# FINAL
# RCRA FACILITY INVESTIGATION REPORT
# MAIN MANUFACTURING AREA
# WATERVLIET ARSENAL,
# Watervliet, New York

## VOLUME I

**U.S. Army Corps of Engineers**
**Baltimore, Maryland**

US Army Corps
of Engineers
Baltimore District
DRIVEN BY A VISION...to be the BEST

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# GLOSSARY OF TERMS

| | |
|---|---|
| AMSL | Above Mean Sea Level |
| ARAR | Applicable or Relevant and Appropriate Requirements |
| AST | Above Ground Storage Tank |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act |
| CLP | Contract Laboratory Protocol |
| CRQL | Contact Required Quantitation Limit |
| CMS | Corrective Measures Study |
| DNAPL | Dense Non-Aqueous Phase Liquid |
| gpd/ft | Gallons per day per foot |
| HEAST | Health Effects Assessment Summary Tables |
| HQ | Hazard Quotients |
| HRS | Hazard Ranking Score |
| LBA | Louis Berger & Associates, Inc. |
| LNAPL | Light Non-Aqueous Phase Liquid |
| MCL | Maximum Contaminant Level |
| MMA | Main Manufacturing Area |
| NCP | National Contingency Plan |
| ND | Non-Detect |
| NOAA | National Oceanic and Atmospheric Administration |
| NPL | National Priority List |
| NTU | Nephelometric Turbidity Units |
| NYCRR | New York Codes, Rules and Regulations |
| NYSDEC | New York State Department of Environmental Conservation |
| NYSDOH | New York State Department of Health |
| OSHA | Occupational Safety and Health Administration |
| PID | Photoionization Detector |
| POLs | Petroleum, Oils, and Lubricants |
| REARM | Renovation of Armament Manufacturing |
| RFA | RCRA Facility Assessment |
| RFI | RCRA Facility Investigation |
| RI | Remedial Investigation |
| RQD | Rock Quality Designation |
| SA | Siberia Area |
| SPDES | State Pollution Discharge Elimination System |
| SPLP | Synthetic Precipitation Leaching Procedure |
| SWMU | Solid Waste Management Unit |
| TAGM | Technical Administrative Guidance Memorandum |
| USACE | United States Army Corps of Engineers |
| USAIOC | United States Army Industrial Operations Command |

# GLOSSARY OF TERMS

| | |
|---|---|
| USATHAMA | United States Army Toxic and Hazardous Materials Agency |
| USEPA | United States Environmental Protection Agency |
| UST | Underground Storage Tank |
| VOC | Volatile Organic Compound |
| WAM | Work Assignment Manager |
| WVA | Watervliet Arsenal |

# CHEMICAL GLOSSARY OF TERMS

| | |
|---|---|
| 1,1,1-TCA | 1,1,1-Trichloroethane |
| 1,1,2,2-PCA | 1,1,2,2-Tetrachloroethane |
| 1,1-DCA | 1,1-Dichloroethane |
| 1,2-DCE | 1,2-Dichloroethene |
| 1,4-DCB | 1,4-Dichlorobenzene |
| BETX | Benzene, Ethylbenzene, Toluene and Xylenes |
| DDD | 1,1-Dichloro-2,2-bis(p-chlorophenyl) ethane |
| DDE | Dichlorodiphenyldichloroethylene |
| DDT | Dichlorodiphenyltrichloroethane |
| PAH | Polyaromatic Hydrocarbons |
| PCB | Polychlorinated Biphenols |
| PCE | Tetrachloroethene |
| SVOC | Semi-Volatile Organic |
| TAL | Target Analyte List |
| TCA | Trichloroethane |
| TCE | Trichloroethene |
| TCL | Target Compound List |
| TOC | Total Organic Carbon |
| TOX | Total Organic Halogens |
| TPAH | Total Polyaromatic Hydrocarbons |
| VC | Vinyl chloride |

| | |
|---|---|
| ND | compound not detected |
| NI | not installed |
| NS | not sampled |
| B | compound also found in lab blank |
| E | estimated value |
| J | estimated value, present below CRQL, but above IDL |
| R | analysis failed EPA QA/QC |
| N | presumptive evidence |

# EXECUTIVE SUMMARY

This report summarizes the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI), conducted by Malcolm Pirnie and Louis Berger & Associates, Inc., (LBA) at the Main Manufacturing Area Watervliet Arsenal (WVA), Watervliet, New York. The RFI was performed under Contract DACA31-94-D-0017 with the U.S. Army Corps of Engineers (USACE), Baltimore District in accordance with an Administrative Order on Consent, Docket No. II RCRA-3008(h)-93-0210, between WVA, the New York State Department of Environmental Conservation (NYSDEC) and the Region II U.S. Environmental Protection Agency (USEPA). The Order on Consent requires the investigation of 27 named and additional unnamed Solid Waste Management Units (SWMUs) at the Watervliet Arsenal. The purpose of this report is to compile existing site information and hydrogeologic and chemical data that has been gathered from individual site RFIs and RFAs conducted concurrently at Buildings 25, 35, 36 and 135, the Arsenalwide Hydrogeologic Investigation, Manhole 43 Investigation, and the SWMUs 7-14 Investigation, as part of these investigations all the SWMUs in the Main Manufacturing Area were investigated. This approach has resulted in a report which provides a better overall picture of the site-wide hydrogeology and contamination distribution. The WVA, NYSDEC, and USEPA will use the results of the report to assess the need for interim corrective measures (ICM) and/or a corrective measures study (CMS).

The WVA is a 140-acre government-owned installation under the command of the U.S. Army Industrial Operations Command (USAIOC). The WVA is located in the City of Watervliet, New York, which is west of the Hudson River, and five miles north of the City of Albany. The WVA consists of two primary areas: the Main Manufacturing Area, where manufacturing and administrative operations occur, and the Siberia Area, which is primarily used for the storage of raw and hazardous materials, finished goods, and supplies brought from the Main Manufacturing Area.

Activities conducted at the WVA include the manufacture of tubes and tube assemblies for cannons, cannon components, mortars, and recoilless rifles. The primary hazardous wastes generated at the WVA are acid and cyanide wastes from plating operations. Additional hazardous wastes generated from site operations include non-halogenated spent solvents, asbestos, mercury containing wastes, small quantities of soluble oils, pesticides, cleaning solutions, and laboratory waste such as sulfuric and phosphoric acid. Petroleum, oil, and lubricants (POLs) have been and are currently used in machining operations.

Several environmental studies have been conducted in the Main Manufacturing Area of WVA. Detailed information concerning investigations of contamination at the WVA prior to 1980 are not readily available. The following is a list of the previous major investigations completed at the site:

# U.S. Army Toxic and Hazardous Materials Agency, 1980
# William Cosulich Associates, P.C., 1980
# Department of the Army, 1983
# Dames & Moore, 1983
# Empire-Thomsen, 1986
# Groundwater Technology, Inc Report, 1987
# Environmental Science and Engineering, 1987
# C.T. Male Associates (CTM) Report, 1990
# Clough, Harbour and Associates, 1991

The Main Manufacturing Area investigation was conducted during the period of March 1995 through June 1998. Malcolm Pirnie and LBA performed the following tasks in order to assess the nature and extent of contamination at the Main Manufacturing Area:

# Site reconnaissance and document search
# Surface soil sampling and analysis
# Soil Gas survey
# Soil boring sampling and analysis
# Monitoring well installation
# Groundwater sampling and analysis
# Process pit sampling and analysis
# Hydraulic conductivity testing

- Borehole geophysical survey

The results of the hydrogeologic characterization conducted at the Main Manufacturing Area show that a groundwater divide exists in the area of Building 135 which is coincident with a bedrock ridge. Groundwater flows from the divide (bedrock ridge) in the area of Building 135, east towards the Hudson River, which is to the east of WVA, and to the west, towards the Siberia Area. Hydrogeologic flow sections constructed for the Main Manufacturing Area indicate that a intermediate flow system exists across the site, with groundwater being recharged at the bedrock ridge and flowing along intermediate flow paths to the discharge area at the eastern site boundary which is in close proximity to the Hudson River. A deeper flow system is also believed to exist within a lower permeable unit across the site where recharge rates into the monitoring wells is extremely low. However, the whole hydrogeologic system at the site is unconfined and acts as one system with varying hydraulic properties. The results of the site hydrogeologic characterization also shows that the groundwater table is within the competent bedrock in the western portions of the site and as you move eastward the water table is present within the weathered bedrock and then the overburden. Direct recharge of groundwater to the bedrock is occurring in the western portions of the site, and it is probable that this recharge is potentially Adriving≅ contaminants along deeper flow paths, where matrix diffusion limits the migration of the contaminants to areas relatively close to the source areas.

In the area of Building 25, a soil gas survey was conducted to aid in the delineation of the volatile organic contamination. The results of the soil gas survey did not indicate any significant source of volatile organics in the soil within the area surrounding Building 25. However, the soil gas survey did indicate the presence of volatile organics in the area north of Building 25, near Building 20. These volatile organics are not believed to be associated with activities or release from Building 25. As a result a monitoring well was located in the proximity of the former vapor degreaser at Building 20.

The results of the Building 25 monitoring well groundwater sampling indicate that volatile organic contamination is generally limited to the area surrounding Building 25. However, monitoring wells upgradient of Building 25 also exhibit elevated concentrations of volatile organics, which indicate the presence of additional sources such as Building 110 or other vapor degreasers. This is also indicated by the presence of high concentrations of volatile organics in the bedrock at the eastern site boundary. The presence of volatile organics only in the bedrock at the site boundary suggests that migration of volatile organics is occurring within the bedrock from an upgradient source area. However, additional groundwater monitoring well installations have not confirmed the presence of an upgradient source to this contamination. The interpretation of the chemical data is also complicated by the presence of interconnected bedrock fractures, the downward vertical gradients and matrix diffusion of the contaminants into the bedrock pore space water. Based on the available information gathered during the multiple phases of the it is believed that there are numerous sources areas of chlorinated organic contamination. The groundwater plumes emanating from these sources have undergone transformation and have been limited in there migration by such mechanism as matrix diffusion, etc. The results of the groundwater sampling also indicate that semi-volatile organics, pesticides, and inorganics are not of concern for the Main Manufacturing Area. However, in several areas of the Main Manufacturing Area free-phase POLs have been identified on the groundwater table and within the bedrock fractures (Building 35-MW-8). In the area of Building 35 POLs were detected in bedrock fractures at depth below the water table, indicating that the source for the POLs in this area could be in the groundwater recharge area of the Main Manufacturing Area, which is also co-incident with a large spill of POLs. However, POLs were also detected at the water table inside Building 35, at P3, which is believed to from a near by machine based n the visible characteristics of the POL. This would indicate that other sources may exist inside Building 35, which are not related to the recharge area. When free-phase POLs are detected in a monitoring well there is either no detection of semi-volatile organic compounds or semi-volatile organics are detected at very low concentrations in the dissolved phase. Therefore, the POLs detected are not very soluble and do not act as source of dissolved phase POL contamination. Based on the results of water level measurements and analytical data the primary source of the POLs appears to be upgradient of Building 35, and is believed to be associated with previous spills in the area of the bedrock ridge/recharge area. Additional sources of POLs are believed to be leaks from machining equipment foundations within several of the Main Manufacturing Area buildings (i.e., Building 35, 110 and 135).

Soil sampling analytical data indicates that soils in the Main Manufacturing Area have not been contaminated by volatile organics or pesticides above regulatory guidelines. However, semi-volatile and selected inorganics have been detected above NYSDEC Technical Administrative Guidance Memorandum (TAGM) values in several areas of the Main Manufacturing Area. Semi-volatile organics, in particular poly-aromatic hydrocarbons (PAHs), are wide spread throughout the site within the fill materials, especially the former Erie Canal. The inorganics identified as being of concern are arsenic, chromium, and lead, in select areas of the site. The primary area for the occurrence of chromium is the eastern portion of the Main Manufacturing Area. The maximum chromium concentrations detected are in the area of the chromium sludge spill which occurred in the area of Building 36. Other exceedances are noted along chromic acid waste lines and in the former chip handling areas. The arsenic exceedances do not appear to be related to a source other than the fill materials used across the site. The highest concentration of lead at the Main Manufacturing Area was detected in the fill materials in the former Erie Canal, located to the east of Building 25. The source of this elevated lead concentration is believed to be the fill materials used to backfill the canal.

Based on the analytical and hydrogeologic data, the process pits within Buildings 35 and 135 are not believed to be sources of groundwater contamination, but appear to be collection points for POLs and other contaminants that may be in the groundwater within the area of influence of the pumping of sumps located at these locations.

The following recommendations are made based on the analytical results obtained during this investigation and previous investigations:

- The following SWMUs will be considered for Ano further action≅, based on the hydrogeologic and analytical data, SWMU #4 (Demolished Cyanide Treatment Facility), SWMUs #7-#14 (Waste Oil USTs), SWMUs #15-#17 (Waste Oil USTs), SWMU #21 (Incinerator), SWMU #26 (Building 35 Process Pits), and #27 (Building 135 Process Pit).

# A Corrective Measures Study should be conducted to evaluate corrective measures for the soil and groundwater contamination detected in the Main Manufacturing Area.

# A receptor analysis should be implemented upon completion of the additional sampling recommended above.

# 1.0 INTRODUCTION

Malcolm Pirnie, Inc. (Malcolm Pirnie) and its subcontractor, Louis Berger & Associates, Inc. (LBA), have been retained by the Baltimore District of the US Army Corps of Engineers (USACE) to perform various site investigations at the Watervliet Arsenal (WVA) in Watervliet, NY. A United States Environmental Protection Agency (USEPA) Administrative Order on Consent (Docket No. II RCRA-3008(h)-93-0210) requires the investigation of 17 site Solid Waste Management Units (SWMUs) at the Watervliet Arsenal. The purpose of this report is to tie together existing site information and data that has been gathered from the site RFIs and RFAs conducted concurrently at Buildings 25, 35, 36 and 135, the Arsenal-wide Hydrogeologic Investigation, Manhole 43 Investigation, and the SWMUs 7-14 Investigation. This approach has resulted in a report which provides a better overall picture of the site-wide hydrogeology and contamination distribution, including:

# A better definition of the site-wide stratigraphy, rather than the local hydrogeology around individual SWMUs.

# A better definition of the nature, and horizontal and vertical extent of contamination in site soils and groundwater across the arsenal as a whole, rather than at individual SWMUs.

# A better definition of groundwater flow at the arsenal and migration pathways between SWMUs.

Figure 1-1 identifies each of the SWMUs and illustrates the process by which each of the individual SWMUs was investigated and how the results of the investigations will be reported for each SWMU. This compilation of information, presented here as the Main Manufacturing Area RFI, will be used to determine the need for additional investigative or corrective measures.

## 1.1 PURPOSE OF REPORT

The purpose of this RFI report is to present the nature and extent of any release(s) of hazardous constituents resulting from activities in and around the Main Manufacturing Area, including the previously designated SWMUs and Buildings 25, 35, and 135. WVA, NYSDEC, and USEPA will rely on the results of this report to assess the need for further investigation (RFIs) at the Main Manufacturing Area and to assess the need for interim corrective measures (ICMS) and/or a corrective measures study (CMS) at Buildings 25, 35 and 135.

## 1.2 SITE BACKGROUND - MAIN MANUFACTURING AREA

### 1.2.1 Site History

The WVA is a 140-acre government-owned installation under the command of the U.S. Army Industrial Operations Command (USAIOC). The WVA is located in the City of Watervliet, New York, which is west of the Hudson River, and five miles north of the City of Albany, as shown on Figure 1-2. The WVA consists of two primary areas: the Main Manufacturing Area, where manufacturing and administrative operations occur, and the Siberia Area, which is primarily used for the storage of raw and hazardous materials, finished goods, and supplies brought from the Main Manufacturing Area. These areas are shown on Figure 1-3. Buildings 25, 35, and 135 are located in the Main Manufacturing Area.

The WVA is a national registered historic landmark which was established in 1813 with the purchase of 12 acres of land by the U.S. War Department. It's original purpose was to distribute supplies (i.e., ammunition, harnesses, and gun cartridges) to troops along the northern and western frontiers. Over the years, the main function of the WVA changed from the production of small arms ammunition, cannon cartridges, and leather goods, to the production of the nation's first 16-inch gun. The WVA also played a major role in the research and development of cannons, mortars, and recoilless rifles. From 1950 to 1970, the WVA built anti-aircraft weapons, the 90 mm gun for the medium tank, the 152 mm gun launcher, the lightweight 60 mm mortar, and a new 8-inch gun/howitzer for use in the Korean and Vietnam Wars. Currently, the WVA is responsible for the manufacture of cannons the research and development at WVA is conducted by Benet Laboratories, a tenant organization located at WVA.

### 1.2.2 Site Location

# The Main Manufacturing Area of the WVA encompasses approximately 125 acres in the City of Watervliet (Figure 1-3). To the east of WVA, Broadway Street (Route 32) and a six-lane interstate highway (I-787) separate the WVA from the Hudson River. Residential/light commercial properties are located along the northern and southern site boundaries. To the west of the Main Manufacturing Area are residential properties, Perfection Plating, which formerly manufactured metal plates for brake pads and is currently under remediation by the NYSDEC, the Siberia Area of WVA, which extends into the Town of Colonie, Shaker Tire Sales, and lands owned by the Town of Colonie, formerly owned by the Delaware and Hudson Railroad.

### 1.2.3 Summaries of Past Permits

Six outfalls (Figure 1-4) in the Main Manufacturing Area are regulated pursuant to NYSDEC State Pollution Discharge Elimination System (SPDES) permits. In addition to continuous flow measurements, parameters specific to activities affecting influent at each local sewer network are also measured:

# Effluent from the wastewater treatment plant flows through Outfall 002. This effluent is monitored for a wide range of metals as well as total suspended solids, oil and grease, phosphorous and pH, glycols.

# In the vault near the Outfall 003, the effluent from Outfall 002 is mixed with cooling water and storm water runoff before being discharged to the Hudson River through Outfall 003. The effluent from Outfall 003 is monitored for oil and grease, total suspended solids, temperature and pH.

# Cooling water and storm runoff from Building 135 is discharged through Outfall 004. This effluent is monitored for iron, total suspended solids, oil and grease, temperature, and pH.

- Outfall 005A collects effluent from the groundwater treatment operation at RW-2 and transports it via the storm sewer to Outfall 005 in the Siberia Area. The effluent from Outfall 005A is monitored for parameters normally associated with petroleum products (benzene, dichlorobenzene, ethylbenzene, napthalene, toluene, and xylene)., oil and grease, and pH. At Outfall 005 in the Siberia Area, during dry weather, the discharge from the site is directed to the City of Watervliet combined sewer system which discharges to the Albany County Treatment Plant. If the flow in the combined system is in excess of approximately 2.5 times the average dry weather flow, runoff is discharged to the Hudson River rather than the treatment plant.

- Outfall 006 conveys storm runoff from the western portion of the site which is transported off-site and eventually discharged to the Kromma Kill, a tributary to the Hudson River. Effluent from Outfall 006 is monitored for oil and grease and total suspended solids.

- Surface water in the parking lot south of the sludge beds near the wastewater treatment plant is discharged to the Hudson River through Outfall 009.

### 1.2.4 General Summary of Waste Types

Activities conducted at the WVA include the manufacture of tubes and tube assemblies for cannons, cannon components, mortars, and recoilless rifles. The primary hazardous wastes generated at the WVA are acid and cyanide wastes from plating operations. Additional hazardous wastes generated from site operations include non-halogenated spent solvents, asbestos, mercury containing wastes, small quantities of soluble oils, pesticides, cleaning solutions, and laboratory waste such as sulfuric and phosphoric acid. Petroleum, oil, and lubricants (POLs) have been and are currently used in machining operations. There are eleven underground storage tanks (USTs) which store waste oil. Chlorinated solvents were used prior to 1982 in vapor degreasing operations. WVA generates several hundred tons of scrap metals per year, most of which is in chip form and contaminated with oil. During the 1950's and 1960's the chips were stored on the ground in the area south of Building 132. Also, it was a common practice in the past to spray a mixture of oil and solvents for dust control. This practice may be responsible for some of the petroleum, oil and grease (POL) contamination in the Main Manufacturing Area. Small quantities of silver from photo-manufacturing operations have been disposed of in the sanitary sewer system with the authorization of the local sewer district.

### 1.2.5 Summary of General Main Manufacturing Area Investigations

Several environmental studies have been conducted in the Main Manufacturing Area of WVA. Descriptions of detailed investigations at specific SWMU locations are provided in Section 1.2.6. Descriptions of general investigations are provided below. Detailed information concerning investigations of contamination at the WVA prior to the 1980 is not readily available.

#### U.S. Army Toxic and Hazardous Materials Agency - 1980

The U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) prepared a report titled AInstallation Assessment of Watervliet Arsenal≅, dated May 1980. Subsequent to inclusion in the U.S. Army Installation Restoration Program, USATHAMA initiated an installation assessment of the WVA. The purpose of this assessment was to determine the overall environmental quality of the facility.

This USATHAMA report lists the operations conducted in each building at WVA. Operations listed for buildings located in the Main Manufacturing Area include lead plating, machining, alkali cleaning, stress relieving, asbestos gasket manufacturing, and magnaflux testing.

The USATHAMA report states that the pesticides which are known to be used at WVA include sevin, chlordane, baygon, and malathion (it is noted that the use of DDT was discontinued at WVA in 1977). The report also notes that WVA was issued a NPDES permit (Permit No. 0023361) in March 1975.

#### William F. Cosulich Associates, P.C. Report - 1980

William F. Cosulich Associates, P.C. submitted a report to the New York District of the ACOE entitled Oil Pollution Source Elimination Study, dated January 1980. The study was initiated in November 1978 due to the presence of oil in the WVA storm water drainage system. The report identifies a number of oil spills and conditions at the WVA which have contributed to the presence of oil in the storm water discharge.

Oil contamination observed at the fuel storage area (Building 136) was suspected to have occurred during filling of the No. 6 fuel oil USTs. The investigation indicated that the oil contamination was limited to the fill area.

Department of the Army - 1983

Watervliet Arsenal prepared a report entitled Identification and Decontamination of Hydraulic Systems Containing PCBs at Watervliet Arsenal, dated June 1983. This report details a sampling program of all hydraulic oil-containing machines and equipment throughout WVA. During the period of September 1982 and June 1983 over 2,800 samples were collected and analyzed for PCBs. Results indicated that less than one percent of the machines tested were contaminated (i.e., contained greater than 50 mg/l) with PCBs. This accounted for 27 machines, of which 16 were active at that time. These machines were drained, filled, cycled, and retested, this process was continued until the hydraulic oil was below 50 mg/l of PCBs.

Groundwater Technology, Inc Report - 1987

Groundwater Technology, Inc. prepared a report titled AGround Water Monitoring Well Installation, Building 136, Boiler House Fuel Oil Containment Area≅, dated November 1987. In this report they describe the installation and sampling of four monitoring wells around the fuel oil containment area near Building 136. The four wells installed are identified as 87GTI-MW-1BP through 87GTI-MW-4BP on the potentiometric contour map (Plate 1-1). The drilling logs for those four wells (Appendix A) indicate that the stratigraphy around the fuel oil containment area consists of approximately 2 feet of fill, underlain by weathered shale grading into competent shale bedrock. In their report, Groundwater Technology, Inc. concluded that there was no indication of a barrier to the vertical movement of groundwater from the fill to the bedrock. Groundwater samples from these wells were analyzed for petroleum constituents but all analyzed parameters were below detection limits for the samples collected. These wells continue to be sampled on an annual basis and the results are reported to the NYSDEC.

Environmental Science and Engineering, Inc. - 1987

Environmental Science and Engineering, Inc. prepared a report titled AUpdate of the Initial Installation Assessment of Watervliet Arsenal≅, dated July 1987. This report incorporates the findings of the Initial Installation Assessment (1980) regarding conditions throughout WVA and the Cosulich report (1980) regarding conditions at areas impacted by activities at Building 25 (Figure 1-3).

A portion of this report presents results from an oil spill at Building 147 (Plate 1-2). An oil release reportedly occurred from underground piping connecting the aboveground fuel oil tank (Structure 147) to the boiler house (Building 136). The old lines were replaced with aboveground lines, contaminated soils were removed and monitoring wells were installed adjacent to Building 136.

Disposal practices for combustible waste oil were investigated. In 1985 the combustible waste oil was analyzed by WVA and found to contain a chloride content too high for acceptance by waste oil handlers. Sale to outside contractors was terminated at this time.

## 1.3 SUMMARY OF SOLID WASTE MANAGEMENT UNITS (SWMUs)

Twenty-four Solid Waste Management Units (SWMUs) have been identified in the Main Manufacturing Area. The approximate locations of the SWMUs are shown on Plate 1-2. The following is a summary of the SWMUs identified in the Main Manufacturing Area, with the addition of SWMU #7, an underground storage tank (UST) which is located in the Siberia Area and was included as part of the SWMU 7 through 14 Investigation.

### 1.3.1 Surface Impoundment and Sludge Drying Beds (SWMU #1)

#### 1.3.1.1 Site Location

Five sludge drying beds (Structure 39) are located in the area of the wastewater treatment plant (Building 36), which was built in 1970 (Plate 1-2). The chromium hydroxide sludges, in these surface impoundments, have been successfully delisted to RCRA nonhazardous wastes.

#### 1.3.1.2 Waste Types

The sludge drying beds are used to dewater sludge containing chromium, lead, cadmium, and oily material. After dewatering, the sludge is shipped off-site for disposal (non-hazardous). In 1975, a synthetic liner was installed in one of the beds and it was converted to an emergency holding tank for the storage of liquid waste from metal, non-cyanide, plating operations (predominantly chromium).

#### 1.3.1.3 Summary of Previous Investigations

This bed was determined to be a surface impoundment and was formerly closed in 1987 and accepted as a clean closure by the NYSDEC in 1994.

Watervliet Arsenal - 1996

In January 1996, an underground transfer line from the indoor clarifiers to the outside sludge drying beds broke. The break occurred during the replacement of the underground waste soluble oil collection tank. A seep was detected on the eastern wall of the treatment plant and was sampled by WVA. The results of the analysis indicated the presence of chromium. Subsequently, WVA collected soil samples two feet east of the break in the line at approximately six inches and 12 inches below grade. The sample collected at six inches depth contained 28 mg/kg of chromium and the sample collected from 12 inches depth contained 318 mg/kg of chromium.

### 1.3.2 Demolished Cyanide Treatment Facility (SWMU #4)

#### 1.3.2.1 Site Location

The Cyanide Treatment Facility, formerly located in Building 110A, was constructed in 1969 and put on-line in 1978 (Plate 1-2).

#### 1.3.2.2 Waste Types

All treatment tanks and waste transfer lines were above ground and there are no known releases.

#### 1.3.2.3 Summary of Previous Investigations

In 1982, the cyanide treatment operations were relocated to the wastewater treatment plant and the cyanide treatment facility was demolished. All of the building materials and cyanide treatment units were shipped to a hazardous waste disposal facility.

### 1.3.3 Building 25 (SWMU # 5)

#### 1.3.3.1 Site Location

Building 25, also known as the Minor Components Building, is located in the southeast corner of the Main Manufacturing Area of WVA (Plate 1-2). As shown on Plate 1-2, it is bordered on the south by residential properties, on the east by the former Erie Canal and the wastewater treatment plant, and on the west and north by other WVA buildings. The area around the building is currently paved, however, the area to the south and east of the building was not paved until the 1960s/1970s. Adjacent to the eastern wall of the building is a parking lot. There is a second, lower parking lot east of this lot, separated by a paved slope. East of the lower parking lot is a road which, along with a portion of the lower parking lot, overlies the former Erie Canal. East of the former canal is the wastewater treatment plant.

Building 25 was built in 1918, with additions in 1942. This three-story building is approximately 300-feet long and 200-feet wide. Small metal components are manufactured on the lower floors of this building. These components are then attached to either gun tubes or barrels. Manufacturing equipment includes lathes, milling machines, grinders, drills, etc. Administrative offices, connected to the manufacturing operations, occupy the third floor. Until 1982, the building housed a self-contained vapor degreaser unit, thought to be located along the eastern wall in the southeast quadrant of the building, according to personal communications with WVA personnel (Figure 1-5).

Building 25 is concrete and the manufacturing floor (first floor) is concrete with walkways composed of wood inlays. There are no floor drains in the manufacturing area; floor drains are, however, still operating in the bathrooms. There are shallow, approximately one inch, recessed areas beneath several machines used to collect tramp oil (a mixture of machine and cutting oils). A waste oil underground storage tank (UST) is located on the northeast side of the building.

Building 25 has an extensive network of underground utilities and liquid waste lines around and connected to the building. The utilities are concentrated on the south side of the building and consist of sanitary and communication lines, storm sewer lines, chromic waste line, soluble waste oil line, cyanide waste line, and water line. The waste lines are connected to the industrial wastewater treatment plant.

#### 1.3.3.2 Waste Types

The vapor degreaser unit was reportedly located along the eastern wall in the southeastern quadrant of the building (see Figure 1-5). The degreaser was self-contained and measured approximately 42 inches in diameter and five feet in height, with a liquid capacity of approximately 70 gallons. The exact date of installation of the unit is not known, but is thought to be around 1970. The vapor degreaser cleaned small metal components that were placed in a metal basket, and then immersed in the degreaser. According to WVA personnel, the degreaser originally utilized tetrachloroethene (PCE). This solvent was later replaced with trichloroethene (TCE) and 1,1,1-trichloroethane. The change in solvents was due to lower boiling points and "safer use". Fumes were vented outside of the building through an exhaust system that was located about seven feet above the ground. It is not known how often solvents were changed out or the final disposition of the solvents. Potential releases from the degreaser may have occurred through vents in the exhaust system, spills, or disposal of spent solvents. In 1982, the vapor degreaser unit was replaced with a water-soluble (alkaline) parts cleaner. The former vapor degreaser unit is considered a potential source for soil and groundwater contamination.

The manufacturing processes and equipment in Building 25 are believed to have changed very little since its construction, except for the removal of the vapor degreaser unit. These manufacturing processes are machining and Zyglo[7] testing of aluminum.

Building 25 was originally "M" shaped. Two courtyards formerly located on the western side of the building were used to store drums of raw materials, such as oils and paints. Five-gallon buckets were filled from these drums and used to 'top off' machines as needed. The courtyards were removed and the building redeveloped in the late 1970's and early 1980's during the Renovation of Armament Manufacturing (REARM) program.

Water soluble cutting oil, combustible waste oil, and metal chips from the milling operations are additional waste types generated at Building 25. Cutting oil used to cool the cutting heads of the milling machinery is collected in metal drip pans located beneath each machine and recirculated. Chemical analysis conducted on the cutting oil by the WVA in 1985 indicated that it was a chlorinated paraffinic hydrocarbon.

The water soluble cutting oils have been used since the early 1970's. Prior to that, it is not certain what type of cutting oils were used at WVA. Cutting oils currently and previously used at WVA are selected based on performance specifications rather than on chemical composition. Data on the chemical makeup of cutting oils used at WVA in the past is therefore unavailable. However, based on a review of available published literature, it has been determined that PCBs have historically been used in cutting oils and it is probable that PCB-containing cutting oils were used at WVA at some time in the past.

Spent cutting oil is collected as waste oil and sent to USTs located at each building and removed as nonhazardous waste to an approved TSDF.

Combustible waste oil is also generated at Building 25 from lubricating oils used for the milling machinery. The combustible waste oil is stored in a UST (SWMU # 14) located to the north of the building. Approximately 40,000 to 60,000 gallons of combustible waste oil are generated annually at WVA. Information on the amount generated at individual buildings is not available.

In addition to the waste generation associated with soluble and combustible waste oils, potentially contaminated metal cuttings/chips are generated during the milling of the rough cannon tubes. Metal cuttings are collected beneath each machine on a conveyor belt and dropped into small dumpsters. The conveyor belts are perforated with small holes to allow much of the cutting oil to drip back into the troughs for recirculation. However, not all of the oil can be removed from the metal chips in this manner. The dumpsters are periodically emptied and the metal chips are taken to the Siberia Area for interim storage prior to ultimate disposal. The specific amount of metal chips which are generated at any time varies greatly depending on production demand. In 1995, manufacturing activities at WVA generated a total of 1.5 million pounds of metal chips.

Zyglo[7] testing is conducted in Building 25. Parts are immersed in a penetrant liquid which removes impurities on the surface of the metal undergoing inspection. Solvents, oils and other chemicals are dissolved into the penetrant. Waste from this process is drummed at the point of generation and later disposed of in the combustible waste oil sump located at the north end of the building, prior to off-site shipment. The amount of waste oil generated from the Zyglo[7] testing operations is approximately 55 gallons per annum.

#### 1.3.3.3 Summary of Previous Investigations

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) - 1980

This report states that operations conducted at Building 25 are largely machining and the wastes generated are volatile and water soluble waste oils, lubricants, and metal cuttings. It also notes that a Zyglo[7] testing operation is present in Building 25.

William F. Cosulich Associates, P.C. Report - 1980

The report notes two operations in Building 25, that may have contributed to the presence of oil in the storm water discharge. These are a heat exchanger and a compressor room reportedly located on the third floor and a Zyglo[7] inspection station. The Zyglo[7] inspection operation reportedly discharged an oil emulsion to a sump connected to the storm drain.

Dames & Moore - 1983 and Empire-Thomsen - 1986

Monitoring wells installed in 1983 as part of a study involving the wastewater treatment plant were sampled on a quarterly basis during 1983 and semi-annually for the next several years. Concentrations of several chlorinated organics were detected in SP-1, including TCE (80 μg/l) and 1,1,1-trichloroethane (25 μg/l) (ESE, 1987). The source of the chlorinated organics was assumed to be the vapor degreaser located in Building 25.

### C.T. Male Associates (CTM) Report - 1990

CTM was retained to assess the nature and extent of contamination east of Building 25. This investigation involved the installation of nine soil borings, chemical analyses of selected soil samples from these borings, and the collection and analysis of groundwater from wells 83DM-SP-1, 86-EM-SP-1A and 86-EM-SP-1B. From their investigations, CTM prepared a report titled ASubsurface Investigation Report for Watervliet Arsenal Former Degreaser Unit≅, dated October 1990 and revised November 1990.

A total of nine soil borings, as shown in Figure 1-6, were installed between July 23 and 25, 1990. Six (SB-25-1 through SB-25-6/6A) of the nine borings were located in the upper parking lot, and three (SB-25-7, -8, and -9) were located in the lower parking lot. Soil samples were generally collected at two foot depth intervals from all the borings. The soil borings were advanced to depths of between 6.3 feet and 12 feet below existing grade. PID readings field screening observations during soil boring installation ranged from 3 to 210 ppm in SB-25-3, SB-25-5, SB-25-7, SB-25-9, indicating the presence of volatile organic contamination. These borings are all located east-southeast of the former degreaser location. PID readings in all other borehole samples did not exceed the background readings of 1 to 3 ppm.

Three wells were installed, one weathered/competent bedrock well (83DM-SP-1) and two overburden wells (86-EM-SP-1A and 86-EM-SP-1B, Plate 1-1). The depths of these wells are 21 feet, 16.5 feet, and 11.4 feet below ground surface, respectively. Chlorinated organics, primarily TCE and PCE, were detected in soil samples collected during the installation of these monitoring wells and soil borings. However, analyzation of samples by EPA Method 1312, the Synthetic Precipitation Leaching Procedure (SPLP) indicated that only total xylenes and t-butylbenzene might potentially exceed the Class GA groundwater Standards at any boring location.

### Groundwater Monitoring by Watervliet Arsenal

WVA collected and analyzed groundwater samples from several wells located in the vicinity of Building 25 between 1990 to 1993. Samples were analyzed for volatile organic compounds, metals, total organic carbon (TOC), and total organic halogens (TOX) by Huntingdon Analytical Services. Maximum chromium concentrations were measured in samples collected at 83DM-SP-4

(47 µg/l, dissolved) and 83DM-SP-3 (83 µg/l, total). Chlorinated solvents (chloroethane at 13.7 µg/l, 1,1-dichloroethane at 1.6 µg/l, and tetrachloroethene at 0.88 µg/l) and 2-methylnapthalene (88 µg/l) were also detected. TOC was detected at concentrations up to 133,000 µg/l (86EM-SP-5) and TOX at as high as 38,000,000 µg/l (86EM-SP-5), this result was not confirmed by later sampling at this location. Oil and grease data were detected in wells 93EM-SP-9 through 93EM-SP-12 at concentrations ranging from 1,500 to 8,900 µg/l.

### 1.3.4 Wastewater Treatment Plant (SWMU #6)

#### 1.3.4.1 Site Location

The industrial wastewater treatment plant was constructed in 1969 and put on-line in 1970 (Plate 1-2). In 1992, the plant treated an average of 120,000 gallons of wastewater per day (NYSDEC, 1992). A 39,000-gallon chromic acid waste holding tank, a 75,000 gallon waste holding tank, one sodium hydroxide AST (5,000 gallons), a 1,200 gallon sulfuric acid tank, and a 12,000 soluble waste oil holding tank are located at or near the wastewater treatment plant.

#### 1.3.4.2 Waste Types

Three types of wastewater are treated at the plant: acidic chromium and metal plating wastes, metal cyanide wastes, and soluble oil. The acid treatment process consists of a reaction tank, blending tank, clarifier and a final pH adjustment. The cyanide treatment process consists of a receiving sump and a holding/treatment tank to which chlorine is added to treat the cyanide. The soluble oil treatment consists of a batch treatment tank, from which skim oil is mixed with combustible skim oil and sold for commercial use. Effluents from the cyanide and soluble oil treatments are blended into the acid treatment process. Sludge generated from these processes is dewatered in the sludge drying beds and disposed of in an industrial waste landfill (non-hazardous). The treated effluent is discharged to the Hudson River (outfall 002).

In 1983 approximately 1,600 gallons of waste chromic acid solution leaked from the chromic acid holding tank when a gasket connection failed. Waste solution and contaminated material were removed and the gasket was replaced (NYSDEC 1992). The process tanks and acid receiving wells are cleaned and checked annually for cracks and deterioration.

In January 1996, an underground transfer line from the indoor clarifiers to the outside sludge drying beds broke during the replacement of the underground waste soluble oil collection tank.

### 1.3.4.3 Summary of Previous Investigations

Dames & Moore - 1983 and Empire-Thompsen - 1986

Two studies were conducted in the area of wastewater treatment plant by Dames & Moore in 1983 and Empire-Thompsen in 1986. Dames & Moore and Empire-Thompsen installed a total of eight monitoring wells in the period from 1983 through 1986 (83DM-SP-1 through 83DM-SP-4 by Dames & Moore; 86-EM-SP-1A, 86-EM-SP-1B, 86EM-SP-5 and 86EM-SP-6 by Empire-Thomsen) in the vicinity of sludge ponds located at the wastewater treatment plant. The boring logs indicate that bedrock is overlain by 13.5 to 19 feet of overburden. The overburden is a combination of fill and natural soils (silty sands and clays). These two reports concluded that the wells monitor groundwater in an unconfined aquifer that extends from the overburden to an undetermined depth within the bedrock. In addition, both reports note that groundwater flow is to the east and the southeast.

The monitoring wells installed by Empire Soils were sampled on a quarterly basis during 1983 and semi-annually for the next several years. Inorganic parameters in the groundwater samples were determined to be of Ano toxicological significance≅, but concentrations of several chlorinated organics were detected in SP-1, including TCE (80 μg/l) and 1,1,1-trichloroethane (25 μg/l) (ESE, 1987). The source of the chlorinated organics was assumed to be the vapor degreaser located in Building 25, as SP-1 is located hydraulically upgradient of the sludge drying beds and surface impoundment.

An underground storage tank located behind Building 36 and above the break in the underground transfer line leading to the sludge drying beds was removed in late 1995. The broken transfer line was replaced in 1996 when a 12,000-gallon waste soluble oil underground storage tank was installed.

### 1.3.5 Waste Oil USTs (SWMUs # 7 through 14)

### 1.3.5.1 Site Location

SWMUs 7 through 14 are located in different areas throughout WVA. The specific location of each SWMU is listed below, and is shown on Plate 1-2:

SWMU 7 - Building 141 (NW Quadrant of the Siberia Area)
SWMU 8 - Building 135 (along north wall)
SWMU 9 - Building 115 (along south wall)
SWMU 10 - Building 110, South (along west wall)
SWMU 11 - Building 110, North (along west wall)
SWMU 12 - Building 44 (along south wall)
SWMU 13 - Building 35, South (along south wall)
SWMU 14 - Building 25 (along northwest wall)

In addition to these SWMUs several other USTs exits throughout WVA, one of which is known as SWMU 7a. This SWMU is located in the Northeast Quadrant of the Siberia Area and was not investigated under this RFI since it was scheduled to be removed and replaced with a double walled tank by WVA. The analytical data and the associated removal action report are presented in Appendix L. The results of the soil sampling conducted during the removal action indicate the presence of n-Propylbenzene at a concentration of 18 ug/kg, all other compounds were not detected.

### 1.3.5.2 Waste Types

All eight USTs were designated for waste oil storage but were reportedly used to store hydraulic oil, lubricants, non-chlorinated degreasing solvents, chlorinated solvents, and skim oil. These waste materials were generated as a result of the various machining, process, testing and maintenance activities which took place at WVA. Two of the eight USTs were found to be leaking upon removal, but no significant residual contamination remained after removal and/or replacement of the eight USTs which was completed by WVA (with NYSDEC oversight).

Historical waste characterization data for waste oils (September 1993) indicate that the waste oil was sampled for total chlorine, flashpoint, heating value, PCBs, and Toxicity

Characteristic Leaching Procedure (TCLP) extraction for volatile organic compounds, semi-volatile organic compounds, and metals. TCLP detections/exceedances occurred for the metals (barium and lead) and PCE. TCLP barium was detected at Building 35 south at 5 mg/l, Building 115 at 7.5 mg/l, Building 15 at 5.5 mg/l, and Building 35 west at 6 mg/l. TCLP lead was detected at DRMO at 219 mg/l, Building 20 and 25 at 6 mg/l, and Building 15 at 10 mg/l. TCLP PCE was detected at 19 mg/l at Building 35 south. According to WVA personnel, the waste oils are currently being shipped off-site as non-hazardous material for blending and recycling (i.e., heat recovery, redistillation).

#### 1.3.5.3 Summary of Previous Investigations

Since September 1987, eight underground storage tanks (USTs) have been removed and/or replaced at WVA. Two of these tanks (SWMUs 11 and 12) were reported to be leaking upon removal. Based on a file review and conversations with WVA personnel, no UST closure reports were prepared for any of these tank removals. The UST removals were overseen by WVA and NYSDEC personnel, with closure being approved on-site by NYSDEC personnel.

The seven existing/replacement waste oil USTs were installed in 1987 and 1988 and are constructed of double-walled steel with cathodic protection and leak detection. The original USTs which were replaced at these locations had been in service for 17 years and were of single-walled steel construction. When the waste oil UST located east of Building 44 (SWMU 12) was removed, it was observed to be leaking. The waste oil UST north of Building 110 (SWMU 11) was also observed to be leaking upon removal. No significant residual contamination remained after UST removal and replacement operations were completed. No evidence of release was observed during the UST removal and replacement at the six remaining SWMUs.

### 1.3.6 UST 13 (SWMU #15)

#### 1.3.6.1 Site Location

SWMU 15 (UST 13) is the former location of a leaking 1,000-gallon waste oil tank east of Building 15 (Plate 1-2).

#### 1.3.6.2 Waste Types

The potential for contamination by volatile organic compounds, semi-volatile organic compounds, inorganic parameters, herbicides, pesticides and PCBs was considered.

#### 1.3.6.3 Summary of Previous Investigations

Empire Soils, 1994

SWMU 15 (UST 13) was removed and replaced in 1995. Two soil samples were collected from the pile of excavated soils and analyzed for TCLP volatiles, semi-volatiles, metals, herbicides, pesticides, and PCBs. The only exceedance of environmental standards was the PCB-1254 concentration of 360 mg/Kg (TAGM standard, 10 mg/Kg) noted in one sample. Sediment and groundwater/accumulated rainwater samples were obtained from the pit and analyzed for volatiles and semi-volatiles. No detections of any compound were reported. WVA deemed the excavated pit at SWMU 15 to be satisfactorily clean and new piping and a new tank were installed. The site was closed clean by the NYSDEC in February 1995.

As part of this study monitoring wells 94EM-SP-19, 94EM-SP-20, and 94EM-SP-21 were installed. Groundwater and soil samples were collected from all three monitoring wells and analyzed for volatile organics by method 602. No detection of any compounds were reported for groundwater. Concentrations of volatile compounds below regulatory standards were noted in the soil samples.

### 1.3.7 SWMU #16

#### 1.3.7.1 Site Location

SWMU 16 (UST 23) is the former location of a 1,000-gallon waste oil storage tank in the west central portion of Building 35 (Plate 1-2).

#### 1.3.7.2 Waste Types

The potential for contamination by volatile and semi-volatile organic compounds was considered.

#### 1.3.7.3 Summary of Previous Investigations

The original single walled fiberglass tank was removed in 1994. Two composite soil samples were collected from the excavation area and analyzed for volatile and semi-volatile compounds. There were no reported detections of any compounds. A new tank and piping were installed and the excavated pit was backfilled with clean sand.

### 1.3.8 SWMU #17

#### 1.3.8.1 Site Location

SWMU 17 (UST 25) is the location of a 5,000-gallon waste oil storage tank located east of Building 36 (Plate 1-2).

#### 1.3.8.2 Waste Types

The potential for waste oil leaks was assessed.

#### 1.3.8.3 Summary of Previous Investigations

UST 25 was tightness tested on January 10, 1995 and again on February 22, 1996. On both occasions the line and the tank were certified as being free of any leaks.

### 1.3.9 Outfall to Hudson River (Outfall 003) (SWMU #19)

#### 1.3.9.1 Site Location

Outfall 003 is the main outfall to the Hudson River. It is located east of Building 40, as shown on Figure 1-4.

#### 1.3.9.2 Waste Types

Prior to the construction of the wastewater treatment plant in 1970, waste was discharged directly to the Hudson River via this outfall. The cyanide treatment plant was not put on-line until 1978, and prior to that date all cyanide waste was discharged directly to the Hudson River through this outfall. According to site personnel, there have been exceedances of several of the parameters monitored as part of the SPDES program, though the exceedances were considered Aminor≅ and were never repeated with any frequency. The parameters which were exceeded included temperature, total suspended solids, and pH.

#### 1.3.9.3 Summary of Previous Investigations

No leaks or breaks in the pipe have been documented and it is unknown if any releases occurred to the groundwater. According to the RFA Report (NYSDEC, 1992), it is likely that all traces of hazardous material have been eliminated from this outfall because the last discharge of untreated hazardous waste to the Hudson River occurred in 1978 and the outfall is frequently subjected to high flow rates associated with storm events.

### 1.3.10 Industrial Sewers (SWMU #20)

#### 1.3.10.1 Site Location

The three types of waste (soluble oil, chromic, and metal cyanide wastes) are conveyed to the treatment plant by separate industrial sewers. The chromic and soluble oil sewers are clay tile and were installed in the early 1970's. The cyanide sewers are constructed of ductile iron pipe and were installed in the late 1970's. Plate 1-3 shows the layout of the industrial sewers. As shown on the plate, Manhole 43 is located along the waste oil line within the area of the former Erie Canal between the WVA Museum and wastewater treatment plant. The chromic waste line is approximately 4,500 feet in length.

Plate 1-3 also shows areas of the industrial sewers which are submerged during the seasonal low groundwater conditions. As shown on the plate, several areas of both the soluble oil and chromic waste lines remain submerged during seasonal low groundwater conditions. The cyanide waste line is not submerged during any season.

### 1.3.10.2 Waste Types

The following table summarizes the waste materials which are conveyed to the waste water treatment plant through the industrial sewer system.

| LINE TYPE | DESCRIPTION | VOLUME |
|---|---|---|
| Waste Soluble Oil Line | Waste fluid consists of spent water-based coolants used in the machining processes. Nine collector sumps located at manufacturing buildings are connected to the line. There are no hazardous constituents in the approved machining soluble oils. No other machining fluids are authorized for disposal at sumps. There is no sampling of incoming fluids, only of the treated batch, per SPDES permit. | 1996<br>6,150,600 gal<br>1997*<br>5,011,600 gal<br>1998<br>4,958,000 gal |
| Waste Acid Line | Waste fluids consist of spent chromic acid from plating operations, plating rinse waters, spent caustic cleaners (sodium hydroxide), and other spent plating solutions such as phosphoric and sulfuric acids (electropolish tanks). This waste is mostly generated at Bldg. 35, 110, 115, and 120. There is daily sampling of pH and glycol from incoming waste fluids. | 1996<br>22,510,396 gal.<br>1997*<br>18,613,986 gal |
| Waste Cyanide Line | Cyanide-based CAD Plating was eliminated at WVA in 1995. The line was kept to treat waste generated at a Barium Chloride Furnace located in the Heat Treat Area (Bldg. 35). Although all cyanide-containing chemicals have been eliminated from use at WVA, attempts to phase-out the line have been unsuccessful. | 1996<br>25,000 gal<br>1997*<br>30,000 gal<br>1998<br>16,819,486 gal |

*Cumulative totals up to November

### 1.3.10.3 Summary of Previous Investigations

Empire Soils Investigations, Inc Report - 1993

Empire Soils Investigations, Inc. conducted an investigation of chromic acid waste line leaks from the line located in the main manufacturing area of WVA. The findings of this investigation are presented in a report titled AHydrogeological Investigation Area Adjacent to Manhole 34D Chromic Acid Waste Line≅, dated August 1993. Empire Soils Investigations, Inc. installed eight monitoring wells along various segments of the chromic acid waste line, identified as 93-EM-SP-9 through 93-EM-SP-16 (Plate 1-1).

At the depths explored, the subsurface conditions were relatively uniform beneath the study areas. Fill material was encountered beneath the asphalt pavement and consisted of graded sands and gravels with lesser amounts of silt, cinders and brick fragments. The fill material ranged in depth from 1.5 to 11 feet below ground surface. The fill material at each location, with the exception of boring 93-EM-SP-12, was underlain by bedrock. The upper portion of the bedrock encountered at each location consisted of weathered shale. This weathered zone ranged in thickness from 2 to 4 feet. Each of the borings was terminated within the competent shale bedrock underlying the weathered zone, at depths ranging from 13.5 to 22 feet below ground surface.

Empire Soils Investigations, Inc. sampled and analyzed groundwater from wells SP-9 through SP-16 for metals, oil, and grease. The results indicated that several metals were present above the detection limit in the groundwater of all the wells. However, only iron and manganese exceeded the NYSDEC Maximum Concentration Levels (MCLs). Oil and grease were detected in all eight wells and ranged in concentration from 1.0 to 8.9 mg/l.

Additional Work

A video survey of the acid line was conducted in 1992. Twenty-three defects were noted during the survey. The repair of the defects and re-sleeving of the line were completed in 1992 (Empire Soils 1993). It has been concluded that the work described in the referenced AClean and Inspect≅ report dated 8 January 1993, was actually never completed. Furthermore, video inspection of the waste soluble oil line could have never been completed as described due to the fact the waste soluble oil line is lined with black polyethylene liner. Therefore, the recommendations presented is this report and the reported work were never completed, additional methods of investigation are currently under review.

After oil was observed seeping into an excavation in the area of Manhole 43 by WVA personnel, approximately 15 to 30 yards of soil were excavated and a soil sample was collected and analyzed for TCLP volatiles, semi-volatiles, and metals, PCBs, and ignitability. All parameters were found to be non-detect except for barium (0.42 mg/l).

### 1.3.11 Incinerator (SWMU #21)

#### 1.3.11.1 Site Location

Building 132 was built in 1944 and the incinerator was put on-line in 1945. It is located at the western edge of the main manufacturing area near the gate leading to the Siberia Area (Plate 1-2).

#### 1.3.11.2 Waste Types

The incinerator was used for the disposal of waste paper and office trash. The incinerator was not used for hazardous wastes and has not been active since 1975. Building 132 is presently used to store insecticides and pesticides.

#### 1.3.11.3 Summary of Previous Investigations

There are no known intrusive investigations at this SWMU location.

### 1.3.12 Erie Canal Site (SWMU #25)

#### 1.3.12.1 Site Location

The Erie Canal, formerly located in the eastern portion of the Main Manufacturing Area (Plate 1-2), was built between 1817 and 1824. The Canal provided the WVA with transportation, power, and water for fire protection until it was relocated to Waterford in 1922.

#### 1.3.12.2 Waste Types

The Canal was filled in with dirt, brick and other fill materials around 1940 during World War II expansion of the Arsenal. Portions of the canal walls were also pushed into the canal with the fill material. Remnants of the Erie Canal remain along Gibson Street and east of Mettler Road at the former Parade Grounds.

On May 7, 1993 machining coolant oil was observed seeping into an excavation in the area of the waste oil line at Manhole 43. Manhole 43 is located within the area of the former Erie Canal.

#### 1.3.12.3 Summary of Previous Investigations

There are no known, previous, intrusive investigations in this area.

### 1.3.13 Building 35 Process Pits (SWMU # 26)

#### 1.3.13.1 Site Location

Building 35, also known as the Heat Treat and Metal Processing Building, was constructed in 1918 (WVA, 1984). Building 35 is located along the southern property boundary of the Main Manufacturing Area at WVA (Plate 1-2). It is bounded to the east by Buildings 20 and 25, to the south by residential property, to the west by Building 110, and to the north by the WVA fire house (Buildings 21 and 22).

Building 35 is a single story structure approximately 850 feet long and 600 feet wide at its widest point. A 1983 floor plan shows the building divided, east to west, into 17 bays, labeled A through S, excluding I and O. Bays C through J comprise the original extent of Building 35 and Bays H and J represent the 1942 extension. During the mid to late 1970s, Building 35 was expanded further as part of the REARM program and buildings to the east, north and west were razed to accommodate this expansion. Bays A and B and Bays K through S are extensions to the west and east, respectively, built during this period. The shop floor level is at an elevation of approximately 55 feet AMSL. The east side of the building has a basement level.

There were two process pits at the south end of the building at the time of construction. Formerly referred to as the West and East Pits, these pits are currently called the 120 mm, the 8-inch Gun Pit, and NMT pit, respectively. Extensions were added to the west, east, and north and two additional process pits were installed in 1978. A number of reconstructions/conversions have been made to the process pits since their installation.

Following is a chronology of events relating to the process pits based on available WVA drawings and information provided by WVA personnel:

- 1918 - Two pits installed during construction of Building 35.
- 1952 - West Pit converted to chrome plating of 155 mm guns.
- 1976 - East Pit converted to chrome plating of 8-inch guns.
- 1978 - New Medium Tube Pit installed, as an extension to the 8-inch Gun Pit. This pit is used for chrome plating.
- 1979/1980 - 120mm Gun Pit constructed, but left idle.
- 1986/1987 - Chrome plating equipment installed in 120mm Gun Pit.
- 1990 - West pit converted to a furnace pit.

There are four process pits located at the south end of Building 35. Note that the 8-inch Gun Pit and the New Medium Tube Pit are contiguous. Three are used for chrome plating and one is used for heat treatment of the cannon tubes. From west to east these pits are called the 120-mm Gun Pit, the Furnace Pit, the 8-inch Gun Pit, and the New Medium Tube Pit. As-built construction drawings for these pits were not available but it is presumed that the pits were constructed in a similar manner to the Shrink Pit at Building 135, for which construction drawings are available. Possibly the major difference between the Shrink Pit and the chrome plating pits is that a waterproof membrane was reportedly installed in the latter. This information was documented during construction for the conversion of one pit from a chrome plating pit to a furnace pit in 1986.

The Furnace Pit is 45 feet long, 20 feet wide and 30 feet deep with a 3 feet cubed sump located at the southwest corner. It is at this location that POLs are accumulating. During conversion of this pit from chrome plating to heat treating operations in 1987, the acid resistant brick, waterproof membrane, and part of the concrete floor slab, were removed. At that time, oil was observed to be seeping through cracks in the concrete walls. A groundwater/oil collection channel is located around the walls of the pit, approximately 3 feet above the concrete floor slab, and directs groundwater/oil seepage towards the sump. The New Medium Tube/8-inch Gun Pit is 60 feet long, 60 feet wide and approximately 40 feet deep. A small sump is located in the southwest corner which collects condensate blowdown and some groundwater seepage. Unlike the Shrink Pit at Building 135, the pits at Building 35 were not constructed entirely in bedrock. They are constructed partially in overburden material and partially in bedrock. This is confirmed by a soil boring installed adjacent to the New Medium Tube Pit (East Pit) in 1978 by the ACOE. Drilling logs for this boring shows the top of bedrock at 19.5 feet below shop floor level. Drawings for the 120mm Gun Pit were not available for review.

#### 1.3.13.2 Waste Types

Current manufacturing operations at Building 35 include cannon tube chrome plating and heat treatment in the four process pits located at the southern end of the building. Cadmium-cyanide plating, previously conducted at Building 110, was relocated to Building 35 in 1985 and discontinued in 1994. In general, however, the manufacturing processes and equipment in Building 35 is believed to have changed very little since its construction. The remainder of the main floor is occupied by machining equipment used for finishing the cannon tubes and for conducting magnaflux testing operations.

A number of distinct operations occur within Building 35. Four process pits are located at the southern end of the building. Three of these pits are currently used for chrome plating and one pit is used for heat treatment. Cooling towers for the chrome plating process are located outside the southern end of the building. Milling machinery occupies much of the shop floor. A cyanide treatment plant was constructed at the on-site industrial waste treatment plant to handle the waste stream generated from this process. Magnaflux testing operations are also conducted at Building 35. A stoddard type solvent is used for this process, but the amount of oil used in this process is small compared to that used for milling operations. A spray painting booth, formerly located on the west center side of the building prior to REARM expansion, is currently located at the southeast end of Building 35.

Water soluble cutting oil, combustible waste oil, metal chips, magnaflux testing oil, and process water from the chrome plating operations are the main waste types generated at Building 35. These waste streams are similar to those generated in Building 25 and are handled in a similar manner, as discussed above.

#### 1.3.13.3 Summary of Previous Investigations

U.S. Army Toxic and Hazardous Materials Agency - 1980

The USATHAMA Report states that operations conducted at Building 35 are chrome plating and magnaflux testing operations and the wastes generated from these processes are chrome solutions, paint, dry lubricants, and water soluble oils.

William F. Cosulich Associates, P.C. Report - 1980

This report identifies a number of oil spills and conditions at WVA which have contributed to the presence of oil in the storm water discharge. Two locations within Building 35 were identified as locations potentially contributing to contamination in the storm water discharge. The first potential source is a floor drain in the lower level of the building near a small compressor. It was noted that both the upper level compressor and the lower level compressor discharge to this floor drain. The area around the drain was saturated with oil. The second potential source is the air piping condensate traps in Bays 12-E, 21-E, 13-A, 16-A, 21-A, and 11-G. These traps are connected to the storm drainage system through roof leaders. Small quantities of oil were observed to have accumulated in these traps and to have discharged to the storm drain.

Sampling activities conducted at Building 35 included the collection of storm water samples from Manhole (MH) 11, located at the southwest corner of the building. Eight (8) samples were collected between August 7 and August 23, 1979 and analyzed for oil content. Oil concentrations in these samples ranged from 2 mg/l to 26 mg/l. A visible sheen was reported on seven of the eight samples collected. It is noted, however, that this manhole is located upgradient of Building 35 and is therefore more representative of discharge to storm sewer from Building 110 and 125. Samples collected from a downgradient manhole (MH-4) did not indicate increased oil concentrations relative to MH-11 as oil concentrations detected in storm water samples collected from MH-4 ranged from 0.8 mg/l to 6.6 mg/l. No mention of free product in the Building 35 process pits was made in this report.

### Environmental Science and Engineering, Inc. - 1987

Additional information presented in this report concerning Building 35 included the relocation of the cadmium-cyanide plating operation from Building 110 to Building 35. The wastes generated are piped to a new cyanide treatment system at Building 36. Heat treatment and minor component plating operations were relocated from Building 110 to a new portion of Building 35.

### Clough, Harbour and Associates Report - 1991

Clough, Harbour and Associates prepared a report, titled APhase I Subsurface Contamination Investigation of the Chrome and Shrink Pit Areas in Building 35 and 135 of the Watervliet Arsenal≅, dated March 8, 1991. This report outlines sampling of the water and floating product from both of the referenced pits within Buildings 35 and 135, an evaluation of construction drawings, an assessment of hydrogeologic conditions, an examination of potential sources of POLs, and a description of the past and present operational history of each building. No borings or groundwater monitoring wells were installed during this investigation.

Review of WVA drawings indicated that the Chrome (Furnace) Pit in Building 35 was designed in 1952 and was constructed as an extension to what has been referred to as Pit No. 1. The Chrome (Furnace) Pit is smaller than the original pit and approximately 18 feet deeper. The report states that the pit was reconstructed in 1987/88, and converted from chrome plating to heat treating operations.

Clough, Harbour and Associates collected oil and water samples from inside the Chrome (Furnace) Pit within Building 35 in October 1990. Samples were analyzed for polychlorinated biphenyls (PCBs) by EPA Method 8080, petroleum identification by NYSDOH Method 310.13, and infrared scan. The petroleum identification analysis results from the samples collected from Building 35 indicate that the product present in the Furnace Pit at that time contained constituents characteristic of kerosene. An infrared scan conducted on the sample further revealed that the major component of the hydrocarbons is a synthetic hydrocarbon commonly made in petroleum refineries, referred to as a "heavy odorless mineral spirit". The results also indicate that the presence of PCBs in the Building 35 sample was below the detection limit of 4 mg/l.

Potential sources listed in this report are four 1,000-gallon waste oil USTs located 100 feet to the south, 500 feet to the northwest, 400 feet to the north, and 600 feet to the northeast. During replacement in 1981 and 1988 no significant soil contamination was noted by WVA personnel. Clough, Harbour and Associates concluded that POLs leaking from the machinery in Buildings 35 and 110 is probably the source of the oil found in the Chrome (Furnace) Pit.

### 1.3.14 Building 135 Process Pit (SWMU # 27)

#### 1.3.14.1 Site Location

Building 135 was built in 1943 to meet production demand during World War II (WVA, 1984) (Plate 1-2). It is located in the southwest corner of the Main Manufacturing Area at the highest elevation at WVA (approximately 74 feet above mean sea level [AMSL]). As shown in Figure 1-2, it is bound on the east by residential properties, on the south by undeveloped land and the former Delaware & Hudson railroad yard, and on the west and north by other WVA buildings (Buildings 136, 133 and 125). Building 133 is a drum storage area and is contiguous with the northwest corner of Building 135.

Building 135 is a single story structure approximately 600 feet long and 300 feet wide. The main shop floor area is divided into five (5) bays. A High Bay section is located at the south end of building. This bay is approximately 108-feet high, rising 50 feet above the rest of the building to facilitate lifting the cannon tubes into and out of the various pits. Three pits are located within the High Bay area. They are commonly referred to by WVA personnel as the Cold Works Pit, the Furnace Pit, and the Shrink Pit. The Cold Works Pit is approximately 35 feet deep, the Furnace Pit is approximately 20 feet deep, and the Shrink Pit is 100 feet deep. Figure 1-7 shows the generalized floor plan of Building 135 as well as the locations of the three process pits within the building.

An aerial photograph taken in September 1939 shows the area currently occupied by Building 135 to be largely undeveloped. In the aerial photograph there are a number of small buildings and four above ground storage tanks (ASTs) located adjacent to what is currently Parker

Road. The buildings and tanks appear to be associated with a rail system that was possibly servicing the WVA. Figure 1-8 is a graphic representation of this aerial photograph and shows the most relevant features with regard to Building 135.

The main focus of the Building 135 RFA is the Shrink Pit, located in the southeast corner of the building. The pit was used to shrink a part of the gun tube, known as the hoop, onto the gun barrel. No chemicals were reportedly used during this process.

At its deepest point, the pit is approximately 100 feet deep. Its shape and dimensions vary with depth, but it measures 51.5 feet by 40.5 feet at its widest point (at the shop floor level). It houses three furnaces (two are 9 feet in diameter and one is 10.5 feet in diameter), an elevator, a metal stair case for access, and a wet pit. Its southern wall is vertical while the northern wall is stepped, such that the cross sectional area decreases with depth. A wet pit (commonly referred to as the Blue Lagoon) and dry pit are located at the bottom. Figure 1-9 is a generalized north-south cross-section through the Shrink Pit, showing the main structural features of the pit as determined from construction drawings. As shown in this cross-section the pit is constructed entirely in shale bedrock.

The pit walls are constructed of reinforced concrete, minimum 1 foot thick, which was apparently poured directly against the shale bedrock. Steel anchors, which were set 4 feet into the shale are tied to the concrete wall for support. Drainage chases were installed around the perimeter wall of the structure to collect groundwater for use in the shrinking process. The chases were constructed by chiseling 2 feet by 1 foot shafts into the bedrock and filling them with coarse gravel. A network of pipes connect the drainage chases to the wet pit. The discharge from the drainage chases to the wet pit is at a depth of 96 feet. The chases are connected to the fill material, underneath the concrete floor slab, via 4-inch diameter cast iron drainage weepers (pipes). Eleven drainage chases are located at the surface of the pit, but there are fewer at deeper levels as the cross-sectional area of the process pit decreases with depth.

Groundwater used for the Shrink Pit process was circulated from the wet pit via pumps housed at the 72.5-feet level. A pump located at the 100-feet level in the dry pit is used to discharge water to the storm sewer at the southern side of the building. This discharge is regulated under a SPDES permit (Permit No. 0023361) issued by the New York State Department of

Environmental Conservation (NYSDEC). The discharge from the Shrink Pit at Building 135 is listed as outfall No. 4 under this SPDES permit. Monthly monitoring for oil and grease, total suspended solids, iron and pH is conducted as a condition of this permit. Based on discharge records provided by WVA, monthly discharge between September 1994 and August 1995 averaged approximately 30,000 gallons. The water level in the wet pit is reportedly maintained between 90 and 83 feet below the shop floor level. Water levels in the pit which were taken in March 1995 varied between 82 and 84 feet below the shop floor level.

In 1973, a contract was granted to GFM Company of Steyr, Austria for the manufacture of a Rotary Forge machine. The rotary forge was delivered in January 1975 and installed on Building 135 in June of the same year. It is 195 feet long and weighs approximately 935 tons, it was considered the largest rotary forge in the world at the time. The forge itself and the associated continuous horizontal heat treating system is a 288 feet long cylindrical furnace. The combination furnace-forge is capable of forging hollow cylinders (the shape of an artillery gun tube) from 6 inches to 18 inches in diameter and up to33 feet in length. The forge, operated beginning with raw material in the form of a short steel "preform", utilizes chuck jaws to grip the preform which is heated red-hot. This is mounted on a moving platform and fed through a central housing where, while being rotated by the gripping jaws, is struck with rapid blows (200 blows/minute) by four opposing hammers with a force of 1,000 tons each.

The machining fluids used during this whole process are lubricating oils and hydraulic fluids (i.e. MobilGear 634 and 636, Citgo Hyd Oil 68). Most of these chemicals are replenished following a routine preventive maintenance schedule. The spent fluid is drummed and disposed of in the combustible waste oil sump within the building. The combustible oil sump is pumped regularly by a waste hauler and transported as non-hazardous waste to Connecticut where it is used for fuel blending. Because the machine is located in a trench, there is a small sump (4 ft wide X 3 ft. deep X 3 ft. long) used to capture any spillage of these fluids, if they ever occurred. This sump pumps automatically (level pump) to a reservoir sump in the North end of Bldg. 135. This reservoir is piped to the Soluble Waste Oil line onto the IWTP where is skimmed off the top of the soluble waste oil prior to treatment.

### 1.3.14.2 Waste Types

Current manufacturing operations in the building consist of a number of processes including forging, heat treatment and machining to convert steel billets into rough cannon tubes. The steel billets are hollow steel stock used in an intermediate stage of manufacture. The manufacturing processes and equipment in Building 135 have changed very little since its construction. The most significant change in Building 135 is the installation of an electric arc furnace and the upgrade of other process machinery in the mid to late 1970's as part of the REARM program. The operations which occur within Building 135 include: the delivery of the raw steel billets; the forging of the billets into rough cannon tubes; the machining of the outside of the tubes; the lead plating and rifling of the inner bore; heat treatment; and, various quality control and strength tests on the partially completed cannon tubes prior to shipment to other buildings at WVA for finishing. Lead plating of the inner bore of cannon tubes is conducted at the southern end of Bay C. Alkali cleaning is a component of the lead plating process. The manufacture of asbestos gaskets was formerly conducted at the northern end of Bay A. This operation ceased in the early 1980s.

Water soluble cutting oil, combustible waste oil, and metal chips from the milling operations are the main waste types generated at Building 135. These waste streams are similar to those generated in Building 25 and are handled in a similar manner, as discussed above.

The capacitors located in Building 135 formerly contained PCBs, as did the hydraulic oils used in the machinery throughout WVA. All PCB-containing capacitors have been removed and replaced. All machines containing hydraulic oil with PCBs were drained, flushed, and refilled with hydraulic oil containing less than 50 mg/l PCBs. Plate 1-4 shows the current or former locations of PCB containing transformers and capacitors at WVA.

### 1.3.14.3 Summary of Previous Investigations

U.S. Army Toxic and Hazardous Materials Agency - 1980

This USATHAMA report states that operations conducted at Building 135 are lead plating, machining, alkali cleaning, stress relieving, asbestos gasket manufacturing, and magnaflux testing. The manufacture of the asbestos gaskets is conducted in a controlled area. The magnaflux testing operations use a water soluble oil to detect flaws in metal. According to this report the oil used is not compatible with the lubricating oil and therefore the waste oil generated from this process is not mixed with the soluble waste oil. The water soluble waste oil used for magnaflux testing is reportedly taken off-site for disposal by an outside contractor.

William F. Cosulich Associates, P.C. Report - 1980

The report identifies a number of oil spills and conditions at the WVA which have contributed to the presence of oil in the storm water discharge. Two sumps located in Building 135 were identified as potential sources of oil sheen found in the storm water discharge.

The first sump was located at the Rotary Forge on the western side of the building. This sump, which discharges to the storm drain, was heavily stained with oil. The sump, at the time of the Cosulich report, had recently been connected to the waste oil collection system. The second sump was located in the railroad car service pit in the southwest corner of the building. This sump pit had an overflow pipe which discharged to the storm drain. No mention of oil staining around the sump was made.

Sampling activity conducted at Building 135 included the collection of storm water samples from Manhole 108, located at the northwest corner of the building. Six (6) samples were collected between August 9 and August 24, 1979 and analyzed for oil concentration. Oil concentrations ranged from 0.5 mg/l to 3 mg/l. No visible sheen was reported on any of the samples. A water sample taken from the Shrink Pit contained an oil concentration of 2 mg/l. No mention of free product in the Shrink Pit was made in this report.

Clough, Harbour and Associates Report - 1991

Clough, Harbour and Associates prepared a report, titled APhase I Subsurface Contamination Investigation of the Chrome and Shrink Pit Areas in Building 35 and 135 of the Watervliet Arsenal≅, dated March 8, 1991. This report outlines sampling of the water and floating product from both of the referenced pits within Buildings 35 and 135, an evaluation of construction drawings, an assessment of hydrogeologic conditions, an examination of potential sources of POLs, and a description of the past and present operational history of each building. No borings or groundwater monitoring wells were installed during this investigation.

Review of WVA drawings indicated that Building 135, including the Shrink Pit, was constructed in 1943. A small furnace pit is located immediately to the west of the Shrink Pit and a Cold Works Pit is located 90 feet to the west. A Forge Plunger Pit occupied the current location of the Rotary Forge, approximately 290 feet to the northwest of the Shrink Pit. Operations conducted at Building 135 as listed in this report are heating the billets; forging; reaming and rifling the cannon's bore, rough machining of the cannon's exterior; and heat treating. Heat treating in the Shrink Pit was terminated in approximately 1978. The furnaces at the Rotary Forge were initially fueled with No. 2 fuel oil, but was switched to natural gas in 1982.

Clough, Harbour and Associates collected oil and water samples from inside the Shrink Pit within Building 135 in October 1990. Samples were analyzed for PCBs by EPA Method 8080, petroleum identification by NYSDOH Method 310.13, and infrared scan.

Results of these analyses from the samples collected from the Shrink Pit in Building 135 indicate a PCB (Aroclor-1254) concentration of 22.0 mg/l and the presence of compounds characteristic of a refined petroleum lubricating oil. The presence of PCBs in this sample was confirmed with GC/MS analysis. A second sample collected on the same day from the Shrink Pit by WVA personnel was analyzed separately for PCBs by EPA Method 608 and indicated a concentration of PCBs below the method detection limit of 0.05 mg/l.

Potential sources listed in this report are the fuel oil storage tanks located to the west of building, the combustible waste oil tank located at the north end of the building, and the lubricating and hydraulic oils used in the machinery within the building. Leakage from the fuel oil tanks was ruled out based on the results of a petroleum identification analysis conducted on a sample of the oil collected from the Shrink Pit. This analysis indicated that the oil found in the Shrink Pit is a refined lubricated oil, not a heavy fuel oil. The combustible waste oil tank was also eliminated as a potential source. During its replacement in 1988 no significant soil contamination was found. Clough, Harbour and Associates concluded that POLs leaking from the machinery may collect in a preexisting bedrock depression and gradually migrate towards, and eventually drain into the Shrink Pit, located at the southern end of the depression.

### Watervliet Arsenal Sampling - February 1995

In February 1995 WVA personnel collected samples from four drums of recovered free phase product from the Shrink Pit in Building 135. All samples were analyzed for PCBs using EPA Method 8080 by CTM Analytical Laboratories, Ltd. All samples were non-detect (<2.5 μg/l) for PCBs.

### Watervliet Arsenal Sampling - March 1995

In March 1995 WVA personnel collected samples of petroleum from five locations in Building 135. All samples were analyzed for petroleum identification using NYSDOH Method 310-14 by CTM Analytical Laboratories, Ltd. Below is a summary of samples collected and type of petroleum product identified.

| **Sample ID** | **Sample Location** | **Type of Petroleum Product** |
|---|---|---|
| Shrink pit | Floating product from Shrink Pit | Lubricating or Motor Oil |
| 3rd Floor | Wall seepage at 3rd floor of Shrink Pit | Lubricating or Motor Oil |
| WV 12175 | Oil from machine guided bore tool | Lubricating or Motor Oil |
| WV 11640 | Oil from machine | Fuel Oil #4 |
| WV 11190 | Oil from machine | Fuel Oils #4, 6 and Motor or Lubricating Oil |
| Drum Citgo ISOG-68 | Drum of product | Lubricating or Motor Oil |

This report only presented the results of the petroleum identification analysis. No conclusions or recommendations drawn from these results were presented in this report.

Watervliet Arsenal Sampling - February 1996

In February 1996 WVA personnel collected samples of petroleum and seep water from fourteen locations in Building 135. All samples were analyzed for petroleum identification - cross match. Below is a summary of samples collected and type of petroleum product identified.

| Sample ID | Sample Location | Type of Petroleum Product |
|---|---|---|
| ORD#1 | Tramp oil - Shrink Pit | Mix of ORD #8 and ORD#10 |
| ORD#2 | Water/oil mix - south wall seep level 6 | Lubricating oil, like ORD#8 |
| ORD#3 | Drain water sample - west wall level 6 | No petroleum detected |
| ORD#4 | Citgo AW hydraulic fluid #32 | Lubricating oil (mix of 2) |
| ORD#5 | Citgo AW hydraulic fluid #46 | Lubricating oil |
| ORD#6 | Citgo AW hydraulic fluid #68 | Lubricating oil (mix of 2) |
| ORD#7 | Citgo Slide Rite 68 | Lubricating oil |
| ORD#8 | Shell Omala oil 150 | Lubricating oil |
| ORD#9 | Shell Omala oil 680 | Did not chromatograph |
| ORD#10 | Hone cutting oil | Fuel oil No. 6 |
| ORD#11 | Century Detroit guide oil | Fuel oil No. 2 or 4, plus lubricating oil |
| ORD#12 | Show bore cutting oil | Fuel oil No. 2 or 4, plus lubricating oil |
| ORD#13 | Oil seep - northeast corner level 4 | Mix of DR #8 and DR#10 |
| 001 | Oil - Shrink Pit lower level | Mix of DR #8 and DR#10 |

This report only presented the results of the petroleum identification analysis. No conclusions or recommendations drawn from these results were presented in this report.

### 1.3.15 Additional Vapor Degreaser Units

#### 1.3.15.1 Site Locations

The locations of each of the additional vapor degreaser units designated as SWMUs are presented on Plate 1-2.

# *Building 123 Vapor Degreaser* - This vapor degreaser was in operation from 1959 to 1972. It was approximately 5x8x7 feet deep. The unit may have been periodically drained to an outdoor drum.

# *Building 20 Vapor Degreaser* - The installation date of this degreaser is unknown. The unit was idle from 1976 until its removal circa 1978. The dimensions of the degreaser were approximately 3 feet by 4 feet by 5 feet deep.

# *Building 110 Vapor Degreasers* - The installation dates of these degreasers is unknown. Both units were removed around 1976. The dimensions of the units were approximately 4 feet by 6 feet by 6 feet deep. According to WVA personnel, one of the units had been located in a section of the building called 110A which was demolished several years ago.

# *Building 120 Vapor Degreaser* - The installation date of this degreaser is unknown. The unit was removed around 1981. The dimensions of this unit were approximately 3 feet by 6 feet by 5 feet deep.

# *Building 130 Vapor Degreaser* - The installation date of this degreaser is unknown. The date that this unit is presumed to have been removed in 1981. The dimensions of this unit were approximately 4 feet by 6 feet by 5 feet deep.

#### 1.3.15.2 Waste Types

Vapor degreasers were used for removing protective oil coatings from the surfaces of metal parts. The parts were placed in a basket, or lowered directly into the degreaser with an overhead hoist. When the degreasing was complete, the basket or part was raised out of the unit, where it was removed and worked on. The units were exhausted to the outdoors. According to WVA, wastes were never placed into these units. However, the units were shut down periodically to remove accumulated sludges and oil. The units used a halogenated solvent suspected to be either tetrachloroethene, trichloroethene, or 1,1,1-trichloroethane.

### 1.3.15.3 Summary of Previous Investigations

- *Building 123 Vapor Degreaser* - Approximately 200 feet north of the unit=s former location, a recovery well (RW-2) was installed as the result of an underground diesel fuel oil line leak. According to WVA, various monthly and quarterly sampling of this well since June 1993 for EPA 503.1 parameters have shown the presence of chlorinated solvents. The recovery operation has been terminated, no additional is conducted at this location as authorized by the NYSDEC.

- *Building 20 Vapor Degreaser* - There have been no previous intrusive investigations completed for this SWMU.

- *Building 110 Vapor Degreasers* - There have been no previous intrusive investigations completed for this SWMU.

- *Building 120 Vapor Degreaser* - Approximately 250 feet south of the former location of this unit is RW-2, installed in 1993. As discussed for Building 123, halogenated organics and other aromatics have been detected, including trichloroethylene and tetrachloroethylene at levels of 32 ppb and 31 ppb, respectively.

- *Building 130 Vapor Degreaser* - There have been no previous intrusive investigations completed for this SWMU.

### 1.3.16 Chip Handling Facility Areas

### 1.3.16.1 Site Location

The locations of each of the chip handling facility areas designated as SWMUs are presented on Plate 1-2.

- *Building 132 South Chip Handling Area* - This area was roughly 50 x 100 feet in size. It has been estimated that up to 80 tons of waste metal chips, or approximately 40 cubic yards, was stored in this area. The exact dates of operation are unknown, but it is believed to have been operational in the mid to late 1950's.

- *Building 123 Chip Handling Area* - According to WVA, the area surrounded by Buildings 121, 122 and 123 was referenced on an old drawing as a chip handling area. A concrete pad exists where the chips were thought to have been stored, and an adjacent rail line implies transportation by that route. The storage capacity of this area is estimated to have been up to 80 tons, or approximately 40 cubic yards.

### 1.3.16.2 Waste Types

These two locations have been identified on the manufacturing section of WVA as being Aoutdoor waste metal chip storage pile≅ areas. Waste metal gun steel chips were generated and placed in these areas, directly on the ground. Various cutting oils coated the chips, which, according to WVA, Adripped off or washed off during storm events.≅

According to the AOil Pollution Source Elimination Study≅ by Cosulich (January 1980), between the late 1950's and 1960's Agrounds at the west end of Building 121 were used as a chip storage area≅ and then up until approximately 1976 Aas a wash rack area for cleaning oil from metal≅. According to the report, the oil was allowed to run into the ground.

In addition, approximately 8,000 gallons of Number 2 fuel oil were spilled from a pipeline leading to a fuel oil storage tank in the vicinity of Building 121. Although an attempt was made to contain the fuel oil spill, oil did seep into the ground.

### 1.3.16.3 Summary of Previous Investigations

# *Building 132 South Chip Handling Area* - Two engineering studies have been completed for this SWMU. In November 1992, Lockwood Greene Engineers, Inc. completed a APreliminary Assessment Screening Report. In June 1993, Huntingdon-Empire Soils completed a soil characterization report. Both reports were completed for the installation of a natural gas line to the arsenal=s boiler plant. Soils contamination for total petroleum hydrocarbons was confirmed at this location. Contaminated soils were excavated as part of the natural gas line installation that was completed from January through March 1994. The soils were removed and disposed of at the Colonie Landfill, Colonie, New York.

# *Building 123 Chip Handling Area* - There have been no intrusive previous investigations completed specifically for this SWMU. However, piezometers and test holes were completed as part of the Cosulich study which indicated the presence of oil in this area. The Aoil impregnating process≅ in Building 121, the diesel oil spill at Building 116, and the chip storage area were all listed as sources of groundwater and soil contamination in this area.

<u>William F. Cosulich Associates, P.C. Report - 1980</u>

William F. Cosulich Associates, P.C. submitted a report to the ACOE entitled Oil Pollution Source Elimination Study, dated January 1980. The study was initiated in November 1978 due to the presence of oil in the WVA storm water drainage system. The report identifies a number of oil spills and conditions at the WVA which have contributed to the presence of oil in the storm water discharge.

In addition to inspection of the manufacturing buildings and collection and analysis of storm sewer samples, subsurface investigations were conducted at three areas; the area around Building 121 where an 8,000-gallon fuel oil release occurred, the fuel oil storage area near Building 136, and the Siberia Area. Building 121 and the fuel oil storage area near Building 136 are located in the main manufacturing area of WVA.

The investigation in the area of Building 121 indicated the presence of oil contamination in the soil and groundwater. Up to four inches of free phase product was observed in the wells, piezometers, and test pits installed in this area. The source of this oil contamination was reportedly due primarily to oil spillage and past operations. A interceptor trench was installed on the north side of Building 121 in 1975 to limit the migration of oil from the source area.

In 1976 an interceptor trench was installed alongside the railroad track that runs northwest of Bldg. 121. This measure was undertaken when an accumulation of water and oil was noted seeping from the ground. The construction of the trench is similar to a french drain, perforated clay pipe in crushed stone. The trench conveys the collected materials and transfers them to the waste soluble oil line. The approximate location of this trench is shown on Plate 1-2.

<u>Environmental Science and Engineering, Inc. - 1987</u>

Environmental Science and Engineering, Inc. prepared a report titled AUpdate of the Initial Installation Assessment of Watervliet Arsenal≅, dated July 1987. A portion of this report concerned remedial measures taken at Building 121. In addition to the installation of an interceptor trench, oil impacted soil was reported removed for hauled off-site for disposal.

### 1.3.17 Chrome Plating Pit Areas

### 1.3.17.1 Site Locations

The locations of the Chrome Plating Pits are marked on Plate 1-2.

# *Building 35 Minor Plating Area* - Four adjacent plating/coating lines occur in a 135x56 foot area in the east-central side of Building 35. The processing tanks in this area range in size from 700 to 2,200 gallons, with most being about 700 gallons. The sumps in the chrome lines are 4 feet by 4 feet by 5.5 feet deep. Other sumps are 1.5 feet by 1.5 feet by 2 feet deep. The plating area operations began in 1983 and are on-going.

# *Building 35 Major Plating Areas* - Four adjacent pits in the southwest corner of Building 35 are identified from west to east as the 120 mm pit (50x60x40 feet deep), the 155 mm furnace pit (40x60x30 feet deep), the 8-inch pit (40x60x30 feet deep) and the new medium tube (NMT) pit (40x60x30 feet deep). Each pit is approximately 25 feet from the next. The four pits are considered to be one SWMU. The 155 mm pit operated from 1952 to 1987 when the pit was converted to an electric oven heat treatment facility. The 8-inch cannon pit began operation in 1976 and is in limited use today. The NMT pit began operation in 1980. The 120 mm cannon pit began operation in 1987. Each pit has a sump which collects spillage, drainage and infiltrating groundwater. The sumps are typically 4 feet by 4 feet by 5 feet deep and hold up to 670 gallons, each of these sumps were lead lined in 1995. Two chrome plating tanks and their sixteen associated tanks which are used for rinse, electropolishing and cleaning, are located in the 120 mm pit. The plating tanks have a capacity of 12,760 gallons. The rinse and cleaning tanks hold 2,800 gallons of fluid. The 8-inch tube pit contains one plating tank and five associated processing tanks. The NMT pit has 2 plating tanks and associated processing tanks. Some groundwater infiltrates through the walls of the pits and is collected at the sumps.

# *Building 110 LC Plating Area* - The LC (liquid chrome) plating area is a deep pit with small individual holding tanks, and is located in the center of Building 110. The shallow half of the pit, 40 feet deep, has been in operation since the 1940's and was renovated from 1982 to 1984. The deeper pit area, 70 feet deep, has been inactive since 1991 because it requires upgrading and equipment repair. The shallow half drains into the deeper half which is then pumped from the sump into the acid waste line for discharge into the industrial wastewater treatment facility. Groundwater seeps into the pit from the walls.

#### 1.3.17.2 Waste Types

The basic function of the units are to collect spillage and drainage from the chromium plating, anodizing, cadmium cyanide (use of this compound was discontinued in 1994), and manganese phosphate lines which contain caustic cleaners, electro-polishing, rinse water, and plating/coating solutions. The sump liquid is pumped to the acid waste line then flows by gravity to the WVA industrial waste treatment plant. Cyanide spillage and drainage is collected separately and delivered to the waste treatment plant by a cyanide waste line. Waste placed into the units include chromic acid and other plating fluids such as caustic cleaners, sulfuric and phosphoric acids; cadmium, nickel, copper, manganese phosphate plating/coating solutions and rinse waters.

#### 1.3.17.3 Summary of Previous Investigations

# *Building 35 Minor Plating Area* - Monitoring wells associated with the chromic acid line repair project by Empire Soils, were sampled in July 1993. These wells are located 100 to 200 feet downgradient from the sump area. Groundwater analyses from these wells (93EM-SP-9, 10, 11 and 12) indicated that no RCRA metals other than lead exceeded the NYS MCL=s. Oil and grease totaled 1.5 ppm.

# *Building 35 Major Plating Areas* - There have been no previous intrusive investigations for this SWMU.

# *Building 110 LC Plating Area* - There have been no previous intrusive investigations for this SWMU.

### 1.3.18 Chrome Plating Scrubbers

#### 1.3.18.1 Site Location

# *Building 114 Chrome Plating Scrubber* - This scrubber was installed in 1978 and is still in operation on an intermittent basis. The scrubber is approximately 3.5 feet in diameter and 6 feet high, and is located inside of Building 114. The working capacity of the scrubber is approximately 75 gallons.

# *Building 110 Chrome Plating Scrubber* - This scrubber was installed in approximately 1975 and is still in operation. The scrubber is approximately 6 feet in diameter and 9 feet high, and is located inside of Building 110. The working capacity of the scrubber is approximately 400 gallons.

# *Building 35 Minor Plating Scrubber* - The scrubber is approximately 10 to 12 feet in diameter and 8 to 10 feet high, and is located inside of Building 35. The working capacity of the scrubber is approximately 1,200 to 1,700 gallons. This scrubber is still in operation.

# *Building 35 South Chrome Plating Scrubbers* - Three scrubbers are located outside of Building 35 and are approximately 10 to 12 feet in diameter and 8 to 10 feet high. Their working capacities are about 1,200 to 1,700 gallons. These scrubbers include the eight inch facility scrubber which has been operating since 1976, a medium tube facility which has been operating since 1985, and a 120 mm facility which has been operating since 1992.

#### 1.3.18.2 Waste Types

The scrubbers are used to remove contaminants entrained in the exhaust air from chrome plating operations, prior to discharge to the atmosphere. The units are equipped with filter media and water wash curtains. Water is continuously recycled in the unit until conductivity probes indicate that fresh water is required. At that point, water and contaminants are automatically discharged to the wastewater treatment plant via the waste acid line. The main contaminant is chromic acid. The scrubbers are variable in size and cylindrical in shape. The scrubbers are located inside/outside of the following buildings:

#### 1.3.18.3 Summary of Previous Investigations

There have been no previous intrusive investigations performed specifically for this SWMU.

## 1.4 CONCEPTUAL SITE MODEL

### 1.4.1 General Overview

Based on the historical information and previous site investigations discussed in Section 1.3, there are several areas where wastes have leaked or spilled, have been stored, collected, or removed, or have migrated through time which could act as sources of contamination. These areas include locations that presently or formerly were associated with vapor degreasers, chip handling areas, plating scrubbers and plating sump areas, process pits, machining operations, waste oil USTs, industrial sewers/waste lines, and the fill associated with the former Erie Canal. Conceptual site models are provided as a visual representation of potential sources of contamination and migration pathways at Buildings 25, 35, and 135 and across the Main Manufacturing Area (Figures 1-10, 1-11, 1-12, and 1-13).

Oil spills have been identified which have contributed to the presence of oil in the soil, groundwater, and storm water discharge. Spillage and past chip storage operations in the Building 121 area are likely to contribute to petroleum contamination. Petroleum spillage was also noted to have occurred in the fuel storage area (Building 136). Numerous underground storage tanks, designated as SWMU locations due to potential leaks, are also possible sources of POL contamination.

The source of volatile organic contamination in soil and groundwater is suspected to be the former vapor degreaser units. The Building 25 degreaser is believed to be the primary source. The Building 20 vapor degreaser is also expected to have contributed to volatile organic contamination, as well as a Zyglo[7] inspection station in Building 25 and individual USTs or drums in which volatile organic compounds were stored. Vapor degreasers that were previously operated upgradient of Building 25, such as the one in Building 110, may also have contributed significantly to volatile organic contamination.

### 1.4.2 Source Characterization

#### 1.4.2.1 Building 25

Figure 1-10 shows the Conceptual Site Model developed for Building 25 prior to implementation of the RFI. Previous investigations have indicated a presence of chlorinated solvents to the east-southeast of Building 25.

The vapor degreaser unit, assumed to be the primary source of volatile organic contamination, was reportedly located along the eastern wall in the southeastern quadrant of the building. Exhaust was vented outside of the building through an exhaust system that was located about seven feet above the ground. The amount of contaminants infiltrating the ground at the exhaust discharge point is estimated to have been small, and was probably insufficient to cause the observed levels of contamination in the soil and groundwater. It is possible that waste solvents from the degreaser were disposed of or spilled directly on the ground outside Building 25, near the degreaser unit location. The area east of the building was reportedly unpaved until the 1960's/1970's and thus would have been unpaved at some time while the vapor degreaser was in operation.

A 2,000-gallon underground storage tank (UST) (SWMU #14), this SWMU was previously a 1,000 gallon waste oil tank, was located on the northeast side of Building 25 (Plate 1-2). It was replaced in 1980 and is currently shared with Building 20. A Zyglo[7] inspection process was conducted in Building 25. In past practices, emulsion from this process was reportedly rinsed off and washed down the previously existing floor drains which lead to the storm drain system. According to WVA personnel, Zyglo[7] inspection is still conducted in Bay O-4, located at the south end of the building in the middle, adjacent to the location of an overhead door. Wastes from this operation are discharged to a sump where it is piped overhead to the IWTP soluble oil collection system, and not to the storm sewer. Approximately one drum of waste is generated per year.

#### 1.4.2.2 Building 35

Manufacturing activities conducted at Building 35 include chrome plating, cadmium-cyanide plating (closed 1994-1995), magnaflux testing, heat treatment, and cannon tube machining. Four process pits for plating and heat treatment are located at the southern end of the building. Much of the remainder of the main floor is used for machining operations. POL contamination was discovered entering the pit, with the groundwater, during the conversion of the chrome plating pit to the Furnace Pit in 1987. After the upper concrete layer of the floor slab and underlying waterproof membrane were removed, POLs were observed seeping into the pit, thus identifying Building 35 as an environmental area of concern at the WVA.

A conceptual site model has been developed for Building 35 and is included as Figure 1-11.

#### 1.4.2.3 Building 135

Leakage from the secondary collection system (machine foundations) in and beneath the floor of Building 135 is suspected to be the primary release mechanism for the cutting oils. The released oil is believed to be present beneath the floor in the subbase, and possibly in the material filling the natural bedrock swale and pipe trenches. Some of the oil is suspected to have migrated to the drainage chases of the Shrink Pit, and subsequently seeped into the pit. The PCBs identified are believed to be constituents of a cutting oil that may have been used in the past at Building 135.

Another potential release mechanism is believed to be leakage from the underground waste pipeline immediately north of Building 135. This potential would be higher prior to the lining of the clay-tile pipes in the mid 1970's. The free product observed in monitoring well 93-EM-SP-13 may be the result of a release and migration from the pipeline in that area, or the migration of POLs beneath the building floor.

It has also been past practice at Building 135 to use the sumps, located beneath some of the machinery, as disposal areas for waste oils. This practice was observed by WVA personnel at the Rotary Forge. A collection system was installed at the forge to collect groundwater seepage and oil, and was therefore designed to be periodically pumped out. However, it was erroneously thought to be a drainage/disposal system ("soak away") by some WVA workers. As a result, WVA personnel disposed of waste oil and glycol there. However, this practice has been discontinued. The rotary forge has since been identified as a separate SWMU.

The capacitors formerly located in Building 135 contained PCBs, as did the hydraulic oils used in the machinery throughout WVA. According to WVA personnel, PCB-containing capacitors were located within the Shrink Pit and many more were located throughout the building. Some of these had reportedly failed and leaked PCB-containing oils onto the floors and equipment in the building. The PCB-containing oils may potentially have seeped directly through cracks in the concrete floor slab or have mixed with the cutting and lubricating oils prior to leaking through the floor slab and migrated towards the Shrink Pit. There are no continuing PCB releases because all PCB-containing capacitors have been removed and replaced with their non-PCB-containing equivalents.

The fracture pattern developed from blasting activities during the excavation of the Shrink Pit would be expected to extend radially outward from the center of explosion, creating a preferred pathway for groundwater and POL movement towards the pit. Indeed, this effect may have been intended since groundwater seepage into the pit is used as the source of cooling water for the shrinkage operation (i.e., blasting served the dual purpose of removing rock for the pit construction and increasing groundwater yield in the bedrock). It is therefore feasible that some POLs have migrated downward, through fractures in the bedrock to the groundwater table, and are migrating towards the pit along the depressed groundwater table caused by pumping at the pit.

In the absence of fractures, contaminant migration within the bedrock would be very limited, confined almost exclusively to the weathered bedrock zone.

A site conceptual model exhibiting the primary potential contamination pathways for Building 135 has been included as Figure 1-12.

#### 1.4.2.4 Main Manufacturing Area

A number of SWMUs have been identified which are not directly connected to activities at Buildings 25, 35 and 135. These SWMUs were deemed as a potential source of contamination during site conceptualization and are included in Figure 1-13.

Building 110, located immediately west and upgradient of Building 35, is a potential source of POL contamination. Numerous areas in and around Building 110 have been associated with evidence of POL spills. WVA utility drawings show underground utilities running from Building 110 toward Building 35. These may provide a preferred migration pathway for POL movement between the two buildings.

Waste oil, chromic acid, and cyanide flow through the industrial sewers to the treatment facility at Building 36. Leaks have been previously detected in portions of this sewer system and were promptly repaired following a stoppage in manufacturing to stop further releases.

A significant potential source of POL contamination is isolated spills upgradient of Building 35. One documented spill is an approximate 8,000-gallon No. 2 fuel oil spill that reportedly occurred between Buildings 110 and 116 in March 1975. POL contaminants associated with that spill may have migrated downgradient toward Building 35.

Four 50,000 gallon underground storage tanks were removed approximately 550 feet northwest of Building 135 in August 1990. They contained No. 6 fuel oil. Investigations conducted in 1979 by W. F. Cosulich Associates, P.C. found that the soil surrounding the four 50,000-gallon underground storage tanks was saturated with oil. These leaks have been associated with fill ports and transfer pipes. During the closure investigation, a hand-held photoionization meter, along with visual evidence of contamination, was used to pin-point the locations for soil removals. Visually contaminated soils removed from around the fill ports and transfer piping areas were taken to a local landfill. Sampling activities consist of monthly visual sampling of monitoring wells 1 through 4 located southwest of Bldg. 136 - Boiler House. A log of this inspection activity is maintained and is available at the ISH office.

Similar manufacturing activities to those at Building 35 were conducted at Building 110. As Building 110 is located upgradient of Building 35, it is considered as an important potential source of the POL contamination observed infiltrating the Furnace Pit at Building 35.

The Main Manufacturing Area locations where historic observations of POL contamination have been made are listed below:

| Location | Date | Description |
|---|---|---|
| Building 116 | March 14, 1975 | Discharge of 8,000 gallons of No.2 fuel oil. Interceptor trench installed/contaminated soils removed. |
| Building 116 | March 10, 1976 | Discharge of 266 gallons of No. 2 fuel oil during filling operation. |
| Building 116/RW-2 | May 13, 1993 | 400 - 500 gallons of diesel fuel discharged from underground distribution line. Recovery system installed. |
| Buildings 136/147 | Early -mid 1980s | Underground distribution line leak. Soils were removed/piping was replaced. |
| Manhole 43D | 1995 | Leakage from the soluble waste oil line near Building 20. Seepage of oil into nearby excavation. Manhole resolved |
| 93-EM-SP-13 | -- | Oil observed during September 1995 sampling. |
| 95MPI-B35-MW-8 | -- | Oil observed during well installation in June 1995. |
| MW-B121S | -- | Installed in 1978 following oil spill. |
| MW-B121N | -- | Installed in 1978 following oil spill. |
| MW-B110 | -- | Oil observed in well during Arsenal-wide investigation in 1995. |

### 1.4.3 Contamination Characterization

In previous investigations at WVA, halogenated hydrocarbons (primarily PCE, TCE, and 1,1,1-TCA), petroleum products, and chromium were found in the groundwater and soil.

#### 1.4.3.1 Chlorinated Organic Compounds

##### 1.4.3.1.1 Building 25

During the CTM investigation (1990), PID field screening (headspace method) observations during soil boring installations at locations downgradient of Building 25 indicated the presence of volatile organic contamination in the area. These borings were located east-southeast of the former vapor degreaser. Elevated concentrations of halogenated hydrocarbons, primarily TCE and PCE, and total xylenes were detected in collected soil samples, all below the soil cleanup guidance TAGM. Details of the investigation are discussed in Section 1.3.3.

Concentrations of halogenated hydrocarbons (TCE and TCA) exceeding their NYSDEC Class GA groundwater standard of 5 μg/l were detected in monitoring wells downgradient of Building 25.

##### 1.4.3.1.2 Building 35

During previous site investigations, TCLP exceedances for PCE were detected at SWMU 13, adjacent to the southern wall of Building 35 (Section 1.3.6).

##### 1.4.3.1.3 Main Manufacturing Area

Vapor degreasers, the presumed source of the majority of chlorinated organic contamination in the Main Manufacturing Area, were formerly located at six different locations discussed in Sections 1.3.3 and 1.3.15. The existence of chlorinated organic contamination in the groundwater near the degreasers at Buildings 120 and 123 has been confirmed by previous sampling and analysis. (Section 1.3.15).

### 1.4.3.2 Petroleum, Oil and Lubricants

#### 1.4.3.2.1 Building 35

POLs have been observed in the Furnace Pit water at Building 35 and in storm water samples collected from Manhole (MH) 11. It is noted, however, that MH 11 is located upgradient of Building 35 and is therefore more representative of discharge to storm sewer from Building 110.

Soil contamination has not been noted in any previous intrusive studies at Building 35.

#### 1.4.3.2.2 Building 135

POLs are currently present in the groundwater recharging the Shrink Pit. The presence of PCBs in these POLs has been identified through sampling and analysis (Section 1.3.14). POLs have also been identified in machinery sumps within the building, most notable beneath the Rotary Forge and a railroad car service pit.

Storm water samples collected from MH 108, at the northwest corner of Building 135, contained low level concentrations (<3 mg/l) of oil.

A review of related investigation reports did not indicate the presence of visible contamination in the subsurface soils.

#### 1.4.3.2.3 Main Manufacturing Area

POL contamination in the soil has been observed at Building 136 and 147 (Section 1.2.5), Buildings 44 and 110 (Section 1.3.5), the Erie Canal near Manhole 43 (Section 1.3.12), Buildings 121 and 132 (Section 1.3.16),

Oil and grease were detected in groundwater samples collected at monitoring wells installed along the soluble waste oil line southwest of Building 25 between 1990 and 1993, at monitoring wells installed along the soluble waste oil line surrounding Building 135, and in the Motor Pool Yard (Section 1.3.10).

### 1.4.3.3 Inorganics

#### 1.4.3.3.1 Main Manufacturing Area

Chromium concentrations exceeding background concentrations have been found in soils at Building 136.

Groundwater samples collected at monitoring wells near Buildings 35, 121 and 135 have exhibited iron and manganese concentrations above the NYSDOH Maximum Concentration Levels (NYSDOH MCLs), Clough, Harbour and Associates, 1991. However, these concentrations are likely to be due to elevated site background concentrations for these metals.

# 2.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

## 2.1 GENERALIZED TOPOGRAPHY AND GEOLOGY

The Main Manufacturing Area ranges in elevation from approximately 18 feet above mean sea level (AMSL) at the eastern site boundary, along the Hudson River, to approximately 75 feet AMSL in the area of Buildings 135 and 125, along the western boundary of the Main Manufacturing Area. Topography at the site generally slopes gently to the east and west from the topographic high, previously discussed, with exceptions to this noted to the west of Building 135 where the topography decreases sharply form a high of approximately 74 feet AMSL to 50 feet AMSL along the railroad bed leading to the Siberia Area of WVA. Other locations within the Main Manufacturing Area which show marked elevation change are the areas directly to the west of Building 110, which has a 10 foot elevation change in approximately 20 feet, and the area along Westervliet Avenue, directly north of Building 20, where the elevation changes approximately eight feet over approximately 50 feet. The topography of these areas is believed to have significantly altered through the filling and construction activities at the site (i.e., road construction and building foundation construction).

According to the "Surficial Geologic Map of New York - Hudson-Mohawk Sheet, 1987", a majority of WVA is underlain by recent alluvial deposits. The National Cooperative Soil Survey (NCSS) has mapped the native soils on site as a silt loam.

The "Geologic Map of New York - Hudson-Mohawk Sheet, 1970", shows that the site is underlain by the Normanskill Shale of the Lorraine, Trenton, and Black River Groups. This formation is comprised of minor mudstone and sandstone and is dark gray to black in color. However, based on recent field observations, and the absence of sandstone, it is likely that the bedrock beneath the site is the Snake Hill Formation mapped by LaFleur (New York State Geological Association Guidebook, 1961), which is comprised mainly of dark gray shale. This unit lies stratigraphically above the Normanskill Shale. During the site investigations, highly weathered shale was encountered from approximately one to 18 feet below ground surface (bgs). In general, competent bedrock was encountered from approximately 12 to 18 feet bgs. The upper portion of the competent bedrock was found to be fissile and highly fractured with 45 to 60 degree bedding planes. The depth to competent bedrock was based on auger refusal during drilling activities.

## 2.2 GENERALIZED HYDROLOGY AND METEOROLOGY

Groundwater flow at the Main Manufacturing Area is primarily controlled by topography which is coincident with the bedrock surface. The most prominent feature on the potentiometric surface is a hydraulic divide running roughly north to south through buildings 135 and 130. The position of this divide follows the bedrock ridge which has been identified in the area of these buildings, and the site topographic high. Groundwater to the east of this divide flows eastward towards the Hudson River. Groundwater to the west of this divide flows westward towards the Siberia Area.

The depth to the water table is generally greatest in the shallow groundwater monitoring wells at the top of the topographic divide which is coincident with the bedrock ridge. The depth to weathered bedrock is fairly shallow at the divide. Groundwater is typically not found in the overburden near the divide during any portion of the year. However, approaching the eastern boundary of WVA, towards the Hudson River, the depth to bedrock generally increases and groundwater is frequently encountered in the overburden. The general location at which the water table is encountered in the overburden is a north-south trending line in the vicinity of Farley Drive. The majority of the overburden deposits west of Farley Drive are not saturated while those east of Farley Drive are saturated. The GTI wells (87GTI-MW-1BP through -4BP), B135-MW-5 and B135-MW-6 are wells where the overburden is saturated only during portions of the year.

Precipitation which collects on impermeable surfaces in the Main Manufacturing Area of WVA typically is transported down paved streets and into the WVA storm sewer system. The majority of surface water runoff collected in the Main Manufacturing Area is discharged through outfall 003 into the Hudson River. In other areas of the Main Manufacturing Area, storm water is discharged through other outfalls into the Hudson River, onto the Delaware & Hudson (D&H) property, and into the Siberia Area storm sewer system.

Based on data compiled by the National Climatic Data Center (NCDC) between 1965 and 1998, the average annual precipitation for the Albany, New York area is approximately 36 inches per year. The precipitation is evenly distributed throughout the year, with an approximate monthly average of 3.05 inches. The highest average amount of precipitation, 3.69 inches, typically occurs in July. February has the least average amount of precipitation, with approximately 2.35 inches. In the nine months preceding the first round groundwater sampling effort, the average precipitation per month was 2.20 inches, almost an inch less than normal. The impact of the reduced rainfall was apparent in a lower groundwater table elevation as measured during field activities.

During the months after the first round of groundwater sampling but preceding the second round of groundwater sampling (October 1995 through May 1996), the monthly precipitation values were 1.23 inches per month greater than the average monthly precipitation values. During April and May 1996, immediately before sampling, a total of 10.00 inches of precipitation was measured, compared to the average amount of 6.40 inches. This resulted in an even higher than normal water table present during this high water season. During the five months preceding the February 11, 1999 water level measurements, the total precipitation was 2.26 inches above normal. In January 1999, 7.75 inches of precipitation fell, which was 5.39 inches above normal. Groundwater elevations in February 1999 were generally the same as in May 1996.

According to the NCDC, the climate in the Albany area is primarily continental in character, but is subject to some modification by the Atlantic Ocean. In the warmer seasons, temperatures rise rapidly during the day, and fall rapidly after sunset. Winters are usually cold and sometimes fairly severe with maximum temperatures generally below freezing and nighttime lows below 10 degrees Fahrenheit. Sub-zero temperatures occur about twelve times a year. Snowfall is variable. Wind velocities are moderate (mean speed of 8.9 mph) and are usually southerly.

## 2.3 LAND USE

The Main Manufacturing Area is located within a light industrial area and is bounded by residential to the north, residential/light commercial to the south, light industrial/ commercial to the west (Perfection Plating, Shaker Tire Company, former Delaware & Hudson railroad yard, the Siberia Area), and heavier industrial activity located further to the west (former Adirondack Steel). The Main Manufacturing Area is bound on the east by Broadway (Route 32) and interstate highway I-787.

# 3.0 METHODS OF INVESTIGATION

## 3.1 SOIL SAMPLING

### 3.1.1 Background Surface Soil Sampling

Due to the lack of established background concentrations for inorganic parameters, four surface soil samples were collected and analyzed for RCRA Metals. The samples were collected from the golf course area because it is a relatively Aclean≅ area of the WVA where no previous manufacturing has occurred. Sample locations are shown on Figure 3-1.

The four surface soil samples (SS-51 through SS-54) were collected in July 1995. The samples were collected from between 0 and 0.5 feet below ground surface with a stainless steel trowel and bowl. The samples were homogenized prior to being placed in the sample containers. Background samples were analyzed for RCRA Metals only. The results of the background surface soil sampling are discussed in Section 5.4.

### 3.1.2 Subsurface Soil Sampling

A total of 47 soil borings, including 23 Geoprobe soil borings, and 64 groundwater monitoring well borings have been drilled as part of the RFI. To date, a total of 91 groundwater monitoring and recovery wells have been installed in the MMA as part of the various investigations. The locations of the soil borings, monitoring wells, and piezometers are shown on Plate 3-1. For discussion purposes, the year (A95",≅ 96", A97", or A98") and AMPI≅ prefix on the boring and monitoring well locations has been omitted in the text. In general, the subsurface soil sampling was conducted in accordance with the approved Building 25 RFI, Building 35 RFA and Building 135 RFA, and Hydrogeologic Investigation Final Work Plans (February, May, and June of 1995, respectively) and the associated Addendas. However, the depth to weathered bedrock/bedrock was much shallower than expected in some locations, requiring several of the proposed overburden borings to be drilled into the weathered bedrock or bedrock. A discussion on the specific monitoring well/piezometer borings that were effected by the shallow depth to bedrock is included in Section 3.2.

Soil samples were collected from above the water table, except in instances where the water table was less than two feet bgs. No soil sample was collected from AW-MW-25 due to the absence of unconsolidated deposits at this location. Selection of the soil samples was based on visual, olfactory, and field screening photoionization detector (HNu headspace readings). The samples were containerized and analyzed as described in the approved Work Plans. Rocks, twigs, and debris were removed from soil samples being analyzed for volatile organic compounds (VOCs) prior to being placed in the appropriate containers. The remaining portion of the sample was homogenized in a stainless steel bowl and placed into sample containers. Soil boring logs are provided in Appendix B.

#### 3.1.2.1 SWMUs No. 7 through 14

Sixteen soil borings were drilled and sampled to investigate several of the waste oil USTs (SWMUs 7 through 14). Subsurface soil samples were collected at each of the borings except as noted. Soil samples could not be collected from SWMUs 8 and 11 because of the shallow depth to bedrock. According to WVA personnel, the tank pits at these SWMUs were excavated into bedrock. Four samples, two each from SWMUs 9 and 13, had to be re-collected due to exceedance of laboratory holding time for extraction on all but one of the samples. The fourth sample, SWMU-9-2 was broken by the laboratory.

#### 3.1.2.2 Geotechnical Sampling - Building 25

The geotechnical sampling at Building 25 was conducted in accordance with the approved Work Plan with the following exceptions. Only one sample was collected from B25-MW-1 for geotechnical analysis, however, due to the homogenous nature of the soils encountered in this boring, the sample collected is considered representative. At location B25-MW-3, there was insufficient sample recovered by the split-spoon to provide both environmental and geotechnical samples; therefore, the environmental samples were taken from the split- spoon, and the geotechnical samples were collected from the drill cuttings. Cohesive soils, evaluated by Atterberg Limits, were encountered only in B25-MW-2, B25-MW-3, B25-MW-4, and B25-MW-6. As a result, the number of samples analyzed for Atterberg Limits was reduced.

#### 3.1.2.3 Geoprobe Soil Sampling - Building 135 and Erie Canal

Nine Geoprobe soil borings were completed through the floor at Building 135 to assess the depth to bedrock and determine the presence or absence of POLs beneath the slab. Two-inch Macrocore soil cores were collected continuously from the ground surface to the bottom depth of each boring. Each core was examined for visual evidence of POL contamination and field screened with a PID. Soil samples were not collected from these borings. Any visual and/or olfactory evidence of contamination was noted. The approximate locations of the borings are shown on Plate 3-1.

Twelve Geoprobe soil borings were completed in the backfilled Erie Canal near wells 25-MW-5, 25-MW-35, and 25-MW-36 for the purpose of collecting soil samples for chemical analysis to assess any soil contamination associated with the backfill placed in the Canal during decommissioning. Two of the soil borings, WVA-GP-13 and WVA-GP-14, were completed to the water table downgradient of well 86EM-SP-1B, on the site property line, to assess the extent of contamination, if any, in this area. Two-inch Macrocore soil cores were collected continuously from the ground surface to the bottom depth of each boring. Each soil core was visually examined and field screened with a PID. Soil samples were collected from each of the borings, with the exception of boring WVA-GP-14, at which no evidence of potential soil contamination was encountered. Soil samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and RCRA metals.

## 3.2 SOIL GAS SURVEY

A soil gas survey was conducted in the area east of Building 25. The soil gas survey was conducted at 42 locations as shown on Figure 3-2. Soil gas samples were collected from a depth of three to four feet below ground surface on a 50-foot grid spacing. The soil gas locations radiated southeast, east and northeast from the location of the former vapor degreaser unit in order to assess the lateral extent of volatile organic contamination. A copy of the Target Environmental Services report is provided as Appendix C.

Several sample locations identified in the Work Plan could not be sampled due to interference with underground utilities. These locations were: B25-SG-1, B25-SG-2, B25-SG-3, B25-SG-4, B25-SG-5, B25-SG-7, B25-SG-9, B25-SG-18, B25-SG-28, and B25-SG-38. The soil gas grid was expanded to the southeast of Building 25 to include locations B25-SG-51 and B25-SG-52 based on the detection of volatile organics at location B25-SG-41. Additional soil gas points were attempted east and northeast of B25-SG-41, but could not be sampled due to interference with underground utilities.

In addition to the soil gas points in the vicinity of Building 25, four soil gas samples were collected northeast of Building 25 to investigate the lateral extent of volatile organic contamination due to a leak in a segment of the soluble oil line in May 1993. This area is east and southeast of the location of the former vapor degreaser in Building 25. These samples were designated WOL-SG-1 through WOL-SG-4.

## 3.3 MONITORING WELL INSTALLATION

A total of 64 monitoring wells were installed in the Main Manufacturing Area during the RFI. With the exception of the five wells installed as part of the ICMS study performed in the vicinity of Building 35, groundwater monitoring well installation was conducted in three phases. Phase I monitoring wells targeted known or suspected areas of contamination and areas of the MMA which were previously uncharacterized. A total of 39 monitoring wells were installed during Phase I at the following locations:

- Six wells at Building 25 (25-MW-1 through 6);
- Four wells at Building 35 (35-MW-5 through 8);
- Four wells at Building 135 (135-MW-1 through 4); and
- 25 wells in the remaining portions of the MMA (AW-MW-20 through 44).

Phase II monitoring well installation was conducted in 1997. The objective of Phase II was to characterize groundwater conditions in the intermediate or deep bedrock flow zones at locations where contamination was identified in the shallow flow zone during installation and sampling of the Phase I wells. A total of 11 groundwater monitoring wells (AW-MW-45 through 55) were installed in the MMA during Phase II. Well AW-MW-55 was installed along the property line in the vicinity of Building 135 to monitor shallow groundwater conditions in the area.

Phase III monitoring well installation was conducted in 1998. A total of nine groundwater monitoring wells (AW-MW-56 through 64) were installed in the MMA during Phase III. With the exception of wells AW-MW-56, AW-MW-57, and AW-MW-63, the objective of the Phase III monitoring well installation was to further characterize zones of elevated VOC concentrations in the intermediate and deep bedrock flow zones which were discovered during installation and sampling of the Phase II wells. Well AW-MW-63 was installed to monitoring shallow groundwater conditions along the northwester property line. Overburden wells AW-MW-56 and AW-MW-57 were installed to further characterize shallow groundwater conditions downgradient of Manhole 43.

As mentioned above, a total of five wells, four bedrock piezometers (P-1 through 4) and one recovery well (PW-1), were installed in the vicinity of Building 35 as part of the ongoing ICMS study.

Monitoring well locations are shown on Plate 3-1. Monitoring well descriptions including total depths, screened intervals, and screened lengths are provided in Table 3-1.

### 3.3.1 Installation Methods

In general, well installations were conducted in accordance with the approved Building 25 RFI, Building 35 and Building 135 RFA, and Hydrogeologic Investigation Final Work Plans and associated Addenda. However, due to the shallow depth of weathered bedrock/bedrock, many of the proposed overburden wells were installed as weathered bedrock wells or bedrock wells. Proposed overburden monitoring wells which were installed as weathered bedrock wells were AW-MW-23, AW-MW-25, AW-MW-27, AW-MW-30, and AW-MW-32. Proposed overburden monitoring wells which were installed as bedrock wells were AW-MW-22, AW-MW-26, AW-MW-28, AW-MW-29, AW-MW-38, AW-MW40, B135-MW-2, B135-MW-3, B135-MW-4, B35-MW-5, B35-MW-7, and B35-MW-8. Monitoring well AW-MW-41 was a proposed weathered bedrock well. However, groundwater was not encountered at the proposed depth and was converted to a bedrock well.

In order to further characterize specific zones of known or suspected VOC contamination, bedrock monitoring wells AW-MW-48, AW-MW-51, AW-MW-52, AW-MW-53, AW-MW-54, AW-MW-58, AW-MW-59, AW-MW-60, AW-MW-61, and AW-MW-62, were installed during Phases II and III using a discrete zone groundwater characterization method, as outlined in the Work Plan Addendum. This installation method involved the following procedures. Boreholes were advanced to a depth equivalent to the total depth of the existing bedrock well in the cluster by augering through the overburden and weathered bedrock and drilling through the competent bedrock. Upon reaching the target depth, the borehole was advanced with HQ coring. The well was then sampled after each 20 foot corehole advance to assess the groundwater quality using an inflatable packer system with an attached bladder pump. Samples were collected from the packer assembly and analyzed for volatile organics. The casing for each well was installed when a decrease in the concentration of volatile organics was detected. A 10 to 15 foot open rock section was then drilled below the cased interval. Monitoring well AW-MW-61 was installed utilizing a triple-casing construction to prevent groundwater from the overburden, shallow, and intermediate bedrock from entering the open interval of this deep bedrock well.

In addition to the monitoring wells, two piezometers were to be installed: one inside and one outside of Building 135. The piezometer inside the building (PZ-1) was converted to a monitoring well (B135-MW-1) and installed to a depth of 120 feet bgs due to the lack of shallow groundwater encountered during installation. The piezometer scheduled to be installed outside the building (PZ-2) was advanced to a depth of 20 feet bgs and was grouted due to the lack of groundwater at this depth.

During the course of the investigations, bedrock cores were obtained from several of the monitoring well borings. Information obtained from the bedrock core included percent recovery, RQD, bedrock classification, and soundness (i.e. competency) of the bedrock. Boring logs are included in Appendix B. Monitoring well construction diagrams are included in Appendix D.

### 3.3.2 Well Development

Development activities at the newly installed monitoring wells were conducted according to procedures outlined in the approved Work Plans. However, due to the slow recharge rates at several of the wells, the criteria for well development was adjusted by Malcolm Pirnie and the USACE. The revised criteria included, a) to remove as much silt as possible from the well, b) to obtain a turbidity level less than 50 NTU=s, and c) to purge five well volumes. Every reasonable effort to obtain these goals was made during field activities. However, in several instances the criteria were not met, development was considered complete when a total of five hours of development had been completed. These deviations from the Work Plan were discussed with the USACE, USEPA and the NYSDEC and approved prior to implementation. Well development logs are presented in Appendix E.

## 3.4 GROUNDWATER SAMPLING

### 3.4.1 Sampling Locations and Analyses

Four rounds of groundwater samples were collected from the newly installed and existing monitoring wells (Plate 3-1). Round 1 of sampling was completed in September 1995 and included all wells installed at the MMA as of that date. Round 2 was completed in May and June 1996. Round 2 included the same wells sampled during Round 1. Round 3 of groundwater sampling was completed in October 1997. Round 3 included all wells installed during Phase II monitoring well installation and the associated monitoring wells in each well cluster. Round 4 was completed in 1998 and included all wells installed during Phase III monitoring well installation and the associated wells in each well cluster. Grab groundwater samples were also obtained from the Geoprobe boreholes drilled in the Erie Canal area in February 1998. All groundwater sampling was conducted in accordance with the approved Work Plans, with the exception of the procedures outlined below. Each well was purged with either a dedicated Teflon bailer, a check valve attached to polyethylene tubing, or a centrifugal pump with polyethylene tubing.

Groundwater samples collected during Round 1 were analyzed for VOCs, SVOCs, pesticides and PCBs, total and dissolved RCRA Metals, total and dissolved hexavalent chromium, and cyanide. In addition, a sample of the LNAPL discovered in well B35-MW-8 was collected for petroleum identification analysis.

Groundwater samples collected during Round 2 were analyzed for VOCs, SVOCs, pesticides and PCBs, and total inorganics. In addition, groundwater was collected for dissolved inorganic analysis at locations listed in the Second Round of Groundwater Sampling Addendum (May 1996). The following samples were also analyzed for diesel range organics (DRO) analysis: AW-MW-24, AW-MW-27, AW-MW-30, MW-B121S, and RW-2.

Round 3 groundwater samples were collected from 40 monitoring wells, including all monitoring wells installed during Phase II monitoring well installation, with the exception of AW-MW-52, which was purged to dryness and did yield water for over one month following purging.

All groundwater samples collected during Round 3 were analyzed for VOCs. In addition, groundwater samples collected from selected wells were analyzed for SVOCs, total and dissolved RCRA metals, and DRO as follows:

# Groundwater from wells 93EM-SP-13, 93EM-SP-14, 93EM-RW-2, 35-MW-8, AW-MW-41, AW-MW-45, AW-MW-48, and AW-MW-55 were analyzed for SVOCs;

# Groundwater from wells AW-MW-45 through 55 (with the exception of AW-MW-52) were analyzed for total and dissolved RCRA metals; and

# Groundwater from wells 93EM-SP-13, 93EM-SP-14, 93EM-RW-2, 35-MW-8, AW-MW-24, AW-MW-41, AW-MW-45, AW-MW-48, and AW-MW-55 were analyzed for DRO.

Round 4 groundwater samples were collected from 11 monitoring wells, including all monitoring wells installed during Phase III monitoring well installation. All groundwater samples collected during Round 4 were analyzed for VOCs. Selected groundwater samples were also analyzed SVOCs, Pesticides and PCBs, total and dissolved RCRA metals, and natural attenuation parameters as follows:

# Groundwater samples from wells AW-MW-56, 57, and 63 were analyzed for SVOCs as well as total and dissolved RCRA metals;

# The groundwater samples from well AW-MW-63 was analyzed for Pesticides and PCBs; and

# The groundwater samples from wells AW-MW-33, 34, 51, 58, 59, 60, 61, and 62 were analyzed for various natural attenuation parameters.

Groundwater samples were collected from all Geoprobe borings installed in the Erie Canal/Building 25 area with the exception of borings WVA-GP-4 and WVA-GP-5, where groundwater was not encountered. All Geoprobe groundwater samples were analyzed for VOCs, SVOCs, and total RCRA metals.

The locations of the groundwater sampling points are shown on Plate 3-1. A copy of the purge logs for Rounds 1, 2, 3, and 4 of groundwater sampling are presented in Appendix F. Purge logs were not generated for Geoprobe groundwater samples since these were grab samples collected directly from the borehole.

### 3.4.2 Inadequate Recharge

Due to inadequate groundwater recharge rates, a sample volume sufficient to allow for all intended analyses was not available for collection at some sampling locations. If sufficient volume could not be obtained, groundwater samples were collected for analysis in the following order: VOCs, SVOCs, pesticides and PCBs analysis, and then inorganics analysis (including hexavalent chromium during round one). Groundwater samples for VOC analysis were collected as soon as enough groundwater entered the well after purging was completed. Samples for the remaining analyses were subsequently collected over a period which did not exceed two days.

During the first round of groundwater sampling, there were several samples that were not collected due to inadequate recharge. At AW-MW-20, groundwater could not be collected for SVOC, pesticide and PCB, and inorganic analyses. At AW-MW-32, groundwater could not be collected for pesticide and PCB analysis. At AW-MW-36, groundwater could not be collected for SVOC, pesticide and PCB, and inorganic analyses. Also, there was only sufficient volume of LNAPL in B35-MW-8 to collect a sample for volatile organics.

During the second round of groundwater sampling, there were also several locations where the intended groundwater samples could not be collected due to inadequate recharge. Groundwater samples could not be collected for pesticide and PCB analysis at AW-MW-29, AW-MW-33 and

AW-MW-36. In addition, at AW-MW-36, a groundwater sample could not be collected for inorganic analysis.

During Round 3, a groundwater sample could not be collected from AW-MW-52 since this well took over one month to yield water after being purged to dryness.

## 3.5 PROCESS PIT SAMPLING

Two rounds of process pit water/floating product samples were collected from the Shrink Pit at Building 135, and the Furnace, New Medium Tube, and 8-inch Gun Pits at Building 35 (Plate 3-1). These sampling events coincided with groundwater sampling. The work was conducted in accordance with the approved Work Plans, with the exception of the procedures outlined below.

During the first round of sampling, samples were collected from the water and floating product present in the Shrink Pit at Building 135. Collection of the floating contamination layer samples was modified from the procedures outlined in the Work Plan because the product thickness was too small to collect samples with a pump. Attempts to collect samples using a bailer failed and therefore, the existing dedicated product recovery system was used to obtain samples instead of the proposed peristaltic pump. There was no floating product present during the second round sampling event.

Samples were collected from the water and floating product layer from the Furnace Pit sump in Building 35. In addition, water samples were collected from two of the process pits at Building 35. Sample collection followed the procedures outlined in the Work Plan, except where field conditions required that modifications be made. Samples were collected with a dedicated Teflon bailer and a dedicated pond sampler from the New Medium Tube and 8-inch Gun Pits, respectively. The use of the pond sampler at the 8-inch Gun Pit was necessary to collect a sample from the shallow waste stream which was entering the sump because sampling from the pit sump itself was impossible due to access constraints.

Samples of pit water collected during both sampling events were analyzed for the same parameters as the groundwater samples collected from the wells at that time. During the first round sampling, the floating product was analyzed for volatile organics, semi-volatile organics, PCBs, hexavalent chromium, cyanide, and RCRA metals (unfiltered). Analysis for the second round sampling included volatile organics, semi-volatile organics, PCBs, glycol, and RCRA metals (unfiltered).

## 3.6 HYDRAULIC CONDUCTIVITY TESTING

After the wells had fully recovered from the first round of groundwater sampling, hydraulic conductivity tests were performed at a majority of the newly installed wells. Two types of hydraulic conductivity tests were performed: rising head tests at the overburden wells and packer tests at the bedrock wells.

Rising head tests were performed by introducing a Aslug≅ of known volume into the wells, allowing the water level to equilibrate, then removing the Aslug≅ and measuring the rise of the water level. The change in water level with time was monitored and recorded by a pressure transducer linked to a data logger.

Packer tests were conducted using the constant-pressure-injection test. Falling-head tests were not used because the zones to be tested were not completely saturated. The zone to be tested was isolated with inflatable packers and potable water was pumped into the isolated section under a fixed pressure. The quantity of water which entered the formation with time was measured. The test was run until stabilization occurred; that is, three or more readings of water intake and pressure taken at five-minute intervals are essentially equal. Packer tests were also performed in several of the bedrock wells installed during Phases II and III of monitoring well installation.

## 3.7 INVESTIGATION DERIVED WASTES (IDW)

All drill cuttings and spoils were contained in U.S. Department of Transportation (DOT)-approved 55-gallon drums. Based upon the analytical results obtained from soil samples collected during the investigations, nine drums were potentially hazardous for lead, two for arsenic, and ten drums contained soil which had an odor. From these drums, three composite samples were collected and analyzed for TCLP and PCBs. Samples collected for VOC analysis were not composited/homogenized. The soil samples were determined to be non-hazardous and IDW was disposed of at the Town of Colonie Landfill.

Drilling water and groundwater were placed on the ground or in drums at the direction of the NYSDEC. The water contained in the drums was discharged to the ground surface in the Siberia Area after evaluating the analytical results. Disposal of the IDW was approved by the NYSDEC and the USEPA. A summary of the drums of investigation derived wastes generated during the field investigations is presented in Appendix G.

## 3.8 BOREHOLE GEOPHYSICAL SURVEY

A borehole geophysical survey was conducted by Colog, Inc., under subcontract to Malcolm Pirnie, in 17 bedrock groundwater monitoring wells across the MMA in late October/early November 1997. The objective of the borehole geophysical survey was threefold: 1) to determine the presence or absence of any water bearing linear features (i.e., fractures or bedding planes) in the wells; 2) to evaluate the magnitude and orientation of these features, if encountered; and 3) to aid in locating the additional bedrock monitoring wells installed during Phase III of monitoring well installation.

The investigative techniques used during the borehole geophysical survey were standard video logging, temperature and fluid resistivity logging, and enhanced video logging using the Borehole Image Processing System (BIPS). BIPS utilizes panoramic high resolution video to image the entire circumference simultaneously, thus making it possible to determine the orientation, magnitude, and distribution of fractures, bedding planes, and other linear features which intersect the borehole. The results of these investigations are presented in Section 4.0, of this document.

# 4.0 GEOLOGY AND HYDROGEOLOGY

## 4.1 GEOLOGY

### 4.1.1 Surface Soils

Surface soils in the manufacturing area have been mapped by the National Cooperative Soil Survey (NCSS) as one of three distinct units. Surface soils in the southern and western portion of the site, the area where the majority of manufacturing is done, has been classified as Ur. The northeastern portion of the area, containing the majority of residences, the golf course, the swimming pool area, and a softball field is classified as NaB. A small natural area in the block between AW-MW-22 and AW-MW-25 has been classified as NaC.

Ur is classified as Aurban land≅ and described as typically being at least 85 percent impervious to infiltration and having a slope of 0 to 15 degrees. Areas of miscellaneous fill are included within this unit by definition. The NCSS notes that these areas are often the result of several feet of fill being placed in a wetland, stream or flood plain.

NaB is classified as ANassau channery silt loam, undulating.≅ The NCSS has described this soil as a dark grayish brown channery loam about eight inches thick underlain by a yellowish-brown very channery silt loam of similar thickness. This soil is typically found on bedrock controlled ridges and plains, is somewhat excessively drained and ranges in slope from 3 to 8 percent. The bedrock beneath these soils is very shallow, typically at a depth of sixteen inches.

NaC is classified as ANassau channery silt loam, rolling.≅ This soil is very similar to NaB and the only obvious difference is that it is typically found on slopes of up to 15 percent. The location of each surface soil type at Watervliet Arsenal is marked on Figure 4-1 (Sheet 14, Soil Survey of Albany County, New York, USDA, 1992).

### 4.1.2 Overburden

The major overburden unit identified in the Main Manufacturing Area has been described as fill, consisting of brown or dark gray silty sand with angular gravel. Fill was primarily used along the eastern edge of the Main Manufacturing Area near Route 32, along Dallisa and Westervelt Avenues, each of which where built up in order to have a gentle slope towards the front of WVA, and to level out the ground surface around and beneath the large buildings. Results of the grain size analyses, from samples collected in the area of Building 25 (B25-MW-4 and B25-MW-6) indicated that sand was the primary constituent of the fill at both locations, ranging from 49.6 percent at B25-MW-6 to 66.1 percent at B25-MW-4. Gravel averaged 24 percent, silt 11 percent and clay 10 percent. The fill in the former Erie canal is composed of very dark grayish brown sand and gravel and includes wire conduit, gravel, charcoal, glass, and wood. The generalized geologic data shown on the hydrogeologic cross-sections presented on Plates 4-2 through 4-7 show that fill materials are present throughout the Main Manufacturing Area with the thickest amount of fill being in the eastern portion of the Main Manufacturing Area as previously discussed.

The fill material is the only unit consistently found throughout the site. Underlying the fill are the following native overburden units: a fine grained alluvium, a coarser alluvium, and glacial till. As can be seen in the generalized cross-sections, located in plan view on Plate 4-1, and presented on Plates 4-2 through 4-7, and the building specific geologic cross-sections, Figures 4-2 through 4-7, these units are not present in all areas of the site. The following is a discussion of the composition of each overburden geologic unit encountered below the fill material, the unit discussions have not been presented in stratigraphic order due to the reason previously stated.

The fine grained alluvium is characterized as being an olive-tinged dark brown or gray clayey silt with traces of fine sand and fine gravel reaching a maximum thickness of approximately three feet at AW-MW-35. This unit is similar in appearance and composition as the clayey silt unit encountered during the investigations in the Siberia Area of WVA. As shown on Plates 4-2 through 4-7, the majority of the clayey silt unit encountered is in the eastern portion of WVA, towards the Hudson River, below an elevation of approximately 40 feet AMSL.

The coarse grained alluvium deposit at the site consists primarily of brown or reddish-brown sand with fine gravel and occasional traces of silt. This unit is primarily found in the area of Buildings 25 and 35 on the eastern portion of WVA. The maximum thickness, of 7 feet, was encountered at B35-MW-5, as shown on Figure 4-2. This unit, other than the fill material, was the most consistently encountered unit at the site, and the only native geologic unit to be encountered at the ground surface, in the area of the wastewater treatment plant, at wells SP-7 and SP-3, as shown on Figure 4-4. The average composition of this unit, as indicated by samples collected and analyzed from B25-MW-1 and B25-MW-4, is 40 percent sand, 26 percent gravel, 16 percent silt, and 18 percent clay.

The third overburden unit encountered at the site is glacial till, described as mottled olive-gray silty sand and subangular to subrounded gravel. The maximum thickness of the till is approximately 8 feet and was encountered in the area of monitoring well B25-MW-6, Figure 4-5. The till encountered at WVA is typically separated from the underlying bedrock by a thin layer of what is described as alluvium, as shown on Figures 4-3 and Plates 4-2 through 4-7. The presence of alluvium directly below the till may be attributable to partial erosion of the alluvial layer during deposition of till or erosion of glacial till in an upstream area and deposition of blocks of till in the form of Arafts≅ in the area of WVA. These phenomenon would explain the presence of the till above alluvial units in certain areas of the site.

West of the bedrock ridge, overburden thickness is minimal (Plates 4-2 through 4-7). Native overburden was not encountered in any of the borings drilled at Building 135, the 87GTI wells, or Malcolm Pirnie wells in the central portion of the manufacturing area (AW-MW-39/AW-MW-40) or along the northern edge of the site (AW-MW-25 or AW-MW-26). The fill materials in these locations are typically less than five feet thick. Only in the area around Building 135 are overburden (fill) thicknesses of greater than five feet encountered. At SP-14 the overburden is 11 feet thick, at B135-MW-4 (Figure 4-6) the overburden was five feet thick in the initial boring, and at B135-PZ-2 the overburden was seven feet thick. The thicker occurrence of overburden at B135-PZ-2 is thought to be related to a subslab swale filled with well-sorted sand to provide a base for the concrete slab at Building 135. The location of this swale has been identified in aerial photographs taken in 1939 (Figure 1-5) and a contour map from June 1942. Due to the observed overburden thickness and the location of B135-PZ-2, it is suspected that this boring is located along the southeast edge of this swale. It should be noted that to the west and within 20 feet of B135-MW-2 there are outcrops of weathered shale bedrock.

The thickness of the overburden at a particular location is directly related to the distance between that location and the bedrock ridge. As shown on Plates 4-2 through 4-7, the thickness of the overburden deposits increases from west to east with the thickest amount of overburden being encountered at AW-MW-21. Conversely the thinnest amount of overburden was encountered at the top of the bedrock ridge in the area of AW-MW-39.

Complete boring logs are included in Appendices A and B of this report.

### 4.1.3 Bedrock

The bedrock underlying the site is a black, medium-hard, laminated shale, showing some characteristics of minor metamorphism. This shale has been identified as part of the Snake Hill Formation. The Snake Hill Formation has been described as heavily folded, and the effects of this were noted during split-spooning as the shale displayed bedding planes at angles as high as 70 degrees. During coring, nearly vertical fractures were often encountered. The lack of mineralization, aside from occasional calcite and pyrite deposited secondarily by groundwater, tends to support the observation that little metamorphism has taken place, although outcrops near AW-MW-29 show some quartzites and slaty cleavage.

The bedrock beneath WVA has previously been reported as Normanskill Shale in some prior investigations. This designation is consistent with the Bedrock Geological Map of New York State, Hudson-Mohawk Sheet, published by the New York State Museum and Science Service in 1970, as shown on Figure 4-8. However, the Normanskill Shale is described as a shale interbedded with thick sandstones, which does not match the observations made during bedrock coring during this investigation. The bedrock cores more closely resemble the Snake Hill Formation mapped by LaFleur and published in the New York State Geological Association Guidebook in 1961. This classification is supported by the Generalized Bedrock Geology of Albany County map, New York State Museum. (Fickles, R.H., 1982, Generalized Bedrock Geology of Albany County, New York. N.Y. State Mus. Lft. 25.) It is believed that the classification of the bedrock immediately beneath the Main Manufacturing Area is to the Snake Hill Formation.

The bedrock can be described in three ways, based on the degree of weathering observed. The first is an extremely weathered zone approximately four feet thick. Split-spoons collected from this zone were filled with gravel sized shale fragments. These fragments were often oriented at near vertical angles. This extremely weathered bedrock unit was encountered at depths ranging from near ground surface at AW-MW-27 to approximately 20 feet bgs at AW-MW-31, as shown on Plate 4-3, 4-5, and 4-7. Typically it is described as either shale fragments containing interstitial clay and silt, or as clay or silt containing shale fragments. Complete boring logs are provided as Appendices A and B.

Beneath this extremely weathered bedrock is a zone of less weathered shale showing minimal competency. Augers could drill five to ten feet into this weathered zone before encountering competent bedrock. Bedrock cores collected from this zone generally had RQD=s below 20 percent. Coring in this zone was often interrupted by core blockages.

Competent bedrock was generally encountered at depths ranging from approximately 1.5 feet bgs at SP-13 on the bedrock divide to 18 feet bgs at SP-1 (Plates 4-2 through 4-7). Typically, competent bedrock was encountered at shallower depths and at higher elevations, as the bedrock ridge is approached. Competent bedrock had reported RQD=s frequently in the 80 to 90 percent range. The top of the competent bedrock surface is presented on Plate 4-8, which illustrates the bedrock ridge which trends approximately north to south in the western portion of WVA.

Within the MMA, two monitoring wells encountered what appears to be either a different geologic unit or a more massive section of the Normanskill Shale. This variation within the bedrock at the site was noted during the third phase of the site investigation. Bedrock cores collected from MW-61 indicated a significant increase in the RQD values reported for the bedrock cores collected from 120 to 140 feet bgs and the cores collected from 140 to 160 feet bgs. This variation in the bedrock was also noted during the collection of groundwater packer samples during the well installation. The upper sample interval during collection (120 to 140 feet bgs) yielded groundwater during purging, and the depth to water did not change significantly during the purging activities.

However, during the purging of the lower sample interval (140 to 160 feet bgs) no significant yield of groundwater was noted, and during purging, the sample zone purged to dryness. Analytical data for the packer sample intervals, noted above, were also significantly different indicating that there is limited hydraulic connection between the two zones.

This "boundary" is also evident, to a lesser extent, in the MW-52 area. At this location, the main lines of evidence are the groundwater elevation data and slow rate of recharge to the well. The RQD data collected from this location did not show as significant a change between the cased section of the monitoring well and the open, completed section, of the monitoring well.

A third monitoring well, DEC-3, located in the Siberia Area of Watervliet Arsenal, also shows evidence of the "boundary". This well exhibits water levels below sea level and has exhibited slow recharge, significantly slower than other bedrock wells at the Siberia Area.

#### 4.1.3.1 Linear Features

As discussed in Section 3.8, a borehole geophysical survey was conducted in 17 monitoring wells located across the MMA. The objective of the survey was to characterize the extent, orientation, and magnitude of linear features (i.e., bedding and fractures) which intersect each of the well boreholes investigated. As part of the survey, Borehole Image Processing System (BIPS) high resolution panoramic video logging and standard video logging were used to identify fracture and or bedding plane magnitude and orientation. In addition, standard temperature and fluid resistivity logging were used to identify areas where groundwater recharge was occurring into the borehole. The results of the geophysical survey are presented in Appendix M.

Linear feature orientations derived from the BIPS survey and video logs are presented on Plate 4-9. Plate 4-9 shows linear features in both polar stereographic projections of each linear feature in each borehole as well as rose diagrams. As shown in Plate 4-9, and the with exception of well AW-MW-45, the primary direction of all linear features encountered in the well boreholes is to the east at an average dip direction of 100 to 110 degrees. Monitoring well AW-MW-45, which is located west of the topographic high and the groundwater divide, shows a dip direction to the west at an angle of approximately 125 degrees. This data corresponds to the direction of groundwater flow as delineated from water level measurements and discussed further in Section

4.2.2, and the groundwater flow does not exhibit flow control in a secondary direction from fracture orientation. Figure M-1 (Appendix M) shows a rose diagram which was produced for all linear features measured in the well boreholes. Based on this figure, the average angle of dip across the site is approximately 60 degrees. It should be noted that, in general, the dip angle of the linear features encountered in the shallow bedrock zone were steeper than those of the deeper bedrock zone, which may be potentially related to the weathering of the upper bedrock.

In addition to the collection of linear feature orientation and direction, the BIPS survey also assessed the magnitude of each feature as it relates to potential water bearing capacity. Each feature was assigned a rank based on the potential for groundwater flow through or from the feature. For example, a bedding feature with no visible openings was assigned a rank of “0” (the lowest rank), signifying that no flow was possible at that depth location. Likewise, a major fracture zone with large visible openings, if encountered, would be assigned a rank of “5” (the highest rank), indicating that this feature was capable of conducting large quantities of groundwater. The highest rank assigned to any fracture in the MMA survey was “3”, which indicates an open feature. The BIPS ranking system is presented graphically in Appendix M.

Plate 4-10 shows the depth and orientation of potential water-bearing fractures (ranks 1 through 3) in cross-section view at each survey location. As shown on Plate 4-10, potential water-bearing fractures occur at depths no greater than approximately 86 feet bgs, with the majority occurring between approximately 15 to 40 feet bgs.

Table M-1 (Appendix M) presents a summary of depth, dip direction, and dip angle of all linear features logged during the BIPS survey. As shown in Table M-1, 87.6% of the 427 features logged by the BIPS survey were assigned a rank of “0”. The remaining 12.4% were assigned ranks of “1” through “3”, with 9.4% assigned a rank of “1”, 1.6% assigned a rank of “2”, and 1.4% assigned a rank of “3”. Rank 1 features were found at depths ranging from approximately 13 to 86 feet bgs. Rank 2 features were found at depths ranging from approximately 17 to 67 feet bgs. Rank 3 features were found at depths ranging from approximately 14 to 24 feet bgs.

Plate 4-10 and Table M-1 show that, as expected, both the number and magnitude of potential water-bearing fractures (Ranks 1 through 3) decrease with depth. This indicates that the preponderance of groundwater flow in the bedrock is occurring in the shallow and intermediate flow zones.

Table M-1 also presents the average dip directions and dip angles for each feature Rank. As shown in the table, bedding features (Rank 0) have an average dip direction of approximately 113 degrees (i.e., generally east), with an average dip angle of 47.4 degrees (where 0 degrees is horizontal and 90 degrees is vertical). The potential water-bearing fractures, however, have an average dip direction of approximately 174 degrees (i.e., south), with an average dip angle of 38.1 degrees, which is shallower than that of the bedding features. The southerly fracture dip direction does not appear to affect local groundwater flow directions since, as shown in the shallow and intermediate potentiometric contour maps (Plates 4-11 though 4-14), and the hydrogeologic cross-sections (Plates 4-2 through 4-7), the documented direction of groundwater flow is to the east, towards the Hudson River. It should also be noted that, as shown on Plate 4-10, several of the fractures cross-cut each other (i.e., two or more fractures with nearly opposite dip directions exist in the same section of the borehole). For example, in well AW-MW-35, two fractures with dip directions of 107 degrees and 296 degrees, respectively, were found at nearly the same elevation (10.16 ft amsl). This cross cutting of the fractures indicates that groundwater traveling through the fractures will travel a tortuous flow path, both in a vertical and horizontal direction, making interpretation of the hydrogeologic and chemical data difficult.

Temperature and fluid resistivity logs collected during the geophysical survey are also contained in Appendix M. As shown in the logs, definite zones of groundwater recharge into the well boreholes, which would be indicated by significant temperature or conductivity anomalies, were not evident. This shows that recharge of groundwater into the boreholes is either occurring slowly (i.e., the recharge is slow enough to allow the recharging water to equilibrate with the water in the borehole without creating a temperature or conductivity anomaly) or that there are no distinct zones of groundwater recharge (i.e., significant flow through fractures). This concurs with field observations of borehole recharge rates which were noted during well development and purging.

## 4.2 HYDROGEOLOGY

### 4.2.1 Surface Hydrology

The majority of the Main Manufacturing Area is relatively impervious to rainfall. Only in the residential and recreational areas of the northeastern portion of WVA is infiltration of surface waters expected due to the presence of grass cover in these areas. Infiltration of surface water also occurs in the recharge area where asphalt is absent and bedrock is exposed at the ground surface.

The precipitation which collects on relatively impermeable surfaces in the manufacturing area of WVA is typically transported down paved streets toward storm sewer grates. The surface topography at WVA exhibits a divide which trends approximately north-south through the middle of Buildings 135 and 130 and is coincident with the bedrock ridge present in this area.

Precipitation or runoff north of Building 40 or northeast of Building 1 is discharged into the Hudson River through small, local outfalls (007). In the region near the main gate, near AW-MW-20, surface water discharges through outfall 008. The majority of surface waters in the southern portion of WVA and east of the topographic divide is discharged through outfall 003 near the AW-MW-33/AW-MW-34 cluster. Surface water in the parking lot south of the sludge beds near the wastewater treatment plant is discharged to the Hudson River through outfall 009. West of the topographic divide, near Buildings 135, 125 and 136, surface water discharges to the D&H railroad yard through outfall 006 and eventually reaches the Kromma Kill, a Class D surface water body, as overland runoff. Surface water west of topographic divide, but north of Building 125 is discharged into the Siberia Area sewer system.

### 4.2.2 Groundwater Hydrology

Due to the shallow depth to bedrock and the limited amount of overburden in several areas of WVA, as shown on Plates 4-2 through 4-7, groundwater was encountered within different geologic units (overburden, weathered bedrock, or bedrock) depending on the drilling location. Because of this, Plates 4-11, 4-12, and 4-13 represent the potentiometric surface of the first water bearing unit encountered during drilling of the monitoring wells. As an example, groundwater is encountered in the bedrock at the western end of WVA, however, as you progress eastward, groundwater was encountered in the weathered bedrock and then in the overburden deposits. The only area at WVA which has sufficient saturated thicknesses of individual geologic units and hydraulic data to construct individual potentiometric maps for overburden, weathered bedrock, and bedrock, is in the vicinity of Building 25.

Groundwater flow in the Main Manufacturing Area is primarily controlled by both the bedrock topography and the degree of fracturing within the bedrock itself. The most prominent feature on the potentiometric surface is a groundwater divide trending approximately north to south through Buildings 135 and 130. This feature appears to mirror the bedrock ridge which is shown on Plate 4-8, top of bedrock contour map. As shown on Plates 4-2 through 4-7, the primary discharge for groundwater from the Main Manufacturing Area is to the Hudson River which is located to the east of WVA. As shown on Figures 4-9 through 4-17, for the area surrounding Building 25, each of the potentiometric maps shows that groundwater in each of the hydrostratigraphic units, flows from west to east towards the Hudson River, with a component of flow to the northeast. Plates 4-2 through 4-7 show that west of the groundwater divide shallow groundwater flow discharges towards the Kromma Kill. These plates also shows that groundwater recharge occurs in the area of the bedrock ridge. The effects of recharge are also shown on Plates 4-2 through 4-7, which show constant downward vertical gradients in this area.

Water level and precipitation data collected as part of background monitoring during a pump test conducted during the ICMS study confirms that groundwater recharge is occurring in the area of the bedrock ridge. Figure 4-18 presents the both the water level in well AW-MW-40, located on the bedrock ridge, and the precipitation amount recorded at the Albany International Airport from December 22, 1998 through January 18, 1999. As shown in the figure, groundwater levels in well AW-MW-40 correspond directly with precipitation events during this time period, indicating that precipitation is recharging the groundwater at this location with minimal time lag.

As can be seen from Plates 4-2, 4-4, 4-6, and Plates 4-11 through 4-13, the horizontal gradient is less steep or flattens in the area of Building 35, east of the 35 foot equipotential contour. This change in the horizontal gradient, represented by the increased spacing of the equipotential contour lines, may be related to either the increasing overburden thickness in this area or the increase in hydraulic conductivity between the weathered bedrock and the overburden at the point where the water table enters the overburden

A total of nine complete rounds of water level measurements were collected from the on-site monitoring wells by Malcolm Pirnie between July 1995 and February 1999 (Table 4-1). The largest fluctuations in measured water levels occurred in the monitoring wells constructed in the overburden. The potentiometric surface and general flow directions at the site do not significantly vary from season to season, as shown on Plates 4-11 through 4-13 and Figures 4-9 through 4-17, which represent flow conditions on September 11, 1995, May 20, 1996, and February 11, 1999, respectively. Seasonal variations in groundwater elevations measured in individual monitoring wells are presented in Table 4-1.

Prominent deflections in the potentiometric contour lines presented on Plates 4-11 through 4-13, most noticeably near AW-MW-30 and RW-2 and in the region southeast of Building 25 (Figures 4-9 though 4-11), can be attributed to bedrock surface features. As shown on Plates 4-8, and 4-11 through 4-13, the 55 foot and 60 foot AMSL bedrock surface contours mirror the deflection seen on the 60 foot and 55 foot AMSL potentiometric contour lines on the Plates. The protruding bedrock knob which is apparent by deflections in the 15 foot and 20 foot AMSL bedrock surface contour lines, is reflected by deflections in the 20 foot and 25 foot AMSL potentiometric contour lines on Plates 4-11 through 4-13.

Plate 4-14 presents the potentiometric surface map for the intermediate flow zone on February 11, 1999. Intermediate flow zone potentiometric maps were not constructed for the September 11, 1995 and May 20, 1996 water level measurement events since several of the intermediate zone monitoring wells were not installed at those times. As shown on Plate 4-14, both the location of the groundwater divide and the general direction of groundwater flow in the intermediate flow zone mirror that of the shallow flow zone.

In addition to the geologic and topographic effects on the water table, several man made features also effect the potentiometric surface in several areas of the site. A discussion of the man-made effects on the potentiometric surface is presented in Section 4.2.2.5.

#### 4.2.2.1 Vertical Hydraulic Gradients

Calculated vertical hydraulic gradients in the manufacturing area vary based on date and location. Vertical hydraulic gradients were calculated by dividing the difference in measured hydraulic head at two clustered wells by the distance between the midpoint of the saturated screen or open hole interval in each of the wells. The calculated vertical gradients are presented in Table 4-2.

The AW-MW-39/AW-MW-40 cluster is located close to the groundwater divide. Due to the location of this cluster near the topographic divide, the vertical gradient at this location is always downward and is indicative of groundwater recharge in this area. Paved areas surround this cluster and thus the downward vertical gradient varies little throughout the year, fluctuating between 0.03 and 0.04. The hydrogeologic conditions at this cluster closely represent the conditions in the area of Building 135. Therefore, based on the observed vertical gradients at the AW-MW-39/AW-MW-40 cluster, and the general conditions expected at the topographic divide, it is most likely that a downward vertical gradient exists in the vicinity of Building 135.

At the cluster east of Building 40, the calculated vertical gradient between AW-MW-33/AW-MW-34 appears to be upward during the majority of the monitoring period, varying between 0.02 and 0.03. However, during times of infiltration, such as after the large runoff event before measurements on January 22, 1996 and February 11, 1999, a downward gradient of 0.07 and 0.08, respectively was calculated. However, the static water levels in these wells generally indicate an upward vertical gradient associated with discharge to the Hudson River. The calculated vertical gradient between the intermediate bedrock (AW-MW-51) and the deep bedrock (AW-MW-61) at this cluster was strongly downward, with a gradient of 1.48. However, it should be noted that the water level data collected from AW-MW-61 are suspect due to the extremely low recharge rate that has been observed at this well location, and the reported water levels are not considered to be at static equilibrium at this time. This indicates that groundwater in the intermediate bedrock at this location may not discharge to the Hudson River. However, as shown on hydrogeologic cross-section E-E' (Plate 4-7), and discussed in Section 4.1.3, an apparent low permeability unit, or "boundary", appears to exist in the bedrock approximately 120 to 140 feet bgs at this location. Evidence for the "boundary" is based on packer testing results, bedrock core samples, well recharge rates, and the low elevation of the water levels AW-MW-61 and AW-MW-52 (see below), as well as that of DEC-3, which is located in the Siberia Area. Based on the potentiometric flow lines shown on Plate 4-7, groundwater above the "boundary" will likely discharge to the Hudson River.

The AW-MW-35/AW-MW-36 cluster, also located in the eastern portion of the Main Manufacturing Area, exhibits similar hydraulic characteristics to those seen between AW-MW-33/AW-MW-34. However, since it is located in a parking lot, and the areas immediately upgradient are also paved, runoff events appear to have little effect on vertical gradients at this location. A small downward hydraulic gradient of 0.01 was observed between these wells in February 1999. The calculated vertical gradient between intermediate bedrock well AW-MW-48, installed in 1997, and shallow bedrock well AW-MW-35, was slightly upward at a gradient 0.01. This indicates that contamination in the shallow bedrock will likely not reach the deep bedrock at this location. This fits the groundwater sampling data to date which is discussed in Section 5.

The AW-MW-37/AW-MW-38 cluster is located in a portion of the Main Manufacturing Area where vertical gradients vary throughout the year. To the west of this location, vertical gradients are typically downward. East of this location vertical gradients are typically upward. The location where this transition occurs appears to vary depending on water levels and infiltration conditions, because no apparent pattern in the direction of vertical gradients is observed at the AW-MW-37/AW-MW-38 cluster (i.e. a transition zone).

The AW-MW-52/AW-MW-64 cluster is located in the central-eastern section of the MMA, at the western end of the topographic high. This well cluster exhibits a strong downward gradient of 0.83, as is expected in this recharge area. As noted above, the low water level elevation in AW-MW-52 may be due to the presence of a low permeability “boundary” in the bedrock.

The well cluster located southeast of Building 25 is comprised of an overburden, hybrid, and bedrock well (B25-MW-3, SP-1, and B25-MW-2, respectively). Although these wells are located no more than 15 feet apart, the vertical hydraulic gradients are not consistent between the three wells. There is an upward gradient between the weathered bedrock and overburden, but a consistent downward gradient between the weathered bedrock and shallow bedrock (SP-1/B25-MW-3) monitoring wells at this location. However, as expected, there is a downward gradient of 0.05 between the overburden and the intermediate bedrock (AW-MW-53/B25-MW-3). The reason for the anomaly between the overburden, weathered bedrock, and shallow bedrock is not fully understood, however, the following are several potential explanations:

# Well SP-1 is a hybrid well and the head measured may not accurately reflect the head in the overburden. The higher hydraulic head measured in hybrid well SP-1 may be the result of increased hydraulic heads present in the weathered bedrock and/or utility line bedding further upgradient. These upgradient areas with higher hydraulic head are assumed to be in hydraulic communication with the weathered bedrock screened at hybrid monitoring well SP-1.

# Localized pumping of groundwater (i.e. sumps) from the bedrock in the vicinity of this triplet may have resulted in a lower hydraulic head in the bedrock. There is, however, no known pumping in this area.

# Poor hydraulic communication between the formation and either monitoring well 95MPI-B25-MW-2 or 83DM-SP-1 may result in a measured hydraulic head that is lower than anticipated. Both monitoring wells, however, appear to recharge at their expected rates.

# The possibility also exists that there is a leaking waterline in the area of the triplet. This theory is supported by the presence of low concentrations of chloroform in the groundwater sampled from the overburden and hybrid wells during the first round of groundwater sampling.

Plates 4-11 through 4-13 show a bulge in the potentiometric contour lines on the three potentiometric maps provided (Plates 4-11 through 4-13), signifying elevated groundwater levels in the overburden. This bulge may merely be the potentiometric surface mirroring the bedrock at that location. The elevated hydraulic head in the weathered bedrock is apparent on flow section B-B’ for September 11, 1995 (Plate 4-2) and May 20, 1996 (Plate 4-4), and in flow section E-E' for February 11, 1999 (Plate 4-6). Note that the flow section depicts groundwater flowing both upward and downward from the weathered bedrock at this location.

The direction and magnitude of vertical gradients is shown on the flow sections provided (Plates 4-2 through 4-7). These flow sections are intended to be representative of gradients in the vicinity of Flow Paths 2 and 4 shown on the potentiometric contour maps (Plates 4-11 through 4-13). Note that Plate 4-6 and 4-7 are modified slightly to include wells which were not present at the time Plates 4-2 through 4-5 were constructed.

#### 4.2.2.2 Horizontal Hydraulic Gradients

Calculated horizontal gradients for flow paths, shown on Plate 4-11 through 4-13, running eastward across WVA towards the Hudson River typically have gradients between 0.024 and 0.031. In the upgradient portion of the site, approximately between Building 110 and the eastern edge of Building 35, horizontal gradients are steeper, approximately 0.035, as compared to downgradient of Building 35, where horizontal gradients are approximately 0.020. There are small, seasonal variations in horizontal gradient, typically on the order of a few thousandths. Horizontal gradients are slightly steeper during periods of seasonal low groundwater elevations. The direction and location of the flow paths, however, are not altered significantly due to seasonal fluctuations in groundwater elevations. Groundwater flow continues to be to the east, towards the Hudson River.

On May 20, 1996, during a period of seasonal high water levels, horizontal gradients for all four calculated flow paths were between 0.024 and 0.028. On September 11, 1995, with seasonal low groundwater conditions, calculated horizontal gradients ranged from 0.027 to 0.031. On February 11, 1999, following a month of high precipitation, horizontal gradients ranged from 0.024 to 0.027. For potentiometric maps drawn during times where there is little recharge occurring (i.e. not during runoff events), Flow Path 1, the most northern flow path, typically had the shallowest gradient on each date, and each flow path drawn successively southward had a steeper gradient.

Flow sections, constructed using groundwater elevation data for September 11, 1995, May 20, 1996, and February 11, 1999, are shown on Plates 4-2 through 4-7 and represent groundwater flow conditions along Flow Paths 2 and 4 on Plates 4-11 through 4-13, respectively.

#### 4.2.2.3 Overburden and Weathered Bedrock Hydraulic Conductivities

As discussed in Section 3, hydraulic conductivity testing (slug testing) was conducted on several of the overburden/weathered bedrock monitoring wells. Rising head tests were performed at each of the monitoring well locations and the data were evaluated by means of the Bouwer-Rice method.

The geometric mean of hydraulic conductivities calculated for overburden wells is 4.78 x $10^{-4}$ cm/sec. The geometric mean of hydraulic conductivities in weathered bedrock wells was 2.25 x $10^{-3}$. Calculated hydraulic conductivities in overburden wells screened in the fill had a geometric mean of 3.37 x $10^{-3}$ cm/sec. The geometric mean of the calculated hydraulic conductivities in the overburden wells screened in the dense clayey silt or till was 4.34 x $10^{-6}$ cm/sec. The geometric mean of hydraulic conductivities in the alluvium in the area of Building 25 was 5.76 x $10^{-4}$ cm/sec. The results at individual wells are summarized on Table 4-3 and the plots and associated calculations are provided as part of Appendix H.

#### 4.2.2.4 Bedrock Hydraulic Conductivities

As discussed in Section 3, data collected from constant pressure injection testing was used to calculate hydraulic conductivities of monitoring wells constructed in the bedrock, using the method outlined in the United States Department of the Interior Ground Water Manual. The data collected during these tests is included in Appendix I. Table 4-3 summarizes the results of the hydraulic conductivity testing. Due to access constraints packer testing could not be conducted at monitoring wells AW-MW-51, AW-MW-52, AW-MW-59, and AW-MW-61.

Hydraulic conductivity testing (packer testing) results at bedrock monitoring wells in the manufacturing area typically in the range of $10^{-3}$ cm/sec to $10^{-5}$ cm/sec. This is within the range of hydraulic conductivities, $10^{-1}$ cm/sec to $10^{-6}$ cm/sec, normally attributed to fractured metamorphic rock (Domenico/Schwartz, p.65). At monitoring wells AW-MW-35, AW-MW-38, AW-MW-58, and AW-MW-60, where packer testing was conducted at different depth intervals along the open bedrock hole, hydraulic conductivities decreased with increasing depths. This is believed to be due to the increasing competency, and decreasing fracture density, of the bedrock with increasing depth. Hydraulic conductivities ranging from 1.23 x $10^{-3}$ cm/sec to 5.99 x $10^{-2}$ cm/sec were measured for monitoring wells AW-MW-34, AW-MW-35, AW-MW-40, and AW-MW-63, which are constructed in the upper portion of competent bedrock. However, at AW-MW-38, the hydraulic conductivity differs significantly from results at the other bedrock monitoring wells. The calculated hydraulic conductivity was 7.39 x $10^{-5}$ cm/sec. There have been no reasons identified as possible causes for this inconsistency.

A step-rate aquifer test was conducted at well PW-1 as part of the ICMS activities at the MMA. The time-drawdown graph generated for the test is included in Appendix N. As shown in the time-drawdown graph, the conductivity of the bedrock at this location is extremely low.

#### 4.2.2.5 Effects of Manmade Features

Although the geology beneath the Main Manufacturing Area has a major effect on the migration of contaminants, the most important conduit for groundwater flow in the Main Manufacturing Area is believed to be the disturbed area around the utilities or the utility bedding materials themselves. An examination of the potentiometric maps provided for (Plate 4-11 through 4-13), along with the locations of storm and sanitary sewers shown on Plate 4-15, reveals that the direction of groundwater flow closely approximates the location of utility lines and is heavily affected by pumping of groundwater at various locations across WVA.

As shown on Plates 4-11 through 4-13, pumping inside of Building 121 has affected the potentiometric surface locally, creating a local deflection in the 55 ft. AMSL equipotential line and creating a local depression in the groundwater table of approximately five feet. The exact magnitude of the effects of this pumping are difficult to determine due to the presence of a trough in the bedrock surface, as shown on Plate 4-8, which may produce similar effects.

Pumping of groundwater from the Shrink pit (the shrink pit in Building 135) occurs on an irregular schedule, but is believed to occur at least once a week. The water level in the pit is held at approximately 80 feet bgs, approximately 70 feet below what is believed to be the static water table conditions in this area. Pumping within the pit is responsible for depressing the water table locally under Building 135 by more than 60 feet. The effects of pumping in the shrink pit has a limited areal extent as shown on Plates 4-11 through 4-13. However, based on the field observations during drilling and limited water level data for B135-MW-1, it appears as if this well was affected by pumping in the process pit. During drilling, groundwater was not encountered until a depth of approximately 90 feet bgs, following a short period of time the water level in B135-MW-1 recovered to approximately 45 to 50 feet bgs. Discussions with site personnel later revealed that during the time of installation the process pit was being pumped down, which in-turn affected the groundwater levels in the immediate area around the pit.

Contour lines presented on Plates 4-11 through 4-13 show deflections westward as they cross Westervelt Avenue. This deflection in the contours lines is believed to be related to the groundwater draining into the bedding of utility lines running down this road, as shown in Plate 4-15. A similar deflection is also visible in the area of Parker Road.

As shown on the three potentiometric maps (Plates 4-11 through 4-13), the effects of the sewer lines running beneath Westervelt Avenue are evident in the deflection of Flow Paths 3 and 4. Both flow paths are diverted upon reaching Westervelt Avenue, presumably due to the presence of high permeability fill materials around the water and sewer lines. These lines could presumably be the migration pathway for contaminants.

The effects of sewer lines beneath Parker Road are also visible in deflections of Flow Paths 1 and 2. On all three potentiometric maps these flow paths appear to move towards or along the path of Parker Road. On the May 20, 1996 potentiometric map (Plate 4-12) the deflection of Flow Path 2 along the sewer lines running from the area of the water treatment plant to outfall 003 is readily apparent. However, it is also possible that the deflection of the flow paths in this area is due to the localized bedrock high, which is shown in Plate 4-8.

An effect of a man-made conduit may explain the vertical hydraulic head incongruities in the B25-MW-2/B25-MW-3/SP-1 cluster. The hydraulic head in the weathered bedrock well at this location, SP-1, is typically a foot higher than in the overburden well, B25-MW-3, and three feet higher than in the bedrock well, B25-MW-2. This may be attributable to groundwater flowing through the utility bedding materials, which have been excavated into the weathered bedrock in this area, and therefore artificially supporting water levels in the overburden and weathered bedrock in this area. It may also be attributable to a leaking water line beneath Parker Road that is discharging to the weathered bedrock. Either of these scenarios will explain why there continues to be a downward gradient downgradient of Building 25 along section lines B-B' and D-D' (Plates 4-2, 4-4, and 4-6) even though at a similar surface elevation along flow section lines C-C' and E-E' (AW-MW-33/ AW-MW-34) the hydraulic gradients are upward, as would be expected for discharge into the Hudson River. It may also explain why the hydraulic head in the weathered bedrock at this location (B25-MW-2/B25-MW-3/SP-1) is higher than that in the overburden or the bedrock. An examination of the potentiometric maps (Plates 4-11 through 4-13) shows a bulge in the 20 foot AMSL contour in the area south of Building 25 which is presumed to be an effect of this same scenario.

Table 4-4 presents the range of approximate horizontal travel times for groundwater originating at the center of the MMA (RW-2 Area) to reach the eastern property boundary in the vicinity of Building 40, based on the potentiometric flow contours shown on Plate 4-7. Travel times for this path were calculated based on the high, low and average bedrock hydraulic conductivities derived from the packer hydraulic conductivity tests which were applied over a range of porosities. As shown in Table 4-3, the time required for groundwater originating at the center of the MMA to reach the eastern property boundary ranges from approximately one month to 73 years, depending on the hydraulic conductivity and the effective porosity. It should be noted that these calculations are only approximations and that the actual travel times are likely to be influenced by the amount, magnitude, and interconnectedness of the bedrock fracture network beneath the MMA.

#### 4.2.2.6 Travel Times

Travel times across the site vary seasonally. A range of seepage velocities is provided for each flow path delineated on Plates 4-11 through 4-13. For each flow path, seepage velocities were used to estimate minimum (flow in the clayey silt or till), maximum (flow in the fill) and average travel times for groundwater flowing across the site. Porosity and hydraulic gradients were determined for each flow path in order to calculate the travel time.

A porosity of 0.45 was assumed for the clayey silt and 0.30 was applied to the fill (mixed sand and gravel). A porosity of 0.4 was applied to the weathered bedrock unit, and a porosity of 0.35 was applied to the alluvial sediments. (Domenico/Schwartz, p.26)

An average gradient along each flow path was used in the calculations, 0.0284 for Flow Path 1, 0.0265 for Flow Path 2, 0.0269 for Flow Path 3, and 0.0276 for Flow Path 4. Flow along these four flow paths is assumed to be exclusively in the on-site sediments, whether they are native or fill soil, and not through man-made conduits such as sewer bedding materials.

A maximum seepage velocity for groundwater was calculated using the geometric mean fill hydraulic conductivity value of $3.37 \times 10^{-3}$ cm/sec (9.56 ft/day). The length of each flow path used for this calculation is the average of the length of the individual flow paths in the wet and dry periods. Flow Paths 1, 2, 3, and 4 have calculated seepage velocities of $3.19 \times 10^{-4}$ cm/sec (0.90 ft/day), $2.98 \times 10^{-4}$ cm/sec (0.84 ft/day), $3.02 \times 10^{-4}$ cm/sec (0.85 ft/day), and $3.10 \times 10^{-4}$ cm/sec (0.88 ft/day), respectively. At these seepage velocities, the time necessary for groundwater to travel 1,268 feet across the site along Flow Path 1 would be approximately 3.83 years. Groundwater traveling 1,545 feet along Flow Path 2 would require approximately 5.01 years to cross the site. In order for groundwater to travel 1,673 feet along Flow Path 3, it would require approximately 5.34 years. Groundwater traveling the 1,703 feet along Flow Path 4 would require 5.31 years to cross the site.

A minimum seepage velocity for groundwater flow in the Main Manufacturing Area was determined based on groundwater flowing through the clayey silt or till. A geometric mean hydraulic conductivity of $4.78 \times 10^{-6}$ cm/sec ($1.35 \times 10^{-2}$ ft/day) was previously calculated for the clayey silt or till. This would result in seepage velocities of $2.74 \times 10^{-7}$ cm/sec ($7.80 \times 10^{-4}$ ft/day), $2.56 \times 10^{-7}$ cm/sec ($7.28 \times 10^{-4}$ ft/day), $2.59 \times 10^{-7}$ cm/sec ($7.39 \times 10^{-4}$ ft/day), and 2.66 x

$10^{-7}$ cm/sec (7.57 x $10^{-4}$ ft/day) along Flow Paths 1, 2, 3, and 4, respectively. These seepage velocities and the flow paths lengths described in the previous paragraph would result in travel times of 4,466 years, 5,831 years, 6,224 years, and 6,178 years along each flow path, respectively.

These scenarios are only meant to serve as extreme cases. Groundwater flowing across the site travels through several different hydrostratigraphic units. During all seasons of the year, the water table near the groundwater divide is within the bedrock. At the eastern edge of the site groundwater is present in the overburden. To take into consideration the variety of units that groundwater flows through during its migration across the Main Manufacturing Area, the seepage velocities for flow along the four flow paths were estimated using the geometric mean of all the reported hydraulic conductivities, 5.03 x $10^{-4}$ m/sec (1.42 ft/day). For Flow Path 1, the calculated seepage velocity of 3.86 x $10^{-5}$ cm/sec (0.11 ft/day) would result in a travel time of 31.7 years. Along Flow Path 2, the seepage velocity was calculated to be 3.60 x $10^{-5}$ cm/sec (0.10 ft/day), which results in a travel time of 41.4 years. The seepage velocity calculated for Flow Path 3, 3.66 x $10^{-5}$ cm/sec (0.10 ft/day), results in a travel time of 44.2 years. Groundwater traveling along Flow Path 4 at a seepage velocity of 3.75 x $10^{-5}$ cm/sec (0.11 ft/day) would require 43.8 years to cross the site. As previously stated, the time of travel calculations for each flow path do not take into account flow in utility bedding materials. Based on the characteristics of the bedding materials expected to be present, it is expected that time of travel would be significantly faster within the bedding materials than the surrounding native materials. Information as to the construction and type of sewer bedding materials is not currently available.

# 5.0 NATURE AND EXTENT OF CONTAMINATION

## 5.1 INTRODUCTION

The following discussion on the nature and extent of contamination at the Watervliet Arsenal is based on the data obtained from the sampling events conducted by Malcolm Pirnie and Louis Berger and Associates as described in Section 3, and historical data obtained during previous investigations (USATHAMA 1980; Couslich 1980; Dames and Moore 1983; Environmental Science and Engineering 1987; Groundwater Technology, Inc. 1987; C.T. Male 1990; Clough, Harbour and Associates 1991; Empire Soils Investigations 1993; and Watervliet Arsenal 1995, 1996). As discussed in Section 3, samples collected by Malcolm Pirnie and LBA include soil gas, surface soil, subsurface soil, groundwater, and pit water and product samples. The complete analytical results obtained from this investigation are summarized in tables provided in Appendix J. Data qualifiers identified by the laboratory are defined in Appendix J.

## 5.2 DATA USABILITY - ARSENAL-WIDE

### 5.2.1 Introduction

Approximately 20 percent of the analytical data from the subsurface soil sampling and the first round of groundwater sampling has been validated by a third party data validator (EA Engineering, Science, and Technology). Five percent of the analytical data from the second round of groundwater sampling has been validated by the USACE. Data from the third and fourth round of groundwater sampling, as well as from the Geoprobe sampling, was not validated. Data validation reports are included as Appendix K and the analytical data provided by IEA Laboratories, Inc. and E3I Environmental Laboratory is included as Appendix J. A summary of the data validation results and data usability is provided below. The data usability for any subsurface soil data or first round of groundwater sampling data associated with the Building 25, 35, and 135 and SWMUs 7 through 14 investigations are discussed separately from the rest of the Main Manufacturing Area data usability since a different laboratory (E3I) was used to analyze the data.

### 5.2.2 Soil

#### 5.2.2.1 Organic Compounds

IEA Laboratory Data

All VOC data are usable with the exception of the 2-chloroethylvinylether concentrations in samples AW-MW-21 (8-10 feet) and AW-MW-36 (10-12 feet). The 2-chloroethylvinylether concentrations were rejected due to laboratory non-compliances during the calibrations. Many compounds in the validated samples were qualified as estimated non-detect (“UJ”) due to the percent differences of the continuing calibrations being greater than 25 percent. Several samples were reanalyzed due to surrogate recoveries out of criteria.

All SVOC data is usable with the exception of benzidine in samples AW-MW-6 (10-12 feet) and AW-MW-34 (0-2 feet) and the dichlorobenzidine concentration in FB-2. The benzidine concentrations were rejected due to the relative response factor (RRF) being below the control limit in the continuing calibration and the dichlorobenzidine concentration was rejected due to the percent difference being greater than 90 percent and the compound concentration being non-detect in the continuing calibration. Many of the SVOC concentrations were qualified as estimated (“J”) estimated non-detect (“UJ”), or as non-detect (“U”) by the data validator due to non-compliant continuing calibrations or extraction blank contamination.

The 4,4'-DDT concentrations were rejected in samples AW-MW-21 (8-10 feet) and AW-MW-34 (0-2 feet) due to the column confirmation percent difference exceeding 100 percent. All other pesticides/PCBs data is usable. Many other pesticide compounds were qualified as estimated (“J”) or estimated non-detect (“UJ”) due to non-compliant initial and continuing calibrations and column confirmation percent differences exceedences.

E3I Laboratory Data

All VOC data for soils collected as part of the Building 25 will be considered usable, except for non-detects of dichlorofluoromethane in B25-MW-5 (5-7 feet). Other VOC data were qualified as estimated ("J"), estimated non-detect ("UJ"), or ("D") diluted. These qualifiers were due to non-conformance in the initial and continuing calibrations of the instruments, internal standards, method blank contamination, and dilutions. Most qualifiers resulting from continuing calibration non-conformances were from relative response factors (RRFs) having a percent difference which was greater than 25 percent. There were also matrix interferences in the spiking of samples with laboratory standards.

Similarly, VOC data for soils collected at SWMUs 7 through 14 will be considered usable. Several VOCs were qualified as estimated ("J") or estimated not detected ("UJ"). These qualifiers were due to the percent relative standard deviation exceeding 30 percent in the initial calibration (2-butanone qualified with a "J") and 25 percent in the continuing calibrations (Chloromethane, 2-butanone, 1,2-dichloroethane, and 4-methyl-2-pentanone qualified as "UJ").

All Building 25 SVOC data for soils are usable, except for non-detects of benzidine in samples B25-MW-6 (6.5-8.5 feet), B25-MW-2 (8.5-10.5 feet) and B25-MW-5 (5-7 feet); and n-nitrosodimethylamine in samples B25-MW-2 (8.5-10.5 feet) and B25-MW-5 (5-7 feet). Benzidine and n-nitrosodimethylamine were rejected in these samples due to non-conformances during the initial calibrations. In addition, certain analytes were qualified as estimated ("J" or "JN"), due to non-conformances in continuing calibrations and co-elution of two benzofluoranthenes. Finally, sample B25-MW-6 (6.5-8.5 feet) had numerous low surrogate recoveries in the associated extraction blank. This sample was re-extracted and reanalyzed and the re-extraction and reanalysis met the required quality control guidelines, the resulting data is considered usable.

For SWMUs 7 through 14, all semi-volatile data for soils is usable, except for the non-detect of benzidine in sample SWMU-10-2 (1-3 feet). Benzidine was rejected in this sample due to a noncompliant RRF in the continuing calibration. In addition, certain analytes were qualified as "U" (estimated), "UJ", or "N" (presumptive evidence of the presence of the compound), due to extraction blank contamination, noncompliant percent differences in the continuing calibration and co-elution with internal standards.

Most Building 25 pesticide and PCB data for soils are usable. The data validator rejected data due to discrepancies between the primary and secondary columns; data with lesser discrepancies between the two columns was qualified as estimated ("J" or "JN"). Other data was qualified as estimated due to low surrogate recoveries and non-compliant results of performance evaluation mixtures and continuing calibrations. For sample B25-MW-5 (5-7 feet), the data validator indicated that the results of the acid cleaned analysis should be used for the PCB analyses.

Most pesticide and PCB data for soils at SWMUS 7 through 14 are also considered usable. The data validator rejected data for endrin ketone in sample SWMU-10-2 (1-3 feet) and SWMU-12-2 (4-6 feet) due to non-compliant percent difference (greater than 90 percent) in one of the bracketing continuing calibrations. Other data was qualified as "UJ" due to non-compliant percent difference (greater than 25 percent) in one of the bracketing continuing calibrations.

#### 5.2.2.2 Inorganics

IEA Laboratory Data

All inorganic data for soils is usable. There were no identified problems with the arsenic, cadmium, chromium, selenium, and silver data. The spike recovery for barium was below the lower control limit for sample AW-MW-36 (0-2 feet), suggesting that the barium concentrations in samples included in this SDG may be biased low. The mercury concentration in sample AW-MW-21 (8-10 feet) was qualified as estimated (“J”) due to a low correlation coefficient during instrument calibration. The laboratory reported that mercury failed the controls for two spike recovery analyses and the affected samples have been qualified with an “N”. Lead concentrations may be biased high in the samples analyzed in the same SDG as sample AW-MW-41 (0-2 feet) due to a high accuracy (>120 percent) for the detection limit standards. The lead concentration in sample AW-MW-21 (8-10 feet) was qualified as estimated (“J”) due to a high relative percent difference of precision. The duplicate analysis of sample AW-MW-36 (0-2 feet) for lead was not within the control limit, and the affected samples have been qualified by the laboratory with an “*”.

E3I Laboratory Data

All inorganic data for soils at Building 25 are usable, except for chromium and selenium in samples B25-MW-2 (8.5 to 10.5 feet), B25-MW-5 (5 to 7 feet), and B25-MW-6 (6.5 to 8.5 feet). Non-conformance of the CRDL standard requirement occurred for selenium.

All inorganic data for soils at SWMUs 7 through 14 are usable. Some data was qualified as "UJ" or "J" due to matrix spikes below the lower control limits and failure of the percent difference recovery to agree within 10 percent of the original sample results.

### 5.2.3 Groundwater

#### 5.2.3.1 Organic Compounds

IEA Laboratory Data - Rounds 1 and 2

The volatile organic data for both first and second rounds of groundwater samples is usable with the exception of vinyl acetate in first round samples EM-SP-7, EM-SP-8, AW-MW-34, AW-MW-22, and GTI-BP-1. Vinyl acetate was rejected in these samples due to the percent difference (percent D) exceeding 90 percent in the continuing calibrations and the compound concentrations being non-detect. In addition, chloromethane was qualified as estimated non-detect ("UJ") in first round samples AW-MW-22 and AW-MW-24 due to the continuing calibration percent difference being greater than 25 percent, but less than 90 percent, and the compound concentrations being non-detect. The vinyl chloride concentration in the second round sample AW-B121N was qualified as estimated ("J") due to the low recovery of vinyl chloride in a laboratory quality control sample analyzed in conjunction with the MS/MSD, and the variation in vinyl chloride concentrations detected in the MS (110 μg/l) and MSD (150 μg/l). Samples associated with this SDG may be based low.

Due to low surrogate recoveries (less than 10 percent), all acid compounds in first round samples AW-MW-24 and GTI-BP-1 were rejected, and acid compounds in the samples associated with these SDGs may be biased low. Benzidine was rejected in all first round samples which were validated due to a low relative response factor (RRF) in the continuing calibration. Several phthalate compounds were detected in the extraction blanks associated with the first round samples and have been qualified with a “J” or “UJ”. Benzidine and phthalates are not considered site contaminants of concern. In the second round samples, several SVOCs were rejected due to internal standard area counts being less than 25 percent and being non-detect. In sample process pit sample PW-2F, compounds were rejected for this reason. Also, fluorene was qualified as estimated (“J”) in this sample due to area counts being below the lower limit with positive results.

In the first round samples, heptachlor, 4,4'-DDD, Dieldrin, and 4,4'-DDT were rejected in some samples due to the column confirmation percent difference being greater than 100 percent. All pesticides data for the second round is usable. Many other pesticide compounds in the first and second round samples, including delta-BHC, endosulfan sulfate, endosulfan II, aldrin, 4,4'-DDD, alpha-BHC, heptachlor, methoxychlor, endrin aldehyde and endrin ketone were qualified as estimated (“J”) or estimated non-detect (“UJ”) due to non-compliant initial and continuing calibrations and column confirmation exceedances. All PCB data from the first and second rounds is usable.

### E3I Laboratory Data - Round 1

With the exception of B25-MW-3 all volatile organic data for water will be considered usable. The following discussion details the inclusion of volatile organic data qualified as estimated ("J"), estimated non-detect ("U J"), or ("D") diluted. These qualifiers were due to non-conformance in the initial and continuing calibrations of the instruments, internal standards, method blank contamination, and dilutions. Most qualifiers resulting from continuing calibration non-conformances were from relative response factors (RRFs) having a percent difference which was greater than 25 percent. There were also matrix interferences in the spiking of samples with laboratory standards. Volatile organic analyses for B25-MW-3 were considered unusable, except TCE, due to method blank contamination. This result was transferred to B25-MW-3 and the result is indicated as a diluted sample. The volatile organic data for water samples associated with Buildings 35 and 135 is usable. Dichlorodifluoromethane and 2-chloroethylvinyl ether, and chloroethane were qualified as estimated not detects "UJ" due to their respective percent differences exceeding 25 percent in the continuing calibration.

All SVOC data associated with Building 25 is considered usable, except for benzidine in samples B25-MW-3, B25-MW-4 and EM-SP-5. Blank contamination led to instances of false positives for di-n-butyl phthalate. All SVOC data associated with Buildings 35 and 135 is usable with the exception of the benzidine concentration in the water sample collected from the Shrink Pit (PW-1). Benzidine was rejected in this sample due to the average RRFs less than 0.05 in the continuing calibration and non-detected sample result. However, benzidine is not among the contaminants of concern at the site and rejection of the results for this analyte in samples PW-1, B135-MW-3, B135-MW-4, and EM-SP-9 does not affect data usability. Although we can not say whether benzidine is present in the aforementioned samples based upon the laboratory QC, the fact that it was not detected in any of the samples at the site is in agreement with our assessment of site contamination. Di-n-butylphthalate concentrations in several samples were qualified as false-positive "U" due to the presence of this compound in the extraction blank. Several other SVOCs were qualified as estimated non-detects due mainly to initial calibration factors out of range and partially due to continuing calibration exceedances and therefore will be considered as non-detect values.

All pesticide and PCB data for water samples collected as part of the Building 25 investigation are usable except beta-BHC, endrin and endosulfan II in EM-SP5; and endosulfan sulfate in B25-MW-4. Other validated pesticide data was qualified as estimated ("J") due to discrepancies between the primary and secondary column, and continuing calibration non-compliances. Blank contamination from 4,4'-DDT and endrin resulted in false positives. For pesticides/PCB analysis, the secondary column was used instead of the primary columns for the compounds dieldrin and 4,4'-DDE in sample B25-MW-3; 4,4'-DDT in sample B25-MW-4; and heptachlor epoxide, dieldrin, 4,4'-DDT and endosulfan sulfate in sample EM-SP5. In addition, all non-detects in samples B25-MW-3 and B25-MW-4 were qualified as estimated ("UJ") due to all surrogate recoveries between 10 percent and 60 percent. As part of the Building 35 and 135 investigations, several pesticide compounds (4,4'-DDT in B135-MW-2, aldrin, dieldrin, 4,4'-DDD, 4,4'-DDT, endrin ketone, and endrin aldehyde in B35-MW-8, and heptachlor and endosulfan II in PW-1) were rejected by the validator due to the percent difference for the 2-column compound identification exceeding 100 percent. Delta-BHC was qualified as non-detect "U" in B135-MW-2 due to the reported pesticide concentration being less than the CRQL and the percent difference exceeding 50 percent. Alpha-BHC was qualified as an estimated non-detect "UJ" in B135-MW-2, B35-MW-8, EM-SP-9, and PW-1 due to non-compliant florisil check recovery. Endrin was qualified as presumptively present at an estimated quantity "NJ" in B35-MW-8 due to the column confirmation percent difference between 70 percent and 100 percent. Alpha-chlordane and gamma-chlordane in B35-MW-8 and aldrin and aroclor-1254 in PW-1 were qualified as estimated "J" due to the column confirmation percent difference between 25 percent and 70 percent. In PW-1 4,4'-DDT and methoxychlor were qualified as estimated non-detects "UJ" due to non-compliant performance evaluation mixture and Beta-BHC was qualified as an estimated non-detect "UJ" due to a non-compliant percent difference in the bracketing continuing calibration.

#### 5.2.3.2 Inorganics

IEA Laboratory - Rounds 1 and 2

All inorganic data for the first and second rounds of groundwater sampling was considered usable. Lead (total and dissolved) was qualified as estimated (“J”) or estimated non-detect (“UJ”) in all of the validated samples for the first round except for one due to the spike and/or the contract required detection limit (CRDL) recoveries. Lead concentrations in the samples associated with the SDG containing samples EM-SP-8, EM-SP-7, AW-MW-34, and GTI-BP-1 are biased low due to a low CRDL recovery. Lead concentrations may also be biased low in the Manhole 43 samples due to a low spike recovery. Lead concentrations in the samples associated with sample AW-MW-24 may be biased high due to a high CRDL recovery. Also in the first round samples, barium (total) in AW-MW-24 was qualified due to a non-compliant ICP interference check, mercury and silver in the Manhole 43 samples may be biased low due to low spike recovery, selenium may be biased low in AW-MW-22 due to a low laboratory control sample recovery, and hexavalent chromium in EM-SP-8 was qualified due to matrix interference.

For the second round samples, in sample PW-2, cadmium and silver were qualified as estimated 'J' due to the percent difference being greater than or equal to 100 percent. In sample PW-2F, cadmium and silver were qualified as estimated non-detect due to the percent difference being greater than or equal to 100 percent and is reported at the instrument detection limit.

E3I Laboratory Data - Round 1

All inorganic data for groundwater samples collected as part of the Building 25 investigation is considered usable except for unfiltered lead in samples B25MW-3 and B25-MW-4. Nonconformance of the CRDL standard requirement occurred for selenium in both sample delivery groups. Identified problems with individual inorganic parameters are discussed below. Other metals data were qualified as estimated ("J") or estimated non-detect ("UJ"). These qualifiers were due to physical, chemical or matrix interferences, and non-conformance of the contract required detection limit standard requirements. There were also matrix interferences in the spiking of samples with laboratory standards.

For the Building 35 and 135 investigations, the inorganic data for the groundwater samples is usable, with the exception of lead, selenium, and hexavalent chromium. Lead was rejected by the validator in samples PW-1 filtered and unfiltered due to non-conformance of CRQL standard requirement. For the same reason, selenium was rejected in samples B35-MW-8 filtered and unfiltered, and EM-SP-9 filtered and unfiltered. Hexavalent chromium was rejected in sample PW-1F (floating product sample) due to an exceedance of the holding time criteria. In addition selenium in PW-1 and B35-MW-8 (filtered and unfiltered) and arsenic in EM-SP-9 (filtered) was qualified estimated non-detect due to non-conformance of CRQL standard requirement, indicating a slight low bias. Hexavalent chromium was qualified as estimated in PW-1 and B35-MW-8 (unfiltered) due to matrix interference and because a matrix spike was not performed for the unfiltered matrix type. Barium was qualified as estimated in PW-1 (filtered) due to possible chemical and physical interferences. Arsenic was qualified as estimated in B35-MW-8 (filtered and unfiltered) and EM-SP-9 (unfiltered) due to non-conformance of CRQL standard requirement, indicating a slight low bias. No other inorganic compounds in the water samples selected for validation were qualified by the data validator.

## 5.3 SOIL GAS

Prior to the installation of the new monitoring wells at Building 25, a soil gas survey was conducted in December of 1994. All samples were analyzed on-site for VOCs using a gas chromatograph. Total FID (Flame Ionization Detector) VOC concentrations and petroleum hydrocarbon concentrations were calculated using the sum of the areas of all chromatogram (GC/FID) peaks. Chlorinated organics were detected using an electron capture detector (GC/ECD). The results are presented in the report prepared by Target Environmental Services (Appendix C).

From the survey, there were positive analyte detections at five sample locations (Figure 3-2 soil gas locations). Total VOCs were observed at a concentration of 39.5 µg/l in sample B25-SG-41. Ethylbenzene, meta- and/or para- xylenes and ortho-xylene were also present in this sample at 4.9 µg/l, 27.5 µg/l and 5.9 µg/l, respectively. No halogenated compounds were detected in this sample. The chromatogram signature of this sample was too weak for either a fuel identification or petroleum fingerprint. No other samples revealed any petroleum hydrocarbons.

Trichloroethene (TCE) was the only chlorinated compound observed above the reporting limit. It occurred in samples B25-SG-12, B25-SG-15, B25-SG-16 and B25-SG-24 at concentrations ranging from 1.4 µg/l to 7.0 µg/l. Halogenated compounds were not detected in any other samples.

## 5.4 SOIL

Surface and subsurface soil samples were collected as part of the various investigations. For comparison purposes, values published in the NYSDEC Technical Administrative Guidance Memorandum (TAGM) HWR-94-4046 Determination of Soil Cleanup Levels, revised January 24, 1994, are presented on the tables of analytical results for the soil samples in Appendix J. The TAGM values are conservative guidance values, meant to be protective of human health and the environment. It is necessary to adjust TAGM values for many of the organic compounds at each site based on the site-specific carbon content of the soils. The exceptions are the TAGM values for SVOCs which are based on the USEPA Health-Based Criteria or the generic criteria for individual SVOCs (50 mg/kg). These TAGM values are not adjusted for carbon content. The TAGM values are not cleanup action levels and will be used for comparison of data only. Published TAGM guidance values for organic compounds other than PCBs are based on a soil total organic carbon (TOC) content of one percent. PCB guidance values are based on a TOC of five percent.

Three soil samples were collected and analyzed for TOC as part of the Building 25 investigation. One of the samples consisted of fill soils from the former Erie Canal, and two samples were collected from native soils. Two fill samples from the Manhole 43 investigation were also analyzed for TOC.

The TOC value of the fill sample from the Erie Canal, approximately four percent, the average TOC for the Manhole 43 fill soils, approximately two percent, and the average TOC for the native soils, approximately one percent, were used as correction factors to establish site-specific TAGM values for soil samples in each strata. A correction factor of four for the fill samples collected in the Erie Canal, and two for all other fill samples, was applied to the TAGM values for organic compounds (with the exception of PCBs). Since the uncorrected TAGM value for PCBs is based on a TOC of five percent, the TAGM values for PCBs in fill soils were multiplied by a correction factor of 0.8 (four percent divided by five percent) for the Erie Canal samples and 0.4 (two percent divided by five percent) for the remainder of the fill samples. For native soils, no correction factor was necessary for organic compounds except PCBs due to the TOC of one percent, but a correction factor of 0.2 was applied to PCB TAGM values (one percent divided by five percent). On the analytical summary tables in Appendix J and in the following discussion, each soil sample is compared to these adjusted TAGM values based on its designation as either a fill soil sample or a native soil sample.

TAGM values for inorganic soils are not based on TOC values. The TAGM values for most of the inorganic analytes are based on site background concentrations. The average concentrations of inorganic compounds in four surface soil samples obtained from a Aclean≅ area of the Arsenal where no previous manufacturing has occurred, were designated as site background samples. The background sample concentrations and their averages are included in Table 5-1. These TAGM values will be used for comparison of data only, they are not proposed cleanup objectives/action levels.

### 5.4.1 Surface Soils

Malcolm Pirnie collected four surface soil samples from the golf course area in July, 1995. The samples were analyzed for RCRA Metals, and the results of these analyses are included on Table 5-1. The average concentrations of each metal was calculated (Table 5-1) and will be used for comparative purposes in the discussion of the nature and extent of inorganics in the sub-surface soil. In cases where the TAGM value is based on site background, the average concentration from these samples will be considered site background.

### 5.4.2 Sub-Surface Soils

The concentrations of individual organic and inorganic parameters detected in the sub-surface soil samples are shown on Plate 5-1 (2 sheets). The concentrations of total volatile, total chlorinated volatile, and total SVOCs are provided on Plate 5-2. The sub-surface soil results with comparisons to TAGM values are summarized in Appendix J, and Table 5-2 is a statistical summary of these results.

#### 5.4.2.1 Organics

The nature of the sub-surface soil organic contamination is primarily limited to the presence of SVOCs, more specifically, polycyclic aromatic hydrocarbons (PAHs). The PAHs are a class of non-chlorinated hydrocarbons of petroleum origin. Several of the PAHs are regarded as potentially carcinogenic, including: benzo-(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluorothene, chrysene, dibenzo(a,h)anthracene, and ideno(1,2,3-cd)pyrene.

Twenty-one of the 66 sub-surface soil samples (approximately 32 percent) contained concentrations of SVOCs above TAGM values. All of the compound concentrations which exceeded the TAGM values were potentially carcinogenic PAHs. Nineteen of the 21 samples which exceeded the TAGM values were collected from the fill and two were collected from the native soils.

The sample with the highest concentration of total SVOCs was Geoprobe sample WVA-GP-1 (2-3 feet), which contained 477,420 μg/kg of SVOCs. The next highest sample, B25-MW-5 (9-11 feet), and its duplicate, contained 82,380 μg/kg and 42,440 μg/kg of total SVOCs, respectively. Both of these samples were collected from the Erie Canal in the vicinity of Building 25. No samples exceeded the TAGM value of 500,000 μg/kg for total semi-volatiles.

Sample WVA-GP-1 (2-3 feet) contained exceedences of nine PAHs: phenanthrene (140,000 μg/kg), fluoranthene (58,000 μg/kg), pyrene (58,000 μg/kg), benzo(a)anthracene (20,000 μg/kg), chrysene (27,000 μg/kg), benzo(b)fluoranthene (11,000J μg/kg), benzo(k)fluoranthene (12,000J μg/kg), benzo(a)pyrene (14,000J μg/kg), and ideno(1,2,3-cd)perylene (7,900J μg/kg). Sample B25-MW-5(9-11 feet) contained exceedances of six of the seven potentially carcinogenic PAHs: benzo(a) anthracene (5,000 μg/kg), chrysene (4,700 μg/kg), benzo(b)fluoranthene (3,500 μg/kg), benzo(k)fluoranthene (2,400 μg/kg), benzo(a)pyrene (3,200 μg/kg), and dibenzo(a,h)anthracene (950J μg/kg). Nine other soil samples collected in the vicinity of Building 25, including six additional Geoprobe samples, had SVOCs (PAHs) concentrations that exceeded TAGM values. One of these samples was also collected from the B25-MW-5 boring, at the 5 to 7 feet interval (2,800 μg/kg benzo(a)anthracene, 2,400 μg/kg chrysene, 2,000 μg/kg benzo(a)pyrene, and 690J μg/kg dibenzo(a,h)anthracene). The other samples were collected from B25-MW-1(5-7 feet) (110 μg/kg benzo(a)pyrene, 30J μg/kg dibenzo(a,h)anthracene); B25-MW-2(8.5-10.5 feet) (73 μg/kg benzo(a)pyrene); B25-MW-6(6.5-8.5 feet) (82 μg/kg benzo(a)pyrene); WVA-GP-2 (12 feet) (92J μg/kg benzo(a)pyrene); WVA-GP-6 (3.0-3.5 feet and 13-14 feet, respectively) (480 μg/kg and 390 μg/kg benzo(a)anthracene, 550 μg/kg and 380J μg/kg benzo(a)pyrene, 180J μg/kg and 89J μg/kg dibenz(a,h)anthracene); WVA-GP-7 (11-12 feet) (1,800 µg/kg benzo(a)anthracene, 2,000 µg/kg chrysene, 1,600 µg/kg benzo(a)pyrene, 470J dibenz(a,h)anthracene); WVA-GP-8 (13-14 feet) (460 µg/kg benzo(a)anthracene, 130J dibenz(a,h)anthracene); WVA-GP-11 (2.5-3.0 feet) (290 µg/kg benzo(a)anthracene, 230J µg/kg benzo(a)pyrene, 66J µg/kg dibenz(a,h)anthracene); and WVA-GP-13 (9-10 feet) (420 µg/kg benzo(a)anthracene, 410J µg/kg benzo(a)pyrene, 94J µg/kg dibenz(a,h)anthracene. Visual observations of petroleum contamination and slight to strong petroleum odors were noted during the installation of B25-MW-2, B25-MW-3, B25-MW-5, WVA-GP-1, and WVA-GP-6. In B25-MW-2, a solvent odor was noted in the 8.5 to 10.5 foot soil interval and a fuel odor was noted in the 10.5 to 12.5 foot soil interval. In B25-MW-3, a fuel odor was noted in the 11 to 11.3 foot soil interval. In B25-MW-5, a creosote type odor was noted at the 5 to 7 foot interval. A solvent odor was also observed in boring WVA-GP-6. No petroleum-saturated soils were observed.

Sample AW-MW-24(2-4 feet) and its duplicate AW-MW-60(2-4 feet), collected near the demolished cyanide treatment facility on the east side of Building 110, contained concentrations of five potentially carcinogenic PAHs which exceeded the TAGM values: benzo(a)anthracene (2,600 µg/kg), chrysene (2,700 µg/kg), benzo(b)fluorothene (2,400 µg/kg), benzo(a)pyrene (2,400 µg/kg), and dibenzo(a,h)anthracene (470J µg/kg). Concentrations of PAHs in exceedance of the TAGM values were also detected in samples AW-MW-35(0-2 feet) and AW-MW-36 (0-2 feet), near the former vapor degreaser in Building 20. Sample AW-MW-35 (0-2 feet) contained 750 µg/kg benzo(a)anthracene, 860 µg/kg chrysene, and 1,300 µg/kg benzo(a)pyrene, and sample AW-MW-36 (0-2 feet) contained 1,200 µg/kg benzo(a)anthracene, 1,200 µg/kg chrysene, 1,200 µg/kg benzo(a)pyrene, and 100J µg/kg dibenzo(a,h)anthracene. Strong solvent odors were noted during the drilling of both of these borings.

Lower concentrations of PAHs, though still exceeding TAGM values, were also detected in samples AW-MW-21 (8-10 feet) (85J µg/kg benzo(a)pyrene) near the golf course; AW-MW-23 (2-4 feet) (17J µg/kg dibenzo(a,h)anthracene) north of the demolished cyanide treatment plant; AW-MW-26 (0-2 feet) (180J µg/kg benzo(a)pyrene and 49J µg/kg dibenzo(a,h)anthracene) along the northwestern site boundary; AW-MW-29 (0.5-2 feet) (220J µg/kg benzo(a)pyrene), AW-MW-34 (0-2 feet) (95J µg/kg benzo(a)pyrene) along the eastern site boundary; AW-MW-38 (0-2 feet) (360J µg/kg benzo(a)pyrene and 76J µg/kg dibenzo(a,h)anthracene) along the southern site boundary; AW-B4 (0-2 feet) (200J µg/kg benzo(a)pyrene) near the former chip handling area; SWMU-9-2 (2-4 feet) (84J µg/kg benzo(a)pyrene); and SWMU-13-1 (12-14 feet) (76J µg/kg benzo(a)pyrene). Though the samples did not contain compound concentrations in exceedance of the TAGM values, visual and olfactory petroleum contamination was observed in the borings near several of the waste oil USTs (specifically SWMU Nos. 7, 10, 12 and 13) and in the area of Manhole 43 (AW-MW-43 and AW-MW-44).

TPH was analyzed in three of the Building 25 samples. The maximum concentration of 620 mg/kg was found in B25-MW-5 (9-11 feet) (duplicate). TPH was also detected in B25-MW-2 at 340 mg/kg. No previous investigations included analyses for TPH.

During the installation of a majority of the borings, only one soil sample per boring was submitted for chemical analysis so it is difficult to define the vertical extent of soil contamination. Seven of the 21 samples which contained SVOCs above the TAGM values were collected from the 0 -2 feet bgs interval, suggesting that soil contamination may decrease with depth. Several of these samples were collected below asphalt, which may act as a source of PAHs. However, asphalt is not a likely a source of PAHs in the soil since field observations noted strong odors in a few of these samples, which would not be related to asphalt. The total concentrations of SVOCs increased with depth in the boring B25-MW-5, installed in the Erie Canal, where the 5 to 7 foot sample had a total semi-volatile concentration of 36,820 µg/kg, and the sample collected from 9 to 11 feet below grade had a total semi-volatile concentration of 82,380 µg/kg. However, this trend was not observed in the Geoprobe samples drilled in this area.

There was only one sub-surface soil sample which contained VOC concentrations which exceeded TAGM values. The only exceedance of TAGMs occurred in SWMU-12-2 (4-6 feet) where chloroform was detected at a concentration of 1,800 µg/kg. The TAGM value is 300 µg/kg for chloroform. Though below TAGM values, samples AW-MW-35 (0-2 feet) and AW-MW-36(10-12 feet) contained 101 µg/kg and 115 µg/kg of 1,2-DCE, respectively. These samples were collected near the former vapor degreaser in Building 20, had strong solvent odors, and contained exceedances of PAHs. In addition, Geoprobe samples WVA-GP-3 (12-13 feet) (15 µg/kg PCE, 3J µg/kg TCE) and WVA-GP-6 (13-14) (120 µg/kg 2-butanone) also contained concentrations of VOCs. Previous investigations detected TCE and PCE in the subsurface soils (to a depth of 8 feet bgs) in borings east and southeast of the Building 25, at concentrations below TAGM values. No samples exceeded the TAGM value for total volatiles of 10,000 µg/kg. The previous investigation by Empire Soils (1994) in the motor pool area detected only very low concentrations (less than 10 µg/kg) of volatile organics.

None of the sub-surface soil samples exceeded the TAGM values for pesticides. The highest concentration of a pesticide compound was detected in AW-MW-21 (8-10 feet) (1,700 µg/kg DDE). This sample was collected near the golf course in the former Erie Canal. None of the samples contained concentrations of PCBs above the detection limit.

#### 5.4.2.2 Inorganics

The subsurface soil samples contained concentrations of all of the inorganic parameters above the TAGM values.

Twenty-six of the 69 sub-surface soil samples (approximately 38 percent) contained chromium concentrations in exceedance of the TAGM value (20.7 mg/kg). These samples were distributed throughout the site, though the highest concentrations were detected in two of the Building 36 (wastewater treatment plant) borings and the borings in the former Erie Canal (B25-MW-5, WVA-GP-8, WVA-GP-13). The maximum chromium concentration of 237 mg/kg was detected in sample B36-B1 (3-6 feet), in the area where a spill of treated chromium clarifier sludge occurred in January 1996. Samples B25-MW-5 (9-11 feet) in the former Erie Canal, and B36-B3 (3-6 feet), in the area of the chromium clarifier sludge spill, contained chromium concentrations, with 57.1 EN mg/kg and 51.5 mg/kg of chromium, respectively. Geoprobe samples WVA-GP-8 (13-14 feet) and WVA-GP-13 (9-10 feet) contained 42.9 mg/kg and 92.7 mg/kg of chromium, respectively. Other samples which exceeded the chromium TAGM were collected from the fill in the vicinity of Building 20, from native soils in the northwest portion of the site near the railroad tracks or former chip handling facility, near the demolished cyanide treatment facility, and along the southern site boundary. The previous investigation by Empire Soils (1994) detected chromium at 22.5 mg/kg in the EM-SP-21 boring. None of the samples exceeded the recommended NYSDEC site cleanup objective for Perfection Plating (390 mg/kg) (E&E, 1995) or the EPA Region III Risk-Based Criteria for chromium (78,000 mg/kg).

Lead exceeded the TAGM value of 185.5 mg/kg (average site background) in 11 of the sub-surface soil samples. All of the samples which contained lead exceedances were collected from the fill. An extremely high lead concentration relative to the other samples was detected in sample B25-MW-5 (5-7 feet). This sample was collected from the former Erie Canal and contained 17,800J mg/kg of lead. Sample B25-MW-5 (9-11), collected from the same boring, contained 507E mg/kg of lead. Other samples which exceeded the lead TAGM were AW-MW-34 (0-2) (2,020 mg/kg), near Outfall 003 along the eastern site boundary; AW-MW-36 (0-2 feet) (613* mg/kg), on the east side of Building 20; AW-MW-24 (2-4 feet) (280 mg/kg), in the area of the demolished cyanide treatment facility. Four of the Geoprobe samples collected in the Erie Canal area: WVA-GP-6 (13-14 feet) (237 mg/kg); WVA-GP-7 (11-12 feet) (1,480 mg/kg); WVA-GP-11 (2.5-3.0 feet) (502 mg/kg); and WVA-GP-13 (9-10 feet) (1,560 mg/kg), also had concentrations of lead which exceeded the TAGM. Soil from the EM-SP-19 boring drilled by Empire Soils (1994) contained 982 mg/kg of lead. The EPA Revised Interim Soil Lead Guidance and proposed NYSDEC soil cleanup objective for lead is 400 mg/kg, which was exceeded by all of these samples except for AW-MW-24 (2-4 feet) and WVA-GP-6 (13-14 feet).

Twenty-eight of the 66 (approximately 42 percent) sub-surface soil samples contained arsenic concentrations above the TAGM value (average site background) of 10.5 mg/kg. The maximum arsenic concentration of 111 mg/kg was detected in AW-MW-30 (2.5-4.5 feet) near the former vapor degreaser in Building 123. This sample and samples AW-MW-28 (0-2 feet), from the general drum storage area, B25-MW-5 (5-7 feet), and WVA-GP-13 (9-10 feet), exceeded the EPA Region III Risk-Based Criteria for arsenic of 23 mg/kg, with 23.5 mg/kg, 23.1 mg/kg, and 51.3 mg/kg of arsenic, respectively. The samples which contained arsenic exceedances were distributed primarily throughout the western portion of the site, exceptions being samples AW-MW-34 (0-2 feet) on the eastern site boundary, AW-MW-44 (3-5 feet) near Manhole 43 and several samples from the eastern side of Building 25. Seven of the 14 Geoprobe samples collected in the Erie Canal area, including WVA-GP-13, had TAGM exceedences for arsenic. A concentration of 12.2 mg/kg arsenic was detected in EM-SP-21 during the Empire Soils Investigation (1994). Arsenic exceedances were detected in both the fill and the native soils.

Nine samples exceeded the TAGM value of 300 mg/kg for barium. All six of these samples were collected from the fill at locations throughout the site. The maximum barium concentrations were detected in B25-MW-5 (5-7 feet) (2,910 mg/kg) and B25-MW-2 (8.5-10.5 feet) (442J mg/kg), east of Building 25. None of the subsurface soil samples exceeded 5,500 mg/kg for barium, the EPA Region III Risk-Based Criteria.

Mercury concentrations exceeded the TAGM value (0.1 mg/kg) in 25 of the 46 samples (approximately 38 percent). Three of these samples, all of which were collected in the Erie Canal area, exceeded the maximum site background mercury concentration of 0.56 mg/kg. The maximum mercury concentration detected in the soil samples was 0.84 mg/kg in Geoprobe boring WVA-GP-7 (11-12 feet). None of the subsurface soil samples exceeded the EPA Region III Risk-Based Criteria for mercury of 23 mg/kg.

Cadmium concentrations exceeded the TAGM value (1 mg/kg) in seven samples, all of which were collected from the fill. None of these samples exceeded the EPA Region III Risk-Based Criteria for cadmium of 39 mg/kg. The maximum cadmium concentration of 5 mg/kg was detected in B25-MW-5 (5 -7 feet).

Silver was detected at concentrations above the TAGM value of non-detect in three samples: B25-MW-5 (5-7 feet) at a concentration of 2B mg/kg, SWMU-14-1 (12-14 feet) at a concentration of 0.21 mg/kg, and WVA-GP-7 (11-12 feet), at a concentration of 1.7B mg/kg. The Empire Soils Investigation (1994) samples contained 3.85 mg/kg, 4.36 mg/kg, and 4.81 mg/kg of silver in samples EM-SP-19, 20, and 21, respectively.

Selenium exceeded the TAGM value (3.075 mg/kg) in eight samples, with the maximum concentration of 10.5 mg/kg detected in WVA-GP-7 (11-12). The samples were distributed throughout the site, and none of the samples exceeded the EPA Region III Risk-Based Criteria of 390 mg/kg.

## 5.5 GROUNDWATER

Following the installation of the monitoring wells, two complete rounds (Rounds 1 and 2), and three partial rounds (Rounds 3, 4, and Geoprobe) of groundwater samples were collected.

During the first round, samples were obtained from all existing and newly installed wells. During the second round, samples were obtained from all the newly installed wells and all except eight of the existing wells. In addition, unfiltered metals samples were not collected from all of the wells during the second sampling round. Round 3 included all wells installed during Phase II monitoring well installation and the associated monitoring wells in each well cluster. Round 4 was completed in 1998 and included all wells installed during Phase III monitoring well installation and the associated wells in each well cluster. Grab groundwater samples were also obtained from the Geoprobe boreholes drilled in the Erie Canal area in February 1998. The groundwater purge logs are provided in Appendix F, the laboratory packages are included in Appendix L, and the results of the chemical analyses are summarized on tables in Appendix J. For comparison, Appendix J also contains the appropriate Federal and New York State standards, where applicable. These standards include the USEPA Maximum Contaminant Levels (MCLs), the NYSDOH MCLs, and the NYSDEC Class GA Drinking Water Standards. Tables 5-3 (Round 1), 5-4 (Round 2), and 5-5 (Rounds 3, 4, and Geoprobe) provide a statistical summary of the results. Rounds 3, 4, and Geoprobe sampling are grouped together in the statistical summary due to the limited number and types of samples collected, as well as the fact that all three rounds were conducted within one year (October 1997 to through June 1998). The analytical results of the samples collected from the process pits in Buildings 35 and 135 are discussed in Section 5.6.

### 5.5.1 Groundwater - Round 1- Organic Compounds

Unlike the nature of the sub-surface soil organic compound contamination which is primarily limited to PAHs, the nature of the groundwater contamination appears to be primarily related to the presence of volatile organics. The individual and total organic compound concentrations detected in the groundwater samples are shown on Plates 5-3 and 5-4.

Fifteen groundwater samples (approximately 23 percent) contained concentrations of VOCs above the applicable standards. Eleven of the 15 samples were collected from the wells downgradient of Building 25. The nature of the volatile organic contamination in the Building 25 area is primarily chlorinated organic compounds, such as chloroform, 1,1,1-Trichloroethane (1,1,1-TCA) and TCE, solvents formerly used at Building 25 and other locations around the WVA (Plate

5-3, Sheet 3). The maximum chloroform, 1,1,1-TCA, and TCE concentrations were 630 µg/l (EM-SP-7), 100 µg/l (B25-MW-3), and 410 µg/l (B25-MW-3), respectively. Groundwater results obtained by CTM indicated chlorinated organic compound contamination, particularly TCE, east and southeast of Building 25, downgradient of the former vapor degreaser. Historical TCE concentrations ranged from 6 µg/l to 183 µg/l, between 1985 and 1990. The higher detections were predominantly found in the hybrid well DM-SP-1 (screened in both weathered bedrock and bedrock).

Ten of the 15 samples which exceeded the standards for VOCs were collected from wells installed in the overburden. The vertical distribution of TCE in the groundwater can be assessed using the samples from the well cluster located southeast of Building 25, where TCE concentrations of 410D µg/l in the overburden (B25-MW-3), 120 µg/l in the weathered bedrock/bedrock (hybrid) (DM-SP1), and 37 µg/l in the bedrock (B25-MW-2) were detected. This decrease in concentration with depth also occurs for 1,1,1-TCA, with concentrations of 100 µg/l in the overburden well, 33 µg/l in the hybrid well, and 21 µg/l in the bedrock well. Chloroform was detected in one overburden well at 300 µg/l (86-EM-SP-1A) and in the hybrid well at a concentration of 7 µg/l.

Though the majority of the wells which exceeded the volatile organic standards were collected from wells downgradient of Building 25, the samples with the highest concentrations of volatile organics were not located in this area. The highest concentrations of total VOCs were detected in samples AW-MW-34 (2,689 µg/l) near Outfall 003 and AW-MW-36 (801 µg/l) near the former vapor degreaser on the east side of Building 20. The compound with the highest concentration in both of these wells was cis-1,2-dichloroethene, with concentrations of 2,000 µg/l in AW-MW-34 and 460 µg/l in AW-MW-36. Also, the wells located in the vicinity of Manhole 43, AW-MW-43 and AW-MW-44, contained exceedances of 1,1-dichloroethane (22 µg/l and 7 µg/l, respectively). The vinyl chloride standard (2 µg/l) was exceeded in four of the samples, with the maximum concentration detected in AW-MW-34 (89J µg/l).

Volatile organics and petroleum identification analysis was also conducted on the floating product sample collected from B35-MW-8 during the round one groundwater sampling event. Analysis could not be matched with any of the laboratory's petroleum standards. The petroleum pattern is described as having two components; the first eluting in the diesel range and the second eluting as 20W motor oil. The appearance of the product in B35-MW-8 differed from that in the Furnace Pit, as it appeared darker and more weathered with a more pungent odor. Concentrations of volatile organics were non-detect.

Eleven groundwater samples exceeded the State and/or Federal standards for at least one of the SVOCs. However, the semi-volatile compound which exceeded the standards in five of these samples (AW-MW-29, AW-MW-38RE, DM-SP-2, EM-SP-12, and MW-SP-19) was either diethylphalate, di-n-butylphthalate, or bis(2-Ethylhexyl)phalate. These compounds are not considered to be site contaminants and are common sampling and/or laboratory contaminants.

The maximum concentration of total SVOCs was detected in EM-SP-5 (890 μg/l). The groundwater samples collected from EM-SP-5, EM-SP-8, and AW-MW-43 contained 4-Chloro-3-methylphenol at concentrations of 890 μg/l, 110 μg/l and 240 μg/l, respectively. The compound 4-Chloro-3-methylphenol is indicative of soluble waste oil, and all of these wells are located along the soluble waste oil line. The NYSDOH MCL for 4-Chloro-3-methylphenol is 50 μg/l. A sheen was noted during the development and sampling of MW-43.

Only three samples, EM-SP-13, B35-MW-8, and RW-2, contained concentrations of potentially carcinogenic PAHs above the standards. All three of these samples were collected from wells installed in bedrock. Sample EM-SP-13 contained low concentrations (3 μg/l or less) of five of the potentially carcinogenic PAHs; the Class GA standard for each of which is 0.002 μg/l. The sample collected from B135-MW-8 contained 10J μg/l of benzo(a)anthracene and 14J μg/l of chrysene. As discussed above, product was observed and sampled in this well during field activities. Sample RW-2 contained 1J μg/l of chrysene, though it=s duplicate sample, AW-MW-300, was non-detect for chrysene. The Class GA standard for chrysene is 0.002 μg/l. The duplicate sample (AW-MW-300) contained 2J μg/l of benzo(a)anthracene, above the Class GA standard of 0.002 μg/l, though sample RW-2 was non-detect for benzo(a)anthracene.

Pesticides were detected at concentrations exceeding the standards in 27 of the 63 (approximately 43 percent) round one groundwater samples that were collected. The samples were collected throughout the site. Thirteen samples exceeded the Class GA standard for Dieldrin, which is non-detect. The maximum Dieldrin concentration was detected in the sample from the bedrock well EM-SP-21 (0.02J µg/l). Twelve samples exceeded the GA standard for DDE (non-detect), seven exceeded for Endrin (non-detect), six exceeded for Aldrin (non-detect), and 12 exceeded for DDT (non-detect). The maximum concentration of an individual pesticide compound was 0.069P µg/l of Heptachlor detected in EM-SP-13. PCBs were detected above the standards in only one sample. The sample collected from B135-MW-4, a bedrock well on the east side of Building 135, contained 0.15P µg/l of Aroclor-1260.

### 5.5.2 Groundwater - Round 1- Inorganics

For the first round of sampling, analytical results for the unfiltered samples indicate the presence of all inorganic parameter at concentrations above the standards with the exception of cyanide, mercury, and selenium. However, exceedances in the filtered samples occurred for only barium and lead, suggesting that the inorganics are primarily associated with the particulate matter.

The chromium standards (50 µg/l for the Class GA and NYSDOH standards) were exceeded in 15 of the 63 unfiltered groundwater samples (approximately 23 percent), but none of the filtered samples exceeded this standard. The highest chromium concentration (17,600 µg/l) was detected in the unfiltered sample from EM-SP-9, south of Building 35. The three unfiltered samples collected from wells in the motor pool area (EM-SP-19, EM-SP-20, and EM-SP-21) also contained high concentrations of chromium (3,250 µg/l, 1,170 µg/l, and 2,250 µg/l, respectively). Many of the other unfiltered samples which exceeded the chromium standards were collected along the southern site boundary near the chromic acid waste line (Plate 5-3, sheets 2 and 3). Eight of the 15 groundwater samples which exceeded the chromium standards were collected from wells installed in the bedrock.

Twelve of the 61 unfiltered groundwater samples (approximately 20 percent) exceeded the Class GA standard for lead (25 µg/l), but only one of the 63 filtered samples exceeded this standard. The only filtered sample to exceed this standard was collected from the hybrid well AW-RW-1 (32.3 µg/l filtered), though the corresponding unfiltered sample from AW-RW-1 contained only 6.6 µg/l of lead. The maximum lead concentrations were detected in B35-MW-5 (161 µg/l) south of Building 35 and EM-SP-1B (149 µg/l) southeast of Building 25. Lead exceedances were detected in five of the bedrock wells, four of the overburden wells, and three of the hybrid wells.

The barium standard (1,000 µg/l for the Class GA and NYSDOH standards) was exceeded in 10 of the 63 unfiltered groundwater samples (approximately 16 percent) and four of the filtered groundwater samples (approximately six percent). All of the samples which exceeded the barium standard were collected from bedrock wells, suggesting that the barium is indigenous in the bedrock. The median concentration of barium detected in bedrock wells is 2,265 µg/l. It is noted that barium compounds are often used as additives in lubricating oils and greases; however, barium is found at low concentrations in the product samples collected from the process pit at both Buildings 35 and 135. The highest barium concentration was detected in the unfiltered sample from B35-MW-5 (31,400 µg/l), south of Building 35, though the filtered sample from this well was non-detect for barium. The four samples which contained barium exceedances in both the filtered and unfiltered samples were: AW-MW-22 (3,320 µg/l unfiltered, 2,700 µg/l filtered), AW-MW-34 (1,100 µg/l unfiltered, 1,200 µg/l filtered), B135-MW-1 (2,640 µg/l unfiltered, 1,240E µg/l filtered), and B35-MW-8 (1,890 µg/l unfiltered, 1,680 µg/l filtered).

Arsenic was detected above the Class GA standard (25 µg/l) in four of the 63 unfiltered samples (approximately six percent), though none of the filtered samples contained arsenic exceedances. Of the four exceedances, two were detected in samples from bedrock wells and two were from overburden wells. The maximum arsenic concentrations were contained in B35-MW-5 (97.5 µg/l) south of Building 35 and AW-RW-2 (62 µg/l). The other two samples which contained arsenic exceedances were EM-SP-1B (26.0 µg/l), and B35-SP-9 (37.6J µg/l) along the southern site boundary near the chromic acid and waste oil lines.

The standards for silver (50 µg/l) were exceeded in only one sample, B135-MW-2 unfiltered (104 µg/l), along the western side of Building 135. Cadmium was detected in four unfiltered samples above the USEPA standard of 5 µg/l. However, only one of these samples exceeded the Class GA and NYSDOH standard of 10 µg/l. This sample was B25-MW-6 unfiltered (427 µg/l), located along the northeast side of Building 25. None of the filtered samples exceeded the cadmium standards.

Total iron was analyzed for in samples collected from three of the wells in the Building 25 area: B25-MW-2, a bedrock well, B25-MW-3, and overburden well, and B25-MW-4, a weathered bedrock well. The standards for iron (300 µg/l) were exceeded by all three samples.

B25-MW-4 contained the highest iron concentration (67,100 µg/l), followed by B25-MW-3 (17,900 µg/l) and B25-MW-2 (880 µg/l).

Three unfiltered and one filtered groundwater sample exceeded the standards for hexavalent chromium (50 µg/l). The maximum concentration was detected in B35-MW-8, with 18J µg/l in the unfiltered sample and 13 µg/l in the filtered sample. This well was noted to contain product during field activities. The other two samples which contained hexavalent chromium exceedances were B135-MW-1 (5 µg/l unfiltered) near the process pits and AW-MW-35 (0.1 µg/l) near the former vapor degreaser near Building 20.

### 5.5.3 Groundwater - Round 2 - Organic Compounds

The concentration of organic compounds were generally lower in the samples collected in the second sampling round than the concentrations detected in the samples collected in the first sampling round. Fifteen groundwater samples (approximately 25 percent) contained concentrations of VOCs above the applicable standards, which is the same number of samples as in the first round. However, the maximum concentrations which were detected in these second round samples were generally lower than those detected in the samples from the first round. The maximum concentration of total volatile organics was 1,400 µg/l (AW-MW-34), as compared to 2,689 µg/l (AW-MW-34) in the first round.

Eight of the 15 second round samples which exceeded the standards were collected from wells downgradient of Building 25, as compared to 11 of the 15 samples collected during the first round of sampling. Chlorinated organics were detected in all eight wells, with the primary contaminants of concern again being 1,1,1-TCA and TCE. The maximum TCE concentrations were 310 µg/l (B25-MW-3) and 280 µg/l (B25-MW-6), as compared to a maximum of 410 µg/l (B25-MW-3) obtained during the first sampling round. Also downgradient of Building 25, there were four samples (EM-SP-1B, EM-SP-7, EM-SP-8, and B25-MW-5) which exceeded the standards during the first round of sampling but did not exceed any standards during the second round of sampling. The maximum chloroform concentration was 28 µg/l (EM-SP-9) which is much lower than the maximum chloroform concentration detected in the first sampling round (630 µg/l EM-SP-7 first round; non-detect second round). Cis-1,2-Dichloroethene was detected at a concentration of 2,000 µg/l (AW MW-34) in the first round but at a maximum concentration of 1,100 µg/l (AW-MW-34) in the second round samples. The sample from AW-MW-34, which contained 89J µg/l of vinyl chloride in the first round, only contained 22J µg/l vinyl chloride in the second round. The maximum vinyl chloride concentration detected during the second round were from samples collected from two wells which were not sampled during the first round: AW-B121N (160J µg/l) and AW-B121S (48 µg/l). As described in the Cosulich Report (1980), Building 121 was used for an oil impregnating process and these wells had several inches of oil in them.

The vertical distribution of TCE is again represented in the well cluster located southeast of Building 25 with TCE concentrations of 310 µg/l in the overburden (B25-MW-3), 42 µg/l in the weathered bedrock/bedrock (hybrid) (DM-SP-1), and 51 µg/l in the bedrock (B25-MW-2). 1,1,1-TCA was also detected in this cluster at a concentration of 82 µg/l in the overburden well, 9 µg/l in the hybrid well, and 20 µg/l in the bedrock well. 1,1-dichloroethane (1,1,1-DCA) was detected in one overburden well at 11 µg/l (86-EM-SP-5).

The NYSDOH also collected water samples from several locations at WVA on May 30, 1996. These samples were collected from the Furnace Pit at Building 35, the Shrink Pit at Building 135, EM-SP-13, MW-BLDG110, B35-MW-8, and AW-MW-27. Samples were analyzed for ketone and petroleum products, hydrocarbon scan, and VOCs using Method 502.2. Gas chromatographs generated from the petroleum products analysis were compared against gas chromatographic standards generated from known petroleum products provided by WVA. The samples from EM-SP-13 and MW-BLDG110 were described as similar to A3 in 1 Oil≅. The sample from AW-MW-27 was similar to a material supplied by WVA and the sample from B35-MW-8 was similar to Steco Corporation cutting fluid. All four samples were non-detect or contained low concentrations of volatiles: EM-SP-13 was non-detect, MW-BLDG110 was non-detect, AW-MW-27 contained chloroform (1.6 µg/l), and B35-MW-8 contained benzene (0.5 µg/l), n-butylbenzene (1.2 µg/l), and 4-isopropyltoluene (0.8 µg/l). The analytical results of the Furnace Pit and Shrink Pit samples are discussed in Section 5.6.

Only four samples collected during the second sampling round exceeded the applicable standards for semi-volatile organics, as compared to 11 samples collected during the first sampling round. The four samples include three downgradient of Building 25, EM-SP-5, EM-SP-7, and

AW-MW-43, and one in the Building 35 well which contained product, B35-MW-8. The maximum concentration of total semi-volatiles was 310 µg/l (EM-SP-5), as compared to 890 µg/l (EM-SP-5) in the first round.

Two of the four samples which exceeded the standards contained concentrations of potentially carcinogenic PAHs above the available standards. Sample EM-SP-7, which was non-detect for PAHs in the first sampling round, contained concentrations of five potentially carcinogenic PAHs above the standards in the second round: 0.8J µg/l benzo(a)anthracene, 0.9J µg/l chrysene, 0.9J µg/l benzo(b)fluoranthene, 1J µg/l benzo(k)fluoranthene, and 0.7J µg/l benzo(a)pyrene. Sample B35-MW-8 contained 18J µg/l of benzo(a)anthracene and 40 µg/l of chrysene in the second round, slightly higher than the concentrations detected in the first round (10J µg/l benzo(a)anthracene and 14J µg/l chrysene). The maximum concentration of 4-chloro-3-methylphenol, detected in EM-SP-5 at a concentration of 310 µg/l, was much less than the maximum concentration detected in EM-SP-5 during the first sampling round (890 µg/l). The NYSDOH standard for 4-chloro-3-methylphenol is 50 µg/l.

Pesticides were detected at concentrations exceeding the standards in 10 of the 58 second round samples (approximately 17 percent), as compared to 43 percent of the first round samples. Only three samples exceeded the Class GA standard for Dieldrin (non-detect), with the maximum concentration being 0.019 µg/l (B135-MW-2). This sample, collected from bedrock well B135-MW-2, contained exceedances of three other pesticides (also heptachlor 0.049 µg/l, aldrin 0.0078 µg/l, and 4,4'-DDE 0.016 µg/l). The maximum concentration of a pesticide compound was 0.22 µg/l of endrin aldehyde in B35-MW-8.

### 5.5.4 Groundwater - Round 2 - Inorganics

Only 11 of the RCRA Metals samples collected during the second round of groundwater sampling were submitted for both filtered and unfiltered metals. The remainder were submitted for unfiltered metals only. The unfiltered samples contained at least one exceedance of every metal except for mercury and silver. However, for the filtered samples only lead and barium standards were exceeded.

The chromium standard was exceeded in 14 of the 60 unfiltered samples (23 percent), the same percentage as in the first round. Also the same as the first round, none of the filtered samples exceeded the chromium standards. However, the maximum chromium concentration detected in the second round, 2,570 µg/l (EM-SP-21), was much lower than the maximum concentration detected in the first round samples (17,600 µg/l in EM-SP-9). The location of the chromium contamination appears to be the same as seen in the first sampling round results, along the southern site boundary and in the motor pool area.

Fourteen of the 60 unfiltered samples (approximately 23 percent) and one of the 11 filtered samples exceeded the Class GA standard for lead (25 µg/l). The only filtered sample to exceed was collected from B35-MW-5 (64.4 E µg/l), which had the highest unfiltered lead concentration in it=s corresponding unfiltered sample (810E µg/l). Unlike the first round, four of the samples which exceed are located near the western site boundary (AW-MW-26, 27, 28, and 41). A majority of the other samples were collected near Buildings 25 and 35.

Barium was detected above the standards in 20 percent (12 out of 60) of the second round unfiltered groundwater samples, compared to 16 percent in round one. Eight of the 12 samples which exceeded were collected from bedrock wells. The maximum barium concentration was much lower in the second round (8,220 µg/l in B35-MW-8) compared to the first round (31,400 µg/l in B35-MW-5). Also, one filtered sample exceeded the barium standard. Sample B135-MW-1 contained 1,520 µg/l of barium.

The maximum concentration of arsenic was much higher in the second round of sampling. The sample collected from B35-MW-5 contained 744 µg/l arsenic, compared to 97.5 µg/l in the first round (this was the first round maximum also). A total of seven samples contained arsenic exceedances in the second round. The samples were collected from wells near Building 25, Building 35, and along the railroad tracks near the western site boundary.

Two samples exceeded the standard (10 µg/l) for selenium: unfiltered EM-SP-21 contained 14 µg/l and unfiltered B35-MW-5 contained 23B µg/l. Both of these samples were collected from bedrock wells. There were no samples in the first round which exceeded the selenium standards.

Eleven of the 60 unfiltered groundwater samples (approximately 18 percent) exceeded the USEPA cadmium standard of 5 µg/l. Seven samples exceeded the NYSDOH and Class GA standards of 10 µg/l. The maximum concentration of 127 µg/l (B35-MW-5) was well below the maximum concentration obtained during the first round of sampling (427 µg/l in B25-MW-4).

### 5.5.5 Groundwater - Rounds 3, 4, and Geoprobe - Organic Compounds

A total of 66 groundwater samples were collected for VOC analysis during Rounds 3, 4, and Geoprobe sampling. Thirteen groundwater samples from 12 monitoring wells (approximately 20 percent) collected during Rounds 3, 4, and Geoprobe sampling, contained concentrations of VOCs above the applicable standards. The maximum concentration of total VOCs detected in these rounds was 121,860 µg/l, at well AW-MW-51. The VOCs in this well were composed of 110,000 µg/l of tetrachloroethene (PCE), 10,000 µg/l of TCE, 1,200J µg/l of cis-1,2-dichloroethene (cis-1,2-DCE), and 660JB µg/l of chlorobenze. Dense Non-Aqueous Phase Liquid (DNAPL) was encountered in this well during installation/packer sampling activities. The results of the packer sampling activities are discussed further in Section 5.5.7.

The remaining wells at which VOCs were detected above the applicable standards during Rounds 3, 4, and Geoprobe sampling were: AW-MW-27, AW-MW-34, AW-MW-35, AW-MW-36, AW-MW-47, AW-MW-59, AW-MW-61, AW-MW-64, 25-MW-6, and 86EM-SP-5. VOCs were not detected in groundwater above standards in any of the samples collected from the Geoprobe borings in the Erie Canal area.

Wells AW-MW-33 (15 µg/l total VOCs), AW-MW-34 (2,233 µg/l total VOCs (Round 4)), AW-MW-61 (211.9 µg/l total VOCs (Round 4)), and AW-MW-59 (151 µg/l total VOCs (Round 4)), are located downgradient of Building 40, adjacent to the site boundary. VOCs detected in these wells are composed predominantly of PCE and cis-1,2-DCE, with a lesser percentage of TCE.

Wells AW-MW-36 (414 µg/l total VOCs (Round 3)), AW-MW-47 (46 µg/l total VOCs (Round 3)), AW-MW-35 (121 µg/l total VOCs (Round 3)), 25MW-6 (249 µg/l total VOCs (Round 3)), and 86EM-SP-5 (8.7 µg/l total VOCs (Round 3) are located downgradient of Buildings 20 and 25. VOCs detected in these wells are composed primarily of TCE, with the exception of AW-MW-36, which has a high percentage of cis-1,2-DCE.

Well AW-MW-64 is located in the central portion of the MMA, east of the hazardous materials storage area and adjacent to RW-2. The total VOC concentration in this well was 14,400 µg/l, composed of 7,200 µg/l of PCE, 5,500 µg/l of TCE, and 1,700 µg/l of vinyl chloride.

The vertical distribution of volatile organics in Rounds 3 and 4 is represented in three well clusters: AW-MW-53/83DM-SP-1/25-MW-2, located southeast of Building 25; AW-MW-35/AW-MW-36/AW-MW-48, located adjacent to the northeast corner of Building 20; and AW-MW-33/AW-MW-34/AW-MW-51/AW-MW-61, located east of Building 40.

The AW-MW-53/83DM-SP-1/25-MW-2 cluster was sampled during Round 3. Total VOCs detected in these wells were highest in the shallow bedrock, with 64 µg/l at in the overburden and weathered zone (83DM-SP-1), 100 µg/l in the shallow bedrock (25-MW-2), and not-detected in the intermediate bedrock (AW-MW-53).

The AW-MW-35/AW-MW-36/AW-MW-48 cluster was also sampled during Round 3. Total VOCs detected in these wells were highest in the overburden with 414 µg/l (AW-MW-36), 121 µg/l in the shallow bedrock (AW-MW-35), and not-detected in the intermediate bedrock (AW-MW-48).

The AW-MW-33/AW-MW-34/AW-MW-51/AW-MW-61 cluster was sampled during Round 4. Total VOCs detected in these wells were highest in the intermediate bedrock, with 15 µg/l in the overburden (AW-MW-33), 2,233 µg/l in the shallow bedrock (AW-MW-34), 51,900 µg/l in the intermediate bedrock (AW-MW-51), and 212.9 µg/l in the deep bedrock (AW-MW-61).

A total of 28 groundwater samples were collected for SVOC analysis during Rounds 3, 4, and Geoprobe. Of these, a total of 10 samples from eight wells exceeded the applicable standards for SVOCs during Rounds 3, 4, and Geoprobe sampling. Seven (six samples and one duplicate sample) of the samples were collected from Geoprobe borings (WVA-GP-2, WVA-GP-6, WVA-GP-7, WVA-GP-8, WVA-GP-13, and WVA-GP-14) which were drilled in the Erie Canal area. The remaining samples were collected from wells 35-MW-8 and 93EM-SP-13. The maximum concentration of total semi-volatiles in these rounds was 318 µg/l, which was detected in well 93EM-SP-13. Samples from all eight wells exceeded the standards for the potentially carcinogenic PAHs above the available standards.

Groundwater samples were not analyzed for Pesticides and PCBs during Rounds 3, 4, and Geoprobe sampling.

### 5.5.6 Groundwater - Rounds 3, 4, and Geoprobe - Inorganics

A total of 27 unfiltered samples and 14 filtered samples were collected for inorganics analysis during Rounds 3, 4, and Geoprobe sampling. The 27 samples analyzed for unfiltered metals had least one exceedance of the applicable standards, with the exception of silver. Only barium standards were exceeded in the 14 filtered samples.

The chromium standard was exceeded in nine of the 27 unfiltered samples (approximately 33 percent). The maximum chromium concentration in the unfiltered samples was 1,690 μg/l at Geoprobe location WVA-GP-8, located in the former Erie Canal area.

Fifteen of the 27 unfiltered samples (approximately 56 percent) exceeded the Class GA standard for lead (25 μg/l). None of the 14 filtered samples exceeded the lead standard. The maximum concentration of lead in the unfiltered samples was detected at Geoprobe location WVA-GP-8 (1,690 μg/l), which is located in the Erie Canal area.

Barium was detected above the standards in 44 percent (12 out of 27) of the unfiltered groundwater samples and in 7 percent (1 out of 14) of the filtered groundwater samples from Rounds 3, 4, and Geoprobe sampling. Seven of the 12 unfiltered samples which exceeded the standard were collected from overburden wells. The maximum barium concentration in the unfiltered samples collected during Rounds 3, 4, and Geoprobe sampling, was 7,460 μg/l, at Geoprobe location WVA-GP-8, located in the Erie Canal area. The maximum barium concentration in filtered samples collected during these rounds was 3,450 μg/l, at AW-MW-45, located in the northwestern portion of the MMA, near the site boundary.

Arsenic was detected above the applicable standards in seven of the 27 unfiltered samples and in none of the filtered samples collected during Rounds 3, 4, and Geoprobe sampling. The maximum concentration of arsenic was detected in the unfiltered sample from Geoprobe location WVA-GP-8, located in the Erie Canal area. Six of the seven standard exceedences were detected in the Geoprobe samples from this area.

Five of the 27 filtered samples exceeded the standard for selenium. None of the filtered samples exceeded the selenium standards. The maximum selenium concentration was detected at Geoprobe location WVA-GP-8. All of the selenium exceedences were from the Erie Canal area.

One of the 27 unfiltered groundwater samples, collected from Geoprobe located WVA-GP-8, exceeded the USEPA cadmium standard of 5 μg/l and the NYSDOH and Class GA standards of 10 μg/l in Rounds 3, 4, and Geoprobe sampling. The unfiltered cadmium concentration at this location was 99.4 μg/l. A total of five unfiltered groundwater samples had cadmium detections. Four of these samples were collected from the Erie Canal area. Cadmium was not detected in any of the filtered samples collected during Rounds 3, 4, and Geoprobe sampling.

Mercury exceeded the applicable standards in one of the 27 filtered samples collected during these rounds. This sample, collected from Geoprobe location WVA-GP-8, had a mercury concentration of 2.10 μg/l. Six of the seven unfiltered samples which had mercury detections were collected from the Geoprobe locations in the Erie Canal area. Mercury was not detected in the filtered groundwater samples collected during these rounds.

Silver was detected in seven of the 27 unfiltered groundwater samples collected during Rounds 3, 4, and Geoprobe sampling. None of these detections exceeded the Class GA standard. Five of the seven samples were collected from the Geoprobe locations in the Erie Canal area.

### 5.5.7 Packer Samples

As discussed in Section 3.3.1, bedrock monitoring wells AW-MW-48, AW-MW-51, AW-MW-52, AW-MW-53, AW-MW-54, AW-MW-58, AW-MW-59, AW-MW-60, AW-MW-61, and AW-MW-62, were installed during Phases II and III of well installation using a discrete zone groundwater characterization method to further characterize specific zones of known or suspected VOC contamination. As part of this method, samples of groundwater were collected from discrete zones and analyzed for VOCs. Analytical results for these “packer samples” were used to determine the vertical extent of contamination in the borehole and to aid in the placement of the open borehole section of the well.

The results of the packer sampling are presented on Table O-1, contained in Appendix O. Appendix O also contains the laboratory reporting forms for all packer samples. As shown in Table O-1, three wells, AW-MW-51, AW-MW-52, and AW-MW-61, contained discrete zones of elevated VOC concentrations.

Well AW-MW-51, located adjacent to Building 40, contained elevated VOC concentrations from 32 to 52 feet bgs (2,408 µg/l total VOCs), and extremely high VOC concentrations from 51 to 72 feet bgs (66,220 µg/l total VOCs). Upon retrieval of the sampling apparatus from the 51 to 72 feet bgs interval, a small amount (less than 20 milliliters) of DNAPL was discovered in the bottom of the sampling pump. The fact that no significant shallow groundwater contamination was discovered at overburden well AW-MW-33, adjacent to this location, indicates that the source of the DNAPL is upgradient of this well. All packer samples from well AW-MW-51 contained at least one VOC which exceeded groundwater standards.

Well AW-MW-61, located adjacent to AW-MW-51, was installed to determine the vertical extent of the elevated VOCs/DNAPL contamination discovered in well AW-MW-51. Elevated VOC concentrations (11,820 µg/l total VOCs) were observed in this well in the 100 to 120 foot bgs interval. However, only 62.2 µg/l total VOCs were detected in the 120 to 140 foot bgs interval, indicating that, inclusive of the results from AW-MW-51, the vertical extent of the VOC contamination in this area is limited to the range from 51 to 120 feet bgs. DNAPL was not encountered in well AW-MW-61, however both packer samples from this well contained concentrations of at least one VOC which exceeded groundwater standards.

At well AW-MW-52, located in the central portion of the MMA, adjacent to the Hazardous Materials Storage Area, a zone of elevated VOC concentrations (6,910 µg/l total VOCs) was encountered from 47 to 67 feet bgs. Above this zone (27-47 feet bgs), only 217 µg/l of total VOCs was detected. Below the zone (67-87 feet bgs), only 475 µg/l total VOCs was detected. This data indicates that VOC contamination in this area is limited to a discrete zone in the bedrock. All packer samples from well AW-MW-52 contained concentrations of at least one VOC which exceeded groundwater standards.

As shown in Table O-1, the remaining wells at which packer sampling was performed contained zones of minor VOC contamination, some of which exceeded groundwater standards.

However, concentrations of VOCs in these wells were orders of magnitude less than those detected in AW-MW-51, AW-MW-61, and AW-MW-52.

### 5.5.8 Water Quality Parameters

Additional water quality parameters were collected during Round 4 of groundwater sampling to evaluate the potential for the natural attenuation of the VOCs detected in the groundwater at various locations. These parameters included: dissolved oxygen, reduction-oxidation (REDOX) potential, pH, alkalinity, ammonia, chloride, fluoride, hardness, nitrate/nitrite nitrogen, total phosphorous, sulfate, total dissolved solids (TDS), and total suspended solids (TSS). Results for these parameters are presented in the summary tables contained in Appendix J.

## 5.6 PROCESS PIT SAMPLING

The floating product and water in the process and shrink pits in Buildings 35 and 135 were sampled as part of this investigation. The analytical results are provided in Appendix L and are included in the groundwater sampling summary tables (Appendix J). The analytical results are compared to the groundwater standards in Appendix J, though it should be noted that the water in the process pits is process water and not groundwater. Thus, the groundwater standards provided for the floating product and process pit water samples are for comparison only.

### 5.6.1 Building 35

Water samples were collected from the three process pit located at the southern end of Building 35 during both the first and second round sampling events. Samples were analyzed for the same parameters as that for the groundwater samples. Samples of the floating product were also collected from the Furnace Pit at Building 35. In addition to the organic and inorganic analyses, petroleum identification analysis was also conducted on the floating product sample collected from the Furnace Pit during the September 1995 sampling event.

#### 5.6.1.1 Building 35 Process Pit Sampling - Organics Compounds

Analyses of the pit water samples, collected during the first sampling event, indicated the presence of VOCs, SVOCs, and pesticides in the aqueous samples collected from the process pits. Chloroform, 2-butanone, and bromodichloromethane are the VOCs found in the aqueous samples collected from New Medium Tube Pit (PW-3) and the 8-inch Gun Tube Pit (PW-4). The latter two were at concentrations below Class GA groundwater standards, while the chloroform concentrations (8 μg/l in PW-3 and 15 μg/l in PW-4) were slightly in exceedance of Class GA groundwater standards. VOCs were not detected in the aqueous or product samples collected from the Furnace Pit (PW-2). It should be noted again that the samples collected from PW-3 and PW-4 are believed to be primarily representative of the process water in these pits, and not groundwater seepage.

Fewer VOCs were detected in the pit water samples collected during the second sampling event. In fact, only chloroform was detected in PW-3 at a concentration of 10 μg/l, slightly higher than its concentration detected in the first sampling round. PW-2 and PW-4 were non-detect for VOCs. These lower levels are likely a result of changes in the process activity or due to sample collection during different stages of the process. As in the first round, the floating product sample was non-detect for VOCs.

SVOCs were detected in aqueous samples collected from all three process pits; however, samples PW-3 and PW-4 only had detections of phthalates. The concentration of total SVOCs in the aqueous sample from the Furnace Pit was 20,600 μg/l. Compounds detected were fluorene (1,600J μg/l), phenanthrene (2,600J μg/l), fluoranthene (6,900J μg/l), pyrene (5,300J μg/l), and bis(2-ethylhexyl)phthalate (4,200J μg/l). Other compounds were likely masked due to the high detection limit in this sample. These five compounds are consistent with the floating product present at this location, which had a golden brown color and the consistency of a low viscosity cutting oil. SVOC analysis on the floating product identified the presence of fluorene (130,000J μg/l), phenanthrene (190,000J μg/l), anthracene (99,000J μg/l), fluoranthene (530,000J μg/l), pyrene (370,000 μg/l), benzo(a)anthracene (85,000J μg/l), chrysene (87,000J μg/l), and bis(2-ethylhexyl)phthalate (100,000J μg/l). The concentrations of these compounds are more than two orders of magnitude higher than that in the aqueous sample, thus indicating a relatively low solubility.

Similar semi-volatile organic results were obtained during the second round sampling event. PW-4 only had phthalate detections. At PW-3, the detections were mainly phthalates, but low concentrations of POL constituents were also detected. The concentration of total SVOCs in the aqueous sample from the Furnace Pit was 4,821 µg/l. This is lower than that detected during the first round; however, the suite of SVOCs detected was greater (16 versus five SVOCs detected in the first round sample). Concentrations were generally in the 200 µg/l to 400 µg/l range. A similar pattern to that of the Furnace Pit aqueous sample was observed in the SVOC analysis for the floating product sample. Concentrations were slightly lower (typically 25 percent lower) than detected in the first round sample, but the suite of SVOCs detected was greater (15 versus eight SVOCs detected in the first round sample).

Pesticide compounds were detected in all three aqueous pit samples. Concentrations were low in PW-3 and PW-4; however, the Class GA groundwater standard of 'non-detect' for delta-BHC, dieldrin, heptachlor, and heptachlor epoxide resulted in exceedances for these compounds. Pesticide concentrations in PW-2 were higher by four orders of magnitude. In fact, pesticide concentrations in PW-2 were the highest at Building 35. This increase is not likely to be indicative of levels in the groundwater seepage, however, since the Furnace Pit also receives water (and potentially contaminants) from other direct sources, including a hand-wash basin on the shop floor. Exceedances occurred in heptachlor (6.6P µg/l), alpha-chlordane (3P µg/l), and gamma-chlordane (2P µg/l). Pesticides were not detected in the aqueous pit samples during the second round of sampling. Pesticide analysis was not conducted on the floating product samples during the second sampling round. PCBs were not detected in any of the aqueous or floating product samples collected from the process pits collected during both sampling rounds.

#### 5.6.1.2 Building 35 Process Pit Sampling - Inorganics

Arsenic, chromium, and lead were detected in exceedance of the Class GA groundwater standards in the unfiltered aqueous sample collected from the Furnace Pit, which had concentrations of 55.9 µg/l, 1,220 µg/l, and 130 µg/l, respectively. Only chromium exceeded Class GA groundwater standards in the filtered sample (B35-PW-2) at a concentration of 62.4 µg/l. Chromium (64 µg/l) and lead (57.1 µg/l) were detected at concentrations in exceedance of Class

GA groundwater standards in the filtered aqueous sample from PW-3. A hexavalent chromium concentration of 85 µg/l was detected for the total (unfiltered) PW-3 aqueous sample and a concentration of 54 µg/l was detected in the dissolved (filtered) sample, both above the GA standard of 0.05 µg/l. Lead, chromium, and hexavalent chromium in both the filtered and unfiltered samples from PW-4 also exceeded Class GA groundwater standards. Chromium concentrations in the filtered and unfiltered samples were 14,700 µg/l and 19,600 µg/l respectively, lead concentrations in the filtered and unfiltered samples were 191 µg/l and 5,570 µg/l, respectively, and hexavalent chromium concentrations were 10,5000 µg/l and 17,410 µg/l in the filtered and unfiltered samples, respectively. These samples do not represent groundwater conditions at the site, as all three pits collect water from the electroplating processes conducted in the respective pits.

Barium and chromium were detected in the floating product sample collected from the Furnace Pit during the first sampling round, but at very low concentrations. Barium is a naturally occurring mineral at the site as well as a constituent of some lubricating oils and greases used at WVA. Analytical results from the aqueous and product samples collected from the Furnace Pit do not indicate that the free phase product is the source of barium in the groundwater. Concentrations in the pit water sample were greater than that in the product sample by two orders of magnitude and a factor of twenty in the filtered and unfiltered aqueous samples, respectively.

The second round of sampling indicated that chromium and lead concentrations were in exceedance in all three pits. PW-3 showed a marked increase in the concentration of chromium (14,500 µg/l) and lead (463E µg/l). PW-2 had similar concentrations of these compounds, while PW-4 showed a significant decrease in chromium and lead concentrations. These fluctuations in concentrations are believed to be related directly to the manufacturing process ongoing at the time of sampling and not seasonal changes in site conditions. Barium, chromium, and lead were detected in the floating product sample collected from the Furnace Pit during the second round sampling.; again, at very low concentrations which were below Class GA standards.

#### 5.6.1.3 Building 35 Process Pit Sampling - Petroleum Identification

Petroleum identification analysis was conducted on the product sample from the Furnace Pit in an attempt to identify its origins but could not be matched with any of the laboratory's petroleum standards, so no conclusive identifications could be made. The Furnace Pit sample is described as exhibiting a single petroleum pattern, eluting in the diesel range. The petroleum identification alone is inconclusive as the diesel range referred to encompasses a broad range of petroleum distillates. However, in combination with the other analyses conducted (specifically, the semi-volatile analysis and visual observations), the type of product present in the Furnace Pit can be tentatively identified as a middle distillate such as diesel fuels, kerosene, and lubricating/cutting oil. Previous petroleum identification analysis conducted for Clough, Harbour and Associates in 1990 indicated that the product present in the Furnace Pit at that time contained constituents characteristic of kerosene. An infrared scan conducted on the sample further revealed that the major component of the hydrocarbons is a synthetic hydrocarbon commonly made in petroleum refineries, referred to as a "heavy odorless mineral spirit".

### 5.6.2 Building 135

Samples of the water and floating product were also collected from the Shrink Pit at Building 135 during the September 1995 sampling event. In addition to the organic and inorganic analyses, petroleum identification analysis was also conducted on the floating product sample collected from the Shrink Pit. In February 1996 the Shrink Pit was drained and cleaned. As a result, a sample of the floating product layer was not collected during the second sampling event. Samples of the water from the Shrink Pit were however, collected and analyzed for the same parameters listed for the groundwater samples.

#### 5.6.2.1 Shrink Pit Water and Free Product Sampling - Organic Compounds

Analyses indicated the presence of VOCs, SVOCs, pesticides, and PCBs in the samples collected from the Shrink Pit during the first sampling round. Chloroform (9 µg/l) was the only VOC detected above the standards in the aqueous sample. However, chloroform (79J µg/l), total xylenes (260 µg/l), and toluene (98J µg/l) were detected above Class GA standard in the floating product sample. During the second round of sampling, concentrations of all the volatile compounds in the aqueous sample were non-detect.

The only SVOCs detected in the aqueous sample collected during the first sampling round above Class GA standards were bis(2-ethylhexyl)phthalate and di-n-butylphthalate (63B µg/l). No SVOCs were detected above the standards in the aqueous sample collected during the second sampling round. SVOC analyses identified the presence of fluoranthene (64,000J µg/l), pyrene (100,000J µg/l), and bis(2-ethylhexyl)phthalate (200,000J µg/l) in the floating product sample, all exceeding the applicable standards.

Three pesticide compounds were detected, aldrin (0.0057J µg/l), 4,4'-DDD (0.026 µg/l), and endrin ketone (0.009J µg/l) in the aqueous sample collected during the first round. Aldrin was in exceedance of the Class GA groundwater standard of "non-detect". 4,4'-DDE was the only pesticide compound detected in the aqueous sample during the second round, at a concentration of 0.032 µg/l. This is in exceedance of the Class GA groundwater standard of "non-detect" for this compound.

A PCB (Aroclor-1254) concentration of 0.31P µg/l was detected in the first round aqueous sample, above the Class GA groundwater standard of 0.1 µg/l. In the floating product sample PCBs (Aroclor-1254) were detected at a concentration of 4,800P µg/l. Clough, Harbour and Associates and WVA personnel also analyzed samples of floating product from the Shrink Pit for PCBs in 1990. These samples had PCB (Aroclor-1254) concentrations of 22,000 µg/l and non-detect, respectively. The PCBs are interpreted to have been a constituent of cutting oils used in the past. Other potential sources are the PCB-containing transformers and capacitors formerly located in and adjacent to the Shrink Pit and throughout the building, some of which had reportedly failed, and PCB-containing lubricating oil formerly used in the machines at WVA.

Analyses during the second round of sampling indicated the absence of VOCs and PCBs, and low concentrations of SVOCs and pesticides. The reduction of organic compound concentrations in the Shrink Pit water is believed to be attributable to the recent cleaning of the pit.

#### 5.6.2.2 Shrink Pit Water and Free Product Sampling - Inorganics

Barium, chromium, and lead were detected in the aqueous sample, while arsenic, barium, cadmium, chromium, and lead were detected in the floating product sample collected from the Shrink Pit. No exceedences of applicable Class GA groundwater standards for these inorganic constituents was present. Barium was the only inorganic compound detected (unfiltered sample), at a concentration of 64.6 NE µg/l, during the second round sampling event. This is well below the Class GA groundwater standard of 1,000 µg/l for barium.

#### 5.6.2.3 Shrink Pit Water and Free Product Sampling - Petroleum Identification

Petroleum identification analysis conducted on the product sample from the Shrink Pit could not be matched with any of the laboratory's petroleum standards, so no conclusive identifications could be made. The Shrink Pit sample is described as consisting of two constituents; the first eluting in the diesel range and the later eluting constituent identified as 20W motor oil. Previous petroleum identification analysis conducted for Clough, Harbour and Associates in 1990 indicated the presence of compounds characteristic of a refined petroleum lubricating oil. Further sampling was conducted by Arsenal personnel in March, 1995 of POLs within Building 135. Sampling locations included three milling machines, fresh oil from drums, POL seepage onto the third floor of the Shrink Pit, and the floating product in the Shrink Pit (Blue Lagoon). The two samples from the Shrink Pit were both identified as lubricating or motor oil. It should be noted, however, that the cutting oils used by WVA are performance based. Therefore, the cutting oils must meet certain performance specifications while the composition is not a concern (provided they are PCB free). The composition of the cutting oils used at WVA has changed as performance specifications changed and improvements in cutting oil performance were made. So, petroleum identification of POLs collected from the Shrink Pit may show characteristics of motor oil or lubricating oil, but are believed to be cutting oils which are currently in use or were formerly used at WVA. The total petroleum hydrocarbon chromatograph for the NYSDOH sample showed patterns comparable to Steco Corp. cutting oil and some similarity to the sample collected from B35-MW-8.

## 5.7 SUMMARY

### 5.7.1 Soils

The nature of the organic sub-surface soil contamination is primarily related to the presence of potentially carcinogenic PAHs throughout the site, especially to the east of Buildings 20 and 25, along the Erie Canal, and in the vicinity of Building 110. Four of the samples which exceeded TAGMs were collected near site boundaries - AW-MW-34 along the eastern boundary, AW-MW-38 along the southern boundary, and AW-B4 and AW-MW-25 along the western site boundary. A majority of the samples which exceeded the TAGM values were fill, rather than native soils. The soil samples collected from the former Erie Canal (B25-MW-5 and Geoprobe samples WVA-GP-1 through WVA-GP-13) contained the highest concentrations of PAHs.

Chromium, arsenic, and mercury appear to be the primary inorganic analytes of concern in the sub-surface soil samples. Approximately 38 percent of the soil samples exceeded the standard for chromium. Approximately 42 percent of the soil samples exceeded the standard for arsenic. Almost 38 percent of the soil samples exceeded the standard for mercury. As with the organic compounds, a majority of the exceedances were detected in samples collected from the fill, rather than the native, soils. The samples which contained chromium exceedances were distributed throughout the site, with the maximum concentration (237 mg/kg) detected in the area of Building 36, where there was a spill of treated chromium clarifier sludge in January 1996. Arsenic exceedances were distributed primarily throughout the western portion of the site, with the maximum concentration (111 mg/kg) detected in AW-MW-30, near the former vapor degreaser in Building 123. The maximum concentration of mercury in soil (0.84 mg/kg) was detected in Geoprobe location WVA-GP-8, located in the Erie Canal. Several other samples from the former Erie Canal (B25-MW-5 and the other Geoprobe samples) also contained elevated arsenic, chromium, and mercury concentrations.

While chromium and arsenic were the inorganic analytes which most frequently exceeded the TAGM values, each of the inorganic analytes were detected above the TAGM value in at least one sample. Three of the samples from the former Erie Canal (B25-MW-5, WVA-GP-7, and WVA-GP-13) contained the highest concentrations of a majority the inorganic analytes. The lead concentration in B25-MW-5 (5-7 feet) was 17,800J mg/kg, almost 100 times the TAGM value of 185.5 mg/kg. Likewise the lead concentrations in WVA-GP-7 and WVA-GP-13 were 1,480 mg/kg and 1,560 mg/kg, respectively, almost 10 times the standard.

### 5.7.2 Groundwater

#### 5.7.2.1 Main Manufacturing Area

Unlike the nature of the soil contamination in the Main Manufacturing Area which is primarily PAHs, the nature of the organic groundwater contamination is primarily related to the presence of VOCs. The majority of samples which contained VOC exceedances were collected to the east of Building 40, east and southeast of Building 25, and in the vicinity of the Hazardous Materials Storage Area located in the central section of the MMA. VOCs detected in these areas were chlorinated organic compounds, composed primarily of PCE, TCE, cis-1,2-DCE, and vinyl chloride. The maximum VOC concentrations were detected east of Building 40 in well AW-MW-51, where over 120,000 µg/l of total VOCs were detected and where DNAPL was observed during well installation. In addition, more than 14,000 µg/l of total VOCs were detected in well AW-MW-64. Elevated VOC concentrations were also detected near the former vapor degreaser in Building 20 (AW-MW-35 and AW-MW-36).

SVOC exceedances were occurred in three samples during the first sampling round and two samples during the second sampling round, and in ten samples from Rounds 3, 4, and Geoprobe sampling. SVOC exceedences in groundwater occurred primarily in the Erie Canal area (Geoprobe samples) and in the vicinity of Building 35 (35-MW-8).

Pesticides were detected above the standards (non-detect for most pesticide compounds) in approximately 43 percent of the first round samples but only 17 percent of the second round samples. PCBs were detected above the standards in only one sample, B135-MW-4.

Analytical results for both filtered and unfiltered metals suggest that a majority of the inorganic analytes detected in the groundwater are associated with particulate matter. Only barium (6 out of 88 samples) and lead (2 out of 88 samples) were detected above the standards in the filtered samples collected during all sampling rounds, as compared to the unfiltered samples where all metals were detected above the standards in at least one sample. The chromium concentration exceeded the standard in over 24 percent of the unfiltered samples collected during all sampling rounds. The maximum chromium concentration in groundwater was 17,600 µg/l in EM-SP-9, located south of Building 35. Likewise, 28 percent of the unfiltered groundwater samples collected during all sampling rounds exceeded the standards for lead. The maximum concentration of lead in the unfiltered groundwater was 10,600 µg/l at Geoprobe location WVA-GP-8, located in the Erie Canal.

Further information concerning the nature and extent of groundwater contamination in the vicinity of Buildings 35, 25, and 135 is provided below.

#### 5.7.2.2 Building 35

Review of the available analytical data indicates that the groundwater contamination in the vicinity of Building 35 is likely attributable to the more widespread groundwater contamination associated with the Main Manufacturing Area of WVA. VOCs detected in these wells were toluene or chloroform at concentrations below Class GA groundwater standards.

The POL contamination at Building 35 has been found to extend into the bedrock. During renovations at the Furnace Pit, POLs were observed seeping through the concrete walls at a depth of approximately 25 feet below grade. The Furnace Pit is approximately 30 feet deep, at least 20 feet of which is beneath the top of competent bedrock. Additionally, POLs were not encountered until 23 feet below grade during the installation of B35-MW-8, PW-1, and P-3 (installed during ICMS activities), approximately 15 feet into competent bedrock.

Contamination potentially associated with the electroplating operations and acid waste lines is indicated by the exceedances of arsenic, chromium, cadmium, and/or lead in wells B35-MW-5, EM-SP-9 and EM-SP-12 on the south side of the building, B35-MW-6 at the northeast corner, and B35-MW-8 on the west side of Building 35. It should be noted that these metals were detected mainly in the unfiltered samples, indicating contamination from suspended particulates rather than dissolved metals in groundwater.

#### 5.7.2.3 Building 25

Groundwater contamination in the vicinity of Building 25 is located to the east and southeast of the building itself. The contamination consists of chlorinated VOCs, composed primarily of TCE. These chlorinated organics were detected in the bedrock near Building 20 and in the overburden at the site boundary east of Building 25. Based on the results of the RFI, the horizontal extent of contamination associated with solvent use at Building 25 is limited to the vicinity of well cluster EM-

SP-1B/AW-MW-47 to the south, and by the eastern edge of the Erie Canal to the east. The vertical extent of the contamination appears to be limited to the overburden, weathered bedrock, and shallow bedrock. Based on the data collected to date, it appears that Building 25 is the sole source of the contamination in this area.

#### 5.7.2.4 Building 135

Based on the history and operations at Building 135, POLs are the primary concern and have been identified previously as floating free phase product at the Shrink Pit. Overburden soils in this area of WVA are very thin and the soils encountered during monitoring well installation did not show any signs of POL contamination (and were therefore not submitted for analysis).

Review of the available analytical data indicates that the horizontal distribution of groundwater contamination originating from within Building 135 does not extend beyond its perimeter of the building. With the exception of EM-SP-13, the monitoring wells located within and along the perimeter of Building 135 show very low concentrations of semi-volatile organic constituents. Inorganic concentrations in the groundwater at Building 135 are generally low. Barium and iron were the only inorganic compounds (currently and historically) detected above GA standards in the filtered samples. Chromium, lead, silver, cadmium, manganese, iron, and zinc were also detected above Class GA standards in several samples, but only in the unfiltered samples which is likely attributable to the high turbidity of the samples. Although barium is often used in oils and greases, it appears to be indigenous in the local groundwater and should not be considered a site contaminant.

### 5.7.3 Petroleum, Oil and Lubricants

#### 5.7.3.1 Potential POL Sources

A discussion of the potential POL sources is provided to aid in the evaluation of the nature and extent of POLs. Petroleum, oils and lubricants (POLs) have been used for different purposes throughout the main manufacturing area of WVA since the early 1900s. As a result, contamination associated with these materials is also well distributed. Numerous types of POLs have been used including: fuel oils (Numbers 2, 4, and 6), cutting oils, lubricating oils, hydraulic fluid, kerosene-like oil used for magnaflux testing, and dust-control oils. Since World War I the type, use, and storage of POLs has changed considerably. Currently, the fuel oils are stored in ASTs adjacent to Building 136; fuel oil, cutting oil, kerosene and diesel fuel are stored at Building 116; various cutting and lubricating oils are stored in drums at Building 133; and waste oils are stored in multiple USTs throughout WVA prior to off-site shipment or transfer to the IWTP through an underground network of pipes. However, the oils are used, and their associated wastes are generated, throughout the main manufacturing area of WVA.

Concern that POL contamination might be adversely affecting the environment at WVA was first documented in the William F. Cosulich report titled "Oil Pollution Source Elimination Study," dated January 1980. Since that time a number of reports have been written which further document the occurrence of POLs in the soil and groundwater in the main manufacturing area of WVA. Of particular note is the occurrence of POLs in the soil and groundwater at the fuel storage area adjacent to Building 136 and soils impacted by an 8,000-gallon No. 2 fuel oil spill between Buildings 116 and 121. Section 1.4.2.4 lists the most significant, documented spills and known occurrences of POLs in the main manufacturing area of WVA.

Cutting oils are another significant source for POL contamination at WVA. Two potential sources for cutting oil releases are the manufacturing buildings and the associated soluble waste oil collection systems. Cutting oils are used at each of the manufacturing buildings where large amounts of cutting oils are used during machining operations. It is believed that the recirculation troughs located beneath the milling machines and the subfloor oil collection systems have leaked cutting oils to the soils, bedrock, and groundwater beneath the footprint of each building.

Soluble waste oil generated from spent cutting oil is conveyed from each of these buildings to the IWTP through a network of underground gravity feed pipes for treatment. The IWTP is located in Building 36, at the southeast corner of WVA. The first 8-inch line runs along Parker Road, from which a number of branches extend. One branch extends approximately halfway along the alley between Buildings 35 and 110 and services Building 35; a second branch extends along Whittemore Road to Building 120 and services Buildings 114 and 115, and Buildings 120 through 126; and a third branch extends along Gillespie Road and services Building 135.

Building 110 has two open trenches, into which the waste oil collects, no longer in use. A $2^1/_2$-inch diameter overhead line conveys this waste oil to the main line on Parker Road. The second line extends from the IWTP to the alley between Buildings 20 and 25. Leakage from this system has been documented at a number of locations, including manhole MH-43D and most recently.

The preliminary phases of the Industrial Sewer Assessment were conducted as required by the consent order. As outlined in Appendix D of the consent order, the depths of the inverts of the soluble waste oil line were compared to groundwater elevations during the low water season to determine which sections of the line are submerged throughout the year (Plate 5-5).

Other documented and/or potential sources of POL and PCB contamination also exist. These include lubricating oils (POL and PCBs), leakage from oil storage and distribution centers, poor housekeeping practices, and leakage from transformers and capacitors (POL and PCBs).

Combustible waste oil is generated from lubricating oils used in milling machinery. Analysis of lubricating oils by WVA in 1982 indicated the presence of PCBs in a number of machines. Spent lubricating oil is collected in a number of USTs, typically 1,000-gallon capacity, prior to off-site shipment. The potential exists for these collection lines and USTs to leak contributing to the POL contamination in the main manufacturing area of WVA. Several of the USTs used to store combustible waste oils have been investigated as separate SWMU's.

Leakage, spills and poor housekeeping practices in and around the buildings in the main manufacturing area of WVA has also contributed to POL contamination. In addition to numerous minor spills, three major spills have been documented since 1974. It should be noted that spills occurring prior to 1974 were not documented. The first of the documented spills happened on March 14, 1975. On this occasion a 2-inch diameter distribution line ruptured releasing 8,000 gallons of No. 2 fuel oil into the ground around Building 116. An estimated 400 gallons was reportedly recovered. A second spill occurred on March 10, 1976. In this instance, 266 gallons of No. 2 fuel oil was released while filling a storage tank. The third documented spill was discovered on May 13, 1993 to the east of Building 116. An underground diesel fuel distribution line was found to have discharged approximately 400 gallons of diesel fuel. A recovery well (RW-2) was subsequently installed and approximately 30 gallons of product was recovered.

The Cosulich report documents many poor housekeeping practices in the past at WVA, each of which potentially contributed to the POL contamination. Cited in the report are instances of oil spillage and staining in many of the manufacturing buildings, but especially in Building 110. Dumping of waste oil into machine sumps has been documented at Building 135. This practice may have also been common in the other, older manufacturing buildings.

Plate 1-4 shows the locations of current and former PCB and non-PCB capacitors and transformers at the WVA. According to WVA personnel, a number of capacitors have failed, releasing PCB oils. The number of equipment failures and amount of oil released is not known. Capacitors and transformers remain a potential source for the PCBs (and POLs) found at WVA. The WVA is currently in the process of removing all PCB-containing (greater then 50 ppm) capacitors and transformers.

As summarized above, the sources of the POL contamination are numerous and the type of POL released to the environment are varied. Once released, mixing of different petroleum products and degradation would occur making source determination of specific occurrences of POLs in the soil and groundwater difficult. Also, the petroleum identification analysis conducted on the product sample from B35-MW-8 is non-specific and does not indicate a particular POL product or origin.

#### 5.7.3.2 Nature of POLs

Without an identified singular source or product origin, sampling and analysis of observed POL contamination was the only way to further evaluate the nature of the POL contamination at WVA. Samples of the free phase product were therefore collected from the Shrink Pit in Building 135, monitoring well B35-MW-8, and the Furnace Pit at Building 35 in September 1995. Additional samples were collected during the second round of sampling in May 1996 from the Furnace Pit in Building 35. In addition, WVA personnel collected and analyzed samples of product from various locations within Building 135 for petroleum identification. The results of these analyses are discussed in Section 5.6.

SVOCs were the main constituents of the free phase product identified. Fluoranthene, pyrene, and bis(2-ethylhexyl)phthalate were identified in the sample collected from the Shrink Pit. A greater range of SVOCs were identified in the samples collected from the Furnace Pit at Building 35. They included those compounds detected in Shrink Pit sample and other PAHs. Of interest is the occurrence of bis(2-ethylhexyl)phthalate. This compound is generally associated with plastics, however, it is also used as a substitute for PCBs. Its occurrence in free phase product samples, believed to be of a cutting oil source, supports the theory that the source of the PCB contamination is the cutting oils.

VOCs were only detected in the product sample collected from the Shrink Pit at Building 135. Concentrations were much lower than for SVOCs, typically three orders of magnitude. Chloroform, toluene, and xylene were detected in this sample. Toluene and xylene are not typically associated with cutting or lubricating oils, but rather with lighter petroleum distillates such as gasoline. They may be associated with the kerosene-like oil used for the magnaflux testing operations, which occur to the west of the Shrink Pit.

PCBs (Aroclor-1254) were detected at a concentration of 4,800P µg/l. Clough, Harbour and Associates and WVA personnel also analyzed samples of floating product from the Shrink Pit for PCBs in 1990. These samples had PCB (Aroclor-1254) concentrations of 22,000 µg/l and non-detect, respectively. The PCBs are interpreted to have been a constituent of cutting oils used in the past. It is believed that bis(2-ethylhexyl)phthalate is currently used as a substitute for PCBs in the cutting oils.

Other potential but less likely sources are the PCB-containing transformers and capacitors formerly located in and adjacent to the Shrink Pit and throughout the building, some of which had reportedly failed and discharged fluids, and PCB-containing lubricating oil formerly used in the machines at WVA.

Petroleum identification analysis was also conducted on the product samples collected at Building 35 from the Shrink Pit, the Furnace Pit, and 95MPI-B35-MW-8. No sample could be matched with any of the laboratory's petroleum standards, so no conclusive identifications could be made. Previous petroleum identification analysis conducted for Clough, Harbour and Associates in 1990 on the Shrink Pit sample indicated the presence of compounds characteristic of a refined petroleum lubricating oil. Two samples collected from the Shrink Pit by WVA personnel were identified as lubricating or motor oil. Clough, Harbour and Associates also ran petroleum identification analysis on the Furnace Pit sample in 1990. This analysis indicated that the product present in the Furnace Pit at that time contained constituents characteristic of kerosene. An infrared scan conducted on the sample further revealed that the major component of the hydrocarbons is a synthetic hydrocarbon commonly made in petroleum refineries, referred to as a "heavy odorless mineral spirit". Petroleum identification analysis conducted by WVA on samples of floating product collected from the Shrink Pit indicated a mix of lubricating, motor, and/or fuel oil. Similar analysis conducted on different varieties of fresh cutting oil indicted similar results, but they are believed to cutting oils being used or formerly used at WVA.

Petroleum identification was not performed on the product contained in MPI-P-3, located in Building 35. The product has a clear appearance with a very light odor. Based on observations of the oils used in the machinery located adjacent to this well, it is possible that the product is Norpar 13, a lubricating oil used at the WVA to aid in the analysis of the structural integrity of gun barrels.

### 5.7.3.3 Extent of POLs

The occurrence of POLs was documented during RFA/RFI field investigations conducted between January 1995 and February 1999, although not all areas of WVA were investigated. Free phase product was observed at Building 135 in the Shrink Pit, monitoring well EM-SP-13, and at the Rotary Forge. At Building 35, free phase product was observed in the Furnace Pit and in monitoring wells B35-MW-8, PW-1, and MPI-P-3. In addition, several other wells showed evidence of POL contamination. Product was also observed in the Auto Frettage Pit in Building 110. Table 4-1 summarizes the product thickness measurement recorded in the monitoring wells and process pits. As shown in Table 4-1, with the exception of MPI-P-3, product thickness generally ranged from only a few hundreds to a few tenths of a foot. More than one foot of product was observed at MPI-P-3. Significant product thicknesses were also recorded in the Furnace Pit in Building 35; however, this is believed to be the result of product accumulation in the sump pit, and not necessary representative of the true product thickness outside the pit.

In some instances, the POL contamination can be directly attributed to activities conducted at specific areas of WVA. For example, at the fuel storage area (Structure 147) the source of the POL contamination is well defined and the extent is localized (GTI, 1987). The monitoring wells GTI-MW-1BP through GTI-MW-4BP, installed at the fuel storage area, were non-detect for all POL associated VOCs and SVOC constituents during the September 1995 sampling event.

In addition to Building 135 the other locations within the Main Manufacturing Area of WVA with POL concerns extends from Building 25, west to Building 125, north to Building 120, and east to Building 20. Many of the buildings in this area either store, distribute, or use oil products. Milling activities which utilize cutting oils are conducted at Buildings 20, 25, 35, 110, and 125. Magnaflux testing operations are or were previously conducted at Buildings 20, 25, 35, 110, 125, 115, and 120. Fuel oil was also stored in a 19,020-gallon vaulted UST (Building 101) formerly located at the southwest corner of Building 35. Numerous storage vessels are located at Building 116, including a 20,000-gallon fuel oil AST, a 4,000-gallon diesel fuel UST, and a kerosene UST (capacity not specified). In addition, four USTs, with capacities ranging from 6,000 to 17,000 gallons, were formerly located at Building 116. Oil impregnating processes were conducted at Building 121. During the 1950s and 1960s the area west of Building 121 was used as a chip storage area. Typically these metal chips are saturated with cutting oils. Until approximately 1976 this location was the wash rack area, used to clean oil from the metal parts.

POL contamination, as evidenced by odors and/or staining, in the overburden soils was observed during the installation of several monitoring wells. Odors were observed in AW-MW-27 and AW-MW-28 on the western side of WVA. This area of WVA was formerly used for the interim storage of oil-soaked metal chips, thus the POL soil contamination evidenced in this area may be the result of metal chip storage. Well boring AW-MW-24 had petroleum sheen and odor in the soils. This well is located downgradient of the northern section of Building 110. Thus the POL contamination observed may be the result of operations conducted in Building 110. POL staining and odor was observed in the two wells installed adjacent to the IWTP, identified as AW-MW-43 and AW-MW-44. A soluble waste oil line runs adjacent to these wells. This line is known to have been leaking at Manhole-43, resulting in the POL contamination observed. To the north of this location, at AW-MW-35 and AW-MW-36 odor was observed in the overburden soils. However, chlorinated solvents are believed to be the main contaminants of concern in this area of the WVA. The four soil boring locations showing the greatest evidence of POL contamination are AW-MW-25, AW-MW-28, AW-MW-29, and AW-MW-36. SVOCs including benzo(a) anthracene, chrysene, and benzo(a) pyrene, indicating the presence of potential POL contamination, were detected in exceedance of the NYSDEC TAGMs in soil samples collected at these locations.

POL contamination extends into the bedrock to an unknown extent. Free phase product has been observed in bedrock monitoring wells B35-MW-8, PW-1, MPI-P-3, EM-SP-13, MW-

121-S, MW-121-N, MW-BLDG110, 35-MW-5, AW-MW-43, the Shrink Pit and Rotary Forge at Building 135, the Auto Frettage Pit in Building 110, and also in the Furnace Pit at Building 35, the lower half of which is constructed in bedrock. Product sheen has been observed in AW-MW-24, AW-MW-27, AW-MW-44, EM-SP-5, DM-SP-3, and EM-RW-2. In addition, following the POL spills near Building 116, product was observed seeping from bedrock roadcuts in this area during rain events. It is uncertain weather this seepage was caused by rising water table elevation or flushing of bedrock fractures/joints by percolating rain water. Evidence of dissolved phase POL constituents in groundwater in exceedance of regulatory standards was observed in bedrock monitoring wells EM-SP-13, B35-MW-8, and AW-MW-38 and in overburden monitoring well AW-MW-43. It should be noted however that low concentrations of dissolved organic compounds typically associated with POL contamination have been detected in wells with free phase product. This indicates that the constituents comprising the POLs have low solubilities. Therefore, their absence in the aqueous phase does not preclude the presence of free phase POL product.

# 6.0 FATE AND TRANSPORT

Fate and transport has been organized into several sections. The first section provides a general description of the fate and transport mechanisms at the MMA. Following this, fate and transport descriptions are provided for groups of chemical, including organics (chlorinated solvents), inorganics, and POLs. Within each section a general description of the fate and transport process is given, followed by a site-specific data to show what fate and transport process are occurring at the MMA.

## 6.1 FATE AND TRANSPORT PROCESS DESCRIPTION

### 6.1.1 Advection and Diffusion

Advection and dispersion are the two mechanisms by which a contaminant is transported in a fluid medium such as air or water. Advection is transport of solute by the bulk movement of the media. Typically, advection is the most important process driving contaminant migration. However, if advection alone was the only transport mechanism, contaminants would be moved through the media as a slug of mass, with a sharp concentration front. In reality, the dissolved plumes are spread out B the result of hydrodynamic dispersion. Hydrodynamic dispersion is the sum of mechanical dispersion and molecular diffusion. Mechanical dispersion is the mixing that occurs as a result of the local variation of velocity around the mean velocity of flow. Molecular diffusion is independent of velocity and is due solely to concentration gradients, where solutes will flow from areas of higher concentration to areas of lower concentration. In most groundwater settings, mechanical dispersion has a much greater effect than molecular diffusion on contaminant migration.

### 6.1.2 Biodegradation

Once released into the environment, many contaminants are subject to breakdown or transformation by naturally occurring microorganisms in the environment. This is commonly referred to as biodegradation or biotransformation. The degree to which a chemical is broken down depends on several factors, including the type of chemical, the number and types of microorganisms present, the availability of nutrients and electron acceptors, and the ambient conditions at the site. Biodegradation tends to decrease with both increasing molecular size of a compound and increasing degree of halogenation. Large, chlorinated compounds (e.g., PCBs) are the least susceptible to biodegradation while low molecular weight non-halogenated compounds (e.g., xylene) are easily broken down. Chlorinated solvents are susceptible to biodegradation as a primary substrate, as an electron acceptor, or under cometabolism (Wiedemeier et al., 1996).

Inorganic compounds can be converted to different oxidation states by biologic activity.

### 6.1.3 Volatilization

Volatilization of a compound can either occur from the pure liquid phase or from the dissolved phase. For the pure phase, volatilization is related to the vapor pressure. Vapor pressure is a measure of the tendency of a substance to evaporate and can be considered the solubility of the material in air at a given temperature. The higher the vapor pressure, the greater the tendency for the substance to volatilize. For the dissolved phase, volatilization is governed by Henry's Law, which states that the concentration of a contaminant in the gaseous phase is directly proportional to the concentration of the compound in the aqueous phase, with Henry's Law constant being the proportionality constant. Thus, Henry's Law constant of a chemical determines the tendency of a contaminant to volatilize from groundwater into soil gas. The higher Henry's Law constant, the greater the tendency for the chemical to volatilize from the aqueous phase to the vapor phase.

Contaminants which volatilize at or near the ground surface will be dispersed into the atmosphere. Contaminants adsorbed to soil particles and dissolved contaminants in the groundwater will volatilize into the soil pore spaces above the water table (vadose zone). Contaminants which volatilize into the pore space will diffuse over time into pore space which is less contaminated.

### 6.1.4 Adsorption

Adsorption is the process whereby dissolved contaminants partition from the groundwater to the particles comprising the aquifer matrix. Sorption of dissolved contamination onto the aquifer matrix results in the slowing (retarding) of the contaminant relative to the advective groundwater flow velocity. Sorption of dissolved contaminants is a complex phenomenon caused by several mechanisms, including London-van der Waals forces, Coulomb forces, hydrogen bonding, ligand exchange, covalent bonding between chemicals and aquifer matrix, dipole-dipole forces, and hydrophobic forces. Adsorption is a reversible mechanisms, therefore, the aquifer matrix may act as a secondary source of groundwater contamination.

The two most important factors of the aquifer matrix affecting sorption are the quantities of organic matter and clay minerals present in the aquifer matrix. In most aquifers, the organic content tends to govern the sorption of organic chemicals. The two most important factors of the chemical affecting sorption are the molecular weight and hydrophobicity; increasing values of either tend to increase the relative sorption of the compound.

Mathematically, the partitioning of chemicals between the aqueous phase and the aquifer matrix is expressed as:

$$C_s = K_d C_l$$

where: $C_s$ = sorbed concentration (mg/kg)
$C_l$ = dissolved concentration (mg/l)
$K_d$ = distribution coefficient (L/kg)

The distribution coefficient can be determined experimentally, but may also be estimated mathematically using the following:

$$K_d = f_{oc} K_{oc}$$

where: $f_{oc}$ = fraction of organic content (mg organic carbon/mg soil, assumed to be 0.001) $K_{oc}$
= soil sorption coefficient normalized for total organic carbon content

As mentioned previously, sorption slows, or retards, the transport velocity of the contaminant dissolved in the groundwater. The coefficient of retardation, R, is used to estimate the retarded contaminant velocity. The coefficient of retardation, assuming linear partitioning as described above, may be calculated using the relationship:

$$R = 1 + \frac{r_b K_d}{n}$$

where $R$ = coefficient of retardation (dimensionless)

$r_b$ = bulk density of the aquifer (assumed to be 1.7 g/cm$^3$)

n = porosity (assumed to be 0.25)

### 6.1.5 Sediment Transport

Contaminants present in surface soil can be transported by erosion due to storm events. Transport pathways are determined by site topography and drainage patterns. The amount of contaminants transported are determined by storm frequency and intensity, and the erosion potential of the site.

## 6.2 FATE AND TRANSPORT OF ORGANIC COMPOUNDS

The focus of this section is on the fate and transport of the primary organic compounds (i.e., chlorinated solvents) detected at WVA: tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-Trichloroethane (1,1,1-TCA), dichloroethene (DCE), and vinyl chloride (VC).

### 6.2.1 Fate and Transport Processes

The primary mechanisms affecting the fate and transport of chlorinated solvents at the MMA are advection of the dissolved phase constituents, degradation, and DNAPL migration.

Advection

The transport of the chlorinated solvents through the aquifer matrix is governed by the effects of sorption, or retardation. Retardation coefficients are calculated, using the equations presented in Section 6.1, to demonstrate how much slower the dissolved constituents will travel than groundwater seepage velocity. Table 6-1 lists the soil sorption coefficient constant ($K_{oc}$) for the primary contaminants found at the site. Assuming a fraction organic content of 0.001, partition coefficients are calculated. Using the partition coefficient and a bulk density value of 1.7 and a porosity of 0.25, retardation coefficient were also calculated and shown in Table 5-1. The retardation factors range from 1.39 (vinyl chloride) to 3.48 (PCE), with the retardation increasing with the degree of halogenation. Therefore, PCE will be transported at 0.29 times the rate of the groundwater seepage velocity, while vinyl chloride will be transported at 0.72 times the rate of the groundwater seepage velocity.

Degradation

Once released into the environment, many contaminants are subject to breakdown by naturally occurring micro-organisms (biotic) and by chemical (abiotic) processes in the environment. Figure 6-1 shows the biotic and abiotic transformations and degradation mechanisms of the contaminants of concern, each are discussed below (Wiedemeier et al., 1996).

The biodegradation of organic compounds occurs by three mechanisms:

- Use of the organic compound as the primary growth substrate.
- Use of the organic compound as an electron acceptor (reductive dechlorination).
- Cometabolism.

Chemotrophic organisms obtain energy for growth and activity from oxidation and reduction reactions. Under aerobic conditions, micro-organisms couple the oxidation of organic compounds with the reduction of oxygen. In the absence of oxygen (anaerobic), micro-organisms use other compounds (e.g., nitrate, ferric iron, carbon dioxide) as electron acceptors. PCE and TCE are biologically recalcitrant under aerobic conditions, however, DCE and VC can be utilized as primary substrate and oxidized under aerobic conditions. Under anaerobic conditions, PCE, TCE, and DCE are unlikely to undergo oxidation in the groundwater environment. On the other hand, VC can be directly oxidized to water and carbon dioxide via iron (III) reduction.

Chlorinated solvents have been shown to undergo reductive dechlorination under anaerobic conditions. During this process, the chlorinated hydrocarbon is not used as a carbon source, but as an electron acceptor (rather than oxygen, nitrate, etc.), and a chlorine atom is cleaved from the hydrocarbon and replaced with a hydrogen atom. Because the chlorinated hydrocarbon is used as an electron acceptor during reductive dechlorination, there must be an appropriate carbon source for microbial growth to occur. Potential carbon sources include naturally-occurring organic matter, organic compounds such as lactate, acetate, methanol, and other organic contaminants, such as fuel hydrocarbons.

Cometabolism is a biologically mediated redox reaction in which a fortuitous enzyme is produced by a microorganism during metabolism of separate organic matter. The fortuitous enzyme is then used as a catalyst to partially degrade the chlorinated hydrocarbon. Additional biotic or abiotic degradation is then required to complete the mineralization process. During the cometabolism process, the microorganism receives no known benefit; in some cases the cometabolism process may be harmful to the organism. Cometabolism is not nearly as important a degradation pathway in a groundwater environment as reductive dechlorination.

Chlorinated solvents dissolved in groundwater may also be degraded by abiotic mechanisms, although the reactions are typically not complete. The most common reaction affecting chlorinated compounds are hydrolysis and dehalogenation. Hydrolysis is a substitution reaction in which an organic molecule reacts with water or a component ion of water, and a chlorine atom is substituted with a hydroxyl (OH-) group. In general, rates of reactions are often quite slow within the rate of normal groundwater temperatures, with half-lives on the order of centuries. Hydrolysis rates are generally slower as the number of chlorine atoms on the hydrocarbon increase.

Dehalogenation is an reaction involving chlorinated hydrocarbons in which a chlorine atom is removed from one carbon atom, followed by the subsequent removal of a hydrogen atom from an adjacent carbon atom. Contrary to hydrolysis, the likelihood of dehalogenation increases with the number of chlorine substitutions.

DNAPL Migration

The retention capacity of DNAPLs in the vadose zone is typically small, therefore, even small releases of DNAPL commonly result in movement of DNAPL through the vadose zone and into the saturated zone. Considerable lateral movement of the DNAPL may also be possible. Movement of DNAPL, however, typically ceases shortly after the spill, perhaps within weeks or months of the spill, with the resulting immobile DNAPL existing as Aresidual≅ non-aqueous liquid on lower permeability layers within aquifers or on top of confining layers. The Aresidual≅ DNAPL will not become mobile again unless an additional release of DNAPL occurs or hydraulic stress are forced upon the aquifer (Panikow and Cherry, 1996).

Studies of DNAPL plumes have shown that the movement of chlorinated solvents in the subsurface is very complex. Subtle changes in permeability can greatly affect the distribution of chlorinated solvents, with differences of permeability of a factor of two or less capable of completely redirecting solvent movement. Due to this phenomena, historical movement of chlorinated solvents can not be calculated in a simple, deterministic manner.

In fractured media, DNAPL will preferentially migrate through the larger aperture pathways of a fracture plane since these offer the least capillary resistance to movement. DNAPL will enter intersecting fractures only if the local capillary pressure exceeds the entry pressure of the newly encountered fractures. The overall pattern of DNAPL migration will be governed by both fluid and media properties. Once entering the fracture network, much or all of the DNAPL can dissolve and diffuse into the low-permeability material surrounding the fractures. For typical fractures in unlithified clay-rich deposits or for small to medium size fractures in sedimentary rocks, matrix diffusion can cause DNAPL solvents such as PCE and TCE to completely dissolve and disappear in time periods ranging from a few months to years (Panikow and Cherry, 1996).

The disappearance time is directly proportional to porosity. Fractured media with higher porosities allow for quicker disappearance times of DNAPL. For example clay (n=0.40) and limestone (n=30) will allow for quicker disappearance than will shale (n=0.10) and quartz (n=0.05). For example, given the same fracture aperture size, a clay with a porosity of 0.35 percent will have a TCE disappearance time of 10 days while a shale with a porosity of 0.10 percent will have a TCE disappearance time of 1,000 days.

In addition, disappearance time is inversely proportional to fracture aperture size. Larger fracture apertures allow for quicker migration through the media, but shorter residence times, resulting in less matrix diffusion. For example, for a shale with a porosity of 10 percent, an aperture of 100 μm will have a TCE disappearance time on the order of 10,000 days, while an aperture of 10 μm will have a TCE disappearance time on the order of 100 days.

In media where matrix diffusion is not as important, DNAPL zones often persist because a majority of the contaminant mass remains in the source area, and the release of the DNAPL is slow, often diffusion limited. In these cases, source depletion mechanisms include volatilization loss to the vadose zone and diffusive loss to flowing groundwater.

The rate of dissolution of DNAPL to the groundwater is commonly expressed as a function of a mass transfer between the contact area of the groundwater and DNAPL B to date, no universal approach has been developed for the calculation of mass transfer between the contact surface of the DNAPL and the groundwater. Research suggests that the effective solubility of a given constituent compound can be estimated as the product of the mole fraction of that compound in the DNAPL with its pure-phase solubility (Panikow and Cherry, 1996). Effective solubilities for the chlorinated hydrocarbons at the WVA are shown in Table 6-1. The chemicals having the highest effective solubility will then be dissolved preferentially from the DNAPL. In many instances, while groundwater concentrations of solvents are below their effective solubility, DNAPL may exist. The finding of dissolved concentrations exceeding 1 percent of the effective solubility may be used as an indication that DNAPL exists (Panikow and Cherry, 1996). In the MMA, the highest concentration of total chlorinated solvents, where DNAPL was not identified in the field, was 14.4 mg/l at AW-MW-64, which is 7.2 percent of the effective solubility of PCE, indicating the potential presence of DNAPL at this location.

### 6.2.2 Site-Specific Fate and Transport

The fate and transport of chlorinated solvents at WVA is very complex due to the heterogeneity of the subsurface (e.g., fractured bedrock), fragmented historical use of solvents, and complex chemical and geochemical reactions occurring. This is evident in the characteristics of the different dissolved-phase chlorinated groundwater plumes that have been identified with the MMA:

1) RW-2 Area
2) Building-121 Area
3) Building 25 Area
4) Building 20 Area
5) Building 40 Area

The characteristics vary widely from plume to plume, within individual plumes at any given time, and within any well over time. Two identifiable trends that are consistent within these plumes, are described below:

1) the chlorinated solvent contamination has migrated vertically
2) the chlorinated solvents have degraded

The horizontal and vertical distribution of chlorinated compounds (PCE, TCE, DCE, and VC) in groundwater at the MMA is shown on Plates 6-1 and 6-2. In each plate, the relative concentration of chlorinated compounds in groundwater is represented by the diameter of the pie-chart, or "bubble plot". The relative percentage of each compound is shown in each chart.

The vertical migration of the chlorinated compounds is exemplified by the vertical profiles of chlorinated compound concentrations in groundwater at the Building 40 Area and the RW-2 Area (Plate 6-2). In both profiles, total chlorinated concentrations increase with depth, reach a peak concentration, and then decrease with continued increase in depth. In both cases, the maximum detected concentration was measured at approximately 60 feet below ground surface. At the Building 40 area, however, high concentrations (> 10,000 µg/l) continue downwards to depths of 100 feet bgs, while at the RW-2 area, the concentrations drop off significantly below depths of 60 feet bgs.

In AW-MW-52, located in the RW-2 area, not only did the total chlorinated concentrations change with depth, but so did the composition. In the shallower depth (27-47 feet), PCE and TCE totaled 8 µg/l, while DCE and VC totaled 209 µg/l. In the 47-67 feet interval, the PCE and TCE totaled 5,600 µg/l, while the DCE and VC totaled 1,300 µg/l. In the 67-87 feet interval, the PCE and TCE totaled 435 µg/l, while the DCE and VC were not detected at 10 µg/l. This indicates that breakdown of the chlorinated compounds are occurring at shallower depths, as shown by the ratio of PCE and TCE to DCE and VC, while at deeper depths, only minor amounts of degratation is occurring. The cause of this breakdown may be due to cometabolism of the chlorinated solvents with another substrate, such as naturally-occurring organics or POL contamination. Another possible hypothesis would be that the right geochemical or biological conditions exist for reductive dechlorination to occur.

Similar trends are observed in the Building 40 area for both chlorinated concentrations and compositions. From the June 1997 packer sampling event, the highest concentrations were found at AW-MW-51 in the 52-72 feet interval - 66,000 µg/l of PCE only, no other chlorinated compounds were detected above 50 µg/l. The interval immediately above this (32-52 feet), the PCE and TCE concentrations were 1,340 µg/l, while the DCE and VC concentrations were 1,060 µg/l. However, this trend does not appear to continue over time. From samples collected in 1998, the PCE and TCE concentrations from the 52-72 feet interval were at 29,000 µg/l, while the DCE and VC concentrations were at 22,000 µg/l. In addition, in AW-MW-61 at the 100-120 feet interval, the PCE and TCE concentrations were 6,000 µg/l, while the DCE and VC concentrations were also 6,000 µg/l. This indicates that degradation is occurring at depth in the Building 40 area.

In the Building 20 area, three wells - AW-MW-36 (overburden), AW-MW-35 (shallow bedrock) and AW-MW-48 (deep bedrock) - had total chlorinated organic concentrations of 120 µg/l, 410 µg/l, and non detect at 1 µg/l, respectively. AW-MW-36 had TCE levels of 12 µg/l, while DCE and VC levels were 390 µg/l. AW-MW-35 had TCE levels of 98 µg/l, while the DCE and VC levels were 22 µg/l. This shows a similar trend to that in the RW-2 area, where degradation is occurring in the shallower zone, but not the deeper zone.

To summarize, the transport of chlorinated solvents has occurred vertically, both by density-driven migration of DNAPL and from dissolved-phase constituents being transported by vertical groundwater flow. In addition, most DNAPL likely has been diffused into the rock matrix, making the detection of DNAPL difficult. Further movement of the dissolved phase contamination will be dictated by the fracture network and hydraulic gradients. Fracture patterns in the deformed shale at WVA are very complex, therefore, the migration of chlorinated solvents within the bedrock system will also be equally complex.

The breakdown of chlorinated solvents has been shown to occur more readily in the overburden and shallow bedrock than in the deeper bedrock. The breakdown may be due to the cometabolism with another substrate, such as naturally-occurring organics or POL contamination, or may be due to reductive dechlorination with the chlorinated compound acting as an electron acceptor.

## 6.3 INORGANICS

### 6.3.1 Fate and Transport

Unlike most organic compounds, metals do not degrade, but may change in oxidation state. The mobility of metals in the environment is primarily dependent upon pH, oxidation state, solubility, and sorption capacity. Metals may adsorb to clays, hydrous iron and manganese oxides, and organic compounds, and be rendered virtually immobile. The adsorption and desorption of metals at the soil/water interface greatly affects the mobility and transport of metals. Biological transformations which change the oxidation state of metals are common, and metals may adsorb to both living and nonliving biological matter. Metals may be dispersed in the air by wind, insofar as the metals are part of lightweight particles.

### 6.3.2 Site-Specific Fate and Transport

Inorganics exist in the sub-surface as solid species and ions in solution. All eight metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver) were detected above TAGM values in the sub-surface soils. Of these, only barium and lead were detected above Class GA standards in any of the filtered groundwater samples. Therefore, the remaining metals are considered present in the solid form since they are associated with the particulate matter. These metals are immobilized under the conditions of the site and therefore will not be considered further. Barium will remain in ionic form at all pHs and redox states which explains why it was detected in the filtered groundwater samples. Lead, in the presence of $CO_2$, will be present as an insoluble carbonate or carbonate-hydroxide species at pHs over 6.5. Lead oxides are not likely to form at the low concentrations of lead detected in the groundwater samples.

## 6.4 PETROLEUM, OILS, AND LUBRICANTS

Manufacturing activities conducted within the main manufacturing area of WVA incorporate the usage of various types of petroleum products, including fuel oils, cutting oils, lubricating oils, hydraulic oils, transformer/capacitor cooling oils, and various types of speciality oils and greases. A review of the available material safety data sheets (MSDSs) provided by WVA indicated that there are currently over 100 types of petroleum products being used at WVA. The storage and use of these materials and the handling of the associated wastes has resulted in releases to the overburden soils, bedrock, and groundwater at the site. Occurrences of free phase product have been documented at numerous locations throughout the main manufacturing area of WVA, including the Shrink Pit in Building 135, the fuel storage areas at Buildings 147 and 116, the Furnace Pit at Building 35, numerous locations within Building 110, and in groundwater monitoring wells MW-121S, MW-121N, B35-MW-8, SP-13 P-3 and PW-1.

### 6.4.1 Fate and Transport Processes for POLs

The POLs released into the environment as bulk phase liquid may exist in a number of physical forms or phases, including vapor phase, adsorbed phase, and aqueous or dissolved phase. When released into the subsurface soils, a bulk liquid phase POL will partition into the different phases until equilibrium is reached. The partitioning processes will generally be dependent upon the type of petroleum hydrocarbon released and the physical environment into which it is released.

The physical properties of the various oils which are important in terms of fate and transport are similar. The most important of these characteristics are specific gravity, solubility, kinematic viscosity, organic partitioning, and vapor pressure. Based on the information provided in the MSDSs, all of the petroleum products used, except for some heavy greases and solvents, have specific gravities less than water (i.e., less than 1) and are therefore LNAPLs. Most are insoluble or have negligible solubility in water and the concentrations of the various constituents comprising the POL in the aqueous phase are very low. For example, although free phase product was observed in monitoring well 93-EM-SP-13, the low concentration of volatile and semi-volatile organic compounds in the aqueous phase would not have indicated its presence. Because they are LNAPLs which move under the influence of gravity in bulk phase, the viscosity of the POLs will determine the rate of migration. Lower viscosity hydrocarbons, such as gasoline, will migrate much more rapidly than heavier hydrocarbons, such as fuel oils and diesel. Lower viscosity POLs will also tend to be more volatile and more soluble, resulting in a higher portion partitioning to the vapor and aqueous phases. The vapor pressure of any constituent of a POL will dictate how easily that constituent will form a vapor phase. In general, the lower the vapor pressure of a compound, the greater its readiness to partition to the vapor phase.

Other factors affecting the fate and transport of POLs in the environment are the volume of POLs released and the local hydrogeologic conditions. Petroleum products released to the subsurface by leaks or spills will tend to follow the most permeable zones, such as artificial fills, utility trenches, and building foundations. These backfilled excavations are commonly filled with a more permeable material than the native soils and thus offer a preferential pathway for migration. Similarly, a bedrock fracture system would offer preferential pathways for POL migration. In both situations, a release which might otherwise have had limited extent, can relatively quickly migrate through artificially high permeable zones and bedrock fractures thus making identification of the source and extent of a POL release difficult.

The migration of POLs would vary depending on the combination of the aforementioned variables existing at the time and location of the release. In general, POLs will migrate downward through the vadose zone towards the capillary fringe under the force of gravity with some lateral spreading. The rate of migration will depend on the size of the release, the viscosity of the product released, and the nature of the soil. For example, a small volume of POL released to the subsurface soils will migrate downward but may not reach the water table because its entire volume will be trapped in the pores and fractures in the unsaturated zone. In general, the greater the permeability and volume of a release and the lower its viscosity, the more rapid the migration of the POLs. For those instances where the entire volume of the spill is held in the soil, dissolved phase organic constituents from this residual saturation of POLs may be transported to the water table by infiltration. In cases where spills occurred at paved interior locations, transport of dissolved phase or foundation-cover constituents to the groundwater by infiltration is of lesser influence.

In cases where the POLs reach and accumulate at the water table, the weight of the POLs will to some extent depress the water table. At this point it is believed that the POLs will behave in one of two ways. Under the first scenario, with the addition of no new product over time, the POLs will spread to a critical thickness and stop moving; thus forming a pancake-shaped layer over the water table. The second potential scenario occurs when a large volume of POLs is released, moves rapidly to the water table, and depresses the water table to form a lens shaped plume. The lens will migrate downgradient with the water as a unit and may be several feet thick with a limited dispersion front. In either case, upon reaching the water table, dissolved phase hydrocarbons are transferred to the groundwater until chemical equilibrium is achieved. The equilibrium concentration is dependent on the effective solubility of the constituents comprising the hydrocarbon.

Those POLs situated in the water table fluctuation zone may become trapped by the rising groundwater during wet seasons. These hydrocarbons will tend to break up into globules, termed ganglia, which are persistent, long term sources of hydrocarbon contamination both in soil and groundwater. The formation of ganglia and the fluctuation of the groundwater level will tend to increase the movement of dissolved phase hydrocarbon constituents relative to static groundwater levels.

Whether in the bulk liquid phase or the aqueous phase, POLs may volatilize, forming a vapor phase in the pore spaces of the vadose zone. The type of petroleum hydrocarbons of concern at WVA are diesel fuels and other middle distillates. Only a very small percentage of the compounds which comprise these hydrocarbons tend to form a vapor phase. Rather, they tend to adsorb preferentially to the soil particles. It is also believed that these compounds are not very susceptible to biodegradation. In addition, any biodegradation of the POLs which might occur in the overburden soils, would be diminished in the shale bedrock due to lack of available nutrients and replenishment of oxygen.

### 6.4.2 Site-Specific Fate and Transport

At WVA, POL releases are believed to primarily occur from milling machinery located in the manufacturing buildings and the associated waste oil lines. Released POLs migrate through the relatively thin overburden soils under the influence of gravity down to the bedrock. Overburden soils at WVA consist of fill, glacial till, and alluvial deposits. Total organic carbon (TOC) analysis conducted on soil samples collected at Building 25 indicate ranges from 2,500 mg/kg to 39,000 mg/kg. Organic partitioning of POL constituents to the soil particles is therefore excepted to occur at the high end of this range, but not at the low end. At WVA, fractured shale bedrock occurs at a shallow depth, typically 5 to 6 feet below ground surface. TOC analysis from bedrock core samples collected from 95MPI-135-MW-1 indicate ranges from 6,240 mg/kg to 6,760 mg/kg. Organic partitioning of POL constituents to the bedrock will not occur. The relatively low TOC content (0.6%) in the shale does not therefore account for the absence of dissolved phase constituents in groundwater monitoring wells in the presence of free phase product. Adsorption of organic constituents to the shale is not considered a significant factor at the site based on these results.

Upon reaching the groundwater table at WVA, POLs will tend to follow the direction of groundwater flow to the east towards the Hudson River. Isolated exceptions to this are localized artificial groundwater depressions that occur at locations such as the Shrink Pit in Building 135. Induced POL migration towards the pit in this area is therefore believed to occur.

Movement of POLs to and through the bedrock is controlled by the groundwater elevation at WVA which occurs in the overburden or shallow bedrock throughout the site. Where the water table is in the overburden, the migration of POLs to the fractured bedrock will be inhibited. Where groundwater is in the shallow bedrock, especially in the areas of higher elevation at WVA, the POLs will enter the fractures of the shallow weathered bedrock and further movement will be dictated by the fracture network. Fracture patterns in the deformed shale at WVA are likely to be very complex. The migration of POLs within the bedrock system may also, therefore, be equally complex.

As noted in Section 5, POLs do occur in the bedrock at WVA. At monitoring well B35-MW-8 for example, POLs were encountered in a bedrock fracture at a depth of 23 feet below ground surface, approximately 15 feet below the top of competent bedrock and approximately 17 feet below the current static water level in that well. This occurrence indicates that POLs have entered the bedrock fracture system at upgradient locations and are forced downwards, possibly as a result of downward migration and trapping during subsequent recharge in downgradient areas.

It is therefore expected that the bulk of the POLs released into the subsurface at WVA do not form a simple lens shaped plume sitting on the water table, but rather from a very complex network of interconnected or discontinuous plumes of product following the bedrock fracture system.

# 7.0 CONCLUSIONS/RECOMMENDATIONS

## 7.1 CONCLUSIONS

The physical and chemical analytical data generated during these investigations, are of acceptable quality to assess the nature and extent of contamination detected in the Main Manufacturing Area and make recommendations for future Corrective Measure Studies.

Leakage from machinery, storage areas, and sewer lines, as well as discharges relative to historical practices at the site have contributed to site contamination. The primary contaminants of concern are:

- Chlorinated organic compounds. Activities at former vapor degreaser locations and potential spills have resulted in elevated concentrations of halogenated hydrocarbons in the groundwater.
- Petroleum, oil, and lubricants (POLs) in soils and as free phase, and to a lesser extent in the aqueous phase. Multiple sources have been identified for POLs, including spills in the Building 121 area, machinery and sumps at Buildings 35 and 135, leaking underground storage tanks (USTs), and ruptured waste oil lines.

Groundwater samples obtained in several areas of the Main Manufacturing Area have detected contamination of inorganics above applicable guidance values. However, these are not believed to be contaminants of concern because they were detected in unfiltered samples (total metals) rather than filtered (dissolved metals). Based on the results of the site investigations the conceptual models presented in Section 1.0 were revised, the revised site conceptual models are presented in Figures 7-2 through 7-5.

### 7.1.1 Chlorinated Organic Compounds

#### 7.1.1.1 Building 25

Chlorinated organic compound groundwater contamination is primarily located east and southeast of Building 25. The contamination consists of volatile organic compounds, particularly TCE and 1,1,1-TCA, in the overburden, weathered bedrock, and bedrock. These contaminants were detected at levels exceeding NYSDEC Class GA groundwater standards.

Groundwater contamination in this area follows the groundwater flow path east-southeast of Building 25. Chlorinated organics were also detected in the bedrock near Building 20 and Outfall 003. The vertical extent of contamination in both of these areas were defined during the 1997 and 1998 drilling activities. The source of the contamination in the area of Outfall 003 has not been confirmed. It does appear, however, that multiple sources contribute to the volatile organic contamination in these areas.

The extent and magnitude of contamination in the area surrounding Building 25 is most likely a result of numerous conditions:

# There may be several sources in the area, most likely the vapor degreasers previously located at Buildings 25 and 20. Sources of chlorinated organic contamination immediately upgradient of these buildings (Buildings 20 and 25) are unlikely due to the absence of TCE and its degradation products in groundwater samples collected in monitoring wells located immediately upgradient (RW-2, SP-10, SP-11, SP-12, B25-MW-1 and B35-MW-6), and the deep groundwater monitoring well (AW-MW-54) which intercepts deeper flow paths also does not indicate the presence of contamination from an upgradient source.

# The sewer lines and the sewer bedding materials in this area, particularly the sewer lines located beneath Westervelt Avenue are expected to be a preferential groundwater flow path in the area, as discussed in Section 4.2.

# The plume appears to be degrading as evidenced by the variations in the concentrations of TCE and its degradation products, DCE, and vinyl chloride. Groundwater samples collected in the monitoring wells along the eastern edge of Buildings 25 and 20 (AW-MW-35, B25-MW6, SP-1A, SP-1, B25-MW-2, B25-MW-3) exhibit higher ratios of TCE and TCA while groundwater samples collected downgradient (AW-MW-33, AW-MW-43, SP-5) exhibit higher ratios of DCE and DCA.

TCE is the primary volatile organic detected in the soils in the area surrounding Building 25. Of the 12 soil samples collected, TCE and its degradation products in the Building 25 area, were greater than the total concentration of degradation compounds detected in these samples. However, the low levels of volatile organics detected in the soil samples collected in this area (none of which exceeded TAGM values), when compared to the concentration detected in the groundwater do not indicate a source of contamination within the soils. This was also evident in the results of the soil gas survey which did not detect elevated concentrations of chlorinated organics immediately downgradient of Building 25, therefore soil contamination in this area is not considered to be of concern.

#### 7.1.1.2 Main Manufacturing Area

In addition to vapor degreasers located at Buildings 20 and 25, vapor degreasers were also in use at Buildings 110 and 123, along with other potential sources of chlorinated organics upgradient of Buildings 20 and 25. The potential for upgradient sources from Buildings 20 and 25 is evident in the results of groundwater contamination at B35-MW-5, B35-MW-7, MW-B121N, MW-B121S, RW-2, SP-21, and other deep bedrock wells in the recharge area of the site (AW-MW-64). The results of TCLP analyses from a sample obtained from the collection trench located within Building 110, indicated the presence of vinyl chloride in the sludges. As a result of these data the collection trench within Building 110 may also be a potential source of contamination. As indicated by the analytical data, several areas of groundwater contamination exist throughout the MMA which appear to related to individual source areas, or locally co-mingled plumes. However, the data indicates that the potential for one continuous plume emanating from the recharge area does not exist.

### 7.1.2 Petroleum, Oil, and Lubricants

#### 7.1.2.1 Building 25

Soil contamination in the Building 25 Area is primarily located in the area of the former Erie Canal. Organic compound contamination in the soils is primarily limited to semi-volatile organic compounds (volatile organic compounds, pesticides, and PCBs were below TAGM values). Semi-volatile organic compounds, specifically PAHs, were detected above TAGMs in soils at B25-MW-5 and B25-MW-6 and several of the geoprobe borings, within or near the former Erie Canal, and were not present at concentrations exceeding TAGMs in groundwater at these locations. The fate and transport analysis indicates that the semi-volatile organic compounds will remain immobile in the soil because of their low solubilities and high partition coefficients. The concentrations of several of the potentially carcinogenic PAHs (including benzo(a)pyrene, benzo(a)anthracene, and dibenzo(a,h)anthracene) were detected above TAGM values in the subsurface soils in the area of the former canal. The extent of the PAH soil contamination however, appears to be localized, and within the former Erie Canal, based on the results of the soil samples collected further north of B25-MW-5 at AW-MW-21 and the well cluster at AW-MW-36, which exhibit significantly lower levels of PAHs.

Field observations noted the presence of petroleum odors in the subsurface soils southeast of Building 25, however, volatile organic compounds and potentially carcinogenic PAHs were not detected above TAGM values in this location.

#### 7.1.2.2 Building 35

The Furnace Pit and other process pits at the southern end of Building 35 are the focus of this investigation with particular emphasis on POL contamination which has historically been observed. The Furnace Pit is approximately 35 feet deep and was excavated into bedrock. It contains a sump into which groundwater and free phase product collects. Leakage of groundwater and POLs into the pit sump is apparently through a drainage system installed around the base of the pit. POLs have not been discovered in any of the other process pits. POLs were also discovered in the bedrock at a depth of 23 feet bgs in B35-MW-8, and PW-1, upgradient of Building 35 and P-3 located inside Building 35. Measurements taken at B35-MW-8 indicate a product thickness of approximately 0.03 feet, while product thickness in the Furnace Pit sump is approximately 0.2 feet. The maximum product thickness detected was at P-3, where approximately 1.4 feet was detected during the ICMS pumping test. Although petroleum identification analysis did not confirm an origin for this product, results of other analyses and visual observations indicated potential origins from the middle distillate range, including cutting/lubricating oils, diesel fuel, and kerosene. It is also believed that the product present at these locations are likely from different sources. A number of potential sources do exist in the immediate vicinity of B35-MW-8, PW-1, and P-3, including lubricating and cutting oils used upgradient at Building 110 and/or upgradient POL spills and machinery located in Building 35. The source for the product in the Furnace Pit is believed to be largely from cutting, lubricating and/or kerosene type oils used within that building and upgradient in Building 110.

Despite the presence of free phase product, concentrations of organic compounds in the groundwater are low, generally below Class GA groundwater standards.

The relatively low concentrations of POL-related constituents in the aqueous/ dissolved phase is believed to be the result of the low solubilities of the compounds. TOC analysis of the shale bedrock collected from monitoring well B135-MW-1 did not indicate that adsorption of POL constituents to the shale bedrock would be a significant factor in reducing POL concentrations in the groundwater. However, diffusion of the POL contaminants into the matrix of the bedrock maybe a major consideration in the distribution of the contaminants in the groundwater at the site.

#### 7.1.2.3 Building 135

The Shrink Pit, located at the southeast corner of Building 135, is the focus of this investigation. It is approximately 100 feet deep and was excavated almost entirely into bedrock. It contains a sump in which groundwater collects for use in shrinking operation for the gun barrel rings. POLs and PCBs have been discovered to be leaking into the Shrink Pit since 1985. A product recovery system is currently in place skimming floating product from the surface of water in the pit sump. Identified leakage of POLs into the pit is through cracks in the concrete walls at various levels throughout the pit and through the drainage chase system which discharges into the pit sump. POLs have also been discovered in the groundwater beneath Parker Road at the north end of Building 135 and the Rotary Forge. Despite the presence of free phase product, concentrations of organic compounds in the groundwater are low, generally below Class GA groundwater standards. Some exceedances of semi-volatile organics slightly above Class GA groundwater standards do occur at EM-SP-13, the monitoring well in which the presence of free product has been identified.

The primary source of both occurrences of POLs is believed to be attributable to the use of cutting oils within the building and the handling (both inside and outside of the building) of the waste oil generated at Building 135. Other potential but less likely contributing sources include leakage from PCB-containing oils formerly used in transformers and capacitors, lubricating oil used in the milling machines, and USTs located in the vicinity of Building 135.

Analysis of groundwater samples collected from monitoring wells located within and around Building 135 indicates low concentrations of POL related constituents. This is believed to be the result of the low solubilities of the POL compounds. TOC analysis of the shale bedrock collected from monitoring well B135-MW-1 did not indicate that adsorption of POL constituents to the shale bedrock would be a significant factor in reducing POL concentrations in the groundwater. However, diffusion of the POL contaminants into the matrix of the bedrock maybe a major consideration in the distribution of the contaminants in the groundwater at the site.

The occurrence of free phase product at SP-13 is believed to be the result of leakage from the waste oil tank in the area of the monitoring well. POLs originating from within the building have not been discovered in the surrounding monitoring wells. A number of circumstances may explain the confinement of POLs within the perimeter of the building:

# The existence of a subslab bedrock swale would at least partially restrict horizontal POL migration. This swale is interpreted to act as a preferential pathway, causing flow of contaminants toward and into the Shrink Pit, possibly through drainage weepers installed during construction of the pit.

# The area is paved and/or covered, rain water can not infiltrate and displace the POLs from the subslab swale, nor can it wash it through the unsaturated zone. Vertical POL migration downward to the groundwater table (at approximately 12 feet below grade) can only occur under the influence of gravity via bedrock fractures and joints.

# Groundwater has repeatedly been pumped from the bottom of the Shrink Pit, which has created a depression in the groundwater table around the pit. Due to the sparse distribution of wells in this area, the exact zone of influence of this pumping can not be determined with any great degree of accuracy. However, it is thought that groundwater beneath the southern half of the building is likely to be affected. To an unknown extent, this pumping has inadvertently acted as an interim remedial measure, pulling floating product and groundwater potentially contaminated with POL and PCB constituents towards the pit. The floating product in the pit is subsequently collected and drummed and the pumped groundwater is then conveyed to the storm water system in controlled quantities.

A review of drawings at WVA and past reports indicate that the most likely source for the POLs seeping through the walls of the Shrink Pit are the cutting oils used for machining. A topographic map, dated 1942 shows a bedrock swale running north-south, transecting the current location of the pit. An aerial photograph, dated September 1939, indicates ponding water in the area of the pit. During construction of the building foundation this low lying area was filled and it is likely that this feature is acting as a preferential pathway for POLs that have leaked from the floor trough and piping beneath the floor. POLs observed seeping through the north wall of the pit seem to confirm this hypothesis. It is also believed that these POLs accumulating in the subslab bedrock depression have the potential of migrating into the bedrock fracture system and eventually off-site, depending on deep bedrock flow patterns and the extent of influence that the Shrink Pit pumping exerts on groundwater movement.

#### 7.1.2.4 Main Manufacturing Area

Soil samples collected from the SWMU 7-14 borings showed little or no subsurface POL contamination. These areas should not be considered as areas of significant POL contamination.

The presence of free product was noted in monitoring wells MW-B110, B35-MW-8, PW-1, and P-3. These wells are upgradient of Building 35 or within Building 35 and indicate that while Building 35 is most likely the source of some contamination in that area, there are contributing upgradient sources. These sources include:

- Historic industrial activities at Building 110 were similar to those conducted at Building 35, and thus similar waste products are expected to be found.

- A number of petroleum spills have been noted at locations of upgradient of Building 35, most notably 25,000 liters of Number 2 fuel oil that were spilled from a pipeline leading to a fuel oil storage tank in the vicinity of Building 121.

Semi-volatile organic contamination of the soils within the Main Manufacturing Area appears to be ubiquitous and have no discernable pattern. However, several of the samples, including those from the area of AW-MW-27 were collected from areas of former chip handling operations. Several samples were also collected from the former Erie Canal, east of Building 25, which exhibited elevated levels of semi-volatile organics.

### 7.1.3 Inorganics

#### 7.1.3.1 Main Manufacturing Area

Chromium and arsenic appear to be the primary inorganic analytes of concern in the subsurface soil samples. As is the case for organic compounds, the majority of the exceedances were detected in samples collected from the fill, rather than the native, soils. The samples which contained chromium exceedances were distributed throughout the site, with the maximum concentration in the area of Building 36, where a spill of treated chromium clarifier sludge occurred in January 1996. Arsenic exceedances were distributed primarily throughout the western portion of the site, with the maximum concentration detected in the soils collected from AW-MW-30. The samples from the former Erie Canal (B25-MW-5 and geoprobe borings) contained elevated levels of chromium and arsenic.

Soil samples collected from the former Erie Canal at B25-MW-5 and geoprobe borings also contained the highest concentrations of a majority the inorganic analytes (barium, cadmium, lead, mercury, and silver), with lead being detected at almost 100 times the TAGM value of 185.5 mg/kg at B25-MW-5.

## 7.2 RECOMMENDATIONS

The following recommendations are made based upon the analytical results obtained during this and previous investigations and are presented graphically on Figure 7-1.

Based on the results of this investigation as presented previously in the text the following SWMUs have been identified as not being sources of contamination, therefore no further individual actions will be conducted, a summary is also provided in Table 7-1:

- # SWMU #4: The results of the soil and groundwater analyses from AW-MW-24 do not exhibit elevated concentrations of cyanide in the environment in this area.

- # SWMUs #7-14: The results of the soil sampling, from the SWMUs where the soil samples were able to be collected, indicate the presence of low levels of POL contamination, below action levels. However, at several of the SWMUs, soil samples were unable to be collected due to the shallow depth to bedrock, soil samples were also unable to be collected from the bottom of the tanks. Due to the location of the SWMUs within the Main Manufacturing Area and the types of contaminants present, these SWMUs will be addressed as part of the POL corrective measures for WVA.

# SWMUs #15 - #17: Based on the analytical results and the fact that these SWMUs have been removed or are scheduled to be removed, and any encountered soil contamination was excavated and disposed of off-site. No further action is proposed.

# SWMU #21: The results of the soil and groundwater analyses from AW-MW-27 do not indicate the presence of any contaminants believed to be related to the former operation of the incinerator. Soils in this area do exhibit POL contamination which is believed to be related to a former chip handling area in this vicinity.

# SWMUs #26 and #27: Neither of these SWMUs, based on the existing site hydrogeologic conditions are believed to be sources of contamination. The POLs present at both locations will be addressed as part of the corrective measures within the Main Manufacturing Area, and will continue to be used as collection points for the removal of POLs from the groundwater.

### 7.2.1 Chlorinated Organic Contamination

# Corrective measures studies should be conducted to address the chlorinated organic and POL contamination detected in the overburden, weathered bedrock, and bedrock. These studies will identify potential remedial alternatives and the associated risk associated with the contamination levels detected at the site.

### 7.2.2 Petroleum, Oil and Lubricants Contamination

# Additional investigations will be undertaken along the portions of the soluble waste oil line which are not submerged, as discussed previously in the report. The methods of investigation are currently under review by the USEPA and NYSDEC.

As part of the on-going ICMS at the Main Manufacturing Area, a passive skimming plan is under review. The existing plan will include an evaluation as to the quantity of POLs which maybe recoverable in the area of B35-MW-8 and P-3, and the need to change the system to an active skimming system.

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# Ta
# Monitoring W escriptions
# Main Manufacturing Area
# Watervliet Arsenal

| Well | Measuring Pt Elevation (ft AMSL) | Ground Elevation (ft AMSL) | Stickup (ft.) | Well Designation | Casing Diameter (in.) | Screened or Open Length (ft) | Top of Open or Screened Interval |  | Bottom of Open or Screened Interval |  | Total Depth of Well |  | Screen Slot Size and Construction | Sand Size | Depth to Competant Bedrock |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | (ft B.G.) | (ft AMSL) | (ft B.G.) | (ft AMSL) | (ft B.G.) | (ft AMSL) |  |  | (ft B.G.) | (ft AMSL) |
| 93-EM-SP-9 | 44.29 | 44.62 | -0.33 | Overburden | 4" | 10.00 | 6.80 | 37.82 | 16.80 | 27.82 | 17.00 | 27.62 | 10-slot SS | #0 | 17.00 | 27.62 |
| 93-EM-SP-10 | 35.40 | 36.03 | -0.63 | Hybrid | 4" | 10.00 | 4.00 | 32.03 | 14.00 | 22.03 | 14.00 | 22.03 | 10-slot SS | #0 | 11.00 | 25.03 |
| 93-EM-SP-11 | 35.39 | 35.67 | -0.28 | Hybrid | 4" | 10.00 | 3.60 | 32.07 | 13.60 | 22.07 | 13.80 | 21.87 | 10-slot SS | #0 | 13.80 | 21.87 |
| 93-EM-SP-12 | 35.73 | 36.25 | -0.52 | Overburden | 4" | 10.00 | 3.50 | 32.75 | 13.50 | 22.75 | 14.00 | 22.25 | 10-slot SS | #0 | 14.00 | 22.25 |
| 93-EM-SP-13 | 71.14 | 71.74 | -0.60 | Bedrock | 4" | 10.00 | 10.70 | 61.04 | 20.70 | 51.04 | 21.00 | 50.74 | 10-slot SS | #0 | 1.50 | 70.24 |
| 93-EM-SP-14 | 71.48 | 71.90 | -0.42 | Bedrock | 4" | 10.00 | 10.80 | 61.10 | 20.80 | 51.10 | 22.00 | 49.90 | 10-slot SS | #0 | 11.00 | 60.90 |
| 93-EM-SP-15 | 66.80 | 67.23 | -0.43 | Bedrock | 4" | 10.00 | 10.70 | 56.53 | 20.70 | 46.53 | 21.00 | 46.23 | 10-slot SS | #0 | 5.20 | 62.03 |
| 93-EM-RW-2 | 70.32 | 70.83 | -0.51 | Bedrock | 4" | 16.00 | 11.00 | 59.83 | 27.00 | 43.83 | 27.00 | 43.83 | 10-slot PVC | #0 | 3.00 | 67.83 |
| 87GTI-MW-1BP | 66.68 | 63.84 | 2.84 | Hybrid | 4" | 5.00 | 8.00 | 55.84 | 13.00 | 50.84 | 13.00 | 50.84 | 20-slot PVC | NA | 3.50 | 60.34 |
| 87GTI-MW-2BP | 67.07 | 64.20 | 2.87 | Hybrid | 4" | 3.50 | 9.00 | 55.20 | 12.50 | 51.70 | 12.50 | 51.70 | 20-slot PVC | NA | 3.50 | 60.70 |
| 87GTI-MW-3BP | 67.78 | 66.10 | 1.68 | Hybrid | 4" | 1.50 | 8.50 | 57.60 | 10.00 | 56.10 | 10.00 | 56.10 | 20-slot PVC | NA | 3.50 | 62.60 |
| 87GTI-MW-4BP | 66.90 | 64.84 | 2.06 | Hybrid | 4" | 3.00 | 9.50 | 55.34 | 12.50 | 52.34 | 12.50 | 52.34 | 20-slot PVC | NA | 4.00 | 60.84 |
| 83DM-SP-1 | 37.79 | 34.70 | 3.09 | Hybrid | 2" | 4.50 | 13.60 | 21.10 | 18.10 | 16.60 | 21.00 | 13.70 | 10-slot PVC | #2Q | 18.00 | 16.70 |
| 86-EM-SP-1A | 35.34 | 35.80 | -0.46 | Overburden | 2" | 10.00 | 6.50 | 29.30 | 16.50 | 19.30 | 16.50 | 19.30 | 10-slot PVC | #2Q | --- | --- |
| 86-EM-SP-1B | 29.92 | 27.50 | 2.42 | Overburden | 2" | 8.00 | 3.40 | 24.10 | 11.40 | 16.10 | 11.40 | 16.10 | 10-slot PVC | #2Q | --- | --- |
| 83DM-SP-2 | 29.20 | 26.30 | 2.90 | Bedrock | 2" | 4.40 |  |  |  |  | 20.70 | 5.60 | PVC | USP | 15.50 | 10.80 |
| 83DM-SP-3 | 25.70 | 22.40 | 3.30 | Bedrock | 2" | 4.40 |  |  |  |  | 19.90 | 2.50 | PVC | USP | 5.00 | 17.40 |
| 83DM-SP-4 | 24.20 | 22.10 | 2.10 | Bedrock | 2" | 4.40 |  |  |  |  | 19.70 | 2.40 | PVC | USP | 13.00 | 9.10 |
| 86EM-SP-5 | 28.30 | 25.40 | 2.90 | Overburden | 2" | 6.00 | 5.40 | 20.00 | 11.40 | 14.00 | 11.40 | 14.00 | 10-slot PVC | #2Q | --- | --- |
| 86EM-SP-6 | 30.50 | 27.60 | 2.90 | Overburden | 2" | 10.00 | 6.80 | 20.80 | 16.80 | 10.80 | 16.80 | 10.80 | 10-slot PVC | #2Q | --- | --- |
| 92EM-SP-7 | 27.58 | 25.74 | 1.84 | Overburden | 4" | 10.30 |  |  |  |  | 13.00 | 12.74 | SS | USP | --- | --- |
| 92EM-SP-8 | 25.33 | 26.14 | -0.81 | Overburden | 4" | 10.30 |  |  |  |  | 12.50 | 13.64 | SS | USP | --- | --- |
| 94EM-SP-16 | 57.92 | 58.31 | -0.39 | Bedrock | 4" | 10.00 | 5.70 | 52.61 | 15.70 | 42.61 | 15.70 | 42.61 | 10-slot SS | #2Q | 2.50 | 55.81 |
| 94EM-SP-19 | 52.83 | 53.69 | -0.86 | Bedrock | 4" | 10.00 |  |  |  |  | 14.80 | 38.89 | SS | USP | 6.00 | 47.69 |
| 94EM-SP-20 | 50.76 | 51.41 | -0.65 | Bedrock | 4" | 10.00 |  |  |  |  | 15.00 | 36.41 | SS | USP | 4.00 | 47.41 |
| 94EM-SP-21 | 52.61 | 53.12 | -0.51 | Bedrock | 4" | 10.00 |  |  |  |  | 18.00 | 35.12 | SS | USP | 5.50 | 47.62 |
| 95MPI-25-MW-1 | 36.32 | 36.67 | -0.35 | Weathered Bedrock | 2" | 3.00 | 11.00 | 25.67 | 14.00 | 22.67 | 14.50 | 22.17 | 10-slot PVC | #0 | --- | --- |
| 95MPI-25-MW-2 | 34.66 | 34.96 | -0.30 | Bedrock | 4" | 15.50 | 18.60 | 16.36 | 34.10 | 0.86 | 34.10 | 0.86 | PVC Riser | --- | 17.00 | 17.96 |
| 95MPI-25-MW-3 | 34.34 | 34.57 | -0.23 | Overburden | 2" | 3.00 | 11.60 | 22.97 | 14.60 | 19.97 | 15.00 | 19.57 | 10-slot PVC | #0 | --- | --- |
| 95MPI-25-MW-4 | 27.40 | 27.70 | -0.30 | Weathered Bedrock | 2" | 4.50 | 9.00 | 18.70 | 13.50 | 14.20 | 14.25 | 13.45 | 10-slot PVC | #0 | --- | --- |
| 95MPI-25-MW-5 | 29.08 | 29.36 | -0.28 | Hybrid | 2" | 2.00 | 11.30 | 18.06 | 13.30 | 16.06 | 15.40 | 13.96 | 10-slot PVC | #0 | 13.50 | 15.86 |
| 95MPI-25-MW-6 | 34.67 | 35.06 | -0.39 | Overburden | 2" | 6.50 | 11.00 | 54.06 | 17.50 | 47.56 | 18.00 | 47.06 | 10-slot PVC | #0 | --- | --- |
| 95MPI-135-MW-1 | 71.57 | 71.89 | -0.32 | Bedrock | 4" | 102.00 | 18.00 | 53.89 | 120.00 | -48.11 | 120.00 | -48.11 | PVC Riser | --- | 7.30 | 64.59 |
| 95MPI-135-MW-2 | 70.67 | 70.99 | -0.32 | Bedrock | 4" | 9.50 | 10.50 | 60.49 | 20.00 | 50.99 | 20.00 | 50.99 | PVC Riser | --- | 7.00 | 63.99 |
| 95MPI-135-MW-3 | 71.14 | 71.40 | -0.26 | Bedrock | 4" | 9.80 | 10.50 | 60.90 | 20.30 | 51.10 | 20.30 | 51.10 | PVC Riser | --- | 6.00 | 65.40 |
| 95MPI-135-MW-4 | 70.84 | 71.35 | -0.51 | Bedrock | 4" | 43.00 | 7.00 | 64.35 | 50.00 | 21.35 | 50.00 | 21.35 | PVC Riser | --- | 6.60 | 64.75 |
| 95MPI-35-MW-5 | 53.56 | 53.84 | -0.28 | Bedrock | 4" | 32.50 | 17.50 | 36.34 | 50.00 | 3.84 | 50.00 | 3.84 | PVC Riser | --- | 14.00 | 39.84 |
| 95MPI-35-MW-6 | 38.92 | 39.24 | -0.32 | Overburden | 2" | 5.00 | 7.00 | 32.24 | 12.00 | 27.24 | 12.00 | 27.24 | 10-slot PVC | #0 | --- | --- |
| 95MPI-35-MW-7 | 55.01 | 55.31 | -0.30 | Bedrock | 4" | 34.75 | 10.00 | 45.31 | 44.75 | 10.56 | 44.75 | 10.56 | PVC Riser | --- | 6.00 | 49.31 |
| 95MPI-35-MW-8 | 57.37 | 57.71 | -0.34 | Bedrock | 4" | 15.40 | 9.60 | 48.11 | 25.00 | 32.71 | 25.00 | 32.71 | PVC Riser | --- | 7.00 | 50.71 |
| RW-1 | 33.00 |  |  | Hybrid | 4.5" | 10.00 | 4.00 |  | 14.00 |  | 14.00 |  | PVC | --- | --- | --- |
| 95MPI-AW-MW-20 | 19.42 | 19.70 | -0.28 | Overburden | 2" | 8.00 | 2.00 | 17.70 | 10.00 | 9.70 | 11.00 | 8.70 | 10-slot PVC | #0 | --- | --- |
| 95MPI-AW-MW-21 | 31.16 | 31.59 | -0.43 | Overburden | 2" | 10.00 | 4.00 | 27.59 | 14.00 | 17.59 | 16.00 | 15.59 | 10-slot PVC | #0 | --- | --- |
| 95MPI-AW-MW-22 | 49.47 | 49.71 | -0.24 | Bedrock | 4" | 11.00 | 14.00 | 35.71 | 25.00 | 24.71 | 25.00 | 24.71 | PVC Riser | --- | 14.00 | 35.71 |
| 95MPI-AW-MW-23 | 56.54 | 56.89 | -0.35 | Weathered Bedrock | 2" | 4.00 | 7.00 | 49.89 | 11.00 | 45.89 | 12.50 | 44.39 | 10-slot PVC | #0 | 11.00 | 45.89 |
| 95MPI-AW-MW-24 | 55.39 | 56.00 | -0.61 | Overburden | 2" | 2.50 | 3.00 | 53.00 | 5.50 | 50.50 | 6.50 | 49.50 | 10-slot PVC | #0 | --- | --- |
| 95MPI-AW-MW-25 | 67.07 | 37.29 | 29.78 | Weathered Bedrock | 2" | 10.00 | 5.00 | 32.29 | 15.00 | 22.29 | 15.00 | 22.29 | 10-slot PVC | #0 | --- | --- |
| 95MPI-AW-MW-26 | 69.69 | 67.96 | 1.73 | Bedrock | 4" | 14.50 | 10.50 | 57.46 | 25.00 | 42.96 | 25.00 | 42.96 | PVC Riser | --- | 10.50 | 57.46 |
| 95MPI-AW-MW-27 | 62.05 | 59.60 | 2.45 | Weathered Bedrock | 2" | 6.00 | 5.50 | 54.10 | 11.50 | 48.10 | 12.00 | 47.60 | 10-slot PVC | #0 | --- | --- |
| 95MPI-AW-MW-28 | 68.50 | 65.90 | 2.60 | Bedrock | 4" | 13.00 | 12.00 | 53.90 | 25.00 | 40.90 | 25.00 | 40.90 | PVC Riser | --- | 12.00 | 53.90 |
| 95MPI-AW-MW-29 | 70.98 | 71.22 | -0.24 | Bedrock | 4" | 15.50 | 9.50 | 61.72 | 25.00 | 46.22 | 25.00 | 46.22 | PVC Riser | --- | 9.40 | 61.82 |
| 95MPI-AW-MW-30 | 69.70 | 70.11 | -0.41 | Weathered Bedrock | 2" | 10.00 | 7.00 | 63.11 | 17.00 | 53.11 | 17.50 | 52.61 | 10-slot PVC | #0 | 17.50 | 52.61 |
| 95MPI-AW-MW-31 | 41.06 | 41.46 | -0.40 | Overburden | 2" | 10.00 | 11.50 | 29.96 | 21.50 | 19.96 | 21.50 | 19.96 | 10-slot PVC | #0 | --- | --- |
| 95MPI-AW-MW-32 | 26.24 | 26.71 | -0.47 | Weathered Bedrock | 2" | 5.00 | 9.50 | 17.21 | 14.50 | 12.21 | 14.50 | 12.21 | 10-slot PVC | #0 | 14.50 | 12.21 |
| 95MPI-AW-MW-33 | 18.95 | 19.29 | -0.34 | Overburden | 2" | 5.00 | 7.00 | 12.29 | 12.00 | 7.29 | 12.00 | 7.29 | 10-slot PVC | #0 | --- | --- |
| 95MPI-AW-MW-34 | 18.31 | 18.56 | -0.25 | Bedrock | 4" | 15.00 | 16.50 | 2.06 | 31.50 | -12.94 | 31.50 | -12.94 | PVC Riser | --- | 16.50 | 2.06 |

# Ta[illegible]
# Monitoring Well Descriptions
# Main Manufacturing Area
# Watervliet Arsenal

| Well | Measuring Pt Elevation (ft AMSL) | Ground Elevation (ft AMSL) | Stickup (ft.) | Well Designation | Casing Diameter (in.) | Screened or Open Length (ft) | Top of Open or Screened Interval (ft B.G.) | Top of Open or Screened Interval (ft AMSL) | Bottom of Open or Screened Interval (ft B.G.) | Bottom of Open or Screened Interval (ft AMSL) | Total Depth of Well (ft B.G.) | Total Depth of Well (ft AMSL) | Screen Slot Size and Construction | Sand Size | Depth to Competant Bedrock (ft B.G.) | Depth to Competant Bedrock (ft AMSL) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 95MPI-AW-MW-35 | 30.53 | 30.96 | -0.43 | Bedrock | 4" | 15.50 | 17.50 | 13.46 | 33.00 | -2.04 | 33.00 | -2.04 | PVC Riser | --- | 17.50 | 13.46 |
| 95MPI-AW-MW-36 | 30.57 | 30.98 | -0.41 | Overburden | 2" | 9.50 | 2.00 | 28.98 | 11.50 | 19.48 | 11.50 | 19.48 | 10-slot PVC | #0 | --- | --- |
| 95MPI-AW-MW-37 | 57.85 | 57.69 | 0.16 | Bedrock | 4" | 9.00 | 36.00 | 21.69 | 45.00 | 12.69 | 45.00 | 12.69 | PVC Riser | --- | 12.00 | 45.69 |
| 95MPI-AW-MW-38 | 57.30 | 57.57 | -0.27 | Bedrock | 4" | 10.50 | 15.50 | 42.07 | 26.00 | 31.57 | 26.00 | 31.57 | PVC Riser | --- | 12.00 | 45.57 |
| 95MPI-AW-MW-39 | 71.76 | 69.49 | 2.27 | Bedrock | 4" | 10.70 | 35.50 | 33.99 | 46.20 | 23.29 | 46.20 | 23.29 | PVC Riser | --- | 8.50 | 60.99 |
| 95MPI-AW-MW-40 | 71.83 | 69.53 | 2.30 | Bedrock | 4" | 15.00 | 10.50 | 59.03 | 25.50 | 44.03 | 25.50 | 44.03 | PVC Riser | --- | 8.50 | 61.03 |
| 95MPI-AW-MW-41 | 67.03 | 67.31 | -0.28 | Bedrock | 4" | 10.00 | 14.50 | 52.81 | 24.50 | 42.81 | 24.50 | 42.81 | PVC Riser | --- | 14.50 | 52.81 |
| 95MPI-AW-MW-42 | 67.71 | 67.90 | -0.19 | Weathered Bedrock | 2" | 5.00 | 5.00 | 62.90 | 10.00 | 57.90 | 10.00 | 57.90 | 10-slot PVC | #0 | 10.00 | 57.90 |
| 95MPI-AW-MW-43 | 25.51 | 25.90 | -0.39 | Overburden | 2" | 7.50 | 2.00 | 23.90 | 9.50 | 16.40 | 9.50 | 16.40 | 10-slot PVC | #0 | --- | --- |
| 95MPI-AW-MW-44 | 24.98 | 25.52 | -0.54 | Overburden | 2" | 6.00 | 2.00 | 23.52 | 8.00 | 17.52 | 8.00 | 17.52 | 10-slot PVC | #0 | --- | --- |
| MPI-P-1 | 57.61 | 58.03 | -0.42 | Bedrock | 4" | 19.00 | 11.00 | 47.03 | 30.00 | 28.03 | 30.00 | 28.03 | PVC Riser | --- | 6.00 | 52.03 |
| MPI-P-2 | 57.18 | 57.42 | -0.24 | Bedrock | 4" | 19.00 | 11.00 | 46.42 | 30.00 | 27.42 | 30.00 | 27.42 | PVC Riser | --- | 6.00 | 51.42 |
| MPI-P-3 | 55.86 | 55.86 | 0.00 | Bedrock | 4" | 20.20 | 10.00 | 45.86 | 30.20 | 25.66 | 30.20 | 25.66 | PVC Riser | --- | 8.50 | 47.36 |
| MPI-P-4 | 57.23 | 57.53 | -0.30 | Bedrock | 4" | 17.00 | 18.00 | 39.53 | 35.00 | 22.53 | 35.00 | 22.53 | PVC Riser | --- | 13.20 | 44.33 |
| 97MPI-AW-MW-45 | 66.63 | 67.18 | -0.55 | Bedrock | 4" | 15.50 | 45.00 | 22.18 | 60.50 | 6.68 | 60.50 | 6.68 | PVC Riser | --- | 14.50 | 52.68 |
| 97MPI-AW-MW-46 | 26.00 | 26.28 | -0.28 | Bedrock | 4" | 16.00 | 19.00 | 7.28 | 35.00 | -8.72 | 35.00 | -8.72 | PVC Riser | --- | 13.50 | 12.78 |
| 97MPI-AW-MW-47 | 26.90 | 27.36 | -0.46 | Overburden | 4" | 6.40 | 11.00 | 16.36 | 17.40 | 9.96 | 17.50 | 9.86 | 10-slot PVC | #0 | --- | --- |
| 97MPI-AW-MW-48 | 30.82 | 31.06 | -0.24 | Bedrock | 4" | 35.50 | 53.00 | -21.94 | 88.50 | -57.44 | 88.50 | -57.44 | PVC Riser | --- | 17.50 | 13.56 |
| 97MPI-AW-MW-49 | 34.84 | 35.06 | -0.22 | Bedrock | 4" | 12.50 | 23.00 | 12.06 | 35.50 | -0.44 | 35.50 | -0.44 | PVC Riser | --- | 18.00 | 17.06 |
| 97MPI-AW-MW-50 | 70.97 | 69.39 | 1.58 | Bedrock | 4" | 15.00 | 80.00 | -10.61 | 95.00 | -25.61 | 95.00 | -25.61 | PVC Riser | --- | 8.50 | 60.89 |
| 97MPI-AW-MW-51 | 18.39 | 18.71 | -0.32 | Bedrock | 4" | 18.50 | 52.50 | -33.79 | 71.00 | -52.29 | 71.00 | -52.29 | PVC Riser | --- | 16.50 | 2.21 |
| 97MPI-AW-MW-52 | 70.49 | 70.78 | -0.29 | Bedrock | 4" | 13.00 | 109.00 | -38.22 | 122.00 | -51.22 | 122.00 | -51.22 | PVC Riser | --- | 3.00 | 67.78 |
| 97MPI-AW-MW-53 | 29.83 | 30.24 | -0.41 | Bedrock | 4" | 15.00 | 61.00 | -30.76 | 76.00 | -45.76 | 76.00 | -45.76 | PVC Riser | --- | 18.00 | 12.24 |
| 97MPI-AW-MW-54 | 55.15 | 55.42 | -0.27 | Bedrock | 4" | 15.00 | 65.00 | -9.58 | 80.00 | -24.58 | 80.00 | -24.58 | PVC Riser | --- | 6.00 | 49.42 |
| 97MPI-AW-MW-55 | 70.98 | 71.25 | -0.27 | Bedrock | 4" | 38.00 | 12.00 | 59.25 | 50.00 | 21.25 | 50.00 | 21.25 | PVC Riser | --- | 6.50 | 64.75 |
| 98MPI-AW-MW-56 | 25.06 | 24.81 | 0.25 | Overburden | 2" | 11.00 | 3.00 | 21.81 | 14.00 | 10.81 | 14.00 | 10.81 | 10-slot PVC | #0 | --- | --- |
| 98MPI-AW-MW-57 | 23.92 | 23.65 | 0.27 | Overburden | 2" | 6.00 | 3.50 | 20.15 | 9.50 | 14.15 | 10.00 | 13.65 | 10-slot PVC | #0 | --- | --- |
| 98MPI-AW-MW-58 | 20.54 | 20.19 | 0.35 | Bedrock | 4" | 20.00 | 63.00 | -42.81 | 83.00 | -62.81 | 83.00 | -62.81 | PVC Riser | --- | 17.50 | 2.69 |
| 98MPI-AW-MW-59 | 20.17 | 19.95 | 0.22 | Bedrock | 4" | 21.00 | 75.00 | -55.05 | 96.00 | -76.05 | 96.00 | -76.05 | PVC Riser | --- | 18.50 | 1.45 |
| 98MPI-AW-MW-60 | 25.32 | 25.06 | 0.26 | Bedrock | 4" | 20.00 | 85.00 | -59.94 | 105.00 | -79.94 | 105.00 | -79.94 | PVC Riser | --- | 10.00 | 15.06 |
| 98MPI-AW-MW-61 | 18.96 | 18.64 | 0.32 | Deep Bedrock | 4" | 20.00 | 140.00 | -121.36 | 160.00 | -141.36 | 160.00 | -141.36 | PVC Riser | --- | 16.50 | 2.14 |
| 98MPI-AW-MW-62 | 23.15 | 22.87 | 0.28 | Bedrock | 4" | 20.00 | 75.00 | -52.13 | 95.00 | -72.13 | 95.00 | -72.13 | PVC Riser | --- | 11.00 | 11.87 |
| 98MPI-AW-MW-63 | 70.50 | 70.37 | 0.13 | Bedrock | 4" | 20.00 | 23.00 | 47.37 | 43.00 | 27.37 | 43.00 | 27.37 | PVC Riser | --- | 15.00 | 55.37 |
| 98MPI-AW-MW-64 | 70.65 | 70.43 | -0.22 | Bedrock | 4" | 20.00 | 47.00 | 23.43 | 67.00 | 3.43 | 67.00 | 3.43 | PVC Riser | --- | 8.00 | 62.43 |
| 98MPI-PW-1 | 57.60 | 57.74 | -0.14 | Bedrock | 6" | 57.00 | 13.00 | 44.74 | 70.00 | -12.26 | 70.00 | -12.26 | PVC Riser | --- | 8.00 | 49:74 |

NOTES:

| | |
|---|---|
| NA | Type of Sand used is Not Available |
| USP | Type and/or presence of sand pack unknown. |
| Blank | Information not available. |

# Table 4-1
## Groundwater Elevations
## Main Manufacturing Area
## Watervliet Arsenal
## Watervliet, New York

| Well | Elevation of Groundwater from MSL (feet) | | | | | | | | | | | | | | | Maximum Fluctuations (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9/25/79 | 10/27/87 | 8/4/93 | 7/20/95 | 9/6/95 | 9/11/95 | 10/30/95 | 1/22/96 | 5/20/96 | 2/9/97 | 8/14/97 | 10/20/97 | 6/24/98 | 2/11/99 | 4/1/99 | |
| 93-EM-SP-9 | | | 35.34 | 33.30 | 33.26 | 33.45 | 34.09 | 34.38 | 39.02 | | 36.08 | | | Dry | | 5.76 |
| 93-EM-SP-10 | | | 28.37 | 27.75 | 27.69 | 27.75 | 28.51 | | 34.37 | | 28.08 | 27.85 | | | | 6.68 |
| 93-EM-SP-11 | | | 25.92 | 25.70 | 25.67 | 25.74 | 26.29 | | 26.63 | | 26.06 | 26.00 | | | | 0.96 |
| 93-EM-SP-12 | | | 29.41 | 28.87 | 28.80 | 28.85 | 29.32 | 29.45 | 29.35 | | 29.16 | 29.08 | | 29.43 | | 0.65 |
| 93-EM-SP-13 | | | 62.19 | 62.19 | 62.19 | 61.56 | 62.33 | | 62.45 | | 62.66 | 62.22 | | 61.68 | | 1.10 |
| *LNAPL thickness, SP-13* | | | | | | | | | *0.05* | | | *0.12* | | *no LNAPL* | | 0.07 |
| 93-EM-SP-14 | | | 62.95 | 62.84 | 62.93 | 63.05 | 63.10 | 62.99 | 62.77 | | 63.23 | 62.94 | | 62.88 | | 0.46 |
| 93-EM-SP-15 | | | 59.80 | 58.95 | 59.01 | 59.24 | 59.90 | 60.06 | 59.59 | | 59.67 | 59.68 | | 59.59 | | 1.11 |
| 93-EM-RW-2 | | | | 57.06 | | 57.00 | 58.42 | 58.16 | | | 58.17 | 58.50 | | 58.81 | 58.70 | 1.81 |
| 87GTI-MW-1BP | | 61.68 | 63.06 | 60.48 | 60.47 | 60.49 | 63.56 | 63.83 | 63.42 | | 63.94 | 62.19 | | 63.43 | | 3.47 |
| 87GTI-MW-2BP | | 61.95 | 62.79 | 60.88 | 61.29 | 61.45 | 63.40 | 63.24 | 63.07 | | 64.04 | 62.02 | | 63.36 | | 3.16 |
| 87GTI-MW-3BP | | 62.58 | 62.52 | 60.69 | 61.14 | 61.28 | 62.91 | 63.16 | 62.73 | | 62.35 | 61.84 | | 62.93 | | 2.47 |
| 87GTI-MW-4BP | | 60.52 | 61.79 | 58.97 | 59.75 | 59.48 | 63.09 | 62.79 | 62.43 | | 63.25 | 60.66 | | 63.06 | | 4.28 |
| 83DM-SP-1 | | | 23.99 | 23.61 | 24.16 | 24.13 | 24.41 | | 25.92 | | 24.41 | 23.87 | | 24.13 | | 2.31 |
| 86-EM-SP-1A | | | 25.69 | 25.30 | 25.45 | 25.46 | 25.49 | 25.52 | 25.52 | | 25.57 | 25.39 | | 25.34 | | 0.39 |
| 86-EM-SP-1B | | | 21.68 | 21.56 | 21.55 | 21.54 | 22.40 | 22.48 | 22.30 | | 22.47 | 21.78 | | 22.01 | | 0.94 |
| 83DM-SP-2 | | | | 16.02 | 15.83 | 15.80 | 16.92 | 17.43 | 17.01 | | 16.39 | 16.29 | | 16.28 | | 1.63 |
| 83DM-SP-3 | | | | 17.56 | 17.61 | 17.60 | 18.27 | 18.26 | 18.13 | | 17.96 | 17.70 | | 18.09 | | 0.71 |
| 83DM-SP-4 | | | | 17.87 | 17.87 | 17.94 | 18.62 | 18.62 | 18.45 | | 18.44 | 17.99 | | 18.34 | | 0.75 |
| 86EM-SP-5 | | | | 20.29 | 20.23 | 20.21 | 21.04 | 21.47 | 21.19 | | 20.67 | 19.82 | | 21.01 | | 1.65 |
| 86EM-SP-6 | | | | 20.24 | 20.07 | 20.12 | 20.45 | 20.52 | 19.66 | | 20.53 | 20.04 | | 20.44 | | 0.87 |
| 92EM-SP-7 | | | | 19.32 | 19.03 | 19.40 | 20.11 | 20.43 | 20.26 | | 20.34 | 18.57 | | 19.96 | | 1.86 |
| 92EM-SP-8 | | | | 20.17 | 20.00 | 20.05 | 20.57 | 20.94 | 20.75 | | 21.17 | 19.03 | | 20.53 | | 2.14 |
| 93EM-SP-16 | | | 53.40 | 53.75 | 53.91 | 53.95 | 53.82 | 54.02 | 53.80 | | 53.97 | 53.65 | | 53.60 | | 0.62 |
| 94EM-MW-19 | | | | 46.87 | 46.85 | 46.92 | 48.12 | 48.28 | 47.84 | | 47.85 | 47.15 | | 47.90 | | 1.43 |
| 94EM-MW-20 | | | | 43.47 | 43.44 | 44.44 | 44.20 | 44.69 | | | 44.90 | 43.43 | | 43.94 | | 1.47 |
| 94EM-MW-21 | | | | 46.15 | 46.50 | 46.63 | 46.63 | 46.83 | 46.50 | | 46.88 | 46.55 | | 46.41 | | 0.73 |
| 95MPI-25-MW-1 | | | | 29.81 | 29.59 | 29.68 | 30.01 | 30.23 | 30.19 | | 29.79 | 29.67 | | 30.13 | | 0.64 |
| 95MPI-25-MW-2 | | | | 21.74 | 22.21 | 22.29 | 22.74 | 23.00 | 21.41 | | 22.48 | 22.21 | | 22.59 | | 1.59 |
| 95MPI-25-MW-3 | | | | 22.46 | 22.63 | 23.46 | 23.54 | | 24.24 | | 23.60 | 23.39 | | 23.57 | | 1.78 |
| 95MPI-25-MW-4 | | | | 20.20 | 20.25 | 20.45 | 20.22 | | 20.50 | | 19.44 | 20.29 | | 20.88 | | 1.44 |
| 95MPI-25-MW-5 | | | | 18.00 | 18.43 | 18.65 | 18.65 | 19.54 | 19.28 | | 14.83 | 19.33 | | 19.47 | | 4.71 |
| 95MPI-25-MW-6 | | | | 23.51 | 24.12 | 24.86 | 25.21 | 28.82 | 25.41 | | 24.98 | 24.85 | | 25.08 | | 5.31 |
| 95MPI-135-MW-1 | | | | 17.54 | 17.39 | 16.86 | 18.19 | 19.59 | 19.48 | | 17.07 | 17.65 | | 17.66 | | 2.73 |
| 95MPI-135-MW-2 | | | | 65.22 | 65.40 | 64.96 | 64.86 | | 65.39 | | 66.57 | 65.67 | | 66.19 | | 1.71 |
| 95MPI-135-MW-3 | | | | 61.56 | 61.51 | 64.71 | | | 62.51 | | 63.33 | 62.50 | | 62.45 | | 3.20 |
| 95MPI-135-MW-4 | | | | 56.59 | 57.34 | 57.33 | 55.83 | 57.81 | 58.21 | | 57.69 | 57.51 | | 58.19 | | 2.38 |
| 95MPI-35-MW-5 | | | | 38.70 | 39.15 | 38.99 | 40.13 | 40.45 | 40.19 | | 39.31 | 39.12 | | 40.48 | | 1.78 |
| 95MPI-35-MW-6 | | | | 30.26 | 29.86 | 29.95 | 30.73 | | 30.66 | | 30.61 | 30.15 | | 30.65 | | 0.87 |
| 95MPI-35-MW-7 | | | | 43.20 | 43.25 | | 43.23 | 43.82 | 43.70 | | 43.05 | 44.20 | | 43.79 | 43.86 | 1.15 |
| 95MPI-35-MW-8 | | | | 49.11 | 49.52 | 49.60 | 49.65 | 50.41 | 49.87 | | 49.78 | 49.85 | | 50.50 | | 1.39 |
| *LNAPL thickness, 35-MW-8* | | | | | *0.13* | | | *~1.5* | *0.03* | | | *0.02* | | *sheen* | | 0.11 |

# Table 4-1
# Groundwater Elevations
# Main Manufacturing Area
# Watervliet Arsenal
# Watervliet, New York

| Well | Elevation of Groundwater from MSL (feet) | | | | | | | | | | | | | | | Maximum Fluctuations (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9/25/79 | 10/27/87 | 8/4/93 | 7/20/95 | 9/6/95 | 9/11/95 | 10/30/95 | 1/22/96 | 5/20/96 | 2/9/97 | 8/14/97 | 10/20/97 | 6/24/98 | 2/11/99 | 4/1/99 | |
| RW-1 | | | 28.89 | | | | | | | | | | | | | |
| 95MPI-AW-MW-20 | | | | | 10.40 | 10.04 | 12.16 | 15.00 | 12.13 | | 10.17 | 10.90 | | Dry | | 4.96 |
| 95MPI-AW-MW-21 | | | | | 20.48 | 20.44 | 21.18 | 22.04 | 21.13 | | 20.63 | 20.48 | | 20.99 | | 1.60 |
| 95MPI-AW-MW-22 | | | | | 40.55 | 40.78 | 41.10 | 40.91 | 40.99 | | 40.92 | 41.00 | | 41.08 | | 0.55 |
| 95MPI-AW-MW-23 | | | | | 48.25 | 49.19 | 49.20 | 49.18 | 48.96 | | 49.52 | 48.82 | | | | 1.27 |
| 95MPI-AW-MW-24 | | | | | | 51.97 | 51.91 | 51.97 | 51.91 | | 52.06 | 51.89 | | 52.13 | | 0.24 |
| 95MPI-AW-MW-25 | | | | | 55.23 | 55.62 | 56.11 | 56.63 | 56.00 | | 56.68 | 55.89 | | 55.92 | | 1.45 |
| 95MPI-AW-MW-26 | | | | | 59.26 | 59.19 | 59.31 | 59.04 | 58.85 | | 59.34 | 58.84 | | 59.20 | | 0.50 |
| 95MPI-AW-MW-27 | | | | | 51.43 | 51.67 | 52.60 | 53.11 | 52.80 | | 53.14 | 52.29 | | 53.08 | | 1.71 |
| 95MPI-AW-MW-28 | | | | | 60.46 | 60.48 | 60.58 | 61.15 | 60.80 | | 60.83 | 60.50 | | 60.41 | | 0.74 |
| 95MPI-AW-MW-29 | | | | | 59.96 | 59.98 | 59.91 | 60.13 | 60.02 | | 60.38 | 60.31 | | 60.10 | | 0.47 |
| 95MPI-AW-MW-30 | | | | | 62.21 | 62.16 | 62.91 | 63.02 | 62.94 | | 62.80 | 62.95 | | 62.90 | | 0.86 |
| 95MPI-AW-MW-31 | | | | | 22.36 | 22.34 | 23.33 | | 22.78 | | 22.22 | 22.28 | | 22.70 | 22.71 | 1.11 |
| 95MPI-AW-MW-32 | | | | | 14.72 | 14.70 | 15.69 | 16.38 | 16.20 | | 14.77 | 15.14 | | 16.37 | | 1.68 |
| 95MPI-AW-MW-33 | | | | | 7.98 | 8.08 | 9.03 | 11.38 | 8.48 | | 8.37 | 8.05 | 8.97 | 8.25 | 8.46 | 3.40 |
| 95MPI-AW-MW-34 | | | | | 8.23 | 8.28 | 8.97 | 10.49 | 8.92 | | 8.65 | 8.31 | 8.81 | 8.62 | 8.50 | 2.26 |
| 95MPI-AW-MW-35 | | | | | 20.71 | 20.67 | 20.87 | 21.40 | 22.41 | | 20.91 | 20.93 | | 21.07 | 21.10 | 1.74 |
| 95MPI-AW-MW-36 | | | | | 20.20 | | 20.80 | 20.94 | 21.71 | | 20.79 | 20.90 | | 21.23 | 21.32 | 1.51 |
| 95MPI-AW-MW-37 | | | | | 46.64 | 47.81 | 47.80 | 49.15 | 48.37 | | 50.02 | 47.27 | | 48.13 | | 3.38 |
| 95MPI-AW-MW-38 | | | | | 47.05 | 46.86 | 48.49 | 48.68 | 47.17 | | 48.63 | 45.58 | | 46.99 | | 3.10 |
| 95MPI-AW-MW-39 | | | | | 63.59 | 63.79 | 64.38 | 64.50 | 64.15 | | 64.96 | 63.79 | | 64.20 | 63.99 | 1.37 |
| 95MPI-AW-MW-40 | | | | | 64.39 | 64.51 | 65.29 | 65.44 | 65.08 | | 66.15 | 64.96 | | 65.32 | 64.90 | 1.76 |
| 95MPI-AW-MW-41 | | | | | 57.68 | 58.09 | 58.15 | 58.66 | 58.42 | | 59.17 | 58.55 | | 58.69 | 58.82 | 1.49 |
| 95MPI-AW-MW-42 | | | | | 59.68 | 59.73 | 59.72 | 59.97 | 59.63 | | 59.93 | 59.73 | | 59.66 | | 0.34 |
| 95MPI-AW-MW-43 | | | | | | | | 21.56 | 21.10 | | 20.64 | 20.11 | | 20.78 | | 1.45 |
| *LNAPL thickness, AW-MW-43* | | | | | | | | | | | | | | *0.01* | | |
| 95MPI-AW-MW-44 | | | | | | | | 21.38 | 20.98 | | 20.55 | 19.94 | | 20.65 | | 1.44 |
| P-121 | | | | | | | | | | | | | | | | |
| P-122 | | | | | | | | | | | | | | | | |
| Bldg 35-8" Pit | | | | | | | | | | | | | | | | |
| Bldg 35-Floor 120 Pit | | | | | | | | | | | | | | | | |
| Bldg 35-Furnace Pit | | | | | | | | | | | | | | | | |
| Bldg 110-Auto Frotage | | | | | | | | 25.69 | | | | | | | | |
| Bldg 110-North Well | | | | | | | | 51.53 | | | | | | 50.89 | | 0.64 |
| *LNAPL thickness, B110N* | | | | | | | | | *0.01* | | *0.01* | | | *no LNAPL* | | |
| Bldg 121-North Well | 54.60 | | | | | | | 51.91 | 55.09 | | 56.47 | 56.49 | | 52.21 | | 4.58 |
| Bldg 121-South Well | 55.30 | | | | | | | 51.67 | 55.01 | | 56.43 | 56.45 | | 52.04 | | 4.78 |
| Bldg 135-Pit | | | | | | | | -9.61 | -15.63 | | -17.00 | -13.81 | | -15.88 | | 7.39 |
| 97MPI-AW-MW-45 | | | | | | | | | | | 32.84 | 53.81 | | 53.92 | 53.30 | 21.08 |
| 97MPI-AW-MW-46 | | | | | | | | | | | 20.69 | 19.50 | | 20.53 | | 1.19 |
| 97MPI-AW-MW-47 | | | | | | | | | | | 21.92 | 21.34 | | 21.46 | | 0.58 |
| 97MPI-AW-MW-48 | | | | | | | | | | | 20.87 | 20.88 | | 21.41 | 21.51 | 0.64 |

# Table 4-1
# Groundwa[illegible]levations
# Main Manu[illegible]uring Area
# Watervliet Arsenal
# Watervliet, New York

| Well | Elevation of Groundwater from MSL (feet) | | | | | | | | | | | | | | | Maximum Fluctuations (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9/25/79 | 10/27/87 | 8/4/93 | 7/20/95 | 9/6/95 | 9/11/95 | 10/30/95 | 1/22/96 | 5/20/96 | 2/9/97 | 8/14/97 | 10/20/97 | 6/24/98 | 2/11/99 | 4/1/99 | |
| 97MPI-AW-MW-49 | | | | | | | | | | | 23.18 | 22.86 | | 22.94 | | 0.32 |
| 97MPI-AW-MW-50 | | | | | | | | | | | 34.64 | 50.98 | | 55.26 | 53.32 | 20.62 |
| 97MPI-AW-MW-51 | | | | | | | | | | | 8.31 | 8.39 | 6.13 | 7.71 | 8.40 | 2.27 |
| 97MPI-AW-MW-52 | | | | | | | | | | | -17.12 | 22.30 | | 10.63 | 67.81 | 84.93 |
| 97MPI-AW-MW-53 | | | | | | | | | | | 20.44 | 20.07 | | 20.30 | | 0.37 |
| 97MPI-AW-MW-54 | | | | | | | | | | | 43.53 | 43.68 | | 43.83 | 43.85 | 0.32 |
| 97MPI-AW-MW-55 | | | | | | | | | | | 66.53 | 66.59 | | 66.77 | | 0.24 |
| 98MPI-AW-MW-56 | | | | | | | | | | | | | 20.36 | 20.11 | | 0.25 |
| 98MPI-AW-MW-57 | | | | | | | | | | | | | 19.99 | 20.13 | | 0.14 |
| 98MPI-AW-MW-58 | | | | | | | | | | | | | 9.83 | | | |
| 98MPI-AW-MW-59 | | | | | | | | | | | | | 9.00 | 8.73 | | 0.27 |
| 98MPI-AW-MW-60 | | | | | | | | | | | | | 18.00 | 17.69 | | 0.31 |
| 98MPI-AW-MW-61 | | | | | | | | | | | | | -116.43 | -127.01 | -124.96 | 10.58 |
| 98MPI-AW-MW-62 | | | | | | | | | | | | | 14.73 | 14.55 | | 0.18 |
| 98MPI-AW-MW-63 | | | | | | | | | | | | | 62.86 | 62.86 | | |
| 98MPI-AW-MW-64 | | | | | | | | | | | | | | 59.38 | 59.18 | 0.20 |
| PW-1 | | | | | | | | | | | | | | 48.98 | | |
| MPI-P-1 | | | | | | | | | | 35.41 | | 54.80 | | 56.19 | | 20.78 |
| MPI-P-2 | | | | | | | | | | 47.33 | | 46.29 | | 46.92 | 46.69 | 1.04 |
| MPI-P-3 | | | | | | | | | | 29.76 | | 44.72 | | 45.25 | | 15.49 |
| *LNAPL thickness, P-3* | | | | | | | | | | | | | | *1.78* | | |
| MPI-P-4 | | | | | | | | | | 44.83 | | 44.53 | | 46.15 | | 1.62 |

NOTES:

Water level adjusted for LNAPL thickness, where present.

Blank Space - Water level not measured.

MSL - Mean Sea Level

LNAPL - Light Non-Aqueous Phase Liquids

## Tal -2
## Vertical Gradients in Clustered Wells
## Main Manufacturing Area
## Watervliet Arsenal
## Watervliet, New York

| Well Pair | 9/6/95 | | 9/11/95 | | 10/30/95 | | 1/22/96 | |
|---|---|---|---|---|---|---|---|---|
| | Interval Difference (feet)[1] | Hydraulic Gradient[2] | Interval Difference (feet)[1] | Hydraulic Gradient[2] | Interval Difference (feet)[1] | Hydraulic Gradient[2] | Interval Difference (feet)[1] | Hydraulic Gradient[2] |
| MW-33/ MW-34 | 13.08 | -0.02 | 13.13 | -0.02 | 13.60 | 0.00 | 14.78 | 0.06 |
| MW-35/ MW-36 | 14.13 | -0.04 | 4.03 | NM | 14.43 | 0.00 | 14.50 | -0.03 |
| MW-48/ MW-35 | NI | --- | NI | --- | NI | --- | NI | --- |
| MW-37/ MW-38 | 19.63 | 0.02 | 19.63 | -0.05 | 19.63 | 0.04 | 19.63 | -0.02 |
| MW-39/ MW-40 | 22.89 | 0.03 | 22.89 | 0.03 | 22.89 | 0.04 | 22.89 | 0.04 |
| MW-61/ MW-51 | NI | --- | NI | --- | NI | --- | NI | --- |
| MW-52/ MW-64 | NI | --- | NI | --- | NI | --- | NI | --- |
| MW-53/ B25-MW-3 | NI | --- | NI | --- | NI | --- | NI | --- |
| B25-MW-2/ B25-MW-3 | 12.69 | 0.03 | 12.86 | 0.09 | 12.86 | 0.06 | 1.38 | NM |

[1] the interval distance is the distance between the midpoints of the saturated screen intervals of both wells in the cluster

[2] a negative gradient is an upward gradient

NM - A measurement was not taken at one of the wells in the cluster at this time.

NI - At least one well in cluster not installed at time of measurement.

# Tal -2
# Vertical Gradients in Clustered Wells
# Main Manufacturing Area
# Watervliet Arsenal
# Watervliet, New York

| Well Pair | 5/20/96 | | 2/11/99 | |
|---|---|---|---|---|
| | Interval Difference (feet)[1] | Hydraulic Gradient[2] | Interval Difference (feet)[1] | Hydraulic Gradient[2] |
| MW-33/<br>MW-34 | 13.33 | -0.03 | 13.21 | -0.03 |
| MW-35/<br>MW-36 | 14.89 | -0.05 | 14.65 | 0.01 |
| MW-48/<br>MW-35 | NI | --- | 45.40 | -0.01 |
| MW-37/<br>MW-38 | 19.63 | -0.06 | 19.63 | -0.06 |
| MW-39/<br>MW-40 | 22.89 | 0.04 | 22.89 | 0.05 |
| MW-61/<br>MW-51 | NI | --- | 91.15 | 1.48 |
| MW-52/<br>MW-64 | NI | --- | 58.15 | 0.83 |
| MW-53/<br>B25-MW-3 | NI | --- | 59.73 | 0.05 |
| B25-MW-2/<br>B25-MW-3 | 12.86 | 0.22 | 12.86 | 0.08 |

[1] the interval distance is the distance between the midpoints of the saturated screen intervals of both wells in the cluster

[2] a negative gradient is an upward gradient

NM - A measurement was not taken at one of the wells in the cluster at this time.

NI - At least one well in cluster not installed at time of measurement.

# Table 4-3
# Hydraulic Conductivity Values
# Main Manufacturing Area, Watervliet Arsenal

| Monitoring Well | Hydraulic Conductivity (ft/min) | Hydraulic Conductivity (cm/sec) | Well Type |
|---|---|---|---|
| MW-20 | 1.95 x 10-5 | 1.40 x 10-5 | Overburden |
| MW-21 | 6.20 x 10-3 | 3.30 x 10-3 | Overburden |
| MW-23 | 6.33 x 10-4 | 3.36 x 10-4 | Weathered Bedrock |
| MW-24 | 5.23 x 10-3 | 2.78 x 10-3 | Overburden |
| MW-25 | 1.71 x 10-2 | 9.10 x 10-3 | Weathered Bedrock |
| MW-27 | 8.54 x 10-3 | 4.54 x 10-3 | Weathered Bedrock |
| MW-30 | 1.35 x 10-3 | 7.17 x 10-4 | Weathered Bedrock |
| MW-31 | 7.85 x 10-3 | 4.17 x 10-3 | Overburden |
| MW-32 | 3.85 x 10-3 | 2.04 x 10-3 | Weathered Bedrock |
| MW-33 | 1.92 x 10-6 | 1.02 x 10-6 | Overburden |
| MW-34 | 2.32 x 10-3 | 1.23 x 10-3 | Bedrock |
| MW-35 | 1.20 x 10-3 | 6.39 x 10-4 | Bedrock |
| MW-36 | 2.95 x 10-7 | 1.56 x 10-7 | Overburden |
| MW-38 | 1.04 x 10-4 | 5.51 x 10-5 | Bedrock |
| MW-40 | 4.30 x 10-3 | 2.29 x 10-3 | Bedrock |
| MW-42 | 8.44 x 10-3 | 4.49 x 10-3 | Weathered Bedrock |
| MW-45 | 1.08 x 10-3 | 5.49 x 10-4 | Bedrock |
| MW-50 | 9.70 x 10-4 | 4.93 x 10-4 | Bedrock |
| MW-54 | 1.16 x 10-2 | 5.88 x 10-3 | Bedrock |
| MW-58 | 2.70 x 10-3 | 1.37 x 10-3 | Bedrock |
| MW-60 | 4.97 x 10-3 | 2.53 x 10-3 | Bedrock |
| MW-62 | 7.71 x 10-4 | 3.92 x 10-4 | Bedrock |
| MW-63 | 1.86 x 10-2 | 9.43 x 10-3 | Bedrock |
| MW-64 | 2.60 x 10-4 | 1.32 x 10-4 | Bedrock |
| B25-MW-1 | 1.60 x 10-2 | 8.48 x 10-3 | Weathered Bedrock |
| B25-MW-3 | 1.13 x 10-3 | 6.01 x 10-4 | Overburden |
| B25-MW-4 | 1.59 x 10-3 | 8.43 x 10-4 | Weathered Bedrock |
| B25-MW-5 | 5.74 x 10-5 | 3.05 x 10-5 | Hybrid |
| B25-MW-6 | 4.03 x 10-4 | 2.14 x 10-4 | Overburden |
| B35-MW-6 | 1.96 x 10-2 | 1.04 x 10-2 | Overburden |

Note: Hydraulic conductivities of bedrock wells are the geometric means calculated at each interval. If multiple tests were conducted at an interval, the geometric mean of representative tests was used.

f:\project\0285587\file\hermit\Kvalues.xls!Sheet1

# Table 4-4
## Horizontal Groundwater Travel Time
## Recharge Area (Groundwater Divide) to Property Boundary
## Main Manufacturing Area, Watervliet Arsenal

$V=K/n(dh/dl)$ (Assumes Darcy Flow)

| | |
|---|---|
| K*: | 1.96E-03 ft/min |
| K (Site Bedrock High): | 1.86E-02 ft/min |
| K (Site Bedrock Low): | 9.70E-04 ft/min |

*Average of MW-34, MW-40, MW-50, MW-64

| Effective Porosity | 0.01 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 |
|---|---|---|---|---|---|---|---|
| **Travel Times** | | | | | | | |
| *Average K* | | | | | | | |
| Travel Time (days) | 439 | 2,197 | 4,395 | 6,592 | 8,789 | 10,987 | 13,184 |
| Travel Time (years) | 1.2 | 6.0 | 12.0 | 18.0 | 24.1 | 30.1 | 36.1 |
| *High K* | | | | | | | |
| Travel Time (days) | 46 | 232 | 463 | 695 | 926 | 1,158 | 1,389 |
| Travel Time (years) | 0.1 | 0.6 | 1.3 | 1.9 | 2.5 | 3.2 | 3.8 |
| *Low K* | | | | | | | |
| Travel Time (days) | 888 | 4,440 | 8,880 | 13,320 | 17,760 | 22,200 | 26,640 |
| Travel Time (years) | 2.4 | 12.2 | 24.3 | 36.5 | 48.6 | 60.8 | 72.9 |

# Table 5-2
# Statistical Summary of Soil Analytical Results
# Main Manufacturing Area, Watervliet Arsenal

| | New York State TAGM Native Soils ug/Kg | New York State TAGM Fill Soils ug/Kg | NATIVE SOILS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *# of TAGM Exceedances* | *% of TAGM Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | | |
| 2-Methylnaphthalene | 36,400 | 72,800 | 0 / 19 | 0.00% | 4 / 19 | 21.05% | 23 | 1200 | 225 |
| 4-Chloro-3-methylphenol | 240 | 480 | 0 / 19 | 0.00% | 0 / 19 | 0.00% | 0 | 0 | 0 |
| Acenaphthene | 50,000 | 50,000 | 0 / 19 | 0.00% | 2 / 19 | 10.53% | 34 | 38 | 36 |
| Acenaphthylene | 41,000 | 82,000 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 15 | 15 | 15 |
| Anthracene | 50,000 | 50,000 | 0 / 19 | 0.00% | 5 / 19 | 26.32% | 9 | 36 | 23 |
| Benzo(a)anthracene | 224 | 224 | 0 / 19 | 0.00% | 8 / 19 | 42.11% | 11 | 160 | 37.5 |
| Benzo(a)pyrene | 61 | 61 | 2 / 19 | 10.53% | 8 / 19 | 42.11% | 9 | 180 | 42.5 |
| Benzo(b)fluoranthene | 1,100 | 2,200 | 0 / 19 | 0.00% | 8 / 19 | 42.11% | 9 | 240 | 51.5 |
| Benzo(g,h,l)perylene | 50,000 | 50,000 | 0 / 19 | 0.00% | 5 / 19 | 26.32% | 8 | 80 | 26 |
| Benzo(k)fluoranthene | 1,100 | 2,200 | 0 / 19 | 0.00% | 8 / 19 | 42.11% | 8 | 140 | 44.5 |
| bis(2-Ethylhexyl)phthalate | 50,000 | 50,000 | 0 / 19 | 0.00% | 15 / 19 | 78.95% | 24 | 6800 | 100 |
| Butylbenzylphthalate | 50,000 | 50,000 | 0 / 19 | 0.00% | 3 / 19 | 15.79% | 13 | 750 | 27 |
| Chrysene | 400 | 800 | 0 / 19 | 0.00% | 11 / 19 | 57.89% | 5 | 220 | 58 |
| Di-n-butylphthalate | 8,100 | 16,200 | 0 / 19 | 0.00% | 12 / 19 | 63.16% | 7 | 2500 | 16.5 |
| Di-n-octyl phthalate | 50,000 | 50,000 | 0 / 19 | 0.00% | 2 / 19 | 10.53% | 8 | 41 | 24.5 |
| Dibenzo(a,h)anthracene | 14 | 14 | 2 / 19 | 10.53% | 2 / 19 | 10.53% | 17 | 49 | 33 |
| Diethylphthalate | 7,100 | 14,200 | 0 / 19 | 0.00% | 4 / 19 | 21.05% | 8 | 530 | 12 |
| Fluoranthene | 50,000 | 50,000 | 0 / 19 | 0.00% | 13 / 19 | 68.42% | 4 | 260 | 85 |
| Fluorene | 50,000 | 50,000 | 0 / 19 | 0.00% | 2 / 19 | 10.53% | 33 | 43 | 38 |
| Indeno(1,2,3-cd)pyrene | 3,200 | 6,400 | 0 / 19 | 0.00% | 5 / 19 | 26.32% | 12 | 130 | 26 |
| Naphthalene | 13,000 | 26,000 | 0 / 19 | 0.00% | 3 / 19 | 15.79% | 18 | 24 | 23 |
| Phenanthrene | 50,000 | 50,000 | 0 / 19 | 0.00% | 13 / 19 | 68.42% | 6 | 270 | 39 |
| Pyrene | 50,000 | 50,000 | 0 / 19 | 0.00% | 15 / 19 | 78.95% | 7 | 270 | 72 |
| Total benzofluoranthene | N/A | N/A | — | N/A | 0 / 0 | N/A | 0 | 0 | 0 |
| **Volatile Compounds** | | | | | | | | | |
| 1,1,1-Trichloroethane | 800 | 1,600 | 0 / 19 | 0.00% | 2 / 19 | 10.53% | 2 | 4 | 3 |
| 1,1-Dichloroethane | 200 | 400 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 1 | 1 | 1 |
| 1,2-Dichloroethene (total) | 0 | 0 | — | N/A | 1 / 11 | 9.09% | 115 | 115 | 115 |
| 2-Butanone | 300 | 600 | 0 / 19 | 0.00% | 3 / 19 | 15.79% | 5 | 10 | 9 |
| Benzene | 60 | 120 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 0.6 | 0.6 | 0.6 |
| Bromodichloromethane | 0 | 0 | — | N/A | 1 / 19 | 5.26% | 240 | 240 | 240 |
| Carbon Disulfide | 2,700 | 5,400 | 0 / 19 | 0.00% | 2 / 19 | 10.53% | 0.6 | 7 | 3.8 |
| Chloroform | 300 | 600 | 1 / 19 | 5.26% | 5 / 19 | 26.32% | 2 | 1800 | 4 |
| cis-1,2-Dichloroethene | 0 | 0 | — | N/A | 4 / 8 | 50.00% | 78 | 78 | 78 |
| Ethylbenzene | 5,500 | 11,000 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 3 | 3 | 3 |
| Methylene Chloride | 100 | 200 | 0 / 19 | 0.00% | 8 / 19 | 42.11% | 2 | 18 | 4.5 |
| Tetrachloroethene | 1,400 | 2,800 | 0 / 19 | 0.00% | 0 / 19 | 0.00% | 0 | 0 | 0 |
| Toluene | 1,500 | 3,000 | 0 / 19 | 0.00% | 7 / 19 | 36.84% | 1 | 10 | 4 |
| Trichloroethene | 700 | 1,400 | 0 / 19 | 0.00% | 4 / 19 | 21.05% | 3 | 250 | 31.5 |
| Vinyl Acetate | 0 | 0 | — | N/A | 1 / 19 | 5.26% | 2 | 2 | 2 |
| Vinyl Chloride | 200 | 400 | 0 / 19 | 0.00% | 0 / 19 | 0.00% | 0 | 0 | 0 |
| Xylene (total) | 1,200 | 2,400 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 15 | 15 | 15 |
| **Pesticides and PCBs** | | | | | | | | | |
| alpha-BHC | 300 | 600 | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| beta-BHC | 600 | 1,200 | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| delta-BHC | 100 | 200 | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| Heptachlor | 41 | 82 | 0 / 18 | 0.00% | 1 / 18 | 5.56% | 2.1 | 2.1 | 2.1 |
| Heptachlor Epoxide | 44 | 88 | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| Aldrin | 100 | 200 | 0 / 18 | 0.00% | 1 / 18 | 5.56% | 1.8 | 1.8 | 1.8 |
| Dieldrin | N/A | N/A | — | N/A | 2 / 18 | 11.11% | 0.36 | 0.64 | 0.5 |
| Endrin | N/A | N/A | — | N/A | 0 / 18 | 0.00% | 0 | 0 | 0 |
| Endrin Ketone | 1,000 | 2,000 | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| Endosulfan II | 2,100 | 4,200 | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| Endosulfan Sulfate | 2,900 | 5,800 | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| 4,4'-DDE | 2,100 | 4,200 | 0 / 18 | 0.00% | 2 / 18 | 11.11% | 1.5 | 6.5 | 4 |
| 4,4'-DDD | 10,000 | 20,000 | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| 4,4'-DDT | 10,000 | 40,000 | 0 / 18 | 0.00% | 4 / 18 | 22.22% | 1.4 | 4.3 | 2.2 |
| Methoxychlor | 2,000 | 4,000 | 0 / 17 | 0.00% | 1 / 17 | 5.88% | 6.6 | 6.6 | 6.6 |
| Aroclor-1254 | N/A | N/A | — | N/A | 1 / 18 | 5.56% | 23 | 23 | 23 |
| Aroclor-1260 | N/A | N/A | — | N/A | 1 / 18 | 5.56% | 24 | 24 | 24 |
| **Inorganic Compounds** | | | | | | | | | |
| Arsenic | 10.5 | 10.5 | 6 / 18 | 33.33% | 18 / 18 | 100.00% | 1.9 | 18.5 | 8.85 |
| Barium | 300 | 300 | 0 / 18 | 0.00% | 18 / 18 | 100.00% | 44.7 | 274 | 127 |
| Cadmium | 1 | 1 | 0 / 18 | 0.00% | 3 / 18 | 16.67% | 0.64 | 0.79 | 0.79 |
| Chromium | 20.725 | 20.725 | 9 / 18 | 50.00% | 18 / 18 | 100.00% | 13.4 | 42.8 | 20.45 |
| Lead | 185.5 | 185.5 | 0 / 18 | 0.00% | 18 / 18 | 100.00% | 12 | 177 | 23.4 |
| Mercury | 0.1 | 0.1 | 4 / 18 | 22.22% | 4 / 18 | 22.22% | 0.11 | 0.22 | 0.165 |
| Selenium | 3.075 | 3.075 | 1 / 18 | 5.56% | 15 / 18 | 83.33% | 1.4 | 4 | 2 |
| Silver | ND | ND | 1 / 18 | 5.56% | 1 / 18 | 5.56% | 0.21 | 0.21 | 0.21 |

All units in ug/Kg, except inorganics in mg/Kg

# Table 5-2
# Statistical Summary of Soil Analytical Results
# Main Manufacturing Area, Watervliet Arsenal

| | New York State TAGM Native Soils ug/Kg | New York State TAGM Fill Soils ug/Kg | FILL SOILS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *# of TAGM Exceedances* | *% of TAGM Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | | |
| 2-Methylnaphthalene | 36,400 | 72,800 | 0 / 47 | 0.00% | 19 / 47 | 40.43% | 10 | 8,600 | 110 |
| 4-Chloro-3-methylphenol | 240 | 480 | 0 / 47 | 0.00% | 3 / 47 | 6.38% | 160 | 260 | 210 |
| Acenaphthene | 50,000 | 50,000 | 0 / 47 | 0.00% | 21 / 47 | 44.68% | 4 | 30,000 | 63 |
| Acenaphthylene | 41,000 | 82,000 | 0 / 47 | 0.00% | 16 / 47 | 34.04% | 10 | 1,800 | 130 |
| Anthracene | 50,000 | 50,000 | 0 / 47 | 0.00% | 29 / 47 | 61.70% | 5 | 30,000 | 51.5 |
| Benzo(a)anthracene | 224 | 224 | 11 / 47 | 23.40% | 31 / 47 | 65.96% | 2 | 20,000 | 210 |
| Benzo(a)pyrene | 61 | 61 | 19 / 47 | 40.43% | 31 / 47 | 65.96% | 2 | 14,000 | 155 |
| Benzo(b)fluoranthene | 1,100 | 2,200 | 3 / 47 | 6.38% | 28 / 47 | 59.57% | 2 | 11,000 | 220 |
| Benzo(g,h,i)perylene | 50,000 | 50,000 | 0 / 47 | 0.00% | 24 / 47 | 51.06% | 7 | 9,900 | 140 |
| Benzo(k)fluoranthene | 1,100 | 2,200 | 2 / 47 | 4.26% | 26 / 47 | 55.32% | 2 | 12,000 | 210 |
| bis(2-Ethylhexyl)phthalate | 50,000 | 50,000 | 0 / 47 | 0.00% | 32 / 47 | 68.09% | 30 | 930 | 165 |
| Butylbenzylphthalate | 50,000 | 50,000 | 0 / 47 | 0.00% | 1 / 47 | 2.13% | 65 | 65 | 65 |
| Chrysene | 400 | 800 | 8 / 47 | 17.02% | 32 / 47 | 68.09% | 2 | 27,000 | 165 |
| Di-n-butylphthalate | 8,100 | 16,200 | 0 / 47 | 0.00% | 20 / 47 | 42.55% | 6 | 2,500 | 28 |
| Di-n-octyl phthalate | 50,000 | 50,000 | 0 / 47 | 0.00% | 4 / 47 | 8.51% | 6 | 97 | 25 |
| Dibenzo(a,h)anthracene | 14 | 14 | 10 / 47 | 21.28% | 15 / 47 | 31.91% | 10 | 950 | 100 |
| Diethylphthalate | 7,100 | 14,200 | 0 / 47 | 0.00% | 10 / 47 | 21.28% | 8 | 110 | 16 |
| Fluoranthene | 50,000 | 50,000 | 1 / 47 | 2.13% | 37 / 47 | 78.72% | 2 | 58,000 | 310 |
| Fluorene | 50,000 | 50,000 | 0 / 47 | 0.00% | 20 / 47 | 42.55% | 11 | 47,000 | 140 |
| Indeno(1,2,3-cd)pyrene | 3,200 | 6,400 | 1 / 47 | 2.13% | 25 / 47 | 53.19% | 11 | 7,900 | 210 |
| Naphthalene | 13,000 | 26,000 | 0 / 47 | 0.00% | 18 / 47 | 38.30% | 5 | 1,600 | 120 |
| Phenanthrene | 50,000 | 50,000 | 1 / 47 | 2.13% | 34 / 47 | 72.34% | 10 | 140,000 | 235 |
| Pyrene | 50,000 | 50,000 | 1 / 47 | 2.13% | 37 / 47 | 78.72% | 4 | 58,000 | 260 |
| Total benzofluoranthene | N/A | N/A | — | N/A | 2 / 2 | 4.26% | 175 | 3,600 | 1,888 |
| **Volatile Compounds** | | | | | | | | | |
| 1,1,1-Trichloroethane | 800 | 1,600 | 0 / 42 | 0.00% | 1 / 42 | 2.38% | 18 | 18 | 18 |
| 1,1-Dichloroethane | 200 | 400 | 0 / 42 | 0.00% | 0 / 42 | 0.00% | 0 | 0 | 0 |
| 1,2-Dichloroethene (total) | 0 | 0 | — | N/A | 2 / 34 | 4.76% | 4 | 101 | 52.5 |
| 2-Butanone | 300 | 600 | 0 / 42 | 0.00% | 7 / 42 | 16.67% | 6 | 24 | 11 |
| Benzene | 60 | 120 | 0 / 42 | 0.00% | 0 / 42 | 0.00% | 0 | 0 | 0 |
| Bromodichloromethane | 0 | 0 | 0 / 42 | 0.00% | 0 / 42 | 0.00% | 0 | 0 | 0 |
| Carbon Disulfide | 2,700 | 5,400 | 0 / 42 | 0.00% | 4 / 42 | 9.52% | 1 | 6 | 5 |
| Chloroform | 300 | 600 | 0 / 42 | 0.00% | 3 / 42 | 7.14% | 2 | 3 | 3 |
| cis-1,2-Dichloroethene | 0 | 0 | — | N/A | 2 / 8 | 0.00% | 0 | 0 | 0 |
| Ethylbenzene | 5,500 | 11,000 | 0 / 42 | 0.00% | 0 / 42 | 0.00% | 0 | 0 | 0 |
| Methylene Chloride | 100 | 200 | 0 / 42 | 0.00% | 27 / 42 | 64.29% | 1 | 17 | 2.5 |
| Tetrachloroethene | 1,400 | 2,800 | 0 / 42 | 0.00% | 9 / 42 | 21.43% | 3 | 12 | 5 |
| Toluene | 1,500 | 3,000 | 0 / 42 | 0.00% | 12 / 42 | 28.57% | 1 | 40 | 4.5 |
| Trichloroethene | 700 | 1,400 | 0 / 42 | 0.00% | 4 / 42 | 9.52% | 2 | 430 | 6 |
| Vinyl Acetate | 0 | 0 | — | N/A | 0 / 42 | 0.00% | 0 | 0 | 0 |
| Vinyl Chloride | 200 | 400 | 0 / 42 | 0.00% | 1 / 42 | 2.38% | 0 | 0 | 0 |
| Xylene (total) | 1,200 | 2,400 | 0 / 42 | 0.00% | 1 / 42 | 2.38% | 5 | 5 | 5 |
| **Pesticides and PCBs** | | | | | | | | | |
| alpha-BHC | 300 | 600 | 0 / 22 | 0.00% | 1 / 22 | 4.55% | 0.54 | 0.54 | 0.54 |
| beta-BHC | 600 | 1,200 | 0 / 22 | 0.00% | 1 / 22 | 4.55% | 4.4 | 4.4 | 4.4 |
| delta-BHC | 100 | 200 | 0 / 22 | 0.00% | 2 / 22 | 9.09% | 4.4 | 12 | 8.2 |
| Heptachlor | 41 | 82 | 0 / 21 | 0.00% | 1 / 21 | 4.76% | 0.83 | 0.83 | 0.83 |
| Heptachlor Epoxide | 44 | 88 | 0 / 22 | 0.00% | 1 / 22 | 4.55% | 1.3 | 1.3 | 1.3 |
| Aldrin | 100 | 200 | 0 / 22 | 0.00% | 2 / 22 | 9.09% | 2 | 16 | 9 |
| Dieldrin | N/A | N/A | — | N/A | 2 / 22 | 9.09% | 0.83 | 12 | 6.415 |
| Endrin | N/A | N/A | — | N/A | 3 / 22 | 13.64% | 2.4 | 21 | 9.9 |
| Endrin Ketone | 1,000 | 2,000 | 0 / 21 | 0.00% | 1 / 21 | 4.76% | 3.3 | 3.3 | 3.3 |
| Endosulfan II | 2,100 | 4,200 | 0 / 21 | 0.00% | 1 / 21 | 4.76% | 3.9 | 3.9 | 3.9 |
| Endosulfan Sulfate | 2,900 | 5,800 | 0 / 22 | 0.00% | 2 / 22 | 9.09% | 0.42 | 2.4 | 1.41 |
| 4,4'-DDE | 2,100 | 4,200 | 0 / 22 | 0.00% | 7 / 22 | 31.82% | 0.2 | 1,700 | 20 |
| 4,4'-DDD | 10,000 | 20,000 | 0 / 21 | 0.00% | 5 / 21 | 23.81% | 1.4 | 27 | 2.7 |
| 4,4'-DDT | 10,000 | 40,000 | 0 / 20 | 0.00% | 7 / 20 | 35.00% | 0.59 | 13 | 1.1 |
| Methoxychlor | 2,000 | 4,000 | 0 / 20 | 0.00% | 2 / 20 | 10.00% | 11 | 11 | 11 |
| Aroclor-1254 | N/A | N/A | — | N/A | 1 / 22 | 4.55% | 270 | 270 | 270 |
| Aroclor-1260 | N/A | N/A | — | N/A | 1 / 22 | 4.55% | 3.5 | 3.5 | 3.5 |
| **Inorganic Compounds** | | | | | | | | | |
| Arsenic | 10.5 | 10.5 | 22 / 48 | 45.83% | 48 / 48 | 100.00% | 1.30 | 111 | 10.2 |
| Barium | 300 | 300 | 9 / 48 | 18.75% | 48 / 48 | 100.00% | 44.90 | 2,910 | 150.5 |
| Cadmium | 1 | 1 | 7 / 48 | 14.58% | 17 / 48 | 35.42% | 0.38 | 5 | 0.98 |
| Chromium | 20.725 | 20.725 | 18 / 51 | 35.29% | 49 / 51 | 96.08% | 9.40 | 237 | 18.8 |
| Lead | 185.5 | 185.5 | 11 / 48 | 22.92% | 48 / 48 | 100.00% | 7.20 | 17,800 | 69.6 |
| Mercury | 0.1 | 0.1 | 21 / 48 | 43.75% | 22 / 48 | 45.83% | 0.09 | 0.84 | 0.22 |
| Selenium | 3.075 | 3.075 | 7 / 48 | 14.58% | 38 / 48 | 79.17% | 0.32 | 10.5 | 1.9 |
| Silver | ND | ND | 2 / 48 | 4.17% | 2 / 48 | 4.17% | 1.70 | 2 | 1.85 |

All units in ug/Kg, except inorganics in mg/Kg

# Table 5-2
## Statistical Summary of Soil Analytical Results
## Main Manufacturing Area, Watervliet Arsenal

|  | New York State TAGM Native Soils ug/Kg | New York State TAGM Fill Soils ug/Kg | TOTAL SOILS |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | *# of TAGM Exceedances* | *% of TAGM Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** |  |  |  |  |  |  |  |  |  |
| 2-Methylnaphthalene | 36,400 | 72,800 | 0 / 66 | 0.00% | 23 / 66 | 34.85% | 10 | 8,600 | 155 |
| 4-Chloro-3-methylphenol | 240 | 480 | 0 / 66 | 0.00% | 3 / 66 | 4.55% | 160 | 260 | 210 |
| Acenaphthene | 50,000 | 50,000 | 0 / 66 | 0.00% | 23 / 66 | 34.85% | 4 | 30,000 | 60 |
| Acenaphthylene | 41,000 | 82,000 | 0 / 66 | 0.00% | 17 / 66 | 25.76% | 10 | 1,800 | 130 |
| Anthracene | 50,000 | 50,000 | 0 / 66 | 0.00% | 34 / 66 | 51.52% | 5 | 30,000 | 39 |
| Benzo(a)anthracene | 224 | 224 | 11 / 66 | 16.67% | 39 / 66 | 59.09% | 2 | 20,000 | 100 |
| Benzo(a)pyrene | 61 | 61 | 21 / 66 | 31.82% | 39 / 66 | 59.09% | 2 | 14,000 | 84.5 |
| Benzo(b)fluoranthene | 1,100 | 2,200 | 3 / 66 | 4.55% | 36 / 66 | 54.55% | 2 | 11,000 | 99.5 |
| Benzo(g,h,i)perylene | 50,000 | 50,000 | 0 / 66 | 0.00% | 29 / 66 | 43.94% | 7 | 9,900 | 78 |
| Benzo(k)fluoranthene | 1,100 | 2,200 | 2 / 66 | 3.03% | 32 / 66 | 48.48% | 2 | 12,000 | 84 |
| bis(2-Ethylhexyl)phthalate | 50,000 | 50,000 | 0 / 66 | 0.00% | 47 / 66 | 71.21% | 24 | 6,800 | 160 |
| Butylbenzylphthalate | 50,000 | 50,000 | 0 / 66 | 0.00% | 4 / 66 | 6.06% | 13 | 750 | 46 |
| Chrysene | 400 | 800 | 8 / 66 | 12.12% | 43 / 66 | 65.15% | 2 | 27,000 | 110 |
| Di-n-butylphthalate | 8,100 | 16,200 | 0 / 66 | 0.00% | 32 / 66 | 48.48% | 6 | 2,500 | 18.5 |
| Di-n-octyl phthalate | 50,000 | 50,000 | 0 / 66 | 0.00% | 6 / 66 | 9.09% | 6 | 97 | 9 |
| Dibenzo(a,h)anthracene | 14 | 14 | 12 / 66 | 18.18% | 17 / 66 | 25.76% | 10 | 950 | 94 |
| Diethylphthalate | 7,100 | 14,200 | 0 / 66 | 0.00% | 14 / 66 | 21.21% | 6 | 530 | 14 |
| Fluoranthene | 50,000 | 50,000 | 1 / 66 | 1.52% | 50 / 66 | 75.76% | 2 | 58,000 | 160 |
| Fluorene | 50,000 | 50,000 | 0 / 66 | 0.00% | 22 / 66 | 33.33% | 11 | 47,000 | 105 |
| Indeno(1,2,3-cd)pyrene | 3,200 | 6,400 | 1 / 66 | 1.52% | 30 / 66 | 45.45% | 11 | 7,900 | 85 |
| Naphthalene | 13,000 | 26,000 | 0 / 66 | 0.00% | 21 / 66 | 31.82% | 5 | 1,600 | 100 |
| Phenanthrene | 50,000 | 50,000 | 1 / 66 | 1.52% | 47 / 66 | 71.21% | 6 | 140,000 | 110 |
| Pyrene | 50,000 | 50,000 | 1 / 66 | 1.52% | 52 / 66 | 78.79% | 4 | 58,000 | 135 |
| Total benzofluoranthene | N/A | N/A | — | N/A | 2 / 2 | 100.00% | 175 | 3,600 | 1,888 |
| **Volatile Compounds** |  |  |  |  |  |  |  |  |  |
| 1,1,1-Trichloroethane | 800 | 1,600 | 0 / 61 | 0.00% | 3 / 61 | 4.92% | 2 | 18 | 4 |
| 1,1-Dichloroethane | 200 | 400 | 0 / 61 | 0.00% | 1 / 61 | 1.64% | 1 | 1 | 1 |
| 1,2-Dichloroethene (total) | 0 | 0 | — | N/A | 3 / 53 | 5.66% | 4 | 115 | 101 |
| 2-Butanone | 300 | 600 | 0 / 61 | 0.00% | 10 / 61 | 16.39% | 5 | 39 | 10.5 |
| Benzene | 60 | 120 | 0 / 61 | 0.00% | 1 / 61 | 1.64% | 0.6 | 3 | 1.8 |
| Bromodichloromethane | 0 | 0 | 0 / 61 | 0.00% | 1 / 61 | 1.64% | 240 | 240 | 240 |
| Carbon Disulfide | 2,700 | 5,400 | 0 / 61 | 0.00% | 6 / 61 | 9.84% | 0.6 | 30 | 5 |
| Chloroform | 300 | 600 | 1 / 61 | 1.64% | 8 / 61 | 13.11% | 2 | 1,800 | 3 |
| cis-1,2-Dichloroethene | 0 | 0 | — | N/A | 6 / 8 | 75.00% | 2 | 78 | 8 |
| Ethylbenzene | 5,500 | 11,000 | 0 / 61 | 0.00% | 1 / 61 | 1.64% | 2 | 3 | 2 |
| Methylene Chloride | 100 | 200 | 0 / 61 | 0.00% | 35 / 61 | 57.38% | 1 | 18 | 3 |
| Tetrachloroethene | 1,400 | 2,800 | 0 / 61 | 0.00% | 9 / 61 | 14.75% | 2 | 25 | 5 |
| Toluene | 1,500 | 3,000 | 0 / 61 | 0.00% | 21 / 61 | 34.43% | 1 | 40 | 4 |
| Trichloroethene | 700 | 1,400 | 0 / 61 | 0.00% | 8 / 61 | 13.11% | 2 | 430 | 17 |
| Vinyl Acetate | 0 | 0 | — | N/A | 1 / 61 | 1.64% | 2 | 2 | 2 |
| Vinyl Chloride | 200 | 400 | 0 / 61 | 0.00% | 1 / 61 | 1.64% | 15 | 15 | 15 |
| Xylene (total) | 1,200 | 2,400 | 0 / 61 | 0.00% | 2 / 61 | 3.28% | 3 | 26 | 5 |
| **Pesticides and PCBs** |  |  |  |  |  |  |  |  |  |
| alpha-BHC | 300 | 600 | 0 / 40 | 0.00% | 1 / 40 | 2.50% | 0.54 | 0.54 | 0.54 |
| beta-BHC | 600 | 1,200 | 0 / 40 | 0.00% | 1 / 40 | 2.50% | 4.4 | 4.4 | 4.4 |
| delta-BHC | 100 | 200 | 0 / 40 | 0.00% | 2 /40 | 5.00% | 2.2 | 12 | 4.4 |
| Heptachlor | 41 | 82 | 0 / 39 | 0.00% | 2 / 39 | 5.13% | 0.83 | 2.1 | 1.47 |
| Heptachlor Epoxide | 44 | 88 | 0 / 40 | 0.00% | 1 / 40 | 2.50% | 1.3 | 1.3 | 1.3 |
| Aldrin | 100 | 200 | 0 / 40 | 0.00% | 3 / 40 | 7.50% | 1.8 | 16 | 2.25 |
| Dieldrin | N/A | N/A | — | N/A | 4 / 40 | 10.00% | 0.36 | 12 | 0.74 |
| Endrin | N/A | N/A | — | N/A | 3 / 40 | 7.50% | 2.4 | 21 | 9.6 |
| Endrin Ketone | 1,000 | 2,000 | 0 / 39 | 0.00% | 1 / 39 | 2.56% | 3.3 | 3.3 | 3.3 |
| Endosulfan II | 2,100 | 4,200 | 0 / 39 | 0.00% | 1 / 39 | 2.56% | 1.3 | 3.9 | 2.6 |
| Endosulfan Sulfate | 2,900 | 5,800 | 0 / 40 | 0.00% | 2 / 40 | 5.00% | 0.42 | 2.4 | 1.41 |
| 4,4'-DDE | 2,100 | 4,200 | 0 / 40 | 0.00% | 9 / 40 | 22.50% | 0.2 | 1,700 | 19 |
| 4,4'-DDD | 10,000 | 20,000 | 0 / 39 | 0.00% | 5 / 39 | 12.82% | 1.1 | 27 | 2.55 |
| 4,4'-DDT | 10,000 | 40,000 | 0 / 38 | 0.00% | 11 / 38 | 28.95% | 0.59 | 13 | 1.95 |
| Methoxychlor | 2,000 | 4,000 | 0 / 37 | 0.00% | 3 / 37 | 8.11% | 5.5 | 11 | 8.8 |
| Aroclor-1254 | N/A | N/A | — | N/A | 2 / 40 | 5.00% | 23 | 270 | 92 |
| Aroclor-1260 | N/A | N/A | — | N/A | 2 / 40 | 5.00% | 3.5 | 24 | 6.7 |
| **Inorganic Compounds** |  |  |  |  |  |  |  |  |  |
| Arsenic | 10.5 | 10.5 | 28 / 66 | 42.42% | 66 / 66 | 100.00% | 1.3 | 111 | 10 |
| Barium | 300 | 300 | 9 / 66 | 13.64% | 66 / 66 | 100.00% | 44.7 | 2,910 | 137.5 |
| Cadmium | 1 | 1 | 7 / 66 | 10.61% | 20 / 66 | 30.30% | 0.38 | 5 | 0.92 |
| Chromium | 20.725 | 20.725 | 26 / 69 | 37.68% | 67 / 69 | 97.10% | 8.9 | 237 | 18.8 |
| Lead | 185.5 | 185.5 | 11 / 66 | 16.67% | 66 / 66 | 100.00% | 7.2 | 17,800 | 47.3 |
| Mercury | 0.1 | 0.1 | 25 / 66 | 37.88% | 26 / 66 | 39.39% | 0.09 | 0.84 | 0.200 |
| Selenium | 3.075 | 3.075 | 8 / 66 | 12.12% | 54 / 66 | 81.82% | 0.32 | 10.5 | 2.0 |
| Silver | ND | ND | 3 / 66 | 4.55% | 3 / 66 | 4.55% | 0.21 | 2 | 1.7 |

All units in ug/Kg, except inorganics in mg/Kg

# Table 5-3
## Statistical Summary of Round One Groundwater Results
## Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | OVERBURDEN WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| 4-Chloro-3-methylphenol | N/A | --- | N/A | 4 / 16 | 25.00% | 4 | 890 | 175 |
| Diethylphthalate | 50 | 0 / 17 | 0.00% | 2 / 17 | 11.76% | 2 | 4 | 3 |
| Dimethyl phthalate | 50 | 0 / 17 | 0.00% | 1 / 17 | 5.88% | 2 | 2 | 2 |
| Acenaphthene | 20 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Fluorene | 50 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Phenanthrene | 50 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Anthracene | 50 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Napthalene | 10 | 0 / 17 | 0.00% | 1 / 17 | 5.88% | 2 | 2 | 2 |
| Di-n-butylphthalate | N/A | --- | N/A | 10 / 17 | 58.82% | 0.3 | 11 | 2 |
| Fluoranthene | 50 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Pyrene | 50 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Butylbenzylphthalate | 50 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Benzo(a)anthracene | 0.002 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Chrysene | 0.002 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| bis(2-Ethylhexyl)phthalate | 50 | 0 / 17 | 0.00% | 5 / 17 | 29.41% | 0.3 | 4 | 2 |
| Di-n-octylphthalate | N/A | --- | N/A | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Benzo(b)fluoranthene | 0.002 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Benzo(k)Fluoranthene | 0.002 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| Benzo(a)Pyrene | 0.002 | 0 / 17 | 0.00% | 0 / 17 | 0.00% | 0 | 0 | 0 |
| **Volatile Compounds** | | | | | | | | |
| Vinyl Chloride | 2 | 1 / 19 | 5.26% | 1 / 19 | 5.26% | 32 | 32 | 32 |
| Chloroethane | 5 | 2 / 19 | 10.53% | 2 / 19 | 10.53% | 7 | 7 | 7 |
| Methylene Chloride | 5 | 0 / 19 | 0.00% | 0 / 19 | 0.00% | 0 | 0 | 0 |
| Carbon Disulfide | N/A | --- | N/A | 0 / 19 | 0.00% | 0 | 0 | 0 |
| 1,1-Dichloroethane | 5 | 4 / 19 | 21.05% | 6 / 19 | 31.58% | 2 | 26 | 6.5 |
| cis-1,2-Dichloroethene | 5 | 1 / 11 | 9.09% | 2 / 11 | 18.18% | 3 | 460 | 231.5 |
| trans-1,2-Dichloroethene | 5 | 1 / 11 | 9.09% | 1 / 11 | 9.09% | 10 | 10 | 10 |
| 1,2-Dichloroethene (total) | N/A | --- | N/A | 1 / 10 | 10.00% | 2 | 2 | 2 |
| Chloroform | 7 | 2 / 19 | 10.53% | 4 / 19 | 21.05% | 3 | 630 | 151.5 |
| 2-Butanone | 5 | 0 / 19 | 0.00% | 0 / 19 | 0.00% | 0 | 0 | 0 |
| Trichloroethene | 5 | 5 / 19 | 26.32% | 5 / 19 | 26.32% | 16 | 410 | 200 |
| Benzene | 0.7 | 1 / 19 | 5.26% | 1 / 19 | 5.26% | 2 | 2 | 2 |
| Tetrachloroethene | 5 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 4 | 4 | 4 |
| Toluene | 5 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 1 | 1 | 1 |
| 1,1-Dichloroethene | 5 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 3 | 3 | 3 |
| 1,1,1-Trichloroethane | 5 | 1 / 19 | 5.26% | 2 / 19 | 10.53% | 3 | 100 | 51.5 |
| Acetone | 50 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 30 | 30 | 30 |
| Bromodichloromethane | 5 | 0 / 19 | 0.00% | 0 / 19 | 0.00% | 0 | 0 | 0 |
| Chlorobenzene | 5 | 0 / 19 | 0.00% | 0 / 19 | 0.00% | 0 | 0 | 0 |
| Ethylbenzene | 5 | 0 / 19 | 0.00% | 0 / 19 | 0.00% | 0 | 0 | 0 |
| Xylene (total) | 5 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 2 | 2 | 2 |
| **Pesticides and PCBs** | | | | | | | | |
| alpha-BHC | N/A | --- | N/A | 1 / 15 | 6.67% | 0.005 | 0.005 | 0.005 |
| beta-BHC | N/A | --- | N/A | 0 / 14 | 0.00% | 0 | 0 | 0 |
| delta-BHC | N/A | --- | N/A | 2 / 15 | 13.33% | 0.0012 | 0.0018 | 0.0015 |
| gamma-BHC (Lindane) | N/A | --- | N/A | 0 / 14 | 0.00% | 0 | 0 | 0 |
| Heptachlor | ND | 0 / 15 | 0.00% | 0 / 15 | 0.00% | 0 | 0 | 0 |
| Aldrin | ND | 2 / 15 | 13.33% | 2 / 15 | 13.33% | 0.015 | 0.047 | 0.031 |
| Heptachlor Epoxide | ND | 1 / 15 | 6.67% | 1 / 15 | 6.67% | 0.022 | 0.022 | 0.022 |
| Endosulfan I | 0.1 | 0 / 15 | 0.00% | 0 / 15 | 0.00% | 0 | 0 | 0 |
| Dieldrin | ND | 4 / 13 | 30.77% | 4 / 13 | 30.77% | 0.0014 | 0.016 | 0.0027 |
| 4,4'-DDE | ND | 4 / 15 | 26.67% | 4 / 15 | 26.67% | 0.0017 | 0.045 | 0.0052 |
| Endrin | ND | 3 / 14 | 21.43% | 3 / 14 | 21.43% | 0.00061 | 0.0035 | 0.0021 |
| Endosulfan II | N/A | --- | N/A | 1 / 14 | 7.14% | 0.0034 | 0.0034 | 0.0034 |
| 4,4'-DDD | ND | 3 / 14 | 21.43% | 3 / 14 | 21.43% | 0.0013 | 0.038 | 0.0021 |
| Endosulfan Sulfate | N/A | --- | N/A | 1 / 15 | 6.67% | 0.018 | 0.018 | 0.018 |
| 4,4'-DDT | ND | 3 / 15 | 20.00% | 3 / 15 | 20.00% | 0.002 | 0.0035 | 0.0025 |
| Methoxychlor | 35 | 0 / 15 | 0.00% | 0 / 15 | 0.00% | 0 | 0 | 0 |
| Endrin Ketone | N/A | --- | N/A | 1 / 15 | 6.67% | 0.0011 | 0.0011 | 0.0011 |
| Endrin Aldehyde | N/A | --- | N/A | 2 / 15 | 13.33% | 0.0024 | 0.003 | 0.0027 |
| alpha-Chlordane | 0.1 | 0 / 15 | 0.00% | 0 / 15 | 0.00% | 0 | 0 | 0 |
| Gamma-Chlordane | N/A | --- | N/A | 3 / 15 | 20.00% | 0.00071 | 0.0013 | 0.0012 |
| Aroclor-1254 | 0.1 | 0 / 15 | 0.00% | 0 / 15 | 0.00% | 0 | 0 | 0 |
| Aroclor-1260 | 0.1 | 0 / 15 | 0.00% | 1 / 15 | 6.67% | 0.059 | 0.059 | 0.059 |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (unfiltered) | 25 | 2 / 16 | 12.50% | 11 / 16 | 68.75% | 4.2 | 37.6 | 10.8 |
| Barium (unfiltered) | 1000 | 0 / 16 | 0.00% | 16 / 16 | 100.00% | 63.7 | 874 | 248 |
| Cadmium (unfiltered) | 10 | 1 / 16 | 6.25% | 6 / 16 | 37.50% | 0.92 | 427 | 2.25 |
| Chromium (unfiltered) | 50 | 3 / 16 | 18.75% | 15 / 16 | 93.75% | 2.5 | 17600 | 15.3 |
| Cyanide (unfiltered) | 100 | 0 / 10 | 0.00% | 0 / 10 | 0.00% | 0 | 0 | 0 |
| Iron (unfiltered) | 300 | 1 / 1 | 100.00% | 1 / 1 | 100.00% | 17900 | 17900 | 17900 |
| Lead (unfiltered) | 25 | 4 / 15 | 26.67% | 13 / 15 | 86.67% | 2.8 | 149 | 16.2 |
| Mercury (unfiltered) | 2 | 0 / 16 | 0.00% | 5 / 16 | 31.25% | 0.04 | 0.41 | 0.31 |
| Selenium (unfiltered) | 10 | 0 / 14 | 0.00% | 2 / 14 | 14.29% | 2.1 | 3.2 | 2.65 |
| Silver (unfiltered) | 50 | 0 / 16 | 0.00% | 5 / 16 | 31.25% | 2 | 4.2 | 2.5 |
| Arsenic (filtered) | 25 | 0 / 16 | 0.00% | 8 / 16 | 50.00% | 4.9 | 11.8 | 6.8 |
| Barium (filtered) | 1000 | 0 / 16 | 0.00% | 16 / 16 | 100.00% | 40.3 | 398 | 95.65 |
| Cadmium (filtered) | 10 | 0 / 16 | 0.00% | 2 / 16 | 12.50% | 1.5 | 2 | 1.75 |
| Chromium (filtered) | 50 | 0 / 16 | 0.00% | 10 / 16 | 62.50% | 1.2 | 14 | 2.4 |
| Lead (filtered) | 25 | 0 / 16 | 0.00% | 5 / 16 | 31.25% | 2.4 | 6.9 | 4.7 |
| Mercury (filtered) | 2 | 0 / 16 | 0.00% | 1 / 16 | 6.25% | 0.23 | 0.23 | 0.23 |
| Selenium (filtered) | 10 | 0 / 15 | 0.00% | 2 / 15 | 13.33% | 2.4 | 5.2 | 3.8 |
| Silver (filtered) | 50 | 0 / 16 | 0.00% | 4 / 16 | 25.00% | 1.8 | 3.4 | 1.8 |

All units in ug/L

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# Table 5-3
# Statistical Summary of Round One Groundwater Results
# Manufacturing Area, Watervliet Arsenal

|  | NYSDEC Class GA Groundwater Standards ug/L | BEDROCK WELLS |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** |  |  |  |  |  |  |  |  |
| 4-Chloro-3-methylphenol | N/A | — | N/A | 0 / 29 | 0.00% | 0 | 0 | 0 |
| Diethylphthalate | 50 | 0 / 30 | 0.00% | 6 / 30 | 20.00% | 0.6 | 7 | 4 |
| Dimethyl phthalate | 50 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Acenaphthene | 20 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 1 | 1 | 1 |
| Fluorene | 50 | 0 / 30 | 0.00% | 2 / 30 | 6.67% | 2 | 10 | 6 |
| Phenanthrene | 50 | 0 / 30 | 0.00% | 2 / 30 | 6.67% | 1 | 10 | 5.5 |
| Anthracene | 50 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 1 | 1 | 1 |
| Napthalene | 10 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Di-n-butylphthalate | N/A | — | N/A | 18 / 30 | 60.00% | 0.3 | 34 | 0.7 |
| Fluoranthene | 50 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 13 | 13 | 13 |
| Pyrene | 50 | 0 / 30 | 0.00% | 3 / 30 | 10.00% | 5 | 13 | 12 |
| Butylbenzylphthalate | 50 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 2 | 2 | 2 |
| Benzo(a)anthracene | 0.002 | 2 / 30 | 6.67% | 2 / 30 | 6.67% | 3 | 10 | 6.5 |
| Chrysene | 0.002 | 3 / 30 | 10.00% | 3 / 30 | 10.00% | 1 | 14 | 3 |
| bis(2-Ethylhexyl)phthalate | 50 | 2 / 30 | 6.67% | 12 / 30 | 40.00% | 0.5 | 300 | 4 |
| Di-n-octylphthalate | N/A | — | N/A | 1 / 30 | 3.33% | 0.6 | 0.6 | 0.6 |
| Benzo(b)fluoranthene | 0.002 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 1 | 1 | 1 |
| Benzo(k)Fluoranthene | 0.002 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 2 | 2 | 2 |
| Benzo(a)Pyrene | 0.002 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 1 | 1 | 1 |
| **Volatile Compounds** |  |  |  |  |  |  |  |  |
| Vinyl Chloride | 2 | 2 / 30 | 6.67% | 2 / 30 | 6.67% | 42 | 89 | 65.5 |
| Chloroethane | 5 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Methylene Chloride | 5 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Carbon Disulfide | N/A | — | N/A | 1 / 30 | 3.33% | 2 | 2 | 2 |
| 1,1-Dichloroethane | 5 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| cis-1,2-Dichloroethene | 5 | 2 / 20 | 10.00% | 3 / 20 | 15.00% | 2 | 2000 | 38 |
| trans-1,2-Dichloroethene | 5 | 0 / 20 | 0.00% | 0 / 20 | 0.00% | 0 | 0 | 0 |
| 1,2-Dichloroethene (total) | N/A | — | N/A | 1 / 10 | 10.00% | 2 | 2 | 2 |
| Chloroform | 7 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| 2-Butanone | 5 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Trichloroethene | 5 | 2 / 30 | 6.67% | 3 / 30 | 10.00% | 4 | 250 | 37 |
| Benzene | 0.7 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 2 | 2 | 2 |
| Tetrachloroethene | 5 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 350 | 350 | 350 |
| Toluene | 5 | 0 / 30 | 0.00% | 3 / 30 | 10.00% | 1 | 2 | 1 |
| 1,1-Dichloroethene | 5 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| 1,1,1-Trichloroethane | 5 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 21 | 21 | 21 |
| Acetone | 50 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Bromodichloromethane | 5 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Chlorobenzene | 5 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 4 | 4 | 4 |
| Ethylbenzene | 5 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Xylene (total) | 5 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 1 | 1 | 1 |
| **Pesticides and PCBs** |  |  |  |  |  |  |  |  |
| alpha-BHC | N/A | — | N/A | 2 / 30 | 6.67% | 0.01 | 0.02 | 0.015 |
| beta-BHC | N/A | — | N/A | 0 / 30 | 0.00% | 0 | 0 | 0 |
| delta-BHC | N/A | — | N/A | 2 / 30 | 6.67% | 0.0024 | 0.039 | 0.0207 |
| gamma-BHC (Lindane) | N/A | — | N/A | 2 / 30 | 6.67% | 0.013 | 0.024 | 0.0185 |
| Heptachlor | ND | 3 / 30 | 10.00% | 3 / 30 | 10.00% | 0.0091 | 0.069 | 0.012 |
| Aldrin | ND | 3 / 29 | 10.34% | 3 / 29 | 10.34% | 0.0014 | 0.0052 | 0.0025 |
| Heptachlor Epoxide | ND | 3 / 30 | 10.00% | 3 / 30 | 10.00% | 0.00072 | 0.048 | 0.001 |
| Endosulfan I | 0.1 | 0 / 30 | 0.00% | 2 / 30 | 6.67% | 0.0017 | 0.0022 | 0.00195 |
| Dieldrin | ND | 6 / 29 | 20.69% | 6 / 29 | 20.69% | 0.00082 | 0.02 | 0.003 |
| 4,4'-DDE | ND | 3 / 30 | 10.00% | 3 / 30 | 10.00% | 0.0011 | 0.036 | 0.0028 |
| Endrin | ND | 2 / 30 | 6.67% | 2 / 30 | 6.67% | 0.0065 | 0.15 | 0.07825 |
| Endosulfan II | N/A | — | N/A | 2 / 30 | 6.67% | 0.0041 | 0.016 | 0.01005 |
| 4,4'-DDD | ND | 2 / 28 | 7.14% | 2 / 28 | 7.14% | 0.0019 | 0.0022 | 0.00205 |
| Endosulfan Sulfate | N/A | — | N/A | 1 / 30 | 3.33% | 0.0037 | 0.0037 | 0.0037 |
| 4,4'-DDT | ND | 5 / 27 | 18.52% | 5 / 27 | 18.52% | 0.0011 | 0.0047 | 0.0028 |
| Methoxychlor | 35 | 0 / 30 | 0.00% | 2 / 30 | 6.67% | 0.017 | 0.2 | 0.1085 |
| Endrin Ketone | N/A | — | N/A | 2 / 29 | 6.90% | 0.001 | 0.0015 | 0.00125 |
| Endrin Aldehyde | N/A | — | N/A | 2 / 29 | 6.90% | 0.0058 | 0.024 | 0.0149 |
| alpha-Chlordane | 0.1 | 0 / 30 | 0.00% | 5 / 30 | 16.67% | 0.00072 | 0.036 | 0.0024 |
| Gamma-Chlordane | N/A | — | N/A | 6 / 30 | 20.00% | 0.00053 | 0.022 | 0.00185 |
| Aroclor-1254 | 0.1 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 0.022 | 0.022 | 0.022 |
| Aroclor-1260 | 0.1 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 0.15 | 0.15 | 0.15 |
| **Inorganic Compounds** |  |  |  |  |  |  |  |  |
| Arsenic (unfiltered) | 25 | 2 / 30 | 6.67% | 13 / 30 | 43.33% | 3.2 | 97.5 | 7.8 |
| Barium (unfiltered) | 1000 | 10 / 30 | 33.33% | 30 / 30 | 100.00% | 60.5 | 31400 | 260 |
| Cadmium (unfiltered) | 10 | 0 / 30 | 0.00% | 10 / 30 | 33.33% | 1.1 | 7.2 | 1.85 |
| Chromium (unfiltered) | 50 | 8 / 30 | 26.67% | 26 / 30 | 86.67% | 1.3 | 3250 | 11.3 |
| Cyanide (unfiltered) | 100 | 0 / 29 | 0.00% | 0 / 29 | 0.00% | 0 | 0 | 0 |
| Iron (unfiltered) | 300 | 1 / 1 | 100.00% | 1 / 1 | 100.00% | 880 | 880 | 880 |
| Lead (unfiltered) | 25 | 5 / 30 | 16.67% | 24 / 30 | 80.00% | 2.8 | 161 | 11.25 |
| Mercury (unfiltered) | 2 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Selenium (unfiltered) | 10 | 0 / 29 | 0.00% | 4 / 29 | 13.79% | 4 | 5.7 | 5.15 |
| Silver (unfiltered) | 50 | 1 / 30 | 3.33% | 5 / 30 | 16.67% | 1.6 | 104 | 2.7 |
| Arsenic (filtered) | 25 | 0 / 30 | 0.00% | 7 / 30 | 23.33% | 5.8 | 10.1 | 6.9 |
| Barium (filtered) | 1000 | 4 / 30 | 13.33% | 30 / 30 | 100.00% | 36.6 | 2700 | 121 |
| Cadmium (filtered) | 10 | 0 / 30 | 0.00% | 4 / 30 | 13.33% | 1 | 1.6 | 1.35 |
| Chromium (filtered) | 50 | 0 / 30 | 0.00% | 13 / 30 | 43.33% | 1 | 6 | 2.2 |
| Lead (filtered) | 25 | 0 / 30 | 0.00% | 19 / 30 | 63.33% | 2.8 | 25 | 6.4 |
| Mercury (filtered) | 2 | 0 / 30 | 0.00% | 2 / 30 | 6.67% | 0.05 | 0.2 | 0.125 |
| Selenium (filtered) | 10 | 0 / 29 | 0.00% | 3 / 29 | 10.34% | 5 | 8.3 | 6.3 |
| Silver (filtered) | 50 | 0 / 30 | 0.00% | 2 / 30 | 6.67% | 1.7 | 2.6 | 2.15 |

All units in ug/L

# Table 5-3
# Statistical Summary of Round One Groundwater Results
# Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | WEATHERED BEDROCK WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| 4-Chloro-3-methylphenol | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Diethylphthalate | 50 | 0 / 8 | 0.00% | 2 / 8 | 25.00% | 0.5 | 0.5 | 0.5 |
| Dimethyl phthalate | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Acenaphthene | 20 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Fluorene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Phenanthrene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Anthracene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Napthalene | 10 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Di-n-butylphthalate | N/A | --- | N/A | 4 / 8 | 50.00% | 0.3 | 3 | 0.8 |
| Fluoranthene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Pyrene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Butylbenzylphthalate | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Benzo(a)anthracene | 0.002 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Chrysene | 0.002 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| bis(2-Ethylhexyl)phthalate | 50 | 0 / 8 | 0.00% | 2 / 8 | 25.00% | 0.6 | 18 | 9.3 |
| Di-n-octylphthalate | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Benzo(b)fluoranthene | 0.002 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Benzo(k)Fluoranthene | 0.002 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Benzo(a)Pyrene | 0.002 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| **Volatile Compounds** | | | | | | | | |
| Vinyl Chloride | 2 | 1 / 8 | 12.50% | 1 / 8 | 12.50% | 3 | 3 | 3 |
| Chloroethane | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Methylene Chloride | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Carbon Disulfide | N/A | --- | N/A | 1 / 8 | 12.50% | 4 | 4 | 4 |
| 1,1-Dichloroethane | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| cis-1,2-Dichloroethene | 5 | 0 / 6 | 0.00% | 1 / 6 | 16.67% | 1 | 1 | 1 |
| trans-1,2-Dichloroethene | 5 | 0 / 6 | 0.00% | 0 / 6 | 0.00% | 0 | 0 | 0 |
| 1,2-Dichloroethene (total) | N/A | --- | N/A | 0 / 2 | 0.00% | 0 | 0 | 0 |
| Chloroform | 7 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 2-Butanone | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Trichloroethene | 5 | 0 / 8 | 0.00% | 1 / 8 | 12.50% | 0.7 | 0.7 | 0.7 |
| Benzene | 0.7 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Tetrachloroethene | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Toluene | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 1,1-Dichloroethene | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 1,1,1-Trichloroethane | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Acetone | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Bromodichloromethane | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Chlorobenzene | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Ethylbenzene | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Xylene (total) | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| **Pesticides and PCBs** | | | | | | | | |
| alpha-BHC | N/A | --- | N/A | 1 / 8 | 12.50% | 0.0025 | 0.0025 | 0.0025 |
| beta-BHC | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| delta-BHC | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| gamma-BHC (Lindane) | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Heptachlor | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Aldrin | ND | 1 / 8 | 12.50% | 1 / 8 | 12.50% | 0.00095 | 0.00095 | 0.00095 |
| Heptachlor Epoxide | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Endosulfan I | 0.1 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Dieldrin | ND | 1 / 8 | 12.50% | 1 / 8 | 12.50% | 0.0017 | 0.0017 | 0.0017 |
| 4,4'-DDE | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Endrin | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Endosulfan II | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 4,4'-DDD | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Endosulfan Sulfate | N/A | --- | N/A | 0 / 7 | 0.00% | 0 | 0 | 0 |
| 4,4'-DDT | ND | 1 / 8 | 12.50% | 1 / 8 | 12.50% | 0.0026 | 0.0026 | 0.0026 |
| Methoxychlor | 35 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Endrin Ketone | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Endrin Aldehyde | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| alpha-Chlordane | 0.1 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Gamma-Chlordane | N/A | --- | N/A | 1 / 8 | 12.50% | 0.0013 | 0.0013 | 0.0013 |
| Aroclor-1254 | 0.1 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Aroclor-1260 | 0.1 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (unfiltered) | 25 | 0 / 8 | 0.00% | 4 / 8 | 50.00% | 3.1 | 6.4 | 4.25 |
| Barium (unfiltered) | 1000 | 0 / 8 | 0.00% | 8 / 8 | 100.00% | 69.6 | 683 | 279.5 |
| Cadmium (unfiltered) | 10 | 0 / 8 | 0.00% | 3 / 8 | 37.50% | 1.1 | 8.5 | 2.5 |
| Chromium (unfiltered) | 50 | 1 / 8 | 12.50% | 8 / 8 | 100.00% | 2.1 | 57.1 | 10.95 |
| Cyanide (unfiltered) | 100 | 0 / 6 | 0.00% | 0 / 6 | 0.00% | 0 | 0 | 0 |
| Iron (unfiltered) | 300 | 1 / 1 | 100.00% | 1 / 1 | 100.00% | 57100 | 57100 | 57100 |
| Lead (unfiltered) | 25 | 0 / 7 | 0.00% | 7 / 7 | 100.00% | 7.2 | 20.8 | 13.3 |
| Mercury (unfiltered) | 2 | 0 / 8 | 0.00% | 2 / 8 | 25.00% | 0.41 | 0.42 | 0.415 |
| Selenium (unfiltered) | 10 | 0 / 7 | 0.00% | 1 / 7 | 14.29% | 3.2 | 3.2 | 3.2 |
| Silver (unfiltered) | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Arsenic (filtered) | 25 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Barium (filtered) | 1000 | 0 / 8 | 0.00% | 8 / 8 | 100.00% | 20.5 | 368 | 87.15 |
| Cadmium (filtered) | 10 | 0 / 8 | 0.00% | 1 / 8 | 12.50% | 1.1 | 1.1 | 1.1 |
| Chromium (filtered) | 50 | 0 / 8 | 0.00% | 3 / 8 | 37.50% | 1.2 | 2.3 | 1.4 |
| Lead (filtered) | 25 | 0 / 8 | 0.00% | 7 / 8 | 87.50% | 3.4 | 8.1 | 5.3 |
| Mercury (filtered) | 2 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Selenium (filtered) | 10 | 0 / 8 | 0.00% | 2 / 8 | 25.00% | 2.3 | 2.5 | 2.4 |
| Silver (filtered) | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |

All units in ug/L

# Table 5-3
# Statistical Summary of Round One Groundwater Results
# Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | HYBRID WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| 4-Chloro-3-methylphenol | N/A | — | N/A | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Diethylphthalate | 50 | 0 / 9 | 0.00% | 1 / 9 | 11.11% | 3 | 3 | 3 |
| Dimethyl phthalate | 50 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Acenaphthene | 20 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Fluorene | 50 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Phenanthrene | 50 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Anthracene | 50 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Napthalene | 10 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Di-n-butylphthalate | N/A | — | N/A | 6 / 9 | 66.67% | 0.5 | 6 | 1.95 |
| Fluoranthene | 50 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Pyrene | 50 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Butylbenzylphthalate | 50 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Benzo(a)anthracene | 0.002 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Chrysene | 0.002 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| bis(2-Ethylhexyl)phthalate | 50 | 0 / 9 | 0.00% | 5 / 9 | 55.56% | 0.5 | 2 | 1 |
| Di-n-octylphthalate | N/A | — | N/A | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Benzo(b)fluoranthene | 0.002 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Benzo(k)Fluoranthene | 0.002 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Benzo(a)Pyrene | 0.002 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| **Volatile Compounds** | | | | | | | | |
| Vinyl Chloride | 2 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Chloroethane | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Methylene Chloride | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Carbon Disulfide | N/A | — | N/A | 1 / 9 | 11.11% | 0.3 | 0.3 | 0.3 |
| 1,1-Dichloroethane | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| cis-1,2-Dichloroethene | 5 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | 0 |
| trans-1,2-Dichloroethene | 5 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | 0 |
| 1,2-Dichloroethene (total) | N/A | — | N/A | 1 / 4 | 25.00% | 5 | 5 | 5 |
| Chloroform | 7 | 0 / 9 | 0.00% | 1 / 9 | 11.11% | 7 | 7 | 7 |
| 2-Butanone | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Trichloroethene | 5 | 1 / 9 | 11.11% | 1 / 9 | 11.11% | 120 | 120 | 120 |
| Benzene | 0.7 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Tetrachloroethene | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Toluene | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| 1,1-Dichloroethene | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| 1,1,1-Trichloroethane | 5 | 1 / 9 | 11.11% | 1 / 9 | 11.11% | 33 | 33 | 33 |
| Acetone | 50 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Bromodichloromethane | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Chlorobenzene | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Ethylbenzene | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Xylene (total) | 5 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| **Pesticides and PCBs** | | | | | | | | |
| alpha-BHC | N/A | — | N/A | 0 / 9 | 0.00% | 0 | 0 | 0 |
| beta-BHC | N/A | — | N/A | 0 / 9 | 0.00% | 0 | 0 | 0 |
| delta-BHC | N/A | — | N/A | 0 / 9 | 0.00% | 0 | 0 | 0 |
| gamma-BHC (Lindane) | N/A | — | N/A | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Heptachlor | ND | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Aldrin | ND | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Heptachlor Epoxide | ND | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Endosulfan I | 0.1 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Dieldrin | ND | 2 / 9 | 22.22% | 2 / 9 | 22.22% | 0.0011 | 0.0011 | 0.0011 |
| 4,4'-DDE | ND | 5 / 9 | 55.56% | 5 / 9 | 55.56% | 0.0021 | 0.012 | 0.003 |
| Endrin | ND | 2 / 9 | 22.22% | 2 / 9 | 22.22% | 0.0018 | 0.0034 | 0.0026 |
| Endosulfan II | N/A | — | N/A | 1 / 9 | 11.11% | 0.0029 | 0.0029 | 0.0029 |
| 4,4'-DDD | ND | 1 / 9 | 11.11% | 1 / 9 | 11.11% | 0.0022 | 0.0022 | 0.0022 |
| Endosulfan Sulfate | N/A | — | N/A | 1 / 9 | 11.11% | 0.0039 | 0.0039 | 0.0039 |
| 4,4'-DDT | ND | 3 / 9 | 33.33% | 3 / 9 | 33.33% | 0.0043 | 0.014 | 0.011 |
| Methoxychlor | 35 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Endrin Ketone | N/A | — | N/A | 1 / 9 | 11.11% | 0.001 | 0.001 | 0.001 |
| Endrin Aldehyde | N/A | — | N/A | 1 / 9 | 11.11% | 0.0053 | 0.0053 | 0.0053 |
| alpha-Chlordane | 0.1 | 0 / 9 | 0.00% | 1 / 9 | 11.11% | 0.0017 | 0.0017 | 0.0017 |
| Gamma-Chlordane | N/A | — | N/A | 2 / 9 | 22.22% | 0.00059 | 0.001 | 0.000795 |
| Aroclor-1254 | 0.1 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Aroclor-1260 | 0.1 | 0 / 9 | 0.00% | 1 / 9 | 11.11% | 0.065 | 0.065 | 0.065 |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (unfiltered) | 25 | 0 / 9 | 0.00% | 3 / 9 | 33.33% | 5.7 | 21.6 | 19 |
| Barium (unfiltered) | 1000 | 0 / 9 | 0.00% | 9 / 9 | 100.00% | 83.1 | 694 | 178 |
| Cadmium (unfiltered) | 10 | 0 / 9 | 0.00% | 1 / 9 | 11.11% | 1.3 | 1.3 | 1.3 |
| Chromium (unfiltered) | 50 | 3 / 9 | 33.33% | 8 / 9 | 88.89% | 1.6 | 545 | 19.75 |
| Cyanide (unfiltered) | 100 | 0 / 7 | 0.00% | 0 / 7 | 0.00% | 0 | 0 | 0 |
| Iron (unfiltered) | 300 | 0 / 0 | N/A | 0 / 0 | N/A | 0 | 0 | 0 |
| Lead (unfiltered) | 25 | 3 / 9 | 33.33% | 9 / 9 | 100.00% | 3 | 39.9 | 6.6 |
| Mercury (unfiltered) | 2 | 0 / 9 | 0.00% | 1 / 9 | 11.11% | 0.21 | 0.21 | 0.21 |
| Selenium (unfiltered) | 10 | 0 / 9 | 0.00% | 3 / 9 | 33.33% | 2.7 | 6 | 3.4 |
| Silver (unfiltered) | 50 | 0 / 9 | 0.00% | 1 / 9 | 11.11% | 2.3 | 2.3 | 2.3 |
| Arsenic (filtered) | 25 | 0 / 9 | 0.00% | 1 / 9 | 11.11% | 3.8 | 3.8 | 3.8 |
| Barium (filtered) | 1000 | 0 / 9 | 0.00% | 9 / 9 | 100.00% | 56.1 | 664 | 75.9 |
| Cadmium (filtered) | 10 | 0 / 9 | 0.00% | 2 / 9 | 22.22% | 1 | 1.4 | 1.2 |
| Chromium (filtered) | 50 | 0 / 9 | 0.00% | 6 / 9 | 66.67% | 1.1 | 38.4 | 2.15 |
| Lead (filtered) | 25 | 1 / 9 | 11.11% | 6 / 9 | 66.67% | 2.4 | 32.3 | 3.05 |
| Mercury (filtered) | 2 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Selenium (filtered) | 10 | 0 / 9 | 0.00% | 0 / 9 | 0.00% | 0 | 0 | 0 |
| Silver (filtered) | 50 | 0 / 9 | 0.00% | 2 / 9 | 22.22% | 2.5 | 3 | 2.75 |

All units in ug/L

# Table 5-3
# Statistical Summary of Round One Groundwater Results
# Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | ALL WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exdkedandks* | *% of GA Exdkedandks* | *Frequency of Detection* | *Detection Perdkntage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| 4-Chloro-3-methylphenol | N/A | — | 0.00% | 4 / 62 | 6.45% | 4 | 890 | 175 |
| Diethylphthalate | 50 | 0 / 64 | 0.00% | 11 / 64 | 17.19% | 0.5 | 7 | 3 |
| Dimethyl phthalate | 50 | 0 / 64 | 0.00% | 1 / 64 | 1.56% | 2 | 2 | 2 |
| Acenaphthene | 20 | 0 / 64 | 0.00% | 1 / 64 | 1.56% | 1 | 1 | 1 |
| Fluorene | 50 | 0 / 64 | 0.00% | 2 / 64 | 3.13% | 2 | 10 | 6 |
| Phenanthrene | 50 | 0 / 64 | 0.00% | 2 / 64 | 3.13% | 1 | 10 | 5.5 |
| Anthracene | 50 | 0 / 64 | 0.00% | 1 / 64 | 1.56% | 1 | 1 | 1 |
| Napthalene | 10 | 0 / 64 | 0.00% | 1 / 64 | 1.56% | 2 | 2 | 2 |
| Di-n-butylphthalate | N/A | — | 0.00% | 38 / 64 | 59.38% | 0.3 | 34 | 1.45 |
| Fluoranthene | 50 | 0 / 64 | 0.00% | 1 / 64 | 1.56% | 13 | 13 | 13 |
| Pyrene | 50 | 0 / 64 | 0.00% | 3 / 64 | 4.69% | 5 | 13 | 12 |
| Butylbenzylphthalate | 50 | 0 / 64 | 0.00% | 1 / 64 | 1.56% | 2 | 2 | 2 |
| Benzo(a)anthracene | 0.002 | 2 / 64 | 3.13% | 2 / 64 | 3.13% | 3 | 10 | 6.5 |
| Chrysene | 0.002 | 3 / 64 | 4.69% | 3 / 64 | 4.69% | 1 | 14 | 3 |
| bis(2-Ethylhexyl)phthalate | 50 | 2 / 64 | 3.13% | 24 / 64 | 37.50% | 0.3 | 300 | 2 |
| Di-n-octylphthalate | N/A | — | 0.00% | 1 / 64 | 1.56% | 0.6 | 0.6 | 0.6 |
| Benzo(b)fluoranthene | 0.002 | 1 / 64 | 1.56% | 1 / 64 | 1.56% | 1 | 1 | 1 |
| Benzo(k)Fluoranthene | 0.002 | 1 / 64 | 1.56% | 1 / 64 | 1.56% | 2 | 2 | 2 |
| Benzo(a)Pyrene | 0.002 | 1 / 64 | 1.56% | 1 / 64 | 1.56% | 1 | 1 | 1 |
| **Volatile Compounds** | | | | | | | | |
| Vinyl Chloride | 2 | 4 / 66 | 6.06% | 4 / 66 | 6.06% | 3 | 89 | 37 |
| Chloroethane | 5 | 2 / 66 | 3.03% | 2 / 66 | 3.03% | 7 | 7 | 7 |
| Methylene Chloride | 5 | 0 / 66 | 0.00% | 0 / 66 | 0.00% | 0 | 0 | 0 |
| Carbon Disulfide | N/A | — | 0.00% | 3 / 66 | 4.55% | 0.3 | 4 | 2 |
| 1,1-Dichloroethane | 5 | 4 / 66 | 6.06% | 6 / 66 | 9.09% | 2 | 26 | 6.5 |
| cis-1,2-Dichloroethene | 5 | 3 / 42 | 7.14% | 6 / 42 | 14.29% | 1 | 2000 | 20.5 |
| trans-1,2-Dichloroethene | 5 | 1 / 42 | 2.38% | 1 / 42 | 2.38% | 10 | 10 | 10 |
| 1,2-Dichloroethene (total) | N/A | — | 0.00% | 3 / 26 | 11.54% | 2 | 5 | 2 |
| Chloroform | 7 | 2 / 66 | 3.03% | 5 / 66 | 7.58% | 3 | 630 | 7 |
| 2-Butanone | 5 | 0 / 66 | 0.00% | 0 / 66 | 0.00% | 0 | 0 | 0 |
| Trichloroethene | 5 | 8 / 66 | 12.12% | 10 / 66 | 15.15% | 0.7 | 410 | 78.5 |
| Benzene | 0.7 | 2 / 66 | 3.03% | 2 / 66 | 3.03% | 2 | 2 | 2 |
| Tetrachloroethene | 5 | 1 / 66 | 1.52% | 2 / 66 | 3.03% | 4 | 350 | 177 |
| Toluene | 5 | 0 / 66 | 0.00% | 4 / 66 | 6.06% | 1 | 2 | 1 |
| 1,1-Dichloroethene | 5 | 0 / 66 | 0.00% | 1 / 66 | 1.52% | 3 | 3 | 3 |
| 1,1,1-Trichloroethane | 5 | 3 / 66 | 4.55% | 4 / 66 | 6.06% | 3 | 100 | 27 |
| Acetone | 50 | 0 / 66 | 0.00% | 1 / 66 | 1.52% | 30 | 30 | 30 |
| Bromodichloromethane | 5 | 0 / 66 | 0.00% | 0 / 66 | 0.00% | 0 | 0 | 0 |
| Chlorobenzene | 5 | 0 / 66 | 0.00% | 1 / 66 | 1.52% | 4 | 4 | 4 |
| Ethylbenzene | 5 | 0 / 66 | 0.00% | 0 / 66 | 0.00% | 0 | 0 | 0 |
| Xylene (total) | 5 | 0 / 66 | 0.00% | 2 / 66 | 3.03% | 1 | 2 | 1.5 |
| **Pesticides and PCBs** | | | | | | | | |
| alpha-BHC | N/A | — | 0.00% | 4 / 62 | 6.45% | 0.0025 | 0.02 | 0.0075 |
| beta-BHC | N/A | — | 0.00% | 0 / 61 | 0.00% | 0 | 0 | 0 |
| delta-BHC | N/A | — | 0.00% | 4 / 62 | 6.45% | 0.0012 | 0.039 | 0.0021 |
| gamma-BHC (Lindane) | N/A | — | 0.00% | 2 / 61 | 3.28% | 0.013 | 0.024 | 0.0185 |
| Heptachlor | ND | 3 / 62 | 4.84% | 3 / 62 | 4.84% | 0.0091 | 0.069 | 0.012 |
| Aldrin | ND | 6 / 61 | 9.84% | 6 / 61 | 9.84% | 0.00095 | 0.047 | 0.00385 |
| Heptachlor Epoxide | ND | 4 / 62 | 6.45% | 4 / 62 | 6.45% | 0.00072 | 0.048 | 0.0115 |
| Endosulfan I | 0.1 | 0 / 62 | 0.00% | 2 / 62 | 3.23% | 0.0017 | 0.0022 | 0.00195 |
| Dieldrin | ND | 13 / 59 | 22.03% | 13 / 59 | 22.03% | 0.00082 | 0.02 | 0.0021 |
| 4,4'-DDE | ND | 12 / 62 | 19.35% | 12 / 62 | 19.35% | 0.0011 | 0.045 | 0.0029 |
| Endrin | ND | 7 / 61 | 11.48% | 7 / 61 | 11.48% | 0.00061 | 0.15 | 0.0034 |
| Endosulfan II | N/A | — | 0.00% | 4 / 61 | 6.56% | 0.0029 | 0.016 | 0.00375 |
| 4,4'-DDD | ND | 6 / 59 | 10.17% | 6 / 59 | 10.17% | 0.0013 | 0.038 | 0.00215 |
| Endosulfan Sulfate | N/A | — | 0.00% | 3 / 61 | 4.92% | 0.0037 | 0.018 | 0.0039 |
| 4,4'-DDT | ND | 12 / 59 | 20.34% | 12 / 59 | 20.34% | 0.0011 | 0.014 | 0.00315 |
| Methoxychlor | 35 | 0 / 62 | 0.00% | 2 / 62 | 3.23% | 0.017 | 0.2 | 0.1085 |
| Endrin Ketone | N/A | — | 0.00% | 4 / 61 | 6.56% | 0.001 | 0.0015 | 0.00105 |
| Endrin Aldehyde | N/A | — | 0.00% | 5 / 61 | 8.20% | 0.0024 | 0.024 | 0.0053 |
| alpha-Chlordane | 0.1 | 0 / 62 | 0.00% | 6 / 62 | 9.68% | 0.00072 | 0.036 | 0.00205 |
| Gamma-Chlordane | N/A | — | 0.00% | 12 / 62 | 19.35% | 0.00053 | 0.022 | 0.00125 |
| Aroclor-1254 | 0.1 | 0 / 62 | 0.00% | 1 / 62 | 1.61% | 0.022 | 0.022 | 0.022 |
| Aroclor-1260 | 0.1 | 1 / 62 | 1.61% | 3 / 62 | 4.84% | 0.059 | 0.15 | 0.065 |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (unfiltered) | 25 | 4 / 63 | 6.35% | 31 / 63 | 49.21% | 3.1 | 97.5 | 7.8 |
| Barium (unfiltered) | 1000 | 10 / 63 | 15.87% | 63 / 63 | 100.00% | 60.5 | 31400 | 251 |
| Cadmium (unfiltered) | 10 | 1 / 63 | 1.59% | 20 / 63 | 31.75% | 0.92 | 427 | 1.95 |
| Chromium (unfiltered) | 50 | 15 / 63 | 23.81% | 57 / 63 | 90.48% | 1.3 | 17600 | 14.5 |
| Cyanide (unfiltered) | 100 | 0 / 52 | 0.00% | 0 / 52 | 0.00% | 0 | 0 | 0 |
| Iron (unfiltered) | 300 | 3 / 3 | 100.00% | 3 / 3 | 100.00% | 880 | 57100 | 17900 |
| Lead (unfiltered) | 25 | 12 / 61 | 19.67% | 53 / 61 | 86.89% | 2.8 | 161 | 11.7 |
| Mercury (unfiltered) | 2 | 0 / 63 | 0.00% | 8 / 63 | 12.70% | 0.04 | 0.42 | 0.32 |
| Selenium (unfiltered) | 10 | 0 / 59 | 0.00% | 10 / 59 | 16.95% | 2.1 | 6 | 3.7 |
| Silver (unfiltered) | 50 | 1 / 63 | 1.59% | 11 / 63 | 17.46% | 1.6 | 104 | 2.5 |
| Arsenic (filtered) | 25 | 0 / 63 | 0.00% | 16 / 63 | 25.40% | 3.8 | 11.8 | 6.7 |
| Barium (filtered) | 1000 | 4 / 63 | 6.35% | 63 / 63 | 100.00% | 20.5 | 2700 | 115 |
| Cadmium (filtered) | 10 | 0 / 63 | 0.00% | 9 / 63 | 14.29% | 1 | 2 | 1.4 |
| Chromium (filtered) | 50 | 0 / 63 | 0.00% | 32 / 63 | 50.79% | 1 | 38.4 | 2.15 |
| Lead (filtered) | 25 | 1 / 63 | 1.59% | 37 / 63 | 58.73% | 2.4 | 32.3 | 5.2 |
| Mercury (filtered) | 2 | 0 / 63 | 0.00% | 3 / 63 | 4.76% | 0.05 | 0.23 | 0.2 |
| Selenium (filtered) | 10 | 0 / 61 | 0.00% | 7 / 61 | 11.48% | 2.3 | 8.3 | 5 |
| Silver (filtered) | 50 | 0 / 63 | 0.00% | 8 / 63 | 12.70% | 1.7 | 3.4 | 2.15 |

All units in ug/L

# Table 5-4
# Statistical Summary of Round Two Groundwater Results
# Manufacturing Area, Watervliet Arsenal

|  | NYSDEC Class GA Groundwater Standards ug/L | OVERBURDEN WELLS |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** |  |  |  |  |  |  |  |  |
| Naphthalene | 10 | 0 / 20 | 0.00% | 0 / 20 | 0.00% | 0 | 0 | 0 |
| 4-Chloro-3-methylphenol | N/A | — | N/A | 5 / 20 | 25.00% | 1 | 310 | 18 |
| Dimethylphthalate | 50 | 0 / 20 | 0.00% | 0 / 20 | 0.00% | 0 | 0 | 0 |
| Acenaphthylene | 20 | 0 / 20 | 0.00% | 0 / 20 | 0.00% | 0 | 0 | 0 |
| Acenaphthene | 20 | 0 / 20 | 0.00% | 0 / 20 | 0.00% | 0 | 0 | 0 |
| Diethylphthalate | 50 | 0 / 20 | 0.00% | 4 / 20 | 20.00% | 0.3 | 0.6 | 0.5 |
| Fluorene | 50 | 0 / 20 | 0.00% | 0 / 20 | 0.00% | 0 | 0 | 0 |
| N-Nitrosodiphenylamine (1) | 50 | 0 / 20 | 0.00% | 1 / 20 | 5.00% | 0.5 | 0.5 | 0.5 |
| Phenanthrene | 50 | 0 / 20 | 0.00% | 1 / 20 | 5.00% | 0.4 | 0.4 | 0.4 |
| Anthracene | 50 | 0 / 20 | 0.00% | 1 / 20 | 5.00% | 0.2 | 0.2 | 0.2 |
| Di-n-butylphthalate | N/A | — | N/A | 15 / 20 | 75.00% | 0.2 | 1 | 0.5 |
| Fluoranthene | 50 | 0 / 20 | 0.00% | 1 / 20 | 5.00% | 0.6 | 0.6 | 0.6 |
| Pyrene | 50 | 0 / 20 | 0.00% | 1 / 20 | 5.00% | 1 | 1 | 1 |
| Butylbenzylphthalate | 50 | 0 / 20 | 0.00% | 2 / 20 | 10.00% | 0.3 | 0.8 | 0.55 |
| Benzo(a)anthracene | 0.002 | 1 / 20 | 5.00% | 1 / 20 | 5.00% | 0.8 | 0.8 | 0.8 |
| Chrysene | 0.002 | 1 / 20 | 5.00% | 1 / 20 | 5.00% | 0.9 | 0.9 | 0.9 |
| bis(2-Ethylhexyl)phthalate | 50 | 1 / 20 | 5.00% | 6 / 20 | 30.00% | 0.4 | 65 | 0.95 |
| Di-n-octylphthalate | N/A | — | N/A | 1 / 20 | 5.00% | 0.9 | 0.9 | 0.9 |
| Benzo(b)fluoranthene | 0.002 | 1 / 20 | 5.00% | 1 / 20 | 5.00% | 0.9 | 0.9 | 0.9 |
| Benzo(k)fluoranthene | 0.002 | 1 / 20 | 5.00% | 1 / 20 | 5.00% | 1 | 1 | 1 |
| Benzo(a)pyrene | ND | 1 / 20 | 5.00% | 1 / 20 | 5.00% | 0.7 | 0.7 | 0.7 |
| Indeno(1,2,3-cd)pyrene | 0.002 | 0 / 20 | 0.00% | 0 / 20 | 0.00% | 0 | 0 | 0 |
| Dibenzo(a,h)anthracene | 50 | 0 / 20 | 0.00% | 0 / 20 | 0.00% | 0 | 0 | 0 |
| Benzo(g,h,i)perylene | 50 | 0 / 20 | 0.00% | 0 / 20 | 0.00% | 0 | 0 | 0 |
| **Volatile Compounds** |  |  |  |  |  |  |  |  |
| Vinyl Chloride | 2 | 1 / 20 | 5.00% | 1 / 20 | 5.00% | 9 | 9 | 9 |
| Methylene Chloride | 5 | 0 / 20 | 0.00% | 9 / 20 | 45.00% | 0.4 | 2 | 0.7 |
| Carbon Disulfide | N/A | — | N/A | 0 / 20 | 0.00% | 0 | 0 | 0 |
| 1,1-Dichloroethene | 5 | 0 / 20 | 0.00% | 1 / 20 | 5.00% | 2 | 2 | 2 |
| 1,1-Dichloroethane | 5 | 3 / 20 | 15.00% | 7 / 20 | 35.00% | 0.7 | 12 | 4 |
| cis-1,2-Dichloroethene | 5 | 2 / 20 | 10.00% | 7 / 20 | 35.00% | 0.3 | 230 | 3 |
| Chloroform | 7 | 1 / 20 | 5.00% | 1 / 20 | 5.00% | 28 | 28 | 28 |
| 2-Butanone | N/A | — | N/A | 1 / 20 | 5.00% | 2 | 2 | 2 |
| 1,1,1-Trichloroethane | 5 | 3 / 20 | 15.00% | 3 / 20 | 15.00% | 6 | 82 | 9 |
| Trichloroethene | 5 | 5 / 20 | 25.00% | 6 / 20 | 30.00% | 2 | 310 | 47 |
| Benzene | 0.7 | 0 / 20 | 0.00% | 0 / 20 | 0.00% | 0 | 0 | 0 |
| Tetrachloroethene | 5 | 0 / 20 | 0.00% | 3 / 20 | 15.00% | 0.6 | 2 | 0.7 |
| trans-1,2-Dichloroethene | 5 | 0 / 20 | 0.00% | 1 / 20 | 5.00% | 3 | 3 | 3 |
| Trichlorofluoromethane | 5 | 0 / 20 | 0.00% | 1 / 20 | 5.00% | 2 | 2 | 2 |
| **Pesticides and PCBs** |  |  |  |  |  |  |  |  |
| beta-BHC | N/A | — | N/A | 1 / 18 | 5.56% | 0.007 | 0.007 | 0.007 |
| delta-BHC | N/A | — | N/A | 0 / 18 | 0.00% | 0 | 0 | 0 |
| gamma-BHC (Lindane) | N/A | — | N/A | 0 / 18 | 0.00% | 0 | 0 | 0 |
| Heptachlor | ND | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| Aldrin | ND | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| Dieldrin | ND | 0 / 18 | 0.00% | 0 / 18 | 0.00% | 0 | 0 | 0 |
| 4,4'-DDE | ND | 2 / 18 | 11.11% | 2 / 18 | 11.11% | 0.00089 | 0.0034 | 0.002145 |
| 4,4'-DDD | ND | 1 / 18 | 5.56% | 1 / 18 | 5.56% | 0.017 | 0.017 | 0.017 |
| 4,4'-DDT | ND | 2 / 18 | 11.11% | 2 / 18 | 11.11% | 0.0029 | 0.013 | 0.00795 |
| Endrin Ketone | N/A | — | N/A | 0 / 18 | 0.00% | 0 | 0 | 0 |
| Endrin Aldehyde | N/A | — | N/A | 0 / 18 | 0.00% | 0 | 0 | 0 |
| **Inorganic Compounds** |  |  |  |  |  |  |  |  |
| Arsenic (filtered) | 25 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Barium (filtered) | 1000 | 0 / 3 | 0.00% | 3 / 3 | 100.00% | 98.5 | 219 | 131 |
| Cadmium (filtered) | 10 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 3.1 | 3.1 | 3.1 |
| Chromium (filtered) | 50 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 8.7 | 8.7 | 8.7 |
| Lead (filtered) | 25 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 2.2 | 2.2 | 2.2 |
| Mercury (filtered) | 2 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Selenium (filtered) | 10 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 4.2 | 4.2 | 4.2 |
| Silver (filtered) | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Arsenic (unfiltered) | 25 | 2 / 19 | 10.53% | 15 / 19 | 78.95% | 1.7 | 53.6 | 5.5 |
| Barium (unfiltered) | 1000 | 1 / 19 | 5.26% | 19 / 19 | 100.00% | 47.7 | 1400 | 136 |
| Cadmium (unfiltered) | 10 | 0 / 19 | 0.00% | 7 / 19 | 36.84% | 1.1 | 8.2 | 3.2 |
| Chromium (unfiltered) | 50 | 4 / 19 | 21.05% | 19 / 19 | 100.00% | 1.1 | 1440 | 9.3 |
| Lead (unfiltered) | 25 | 4 / 19 | 21.05% | 15 / 19 | 78.95% | 2.4 | 133 | 9 |
| Mercury (unfiltered) | 2 | 0 / 19 | 0.00% | 1 / 19 | 5.26% | 0.45 | 0.45 | 0.45 |
| Selenium (unfiltered) | 10 | 0 / 19 | 0.00% | 5 / 19 | 26.32% | 1.8 | 4.9 | 2.7 |
| Silver (unfiltered) | 50 | 0 / 19 | 0.00% | 0 / 19 | 0.00% | 0 | 0 | 0 |

All units in ug/L

# Table 5-4
# Statistical Summary of Round Two Groundwater Results
# Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | BEDROCK WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| Naphthalene | 10 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 0.8 | 0.8 | 0.8 |
| 4-Chloro-3-methylphenol | N/A | --- | N/A | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Dimethylphthalate | 50 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Acenaphthylene | 20 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Acenaphthene | 20 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 1 | 1 | 1 |
| Diethylphthalate | 50 | 0 / 30 | 0.00% | 6 / 30 | 20.00% | 0.2 | 0.9 | 0.3 |
| Fluorene | 50 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 0.7 | 0.7 | 0.7 |
| N-Nitrosodiphenylamine (1) | 50 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Phenanthrene | 50 | 0 / 30 | 0.00% | 2 / 30 | 6.67% | 2 | 10 | 6 |
| Anthracene | 50 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Di-n-butylphthalate | N/A | --- | N/A | 20 / 30 | 66.67% | 0.2 | 0.8 | 0.4 |
| Fluoranthene | 50 | 0 / 30 | 0.00% | 2 / 30 | 6.67% | 2 | 24 | 13 |
| Pyrene | 50 | 0 / 30 | 0.00% | 3 / 30 | 10.00% | 1 | 24 | 1 |
| Butylbenzylphthalate | 50 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 0.3 | 0.3 | 0.3 |
| Benzo(a)anthracene | 0.002 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 17 | 17 | 17 |
| Chrysene | 0.002 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 40 | 40 | 40 |
| bis(2-Ethylhexyl)phthalate | 50 | 0 / 30 | 0.00% | 11 / 30 | 36.67% | 0.2 | 6 | 2 |
| Di-n-octylphthalate | N/A | --- | N/A | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Benzo(b)fluoranthene | 0.002 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Benzo(k)fluoranthene | 0.002 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Benzo(a)pyrene | ND | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Indeno(1,2,3-cd)pyrene | 0.002 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Dibenzo(a,h)anthracene | 50 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| Benzo(g,h,i)perylene | 50 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| **Volatile Compounds** | | | | | | | | |
| Vinyl Chloride | 2 | 4 / 30 | 13.33% | 4 / 30 | 13.33% | 22 | 160 | 44 |
| Methylene Chloride | 5 | 1 / 30 | 3.33% | 11 / 30 | 36.67% | 0.4 | 48 | 0.8 |
| Carbon Disulfide | N/A | --- | N/A | 1 / 30 | 3.33% | 1 | 1 | 1 |
| 1,1-Dichloroethene | 5 | 0 / 30 | 0.00% | 1 / 30 | 3.33% | 0.8 | 0.8 | 0.8 |
| 1,1-Dichloroethane | 5 | 0 / 30 | 0.00% | 2 / 30 | 6.67% | 0.5 | 1 | 0.75 |
| cis-1,2-Dichloroethene | 5 | 5 / 30 | 16.67% | 6 / 30 | 20.00% | 4 | 1100 | 60 |
| Chloroform | 7 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| 2-Butanone | N/A | --- | N/A | 0 / 30 | 0.00% | 0 | 0 | 0 |
| 1,1,1-Trichloroethane | 5 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 20 | 20 | 20 |
| Trichloroethene | 5 | 3 / 30 | 10.00% | 7 / 30 | 23.33% | 0.5 | 120 | 2 |
| Benzene | 0.7 | 1 / 30 | 3.33% | 1 / 30 | 3.33% | 0.8 | 0.8 | 0.8 |
| Tetrachloroethene | 5 | 1 / 30 | 3.33% | 2 / 30 | 6.67% | 0.7 | 120 | 60.35 |
| trans-1,2-Dichloroethene | 5 | 1 / 30 | 3.33% | 5 / 30 | 16.67% | 0.7 | 10 | 2 |
| Trichlorofluoromethane | 5 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |
| **Pesticides and PCBs** | | | | | | | | |
| beta-BHC | N/A | --- | N/A | 0 / 29 | 0.00% | 0 | 0 | 0 |
| delta-BHC | N/A | --- | N/A | 1 / 29 | 3.45% | 0.016 | 0.016 | 0.016 |
| gamma-BHC (Lindane) | N/A | --- | N/A | 1 / 29 | 3.45% | 0.15 | 0.15 | 0.15 |
| Heptachlor | ND | 1 / 29 | 3.45% | 1 / 29 | 3.45% | 0.049 | 0.049 | 0.049 |
| Aldrin | ND | 3 / 29 | 10.34% | 3 / 29 | 10.34% | 0.0078 | 0.061 | 0.0083 |
| Dieldrin | ND | 3 / 29 | 10.34% | 3 / 29 | 10.34% | 0.0017 | 0.019 | 0.0094 |
| 4,4'-DDE | ND | 3 / 29 | 10.34% | 3 / 29 | 10.34% | 0.0022 | 0.1 | 0.016 |
| 4,4'-DDD | ND | 1 / 29 | 3.45% | 1 / 29 | 3.45% | 0.01 | 0.01 | 0.01 |
| 4,4'-DDT | ND | 1 / 29 | 3.45% | 1 / 29 | 3.45% | 0.0021 | 0.0021 | 0.0021 |
| Endrin Ketone | N/A | --- | N/A | 1 / 29 | 3.45% | 0.0045 | 0.0045 | 0.0045 |
| Endrin Aldehyde | N/A | --- | N/A | 1 / 29 | 3.45% | 0.22 | 0.22 | 0.22 |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (filtered) | 25 | 0 / 7 | 0.00% | 2 / 7 | 28.57% | 5.4 | 13.7 | 9.55 |
| Barium (filtered) | 1000 | 1 / 7 | 14.29% | 7 / 7 | 100.00% | 94.5 | 1520 | 400 |
| Cadmium (filtered) | 10 | 0 / 7 | 0.00% | 1 / 7 | 14.29% | 1.3 | 1.3 | 1.3 |
| Chromium (filtered) | 50 | 0 / 7 | 0.00% | 1 / 7 | 14.29% | 26.2 | 26.2 | 26.2 |
| Lead (filtered) | 25 | 1 / 7 | 14.29% | 4 / 7 | 57.14% | 2 | 64.4 | 7.15 |
| Mercury (filtered) | 2 | 0 / 7 | 0.00% | 1 / 7 | 14.29% | 0.2 | 0.2 | 0.2 |
| Selenium (filtered) | 10 | 0 / 7 | 0.00% | 1 / 7 | 14.29% | 2 | 2 | 2 |
| Silver (filtered) | 50 | 0 / 7 | 0.00% | 1 / 7 | 14.29% | 2 | 2 | 2 |
| Arsenic (unfiltered) | 25 | 3 / 30 | 10.00% | 16 / 30 | 53.33% | 1.6 | 744 | 5.6 |
| Barium (unfiltered) | 1000 | 8 / 30 | 26.67% | 30 / 30 | 100.00% | 26.2 | 8220 | 461.5 |
| Cadmium (unfiltered) | 10 | 4 / 30 | 13.33% | 11 / 30 | 36.67% | 1 | 127 | 2.9 |
| Chromium (unfiltered) | 50 | 5 / 30 | 16.67% | 23 / 30 | 76.67% | 1 | 2570 | 8.9 |
| Lead (unfiltered) | 25 | 7 / 30 | 23.33% | 20 / 30 | 66.67% | 2 | 810 | 10.05 |
| Mercury (unfiltered) | 2 | 0 / 30 | 0.00% | 2 / 30 | 6.67% | 0.32 | 0.78 | 0.55 |
| Selenium (unfiltered) | 10 | 2 / 30 | 6.67% | 6 / 30 | 20.00% | 1 | 23 | 4.05 |
| Silver (unfiltered) | 50 | 0 / 30 | 0.00% | 0 / 30 | 0.00% | 0 | 0 | 0 |

All units in ug/L

# Table 5-4
# Statistical Summary of Round Two Groundwater Results
# Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | WEATHERED BEDROCK WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| Naphthalene | 10 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 4-Chloro-3-methylphenol | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Dimethylphthalate | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Acenaphthylene | 20 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Acenaphthene | 20 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Diethylphthalate | 50 | 0 / 8 | 0.00% | 1 / 8 | 12.50% | 0.6 | 0.6 | 0.6 |
| Fluorene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| N-Nitrosodiphenylamine (1) | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Phenanthrene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Anthracene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Di-n-butylphthalate | N/A | --- | N/A | 5 / 8 | 62.50% | 0.2 | 0.4 | 0.3 |
| Fluoranthene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Pyrene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Butylbenzylphthalate | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Benzo(a)anthracene | 0.002 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Chrysene | 0.002 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| bis(2-Ethylhexyl)phthalate | 50 | 0 / 8 | 0.00% | 1 / 8 | 12.50% | 0.8 | 0.8 | 0.8 |
| Di-n-octylphthalate | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Benzo(b)fluoranthene | 0.002 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Benzo(k)fluoranthene | 0.002 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Benzo(a)pyrene | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Indeno(1,2,3-cd)pyrene | 0.002 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Dibenzo(a,h)anthracene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Benzo(g,h,i)perylene | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| **Volatile Compounds** | | | | | | | | |
| Vinyl Chloride | 2 | 1 / 8 | 12.50% | 1 / 8 | 12.50% | 4 | 4 | 4 |
| Methylene Chloride | 5 | 0 / 8 | 0.00% | 4 / 8 | 50.00% | 0.4 | 2 | 1.5 |
| Carbon Disulfide | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 1,1-Dichloroethene | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 1,1-Dichloroethane | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| cis-1,2-Dichloroethene | 5 | 0 / 8 | 0.00% | 1 / 8 | 12.50% | 1 | 1 | 1 |
| Chloroform | 7 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 2-Butanone | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 1,1,1-Trichloroethane | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Trichloroethene | 5 | 0 / 8 | 0.00% | 1 / 8 | 12.50% | 0.7 | 0.7 | 0.7 |
| Benzene | 0.7 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Tetrachloroethene | 5 | 0 / 8 | 0.00% | 2 / 8 | 25.00% | 0.4 | 0.6 | 0.5 |
| trans-1,2-Dichloroethene | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Trichlorofluoromethane | 5 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| **Pesticides and PCBs** | | | | | | | | |
| beta-BHC | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| delta-BHC | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| gamma-BHC (Lindane) | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Heptachlor | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Aldrin | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Dieldrin | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 4,4'-DDE | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 4,4'-DDD | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| 4,4'-DDT | ND | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Endrin Ketone | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| Endrin Aldehyde | N/A | --- | N/A | 0 / 8 | 0.00% | 0 | 0 | 0 |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (filtered) | 25 | 0 / 1 | 0.00% | 1 / 1 | 100.00% | 2.5 | 2.5 | 2.5 |
| Barium (filtered) | 1000 | 0 / 1 | 0.00% | 1 / 1 | 100.00% | 812 | 812 | 812 |
| Cadmium (filtered) | 10 | 0 / 1 | 0.00% | 0 / 1 | 0.00% | 0 | 0 | 0 |
| Chromium (filtered) | 50 | 0 / 1 | 0.00% | 1 / 1 | 100.00% | 2.3 | 2.3 | 2.3 |
| Lead (filtered) | 25 | 0 / 1 | 0.00% | 0 / 1 | 0.00% | 0 | 0 | 0 |
| Mercury (filtered) | 2 | 0 / 1 | 0.00% | 0 / 1 | 0.00% | 0 | 0 | 0 |
| Selenium (filtered) | 10 | 0 / 1 | 0.00% | 0 / 1 | 0.00% | 0 | 0 | 0 |
| Silver (filtered) | 50 | 0 / 1 | 0.00% | 0 / 1 | 0.00% | 0 | 0 | 0 |
| Arsenic (unfiltered) | 25 | 2 / 8 | 25.00% | 4 / 8 | 50.00% | 3.7 | 183 | 90.8 |
| Barium (unfiltered) | 1000 | 2 / 8 | 25.00% | 8 / 8 | 100.00% | 86.4 | 3920 | 259.5 |
| Cadmium (unfiltered) | 10 | 2 / 8 | 25.00% | 4 / 8 | 50.00% | 1.9 | 29.2 | 15.55 |
| Chromium (unfiltered) | 50 | 2 / 8 | 25.00% | 8 / 8 | 100.00% | 1.1 | 357 | 3.1 |
| Lead (unfiltered) | 25 | 2 / 8 | 25.00% | 6 / 8 | 75.00% | 2.2 | 336 | 11.9 |
| Mercury (unfiltered) | 2 | 0 / 8 | 0.00% | 1 / 8 | 12.50% | 0.49 | 0.49 | 0.49 |
| Selenium (unfiltered) | 10 | 0 / 8 | 0.00% | 4 / 8 | 50.00% | 1.8 | 6.6 | 2.65 |
| Silver (unfiltered) | 50 | 0 / 8 | 0.00% | 0 / 8 | 0.00% | 0 | 0 | 0 |

All units in ug/L

# Table 5-4
## Statistical Summary of Round Two Groundwater Results
## Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | HYBRID WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| Naphthalene | 10 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| 4-Chloro-3-methylphenol | N/A | — | N/A | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Dimethylphthalate | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Acenaphthylene | 20 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Acenaphthene | 20 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Diethylphthalate | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Fluorene | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| N-Nitrosodiphenylamine (1) | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Phenanthrene | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Anthracene | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Di-n-butylphthalate | N/A | — | N/A | 1 / 3 | 33.33% | 0.6 | 0.6 | 0.6 |
| Fluoranthene | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Pyrene | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Butylbenzylphthalate | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Benzo(a)anthracene | 0.002 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Chrysene | 0.002 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| bis(2-Ethylhexyl)phthalate | 50 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 1 | 1 | 1 |
| Di-n-octylphthalate | N/A | — | N/A | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Benzo(b)fluoranthene | 0.002 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Benzo(k)fluoranthene | 0.002 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Benzo(a)pyrene | ND | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Indeno(1,2,3-cd)pyrene | 0.002 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Dibenzo(a,h)anthracene | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Benzo(g,h,i)perylene | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| **Volatile Compounds** | | | | | | | | |
| Vinyl Chloride | 2 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Methylene Chloride | 5 | 0 / 3 | 0.00% | 2 / 3 | 66.67% | 0.8 | 2 | 1.4 |
| Carbon Disulfide | N/A | — | N/A | 0 / 3 | 0.00% | 0 | 0 | 0 |
| 1,1-Dichloroethene | 5 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| 1,1-Dichloroethane | 5 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 0.6 | 0.6 | 0.6 |
| cis-1,2-Dichloroethene | 5 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 0.5 | 0.5 | 0.5 |
| Chloroform | 7 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| 2-Butanone | N/A | — | N/A | 0 / 3 | 0.00% | 0 | 0 | 0 |
| 1,1,1-Trichloroethane | 5 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Trichloroethene | 5 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Benzene | 0.7 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Tetrachloroethene | 5 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| trans-1,2-Dichloroethene | 5 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Trichlorofluoromethane | 5 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 4 | 4 | 4 |
| **Pesticides and PCBs** | | | | | | | | |
| beta-BHC | N/A | — | N/A | 0 / 3 | 0.00% | 0 | 0 | 0 |
| delta-BHC | N/A | — | N/A | 0 / 3 | 0.00% | 0 | 0 | 0 |
| gamma-BHC (Lindane) | N/A | — | N/A | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Heptachlor | ND | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Aldrin | ND | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Dieldrin | ND | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| 4,4'-DDE | ND | 1 / 3 | 33.33% | 1 / 3 | 33.33% | 0.0018 | 0.0018 | 0.0018 |
| 4,4'-DDD | ND | 1 / 3 | 33.33% | 1 / 3 | 33.33% | 0.0015 | 0.0015 | 0.0015 |
| 4,4'-DDT | ND | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Endrin Ketone | N/A | — | N/A | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Endrin Aldehyde | N/A | — | N/A | 0 / 3 | 0.00% | 0 | 0 | 0 |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (filtered) | 25 | 0 / 0 | N/A | 0 / 0 | N/A | 0 | 0 | 0 |
| Barium (filtered) | 1000 | 0 / 0 | N/A | 0 / 0 | N/A | 0 | 0 | 0 |
| Cadmium (filtered) | 10 | 0 / 0 | N/A | 0 / 0 | N/A | 0 | 0 | 0 |
| Chromium (filtered) | 50 | 0 / 0 | N/A | 0 / 0 | N/A | 0 | 0 | 0 |
| Lead (filtered) | 25 | 0 / 0 | N/A | 0 / 0 | N/A | 0 | 0 | 0 |
| Mercury (filtered) | 2 | 0 / 0 | N/A | 0 / 0 | N/A | 0 | 0 | 0 |
| Selenium (filtered) | 10 | 0 / 0 | N/A | 0 / 0 | N/A | 0 | 0 | 0 |
| Silver (filtered) | 50 | 0 / 0 | N/A | 0 / 0 | N/A | 0 | 0 | 0 |
| Arsenic (unfiltered) | 25 | 0 / 3 | 0.00% | 3 / 3 | 100.00% | 1.5 | 15.4 | 5.8 |
| Barium (unfiltered) | 1000 | 1 / 3 | 33.33% | 3 / 3 | 100.00% | 117 | 1400 | 149 |
| Cadmium (unfiltered) | 10 | 1 / 3 | 33.33% | 1 / 3 | 33.33% | 117 | 117 | 117 |
| Chromium (unfiltered) | 50 | 3 / 3 | 100.00% | 3 / 3 | 100.00% | 53.2 | 1520 | 738 |
| Lead (unfiltered) | 25 | 1 / 3 | 33.33% | 3 / 3 | 100.00% | 9.6 | 114 | 13.3 |
| Mercury (unfiltered) | 2 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |
| Selenium (unfiltered) | 10 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 1.1 | 1.1 | 1.1 |
| Silver (unfiltered) | 50 | 0 / 3 | 0.00% | 0 / 3 | 0.00% | 0 | 0 | 0 |

All units in ug/L

# Table 5-4
# Statistical Summary of Round Two Groundwater Results
# Manufacturing Area, Watervliet Arsenal

|  | NYSDEC Class GA Groundwater Standards ug/L | ALL WELLS |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Perdkntage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** |  |  |  |  |  |  |  |  |
| Naphthalene | 10 | 0 / 61 | 0.00% | 1 / 61 | 1.64% | 0.8 | 0.8 | 0.8 |
| 4-Chloro-3-methylphenol | N/A | — | 0.00% | 5 / 61 | 8.20% | 1 | 310 | 18 |
| Dimethylphthalate | 50 | 0 / 61 | 0.00% | 0 / 61 | 0.00% | 0 | 0 | 0 |
| Acenaphthylene | 20 | 0 / 61 | 0.00% | 0 / 61 | 0.00% | 0 | 0 | 0 |
| Acenaphthene | 20 | 0 / 61 | 0.00% | 1 / 61 | 1.64% | 1 | 1 | 1 |
| Diethylphthalate | 50 | 0 / 61 | 0.00% | 11 / 61 | 18.03% | 0.2 | 0.9 | 0.4 |
| Fluorene | 50 | 0 / 61 | 0.00% | 1 / 61 | 1.64% | 0.7 | 0.7 | 0.7 |
| N-Nitrosodiphenylamine (1) | 50 | 0 / 61 | 0.00% | 1 / 61 | 1.64% | 0.5 | 0.5 | 0.5 |
| Phenanthrene | 50 | 0 / 61 | 0.00% | 3 / 61 | 4.92% | 0.4 | 10 | 2 |
| Anthracene | 50 | 0 / 61 | 0.00% | 1 / 61 | 1.64% | 0.2 | 0.2 | 0.2 |
| Di-n-butylphthalate | N/A | — | 0.00% | 41 / 61 | 67.21% | 0.2 | 1 | 0.4 |
| Fluoranthene | 50 | 0 / 61 | 0.00% | 3 / 61 | 4.92% | 0.6 | 24 | 2 |
| Pyrene | 50 | 0 / 61 | 0.00% | 4 / 61 | 6.56% | 1 | 24 | 1 |
| Butylbenzylphthalate | 50 | 0 / 61 | 0.00% | 3 / 61 | 4.92% | 0.3 | 0.8 | 0.3 |
| Benzo(a)anthracene | 0.002 | 2 / 61 | 3.28% | 2 / 61 | 3.28% | 0.8 | 17 | 8.9 |
| Chrysene | 0.002 | 2 / 61 | 3.28% | 2 / 61 | 3.28% | 0.9 | 40 | 20.45 |
| bis(2-Ethylhexyl)phthalate | 50 | 1 / 61 | 1.64% | 19 / 61 | 31.15% | 0.2 | 65 | 1 |
| Di-n-octylphthalate | N/A | — | 0.00% | 1 / 61 | 1.64% | 0.9 | 0.9 | 0.9 |
| Benzo(b)fluoranthene | 0.002 | 1 / 61 | 1.64% | 1 / 61 | 1.64% | 0.9 | 0.9 | 0.9 |
| Benzo(k)fluoranthene | 0.002 | 1 / 61 | 1.64% | 1 / 61 | 1.64% | 1 | 1 | 1 |
| Benzo(a)pyrene | ND | 1 / 61 | 1.64% | 1 / 61 | 1.64% | 0.7 | 0.7 | 0.7 |
| Indeno(1,2,3-cd)pyrene | 0.002 | 0 / 61 | 0.00% | 0 / 61 | 0.00% | 0 | 0 | 0 |
| Dibenzo(a,h)anthracene | 50 | 0 / 61 | 0.00% | 0 / 61 | 0.00% | 0 | 0 | 0 |
| Benzo(g,h,i)perylene | 50 | 0 / 61 | 0.00% | 0 / 61 | 0.00% | 0 | 0 | 0 |
| **Volatile Compounds** |  |  |  |  |  |  |  |  |
| Vinyl Chloride | 2 | 6 / 61 | 9.84% | 6 / 61 | 9.84% | 4 | 160 | 31 |
| Methylene Chloride | 5 | 1 / 61 | 1.64% | 26 / 61 | 42.62% | 0.4 | 48 | 0.8 |
| Carbon Disulfide | N/A | — | 0.00% | 1 / 61 | 1.64% | 1 | 1 | 1 |
| 1,1-Dichloroethene | 5 | 0 / 61 | 0.00% | 2 / 61 | 3.28% | 0.8 | 2 | 1.4 |
| 1,1-Dichloroethane | 5 | 3 / 61 | 4.92% | 10 / 61 | 16.39% | 0.5 | 12 | 1.5 |
| cis-1,2-Dichloroethene | 5 | 7 / 61 | 11.48% | 15 / 61 | 24.59% | 0.3 | 1100 | 4 |
| Chloroform | 7 | 1 / 61 | 1.64% | 1 / 61 | 1.64% | 28 | 28 | 28 |
| 2-Butanone | N/A | — | 0.00% | 1 / 61 | 1.64% | 2 | 2 | 2 |
| 1,1,1-Trichloroethane | 5 | 4 / 61 | 6.56% | 4 / 61 | 6.56% | 6 | 82 | 14.5 |
| Trichloroethene | 5 | 8 / 61 | 13.11% | 14 / 61 | 22.95% | 0.5 | 310 | 28 |
| Benzene | 0.7 | 1 / 61 | 1.64% | 1 / 61 | 1.64% | 0.8 | 0.8 | 0.8 |
| Tetrachloroethene | 5 | 1 / 61 | 1.64% | 7 / 61 | 11.48% | 0.4 | 120 | 0.7 |
| trans-1,2-Dichloroethene | 5 | 1 / 61 | 1.64% | 6 / 61 | 9.84% | 0.7 | 10 | 2 |
| Trichlorofluoromethane | 5 | 0 / 61 | 0.00% | 2 / 61 | 3.28% | 2 | 4 | 3 |
| **Pesticides and PCBs** |  |  |  |  |  |  |  |  |
| beta-BHC | N/A | — | 0.00% | 1 / 58 | 1.72% | 0.007 | 0.007 | 0.007 |
| delta-BHC | N/A | — | 0.00% | 1 / 58 | 1.72% | 0.016 | 0.016 | 0.016 |
| gamma-BHC (Lindane) | N/A | — | 0.00% | 1 / 58 | 1.72% | 0.15 | 0.15 | 0.15 |
| Heptachlor | ND | 1 / 58 | 1.72% | 1 / 58 | 1.72% | 0.049 | 0.049 | 0.049 |
| Aldrin | ND | 3 / 58 | 5.17% | 3 / 58 | 5.17% | 0.0078 | 0.061 | 0.0083 |
| Dieldrin | ND | 3 / 58 | 5.17% | 3 / 58 | 5.17% | 0.0017 | 0.019 | 0.0094 |
| 4,4'-DDE | ND | 6 / 58 | 10.34% | 6 / 58 | 10.34% | 0.00089 | 0.1 | 0.0028 |
| 4,4'-DDD | ND | 3 / 58 | 5.17% | 3 / 58 | 5.17% | 0.0015 | 0.017 | 0.01 |
| 4,4'-DDT | ND | 3 / 58 | 5.17% | 3 / 58 | 5.17% | 0.0021 | 0.013 | 0.0029 |
| Endrin Ketone | N/A | — | 0.00% | 1 / 58 | 1.72% | 0.0045 | 0.0045 | 0.0045 |
| Endrin Aldehyde | N/A | — | 0.00% | 1 / 58 | 1.72% | 0.22 | 0.22 | 0.22 |
| **Inorganic Compounds** |  |  |  |  |  |  |  |  |
| Arsenic (filtered) | 25 | 0 / 11 | 0.00% | 3 / 11 | 27.27% | 2.5 | 13.7 | 5.4 |
| Barium (filtered) | 1000 | 1 / 11 | 9.09% | 11 / 11 | 100.00% | 94.5 | 1520 | 280 |
| Cadmium (filtered) | 10 | 0 / 11 | 0.00% | 2 / 11 | 18.18% | 1.3 | 3.1 | 2.2 |
| Chromium (filtered) | 50 | 0 / 11 | 0.00% | 3 / 11 | 27.27% | 2.3 | 26.2 | 8.7 |
| Lead (filtered) | 25 | 1 / 11 | 9.09% | 5 / 11 | 45.45% | 2 | 64.4 | 5.6 |
| Mercury (filtered) | 2 | 0 / 11 | 0.00% | 1 / 11 | 9.09% | 0.2 | 0.2 | 0.2 |
| Selenium (filtered) | 10 | 0 / 11 | 0.00% | 2 / 11 | 18.18% | 2 | 4.2 | 3.1 |
| Silver (filtered) | 50 | 0 / 11 | 0.00% | 1 / 11 | 9.09% | 2 | 2 | 2 |
| Arsenic (unfiltered) | 25 | 7 / 60 | 11.67% | 38 / 60 | 63.33% | 1.5 | 744 | 5.7 |
| Barium (unfiltered) | 1000 | 12 / 60 | 20.00% | 60 / 60 | 100.00% | 26.2 | 8220 | 233 |
| Cadmium (unfiltered) | 10 | 7 / 60 | 11.67% | 23 / 60 | 38.33% | 1 | 127 | 4.3 |
| Chromium (unfiltered) | 50 | 14 / 60 | 23.33% | 53 / 60 | 88.33% | 1 | 2570 | 9.3 |
| Lead (unfiltered) | 25 | 14 / 60 | 23.33% | 44 / 60 | 73.33% | 2 | 810 | 10.05 |
| Mercury (unfiltered) | 2 | 0 / 60 | 0.00% | 4 / 60 | 6.67% | 0.32 | 0.78 | 0.47 |
| Selenium (unfiltered) | 10 | 2 / 60 | 3.33% | 16 / 60 | 26.67% | 1 | 23 | 2.7 |
| Silver (unfiltered) | 50 | 0 / 60 | 0.00% | 0 / 60 | 0.00% | 0 | 0 | 0 |

All units in ug/L

# Table 5-5
# Statistical Summary of Groundwater Results
# Rounds Three, Four, and Geoprobe Samples
# Main Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | **OVERBURDEN WELLS** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| 1,2,4-Trichlorobenzene | 5 | 0 / 15 | 0.00% | 1 / 15 | 6.67% | 0.2 | 0.2 | 0.2 |
| 2-Methylnaphthalene | 50 | 0 / 15 | 0.00% | 1 / 15 | 6.67% | 2 | 2 | 2 |
| 4-Chloro-3-methylphenol | | — | — | 3 / 15 | 20.00% | 0.6 | 30 | 4 |
| Acenaphthene | 20 | 0 / 15 | 0.00% | 4 / 15 | 26.67% | 0.2 | 0.9 | 0.55 |
| Acenaphthylene | 20 | 0 / 15 | 0.00% | 3 / 15 | 20.00% | 0.2 | 0.5 | 0.3 |
| Anthracene | 50 | 0 / 15 | 0.00% | 6 / 15 | 40.00% | 0.1 | 2 | 0.4 |
| Benzo(a)anthracene | 0.002 | 6 / 15 | 40.00% | 6 / 15 | 40.00% | 0.2 | 6 | 1.35 |
| Benzo(a)Pyrene | 0.002 | 5 / 15 | 33.33% | 5 / 15 | 33.33% | 0.3 | 5 | 2 |
| Benzo(b)fluoranthene | 0.002 | 4 / 15 | 26.67% | 5 / 15 | 33.33% | 0.3 | 4 | 1.2 |
| Benzo(g,h,i)perylene | 50 | 0 / 15 | 0.00% | 0 / 15 | 0.00% | 0 | 0 | — |
| Benzo(k)Fluoranthene | 0.002 | 5 / 15 | 33.33% | 5 / 15 | 33.33% | 0.3 | 4 | 2 |
| bis(2-Ethylhexyl)phthalate | 50 | 1 / 15 | 6.67% | 12 / 15 | 80.00% | 0.2 | 57 | 1 |
| Butylbenzylphthalate | 50 | 0 / 15 | 0.00% | 4 / 15 | 26.67% | 0.09 | 3 | 0.3 |
| Chrysene | 0.002 | 6 / 15 | 40.00% | 6 / 15 | 40.00% | 0.2 | 6 | 1.35 |
| Di-n-butylphthalate | 50 | 0 / 15 | 0.00% | 12 / 15 | 80.00% | 0.2 | 0.7 | 0.25 |
| Dibenzo(a,h)anthracene | 50 | 0 / 15 | 0.00% | 0 / 15 | 0.00% | 0 | 0 | — |
| Diethylphthalate | 50 | 0 / 15 | 0.00% | 12 / 15 | 80.00% | 0.2 | 1 | 0.3 |
| Fluoranthene | 50 | 0 / 15 | 0.00% | 7 / 15 | 46.67% | 0.3 | 12 | 2 |
| Fluorene | 50 | 0 / 15 | 0.00% | 0 / 15 | 0.00% | 0 | 0 | — |
| Isophorone | 50 | 0 / 15 | 0.00% | 2 / 15 | 13.33% | 1 | 2 | 1.5 |
| Indeno(1,2,3-cd)pyrene | 0.002 | 0 / 15 | 0.00% | 0 / 15 | 0.00% | 0 | 0 | — |
| Napthalene | 10 | 0 / 15 | 0.00% | 3 / 15 | 20.00% | 0.6 | 2 | 0.8 |
| Phenanthrene | 50 | 0 / 15 | 0.00% | 7 / 15 | 46.67% | 0.5 | 7 | 1 |
| Pyrene | 50 | 0 / 15 | 0.00% | 7 / 15 | 46.67% | 0.2 | 10 | 2 |
| **Volatile Compounds** | | | | | | | | |
| 1,1,1-Trichloroethane | 5 | 0 / 28 | 0.00% | 1 / 28 | 3.57% | 3 | 3 | 3 |
| 1,1-Dichloroethane | 5 | 3 / 28 | 10.71% | 5 / 28 | 17.86% | 3 | 14 | 6 |
| 1,2-Dichloroethene (total) | N/A | — | — | 0 / 28 | 0.00% | 0 | 0 | — |
| 2-Butanone | 50 | 0 / 28 | 0.00% | 0 / 28 | 0.00% | 0 | 0 | — |
| Benzene | 0.7 | 1 / 28 | 3.57% | 1 / 28 | 3.57% | 4 | 4 | 4 |
| Bromodichloromethane | 50 | 0 / 28 | 0.00% | 0 / 28 | 0.00% | 0 | 0 | — |
| Carbon Disulfide | N/A | — | — | 0 / 28 | 0.00% | 0 | 0 | — |
| Chlorobenzene | 5 | 0 / 28 | 0.00% | 0 / 28 | 0.00% | 0 | 0 | — |
| Chloroform | 7 | 0 / 28 | 0.00% | 0 / 28 | 0.00% | 0 | 0 | — |
| cis-1,2-Dichloroethene | 5 | 2 / 28 | 7.14% | 7 / 28 | 25.00% | 2 | 360 | 3 |
| Dibromochloromethane | 50 | 0 / 28 | 0.00% | 0 / 28 | 0.00% | 0 | 0 | — |
| Methylene Chloride | 5 | 1 / 28 | 3.57% | 5 / 28 | 17.86% | 1 | 10 | 2 |
| Tetrachloroethene | 5 | 1 / 28 | 3.57% | 2 / 28 | 7.14% | 1 | 10 | 5 |
| trans-1,2-Dichloroethene | 5 | 0 / 28 | 0.00% | 1 / 28 | 3.57% | 4 | 4 | 4 |
| Trichloroethene | 5 | 4 / 28 | 14.29% | 10 / 28 | 35.71% | 1 | 240 | 4 |
| Vinyl Chloride | 2 | 1 / 28 | 3.57% | 3 / 28 | 10.71% | 2 | 28 | 2 |
| Xylene (total) | 5 | 0 / 28 | 0.00% | 1 / 28 | 3.57% | 2 | 2 | 2 |
| **Pesticides and PCBs** | | | | | | | | |
| Not Analyzed | | | | | | | | |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (unfiltered) | 25 | 6 / 16 | 37.50% | 14 / 16 | 87.50% | 2 | 636 | 19 |
| Barium (unfiltered) | 1000 | 7 / 16 | 43.75% | 15 / 16 | 93.75% | 151 | 7,460 | 976 |
| Cadmium (unfiltered) | 10 | 1 / 16 | 6.25% | 5 / 16 | 31.25% | 1 | 99 | 2 |
| Chromium (unfiltered) | 50 | 7 / 16 | 43.75% | 14 / 16 | 87.50% | 4 | 1,690 | 55 |
| Lead (unfiltered) | 25 | 12 / 16 | 75.00% | 14 / 16 | 87.50% | 3 | 10,600 | 727 |
| Mercury (unfiltered) | 2 | 1 / 16 | 6.25% | 7 / 16 | 43.75% | 0.28 | 2 | 0.41 |
| Selenium (unfiltered) | 10 | 5 / 16 | 31.25% | 11 / 16 | 68.75% | 3 | 366 | 10 |
| Silver | 50 | 0 / 16 | 0.00% | 6 / 16 | 37.50% | 1 | 23 | 2 |
| Arsenic (filtered) | 25 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 3 | 3 | 3 |
| Barium (filtered) | 1000 | 0 / 3 | 0.00% | 3 / 3 | 100.00% | 186 | 617 | 255 |
| Chromium (filtered) | 50 | 0 / 3 | 0.00% | 1 / 3 | 33.33% | 2 | 2 | 2 |
| Lead (filtered) | 25 | 0 / 3 | 0.00% | 2 / 3 | 66.67% | 2 | 24 | 13 |

All units in ug/L
NS - Not Sampled

# Table 5-5
# Statistical Summary of Groundwater Results
# Rounds Three, Four, and Geoprobe Samples
# Main Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | BEDROCK WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| 1,2,4-Trichlorobenzene | 5 | 0 / 13 | 0.00% | 0 / 13 | 0.00% | 0 | 0 | — |
| 2-Methylnaphthalene | 50 | 0 / 13 | 0.00% | 0 / 13 | 0.00% | 0 | 0 | — |
| 4-Chloro-3-methylphenol | | — | — | 0 / 13 | 0.00% | 0 | 0 | — |
| Acenaphthene | 20 | 0 / 13 | 0.00% | 0 / 13 | 0.00% | 0 | 0 | — |
| Acenaphthylene | 20 | 0 / 13 | 0.00% | 0 / 13 | 0.00% | 0 | 0 | — |
| Anthracene | 50 | 0 / 13 | 0.00% | 2 / 13 | 15.38% | 12 | 25 | 18.5 |
| Benzo(a)anthracene | 0.002 | 4 / 13 | 30.77% | 4 / 13 | 30.77% | 6 | 26 | 14 |
| Benzo(a)Pyrene | 0.002 | 4 / 13 | 30.77% | 4 / 13 | 30.77% | 4 | 13 | 7.5 |
| Benzo(b)fluoranthene | 0.002 | 4 / 13 | 30.77% | 4 / 13 | 30.77% | 4 | 14 | 9 |
| Benzo(g,h,i)perylene | 50 | 0 / 13 | 0.00% | 1 / 13 | 7.69% | 11 | 11 | 11 |
| Benzo(k)Fluoranthene | 0.002 | 0 / 13 | 0.00% | 0 / 13 | 0.00% | 0 | 0 | — |
| bis(2-Ethylhexyl)phthalate | 50 | 0 / 13 | 0.00% | 6 / 13 | 46.15% | 0.5 | 48 | 0.6 |
| Butylbenzylphthalate | 50 | 0 / 13 | 0.00% | 0 / 13 | 0.00% | 0 | 0 | — |
| Chrysene | 0.002 | 4 / 13 | 30.77% | 4 / 13 | 30.77% | 5 | 23 | 10 |
| Di-n-butylphthalate | 50 | 0 / 13 | 0.00% | 6 / 13 | 46.15% | 0.3 | 0.4 | 0.3 |
| Dibenzo(a,h)anthracene | 50 | 0 / 13 | 0.00% | 1 / 13 | 7.69% | 4 | 4 | 4 |
| Diethylphthalate | 50 | 0 / 13 | 0.00% | 9 / 13 | 69.23% | 0.4 | 1 | 0.5 |
| Fluoranthene | 50 | 2 / 13 | 15.38% | 2 / 13 | 15.38% | 63 | 65 | 64 |
| Fluorene | 50 | 0 / 13 | 0.00% | 1 / 13 | 7.69% | 5 | 5 | 5 |
| Isophorone | 50 | 0 / 13 | 0.00% | 0 / 13 | 0.00% | 0 | 0 | — |
| Indeno(1,2,3-cd)pyrene | 0.002 | 1 / 13 | 7.69% | 1 / 13 | 7.69% | 9 | 9 | 9 |
| Napthalene | 10 | 0 / 13 | 0.00% | 0 / 13 | 0.00% | 0 | 0 | — |
| Phenanthrene | 50 | 0 / 13 | 0.00% | 3 / 13 | 23.08% | 0.8 | 26 | 3 |
| Pyrene | 50 | 0 / 13 | 0.00% | 4 / 13 | 30.77% | 5 | 49 | 26 |
| **Volatile Compounds** | | | | | | | | |
| 1,1,1-Trichloroethane | 5 | 1 / 31 | 3.23% | 1 / 31 | 3.23% | 19 | 19 | 19 |
| 1,1-Dichloroethane | 5 | 0 / 31 | 0.00% | 1 / 31 | 3.23% | 1 | 1 | 1 |
| 1,2-Dichloroethene (total) | N/A | 5 / 31 | 16.13% | 5 / 31 | 16.13% | 120 | 22,000 | 1,700 |
| 2-Butanone | 50 | 1 / 31 | 3.23% | 1 / 31 | 3.23% | 11 | 11 | 11 |
| Benzene | 0.7 | 0 / 31 | 0.00% | 0 / 31 | 0.00% | 0 | 0 | — |
| Bromodichloromethane | 50 | 0 / 31 | 0.00% | 2 / 31 | 6.45% | 2 | 4 | 3 |
| Carbon Disulfide | N/A | 0 / 31 | 0.00% | 1 / 31 | 3.23% | 5 | 5 | 5 |
| Chlorobenzene | 5 | 1 / 31 | 3.23% | 1 / 31 | 3.23% | 600 | 600 | 600 |
| Chloroform | 7 | 3 / 31 | 9.68% | 3 / 31 | 9.68% | 9 | 24 | 19 |
| cis-1,2-Dichloroethene | 5 | 4 / 31 | 12.90% | 5 / 31 | 16.13% | 4 | 1,200 | 19 |
| Dibromochloromethane | 50 | 0 / 31 | 0.00% | 1 / 31 | 3.23% | 1 | 1 | 1 |
| Methylene Chloride | 5 | 5 / 31 | 16.13% | 10 / 31 | 32.26% | 1 | 440 | 5 |
| Tetrachloroethene | 5 | 5 / 31 | 16.13% | 9 / 31 | 29.03% | 1 | 110,000 | 120 |
| trans-1,2-Dichloroethene | 5 | 0 / 31 | 0.00% | 1 / 31 | 3.23% | 2 | 2 | 2 |
| Trichloroethene | 5 | 8 / 31 | 25.81% | 11 / 31 | 35.48% | 1 | 10,000 | 98 |
| Vinyl Chloride | 2 | 4 / 31 | 12.90% | 8 / 31 | 25.81% | 2 | 160 | 14 |
| Xylene (total) | 5 | 0 / 31 | 0.00% | 0 / 31 | 0.00% | 0 | 0 | — |
| **Pesticides and PCBs** | | | | | | | | |
| Not Analyzed | | | | | | | | |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (unfiltered) | 25 | 1 / 11 | 9.09% | 7 / 11 | 63.64% | 3 | 3 | 6.2 |
| Barium (unfiltered) | 1000 | 5 / 11 | 45.45% | 11 / 11 | 100.00% | 334 | 334 | 607 |
| Cadmium (unfiltered) | 10 | 0 / 11 | 0.00% | 0 / 11 | 0.00% | 0 | 0 | — |
| Chromium (unfiltered) | 50 | 2 / 11 | 18.18% | 11 / 11 | 100.00% | 2 | 2 | 24.6 |
| Lead (unfiltered) | 25 | 3 / 11 | 27.27% | 11 / 11 | 100.00% | 5 | 5 | 9.3 |
| Mercury (unfiltered) | 2 | 0 / 11 | 0.00% | 0 / 11 | 0.00% | 0 | 0 | — |
| Selenium (unfiltered) | 10 | 0 / 11 | 0.00% | 0 / 11 | 0.00% | 0 | 0 | — |
| Silver | 50 | 0 / 11 | 0.00% | 1 / 11 | 9.09% | 1 | 1 | 1 |
| Arsenic (filtered) | 25 | 0 / 11 | 0.00% | 2 / 11 | 18.18% | 3 | 3 | 3.1 |
| Barium (filtered) | 1000 | 1 / 11 | 9.09% | 11 / 11 | 100.00% | 106 | 106 | 254 |
| Chromium (filtered) | 50 | 0 / 11 | 0.00% | 5 / 11 | 45.45% | 1 | 1 | 1.2 |
| Lead (filtered) | 25 | 0 / 11 | 0.00% | 9 / 11 | 81.82% | 2 | 2 | 2 |

All units in ug/L
NS - Not Sampled

# Table 5-5
# Statistical Summary of Groundwater Results
# Rounds Three, Four, and Geoprobe Samples
# Main Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | WEATHERED BEDROCK WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| 1,2,4-Trichlorobenzene | 5 | NS | NS | NS | NS | NS | NS | NS |
| 2-Methylnaphthalene | 50 | NS | NS | NS | NS | NS | NS | NS |
| 4-Chloro-3-methylphenol | | NS | NS | NS | NS | NS | NS | NS |
| Acenaphthene | 20 | NS | NS | NS | NS | NS | NS | NS |
| Acenaphthylene | 20 | NS | NS | NS | NS | NS | NS | NS |
| Anthracene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Benzo(a)anthracene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| Benzo(a)Pyrene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| Benzo(b)fluoranthene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| Benzo(g,h,i)perylene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Benzo(k)Fluoranthene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| bis(2-Ethylhexyl)phthalate | 50 | NS | NS | NS | NS | NS | NS | NS |
| Butylbenzylphthalate | 50 | NS | NS | NS | NS | NS | NS | NS |
| Chrysene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| Di-n-butylphthalate | 50 | NS | NS | NS | NS | NS | NS | NS |
| Dibenzo(a,h)anthracene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Diethylphthalate | 50 | NS | NS | NS | NS | NS | NS | NS |
| Fluoranthene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Fluorene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Isophorone | 50 | NS | NS | NS | NS | NS | NS | NS |
| Indeno(1,2,3-cd)pyrene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| Napthalene | 10 | NS | NS | NS | NS | NS | NS | NS |
| Phenanthrene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Pyrene | 50 | NS | NS | NS | NS | NS | NS | NS |
| **Volatile Compounds** | | | | | | | | |
| 1,1,1-Trichloroethane | 5 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| 1,1-Dichloroethane | 5 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| 1,2-Dichloroethene (total) | N/A | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| 2-Butanone | 50 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| Benzene | 0.7 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| Bromodichloromethane | 50 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| Carbon Disulfide | N/A | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| Chlorobenzene | 5 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| Chloroform | 7 | 0 / 5 | 0.00% | 1 / 5 | 20.00% | 1 | 1 | 1 |
| cis-1,2-Dichloroethene | 5 | 0 / 5 | 0.00% | 1 / 5 | 20.00% | 2 | 2 | 2 |
| Dibromochloromethane | 50 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| Methylene Chloride | 5 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| Tetrachloroethene | 5 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| trans-1,2-Dichloroethene | 5 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| Trichloroethene | 5 | 0 / 5 | 0.00% | 3 / 5 | 60.00% | 1 | 2 | 1 |
| Vinyl Chloride | 2 | 0 / 5 | 0.00% | 1 / 5 | 20.00% | 3 | 3 | 3 |
| Xylene (total) | 5 | 0 / 5 | 0.00% | 0 / 5 | 0.00% | 0 | 0 | — |
| **Pesticides and PCBs** | | | | | | | | |
| Not Analyzed | | | | | | | | |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (unfiltered) | 25 | NS | NS | NS | NS | NS | NS | NS |
| Barium (unfiltered) | 1000 | NS | NS | NS | NS | NS | NS | NS |
| Cadmium (unfiltered) | 10 | NS | NS | NS | NS | NS | NS | NS |
| Chromium (unfiltered) | 50 | NS | NS | NS | NS | NS | NS | NS |
| Lead (unfiltered) | 25 | NS | NS | NS | NS | NS | NS | NS |
| Mercury (unfiltered) | 2 | NS | NS | NS | NS | NS | NS | NS |
| Selenium (unfiltered) | 10 | NS | NS | NS | NS | NS | NS | NS |
| Silver | 50 | NS | NS | NS | NS | NS | NS | NS |
| Arsenic (filtered) | 25 | NS | NS | NS | NS | NS | NS | NS |
| Barium (filtered) | 1000 | NS | NS | NS | NS | NS | NS | NS |
| Chromium (filtered) | 50 | NS | NS | NS | NS | NS | NS | NS |
| Lead (filtered) | 25 | NS | NS | NS | NS | NS | NS | NS |

All units in ug/L
NS - Not Sampled

# Table 5-5
# Statistical Summary of Groundwater Results
# Rounds Three, Four, and Geoprobe Samples
# Main Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | HYBRID WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Percentage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| 1,2,4-Trichlorobenzene | 5 | NS | NS | NS | NS | NS | NS | NS |
| 2-Methylnaphthalene | 50 | NS | NS | NS | NS | NS | NS | NS |
| 4-Chloro-3-methylphenol | | NS | NS | NS | NS | NS | NS | NS |
| Acenaphthene | 20 | NS | NS | NS | NS | NS | NS | NS |
| Acenaphthylene | 20 | NS | NS | NS | NS | NS | NS | NS |
| Anthracene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Benzo(a)anthracene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| Benzo(a)Pyrene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| Benzo(b)fluoranthene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| Benzo(g,h,i)perylene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Benzo(k)Fluoranthene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| bis(2-Ethylhexyl)phthalate | 50 | NS | NS | NS | NS | NS | NS | NS |
| Butylbenzylphthalate | 50 | NS | NS | NS | NS | NS | NS | NS |
| Chrysene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| Di-n-butylphthalate | 50 | NS | NS | NS | NS | NS | NS | NS |
| Dibenzo(a,h)anthracene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Diethylphthalate | 50 | NS | NS | NS | NS | NS | NS | NS |
| Fluoranthene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Fluorene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Isophorone | 50 | NS | NS | NS | NS | NS | NS | NS |
| Indeno(1,2,3-cd)pyrene | 0.002 | NS | NS | NS | NS | NS | NS | NS |
| Napthalene | 10 | NS | NS | NS | NS | NS | NS | NS |
| Phenanthrene | 50 | NS | NS | NS | NS | NS | NS | NS |
| Pyrene | 50 | NS | NS | NS | NS | NS | NS | NS |
| **Volatile Compounds** | | | | | | | | |
| 1,1,1-Trichloroethane | 5 | 1 / 2 | 50.00% | 1 / 2 | 50.00% | 10 | 10 | 10 |
| 1,1-Dichloroethane | 5 | 0 / 2 | 0.00% | 1 / 2 | 50.00% | 1 | 1 | 1 |
| 1,2-Dichloroethene (total) | N/A | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| 2-Butanone | 50 | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| Benzene | 0.7 | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| Bromodichloromethane | 50 | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| Carbon Disulfide | N/A | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| Chlorobenzene | 5 | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| Chloroform | 7 | 0 / 2 | 0.00% | 1 / 2 | 50.00% | 1 | 1 | 1 |
| cis-1,2-Dichloroethene | 5 | 0 / 2 | 0.00% | 2 / 2 | 100.00% | 1 | 3 | 2 |
| Dibromochloromethane | 50 | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| Methylene Chloride | 5 | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| Tetrachloroethene | 5 | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| trans-1,2-Dichloroethene | 5 | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| Trichloroethene | 5 | 1 / 2 | 50.00% | 2 / 2 | 100.00% | 1 | 50 | 26 |
| Vinyl Chloride | 2 | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| Xylene (total) | 5 | 0 / 2 | 0.00% | 0 / 2 | 0.00% | 0 | 0 | — |
| **Pesticides and PCBs** | | | | | | | | |
| Not Analyzed | | | | | | | | |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (unfiltered) | 25 | NS | NS | NS | NS | NS | NS | NS |
| Barium (unfiltered) | 1000 | NS | NS | NS | NS | NS | NS | NS |
| Cadmium (unfiltered) | 10 | NS | NS | NS | NS | NS | NS | NS |
| Chromium (unfiltered) | 50 | NS | NS | NS | NS | NS | NS | NS |
| Lead (unfiltered) | 25 | NS | NS | NS | NS | NS | NS | NS |
| Mercury (unfiltered) | 2 | NS | NS | NS | NS | NS | NS | NS |
| Selenium (unfiltered) | 10 | NS | NS | NS | NS | NS | NS | NS |
| Silver | 50 | NS | NS | NS | NS | NS | NS | NS |
| Arsenic (filtered) | 25 | NS | NS | NS | NS | NS | NS | NS |
| Barium (filtered) | 1000 | NS | NS | NS | NS | NS | NS | NS |
| Chromium (filtered) | 50 | NS | NS | NS | NS | NS | NS | NS |
| Lead (filtered) | 25 | NS | NS | NS | NS | NS | NS | NS |

All units in ug/L
NS - Not Sampled

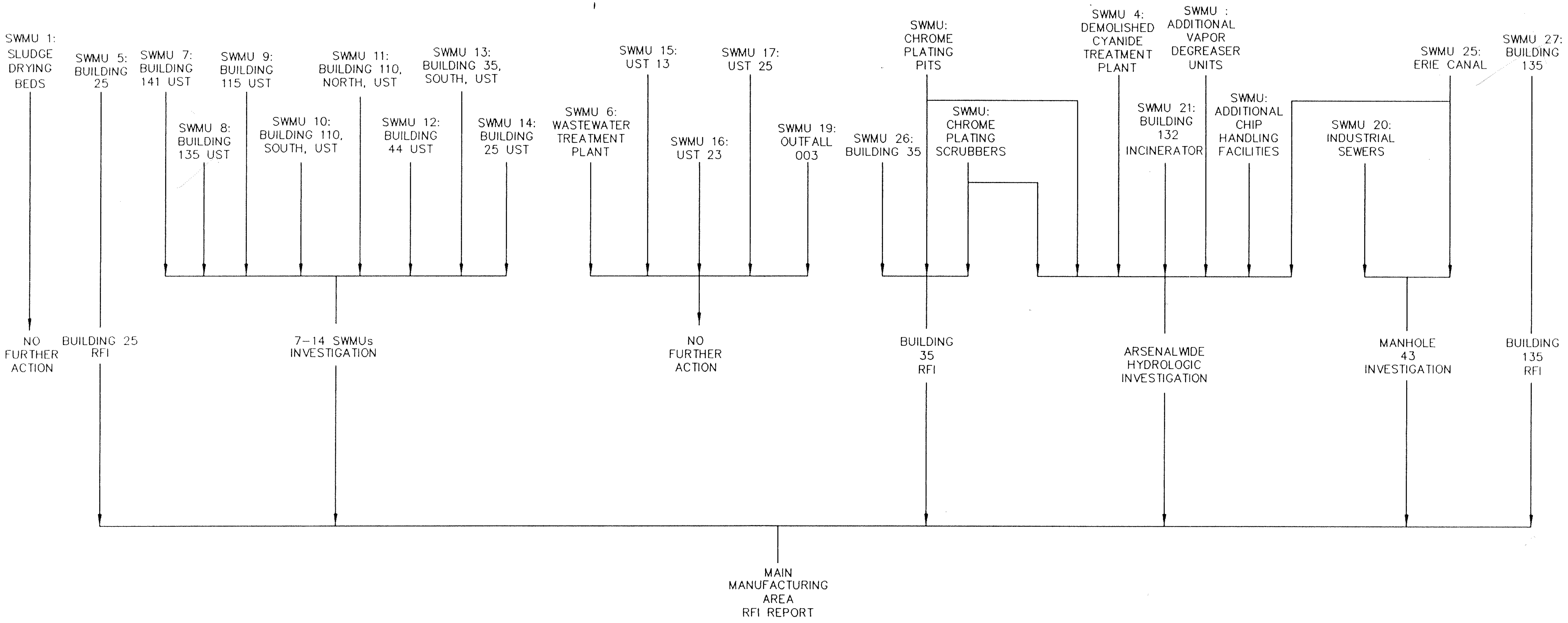
# Table 5-5
# Statistical Summary of Groundwater Results
# Rounds Three, Four, and Geoprobe Samples
# Main Manufacturing Area, Watervliet Arsenal

| | NYSDEC Class GA Groundwater Standards ug/L | ALL WELLS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *# of GA Exceedances* | *% of GA Exceedances* | *Frequency of Detection* | *Detection Perdkntage* | *Minimum Detected Value* | *Maximum Detected Value* | *Median Detected Value* |
| **Semi-Volatile Compounds** | | | | | | | | |
| 1,2,4-Trichlorobenzene | 5 | 0 / 28 | 0.00% | 1 / 28 | 3.57% | 0.2 | 0.2 | 0.2 |
| 2-Methylnaphthalene | 50 | 0 / 28 | 0.00% | 1 / 28 | 3.57% | 2 | 2 | 2 |
| 4-Chloro-3-methylphenol | | — | — | 3 / 28 | 10.71% | 0.6 | 30 | 4 |
| Acenaphthene | 20 | 0 / 28 | 0.00% | 4 / 28 | 14.29% | 0.2 | 0.9 | 0.55 |
| Acenaphthylene | 20 | 0 / 28 | 0.00% | 3 / 28 | 10.71% | 0.2 | 0.5 | 0.3 |
| Anthracene | 50 | 0 / 28 | 0.00% | 8 / 28 | 28.57% | 0.1 | 25 | 0.75 |
| Benzo(a)anthracene | 0.002 | 10 / 28 | 35.71% | 10 / 28 | 35.71% | 0.2 | 26 | 5.5 |
| Benzo(a)Pyrene | 0.002 | 9 / 28 | 32.14% | 9 / 28 | 32.14% | 0.3 | 13 | 4 |
| Benzo(b)fluoranthene | 0.002 | 8 / 28 | 28.57% | 9 / 28 | 32.14% | 0.3 | 14 | 4 |
| Benzo(g,h,i)perylene | 50 | 0 / 28 | 0.00% | 1 / 28 | 3.57% | 11 | 11 | 11 |
| Benzo(k)Fluoranthene | 0.002 | 5 / 28 | 17.86% | 5 / 28 | 17.86% | 0.3 | 4 | 2 |
| bis(2-Ethylhexyl)phthalate | 50 | 1 / 28 | 3.57% | 18 / 28 | 64.29% | 0.2 | 57 | 0.85 |
| Butylbenzylphthalate | 50 | 0 / 28 | 0.00% | 4 / 28 | 14.29% | 0.09 | 3 | 0.3 |
| Chrysene | 0.002 | 10 / 28 | 35.71% | 10 / 28 | 35.71% | 0.2 | 23 | 5 |
| Di-n-butylphthalate | 50 | 0 / 28 | 0.00% | 18 / 28 | 64.29% | 0.2 | 0.7 | 0.3 |
| Dibenzo(a,h)anthracene | 50 | 0 / 28 | 0.00% | 1 / 28 | 3.57% | 4 | 4 | 4 |
| Diethylphthalate | 50 | 0 / 28 | 0.00% | 21 / 28 | 75.00% | 0.2 | 1 | 0.4 |
| Fluoranthene | 50 | 2 / 28 | 7.14% | 9 / 28 | 32.14% | 0.3 | 65 | 4 |
| Fluorene | 50 | 0 / 28 | 0.00% | 1 / 28 | 3.57% | 5 | 5 | 5 |
| Isophorone | 50 | 0 / 28 | 0.00% | 2 / 28 | 7.14% | 1 | 2 | 1.5 |
| Indeno(1,2,3-cd)pyrene | 0.002 | 1 / 28 | 3.57% | 1 / 28 | 3.57% | 9 | 9 | 9 |
| Napthalene | 10 | 0 / 28 | 0.00% | 3 / 28 | 10.71% | 0.6 | 2 | 0.8 |
| Phenanthrene | 50 | 0 / 28 | 0.00% | 10 / 28 | 35.71% | 0.5 | 26 | 1.5 |
| Pyrene | 50 | 0 / 28 | 0.00% | 11 / 28 | 39.29% | 0.2 | 49 | 5 |
| **Volatile Compounds** | | | | | | | | |
| 1,1,1-Trichloroethane | 5 | 2 / 66 | 3.03% | 3 / 66 | 4.55% | 3 | 19 | 10 |
| 1,1-Dichloroethane | 5 | 3 / 66 | 4.55% | 7 / 66 | 16.67% | 1 | 14 | 4 |
| 1,2-Dichloroethene (total) | N/A | — | — | 5 / 66 | 1.52% | 120 | 22,000 | 1,700 |
| 2-Butanone | 50 | 1 / 66 | 1.52% | 1 / 66 | 0.00% | 11 | 11 | 11 |
| Benzene | 0.7 | 1 / 66 | 1.52% | 1 / 66 | 4.55% | 4 | 4 | 4 |
| Bromodichloromethane | 50 | 0 / 66 | 0.00% | 2 / 66 | 1.52% | 2 | 4 | 3 |
| Carbon Disulfide | N/A | — | — | 1 / 66 | 1.52% | 5 | 5 | 5 |
| Chlorobenzene | 5 | 1 / 66 | 1.52% | 1 / 66 | 4.55% | 600 | 600 | 600 |
| Chloroform | 7 | 3 / 66 | 4.55% | 5 / 66 | 10.61% | 1 | 24 | 9 |
| cis-1,2-Dichloroethene | 5 | 6 / 66 | 9.09% | 15 / 66 | 16.67% | 1 | 1,200 | 4 |
| Dibromochloromethane | 50 | 0 / 66 | 0.00% | 1 / 66 | 15.15% | 1 | 1 | 1 |
| Methylene Chloride | 5 | 6 / 66 | 9.09% | 15 / 66 | 21.21% | 1 | 440 | 2 |
| Tetrachloroethene | 5 | 6 / 66 | 9.09% | 11 / 66 | 4.55% | 1 | 110,000 | 10 |
| trans-1,2-Dichloroethene | 5 | 0 / 66 | 0.00% | 2 / 66 | 18.18% | 2 | 4 | 3 |
| Trichloroethene | 5 | 13 / 66 | 19.70% | 26 / 66 | 34.85% | 1 | 10,000 | 6 |
| Vinyl Chloride | 2 | 5 / 66 | 7.58% | 12 / 66 | 6.06% | 2 | 160 | 4 |
| Xylene (total) | 5 | 0 / 66 | 0.00% | 1 / 66 | 1.52% | 2 | 2 | 2 |
| **Pesticides and PCBs** | | | | | | | | |
| Not Analyzed | | | | | | | | |
| **Inorganic Compounds** | | | | | | | | |
| Arsenic (unfiltered) | 25 | 7 / 27 | 25.93% | 21 / 27 | 77.78% | 2.2 | 636 | 14 |
| Barium (unfiltered) | 1000 | 12 / 27 | 44.44% | 26 / 27 | 96.30% | 151 | 7460 | 886.5 |
| Cadmium (unfiltered) | 10 | 1 / 27 | 3.70% | 5 / 27 | 18.52% | 1.4 | 99.4 | 1.9 |
| Chromium (unfiltered) | 50 | 9 / 27 | 33.33% | 25 / 27 | 92.59% | 2.3 | 1690 | 27.9 |
| Lead (unfiltered) | 25 | 15 / 27 | 55.56% | 25 / 27 | 92.59% | 2.9 | 10600 | 56.8 |
| Mercury (unfiltered) | 2 | 1 / 27 | 3.70% | 7 / 27 | 25.93% | 0.28 | 2.1 | 0.41 |
| Selenium (unfiltered) | 10 | 5 / 27 | 18.52% | 11 / 27 | 40.74% | 2.5 | 366 | 10 |
| Silver | 50 | 0 / 27 | 0.00% | 7 / 27 | 25.93% | 1 | 22.7 | 1.9 |
| Arsenic (filtered) | 25 | 0 / 14 | 0.00% | 3 / 14 | 21.43% | 2.8 | 3.1 | 3.10 |
| Barium (filtered) | 1000 | 1 / 14 | 7.14% | 14 / 14 | 100.00% | 106 | 3450 | 254.5 |
| Chromium (filtered) | 50 | 0 / 14 | 0.00% | 6 / 14 | 42.86% | 1.1 | 1.7 | 1.1 |
| Lead (filtered) | 25 | 0 / 14 | 0.00% | 11 / 14 | 78.57% | 2 | 24.4 | 2 |

All units in ug/L
NS - Not Sampled

## Table 6-1
## Summary of Physical and Chemical Properties of Chlorinated Solvents
## Main Manufacturing Area, Watervliet Arsenal

| Compound | MW | Vapor Pressure (torr) | Solubility (mg/L) | Henry's Constant (atm-m3/mol) | Boiling Point (oC) | Density (g/cm3) | Koc (mL/g) | Kd (g/mL) | Retardation Coefficient |
|---|---|---|---|---|---|---|---|---|---|
| Tetrachloroethene (PCE) | 165.8 | 18.9 | 200 | 0.0174 | 121.4 | 1.63 | 364 | 0.364 | 3.48 |
| Trichloroethene (TCE) | 131.5 | 75 | 1,100 | 0.00937 | 86.7 | 1.46 | 126 | 0.126 | 1.86 |
| cis-1,2-Dichlororethene | 97 | 205 | 3,500 | 0.00374 | 60 | 1.28 | 86 | 0.086 | 1.58 |
| trans-1,2-Dichlororethene | 97 | 315 | 6,300 | 0.00916 | 48 | 1.26 | 59 | 0.059 | 1.40 |
| 1,1-Dichloroethene | 97 | 603 | 3,350 | 0.0255 | 31.9 | 1.22 | 65 | 0.065 | 1.44 |
| Vinyl Chloride (VC) | 62.5 | 2660 | 1,100 | 0.7 | -13.9 | 0.91 | 57 | 0.057 | 1.39 |



US Army Corps of Engineers

MAIN MANUFACTURING AREA
SWMU STAGES OF INVESTIGATION

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

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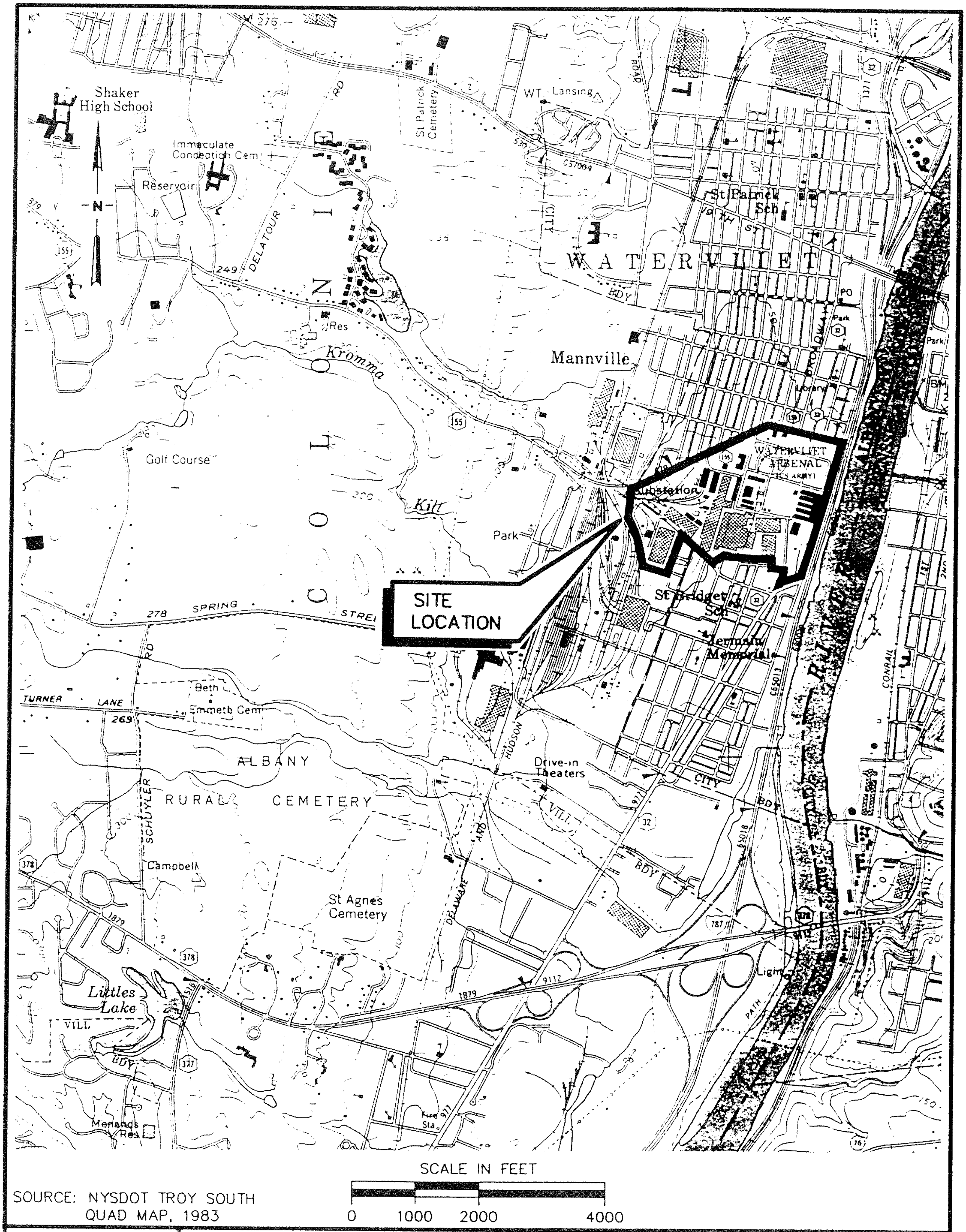
MALCOLM PIRNIE, INC.

FIGURE 1-1



SOURCE: NYSDOT TROY SOUTH
QUAD MAP, 1983

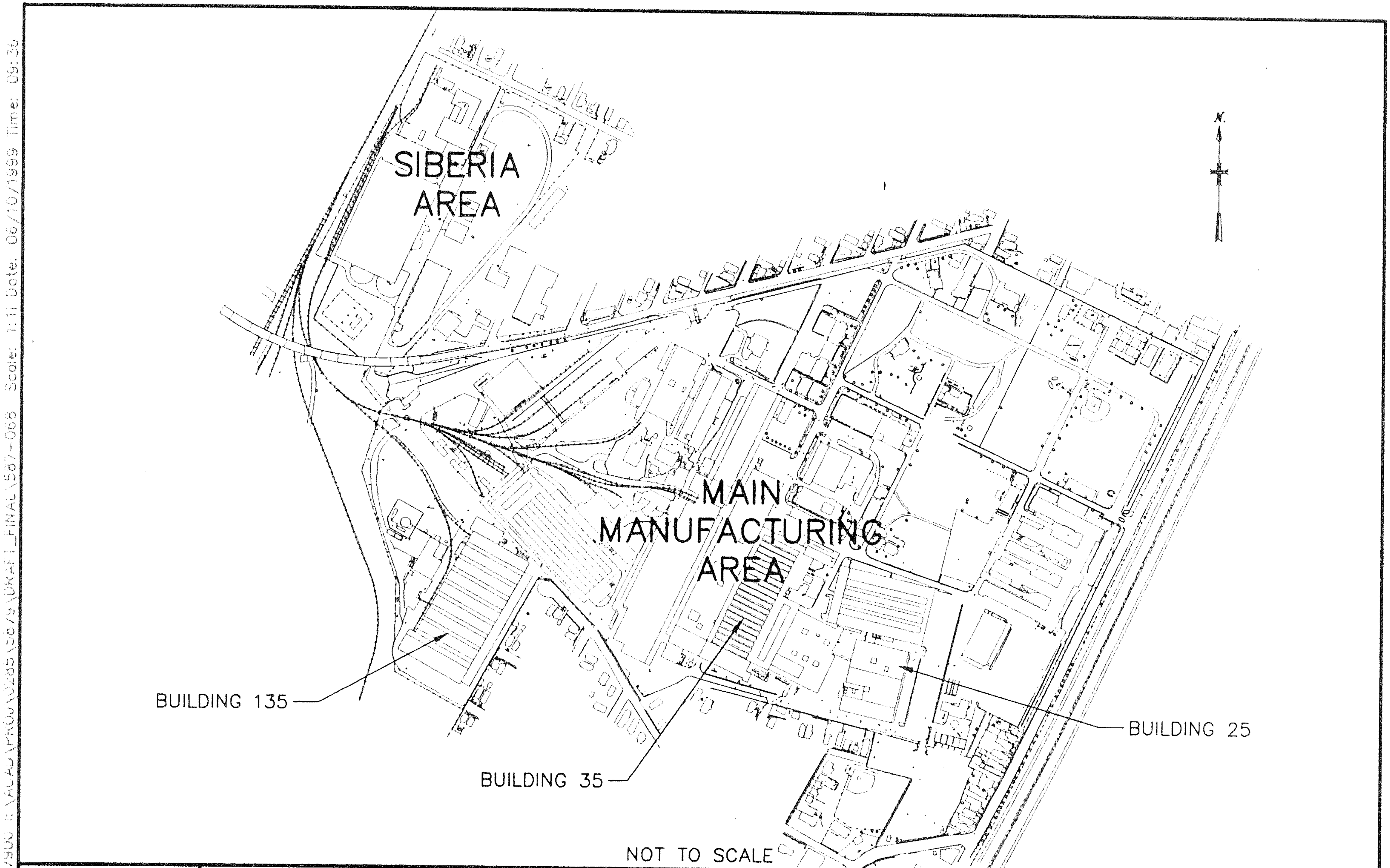
US Army Corps
of Engineers

MAIN MANUFACTURING AREA
SITE LOCATION MAP

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 1-2



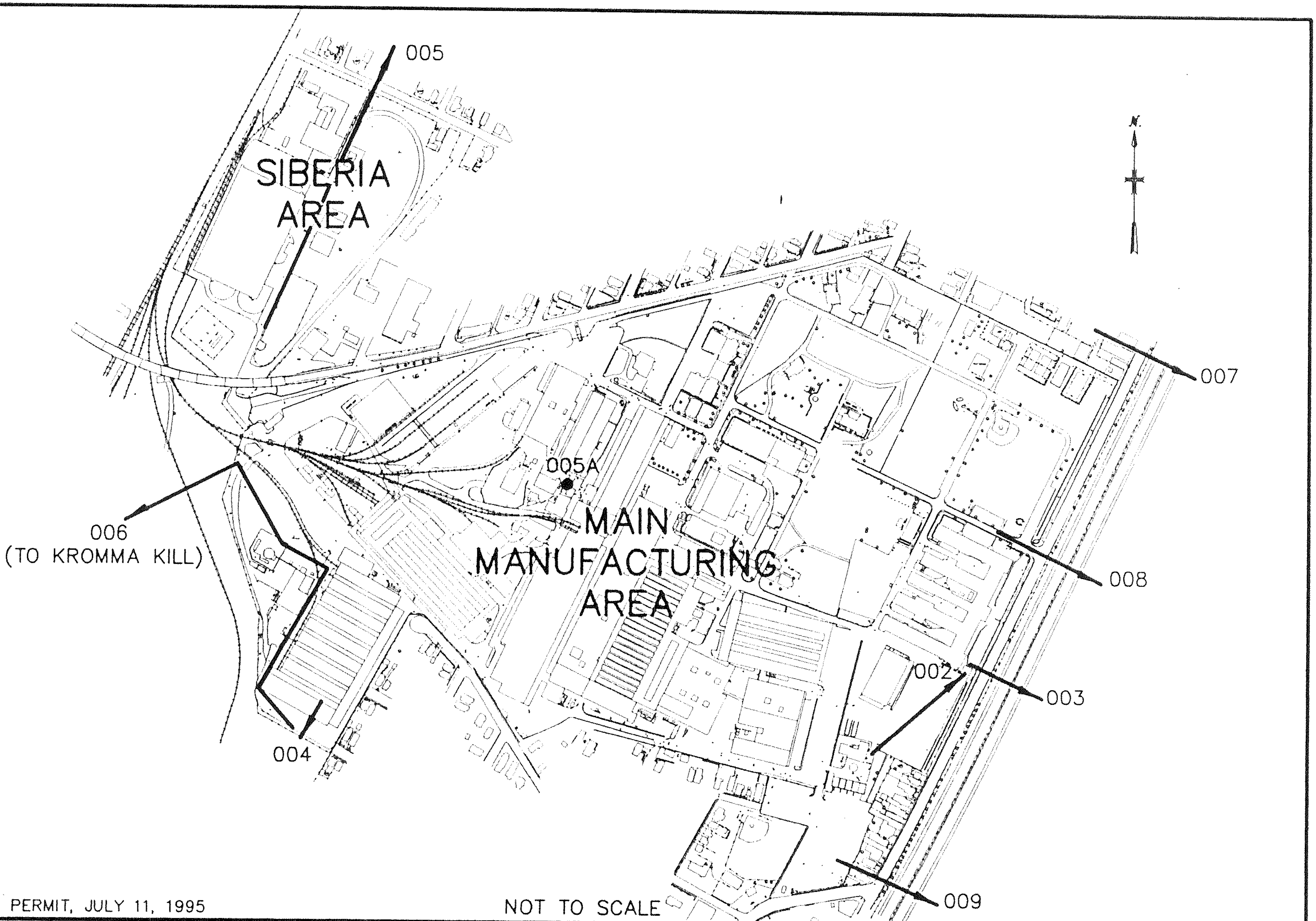
US Army Corps of Engineers

MAIN MANUFACTURING AREA
SITE PLAN

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 1-3



SOURCE: SPDES PERMIT, JULY 11, 1995

NOT TO SCALE

US Army Corps of Engineers

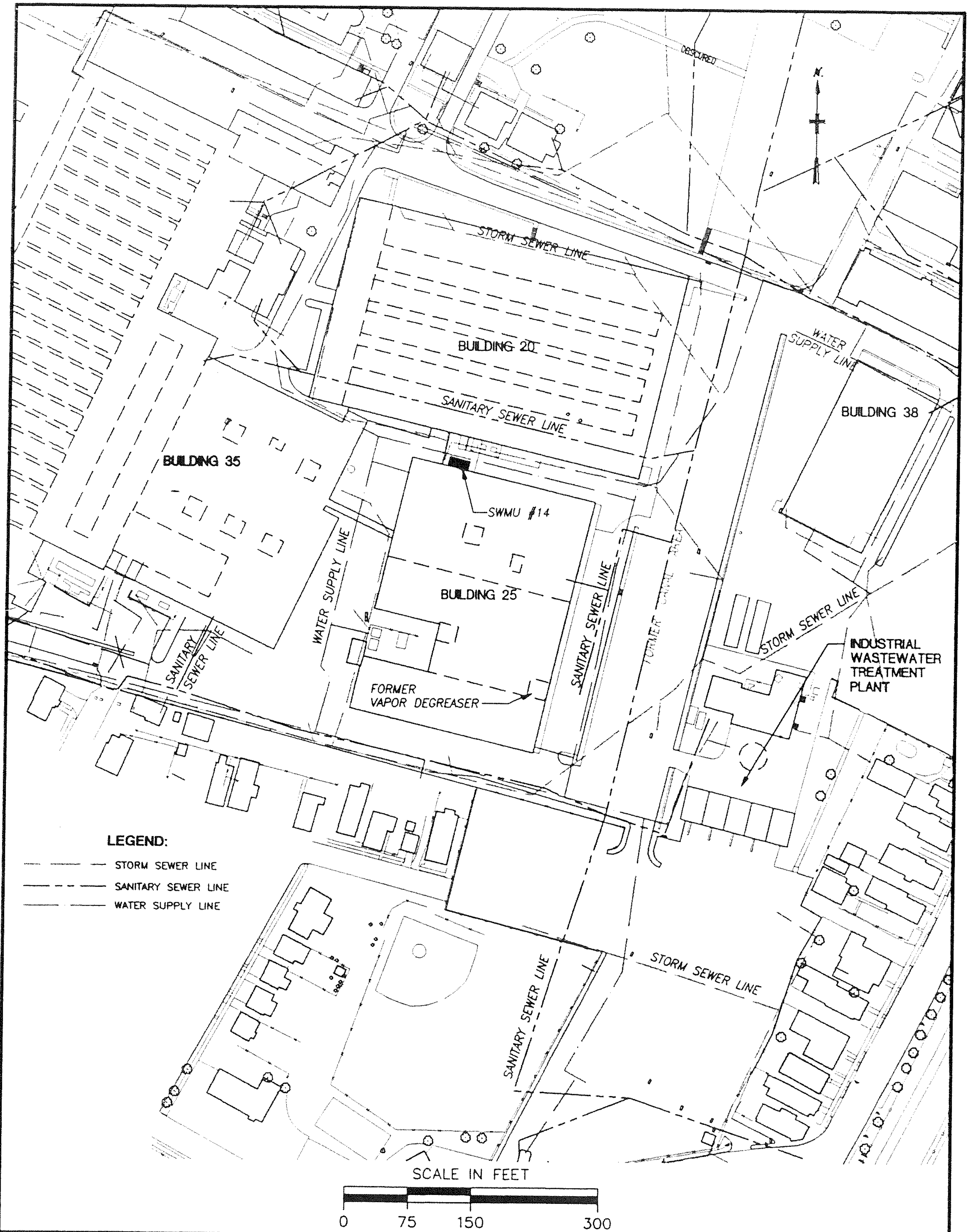
MAIN MANUFACTURING AREA
OUTFALL MAP

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 1-4

XREF: I:\ACAD\PROJ\0285\5879\DRAFT_FINAL\BASEWIDE



US Army Corps of Engineers

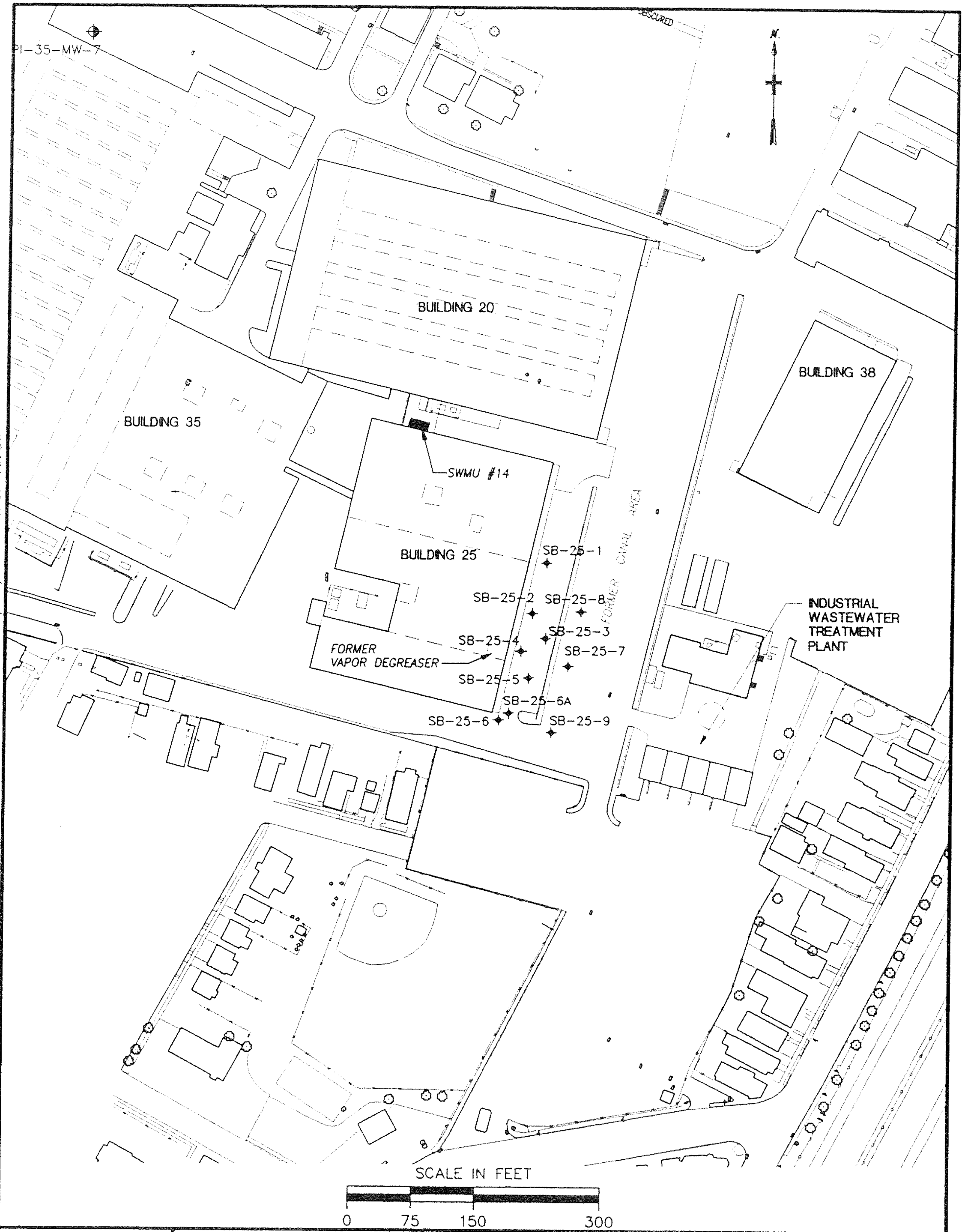
MAIN MANUFACTURING AREA
UTILITY MAP
BUILDING 25

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 1-5

7808 0285587900 I:\ACAD\PROJ\0285\5879\DRAFT_FINAL\25-COM-A Scale: 1:1i Date: 06/09/1999 Time: 16:39



US Army Corps of Engineers

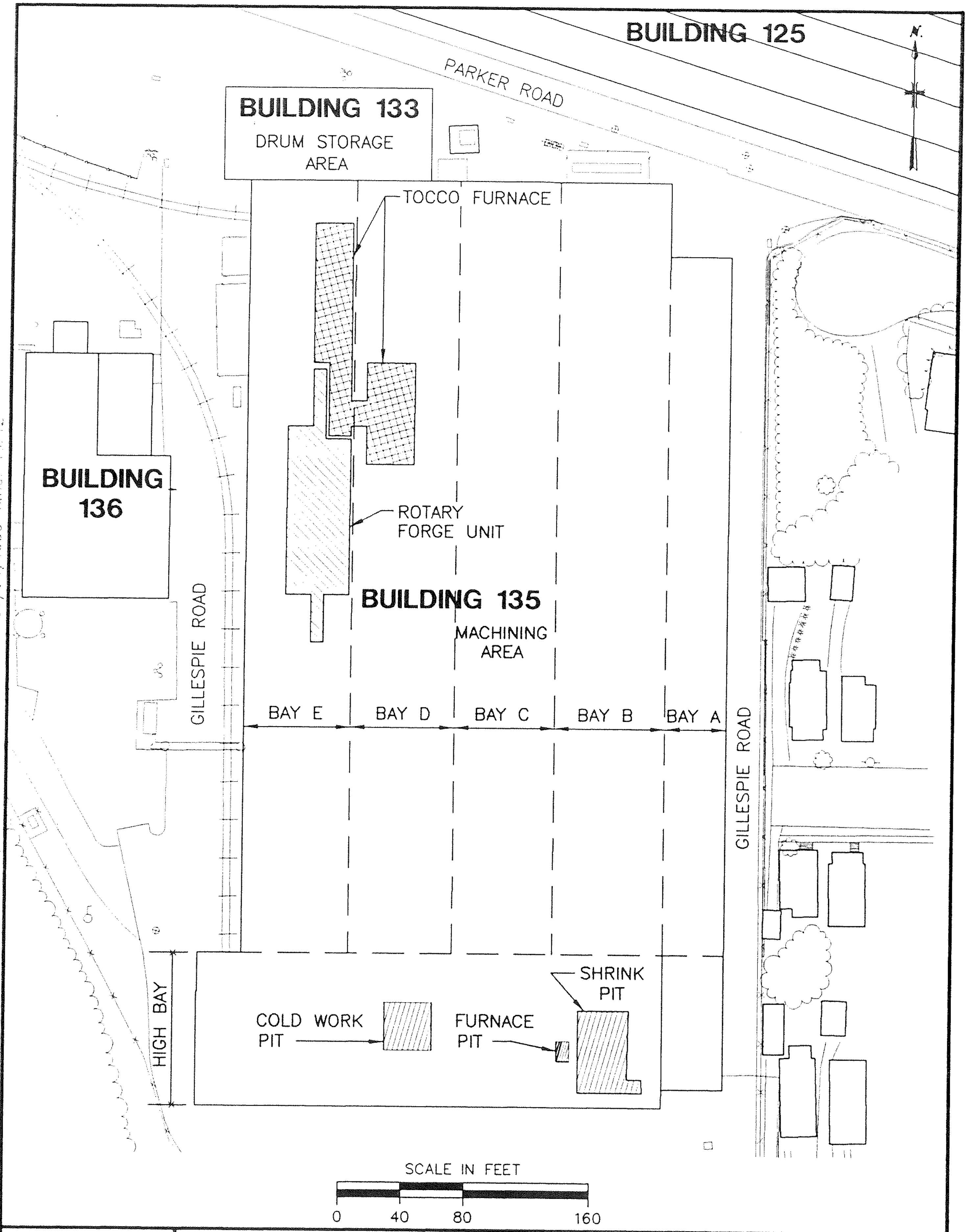
MAIN MANUFACTURING AREA
SOIL BORING LOCATIONS – C.T.MALE INVESTIGATIONS
BUILDING 25

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 1-6

7808 028558790O I:\ACAD\PROJ\0285\5879\BERGER2\25-COM-B Scale: 1:01 Date: 06/09/1999 Time: 16:38



US Army Corps of Engineers

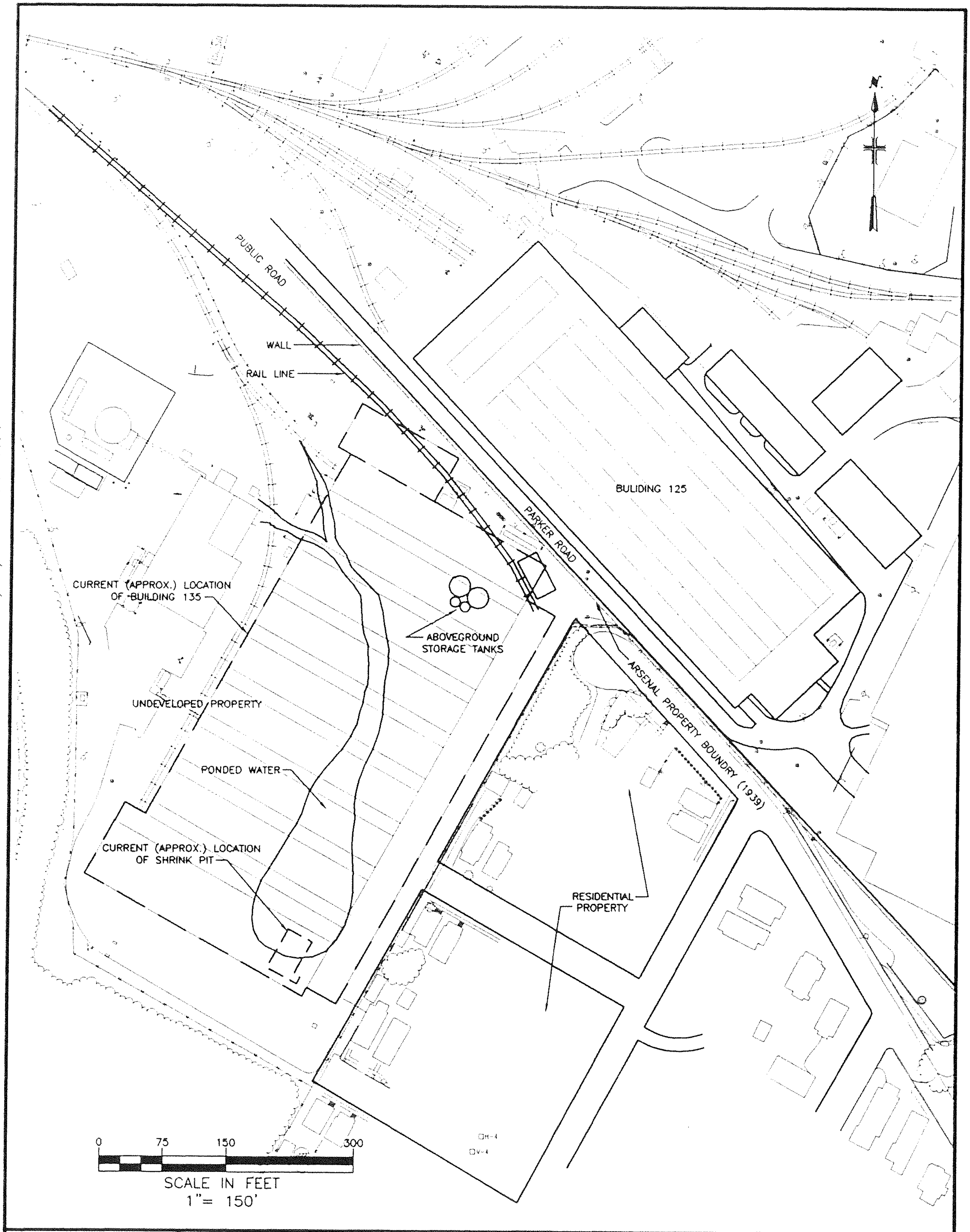
MAIN MANUFACTURING AREA
FLOOR PLAN
BUILDING 135

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 1-7

7308 0285587900 I:\ACAD\PROJ\0285\5879\DRAFT_FINAL\135-CFP Scale: 1:1 Date: 06/09/1999 Time: 15:42



US Army Corps of Engineers

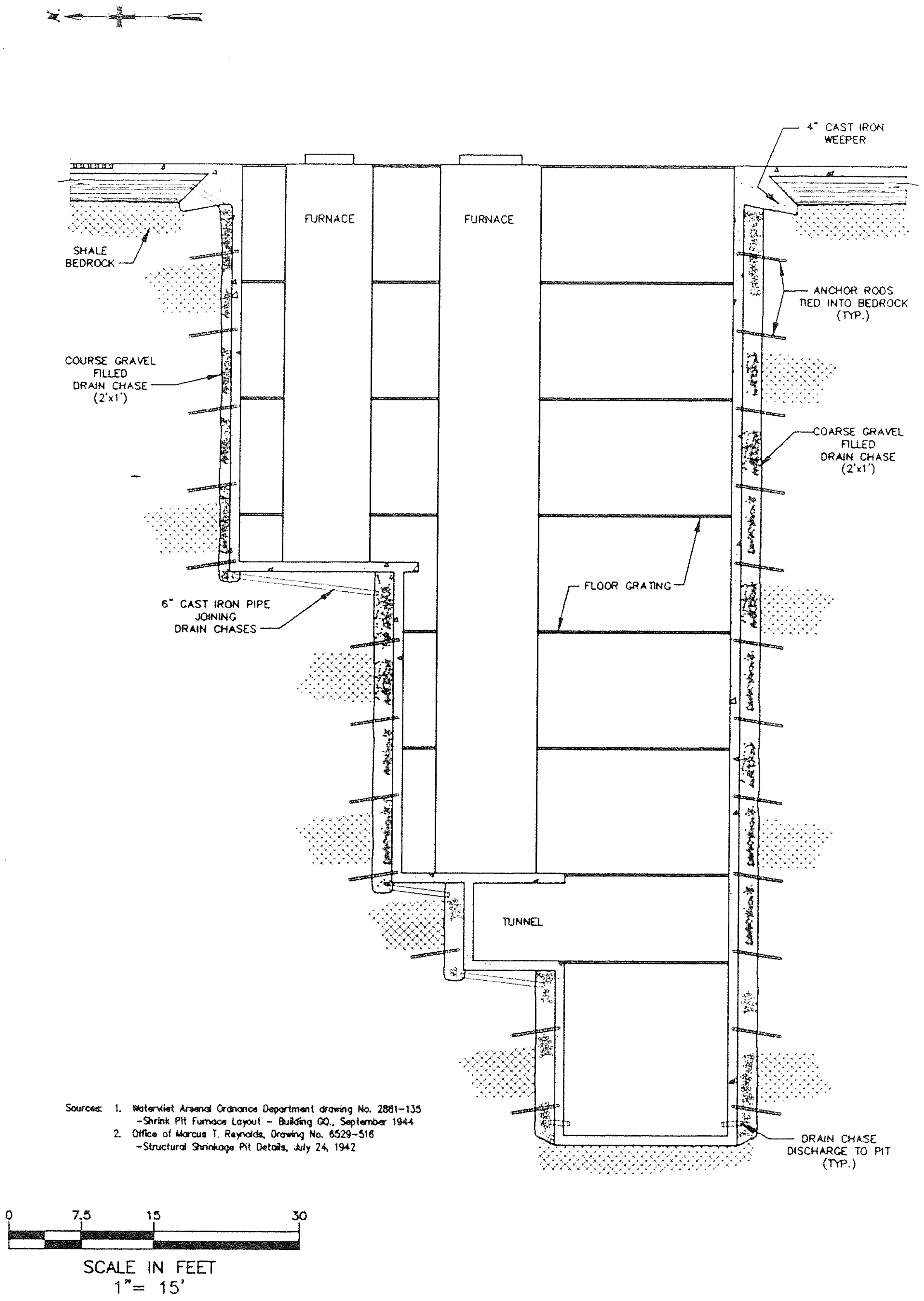
GRAPHICAL REPRESENTATION
OF 1939 AERIAL PHOTOGRAPHS, BUILDING 135

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 1-8

7808 0285587900 I:\ACAD\PROJ\0285\5879\DRAFT_FINAL\135-1939 Scale: 1:1 Date: 06/09/1999 Time: 10:44



Sources:
1. Watervliet Arsenal Ordnance Department drawing No. 2881-135 -Shrink Pit Furnace Layout - Building GQ., September 1944
2. Office of Marcus T. Reynolds, Drawing No. 6529-516 -Structural Shrinkage Pit Details, July 24, 1942

US Army Corps of Engineers

MAIN MANUFACTURING AREA
NORTH-SOUTH GENERALIZED CROSS-SECTION
THROUGH SHRINK PIT, BUILDING 135

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

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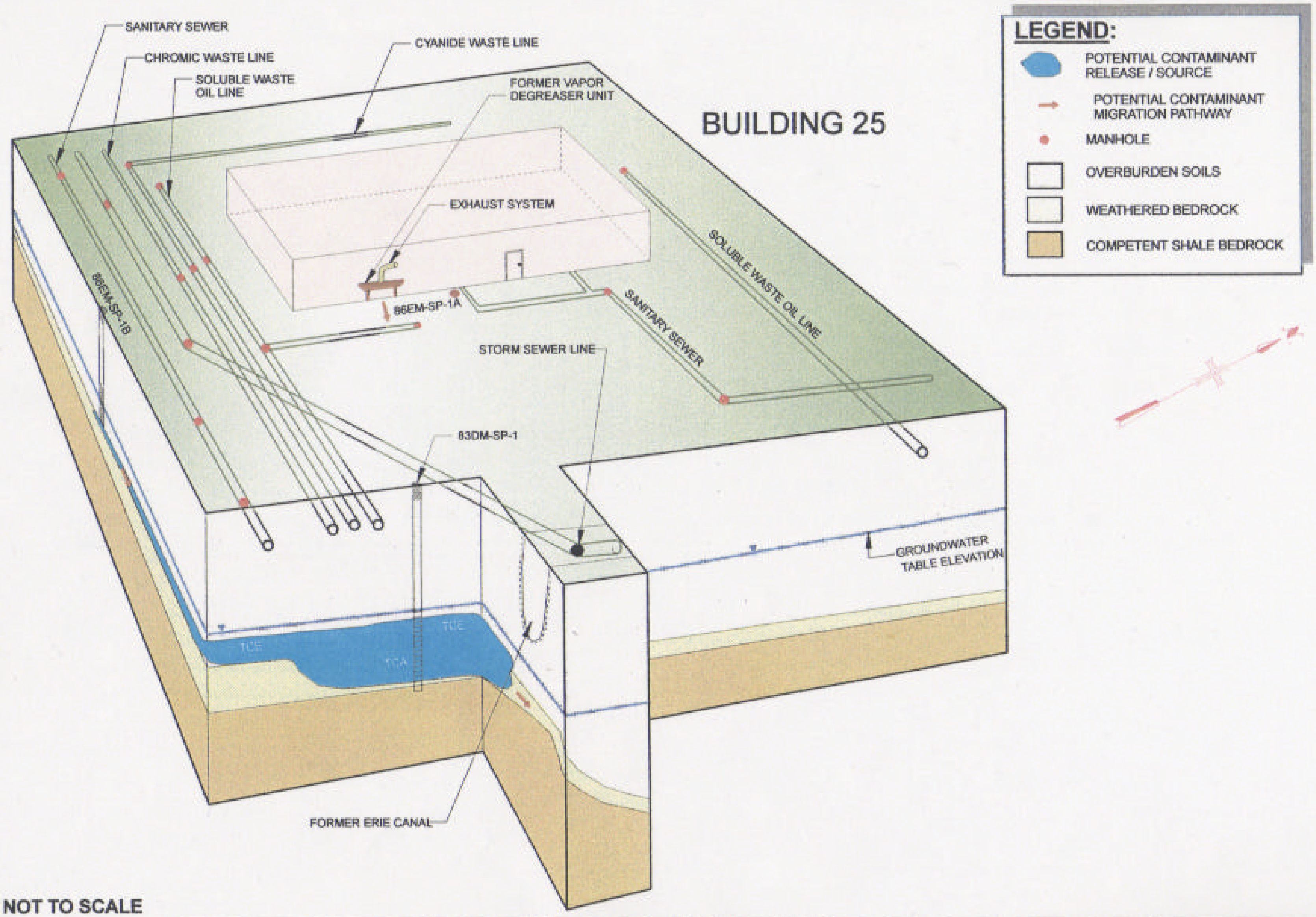
FIGURE 1-9

7808 0285587900 F:\ACAD\PROJ\0285\5879\DRAFT_FINAL\135-SPX Scale: 1:1 Date: 06/09/1999 Time: 16:47

*WVA-CSM / 28OCT96*



**NOT TO SCALE**

US Army Corps of Engineers

WATERVLIET ARSENAL

## CONCEPTUAL SITE MODEL
## BUILDING 25

USACE CONTRACT NO. DACA31-94-D-0017

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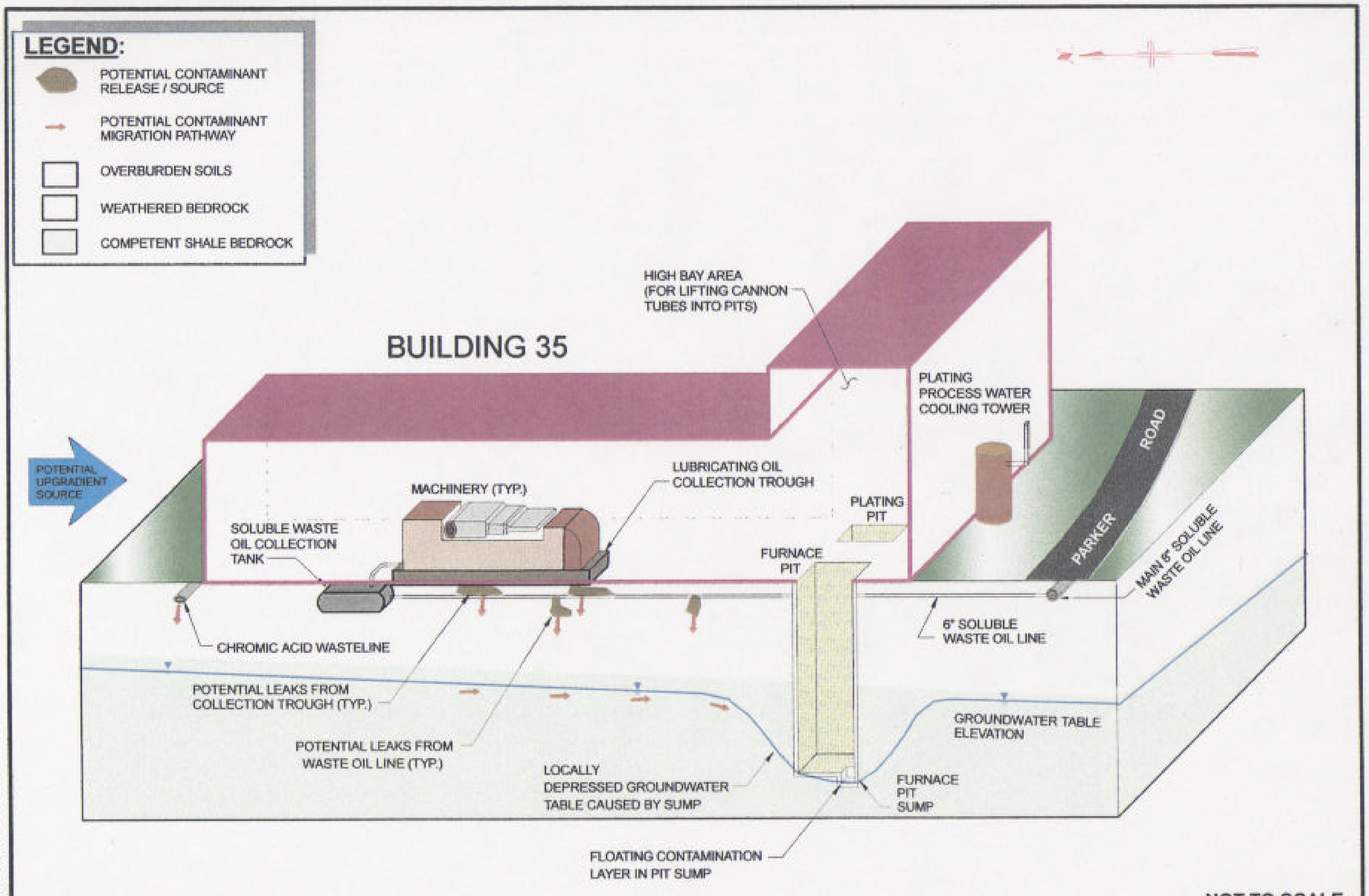
MALCOLM PIRNIE, INC.

**Figure 1-10**



NOT TO SCALE

US Army Corps of Engineers

WATERVLIET ARSENAL

# CONCEPTUAL SITE MODEL
# BUILDING 35

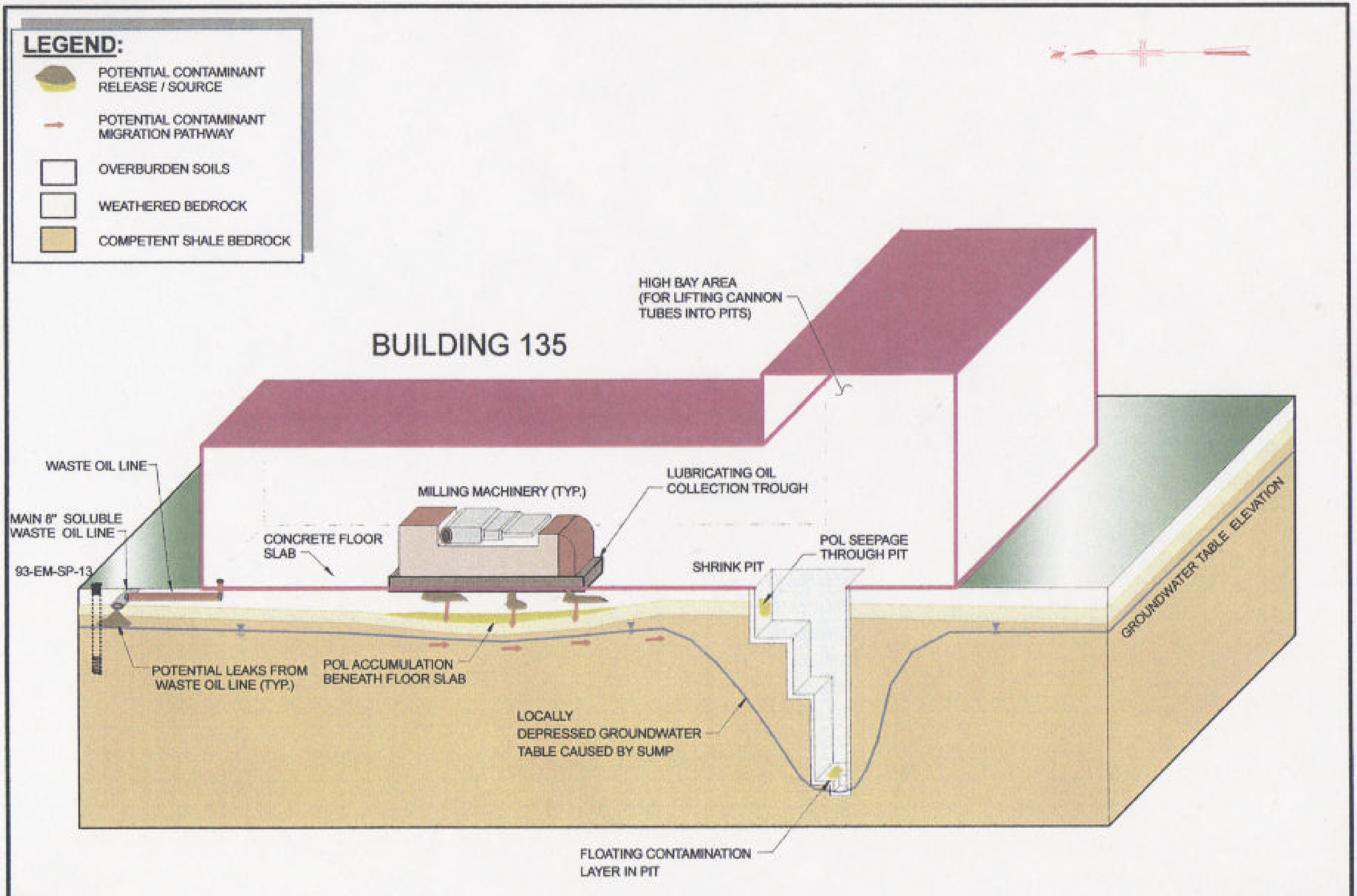
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

Figure 1-11

I:\PROJECT\0285587\FREELANC\WVA-CSM.PRE

*WVA-CSM / 08MAR96*



NOT TO SCALE

US Army Corps
of Engineers

WATERVLIET ARSENAL

**CONCEPTUAL SITE MODEL**
**BUILDING 135**

USACE CONTRACT NO. DACA31-94-D-0017

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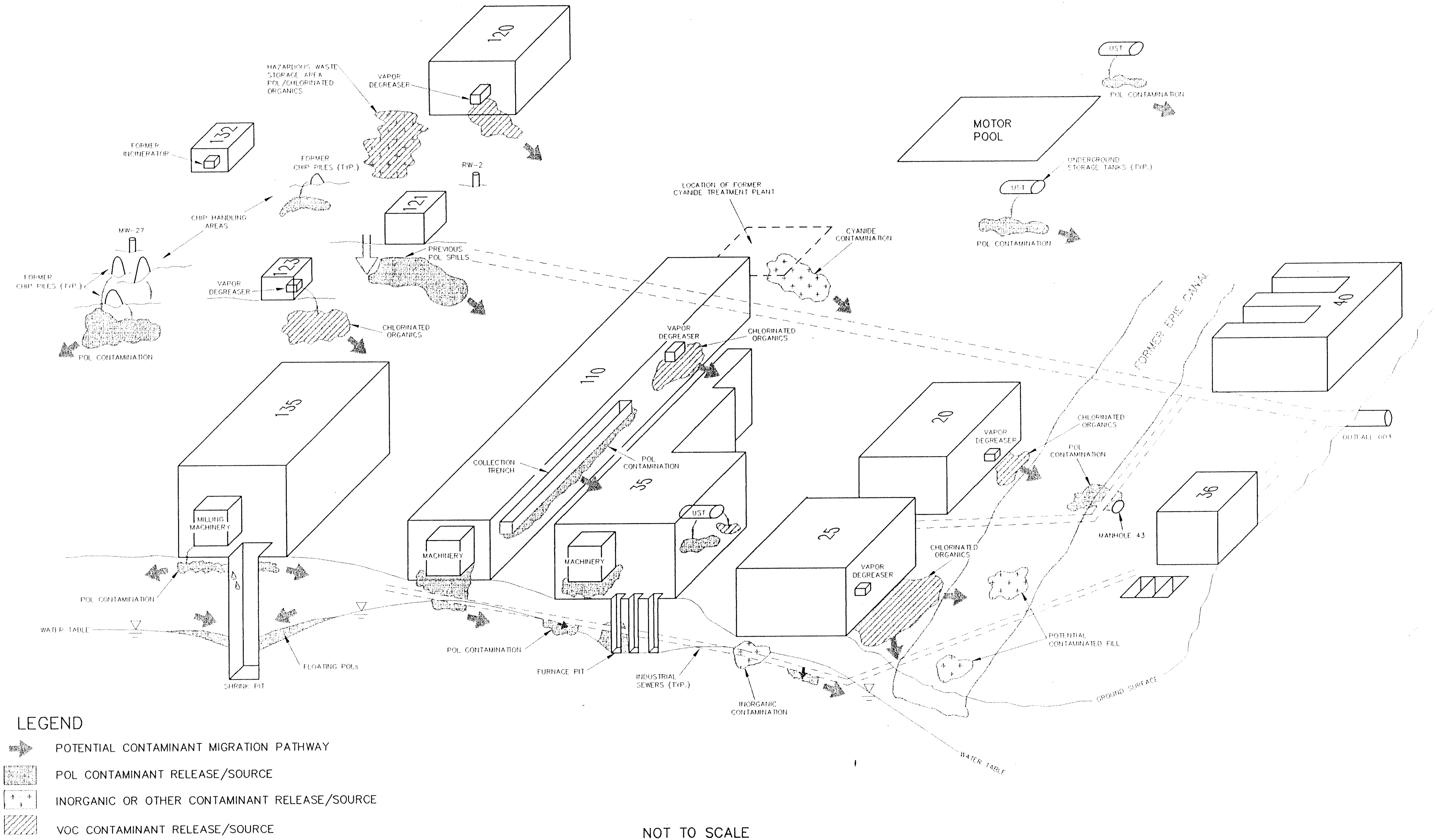
MALCOLM PIRNIE, INC.

**Figure 1-12**



## LEGEND

➔ POTENTIAL CONTAMINANT MIGRATION PATHWAY

▒ POL CONTAMINANT RELEASE/SOURCE

+ INORGANIC OR OTHER CONTAMINANT RELEASE/SOURCE

▨ VOC CONTAMINANT RELEASE/SOURCE

NOT TO SCALE

7808 0285587900 I:\ACAD\PROJ\0285\5879\DRAFT_FINAL\587-071 Scale: 1:1 Date: 06/09/1999 Time: 16:31

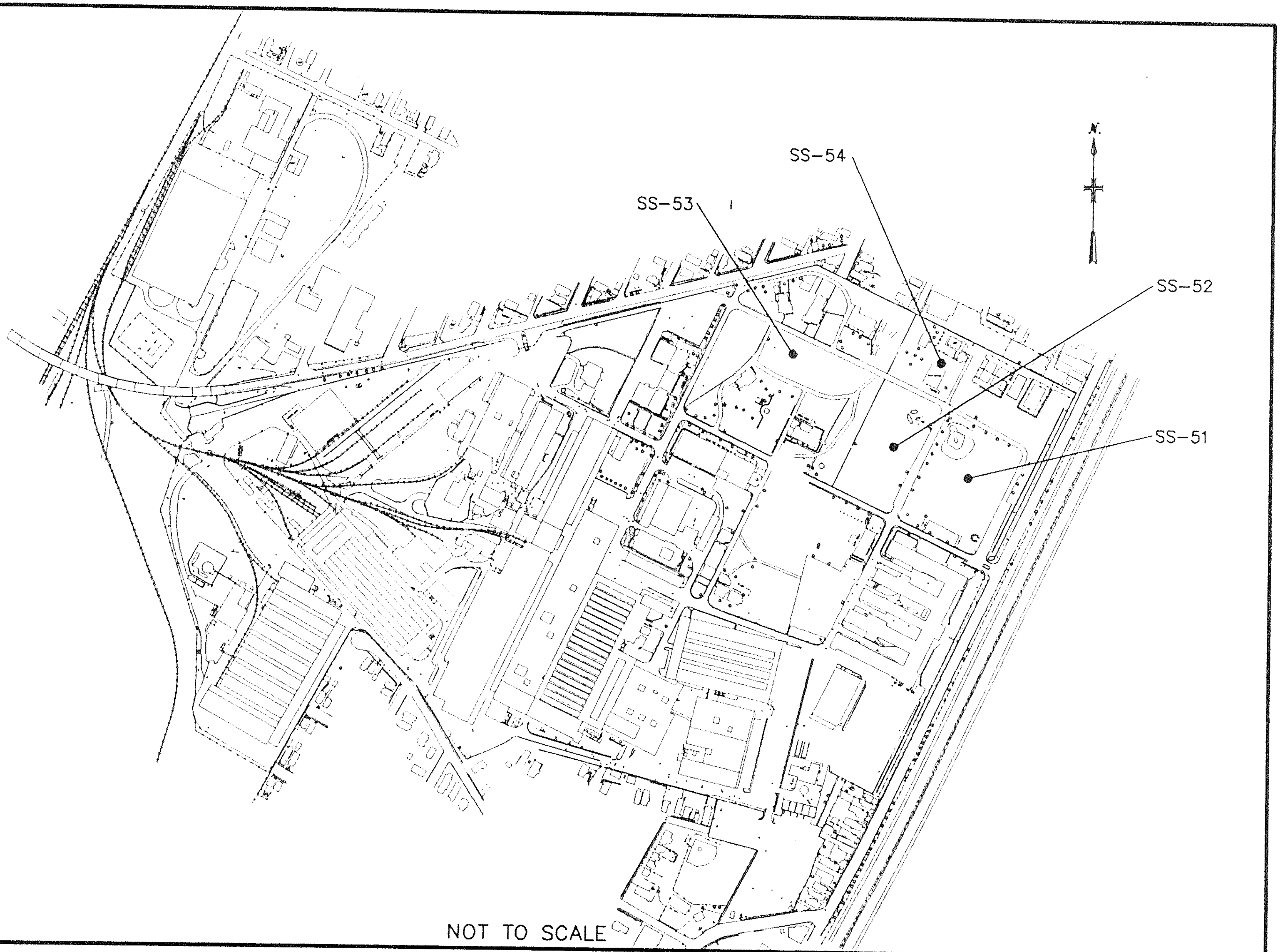
US Army Corps of Engineers

MAIN MANUFACTURING AREA
PRE-INVESTIGATION SITE CONCEPTUAL MODEL

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 1-13



NOT TO SCALE

US Army Corps
of Engineers

MAIN MANUFACTURING AREA
BACKGROUND SHALLOW SOIL SAMPLE LOCATIONS

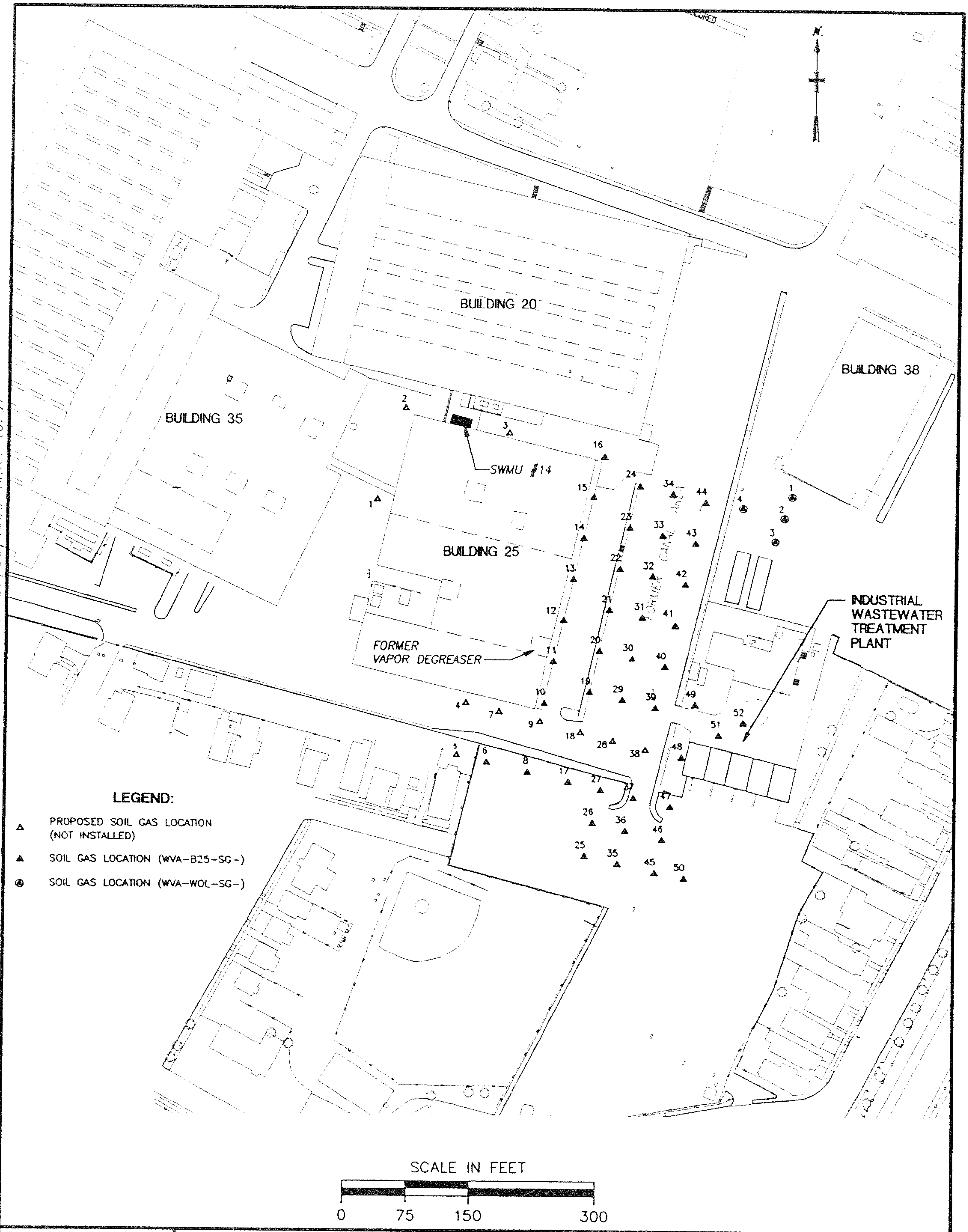
WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 3-1

Job: 02856/900 I:\ACAD\PROJ\0285\5879\DRAFT_FINAL\591-13 Scale: 1:401 Date: 06/09/1999 Time: 16:55

XREF] I:\ACAD\PROJ\0285\DRAFT_FINAL\BASEWIDE



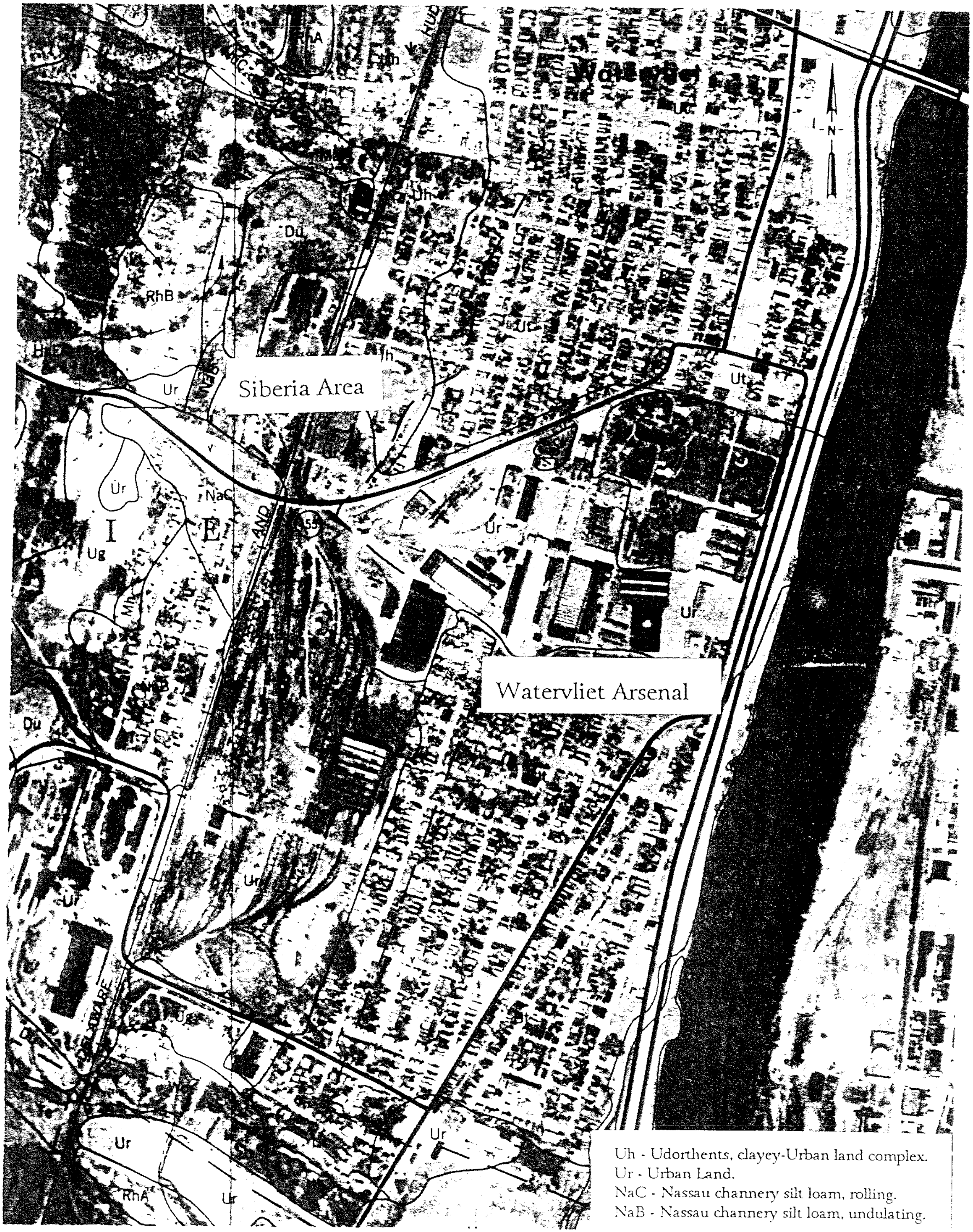
US Army Corps of Engineers

MAIN MANUFACTURING AREA
SOIL GAS SAMPLING LOCATIONS
BUILDING 25

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 3-2



US Army Corps of Engineers

SURFACE SOIL MAP

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

COPYRIGHT © 1995
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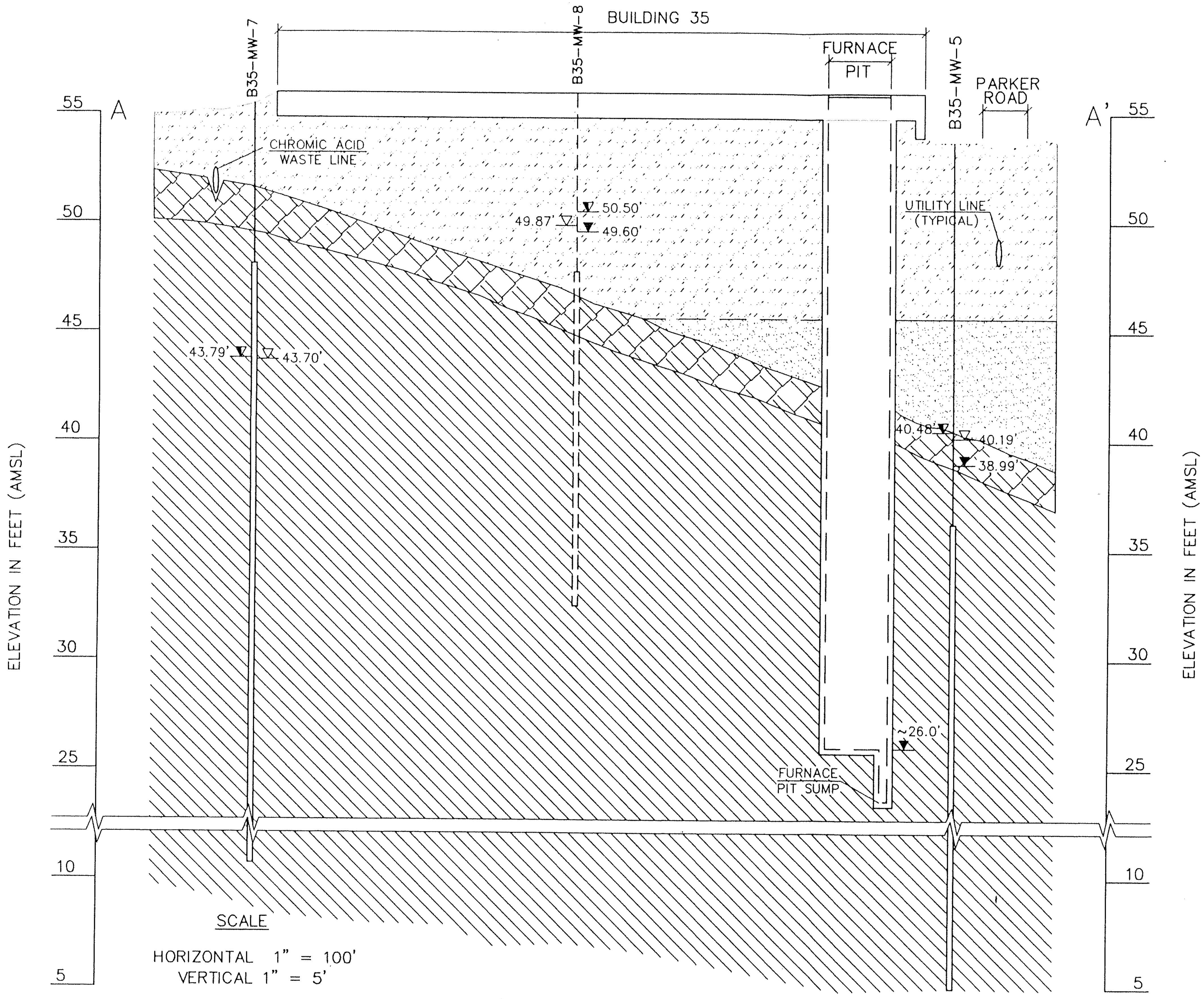
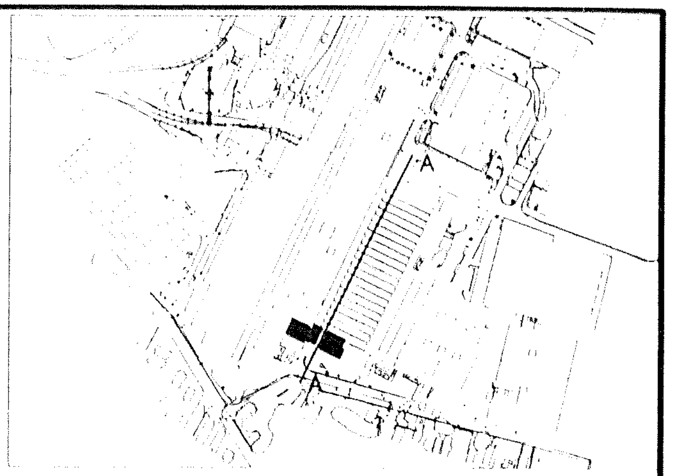
FIGURE 4-1



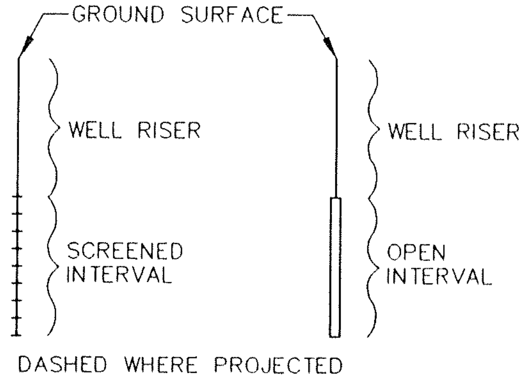
SCALE

HORIZONTAL 1" = 100'
VERTICAL 1" = 5'



# LEGEND

- ▼ WATER LEVEL ELEVATIONS MEASURED 2-11-99
- ▽ WATER LEVEL ELEVATIONS MEASURED 5-20-96
- ▼ WATER LEVEL ELEVATIONS MEASURED 9-11-95



NOTES

1. FOUR (4) KNOWN UTILITY LINES RUN UNDER PARKER ROAD TO THE SOUTH OF BUILDING 35. THEY ARE:

   A) SOLUBLE OIL WASTE
   B) CHROMIC ACID WASTE
   C) STORM SEWER
   D) WATER MAIN

| | | | |
|---|---|---|---|
| ⛆ | FILL | ⛆ | COARSE ALLUVIUM |
| ▩ | WEATHERED BEDROCK | ▨ | BEDROCK |

US Army Corps of Engineers

MAIN MANUFACTURING AREA
CROSS-SECTION A-A', BUILDING 35

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

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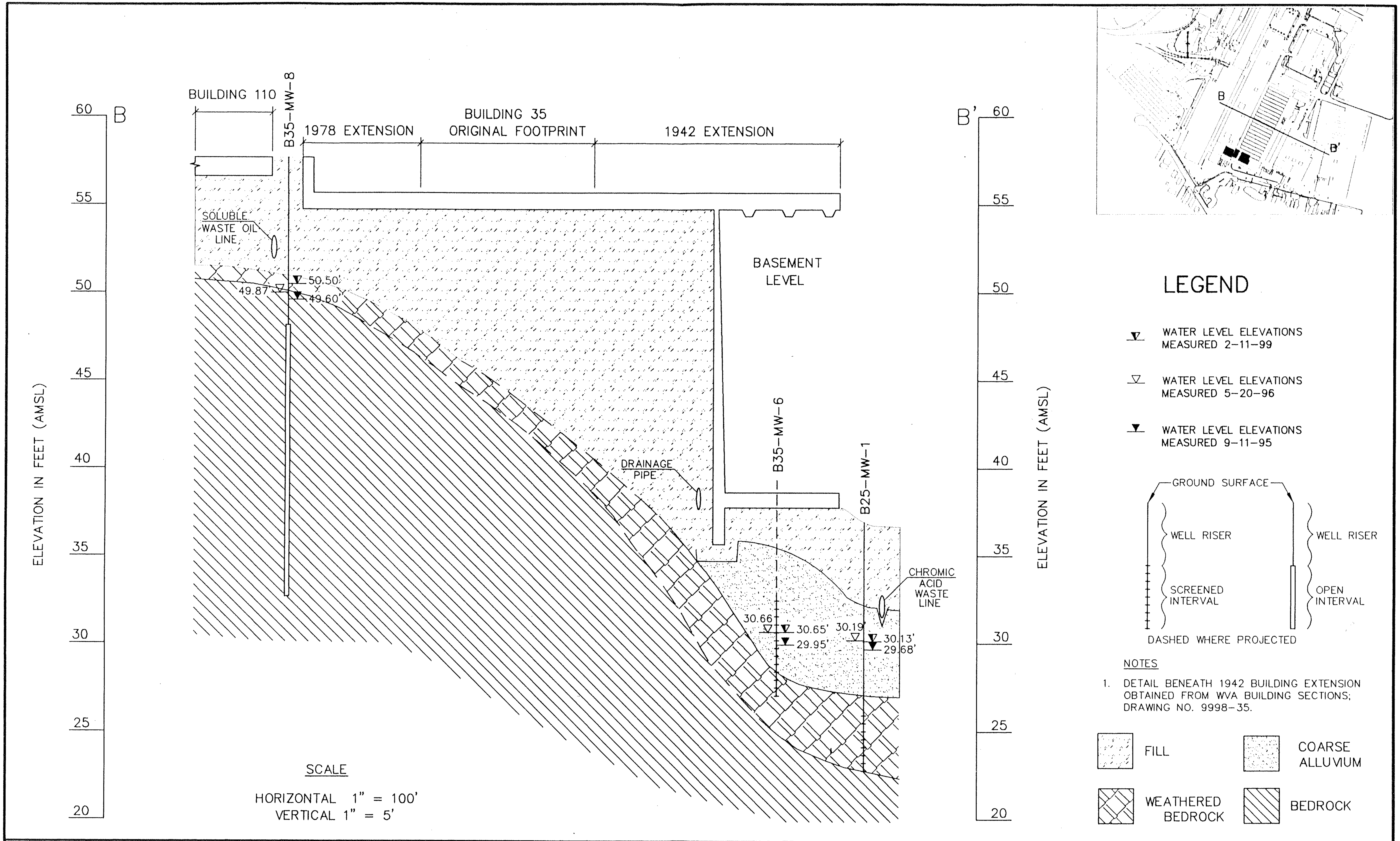
FIGURE 4-2



NOTES

1. DETAIL BENEATH 1942 BUILDING EXTENSION OBTAINED FROM WVA BUILDING SECTIONS; DRAWING NO. 9998-35.

US Army Corps of Engineers

MAIN MANUFACTURING AREA
CROSS-SECTION B-B', BUILDING 35

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

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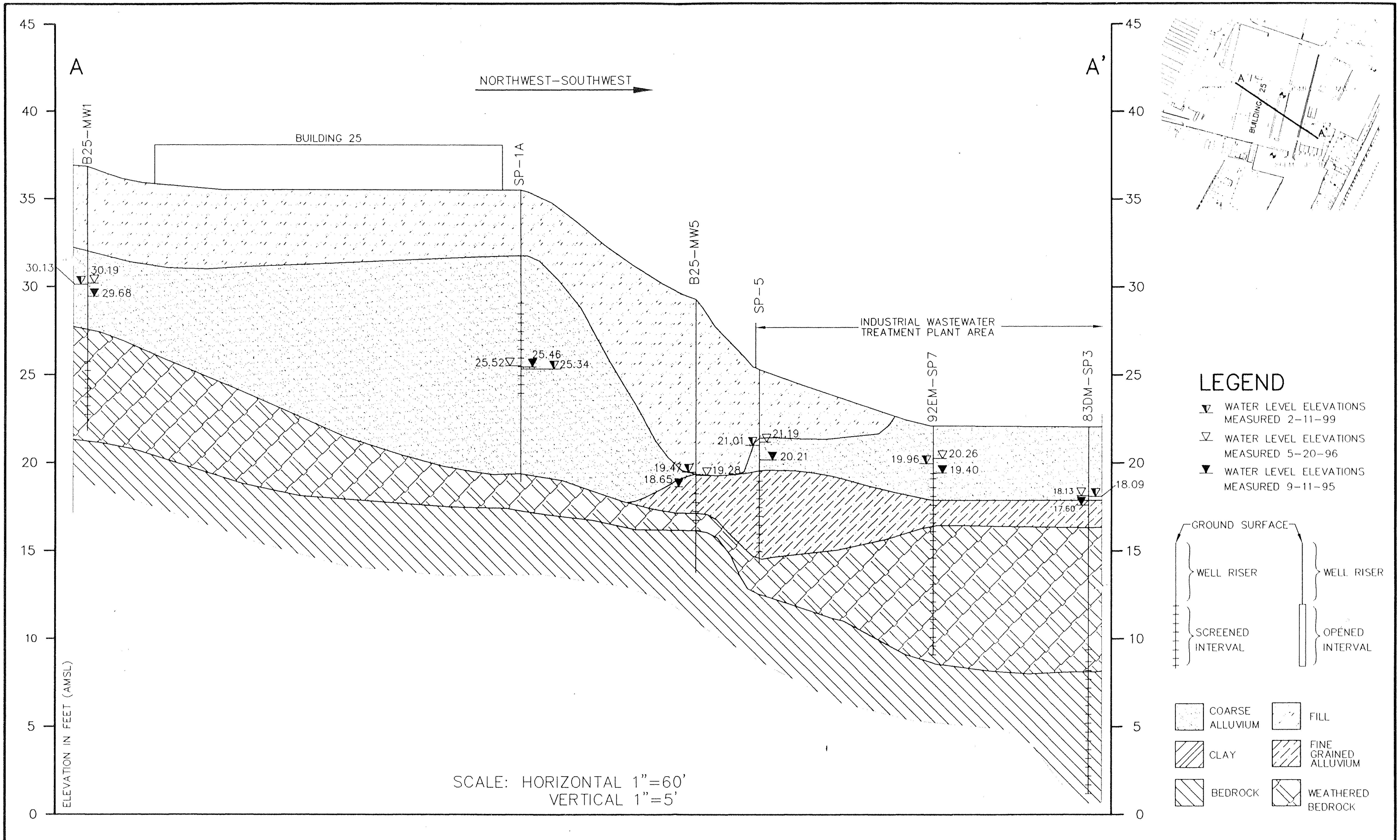
FIGURE 4-3

7308 02855879... :\ACAD\PROJ\0285\5879\DRAFT_FINAL\354BB_2 Scale: 1:1 Date: 06/09/1999 Time: 17:03



US Army Corps of Engineers

MAIN MANUFACTURING AREA
GEOLOGIC CROSS–SECTION A–A', BUILDING 25

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31–94–D–0017

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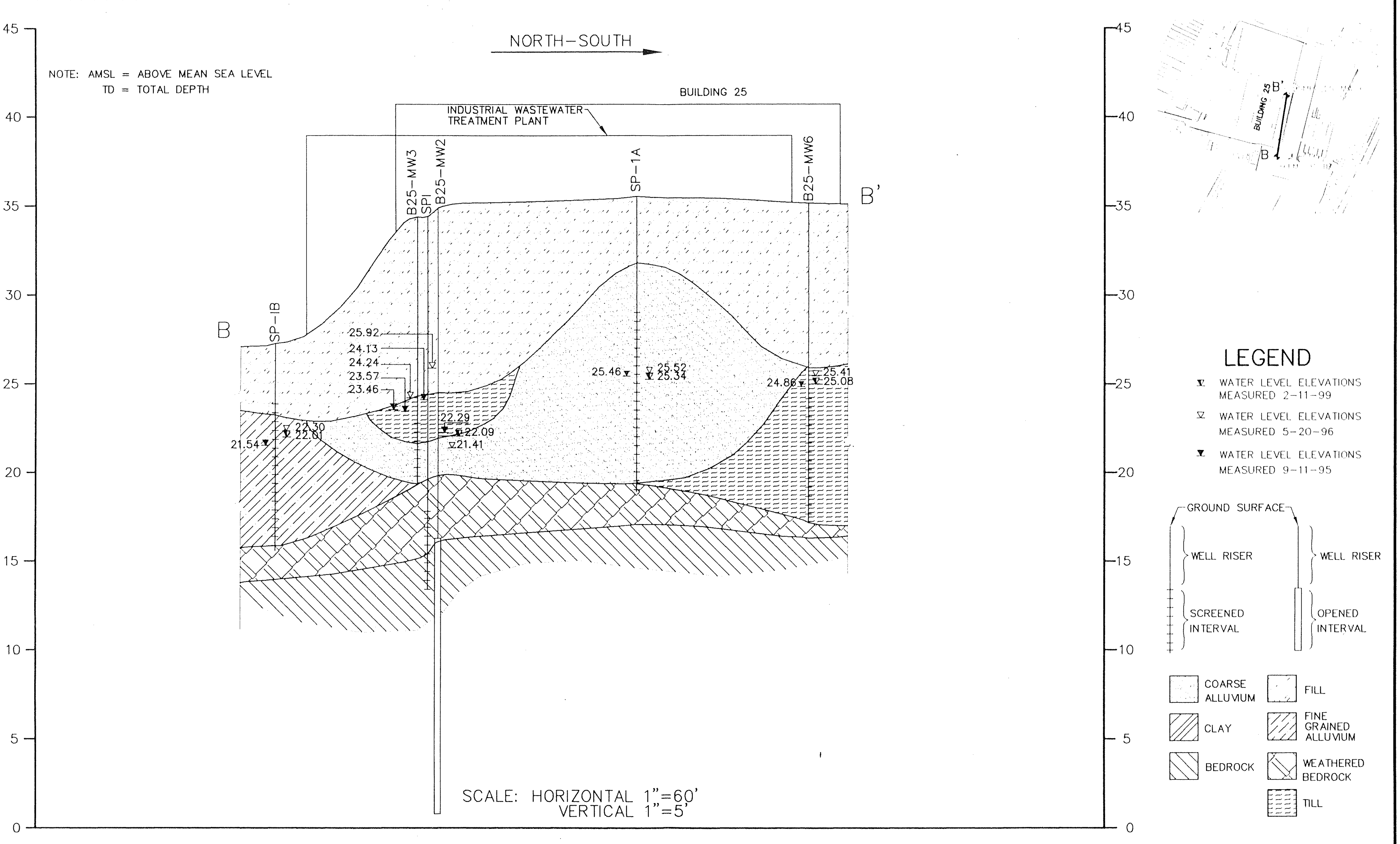
FIGURE 4–4



US Army Corps of Engineers

MAIN MANUFACTURING AREA
GEOLOGIC CROSS-SECTION B-B', BUILDING 25

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

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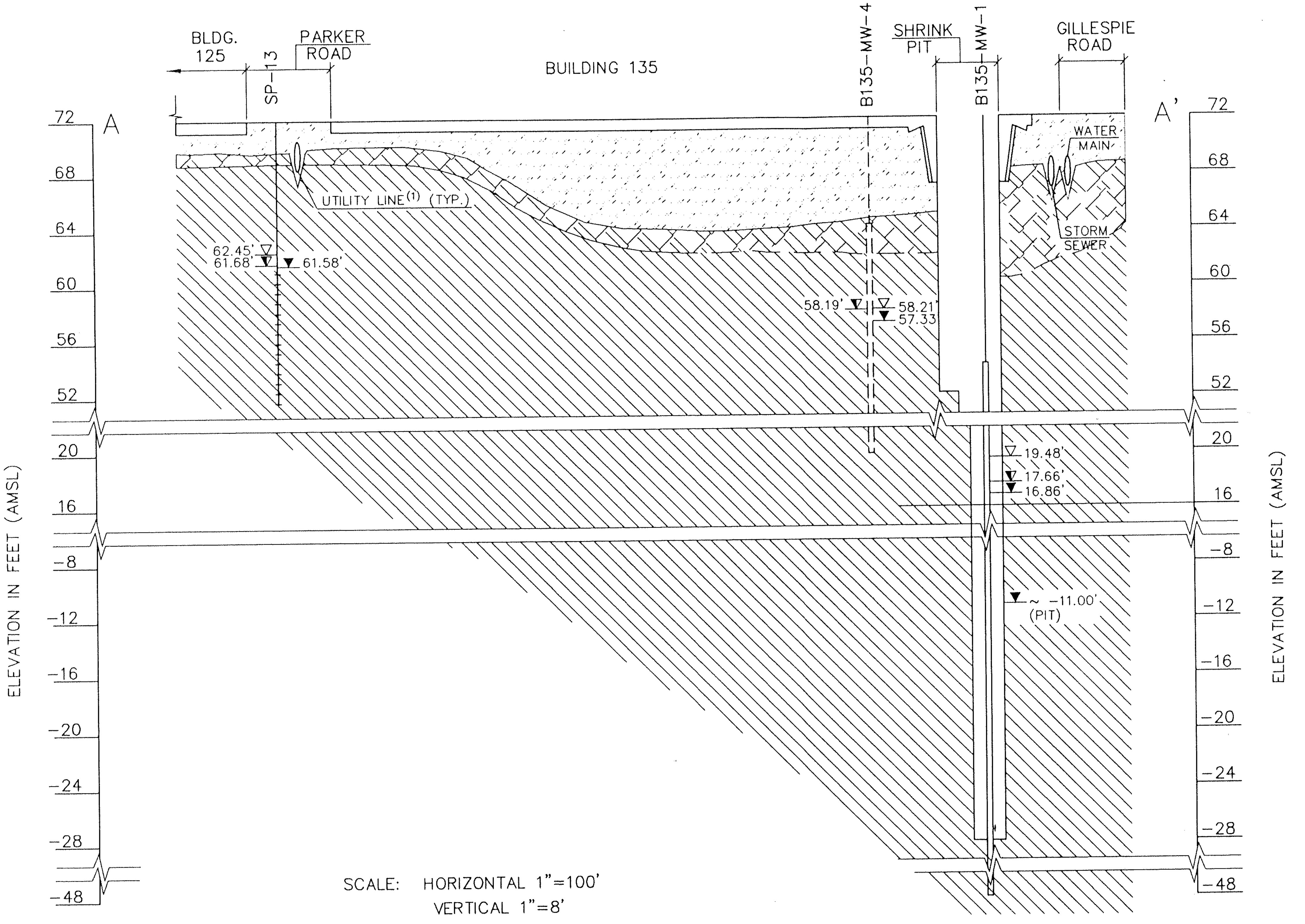
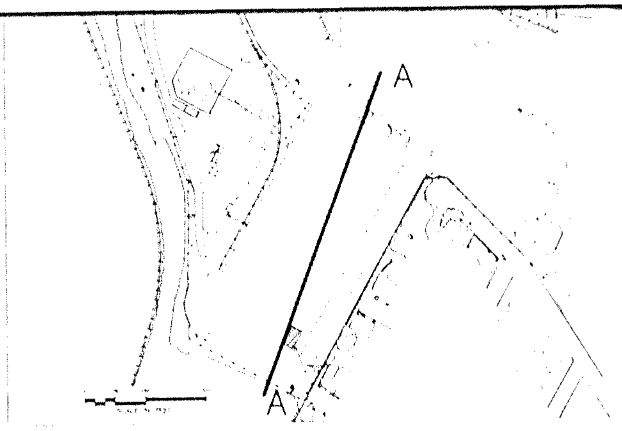
FIGURE 4-5



SCALE: HORIZONTAL 1"=100'
VERTICAL 1"=8'

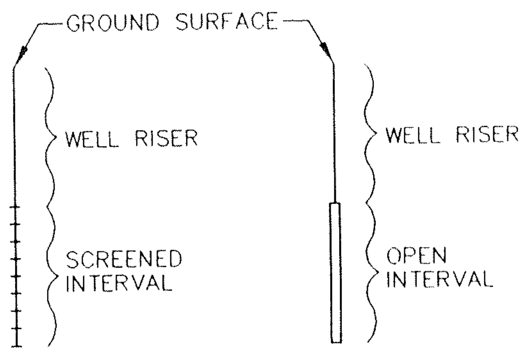


## LEGEND

▼ WATER LEVEL ELEVATIONS MEASURED 2-11-99

▽ WATER LEVEL ELEVATIONS MEASURED 5-20-96

▼ WATER LEVEL ELEVATIONS MEASURED 9-11-95



DASHED WHERE PROJECTED

NOTES

1. FOUR (4) KNOWN UTILITY LINES RUN UNDER PARKER ROAD TO THE NORTH OF BUILDING 135. THEY ARE:

   A) SOLUBLE OIL WASTE
   B) CHROMIC ACID WASTE
   C) STORM SEWER
   D) WATER MAIN

2. BEDROCK SURFACE BENEATH BUILDING IS INFERRED FROM WVA TOPOGRAPHY PLAN DATED 1942, DRAWING NO. 6529-500.

| | |
|---|---|
| ▨ | FILL |
| ▨ | WEATHERED BEDROCK |
| ▨ | BEDROCK |

US Army Corps of Engineers

MAIN MANUFACTURING AREA
CROSS-SECTION A-A', BUILDING 135

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

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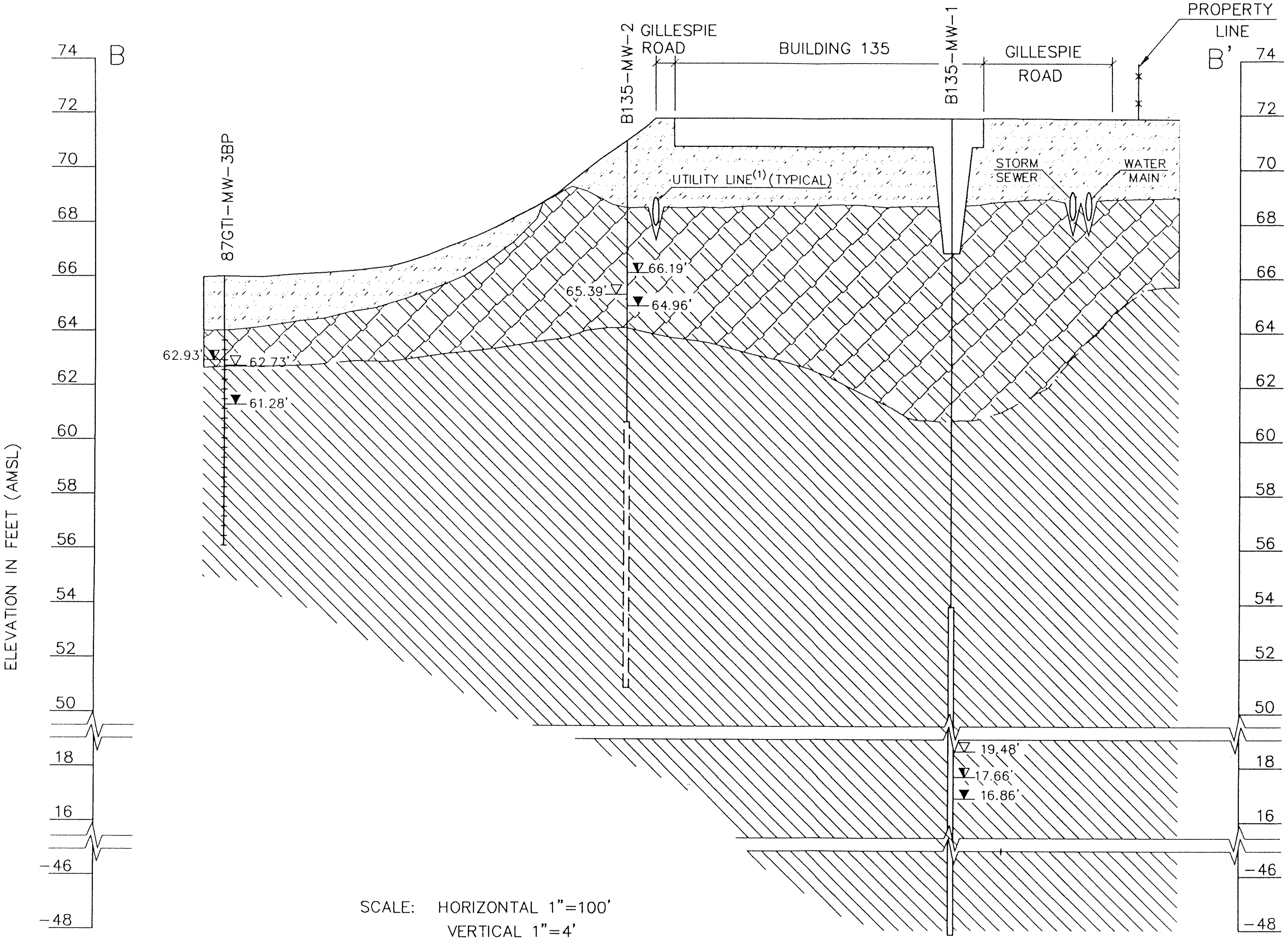
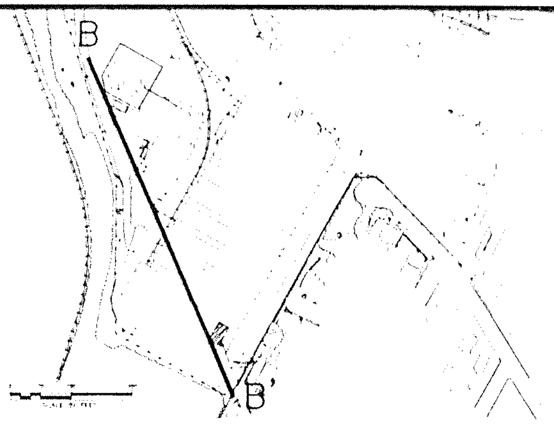
FIGURE 4-6



SCALE: HORIZONTAL 1"=100'
VERTICAL 1"=4'

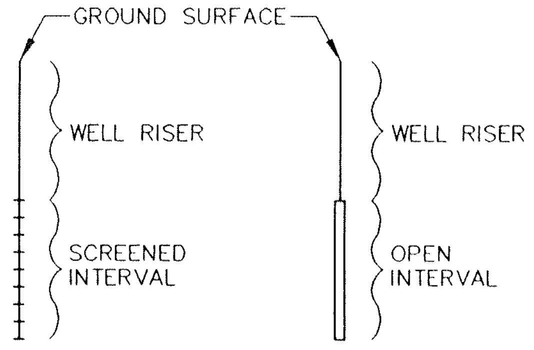


# LEGEND

▼ WATER LEVEL ELEVATIONS MEASURED 2-11-99

▽ WATER LEVEL ELEVATIONS MEASURED 5-20-96

▼ WATER LEVEL ELEVATIONS MEASURED 9-11-95



DASHED WHERE PROJECTED

NOTES

FOUR (4) KNOWN UTILITY LINES RUN UNDER GILLESPIE ROAD TO THE WEST OF BUILDING 135. THEY ARE:

A) SOLUBLE OIL WASTE
B) CHROMIC ACID WASTE
C) STORM SEWER
D) WATER MAIN

░ FILL

▨ WEATHERED BEDROCK

▧ BEDROCK

US Army Corps of Engineers

MAIN MANUFACTURING AREA
CROSS-SECTION B-B', BUILDING 135

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

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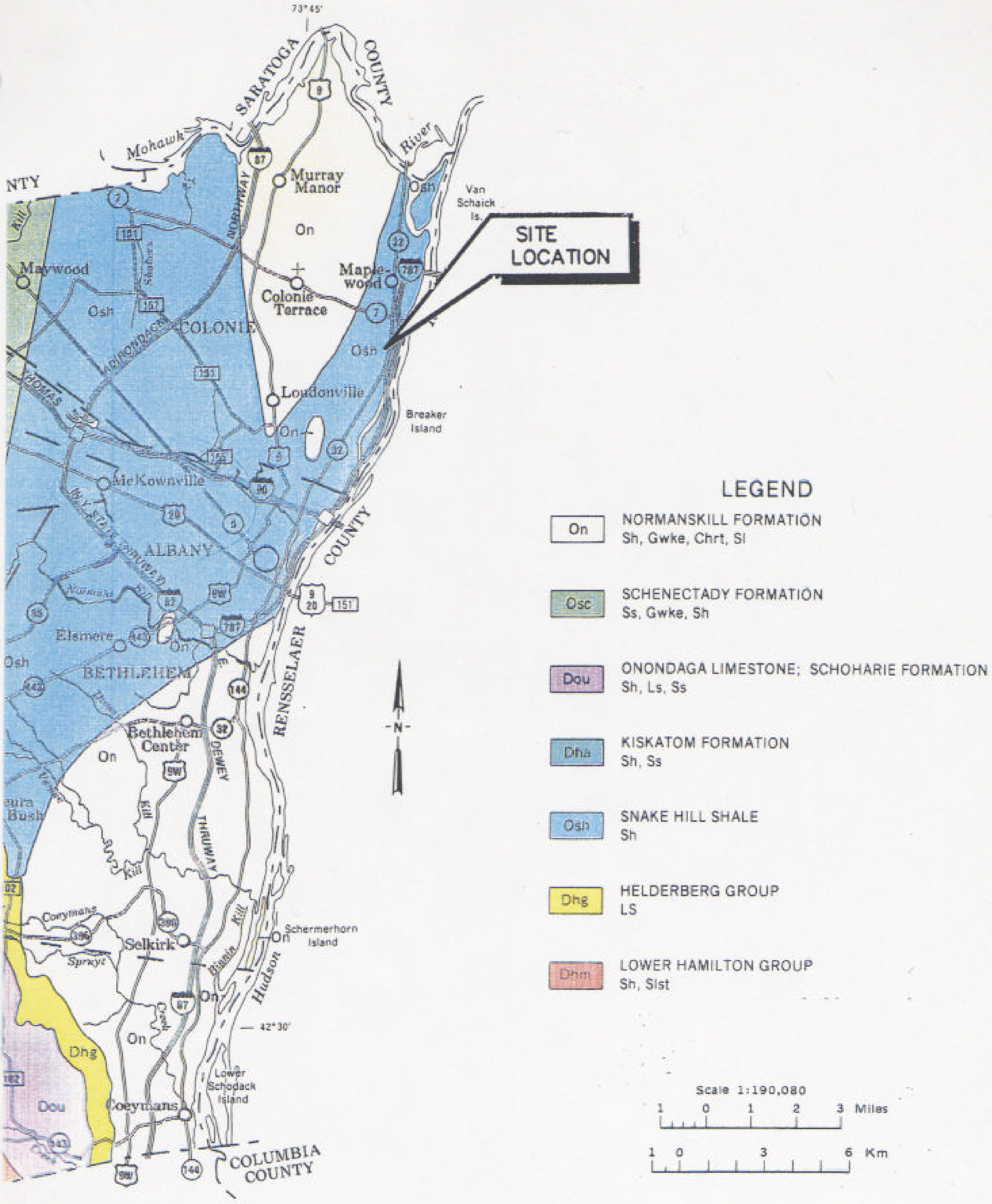
FIGURE 4-7

7308 0285537900 I:\ACAD\PROJ\0285\5379\DRAFT_FINAL\135ABB_2 Scale: 1:1 Date: 06/10/1999 Time: 09:33



US Army Corps of Engineers

GENERAL BEDROCK GEOLOGY MAP

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

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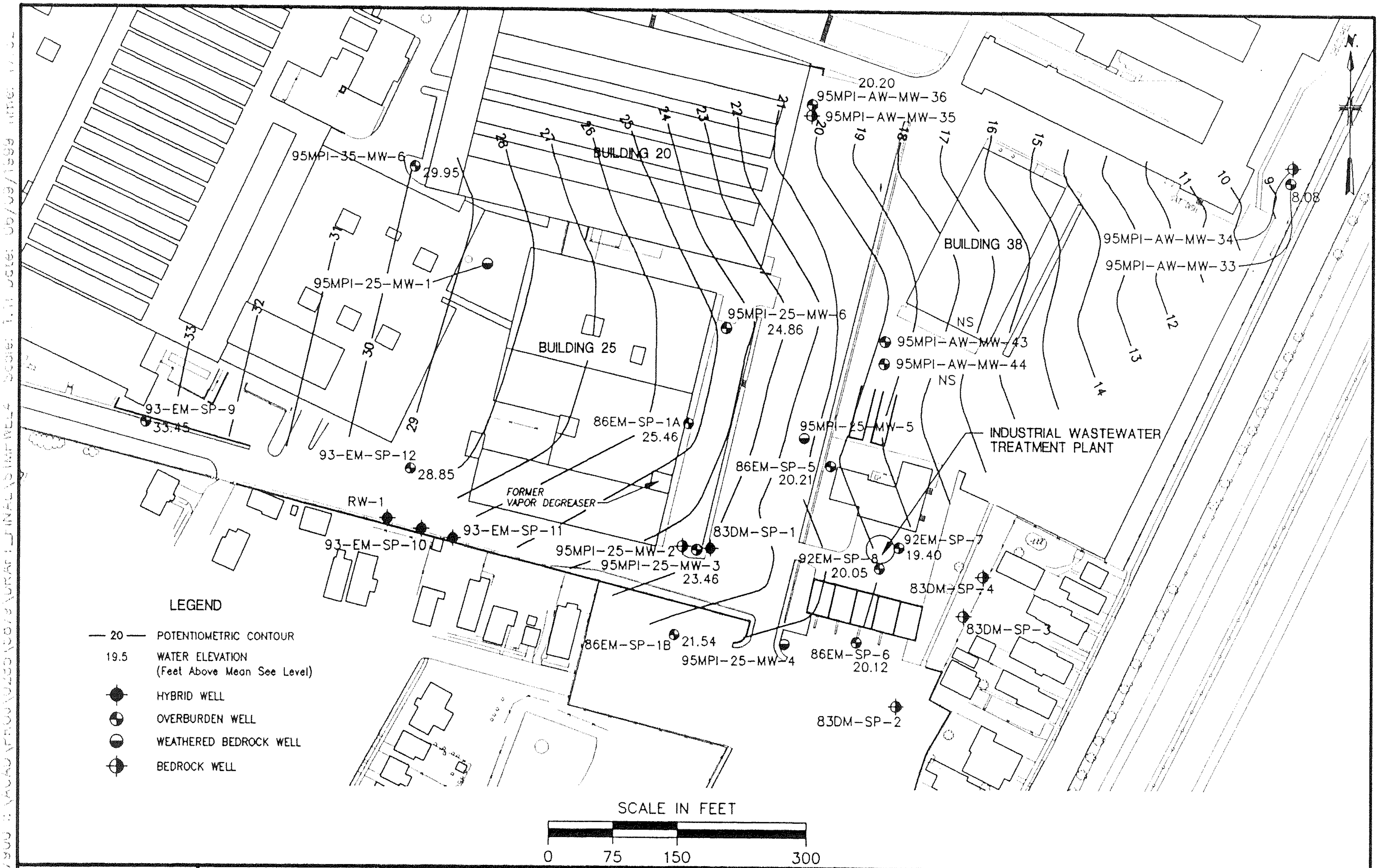
FIGURE 4-8

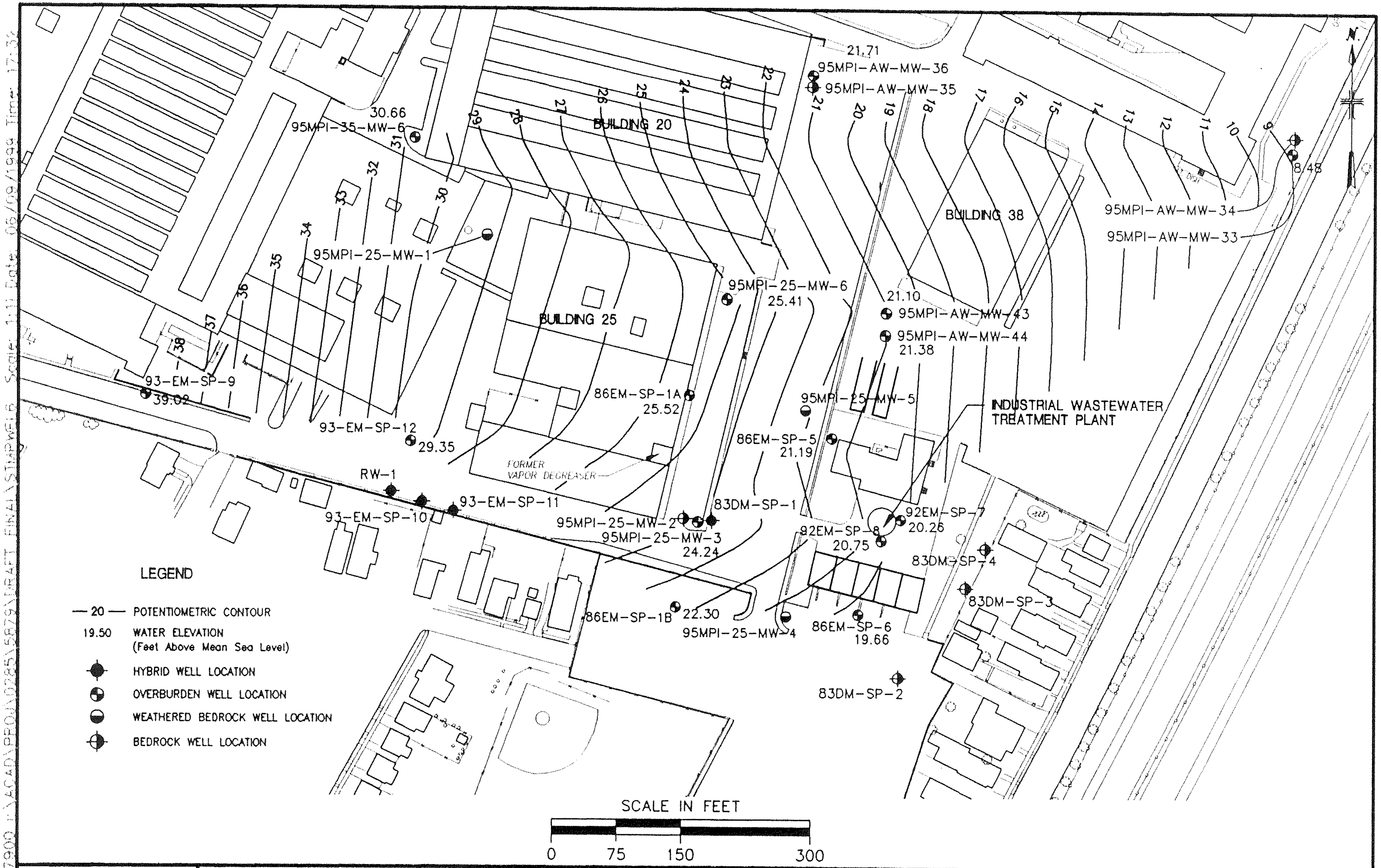


US Army Corps of Engineers

MAIN MANUFACTURING AREA
OVERBURDEN POTENTIOMETRIC CONTOUR MAP
BUILDING 25 (SEPTEMBER 11, 1995)
WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 4-9

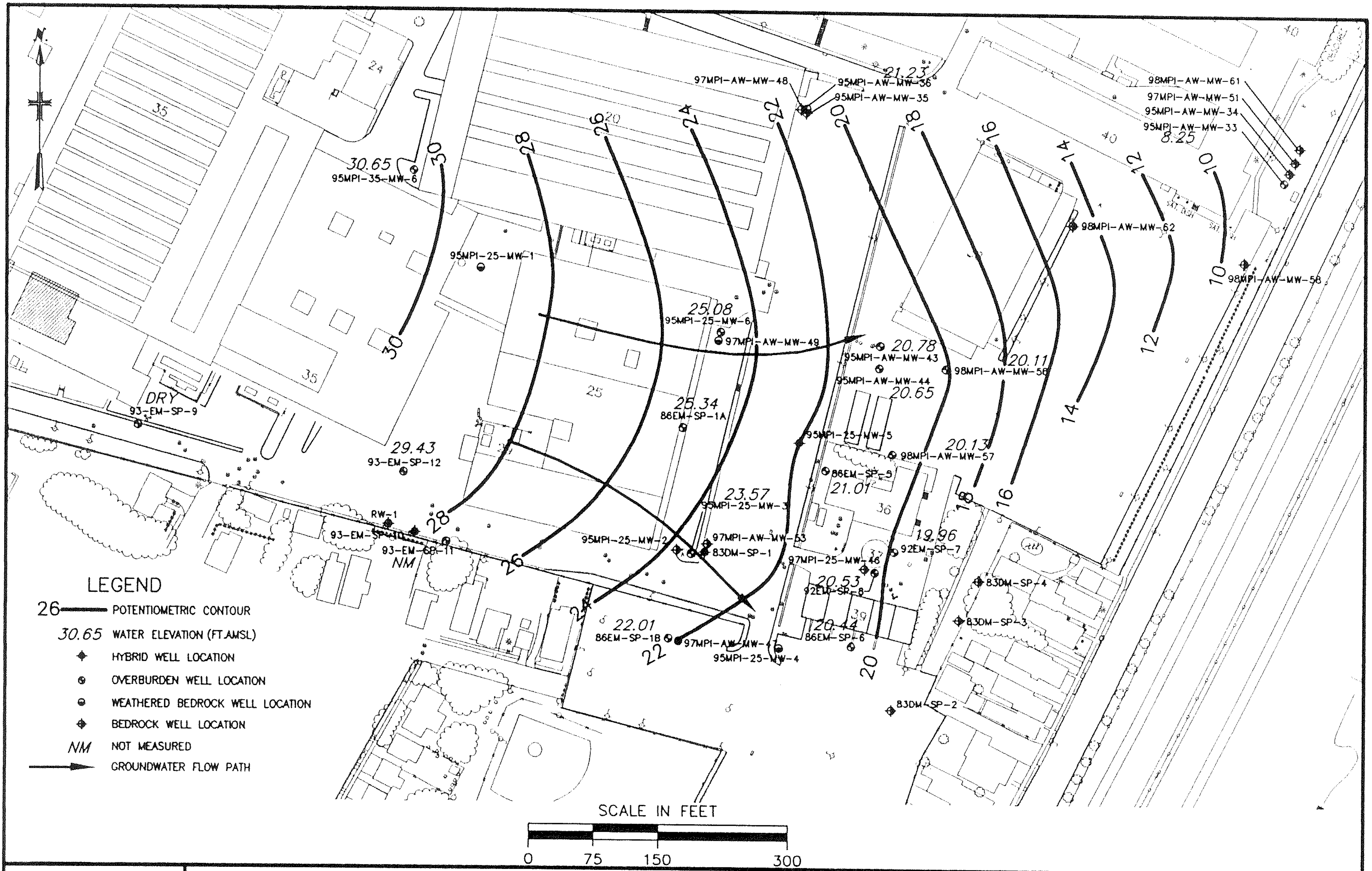


US Army Corps of Engineers

MAIN MANUFACTURING AREA
OVERBURDEN POTENTIOMETRIC CONTOUR MAP
BUILDING 25 (MAY 20, 1996)
WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 4-10

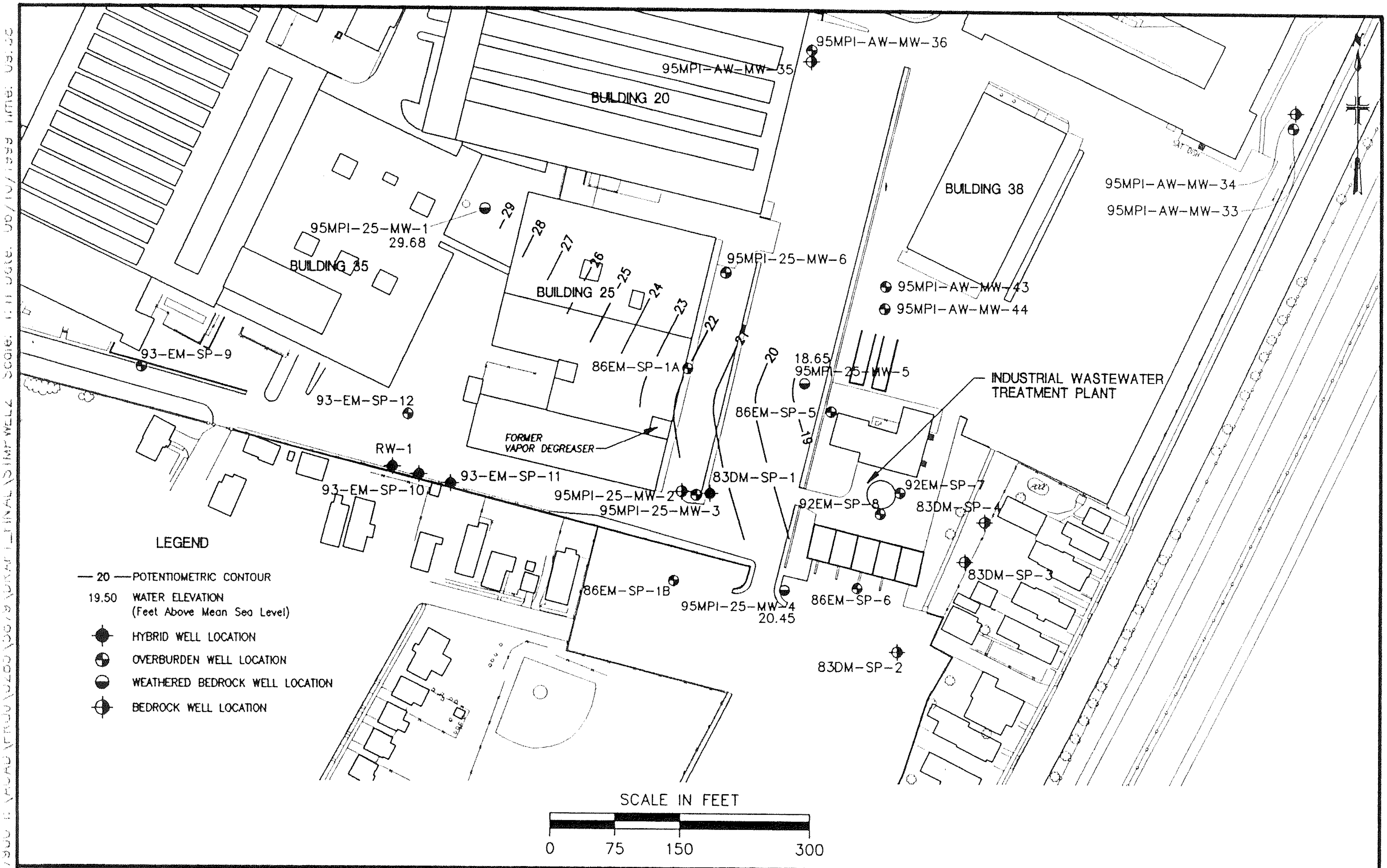


US Army Corps of Engineers

MAIN MANUFACTURING AREA
OVERRBURDEN POTENTIOMETRIC CONTOUR MAP
BUILDING 25 (FEBRUARY 11, 1999)
WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 4-11



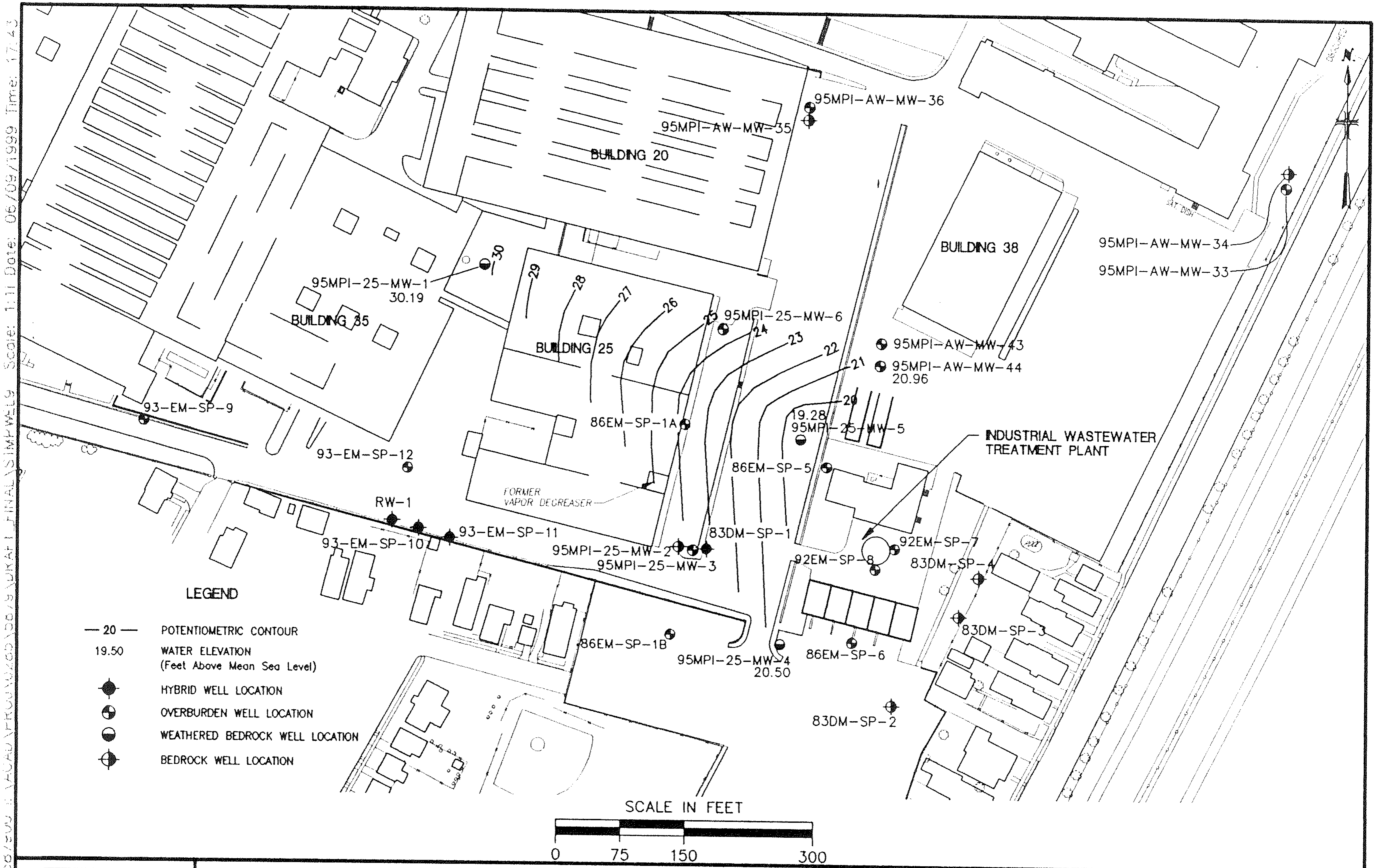
US Army Corps of Engineers

MAIN MANUFACTURING AREA
WEATHERED BEDROCK POTENTIOMETRIC CONTOUR MAP
BUILDING 25 (SEPTEMBER 11, 1995)
WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 4-12

Scale: 1:1 Date: 06/09/1999 Time: 17:43



US Army Corps of Engineers

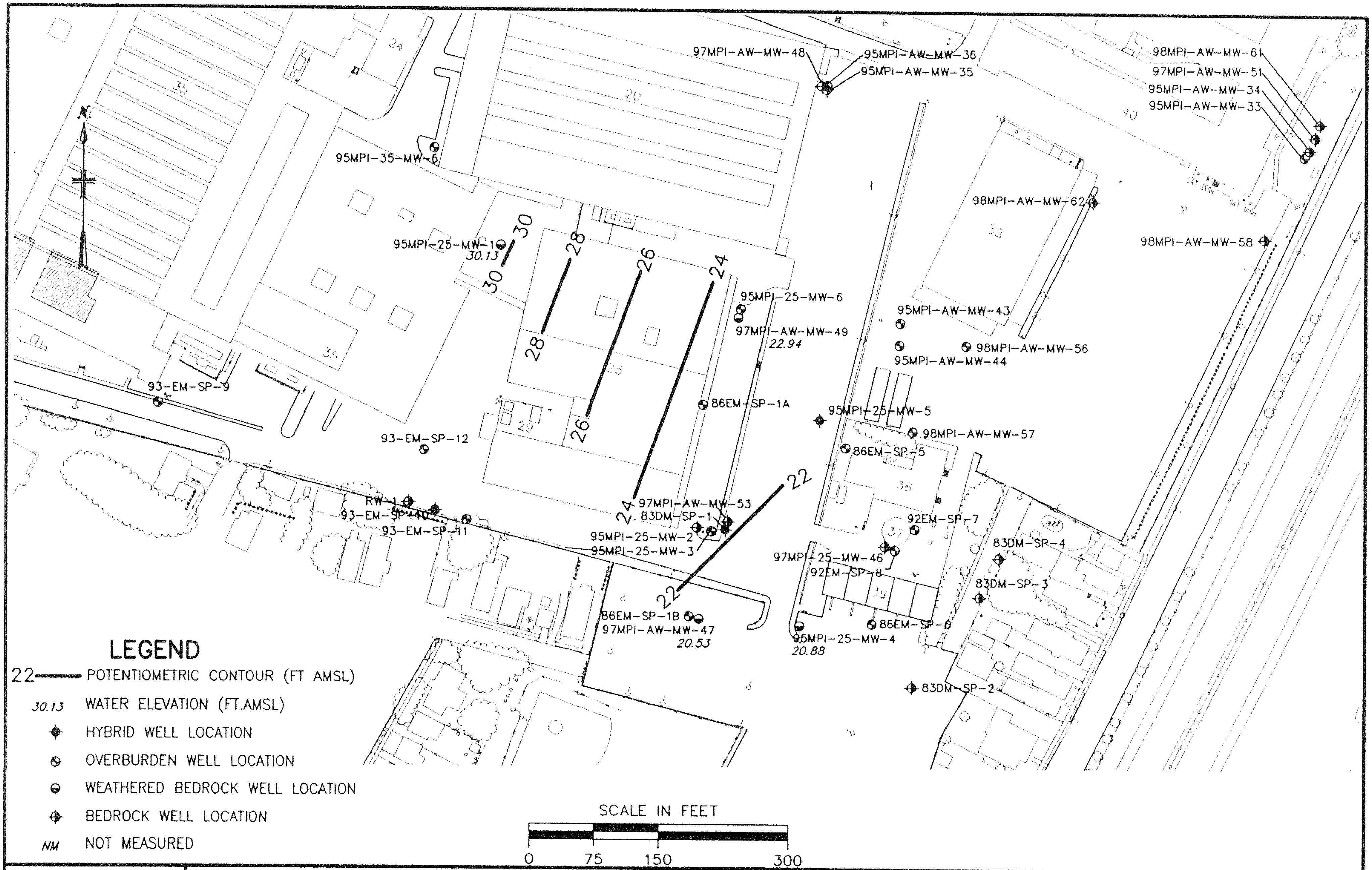
MAIN MANUFACTURING AREA
WEATHERED BEDROCK POTENTIOMETRIC CONTOUR MAP
BUILDING 25 (MAY 20, 1996)

WATERVLIET ARSENAL

USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 4-13

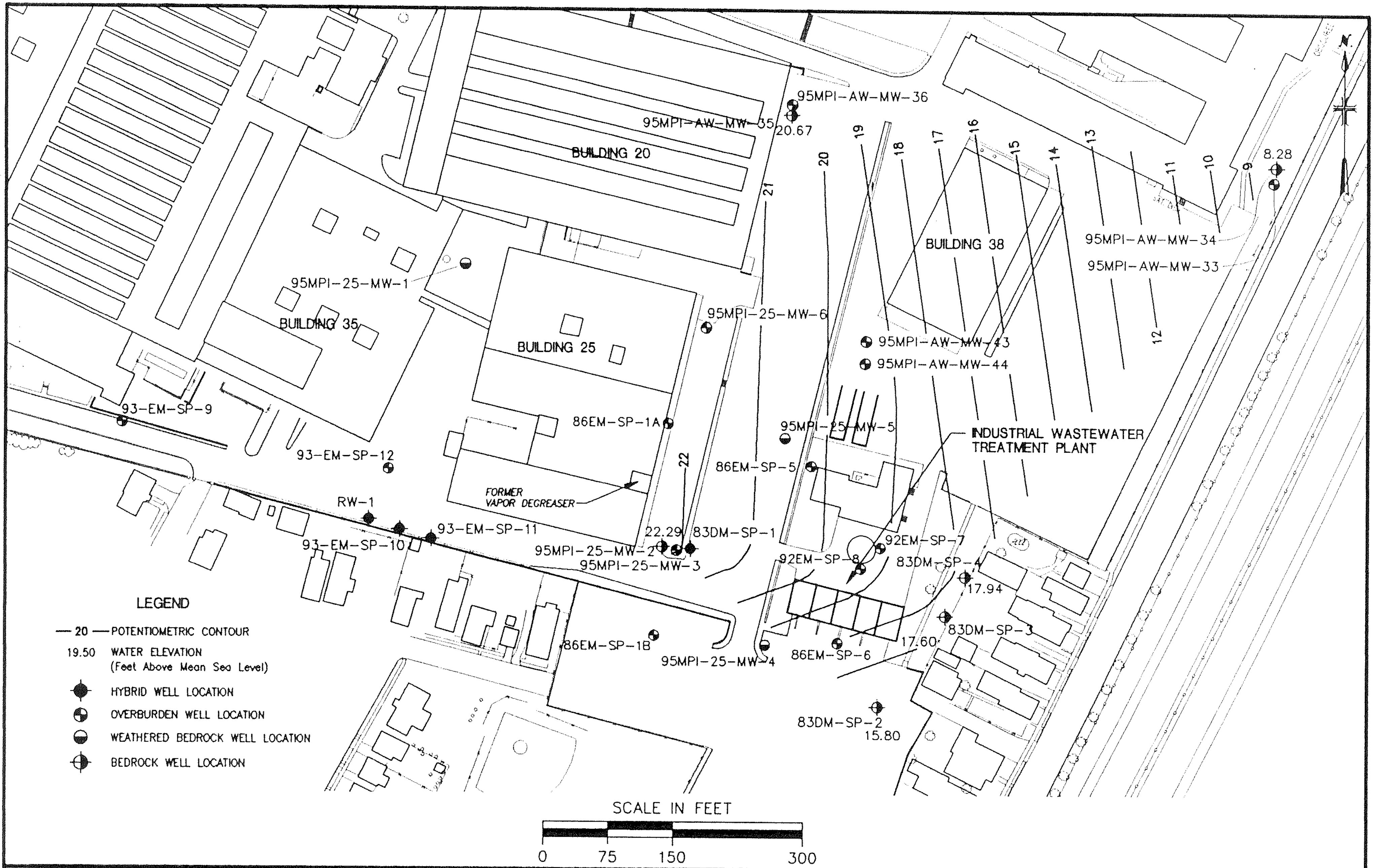


US Army Corps
of Engineers

MAIN MANUFACTURING AREA
WEATHERED BEDROCK POTENTIOMETRIC CONTOUR MAP
BUILDING 25 (FEBRUARY 11, 1999)
WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 4-14

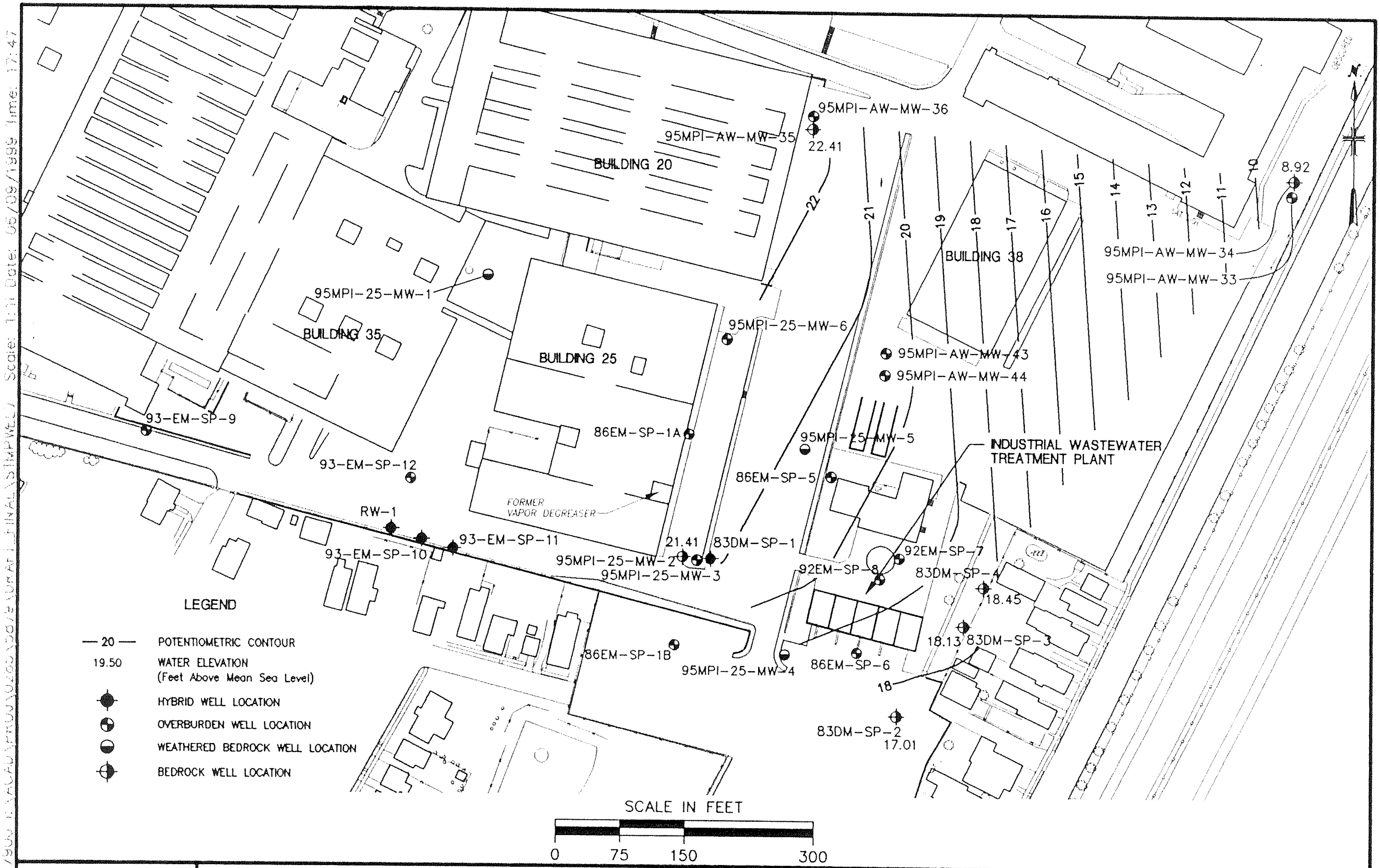


US Army Corps of Engineers

MAIN MANUFACTURING AREA
BEDROCK POTENTIOMETRIC CONTOUR MAP
BUILDING 25 (SEPTEMBER 11, 1995)
WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 4-15

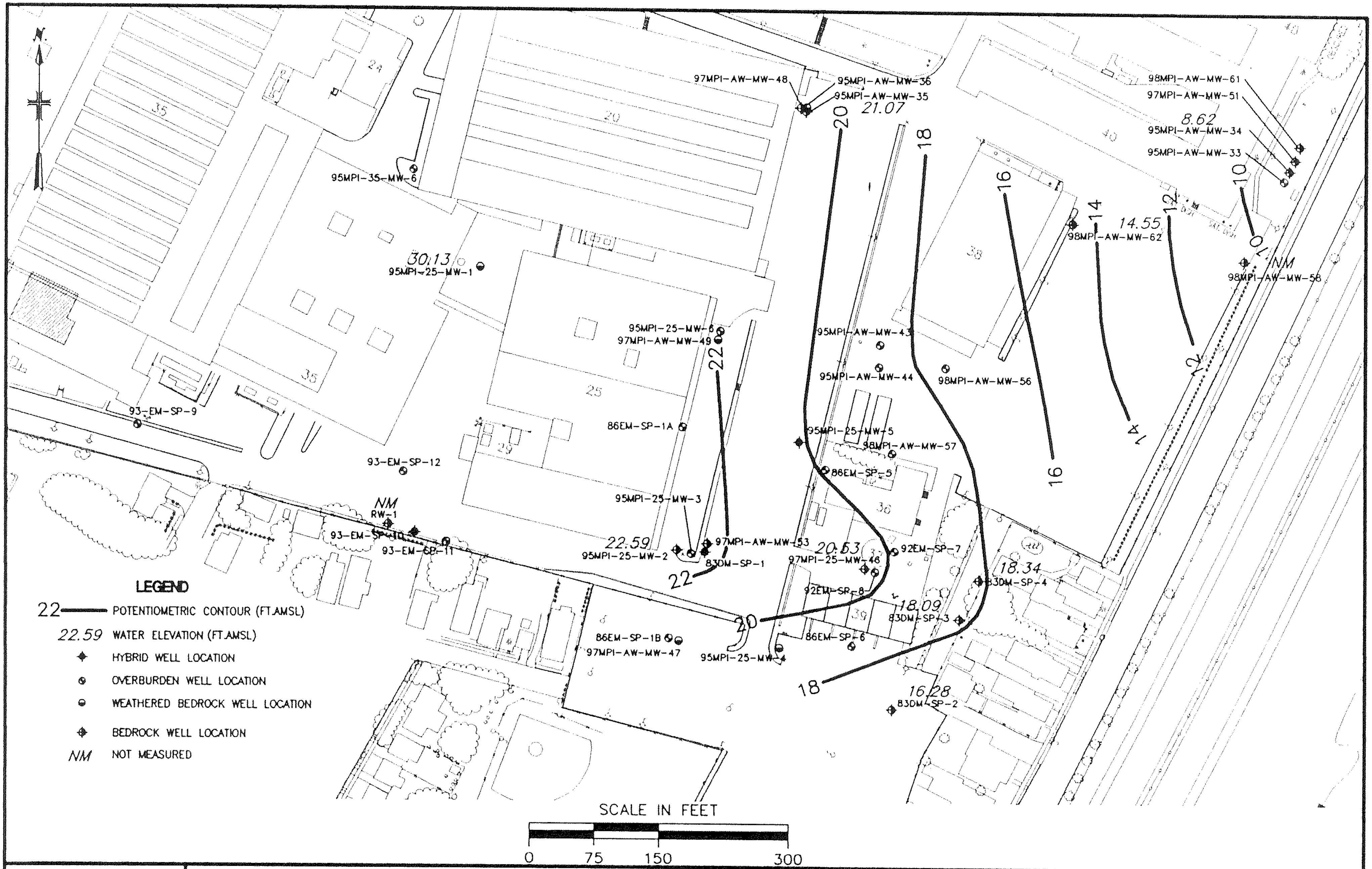


US Army Corps of Engineers

MAIN MANUFACTURING AREA
BEDROCK POTENTIOMETRIC CONTOUR MAP
BUILDING 25 (MAY 20, 1996)
WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 4-16



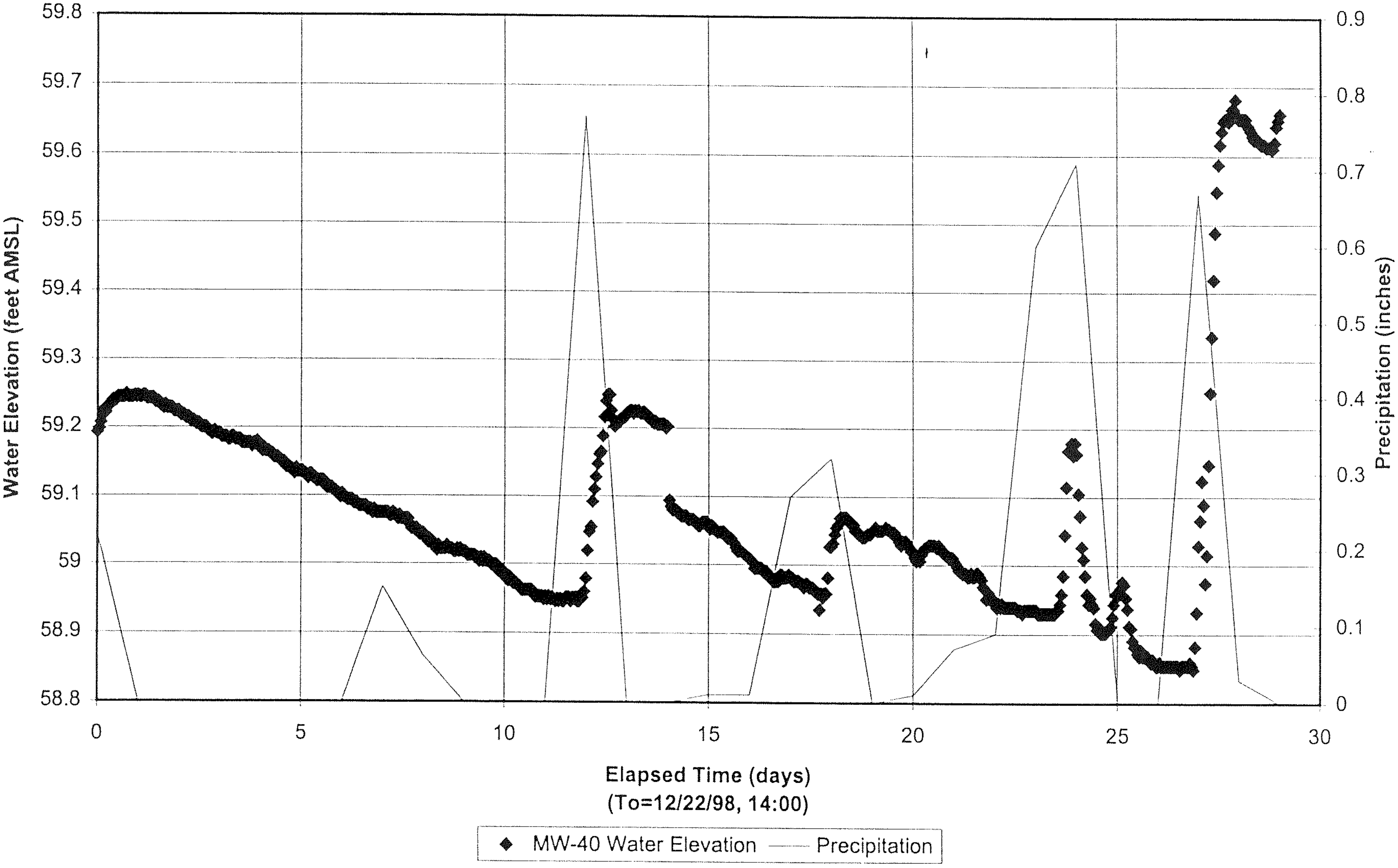
US Army Corps
of Engineers

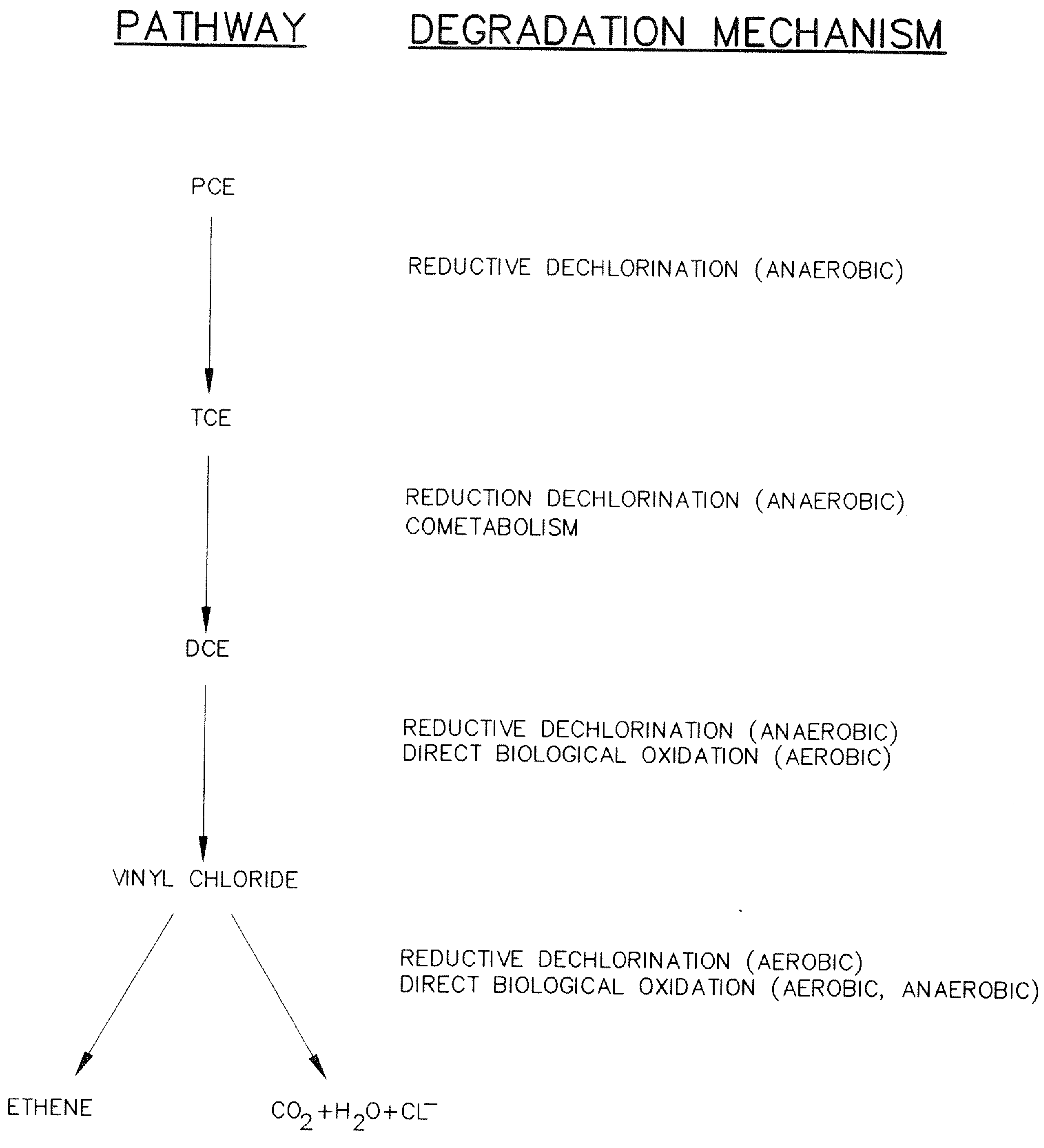
MAIN MANUFACTURING AREA
BEDROCK POTENTIOMETRIC CONTOUR MAP
BUILDING 25 (FEBRUARY 11, 1999)
WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 4-17

## Figure 4-18
## MW-40 Background Water Level Readings and Local Precipitation Data
## Main Manufacturing Area, Watervliet Arsenal



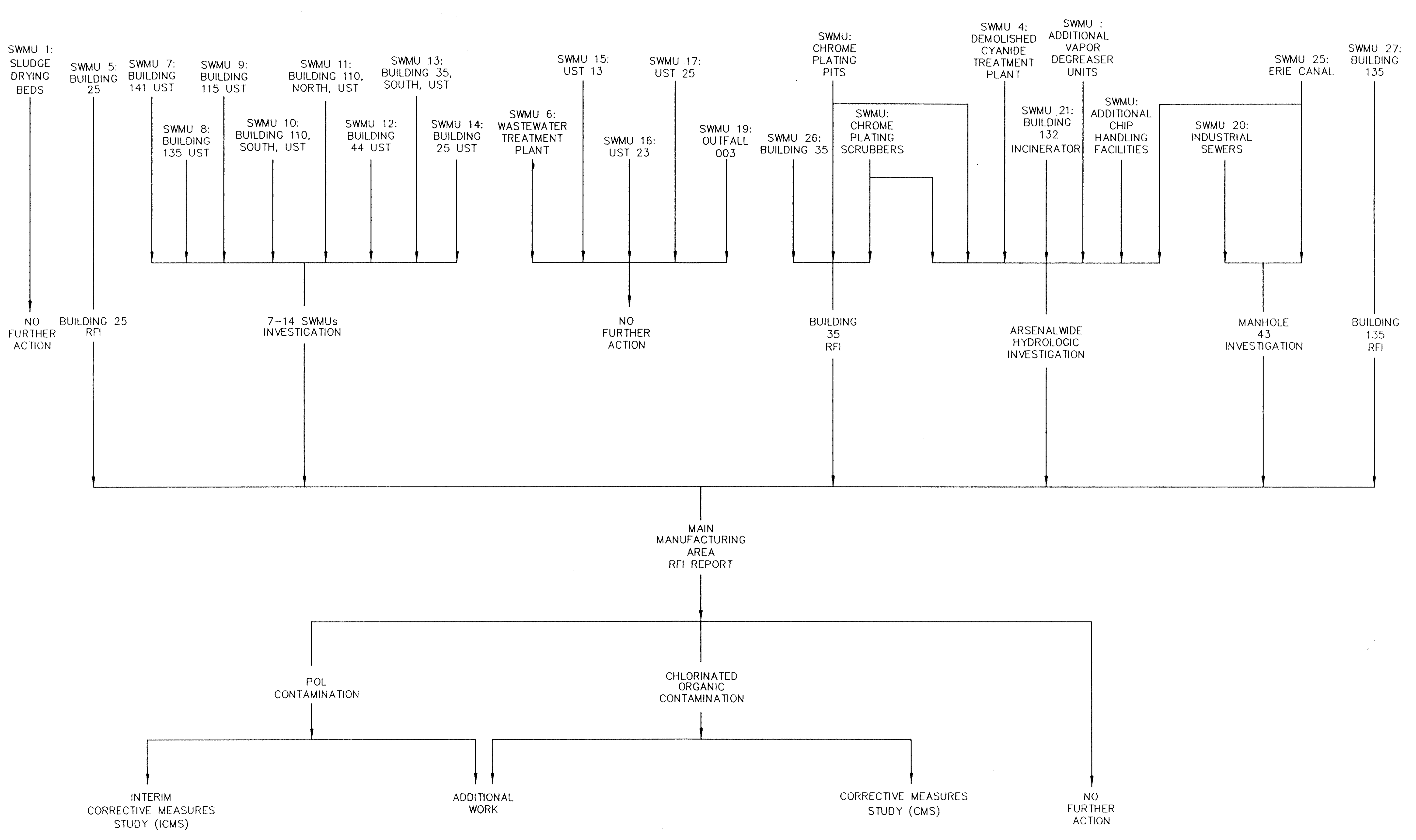


MAIN MANUFACTURING AREA
TETRACHLOROETHENE BREAKDOWN PATHWAYS

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 6-1



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MAIN MANUFACTURING AREA
SWMU STAGES OF INVESTIGATION

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31–94–D–0017

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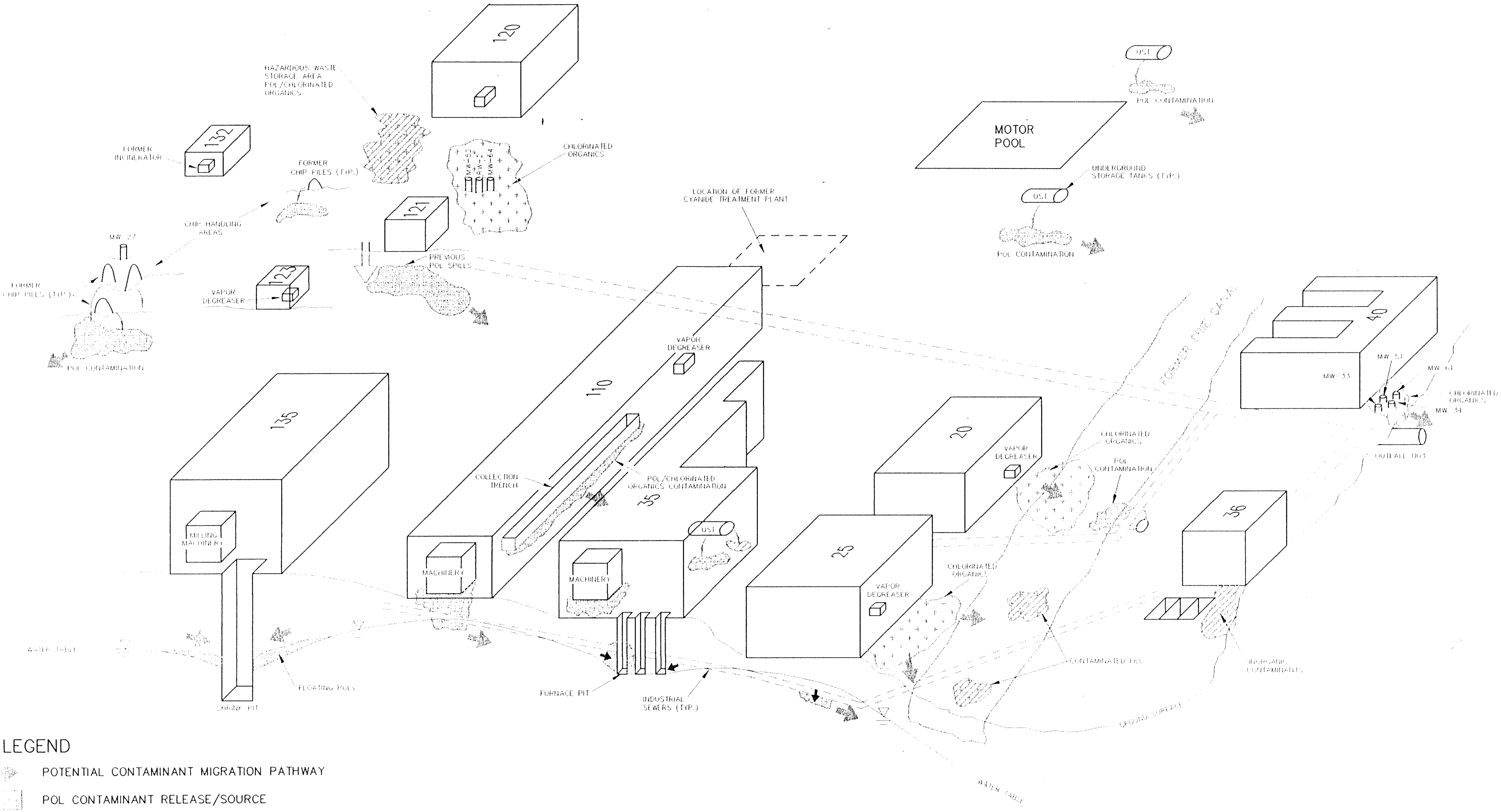
FIGURE 7–1



## LEGEND

- ➔ POTENTIAL CONTAMINANT MIGRATION PATHWAY
- ░ POL CONTAMINANT RELEASE/SOURCE
- ▨ INORGANIC OR OTHER CONTAMINANT RELEASE/SOURCE
- + VOC CONTAMINANT RELEASE/SOURCE

NOT TO SCALE

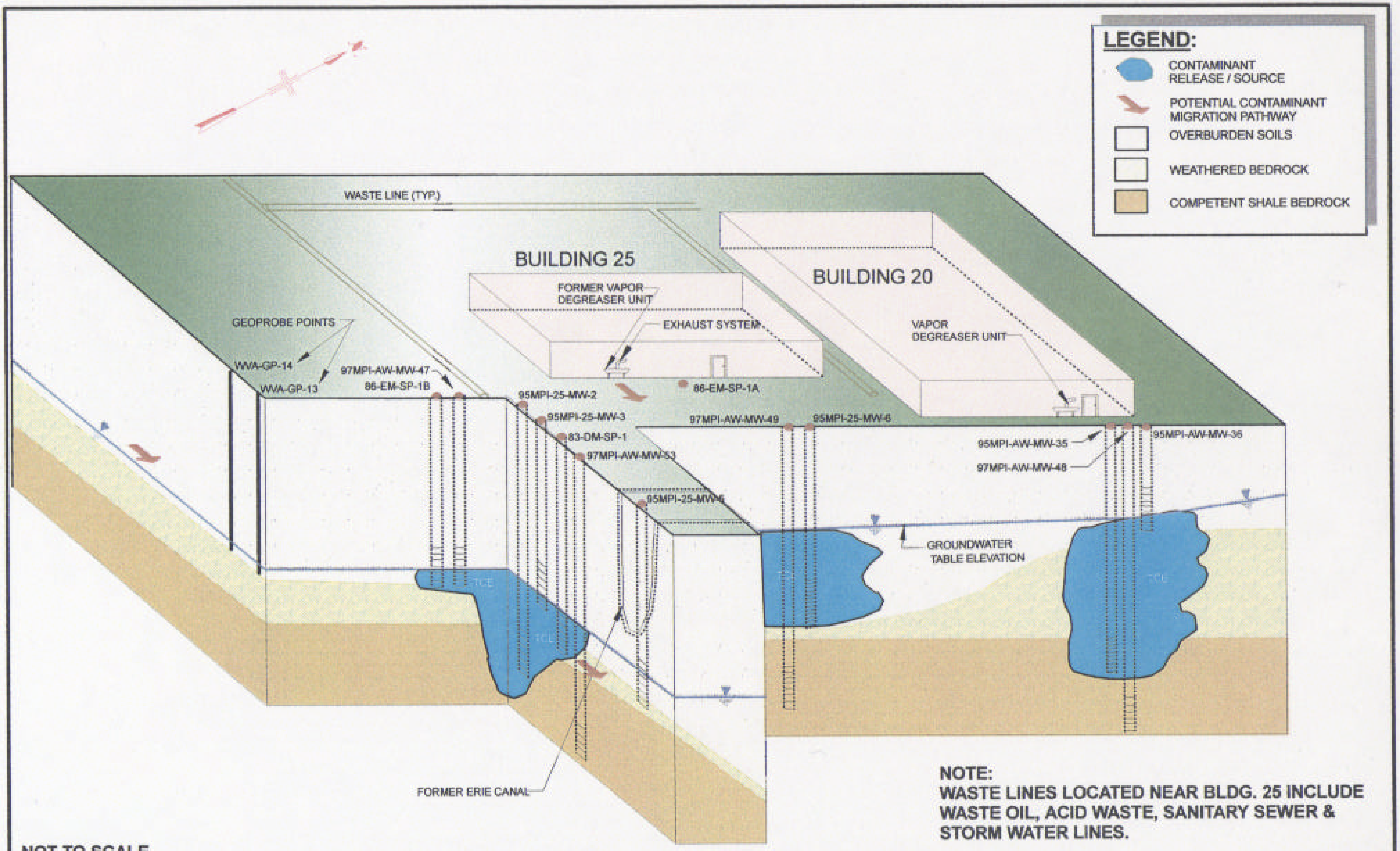
US Army Corps of Engineers

MAIN MANUFACTURING AREA
POST INVESTIGATION SITE CONCEPTUAL MODEL

WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 7-2



**NOTE:**
**WASTE LINES LOCATED NEAR BLDG. 25 INCLUDE WASTE OIL, ACID WASTE, SANITARY SEWER & STORM WATER LINES.**

**NOT TO SCALE**

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WATERVLIET ARSENAL

# POST-RFI CONCEPTUAL SITE MODEL
# BUILDING 25

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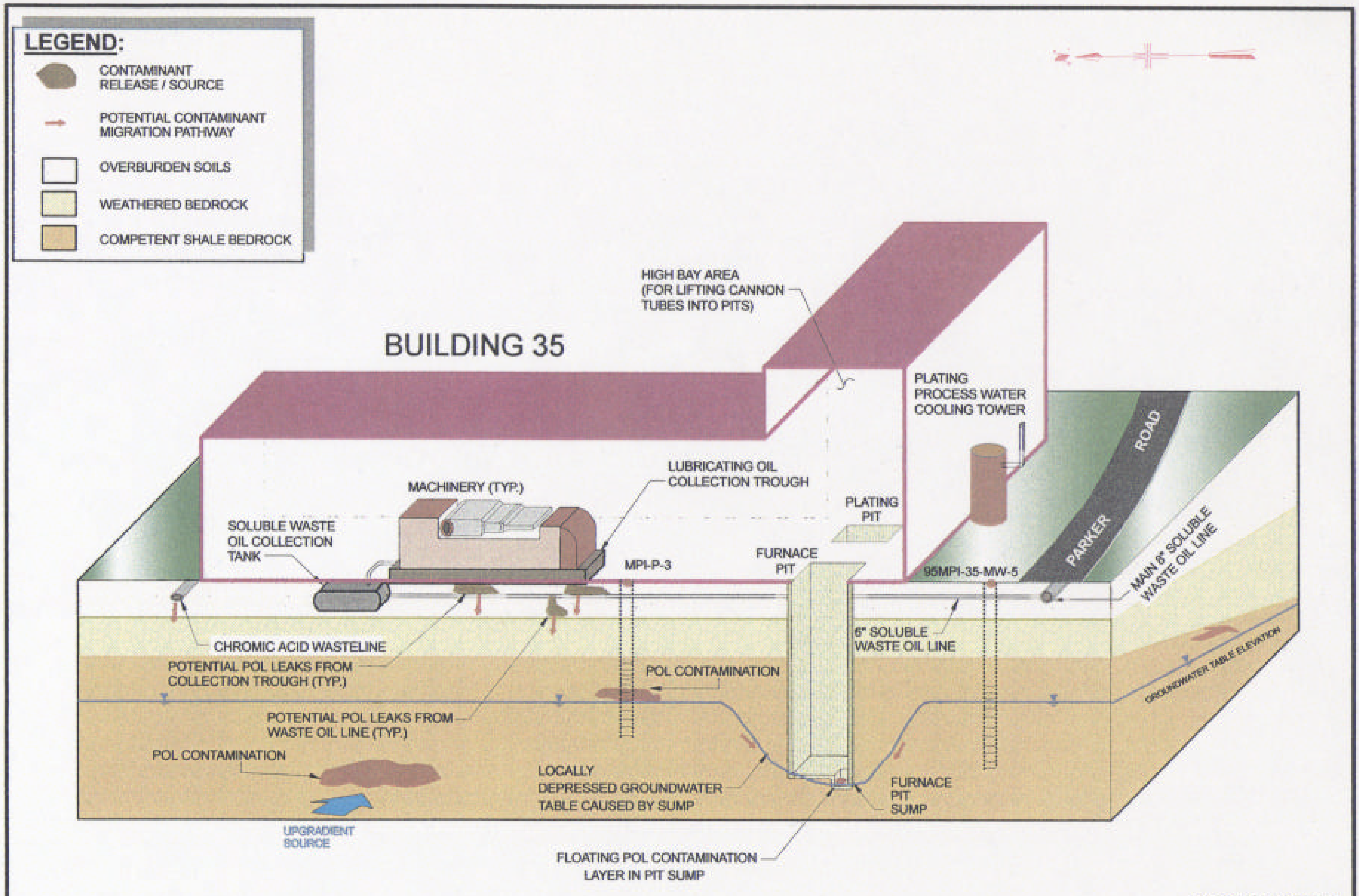
**FIGURE 7-3**

F:\PROJECT\0285587\FREELANC\WVA-CSM\POSTRFI.PRE

*WVA-CSM / MARCH98*



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WATERVLIET ARSENAL

**POST-RFI CONCEPTUAL SITE MODEL**
**BUILDING 35**

USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

**FIGURE 7-4**

*WVA-CSM / MARCH98*

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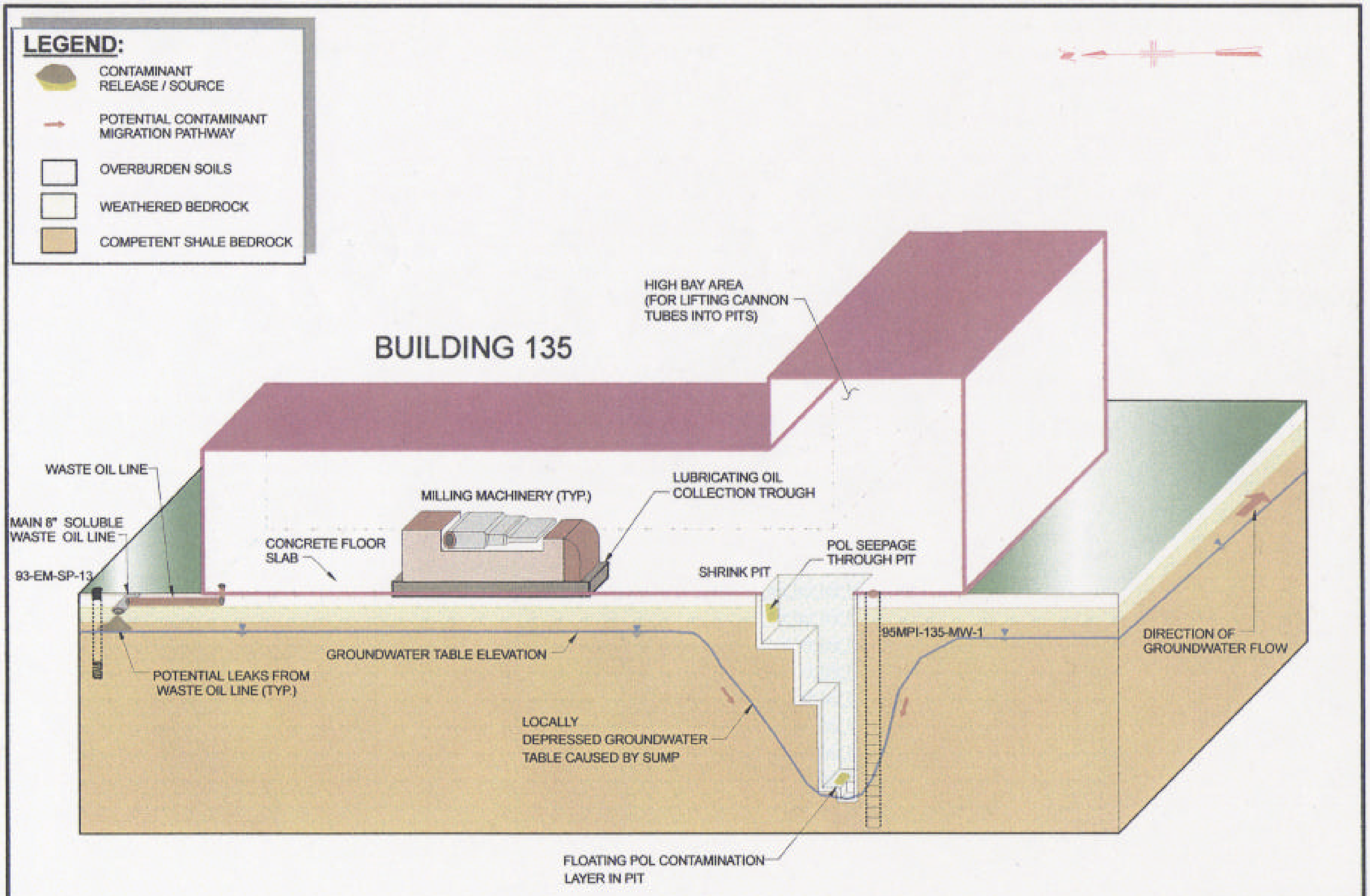

**NOT TO SCALE**

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WATERVLIET ARSENAL

## POST-RFI CONCEPTUAL SITE MODEL
## BUILDING 135

USACE CONTRACT NO. DACA31-94-D-0017

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**FIGURE 7-5**

F:\PROJECT\0285587\FREELANC\WVA-CSM\POSTRFI.PRE

*WVA-CSM / MARCH99*