1966 as a large, linear ground scar containing three trenches. The ground scar was designated Site 10 by EPIC (1986). Adjacent tracks forming a vehicle turnaround were also noted next to the site. According to Norris (1993b), dunnage was stored north of the middle trench in the mid-1960s, as shown on a 1966 aerial photograph (EPIC 1986) (Figure 4.5-2). By 1981, mounds of material, probably the road-renovation and building-construction wastes, had been dumped in a low area east of the SWMU 30 trenches (Site 11) (EPIC 1986). CAMDS was constructed just to the north of SWMU 30 by 1979 (Weston 1991). **Construction material and soil were the only visible wastes in this landfill area during the initial RFI-Phase I visit and during the RFI-Phase II field program (Figure 4.5-3).**

Contaminant sources related to CAMDS (Known Releases SWMU 13) overlap with the area of SWMU 30. Weston (1991) listed four sources of contamination at CAMDS. The first was an open pit in the southwest corner of CAMDS that received sewage effluent from saturation of the leachfield. According to TEAD-S employees (Graham 1994), the leachfield is abandoned in place. The second was the boiler blowdown discharge and life-support compressor cooling water from the southwestern portion of the plant. The discharge water flows into a ditch outside the southern perimeter of CAMDS that runs between the east and central burn trenches and discharges south of the trenches. This ditch used to be shorter and drained to a shallow pond just east of the wastewater lagoon (RUST 1994), in the vicinity of the east end of the center burn trench. The third source was soil contaminated by a diesel fuel spill in January 1983 in the western-central part of the CAMDS facility. The fourth source was soil contaminated by miscellaneous spills (sodium hydroxide, potassium dichromate, and petroleum hydrocarbons) within CAMDS. Other potential contamination sources investigated by Rust (1994) included an inactive drain pipe that discharged into a drainage ditch east of the leachfield and the chemical unloading area outside the northwest corner of CAMDS. The unlined drainage ditch, which manages stormwater, went along the north and west side of the leachfield and cut across the west end of the east trench before discharging to the ground south of the SWMU 30. These features are shown on the cultural features map (Figure 4.5-1) and all contaminant maps at SWMU 30.

4.5.1.2 Geology and Soil at SWMU 30

The geology and soil at SWMU 30 were characterized using a total of 12 surficial soil samples, shallow borings and test pit excavations (Figure 3.7-9). More than one area was excavated before sampling locations were selected for the test pits (i.e., three test pits for 30-TP-1 and two at 30-TP-2). The depth range for the samples collected was between 0.2 and 12 ft.

Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5–2

June 26, 1966 Aerial Photograph of SWMU 30, showing Burn Trenches and Open Storage Area.

Prepared by:
Ebasco Services Incorporated

Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-3

Typical Construction Debris at CAMDS Landfill on East Side of SWMU 30

Prepared by:
Ebasco Services Incorporated

The upper 12 ft of soil at SWMU 30 consists of silty clays (CL) and clayey silts (ML), which are lacustrine in origin. They often contain small amounts of fine- to coarse-grained sand and gravel. The coarse-grained components are not traceable between sample locations and appear to be very localized. These clays and silts show relative moisture conditions ranging from dry to moist. The soil consistency observed ranges from soft to hard.

The trench fill consists of reworked silty clay to clayey silt with debris that includes wood, ash residue, metal wiring, and ammunition boxes. Native soil was encountered below the trench fill at most of the pits.

The moisture conditions of the fill material range from damp to saturated. Groundwater was encountered at each of the three test pit locations. Wet soil and groundwater were first encountered between 6 and 8 ft below ground surface. The relative consistency of the fill was typically firm to stiff. Detailed soil boring logs and test pit diagrams can be found in Appendix A1.

Geotechnical samples were collected from the three open storage area locations (30-OSA-1, 30-OSA-2, and 30-OSA-3). Samples from all three locations indicated moderately alkaline conditions (pH between 8.16 and 9.49). TOC results ranged between 0.31 and 0.46 percent. The USCS symbols obtained from two samples (30-OSA-2 and 30-OSA-1) were both CL and exhibited similar moisture contents of 24.0 to 25.2 percent, respectively, indicating damp conditions. These results are similar to those observed elsewhere in SWMU 30. The coefficients of permeability for two samples (30-OSA-1 and 30-OSA-2) were quite low, with values of 9.4 x 10^{-5} cm/sec to 1.4 x 10^{-6} cm/sec, while CEC values for the same two samples were 23 and 24 meq/100g, respectively. A single effective porosity value of 10.4 percent was obtained from location 30-OSA-1. Detailed geotechnical and geochemical results can be found in Appendix A3.

Unpublished information on soil types at TEAD-S was obtained from SCS (no date). In the investigated area of SWMU 30 only one soil type was mapped. This unit, the Skumpah silt loam, has moderately low permeability due to its fine-grained nature. The unit is often saline and may contain sodium or gypsum salts. The potential use for Skumpah soils is that of irrigated croplands; however, production is generally very limited. In addition, its suitability for livestock grazing is poor.

4.5.1.3 Hydrogeology at SWMU 30

The surface topography at SWMU 30 slopes very slightly to the southwest. This SWMU is near the valley center and is within 15 ft of the elevation of Faust Creek. To the east of the landfill at SWMU 30 the ground abruptly rises about 25 ft. The area west and northwest of SWMU 30 has flooded when Faust Creek discharge was high because the stream is dammed by the railroad embankments that meet in the northwest part of TEAD-S (Weston 1991).

No new hydrogeologic information was collected during the RFI-Phase II investigation. However, groundwater was encountered in the test pits at depths of 6 to 8 ft bgs. These depths correspond to levels within the existing wells in the area (S-1, S-57, S-60, and S-90). The depth to groundwater for November and December 1993 is estimated to be within 2 ft of prior levels. The hydraulic gradient is fairly flat, with groundwater flow toward the west and south.

4.5.2 Nature and Extent of Contamination

This section describes the nature and extent of contamination at SWMU 30. In the assessments of soil and groundwater contamination, only those COCs of potential risk to human or ecological receptors are described in detail. Human health COC selection for SWMU 30 is detailed in Sections 5.6.1, and ecological COC selection for all Group 2 SWMUs is discussed in Section 6.3. Data used in the assessment of groundwater were collected by Rust (1994) for the RFI-Phase II assessment of known releases SWMU 13 (CAMDS). This data was obtained from the IRDMIS database.

4.5.2.1 Soil Contamination Assessment

This section summarizes the chemical analytical results of the RFI-Phase II field sampling program, as well as those conducted previously, at SWMU 30. The RFI-Phase II results and evaluations are grouped by analyte, with significant detections discussed by location within the SWMU. The sample locations are shown on each of the individual contaminant maps. The complete chemical data for the RFI-Phase II soil samples can be found in Appendix F1.

Although this section presents an evaluation of all of the analytical data collected, the discussion focuses on the results for the human health and ecological COCs at SWMU 30 that are being evaluated in the risk assessments. The COCs for SWMU 30 include one organic compounds 1,1,2-trichloro-1,2,2-trifluoroethane, or TCLTFE) and eight metals (arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc).

Previous Investigations

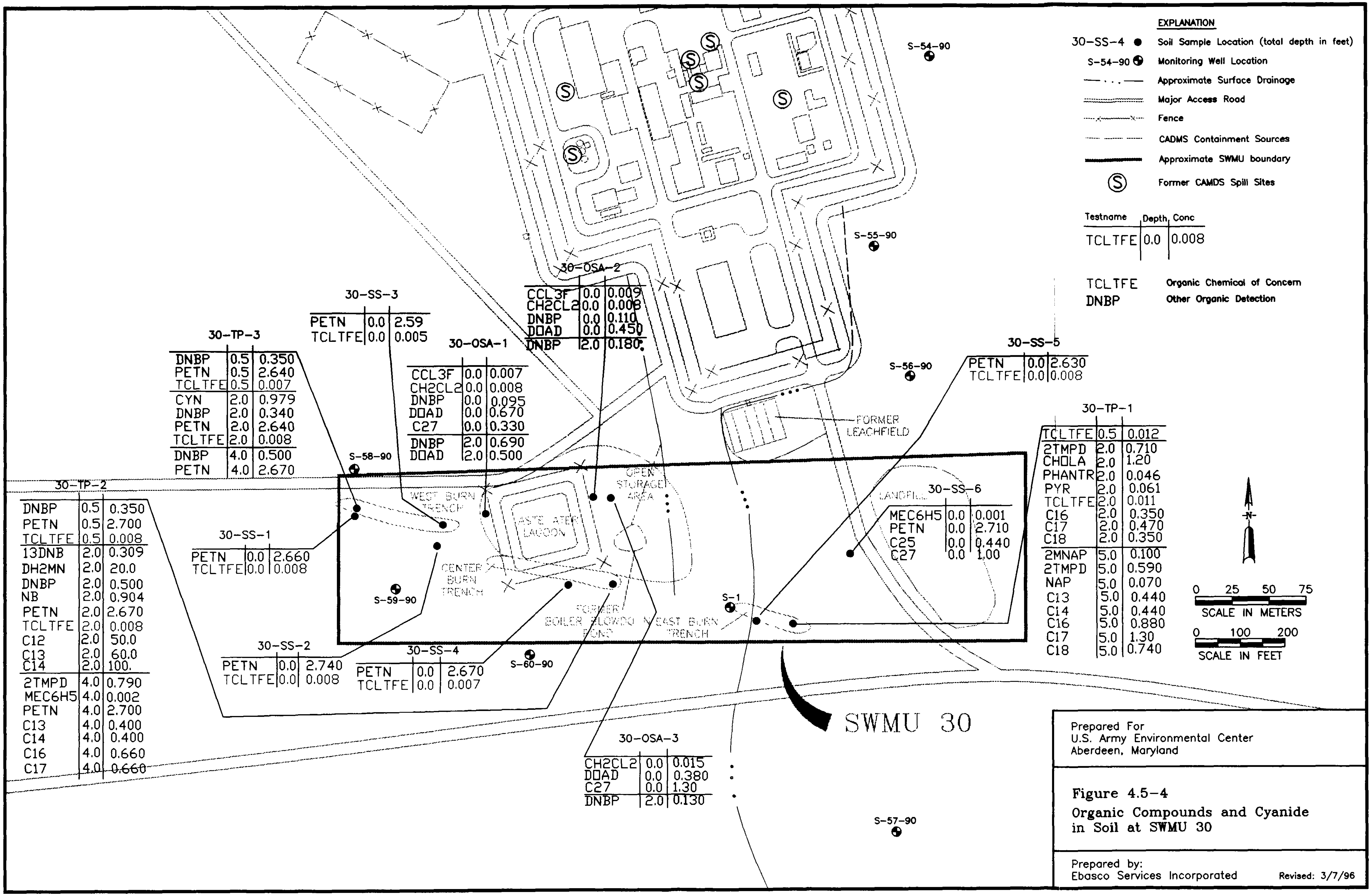
Prior to the RFI-Phase I of the suspected-releases units, sediment samples were collected near SWMU 30 to investigate known releases SWMU 13 (CAMDS). These samples were analyzed for VOCs, SVOCs, explosives, agent breakdown products, total petroleum hydrocarbons, anions, and radionuclides. Sediment samples were collected from three locations along the drainage south of CAMDS. Bis(2-ethylhexyl)phthalate (B2EHP), Tetryl, 1,3,5-trinitrobenzene (135TNB), and total petroleum hydrocarbons were the organic compounds detected in sediments in the boiler blowdown ditch. Eight metals (Ag, As, Ba, Cr, Cu, Ni, Pb, and Zn) were detected in a blowdown ditch sample; chloride (Cl) fluoride (F), phosphate (PO4ORT), sulfate (SO4), and nitrate (NIT) were the anions detected in the ditch sediments.

RFI-Phase II Results

There were a total of 21 soil samples collected at SWMU 30. A test pit was dug at each of three suspected burn trenches. The location of the suspected trenches was determined from old aerial photographs and a nonintrusive geophysical survey that was conducted prior to the sampling program. At the test pit in the eastern burn trench, soil samples were collected at 0.5, 2, and 5 ft bgs. At the test pits in the central and west burn trench, samples were collected at 0.5, 2, and 4 ft bgs. In addition, surficial and subsurface (2 ft bgs) samples were collected from borings at three sampling locations that were identified as an open storage area by aerial photographs and former TEAD-S employees. Six surficial samples were also collected from the area around the burn trenches. All of the soil samples were analyzed for VOCs, SVOCs, explosives, agent breakdown products, and metals. In addition, the samples from the burn trenches were analyzed for dioxins and furans.

<u>Organic Compounds and Cyanide</u>
Methylene chloride (CH2CL2), 1,3-dinitrobenzene (13DNB), 2-methylnaphthalene (2MNAP), di-n-butylphthalate (DNBP), nitrobenzene (NB), toluene (MEC6H5), phenanthrene (PHANTR), and pyrene (PYR) were the target analyte organic compounds detected in soil samples within SWMU 30. Non-target organic analytes detected at SWMU 30 were trichlorofluoromethane (CCL3F), decahydro-2-methylnaphthalene (DH2MN), pentaerythritol tetranitrate (PETN) and 1,1,2-trichloro-1,22-trifluoroethane (TCLTFE). **The risk assessment identified one organic compound (TCLTFE) as a COC in SWMU 30. There were no organic ecological COCs at SWMU 30.**

1,1,2-trichloro-1,2,2-trifluoroethane (TCLTFE) was detected in 11 soil samples from all three burn trenches at SWMU 30 (Figure 4.5-4). The higher concentration (0.012 µg/g) as detected in the test pit (30-TP-1) for the east burn trench at 0.5-ft depth. Three detections occurred in the eastern burn trench in surficial and subsurface samples. Two occurred at one sample location at 0.5 ft and 2 ft bgs. The third detection occurred in a surficial sample collected east of well S-1. Three detections also occurred at the center burn trench in surficial and subsurface samples. Two occurred in sample locations at 0.5 ft bgs and at 2 ft bgs in the test pit and one occurred in a surficial soil sample collected south of the wastewater lagoon fence. At the western burn trench, TCLTFE was detected in subsurface samples (0.5 and 2 ft bgs), as well as in three surficial samples. Although the concentrations of this compound are low, the frequency of detection (>50 percent) indicates that it may be a SWMU-wide COC.



30-TP-3

DNBP	0.5	0.350
PETN	0.5	2.640
TCLTFE	0.5	0.007
CYN	2.0	0.979
DNBP	2.0	0.340
PETN	2.0	2.640
TCLTFE	2.0	0.008
DNBP	4.0	0.500
PETN	4.0	2.670

30-SS-3

PETN	0.0	2.59
TCLTFE	0.0	0.005

30-OSA-1

CCL3F	0.0	0.007
CH2CL2	0.0	0.008
DNBP	0.0	0.095
D□AD	0.0	0.670
C27	0.0	0.330
DNBP	2.0	0.690
D□AD	2.0	0.500

30-OSA-2

CCL3F	0.0	0.009
CH2CL2	0.0	0.008
DNBP	0.0	0.110
D□AD	0.0	0.450
DNBP	2.0	0.180

30-SS-5

PETN	0.0	2.630
TCLTFE	0.0	0.008

30-TP-1

TCLTFE	0.5	0.012
2TMPD	2.0	0.710
CH□LA	2.0	1.20
PHANTR	2.0	0.046
PYR	2.0	0.061
TCLTFE	2.0	0.011
C16	2.0	0.350
C17	2.0	0.470
C18	2.0	0.350
2MNAP	5.0	0.100
2TMPD	5.0	0.590
NAP	5.0	0.070
C13	5.0	0.440
C14	5.0	0.440
C16	5.0	0.880
C17	5.0	1.30
C18	5.0	0.740

30-TP-2

DNBP	0.5	0.350
PETN	0.5	2.700
TCLTFE	0.5	0.008
13DNB	2.0	0.309
DH2MN	2.0	20.0
DNBP	2.0	0.500
NB	2.0	0.904
PETN	2.0	2.670
TCLTFE	2.0	0.008
C12	2.0	50.0
C13	2.0	60.0
C14	2.0	100.
2TMPD	4.0	0.790
MEC6H5	4.0	0.002
PETN	4.0	2.700
C13	4.0	0.400
C14	4.0	0.400
C16	4.0	0.660
C17	4.0	0.660

30-SS-1

PETN	0.0	2.660
TCLTFE	0.0	0.008

30-SS-6

MEC6H5	0.0	0.001
PETN	0.0	2.710
C25	0.0	0.440
C27	0.0	1.00

30-SS-2

PETN	0.0	2.740
TCLTFE	0.0	0.008

30-SS-4

PETN	0.0	2.670
TCLTFE	0.0	0.007

30-OSA-3

CH2CL2	0.0	0.015
D□AD	0.0	0.380
C27	0.0	1.30
DNBP	2.0	0.130

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-4
Organic Compounds and Cyanide in Soil at SWMU 30

Prepared by:
Ebasco Services Incorporated

Revised: 3/7/96

Three samples, one from each burn trench, were analyzed for dioxins and furans. The only detection occurred in a subsurface sample (2 ft bgs) from the east burn trench test pit. The concentration of total tetrachlorodibenzofuran (TCDF) at this location was 2.0 μg/kg (or 0.002 μg/g).

Cyanide was detected in only one soil sample at SWMU 30 (Figure 4.5-4). It was detected at 0.979 μg/g in the west burn trench at a depth of 2 ft.

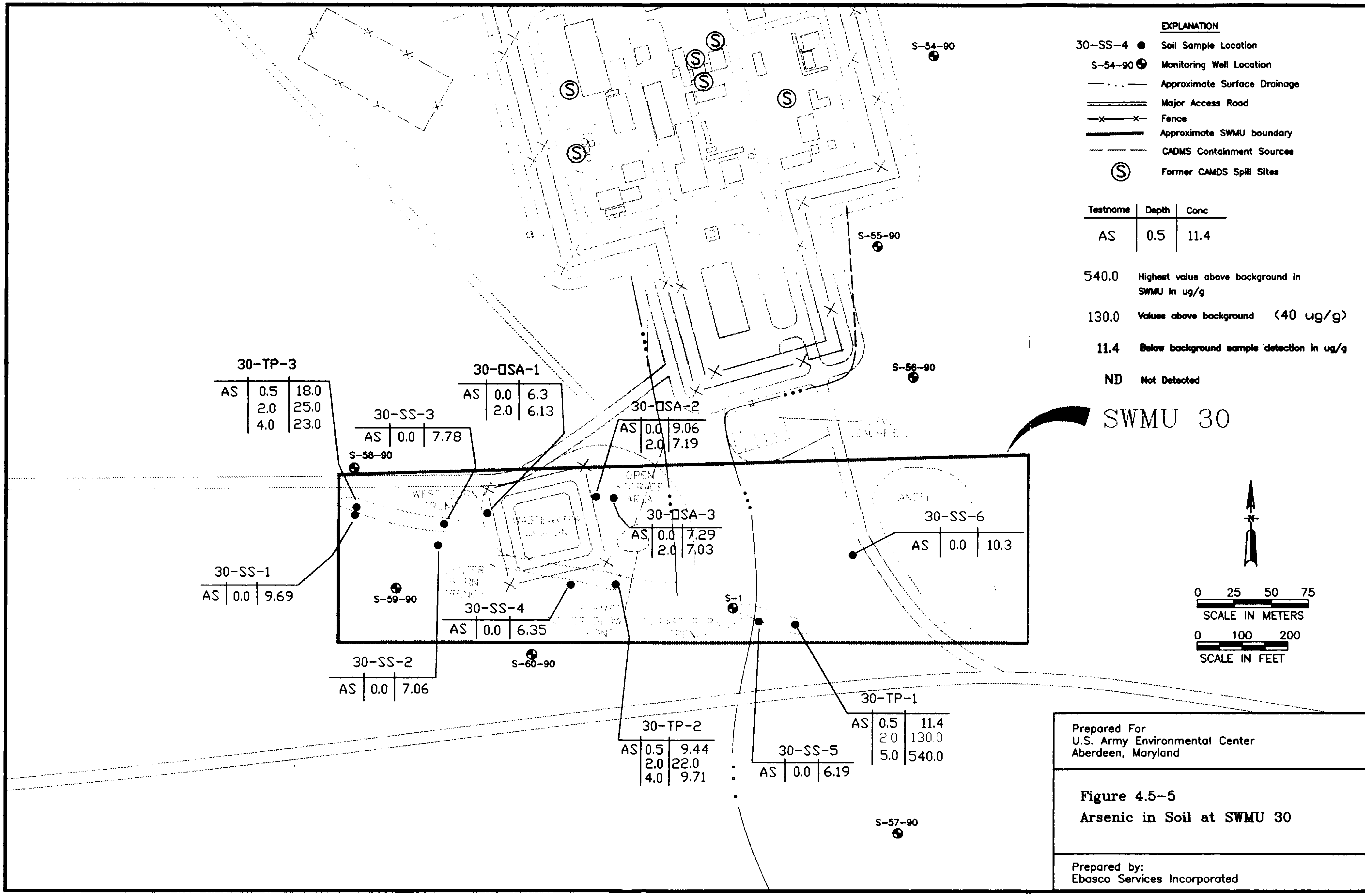
Metals
Above-background concentrations of 14 metals including arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), silver (Ag), sodium (Na), lead (Pb), nickel (Ni), selenium (Se), and zinc (Zn) were detected in soil samples collected in SWMU 30. The risk assessment for SWMU 30 has identified eight metals (As, Cd, Cr, Cu, Pb, Ni, Ag, and Zn) as COCs in this SWMU.

Although arsenic (As), a human health and ecological COC, was detected in all 21 soil samples at SWMU 30 (Figure 4.5-5), above-background concentrations (>40.0 μg/g) were detected in only two subsurface samples from the same sampling location (30-TP-1) in the east burn trench. The maximum concentration (540 μg/g) occurred at 5 ft bgs; the other above-background detection occurred at 2 ft bgs. Arsenic is therefore considered a COC for this sample location, but not for the entire SWMU.

Cadmium (Cd), a human health and ecological COC, was detected in concentrations above background (0.98 μg/g) in 12 soil samples at SWMU 30 (Figure 4.5-6). The maximum concentration (10.1 μg/g) was detected in one subsurface sample (2 ft bgs) collected at the east burn trench test pit (30-TP-1). This was the only detection of cadmium in the east burn trench. Cadmium was detected at all three sample locations at the open storage area. Detections occurred at two locations in both the surficial sample and the subsurface sample (2 ft bgs), but cadmium was above background in the subsurface sample only. Cadmium was detected in all three samples collected at the center burn trench and at the west burn trench. However, cadmium was not detected above background in any of the surficial samples collected at the burn trenches. Although concentrations of cadmium exceed background in 12 samples, only the two highest concentrations (10.1 and 7.8 μg/g), which occur in the east and center burn trenches, are significantly above background. For this reason, cadmium is considered to be a COC only at those locations.

Chromium (Cr), a human health COC, was detected in all 21 soil samples collected at SWMU 30, but it was detected above background (48.5 μg/g) at only one location (Figure 4.5-7). The maximum concentration of chromium at SWMU 30 (104.0 μg/g) occurred in a subsurface sample (2 ft bgs) in the east burn trench test pit (30-TP-1).

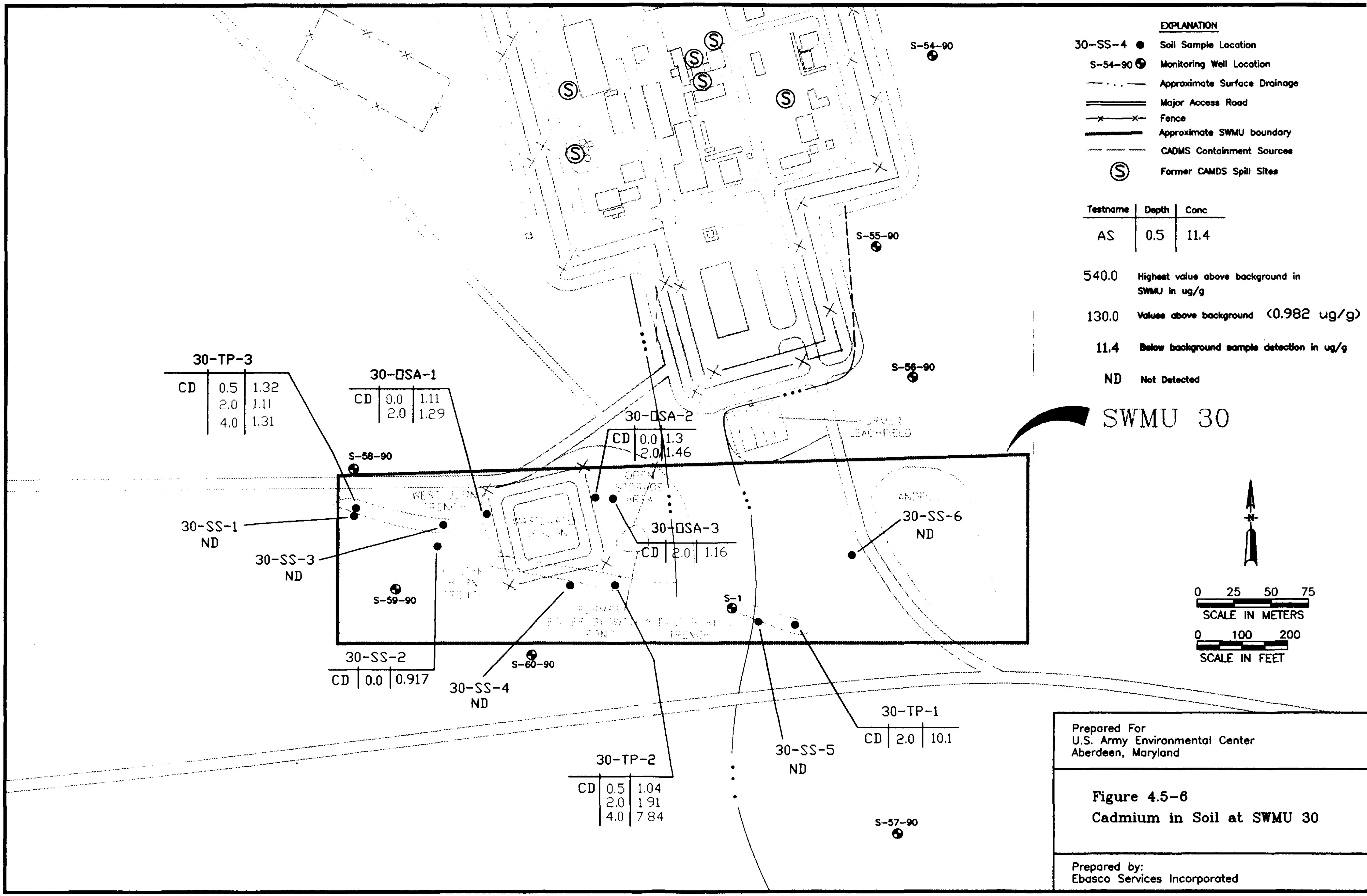
Copper, a human health and ecological COC, was detected at concentrations above background (27.6 μg/g) at all three burn trenches (Figure 4.5-8). It was detected above background in the subsurface samples (2 and 5 bgs) collected from the test pit at the east burn trench (30-TP-1). The maximum concentration of copper (356.0 μg/g) was measured at this location at 5 ft bgs.



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-5
Arsenic in Soil at SWMU 30

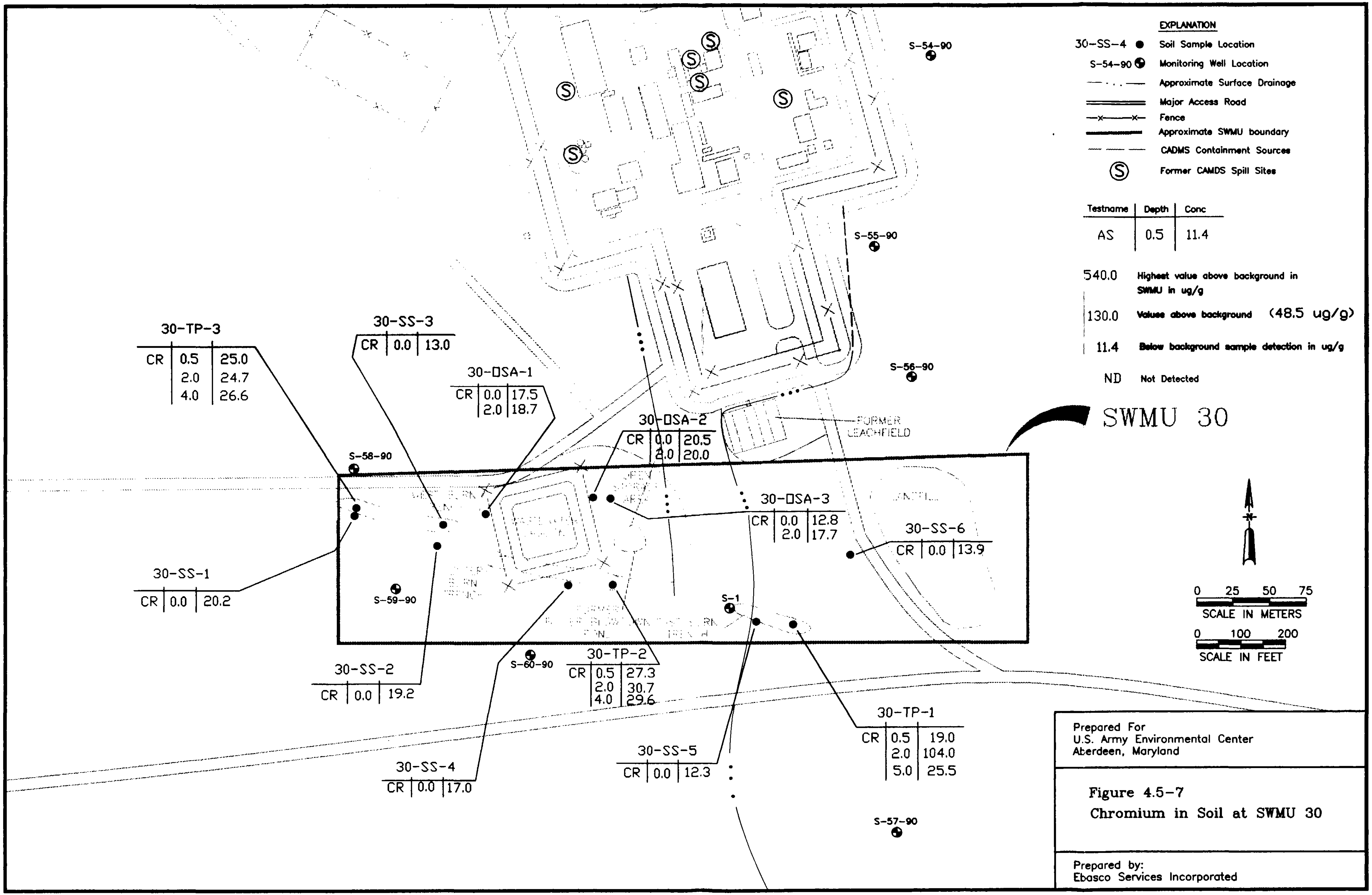
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-6
Cadmium in Soil at SWMU 30

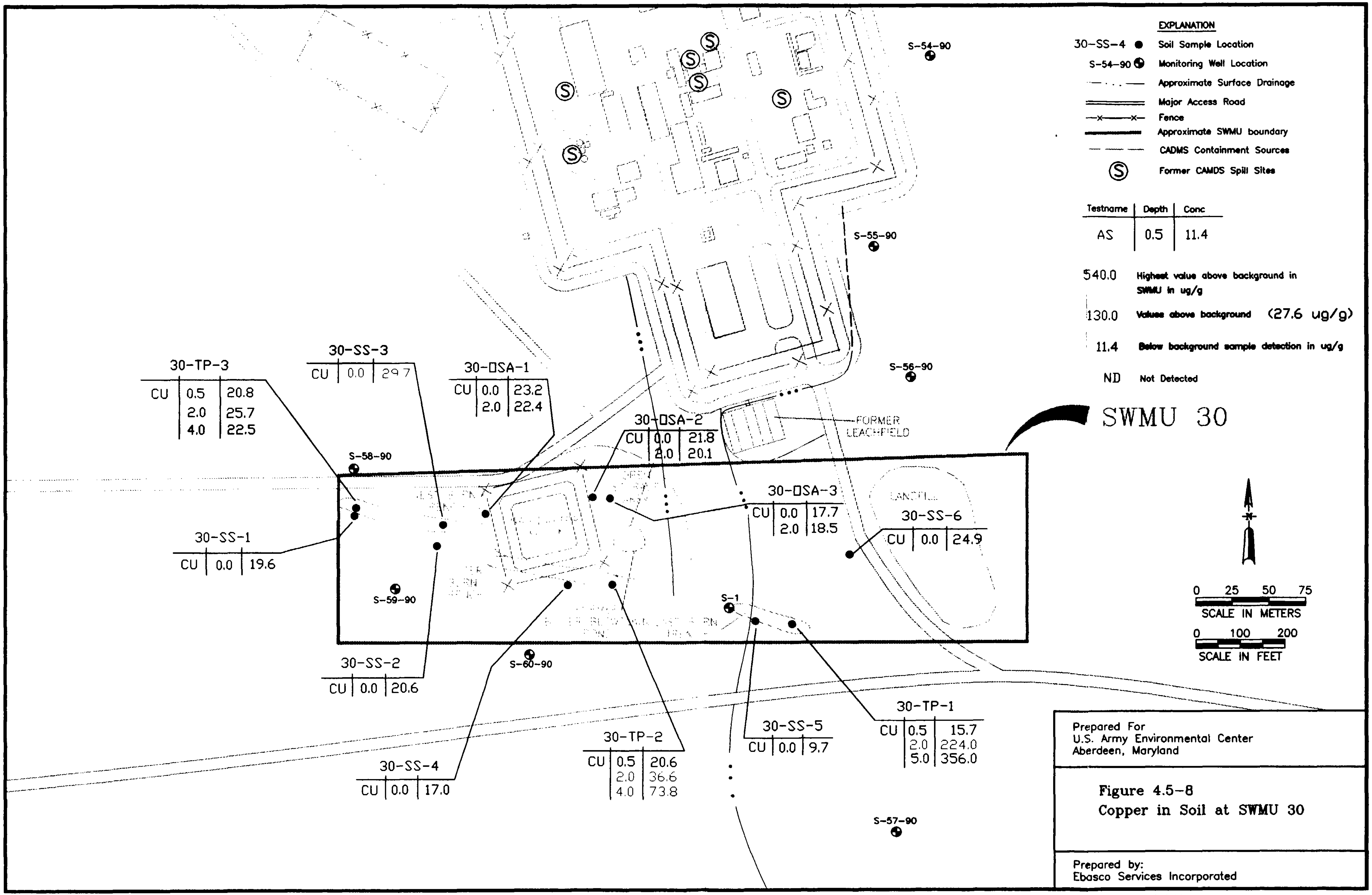
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-7
Chromium in Soil at SWMU 30

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-8
Copper in Soil at SWMU 30

Prepared by:
Ebasco Services Incorporated

In the center test pit, copper was detected above background in subsurface samples (2 and 4 ft bgs). However, copper was detected only in one surface soil sample at the west burn trench. The concentrations of copper are significantly above background only at the test pit sampling locations in the eastern and central burn trenches. Copper is therefore considered to be a COC only for those locations, and not for the entire SWMU.

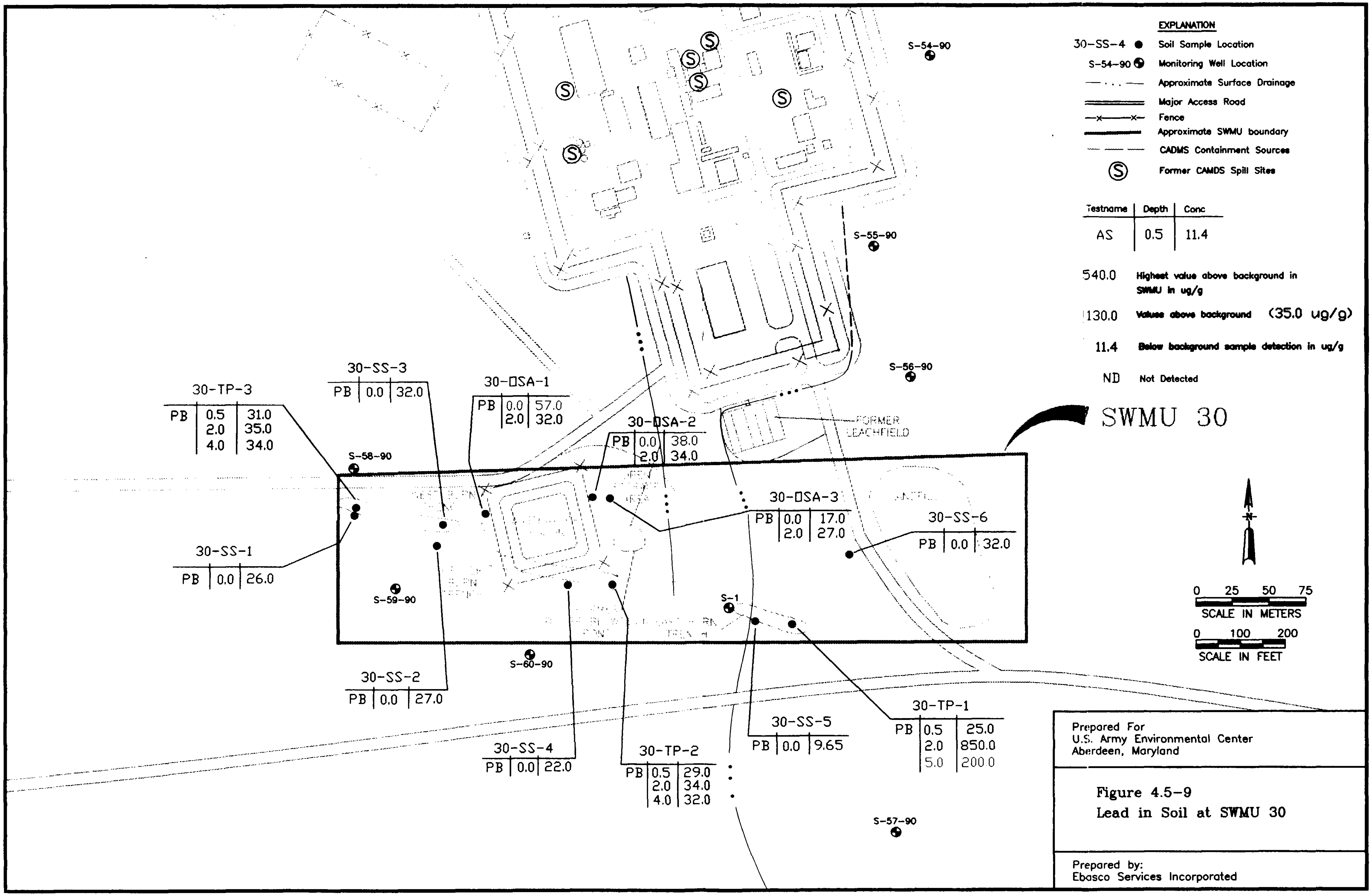
Lead (Pb), a human health and ecological COC, was detected in all 21 soil samples, but was detected above background (35.0 µg/g) in only four samples (Figure 4.5-9). Lead was detected at above-background concentrations in two surficial samples at the open storage area, one to the east and one to the west of the wastewater lagoon fence. Lead was also detected at above-background concentrations in subsurface samples (2 and 5 ft bgs) in the test pit at the east burn trench (30-TP-1). The maximum concentration of lead (850.0 µg/g) at SWMU 30 occurred in a subsurface sample (2 ft bgs) at the east burn trench (30-TP-1). The second highest concentration occurred at the same location at 5 ft bgs. Only these two detections are significantly above background. Lead is therefore a COC for the east burn trench only, but not for the entire SWMU.

Mercury (Hg), a human health and ecological COC, was detected only at concentrations below background (0.143 µg/g) at SWMU 30. Therefore, no figure showing the distribution of mercury detections at the SWMU is included.

Nickel (Ni), a human health COC, was detected in concentrations below background (27.9 µg/g) in all but two soil sample locations from SWMU 30. Only three detections of nickel exceeded background. One detection occurred in a subsurface sample (2 ft bgs) collected from the center of the burn trench test pit and two occurred in subsurface samples (2 and 5 ft bgs) collected from the eastern burn trench (Figure 4.5-10). The maximum concentration (41.5 µg/g) occurs in the subsurface sample collected 2 ft bgs in the eastern burn trench (30-TP 1). Nickel is therefore considered to be a COC only at that location.

Silver (Ag), an ecological COC, was detected in only three samples at SWMU 30, each of which was collected from the open storage area (Figure 4.5-11). The highest concentration of Ag (1.27 µg/g) was detected in the surficial sample west of the wastewater lagoon (30-OSA-3). The only other detection above background (0.35 µg/g) occurred in a subsurface sample (2 ft bgs) west of the lagoon (30-OSA-1). Silver is considered to be a COC only in the open storage area both east and west of the wastewater lagoon.

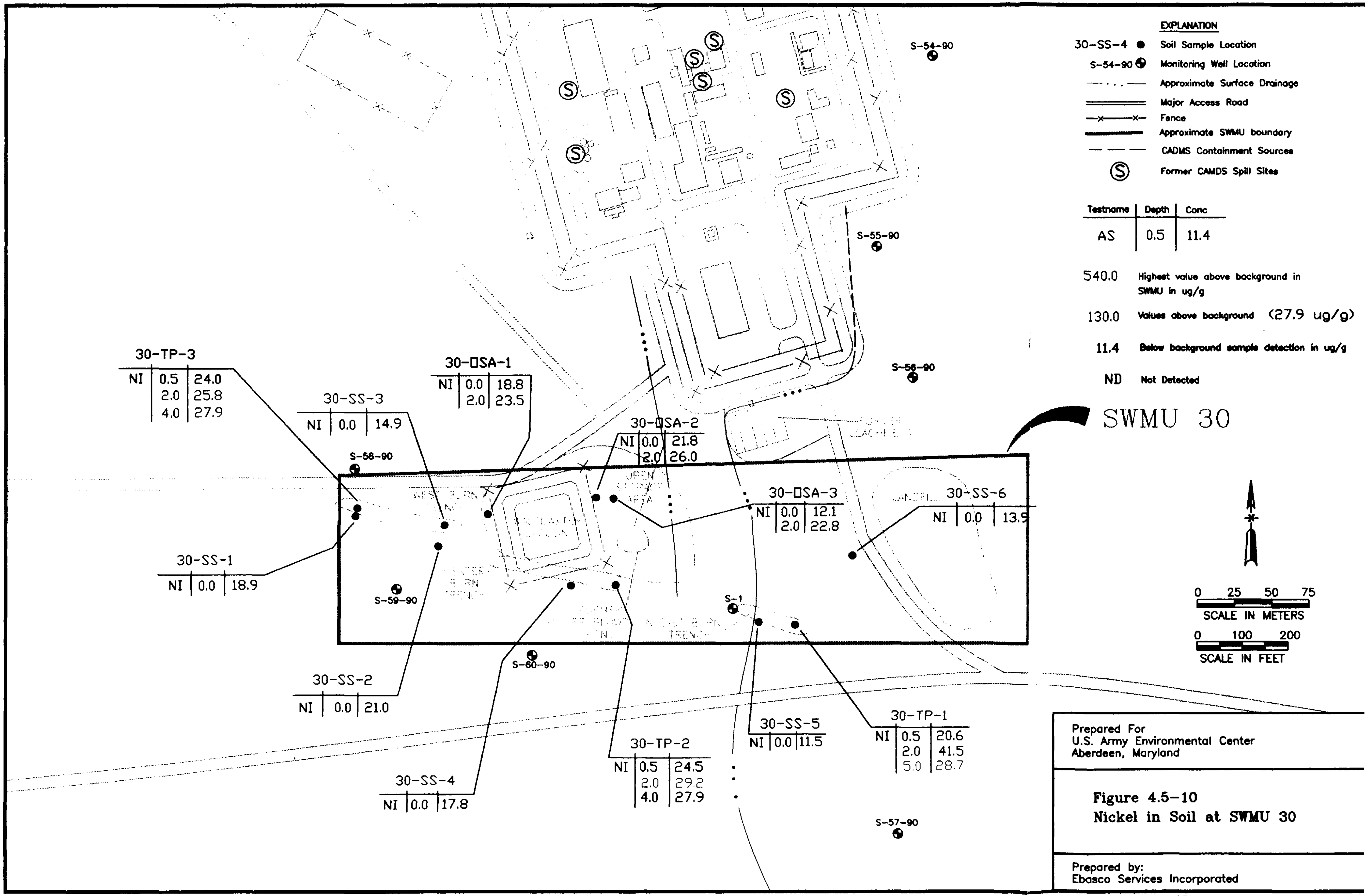
Zinc, a human health and ecological COC), was detected in all 21 soil samples at SWMU 30 (Figure 4.5-12). However, above-background concentrations (>144 µg/g) of zinc were detected in only four samples from two test pits. At the east burn trench, zinc was detected at above-background levels in subsurface samples (2 and 5 ft bgs). At the center burn trench, zinc was also detected at above-background levels in subsurface samples (2 and 4 ft bgs). The maximum concentration (669.0 µg/g) was detected in a subsurface sample (4 ft bgs) at the center burn



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-9
Lead in Soil at SWMU 30

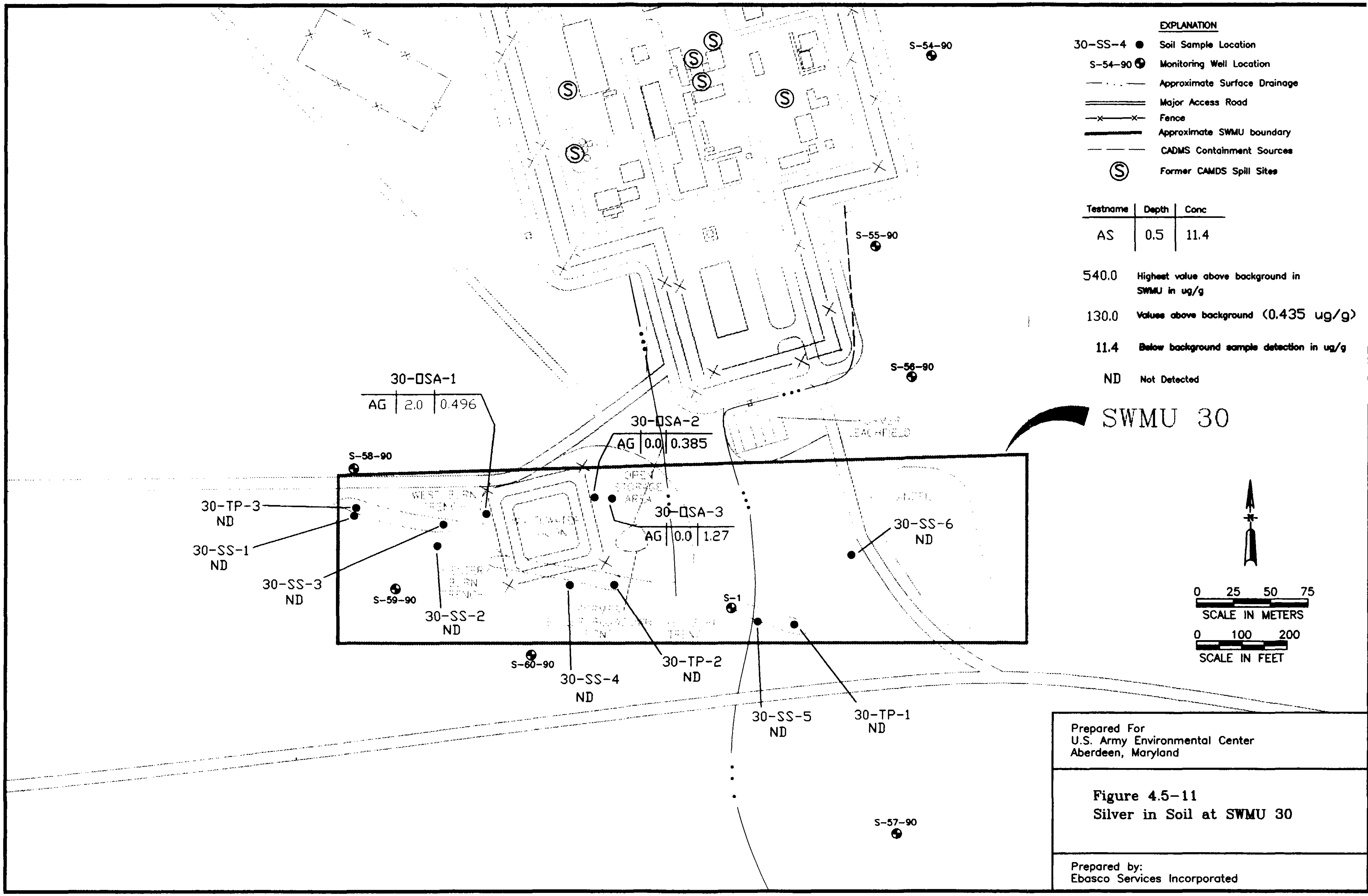
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-10
Nickel in Soil at SWMU 30

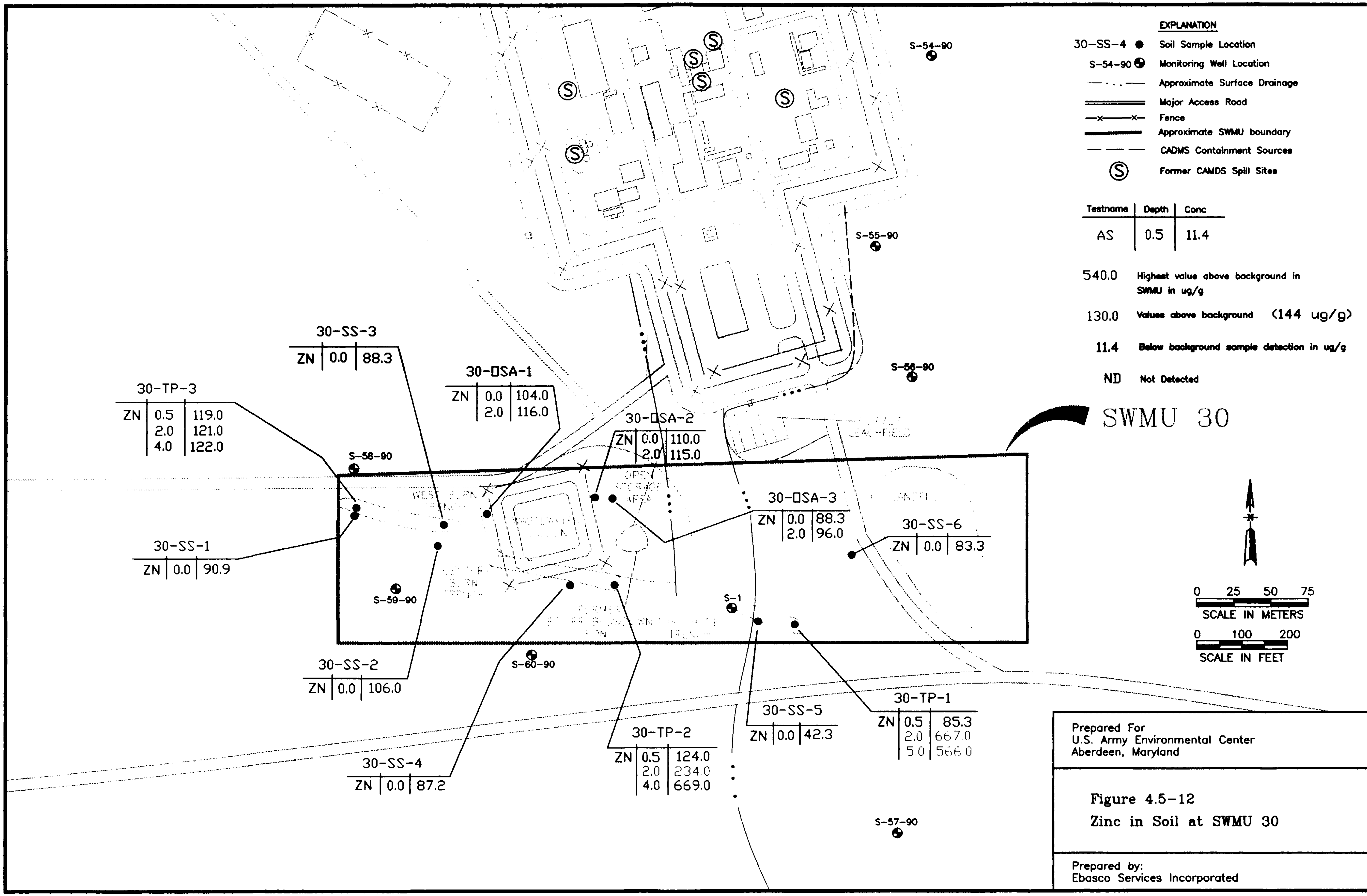
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-11
Silver in Soil at SWMU 30

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.5-12
Zinc in Soil at SWMU 30

Prepared by:
Ebasco Services Incorporated

trench. Since the background exceedances are limited to the east and center burn trenches, zinc is considered to be a COC for these two locations only, and not for the entire SWMU.

Detections above background in SWMU 30 soil are shown in Table 4.5-1.

4.5.2.2 Groundwater Contamination Assessment

Groundwater at SWMU 30 was evaluated by Rust (1994) as part of the risk assessment of the adjacent known releases SWMU 13 (CAMDS). Additional groundwater sampling and analysis, conducted at SWMU 30 in 1993, was evaluated for the RFI-Phase II study at SWMU 13. Based on the previous study and the more recent analytical results, all organic compounds detected in SWMU 30 are probably the result of operations at the CAMDS facility. All metals and anions detected above background levels are probably naturally occurring and are elevated due to the transitional nature of the soil geochemistry at SWMU 30.

4.5.2.3 Air Contamination Assessment

Since suspected releases at SWMU 30 are expected mainly from the covered trenches, no air monitoring was conducted at this site during the RFI-Phase II program.

4.5.3 Contaminant Fate and Transport

This section discusses the probable contaminant fate and transport processes and migration pathways that are operating at SWMU 30 based on site physical characteristics, contaminant chemical and physical characteristics, and the nature and extent of contamination in soils and groundwater.

As outlined in Section 4.5.2, the release of organic and inorganic compounds at SWMU 30 has resulted in the contamination of site soil. While several compounds were identified as potential contaminants at SWMU 30, only those compounds identified as COCs in the risk assessment for SWMU 30 (Section 5.6.1) are described here. These include 1,1,2-trichloro-1,2,2-trifluoroethane, arsenic, cadmium, chromium, copper, lead, nickel, and zinc.

4.5.3.1 Organic Compounds

PETN is a military munitions pollutant that exists in the pure form as crystalline prisms. It has a chemical formula of $C_5H_8N_4O_{12}$, and a molecular weight of 316.15. It has an aqueous solubility of 43 mg/L, making it slightly soluble in water. PETN has a vapor pressure of 1.0×10^{-10} mm Hg, and a Henry's law constant of 1.2×10^{-11} atm-m^3/mole. The octanol-water partition coefficient (K_{ow}) is estimated to be approximately 41; and the organic-carbon partition coefficient (K_{oc}) ranges from 179 to 1720. No data was located concerning biodegradation rates; however, the low octanol-water partition coefficient and moderate water solubility suggest that it does not bioconcentrate and therefore should be relatively degradable by soil and groundwater microorganisms.

PETN was released to the environment at SWMU 30 as a munitions waste product and has been detected in surface and subsurface soil at this site. Given the estimated range of K_{oc} values of

Table 4.5-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 30

Page 1 of 2

Location	Analyte	Depth (ft)	Value (μg/g)	Units	Location	Analyte	Depth (ft)	Value (μg/g)	Units
30-TP2	13DNB	2.000	0.309	UGG	30-TP1	CU	2.000	224	UGG
30-TP1	2MNAP	5.000	0.100	UGG	30-TP1	CU	5.000	356	UGG
30-TP1	2TMPD	2.000	0.710	UGG	30-TP2	CU	2.000	36.6	UGG
30-TP1	2TMPD	5.000	0.590	UGG	30-TP2	CU	4.000	73.8	UGG
30-TP2	2TMPD	4.000	0.790	UGG	30-TP3	CYN	2.000	0.979	UGG
30-OSA-1	AG	2.000	0.496	UGG	30-TP2	DH2MN	2.000	20.0	UGG
30-OSA-3	AG	0.000	1.27	UGG	30-OSA-1	DNBP	0.000	0.095	UGG
30-TP1	AS	2.000	130	UGG	30-OSA-1	DNBP	2.000	0.690	UGG
30-TP1	AS	5.000	540	UGG	30-OSA-2	DNBP	0.000	0.110	UGG
30-OSA-2	BE	0.000	0.943	UGG	30-OSA-2	DNBP	2.000	0.180	UGG
30-TP2	C12	2.000	50.0	UGG	30-OSA-3	DNBP	2.000	0.130	UGG
30-TP1	C13	5.000	0.440	UGG	30-TP2	DNBP	0.500	0.350	UGG
30-TP2	C13	2.000	60.0	UGG	30-TP2	DNBP	2.000	0.500	UGG
30-TP2	C13	4.000	0.400	UGG	30-TP3	DNBP	0.500	0.350	UGG
30-TP1	C14	5.000	0.440	UGG	30-TP3	DNBP	2.000	0.340	UGG
30-TP2	C14	2.000	100	UGG	30-TP3	DNBP	4.000	0.500	UGG
30-TP2	C14	4.000	0.400	UGG	30-OSA-1	DOAD	0.000	0.670	UGG
30-TP1	C16	2.000	0.350	UGG	30-OSA-1	DOAD	2.000	0.500	UGG
30-TP1	C16	5.000	0.880	UGG	30-OSA-2	DOAD	0.000	0.450	UGG
30-TP2	C16	4.000	0.660	UGG	30-OSA-3	DOAD	0.000	0.380	UGG
30-TP1	C17	2.000	0.470	UGG	30-TP1	FE	2.000	36,000	UGG
30-TP1	C17	5.000	1.30	UGG	30-TP2	FE	4.000	40,000	UGG
30-TP2	C17	4.000	0.660	UGG	30-OSA-1	K	2.000	8,050	UGG
30-TP1	C18	2.000	0.350	UGG	30-OSA-2	K	2.000	7,590	UGG
30-TP1	C18	5.000	0.740	UGG	30-OSA-3	K	2.000	7,000	UGG
30-SS-6	C25	0.000	0.440	UGG	30-SS-2	K	0.000	8,860	UGG
30-OSA-1	C27	0.000	0.330	UGG	30-TP1	K	0.500	6,820	UGG
30-OSA-3	C27	0.000	1.30	UGG	30-TP1	K	2.000	4,930	UGG
30-SS-6	C27	0.000	1.00	UGG	30-TP1	K	5.000	6,550	UGG
30-OSA-1	CCL3F	0.000	0.007	UGG	30-TP2	K	0.500	8,630	UGG
30-OSA-2	CCL3F	0.000	0.009	UGG	30-TP2	K	2.000	8,470	UGG
30-OSA-1	CD	0.000	1.11	UGG	30-TP2	K	4.000	5,980	UGG
30-OSA-1	CD	2.000	1.29	UGG	30-TP3	K	0.500	8,550	UGG
30-OSA-2	CD	0.000	1.30	UGG	30-TP3	K	2.000	7,830	UGG
30-OSA-2	CD	2.000	1.46	UGG	30-TP3	K	4.000	8,790	UGG
30-OSA-3	CD	2.000	1.16	UGG	30-SS-6	MEC6H5	0.000	0.001	UGG
30-TP1	CD	2.000	10.1	UGG	30-TP2	MEC6H5	4.000	0.002	UGG
30-TP2	CD	0.500	1.04	UGG	30-OSA-1	MG	0.000	16,900	UGG
30-TP2	CD	2.000	1.91	UGG	30-OSA-1	MG	2.000	23,800	UGG
30-TP2	CD	4.000	7.84	UGG	30-OSA-2	MG	0.000	21,000	UGG
30-TP3	CD	0.500	1.32	UGG	30-OSA-2	MG	2.000	18,000	UGG
30-TP3	CD	2.000	1.11	UGG	30-OSA-3	MG	0.000	37,700	UGG
30-TP3	CD	4.000	1.31	UGG	30-OSA-3	MG	2.000	22,000	UGG
30-OSA-1	CH2CL2	0.000	0.008	UGG	30-SS-1	MG	0.000	21,600	UGG
30-OSA-2	CH2CL2	0.000	0.008	UGG	30-SS-2	MG	0.000	28,100	UGG
30-OSA-3	CH2CL2	0.000	0.015	UGG	30-SS-3	MG	0.000	23,700	UGG
30-TP1	CHOLA	2.000	1.20	UGG	30-SS-4	MG	0.000	22,800	UGG
30-TP1	CO	2.000	11.0	UGG	30-SS-5	MG	0.000	18,400	UGG
30-TP1	CR	2.000	104	UGG	30-SS-6	MG	0.000	39,100	UGG
30-SS-3	CU	0.000	29.7	UGG	30-TP1	MG	0.500	20,600	UGG

Table 4.5-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 30

Page 2 of 2

Location	Analyte	Depth (ft)	Value (µg/g)	Units	Location	Analyte	Depth (ft)	Value (µg/g)	Units
30-TP1	MG	2.000	19,000	UGG	30-TP1	PB	0.500	25.0	UGG
30-TP1	MG	5.000	22,800	UGG	30-TP1	PB	2.000	850	UGG
30-TP2	MG	0.500	23,000	UGG	30-TP1	PB	5.000	200	UGG
30-TP2	MG	2.000	25,400	UGG	30-TP2	PB	0.500	29.0	UGG
30-TP2	MG	4.000	30,500	UGG	30-TP2	PB	2.000	34.0	UGG
30-TP3	MG	0.500	22,000	UGG	30-TP2	PB	4.000	32.0	UGG
30-TP3	MG	2.000	28,500	UGG	30-TP3	PB	0.500	31.0	UGG
30-TP3	MG	4.000	23,000	UGG	30-TP3	PB	2.000	35.0	UGG
30-OSA-1	MN	2.000	495	UGG	30-TP3	PB	4.000	34.0	UGG
30-OSA-3	MN	2.000	532	UGG	30-TP1	PHANTR	2.000	0.046	UGG
30-TP1	MN	2.000	537	UGG	30-TP1	PYR	2.000	0.061	UGG
30-TP1	MN	5.000	638	UGG	30-OSA-3	SB	0.000	10.7	UGG
30-TP2	MN	2.000	516	UGG	30-OSA-3	SE	0.000	0.517	UGG
30-TP2	MN	4.000	607	UGG	30-SS-1	TCLTFE	0.000	0.008	UGG
30-TP3	MN	0.500	476	UGG	30-SS-2	TCLTFE	0.000	0.008	UGG
30-TP3	MN	2.000	541	UGG	30-SS-3	TCLTFE	0.000	0.005	UGG
30-TP3	MN	4.000	536	UGG	30-SS-4	TCLTFE	0.000	0.007	UGG
30-OSA-2	NA	0.000	2,650	UGG	30-SS-5	TCLTFE	0.000	0.008	UGG
30-OSA-3	NA	0.000	5,140	UGG	30-TP1	TCLTFE	0.500	0.012	UGG
30-SS-1	NA	0.000	2,040	UGG	30-TP1	TCLTFE	2.000	0.011	UGG
30-SS-2	NA	0.000	20,400	UGG	30-TP2	TCLTFE	0.500	0.008	UGG
30-SS-4	NA	0.000	19,100	UGG	30-TP2	TCLTFE	2.000	0.008	UGG
30-SS-5	NA	0.000	10,700	UGG	30-TP3	TCLTFE	0.500	0.007	UGG
30-SS-6	NA	0.000	2690	UGG	30-TP3	TCLTFE	2.000	0.008	UGG
30-TP1	NAP	5.000	0.070	UGG	30-TP1	TL	0.500	39.5	UGG
30-TP2	NB	2.000	0.904	UGG	30-TP1	TL	2.000	37.3	UGG
30-OSA-2	NI	0.000	21.8	UGG	30-TP1	TL	5.000	47.7	UGG
30-SS-2	NI	0.000	21.0	UGG	30-OSA-2	V	0.000	29.4	UGG
30-TP1	NI	2.000	41.5	UGG	30-SS-1	V	0.000	29.6	UGG
30-TP1	NI	5.000	28.7	UGG	30-OSA-2	ZN	0.000	110	UGG
30-TP2	NI	2.000	29.2	UGG	30-SS-2	ZN	0.000	106	UGG
30-OSA-1	PB	0.000	57.0	UGG	30-TP1	ZN	2.000	667	UGG
30-OSA-1	PB	2.000	32.0	UGG	30-TP1	ZN	5.000	566	UGG
30-OSA-2	PB	0.000	38.0	UGG	30-TP2	ZN	2.000	234	UGG
30-OSA-2	PB	2.000	34.0	UGG	30-TP2	ZN	4.000	669	UGG
30-OSA-3	PB	2.000	27.0	UGG					

µg/g micrograms per gram
Note: Analyte names are defined in the chemical acronym list.

179 to 1,720, this indicates that PETN will exhibit low to moderate mobility in soil due to the high clay content of the soil at SWMU 30. However, due to the shallow depth of grounwater (6 to 8 ft bgs), some PETN is expected to leach to groundwater. when PETN reaches the groundwater, a stepwise hydrolysis to pentaerythitol and nitrate may be a possible fate process. In addition, give an solubility of 43 mg/L, and the low K_{ow} value of 41, there should be some biodegradation of this compound in groundwater.

Volatilization of PETN from soil to the atmosphere will not be an important fate process based on the extremely low vapor pressure of this compound. The small amount of PETN that may volatilize to the atmosphere will be expected to exist in the particulate form and be rapidly degraded by reaction with photochemically-produced hydroxyl ions brought into solution during periods of rainfall or seasonal snowmelt will not be expected to volatilize from water to the atmosphere due to PETN's extremely low Henry's law constant. In summary, given the chemical and physical properties of PETN and the geologic conditions at the site, PETN is not expected to be very mobile or extremely persistent; however, there may be some redistribution of PETN to deeper soil horizons and groundwatergiven the right conditions and its persistence in soil will depend on the activity of microorganisms to cause degradation.

1,1,2-trichloro-1,2,2-trifluoroethane (TCLTFE), also known as Freon 113, was detected in 11 of 21 soil samples in the 0.0-, 0.5-, and 2.0-ft depth intervals. This compound may have been released to the environment as emissions from its use as a foaming agent, refrigerant, or solvent, or from the disposal of containing this compound. Freon 113 has an aqueous solubility of 170 mg/L and a vapor pressure of 362 mm Hg. Its high vapor pressure is also reflected in its high Henry's law constant of 0.53 atm-m^3/mole. Freon 113 has an octanol-water partition coefficient of 1,445, and an organic-carbon partition coefficient ranging from 191 to 259. Data concerning rates of biodegradation could not be found.

Due to its high vapor pressure and Henry's law constant, volatilization from soil and water is expected to be rapid following its release. Therefore, the presence of Freon 113 in near-surface soil at the site suggests that it exists primarily in residual amounts adsorbed to soil organic matter, and secondarily to the silt- and clay-sized mineral fraction. Slow desorption of this compound from soil will likely result in trace amounts of Freon 113 reaching the atmosphere by volatilization. Similarly, trace amounts will desorb and become dissolved in infiltrating rainwater to be transported to the subsurface. The susceptibility of Freon 113 to biodegradation is poorly known, but is not expected to be significant in the aerobic soil environment at SWMU 30 due to the presence of chlorine and bromine. Degradation of Freon 113 by abiotic reactions (hydrolysis, oxidation, photolysis) is not a significant attenuation because it is generally chemically inert (Howard et al. 1990).

4.5.3.2 Inorganic Compounds

Metal COCs above background levels in soil have been detected in localized areas only (sample-specific COCs). The majority of metal COCs have been detected in surface or near-surface depth the alkaline pH of soils at TEAD-S greatly reduce the potential for dissolution of the metals by rainwater or snowmelt and prevents the leaching of these metals to the subsurface. These conditions act in concert to keep site metal COCs stable in the solid phase. However, for these same reasons, transport of metal COCs as fugitive dust or by particulate erosion from surface water runoff increases as a potentially significant migration mechanism. Because these COCs do not have appreciable vapor pressures or Henry's law constants, migration to the atmosphere is not likely except as fugitive dust. In addition, these COCs do not undergo degradation by microorganisms or other processes, so attenuation of these compounds may only occur by leaching or surface mechanical transport.

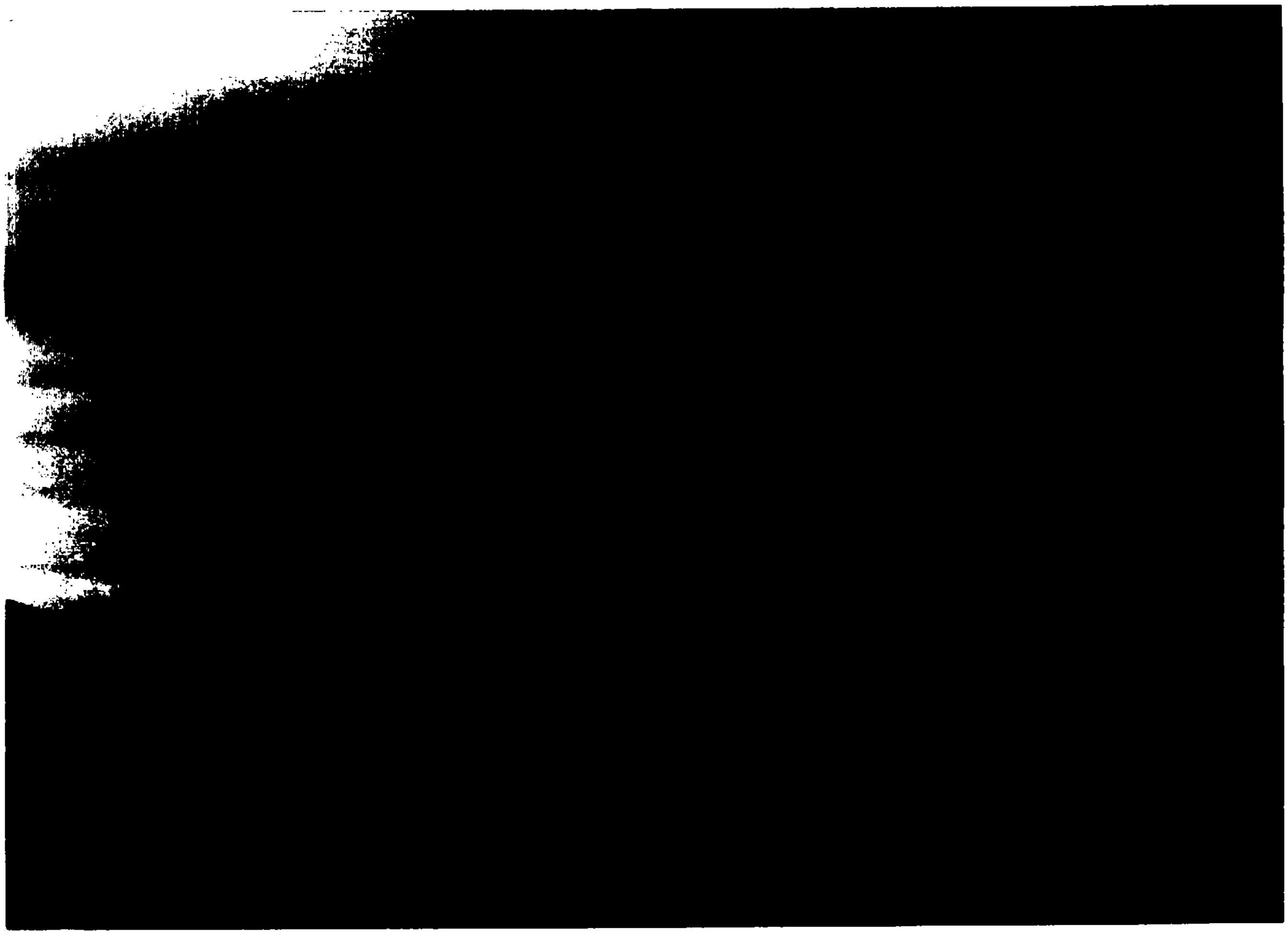
4.6 SWMU 31

4.6.1 Background

This section presents information on the site history and cultural features, geology and soil, and hydrology of SWMU 31.

4.6.1.1 Site History and Description of SWMU 31: Demilitarization Area (Northeast of SWMU 1)

SWMU 31 is an active open detonation (Figure 4.6-1) and open burning area located in the south-central portion of TEAD-S (Figure 4.6-2). The site occupies approximately 29 acres and includes 21 detonation pits approximately 15 ft deep (NUS 1987). According to historical aerial photographs, this site has been active since the early 1980s (EPIC 1986). Munitions to be detonated are placed in the bottom of the pits (Figure 4.6-3) and covered with native soil. The munitions contain explosive or reactive compounds including 2,4,6-trinitrotoluene (TNT), cyclonite (RDX), nitrostarch, PETN (an explosive), Composition B, Tetryl, and black powder (NUS 1987). NUS (1987) noted that lead azide and lead styphnate are components of some of these munitions, and that significant quantities of lead may result as residue after detonation. Detonation of the munitions may throw unexploded incendiary components out of the pits. Incendiary compounds, such as WP or magnesium, often react when exposed to the atmosphere, leaving chunks of white material on the ground around the pits (Figure 4.6-4). Propellant is burned in a 4 ft by 6 ft by 1 ft metal burn pan in the northwestern portion of the unit (Figure 4.6-5). SWMU 31 is currently operating under a RCRA Subpart X permit.

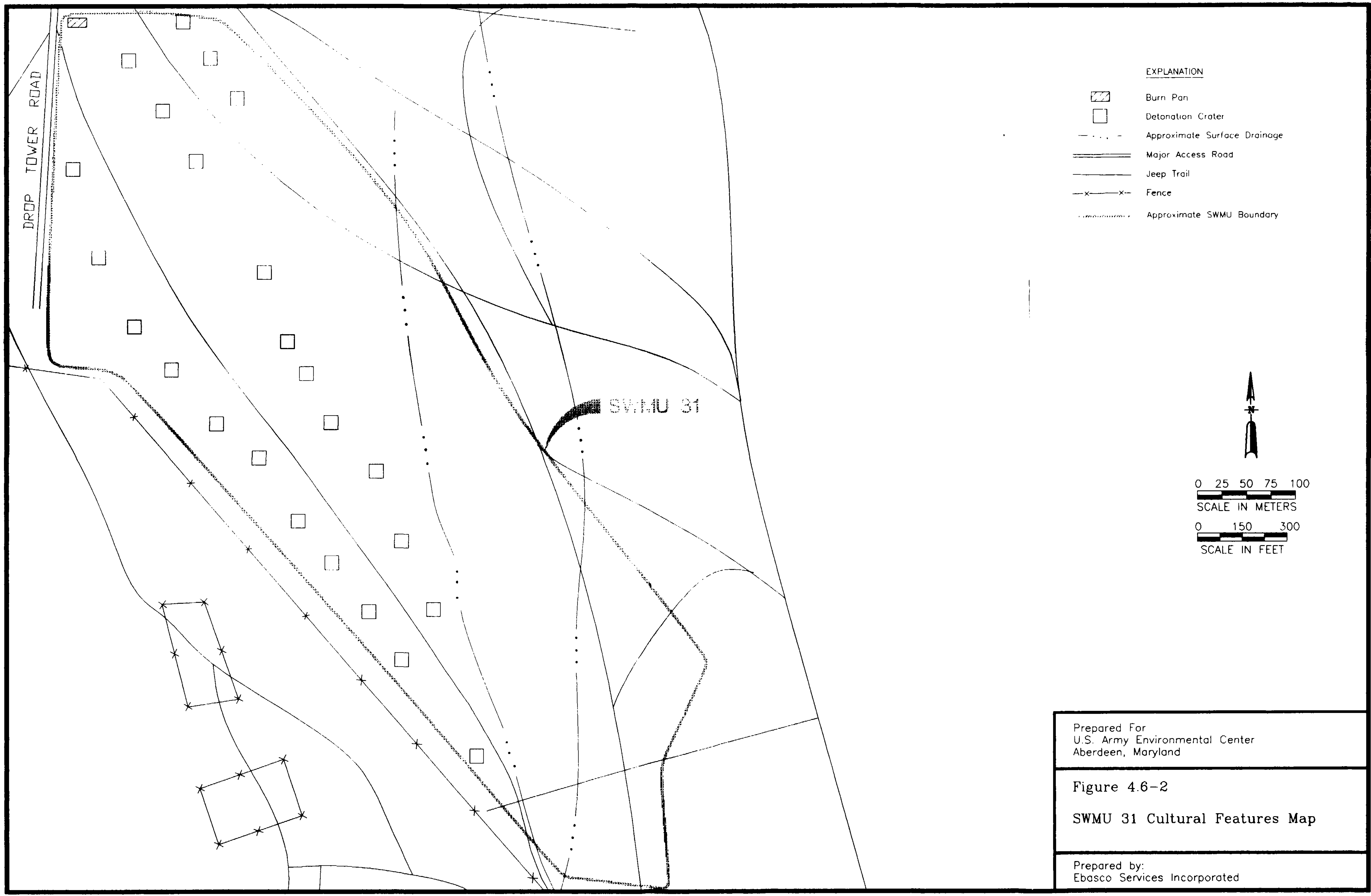


Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-1

Open Detonation of High Explosives at SWMU 31, as seen from SWMU 5.

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-2

SWMU 31 Cultural Features Map

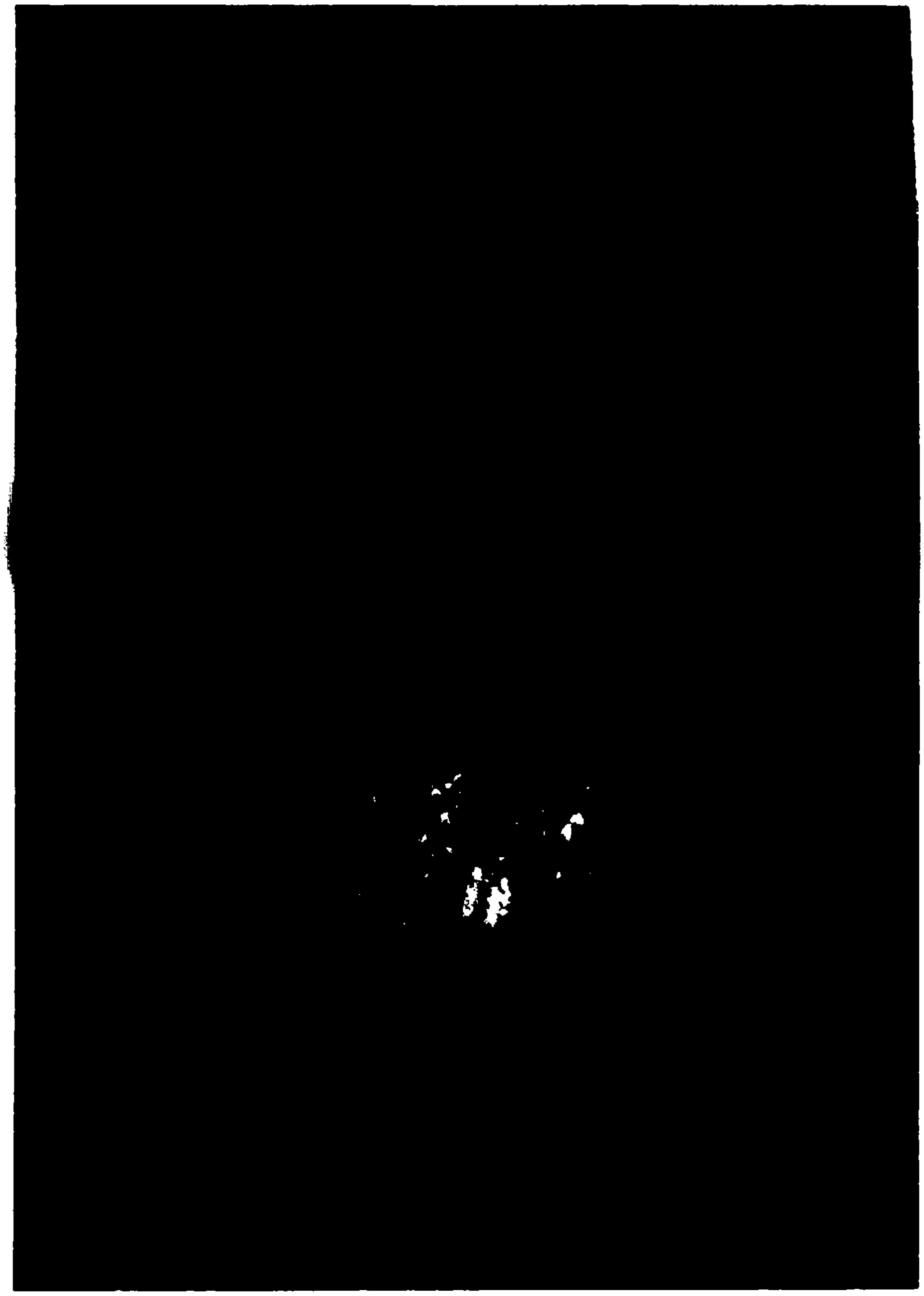
Prepared by:
Ebasco Services Incorporated

Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-3

Pallets of Munitions in Bottom of Detonation Pit at SWMU 31.

Prepared by:
Ebasco Services Incorporated

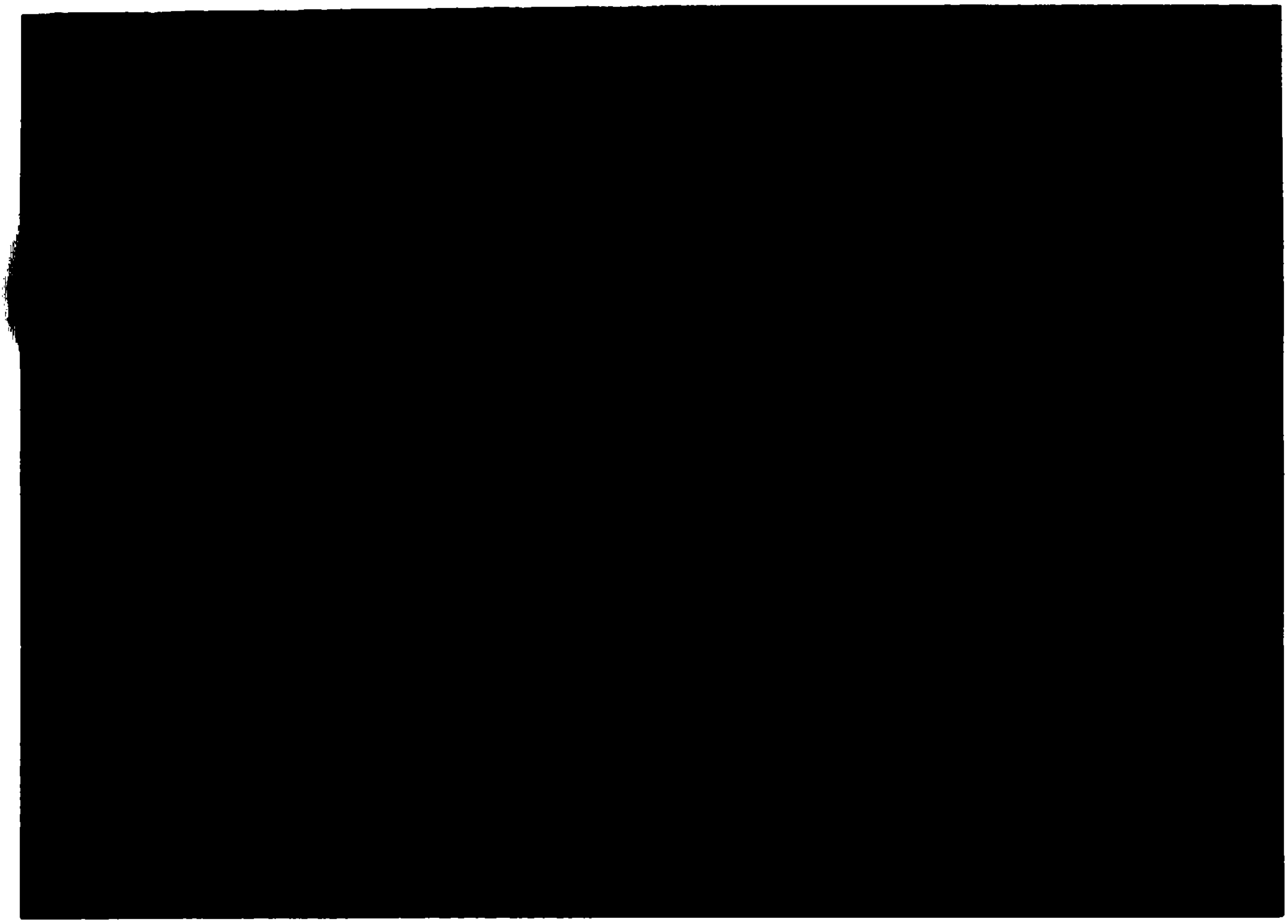


Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-4

Incendiary Material in Soil at SWMU 31

Prepared by:
Ebasco Services Incorporated



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6–5

Burn Pan used for Propellant Burns at SWMU 31.

Prepared by:
Ebasco Services Incorporated

4.6.1.2 Geology and Soil at SWMU 31

The geology and soil at SWMU 31 were characterized using eight shallow test pit excavations (see Figure 3.7-10). The maximum depth investigated was 3 ft.

The soil encountered is all relatively fine-grained lacustrine material that has a USCS classification of clayey silt (ML). In the southern portion of the unit and at background locations to the east of SWMU 31, the soil shows an increase in coarser-grained material, typically fine sand, with depth. However, the material at location 31-BK-2 is a sandy silty gravel (GM) with some cobbles observed from 1.5 to 3.0 ft. Topographically, this location is within the highest part of the SWMU 31. This gravel and cobble material may be alluvial in origin.

The soil has a consistency/density range from soft and very loose to hard and very dense. The soil samples have relative moisture conditions that ranged from dry to moist. Detailed information on these characteristics can be found in the boring logs in Appendix A1.

Geotechnical testing was performed on samples from the two background locations (31-BK-1 and 31-BK-2). The soil is classified as ML-CL soil at location 31-BK-1 and GC soil at location 31-BK-2. This identification closely matches that recorded in the field for these samples. The samples exhibited alkaline conditions, with pH values between 8.76 and 9.67. Measured moisture contents of 4.3 percent in the GC soil and 6.6 percent in the ML-CL soil indicate damp conditions. The coefficients of permeability were nearly identical for both samples, 1.9×10^{-5} cm/sec for the soil GC and 2.5×10^{-5} cm/sec for the ML-CL soil, highlighting the significance of the clay content. The effective porosity was evaluated in the ML-CL soil as 28.9 percent, with a corresponding bulk density of 73 pcf. The GC sample had an expected higher bulk density of 95 pcf. The TOC values at depths from 1 to 3 ft were consistent (0.26 to 0.28 percent). One additional sample from 31-BK-1, a surface soil sample (depth 0.0 to 0.2 ft), was evaluated for TOC; it had a value of 1.75 percent, which reflects near-surface organic matter. The CEC values were relatively low, between 12 and 19 meq/100 g. Detailed information on these characteristics can be found in Appendix A3.

Unpublished information on soil types at TEAD-S was obtained from SCS (no date) in 1993. Two soil types are mapped at SWMU 31, the Cliffdown gravelly sandy loam and Tooele fine sandy loam. The Cliffdown soil is present in the eastern and western portions of the SWMU, and the Tooele soil occupies the central portion of SWMU 31 (Plate 1). The Cliffdown soil is coarser grained and exhibits moderately rapid permeability. It is very slightly to slightly saline and moderately alkaline at the surface, with alkalinity increasing with depth. The Tooele soil is somewhat less coarse than Cliffdown soil, but also exhibits moderately rapid permeability. The Tooele loam is slightly saline and moderately alkaline at the surface and increases in salinity and alkalinity with depth. The characteristics of these soils affect the future uses that can be considered. The Cliffdown and Tooele soil units are suitable for wildlife habitat and irrigated crops of alfalfa, pasture, barley, orchards (Cliffdown loam only), and corn silage (Tooele loam only). Gravels in Cliffdown soil limits its suitability for tillage. Cliffdown soil has poor suitability for livestock grazing and Tooele soil has fair suitability due to low-to-moderate forage production. Rangeland seeding suitability for both units is very poor. Water and wind erosion hazards are moderate for both units.

4.6.1.3 Hydrogeology at SWMU 31

SWMU 31 is located in a low-lying area at the base of a plateau. Surface water occurs primarily as runoff after major storms, and flows south in drainage ditches past the TEAD-S boundary and then west to a low area south of SWMU 1, a Group 1 SWMU. Water also becomes ponded in the detonation pits at this SWMU.

No new hydrogeologic information was collected during the RFI-Phase II program. However, the depth to groundwater from November and December 1993 is estimated to be between 70 and 74 ft below ground surface. The overall groundwater elevation is approximately 5,020 ft msl. Groundwater at SWMU 31 flows southward toward the TEAD-S southern boundary or southwestward into SWMU 1.

4.6.2 Nature and Extent of Contamination

This section describes the nature and extent of contamination in soil, surficial water, and air at SWMU 31. No assessment of groundwater contamination was performed at SWMU 31 because there are no monitoring wells at the SWMU. In the assessments of soil and surface water contamination, only those of potential risk to human or ecological receptors (COCs) are described in detail. Human health COC selection for SWMU 31 is detailed in Sections 5.7.1. Ecological COC selection for all Group 2 SWMUs is discussed in Section 6.3.

4.6.2.1 Soil Contamination Assessment

This section presents the chemical analytical results of the RFI-Phase II soil sampling program only, since no previous soil sampling was conducted at this SWMU. The RFI-Phase II results and evaluations are grouped by analyte, with significant detections discussed by location within the SWMU. The sample locations are shown on each of the individual contaminant maps. The complete chemical data for the RFI-Phase II soil samples can be found in Appendix F1.

Although this section presents an evaluation of all of the analytical data collected, the discussion focuses on the results for the human health and ecological COCs at SWMU 31 that are being evaluated in the risk assessments. The COCs for SWMU 31 include one organic compound (2,4,6-trinitrotoluene, or 246TNT) and three metals (cadmium, copper, and nickel).

Previous Investigations

No soil sampling was previously conducted at SWMU 31.

RFI-Phase II Results

Fifteen soil samples were collected from SWMU 31 during the RFI-Phase II program. Four surficial and subsurface samples (2 ft bgs) were collected from two sampling locations downslope from the detonation pits in the drainage ditch in the southern portion of the SWMU. Eleven soil samples were collected from four detonation pits in the central and northern part of the SWMU. The samples from the drainage ditch were analyzed for VOCs, SVOCs, explosives, agent breakdown products, and metals. The crater soil samples were analyzed for explosives, metals, and cyanide only.

Organic Compounds and Cyanide

Above-background concentrations of two organic compounds, 2,4,6-trinitrotoluene (246TNT) and dioctyl adipate (DOAD), were detected in three samples. The risk assessment determined that only one organic compound (246TNT) is a COC in SWMU 31.

246TNT was detected in two crater surficial soil samples, one in the northern and one in the central part of SWMU 31 (Figure 4.6-6). The maximum concentration of 246TNT (0.958 μg/g) was detected in the surficial soil sample from location 31-CS-4 in the central part of the detonation pits. The 246TNT probably results from the detonation of obsolete ordnance in this SWMU.

Cyanide was detected in six soil samples collected from detonation pits at SWMU 31 (Figure 4.6-6). It was detected at very low levels of 0.286 to 0.768 μg/g, as well as in surface water samples (see Section 4.6.2.2).

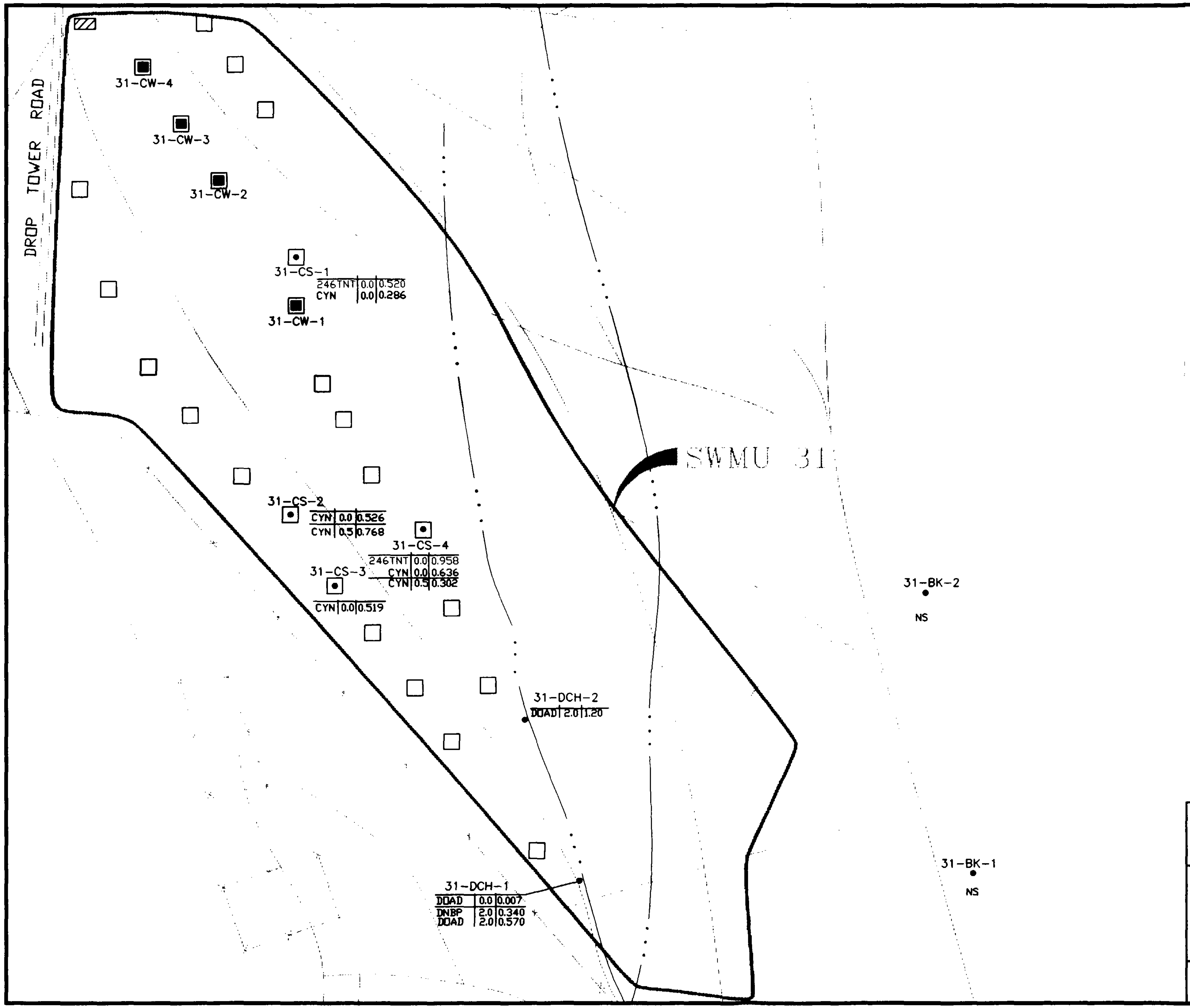
Metals

Above-background concentrations of eight metals, including antimony (Sb), cadmium (Cd), copper (Cu), mercury (Hg), magnesium (Mg), manganese (Mn), nickel (Ni), and zinc (Zn), were detected in both crater and ditch soil samples. The risk assessments determined that three metals (Cd, Cu, and Ni) are COCs in SWMU 31.

Arsenic (As), a facility-wide ecological COC, was detected at SWMU 31 only at concentrations below background (40.0 μg/g). Therefore, no figure is included to illustrate the distribution of arsenic at SWMU 31.

Cadmium (Cd), a facility-wide ecological COC, was detected above background (0.98 μg/g) in 10 of 15 soil samples collected at SWMU 31 (Figure 4.6-7). The highest concentration (2.37 μg/g) was detected in the surficial sample from one of the drainage ditch locations (31-DCH-2). The second-highest concentration also occurred in a surficial sample in the drainage ditch.

Copper (Cu), a human health and ecological COC, was detected in concentrations above background (27.6 μg/g) in four surficial samples in the western and southern portions of the SWMU (Figure 4.6-8). Of these, the two maximum concentrations of Cu (76.2 and 56.8 μg/g), which are significantly higher than background, were detected in surficial soil samples from the drainage ditch. All the remaining sample detections of Cu were at or below background. Given



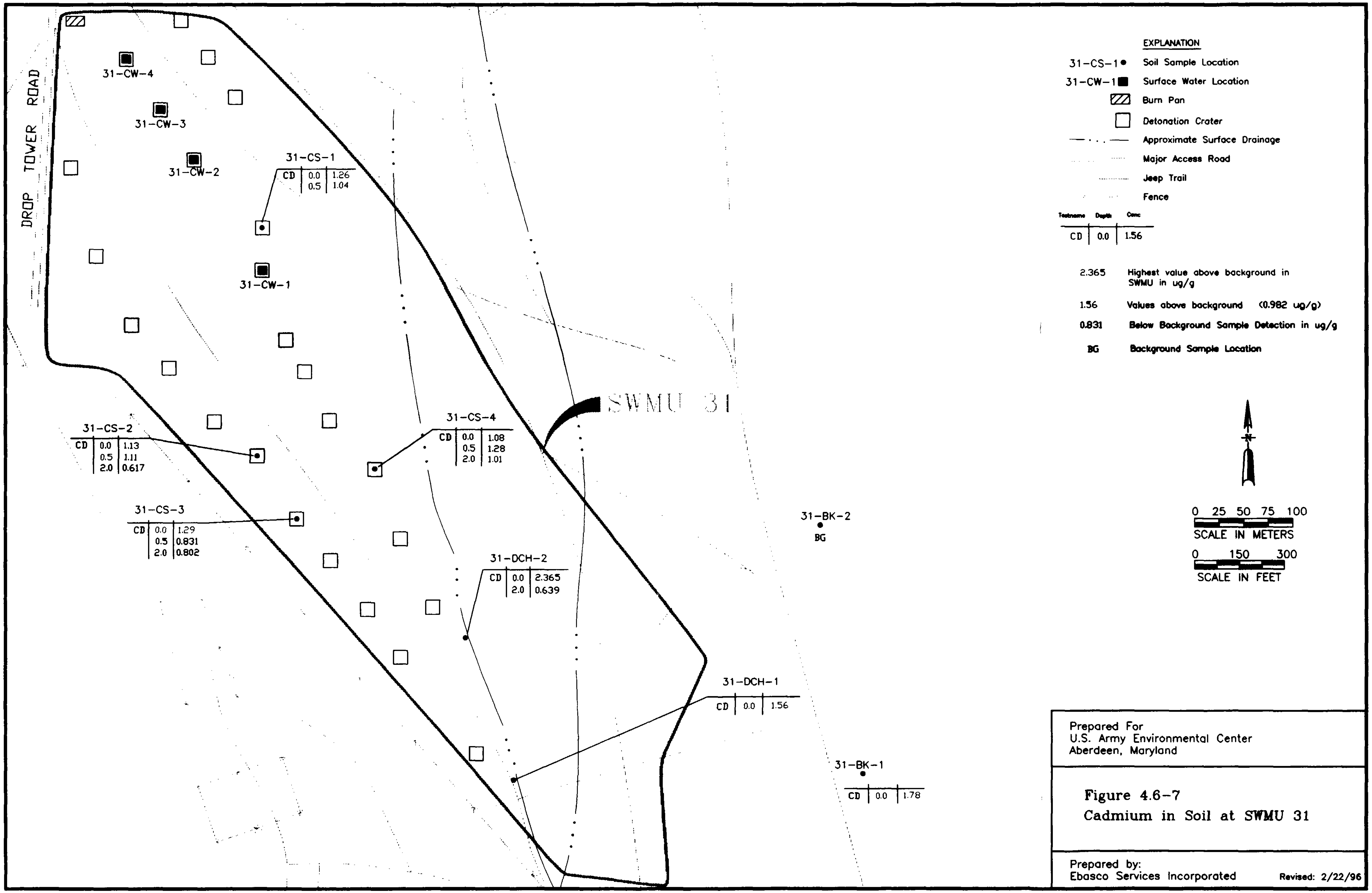
F:\PROJECTS\TOOELE\ARCAD\SWMU31\SWMU-31.DWG

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-6
Organic Compounds and Cyanide in Soil at SWMU 31

Prepared by:
Ebasco Services Incorporated

Revised: 2/22/96

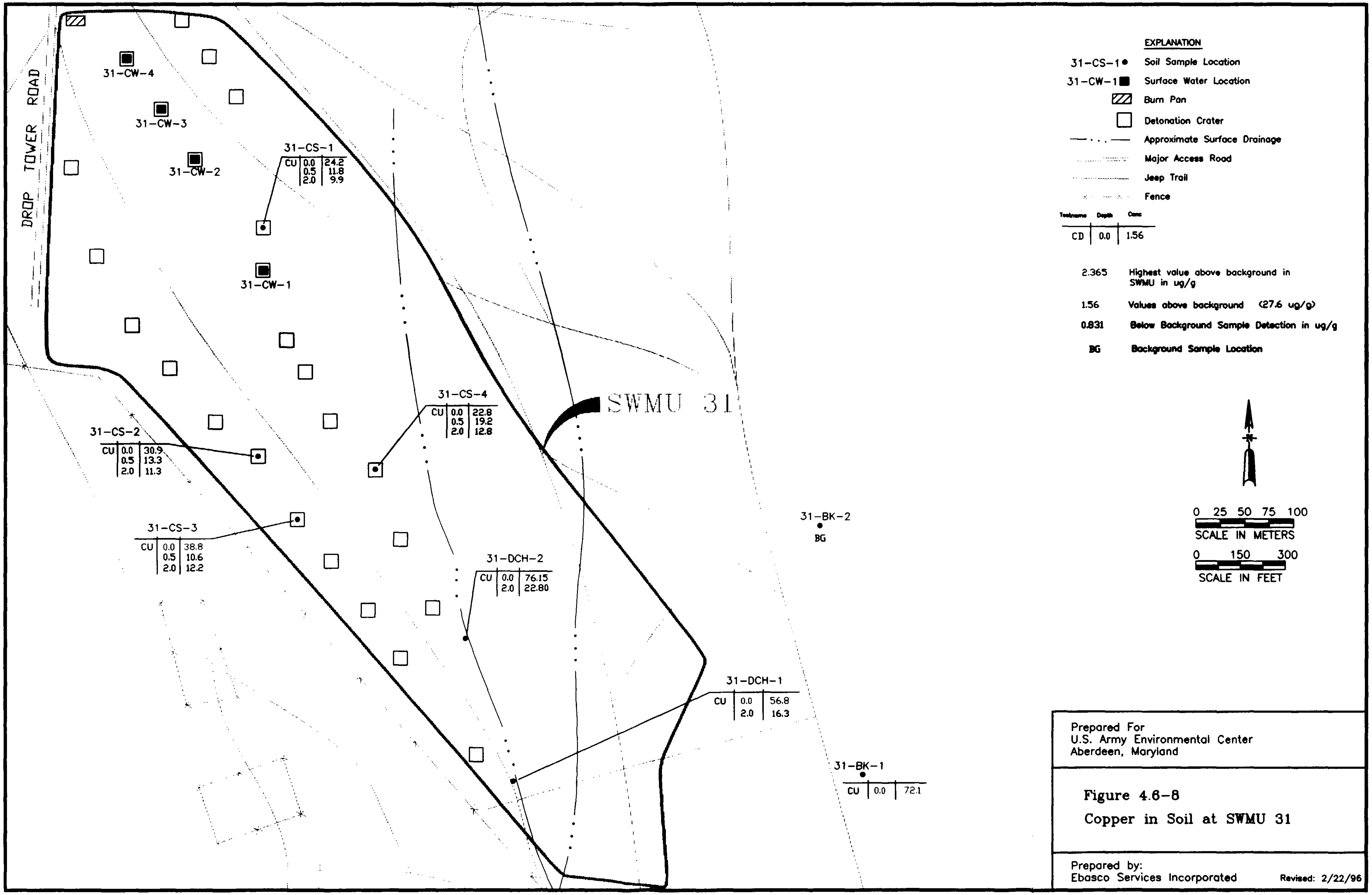


Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-7
Cadmium in Soil at SWMU 31

Prepared by:
Ebasco Services Incorporated
Revised: 2/22/96

F:\PROJECTS\TOOELE\ARCADV\SWMU31\SWMU-31M.DWG



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-8
Copper in Soil at SWMU 31

Prepared by:
Ebasco Services Incorporated

Revised: 2/22/96

F:\PROJECTS\TOOELE\ARCADA\SWMU31\SWMU-31M.DWG these observations, combined with the fact that Cu is widely distributed in nature and is an essential nutrient, the selection of copper as a COC is very conservative.

Lead (Pb), a facility-wide ecological COC, was detected at SWMU 31 only at concentrations below background level (35.0 μg/g). Therefore, no figure is included to illustrate the distribution of lead at SWMU 31.

Mercury (Hg), a facility-wide ecological COC, was detected above background (0.143 µg/g) at only one location (31-DCH-1) in SWMU 31 (Figure 4.6-9). The above-background concentration (0.195 µg/g) at this location was detected in the surficial sample. The three other detections of Hg at SWMU 31 were below background.

Nickel (Ni), a facility-wide ecological COC, was detected above background (27.9 µg/g) in 3 of 15 samples at SWMU 31 (Figure 4.6-10). The maximum concentration (32.2 µg/g), was detected in a subsurface sample (0.5 bgs) in the central section of the detonation pits (31-CS-3). The other above-background detections occurred at this location as well as the adjacent location (31-CS-2).

Silver (Ag), a facility-wide ecological COC, was not detected at SWMU 31.

Zinc (Zn), a facility-wide ecological COC, was detected at only one location (31-DCH-2) above background (144 µg/g). This maximum concentration (166 µg/g) was detected in the surficial sample from the ditch location mentioned above. All other detections were below background (Figure 4.6-11).

Detections above background in SWMU 31 soil are shown in Table 4.6-1.

4.6.2.2 Surface Water Contamination Assessment

This section presents the chemical analytical results of the RFI-Phase II surface water sampling program. There was no previous surface water sampling at this SWMU. The RFI-Phase II results and evaluations are grouped by analytes, with significant detections discussed by location within the SWMU. The sample locations are shown on each of the contaminant maps. The complete chemical data for the RFI-Phase II surface water samples can be found in Appendix F3.

Previous Investigations

No surface water sampling was previously conducted at SWMU 31.

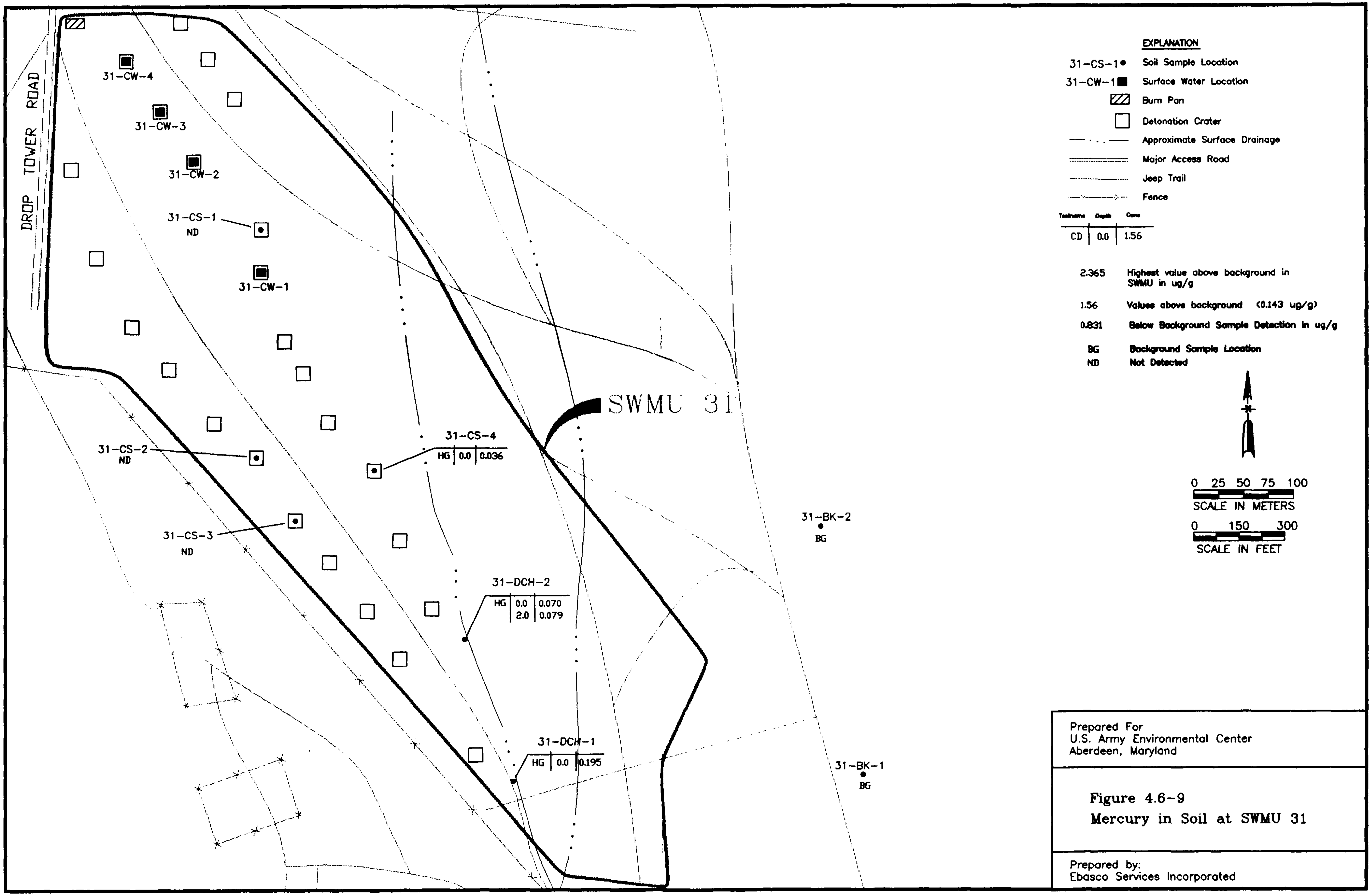
RFI-Phase II Results

Four surface water samples (31-CW-1 through 31-CW-4) were collected from ponded water in the bottom of detonation pits at SWMU 31. The samples were analyzed for explosives, cyanide, and total metals only.

There were no background surface water samples collected to determine background concentrations of the analytes of interest. Therefore, all detections are presented in the summary table (Table 4.6-2) and on the contaminant maps. Of the human health and ecological COCs discussed at this and other SWMUs, As and Cu are the only COCs detected in all four water samples.

Organic Compounds and Cyanide

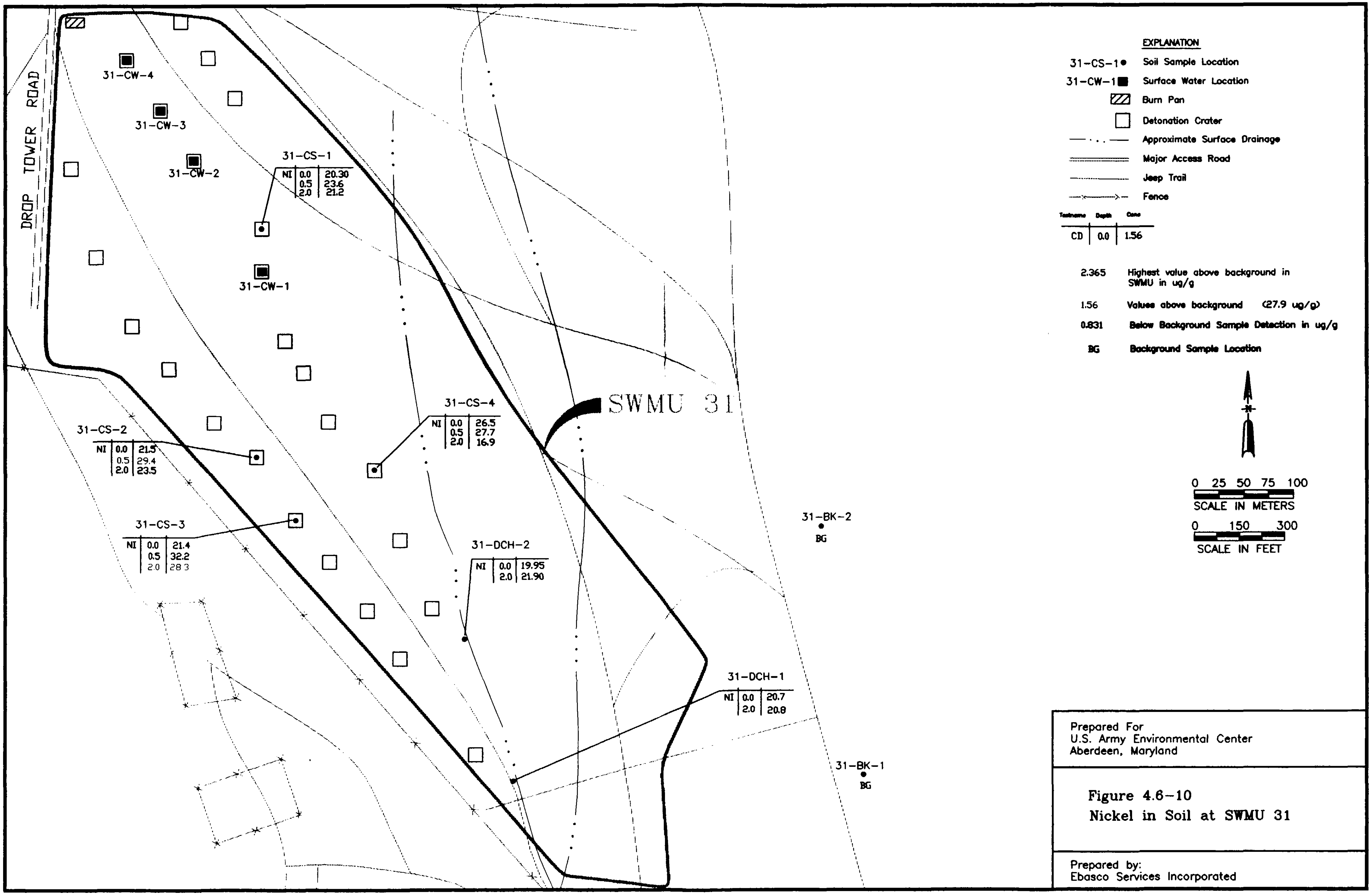
Explosives were detected in all four surface water samples collected during this investigation. The compounds 2,4-dinitrotoluene (24DNT), HMX, and RDX were detected in all samples (Figure 4.6-12). The explosives-related compound nitrobenzene (NB) was detected in one sample



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-9
Mercury in Soil at SWMU 31

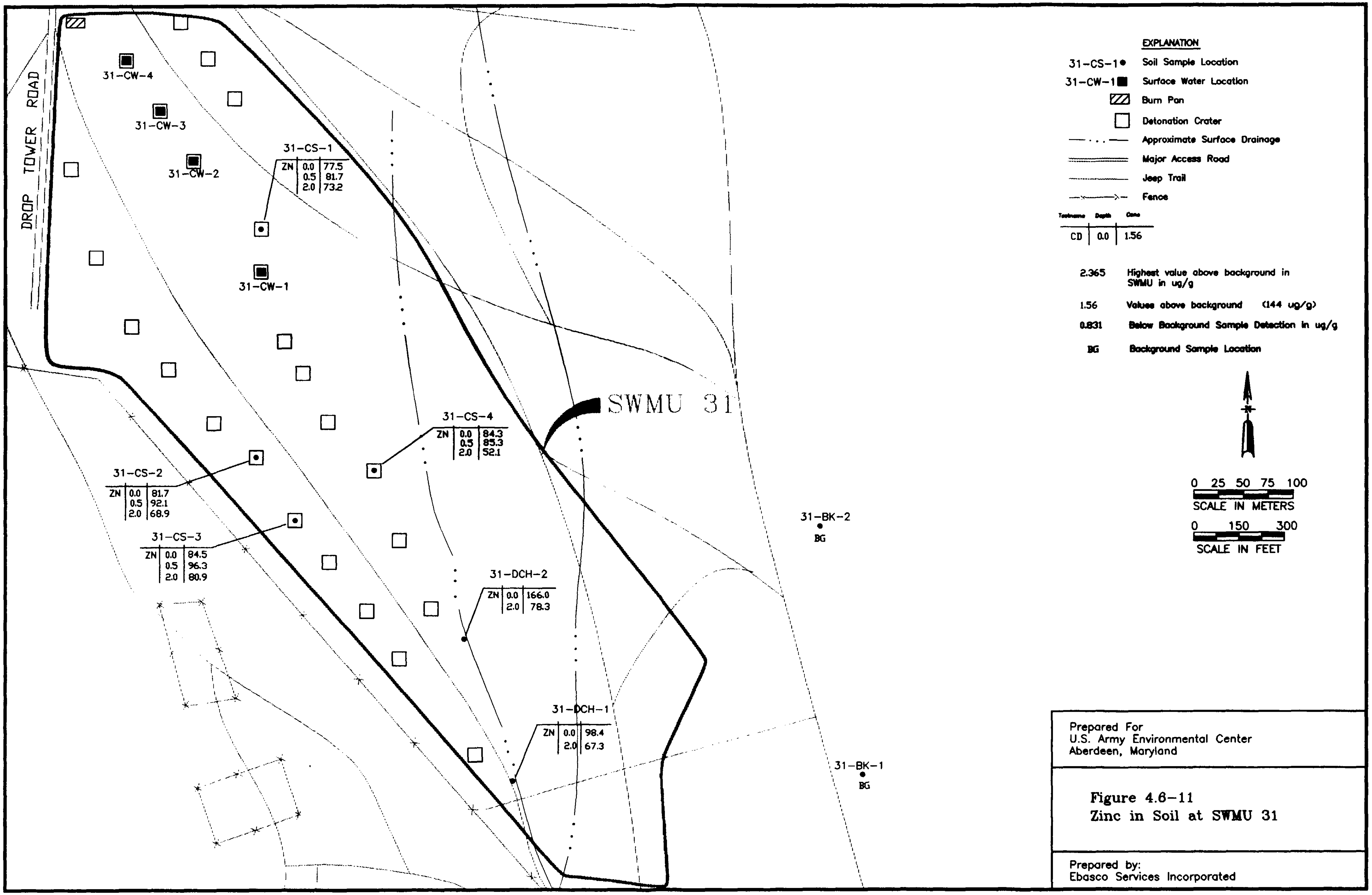
Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-10
Nickel in Soil at SWMU 31

Prepared by:
Ebasco Services Incorporated



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-11
Zinc in Soil at SWMU 31

Prepared by:
Ebasco Services Incorporated

Table 4.6-1 Chemical Analytical Detections Above Background in Soil Samples from SWMU 31

Page 1 of 1

Location	Analyte	Depth (ft)	Value (μg/g)	Units	Location	Analyte	Depth (ft)	Value (μg/g)	Units
31-CS-1	246TNT	0.000	0.520	UGG	31-DCH-1	HG	0.000	0.195	UGG
31-CS-4	246TNT	0.000	0.958	UGG	31-CS-1	MG	0.000	17,200	UGG
31-CS-2	BE	0.000	0.984	UGG	31-CS-1	MG	0.500	16,500	UGG
31-CS-3	BE	0.500	1.11	UGG	31-CS-2	MG	0.000	24,900	UGG
31-DCH-2	BE	0.000	1.15	UGG	31-CS-2	MG	0.500	34,700	UGG
31-BK-1	CD	0.000	1.78	UGG	31-CS-2	MG	2.000	29,800	UGG
31-CS-1	CD	0.000	1.26	UGG	31-CS-3	MG	0.000	22,500	UGG
31-CS-1	CD	0.500	1.040	UGG	31-CS-3	MG	0.500	46,400	UGG
31-CS-2	CD	0.000	1.13	UGG	31-CS-3	MG	2.000	28,700	UGG
31-CS-2	CD	0.500	1.11	UGG	31-CS-4	MG	0.000	27,300	UGG
31-CS-2	CD	2.000	0.617	UGG	31-CS-4	MG	0.500	25,500	UGG
31-CS-3	CD	0.000	1.29	UGG	31-CS-4	MG	2.000	18,200	UGG
31-CS-3	CD	2.000	0.802	UGG	31-CS-4	MN	2.000	678	UGG
31-CS-4	CD	0.000	1.08	UGG	31-DCH-2	MN	2.000	492	UGG
31-CS-4	CD	0.500	1.28	UGG	31-CS-1	NA	0.000	2,440	UGG
31-CS-4	CD	2.000	1.01	UGG	31-CS-2	NA	0.000	2,210	UGG
31-DCH-1	CD	0.000	1.56	UGG	31-CS-3	NA	0.000	1,890	UGG
31-DCH-2	CD	0.000	2.365	UGG	31-CS-3	NA	0.500	1,740	UGG
31-DCH-2	CD	2.000	0.639	UGG	31-CS-4	NA	0.000	2,430	UGG
31-DCH-1	CH2CL2	0.000	0.007	UGG	31-CS-1	NI	0.000	20.3	UGG
31-DCH-1	CO	0.000	6.65	UGG	31-CS-2	NI	0.000	21.5	UGG
31-BK-1	CU	0.000	72.1	UGG	31-CS-2	NI	0.500	29.4	UGG
31-CS-2	CU	0.000	30.9	UGG	31-CS-3	NI	0.000	21.4	UGG
31-CS-3	CU	0.000	38.8	UGG	31-CS-3	NI	0.500	32.2	UGG
31-DCH-1	CU	0.000	56.8	UGG	31-CS-3	NI	2.000	28.3	UGG
31-DCH-2	CU	0.000	76.15	UGG	31-CS-4	NI	0.000	26.5	UGG
31-DCH-1	DNBP	2.000	0.34	UGG	31-DCH-1	NI	0.000	20.7	UGG
31-DCH-1	DOAD	0.000	0.007	UGG	31-DCH-2	NI	0.000	19.95	UGG
31-DCH-1	DOAD	2.000	0.57	UGG	31-CS-1	SB	0.000	12.4	UGG
31-DCH-2	DOAD	2.000	1.20	UGG	31-CS-2	V	0.000	27.8	UGG
31-CS-3	FE	0.500	18,300	UGG	31-DCH-2	ZN	0.000	166	UGG

μg/g	micrograms per gram
Note:	Analyte names are defined in the chemical acronym list.

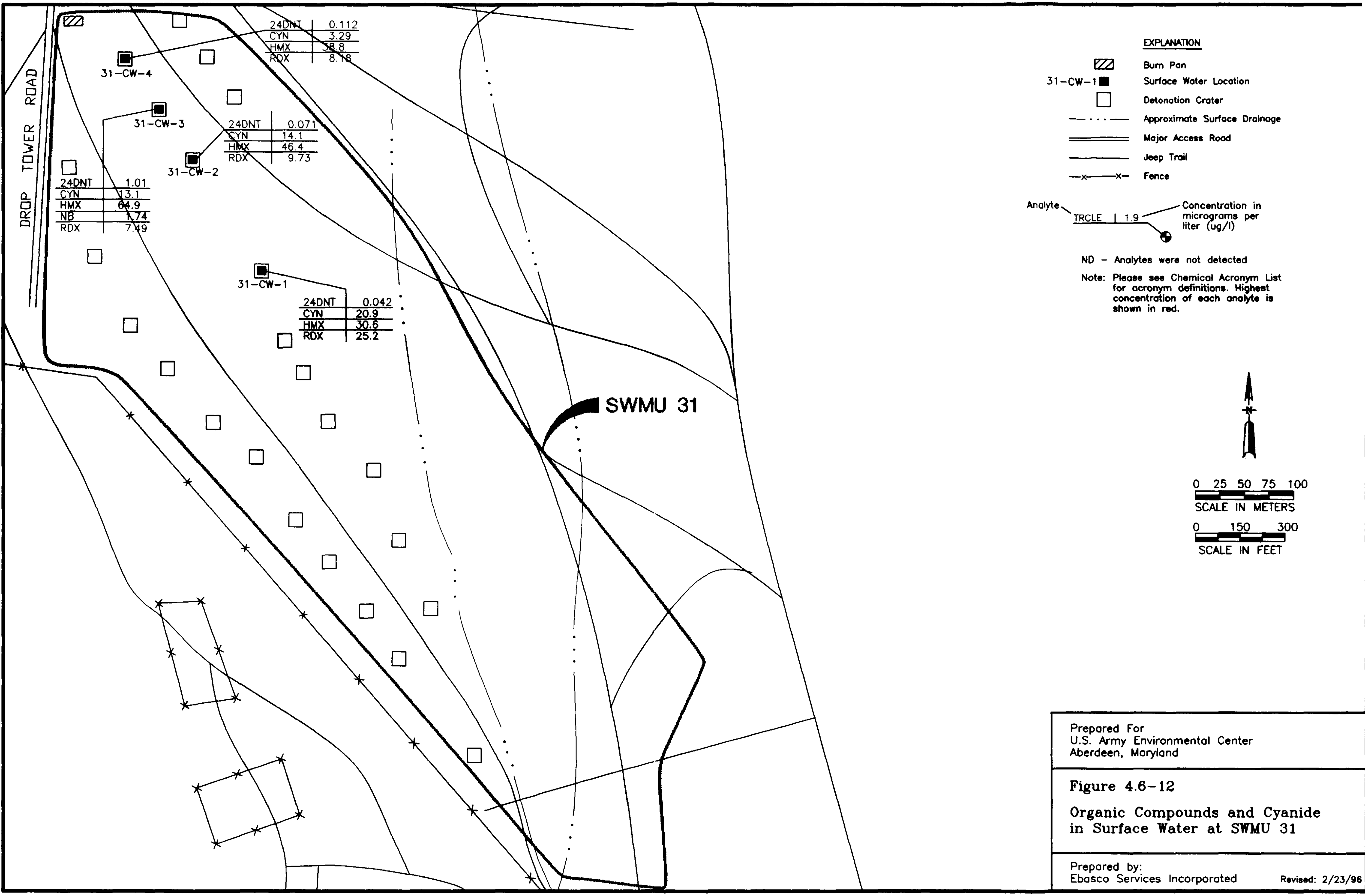
Table 4.6-2 Summary of Analyses for Surface Water at SWMU 31

Analyte	Number of Samples	Number of Detections	Percent of Detections	Minimum Concentration (μg/l)	Maximum Concentration (μg/l)
Explosives					
2,4-Dinitrotoluene (24DNT)	4	4	100	0.042	1.010
HMX	4	4	100	30.600	64.900
Nitrobenzene (NB)	4	1	25	1.740	1.740
RDX	4	4	100	7.490	25.200
Metals and Cyanide					
Aluminum (Al)	4	4	100	186.000	426.000
Antimony (Sb)	4	3	75	27.700	30.500
Arsenic (As)	4	4	100	13.300	32.900
Barium (Ba)	4	4	100	37.000	111.000
Calcium (Ca)	4	4	100	23,500.000	375,000.000
Chromium (Cr)	4	1	25	3.640	3.640
Copper (Cu)	4	4	100	18.700	88.300
Cyanide (CYN)	4	4	100	3.290	20.900
Iron (Fe)	4	4	100	176.000	422.000
Lead (Pb)	4	2	50	1.740	4.230
Magnesium (Mg)	4	4	100	39,000.000	301,000.000
Manganese (Mn)	4	4	100	5.750	39.800

Table 4.6-2 Summary of Analyses for Surface Water at SWMU 31 Page 2 of 2

Analyte	Number of Samples	Number of Detections	Percent of Detections	**Minimum** Concentration (µg/l)	Maximum Concentration (µg/l)
Potassium (K)	4	4	100	9,480.000	26,700.000
Selenium (Se)	4	1	25	43.200	43.200
Sodium (Na)	4	4	100	620,000.000	2,800,000.000
Vanadium (V)	4	4	100	25.600	29.000
Zinc (Zn)	4	1	25	12.400	12.400

Note: Concentrations are in micrograms per liter (µg/l).



Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6–12

Organic Compounds and Cyanide in Surface Water at SWMU 31

Prepared by:
Ebasco Services Incorporated

Revised: 2/23/96

F:\PROJECTS\TOOELE\GRAPHICS\S31-ORG.DWG

collected at 31-CW-3. HMX and RDX typically were found at the highest concentrations in each sample, accompanied by lower levels of 24DNT. The concentration ranges for the different explosives are given in Table 4.6-1. These explosive compounds have been demilitarized at TEAD-S.

Cyanide was detected in all four surface water samples at concentrations ranging from 3.29 μg/L to 20.9 μg/L.

Metals

Sixteen metals and cyanide were detected in the four surface water samples at SWMU 31 (Figure 4.6-13). The metals include aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), calcium (Ca), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), magnesium (Mg), manganese (Mn), potassium (K), selenium (Se), sodium (Na), vanadium (V), and zinc (Zn). Up to 14 metals were detected in all samples of surface water. Chromium, Se, and Zn were only detected in one of the four samples, each in a different sample. Lead was detected in two of the samples: one that also contained chromium (31-CW-3), and one that did not contain any of the other above-mentioned metals. The range of concentrations for each metal are given in Table 4.6-1.

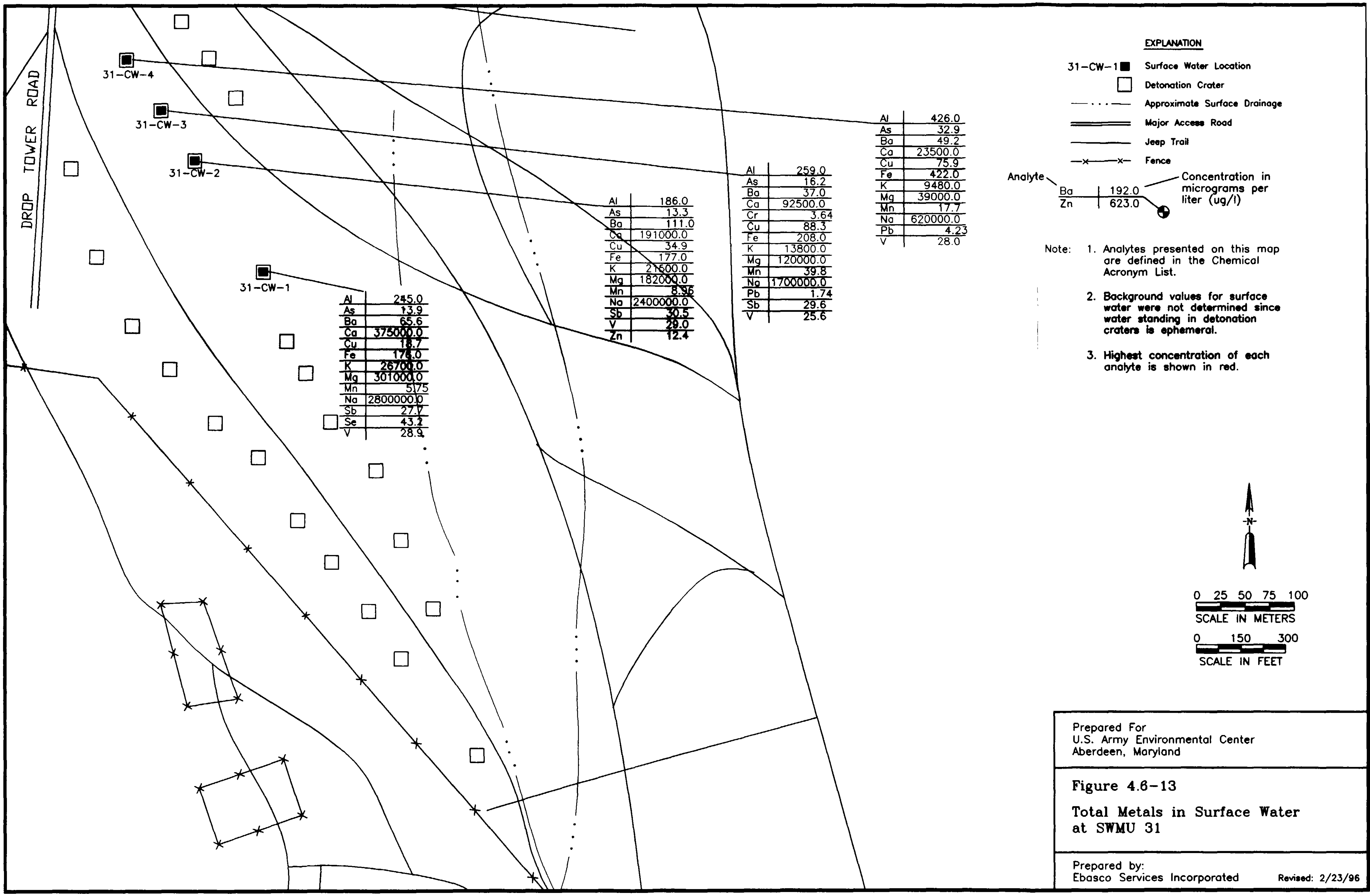
Arsenic and copper were the only facility-wide ecological COCs detected in all four samples. Arsenic concentrations ranged from 13.3 μg/L to 32.9 μg/L (soil background is 40.0 μg/g). Copper concentrations in the surface water ranged from 18.7 μg/L to 88.3 μg/L (soil background for the Group 2 SWMUs is 27.6 μg/g). Soil background concentrations were used as a screening tool for surface water detections because the soil in the craters is the source of contamination in the ephemeral surface water. Cadmium, an ecological COC in SWMU 31 soil, was not detected in the surface water.

4.6.2.3 Air Contamination Assessment

Ambient air sampling was performed at a station located approximately 300 meters southeast (i.e. downwind) of SWMU 31. Samples were analyzed from six 24-hour events collected during the period of September 21, 1993 to October 1, 1993.

Several volatile organic compounds were detected at SWMU 31 during the sampling program. Toluene was detected in five out of six samples with average and maximum concentrations of 2.37 and 13.0 ppbv, respectively. Total xylenes were measured in three samples at an average concentration of 2.63 ppbv. A maximum total xylenes concentration of 9.60 was recorded on October 1, 1993. Ethyl benzene was also detected in three samples with an average concentration of 0.45 ppbv. Low levels (0.18 - 0.36 ppbv) of methylene chloride were measured in three samples. Tetrachloroethene was detected in two samples with a maximum concentration of 0.42 ppbv. Local ambient concentrations for all five of these analytes appear potentially related to SWMU 31 source impacts.

Methyl isobutyl ketone was detected once (0.22 ppbv). Chloroform was measured in one sample at a level of 0.26 ppbv, barely above the method's lower detection limit. Very low levels (0.10 - 0.35 ppbv) of several other volatile organic compounds were regularly detected at SWMU 31 and at other sampling stations located around TEAD-S, including the background station. The list of detected analytes includes 1,1,1-trichloroethane, carbon tetrachloride, and benzene. The



Al	245.0
As	13.9
Ba	65.6
Ca	375000.0
Cu	18.7
Fe	176.0
K	26700.0
Mg	301000.0
Mn	5.75
Na	2800000.0
Sb	27.7
Se	43.2
V	28.9

Al	186.0
As	13.3
Ba	111.0
Ca	191000.0
Cu	34.9
Fe	177.0
K	21600.0
Mg	182000.0
Mn	8.96
Na	2400000.0
Sb	30.5
V	29.0
Zn	12.4

Al	259.0
As	16.2
Ba	37.0
Ca	92500.0
Cr	3.64
Cu	88.3
Fe	208.0
K	13800.0
Mg	120000.0
Mn	39.8
Na	1700000.0
Pb	1.74
Sb	29.6
V	25.6

Al	426.0
As	32.9
Ba	49.2
Ca	23500.0
Cu	75.9
Fe	422.0
K	9480.0
Mg	39000.0
Mn	17.7
Na	620000.0
Pb	4.23
V	28.0

Note:
1. Analytes presented on this map are defined in the Chemical Acronym List.
2. **Background values for surface water were not determined since water standing in detonation craters is ephemeral.**
3. **Highest concentration of each analyte is shown in red.**

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.6-13

Total Metals in Surface Water at SWMU 31

Prepared by:
Ebasco Services Incorporated
Revised: 2/23/96

levels measured at SWMU 31 are similar to those recorded at the other sampling stations including the background station and most likely represent the composition of the background airshed.

Several semivolatile organic compounds were detected in the field samples including naphthalene, di-n-butylphthalte, butylbenzylphthalate, and bis(2-ethylhexyl) phthalate. However, all these analytes were measured at comparable levels in the non aerated blank samples and thus, are most likely indicators of laboratory contamination.

There were no detections of cyanide or PCBs at SWMU 31 during the sampling program. A small amount (0.073 micrograms per cubic meter) of mercury was detected in one sample on September 23, 1993. Similar trace amounts of mercury were detected in a non aerated blank sample on September 27, 1993 and in the sample from the background site on September 29, 1993. The total suspended particulate results and metal results were not used due to laboratory and media problems. It was determined during subsequent laboratory analysis that the sample filters supplied to the field team were contaminated with high background levels of the target elements. This prevented the identification and quantification of metals in the ambient air. To offset this missing data, conservative assumptions were used in the human health risk assessment to estimate ambient concentrations of metal soil COCs resuspended in airborne particulates. Appendix I contains a complete listing of all air monitoring data.

4.6.3 Contaminant Fate and Transport

This section discusses the probable contaminant fate and transport processes and migration pathways that are operating at SWMU 31 based on site physical characteristics, COC physical and chemical characteristics, and the nature and extent of contamination.

As outlined in Section 4.6.2, the release of organic and inorganic compounds at SWMU 31 has resulted in the contamination of site soils and surface water. While several compounds were identified as potential contaminants at SWMU 31, only those compounds identified as COCs in the risk assessment for SWMU 31 (Section 5.7.1) are described here. These include 2,4,6-trinitrotoluene (TNT) and copper in soil, and RDX, antimony, and selenium in surface water.

4.6.3.1 Soils

COCs in soil at SWMU 31 are 246TNT and copper. There were two detections of 246TNT in site soil, at concentrations of 0.52 μg/g and 0.96 μg/g. The maximum detection occurred in a surficial sample at 31-CS-4. The presence of 246TNT in site soil is clearly the result of SWMU-related activities.

246TNT exists as yellowish crystals in pure form, but may also appear reddish in color as a result of exposure to sunlight when present in soil. 246TNT has a relatively low solubility in water (200 mg/L), a low vapor pressure (2×10^{-4} mm Hg), and a relatively high organic carbon partition coefficient (1,600). As a result, 246TNT mobility in soil/water systems is expected to be low, since it would preferentially partition to soil organic matter, particulates, and sediment. Because of its low vapor pressure and very low Henry's law constant (4.6×10^{-7}), volatilization from soil surfaces or from solution is extremely slow and is not expected to be a significant migration pathway under normal environmental conditions.

The biodegradation of 246TNT in soil is not expected to be significant, although 246TNT is readily reduced under anaerobic conditions. The reported degradation half-life of 246TNT in soil ranges from 4 weeks to 6 months and 4 weeks to 12 months in groundwater. When exposed to sunlight at the soil surface, 246TNT can photolyze to 246TNB and trinitrobenzaldehyde. Generally, 246TNT is not expected to hydrolyze in soil or groundwater under normal environmental conditions. 246TNT absorbs UV light in the environmentally significant range (wavelengths > 290 nm), suggesting that 246TNT undergoes direct photolysis in the atmosphere and at the soil-atmosphere interface. The photolysis half-life of 246TNT is approximately 110 days.

Copper was detected in all 15 soil samples at concentrations ranging from 9.9 µg/g to 76.2 µg/g. Copper exceeded site background (27.6 µg/g) in only four samples. The maximum detection (76.2 µg/g) occurred in a surficial sample (31-DCH-2) in the drainage ditch. The second highest detection (57 µg/g) also occurred in a surficial sample (31-DCH-1) in the drainage ditch. All remaining detections of copper were less than or equal to 39 µg/g, which is not significantly different than site background (27.6 µg/g). This suggests that contaminant copper is neither widespread nor present in significant concentrations at the site.

The mobility of copper at SWMU 31 by desorption and leaching from near-surface soil to deeper soil and the water table is expected to be very low for several reasons. First, this metal readily forms solids (oxides and hydroxides) of low solubility that restricts its movement even in the presence of water. Second, copper sorbs strongly to soil organic matter and the silt- and clay-sized mineral fractions of soil that are abundant at TEAD-S. Third, the alkaline pH of soil at TEAD-S greatly reduces the potential for dissolution of copper by rainwater or snowmelt and prevents the leaching of copper to the subsurface. These conditions act in concert to keep copper stable in the solid phase. However, for these same reasons, transport of copper as fugitive dust or by particulate erosion from surface water runoff increases as a potentially significant migration mechanism.

4.6.3.2 Surface Water

COCs in surface water at SWMU 31 are RDX, antimony, and selenium. Because background geochemical data for surface water is not available at TEAD-S due to the ephemeral nature of the surface water bodies, COCs were selected based on comparison of analyte detections to regulatory standards (e.g., MCLs).

RDX, also known as "Cyclonite", is a white crystalline powder having a molecular formula of $C_3H_6N_6O_6$, and a molecular weight of 222.26. The solubility of RDX is 45 mg/L, indicating relative insolubility in water. RDX has a vapor pressure of 4×10^{-9} mm Hg and a Henry's law constant of 2.6×10^{-11} atm-m^3/mole. The octanol-water partition coefficient is 7.4, and the organic-carbon partition coefficient ranges from 42 to 538. RDX is known to undergo significant degradation in the atmosphere with photochemically-produced hydroxyl radicals, with a half-life of 1.5 hours. There is little data concerning biodegradation of this compound.

Based on these characteristics, the RDX detected in surface water may exist either as insoluble RDX adsorbed to suspended soil mineral or organic particulates, or may be dissolved in water. Due to its extremely low vapor pressure and Henry's law constant, RDX remains in the water column as opposed to partitioning to the atmosphere. Prolonged exposure to sunlight may reduce RDX concentrations, but the magnitude of this attenuation mechanism is uncertain. Should a surface water body dry up, the RDX generally will remain behind in surface soil, with very limited vertical infiltration to subsurface soil horizons.

The presence of antimony and selenium in surface water probably also represent resuspended particulates. These compounds also return to surface soil and shallow subsurface soil following evaporation and become adsorbed to soil organic and mineral matter. This increases the potential that migration of these compounds as fugitive dust will occur as the detonation pit dries out.

In summary, the fate of COCs in surface water at SWMU 31 is determined largely by the ephemeral and short-lived nature of the ponds from which the samples were collected. Following spring snowmelt or large rainfall events, surface water collects locally in existing trenches and pits. This water is typically short-lived due to evaporation and limited infiltration. Inorganic COCs detected in surface water at SWMU 31 probably represent resuspended particulates that were originally present in soil and were brought into the water column temporarily. RDX may exist in the dissolved form or as adsorbed particulates. Therefore, it is likely that a cycle exists between the ponding of water in the pit/trench and resuspension and dissolution of COCs and the evaporation of the water and a return of the COCs to surface and shallow near-surface soil.

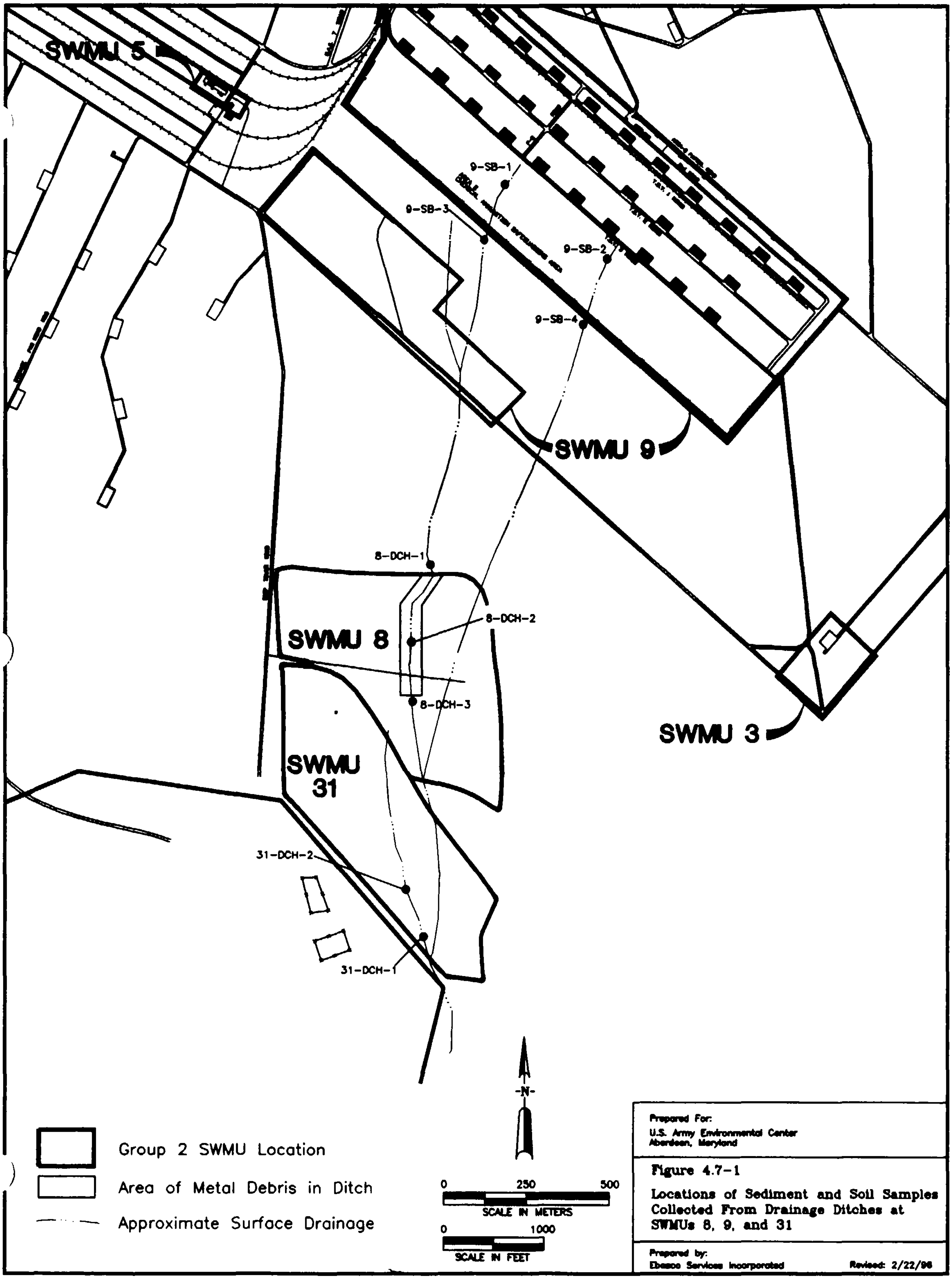
4.7 DITCH AND SEDIMENT SAMPLING

Sediment and soil samples were collected from nine locations along the drainage ditches at SWMUs 8, 9, and 31. Samples were collected from four locations at SWMU 9, three locations at SWMU 8, and two locations at SWMU 31 (Figure 4.7-1). Sediment samples were collected from the ground surface, and soil samples were collected to a depth of 3 ft.

4.7.1 Previous Sampling Results

Prior to the RFI-Phase I, sampling in the drainage ditches was confined to the Old Area 2 of SWMU 9 (Weston 1991). Three soil samples (SDHD-01, SDHD-02, and SDHD-03) were collected at a depth of 1 to 1.5 ft. These samples were analyzed for metals, SVOCs, and agent breakdown products.

Sample results indicate that three metals (chromium, copper, and nickel) were detected at levels above background. There were no detections of organic compounds in the samples. Detections of chromium ranged from 170 µg/g in SDHD-01 to 290 µg/g in SDHD-02; copper ranged in value from 75 µg/g in SDHD-01 to 110 µg/g in SDHD-02; and nickel ranged in value from 11 µg/g in SDHD-01 to 13 µg/g in SDHD-02 and SDHD-03. When the values for chromium, copper, and nickel are compared to the new soil background values established for Group 2 SWMUs (Ebasco 1994), only chromium and copper exceed background values.



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.7-1

Locations of Sediment and Soil Samples Collected From Drainage Ditches at SWMUs 8, 9, and 31

Prepared by:
Ebasco Services Incorporated
Revised: 2/22/96

F:\PROJECTS\TOOELE\GRAPHICS\DITCH1.DWG

4.7.2 <u>RFI-Phase II Results</u>

Sediment and soil samples were analyzed for VOCs and SVOCs, agent breakdown products, explosives, and metals. Table 4.7-1 summarizes the detections of organic and inorganic analytes in ditch sediment and soil samples at SWMUs 8, 9, and 31.

4.7.2.1 Organic Compounds and Cyanide

Seven different organic compounds were detected in sediment and soil samples at the three SWMUs. Organic compounds detected include dioctyl adipate (DOAD), di-n-butylphthalate (DNBP), trichlorofluoromethane (CCL_3F), hexadecanoic acid (C16A), heptacosane (C27), and nonacosane (C29) (Figure 4.7-2).

Four ditch locations at SWMU 9 were sampled for organic compounds. Two organic compounds (DOAD and DNBP) and 3 long-chain hydrocarbon compounds (C16A, C27, and C29) were detected in samples from SWMU 9. These compounds were generally confined to the surficial soil at sample location 9-SB-4, where C16A was detected at 0.51 µg/g, C27 was detected at 0.77 µg/g, DOAD was detected at 5.1 µg/g, and DNBP was detected at 10.0 µg/g. Nonacosane (C29) was detected at 0.5ft bgs at location 9-SB-1.

Three ditch locations at SWMU 8 were sampled for organic compounds. Three organic compounds were detected in sediment and soil samples from SWMU 8. Trichlorofluoromethane (CCL_3F) was detected at 0.5ft bgs (0.006 µg/g) and 2ft bgs (0.007 µg/g) at sample location 8-DCH-1, and at 2ft bgs (0.007 µg/g) at sample location 8-DCH-3. C27 (0.32 µg/g and 0.54 µg/g, respectively). There were no detections of organic compounds at sample location 8-DCH-2.

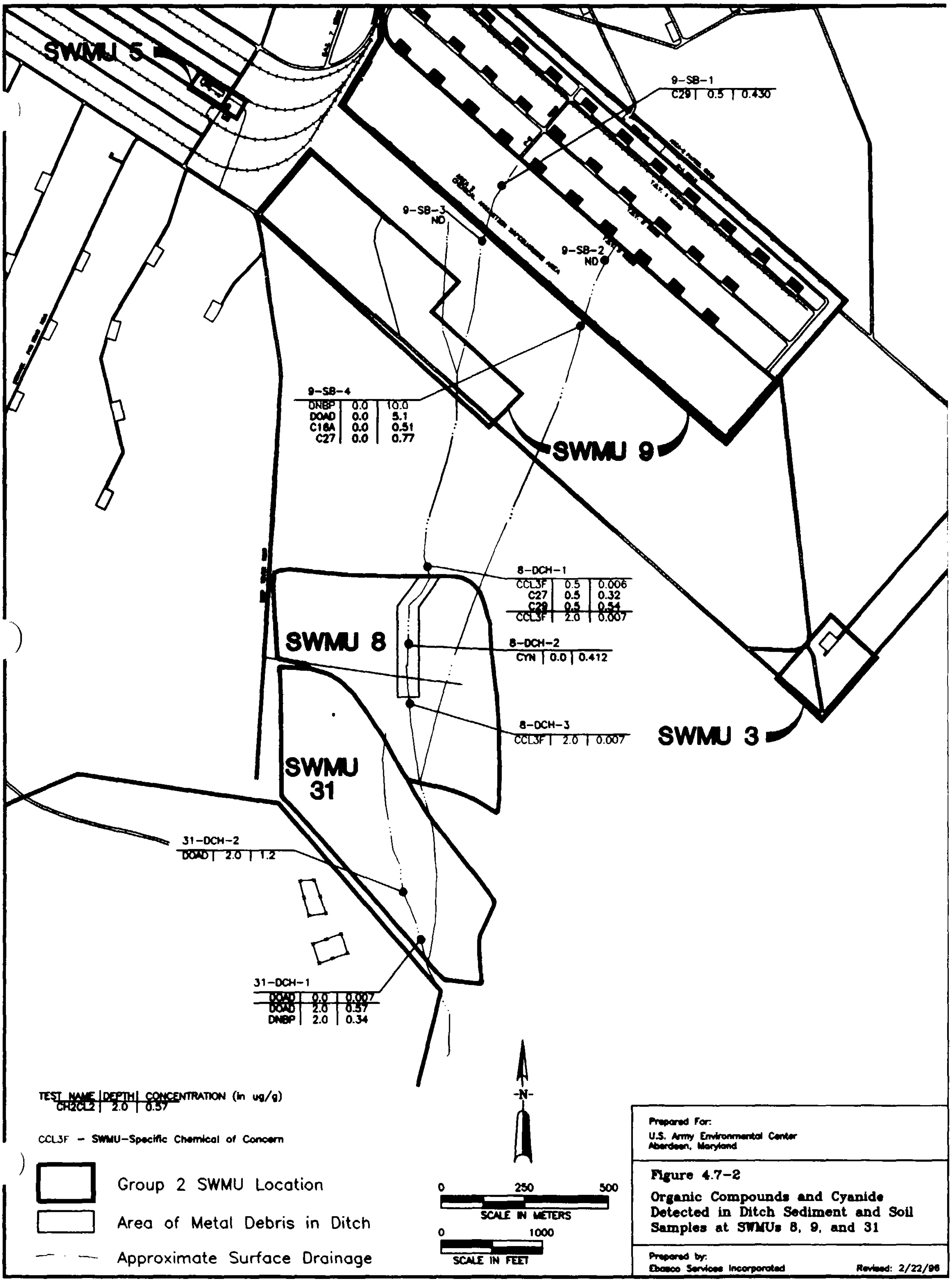
Two ditch locations at SWMU 31 were sampled for organic compounds. Three organic compounds (DOAD and DNBP) were detected in ditch samples at SWMU 8. DOAD was detected at location 31-DCH-1 in the surficial soil (0.007 µg/g) and 2ft bgs (0.57 µg/g), and at location 31-DCH-2 at 2ft bgs (1.2 µg/g). Di-n-butylphthalate was also detected at location 31-DCH-1 at 2ft bgs, at a concentration of 0.34 µg/g.

Results of the sampling for organic compounds at these three SWMUs indicate that sediments and soils in the ditches are relatively free of organic compounds. The isolated detections of trichlorofluoromethane and di-n-butylphthate, and the complete absence of explosives, agent breakdown products or other organic contaminants, suggest that the presence of these organic compounds are probably due to laboratory contamination and not from SWMU-derived activities. Certainly the consistency of the levels of trichlorofluoromethane, also known as Freon 11, of 0.006 µg/g, 0.007 µg/g, and 0.007 µg/g, suggests laboratory cross-contamination and not SWMU-derived field contamination. Freon 11 is a common refrigerant. Similarly, di-n-butylphthalate is a ubiquitous pollutant as a result of its use as a common plasticizer.

Table 4.7-1 Summary of Organic and Inorganic Detections in Ditch Sediment and Soil Samples at SWMUs 8, 9 and 31.

Location	VOCs	SVOCs	Expl.	Agent	Metals>Bkgd	TICs
SWMU 9						
9-SB-1	ND	ND	ND	ND	--	C29
9-SB-3	ND	ND	ND	ND	--	ND
9-SB-2	ND	ND	ND	ND	--	ND
9-SB-4	ND	DNBP,DOAD	ND	ND	--	C16A, C27
SWMU 8						
8-DCH-1	CCL3F	ND	ND	ND	Hg	C27, C29
8-DCH-2	ND	ND	ND	ND	Cd, Cu, Hg, Pb, Zn	ND
8-DCH-3	CCL3F	ND	ND	ND	Cd, Cu, Hg, Zn	ND
SWMU 31						
31-DCH-1	ND	DOAD, DNBP	ND	ND	Cd, Cu, Hg	ND
31-DCH-2	ND	DOAD	ND	ND	Cd, Cu, Zn	ND

DOAD:	dioctyl adipate
DNBP:	Di-n-Butyl Phthalate
CCL3F:	trichlorofluoromethane
C29:	Nonacosane
C27:	Heptacosane
C16A:	Hexadecanoic acid
ND:	Not detected



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.7-2

Organic Compounds and Cyanide Detected in Ditch Sediment and Soil Samples at SWMUs 8, 9, and 31

Prepared by:
Ebasco Services Incorporated

Revised: 2/22/96

4.7.2.2 Metals

Five different metals were detected at levels above background in sediment and soil samples from the nine ditch sample locations (Figure 4.7-3). These metals are cadmium (Cd), copper (Cu), mercury (Hg), lead (Pb), and zinc (Zn). There were no detections of metals above background in any of the samples from the four ditch locations at SWMU 9.

Each of the three sample locations at SWMU 8 had at least one metal occurring above background. Sample location 8-DCH-1 had only one metal (Hg) above background; location 8-DCH-2 had detections of five metals (Cd, Cu, Hg, Pb, and Zn) above background, and location 8-DCH-3 had detections of four metals (Cd, Cu, Hg, and Zn) above background.

Each of the two sample locations at SWMU 31 had at least one metal occurring above background. Sample location 31-DCH-1 had detections of Cd, Cu, and Hg above background, and location 31-DCH-2 had detections of Cd, Cu, and Zn above background.

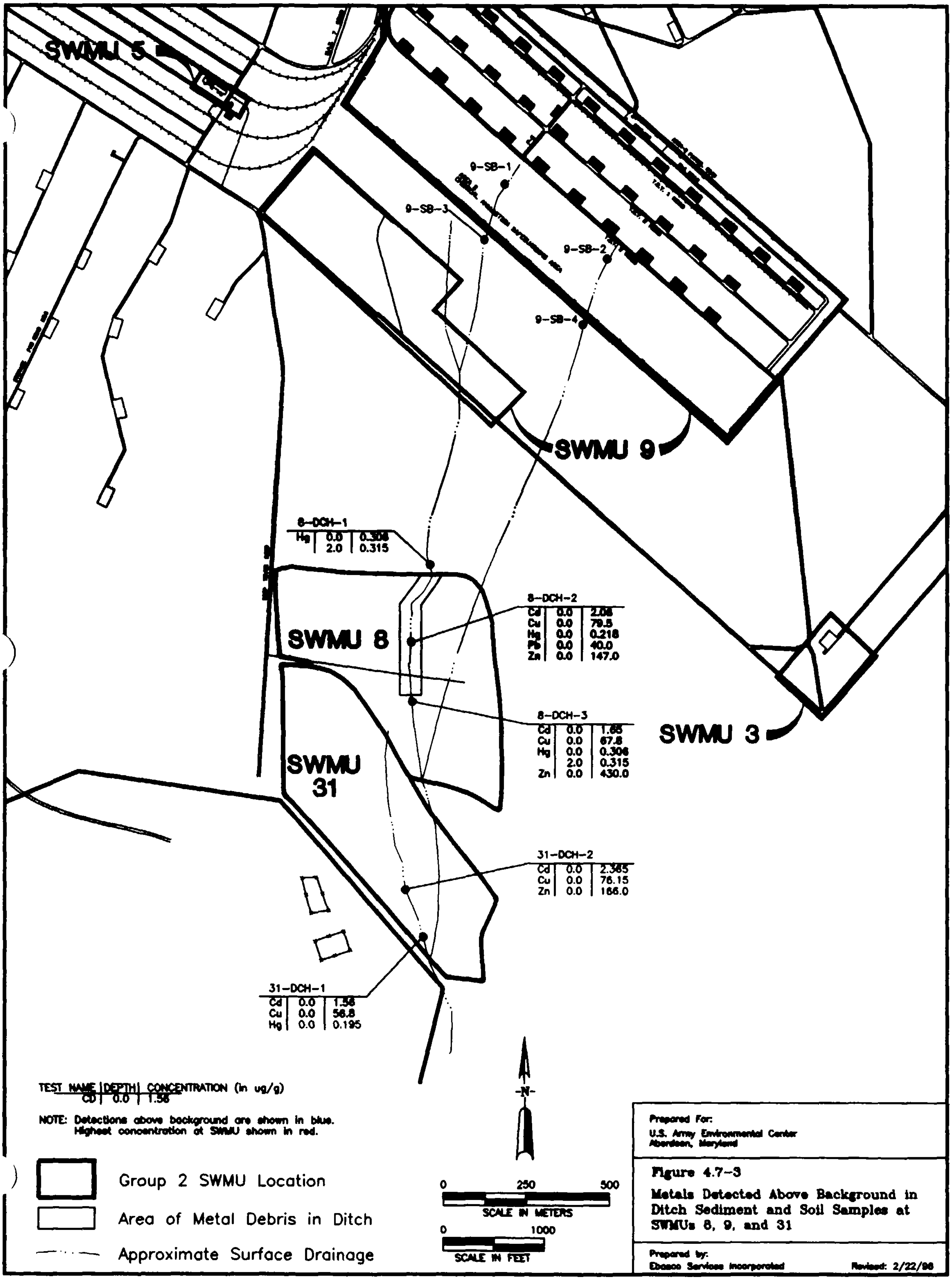
Cadmium was detected at concentrations above background in three samples at SWMU 8 and in 2 samples in SWMU 31. The maximum cadmium concentration (2.06 µg/g) at SWMU 8 occurred in the surficial soil at 8-DCH-2. The maximum concentration at SWMU 31 (2.365 µg/g) occurred in the surficial soil at 31-DCH-2. All detections of cadmium above background at these two SWMUs occurred in the 0.0 ft depth interval.

Copper was detected at concentrations above background in 2 samples at SWMU 8 and in 2 samples at SWMU31. The maximum copper concentration (79.5 µg/g) at SWMU 8 occurred in the surficial soil at 8-DCH-2. The maximum concentration at SWMU 31 (76.15 µg/g) occurred in the surficial soil at 31-DCH-2. All detections of copper above background at these two SWMUs occurred in the surficial soil (0.0 ft).

Lead was detected at concentrations above background in one sample at SWMU 8. Lead was detected at 40.0 µg/g in the surficial soil at 8-DCH-2. There were no other detections of lead above background at any other locations.

Elevated levels of mercury were detected at SWMUs 8 and 31. The maximum concentration of Hg at SWMU 8 (0.317 µg/g) occurred at 2.0 ft in 8-DCH-3. Two other detections of Hg above background at SWMU 8 occurred in surficial soil at 8-DCH-2 (0.218 µg/g), and in surficial soil at 8-DCH-3 (0.306 µg/g). The single detection of Hg above background at SWMU 31 occurred in surficial soil at 31-DCH-1 at 0.195 µg/g.

Zinc was detected at concentrations above background in surficial soil at two locations at SWMU 8, and at one location at SWMU 31. The maximum zinc concentration at SWMU 8 (430.0 µg/g) was detected at 8-DCH-3. The other detection of Zn occurred in 8-DCH-2 at 147 µg/g. The single detection of Zn above background at SWMU 31 occurred in 31-DCH-2 at 166 µg/g.



Prepared For:
U.S. Army Environmental Center
Aberdeen, Maryland

Figure 4.7-3

Metals Detected Above Background in Ditch Sediment and Soil Samples at SWMUs 8, 9, and 31

Prepared by:
Ebasco Services Incorporated
Revised: 2/22/96

4.7.3 Contaminant Fate and Transport

The detection of volatile organic compounds (methylene chloride and trichlorofluoromethane) in sediment and soil at SWMUs 8 and 31 is vexing due to the high vapor pressure of these compounds and the tendency of these compounds to volatile rapidly from soils to the atmosphere. Therefore, assuming that these compounds are not due to laboratory or other sources of cross-contamination, the persistence of these compounds in soil is likely due to adsorption to soil mineral matter (primarily clays and silts) and organic matter. In the adsorbed form, these compounds are relatively immobile and may be recalcitrant to biodegradation and chemical degradation processes.

The existence of semi-volatile organics (DNBP and DOAD) in sediment and soil samples at SWMUs 8, 9, and 31 is almost certainly due to adsorption of these compounds to soil mineral matter and organic matter. Both of these compounds exhibit low aqueous solubilities and high organic-carbon partition coefficients that act to immobilize them and increase their persistence in soil. DOAD and DNBP are susceptible to photolysis with atmospheric half-lives of 17 and 18 hours respectively, and therefore concentrations of these two compounds should slowly decrease over time by photochemical degradation.

The fate and transport of metals in soils and sediments at SWMUs 8 and 31 should be restricted to mechanical migration by seasonal flooding and surface water runoff within the confines of the drainage ditches, and by potential migration as fine particulates by wind transport. There may be some degree of downward transport through soil by infiltrating snowmelt and rainwater, but this migration mechanism should be minor considering the low solubility of these metals. In general, the inorganic contaminants in soil in the drainage ditches should be relatively persistent and concentrations should remain relatively unchanged over time.