2.0 BACKGROUND

Information on physical site characteristics supports a contamination assessment and risk assessment in that these site characteristics influence the distribution and migration of contaminants and the presence of human and ecological receptors. Accordingly, this section describes the physical setting and previous environmental investigations at TEAD-S, which are used as the basis for the sampling rationale and sampling data interpretation, and background soil and groundwater geochemistry, which are used to establish background levels of naturally-occurring metals in site soil and groundwater. A general discussion of chemical fate and transport in the environment is included.

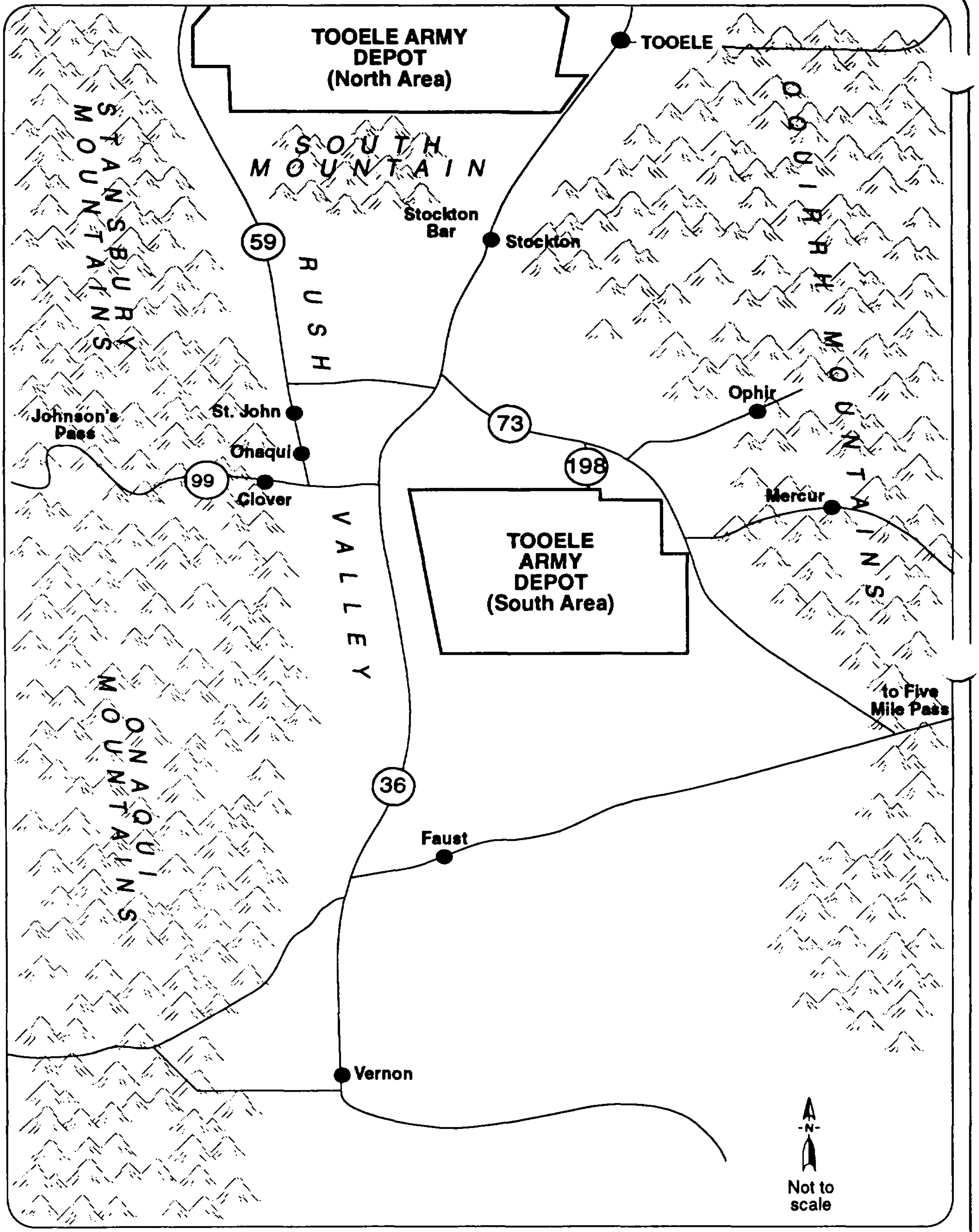
2.1 PHYSICAL SETTING

2.1.1 Location

TEAD consists of three separate areas in north-central Utah (Figure 1.0-1). The North Area (TEAD-N) is 7 miles (mi) south of the Great Salt Lake and 35 mi southwest of Salt Lake City. TEAD-N and TEAD-S are separated from Salt Lake City by the Oquirrh Mountains. The town of Tooele is adjacent to TEAD-N on the east. TEAD-S, which is the subject of this RFI, is located in a separate valley 17 mi south of TEAD-N. Both TEAD-N and TEAD-S are located in Tooele County. The third area controlled by TEAD is the Non-Tactical Generator and Rail Shop Division of the Maintenance Directorate, which is at Hill Air Force Base, 15 mi north of Salt Lake City in Weber County.

TEAD-S is located in Rush Valley, with the Oquirrh Mountains to the east and the Stansbury and Onaqui Mountains to the west of the facility (Figure 2.1-1). Most of the facility is located on the east side of the valley on gently southwestward-sloping ground that is the flank of a large alluvial fan originating from Ophir Creek. The southeastern part of the facility is located on the flank of an alluvial fan originating from Mercur Creek. The southern and western parts of TEAD-S occupy the relatively level valley bottom. Two-lane state highways pass near the site on the north, east, and west sides. The Union Pacific Railroad uses the tracks adjacent to the western boundary of the installation.

The entrance to TEAD-S is off State Highway 73, at the northeastern corner of the installation, on the east side of Rush Valley. Figure 1.0-2 presents a map of the TEAD-S facility. Near the main entrance gate are active administrative buildings and warehouses and the site of a former housing area. To the west of the main gate is a large, secured chemical storage area where chemical agent is stored in bunkers or igloos, and to the south is the former mustard holding area, where warehouses are still being used for a variety of storage purposes, including permitted



T3G2 6.94.jb

Figure 2.1-1

Location of TEAD-S in Rush Valley

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

hazardous waste storage. Former storage magazine areas crossed by roads and railroad tracks are still visible in the central part of the site. In the southwestern part of TEAD-S is a small CAMDS. A larger CSDP plant was recently constructed to the east of the chemical storage area and is currently undergoing testing.

The six Group 2 SWMUs investigated under this part of the RFI-Phase II are SWMUs 3, 5, 8, 9, 30, and 31 (Figure 1.0-2). In the east-central area of TEAD-S are SWMUs 3, 5, 8, 9, and 31. SWMU 31 is an active RCRA-permitted unit used for the open burning and detonation of munitions and propellants. The other four SWMUs are inactive units that were formerly used for munitions renovation and testing and for storage and decontamination of chemical agent containers. SWMU 30, located in the west-central portion of TEAD-S, consists of the CAMDS Landfill, which received a wide variety of construction materials, and a series of covered, inactive burn trenches.

2.1.2 History

TEAD-S was originally constructed as a chemical munitions facility called Deseret Chemical Depot. Construction began in 1942 and was completed in 1943. The primary mission of this facility was to provide storage and maintenance services for chemical munitions. In 1955, the Deseret Chemical Depot was placed under the command of TEAD and underwent a major expansion. At this time, it was renamed the Deseret Depot Activity, and ultimately became known as the Tooele Army Depot "South Area" (USATHAMA 1979).

TEAD-N was established by the Army Ordnance Department on April 7, 1942 as Tooele Ordnance Depot (TOD). On August 1, 1962, TOD was redesignated TEAD. The depot was a World War II reserve installation and was used primarily for storing Army material for the Benicia Arsenal (near Sacramento, California) and the Stockton Ordnance Depot, through which World War II supplies, automotive combat vehicles, and ammunition were shipped to the Pacific Theater. Agent munitions filled with mustard agent were stored at this depot until 1977, when they were moved to TEAD-S (USATHAMA 1979). After World War II, TOD's mission was gradually expanded to include the support of other Army installations in the western United States.

TEAD-S has been used since the 1940s for storage, renovation, disposal, and burial of many types of chemical agent and other munitions. These munitions included mustard, distilled mustard, and mustard-T mixture (H, HD, and HT respectively), Lewisite (L), Sarin (GB), Tabun (GA), o-ethyls-(2-diisopropylaminoethyl) methyl phosphonothiolate (VX), phosgene (CG), o-chlorobenzyl malononitrile (CS), hydrogen cyanide (AC), cyanogen chloride (CK), sulfur trioxide-chlorosulfonic acid (FS), HC smoke, white phosphorus (WP), thermate, and napalm high explosives (NUS 1987). Table 2.1-1 lists explosive and propellant compounds and mixtures that have been managed at TEAD, and Table 2.1-2 lists the chemical agents that have been managed at this site. There is no indication that biological or radiological munitions have been stored at TEAD-S. In addition, pesticides, herbicides, and fertilizers have been used at the installation by Army employees. Parts of TEAD-S have also been leased for grazing livestock (USATHAMA 1979).

Between 1990 and 1993, the Army constructed a large-scale demilitarization facility adjacent to the chemical storage area. This CSDP is designed to reduce chemical munitions wastes from TEAD-S to nonhazardous forms that may be disposed of as conventional nonhazardous waste.

2.1.3 Geology and Soil

Rush Valley is located in the Great Basin Physiographic Province, a vast desert basin stretching from the Sierra Nevada in California to the Wasatch Range in Utah. This province is characterized by a series of north-south trending mountain ranges alternating with valleys. These alternating mountains and valleys formed during the late Miocene Epoch (5 to 23 million years ago) as the valleys were faulted downward relative to the mountains, with vertical displacements of hundreds to thousands of feet (EA 1988).

Rush Valley is approximately 30 mi long and 14 mi wide. It is bounded on the north by the Stockton Bar, on the east by the Oquirrh and East Tintic Mountains, on the south by the Sheeprock and West Tintic Mountains, and on the west by the Stansbury and Onaqui Mountains. The surrounding mountains are composed of Precambrian age metasedimentary rocks, Cambrian quartzite, Paleozoic sedimentary (mainly carbonate) rocks, Tertiary intrusive and extrusive igneous rocks, and the Pliocene Salt Lake Formation (Figure 2.1-2). Precambrian and Cambrian rocks crop out in the Sheeprock Mountains only, and so have little effect on alluvial surficial deposits in the TEAD-S area. The surrounding mountain ranges, including the Oquirrh Mountains, are composed of primarily Paleozoic sedimentary rocks, which are the source of most of the alluvial and lacustrine sediments at TEAD-S. Repeated folding and faulting of the Paleozoic carbonate rocks has resulted in the development of secondary permeability in these otherwise low-permeability rocks.

Igneous intrusive rocks also crop out in the Oquirrh Mountains. The intrusive rocks contain localized metal deposits that may have influenced the geochemistry of valley sediments eroded

Table 2.1-1 Typical Explosives and Propellants Demilitarized at Tooele Army Depot[1]

Page 1 of 3

Propellant/ Explosive	Chemical Formula	Composition		Uses
RDX	$C_3H_6N_6O_6$	Carbon	16.3%	Detonating Cord, Primers, Component of Mixed Explosives, Detonators, Booster for Anti-tank Mines, Burster in Small-Caliber Ammo
		Hydrogen	2.7	
		Nitrogen	37.8	
		Oxygen	43.2	
TNT	$C_7H_5N_3O_6$	Carbon	37.0%	Component of Other Explosives, Demolition Blocks, Bursters, Mines, Primers
		Hydrogen	2.2	
		Nitrogen	18.5	
		Oxygen	42.3	
Tritonal	See TNT	Aluminum	20.0%	Mines, Torpedo Warheads, Depth Charges, Bombs
		TNT	80.0	
		Aluminum	30.0%	
		TNT	70.0	
		Aluminum	40.0%	
		TNT	60.0	
PETN	$C_5H_8N_4O_{12}$	Carbon	19.0%	See RDX
		Hydrogen	2.5	
		Nitrogen	17.7	
		Oxygen	60.8	
Pentolite Series				
50/50	See TNT and PETN	TNT	50.0%	Shaped Charges, Bursting Charges in Bombs and Projectiles
		PETN	50.0	
10/90	See TNT and PETN	PETN	10.0%	
		TNT	90.0	
Nitrostarch	Nitrated starch	Nitrostarch	49.0%	Projectiles, Bombs, Depth Charges, Small-Caliber Ammo, Spotting Charge
		Barium nitrate	40.0	
		Mononitronaphthalene	7.0	
		para-Nitroaniline	3.0	
		Oil	1.0	
Minol-2	NH_4NO_3	Ammonium nitrate	40.0%	See Nitrostarch
	TNT	TNT	40.0	
	Aluminum	Aluminum	20.0	

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[1] Source: NUS 1987

Please see the Chemical Acronym List for acronym definitions.

Table 2.1-1 Typical Explosives and Propellants Demilitarized at Tooele Army Depot[1]

Page 2 of 3

Propellant/ Explosive	Chemical Formula	Composition		Uses
HBX-1	See RDX, TNT, and Aluminum	RDX	40.0%	Boosters, Depth Charges, Torpedoes, Rockets, Mines, Bombs
		TNT	38.0	
		Aluminum	17.0	
		Desensitizer (Comp. D2)	5.0	
HBX-3	See HBX-1	RDX	31.0%	See HBX-1
		TNT	29.0	
		Aluminum	35.0	
		Comp. D2	5.0	
Explosive D	$C_6H_6N_4O_7$	Carbon	29.3%	Bombs, Projectiles, Grenades, Depth Charges
		Hydrogen	2.4	
		Nitrogen	22.7	
		Oxygen	45.6	
Dynamites				
Medium Velocity	See RDX and TNT	RDX	75.0%	Excavation, Demolition, Cratering
		TNT	15.0	
		Starch	5.0	
		Oil	4.0	
		Polyisobutylene	1.0	
Low Velocity	See RDX and TNT	RDX	17.5%	Same as above
		TNT	67.8	
		Tripentaerythritol	8.6	
		Binder	4.1	
		Cellulose acetate	2.0	
Cyclotol	See RDX and TNT	RDX	60.0%	See Explosive D
		TNT	40.0	
		RDX	65.0%	
		TNT	35.0	
		RDX	70.0%	
		TNT	30.0	
		RDX	75.0%	
		TNT	25.0	
Comp. B Series				
Comp. B	See RDX and TNT	RDX	60.0%	Projectiles, Mines, Rockets, Grenades, Bombs
		TNT	39.0	
		Wax	1.0	

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[1] Source: NUS 1987

Please see the Chemical Acronym List for acronym definitions.

Table 2.1-1 Typical Explosives and Propellants Demilitarized at Tooele Army Depot[1]

Page 3 of 3

Propellant/ Explosive	Chemical Formula	Composition		Uses
Comp. B2	See RDX and TNT	RDX	60.0%	Same as above
		TNT	40.0	
Comp. B3	See RDX and TNT	RDX	59.5%	Same as above
		TNT	40.5	
Comp. B4	See RDX and TNT	RDX	60.0%	Same as above
		TNT	39.5	
		Calcium silicate	.5	
Comp. C Series				
Comp. C	See RDX	RDX	88.3%	Demolition explosive
		Plasticizer (non explosive)	11.7	
Comp. C2	See RDX	RDX	78.7%	Same as above
		Plasticizer	21.3	
Comp. C3	See RDX	RDX	77.0%	Same as above
		Plasticizer	23.0	
Comp. C4	See RDX	RDX	91.0%	Same as above
		Polyisobutylene	2.1	
		Oil	1.6	
		Di(2 Ethylhexyl)sebacate	5.3	
Black Powder				
Classes 1-7 and 9		Potassium nitrate	74.0% ± 1.0%	Igniters, Primers, Propellants, Pyrotechnics
		Sulfur	10.4 ± 1.0	
		Charcoal	15.6 ± 1.0	
Class 8		Potassium nitrate	74.0% ± 1.0-2.0%	Detonators, Hand Grenades, Signal Rockets, Depth Charges, Torpedoes
		Sulfur	10.4 ± 1.5-1.0	
		Charcoal	15.6 ± 1.5-1.0	
Amatol Series				
50/50	See TNT	Ammonium nitrate	50.0%	Bombs, Projectiles, Cratering Charge, Bangalore Torpedoes
		TNT	50.0	
60/40	See TNT	Ammonium nitrate	60.0%	
		TNT	40.0	
80/20	See TNT	Ammonium nitrate	80.0%	
		TNT	20.0	

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[1] Source: NUS 1987

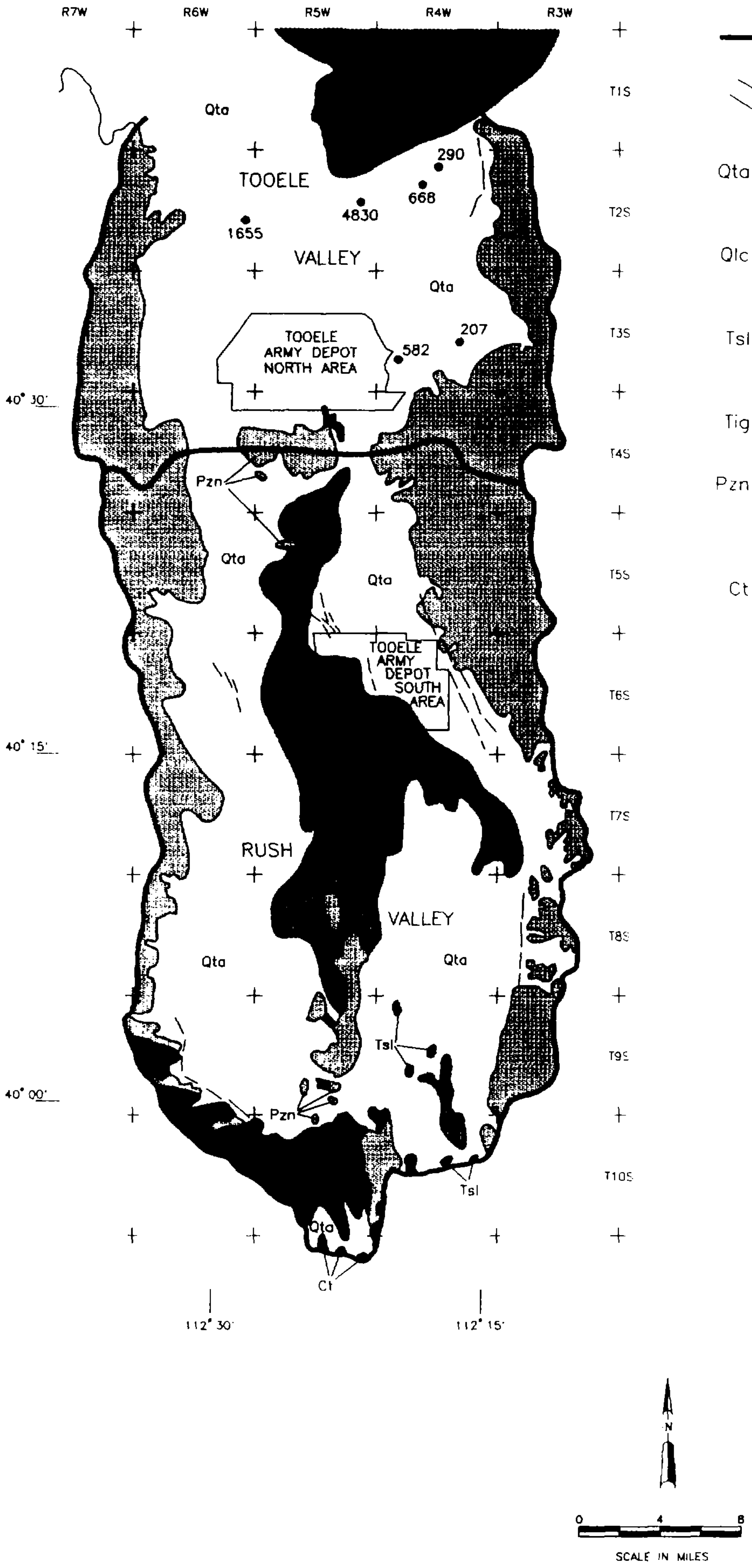
Please see the Chemical Acronym List for acronym definitions.

Table 2.1-2 Chemical Agents at Tooele Army Depot

Page 1 of 1

Common Name	Chemical Name and Formula	Use
H (Mustard)	Bis(2-chloroethyl)sulfide $(ClCH_2CH_2)_2S$	Blister Agent
HD (Distilled Mustard)	Bis(2-chloroethyl)sulfide $(ClCH_2CH_2)_2S$	Blister Agent
HT (Mustard - T Mixture)	Similar to HD (60% HD and 40% T-a sulfur and chlorine compound similar in structure to HD)	Blister Agent
L (Lewisite)	Dichloro(2-chlorovinyl)arsine $ClCH{:}CHAsCl_2$	Blister Agent
GB (Sarin)	Isopropyl methyl phosphonofluoridate $CH_3P(O)(F)OCH(CH_3)_2$	Nerve Agent
VX	o-ethyl-s-(2-diisopropylaminoethyl) methyl phosphonothiolate $CH_3P(O)(C_2H_5O)SCH_2CH_2N[CH(CH_2)_2]_2$	Nerve Agent
GA (Tabun)	Dimethylaminoethoxy-cyanophosphine oxide $(CH_3)_2N(C_2H_5O)CNPO$	Nerve Agent
CG (Phosgene)	Carbonyl chloride $(COCl_2)$	Choking Agent
CS	o-chlorobenzylmalononitrile $ClC_6H_4CHC(CN)_2$	Riot Control Agent
BZ	3-quinuclidinyl benzilate $C_{21}H_{23}NO_3$	Incapacitating Agent
DM (Adamsite)	10-chloro-5,10-dihydrophenarsazine $C_{12}H_9AsClN$	Incapacitating Agent
AC	Hydrogen cyanide HCN	Blood Agent
CK	Cyanogen chloride (CNCL)	Blood Agent
FS	Sulfur trioxide-chlorosulfonic acid (Solution of sulfur trioxide (SO_3) dissolved in chlorosulfonic acid $(ClSO_3H)$)	Smoke
HC	Mix of aluminum, zinc oxide, and hexachloroethane	Smoke
WP	White phosphorus P_4	Smoke
Thermate	Thermite $(Fe_2O_3 + Al)$ with nitrate, sulfur, and binder	Incendiary Mix
M1 Thickener (Napalm)	Mixed aluminum soap (50% coconut oil acids) (25% naphthenic acids) (25% oleic acid)	Incendiary Thickener

Source: NUS 1987, Departments of the Army and Air Force 1963



EXPLANATION

▬	BOUNDARY OF DRAINAGE BASIN
\\	SUSPECTED FAULT SCARPS IN UNCONSOLIDATED DEPOSITS (BUCKNAM, 1977)
Qta ☐	ALLUVIAL DEPOSITS-CLAY, SAND, AND GRAVEL-MODERATE TO HIGH PERMEABILITY
Qlc ■	LAKE SEDIMENTS-CLAYS, SLIGHTLY SALINE-LOW TO MODERATE PERMEABILITY
Tsl ▩	SALT LAKE FORMATION-CONTINENTAL SANDSTONE, CLAYSTONE, LIMESTONE AND TUFF-LOW PERMEABILITY
Tig ■	IGNEOUS ROCKS-RHYOLITE, DACITE, LATITE FLOWS-LOW PERMEABILITY
Pzn ▨	PALEOZOIC SEDIMENTARY ROCKS, CHIEFLY CARBONATES-GENERALLY LOW PERMEABILITY, LOCALLY HIGH ALONG JOINTS, FAULTS, ETC
Ct ■	TINTIC QUARTZITE AND PRECAMBRIAN ROCKS-LOW PERMEABILITY, BUT MAY BE HIGH ALONG FAULTS, FRACTURES ETC
● 4830	WELLS PENETRATING BEDROCK WITH DEPTH TO BEDROCK IN FEET (EVERITT AND KALISER 1920)

Source: ERTEC 1982

Data compiled from:
Rush Valley-Hood, and Others 1969
Tooele Valley-Moore and Sorensen 1979
Quaternary Faults-Bucknam 1977

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

Figure 2.1-2

Geology of Tooele and Rush Valleys, Utah

Prepared by:
Ebasco Services Incorporated

from this area. Mining is ongoing in the Oquirrh Mountains east of TEAD-S, including the Mercur Creek area. Metals mined in this area include gold, silver, arsenic, antimony, beryllium, and tellurium (EA 1988). Mines in Tooele County produce 50 percent of the nation's beryllium ore (Inland Pacific Engineering 1982). Erosion of these rocks and subsequent deposition of the detritus in Rush Valley is one of the causes of elevated background concentrations of these metals in TEAD-S soil compared to the soils found in nonmineralized areas.

The Pliocene Salt Lake Formation is predominantly volcanic tuff, claystone, limestone, and sandstone that has generally low permeability. The Salt Lake Formation crops out approximately one-half mile to the south of TEAD-S and may underlie the site.

Unconsolidated rocks of late Tertiary to Holocene age form the valley floor and underlie all of TEAD-S. The unconsolidated deposits are more than 400 feet (ft) thick beneath TEAD-S (Hood, Price, and Waddell 1969). These basin deposits are primarily clay, silt, sand, and gravel eroded from outcrops of the consolidated rocks in the adjacent mountains. These deposits are generally coarsest adjacent to the mountain fronts and become finer toward the valley floor. Most of the southwestern portion of TEAD-S is covered by 25 to 100 ft of low-permeability Pleistocene lakebed sediments that were deposited when the central portion of Rush Valley was occupied by ancient Lake Bonneville. Younger units include Pleistocene post-Lake Bonneville alluvium and Recent alluvial, lakebed, and dune sand deposits (EA 1988).

Soil at TEAD-S and in Rush Valley reflects the parent materials from which it was developed. Typically, the alluvial deposits near the mountains are coarser-grained sands and gravels, and are relatively permeable. The lacustrine deposits are fine-grained, of low permeability, and typically saline or alkaline. Strong diagnostic horizons, except for salt crusts, are not typically observed in this soil due to the low amounts of precipitation and low biological activity in the near-surface horizons.

At TEAD-S there are seven major and four minor soil types according to the Salt Lake City Office of the Soil Conservation Service (SCS) (no date) (Plate 1). The seven major soil units are the following:

- Birdow loam—Moderately permeable, some areas sandy or gravelly; used for rangeland or cropland. Found in the northeast corner of the site.

- Bramwell silt loam—Low permeability, slightly saline, high seasonal water table; mainly used for irrigated crops. Occurs in the southwestern and northwestern portions of TEAD-S.

- Cliffdown gravelly sandy loam—Moderately permeable, moderately alkaline; used primarily for rangeland. Found in the southern half of the site.

- Hiko Peak gravelly loam—Moderately permeable, often rocky; useful for a variety of purposes, such as building-site development and rangeland, but mostly used for cropland, and if irrigated, to grow alfalfa and barley. Found site wide, but is more prevalent in the eastern half.

- Skumpah silt loam—Includes two units, one of which is more saline, the other more alkaline; both have low permeability, a slightly high seasonal water table, and high shrink- swell potential; used mostly as rangeland and for wildlife habitat. Found in the south-central and southeastern portions of the site.

- Taylorsflat loam—Includes two units, one of which is more saline, the other more alkaline; low permeability, high shrink-swell potential; used primarily for rangeland. Found primarily in the northern half and south-central portion of the site.

- Tooele fine sandy loam—Moderate permeability, slightly saline; used primarily as rangeland with some small irrigated areas. Found primarily in the southeastern portion of the site.

The four minor soil types occur over small areas scattered throughout the central and southern portions TEAD-S. These soil types include the Logan silt loam, the Timpie silt loam, and pits, slickens, and mine dumps of anthropogenic origin. Sections 4.1 through 4.6 provide more detailed descriptions of the soil types that occur in SWMUs 3, 5, 8, 9, 30, and 31.

2.1.4 Surface Water

Rush Valley is part of a large drainage basin known as the Great Salt Lake Basin. This is a closed basin, with no outlet for surface water. Some of the precipitation that falls on the mountains encircling Rush Valley flows to lower elevations in streams. Most of these streams are intermittent and flow only in direct response to snowmelt and summer rainfall.

The principal intermittent streams in the northern part of Rush Valley are Ophir Creek and Mercur Creek, which enter the valley from the Oquirrh Mountains to the east, and Clover Creek, which enters from the Stansbury Mountains to the west. Faust Creek flows northward through the center of the valley, collecting water from Ophir, Mercur, and Clover Creeks, and carrying surface water from numerous other tributaries in the southern half of Rush Valley. Most of the surface water from these streams either recharges groundwater, is lost through evaporation, or is used for irrigation. A small amount of surface water from these streams reaches playas south and southeast of TEAD-S. Some surface water also flows into Rush Lake, at the northern boundary of the valley. Rush Lake is also fed by springs, where groundwater discharges to the surface water system.

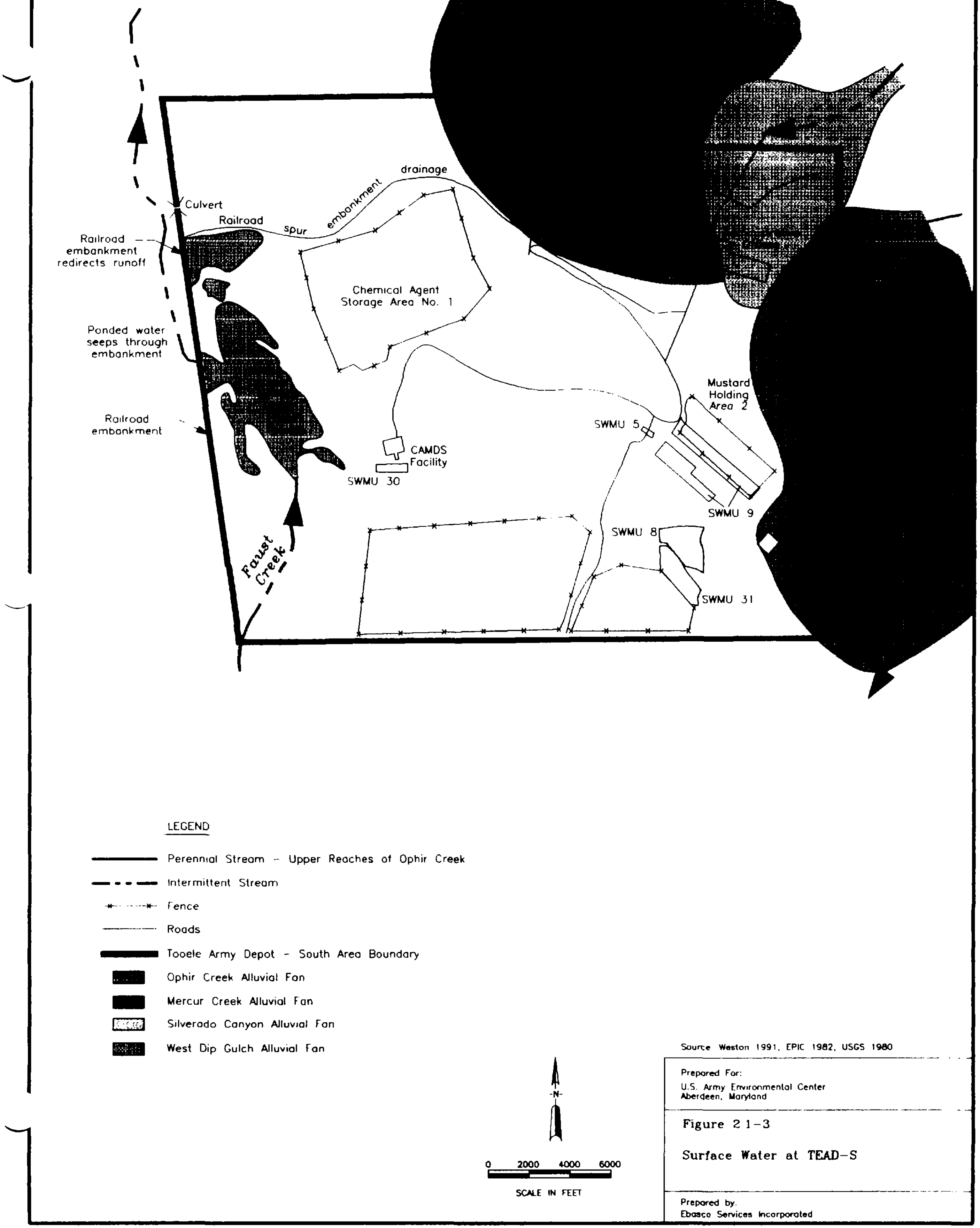
The land surface at TEAD-S slopes gently from the northeast to the southwest, with moderate gradients of 5 percent in the northeast to nearly flat in the southwest (Plate 2). Ophir Creek and Mercur Creek flow southwestern from the Oquirrh Mountains toward TEAD-S, and Faust Creek enters the southwestern corner of the site and flows northward (Figure 2.1-3). However, most of the water in Ophir and Mercur Creeks is now diverted before it reaches TEAD-S. Ophir Creek water is diverted for irrigation, although some of it occasionally flows through the northern part of TEAD-S, and Mercur Creek is channeled into a diversion ditch along the eastern boundary of the site. This ditch carries Mercur Creek water to the playa area south of TEAD-S, rather than across the site. However, runoff on TEAD-S is frequently channeled into drainages which are part of the alluvial fan systems associated with Ophir and Mercur Creeks. The approximate extent of these fan systems, along with smaller fans originating in West Dip Gulch and Silverado Canyon has been transferred from historic aerial photographs onto Figure 2.1-3. This figure indicates that SWMU 3 lies on the Mercur Creek fan, while other Group 2 SWMUs lie at the distal end of the Ophir Creek and other fan systems.

Faust Creek, which intermittently carries flow from the southern half of Rush Valley, enters the southwestern corner of the site and is dammed in the west-central part of the site by the intersection of two railroad embankments (Figure 2.1-3). The north-south embankment was constructed for the Union-Pacific Railroad. The east-west embankment is part of a spur that leads eastward and northeastward through TEAD-S. When stream flow is high, Faust Creek overflows its banks and water is ponded against the embankments. During a previous investigation (Weston 1991), Faust Creek flowed until late May in 1989, and several hundred acres of land between CAMDS and the embankment junction were flooded with up to 5 ft of water until early August 1989. During the RFI-Phase I field program in summer 1990, no flooding occurred. This low area along the western boundary of TEAD-S was flooded again in spring 1993. During times of flooding this area may serve as a groundwater recharge area. The Faust Creek channel continues northward through the valley on the west side of the north-south embankment, eventually discharging into Rush Lake.

2.1.5 Groundwater

The groundwater system at TEAD-S is part of a regional flow system that includes Rush Valley and Tooele Valley. Groundwater within the regional flow system is recharged by streams that flow intermittently from the mountains in response to rain or snowmelt. These streams typically disappear through evaporation and infiltration as they cross the permeable basin sediments, and such an episodic flow and infiltration of runoff may affect local groundwater levels. Groundwater generally moves from these localized recharge areas to and then along the valley axis toward discharge points such as Rush Lake.

Hood, Price, and Waddell (1969) found that a regional groundwater flow divide exists in Rush Valley. The groundwater divide trends northeastward across TEAD-S and is apparently the result of recharge in the area of the Ophir Creek alluvial fan (Figure 2.1-4). Groundwater northwest of the divide flows north toward Rush Lake, the lowest point in Rush Valley. Hood, Price, and Waddell also indicate that a small yet significant amount of groundwater discharges from Rush



Source Weston 1991, EPIC 1982, USGS 1980

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U.S. Army Environmental Center
Aberdeen, Maryland

Figure 2 1-3

Surface Water at TEAD-S

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Ebasco Services Incorporated

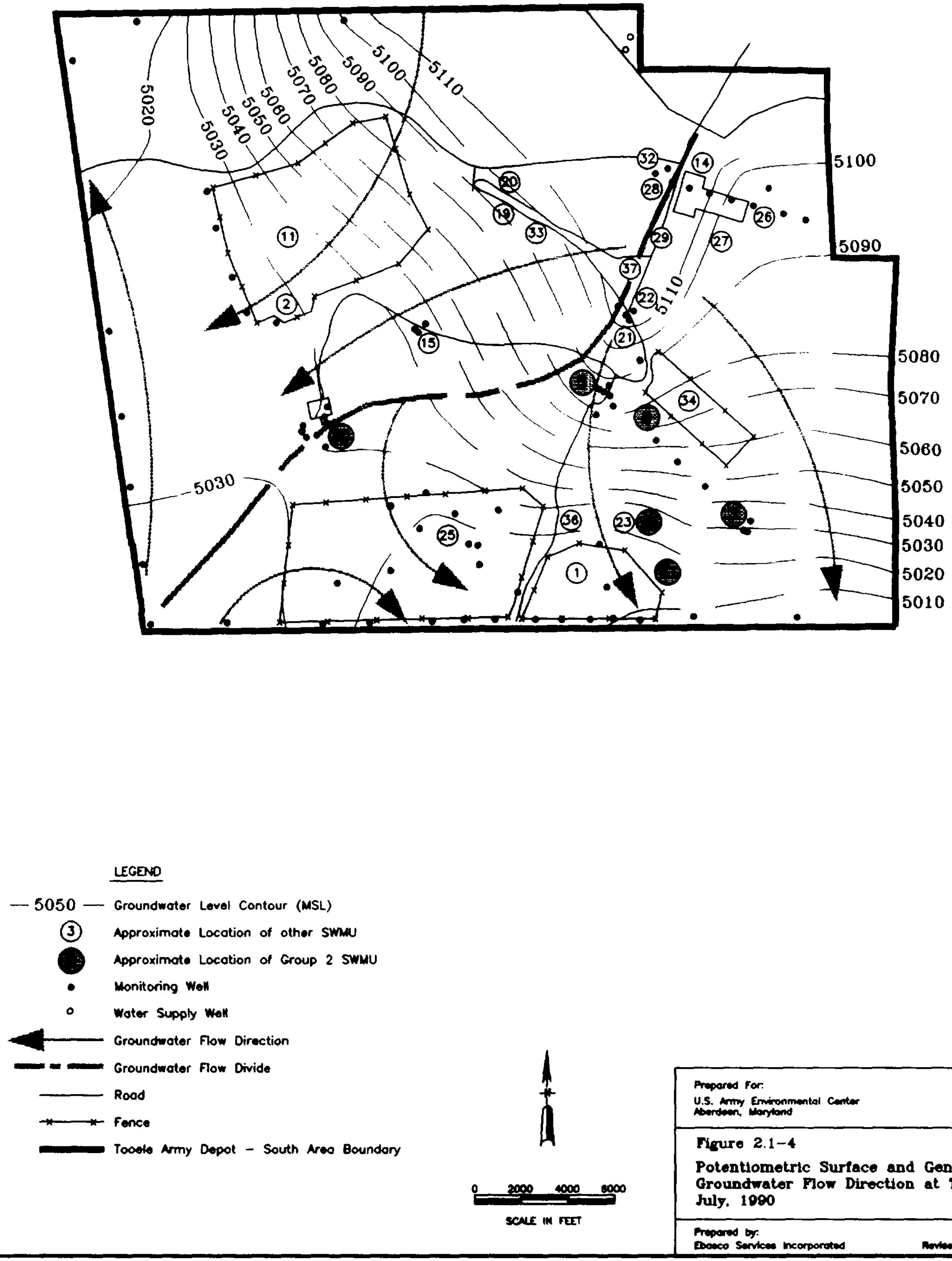

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Figure 2.1-4

Potentiometric Surface and General Groundwater Flow Direction at TEAD-S, July, 1990

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

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Valley to the northward under and through the Stockton Bar into the Tooele Valley. The rest of the groundwater in the Rush Lake area is lost through evaporation in Rush Lake and through transpiration by vegetation in the Rush Lake area. In the southeastern part of TEAD-S, groundwater flows primarily southward. Some groundwater eventually discharges from Rush Valley to the east through the unconsolidated alluvium and structurally deformed Paleozoic rocks of the Oquirrh and East Tintic Mountains between Five Mile Pass and Ten Mile Pass (Hood, Price, and Waddell 1969). Groundwater may also discharge through evapotranspiration along the southern site boundary and near CAMDS (at SWMU 30), where groundwater is between 6 and 15 ft below the ground surface.

In the eastern part of TEAD-S, the flow directions shown on Figure 2.1-4 may also be affected by local recharge. A higher water table occurs along a line through SWMUs 28, 32, 21 and 22, and 5. This higher water table may be caused by leakage from a water main that parallels Montgomery Road or by discharges from buildings into ditches and septic systems in this area.

Groundwater recharge from Ophir Creek may also contribute to the higher water table in the northern part of the site. Short-term (possibly seasonal) variations in groundwater levels of up to 6 ft have been observed in monitoring wells at TEAD-S. The wells showing the greatest variation are located near the southwestern corner of TEAD-S, where Faust Creek enters the site during the wet season. No significant variation in groundwater flow directions has been observed.

Shallow groundwater at TEAD-S generally occurs under unconfined conditions, although it does occur in localized areas under semiconfined conditions. The depth to groundwater ranges from 289 ft in the topographically high northeastern portion of TEAD-S to 6 ft in the southwestern portion of the site and near CAMDS. The interpretation of groundwater flow directions depicted in Figure 2.1-4 includes data from the RFI-Phase II investigations conducted by EBASCO (Group 1 SWMUs; 1993a) and Rust Environmental and Infrastructure (SWMUs 13 and 17; 1994). The depth to water table and water table elevation maps for the Group 2 SWMUs were compiled from groundwater sampling data gathered in November and December 1993 and in April 1994 (see Section 3.10.2).

Groundwater flow velocities vary across the site according to aquifer hydraulic conductivities and gradients. The higher velocities can occur where groundwater flows through relatively conductive coarse-grained aquifer materials, such as gravel and sand, or in areas of large hydraulic gradients. For example, groundwater flow velocities at SWMUs 5 and 9 range from 5.36 feet per year (ft/yr) to 113.61 ft/yr. Estimates of average groundwater flow velocities in areas near SWMUs 5 and 9 area are presented in Section 4.2.3 and 4.4.3.

2.1.6 Climate

The climate of Rush Valley is semiarid, with four well-defined seasons. Summer is hot and dry, spring and fall are generally cool, and winter is moderately cold. Average monthly temperatures range from a high of 75 degrees Fahrenheit (°F) in July to a low of 28°F in January (EA 1988). The average monthly maximum and minimum temperatures, as well as monthly extreme temperatures, are provided in Table 2.1-3 for a 6-year period from 1982 to 1987 (Tooele Army Depot Met Team 1993). Average first and last frost dates are shown in Table 2.1-4. Low humidity is characteristic of the Rush Valley climate, with an average relative humidity of 44 percent (USATHAMA 1979). The annual precipitation averages 10 to 12 inches in Rush Valley, with nearly half of this amount occurring as snowfall between fall and late spring. The summers are generally dry, with occasional showers and thunderstorms. The lack of precipitation is caused by the presence of the surrounding mountain ranges, which restrict the movement of moisture into Rush Valley (Montgomery 1989). Most of the precipitation falls above an elevation of 5,500 ft (USATHAMA 1979). Monthly average total precipitation data for the period from 1982 to 1987 are provided in Table 2.1-3.

Figure 2.1-5 provides a composite annual windrose developed from unpublished data collected by TEAD meteorologists. These data were collected for 1986 and 1987 at meteorological station 5, which is located west of SWMU 30 along the western perimeter of TEAD-S. The data indicate a bimodal distribution along the valley axis, with a strong wind component from the north-northwest and an equally strong component from the south-southeast to southeast. This windrose reflects both seasonal and diurnal variations. The prevailing wind direction in Rush Valley is from south to north toward the Great Salt Lake during the summer and from north to south during the winter (EA 1988). Local circulations may also occur, with drainage down the sides of the higher topography during the evening and early morning hours and upslope flow on the mountain sides during the daytime. Finally, the passage of transitory synoptic weather systems (i.e., fronts, high- and low-pressure systems) across the area results in occasional flow from all directions, as is evidenced by the composite windrose. Wind speeds are generally light to moderate (9 miles per hour [mph]), except during the passage of strong frontal systems or during summertime thunderstorm activity.

Rush Valley is typical of basin and range areas in that strong inversions occur during nighttime and early morning hours. These inversions generally break up during the summer, but may persist during the winter. The flow of potential regional airshed pollutants is equally distributed along the valley axis, with slightly higher levels to the south where more frequent drainage of stable air occurs.

2.1.7 Vegetation and Wildlife

The vegetation at TEAD-S is best described as a sagebrush community throughout the eastern area and a desert shrub community on the valley floor. SWMUs 3, 5, 8, 9, and 31 fall within the sagebrush community, and SWMU 30 falls within the desert shrub community (Plate 3). These plant communities are typical of the region. The U.S. Forest Service describes the sagebrush physiographic region, of which TEAD-S is a part, as extending into the central portion

Table 2.1-3 Climatological Data for TEAD-S (1982–87) Page 1 of 1

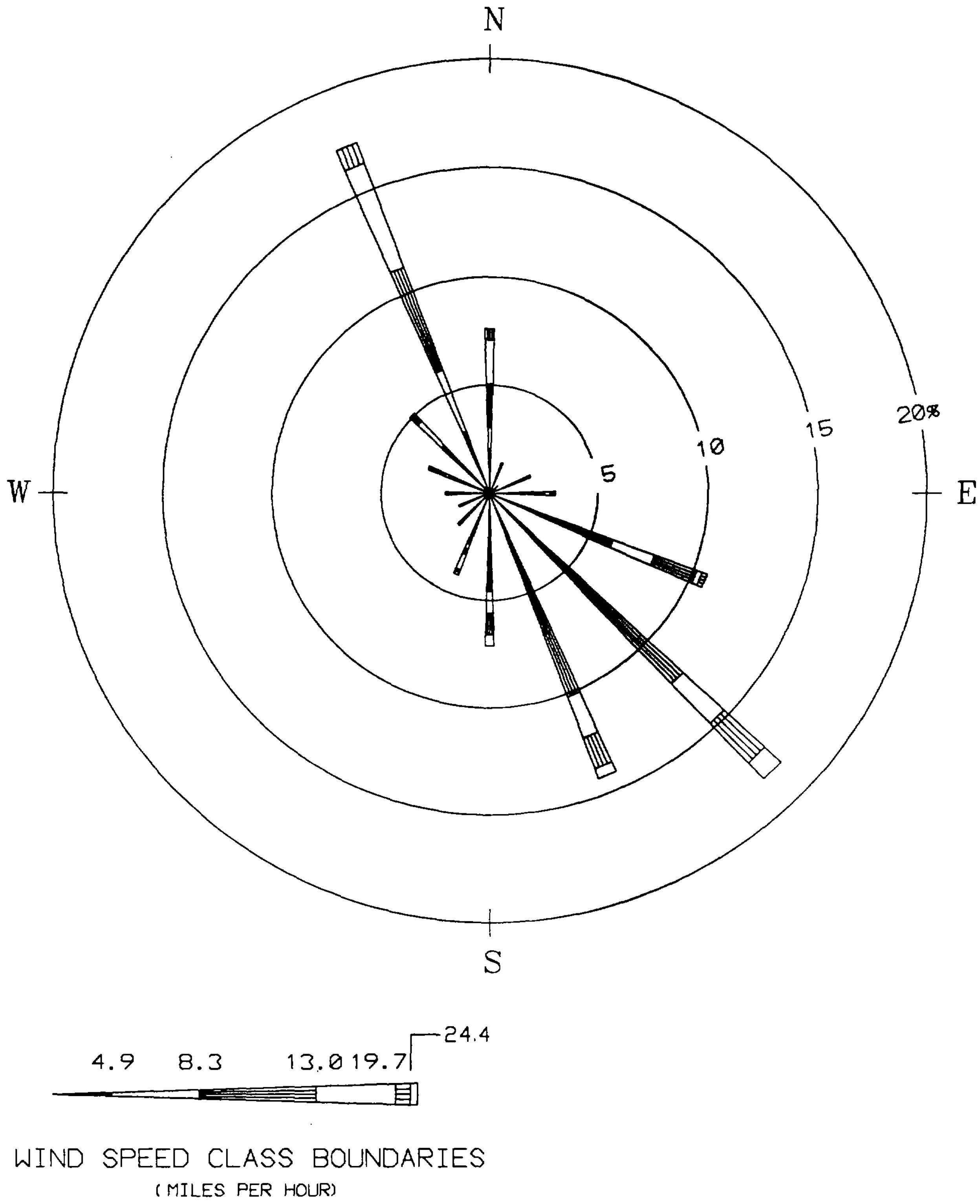
	Temperature (°F)				Precipitation (inches)	
Month	Average Maximum	Average Minimum	Extreme Maximum	Extreme Minimum	Average	Maximum
January	35.0	9.0	55.0	-28.0	0.49	0.78
February	41.0	17.0	68.0	-20.0	0.55	1.40
March	50.0	25.0	76.0	-3.0	0.55	1.21
April	58.0	27.0	83.0	13.0	0.76	1.99
May	70.0	36.0	87.0	18.0	0.58	2.05
June	82.0	43.0	95.0	25.0	0.59	1.28
July	88.0	52.0	100.0	31.0	1.12	2.10
August	88.0	51.0	100.0	35.0	1.19	3.03
September	75.0	40.0	95.0	13.0	0.83	4.33
October	62.0	29.0	85.0	12.0	0.67	1.46
November	49.0	22.0	72.0	0.0	0.53	1.69
December	36.0	13.0	59.0	-15.0	0.31	1.28

Source: Tooele Army Depot Met Team (1993)

Table 2.1-4 First and Last Frost Dates for TEAD-S (1982–87) Page 1 of 1

Year	First Frost	Last Frost
1982	September 12	June 9
1983	September 21	June 14
1984	September 24	June 12
1985	September 20	May 30
1986	September 26	May 25
1987	September 17	June 3
AVERAGE	September 20	June 5

Source: Tooele Army Depot Met Team (1993)



Source: Tooele Army Depot Met. Team 1992

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

Figure 2.1-5

Windrose for TEAD-S
November 1, 1986 - October 31, 1987

Prepared by:
Ebasco Services Incorporated

of the Great Basin in Utah, Nevada, and southern Idaho (Garrison et al. 1977). The desert shrub community occurs on the salt flats of the Great Salt Lake as well as the western one-third of the Great Basin.

The distribution of sagebrush and desert shrub communities at TEAD-S is influenced by environmental changes in geomorphology, soil salinity, and soil drainage. In general, these parameters change from the northeastern corner of the installation to the southwestern corner. Well-drained soils developed on alluvial material characterize the northeastern half of the installation, and poorly drained soils occur on the valley floor in the southwestern corner (see Section 2.1.3). Accordingly, soil salinity changes from relatively low to high in a northeast-to-southwest trend across the installation, and salt crusts, which are a result of high rates of evapotranspiration, are often observed on the ground surface in the western part of TEAD-S.

Six distinct habitats were created by grouping the 17 vegetation types identified at TEAD-S on the basis of their physiognomy (see Section 6.2.1). Of these six habitats, the following five, represented by the vegetation types shown, were found in the Group 2 SWMUs:

- Upland Shrub Habitat
  - Big Sagebrush
  - Big Sagebrush, Greasewood

- Upland Grass Habitat
  - Bunchgrass and Annual Forbs
  - Annual Grass and Forbs

- Salt Shrub Habitat
  - Saltbush
  - Greasewood

- Alkali Meadow Habitat
  - Alkali Pan with Saltblite

- Human-Altered Habitat
  - Disturbed Areas

A wide variety of fauna characteristic of the sagebrush ecosystem and the intermountain region inhabit the vicinity of TEAD-S (see Section 6.2.1). Mammals in the area include mule deer, pronghorn antelope, coyotes, badgers, cottontails, jackrabbits, and several species of rodents. A wide variety of resident and migrant bird species typical of the intermountain region also inhabit the TEAD-S vicinity, and at least 13 species of reptiles are likely to occur.

Federal threatened and endangered species listings for the site include the bald eagle and the peregrine falcon. Roosting bald eagles have been observed during winter ecological surveys along Mercur Creek and in the elm tree directly north of SWMU 1 and west of SWMU 31.

Several bald eagles were also observed along the eastern side of Rush Lake in December 1993. No peregrine falcons have been observed on TEAD-S, but unaltered hunting habitat and a prey base exist within 16 kilometers of potential nesting habitat in the Oquirrh Mountains. The proximity of TEAD-S to this nesting habitat makes repeated usage of the facility by migrating and nesting falcons a possibility (USFWS 1984). State of Utah threatened species include the ferruginous hawk. This species has been observed on TEAD-S during ecological surveys and is a confirmed breeding bird in Rush Valley.

2.1.8 Demographics and Land and Water Use

According to the 1990 census, Tooele County has a population of 26,600, 73 percent of which is located in the cities of Tooele, Grantsville, and Wendover. There are several small towns in the vicinity of TEAD-S including Stockton, Vernon, Faust, St. John, Onaqui, Clover, and Ophir (Figure 1.0-1). The combined population of these towns is approximately 1,000.

Land ownership in Tooele County is divided as follows:

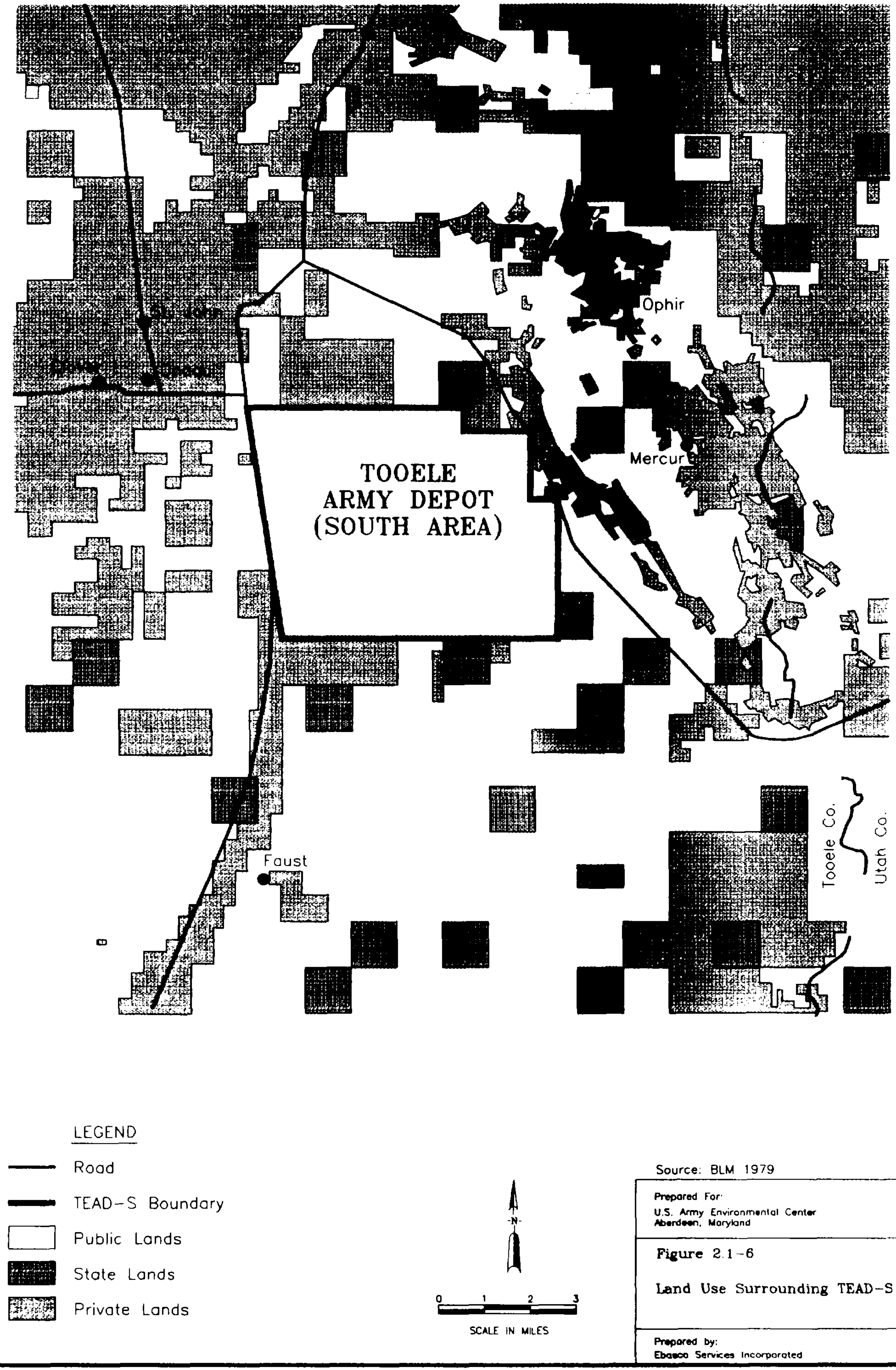
- 56 percent—Federal and Indian lands
- 6 percent—State-owned land
- 38 percent—Privately owned land

Administration of the federally owned land is as follows: 55 percent is through the Bureau of Land Management (BLM), 6 percent through the Forest Service, and 39 percent through the Department of Defense (DOD).

TEAD-S is primarily surrounded by BLM land and a small amount of state-owned land; in addition, it is also surrounded by some privately owned land, especially to the northwest around the towns of Onaqui, Clover, and St. John (Figure 2.1-6) (BLM 1979). Three industries, mining, agriculture, and government, support the local economy. The major industry involves the operation of several DOD facilities; TEAD and Dugway Proving Ground (DPG) are major employers in Tooele County. Deposits of precious metals have been mined from the Oquirrh Mountains east of TEAD-S for many years, while the valley surrounding TEAD-S has been used to graze livestock, including sheep and cattle.

Beyond the northwestern border of TEAD-S on the west side of State Highway 36 is the BLM Clover Reservoir Wildlife Habitat Development Area, an area intended as year-round habitat for waterfowl. Waterfowl and shorebirds have been observed in the area in the last few years, even though water is not always available.

The majority of the water diversions at or near TEAD-S, whether from wells or creeks, are used for stockwatering or irrigation, mining, or domestic purposes. A composite list of the water rights within an approximate 5-mile radius from the center of the TEAD-S site is given in Table 2.1-5, the approximate locations of which are shown in Figure 2.1-7. This list was compiled through two searches of Utah Division of Water Rights (UDWR) records conducted in 1990 and 1993.



Source: BLM 1979

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

Figure 2.1-6

Land Use Surrounding TEAD-S

Prepared by:
Ebasco Services Incorporated

Table 2.1-5 Water Rights Within 5 Miles of TEAD-S[1]

Page 1 of 2

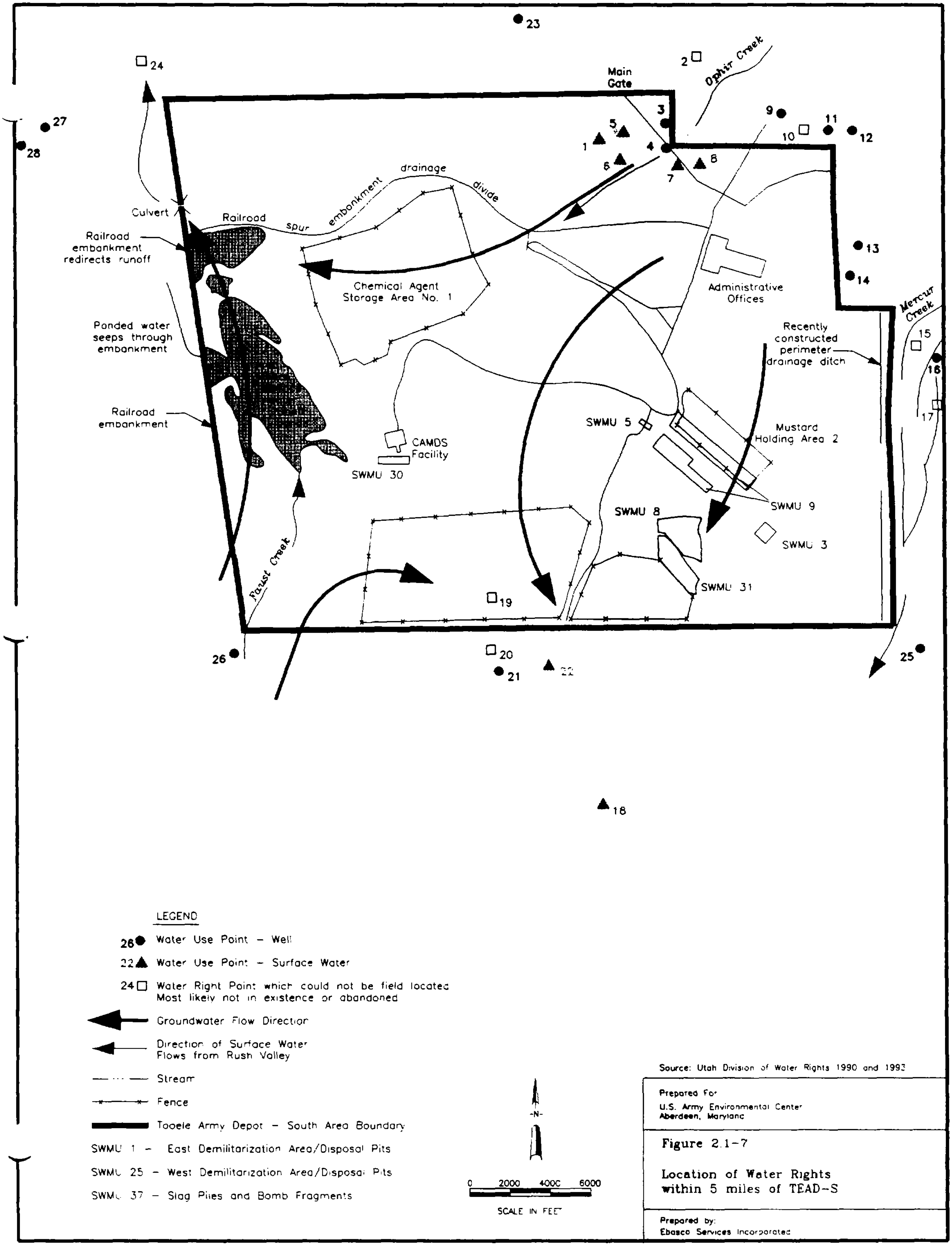
Well No.	Owner	Use	Water Right No.	Quantity (CFS)	Depth of Source (ft)	North (ft)	East (ft)	Corner	Section	Township	Range	Field Verified
1	Ophir Creek Water Co.	Irrigation, Domestic Stockwatering, Other	a14267	11.000	Ophir Creek	S1700	E0	N4	5	6S	4W	2
2	Georgia J. Russell	Domestic Stockwatering	15 2410	0.0150	344	N600	W245	SE	32	5S	4W	5
3	TEAD-S #1	Domestic, Other	15 73	1.6300	404	S1534	E1957	NW	5	6S	4W	2
4	TEAD-S #2	Domestic, Other	15 73	1.6300	428	S1981	E2214	NW	5	6S	4W	2
5	Ophir Creek Water Co.	Irrigation, Domestic, Stockwatering	15 2273	11.000	Ophir Creek	S1580	E175	N4	5	6S	4W	2
6	Ophir Creek Water Co.	Stockwatering	15 2273	11.00	Ophir Creek	S1780	E20	N4	5	6S	4W	6
7	Gillmor	Stockwatering	15 86	0.2500	Ophir Creek	S1585	E2820	NW	5	6S	4W	2
8	Gillmor	Stockwatering	15 8	0.9500	Ophir Creek	S1585	E2820	NW	5	6S	4W	2
9	Barrick Resource	Domestic, Mining	15 2922	1.0000	1000-1500	S1800	E2000	NW	4	6S	4W	3
10	Barrick Resource	Domestic, Mining	15 2922	1.0000	1000	S2600	W2800	NE	4	6S	4W	5
11	Barrick Resource	Domestic, Mining	15 2922	1.0000	1000-1500	N2431	W1851	SE	4	6S	4W	3
12	Barrick Resource	Domestic, Mining	15 2922	1.0000	1000-1500	N2431	W1551	SE	4	6S	4W	3
13	Barrick Resource	Domestic, Mining	15 2922	1.0000	1000-1500	S3033	W4892	NE	10	6S	4W	3
14	Barrick Resource	Domestic, Mining	15 2922	1.0000	1000-1500	S3387	W5246	NE	10	6S	4W	3

Table 2.1-5 Water Rights Within 5 Miles of TEAD-S[1]

Well No.	Owner	Use	Water Right No.	Quantity (CFS)	Depth of Source (ft)	North (ft)	East (ft)	Corner	Section	Township	Range	Field Verified
15	Barrick Mining	Domestic, Mining	15 2922	1.0000	1000-1500	S1850	W1400	NE	15	6S	4W	4,7
16	Barrick Resource	Domestic, Mining	15 2922	1.0000	1000-1500	S2300	W200	NE	15	6S	4W	3
17	Barrick Resource	Other	15 2858	3.5000	Unknown	N200	E100	SW	14	6S	4W	4,7
18	USBLM	Stockwatering	15183	1.5000	Wash	N1046	W371	SE	6	75	4W	3
19	Priority Minerals	Domestic, Mining	15 3199	Unknown	600-1200	N1300	E1400	SW	30	6S	4W	7
20	Priority Minerals	Domestic, Mining	15 3199	Unknown	600-1200	S700	E600	NW	31	6S	4W	7
21	Stookey Estate	Stockwatering	15178	0.0150	50	S1120	E785	NW	31	6S	4W	3
22	Stookey Estate	Stockwatering	15 78	1.8	Wash	S1401	W998	E4	31	6S	4W	6
23	Clark	Irrigation, Domestic Stockwatering	15 1450	0.0150	Unknown	S445	E2370	NW	36	5S	5W	3
24	BLM	Stockwatering	15 2114	0.0000	Stream	N800	W160	S4	33	5S	5W	5
25	Tooele County	Stockwatering	15 124	0.0150	365	S1019	E1233	NW	35	6S	4W	3
26	Stookey Estate	Stockwatering	15 179	0.0150	50	S554	E1536	W4	34	6S	5W	3
27	Daniel H. Russel	Irrigation Stockwatering	15 165	5.0000	105	S600	W1275	NE	5	6S	5W	3
28	Daniel H. Russell	Irrigation, Domestic	15 79	1.5000	100	S1756	W3320	NE	5	6S	5W	3

Source: Utah Division of Water Rights.

ft	feet
CFS	Cubic feet per second
1	Specific information is not field verified.
2	On-post water diversions were not evaluated.
3	Water diversion located by a global positioning system in August 1993.
4	Location not found in August 1993.
5	Location presumed found with evidence of abandonment of this device. August 1993.
6	New locations obtained as a result of November 1993 area request; not field checked.
7	Location not found; probable diversion point not yet constructed.



Source: Utah Division of Water Rights 1990 and 1993

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

Figure 2.1-7

Location of Water Rights within 5 miles of TEAD-S

Prepared by:
Ebasco Services Incorporated

A field crew attempted to locate and verify the water diversions identified during the 1990 records search. Many of the locations were found and a global positioning system (GPS) was used to record their positions. Only one well identified on the list is potentially located downgradient of potential source areas in the eastern Group 2 SWMUs. This well, owned by Tooele County, is approximately 1,500 ft southeast of the southeastern corner of the TEAD-S boundary. The well produces water for stockwatering from a zone approximately 365 ft below ground surface. The current status of the well is unknown. Two surface water sources used for stockwatering are located in washes approximately 1,500 ft and 9,000 ft, respectively, south of the southern boundary of TEAD-S, downgradient from the eastern Group 2 SWMUs. The current status and persistence of these surface water sources are unknown. Two wells, both owned by Daniel Russell, are located 6,000 ft and 7,500 ft, respectively, west of the northwestern part of TEAD-S. These wells, which are permitted to produce water from a depth of approximately 100 ft for irrigation, stockwatering, and domestic use, are the only water supply sources that are located downgradient of SWMU 30. The wells are located approximately 24,000 ft from SWMU 30; SWMUs 13 (CAMDS), 11 (Area 10), and 2 (Gravel Pit) are also located within this intervening distance. Seven wells identified on the list were not located (Figure 2.1-7). Of these seven, three appeared to be abandoned or impounded (Table 2.1-5). Personnel at UDWR indicated that it is most likely that the four other water diversion points have not yet been constructed (UDWR personal communication 1993).

2.2 PREVIOUS INVESTIGATIONS

The following environmental studies have been performed at TEAD-S:

1979 U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) conducted an installation assessment of TEAD to identify past contamination and to assess the potential for contaminant migration. Historic information on operations at the Group 2 SWMUs (SWMUs 3, 5, 8, 9 30 and 31) was provided in the report. This assessment, which included a records search for information on toxic and hazardous materials use, storage, treatment, and disposal, concluded that a potential for contaminant migration existed. In TEAD-S in particular, the mustard storage areas, burial areas, and demolition grounds were thought to have a potential for contaminant migration. Of these, the Demilitarization and Disposal Pits Area (now SWMUs 1 and 25) was thought to have the highest contaminant migration potential due to shallow groundwater. The assessment recommended that the SWMU 1 burial pits be located and investigated and that monitoring wells be installed around landfills.

1982 Through an interagency agreement between the U.S. Environmental Protection Agency (EPA) and the Army, the Environmental Photographic Interpretation Center (EPIC) published an interpretation of aerial photographs as a follow-up to the installation assessment of TEAD-S. The photographs that were available were limited to a timeframe ranging from September 1974 and July 1981. Pits, ground scars, surface drainages, and other features of the SWMUs were detailed on overlays in this report to identify areas of potential contamination and contaminant migration. Photographs of SWMUs 5, 8, 9, 30 and the area that would become SWMU 31 were included in the interpretation.

1982 Inland Pacific Engineering Company prepared a report that summarized all TEAD features that were thought to have environmental significance. Research for this study included an examination of resources in and around the installation, identification of on-base activities, and the evaluation of the potential impacts of these activities or resources on and off base. Eleven areas at TEAD-S were identified as potentially contaminated.

1982 Earth Technology Corporation (ERTEC) conducted a two-phase exploratory survey for USAEC that revealed minimal contamination and contaminant migration at TEAD-S. However, high levels of arsenic were found in the groundwater of the uppermost aquifer, particularly in the south-central part of TEAD-S. The study did not identify the source of the arsenic. Gross alpha and gross beta radiation were found to be high in surface water samples and in one groundwater sample, but the radiation was attributed to naturally occurring radionuclides. The survey recommended that the installation set up a semiannual groundwater monitoring program that would include all existing wells and that samples be collected in the south-central portion of the site, including the Group 2 SWMUs, for arsenic analysis.

1986 The U.S. Army Environmental Hygiene Agency (USAEHA) evaluated 31 SWMUs, 4 of which were identified during this investigation for TEAD-S. The purpose of the study was to review the adequacy of the data that had been submitted on all SWMUs as part of a pending RCRA Part B permit application for the CSDP. This study identified 7 sites that could not be classified as SWMUs and recommended their removal from the list of SWMUs, listed 18 others that needed no further investigation, and identified 6 SWMUs for additional investigation. Among the SWMUs recommended for additional investigation were SWMUs 5 and 9.

1986 EPIC prepared an aerial photography interpretation addendum that provided a more detailed study of selected sites using additional photographs. SWMUs 8 and 30 were included in this study. Demilitarization features such as trenches, pits, and craters were observed in photographic records of the years 1952, 1959, and 1966.

1987 Under contract to EPA Region III, NUS Corporation published the Final Interim RCRA Facility Assessment of TEAD-S. This report described 29 SWMUs, including the potential presence of chemical agent. This report made recommendations as to what sampling should be conducted to assess potential threats to public health and the environment. Soil and groundwater sampling were recommended at SWMUs 3, 5, 8, and 31. Only surface soil sampling was recommended at SWMU 9, and no further action was recommended at SWMU 30.

1988 Under contract to USATHAMA, EA Engineering, Science and Technology, Inc. completed a preliminary assessment/site investigation (PA/SI). This investigation included both a review of the literature and limited field investigations. The report concluded that among other sites, SWMUs 5 and 30 were either contaminated or had a high potential for contamination. No chemical agent breakdown products were detected in any samples. The report stated that the data collected were insufficient to attribute any contamination to a specific TEAD-S site.

1991 A remedial investigation (RI) performed for USATHAMA by Weston investigated four areas at TEAD-S: CAMDS (SWMU 13), the deactivation furnace mercury spill area (SWMU 17), the Mustard Holding Area (SWMU 9), and south general and perimeter areas (including SWMUs 1 and 25). An endangerment assessment of each site indicated that chromium contamination in soil at the SWMU 9 posed an unacceptable risk under present conditions. Other sites posed unacceptable human health risks under certain future-use scenarios that were considered unlikely.

1993 Under contract to USAEC, EBASCO (1993a) completed an RFI-Phase I of 26 suspected releases SWMUs. For each SWMU, all historical data and previous sampling results were combined with the results of a limited RFI-Phase I sampling program. Soil and groundwater were sampled as part of this program and the data were evaluated to assess the presence or absence of contamination at each SWMU. Where contamination was detected, this report recommended an RFI-Phase II investigation. All of the Group 2 SWMUs were included in this recommendation. Additional soil sampling was recommended at all six SWMUs and more groundwater sampling was recommended at SWMUs 3, 5 9, and 30. Ecological surveys and explosive risk determinations were also recommended.

1994 An RFI-Phase II study of known releases SWMUs 13 and 17 was performed by Rust Environmental and Infrastructure for USAEC. The purpose of the study was to determine the extent of any contamination that may be present, perform a risk assessment, and determine whether a corrective measures study (CMS) should be completed for any area within the SWMUs. The investigation was also a requirement of the corrective action permit associated with the TEAD RCRA Part B permit to construct and operate the CSDP.

The analytical results indicated that there was no contamination at SWMU 17, in either the soil, surface water, or groundwater. At SWMU 13 (CAMDS), which is adjacent to SWMU 30, however, results indicated that both soil and groundwater were contaminated, which results prompted a recommendation for additional sampling at this SWMU.

1994 An RFI-Phase II study of SWMUs 1, 25, and 37 was performed by EBASCO for USAEC. The purpose was to characterize these SWMUs and present a human health and ecological risk assessment and recommendations. Characterization of the SWMUs was conducted by collecting, air, groundwater, and soil samples; performing ecological surveys; and compiling disposal pit inventories. In addition, nine new monitoring wells were installed at SWMUs 1 and 25. Limited soil and groundwater contamination was detected at low levels in these SWMUs. The subsequent human health risk assessment concluded that the risk to on-site workers was very low and well below the EPA's target cancer risk. It should be noted that the assumptions used were very conservative, and that they likely overestimate the health risk. Additional sampling is recommended in SWMUs 1 and 25 once the Army has determined the procedures for excavation in agent-contaminated areas. At SWMU 37, further delineation of metals contamination is recommended.

2.3 BACKGROUND SOIL AND GROUNDWATER GEOCHEMISTRY

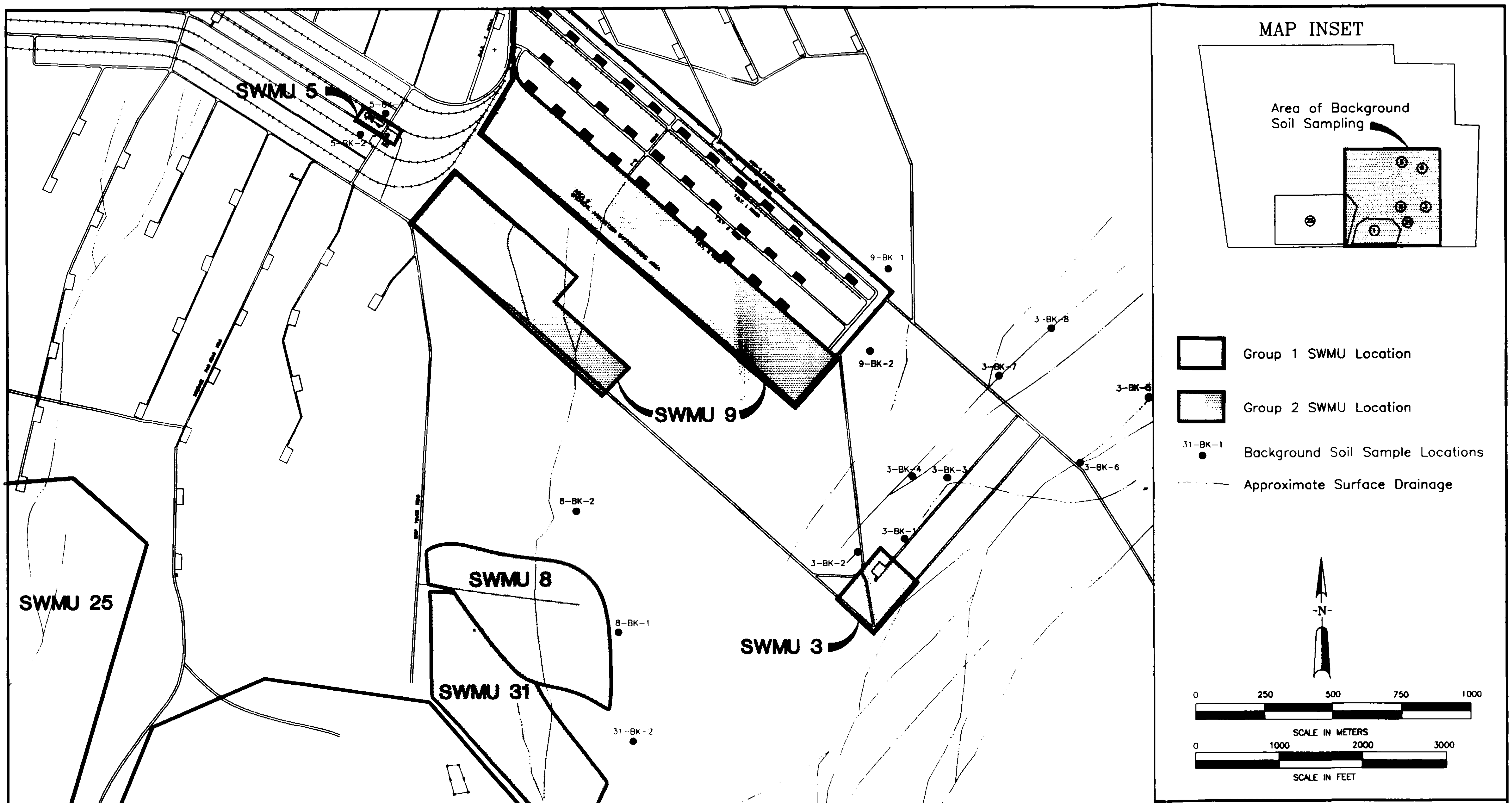
Since inorganic site contaminants can occur naturally in the environment, the natural background levels of these analytes must be determined in order to detect a contaminant release. This section presents the results of the background soil and groundwater sampling program that was undertaken to make this determination.

2.3.1 Soil

2.3.1.1 Developing the Data Set

The background data set is composed of chemical analytical results for 23 metals and cyanide in surface and subsurface soil samples collected during the RFI-Phase II field sampling program at Group 2 suspected releases SWMUs 3, 5, 8, 9, and 31 (Appendix F4). The samples were collected from two boreholes drilled outside of the known or suspected area of contamination at each of the SWMUs, except SWMU 30. (Figure 2.3-1). No background samples were collected at SWMU 30 because sufficient data were already available from adjacent known releases SWMU 13. Samples at each of the 10 locations were collected from the 0- to- 2-inch and 2- to 3-ft depth intervals. Supplemental surficial soil samples were later collected from six additional SWMU 3 background locations. These samples were analyzed for arsenic and mercury to establish SWMU-specific background levels for those two metals. However, the results for these samples were not included in the dataset used for establishing background values for the other Group 2 SWMUs.

One surface soil field duplicate was collected outside the boundaries of SWMU 8 at location 8-BK-1. The detected concentrations in the field duplicate were averaged with the detected concentrations in the investigative sample to provide one set of results. If only one of the two analytical results was a detection, the detected value was used in the background data set. If both sample analyses were nondetections, the result was treated as nondetection in the data set with the value set at the method detection limit (MDL).



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

Figure 2.3-1

RFI Phase II Background Soil Sample Locations at TEAD-S

Prepared by:
Ebasco Services Incorporated

2.3.1.2 Methodology and Results

In order to determine the representativeness of background geochemical analytical results, the soil data set was analyzed for potential upper-extreme outliers. Prior to the evaluation of outliers, the surface (0- to 2-inch depth interval) and subsurface (greater than 2 inch depth) sample results were combined. These data were combined since site samples were collected from areas that have been disturbed by excavation, construction, and explosives demolition, resulting in mixing of the surface and subsurface soil (see Sections 5.1.2 and 6.4). Outliers are extreme values that may not be representative of the conditions of the background population. Outliers may be the result of laboratory or analytical errors, invalid background sample locations, or actual environmental conditions.

Two outlier evaluations were conducted for each of the 23 metals and cyanide in the surface and subsurface soil data subsets. If both evaluations indicated that a result was an outlier, then it was removed from the background data set. The first outlier evaluation was qualitative. Box-and-whisker plots were created for each metal depicting the data distribution at the 5 percent, 25 percent, 50 percent, 75 percent, and 95 percent quartiles. In these plots, data that exceeded the 95 percent quartile were considered to be outliers. This method identified 22 potential outliers. Professional judgment was then used to decide whether each potential outlier should be included as a member of the population. This decision was based on the following criteria:

- The potential outlier is not the only detection in the data set
- The potential outlier is the highest detection of that analyte in either the surface or subsurface data subsets

If both of these criteria were met, the potential outlier was evaluated further.

The second evaluation of potential outliers was quantitative. Using guidance provided by EPA in Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities (1992a), the maximum detection of each metal was tested as a function of the size of the population, the arithmetic mean, and the standard deviation of the appropriate data set. This evaluation assumed that the values, excluding the outlier, were normally distributed. Since lognormally distributed data commonly contain values that are elevated compared to the rest of the data, the test was run on the natural logarithms of the data rather than on the original data itself. For the calculation of arithmetic mean and standard deviation, a value of one-half the analyte MDL was substituted into the data set for all nondetections. The following calculation was completed for each metal in order to determine the potential (T_n) of the maximum detection as an outlier:

$$T_n = \frac{|X_{max} - X_{mean}|}{s} \qquad (2\text{-}1)$$

where: n = number of data points in the data set ($n = 10$)
X_{max} = natural logarithm of maximum detected value
X_{mean} = arithmetic mean of the natural logarithm of values in the data set
s = standard deviation of the natural logarithm of values in the data set

The calculated T_n was then compared to the critical T value (Table 8, Appendix B in EPA 1989a). If the calculated T_n exceeded the critical T value, this maximum value was considered to be an outlier. At this point, the maximum value was included in the data set only if data in the other data set (either surface or subsurface) were greater.

Based on the results of both evaluations, outliers were confirmed for the following metals in the surface soil data subset: arsenic (440 micrograms per gram, or µg/g in surface soil at 3-BK-1), cadmium (1.78 µg/g in surface soil at 3-BK-1), copper (72.1 µg/g in surface soil at 31-BK-1), lead (160 µg/g in surface soil at 5-BK-2), and mercury (2.7 µg/g in surface soil at 3-BK-1). The subsurface soil data subset did not contain any apparent outliers. All outliers were removed from the dataset prior to the determination of background values in surface soil.

Based on the results of the outlier test and the elevated concentrations of arsenic and mercury detected in samples from SWMU 3 and the two background locations, a supplemental background sampling program was conducted in December 1994. Six samples and one field duplicate were collected from surficial soil within the drainage of Mercur Creek which passes to the east of the SWMU 3 boundary. These samples were analyzed for arsenic and mercury only.

Arsenic was detected in each of the supplemental background samples at concentrations ranging from 23 µg/g to 4820 µg/g (Figure 2.3-2). Mercury was also detected in every sample ranging from 0.047 µg/g to 22.1 µg/g (Figure 2.3-2). The levels of arsenic and mercury in these samples are comparable to the concentrations detected in the four samples collected at 3-BK-1 and 3-BK-2. According to a survey completed by the Soil Conservation Service (SCS, no date) the predominant soil type in the vicinity of SWMU 3 is slickens and mine dump (Plate 1). This soil type occurs only where the Mercur creekbed crosses TEAD-S. Therefore, data collected from the supplemental background sampling program were only used to substantiate elevated arsenic and mercury in the vicinity of SWMU 3.

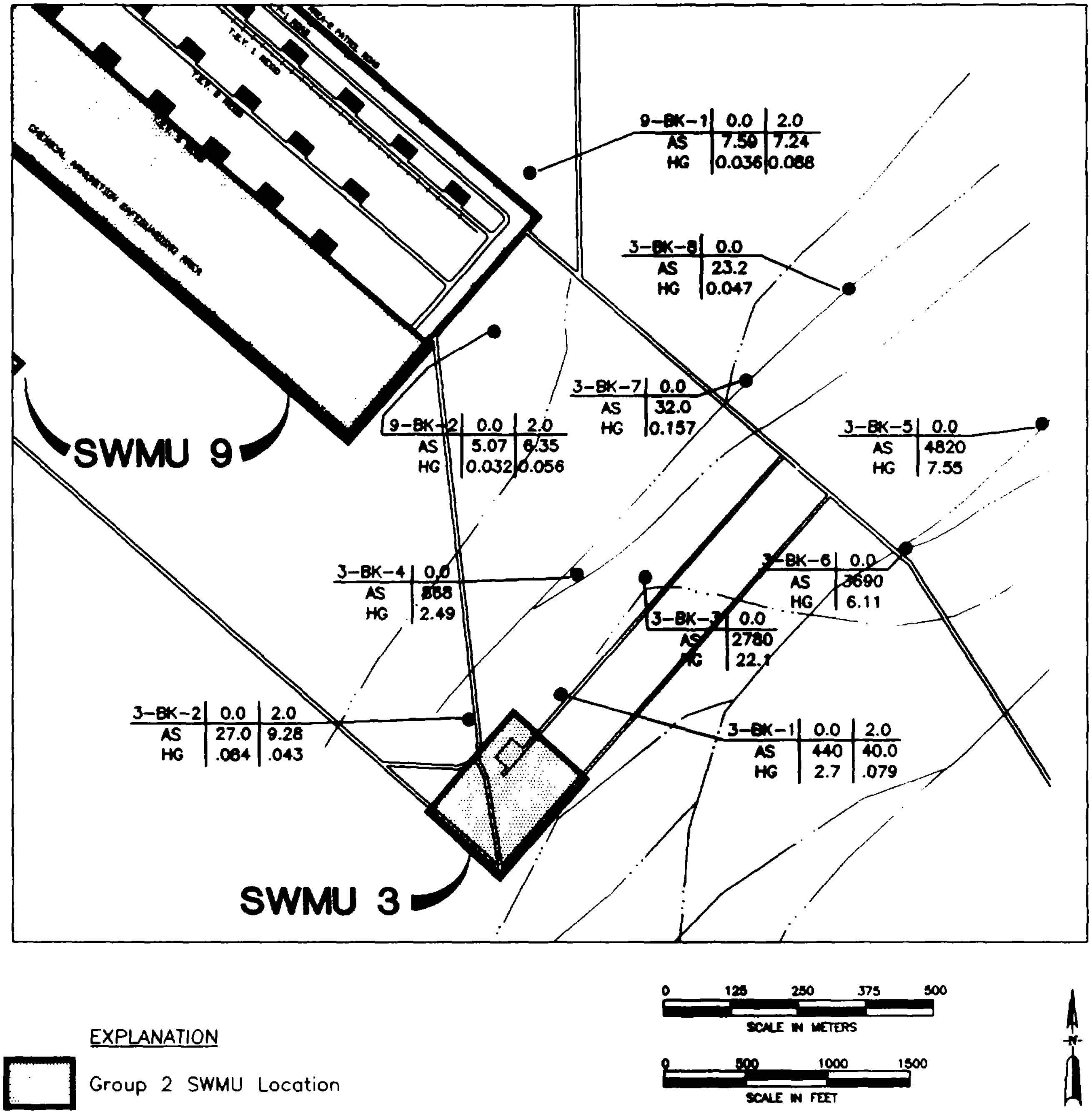
In view of the relatively low number of background data, the maximum concentrations of each metal in the background soil data set (excluding upper-extreme outliers), were selected as comparative values so that contaminant concentration levels could be identified during the field investigation and chemicals of concern (COCs) could be selected during the risk assessment. Table 2.3-1 provides summary statistics completed for the background soil data set that include the range of detected concentrations, arithmetic mean, standard deviation, and background value (maximum detected concentration) for each metal.

Table 2.3-1 Summary of Background Soil Results Page 1 of 1

Analyte	Number of Samples	Number of Detections	Percent Detections	Arithmetic Mean (µg/g)	Standard Deviation	Minimum Detection (µg/g)	Maximum Detection (µg/g)
Aluminum (Al)	20	20	100	13,000	4,700	5,530	25,200
Antimony (Sb)	20	1	5	4.0	1.9	11.9	11.9
Arsenic (As)	19	19	100	11	10	2.98	40
Barium (Ba)	20	20	100	210	110	61.5	537
Beryllium (Be)	20	20	100	0.66	0.22	0.303	1.21
Cadmium (Cd)	19	12	63	0.56	0.22	0.411	0.982
Calcium (Ca)	20	20	100	110,000	54,000	32,200	250,000
Chromium (Cr)	20	20	100	19	8.5	8.12	48.5
Cobalt (Co)	20	20	100	5.4	1.5	2.12	8.59
Copper (Cu)	19	19	100	16	6.3	7.24	27.6
Cyanide (CYN)	20	0	0	ND	ND	ND	ND
Iron (Fe)	20	20	100	13,000	4,000	6,140	24,300
Lead (Pb)	19	19	100	16	9.6	5.45	35.0
Magnesium (Mg)	20	20	100	12,000	2,300	8,930	16,150
Manganese (Mn)	20	20	100	390	160	167	658
Mercury (Hg)	19	14	74	0.05	0.03	0.031	0.143
Nickel (Ni)	20	20	100	16	4.3	10.1	27.9
Potassium (K)	20	20	100	4,400	1,700	2,270	7,940
Selenium (Se)	20	1	5	0.13	0.02	0.208	0.208
Silver (Ag)	20	1	5	0.30	0.03	0.435	0.435
Sodium (Na)	20	20	100	2,000	1,600	429	5,610
Thallium (Tl)	20	17	85	18	13	5.43	49.9
Vanadium (V)	20	20	100	29	14	15.6	62.6
Zinc (Zn)	20	20	100	69	26	36.1	144

ND Not Detected
µg/g micrograms per gram

Note: The maximum detected concentration is considered the background value for comparative purposes in this report.



EXPLANATION

▢ Group 2 SWMU Location

═ Road

—·· – Approximate Surface Drainage

● Background Soil Sample Location

Site ID	Depth (Ft)
Analyte	Concentration (ug/g)

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

Figure 2.3-2

Distribution of Background Arsenic and Mercury in Vicinity of SWMU 3

Prepared by:
Ebasco Services Incorporated

2.3.2 Groundwater

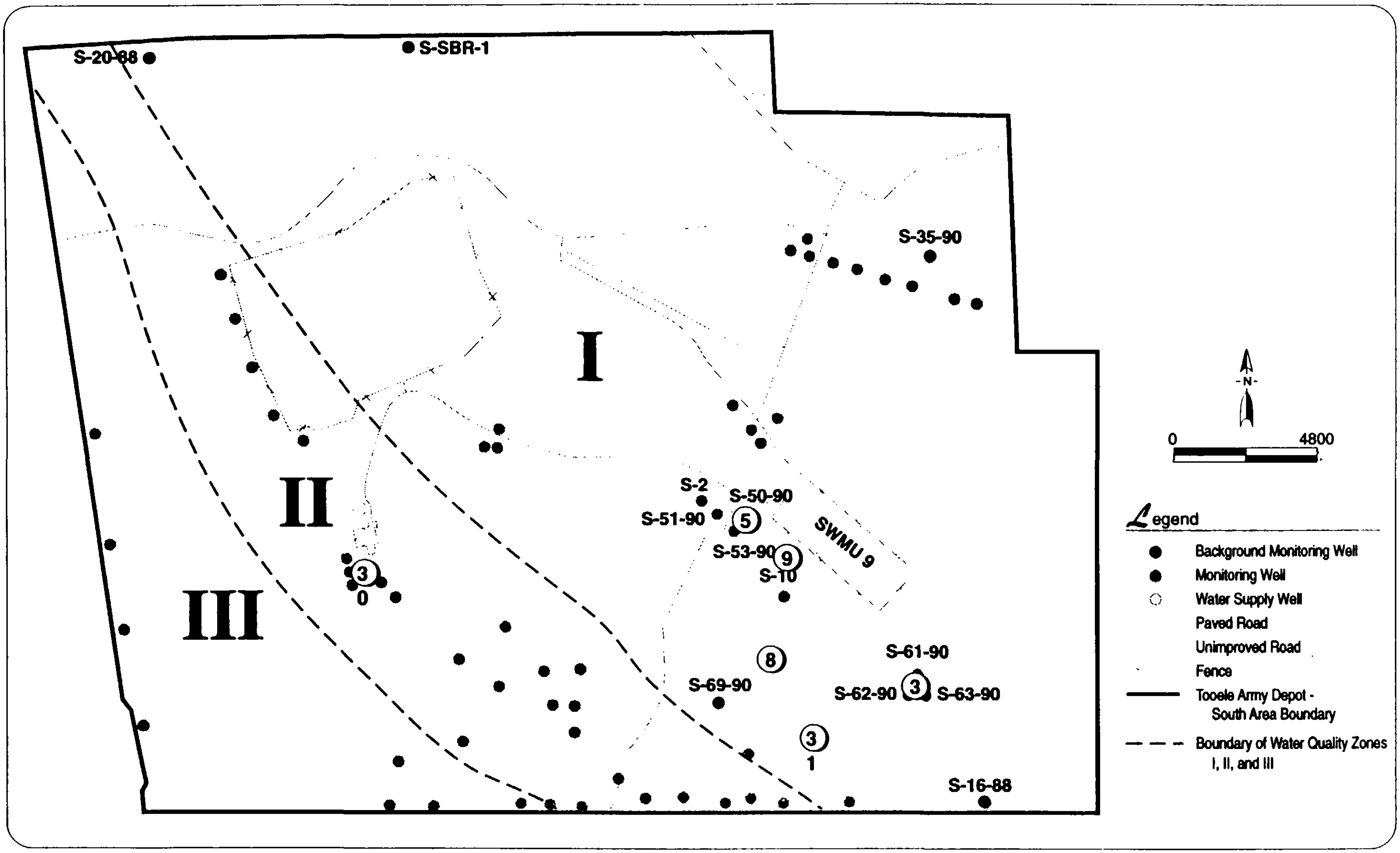
In order to determine whether environmental degradation of groundwater has resulted from past activities at SWMUs 3, 5, and 9, it is necessary to know the natural inorganic chemistry of groundwater from areas that remain unaffected by TEAD-S activities. Data used to establish background concentrations in groundwater were assembled from monitoring wells that are located hydraulically upgradient of known contaminant sources at TEAD-S, are located in the same water-quality zone as SWMUs 3, 5, and 9, and are free of organic compounds that are anthropogenic in origin. Chemical analytical results from these wells (S-20-88, S-SBR-1, S-50-90, S-35-90, S-16-88, and S-69-90) were used to determine site groundwater background chemistry.

Figure 2.3-3 shows the locations of background wells at TEAD-S. Two background wells (S-20-88 and S-SBR-1) are located on the northwestern boundary of TEAD-S and intercept groundwater flowing on post from the northeast. Well S-50-90, the upgradient background well at SWMU 5, is located approximately 150 ft northeast of Building 600 Foundation. Well S-35-90 is located upgradient of SWMU 26 and also intercepts groundwater flowing on post from the northeast. Well S-16-88 is located on the southeast boundary of TEAD-S and intercepts upgradient groundwater flowing to the east of SWMU 3. Well S-69-90, located approximately 6,000 ft south of SWMU 5, is the background well for SWMU 1. Results from wells S-61-90 and S-110-93, which were intended to be background wells for SWMUs 3 and 9, were not included in the background data set because chlorinated solvents were detected in groundwater samples from these wells.

Because RFI-Phase II groundwater samples for metals analyses were not filtered, previous results from unfiltered background samples only were used in combination with these data. Statistical analysis of the data was not performed because of the limited number of data available to analyze each element in the background data set (the mean number of samples per well equaled 2.5). Instead, a range of reported values was used to establish background levels, with the maximum concentrations detected in background wells used to establish the upper-bound limits for each analyte at the site.

Table 2.3-2 lists the range of concentrations of metals and anions in TEAD-S background wells. The metals that were analyzed include aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. The anions include bicarbonate, bromide, chloride, fluoride, nitrate/nitrite, phosphate, and sulfate.

Four metal analytes (cobalt, mercury, selenium, and thallium) were not detected in any background wells. As a result, the detection limits for these analytes were used as the background value. Two other metals (aluminum and vanadium) were typically not analyzed for in background groundwater samples. The background value listed for aluminum is based on one sampling round from well S-50-90, and the range given for vanadium is based on a sample from



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I - **Fresh Zone**

II - **Transition Zone**

III - **Saline Zone**

Figure 2.3-3
Locations of Monitoring Wells Used for the Evaluation of Background Groundwater at TEAD-S for SWMUs 3, 5, 8, 9, 30 and 31

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

Table 2.3-2 Ranges of Total (Unfiltered) Metals and Anions in Background Groundwater at TEAD-S for SWMUs 3, 5, and 9

Page 1 of 1

Analyte	Background Concentration Range (µg/L)[1]
Total Metals	
Aluminum	14,200[2]
Antimony (Sb)	LT (3.0) - 4.54
Arsenic (As)	7.66 - 35.5
Barium (Ba)	20.8 - > 200.0
Beryllium (Be)	0.503 - 0.805
Cadmium (Cd)	LT (4.01) - 10.7
Chromium (Cr)	LT (6.02) - 35.5
Cobalt (Co)	ND[3]
Copper (Cu)	LT (8.09) - 47.7
Lead (Pb)	4.88 - 57.7
Manganese (Mn)	78.6 - 315
Mercury (Hg)	LT(0.17) - LT (0.243)
Nickel (Ni)	16.7 - 45.1
Selenium (Se)	LT (3.02) - LT (50.0)
Silver (Ag)	LT (4.6) - 2.02
Thallium (Tl)	LT (4.65) - LT(6.99)
Vanadium (V)	LT (11.0) - 27.1[4]
Zinc (Zn)	LT (21.1) - 1,100.0
Anions	
Bromide (Br)	LT (50.0) - 577
Chloride (Cl)	18,000 - 1,400,000
Fluoride (F)	LT (50.0) - 2,600
Bicarbonate (HCO_3)	190,000 - 447,000[5]
Nitrate+Nitrite (NIT)	LT (10.0) - 6,100
Sulfate (SO_4)	12,000 - 640,000
Phosphate (PO_4)	LT (56.9) - 1,200

well S-69-90 and well S-50-90. The upper background concentration for barium is difficult to establish, as background values for the maximum concentration are given as "greater than 200 mg/L". It has been established in the database, however, that barium is a fairly abundant metal in TEAD-S groundwater. Analyses for chromium did not differentiate between trivalent and hexavalent species, nor did the analyses differentiate between species for the other redox elements tested (arsenic, antimony, copper, selenium, vanadium).

2.4 GENERAL INFORMATION FOR ENVIRONMENTAL FATE AND TRANSPORT OF CONTAMINANTS

An understanding of the factors controlling the environmental fate and transport of contaminants in soil and groundwater at SWMUs 3, 5, 8, 9, 30, and 31 is essential for determining the potential for on- and off-site migration beyond the SWMU boundaries and to assess the potential and associated risk of current and future exposure to these compounds in environmental media.

This section presents general information relevant to evaluating contaminant fate and transport, and includes both a discussion of the potential contaminant migration pathways and transport mechanisms that could be present at each SWMU, as well as a review of the important physical and chemical characteristics that potentially control the fate of COCs.

2.4.1 Potential Migration Pathways

The release of compounds from past and present activities at the individual SWMUs has resulted in varying degrees of contamination of site soil and groundwater at each SWMU. The presence of contaminants in environmental media at the SWMUs may result in the potential for further migration and redistribution of contaminants to potential receptors. A summary of the potential migration pathways and date and transport processes that could be operating at each SWMU is shown schematically in Figure 2.4-1.

As shown in this figure, contaminants residing in surface soil may be mobilized and transported by wind erosion, volatilization, or episodic overland flow. Contaminants in surface soil may also migrate to subsurface soil by desorption and leaching processes and can potentially enter groundwater. Volatile organic compounds (VOCs) in surface soils can migrate in soil gas, especially in climates with high evaporation rates and little rain (such as TEAD-S), or volatilize directly to the atmosphere.

If mobilized by surface water runoff, contaminants may eventually re-enter the subsurface environment by infiltration, contaminating subsurface soil and eventually reaching the water table. In the process of infiltration, contaminants may also remain behind in the surface soil, where attenuation by photolysis or biodegradation reactions may occur. Transport by surface water to a standing body of water is also possible. Contaminants mobilized as fugitive dust can be deposited onto surface soils, surface water bodies, or dispersed in local air masses.

Contaminants present in subsurface soil can be released to soil gas by volatilization and eventually reach the atmosphere, or migrate to groundwater by desorption or leaching. Volatile

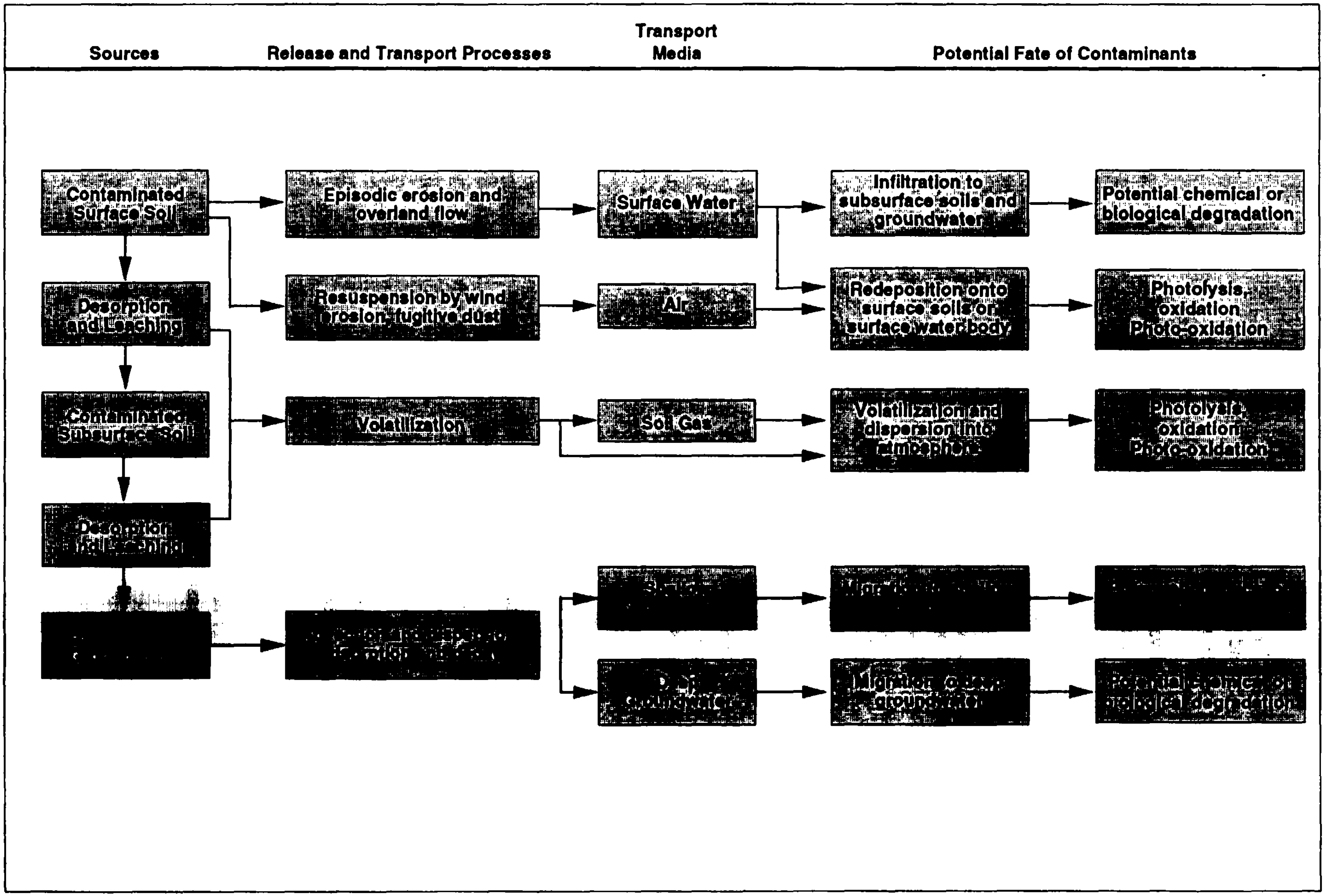

Figure 2.4-1 • Fate and Transport Conceptual Model for SWMUs 3, 5, 8, 9, 30, and 31

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contaminants that migrate to the atmosphere are subject to dispersal by local air masses and attenuation by photolysis and oxidation reactions. Redeposition from the atmosphere to surface soils or surface water bodies may also occur.

Contaminants in site groundwater may migrate by advection and dispersion via groundwater flow, become adsorbed to aquifer solids, or volatilize to soil gas and ultimately disperse into the atmosphere. Advection by groundwater flow may redistribute contaminants in the shallow groundwater environment or transfer them to deeper hydrostratigraphic units. Contaminants that remain in groundwater or soil are subject to attenuation by chemical and biological degradation processes.

2.4.2 Contaminant Mobility and Behavior

The important chemical and physical properties relevant to predicting contaminant mobility and behavior in environmental systems involve parameters describing the partitioning of the contaminant between environmental media. Contaminant partitioning between water, air, and soil is quantified by such properties as aqueous solubility (water), vapor pressure (air) Henry's law constant (water/air), and the octanol-water (K_{ow}) and organic-carbon (K_{oc}) partition coefficients (soil). The physical state of the contaminant determines the state (solid, liquid, or vapor) of the contaminant under conditions of standard temperatures and pressures. Density refers to the mass per unit volume of the contaminant under standard conditions of temperature and pressure. Standard temperature and pressure usually refers to a temperature of 25 degrees Celsius (°C) and 1 atmosphere pressure. These properties are also reflected by the degradation half-lives of the compound in water, air, and soil that reflect a compound's susceptibility to biotic and abiotic attenuation mechanisms.

The aqueous solubility of a contaminant provides considerable information about the fate and transport of a contaminant in the environment. Contaminants with high aqueous solubilities tend to dissolve in infiltrating water and remain in the water column, but not partition to soil or sediment or bioconcentrate in aquatic organisms. Although highly soluble compounds are also less likely to volatilize from water to air, they are more likely to reach the water table via leaching, and are more likely to biodegrade. Conversely, compounds with low solubilities are more likely to partition to soil and sediments, bioconcentrate in organisms, volatilize more readily from water to air, and are less likely to biodegrade.

The vapor pressure determines the volatility or tendency of the compound to exist in the vapor state. Highly volatile compounds, such as VOCs, and in some cases mercury, preferentially partition to the atmosphere or soil pore gas when released to the environment rather than to the water column or soil and sediment. The volatility of the pure compound also determines the form of the compound in the atmosphere. Compounds with vapor pressures less than about 10^{-6} millimeters (mm) mercury (Hg) are associated with airborne particulates (such as dust), while compounds with higher vapor pressures exist primarily in the vapor phase.

The Henry's law constant is often referred to as the air/water partition coefficient. The Henry's law constant relates the compounds concentration in the vapor phase to its concentration in water under equilibrium conditions. The Henry's law constant is determined by dividing the vapor pressure of the compound in atmospheres (atm) by the water solubility in moles per cubic meter (mol/m^3) to give atm-m^3/mole. The Henry's constant provides an indication of the partition between air and water, and is also used to estimate the rate of evaporation of the compound from water. Compounds with a Henry's law constant less than about 10^{-7} atm-m^3/mole volatilize less rapidly than water, so as water evaporates, the concentration of the compound increases. Compounds with a Henry's law constant around 10^{-3} atm-m^3/mole are quickly volatilized from water. Compounds with high Henry's constants tend to accumulate in soil pore gas or in the atmosphere.

K_{ow} and K_{oc} describe the partitioning behavior of a compound between water and organic carbon. The organic carbon may take the form of animal lipids and fats or organic matter in soil and sediment. K_{ow} is an indirect way of measuring the partitioning of a compound to organic carbon using octanol as the carbon matrix. In this process, which is conducted under controlled conditions in a laboratory, the ratio of the concentration of the compound in octanol is divided by the concentration of the compound in water in a two-phase system. K_{ow} has been shown to correlate well with bioconcentration factors in aquatic organisms and adsorption of the compound to organic matter in soil and sediment. K_{oc} is the ratio of the mass of compound per unit weight of organic carbon divided by the concentration of the compound in water. In this case, the carbon matrix may consist of actual organic matter in soil or sediment and may be a more realistic indicator of the partitioning behavior of the compound because actual site samples can be used to measure the concentration ratios. Compounds that have high values of K_{ow} or K_{oc} typically have low aqueous solubilities and bind strongly to soil and sediments that have high organic carbon content or have a high percentage of clay-sized particles. When present in the substance, sorption of these compounds to soil and other geologic materials causes them to be retarded relative to the flow of groundwater.

The density of a compound is significant in instances in which pure liquids are released to the subsurface, such as in a spill. Liquid compounds that are less dense than water (less than 1 gram per cubic centimeter) float on the water table. Liquids that are more dense than water, such as dense nonaqueous phase liquids (DNAPLs), travel past the water table and continue downward until a low-permeability layer is encountered. Liquids that are less dense than water include compounds such as petroleum hydrocarbons. Liquids more dense than water include compounds such as halogenated solvents.

In addition, the chemical and physical properties of a compound are reflected in the susceptibility to chemical and biological degradation mechanisms in the environment. Degradation mechanisms include biological degradation or transformation reactions that result in the production of transformation products or mineralization of the compound by microorganisms in water and soil. Abiotic degradation mechanisms include reactions such as hydrolysis, oxidation/reduction, and photolysis and photooxidation. The susceptibility of the compound to these mechanisms is quantified by the half-life of the compound in soil, water, or air. Compounds with short half-lives are rapidly removed or transformed and exhibit low persistence in the environment. Compounds that have long half-lives will remain relatively unchanged and will be persistent in the environment.