Section 3.0
Site/Facility Description

3.1 Background

3.1.1 Site Selection Criteria

The USAEC, in consultation with TVA, selected TCAAP as the demonstration site based on the soil and geologic conditions, the local climatic conditions, implementation cost, facility interest, and the interest of regulatory agencies in the affected state. TCAAP was selected for the following reasons:

Soil and Geologic Considerations

- TCAAP had sites with both moderate and low levels of ionic lead contamination.
- Metallic debris (i.e., bullet jackets) were present in the soil at Site C, so a demonstration at that site would provide a perspective on the impact of metallic lead particulate on remediation efforts.
- The soils at TCAAP were thought to be sandier than those used during the Sunflower greenhouse study and, therefore, would have better infiltration characteristics.
- The depth of the water tables varied considerably at the TCAAP sites, providing opportunities to examine the effect of these differences on the technology. At Site C, the water table could fluctuate between 2 to 10 feet below the surface, although there is no historical groundwater data at the area where the demonstration plot was located. However, the plot was on the highest part of Site C proper, and groundwater was not encountered beneath the plot area during lysimeter installation or during soil sampling. At Site 129-3, the water table is estimated to be 140 to 200 feet below the surface.

Climatic Considerations

- Minnesota does not have a long growing season and can have early/late frosts, snow, etc. This provided an opportunity to examine operational feasibility in a relatively difficult climate.

Cost Considerations

- Local ATK personnel could be used for demonstration activities.
- A smelter was located nearby.

Local Facility and Regulatory Considerations

- TCAAP was interested in demonstrating the use of innovative technologies.
- The State of Minnesota, in general, has a "forward" thinking approach in environmental matters.
- Regulators in the State of Minnesota are interested in the new technologies.

3.1.2 Facility Description

TCAAP is a 2,370-acre facility located in Arden Hills, Minnesota, approximately ten miles north of Minneapolis-St. Paul, Minnesota (Figure 3-1).

TCAAP is surrounded by four suburban towns including:

- Shoreview to the north and east
- Mounds View to the west
- New Brighton to the southwest
- Arden Hills to the south

TCAAP was established in 1941 and was used for the production and storage of small arms ammunition (.30 and .50 caliber), related materials, fuzes, and artillery shell metal parts. The facility also provided proof testing of small arms ammunition and the storage and handling of strategic and critical raw materials for other government agencies. At its peak, the facility contained 7 major production buildings and over 300 auxiliary buildings (Figure 3-2). The facility is currently inactive.

The phytoremediation demonstration was conducted on areas within Sites C and 129-3. Site C is located immediately east of Mounds View Road, just northeast of the central portion of TCAAP (Figure 3-2). Site C's northern boundary is approximately 0.5 mile south of the northern plant boundary. The site is bounded by railroad tracks to the east and by Building 190 to the south (Figure 3-3). It is about 550 feet wide in the east-west direction and 1,300 feet long in the north-south direction.

Site 129-3 lies west of Snelling Avenue, just south of the Snelling Avenue and Upper Range Road intersection near the center of TCAAP (Figure 3-2). Site 129-3 is located about 0.1 miles west of the TCAAP internal reservoir. The site is roughly shaped like a parallelogram and has approximate dimensions of 225 feet in the north-south direction by 280 feet in the east-west direction (Figure 3-4).

3.1.3 Facility History

3.1.3.1 Current Operations at TCAAP

TCAAP is a government-owned military industrial installation under the jurisdiction of the Commanding General, Headquarters, United States Army Operations Support Command. The OSC was formed on October 1, 1995, and has its headquarters at the Rock Island Arsenal, Rock Island, Illinois. OSC is a major subordinate command of the U.S. Army Materiel Command.

From 1941 to 1976, the mission of TCAAP was to produce a wide variety of ammunition for the U.S. and its allies during World War II, the Korean conflict, and the Southeast Asian conflict. Since active production has not been required since the late 1970s, TCAAP today is in modified caretaker status. This means that there are no active Army production activities

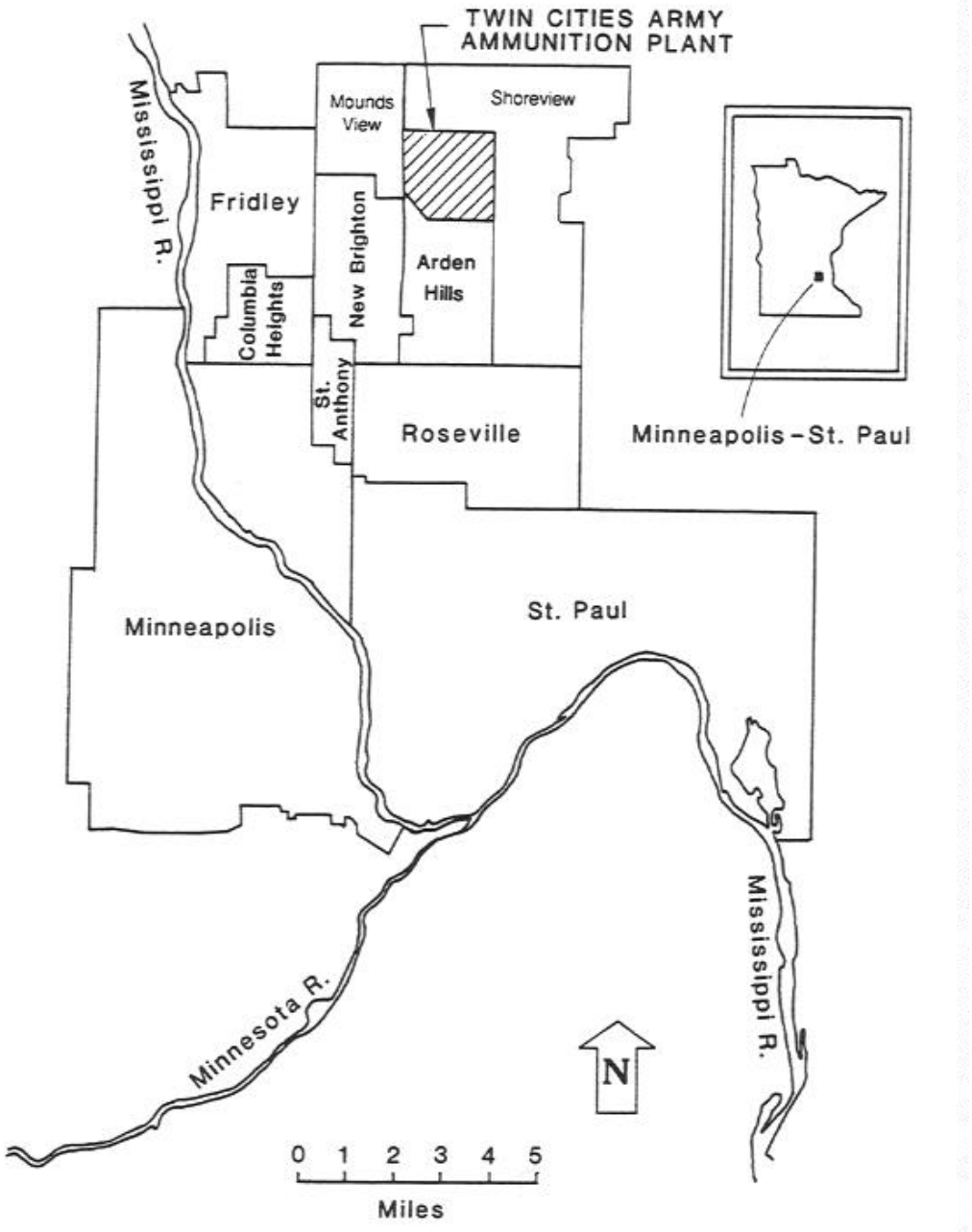

Figure 3-1

Location of TCAAP in the State of Minnesota

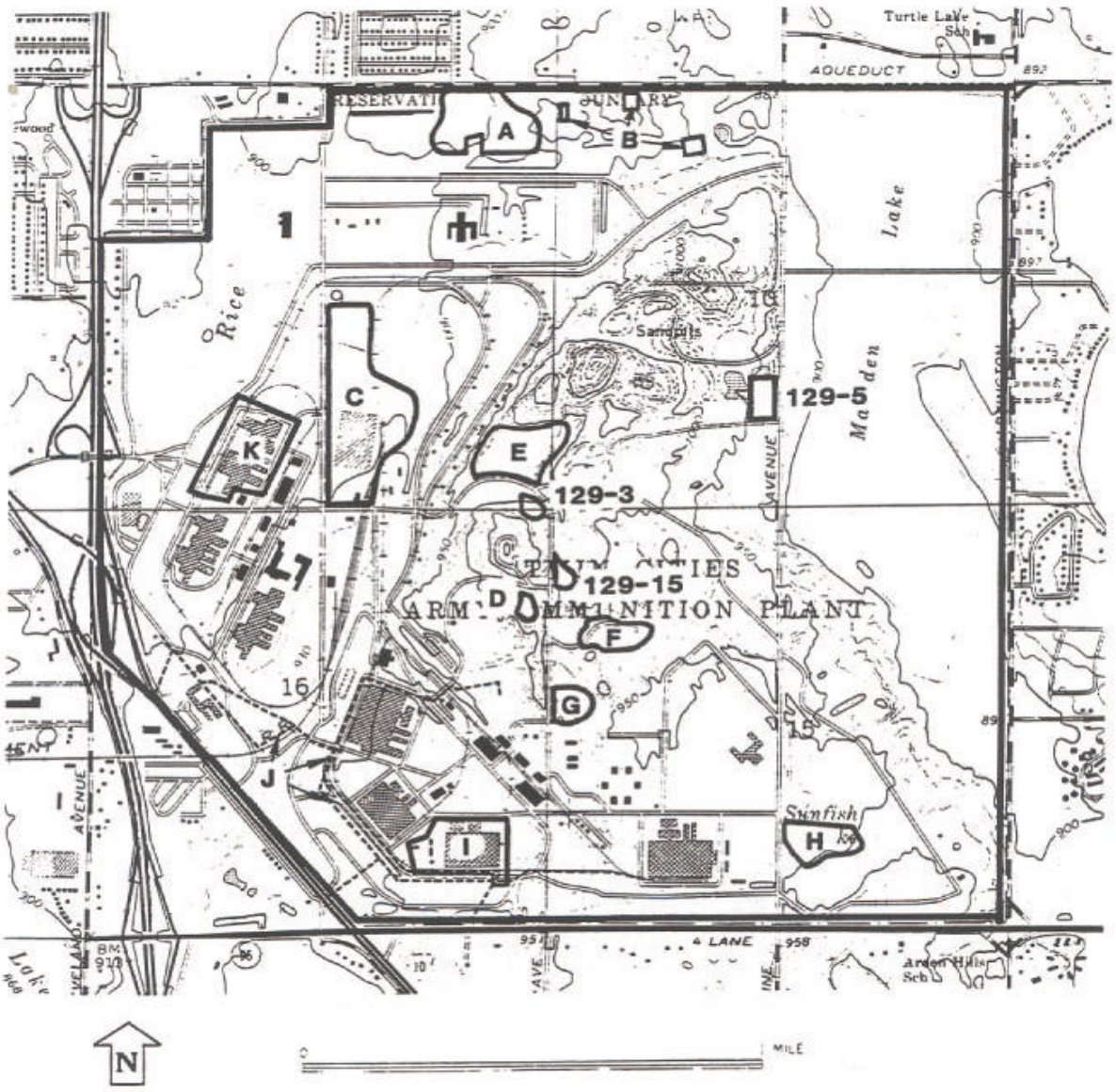

Figure 3-2

TCAAP Boundaries and Potential Contaminant Sources

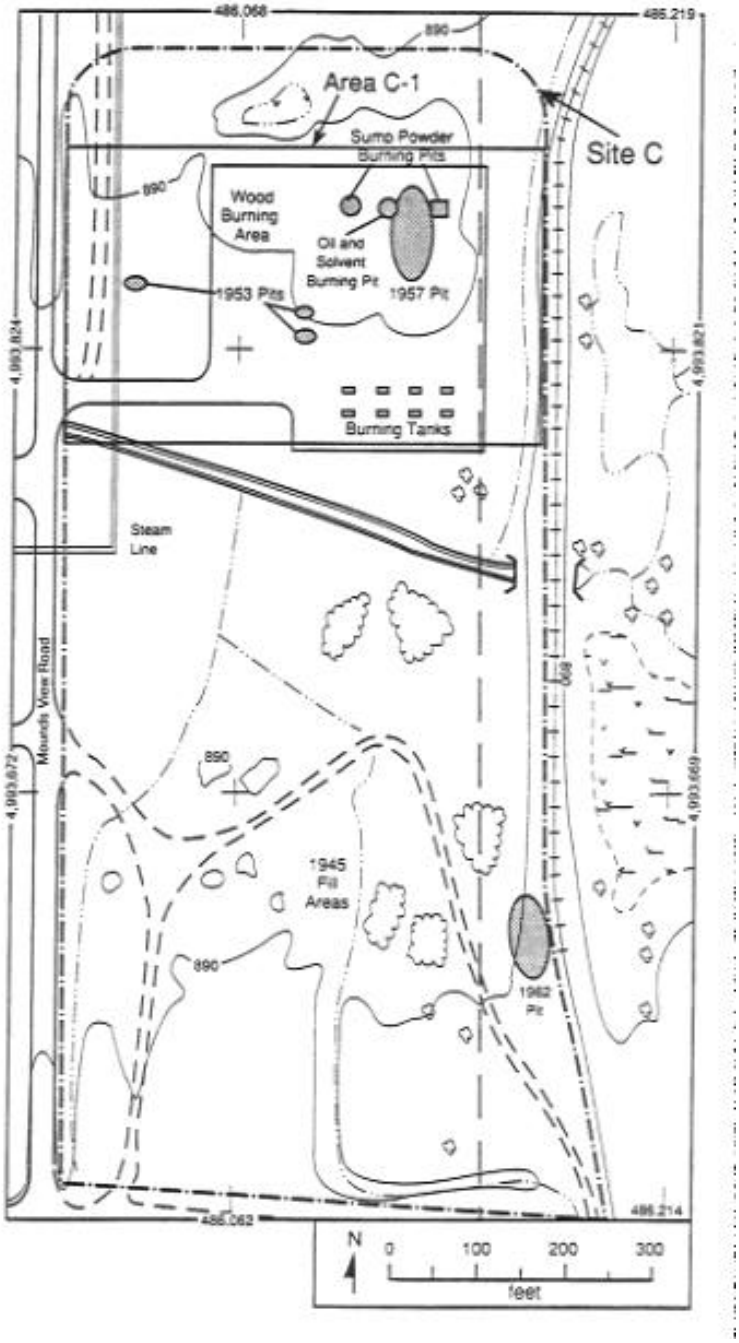

Figure 3-3

Layout of Site C

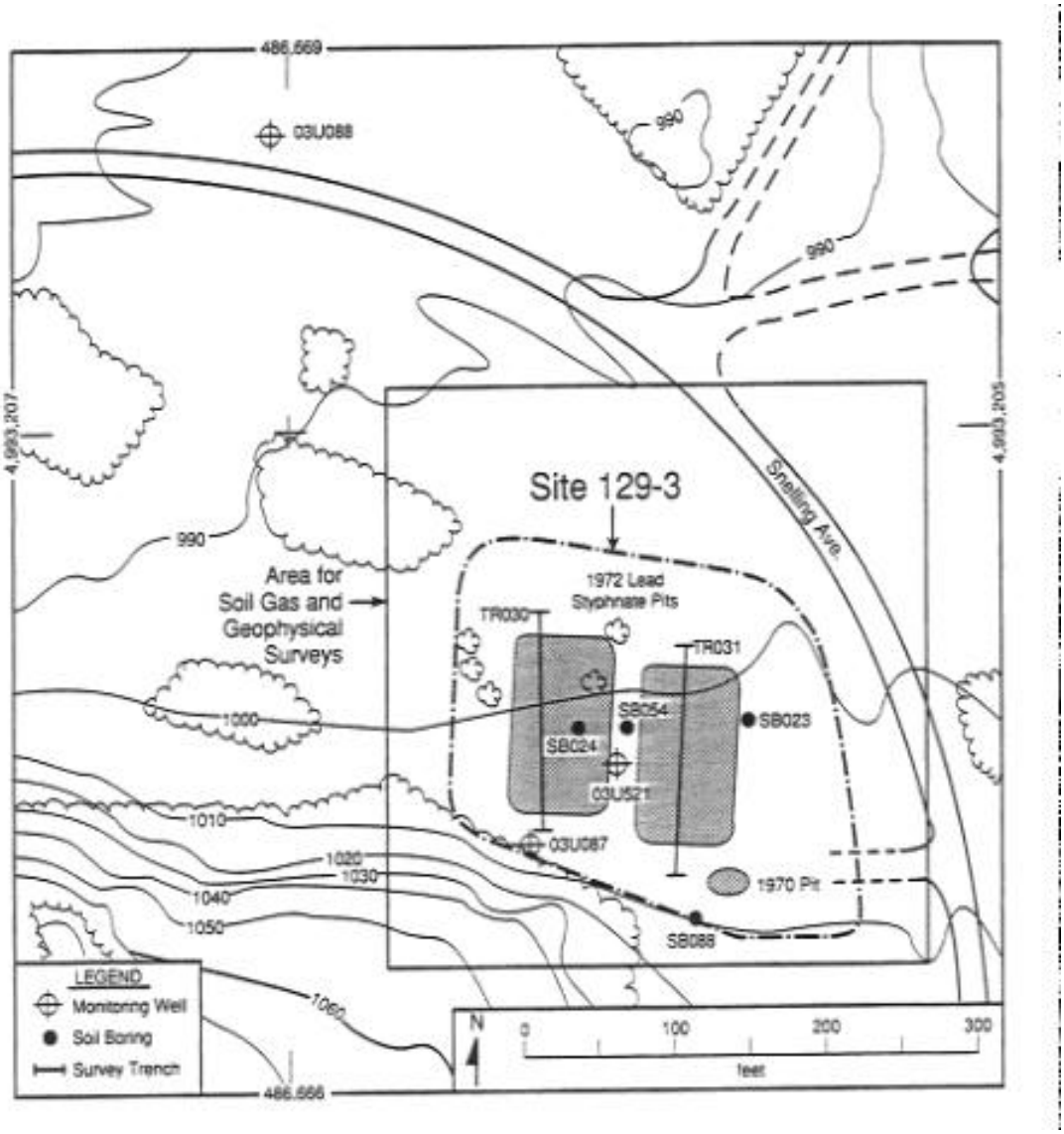

Figure 3-4

Layout of Site 129-3

except for that conducted by companies that occupy facilities on the installation under some form of contractual arrangement with the Army. DoD contractor Alliant Techsystems Inc. is such a tenant that also currently serves as the Installation Support Services contractor. In addition, TCAAP serves as host to the U.S. Army Reserves and the Minnesota National Guard. TCAAP has focused its attention on the mission of environmental cleanup and is implementing its comprehensive environmental cleanup program under CERCLA.

TCAAP's current mission is to retain control of the site until the facility has been remediated to industrial use standards. Ownership of lands is currently retained by the OSC.

TCAAP is participating in the Installation Restoration Program (IRP), a specially funded program developed by DoD in 1978 to identify, investigate, and control the migration of hazardous contaminants on military and other DoD installations.

ATK also operates production facilities on TCAAP property for DoD production contracts. The property was declared excess by OSC in 1992 due to reduction-in-force structure requirements. Remediation efforts are proceeding on the property.

3.1.3.2 Past Operations at TCAAP

TCAAP was established in 1941 as part of the World War II buildup. Employment reached a historic high of near 24,000 during World War II. The installation supported both the Korean and Southeast Asian conflicts. A small-caliber ammunition modernization program was initiated in 1967, with additional prototypes in 1974. Production was completed in 1976.

In 1981, environmental studies indicated that contaminated groundwater from the TCAAP was migrating into the Minneapolis-St. Paul metropolitan groundwater supply. These studies suggested that a number of sites within TCAAP were contributing to groundwater and soil contamination. These sites included: former landfills, impoundments, burning and burial grounds, ammunition testing and disposal sites, industrial operations buildings, and sewer system discharges. The primary groundwater contaminants were volatile organic compounds (VOCs). The primary soil contaminants were ammunition-related heavy metals (copper, lead, and mercury), followed by VOCs and polychlorinated biphenyls (PCBs).

3.1.3.3 Past Operations at Site C

Documentation on materials disposal or other activities at Site C is limited. The site's history has been deduced mainly on a review of aerial photographs. In 1940, Site C consisted of agricultural fields and two farmsteads. From 1947 to 1957, the site was used for burning scrap wood boxes, solvents, oils, corn cobs, and production materials. The site was also used as an open storage site from 1947 to 1982. Typically, the northern portion of Site C, commonly referred to as Site C-1 (Figure 3-3), was used as a burning ground and general waste disposal area. In May 1962, a 60-foot x 20-foot x 30-foot pit was dug in the southeast portion of Site C next to a railroad track (Figure 3-3). This pit, commonly referred to as the 1962 Pit, was used to decontaminate 64 machines from Building 103. These machines, contaminated with explosives, were subjected to open-flamed fires fed with wood and No. 2 fuel oil. The decontaminated machines were later removed and sold as scrap. The phytoremediation demonstration site is located in the approximate area of the 1962 Pit.

3.1.3.4 Past Operations at Site 129-3

Documentation of some of the disposal activities at Site 129-3 is based on aerial photographs. A 1940 aerial photograph indicates that Site 129-3 was once an agricultural field. The photographic evidence suggests the site was vacant from 1945 to 1966. In 1970, aerial photographs indicated that a large rectangular pit had been installed in Site 129-3 and a pipe was extending from the southeast corner of the pit to the adjoining road. By 1972, two rectangular pits appeared (Figure 3-4). Each pit was approximately 65 feet wide x 120 feet long. The pits were separated by about 20 feet. These pits are believed to have contained contaminated wastewater from a lead styphnate production facility constructed in December 1971 during the Southeast Asian conflict.

Production of lead styphnate was carried out in Buildings 138-A, -B, -C, and -D. Contaminated wastewater from the facility was treated with steam at the facility to break down tetracene. Sodium hydroxide was then added to precipitate lead, and aluminum powder was added to neutralize the resulting basic solution. Facility records suggest that after treatment, the wastewater was transported to the lead styphnate leaching pits at Site 129-3. It is believed that wastewaters from primer explosive mixing (Building 328), primer filling (Building 135), and tetracene manufacturing operations (Building 327) were also disposed of in the leaching pits located at Site 129-3.

The material put in the pits was about 90% water and was taken to the pits by sump trucks. Liquids from the trucks were channeled into the leaching pits through pipes in the southeast corner of each pit. An estimated 1,500,000 to 2,000,000 gallons of wastewater were discharged annually into the pits. After discharge, water leached into the ground or evaporated. The pits were also flashed with scrap propellant powder. This flashing may have been done on an irregular basis, especially in winter when several months could pass between flashings because of snow.

Although it has been claimed that the pits were used until 1978, it seems likely that activity ceased in 1976. Activities associated with the Southeast Asian conflict ended at TCAAP in September 1974. A 1977 aerial photograph shows that both pits remained open with no liquid in either pit and with what appeared to be a light-toned residue in the western pit. The pits were eventually sealed, as documented in a letter dated October 25, 1977. According to operating personnel, the pits were filled with sand, capped with clay, and sloped. A 1980 aerial photograph shows that the site had revegetated, but the access road was still visible.

A small circular pit containing light-toned material was also visible in the 1970 photo, but was not evident in the 1972 photo (see 1972 Pit in Figure 3-4). This pit may have been used for the disposal of mercurous nitrate. According to operating personnel, the pit was "filled in", however, no details of this action are available. Spent mercurous nitrate solution, which was used in the quality control (QC) testing of brass cartridge cases, was discharged untreated into the pit. It has been estimated that the solution contained about 10,000 mg/L of mercury. It is not known whether this value represents the total amount of mercury disposed of or the amount

of mercury in solution for each disposal activity. The frequency of disposal between 1970 and 1972 is also unknown.

3.2 Site/Facility Characteristics

3.2.1 Local Climate

The Minneapolis-St. Paul area has a continental climate with wide variations in temperature, ample summer rainfall, and winter precipitation. In general, there exists a tendency toward extremes of almost all climatic aspects.

Regional precipitation data indicate an average total precipitation (both rainfall and snow) rate of 28.6 inches of water per year and an annual snowfall rate of 46 inches of snow per year. The maximum monthly precipitation rate (17.9 inches) was recorded in July 1987. The minimum monthly precipitation rate (a trace) was recorded in December 1943. Temperature data (1966-1996) indicate an annual average temperature of approximately 49.6^{o}F. Monthly highs average 83^{o}F in July with the highest recorded temperature being 105^{o}F. The area experiences an average of 15 +90^{o}F days per year. Monthly lows average 2^{o}F in December with the lowest recorded temperature being -34^{o}F. The area experiences an average of 158 freezing days a year, with 34 of these being below-zero days. Average relative humidity ranges from 68% to 74% year-round. Prevailing winds alternate from May to October in a south and southeasterly direction. From November to April, the prevailing winds are northeasterly.

3.2.2 Regional and Local Geology

3.2.2.1 Geology Beneath Site C

The local geology of the earth beneath Site C consists of bedrock overlain by three thick layers of deposit. The top deposit, generally referred to as Unit 1, primarily consists of fine sand and silt with an occasional clay layer (Figure 3-5). Unit 1 has a thickness ranging from about 10 to 16 feet. This soil is considered a sandy loam under the U.S. Geologic Survey (USGS) soil classification system. Unit 1 was deposited by ancient Lake Fridley during the retreat of the Grantsburg Sublobe ice. Before the lake was completely drained, the site probably became a wetland, resulting in the deposit of a thin layer of organic material and a layer of clayey material near the land surface.

Below Unit 1 is a layer of Twin Cities Till which is commonly referred to as Unit 2. The till is clayey in nature and ranges in thickness from 64 to 120 feet. Unit 2 provides a good hydraulic barrier between Unit 1 and the underlying Unit 3.

Below Unit 2 is Unit 3. These deposits consist of medium to coarse pebble sand (Hillside Sand) and unnamed layers. Unit 3 increases in thickness to the north as the center of an underlying bedrock valley is approached.

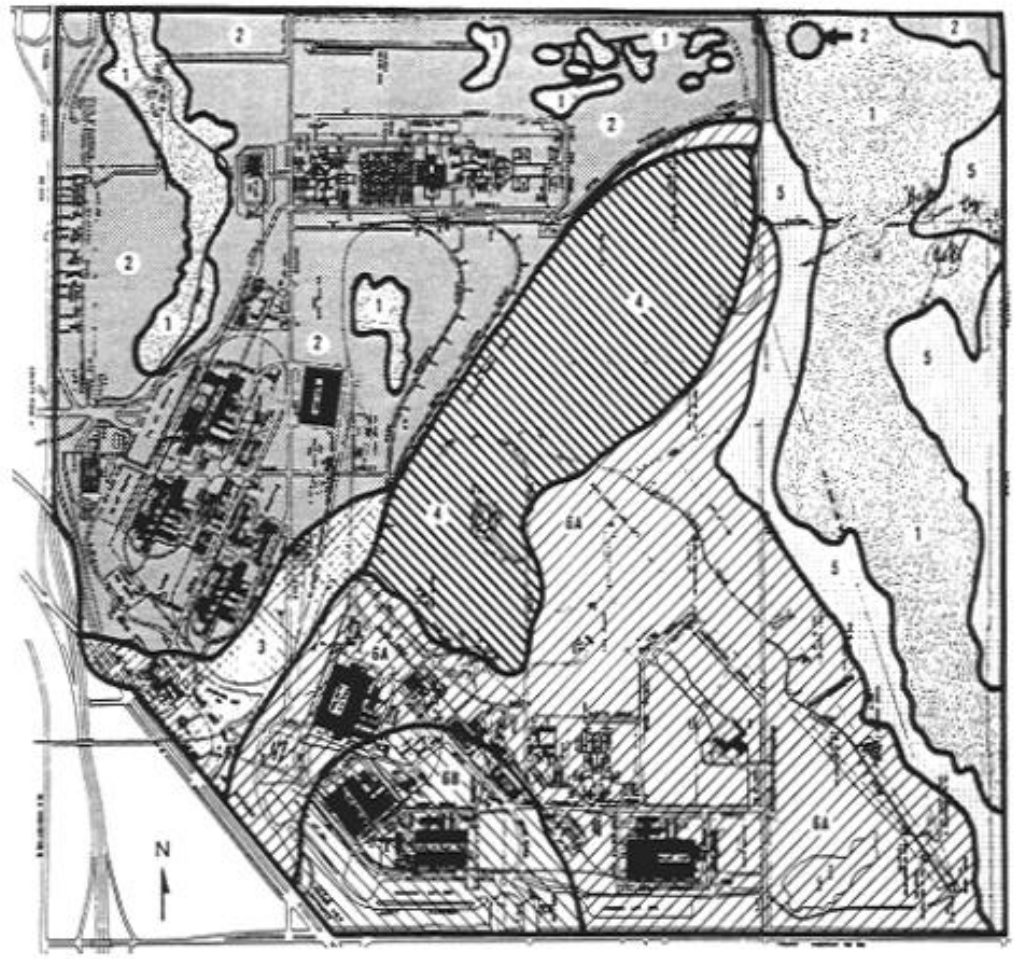

Figure 3-5

Surface Geology at TCAAP

A bedrock valley is located beneath Site C (Figure 3-6). Three kinds of bedrock are exposed under the 246-feet thick deposits above the bedrock. The bedrocks are, from north to south, the St. Lawrence Formation, Jordan Sandstone Formation, and Prairie du Chien Group. Their topographic surface dips to the north.

3.2.2.2 Geology Beneath Site 129-3

The local geology of the earth beneath Site 129-3 consists of bedrock overlain by two layers of glacial deposits consisting of Arsenal and Hillside Sands (Figure 3-5). These deposits are generally referred to as Unit 3. This soil is considered a fine sand under the USGS soil classification system. Site 129-3 itself is located on a mound of stratified drift deposited by glacial meltwater. Such mounds are referred to as kames. At Site 129-3, the kame consists of up to 430 feet of unconsolidated glacial deposits. No distinct lithologic break occurs between the Hillside and Arsenal Sands, so it is difficult to determine the thickness of individual units.

The generally overlying Arsenal Sand is a light gray to brown, well-sorted, fine- to coarse-grained sand. The deposits are probably glacial outwash deposited by both the Superior Lobe and the Grantsburg Sublobe ice. These deposits comprise a kame formed on the terminal margin of the retreating Grantsburg Sublobe ice.

The Hillside Sand is very pale brown to brown, poorly sorted, medium- to coarse-grained, and has some pebbles and cobbles. These deposits are thought to be glacial outwash deposited by both the Superior Lobe and the Grantsburg Sublobe ice.

Unit 3 sand overlies a northwest-southeast trending bedrock valley that runs through the center of TCAAP (Figure 3-6).

3.2.3 Topography

3.2.3.1 Topography of Site C

Site C is located on a lake plane that was once occupied by ancient Lake Fridley. There is a wetland east of the site. The wetland discharges its water into Rice Creek (located to the west of the site) through a drainage channel that transects about one third of Site C from its northern boundary. The site is very flat with a gentle dip toward the drainage ditch from both the south and north.

3.2.3.2 Topography of Site 129-3

No buildings or structures exist on Site 129-3. An access road was in use during the operation of the lead styphnate leaching pits but has revegetated since it was last used in 1976. The surface topography slopes gently to the northwest. Surface elevations range from about 1,055 feet above sea level at the southwest corner to about 994 feet above sea level along the northern boundary.

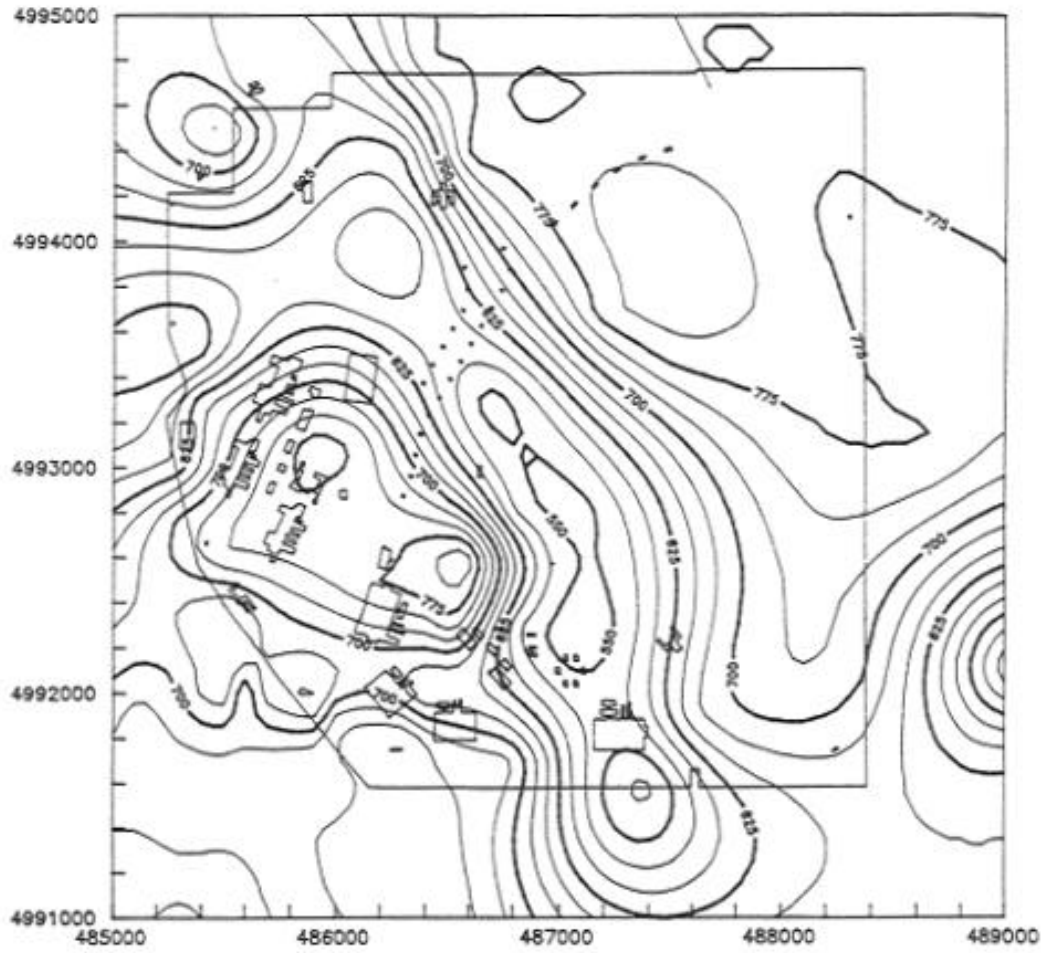

Figure 3-6

Bedrock Surface Topography at TCAAP

3.2.4 Soil Type

3.2.4.1 Soil Type at Site C

Site C is covered by a layer of black decomposed peat, below which are fine sand and sandy clay of lacustrine origin. Oxidation is common in the fine sand and the sandy clay, resulting in molten textures and iron stains for a depth of more than ten feet.

3.2.4.2 Soil Type at Site 129-3

Surface soils on the site consist of brown fine- to medium-grained sand with trace silt and gravel that grade to a light brown fine-grained sand with depth.

3.2.5 Hydrogeology

3.2.5.1 Surface Water

With the exception of drainage basins, no surface waters exist within either Sites C or 129-3.

3.2.5.2 Groundwater

Groundwater Beneath Site C - The aquifers below Site C are located in the Unit 1 and 3 formations. The depth of groundwater in Unit 1 may range from two to ten feet below the ground surface. The soils in Unit 1 consist primarily of decomposed peat overlying layers of fine silt and sandy clay of lacustrine origin with a relatively uniform depth of 12 feet. The soil has a horizontal hydraulic conductivity ranging from 0.007 to 22 feet per day, depending on the presence or absence of higher permeability lenses. If it is assumed that the hydraulic conductivity is as above, the porosity of Unit 1 is 0.3, the hydraulic gradient is 0.002, and the horizontal groundwater flow velocity ranges from 0.017 to 55 feet per year. Unit 1 obtains recharge water from the wetland east of the site. The groundwater flow direction in Unit 1 at Site C is not certain due to limited groundwater level data. However, in the area close to the drainage ditch south of the northern edge of Site C, the groundwater flow is dictated by the presence of the ditch. Water from the south and north is thought to discharge to the ditch. The groundwater in Unit 1 is conservatively estimated to flow in a generally northwesterly direction at a rate of 55 feet per year.

In Site C, the condition of the Unit 1 aquifer suggests a potential for migration of contaminants to the unconfined shallow aquifer. However, from the past data, it appears that contaminant migration in Unit 1 is negligible. The presence of organic peat and clayey soils is thought to have deterred the downward transportation of contaminants in Unit 1. Because organic carbon is an effective absorbent for VOC and clay particles for metals, the migration of VOC and metals is expected to be greatly reduced. This may explain why only slight contamination has been detected at certain wells, despite their close proximity to burning pits.

Unit 2, the Twin Cities Till Formation, ranges from 64- to 120-feet thick and underlies Unit 1. Unit 2 is not an aquifer. The clayey nature of the till restricts, if not completely stops, vertical contaminant migration to Unit 3. The downward movement of groundwater through the Unit 2 formation is estimated to range from 0.82 to 8.2 feet per year assuming:

- The vertical hydraulic conductivity of Unit 2 is the same as the horizontal hydraulic conductivity, i.e., 0.001 to 0.01 foot per day.
- The vertical hydraulic gradient is 0.8.
- The formation porosity is 0.35.

At the location of minimum thickness (64 feet), contaminants would take about eight years to pass through Unit 2. Once in Unit 3, contaminants would generally migrate horizontally toward the southwest. The rate of horizontal groundwater flow in Unit 3 has been estimated to be 333 feet per year.

Groundwater Beneath Site 129-3 - Because only two Unit 3 wells exist at Site 129-3, the local characteristics of the aquifer are not clear. Based on the Unit 3 aquifer levels at Sites D to the south and E to the north, the elevation of the aquifer beneath Site 129-3 is between 850 and 859 feet above sea level. Data specifically listing the aquifer depth at Site 129-3 were not found. Sites D and E encounter the same formation (Unit 3) and are relatively close to Site 129-3 (Figures 3-2 and 3-6). Based on an estimated average groundwater elevation of 855 feet above sea level, the groundwater is expected to be at a depth of 140 to 200 feet below ground level. The estimated average linear groundwater velocity through Unit 3 is expected to be 333 feet/year in the horizontal direction and 833 feet/year in the vertical. Groundwater movement through the underlying bedrock, Unit 4, is also expected. Unit 4 consists of the Prairie du Chien Formation. Horizontal movement of groundwater through Unit 4 is estimated at 1,241 feet/year. Vertical movement is estimated at 621 feet/year. Site 129-3 is approximately 4,400 feet upstream of the TCAAP border. Literature data indicating the direction of groundwater flow from Site 129-3 was not found. Unit 3 groundwater flow from Sites D and E is to the southwest. The direction of groundwater flow in Unit 4 is also to the southwest.

3.2.6 Distribution of Contaminants

3.2.6.1 Distribution of Contaminants in Site C

The contaminants of primary concern at Site C are solvents, oil, grease, explosives, propellants, and metals.

Geophysical and soil gas surveys at Site C-1 consisted of the excavation of three soil trenches in former disposal and burning areas and collection and analysis of numerous soil, surface water, sediment, and groundwater samples from areas within and outside of Site C-1.[Ref. 20] The resulting data indicated that portions of Site C-1 (i.e., the 1957 pits and 1953 pits) had been used for surface burning. Semi-volatile organic compounds, which commonly occur as residues of grease and oil burning, were detected in the soil. In addition, VOCs were detected semi-quantitatively in the soil gas survey. The affected area extended from the center of Site C to its west boundary, with the highest VOC readings detected at a point immediately west of the 1953 burning pits. The vertical extent of soil contamination by VOCs in the area could not be ascertained. Existing data from Site C-1 indicate no contamination by explosives or PCBs.

Analytical data of composite soil samples collected from the 1962 Pit, located in the southeast corner of Site C, indicate a general absence of contamination by VOCs, semi-volatiles, PCBs,

and pesticides.[Ref. 20] However, heavy metals, particularly lead, arsenic, antimony, beryllium, and thallium were encountered (Figure 3-7 and Table 3-1).

Based on the characteristics of local topography and hydrogeology, contaminants at Site C-1 could migrate via surface runoff and groundwater. The surface water and sediment samples collected from the drainage ditch at a downstream point, however, were found to be relatively free of contamination, indicating that contaminants at the site are currently not migrating offsite through surface runoff.

Sampling of Unit 1 aquifer wells at the site indicates slight contamination by organics in well 0lU085, which is located within the burning area. No sign of contamination was detected in wells 0lU045 and 0lU046, which are just off the major burning areas. From the current data, it appears that contaminant migration in the Unit 1 aquifer at Site C-1 is negligible. It is possible that organic contaminants in the former burning and disposal pits are currently being confined at disposal sites because of the clayey soils and decomposed peat that are common at Site C-1.

The potential for contaminant migration to aquifer Units 3 and 4 is probably not significant. The more than 100 feet of clayey soils in Unit 2 have a tendency to restrict downward migration of pollutants. Sporadic detection before 1988 of organics in down-gradient Unit 3 wells (i.e., wells 03U025 and 03UD83) indicates that contamination may originate from other upgradient sources or that Unit 2 has not been totally effective in blocking the downward migration of a few contaminants from Site C. In any event, large-scale migration of contaminants in deeper aquifers under Site C is currently not occurring.

3.2.6.2 Distribution of Contaminants in Site 129-3

The results of the soil investigations at Site 129-3 indicate that VOCs are present in the soil gas of the unsaturated soil layer beneath Site 129-3.[Ref. 20] No VOCs were detected in soil samples collected at depths up to 3 feet, suggesting a deeper VOC source. Because soil moisture content is not known for the soil in this area, it is not possible to predict the partitioning of VOCs between air, water, and soil. Once in groundwater, the VOCs are expected to move at approximately the same velocity as the average linear groundwater velocity, i.e., 333 feet/year in Unit 3 and 1,241 feet/year in Unit 4 (bedrock).

Elevated concentrations of barium, chromium, lead, and antimony have also been found in the soils at Site 129-3 (Figure 3-8 and Table 3-2). Significant metal contamination has not appeared in the groundwater to date. Soil-bearing data indicate that the metals have remained near the surface (upper 10 feet of soil) and apparently have not migrated downward. Because the adsorptive capacity of soil is a function of factors, such as mineralogy, particle size, soil moisture, pH, and conductivity, it is difficult to predict the mobility of metals in the unsaturated soil layer.

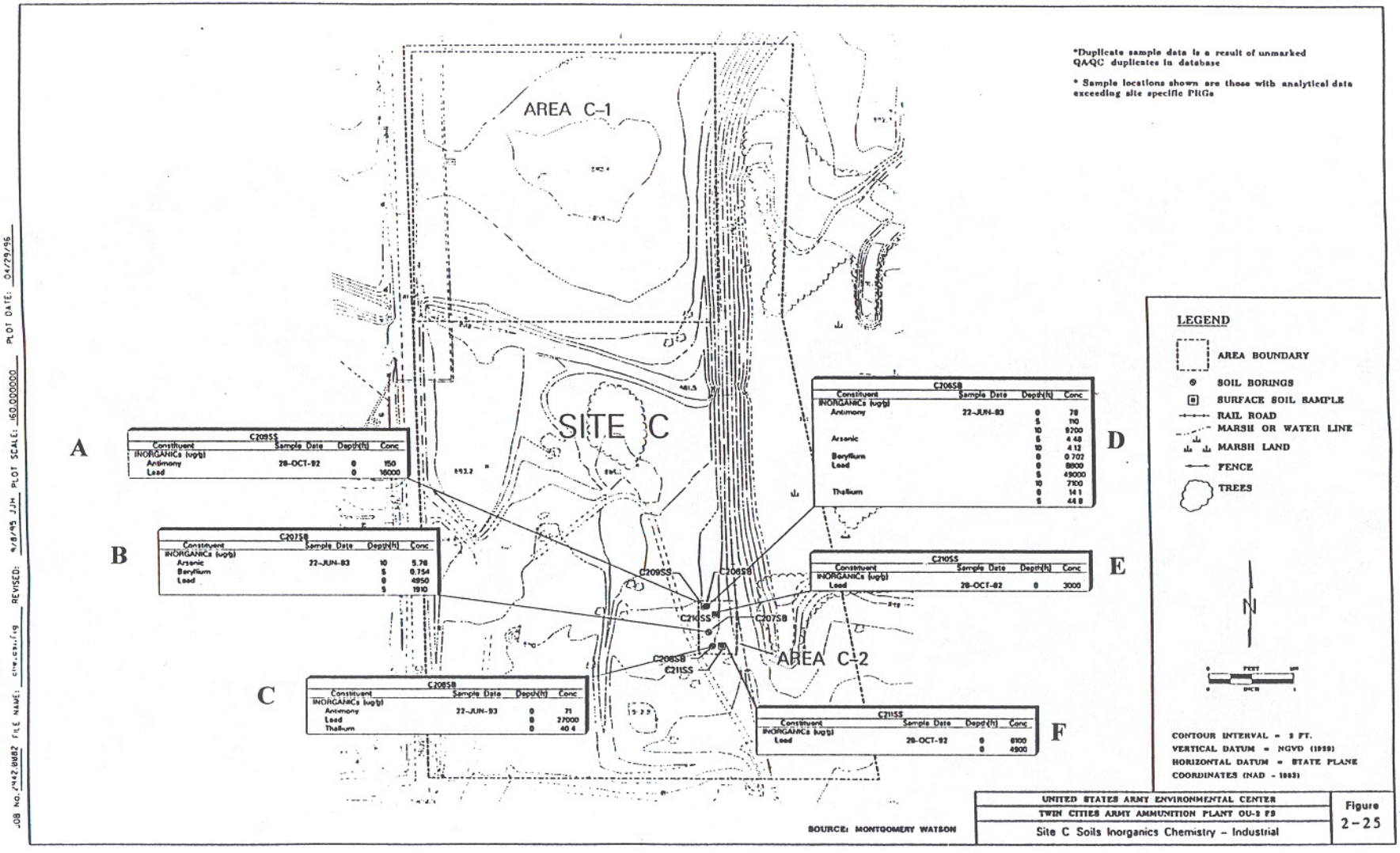

Figure 3-7

Inorganic Contamination at Site C

Table 3-1

Inorganic Contaminants at Site C

Block No.[1]	Depth (ft)	Antimony, mg/kg	Arsenic, mg/kg	Beryllium, mg/kg	Lead, mg/kg	Manganese, mg/kg	Thallium, mg/kg
A	0	150	NA[2]	NA[2]	16,000	NA[2]	NA[2]
B	0	NA[2]	NA	NA	4,950	NA	NA
	5	NA	NA	0.754	1,910	NA	NA
	10	NA	5.76	NA	NA	NA	NA
C	0	71	NA	NA	27,000	NA	40.4
D	0	78	NA	0.702	8,800	NA	14.1
	5	110	4.48	NA	49,000	NA	44.8
	10	9,200	4.12	NA	7,100	NA	NA
E	0	NA	NA	NA	3,000	NA	NA
F	0	NA	NA	NA	6,100	NA	NA
	10	NA	NA	NA	4,900	NA	NA

(1) References block numbers in Figure 3-7.
(2) NA = Not Applicable.

Table 3-2

Inorganic Contaminants at Site 129-3

Block No.[1]	Depth (ft)	Antimony, mg/kg	Lead, mg/kg	Manganese, mg/kg	TCE, mg/kg
A	10	NA[2]	NA[2]	1,100	NA[2]
B	0	40.4	NA	NA	NA
C	3	362	3,700	NA	NA
D	3	NA	NA	NA	120

(1) References block numbers in Figure 3-8.
(2) NA = Not Applicable.

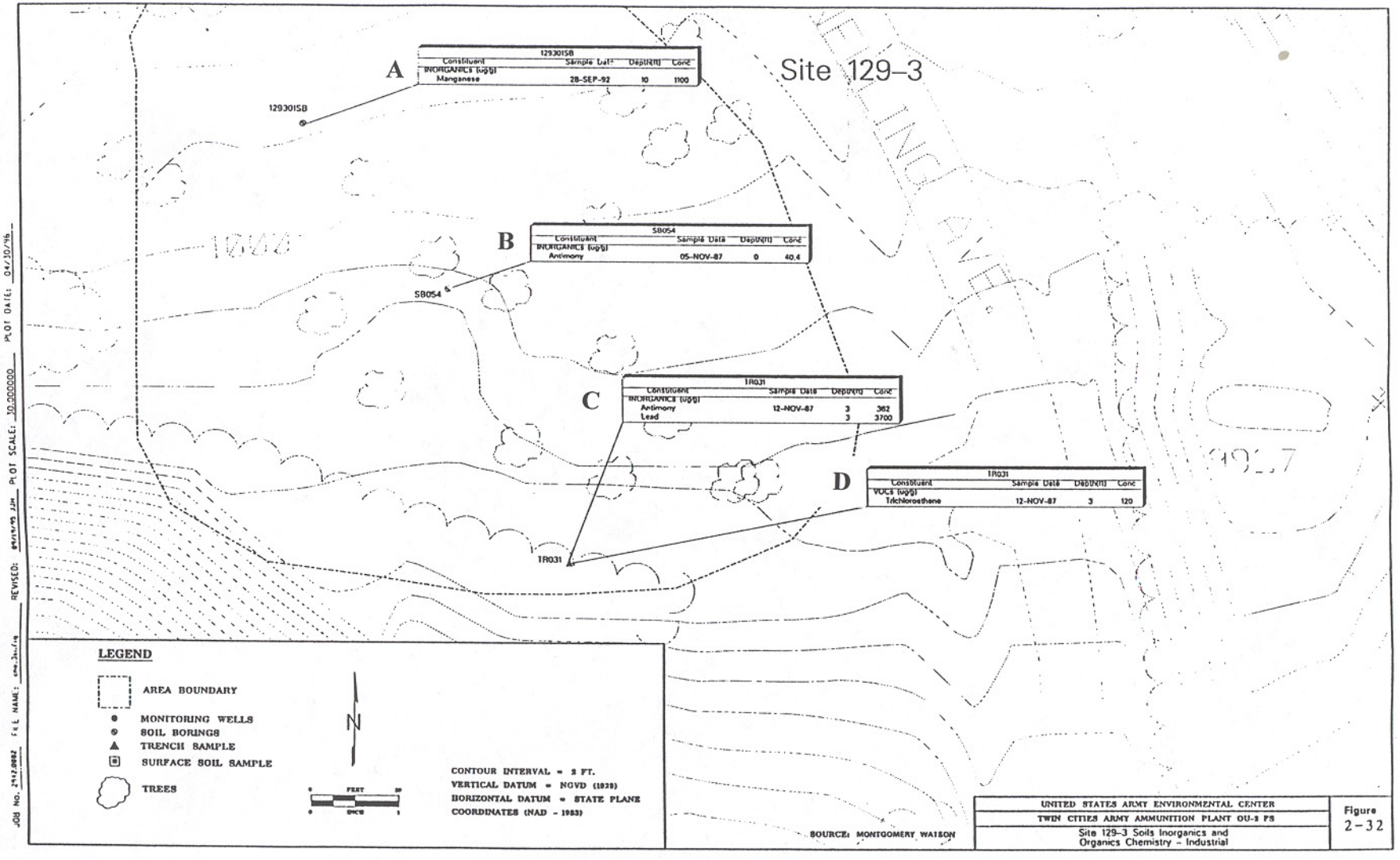

Figure 3-8

Inorganic Contamination at Site 129-3

In general, due to electrical charge imbalances, metal adsorption in soil (particularly clay) prevents metals from moving very quickly through a soil column. Once in groundwater, however, chromium and antimony are estimated to move at a velocity of 5.3 feet/year and lead at a velocity of 0.5 foot/year in the Unit 3 aquifer. In the Unit 4 aquifer, estimated velocities are 5.2 feet/year for chromium and antimony and 0.5 foot/year for lead.

3.3 Information Sources

The technical information presented in this section was obtained from the report "Installation Restoration Program: Remedial Investigation Report for the Twin Cities Army Ammunition Plant (Final Report)," prepared by the U.S. Army Corps of Engineers' Toxic and Hazardous Materials Agency in April 1991.[Ref. 20] Information regarding current operations was updated by ATK.