FINAL

EXPOSURE ASSESSMENT SIBERIA AREA WATERVLIET ARSENAL, Watervliet, New York

Baltimore Corps of Engineers, Baltimore, Maryland

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

Prepared by:
Malcolm Pirnie, Inc.
15 Cornell Road
Latham, New York 12110

December 1998
0285-664

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, U.S. ARMY CORPS OF ENGINEERS
P.O. BOX 1715
BALTIMORE, MD 21203-1715

REPLY TO
ATTENTION OF

December 03 , 1998

Engineering Division
Military HTRW Section

SUBJECT: Administrative Order on Consent Docket No. II RCRA-3008 (H)-93-0210

U.S. Environmental Protection Agency
ATTN: Mr. Raymond Basso
Chief, RCRA Programs Branch
Division of Environmental Planning and Protection
290 Broadway
New York, New York 10007-1866

Dear Mr. Basso:

On behalf of the Watervliet Arsenal (WVA), the Baltimore District U.S. Army Corps of Engineers (BCOE) is pleased to submit herewith two (2) copies of the Final EXPOSURE ASSESSMENT HUMAN HEALTH AND FISH AND WILDLIFE IMPACT ANALYSIS, Watervliet Arsenal, Watervliet, New York, dated December 1998.

The WVA point of contact is Ms. Maira Senick at (518) 266 5731. The BCOE point of contact is Mr. Curt Heckelman, P.E. at (410) 962 2783.

for Myron N. Price
Acting Chief,
Military HTRW Section

Enclosure

Copies Furnished (w/enclosures):

Commander, U.S. Army Industrial Operations, Command, ATTN: AMSIO-EQE (Mr. Tim Howard), Rock Island, Illinois 61299-6000
Commander, U.S. Army Watervliet Arsenal, ATTN: SIOWV-ISH (Ms. Maira Senick), Building 20, Watervliet, New York 12189-4050
New York State Department of Environmental Conservation, ATTN: Mr. Edwin Dassatti, P.E., Chief, Bureau Hazardous Waste Facilities, Division of Solid And Hazardous Materials, 50 Wolf Road, Albany, New York 12233-7252
New York State Department of Environmental Conservation, ATTN: Regional Hazardous Substance Engineer, 1150 North Westcott Road, Schenectady, New York 12306
Commander U.S. Army Corps of Engineers, New York District, ATTN: CENAN-PP-E (Mr. Rich Mandra), 26 Federal Plaza, New York, New York 10278-0090
New York State Department of Health, ATTN: Mr. Fedigan, Bureau of Environmental Exposure Investigation, 2 University Place, Room 205, Albany, New York 12230
Malcolm Pirnie, Inc., ATTN: Mr. Ken Goldstein, One International Boulevard, Box 601, Mahwah, NJ 07430-0601

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EXECUTIVE SUMMARY

This exposure assessment, which includes a human health evaluation and a fish and wildlife impact analysis, evaluates environmental conditions at the Siberia Area Solid Waste Management Unit (Siberia Area) at the Watervliet Arsenal (WVA) to:

- Determine if chemicals detected in the various environmental media investigated pose potential health risks to humans and wildlife, and
- Derive risk-based, site-specific target levels (SSTLs) for those chemicals that are of concern for human health.

The assessment is conducted in accordance with the New York State Department of Environmental Conservation's (NYSDEC) approved work plan and interim deliverables, and in accordance with the suggestions and comments provided by the NYSDEC, United States Environmental Protection Agency (USEPA) and the New York State Department of Health (NYSDOH) through various correspondence.

The WVA is a 140-acre government-owned installation under the command of the U.S. Army Industrial Operations Command (USAIOC). It 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 Siberia Area, a swampy, 14-acre parcel located west of the Main Manufacturing Area, was purchased by the WVA in the early 1940's and immediately filled in with debris consisting of slag, cinders, wood , brick and other available materials of unknown origin. Once filled in, two areas were used for burning combustible material (i.e., scrap lumber and solid waste) until 1967. The Siberia Area is currently used for the interim storage of raw materials, hazardous materials, finished goods, and supplies brought in from the Main Manufacturing Area.

In the human health evaluation, analytical data collected during the RCRA Facility Investigation at the Siberia Area are summarized, the data are evaluated to select environmental media and chemicals of potential concern, and conceptual human exposure scenarios, that may exist currently and/or in the future, are developed. Risk-based SSTLs protective of

human health are then derived for each chemical of potential concern in on-site surface soil, on-site soil at all depths, off-site surface soil and sediment and groundwater for a number of potentially exposed populations based on assumed exposure parameters, available toxicological criteria and acceptable risk levels. The risk-based SSTLs will be included among other criteria (e.g., the NYSDEC TAGM 4046 recommended soil cleanup objectives, the technical practicability of the remedial alternatives, and cost) used to determine the extent of remediation and appropriate media cleanup standards for soil and groundwater contamination at the Siberia Area.

The Siberia Area is an industrial area with minimal habitat in the form of "weedy" patches that do not support wildlife populations; only transient species and a few individual animals utilize the area. The maintained lawns and high percentage of covered areas (i.e., parking lots) associated with the residential/commercial land uses surrounding the Siberia Area do not support large or diverse wildlife populations. The impact analysis is conducted by evaluating chemical concentrations in environmental media of concern, potential exposure mechanisms, frequencies and durations and toxicological criteria protective of wildlife. The major routes of exposure for wildlife potentially exposed to chemicals in soil include incidental contact and ingestion; the exposure frequency and duration would be low for these individuals. Thus, although chemical concentrations in surface and shallow subsurface soils exceed toxicological benchmark values, the potential risk to wildlife is minimal.

The maximum concentrations of several constituents in the sediment exceeded sediment criteria. However, the risk associated with these constituents is minimal. The ditch is a grassy depression that contains water only during rain events and spring melt. During dry periods, it is mowed. This does not allow for development of a diverse benthic community.

1.0 INTRODUCTION

This exposure assessment evaluates environmental conditions at the Siberia Area Solid Waste Management Unit (Siberia Area) at the Watervliet Arsenal (WVA) to:

- Determine if chemicals detected in the various environmental media investigated pose potential health risks to humans and wildlife, and
- Derive risk-based, site-specific target levels (SSTLs) for those chemicals that are of concern for human health.

It includes both a human health evaluation and a fish and wildlife impact analysis and is conducted in accordance with the New York State Department of Environmental Conservation (NYSDEC) approved work plan and interim deliverables, and in accordance with the suggestions and comments provided by the NYSDEC, United States Environmental Protection Agency (USEPA) and the New York State Department of Health (NYSDOH) through various correspondence.

The human health evaluation and derivation of SSTLs is based on guidance provided in the American Society for Testing and Materials' *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM, 1995) which provides a decision-making process intended for use in directing remedial actions and deriving risk-based cleanup levels. The risk-based SSTLs will be included among other criteria (e.g., the NYSDEC TAGM 4046 recommended soil cleanup objectives, the technical practicability of the remedial alternatives, and cost) used to determine the extent of remediation and appropriate media cleanup standards for soil and groundwater contamination at the Siberia Area.

The fish and wildlife impact analysis is based on NYSDEC guidance for characterizing impacts to fish and wildlife at hazardous waste sites (NYSDEC, 1994). In addition, the analysis methods are consistent with USEPA guidance for environmental evaluation of hazardous waste sites (USEPA, 1989a, 1989b, 1992) and the ASTM guidance noted previously.

1.1 SITE BACKGROUND AND DESCRIPTION

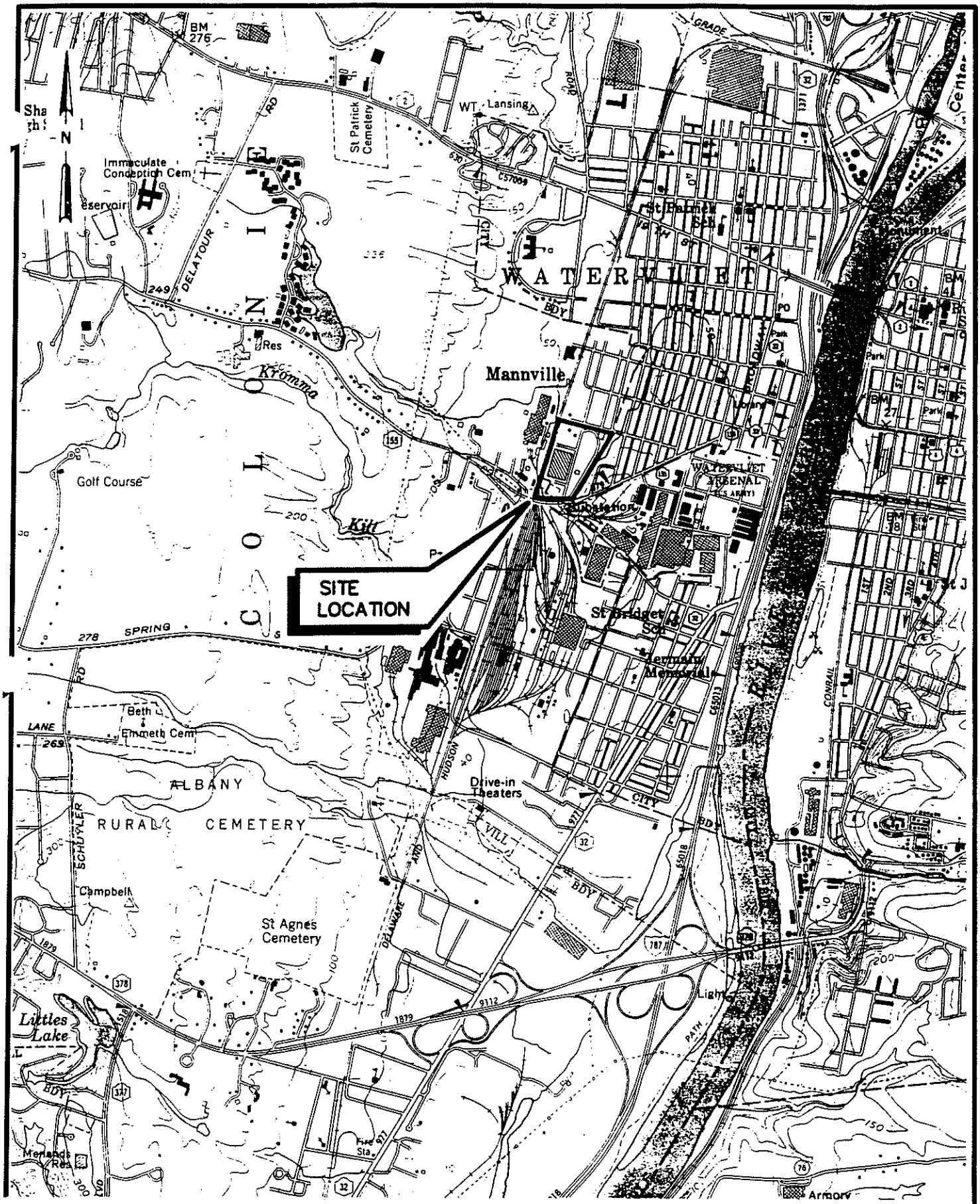
1.1.1 Site History

The WVA, a 140-acre government-owned installation under the command of the U.S. Army Industrial Operations Command (USAIOC), is located in the City of Watervliet, New York, which is west of the Hudson River, and 5 miles north of the City of Albany (see Figure 1-1). It is a national registered historic landmark that was established in 1813 with the purchase of 12 acres of land by the U.S. War Department. The original purpose of the WVA was to distribute supplies (i.e., ammunition, harnesses and gun cartridges) to troops along the northern and western frontiers. The Erie Canal, formerly located in the eastern portion of the main manufacturing area of the WVA, was built between 1817 and 1824 to provide transportation and power. The canal, which was abandoned and relocated to Waterford in 1922, was filled in with dirt, brick and other fill material in the early 1940s. The eastern wall of the canal still remains and forms a portion of the west side of Gibson Street. 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, anti-aircraft weapons, the 90 mm gun of 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 were built at the WVA. Currently, the WVA is responsible for the manufacture of ordnance. Benet Labs, a tenant at the facility, performs research and development.

1.1.2 Site Description

1.1.2.1 Location

A large, swampy, 14-acre area located to the west of the main manufacturing area of the WVA, known as the Siberia Area (see Figure 1-2), was purchased by WVA in the early 1940s and immediately filled in with debris consisting of slag, cinders, wood, brick and any available debris of unknown origin. Once filled in, two areas were used for burning combustible material (i.e., scrap lumber and sanitary waste) until 1967.



SOURCE: TROY SOUTH 7.5 MIN. QUAD. 1983 EDITION

SCALE: 1"=2000'

US Army Corps of Engineers

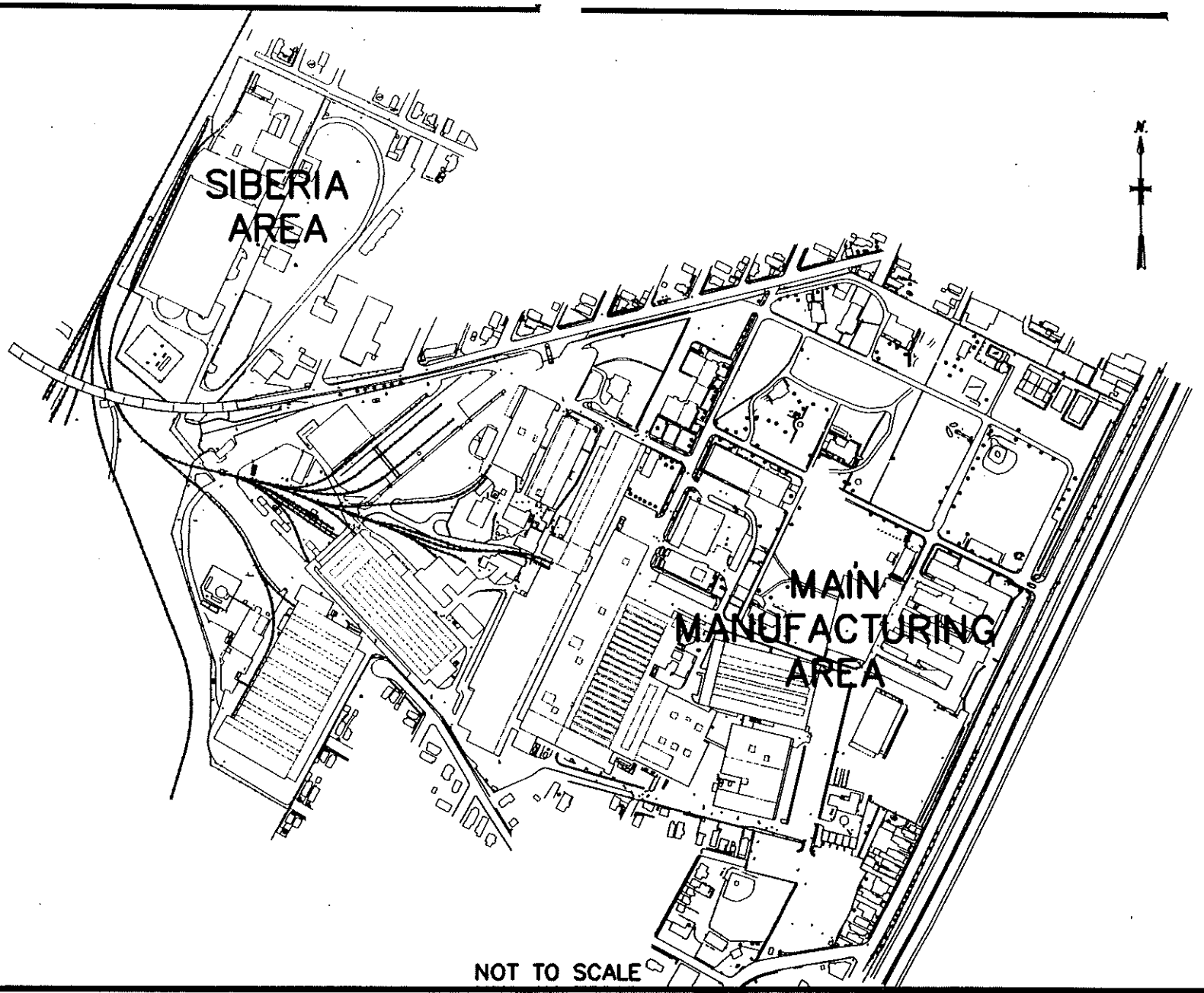
SIBERIA AREA

SITE LOCATION MAP

WATERVLIET ARSENAL

USACE CONTRACT NO. DACA31-94-D-0017

FIGURE 1-1



US Army Corps of Engineers

SITE PLAN

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

FIGURE 1-2

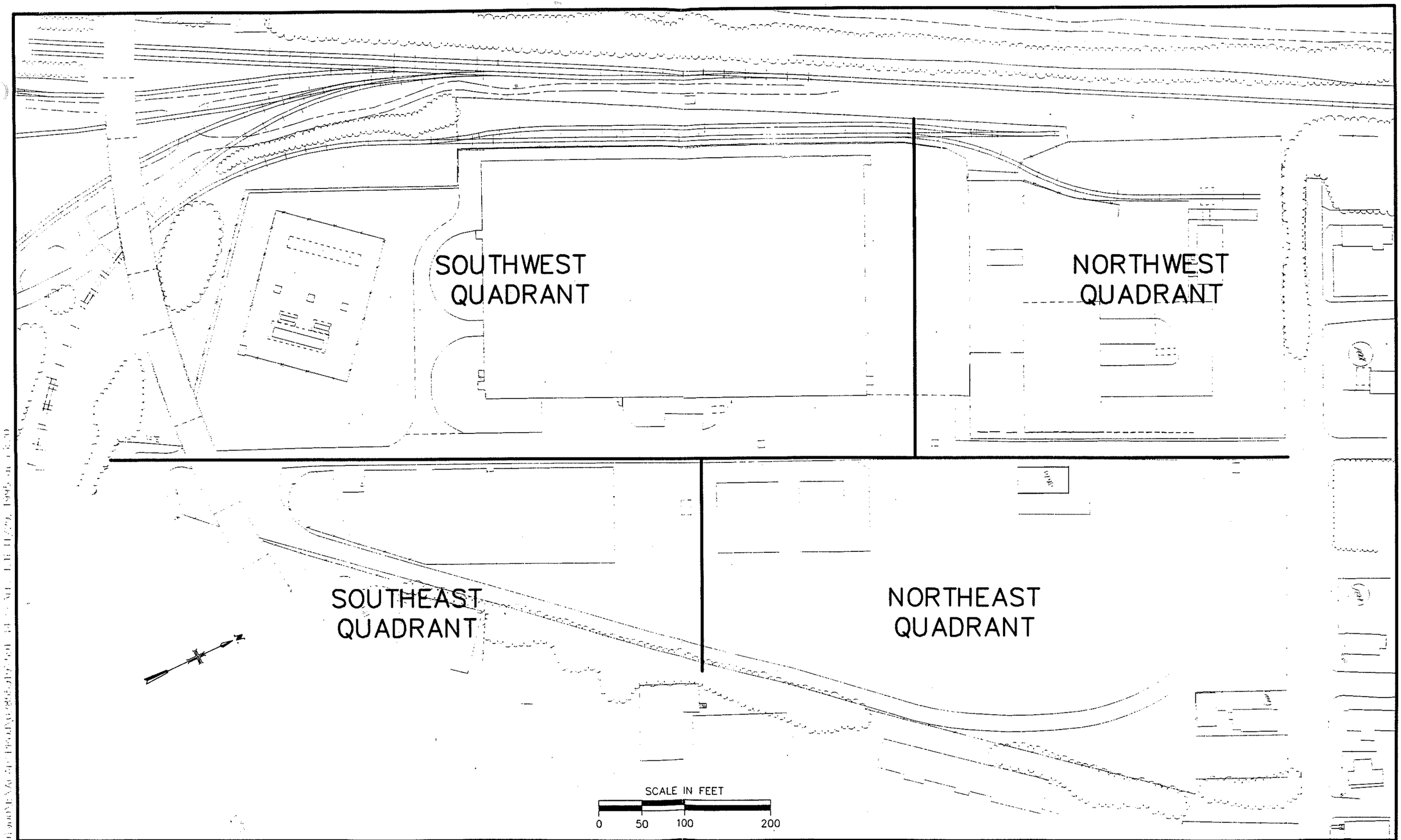
XREF| I:\ACAD\PROJ\0285WVA\BASEWIDE

The Delaware and Hudson Railroad is located adjacent to the western property line, across which the former Adirondack Steel Casting Co. is located. Residential properties adjoin the property to the north and northeast. Perfection Plating, which formerly manufactured metal plates for brake pads, is located along a portion of the eastern property line. This site is currently being remediated by the New York State Department of Environmental Conservation (NYSDEC). Shaker Tire Sales is located along the southeastern property line. Lands owned by the Town of Colonie and formerly owned by the Delaware and Hudson Railroad are located along the southern property boundary.

To assist in the descriptions of locations within the Siberia Area, the Siberia Area has been divided into four quadrants: southwest (SW), southeast (SE), northeast (NE) and northwest (NW) (Figure 1-3). Located in the SW quadrant are the Main Substation and Building 145 (which is the Defense Revitalization Management Area [DRMA]); the lumber yard is located in the SE Quadrant; former burning pits and Buildings 148 and 151 are located in the NE Quadrant and the Chip Handling Facility is located in the NW Quadrant (Figure 1-4).

1.1.2.2 Waste Types

The Siberia Area is used for the interim storage of raw materials, hazardous materials, finished goods, and supplies brought in from the manufacturing area of the WVA. The handling of these materials, particularly the handling of metal chips coated with cutting oils, scrap metals which are salvaged, and scrap lumber that is stockpiled until removed from the site, may have contributed to groundwater and soil contamination. All of these materials have either been historically stored, or are stored presently, directly on the ground surface. In addition, the WVA has reported that mixtures of oils and solvents removed from underground storage tank (USTs) were sprayed on the ground for dust control in the Siberia Area. The WVA no longer employs this practice.

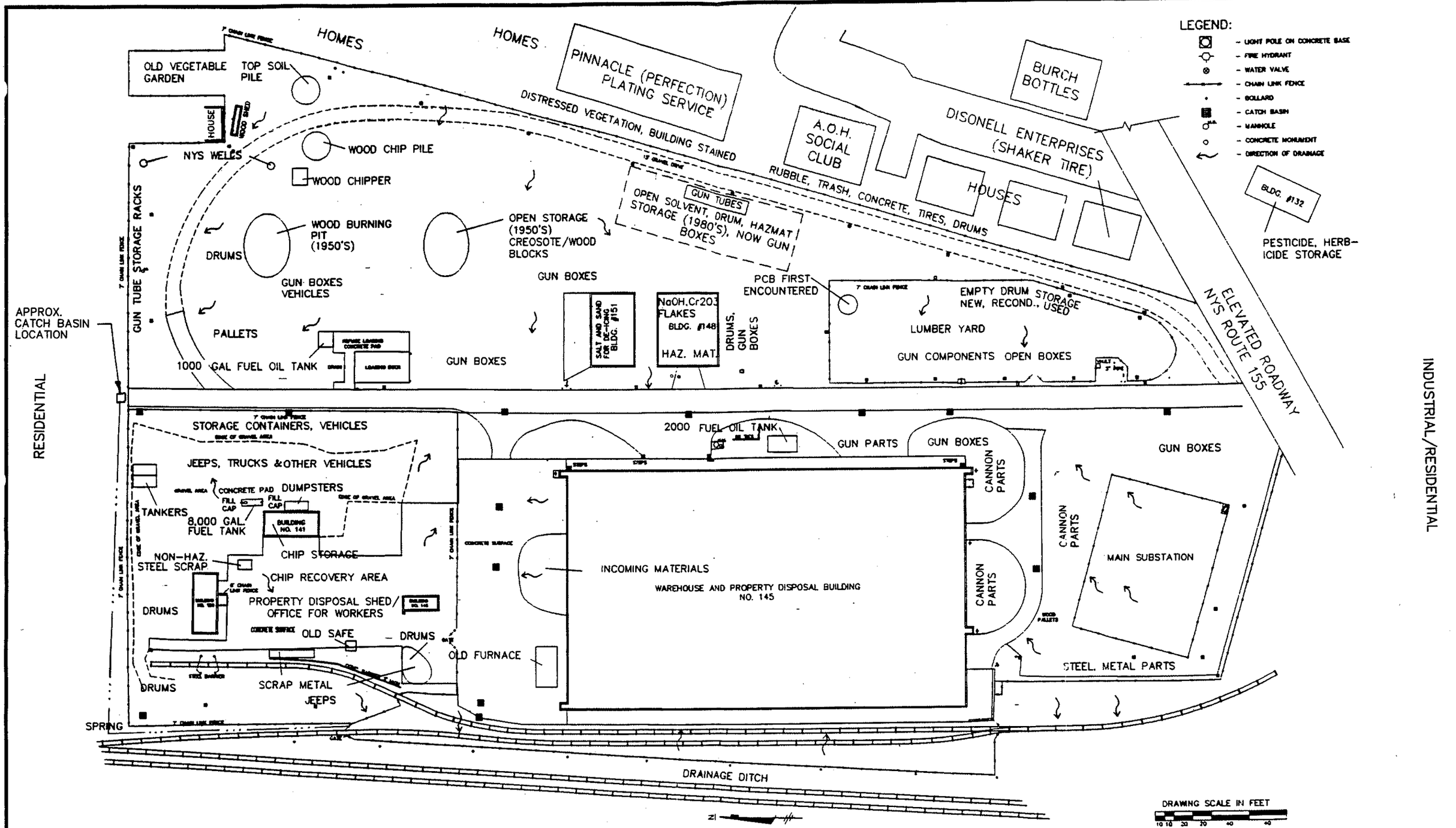


US Army Corps of Engineers

SIBERIA AREA
APPROXIMATE QUADRANT BOUNDRIES

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

FIGURE 1-3



SOURCE: IMS R.F.I. WORKPLAN, 1994.

US Army Corps of Engineers

SIBERIA AREA
LAND USE AND SITE CONDITIONS

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

FIGURE 1-4

1.2 SITE CHARACTERIZATION

Environmental investigations in the Siberia Area began in November 1986 with the discovery of PCB-containing oil during construction of Building 151. Since then numerous soil and groundwater sampling activities have been completed to better delineate the extent of chemical contamination across the Siberia Area. The following is a list of the previous investigations completed at the Siberia Area:

- William F. Cosulich Associates, P.C., 1980 - Oil Pollution Source Elimination Study.
- C.T. Male, 1986 - Preliminary Site Investigation.
- Environmental Science and Engineering - Update of the Initial Installation Assessment.
- EA Science and Technology, 1988 - Surface and Subsurface Contaminant Characterization of the Watervliet Arsenal "Siberia Area".
- Environmental Science and Engineering, 1991 - Phase I RCRA Facility Investigation Report.
- Malcolm Pirnie, Inc., December 1997 - RCRA Facility Investigation Report, Siberia Area, Watervliet Arsenal, Watervliet, NY (RFI Report).

Information and data from the RFI Report are used in this evaluation. Detailed discussions of the sampling procedures, sample analyses, and analytical results are presented in the RFI Report. The RFI tasks conducted to assess the nature and extent of contamination included:

- Surface soil sampling
- Geophysical survey
- Groundwater field screening (Geoprobe sampling)
- Soil boring sampling
- Monitoring well installation
- Groundwater sampling

- Surface water and sediment sampling
- Storm water and sanitary sewer sampling

The results of the first three tasks were analyzed prior to performing the subsequent tasks, in order to stratigraphically locate soil borings and monitoring wells and to help define the lateral extent of contamination.

A total of 37 surface soil samples were collected during this phase of the RFI. These samples were collected to identify chemical contaminants in the vadose zone and potential source areas originating at the ground surface. The analytical results for these samples indicated that surface soil in the Siberia Area is primarily contaminated with non-chlorinated, semi-volatile organic compounds (SVOCs), specifically polycyclic aromatic hydrocarbons (PAHs) and petroleum hydrocarbons related to cutting oil and waste oil disposal. Chlorinated organic compounds were detected in the NE Quadrant and are believed to be related to a former burn pit in this area. The analytical results indicate that the areal extent of contamination in surface soil is limited. Lead, chromium and arsenic contamination is prevalent in the NE and SW Quadrants. Lead and chromium contamination in surface soil in a portion of the NE Quadrant is attributable to the Perfection Plating Facility located directly to the east of the site and is not related to activities at the Siberia Area.

The subsurface soil borings were located at "hot spots" identified during the surface soil sampling to better define the vertical extent of contamination and confirm the results of previous analyses. The primary contaminants were PAH compounds, chromium, lead, arsenic and chlorinated organic compounds. The majority of the contamination is located in the NE Quadrant. The results of the soil boring analyses indicated that the contamination is limited to the near surface soil and the median concentrations significantly decrease with increasing depth. The subsurface soil sampling also revealed the presence of petroleum staining and petroleum odors.

Groundwater field screening was conducted using a Geoprobe system. In addition, groundwater samples were collected from existing monitoring wells. The results of these analyses indicated that hexavalent chromium contamination of groundwater is limited to the

NE Quadrant. Volatile organic compound (VOC) analyses indicated that chlorinated organic compound contamination is limited to the NE Quadrant, coincident with the area where chlorinated organic compounds were detected in surface and subsurface soil. In the SW Quadrant, the analyses indicated the presence of diesel- and kerosene-type hydrocarbons.

The analytical results for groundwater samples from the monitoring wells indicated that contamination is generally limited to the NE Quadrant. Groundwater contamination in the NE Quadrant consists of VOCs that appear to migrate along the shallow groundwater flow path toward the City of Watervliet combined sewer line which discharges to the Albany County Treatment Plant. It is believed that the sewer system bedding material acts as a line sink and is transporting contaminated shallow groundwater from the Siberia Area to the north, and may continue to transport contaminated shallow groundwater off the Siberia Area boundaries. VOCs were present in groundwater in the bedrock well 98 MPI-SA-MW-41.

Chromium (total and hexavalent) concentrations in groundwater collected in the NE Quadrant were elevated compared to concentrations in groundwater collected from the rest of the Siberia Area. Groundwater samples from the NE Quadrant containing elevated chromium concentrations were collected from all stratigraphic units (overburden, weathered bedrock, and bedrock). Groundwater samples collected from monitoring wells located directly downgradient of the Perfection Plating Facility contained hexavalent chromium concentrations in both the filtered and unfiltered samples. Lead and arsenic were also detected in concentrations greater than the New York State Class GA water quality standards in several groundwater samples, but only in the unfiltered samples. The remedial investigation conducted at the Perfection Plating Facility delineated a groundwater contaminant plume originating at the facility and extending north across the Siberia Area toward a private residence. The analytical results for barium in groundwater appeared to indicate that barium is indigenous in the groundwater and is not a site-related contaminant.

Six aqueous and three sediment samples were collected from the storm drain network in the Siberia Area to assess whether the sanitary and storm sewers are transporting contaminated water and/or acting as a continuing contaminant source by allowing contaminated storm water to exfiltrate to the groundwater. The aqueous and sediment samples collected

from inside the storm sewer at location STS-05 were the only samples with SVOC concentrations in excess of the New York State Class GA water quality standards and/or NYSDEC soil cleanup objectives (TAGM 4046). The storm sewer continues off-site from the STS-05 location into the City of Watervliet combined sewer system which discharges to the Albany County Treatment Plant except during wet weather. All flows in excess of approximately 2.5 times the average dry weather flow discharge to the Hudson River. Samples collected at three locations in the sewer network contained VOC concentrations in excess of the Class GA water quality standards and/or TAGM values. The aqueous and sediment samples collected from inside the storm sewer at location STS-06, in the northwestern corner of the site, contained very high concentrations of tetrachloroethene (600 µg/l, aqueous; 3,900,000 µg/kg sediment) in comparison to the other sewer samples. The soil and groundwater sampling results in this area did not indicate elevated tetrachloroethene concentrations, and the aqueous and sediment samples from STS-05, "downgradient" of STS-06, contained only 29 µg/l and 8 µg/kg of tetrachloroethene, respectively. In November 1995, WVA removed contaminated sediment from STS-06. The aqueous sample from the sanitary sewer at location SNS-6, located along the northern fence line, was the only sample to contain pesticides in concentrations in excess of the Class GA water quality standards. The concentration of DDE in SNS-6 was 0.03J µg/l, exceeding the Class GA water quality standard of non-detect. Lead and chromium were the only inorganic chemicals detected in concentrations in excess of the Class GA water quality standards and/or TAGM values.

Sampling of the groundwater present in the sewer bedding was also attempted at several locations along the road which transects the Siberia Area. However, due to the presence of a clayey backfill around the majority of the manholes, only one sample was able to be collected from location SNS-6. The results of the VOC analysis for the groundwater present in the sewer bedding indicated the presence of vinyl chloride in a concentration (17 µg/l) in excess of the Class GA water quality standard.

Additional soil and sediment sampling was completed for the Corrective Measures Study to fill data gaps identified from the results of the RFI. Three surface soil samples were collected from just outside boundaries of the NW and NE Quadrants. Four sediment samples

were collected in the ditch located immediately north of the northern fenceline and six sediment samples were collected from the drainage ditch located west of the NW Quadrant. The analytical results indicated that the contamination is limited primarily to PAHs, lead and arsenic.

2.0 HUMAN HEALTH EVALUATION

The ASTM standard guide presents a multi-tiered approach for evaluating environmental conditions at a site following adequate assessment and evaluation, determining risk-based chemical concentrations in soil and/or groundwater that should be protective of human health, and making rational decisions regarding closure of the site. The derivation of these chemical concentrations at each tier involves increasingly sophisticated levels of data collection and analysis. The primary difference between the tiers is the amount of site-specific data, rather than default values, used in the evaluation (ASTM, 1995). Three tiers of evaluation are outlined in the ASTM standard guide:

- Under Tier 1, a look-up table containing generic, risk-based screening levels (RBSLs) is developed to determine whether site conditions satisfy closure or warrant a more site-specific evaluation. Tier 1 RBSLs are typically derived for standard exposure scenarios using current reasonable maximum exposure scenarios and toxicological criteria recommended by the USEPA. Default values are used for all of the environmental parameters.

- Under Tier 2, a site may be closed if the on-site and off-site representative chemical concentrations do not exceed site-specific target levels (SSTLs). The default values used in Tier 1 are replaced with site-specific data and information to derive SSTLs.

- Under Tier 3, a site may be closed based on a more rigorous evaluation and derivation (e.g., based on computer modeling) of the SSTLs.

Since an extensive amount of environmental data was collected during the RFI and subsequent studies, SSTLs are derived for each chemical of potential concern in each environmental medium consistent with the ASTM Tier 2 guidance as described in the following subsections.

2.1 DATA EVALUATION

The analytical results presented in the RFI Report are briefly summarized and evaluated as follows with the intent of identifying those environmental media and chemicals (termed chemicals of potential concern) that, if contacted, may pose risks to human health.

Chemicals of potential concern were selected based on frequency of detection in an environmental medium (i.e., with sample sizes greater than 20, detection in 5 percent or more of the samples).

2.1.1 Soil

The analytical results for on-site surface soil samples (from the upper 2 feet of soil) and off-site surface soil and sediment are summarized in Table 2-1; the analytical results for the off-site soil and sediment samples are combined. The analytical results for all on-site soil samples regardless of depth are summarized in Table 2-2; separate presentations of the analytical results for fill soil and native soil are also provided for comparison purposes only. The frequency of detection, range of detected concentrations and average concentration are provided for each chemical detected in at least one sample. NYSDEC soil cleanup objectives (TAGM 4046) are also provided for comparison purposes only.

On-site Surface Soil - Thirty-seven surface soil samples (from 0.5 to 1 foot deep) and 37 shallow soil boring samples (from 0 to 2 feet) from soil borehole and monitoring well locations, for a total of 74 samples, were collected on-site and analyzed for SVOCs, VOCs, pesticides, PCBs and inorganic chemicals.

Twenty-six SVOCs were detected in one or more on-site surface soil samples. Of these, three chemicals (4-chloro-3-methylphenol, phenol and 3,3'-dichlorobenzidine) were detected with frequencies of detection less than 5 percent and are not evaluated further. The remaining 23 chemicals are evaluated as chemicals of potential concern.

Thirteen VOCs were detected in one or more on-site surface soil samples. Of these, seven chemicals (methylene chloride, chloroform, 2-butanone, trichloroethene, tetrachloro-

ethene, toluene and xylenes) had frequencies of detection greater than 5 percent and are evaluated as chemicals of potential concern. The remaining six chemicals are not evaluated further.

Thirteen pesticides and two PCB mixtures were detected in one or more on-site surface soil samples. Of these only endosulfan I, with a frequency of detection less than 5 percent, is not evaluated further. The remaining 14 chemicals are evaluated as chemicals of potential concern.

Eight inorganic chemicals were detected in one or more on-site surface soil samples. All of them are evaluated as chemicals of potential concern.

Off-site Surface Soil/Sediment - Thirteen surface soil and sediment samples were collected off-site from drainage ditches located adjacent to the SWMU boundary and analyzed for SVOCs, arsenic and lead. The off-site surface soil/sediment samples were not analyzed for VOCs, pesticides or PCBs.

Twenty SVOCs were detected in one or more off-site surface soil/sediment samples and, regardless of the frequencies of detection, are evaluated as chemicals of potential concern. Arsenic and lead, the only inorganic chemicals analyzed for, are evaluated as chemicals of potential concern in off-site surface soil/sediment.

All On-site Soil - Thirty-seven surface soil samples (6 to 12 inches) and 87 soil boring samples from soil borehole and monitoring well locations, for a total of 124 samples, were collected on-site and analyzed for SVOCs, VOCs, pesticides, PCBs and inorganic chemicals. One hundred-three samples were collected from fill material and 21 were collected from native material.

Twenty-eight SVOCs were detected in one or more soil samples. Of these, five chemicals (4-chloro-3-methylphenol, phenol, pentachlorophenol, 3,3'-dichlorobenzidine and 1,2-dichlorobenzene) had frequencies of detection less than 5 percent and are not evaluated further. The remaining 23 chemicals are evaluated as chemicals of potential concern.

Eighteen VOCs were detected in one or more soil samples. Of these, seven chemicals (chloroethane, 1,1-dichloroethene, 1,3-dichloropropene, ethylbenzene, 1,1,2,2-

tetrachloroethane, 4-methyl-2-pentanone and chlorobenzene) had frequencies of detection less than 5 percent and are not evaluated further. The remaining 11 chemicals are evaluated as chemicals of potential concern.

Thirteen pesticides and two PCB mixtures were detected in one or more soil samples. All of them are evaluated as chemicals of potential concern. Eight inorganic chemicals were detected in one or more soil samples with frequencies of detection greater than 5 percent. All of them are evaluated as chemicals of potential concern.

2.1.2 Groundwater

Overburden, weathered bedrock and bedrock monitoring wells were installed at the Siberia Area. These monitoring wells were sampled on two separate occasions for full TCL/TAL analysis for a total of 78 samples. Groundwater quality data are summarized in Table 2-3; since the deep and shallow water-bearing units are hydraulically connected, the groundwater results were combined. The frequency of detection, range of detected concentrations and average concentration are provided for each chemical detected in at least one sample. New York State Class GA Water Quality Standards are also provided for comparison purposes only.

Twenty-three SVOCs were detected in one or more groundwater samples. Of these, six chemicals (1,2-dichlorobenzene, 4-chloro-3-methylphenol, acenaphthalene, dimethyl-phthalate, phenol and benzo(a)pyrene) had frequencies of detection less than 5 percent and are not evaluated further. The remaining 17 SVOCs are evaluated as chemicals of potential concern.

Sixteen VOCs were detected in one or more groundwater samples. Of these, only one chemical (cis-1,2-dichloroethene) had a frequency of detection greater than 5 percent. Five chemicals (vinyl chloride, chloroform, trichloroethene, tetrachloroethene and xylenes), had frequencies of detection less than 5 percent but are evaluated as chemicals of potential concern since they were detected in groundwater samples from the NE quadrant at concentrations that exceeded the NYS Class GA Water Quality Standards. The contamination in the NE Quadrant migrates along the groundwater flow path toward the combined sewer line. Once in the sewer bedding material, contamination may migrate north and off the

Siberia Area into the adjacent residential area. VOCs that were detected only once are not evaluated further regardless of the detected concentration.

Nine pesticides were detected in one or more groundwater samples. Only 4,4'-DDT was detected at a frequency of detection greater than 5 percent and is evaluated as a chemical of potential of concern. The other pesticides are not evaluated further due to low frequencies of detection.

Six of the eight inorganic chemicals had frequencies of detection greater than 5 percent and are evaluated as chemicals of potential concern.

2.1.3 Summary of Environmental Media and Chemicals of Potential Concern

Based on the nature and extent of the analytical results presented above, all of the environmental media investigated at the Siberia Area pose potential risks to human health. The chemicals of potential concern in each environmental medium are summarized in Table 2-4. The following analyses focus on these chemicals of potential concern.

2.2 CONCEPTUAL EXPOSURE SCENARIOS

Prior to beginning the evaluation, conceptual exposure scenarios were developed to identify mechanisms by which chemicals of potential concern at the Siberia Area may migrate to potential points of human exposure under current conditions and hypothetical future conditions and land uses.

Currently, potentially exposed populations include Arsenal workers and site visitors and off-site residents, both adults and children. Evaluation of the potential for Arsenal worker exposure should adequately characterize the potential for exposure by occasional site visitors. Approximately 15 Arsenal employees work in the Siberia Area; routine activities conducted by these employees include work in the chip handling area, placement of material in outside areas for storage, and retrieval of material stored in the yard. A majority of the Siberia Area is unpaved and sparsely vegetated. Therefore, off-site residents could be exposed to respirable particles released from on-site soil. Children represent sensitive

receptors (i.e., any subpopulation that may be at increased risk from exposure due to increased sensitivity, behavior patterns, and/or current or past exposure from other sources). Since the entire WVA is fenced, has a gate that is guarded 24 hours a day and regularly patrolled by Arsenal personnel, trespassing is unlikely at the Siberia Area.

Congress has not listed the WVA on the Base Realignment and Closure (BRAC) list, and there are no plans in the near future to include it on this list. For the foreseeable future, the long-term use of the WVA is as an active, secure military facility. Thus, the only additional potentially exposed population in the future at the Siberia area may be utility workers conducting occasional maintenance and/or repairs at the site. Depending on future groundwater conditions, off-site residents could be exposed to volatile chemicals of concern due to volatilization from the groundwater.

For exposure to occur, four elements must be present:

- A source and mechanism of chemical release to the environment,
- An environmental transport mechanism,
- A point of human contact, and
- An exposure route (i.e., ingestion, inhalation, or dermal contact).

Thus, the analytical results summarized above indicate that soil provides potential exposure scenarios of concern under current conditions. Likewise, soil and groundwater provide potential exposure scenarios of concern under assumed future conditions. The basis for selection or elimination of conceptual exposure scenarios is presented in Table 2-5.

Potential current and future exposure scenarios for Arsenal workers include contact with on-site surface soil (and exposure via incidental ingestion and dermal contact) and inhalation of vapors and respirable particles released from on-site surface soil. Arsenal workers are assumed to have regular, casual contact with the surficial soil, and would, in general, not be involved in intrusive activities that might involve contact with the deeper soils.

Potential current and future exposure scenarios for off-site residents include contact with off-site soil (and exposure via incidental ingestion and dermal contact) and inhalation of vapors and respirable particles released from on-site surface soil. An additional potential

future exposure scenario for off-site residents is inhalation of vapors released from groundwater and transported to indoor air in the residence.

Potential future exposure scenarios for utility workers during activities involving excavation include contact with the surficial and deeper soils (and exposure via incidental ingestion and dermal contact), dermal contact with groundwater infiltrating an excavation, inhalation of vapors released from soil and groundwater, and inhalation of respirable particles released from soil. Utility workers are assumed to have relatively infrequent, though more intimate contact with the soil and groundwater.

2.3 DERIVATION OF SITE-SPECIFIC TARGET LEVELS

SSTLs are derived for the chemicals of potential concern identified in Table 2-4 using the equations provided in Table 2-6. The environmental parameters, chemical-specific parameters, exposure parameters, and toxicological criteria used to derive the SSTLs are provided in Appendix A. Standard sources were consulted for chemical-specific parameters (USEPA, 1996; Lyman *et al.*, 1990) and toxicological criteria (USEPA 1998, 1997a, and 1997b). The site-specific data used in the evaluation are described in Appendix B.

The only hexavalent chromium contamination in soil or groundwater at the Siberia Area is related to the Perfection Plating site and is being cleaned up under the remedial activities for that site. Hexavalent chromium was not detected in groundwater collected from elsewhere at the Siberia Area during the RFI. Thus, the SSTLs for chromium in soil and groundwater for elsewhere at the Siberia Area are based on trivalent chromium.

2.3.1 SSTLs for Soil

The SSTLs for on-site surface soil, off-site surface soil/sediment, and all on-site soils, are provided in Tables 2-7, 2-8 and 2-9, respectively.

For on-site surface soil, two sets of SSTLs are derived:

- For Arsenal worker exposure to surface soil via incidental ingestion, dermal contact, and inhalation of vapors and respirable particles, and

- For off-site resident exposure via inhalation of vapors and respirable particles.

As indicated in Table 2-7, the maximum concentrations of benzidine, five PAHs [benzo(a)anthracene; benzo(b)fluoranthene; benzo(a)pyrene; dibenz(a,h)anthracene; and ideno(1,2,3-cd)pyrene], two PCB mixtures (Aroclor 1254 and Aroclor 1260), heptachlor epoxide, and arsenic in on-site surface soil exceed their respective SSTLs for off-site residents and/or Arsenal workers.

For off-site surface soil/sediment, one set of SSTLs is derived:

- For off-site resident exposure to soil via incidental ingestion and dermal contact.

As indicated in Table 2-8, the maximum concentrations of four PAHs [benzo(a)anthracene; benzo(b)fluoranthene; benzo(a)pyrene; and ideno(1,2,3-cd)pyrene] and arsenic in off-site surface soil/sediment exceed their respective SSTLs for off-site residents.

For all on-site soil, two sets of SSTLs are derived:

- For utility worker exposure to soil via incidental ingestion, dermal contact, and inhalation of vapors and respirable particles, and in a separate derivation, and

- For utility worker exposure via inhalation of vapors in ambient outdoor air following release from soil.

As indicated in Table 2-9, the maximum concentrations of benzidine, four PAHs [benzo(a)anthracene; benzo(b)fluoranthene; benzo(a)pyrene; and dibenz(a,h)anthracene], two PCB mixtures (Aroclor 1254 and Aroclor 1260), arsenic, and cadmium in all on-site soil exceed their respective SSTLs for utility workers.

2.3.2 SSTLs for Groundwater

The SSTLs for groundwater are presented in Table 2-10. Three sets of SSTLs are derived based on potential exposure other than that from potable use:

- For off-site resident exposure to air in enclosed indoor spaces following chemical release from groundwater,

- For utility worker exposure to ambient outdoor air following chemical release from groundwater, and
- For utility worker exposure to groundwater via dermal contact.

As indicated in Table 2-10, the maximum concentration of vinyl chloride exceeds its respective SSTLs for off-site residents and utility workers.

2.3.3 SSTL Summary

The SSTLs for on-site surface soil, all on-site soil, off-site surface soil/sediment and groundwater are summarized in Table 2-11; for each of these media, the lowest SSTL from among those derived in Tables 2-7 to 2-10 is presented in the summary. The USEPA revised interim soil lead guidance value for lead in soil at residential properties (USEPA, 1998, 1994) is included in Table 2-11 as a SSTL.

Also included in Table 2-11 are site-specific soil saturation concentrations for each organic chemical of potential concern in soil (calculated as described in Appendix B), site-specific inorganic chemical concentrations in background soil, and water solubility limits for the organic chemicals of concern in groundwater. The soil saturation concentrations and water solubility limits are included for comparison purposes since, for some organic chemicals of potential concern in soil or groundwater, the derivation of the SSTLs results in values that are greater than these physicochemical limits. These SSTLs are replaced in Table 2-11 with the notation that they are greater than the respective physicochemical limit. Two of the SSTLs for arsenic in soil are less than the average site-specific background concentration; they are replaced in Table 2-11 with the notation that they are less than background.

For comparison, NYSDEC recommended soil cleanup objectives (TAGM 4046), adjusted NYSDEC recommended soil cleanup objectives to protect groundwater quality, soil cleanup criteria being used by the NYSDEC in remediating chemical contamination on the WVA that originated on the adjacent Perfection Plating site, and New York State water quality standards for Class GA water are presented in Table 2-11. Differences between the SSTLs and NYSDEC recommended soil cleanup objectives are due to the assumptions and

parameters (i.e., the potentially exposed populations, the exposure pathways and exposure routes, the toxicity criteria, and the site-specific data) used to derive the values. For PCBs, the recommended soil cleanup objectives of 1 mg/kg in surface soil and 10 mg/kg in subsurface soil are based on NYSDEC and USEPA policy. The soil cleanup criteria for arsenic and lead being used by the NYSDEC on the WVA are greater than the SSTLs, while the soil cleanup criterion for chromium is less than the SSTL. The NYSDEC's value for arsenic is based on noncarcinogenic rather than carcinogenic effects, their value for lead is based on industrial rather than residential land use, and their value for chromium is based on an assumption that it is all present as hexavalent rather than trivalent chromium.

2.3.4 SSTL Use

The risk-based SSTLs presented in Table 2-11 will be included among other criteria (e.g., the NYSDEC TAGM 4046 recommended soil cleanup objectives, technical practicability of the remedial alternatives, and cost) used to determine the extent of remediation and appropriate media cleanup standards for soil and groundwater contamination at the Siberia Area.

2.4 UNCERTAINTY ANALYSIS

Some uncertainty is inherent in the process of conducting human health evaluations and deriving SSTLs. Environmental sampling and analysis, chemical fate and transport modeling, human exposure modeling and the available toxicity criteria are all prone to uncertainty.

Uncertainty associated with environmental sampling is generally related to the limitations of the sampling in terms of the number and distribution of samples, while uncertainty associated with the analysis of samples is generally associated with systemic or random errors (e.g., false positive or negative results). The Siberia Area is well-studied in terms of both the extent of the sampling and the quality of the analytical data. Only chemicals with low frequency of detection were eliminated from further evaluation.

While aspects of the chemical fate and transport modeling and human exposure modeling can result in overestimation or underestimation of long-term exposure, these components of the SSTL derivation are probably overestimated, overall, for the potentially exposed populations evaluated. The chemical fate and transport models used to estimate VOC and respirable particle release are screening-level models that are conservative (i.e., tending toward overestimation) by design. The actual frequencies and durations of exposure would probably be less than the assumptions and input parameters used to model reasonable maximum exposure.

The toxicological criteria (e.g., RfDs or slope factors) may overestimate or underestimate the potential for adverse health effects; in most cases, the criteria are derived from extrapolation from laboratory animal data to humans and include safety factors to protective of human exposure. For some chemicals, there are insufficient data to derive toxicological criteria for oral and/or inhalation exposure. Thus, the SSTLs may be under protective for some chemicals and it was not possible to derive SSTLs for other chemicals.

3.0 FISH AND WILDLIFE IMPACT ANALYSIS

Malcolm Pirnie conducted this fish and wildlife impact analysis for the Watervliet Arsenal, Siberia Area (Siberia Area) and its vicinity (see Figure 1-1) for the purpose of identifying actual or potential impacts to fish and wildlife at the Siberia Area posed by site-related constituents detected in soil, sediment and groundwater.

The fish and wildlife impact analysis contains:

- A site description including a characterization of the floral and faunal resources present and the value of these resources to humans.
- The identification of applicable fish and wildlife standards and criteria.
- An evaluation of the potential exposure pathways to the fish and wildlife from site-related constituents of potential ecological concern.
- A Tier 1 analysis which includes a comparison of concentrations of constituents of potential ecological concern to regulatory criteria or derived toxicological benchmarks for the protection of fish and wildlife.

From this analysis, conclusions have been drawn regarding the potential exposure and risks to fish and wildlife associated with site-related constituents.

3.1 TERRESTRIAL RESOURCES

Federal and state natural resource agencies were contacted regarding species of concern, significant habitats, and fishery resources that are within a two-mile radius of the Siberia Area. In addition, Malcolm Pirnie obtained copies of the New York State Freshwater Wetland Maps to identify state wetlands in a two-mile radius of the site. U.S. Fish and Wildlife Service (USFWS) National Inventory Wetland Maps have not been completed for the project area (Marcuccio, 1997).

Due to the relatively urban nature of the site, no detailed ecological field reconnaissance surveys were proposed for the initial phase of the project. Instead, ecological

information was collected in conjunction with the sampling activities conducted on site over a three-year period.

Ecosystems were characterized in a 0.5-mile radius of the Siberia Area. Typical wildlife species expected to occur in the study area are discussed based on the geographic range and habitat requirements. The value of each habitat to wildlife is also provided.

Each plant cover type is described below as to plant species composition, vegetation structure, and land use. Whenever possible, these areas were classified according to the New York State Natural Heritage Program's *Ecological Communities of New York State* (Reschke, 1990).

There are no significant vegetative communities in the vicinity of the Siberia Area. The site is located in an urban area. The Siberia Area is primarily used as storage for raw and hazardous materials. The Delaware and Hudson Railroad is adjacent to the western property line and the former Adirondack Steel Casting Co. Residential properties adjoin the property to the north and northeast. Perfection Plating, which formerly manufactured metal plates for brake pads, is located along a portion of the eastern property line. Shaker Tire Sales is located along the southeast property line. This site is currently being remediated by the NYSDEC. Lands owned by the Town of Colonie and formerly owned by the Delaware and Hudson Railroad yard are located along the southern property boundary (see Figure 1-4).

The Siberia Area is almost completely void of vegetation, with the exception of a few small patches of grass. A small area in the northeastern corner of the site was formerly cultivated for vegetables by WVA personnel, but the practice has been stopped. Pesticides and herbicides are regularly used at the site to control weeds. Most of the area is either covered with gravel, concrete, asphalt, a gravel and dirt mixture, or geotextile fabric and fill and gravel. Vehicles, scrap metal, gun boxes and other miscellaneous items are temporarily stored in the Siberia Area. Therefore, there is little area for free growth of vegetation or development of wildlife habitats.

Beyond the site boundaries, habitats are consistent with residential/commercial areas. These areas typically consist of mowed lawns interspersed with trees and shrubs, which are often introduced exotics used for ornamental purposes.

3.2 AQUATIC RESOURCES

The Siberia Area is in the Hudson River Drainage Basin. The NYSDEC classifies surface water bodies as A, B, C or D. Title 6, Chapter 10, Part 700-705 of the New York State Code of Rules and Regulation (6NYCRR) defines the best usage of each water quality classification as:

- Class A waters are suitable for use as a public water supply.
- Class B waters indicate that the waters are suitable for fishing and fish propagation and primary and secondary contact recreation. Class B streams cannot be used as a drinking water source.
- Class C waters are to be maintained as suitable for fish survival and/or reproduction and other aquatic life and for secondary contact recreation but not primary contact recreation.
- Class D streams are suitable for fishing. However, due to natural conditions such as intermittency of flow, water conditions are not conductive to fish propagation.

The standards presented in 6NYCRR also set measurable limits on pollution indicators including dissolved oxygen, turbidity, colloidal solids, oil and floating substances, phosphorus and nitrogen, and taste-, color- and odor-producing toxic or deleterious substances. Class A, B, and C waters should have a pH greater than 6.5 and no more than 8.5. For nontrout waters, the average daily dissolved oxygen content should not be less than 5.0 mg/l and never less than 4.0 mg/l.

The Hudson River, which is approximately 0.3 mile east of the Siberia Area, is classified as Class C. The Kroma Kill (located approximately 0.7 mile west) and a tributary to the Kroma Kill (located approximately 0.5 mile west) are classified as Class D (Streeter, 1996).

No surface water bodies exist on the site. The majority of surface water runoff from the site is handled by means of a storm sewer system which collects surface water at storm grates along the main road, the northern fence line and in the impervious areas in the northwest portion of the Siberia Area. The storm sewer system discharges along

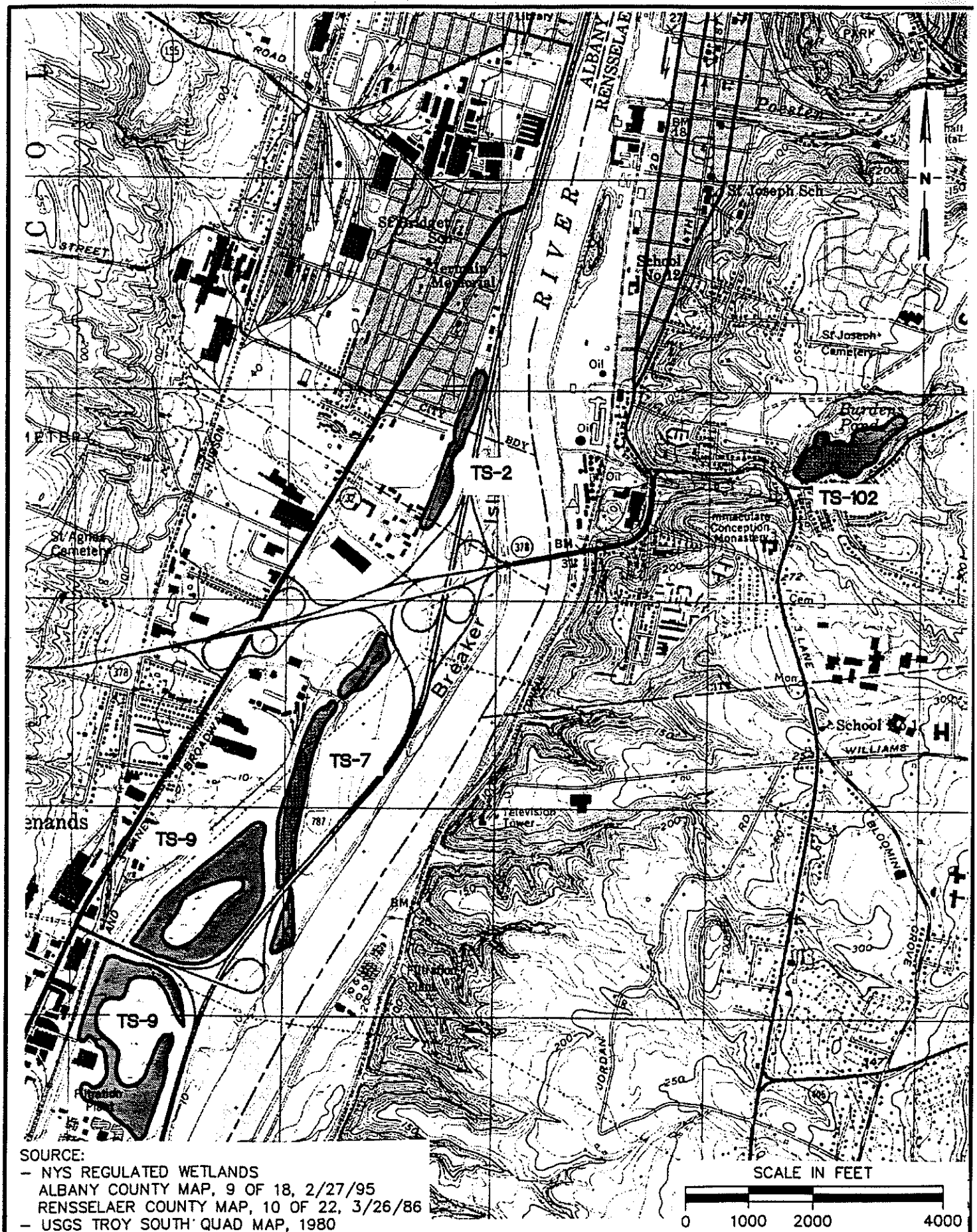
the northern fence line. During dry weather, the discharge from the site is directed to the City of Watervliet combined sewer system which discharges to the Albany County Sewage Treatment Plant. If the flow in the combined system is in excess of approximately 2.5 times the average dry weather flow, runoff is discharged directly to the Hudson River rather than the treatment plant.

Precipitation that is unable to enter the storm sewer system generally collects in large puddles in local low areas and eventually infiltrates or evaporates. However, during periods of heavy rainfall, surface water travels northward across the site as sheet flow and exits the site by passing through the northern fence line.

The continued migration of surface water after it leaves the Siberia Area to the north and west is interrupted by a ditch which runs east-west and the low topographic areas through which the railroad tracks run along the west side of the Siberia Area. This ditch is shown on Figure 1-4 and was sampled as part of the RFI activities. The ditch is approximately 2 to 3 feet wide and 1 foot deep. The banks and bottom are covered by grasses and forbes. At the time of sampling, no water was present in the ditch . The ditch runs east-west along the northern boundary of the site. It enters a catch basin that discharges to storm sewers. Because of these obstacles, it is unlikely that surface flow directly reaches either the Kroma Kill or the unnamed tributary that is located to the west of the Siberia Area.

3.3 FRESHWATER WETLANDS

Numerous wetlands are present around the Siberia Area (see Figure 3-1). A major state wetland (viz. TS-2) is located to the southeast of the Siberia Area, along the western bank of the Hudson River. The northern tip of this wetland is approximately one mile south of the Siberia Area. It is separated from the Siberia Area by the Delaware and Hudson Railroad yard and a residential section of the City of Watervliet. A smaller wetland is located along the eastern bank of the Hudson River, west of Menands. Although the wetlands are downstream and downgradient of the site, there is no known direct route of entry of constituents from the site into the wetlands. As discussed previously, surface water



SOURCE:
- NYS REGULATED WETLANDS
  ALBANY COUNTY MAP, 9 OF 18, 2/27/95
  RENSSELAER COUNTY MAP, 10 OF 22, 3/26/86
- USGS TROY SOUTH QUAD MAP, 1980

US Army Corps of Engineers

SIBERIA AREA
NEW YORK STATE REGULATED WETLANDS
WATERVLIET ARSENAL
USACE CONTRACT NO. DACA31-94-D-0017

MALCOLM PIRNIE, INC.

FIGURE 3-1

from the site enters the ditch or on-site catch basins and eventually into the storm sewer system and is either treated at the Albany County Sewage Treatment Plant or discharged directly to the Hudson River. Due to the distance involved and fate and transport mechanisms, no significant effects on the wetlands or the Hudson River are expected.

3.4 OBSERVATIONS OF STRESS

Signs of stress to vegetation and wildlife from site constituents were not observed during the field sampling activities. The lack of vegetation on the site proper reflects its use as a storage and material handling area.

3.5 FISH AND WILDLIFE RESOURCES

The Siberia Area is located in an industrial/commercial area that is surrounded by mixed commercial/residential neighborhoods. The site and surrounding area do not support an abundance of wildlife due to the limited areas of vegetation to provide food and cover. No Federally-listed threatened, endangered or special concern species were identified within a two-mile radius of the Siberia Area (Clough, 1996). One State-listed plant species, green rock-cress (*Arabis missouriensis*), is listed as occurring within a two-mile radius (Albert, 1996).

3.6 VALUE OF HABITAT TO ASSOCIATED FAUNA

The Siberia Area and adjoining properties are of little value to wildlife. The area is developed, has only isolated pockets of vegetation, and in most cases these areas are maintained by frequent mowing. The wildlife expected to occur in the vicinity of the Siberia Area include the more urbanized bird and mammalian species such as rock dove (*Columbia livia*), cottontail rabbit (*Sylvilagus floridanus*), Norway rat (*Rattus norvegicus*) and European

starling (*Sturnus vulagaris*). Since limited areas of vegetation exist, the population size in the area will also be limited.

3.7 VALUE OF RESOURCES TO HUMANS

The Siberia Area and immediate vicinity are of little value to humans for recreational use of wildlife. Bird feeders were noted in the area during sampling events. The developed nature of the area precludes small game and deer hunting.

3.8 APPLICABLE FISH AND WILDLIFE STANDARDS AND CRITERIA

Site-specific standards and criteria protective of fish and wildlife associated with WVA that may be applicable to future remediation are**:**

- Migratory Bird Treaty Act.
- Water Quality Standards and Guidance Values 6 NYCRR Part 701 through 703 and TOGS 1.1.1, and sediment criteria for the protection of fish and wildlife (Technical Guidance for Screening Contaminated Sediments 1993).

3.9 EXPOSURE ASSESSMENT

3.9.1 Chemicals of Potential Ecological Concern

For this assessment, the organic and inorganic constituents detected in the groundwater will not be considered chemicals of ecological concern for ecological receptors except indirectly as a potential source of contamination to sediment or surface water downgradient of the site. Since actual sediment samples were collected and characterized in the Siberia Area, constituents associated with groundwater were not factored into this fish and wildlife analysis.

Surface and subsurface soil, and sediment samples, were collected from the Siberia Area. Essential nutrients (calcium, iron, potassium, sodium and magnesium) are not considered constituents of concern. The remaining constituents are considered of ecological concern if the frequency of detection in sample sizes ≥20 was greater than 5 percent or one in 20. Only the shallow subsurface data (zero to 2 feet) in combination with the surface soil samples were considered in the fish and wildlife impact analysis. Deeper subsurface soils were not evaluated due to the lack of an exposure route to wildlife. Most burrowing animals create dens in only the upper 2 feet of soil. In addition, the deeper subsurface soil samples (i.e., greater than 4 feet) are below the root zone of most plants. Table 3-1 lists the constituents of ecological concern for the Siberia Area by medium. Analytical results of the investigations are presented in the RFI Report (Malcolm Pirnie, 1997).

3.9.2 Contaminant Migration and Fate

Volatile Organic Compounds - The volatile organic compounds of interest have high vapor pressures and, therefore, would be expected to volatilize readily from surface soil to the atmosphere. Once released to the atmosphere, these compounds are rapidly photodegraded (Howard, 1990).

In deeper soils, these compounds degrade slowly, are water soluble and may leach into groundwater. These compounds have low octanol/water coefficients (log K_{ow}) and therefore don't adsorb to sediment or particulate matter present in the water column. These compounds do not bioconcentrate in aquatic organisms (Howard, 1990).

PAHs - PAHs contain only carbon and hydrogen and consist of two or more fused benzene rings in linear, angular or cluster arrangements. In general, most PAHs can be characterized as having low vapor pressure, low water solubility, low Henry's Law constants, high log K_{ow}, and high organic carbon partition coefficients (K_{oc}). High partition coefficients and low solubilities suggest that PAHs are likely to be adsorbed onto sediment or soil particles. Conversely, these properties indicate that most PAHs will not readily volatilize into the atmosphere (Eisler, 1987).

TABLE 3-1

FISH AND WILDLIFE IMPACT ANALYSIS
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN

Parameter	Surface Soil	Off-Site Soil	Sediment
Volatile Organic Compounds			
Toluene	X	NA	NA
2-Butanone	X	NA	NA
Methylene Chloride	X	NA	NA
Chloroform	X	NA	NA
Trichloroethene	X	NA	NA
Tetrachloroethene	X	NA	NA
Xylene	X	NA	NA
Semivolatile Organic Compounds			
Bis(2-ethylhexyl)phthalate	X	X	X
Chrysene	X	X	X
Benzo(a)anthracene	X	X	X
Dibenzo(a,h)anthracene	X	X	
Benzo(b)flouranthene	X	X	X
Phenanthrene	X	X	X
Fluoranthene	X	X	X
Pyrene	X	X	X
Benzo(k)fluoranthene	X	X	X
Benzo(a)pyrene	X	X	X
Indeno(1,2,3-cd)pyrene	X	X	X
Phenol			X
Naphthalene	X	X	X
Acenaphthylene	X	X	X
Acenaphthene	X	X	X
2-Methylnaphthene	X		
Diethylphthalate	X	X	X
Fluorene	X	X	X
Anthracene	X	X	X
Di-n-butylphthalate	X		
Benzidine	X		

TABLE 3-1

FISH AND WILDLIFE IMPACT ANALYSIS
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN

Parameter	Surface Soil	Off-Site Soil	Sediment
Butylbenzylphthalate	X	X	X
Benzo(g,h,i)perylene	X	X	X
Di-n-octylphthalate	X		
Pesticides/PCBs			
Heptachlor Epoxide	X	NA	NA
Aroclor 1254	X	NA	NA
Aroclor 1260	X	NA	NA
4,4'-DDT	X	NA	NA
beta-BHC	X	NA	NA
delta-BHC	X	NA	NA
Aldrin	X	NA	NA
Dieldrin	X	NA	NA
4,4'-DDE	X	NA	NA
Endrin	X	NA	NA
4,4'-DDD	X	NA	NA
Endosulfan Sulfate	X	NA	NA
Methoxychlor	X	NA	NA
Endrin Ketone	X	NA	NA
Inorganic Compounds			
Arsenic	X	X	X
Barium	X	X	NA
Cadmium	X	X	NA
Chromium	X	X	NA
Lead	X	X	X
Mercury	X	X	NA
Selenium		X	NA
Silver	X	X	NA

Notes:
NA = Constituent not analyzed in the environmental medium

Although PAHs are regarded as persistent in the environment, they can be degraded, under certain physicochemical conditions by microorganisms. Degradation rates and degree of degradation are influenced by environmental factors, microbial flora and physicochemical properties of the PAHs themselves. Important environmental factors influencing degradation include temperature, pH, redox potential and microbial species. Physicochemical properties include chemical structure, concentration and lipophilicity (Eisler, 1987). The more persistent PAHs (i.e., five- and six-ring hydrocarbons) may not be biodegradable and therefore may not be bioavailable.

The fate of adsorbed PAHs in water is influenced by a number of factors including duration of PAH exposure to sunlight which will largely determine the extent of photoxidation. In general, only small amounts of PAHs in aquatic systems will be found in solution, and could be expected to accumulate in the sediments. The ultimate fate of PAHs that accumulate in sediments is biodegradation and biotransformation by benthic organisms. However, biodegradation is slow in the absence of penetrating radiation and oxygen (Eisler, 1987).

Phthalic Esters - Phthalic esters will slightly to moderately sorb to most soils and should not leach appreciably to groundwater. However, phthalic esters have been detected in groundwater at sites where these compounds have been spilled. Phthalic esters may form complexes with fulvic acid, a water-soluble humic material formed from decomposition of plants. These complexes may aid in the transport of these compounds to groundwater (Howard 1990).

The most significant fate of most phthalic esters in soil will be aerobic biodegradation following acclimation. Limited data are available on the rate of biodegradation. However, as presented in Howard 1990, two bench scale studies indicated 98 percent and 66 percent degradation of di-n-butylphthalate in 26 weeks. Oxidation, chemical hydrolysis and volatilization are not expected to be significant fate processes due to low vapor pressure, low water solubility, low Henry's Law constants, high log K_{ow}, and high K_{oc}. Due to its slightly higher vapor pressure from the other phthalate esters, diethylphthalate may volatilize from dry soils (Howard, 1990).

If released to water, phthalate esters will moderately sorb to sediment and complex with humic material in the water. Photolysis, oxidation and hydrolysis are very slow in the aquatic environment and therefore are not environmentally significant in the removal of phthalic compounds. Biodegradation rates are rapid in the aquatic environment. As presented in Howard 1990, studies for di-n-butyl phthalate indicated 90 to 100 percent degradation occurred in 3 to 5 days in a river and 2 to 17 days in water from other freshwater sites. The half-lives of dimethylphthate and diethylphthalate in freshwater systems are reportedly less than 11 days and 2 to 14 days, respectively (Howard, 1990).

Metals - In a terrestrial setting, trace elements released to the environment accumulate in the soil (Sposito and Page, 1984). Mobility of these trace elements in soils is low and accumulated metals are depleted slowly by leaching, plant uptake, erosion or chelation. The half-life of trace elements in a temperate climate ranges from 75 years for cadmium to more than 3,000 years for zinc.

The transport of trace elements in soil may occur via the dissolution of metals into pore water and leaching to groundwater, or colloidal or bulk movement (i.e., wind or surface water erosion). The rates of trace element migration in soil are affected by the chemical, physical and biological characteristics of the soil. The most important characteristics include:

- Eh-pH system
- Cation exchange capacity and salt content
- Quantity of organic matter
- Plant species
- Water content and temperature
- Microbial activity

Most metals exist mainly as cations in the soil solution, and their adsorption therefore depends on the density of negative charges on the surface colloids (Alloway, 1990). Clayey soils such as those found at the Siberia Area, tend to have a large surface area that is negatively charged. This suggests trace elements are tightly bound to the soil and not

mobilized deeper to groundwater or into the aquatic environment (Alloway, 1990; Kabata-Pendias and Pendias, 1992).

Metals which do mobilize from the soil into the water column do so under acid conditions and increasing pH usually reduces their bioavailability. Generally metals do not exist in soluble forms for long and generally accumulate in bottom sediment. Once in the sediments, most metals sorb onto hydrous iron and manganese oxides, clay minerals and organic materials and are eventually partitioned into the sediments. Metal bioavailability from the sediment is enhanced under conditions of low pH, high dissolved oxygen content, high temperature, and oxidation state. During these conditions, metals become soluble and freely move in the interstitial pore water and the water column (McIntosh, 1992).

3.9.3 Exposure Pathways

Wildlife resources on and in the vicinity of the Siberia Area are limited due to the lack of food and cover. No federally-listed endangered or threatened species were identified in a two-mile radius of the study area. One state-listed plant species was identified as occurring in the two-mile radius study area. Several wetlands were identified within the two-mile radius; however, they are too distant from the site for any likely exposure to site-related constituents. Thus exposure is likely to be limited to wildlife on, near or immediately downgradient from the site.

Plants selectively uptake metals in soil by absorption from soil solution by the root. Metals may be bound to exterior exchange sites on the root and not actually taken up. They may enter the root passively in organic or inorganic complexes or actively by way of metabolically controlled membrane transport. Once in the plant, a metal can be stored in the root or translocated to other plant parts. Volatile organic compounds and PAHs have limited entry into plants and minimal translocation once inside (Efroymson *et al.*, 1997a).

Due to the industrial setting and the limited available habitat, the Siberia Area does not support an abundant population of wildlife. The Siberia Area may support a few individual small mammal and bird species (i.e, mice and rats). The available habitat would not support larger mammals or birds of prey, however, these species could potentially pass through. This limited population could be exposed to constituents through direct contact

with or incidental ingestion of contaminated soil or through the terrestrial food chain. The surface soil and sediment contained several organic and inorganic constituents. Therefore a low risk exists to the terrestrial plants and limited wildlife population inhabiting the site.

3.10 CRITERIA-SPECIFIC TOXICITY ASSESSMENT

3.10.1 Soil

The NYSDEC does not have soil clean-up criteria relating to the protection of wildlife and the availability of applicable soil screening values in the scientific literature is limited. The evaluation of constituents of interest was conducted by comparing constituent concentrations to available screening benchmark values derived by the Oak Ridge National Laboratory (Efroymson *et al.*, 1997a; Efroymson *et al.*, 1997b; Sample *et al.*, 1996) for the U.S. Department of Defense. The benchmark values are the tenth percentile of the distribution of various toxic effects thresholds for the group of organisms in the soil.

Transformation or loss due to environmental degradation is not considered in this evaluation. It is assumed that uptake of concentrations in soil results in equal concentrations in organisms. This is a conservative approach in that plants, which are scarce on-site, uptake, to a limited extent, the constituents of ecological concern and wildlife will have limited contact with the soil and plants at the site. This results in an overestimation of ecological exposure.

Benchmark values for three groups of organisms are presented in Table 3-2. Terrestrial plants were selected since they are critical in nutrient cycling and are a source of food in the diet of higher animals. Also, plants may, to a limited extent, uptake the constituents of ecological interest. Earthworms were selected because of their importance in maintaining soil fertility through burrowing and feeding activities. Also, earthworms are at the base of the food chain and are an important food for higher organisms. Cottontail rabbits were selected to represent small mammals. Cottontail rabbits were observed on the property during the field reconnaissance. Small mammals are at the base of the food chain and an important food source for higher organisms. The values for cottontail rabbits are presented as dietary concentrations in mg/kg that would result in a no observed adverse effect level

TABLE 3-2

FISH AND WILDLIFE IMPACT ANALYSIS
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL
SUMMARY OF SURFACE SOIL* DATA

Parameter	Toxicological Benchmarks			On-Site Surface Soil			Off-site Surface Soil		
	Cottontail Rabbit	Terrestrial Plants	Earth Worms	Frequency of Detection	Range of Detected Concentrations	Average Concentration	Frequency of Detection	Range of Detected Concentrations	Average Concentration
Semivolatiles Organic Compounds (ug/kg)									
Naphthalene				48/75	7-18000	488	7/7	19-130	57.3
Acenaphthylene	**351,000**			44/75	5-4400	183.5	7/7	57-440	123
Acenaphthene		20,000		40/75	15-9300	593	7/7	25-360	104
2-Methylnaphthalene				48/75	10-37100	1167	0/7	ND	---
Diethylphthalate	6,869,163	100,000		29/75	7-13000	482.6	3/7	11-14	12.3
Fluorene		200,000	30,000	37/75	13-12000	737	7/7	30-300	95.7
Phenanthrene	**156,000**			69/75	6-42000	2708	7/7	370-3300	1127
Anthracene	**2,008,000**			65/75	6-9800	647	7/7	96-1000	318
Di-n-butylphthalate	824,359	200,000		46/75	10-700	60.2	0/7	ND	---
Fluoranthene	**251,000**			69/75	10-150000	4306	7/7	750-6600	2107
Benzidine	**542**			11/75	89-180000	17709	0/7	ND	---
Pyrene	**151,000**			63/75	9-35000	2684	7/7	600-5500	1837
Butylbenzylphthalate	**590,000**			11/75	32-4000	936	3/7	18-65	42.3
Benzo(a)anthracene				65/75	8-63000	2138	7/7	340-3600	1110
Chrysene				67/75	14-14000	1351	7/7	470-4400	1421
bis(2-Ethylhexyl)phthalate	27,474			43/75	15-79000	2196	7/7	70-520	202
Di-n-octylphthalate	**65,000**			7/75	12-51000	7763	0/7	ND	---
Benzo(b)fluoranthene				65/75	8-58000	2313	7/7	320-3700	1351
Benzo(k)fluoranthene				66/75	14-41000	1821	6/7	30-2600	1113
Benzo(a)pyrene	1,499			60/75	12-15000	1323	7/7	340-3700	1169
Indeno(1,2,3-cd)pyrene				49/75	13-17000	1056	7/7	120-1900	447
Dibenz(a,h)anthracene				19/75	19-1100	256	1/7	34-34	34.0
Benzo(g,h,i)perylene				43/75	11-3400	654	7/7	90-1700	376
Volatile Organic Compounds (ug/kg)									
Methylene Chloride	19,724			29/75	1-400	19.7	Not analyzed		
Chloroform	50,575			4/75	0.6-97	25.2	Not analyzed		
2-Butanone	5,971,274			6/75	30-270	152	Not analyzed		
Trichloroethene	1,049			7/75	1-1600	232	Not analyzed		
Tetrachloroethene	**40,200**			11/75	1-36000	3291	Not analyzed		
Toluene	38,940	200,000		23/75	0.7-190	15.6	Not analyzed		
Xylene (total)	3,088			14/75	1-230	33.0	Not analyzed		
Benzene				4/75	0.6-10	5.7	Not analyzed		
Ethylbenzene				4/75	0.5-33	12.9	Not analyzed		
Pesticide and PCB (ug/kg)									
beta-BHC	1,349			4/71	0.78-3.7	2.2	Not analyzed		
delta-BHC	5,395			17/71	2.1-140	22.7	Not analyzed		
Aldrin	674			19/71	0.71-26	4.1	Not analyzed		
Heptachlor Epoxide	**114**			10/71	0.51-210	28.8	Not analyzed		
Dieldrin	67			5/71	0.41-24	6.9	Not analyzed		
4,4'-DDE	533			22/71	0.42-49	12.4	Not analyzed		
Endrin	138			11/71	4-60	18.0	Not analyzed		
4,4'-DDD	533			23/71	0.88-280	28.6	Not analyzed		
Endosulfin Sulfate				17/71	0.14-44	14.9	Not analyzed		
4,4'-DDT	533			39/71	0.74-380	49.0	Not analyzed		
Methoxychlor	13,487			15/71	1.8-110	23.2	Not analyzed		
Endrin Ketone				11/71	2.6-200	31.7	Not analyzed		
Aroclor-1254	177	40,000		22/71	15-1600	282	Not analyzed		
Aroclor-1260	177	40,000		22/71	28-1900	316	Not analyzed		

TABLE 3-2

FISH AND WILDLIFE IMPACT ANALYSIS
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL
SUMMARY OF SURFACE SOIL* DATA

Parameter	Toxicological Benchmarks			On-Site Surface Soil			Off-site Surface Soil		
	Cottontail Rabbit	Terrestrial Plants	Earth Worms	Frequency of Detection	Range of Detected Concentrations	Average Concentration	Frequency of Detection	Range of Detected Concentrations	Average Concentration
Inorganic Compounds (mg/kg)									
Arsenic	0.189	10	60	75/75	3.4-49.2	13.2	7/7	21.6-104	62.6
Barium	18.33	500		75/75	23.8-439	155	Not analyzed		
Cadmium	0.287	4	20	48/75	0.21-23.8	2.1	Not analyzed		
Chromium	1822	1	0.4	75/75	9.7-2490	139	Not analyzed		
Lead	26.9	50	500	75/75	4.2-17400	418	7/7	320-1130	487
Mercury	0.022	0.3	0.1	53/75	0.094-4	0.37	Not analyzed		
Selenium	0.112	1	70	55/75	0.26-30.1	2.6	Not analyzed		
Silver		2		27/75	0.24-10.5	1.8	Not analyzed		

Notes:
* = Surface soil samples include surface soil samples and shallow boring samples (0 to 2 feet)
Bolded values are derived benchmarks. See Tables 3-3 and 3-4.
N/A = None Available
ND = Not Detected

(NOAEL). For screening purposes, it was assumed that the concentration found in soil would be found in the food items of the cottontail rabbit. As stated previously, this is a conservative approach that results in the overestimation of potential exposure and risk.

Examination of Table 3-2 indicates that few screening values are available for the site-specific organic constituents of ecological concern. Therefore, the methodology of the Oak Ridge National Laboratory (Sample *et al.*, 1996) was used to derive toxicological benchmarks for the cottontail rabbit from published toxicological data for laboratory animals. Literature sources included the USEPA's IRIS and HEAST and toxicological profiles from the Agency for Toxic Substances and Disease Registry (ATSDR). It should be emphasized that the resulting benchmarks obtained from this methodology and toxicological data represent a conservative approach whose resulting relationship to potential population level effects is uncertain.

No observable adverse effect levels (NOAELs) and lowest observable adverse effect levels (LOAELs) are daily dose levels normalized to the weight of the test animal (e.g., milligrams of constituent per kilogram body weight per day [mg/kg/day]). The presentation of toxicity data on a mg/kg/day basis allows for comparison across species with appropriate consideration for differences in body sizes. If a NOAEL (or LOAEL) is available for a mammalian test species ($NOAEL_t$), then the equivalent NOAEL (or LOAEL) for a mammalian wildlife species ($NOAEL_w$) can be calculated by using the adjustment factor for

$$NOAEL_w = NOAEL_t \left(\frac{bw_t}{bw_w} \right)^{1/4}$$

differences in body size:

Where:

$NOAEL_w$ = No observed adverse effect level for wildlife species (mg/kg/day)

$NOAEL_t$ = No observed adverse effect level for test species (mg/kg/day)

bw_w = Body weight for wildlife species

bw_t = Body weight for test species

In some cases, a NOAEL for specific constituents was not available, but a LOAEL or lethal dose (LD50) had been determined experimentally. The NOAEL can be estimated by applying an uncertainty factor (UF) to the LOAEL or LD50. In the USEPA methodology (USEPA, 1995), the LOAEL or LD50 can be reduced by a factor of 10 or 50, respectively to derive the NOAEL.

The dietary level or concentration in food (C_f) of a constituent in milligrams of constituent per kilogram of food that would result in a dose equivalent to the NOAEL or

$$C_f = \frac{NOAEL_w}{f}$$

LOAEL can be calculated from the food factor *f*:

The food factor, *f* is the amount of food consumed per day per unit of body weight. Table 3-3 provides the body weight , food intake and food factors utilized in the derivation of constituent-specific NOAELs for the cottontail rabbit (Sample *et al.,* 1996). Table 3-4 provides the derived toxicological benchmarks.

Seventy-four on-site shallow boring and surface soil samples were collected and analyzed for volatile organic compounds, semi-volatile organic compounds, pesticides and PCBs, and inorganic compounds. Screening the maximum concentrations against the literature and derived benchmark values indicated the following:

- The maximum concentrations of benzidine bis(2-ethylhexyl)phthalate, heptachlor epoxide, benzo(a)pyrnene and trichlorethene exceeded the toxicological benchmarks for cottontail rabbit. No technological benchmarks are available for terrestrial plants or earthworms.

- The maximum concentrations of Aroclor 1254, Aroclor 1260 and barium exceeded the toxicological benchmarks for cottontail rabbit but not for terrestrial plants. No toxicological benchmarks are available for earthworms.

- The maximum concentrations of arsenic and selenium exceeded the toxicological benchmarks for cottontail rabbit and terrestrial plants but not earthworms.

- The maximum concentrations of chromium, mercury, and lead exceeded the toxicological values for cottontail rabbit, terrestrial plants and earthworms.

TABLE 3-3

FISH AND WILDLIFE IMPACT ANALYSIS
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

PARAMETERS FOR CALCULATION OF TOXICOLOGICAL BENCHMARKS

Organism	Body Weight (kg)	Food Intake (kg/day)	Food Fator *f*
Rat	0.35	0.028	0.08
Mouse	0.03	0.0055	0.18
Dog	12.7	0.301	0.024
Laboratory Rabbit	3.8	0.135	0.034
Cottontail Rabbit	1.2	0.237	0.198

Source: Sample et al., 1996

TABLE 3-4

FISH AND WILDLIFE IMPACT ANALYSIS
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

DERIVATION OF TOXICOLOGICAL BENCHMARKS FOR COTTONTAIL RABBIT

Constituent	Test Organism	Endpoint	$NOAEL_t$ (mg/kg/day)	Reference for Test Species	NOAEL for Cottontail Rabbit (mg/kg/day)	Toxicological Benchmark for Cottontial Rabbit (mg/kg)
Naphthalene						
2-Methylnaphthalene						
Acenaphthylene	Mouse	NOAEL	175	IRIS	69.6	351
Anthracene	Mouse	NOAEL	1,000	HEAST	398	2,008
Benzo(a)anthracene						
Benzo(b)fluoranthene						
Benzo(k)fluoranthene						
Butylbenzylphthalate	Rat	NOAEL	159	IRIS	117	590
Chrysene						
Di-n-octylphthalate	Rat	LOAEL (175 mg/kg/day)	17.5	HEAST	12.9	65
Dibenz(a,h)anthracene						
Benzo(g,h,i)perylene						
Benzidine	Mouse	LOAEL (2.7 mg/kg/day)	0.27	HEAST	0.107	0.542
Fluoranthene	Mouse	NOAEL	125	HEAST	49.7	251
Indeno(1,2,3-cd)pyrene						
Phenanthrene	Mouse	LD50 (3889 mg/kg/day)	77.8	Lewis, 1992	30.9	156
Pyrene	Mouse	NOAEL	75	HEAST	29.8	151
Tetrachloroethene	Mouse	NOAEL	20	IRIS	8.0	40.2
Heptachlor Epoxide	Dog	LEL	0.0125	IRIS	0.0225	0.114
Endosulfan sulfate						
Endrin Ketone						

Notes:
Blank spaces indicate no toxicological data was readily available from literature sources

- The maximum concentration of cadmium exceeded the toxicological benchmark for cottontail rabbits but not terrestrial plants and earthworms.

Seven off-site surface soil samples were collected along the northern fence line. Screening the maximum concentrations against the literature or derived benchmark values indicated that all constituents except benzo(a)pyrene, arsenic and lead were detected at concentrations below their respective benchmark values.

Toxicological benchmarks were not derived for naphthalene, 2-methylnaphthalene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno (1,2,3-cd)pyrene, dibenz(a,h)anthracene and benzo(g,h,i)perylene due to lack of toxicological studies in referenced literature.

3.10.2 Sediment

Six sediment samples were collected from the ditch located north of the Siberia Area. The NYSDEC technical guidance for screening contaminated sediments (NYSDEC 1993) was used to evaluate constituent concentrations. The NYSDEC has derived sediment criteria for non-polar organic compounds using the equilibrium partitioning methodology recommended by the USEPA. Equilibrium partitioning methodology contends that sediment toxicity is attributable to the concentration of constituent in the interstitial pore water and considered to be biologically available to benthic organisms. It can be inferred that the water quality criterion developed to protect aquatic life from constituents dissolved in the water column should also protect benthic aquatic life from constituent concentrations dissolved in the pore water. To derive an organic carbon-normalized sediment criterion, the following information is needed:

- An ambient water quality criterion (WQC) for a particular constituent.
- The K_{ow} for the constituent.

The organic carbon-normalized sediment criterion (Sc_{oc}) would be:

$$SC_{oc} = WQC * K_{ow}$$

NYSDEC sediment criteria values are not available for several of the organic constituents detected in the ditch. Therefore, constituent concentrations were also compared to sediment toxicological benchmarks derived by the Oak Ridge National Laboratory and the National Oceanic and Atmospheric Administration (NOAA). The Oak Ridge National Laboratory toxicological benchmarks were derived using the equilibrium partitioning methodology. The NOAA values were developed from data from several investigations throughout the United States. These values are presented in Table 3-5.

The NYSDEC has established two levels of criteria for inorganic compounds in sediments. These are the lowest effect level (LEL) and severe effect level (SEL). The LEL indicates a level of sediment contamination that can be tolerated by the majority of benthic organisms, but still causes toxicity to a few species. The SEL indicates the concentration where effects to the sediment-dwelling community indicate highly polluted sediments.

Six sediment samples were collected from the drainage ditch located north of the Siberia Area and analyzed for SVOCs, arsenic and lead. Screening the maximum concentration against the sediment criteria indicated the following:

- The maximum concentration of phenol exceeded the NYSDEC criteria but not the Oak Ridge criteria. No criteria is available from NOAA.

- The maximum concentrations of acenaphthylene, pyrene, chrysene and fluorene exceeded the NOAA criteria. No critieria is available from NYSDEC and Oak Ridge.

- The maximum concentration of phenanthrene exceeded the NOAA criteria but not the Oak Ridge or NYSDEC criteria.

- The maximum concentrations of anthracene, benzo(a)pyrne and benzo(a)-anthracene exceeded the Oak Ridge and NOAA criteria. No NYSDEC criteria is available.

- The maximum concentration of fluoranthene exceeded the NOAA criteria but not the Oak Ridge or NYSDEC criteria. No NYSDEC criteria is available.

- The maximum concentration of arsenic exceeded the NYSDEC and NOAA criteria but not the Oak Ridge criteria.

- The maximum concentration of lead exceeded all three criteria.

TABLE 3-5

FISH AND WILDLIFE IMPACT ANALYSIS
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF SEDIMENT DATA

Parameter	Sediment Criteria			Frequency of Detection	Range of Detected Concentration	Average Concentration
	NYSDEC[1]	Oak Ridge[2]	NOAA[3]			
Semivolatile Organic Compounds (ug/kg)						
Naphthalene		23,510	2,100	4/6	23-130	68.3
Phenol	30	575		1/6	360-360	360
Acenaphthylene			640	6/6	13-2600	682
Acenaphthene	7,000	477,222	500	4/6	21-150	70.3
Diethylphthalate				1/6	14-14	14
Fluorene			540	4/6	17-880	256
Phenanthrene	6,000	59,770	1,500	6/6	140-5400	1277
Anthracene		628	1,100	6/6	34-2900	735
Fluoranthene	51,000		5,100	6/6	340-8200	2748
Pyrene			2,600	6/6	280-6400	2342
Butylbenzylphthalate				1/6	13-13	13
Benzo(a)anthracene		2,623	1,600	6/6	160-5000	1638
Chrysene			2,800	6/6	240-5600	2052
bis(2-Ethylhexyl)phthalate	9,975			5/6	22-190	89.6
Benzo(b)fluoranthene				6/6	180-4700	1798
Benzo(k)fluoranthene				3/6	980-5900	3360
Benzo(a)pyrene		3,062	1,600	6/6	180-4400	1572
Indeno(1,2,3-cd)pyrene				6/6	130-1500	688
Benzo(g,h,I)perylene				6/6	130-1200	560
Inorganic Compounds (mg/kg)						
Arsenic	33 (6)	70	33 (6)	4/4	9.7-24.4	14.4
Lead	110 (31)	218	250 (31)	4/4	67.4-320	187.6

Notes:

1. NYSDEC, 1993.
2. Jones *et al.* , 1996
3. Long *et al.*, 1991

For Phenol: The sediemnt criteria is equal to $Sc_{oc} * f_{oc}$
f_{oc} = 5% OC/kg sediment = 50 gOC/kg
Phenol SC = 0.6 ug/gOC * 50 gOC/kg = 30 ug/kg sediment

Criteria were not available for diethylphthalate, butlybenzylphthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene.

3.11 SUMMARY

3.11.1 Sediment

The maximum concentrations of several constituents in the sediment exceeded sediment criteria. However, the risk associated with these constituents is minimal. The ditch is a grassy depression that contains water only during rain events and spring melt. During dry periods, it is mowed. This does not allow for development of a diverse benthic community.

3.11.2 Soil

The Siberia Area is an industrial area with minimal habitat in the form of "weedy" patches that would not support wildlife populations. Only transient species and a few individual animals (i.e., rat, house mouse, house sparrow) would utilize the Siberia Area. Land use surrounding the Siberia Area is residential/commercial. The maintained lawns and high percentage of covered areas (i.e., parking lots, buildings) do not support large or diverse wildlife populations. Risk is determined by exposure frequency, constituent concentration, mechanism of exposure and duration of exposure. The major routes of exposures to the constituents of ecological concern detected in soil would be incidental contact and ingestion. The exposure frequency and duration would be low for these individuals. Therefore, even though concentrations of constituents in surface soil and shallow subsurface soil exceed toxicological benchmark values, the potential risk to wildlife is minimal.

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APPENDIX A

Risk-Based Evaluation Parameters

TABLE A-1

CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

FATE AND TRANSPORT AND EXPOSURE PARAMETERS

Parameter	Definition	Off-Site Resident Children	Off-Site Resident Adults	Arsenal Workers	Utility Workers	Source
AT_c	Averaging time for carcinogens, years	70	70	70	70	1
AT_n	Averaging time for noncarcinogens, years	6	30	25	1	1,2
BW	Body weight, kg	15	70	70	70	1,2
d	Thickness of surface soil zone, cm	15.24	15.24	15.24	15.24	5
D^{air}	Diffusion coefficient in air, cm^2/s	Chemical- specific See Table A-2				
D^{wat}	Diffusion coefficient in water, cm^2/s	Chemical- specific - See Table A-2				
D_{crack}^{eff}	Effective diffusion coefficient through foundation cracks, cm^2/s See Table A-3	$D_{crack}^{eff} = D^{air}\left[\frac{q_{acrack}^{3.33}}{q_T^2}\right] + DSUPwat\left[\frac{1}{H} * \frac{q_{wcrack}^{3.33}}{q_T^2}\right]$				1
D_c^{eff}	Effective diffusion coefficient through capillary fringe, cm^2/s See Table A-3	$D_c^{eff} = D^{air}\left[\frac{q_{acap}^{3.33}}{q_T^2}\right] + D^{wat}\left[\frac{1}{H} * \frac{q_{wcap}^{3.33}}{q_T^2}\right]$				1
D_s^{eff}	Effective diffusion coefficient in soil based on vapor-phase concentration, cm^2/s See Table A-3	$D_s^{eff} = D^{air}\left[\frac{q_{as}^{3.33}}{q_T^2}\right] + D^{wat}\left[\frac{1}{H} * \frac{q_{ws}^{3.33}}{q_T^2}\right]$				1
D_{ws}^{eff}	Effective diffusion coefficient between groundwater and soil surface, cm^2/s See Table A-3	$D_{ws}^{eff} = (h_C + h_v)\left[\frac{h_C}{D_c^{eff}} + \frac{h_v}{D_s^{eff}}\right]^{-1}$				1
ED	Exposure duration, years	6	30	25	1	1,2
EF	Exposure frequency, days/year	350	350	250	100	1,3
ER	Enclosed space air exchange rate, L/s	0.00014	0.00014	NA	NA	1
ET	Exposure time, hours/day	24	24	8	8	3 [a]
foc	Fraction organic carbon	0.08	0.08	0.08	0.08	6

TABLE A-1

CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

FATE AND TRANSPORT AND EXPOSURE PARAMETERS

Parameter	Definition	Off-Site Resident Children	Off-Site Resident Adults	Arsenal Workers	Utility Workers	Source
h_c	Thickness of capillary fringe, cm	5	5	NA	5	1
h_v	Thickness of vadose zone, cm	95	95	NA	95	4
H	Henry's Law Constant, unitless	Chemical- specific See Table A-2				
IR_s	Soil ingestion rate, mg/day	200	82	82	480	2,4
IR_a	Daily indoor inhalation rate, m^3/day	4	7.2	NA	NA	4
IR_{amb}	Daily outdoor inhalation rate, m^3/day	5.6	9.6	20	20	4
K_{oc}	Soil-water partition coefficient	Chemical-specific - See Table A-2				
K_{ow}	Octanol/water partition coefficient	Chemical-specific - See Table A-2				
K_s	Soil-water sorption coefficient, foc x Koc	Chemical-specific - See Table A-2				
L_B	Enclosed space volume/infiltration ratio, cm	200	200	NA	NA	1
L_{crack}	Enclosed space foundation or wall thickness	15	15	NA	NA	4
L_{GW}	Depth to groundwater = $h_c + h_v$, cm	100	100	NA	100	3,6
L_s	Depth to subsurface impacted soil, cm	NA	NA	NA	100	1
M	Soil-to-skin adherence factor, mg/cm^2	0.5	0.5	0.5	0.5	1,5
P_e	Particulate emission rate, g/cm^2-s	6.9×10^{-14}	6.9×10^{-14}	6.9×10^{-14}	6.9×10^{-9}	1,5
PC	Permeability coefficient, cm/hr	Chemical- specific - See Table A-5				
RAF_d	Dermal relative absorption factor, volatiles/PAHs/metals/arsenic	0.5/0.05/0.01/ 0.03	0.5/0.05/0.01/ 0.03	0.5/0.05/ 0.01/0.03	0.5/0.05/0.01/ 0.03	1,4
RAF_o	Oral relative absorption factor	1.0	1.0	1.0	1.0	1
RfD_i	Inhalation chronic reference dose, mg/kg-day	Chemical-specific - See Table A-6				

TABLE A-1

CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

FATE AND TRANSPORT AND EXPOSURE PARAMETERS

Parameter	Definition	Off-Site Resident Children	Off-Site Resident Adults	Arsenal Workers	Utility Workers	Source
RfD_o	Oral chronic reference dose, mg/kg-day	Chemical-specific - See Table A-6				
SA	Skin surface area, cm^2	2100	1700	1700	1980	3 [b],5
SF_i	Inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific - See Table A-7				
SF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific - See Table A-7				
THQ	Target quotient for individual constituents, unitless	1.0	1.0	1.0	1.0	1
TR	Target excess individual lifetime cancer risk, unitless	10^{-6}	10^{-6}	10^{-6}	10^{-6}	1
U_a	Wind speed above ground surface in ambient mixing zone, cm/s	334	334	334	334	6
VF_{wesp}	Volatilization factor from groundwater to indoor air (vapors), $(mg/m^3\text{-air})/(mg/l\text{-}H_20)$ See Table A-4	$VF_{wesp} = \frac{H * [\frac{D_{ws}^{eff} / L_{GW}}{ER * L_B}]}{1 + [\frac{D_{ws}^{eff} / L_{GW}}{ER * L_B}] + [\frac{D_{ws}^{eff} / L_{GW}}{(D_{crack}^{eff} / L_{crack})h}]} * 10^3$				1
VF_p	Volatilization factor from soil to ambient air (particulates), $(mg/m^3\text{-air})/(mg/kg\text{-soil})$ See Table A-4	$VF_p = \frac{P_e * W}{U_a * d_a} * 10^3$				1
VF_{samb}	Volatilization factor from subsurface soil to ambient air, $(mg/m^3\text{-air})/(mg/kg\text{-soil})$ See Table A-4	$VF_{samb} = \frac{H * r_s}{(q_{ws} + (K_s * r_s) + (H * q_{as})) * (1 + \frac{U_a d_a * L_s}{D_s^{eff} * W})} * 1$				1
VF_{ss}	Volatilization factor from soil to ambient air (vapors),$(mg/m^3\text{-}$					1

TABLE A-1

CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

FATE AND TRANSPORT AND EXPOSURE PARAMETERS

Parameter	Definition	Off-Site Resident Children	Off-Site Resident Adults	Arsenal Workers	Utility Workers	Source
	air)/(mg/kg-soil), lesser of results from two equations See Table A-4	$VF_{ss} = \frac{2 * W * r_s}{U_a * d_a} * \sqrt{\frac{D_s^{eff} * H}{p * [q_{ws} + K_s * r_s + H * q_{as}] * t}} * 10$ $VF_{ss} = \frac{W * r_s * d}{U_a * d_a * t} * 10^3$				
VF_{wamb}	Volatilization factor from groundwater to ambient air (vapors), (mg/m^3-air)/(mg/l-H_2O) See Table A-4	$VF_{wamb} = \frac{H}{1 + [\frac{U_a * d_a * L_{GW}}{W * D_{ws}^{eff}}]} * 10^3$				1
W	Width of source area parallel to wind, cm	39000	39000	39000	39000	6
d_a	Ambient air mixing zone height, cm	200	200	200	200	1
?	Areal fraction of cracks in foundation walls	0.01	0.01	NA	NA	1
$?_s$	Soil bulk density, g-soil/cm^3-soil	NA	NA	NA	1.70	1
$?_{acap}$	Volumetric air content in capillary fringe soils, cm^3-air/cm^3-soil	0.036	0.036	NA	0.036	6
$?_{wcap}$	Volumetric water content in capillary fringe, cm^3-H_2O/cm^3-soil	0.324	0.324	NA	0.324	6
$?_{wcrack}$	Volumetric water content in foundation/wall cracks, cm^3-H_2O/cm^3-total volume	0.18	0.18	NA	NA	6
$?_{acrack}$	Volumetric air content in foundation/wall cracks, cm^3-air/cm^3-total volume	0.18	0.18	NA	NA	6
$?_{ws}$	Volumetric water content in vadose zone soils, cm^3-H_2O/cm^3- soil	0.18	0.18	0.18	0.18	6

TABLE A-1

CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

FATE AND TRANSPORT AND EXPOSURE PARAMETERS

Parameter	Definition	Off-Site Resident Children	Off-Site Resident Adults	Arsenal Workers	Utility Workers	Source
$?_{as}$	Volumetric air content in vadose zone soils, cm^3 - air/cm^3-soil	0.18	0.18	0.18	0.18	6
$?_T$	Total soil porosity, cm^3/cm^3-soil	0.36	0.36	0.36	0.36	6
t	Averaging time for vapor flux, s	1.89E+08	9.46E+08	7.88E+08	3.15E+07	3 [c]

Notes:

NA = Not applicable for the potentially exposed population.

Sources:

1. ASTM. 1995. *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. E1739-95.

2. USEPA. 1991. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance "Standard Default Exposure Parameters"*. OSWER Directive 9285.6-03. Washington, D.C.

3. Professional judgement.

a = An ET of 24 hours/day is conservatively assumed for the residents; an ET of 8 hours/day or a typical workday is assumed for the arsenal and utility workers.

b = A SA of 1980 cm^2 for the utility workers corresponds to the surface area of the hands and forearms of adult males. USEPA. 1989. *Exposure Factors Handbook*. EPA/600/8-89/043. Washington, DC: Office of Health and Environmental Assessment.

c = The averaging time is the period over which exposure is averaged and is equal to ED in seconds (i.e., [ED x 365 days/year x 8.64E+04 seconds/day]).

4. USEPA/NYSDEC comments regarding July 25, 1997, Risk-Based Corrective Action Interim Deliverable.

5. NYSDEC. 1997. *Interim Procedures for Inactivation of Petroleum-Impacted Sites. Draft.* Division of Environmental Remediation. Albany, New York.

6. Site-specific value or derived from site-specific value.

TABLE A-2

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA-WATERVLIET ARSENAL

CHEMICAL SPECIFIC PARAMETERS FOR TIER 1 ANALYSIS

Parameter	Log K_{ow}	K_{oc}	K_s	D^{air}	D^{water}	H
Volatile Organic Compounds						
Benzene	2.13E+00	3.80E+01	3.04E+00	8.80E-02	9.80E-06	2.28E-01
2-Butanone	8.80E-01	4.59E+01	3.67E+00			
Carbon disulfide	2.00E+00	3.97E+01	3.18E+00	1.04E-01	1.00E-05	1.24E+00
Chloroform	1.92E+00	3.56E+01	2.85E+00	1.04E-01	1.00E-05	1.50E-01
cis-1,2-Dichloroethene	1.86E+00	1.17E+01	9.36E-01	7.36E-02	1.13E-05	1.67E-01
Methylene chloride	1.25E+00	1.56E+02	1.25E+01	1.01E-01	1.17E-05	8.98E-02
Tetrachloroethene	2.67E+00	1.80E+02	1.44E+01	7.20E-02	8.20E-06	7.54E-01
Toluene	2.75E+00	1.35E+02	1.08E+01	8.70E-02	8.60E-06	2.72E-01
Trichloroethene	2.71E+00	1.85E+01	1.48E+00	7.90E-02	9.10E-06	4.22E-01
Vinyl chloride	1.50E+00	1.85E+01	1.48E+00	1.06E-01	1.23E-06	1.11E+00
Xylenes	3.20E+00	2.40E+02	1.92E+01	7.20E-02	8.50E-06	2.90E-01
Semivolatile Organic Compounds						
Acenaphthylene		2.50E+03	2.00E+02	6.40E-02	7.53E-06	6.10E-02
Acenaphthene	3.92E+00	4.60E+03	3.68E+02	4.21E-02	7.69E-06	6.36E-03
Anthracene	4.55E+00	1.41E+04	1.13E+03	3.24E-02	7.74E-06	2.67E-03
Benzidine	1.34E+00					
Benzo(a)anthracene	5.70E+00	1.38E+06	1.10E+05	5.10E-02	9.00E-06	1.37E-04
Benzo(b)fluoranthene	6.20E+00	5.50E+05	4.40E+04	2.26E-02	5.56E-06	4.55E-03
Benzo(k)fluoranthene	6.20E+00	5.50E+05	4.40E+04	2.26E-02	5.56E-06	3.40E-05
Benzo(a)pyrene	6.11E+00	3.89E+05	3.11E+04	4.30E-02	9.00E-06	4.63E-05
Benzo(g,h,i)perylene		1.58E+06	1.26E+05	4.80E-02	5.65E-06	2.21E-06
bis(2-Ethylhexyl)phthalate	7.30E+00	1.11E+05	8.88E+03	3.51E-02	3.66E-06	4.18E-06
Butylbenzylphthalate	4.84E+00	5.73E+04	4.58E+03	1.74E-02	4.83E-06	5.17E-05
Chrysene	5.70E+00	2.00E+05	1.60E+04	2.48E-02	6.21E-06	3.88E-03
Dibenz(a,h)anthracene	6.69E+00	3.30E+06	2.64E+05	2.02E-02	5.18E-06	6.03E-07
Diethylphthalate	2.50E+00	2.87E+02	2.30E+01	2.56E-02	6.35E-06	1.85E-05
Di-n-butylphthalate	4.61E+00	3.40E+04	2.72E+03	4.38E-02	7.86E-06	3.85E-08
Di-n-octylphthatate	8.06E+00	8.38E+07	6.70E+06	1.51E-02	3.58E-06	2.74E-03
Fluoranthene	5.12E+00	1.08E+05	8.64E+03	3.02E+02	6.35E-06	6.60E-04
Fluorene	4.21E+00	7.24E+03	5.79E+02	3.63E-02	7.88E-06	2.61E-03
Indeno(1,2,3-cd)pyrene	6.65E+00	1.60E+06	1.28E+05	1.90E-02	5.66E-06	6.56E-05
2-Methylnaphthalene						
Naphthalene	3.36E+00	1.28E+02	1.02E+01	5.90E-02	7.50E-06	1.98E-02
N-nitrosodimethylamine						
Phenanthrene	4.57E+00	1.41E+04	1.13E+03	5.90E-02	7.47E-06	6.60E-03
Phenol	1.48E+00	2.85E+01	2.28E+00	8.20E-02	9.10E-06	1.63E-05
Pyrene	5.11E+00	3.80E+04	3.04E+03	2.72E-02	7.24E-06	4.51E-04

TABLE A-2

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA-WATERVLIET ARSENAL

CHEMICAL SPECIFIC PARAMETERS FOR TIER 1 ANALYSIS

Parameter	Log K_{ow}	K_{oc}	K_s	D^{air}	D^{water}	H
Pesticide/PCBs						
Aldrin	6.50E+00	2.45E+06	1.96E+05	1.32E-02	4.86E-06	6.97E-03
Aroclor 1254	5.58E+00	3.06E+05	2.45E+04			2.70E-03
Aroclor 1260	5.58E+00	3.06E+05	2.45E+04			7.10E-03
beta-BHC	3.81E+00	5.57E+03	4.46E+02	1.42E-02	7.34E-06	3.05E-05
delta-BHC						
4,4'-DDD	6.10E+00	9.92E+05	7.94E+04	1.69E-02	4.76E-06	1.64E-04
4,4'-DDE	6.76E+00	4.42E+06	3.54E+05	1.44E-02	5.87E-06	8.61E-04
4,4'-DDT	6.53E+00	2.63E+06	2.10E+05	1.37E-02	4.95E-06	3.32E-04
Dieldrin	5.37E+00	1.90E+05	1.52E+04	1.25E-02	4.74E-06	6.19E-04
Endosulfan I	4.10E+00	1.07E+04	8.56E+02	1.15E-02	4.55E-06	4.59E-04
Endosulfan sulfate						
Endrin	5.06E+00	9.42E+04	7.54E+03	1.25E-02	4.74E-06	3.08E-04
Endrin ketone						
Heptachlor epoxide	5.00E+00	8.23E+04	6.58E+03	1.32E-02	4.23E-06	3.90E-04
Methoxychlor	5.08E+00	9.86E+04	7.89E+03	1.56E-02	4.46E-06	6.48E-04
Inorganic Compounds						
Arsenic	NA	NA	29	NA	NA	NA
Barium	NA	NA	41	NA	NA	NA
Cadmium	NA	NA	75	NA	NA	NA
Chromium	NA	NA	19	NA	NA	NA
Lead	NA	NA	126	NA	NA	NA
Mercury	NA	NA	52	3.07E-02	6.30E-06	NA
Selenium	NA	NA	5	NA	NA	NA
Silver	NA	NA	8.3	NA	NA	NA

Notes:

Blank space inidcates information not available

K_{ow} = Octanol/water partition coefficient
K_{oc} = carbon/water sorption coefficient
K_s = Soil-water sorption coefficient
NA = Not Applicable

D^{air} = Diffusion coefficient in air
D^{water} = Diffusion coefficient in water
H = Henry's Law Constant

Sources:

USEPA. 1996. *Soil Screening Guidance: Technical Background Document*. EPA/540/R95/128. Washington, D.C: Office of Solid Waste and Emergency Response. Lyman, W.J., W.F. Reehl, and D.H. Rosenblatt. 1990. *Handbook of Chemical Property Estimation Methods*. McGraw-Hill, New York.

TABLE A-3

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

EFFECTIVE DIFFUSION COEFFICIENTS

Effective Diffusion Coefficient through Foundation Cracks							
Parameter	**3.33** q_{acrack} **(cm^3-air/cm^3-total volume)**	**3.33** q_{wcrack} **(cm^3-H_2O/cm^3-total Volume)**	**2** q_T **(cm^3/cm^3-soil)**	H	D_{air} **(cm^2/s)**	D_{water} **(cm^2/s)**	D^{eff}_{crack}
Volatile Organic Compounds							
Benzene	3.31E-03	3.31E-03	1.30E-01	2.28E-01	8.80E-02	9.80E-06	2.25E-03
2-Butanone	3.31E-03	3.31E-03	1.30E-01				
Carbon disulfide	3.31E-03	3.31E-03	1.30E-01	1.24E+00	1.04E-01	1.00E-05	2.66E-03
Chloroform	3.31E-03	3.31E-03	1.30E-01	1.50E-01	1.04E-01	1.00E-05	2.66E-03
cis-1,2-Dichloroethene	3.31E-03	3.31E-03	1.30E-01	1.67E-01	7.36E-02	1.13E-05	1.88E-03
Methylene chloride	3.31E-03	3.31E-03	1.30E-01	8.98E-02	1.01E-01	1.17E-05	2.58E-03
Tetrachloroethene	3.31E-03	3.31E-03	1.30E-01	7.54E-01	7.20E-02	8.20E-06	1.84E-03
Toluene	3.31E-03	3.31E-03	1.30E-01	2.72E-01	8.70E-02	8.60E-06	2.22E-03
Trichloroethene	3.31E-03	3.31E-03	1.30E-01	4.22E-01	7.90E-02	9.10E-06	2.02E-03
Vinyl chloride	3.31E-03	3.31E-03	1.30E-01	1.11E+00	1.06E-01	1.23E-06	2.71E-03
Xylenes	3.31E-03	3.31E-03	1.30E-01	2.90E-01	7.20E-02	8.50E-06	1.84E-03
Semivolatile Organic Compounds							
Acenaphthylene	3.31E-03	3.31E-03	1.30E-01	6.10E-02	6.40E-02	7.53E-06	1.64E-03
Acenaphthene	3.31E-03	3.31E-03	1.30E-01	6.36E-03	4.21E-02	7.69E-06	1.11E-03
Anthracene	3.31E-03	3.31E-03	1.30E-01	2.67E-03	3.24E-02	7.74E-06	9.02E-04
Benzidine	3.31E-03	3.31E-03	1.30E-01				
Benzo(a)anthracene	3.31E-03	3.31E-03	1.30E-01	1.37E-04	5.10E-02	9.00E-06	2.98E-03
Benzo(b)fluoranthene	3.31E-03	3.31E-03	1.30E-01	4.55E-03	2.26E-02	5.56E-06	6.09E-04
Benzo(k)fluoranthene	3.31E-03	3.31E-03	1.30E-01	3.40E-05	2.26E-02	5.56E-06	4.76E-03
Benzo(a)pyrene	3.31E-03	3.31E-03	1.30E-01	4.63E-05	4.30E-02	9.00E-06	6.07E-03
Benzo(g,h,i)perylene	3.31E-03	3.31E-03	1.30E-01	2.21E-06	4.80E-02	5.65E-06	6.66E-02
bis(2-Ethylhexyl)phthalate	3.31E-03	3.31E-03	1.30E-01	4.18E-06	3.51E-02	3.66E-06	2.33E-02
Butylbenzylphthalate	3.31E-03	3.31E-03	1.30E-01	5.17E-05	1.74E-02	4.83E-06	2.83E-03
Chrysene	3.31E-03	3.31E-03	1.30E-01	3.88E-03	2.48E-02	6.21E-06	6.75E-04
Dibenz(a,h)anthracene	3.31E-03	3.31E-03	1.30E-01	6.03E-07	2.02E-02	5.18E-06	2.20E-01
Diethylphthalate	3.31E-03	3.31E-03	1.30E-01	1.85E-05	2.56E-02	6.35E-06	9.43E-03
Di-n-butylphthalate	3.31E-03	3.31E-03	1.30E-01	3.85E-08	4.38E-02	7.86E-06	5.22E+00
Di-n-octylphthatate	3.31E-03	3.31E-03	1.30E-01	2.74E-03	1.51E-02	3.58E-06	4.19E-04
Indeno(1,2,3-cd)pyrene	3.31E-03	3.31E-03	1.30E-01	6.60E-04	3.02E+02	6.35E-06	7.72E+00
Fluoranthene	3.31E-03	3.31E-03	1.30E-01	2.61E-03	3.63E-02	7.88E-06	1.00E-03
Fluorene	3.31E-03	3.31E-03	1.30E-01	6.56E-05	1.90E-02	5.66E-06	2.69E-03
2-Methylnaphthalene	3.31E-03	3.31E-03	1.30E-01				
Naphthalene	3.31E-03	3.31E-03	1.30E-01	1.98E-02	5.90E-02	7.50E-06	1.52E-03
N-nitrosodimethylamine	3.31E-03	3.31E-03	1.30E-01				
Phenanthrene	3.31E-03	3.31E-03	1.30E-01	6.60E-03	5.90E-02	7.47E-06	1.54E-03
Phenol	3.31E-03	3.31E-03	1.30E-01	1.63E-05	8.20E-02	9.10E-06	1.64E-02
Pyrene	3.31E-03	3.31E-03	1.30E-01	4.51E-04	2.72E-02	7.24E-06	1.11E-03

TABLE A-3

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

EFFECTIVE DIFFUSION COEFFICIENTS

Effective Diffusion Coefficient through Foundation Cracks							
Parameter	**3.33** q_{acrack} **(cm^3-air/cm^3-total volume)**	**3.33** q_{wcrack} **(cm^3-H_2O/cm^3-total Volume)**	**2** q_T **(cm^3/cm^3-soil)**	H	D_{air} **(cm^2/s)**	D_{water} **(cm^2/s)**	D^{eff}_{crack}
Pesticide/PCBs							
Aldrin	3.31E-03	3.31E-03	1.30E-01	6.97E-03	1.32E-02	4.86E-06	3.55E-04
Aroclor 1254	3.31E-03	3.31E-03	1.30E-01	2.70E-03			
Aroclor 1260	3.31E-03	3.31E-03	1.30E-01	7.10E-03			
beta-BHC	3.31E-03	3.31E-03	1.30E-01	3.05E-05	1.42E-02	7.34E-06	6.51E-03
delta-BHC	3.31E-03	3.31E-03	1.30E-01				
4,4'-DDD	3.31E-03	3.31E-03	1.30E-01	1.64E-04	1.69E-02	4.76E-06	1.17E-03
4,4'-DDE	3.31E-03	3.31E-03	1.30E-01	8.61E-04	1.44E-02	5.87E-06	5.42E-04
4,4'-DDT	3.31E-03	3.31E-03	1.30E-01	3.32E-04	1.37E-02	4.95E-06	7.31E-04
Dieldrin	3.31E-03	3.31E-03	1.30E-01	6.19E-04	1.25E-02	4.74E-06	5.15E-04
Endosulfan I	3.31E-03	3.31E-03	1.30E-01	4.59E-04	1.15E-02	4.55E-06	5.47E-04
Endosulfan sulfate	3.31E-03	3.31E-03	1.30E-01				
Endrin	3.31E-03	3.31E-03	1.30E-01	3.08E-04	1.25E-02	4.74E-06	7.13E-04
Endrin ketone	3.31E-03	3.31E-03	1.30E-01				
Heptachlor epoxide	3.31E-03	3.31E-03	1.30E-01	3.90E-04	1.32E-02	4.23E-06	6.14E-04
Methoxychlor	3.31E-03	3.31E-03	1.30E-01	6.48E-04	1.56E-02	4.46E-06	5.75E-04

TABLE A-3

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

EFFECTIVE DIFFUSION COEFFICIENTS

Effective Diffusion Coefficient through Capillary Fringe							
Parameter	**3.33** q_{acap} **(cm^3-air/cm^3-soil)**	**3.33** q_{wcap} **(cm^3-H_2O/cm^3-soil)**	**2** q_T **(cm^3/cm^3-soil)**	H	D_{air} **(cm^2/s)**	D_{water} **(cm^2/s)**	D^{eff}_{cap}
Volatile Organic Compounds							
Benzene	1.56E-05	2.34E-02	1.30E-01	2.28E-01	8.80E-02	9.80E-06	1.84E-05
2-Butanone	1.56E-05	2.34E-02	1.30E-01				
Carbon disulfide	1.56E-05	2.34E-02	1.30E-01	1.24E+00	1.04E-01	1.00E-05	1.40E-05
Chloroform	1.56E-05	2.34E-02	1.30E-01	1.50E-01	1.04E-01	1.00E-05	2.46E-05
cis-1,2-Dichloroethene	1.56E-05	2.34E-02	1.30E-01	1.67E-01	7.36E-02	1.13E-05	2.11E-05
Methylene chloride	1.56E-05	2.34E-02	1.30E-01	8.98E-02	1.01E-01	1.17E-05	3.57E-05
Tetrachloroethene	1.56E-05	2.34E-02	1.30E-01	7.54E-01	7.20E-02	8.20E-06	1.06E-05
Toluene	1.56E-05	2.34E-02	1.30E-01	2.72E-01	8.70E-02	8.60E-06	1.62E-05
Trichloroethene	1.56E-05	2.34E-02	1.30E-01	4.22E-01	7.90E-02	9.10E-06	1.34E-05
Vinyl chloride	1.56E-05	2.34E-02	1.30E-01	1.11E+00	1.06E-01	1.23E-06	1.29E-05
Xylenes	1.56E-05	2.34E-02	1.30E-01	2.90E-01	7.20E-02	8.50E-06	1.40E-05
Semivolatile Organic Compounds							
Acenaphthylene	1.56E-05	2.34E-02	1.30E-01	6.10E-02	6.40E-02	7.53E-06	3.00E-05
Acenaphthene	1.56E-05	2.34E-02	1.30E-01	6.36E-03	4.21E-02	7.69E-06	2.24E-04
Anthracene	1.56E-05	2.34E-02	1.30E-01	2.67E-03	3.24E-02	7.74E-06	5.28E-04
Benzidine	1.56E-05	2.34E-02	1.30E-01				
Benzo(a)anthracene	1.56E-05	2.34E-02	1.30E-01	1.37E-04	5.10E-02	9.00E-06	1.19E-02
Benzo(b)fluoranthene	1.56E-05	2.34E-02	1.30E-01	4.55E-03	2.26E-02	5.56E-06	2.24E-04
Benzo(k)fluoranthene	1.56E-05	2.34E-02	1.30E-01	3.40E-05	2.26E-02	5.56E-06	2.96E-02
Benzo(a)pyrene	1.56E-05	2.34E-02	1.30E-01	4.63E-05	4.30E-02	9.00E-06	3.52E-02
Benzo(g,h,i)perylene	1.56E-05	2.34E-02	1.30E-01	2.21E-06	4.80E-02	5.65E-06	4.63E-01
bis(2-Ethylhexyl)phthalate	1.56E-05	2.34E-02	1.30E-01	4.18E-06	3.51E-02	3.66E-06	1.58E-01
Butylbenzylphthalate	1.56E-05	2.34E-02	1.30E-01	5.17E-05	1.74E-02	4.83E-06	1.69E-02
Chrysene	1.56E-05	2.34E-02	1.30E-01	3.88E-03	2.48E-02	6.21E-06	2.93E-04
Dibenz(a,h)anthracene	1.56E-05	2.34E-02	1.30E-01	6.03E-07	2.02E-02	5.18E-06	1.55E+00
Diethylphthalate	1.56E-05	2.34E-02	1.30E-01	1.85E-05	2.56E-02	6.35E-06	6.21E-02
Di-n-butylphthalate	1.56E-05	2.34E-02	1.30E-01	3.85E-08	4.38E-02	7.86E-06	3.69E+01
Di-n-octylphthatate	1.56E-05	2.34E-02	1.30E-01	2.74E-03	1.51E-02	3.58E-06	2.38E-04
Indeno(1,2,3-cd)pyrene	1.56E-05	2.34E-02	1.30E-01	6.60E-04	3.02E+02	6.35E-06	3.80E-02
Fluoranthene	1.56E-05	2.34E-02	1.30E-01	2.61E-03	3.63E-02	7.88E-06	5.51E-04
Fluorene	1.56E-05	2.34E-02	1.30E-01	6.56E-05	1.90E-02	5.66E-06	1.56E-02
2-Methylnaphthalene	1.56E-05	2.34E-02	1.30E-01				
Naphthalene	1.56E-05	2.34E-02	1.30E-01	1.98E-02	5.90E-02	7.50E-06	7.56E-05
N-nitrosodimethylamine	1.56E-05	2.34E-02	1.30E-01				
Phenanthrene	1.56E-05	2.34E-02	1.30E-01	6.60E-03	5.90E-02	7.47E-06	2.12E-04
Phenol	1.56E-05	2.34E-02	1.30E-01	1.63E-05	8.20E-02	9.10E-06	1.01E-01
Pyrene	1.56E-05	2.34E-02	1.30E-01	4.51E-04	2.72E-02	7.24E-06	2.91E-03

TABLE A-3

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

EFFECTIVE DIFFUSION COEFFICIENTS

Effective Diffusion Coefficient through Capillary Fringe							
Parameter	**3.33** q_{acap} **(cm^3-air/cm^3-soil)**	**3.33** q_{wcap} **(cm^3-H_2O/cm^3-soil)**	**2** q_T **(cm^3/cm^3-soil)**	H	**D_{air} (cm^2/s)**	**D_{water} (cm^2/s)**	**D^{eff}_{cap}**
Pesticide/PCBs							
Aldrin	1.56E-05	2.34E-02	1.30E-01	6.97E-03	1.32E-02	4.86E-06	1.28E-04
Aroclor 1254	1.56E-05	2.34E-02	1.30E-01	2.70E-03			
Aroclor 1260	1.56E-05	2.34E-02	1.30E-01	7.10E-03			
beta-BHC	1.56E-05	2.34E-02	1.30E-01	3.05E-05	1.42E-02	7.34E-06	4.35E-02
delta-BHC	1.56E-05	2.34E-02	1.30E-01				
4,4'-DDD	1.56E-05	2.34E-02	1.30E-01	1.64E-04	1.69E-02	4.76E-06	5.25E-03
4,4'-DDE	1.56E-05	2.34E-02	1.30E-01	8.61E-04	1.44E-02	5.87E-06	1.24E-03
4,4'-DDT	1.56E-05	2.34E-02	1.30E-01	3.32E-04	1.37E-02	4.95E-06	2.70E-03
Dieldrin	1.56E-05	2.34E-02	1.30E-01	6.19E-04	1.25E-02	4.74E-06	1.39E-03
Endosulfan I	1.56E-05	2.34E-02	1.30E-01	4.59E-04	1.15E-02	4.55E-06	1.79E-03
Endosulfan sulfate	1.56E-05	2.34E-02	1.30E-01				
Endrin	1.56E-05	2.34E-02	1.30E-01	3.08E-04	1.25E-02	4.74E-06	2.79E-03
Endrin ketone	1.56E-05	2.34E-02	1.30E-01				
Heptachlor epoxide	1.56E-05	2.34E-02	1.30E-01	3.90E-04	1.32E-02	4.23E-06	1.96E-03
Methoxychlor	1.56E-05	2.34E-02	1.30E-01	6.48E-04	1.56E-02	4.46E-06	1.25E-03

TABLE A-3

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

EFFECTIVE DIFFUSION COEFFICIENTS

Effective Diffusion Coefficient in Soil							
Parameter	**3.33** q_{as} **(cm^3-air/cm^3-soil)**	**3.33** q_{ws} **(cm^3-H_2O/cm^3-soil)**	**2** q_T **(cm^3/cm^3-soil)**	H	D_{air} **(cm^2/s)**	D_{water} **(cm^2/s)**	D^{eff}_s
Volatile Organic Compounds							
Benzene	3.31E-03	3.31E-03	1.30E-01	2.28E-01	8.80E-02	9.80E-06	2.25E-03
2-Butanone	3.31E-03	3.31E-03	1.30E-01				
Carbon disulfide	3.31E-03	3.31E-03	1.30E-01	1.24E+00	1.04E-01	1.00E-05	2.66E-03
Chloroform	3.31E-03	3.31E-03	1.30E-01	1.50E-01	1.04E-01	1.00E-05	2.66E-03
cis-1,2-Dichloroethene	3.31E-03	3.31E-03	1.30E-01	1.67E-01	7.36E-02	1.13E-05	1.88E-03
Methylene chloride	3.31E-03	3.31E-03	1.30E-01	8.98E-02	1.01E-01	1.17E-05	2.58E-03
Tetrachloroethene	3.31E-03	3.31E-03	1.30E-01	7.54E-01	7.20E-02	8.20E-06	1.84E-03
Toluene	3.31E-03	3.31E-03	1.30E-01	2.72E-01	8.70E-02	8.60E-06	2.22E-03
Trichloroethene	3.31E-03	3.31E-03	1.30E-01	4.22E-01	7.90E-02	9.10E-06	2.02E-03
Vinyl chloride	3.31E-03	3.31E-03	1.30E-01	1.11E+00	1.06E-01	1.23E-06	2.71E-03
Xylenes	3.31E-03	3.31E-03	1.30E-01	2.90E-01	7.20E-02	8.50E-06	1.84E-03
Semivolatile Organic Compounds							
Acenaphthylene	3.31E-03	3.31E-03	1.30E-01	6.10E-02	6.40E-02	7.53E-06	1.64E-03
Acenaphthene	3.31E-03	3.31E-03	1.30E-01	6.36E-03	4.21E-02	7.69E-06	1.11E-03
Anthracene	3.31E-03	3.31E-03	1.30E-01	2.67E-03	3.24E-02	7.74E-06	9.02E-04
Benzidine	3.31E-03	3.31E-03	1.30E-01				
Benzo(a)anthracene	3.31E-03	3.31E-03	1.30E-01	1.37E-04	5.10E-02	9.00E-06	2.98E-03
Benzo(b)fluoranthene	3.31E-03	3.31E-03	1.30E-01	4.55E-03	2.26E-02	5.56E-06	6.09E-04
Benzo(k)fluoranthene	3.31E-03	3.31E-03	1.30E-01	3.40E-05	2.26E-02	5.56E-06	4.76E-03
Benzo(a)pyrene	3.31E-03	3.31E-03	1.30E-01	4.63E-05	4.30E-02	9.00E-06	6.07E-03
Benzo(g,h,i)perylene	3.31E-03	3.31E-03	1.30E-01	2.21E-06	4.80E-02	5.65E-06	6.66E-02
bis(2-Ethylhexyl)phthalate	3.31E-03	3.31E-03	1.30E-01	4.18E-06	3.51E-02	3.66E-06	2.33E-02
Butylbenzylphthalate	3.31E-03	3.31E-03	1.30E-01	5.17E-05	1.74E-02	4.83E-06	2.83E-03
Chrysene	3.31E-03	3.31E-03	1.30E-01	3.88E-03	2.48E-02	6.21E-06	6.75E-04
Dibenz(a,h)anthracene	3.31E-03	3.31E-03	1.30E-01	6.03E-07	2.02E-02	5.18E-06	2.20E-01
Diethylphthalate	3.31E-03	3.31E-03	1.30E-01	1.85E-05	2.56E-02	6.35E-06	9.43E-03
Di-n-butylphthalate	3.31E-03	3.31E-03	1.30E-01	3.85E-08	4.38E-02	7.86E-06	5.22E+00
Di-n-octylphthatate	3.31E-03	3.31E-03	1.30E-01	2.74E-03	1.51E-02	3.58E-06	4.19E-04
Indeno(1,2,3-cd)pyrene	3.31E-03	3.31E-03	1.30E-01	6.60E-04	3.02E+02	6.35E-06	7.72E+00
Fluoranthene	3.31E-03	3.31E-03	1.30E-01	2.61E-03	3.63E-02	7.88E-06	1.00E-03
Fluorene	3.31E-03	3.31E-03	1.30E-01	6.56E-05	1.90E-02	5.66E-06	2.69E-03
2-Methylnaphthalene	3.31E-03	3.31E-03	1.30E-01				
Naphthalene	3.31E-03	3.31E-03	1.30E-01	1.98E-02	5.90E-02	7.50E-06	1.52E-03
N-nitrosodimethylamine	3.31E-03	3.31E-03	1.30E-01				
Phenanthrene	3.31E-03	3.31E-03	1.30E-01	6.60E-03	5.90E-02	7.47E-06	1.54E-03
Phenol	3.31E-03	3.31E-03	1.30E-01	1.63E-05	8.20E-02	9.10E-06	1.64E-02
Pyrene	3.31E-03	3.31E-03	1.30E-01	4.51E-04	2.72E-02	7.24E-06	1.11E-03

TABLE A-3

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

EFFECTIVE DIFFUSION COEFFICIENTS

Effective Diffusion Coefficient in Soil							
Parameter	**3.33** q_{as} **(cm^3-air/cm^3-soil)**	**3.33** q_{ws} **(cm^3-H_2O/cm^3-soil)**	**2** q_T **(cm^3/cm^3-soil)**	H	**D_{air} (cm^2/s)**	**D_{water} (cm^2/s)**	**D^{eff}_s**
Pesticide/PCBs							
Aldrin	3.31E-03	3.31E-03	1.30E-01	6.97E-03	1.32E-02	4.86E-06	3.55E-04
Aroclor 1254	3.31E-03	3.31E-03	1.30E-01	2.70E-03			
Aroclor 1260	3.31E-03	3.31E-03	1.30E-01	7.10E-03			
beta-BHC	3.31E-03	3.31E-03	1.30E-01	3.05E-05	1.42E-02	7.34E-06	6.51E-03
delta-BHC	3.31E-03	3.31E-03	1.30E-01				
4,4'-DDD	3.31E-03	3.31E-03	1.30E-01	1.64E-04	1.69E-02	4.76E-06	1.17E-03
4,4'-DDE	3.31E-03	3.31E-03	1.30E-01	8.61E-04	1.44E-02	5.87E-06	5.42E-04
4,4'-DDT	3.31E-03	3.31E-03	1.30E-01	3.32E-04	1.37E-02	4.95E-06	7.31E-04
Dieldrin	3.31E-03	3.31E-03	1.30E-01	6.19E-04	1.25E-02	4.74E-06	5.15E-04
Endosulfan I	3.31E-03	3.31E-03	1.30E-01	4.59E-04	1.15E-02	4.55E-06	5.47E-04
Endosulfan sulfate	3.31E-03	3.31E-03	1.30E-01				
Endrin	3.31E-03	3.31E-03	1.30E-01	3.08E-04	1.25E-02	4.74E-06	7.13E-04
Endrin ketone	3.31E-03	3.31E-03	1.30E-01				
Heptachlor epoxide	3.31E-03	3.31E-03	1.30E-01	3.90E-04	1.32E-02	4.23E-06	6.14E-04
Methoxychlor	3.31E-03	3.31E-03	1.30E-01	6.48E-04	1.56E-02	4.46E-06	5.75E-04

TABLE A-3

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

EFFECTIVE DIFFUSION COEFFICIENTS

Effective Diffusion Coefficient Between Ground Water and Soil Surface					
Parameter	h_c	h_v	D^{eff}_{cap}	D^{eff}_{s}	D^{eff}_{ws}
Volatile Organic Compounds					
Benzene	5.00E+00	9.50E+01	1.84E-05	2.25E-03	3.18E-04
2-Butanone	5.00E+00	9.50E+01			
Carbon disulfide	5.00E+00	9.50E+01	1.40E-05	2.66E-03	2.54E-04
Chloroform	5.00E+00	9.50E+01	2.46E-05	2.66E-03	4.18E-04
cis-1,2-Dichloroethene	5.00E+00	9.50E+01	2.11E-05	1.88E-03	3.48E-04
Methylene chloride	5.00E+00	9.50E+01	3.57E-05	2.58E-03	5.66E-04
Tetrachloroethene	5.00E+00	9.50E+01	1.06E-05	1.84E-03	1.91E-04
Toluene	5.00E+00	9.50E+01	1.62E-05	2.22E-03	2.84E-04
Trichloroethene	5.00E+00	9.50E+01	1.34E-05	2.02E-03	2.38E-04
Vinyl chloride	5.00E+00	9.50E+01	1.29E-05	2.71E-03	2.37E-04
Xylenes	5.00E+00	9.50E+01	1.40E-05	1.84E-03	2.44E-04
Semivolatile Organic Compounds					
Acenaphthylene	5.00E+00	9.50E+01	3.00E-05	1.64E-03	4.45E-04
Acenaphthene	5.00E+00	9.50E+01	2.24E-04	1.11E-03	9.24E-04
Anthracene	5.00E+00	9.50E+01	5.28E-04	9.02E-04	8.71E-04
Benzidine	5.00E+00	9.50E+01			
Benzo(a)anthracene	5.00E+00	9.50E+01	1.19E-02	2.98E-03	3.10E-03
Benzo(b)fluoranthene	5.00E+00	9.50E+01	2.24E-04	6.09E-04	5.61E-04
Benzo(k)fluoranthene	5.00E+00	9.50E+01	2.96E-02	4.76E-03	4.96E-03
Benzo(a)pyrene	5.00E+00	9.50E+01	3.52E-02	6.07E-03	6.33E-03
Benzo(g,h,i)perylene	5.00E+00	9.50E+01	4.63E-01	6.66E-02	6.95E-02
bis(2-Ethylhexyl)phthalate	5.00E+00	9.50E+01	1.58E-01	2.33E-02	2.43E-02
Butylbenzylphthalate	5.00E+00	9.50E+01	1.69E-02	2.83E-03	2.95E-03
Chrysene	5.00E+00	9.50E+01	2.93E-04	6.75E-04	6.33E-04
Dibenz(a,h)anthracene	5.00E+00	9.50E+01	1.55E+00	2.20E-01	2.30E-01
Diethylphthalate	5.00E+00	9.50E+01	6.21E-02	9.43E-03	9.84E-03
Di-n-butylphthalate	5.00E+00	9.50E+01	3.69E+01	5.22E+00	5.45E+00
Di-n-octylphthatate	5.00E+00	9.50E+01	2.38E-04	4.19E-04	4.04E-04
Indeno(1,2,3-cd)pyrene	5.00E+00	9.50E+01	3.80E-02	7.72E+00	6.96E-01
Fluoranthene	5.00E+00	9.50E+01	5.51E-04	1.00E-03	9.65E-04
Fluorene	5.00E+00	9.50E+01	1.56E-02	2.69E-03	2.81E-03
2-Methylnaphthalene	5.00E+00	9.50E+01			
Naphthalene	5.00E+00	9.50E+01	7.56E-05	1.52E-03	7.77E-04
N-nitrosodimethylamine	5.00E+00	9.50E+01			
Phenanthrene	5.00E+00	9.50E+01	2.12E-04	1.54E-03	1.17E-03
Phenol	5.00E+00	9.50E+01	1.01E-01	1.64E-02	1.71E-02
Pyrene	5.00E+00	9.50E+01	2.91E-03	1.11E-03	1.14E-03
Pesticide/PCBs					
Aldrin	5.00E+00	9.50E+01	1.28E-04	3.55E-04	3.26E-04
Aroclor 1254	5.00E+00	9.50E+01			
Aroclor 1260	5.00E+00	9.50E+01			
beta-BHC	5.00E+00	9.50E+01	4.35E-02	6.51E-03	6.80E-03
delta-BHC	5.00E+00	9.50E+01			
4,4'-DDD	5.00E+00	9.50E+01	5.25E-03	1.17E-03	1.22E-03
4,4'-DDE	5.00E+00	9.50E+01	1.24E-03	5.42E-04	5.58E-04
4,4'-DDT	5.00E+00	9.50E+01	2.70E-03	7.31E-04	7.59E-04
Dieldrin	5.00E+00	9.50E+01	1.39E-03	5.15E-04	5.32E-04
Endosulfan I	5.00E+00	9.50E+01	1.79E-03	5.47E-04	5.67E-04
Endosulfan sulfate	5.00E+00	9.50E+01			
Endrin	5.00E+00	9.50E+01	2.79E-03	7.13E-04	7.40E-04
Endrin ketone	5.00E+00	9.50E+01			
Heptachlor epoxide	5.00E+00	9.50E+01	1.96E-03	6.14E-04	6.36E-04
Methoxychlor	5.00E+00	9.50E+01	1.25E-03	5.75E-04	5.90E-04

TABLE A-3

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

EFFECTIVE DIFFUSION COEFFICIENTS

Key:

q_{acrack} = Volumetric air content in foundation/wall cracks
q_{wcrack} = Volumetric water content in foundation/wall cracks
q_T = Total soil porosity
q_{acap} = Volumetric air content in capillary fringe
q_{wcap} = Volumtric water content in capillary fringe
q_{as} = Volumetric air content in vadose zone soils
D^{eff}_{c} = Effective diffusion coefficient through capillary fringe
D^{eff}_{ws} = Effective diffusion coefficient between ground water and soil surface
q_{ws} = Volumetric water content in vadose zone soils
D^{air} = Diffusion coefficient in air
D^{water} = Diffusion coefficient in water
h_c = Thickness of capillary fringe
h_v = Thickness of vadose zone
D^{eff}_{crack} = Effective diffusion coefficient through foundation cracks
H = Henry's Law Constant
D^{eff}_{s} = Effective diffusion coefficient in soil based on vapor-phase concentration

TABLE A-4

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

VOLATILIZATION FACTORS

Parameter	VF_{wesp} (mg/m^3-air)/ mg/l-H_2O)	VF_p [1] (mg/m^3-air)/ mg/kg-soil)	VF_{samb} (mg/m^3-air)/ mg/kg-soil)	VF_{ss} Utility Worker (mg/m^3-air)/ mg/kg-soil)	VF_{ss} Child Resident (mg/m^3-air)/ mg/kg-soil)	VF_{ss} Adult Resident (mg/m^3-air)/ mg/kg-soil)	VF_{ss} Arsenal Worker (mg/m^3-air)/ mg/kg-soil)	VF_{wamb} (mg/m^3-air)/ mg/kg-soil)
Volatile Organic Compounds								
Benzene	8.30E-03	4.03E-11	9.52E-04	4.80E-04	8.00E-05	1.60E-05	1.92E-05	4.23E-04
2-Butanone		4.03E-11		4.80E-04	8.00E-05	1.60E-05	1.92E-05	
Carbon disulfide	4.62E-02	4.03E-11	5.60E-03	4.80E-04	8.00E-05	1.60E-05	1.92E-05	1.84E-03
Chloroform	6.67E-03	4.03E-11	7.92E-04	4.80E-04	8.00E-05	1.60E-05	1.92E-05	3.66E-04
cis-1,2-Dichloroethene	5.50E-03	4.03E-11	1.78E-03	4.80E-04	8.00E-05	1.60E-05	1.92E-05	3.39E-04
Methylene chloride	4.24E-03	4.03E-11	1.08E-04	4.80E-04	8.00E-05	1.60E-05	1.92E-05	2.97E-04
Tetrachloroethene	2.01E-02	4.03E-11	5.55E-04	4.80E-04	8.00E-05	1.60E-05	1.92E-05	8.43E-04
Toluene	9.47E-03	4.03E-11	3.24E-04	4.80E-04	8.00E-05	1.60E-05	1.92E-05	4.51E-04
Trichloroethene	1.30E-02	4.03E-11	3.08E-03	4.80E-04	8.00E-05	1.60E-05	1.92E-05	5.86E-04
Vinyl chloride	4.06E-02	4.03E-11	1.02E-02	4.80E-04	8.00E-05	1.60E-05	1.92E-05	1.54E-03
Xylenes	8.46E-03	4.03E-11	1.61E-04	4.80E-04	8.00E-05	1.60E-05	1.92E-05	4.13E-04
Semivolatile Organic Compounds								
Acenaphthylene	1.91E-03	4.03E-11	2.92E-06	1.08E-04	4.43E-05	1.60E-05	1.92E-05	1.59E-04
Acenaphthene	1.55E-04	4.03E-11	1.12E-07	2.12E-05	8.66E-06	3.87E-06	4.26E-06	3.43E-05
Anthracene	5.36E-05	4.03E-11	1.25E-08	7.09E-06	2.89E-06	1.29E-06	1.42E-06	1.36E-05
Benzidine		4.03E-11		4.80E-04	8.00E-05	1.60E-05	1.92E-05	
Benzo(a)anthracene	9.14E-06	4.03E-11	2.16E-11	2.95E-07	1.21E-07	5.39E-08	5.93E-08	2.48E-06
Benzo(b)fluoranthene	6.15E-05	4.03E-11	3.68E-10	1.22E-06	4.97E-07	2.22E-07	2.45E-07	1.49E-05
Benzo(k)fluoranthene	3.62E-06	4.03E-11	2.15E-11	2.94E-07	1.20E-07	5.37E-08	5.91E-08	9.85E-07
Benzo(a)pyrene	6.28E-06	4.03E-11	5.27E-11	4.61E-07	1.88E-07	8.41E-08	9.26E-08	1.71E-06
Benzo(g,h,i)perylene	3.29E-06	4.03E-11	5.05E-12	1.66E-07	6.76E-08	3.02E-08	3.33E-08	8.97E-07
bis(2-Ethylhexyl)phthalate	2.18E-06	4.03E-11	6.39E-11	5.08E-07	2.07E-07	9.27E-08	1.02E-07	5.93E-07
Butylbenzylphthalate	3.28E-06	4.03E-11	1.86E-10	8.67E-07	3.54E-07	1.58E-07	1.74E-07	8.92E-07
Chrysene	5.82E-05	4.03E-11	9.55E-10	1.96E-06	8.01E-07	3.58E-07	3.94E-07	1.43E-05
Dibenz(a,h)anthracene	2.95E-06	4.03E-11	2.93E-12	1.09E-07	4.44E-08	1.99E-08	2.19E-08	8.08E-07
Diethylphthalate	3.90E-06	4.03E-11	4.42E-08	1.34E-05	5.45E-06	2.44E-06	2.68E-06	1.06E-06
Di-n-butylphthalate	4.03E-06	4.03E-11	4.18E-10	1.32E-06	5.38E-07	2.41E-07	2.65E-07	1.19E-06
Di-n-octylphthatate	2.56E-05	4.03E-11	1.00E-12	6.35E-08	2.59E-08	1.16E-08	1.28E-08	6.46E-06
Indeno(1,2,3-cd)pyrene	6.31E-02	4.03E-11	3.29E-06	1.18E-04	4.81E-05	1.60E-05	1.92E-05	2.67E-03
Fluoranthene	5.84E-05	4.03E-11	2.64E-08	1.03E-05	4.22E-06	1.88E-06	2.08E-06	1.47E-05
Fluorene	3.95E-06	4.03E-11	8.05E-12	1.80E-07	7.36E-08	3.29E-08	3.62E-08	1.07E-06
2-Methylnaphthalene		4.03E-11		4.80E-04	8.00E-05	1.60E-05	1.92E-05	
Naphthalene	6.33E-04	4.03E-11	1.70E-05	2.62E-04	8.00E-05	1.60E-05	1.92E-05	8.98E-05
N-nitrosodimetylamine		4.03E-11		4.80E-04	8.00E-05	1.60E-05	1.92E-05	
Phenanthrene	2.22E-04	4.03E-11	5.25E-08	1.46E-05	5.94E-06	2.66E-06	2.92E-06	4.51E-05
Phenol	5.97E-06	4.03E-11	6.62E-07	5.17E-05	2.11E-05	9.43E-06	1.04E-05	1.62E-06
Pyrene	1.11E-05	4.03E-11	9.57E-10	1.97E-06	8.02E-07	3.59E-07	3.95E-07	3.00E-06

TABLE A-4

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

VOLATILIZATION FACTORS

Parameter	VF_{wesp} (mg/m^3-air)/ mg/l-H_2O)	VF_p [1] (mg/m^3-air)/ mg/kg-soil)	VF_{samb} (mg/m^3-air)/ mg/kg-soil)	VF_{ss} Utility Worker (mg/m^3-air)/ mg/kg-soil)	VF_{ss} Child Resident (mg/m^3-air)/ mg/kg-soil)	VF_{ss} Adult Resident (mg/m^3-air)/ mg/kg-soil)	VF_{ss} Arsenal Worker (mg/m^3-air)/ mg/kg-soil)	VF_{wamb} (mg/m^3-air)/ mg/kg-soil)
Pesticide/PCBs								
Aldrin	5.49E-05	4.03E-11	7.37E-11	5.45E-07	2.23E-07	9.95E-08	1.10E-07	1.33E-05
Aroclor 1254		4.03E-11		4.80E-04	8.00E-05	1.60E-05	1.92E-05	
Aroclor 1260		4.03E-11		4.80E-04	8.00E-05	1.60E-05	1.92E-05	
beta-BHC	4.44E-06	4.03E-11	2.60E-09	3.24E-06	1.32E-06	5.91E-07	6.51E-07	1.21E-06
delta-BHC		4.03E-11		4.80E-04	8.00E-05	1.60E-05	1.92E-05	
4,4'-DDD	4.31E-06	4.03E-11	1.42E-11	2.39E-07	9.76E-08	4.36E-08	4.80E-08	1.17E-06
4,4'-DDE	1.04E-05	4.03E-11	7.71E-12	1.76E-07	7.20E-08	3.22E-08	3.54E-08	2.80E-06
4,4'-DDT	5.43E-06	4.03E-11	6.74E-12	1.65E-07	6.73E-08	3.01E-08	3.31E-08	1.47E-06
Dieldrin	7.13E-06	4.03E-11	1.22E-10	7.03E-07	2.87E-07	1.28E-07	1.41E-07	1.92E-06
Endosulfan I	5.62E-06	4.03E-11	1.71E-09	2.63E-06	1.07E-06	4.80E-07	5.28E-07	1.52E-06
Endosulfan sulfate		4.03E-11		4.80E-04	8.00E-05	1.60E-05	1.92E-05	
Endrin	4.91E-06	4.03E-11	1.70E-10	8.28E-07	3.38E-07	1.51E-07	1.66E-07	1.33E-06
Endrin ketone		4.03E-11		4.80E-04	8.00E-05	1.60E-05	1.92E-05	
Heptachlor epoxide	5.36E-06	4.03E-11	2.12E-10	9.26E-07	3.78E-07	1.69E-07	1.86E-07	1.45E-06
Methoxychlor	8.32E-06	4.03E-11	2.76E-10	1.05E-06	4.30E-07	1.92E-07	2.12E-07	2.23E-06
Inorganic Compounds								
Arsenic		4.03E-11						
Barium		4.03E-11						
Cadmium		4.03E-11						
Chromium		4.03E-11						
Lead		4.03E-11						
Mercury		4.03E-11						
Selenium		4.03E-11						
Silver		4.03E-11						

Notes:

VF_w = Volatilization factor from groundwater to air

VF_p = Volatilization factor from soil to ambient air

VF_{samb} = Volatilization factor from subsurface soil to ambient air

VF_{ss} = Volatilization factor from soil to air

VF_{wamb} = Volatilization factor from groundwater to ambient air

1 Value for resident and arsenal worker exposure scenarios. Construction worker value is 4.03E-06.

TABLE A-5

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

PERMEABILITY COEFFICIENTS

Constituent	Gram Molecular Weight (GMW)	$LogK_{ow}$	Permeability Coefficient[1] (cm/hr)
Volatile Organic Compounds			
Benzene	78.1	2.13E+00	2.1E-02
2-Butanone	72.1	8.80E-01	2.9E-03
Carbon disulfide	80	2.00E+00	1.6E-02
Chloroform	119.4	1.92E+00	8.2E-03
cis-1,2-Dichloroethene	96.9	1.86E+00	1.0E-02
Methylene chloride	84.9	1.25E+00	4.5E-03
Tetrachloroethene	167.9	2.67E+00	1.4E-02
Toluene	92.1	2.75E+00	4.7E-02
Trichloroethene	131.4	2.71E+00	2.5E-02
Vinyl chloride	62.5	1.50E+00	9.2E-03
Xylene	106.2	3.20E+00	8.0E-02
Semivolatile Organic Compounds			
Acenaphthylene			
Acenaphthene	154.2	3.92E+00	1.3E-01
Anthracene	178.2	4.55E+00	2.7E-01
Benzidine	184.2	1.34E+00	1.3E-03
Benzo(a)anthracene	228.3	5.70E+00	8.6E-01
Benzo(b)fluoranthene	252.3	6.20E+00	1.4E+00
Benzo(k)flouranthene	252.3	6.20E+00	1.4E+00
Benzo(a)pyrene	250	6.11E+00	1.2E+00
Benzo(g,h,i)perylene			
Bis(2-ethylhexyl)phthalate	390.5	7.30E+00	1.2E+00
Butylbenzylphthalate	312.4	4.84E+00	6.5E-02
Chrysene	228.3	5.70E+00	8.6E-01
Dibenz(a,h)anthracene	278.4	6.69E+00	2.1E+00
Diethylphthalate	222	2.50E+00	5.0E-03
Di-n-butylphthalate	278	4.61E+00	7.2E-02
Di-n-octylphthalate	390.5	8.06E+00	4.2E+00
Indeno(1,2,3-cd)pyrene	276.3	5.12E+00	1.7E-01
Fluoranthene	202.3	4.21E+00	1.1E-01
Fluorene	166.2	6.65E+00	9.7E+00
2-Methylnaphthalene			
Naphthalene	128.2	3.36E+00	7.6E-02
N-nitrosodimethylamine			
Phenanthrene	178.2	4.57E+00	2.7E-01
Phenol	94	1.48E+00	5.7E-03
Pyrene	202.24	5.11E+00	4.7E-01

TABLE A-5

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

PERMEABILITY COEFFICIENTS

Constituent	Gram Molecular Weight (GMW)	$LogK_{ow}$	Permeability Coefficient[1] (cm/hr)
Pesticide/PCBs			
Aldrin	365	6.50E+00	4.7E-01
Aroclor 1254	327	5.58E+00	1.8E-01
Aroclor 1260	372	5.58E+00	9.4E-02
beta-BHC	290.8	3.81E+00	1.6E-02
delta-BHC			
4,4'-DDD	320	6.10E+00	4.6E-01
4,4'-DDE	318	6.76E+00	1.4E+00
4,4'-DDT	355	6.53E+00	5.6E-01
Dieldrin	381	5.37E+00	5.9E-02
Endosulfan I	407	4.10E+00	5.1E-03
Endosulfan sulfate			
Endrin	381	5.06E+00	3.5E-02
Endrin ketone			
Hepatachlor epoxide	399.3	5.00E+00	2.5E-02
Methoxychlor	345.7	5.08E+00	6.0E-02
Inorganic Compounds			
Arsenic			1.0E-03
Barium			1.0E-03
Cadmium			1.0E-03
Chromium			1.0E-03
Lead			1.0E-03
Mercury			1.0E-03
Selenium			1.0E-03
Silver			1.0E-03

1. Organic Chemicals:
Calculated from:LogPC = -2.72 + 0.7 * 1logKow - 0.0061 * GMW
Inorganic Compounds: default for water
Source: USEPA. 1992. *Dermal Exposure Assessment: Principles and Application*. EPA/600/8-91/011B. Office of Research and Development. Washington, DC.

TABLE A-6

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA, WATERVLIET ARESENAL

TOXICITY VALUES: POTENTIAL NON-CARCINOGENIC EFFECTS

Constituent	Exposure Route	Chronic RfD (mg/kg-day)	Critical Effect	RfD Basis	Confidence Level	Uncertainty Factor	Modifying Factor	RfD Source
Volatile Organic Compounds								
Benzene	Oral	--	--	--	--	--	--	--
2-Butanone	Oral	6.00E-01	Decreased fetal birth weight	Oral	Low	3000	1	IRIS
	Inhalation	2.86E-01	Decreased fetal birth weight	Inhalation	Low	1000	3	IRIS
Carbon disulfide	Oral	1.00E-01	Fetal Toxicity	Oral	Medium	100	1	IRIS
	Inhalation	2.00E-01	Peripheral dysfunction	Inhalation	--	30	--	HEAST
Chloroform	Oral	1.00E-02	Fatty cyst formation in liver	Oral	Medium	1000	1	IRIS
cis-1,2-Dichloroethene	Oral	1.00E-02	Decreased hemocrit	Oral	--	3000	--	HEAST
Methylene chloride	Oral	6.00E-02	Liver toxicity	Oral	--	100	1	IRIS
	Inhalation	8.57E-01	Liver toxicity	Inhalation	--	100	--	HEAST
Tetrachloroethene	Oral	1.00E-02	Hepatotoxicity	Oral	Medium	1000	1	IRIS
Trichloroethene	Oral	--	--	--	--	--	--	--
Toluene	Oral	2.00E-01	Increased liver and kidney weights	Oral	Medium	1000	1	IRIS
	Inhalation	1.14E-01	Neurological effects	Inhalation	Medium	300	1	IRIS
Vinyl chloride	Oral	--	--	--	--	--	--	--
Xylenes	Oral	2.00E+00	Hyperactivity	Oral	Medium	100	1	IRIS
Semivolatile Organic Compounds								
Acenaphthene	Oral	6.00E-02	Hepatotoxicity	Oral	Low	3000	1	IRIS
Acenaphthylene	Oral	--	--	--	--	--	--	--
Anthracene	Oral	3.00E-01	No effects observed	Oral	Low	3000	1	IRIS
Benzidine	Oral	3.00E-03	Brain Cell Vacuolization	Oral	Medium	1000	1	IRIS
Benzo(a)anthracene	Oral	--	--	--	--	--	--	--
Benzo(b)fluoranthene	Oral	--	--	--	--	--	--	--
Benzo(k)flouranthene	Oral	--	--	--	--	--	--	--
Benzo(a)pyrene	Oral	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	Oral	--						
Bis(2-ethylhexyl)phthalate	Oral	2.00E-02	Increased rlative liver weight	Oral	Medium	1000	1	IRIS
Butylbenzylphthalate	Oral	2.00E-01	Increased liver-to-body weight	Oral	Low	1000	1	IRIS
Chrysene	Oral	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	Oral	--	--	--	--	--	--	--
Diethylphthalate	Oral	8.00E-01	Decreased growth weight	Oral	Low	1000	1	IRIS
Di-n-butylphthalate	Oral	1.00E-01	Increased Mortality	Oral	Low	1000	1	IRIS
Di-n-octylphthalate	Oral	2.00E-02	Increased liver and kidney weight	Oral	--	1000	--	HEAST
Fluoranthene	Oral	4.00E-02	Nephropathy, increased liver weight	Oral	Low	3000	1	IRIS
Fluorene	Oral	4.00E-02						
Indeno(1,2,3-cd)pyrene	Oral	--	--	--	--	--	--	--
2-Methylnaphthalene	Oral	--	--	--	--	--	--	--

TABLE A-6

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA, WATERVLIET ARESENAL

TOXICITY VALUES: POTENTIAL NON-CARCINOGENIC EFFECTS

Constituent	Exposure Route	Chronic RfD (mg/kg-day)	Critical Effect	RfD Basis	Confidence Level	Uncertainty Factor	Modifying Factor	RfD Source
Naphthalene	Oral	--	--	--	--	--	--	--
N-nitrosodimethylamine	Oral	--	--	--	--	--	--	--
Phenanthrene	Oral	--	--	--	--	--	--	--
Phenol	Oral	6.00E-01	Reduced fetal body weight	Oral	Low	100	1	IRIS
Pyrene	Oral	3.00E-02	Kidney effects	Oral	Low	3000	1	IRIS
Pesticide/PCBs								
Aldrin	Oral	3.00E-05	Liver lesions	Oral				IRIS
Aroclor 1254	Oral	2.00E-05	Ocular exudate, inflamed and prominent Meivomian glands	Oral	Medium	300	1	IRIS
Aroclor 1260 [1]	Oral	2.00E-05	Ocular exudate, inflamed and prominent Meivomian glands	Oral	Medium	300	1	IRIS
beta-BHC	Oral	--	--	--	--	--	--	--
delta-BHC	Oral	--	--	--	--	--	--	--
4,4'-DDD	Oral	--						
4,4'-DDE	Oral	--						
4,4'-DDT	Oral	5.00E-04	Liver lesions	Oral	Medium	100	1	IRIS
Dieldrin	Oral	5.00E-05						
Endosulfan I	Oral	6.00E-03	Reduced body weight	dd	Medium	100	1	IRIS
Endosulfan sulfate	Oral	--						
Endrin	Oral	3.00E-04						
Endrin ketone	Oral	--						
Hepatachlor epoxide	Oral	1.30E-05	Increased relative weight	Oral	Low	1000	1	IRIS
Methoxychlor	Oral	5.00E-03		Oral				IRIS
Inorganic Compounds								
Arsenic	Oral	3.00E-04	Hyperpigmentation	Oral	Medium	3	1	IRIS
Barium	Oral	7.00E-02	Increased blood pressure	Oral	Medium	3	1	IRIS
	Inhalation	1.43E-04	Fetotoxicity	Inhalation	--	1000	--	HEAST
Cadmium	Oral-water	5.00E-04	Significant proteinurea	Oral	High	10	1	IRIS
	Oral-food	1.00E-03	Significant proteinurea	Oral	High	10	1	IRIS
Chromium	Oral	1.00E+00	No effects observed	Oral	Low	100	1	IRIS
Lead	Oral	--	--	--	--	--	--	--
Mercury	Oral	--	--	--	--	--	--	--
	Inhalation	8.57E-05	Hand tremor	Inhalation	Medium	30	1	HEAST
Selenium	Oral	5.00E-03	Clinical selenosis	Oral	High	3	1	IRIS
Silver	Oral	5.00E-03	Argyria	Oral	Low	3	1	IRIS

TABLE A-6

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA, WATERVLIET ARESENAL

TOXICITY VALUES: POTENTIAL NON-CARCINOGENIC EFFECTS

Constituent	Exposure Route	Chronic RfD (mg/kg-day)	Critical Effect	RfD Basis	Confidence Level	Uncertainty Factor	Modifying Factor	RfD Source

Notes: -- = Not Available
IRIS = Integrated Risk Information System (USEPA data base) (USEPA 1997b)
HEAST = Health Effects Assessment Summary Tables (USEPA, 1997a)
UF = Uncertainty Factor, to account for inter- and intraspecies extrapolation and extrapolation form subchronic to chronic exposures
MF = Modifying Factor, to account for uncertainty in the test program
1 Value for Aroclor 1254 used

TABLE A-7

EXPOSURE ASSESSMENT
CORRECTIVE MEASURE STUDY
SIBERIA AREA, WATERVLIET ARESENAL

TOXICITY VALUES: POTENTIAL CARCINOGENIC EFFECTS

Constituent	Exposure Route	Slope Factor (SF) $(mg/kd\text{-}day)^{-1}$	SF Basis	Type of Cancer	Weight-of-Evidence Classification	SF Source
Benzene	Oral	2.90E-02	Inhalation	Leukemia	A	IRIS
	Inhalation	2.90E-02	Inhalation	Leukemia	A	IRIS
2-Butanone	Oral	--	--	--	D	IRIS
	Inhalation	--	--	--	D	IRIS
Carbon disulfide	Oral	--	--	--	--	IRIS
Chloroform	Oral	6.10E-03	Oral	Several tumor types	B2	IRIS
	Inhalation	8.10E-02	Inhalation	Liver	B2	IRIS
cis-1,2-Dichloroethene	Oral	--	--	--	D	IRIS
Methylene chloride	Oral	7.50E-03	Oral	Hepatocellular neoplasm	B2	IRIS
	Inhalation	1.64E-03	Inhalation		B2	IRIS
Tetrachloroethene	Oral	--	--	--	--	--
Trichloroethene	Oral	--	--	--	--	--
Toluene	Oral	--	--	--	D	IRIS
Vinyl chloride	Oral	1.90E+00	Oral	Lung	A	HEAST
	Inhalation	3.00E-01	Inhalation	Liver	A	HEAST
Xylenes	Oral	--	--	--	D	IRIS
Semivolatile Organic Compounds						
Acenaphthylene	Oral	--	--	--	--	IRIS
Acenaphthene	Oral	--	--	--	--	IRIS
Anthracene	Oral	--	--	--	D	IRIS
Benzidine	Oral	2.30E+02	Oral	Bladder	A	IRIS
	Inhalation	2.35E+02	Inhalation	Bladder	A	IRIS
Benzo(a)anthracene	Oral	7.30E-01	--	--	B2	IRIS
Benzo(b)fluoranthene	Oral	7.30E-01	--	--	B2	IRIS
Benzo(k)flouranthene	Oral	7.30E-02	--	--	B2	IRIS
Benzo(a)pyrene	Oral	7.30E+00	Oral	Forestomach	B2	IRIS
Benzo(g,h,i)perylene	Oral	--	--	--	D	IRIS
Bis(2-ethylhexyl)phthalate	Oral	1.40E-02	Oral	Liver	B2	IRIS
Butylbenzylphthalate	Oral	--	--	--	C	IRIS
Chrysene	Oral	7.30E-03	--	--	B2	IRIS
Dibenz(a,h)anthracene	Oral	7.30E+00	--	--	B2	IRIS
Diethylphthalate	Oral	--	--	--	D	IRIS
Di-n-butylphthalate	Oral	--	--	--	D	IRIS
Di-n-octylphthalate	Oral	--	--	--	--	IRIS
Indeno(1,2,3-cd)pyrene	Oral	7.30E-01	--	--	B2	IRIS
Fluoranthene	Oral	--	--	--	D	IRIS
Fluorene	Oral	--	--	--	D	IRIS
2-Methylnaphthalene	Oral	--	--	--	--	IRIS
Naphthalene	Oral	--	--	--	D	IRIS

TABLE A-7

EXPOSURE ASSESSMENT
CORRECTIVE MEASURE STUDY
SIBERIA AREA, WATERVLIET ARESENAL

TOXICITY VALUES: POTENTIAL CARCINOGENIC EFFECTS

Constituent	Exposure Route	Slope Factor (SF) $(mg/kd\text{-}day)^{-1}$	SF Basis	Type of Cancer	Weight-of-Evidence Classification	SF Source
N-nitrosodimethylamine	Oral	5.10E+01	Oral	Liver	B2	IRIS
	Inhalation	5.10E+01	Inhalation	Liver	B2	HEAST
Phenanthrene	Oral	--	--	--	D	IRIS
Phenol	Oral	--	--	--	D	IRIS
Pyrene	Oral	--	--	--	D	IRIS
Pesticide/PCBs						
Aldrin	Oral	1.70E+01	Oral	Liver	B2	IRIS
	Inhalation	1.70E+01	Inhalation	Liver	B2	IRIS
Aroclor 1254	Oral	2.00E+00	Oral	Liver	B2	IRIS
	Inhalation	2.00E+00	Inhalation	Liver	B2	IRIS
Aroclor 1260	Oral	2.00E+00	Oral	Liver	B2	IRIS
	Inhalation	2.00E+00	Inhalation	Liver	B2	IRIS
beta-BHC	Oral	1.80E+00	Oral	Liver	B2	IRIS
	Inhalation	1.90E+00	Oral	Liver	B2	IRIS
delta-BHC	Oral	--	Oral	--	--	--
4,4'-DDD	Oral	2.40E-01	Oral	Liver	B2	IRIS
4,4'-DDE	Oral	3.40E-01	Oral	Liver	B2	IRIS
4,4'-DDT	Oral	3.40E-01	Oral	Liver	B2	IRIS
	Inhalation	3.40E-01	Inhalation	Liver	B2	IRIS
Dieldrin	Oral	1.60E+01			B2	IRIS
	Inhalation	1.60E+01	Inhalation	Liver	B2	HEAST
Endosulfan I	Oral	--	--	--	--	--
Endosulfan sulfate	Oral	--	--	--	--	--
Endrin	Oral	--	--	--	D	IRIS
Endrin ketone	Oral	--	--	--	--	--
Hepatachlor epoxide	Oral	9.10E+00	Oral	Liver	B2	IRIS
	Inhalation	9.10E+00	Inhalation	Liver	B2	HEAST
Methoxychlor	Oral	--	--	--	D	IRIS
Inorganic Compounds						
Arsenic	Oral	1.50E+00	Oral	Lver, kidney	A	IRIS
	Inhalation	1.50E+00	Inhalation	Liver, kidney	A	IRIS
Barium	Oral	--	--	--	D	IRIS
Cadmium	Oral	--	--	--	B1	IRIS
	Inhalation	6.30E+00	Inhalation	Lung	B1	IRIS
Chromium	Oral	--	--	--	--	IRIS
Lead	Oral	--	--	--	B2	IRIS
Mercury	Oral	--	--	--	D	IRIS

TABLE A-7

EXPOSURE ASSESSMENT
CORRECTIVE MEASURE STUDY
SIBERIA AREA, WATERVLIET ARESENAL

TOXICITY VALUES: POTENTIAL CARCINOGENIC EFFECTS

Constituent	Exposure Route	Slope Factor (SF) $(mg/kd\text{-}day)^{-1}$	SF Basis	Type of Cancer	Weight-of-Evidence Classification	SF Source
Selenium	Oral	--	--	--	D	IRIS
Silver	Oral	--	--	--	D	IRIS

Notes: -- = Not Available
IRIS = Integrated Risk Information System (USEPA data base) (USEPA 1997b)
HEAST = Health Effects Assessment Summary Tables (USEPA, 1997a)
A = Human Carcinogen
B1 = Probable Human Carcinogen
B2 = Probable Human Carcinogen
C = Possible Human Carcinogen
D = Not Classifieable as to Human Carcinogenicity

APPENDIX B

Site-Specific Parameters

Fraction organic carbon (f_{oc}): The site-specific value of 8 percent was measured during the RFI.

Depth to groundwater (L_{gw}): The recommended default value of 100 cm was determined to be a reasonable site-specific value for the Siberia Area based on water elevations measured during the RFI.

Wind speed above ground surface in ambient mixing zone (U_a): The site-specific value of 334 cm/s is based on the mean wind speed for Albany, NY (8.9 mph or 3.98 m/s, measured at an anemometer height of 6.1 m) corrected to an ambient air mixing zone height of 2 m from the following equation:

$$3.98 = U_2 \frac{(\ln 6.1/0.005)}{(\ln 2/0.005)}$$

where:

3.98 = the mean wind speed in m/s at a height of 6.1 m.
0.005 = USEPA default for typical roughness height.

Width of source area parallel to wind (W): The site-specific value of 39,000 cm is the approximate width of the Siberia Area assuming the wind is traveling north-northeast across the Siberia Area towards the residential area of concern.

Total soil porosity (?$_?$): The site-specific value of 0.36 cm^3/cm^3-soil is derived from the following equation (USEPA, 1995):

$$?_? = 1 - \frac{1.7}{2.65}$$

where:

1.7 = average soil dry bulk density in kg/L-soil.
2.65 = soil particle density in kg/L-soil.

Volumetric water content in vadose zone soils (?$_{ws}$): The site-specific value of 0.18 cm^3-H_2O/cm^3-soil is derived from the following equation (USEPA, 1995):

$$?_{ws} = 0.36(0.20/540)^{0.085}$$

where:

0.36 = total soil porosity in cm^3/cm^3-soil.
0.20 = average water infiltration rate in m/yr for the glaciated central region of the U.S. including the Albany, NY area (USEPA, 1995).

540 = soil saturated hydraulic conductivity in m/yr selected from Table 1 in USEPA, 1995 based on the average measured hydraulic conductivity of 579 m/yr for fill, lacustrine silt/clay and weathered bedrock at the Siberia Area

0.085 = unitless, soil-specific exponential parameter from Table 1 in USEPA, 1995 for a soil saturated hydraulic conductivity of 540 m/yr

Volumetric air content in vadose zone soils ($?_{as}$): The site-specific value of 1.18 cm^3-air/cm^3-soil is based on the following equation (USEPA, 1995):

$$?_{as} = 0.36 - 0.18$$

where:

0.36 = total soil porosity in cm^3/cm^3-soil.

0.18 = volumetric water content in vadose zone soils in cm^3-H_2O/cm^3-soil.

Volumetric water content in foundation/wall cracks ($?_{wcrack}$) and volumetric air content in foundation/wall cracks ($?_{wcrack}$): Per the ASTM standard guide, the site-specific values for foundation/wall cracks are set equal to the site-specific values for the vadose zone.

Volumetric air content in the capillary fringe soils ($?_{acap}$): Per the ASTM standard guide, the site-specific value is set equal to 0.1 times the total soil porosity.

Volumetric water content in the capillary fringe soils ($?_{wcap}$): Per the ASTM standard guide, the site-specific value is calculated based on the total soil porosity minus the volumetric air content in the capillary fringe soils.

Saturation concentration of a chemical in the vadose zone ($C_{sat,i}$): The site-specific saturation concentrations presented in Table 2-11 were calculated from the following equation (USEPA, 1995):

$$C_{sat,i} = \frac{S}{ß}(K_d ß + ?_{ws} + H'?_{as})$$

where:

S = solubility in water of chemical in mg/L-water.

K_d = soil/water partition coefficient for chemical in L/kg.

ß = average soil dry bulk density in kg/L-soil.

$?_{ws}$ = volumetric water content in vadose zone soils.

H' = unitless Henry's law constant for chemical.

$?_{as}$ = volumetric air content of vadose zone soils.

REFERENCES

U. S. Environmental Protection Agency. 1995. Air/Superfund National Technical Guidance Study Series. Guideline for Predictive Baseline Emissions Estimation for Superfund Sites. Interim Final. EPA-451/R-96-001. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

TABLE 2-1

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF ON-SITE SURFACE SOIL [1] AND OFF-SITE SURFACE SOIL/SEDIMENT DATA

Parameter	NYSDEC TAGM 4046 Value	On-Site Surface Soil			Off-Site Surface Soil/Sediment		
		Frequency of Detection	Range of Detected Concentrations	Average Concentration	Frequency of Detection	Range of Detected Concentrations	Average Concentration
Semivolatile Organic Compounds (ug/kg)							
Naphthalene	13000	48/75	7-18000	488	11/13	19-130	61.3
4-Chloro-3-methylphenol	240	1/75	47	47.0	0/13	ND	---
Phenol	30	2/75	43	27021.5	1/13	360	360
Acenaphthylene	41000	44/75	5-4400	183.5	13/13	13-2600	381
Acenaphthene	50000	40/75	15-9300	593	11/13	21-360	92.0
2-Methylnaphthalene	36400	48/75	10-37100	1167	0/13	ND	---
Diethylphthalate	7100	29/75	7-13000	482.6	4/13	11-14	12.8
Fluorene	50000	37/75	13-12000	737	11/13	17-880	154
Phenanthrene	50000	69/75	6-42000	2708	13/13	140-5400	1196
Anthracene	50000	65/75	6-9800	647	13/13	34-2900	510
Di-n-butylphthalate	8100	46/75	10-700	60.2	0/13	ND	---
Fluoranthene	50000	69/75	10-150000	4306	13/13	340-8200	2403
Benzidine	N/A	11/75	89-180000	17709	0/13	ND	---
Pyrene	50000	63/75	9-35000	2684	13/13	280-6400	2070
Butylbenzylphthalate	50000	11/75	32-4000	936	4/13	13-65	35.0
3,3'-Dichlorobenzidine	N/A	4/75	10-51000	12814.5	0/13	ND	---
Benzo(a)anthracene	224	65/75	8-63000	2138	13/13	160-5000	1354
Chrysene	400	67/75	14-14000	1351	13/13	240-5600	1712
bis(2-Ethylhexyl)phthalate	50000	43/75	15-79000	2196	12/13	22-520	155
Di-n-octylphthalate	50000	7/75	12-51000	7763	0/13	ND	---
Benzo(b)fluoranthene	1100	65/75	8-58000	2313	13/13	180-4700	1558
Benzo(k)fluoranthene	1100	66/75	14-41000	1821	9/13	30-5900	1862
Benzo(a)pyrene	61	60/75	12-15000	1323	13/13	180-4400	1355
Indeno(1,2,3-cd)pyrene	3200	49/75	13-17000	1056	13/13	120-1900	558
Dibenz(a,h)anthracene	14	19/75	19-1100	256	1/13	34	34.0
Benzo(g,h,i)perylene	50000	43/75	11-3400	654	13/13	90-1700	461
Volatile Organic Compounds (ug/kg)							
Chloroethane	1900	1/75	4	4.0	Not analyzed		
Methylene chloride	100	29/75	1-400	19.7	Not analyzed		
1,2-Dichloroethene	300	2/75	2-450	226	Not analyzed		
Chloroform	300	4/75	0.6-97	25.2	Not analyzed		
2-Butanone	300	6/75	30-270	152	Not analyzed		
Trichloroethene	700	7/75	1-1600	232	Not analyzed		
4-Methyl-2-pentanone	1000	1/75	2	2.0	Not analyzed		
Tetrachloroethene	1400	11/75	1-36000	3291	Not analyzed		
Toluene	1500	23/75	0.7-190	15.6	Not analyzed		
1,1,2,2,-Tetrachloroethane	600	2/75	1-220	111	Not analyzed		
Xylenes	1200	14/75	1-230	33.0	Not analyzed		
Benzene	60	4/75	0.6-10	5.7	Not analyzed		
Ethylbenzene	5500	4/75	0.5-33	12.9	Not analyzed		

TABLE 2-1

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF ON-SITE SURFACE SOIL [1] AND OFF-SITE SURFACE SOIL/SEDIMENT DATA

Parameter	NYSDEC TAGM 4046 Value	On-Site Surface Soil			Off-Site Surface Soil/Sediment		
		Frequency of Detection	Range of Detected Concentrations	Average Concentration	Frequency of Detection	Range of Detected Concentrations	Average Concentration
Pesticide and PCBs (ug/kg)							
beta-BHC	200	4/71	0.78-3.7	2.2	Not analyzed		
delta-BHC	300	17/71	2.1-140	22.7	Not analyzed		
Aldrin	41	19/71	0.71-26	4.1	Not analyzed		
Heptachlor epoxide	20	10/71	0.51-210	28.8	Not analyzed		
Dieldrin	44	5/71	0.41-24	6.9	Not analyzed		
4,4'-DDE	2100	22/71	0.42-49	12.4	Not analyzed		
Endrin	100	11/71	4-60	18.0	Not analyzed		
4,4'-DDD	2900	23/71	0.88-280	28.6	Not analyzed		
Endosulfan sulfate	1000	17/71	0.14-44	14.9	Not analyzed		
4,4'-DDT	2100	39/71	0.74-380	49.0	Not analyzed		
Methoxychlor	**	15/71	1.8-110	23.2	Not analyzed		
Endrin ketone	N/A	11/71	2.6-200	31.7	Not analyzed		
Aroclor-1254	1000	22/71	15-1600	282	Not analyzed		
Aroclor-1260	1000	22/71	28-1900	316	Not analyzed		
Endosulfan I	900	2/71	1.2-24	12.6	Not analyzed		
Inorganic Compounds (mg/kg)							
Arsenic	10.5*	75/75	3.4-49.2	13.2	11/11	9.7-104	45.0
Barium	300	75/75	23.8-439	155	Not analyzed		
Cadmium	1	48/75	0.21-23.8	2.1	Not analyzed		
Chromium	20.7*	75/75	9.7-2490	139	Not analyzed		
Lead	186*	75/75	4.2-17400	418	11/11	67.4-1130	378
Mercury	0.54*	53/75	0.094 - 4	0.37	Not analyzed		
Selenium	3.1*	55/75	0.26-30.1	2.6	Not analyzed		
Silver	ND*	27/75	0.24-10.5	1.8	Not analyzed		

Notes:
1 = Surface soil samples include surface soil samples (6 to 12 inches) and shallow boring samples (0 to 2 feet)
* = Site Background Value
** = As per TAGM 4046, total pesticides < 10 ppm
N/A = None Available
ND = Not Detected

TABLE 2-2

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF ALL ON-SITE SOIL DATA

Parameter	NYSDEC TAGM 4046 Value	Fill Soils			Native Soils			All Soils		
		Frequency of Detection	Range of Detected Concentrations	Average Concentration	Frequency of Detection	Range of Detected Concentrations	Average Concentration	Frequency of Detection	Range of Detected Concentrations	Average Concentration
Semivolatile Organic Compounds (ug/kg)										
4-Chloro-3-methylphenol	240	1/103	47	47.0	1/21	10	10.0	2/124	10-47	28.5
Phenol	30	1/103	43	43.0	0/21	ND	---	1/124	43	43.0
Naphthalene	13000	61/103	7-36000	980	5/21	9-770	193	66/124	7-36000	936
2-Methylnaphthalene	36400	60/103	10-82000	3194	8/21	12-1800	453	68/124	10-82000	2934
Acenaphthylene	41000	56/103	5-4400	234	2/21	8-77	42.5	58/124	5-4400	228
Acenaphthene	50000	48/103	15-16000	857	2/21	7-20	13.5	50/124	7-16000	824
Diethylphthalate	7100	40/103	7-260	39.5	10/21	10-61	18.6	50/124	7-260	35.3
Fluorene	50000	46/103	13-26000	1473	6/21	11-850	274	52/124	11-26000	1347
Pentachlorophenol	1000	1/103	31	31.0	0/21	ND	---	1/124	31	31.0
Phenanthrene	50000	90/103	6-89000	3376	12/21	20-2800	565	102/124	6-89000	3080
Anthracene	50000	82/103	7-13000	750	8/21	6-140	35.4	90/124	6-13000	686
Di-n-butylphthalate	8100	61/103	7-700	51.8	14/21	6-45	18.7	75/124	6-700	45.6
Fluoranthene	50000	92/103	6-150000	4618	14/21	10-470	132	106/124	6-150000	4095
Benzidine	N/A	10/103	89-7900	1480	6/21	12-980	182	16/124	12-7900	993
Pyrene	50000	88/103	8-180000	5272	15/21	12-800	202	103/124	8-180000	4612
Butylbenzylphthalate	50000	12/103	9-4000	859	2/21	17-23	20.0	14/124	9-4000	739
3,3'-Dichlorobenzidine	N/A	3/103	10-170	86.0	0/21	ND	---	3/124	10-170	86.0
Benzo(a)anthracene	224	84/103	5-61000	2175	8/21	6-430	113	92/124	5-61000	1996
Chrysene	400	88/103	8-63000	2336	13/21	10-640	124	101/124	8-63000	2069
bis(2-Ethylhexyl)phthalate	50000	59/103	17-4900	298	14/21	19-860	249	73/124	17-4900	283
Di-n-octylphthalate	50000	7/103	12-2700	505	3/21	15-58	37.0	10/124	12-2700	364
Benzo(b)fluoranthene	1100	85/103	3-79000	2552	11/21	7-450	86.5	96/124	3-79000	2270
Benzo(k)fluoranthene	1100	87/103	2-61000	1957	12/21	6-320	69.0	99/124	2-61000	1728
Benzo(a)pyrene	61	81/103	7-58000	1915	11/21	10-350	78.9	92/124	7-58000	1696
Indeno(1,2,3-cd)pyrene	3200	65/103	12-41000	1438	7/21	6-230	67.1	72/124	6-41000	1305
Dibenz(a,h)anthracene	14	29/103	14-15000	842	3/21	2-13	7.0	32/124	2-15000	764
Benzo(g,h,i)perylene	50000	57/103	11-17000	1035	8/21	7-96	35.8	65/124	7-17000	926
1,2-Dichlorobenzene	7900	2/103	25-630	328	0/21	ND	---	2/124	25-630	328
Volatile Organic Compounds (ug/kg)										
Chloroethane	1900	1/103	4	4.0	0/21	ND	---	1/124	4	4.0
Vinyl chloride	200	1/103	11	11.0	6/21	1-15	4.7	7/124	1-15	5.6
Methylene chloride	100	47/103	0.7-400	19.1	2/21	1-9	5.0	49/124	0.7-400	18.7
Carbon disulfide	2700	14/103	0.6-48	8.5	1/21	1	1.0	15/124	0.6-48	8.0
1,1-Dichloroethene	400	0/103	ND	---	4/21	1-12	6.3	4/124	1-12	6.3
1,2-Dichloroethene	300	7/103	0.9-450	74.3	2/21	5-19	12.0	9/124	0.9-450	60.4

TABLE 2-2

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF ALL ON-SITE SOIL DATA

Parameter	NYSDEC TAGM 4046 Value	Fill Soils			Native Soils			All Soils		
		Frequency of Detection	Range of Detected Concentrations	Average Concentration	Frequency of Detection	Range of Detected Concentrations	Average Concentration	Frequency of Detection	Range of Detected Concentrations	Average Concentration
Chloroform	300	5/103	0.6-97	21.3	4/21	13-43	27.5	9/124	0.6-97	21.7
2-Butanone	300	15/103	1-2100	221.2	6/21	1-44	16.7	21/124	1-2100	163
1,3-Dichloropropene	300	1/103	2100	2100	1/21	2	2.0	2/124	2-2100	1051
Trichloroethene	700	13/103	0.8-1600	127.2	4/21	2-41	12.8	17/124	0.8-1600	106
Benzene	60	9/103	0.5-24	6.3	3/21	0.4-4	2.1	12/124	0.4-24	5.4
Tetrachloroethene	1400	13/103	0.3-36000	2786	0/21	ND	---	13/124	0.3-36000	2786
Toluene	1500	29/103	0.4-310	26.6	1/21	8	8.0	30/124	0.4-310	26.6
Ethylbenzene	5500	5/103	0.5-160	42.3	0/21	ND	---	5/124	0.5-160	42.3
Xylenes	1200	17/103	0.2-1700	128	0/21	ND	---	17/124	0.2-1700	128
1,1,2,2,-Tetrachloroethane	600	2/103	1-220	111	1/21	1	1.0	3/124	1-220	74.0
4-Methyl-2-pentanone	1000	1/103	2	2.0	0/21	ND	---	1/124	2	2.0
Chlorobenzene	1700	0/103	ND	---	2/21	1.2-35	18.1	2/124	1.2-35	35.0
Pesticide and PCBs (ug/kg)										
beta-BHC	200	5/99	0.78-3.7	1.9	3/21	2.3-11	5.4	8/120	0.78-11	2.1
delta-BHC	300	24/99	0.14-160	26.2	2/21	7.4-270	138.7	26/120	0.14-270	25.5
Aldrin	41	23/99	0.71-26	4.4	1/21	1.3	1.3	24/120	0.71-26	4.2
Heptachlor epoxide	20	14/99	0.51-560	62.0	0/21	ND	---	14/120	0.51-560	62.0
Endosulfan I	900	3/99	4.9-180	69.6	3/21	1.2-4.8	3.5	6/120	1.2-180	36.6
Dieldrin	44	5/99	0.41-24	6.9	1/21	1.6	1.6	6/120	0.41-24	6.0
4,4'-DDE	2100	28/99	0.42-75	13.2	2/21	1.3-26	13.7	30/120	0.42-75	13.2
Endrin	100	11/99	4-60	18.0	0/21	ND	---	11/120	4-60	18.0
4,4'-DDD	2900	26/99	0.41-280	36.1	6/21	0.49-18	6.1	32/120	0.41-280	30.5
Endosulfin Sulfate	1000	20/99	0.14-44	15.4	3/21	2.7-27	11.1	23/120	0.14-44	14.8
4,4'-DDT	2100	42/99	0.74-380	45.7	0/21	ND	---	42/120	0.74-380	45.7
Methoxychlor	**	19/99	1.1-370	38.4	1/21	61	61.0	20/120	1.1-370	38.4
Endrin ketone	N/A	16/99	0.54-200	38.3	0/21	ND	---	16/120	0.54-200	38.3
Aroclor-1254	1000	23/99	17-1600	292	0/21	ND	---	23/120	17-1600	292
Aroclor-1260	1000	23/99	12-1900	327	21/21	2.8-37.6	10.6	44/120	2.8-1900	188
Inorganic Compounds (mg/kg)										
Arsenic	10.5*	103/103	3.4-49.2	12.4	1/21	0.44	0.4	104/124	0.44-49.2	12.3
Barium	300	103/103	23.8-439	153	21/21	10.1-42.7	23.9	124/124	10.1-439	134
Cadmium	1	53/103	0.21-23.8	2.0	21/21	17-98.7	35.3	74/124	0.21-98.7	9.7
Chromium	20.7*	103/103	9.7-2490	123	4/21	0.096-2.9	0.8	107/124	0.096-2490	118
Lead	186*	103/103	4.2-17400	373	21/21	0.98-4.9	2.5	124/124	0.98-17400	318
Mercury	0.54*	69/103	0.089-4	0.4	4/21	0.27-0.74	0.4	73/124	0.089-4	0.4
Selenium	3.1*	83/103	0.26-30.1	2.5	0/21	ND	---	83/124	0.26-30.1	2.5

TABLE 2-2

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF ALL ON-SITE SOIL DATA

Parameter	NYSDEC TAGM 4046 Value	Fill Soils			Native Soils			All Soils		
		Frequency of Detection	Range of Detected Concentrations	Average Concentration	Frequency of Detection	Range of Detected Concentrations	Average Concentration	Frequency of Detection	Range of Detected Concentrations	Average Concentration
Silver	ND*	41/103	0.24-10.5	1.4	0/21	ND	---	41/124	0.24-10.5	1.4

Notes:
* = Site Background Value
** = As per TAGM 4046, total pesticides < 10 ppm
N/A = None Available
ND = Not Detected

TABLE 2-3

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF GROUNDWATER DATA

Parameter	NYSDEC Class GA Water Quality Standard	Frequency of Detection	Concentration Range	Average Concentration
Semivolatile Organic Compounds (ug/l)				
1,2-Dichlorobenzene	4.7	1/77	1	1
2-Methylnaphthalene	N/A	7/77	0.2-8	2.7
4-Chloro-3-methylphenol	N/A	1/77	2	2
Acenaphthene	20	3/77	1-2	1.7
Anthracene	N/A	4/77	0.2-1	0.53
Benzo(a)anthracene	0.002	6/77	0.08-0.6	0.21
Benzo(b)fluoranthene	0.002	6/77	0.1-0.2	0.13
Benzo(k)fluoranthene	0.002	6/77	0.1-0.2	0.17
bis(2-Ethylhexyl)phthalate	50	48/77	0.1-210	12.0
Butylbenzylphthalate	50	7/77	0.08-0.7	0.31
Di-n-butylphthalate	50	29/77	0.4-2	0.75
Di-n-octylphthalate	N/A	9/77	0.1-0.4	0.22
Diethylphthalate	50	25/77	0.1-8	0.708
Dimethylphthalate	50	1/77	0.8	0.8
Fluoranthene	50	13/77	0.09-2	0.61
Fluorene	50	13/77	0.5-3	1.7
N-nitrosodimethylamine	50	10/77	0.4-3	1.3
Naphthalene	10	5/77	0.6-16	6.3
Phenanthrene	50	8/77	0.1-3	1.0
Phenol	1	1/77	0.8	0.8
Pyrene	50	13/77	0.08-2	0.48
Chrysene	0.002	5/77	0.1-0.2	0.14
Benzo(a)pyrene	0.002	3/77	0.1-0.1	0.1
Volatile Organic Compounds (ug/l)				
Bromomethane	5	1/78	2	2
Vinyl chloride	2	3/78	2-1100	464
Carbon disulfide	N/A	1/78	2	2
1,1-Dichloroethane	5	1/78	0.9	0.9
cis-1,2-Dichloroethene	5	4/78	1-4200	1511
Chloroform	7	3/78	4-19	10.0
2-Butanone	5	1/78	11	11
1,1,1-Trichoroethane	5	1/78	22	22
Trichloroethene	5	3/78	2-1600	535
Tetrachloroethene	5	2/78	1-600	301
Xylenes	5	2/78	4-43	23.5
1,1-Dichloroethene	5	1/78	7	7
trans-1,2-Dichloroethene	5	1/78	11	11
Benzene	0.7	1/78	8	8
Toluene	5	1/78	8	8
Ethylbenzene	5	1/78	7	7

TABLE 2-3

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF GROUNDWATER DATA

Parameter	NYSDEC Class GA Water Quality Standard	Frequency of Detection	Concentration Range	Average Concentration
Pesticides and PCBs (ug/l)				
alpha-BHC	N/A	1/76	0.002	0.002
beta-BHC	N/A	3/76	0.008-0.02	0.016
delta-BHC	N/A	3/76	0.0051-0.04	0.0217
Aldrin	ND	1/76	0.02	0.02
Heptachlor epoxide	ND	1/76	0.009	0.009
Endosulfan I	N/A	2/76	0.01-0.04	0.025
4,4'-DDD	ND	1/76	0.06	0.06
4,4'-DDT	ND	7/76	0.006-0.01	0.008
Endrin aldehyde	N/A	1/76	0.08	0.08
Total Inorganic Compounds (ug/l)				
Arsenic	25	21/77	1.4-82.6	11.8
Barium	1000	39/77	61.2-19900	2434
Cadmium	10	5/77	2.2-24.4	10.2
Chromium	50	39/77	1.2-41800	1279
Lead	25	37/77	2-989	52.9
Mercury	2	1/77	1.5	1.5
Selenium	10	9/77	2.1-17.7	7.1
Silver	50	1/77	2.5	2.5

Notes:
N/A = None Available
ND = Not Detected

TABLE 2-4

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

CHEMICALS OF POTENTIAL CONCERN

Parameter	On-Site Surface Soil	All On-Site Soil	Off-Site Surface Soil/Sediment	Groundwater
Volatile Organic Compounds				
Benzene	---	X	NA	---
2-Butanone	X	X	NA	---
Carbon disulfide	ND	X	NA	---
Chloroform	X	X	NA	X
1,2-Dichloroethene	---	X	NA	X
Methylene chloride	X	X	NA	---
Tetrachloroethene	X	X	NA	X
Toluene	X	X	NA	---
Trichloroethene	X	X	NA	X
Vinyl chloride	ND	X	NA	X
Xylenes	X	X	NA	X
Semivolatile Organic Compounds				
Acenaphthene	X	X	X	---
Acenaphthylene	X	X	X	ND
Anthracene	X	X	X	X
Benzidine	X	X	ND	ND
Benzo(a)anthracene	X	X	X	X
Benzo(b)flouranthene	X	X	X	X
Benzo(k)fluoranthene	X	X	X	X
Benzo(a)pyrene	X	X	X	---
Benzo(g,h,i)perylene	X	X	X	ND
Bis(2-ethylhexyl)phthalate	X	X	X	X
Butylbenzylphthalate	X	X	X	X
Chrysene	X	X	X	X
Dibenz(a,h)anthracene	X	X	X	ND
Diethylphthalate	X	X	X	X
Di-n-butylphthalate	X	X	ND	X
Di-n-octylphthalate	X	X	ND	X
Indeno(1,2,3-cd)pyrene	X	X	X	ND

TABLE 2-4

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

CHEMICALS OF POTENTIAL CONCERN

Parameter	On-Site Surface Soil	All On-Site Soil	Off-Site Surface Soil/Sediment	Groundwater
Fluoranthene	X	X	X	X
Fluorene	X	X	X	X
2-Methylnaphthalene	X	X	ND	X
Naphthalene	X	X	X	X
N-nitrosodimethylamine	ND	ND	ND	X
Phenanthrene	X	X	X	X
Phenol	---	---	X	---
Pyrene	X	X	X	X
Pesticides/PCBs				
Aldrin	X	X	NA	---
Aroclor 1254	X	X	NA	ND
Aroclor 1260	X	X	NA	ND
beta-BHC	X	X	NA	---
detla-BHC	X	X	NA	---
4,4'-DDD	X	X	NA	---
4,4'-DDE	X	X	NA	ND
4,4'-DDT	X	X	NA	X
Dieldrin	X	X	NA	ND
Endosulfan I	---	X	NA	---
Endosulfan sulfate	X	X	NA	ND
Endrin	X	X	NA	ND
Endrin ketone	X	X	NA	ND
Heptachlor epoxide	X	X	NA	---
Methoxychlor	X	X	NA	ND
Inorganic Compounds				
Arsenic	X	X	X	X
Barium	X	X	NA	X
Cadmium	X	X	NA	X
Chromium	X	X	NA	X
Lead	X	X	X	X
Mercury	X	X	NA	---

TABLE 2-4

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

CHEMICALS OF POTENTIAL CONCERN

Parameter	On-Site Surface Soil	All On-Site Soil	Off-Site Surface Soil/Sediment	Groundwater
Selenium	X	X	NA	X
Silver	X	X	NA	---

Notes:

X	=	Selected as Constituent of Concern
NA	=	Constituent not analyzed
ND	=	Constituent not detected
---	=	Constituent detected but not selected as Constituent of Concern

TABLE 2-5

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SELECTION OF CONCEPTUAL EXPOSURE SCENARIOS

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Current Land Use:			
Trespassers	Incidental ingestion of, dermal contact with and inhalation of constituents in on-site soil	No	The Arsenal is a secure active military facility. Regular patrols of the facility are made.
Arsenal Workers/Site Visitors	Incidental ingestion of, dermal contact with and inhalation (via vapors and fugitive dust) of constituents in on-site surface soil	Yes	Constituents were detected in on-site surface soil at concentrations exceeding TAGM 4046 values. These soils may be encountered by Arsenal workers during routine activities.
Arsenal Workers/Site Visitors	Ingestion of, dermal contact with and inhalation of constituents in groundwater	No	Although groundwater is classified as GA (best use drinking water supply), the WVA, the surrounding off-site area and the City of Watervliet are served by a public water supply. This is unlikely to change in the future.
Off-Site Residents	Dermal contact with and ingestion of constituents in on-site surface soil	No	Access to the Arsenal is restricted.
Off-Site Residents	Inhalation of vapors and fugitive dust released from on-site surface soil.	Yes	Much of the area is unpaved and sparsely vegetated. In dry conditions, dust may be dispersed by wind. Constituents were detected in the surface soils at concentrations exceeding TAGM 4046 values. Residential homes are located downwind and adjacent to the site.
Off-Site Residents	Ingestion of, dermal contact with and inhalation of constituents in groundwater	No	Although groundwater is classified as GA (best use drinking water supply), the WVA, the surrounding off-site area and the City of Watervliet are served by a public water supply. This is unlikely to change in the future.
Off-Site Residents	Ingestion of and dermal contact with off-site soil and sediment in drainage ditches located along the fence line north of the NW and NE	Yes	Constituents were detected in soils and sediment at concentrations exceeding NYS TAGM 4046 values. The drainage ditch is located outside the secure area. Residents, especially children, may come in contact with

TABLE 2-5

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SELECTION OF CONCEPTUAL EXPOSURE SCENARIOS

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation	Reason for Selection or Exclusion
	Quadrants		soils and sediments.
Future Land Use:			
On-Site Residents	Ingestion of, dermal contact with and inhalation of constituents detected in on-site soils.	No	The WVA is the oldest active cannon manufacturing facility in the US and is the only facility in the US manufacturing large cannons. Congress currently has not listed the arsenal on the Base Realignment and Closure (BRAC) list, and there are no plans in the near future to include it on this list. For the foreseeable future, the long-term use of arsenal is an active, secure military facility.
Off-Site Residents	Inhalation of constituents released from groundwater into enclosed spaces	Yes	Groundwater has the potential to migrate under residential areas and volatile constituents may be released and intrude into the basement air.
Utility Workers	Ingestion of, dermal contact with and inhalation (via fugitive dust and vapors) of constituents in surface and subsurface soil	Yes	Constituents were detected in soils on-site at concentrations exceeding TAGM 4046 values. Constituents detected in surface and subsurface soil may be encountered during excavation activities. Also, in dry conditions, dust may be generated during excavation activities and by movement of large equipment over the site.
Utility Workers	Dermal contact with constituents in groundwater and inhalation of vapors released from groundwater.	Yes	Depth to groundwater is approximately 3 to 10 feet. Groundwater may be encountered during excavation activities.

TABLE 2-6

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

RISK-BASED EVALUATION EQUATIONS

Medium	Exposure Route	Noncarcinogenic	Carcinogenic
Air	Inhalation	$RBSL_{air} = \frac{THQ * BW * AT_n * 365 * RfD_i}{IR_a * ED * EF}$	$RBSL_{air} = \frac{TR * BW * AT_c * 365}{IR_a * ED * EF * SF_i}$
Ground water	Outdoor ambient air vapor inhalation	$RBSL_w = \frac{RBSL_{air}}{VF_{wamb}}$	$RBSL_w = \frac{RBSL_{air}}{VF_{wamb}}$
Ground water	Enclosed-space (indoor) air vapor inhalation	$RBSL_w = \frac{RBSL_{air}}{VF_w}$	$RBSL_w = \frac{RBSL_{air}}{VF_w}$
Surface Soil	Inhalation of vapors and particles, dermal contact and ingestion	$RBSL_s = \frac{THQ * BW * AT_n * 365}{EF * ED * [\frac{10^{-6} * (IR_s * RAF_o + SA * M * RAF_d}{RfD_o} + \frac{(IR_a *$	$RBSL_s = \frac{TR * BW * AT_c * 365}{EF * ED * [(SF_o * 10^{-6} * (IR_s * RAF_o + SA * M * RAF_d)) +$
Surface Soil	Inhalation of vapors and particles	$RBSL_s = \frac{THQ * BW * AT_n * 365}{EF * ED * \frac{(IR_a * (VF_{ss} + VF_p))}{RfD_i}}$	$RBSL_s = \frac{TR * BW * AT_c * 365}{EF * ED * (SF_i * IR_a * (VF_{ss} + VF_p))}$
Subsurface and Surface	Inhalation of		

TABLE 2-6

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

RISK-BASED EVALUATION EQUATIONS

Medium	Exposure Route	Noncarcinogenic	Carcinogenic
Soil	particles and vapors, dermal contact and ingestion	$RBSL_s = \frac{THQ * BW * AT_n * 365}{EF * ED * [\frac{10^{-6} * (IR_s * RAF_o + SA * M * RAF_d)}{RfD_o} + \frac{(IR_a$	$RBSL_s = \frac{TR * BW * AT_c * 365}{EF * ED * [(SF_o * 10^{-6} (IR_s * RAFSUBo + SA * M * RAF_$
Subsurface soil	Outdoor ambient air vapor inhalation	$RBSL_s = \frac{RBSL_{air}}{VF_{samb}}$	$RBSL_s = \frac{RBSL_{air}}{VF_{samb}}$
Ground water	Dermal Contact	$RBSL_w = \frac{THQ * RfD_o * BW * AT_n * 365}{PC * SA * 10^{-3} \frac{l}{cm^3} * EF * ED * ET}$	$RBSL_w = \frac{TR * BW * AT_c * 365}{SF_o * PC * SA * 10^{-3} \frac{l}{cm^3} * EF * ED * ET}$
Sediment	Dermal contact and ingestion	$RBSL_s = \frac{THQ * BW * AT_n * 365}{EF * ED * [\frac{10^{-6} * (IR_{soil} * RAF_o + SA * M * RAF_d)}{RfD_o}]}$	$RBSL_s = \frac{TR * BW * AT_c * 365}{EF * ED * [(SF_o * 10^{-6} (IR_s * RAF_o + SA * M * RAF_d)]}$

Notes:

1. See Table A-1 for definition of acronyms and default values.

TABLE 2-7

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

TIER 2 SITE-SPECIFIC TARGET LEVELS FOR ON-SITE SURFACE SOIL

Parameter	Max. Conc. Detected in On-Site Surface Soil			Tier 2 SSTLs Arsenal Worker non	Tier 2 SSTL Arsenal Worker	Tier 2 SSTL Arsenal Worker-Surface Soil	Max. Conc. Detected in On-Site Surface Soil Exceeds Tier 2 SSTL	Tier II SSTL Off-Site Adult Resident - Inhalation	Max. Conc. Detected in On-Site Surface Soil Exceeds Tier 2 SSTL	Tier 2 SSTL Off-Site Child Resident - Inhalation	Max. Conc. Detected in On-Site Surface Soil Exceeds Tier 2 SSTL
Volatile Organic Compounds (mg/kg)											
2-Butanone	2.70E-01	AW/non top	6.39E+05	4.67E+04		4.67E+04		1.36E+05		9.98E+03	
Chloroform	9.70E-02	AW/ef*ed	6.25E+03	2.02E+03	8.37E+00	8.37E+00		1.37E+01		5.03E+00	
Methylene chloride	4.00E-01	AW/car top	1.79E+00	1.15E+04	6.46E+01	6.46E+01		6.77E+02		2.48E+02	
Tetrachloroethene	3.60E+01			2.02E+03		2.02E+03					
Toluene	1.90E-01	AR/car top	1.79E+00	1.73E+04		1.73E+04		1.81E+03		3.98E+03	
Trichloroethene	1.60E+00	AR/non top	7.67E+05								
Xylenes	1.00E-01	AR/ed*ef	1.05E+04	4.03E+05		4.03E+05					
Semivolatile Organic Compounds (mg/kg)		CR/ed*ef	2.10E+03								
Acenaphthene	5.00E+00	CR/non top	3.29E+04	4.93E+04		4.93E+04					
Acenaphthylene	1.00E+00	CR/car top	3.83E-01								
Anthracene	5.70E+00			2.46E+05		2.46E+05					
Benzidine	7.90E+00			2.46E+03	9.99E-03	9.99E-03	X	1.57E-04	X	2.89E-04	X
Benzo(a)anthracene	8.20E+00				3.15E+00	3.15E+00	X				
Benzo(b)fluoranthene	1.40E+01		1.25E+02		3.15E+00	3.15E+00	X				
Benzo(k)fluoranthene	1.90E+01		1.79E+00		3.15E+01	3.15E+01					
Benzo(a)pyrene	7.20E+00				3.15E-01	3.15E-01	X				
Benzo(g,h,i)perylene	3.40E+00										
bis(2-Ethylhexyl)phthalate	4.90E+00			1.64E+04	1.64E+02	1.64E+02					
Butylbenzylphthalate	4.00E+00			1.64E+05		1.64E+05					
Chrysene	1.40E+01				3.15E+02	3.15E+02					
Dibenz(a,h)anthracene	1.10E+00				3.15E-01	3.15E-01	X				
Diethylphthalate	2.30E-01			6.57E+05		6.57E+05					
Di-n-butylphthalate	7.00E-01			8.21E+04		8.21E+04					
Di-n-octylphthalate	2.70E+00			1.64E+04		1.64E+04					
Indeno(1,2,3-cd)pyrene	3.40E+00				3.15E+00	3.15E+00	X				
Fluoranthene	2.20E+01			3.28E+04		3.28E+04					
Fluorene	1.20E+01			3.28E+04		3.28E+04					
2-Methylnaphthalene	3.71E+01										
Naphthalene	1.70E+00										
Phenanthrene	3.40E+01										
Pyrene	3.50E+01			2.46E+04		2.46E+04					
Pesticides/PCBs (mg/kg)											
Aldrin	2.60E-02			2.46E+01	4.83E-02	4.83E-02		1.05E+01		8.61E+00	
Aroclor 1254	1.60E+00			1.64E+01	4.10E-01	4.10E-01	X	5.55E-01	X	2.04E-01	X
Aroclor 1260	1.90E+00			1.64E+01	4.10E-01	4.10E-01	X	5.55E-01	X	2.04E-01	X
beta-BHC	3.70E-03				4.56E-01	4.56E-01		1.58E+01		1.30E+01	
delta-BHC	1.40E-01										
4,4'-DDD	2.80E-01				3.42E+00	3.42E+00					
4,4'-DDE	4.90E-02				2.41E+00	2.41E+00					
4,4'-DDT	3.80E-01			4.10E+02	2.41E+00	2.41E+00		1.73E+03		1.42E+03	
Dieldrin	2.40E-02			4.10E+01	5.13E-02	5.13E-02		8.64E+00		7.10E+00	
Endrin	6.00E-02			2.46E+02		2.46E+02					
Endrin ketone	5.00E-02										
Endosulfan sulfate	2.40E-02										
Heptachlor epoxide	2.10E-01			1.07E+01	9.02E-02	9.02E-02	X	1.29E+01		9.47E+00	
Methoxychlor	1.10E-01			4.10E+03		4.10E+03					
Inorganic Compounds (mg/kg)											
Arsenic	4.92E+01			2.85E+02	1.77E+00	1.77E+00	X	2.94E+05		5.39E+05	
Barium	4.39E+02			7.90E+04		7.90E+04		2.70E+07		9.92E+06	
Cadmium	2.38E+01			1.13E+03	5.64E+04	1.13E+03		6.99E+04		1.28E+05	
Chromium	2.49E+03			1.13E+06		1.13E+06					
Lead	1.74E+04										
Mercury	4.00E+00		1.08E+02	1.09E+07		1.09E+07		1.62E+07		5.94E+06	
Selenium	3.01E+01		9.05E+01	5.65E+03		5.65E+03					
Silver	1.05E+01			5.65E+03		5.65E+03					

TABLE 2-8

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

TIER 2 SITE-SPECIFIC TARGET LEVELS FOR OFF-SITE SURFACE SOIL/SEDIMENT

Parameter	Max. Conc. Detected in Off-Site Surface Soil/Sediment	Tier 2 SSTL Off-Site Adult Resident - Off-Site Surface Soil/Sediment	Max. Conc. Detected in Off-Site Surface Soil/Sediment Exceeds Tier 2 SSTL	Tier 2 SSTL Off-Site Child Resident - Off-Site Surface Soil/Sediment	Max. Conc. Detected in Off-Site Surface Soil/Sediment Exceeds Tier 2 SSTL
Semivolatile Organic Compounds (mg/kg)					
Acenaphthene	3.60E-01	3.52E+04		3.72E+03	
Acenaphthylene	2.60E+00				
Anthracene	2.90E+00	1.76E+05		1.86E+04	
Benzo(a)anthracene	5.00E+00	1.87E+00	X	9.90E-01	X
Benzo(b)fluoranthene	4.70E+00	1.87E+00	X	9.90E-01	X
Benzo(k)fluoranthene	5.90E+00	1.87E+01		9.90E+00	
Benzo(a)pyrene	4.40E+00	1.87E-01	X	9.90E-02	X
Benzo(g,h,i)perylene	1.70E+00				
bis(2-Ethylhexyl)phthalate	5.20E-01	9.77E+01		5.16E+01	
Butylbenzylphthalate	6.50E-02	1.17E+05		1.24E+04	
Chrysene	5.60E+00	1.87E+02		9.90E+01	
Dibenz(a,h)anthracene	3.40E-02	1.87E-01		9.90E-02	
Diethylphthalate	1.40E-02	4.69E+05		4.96E+04	
Indeno(1,2,3-cd)pyrene	1.90E+00	1.87E+00	X	9.90E-01	X
Fluoranthene	8.20E+00	2.35E+04		2.48E+03	
Fluorene	8.80E-01	2.35E+04		2.48E+03	
Naphthalene	1.30E-01				
Phenanthrene	5.40E+00				
Phenol	3.60E-01	3.52E+05		3.72E+04	
Pyrene	6.40E+00	1.76E+04		1.86E+03	
Inorganic Compounds (mg/kg)					
Arsenic	1.04E+02	4.66E+00	X	5.26E-01	X
Lead	1.13E+03				

TABLE 2-9

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

TIER 2 SITE-SPECIFIC TARGET LEVELS FOR ALL ON-SITE SOILS

Parameter	Max. Conc. Detected in On-Site Soil	Tier 2 SSTL Utility Worker-Soil	Max. Conc. Detected in On-Site Soil Exceeds Tier 2 SSTL	Tier 2 SSTL Utility Worker Inhalation	Max. Conc. Detected in On-Site Soil Exceeds Tier 2 SSTL
Volatile Organic Compounds (mg/kg)					
Benzene	2.40E-02	5.79E+01		3.24E+01	
2-Butanone	2.10E+00	7.20E+03			
Carbon disulfide	1.20E-02	4.39E+03		4.56E+02	
Chloroform	9.70E-02	2.26E+01		1.39E+01	
1,2-Dichloroethene	4.50E-01	2.62E+03			
Methylene chloride	4.00E-01	7.71E+02		5.06E+03	
Tetrachloroethene	3.60E+01	2.62E+03			
Toluene	3.10E-01	2.84E+03		4.50E+03	
Trichloroethene	1.60E+00				
Vinyl chloride	1.50E-02	3.76E+00		2.92E-01	
Xylenes	1.60E-01	5.24E+05			
Semivolatile Organic Compounds (mg/kg)					
Acenaphthene	1.60E+01	2.90E+04			
Acenaphthylene	4.40E+00				
Anthracene	1.30E+01	1.45E+05			
Benzidine	7.90E+00	7.46E-03	X		
Benzo(a)anthracene	6.10E+01	4.63E+01	X		
Benzo(b)fluoranthene	7.90E+01	4.63E+01	X		
Benzo(k)fluoranthene	6.10E+01	4.63E+02			
Benzo(a)pyrene	5.80E+01	4.63E+00	X		
Benzo(g,h,i)perylene	1.70E+01				
bis(2-Ethylhexyl)phthalate	4.90E+00	2.41E+03			
Butylbenzylphthalate	4.00E+00	9.65E+04			
Chrysene	6.30E+01	4.63E+03			
Dibenz(a,h)anthracene	1.50E+01	4.63E+00	X		
Diethylphthalate	2.60E-01	3.86E+05			
Di-n-butylphthalate	7.00E-01	4.83E+04			
Di-n-octylphthalate	2.70E+00	9.65E+03			
Indeno(1,2,3-cd)pyrene	4.10E+01	4.63E+01			
Fluoranthene	1.50E+02	1.93E+04			
Fluorene	2.60E+01	1.93E+04			
2-Methylnaphthalene	8.20E+01				
Naphthalene	3.60E+01				
Phenanthrene	8.90E+01				
Pyrene	1.80E+02	1.45E+04			

TABLE 2-9

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

TIER 2 SITE-SPECIFIC TARGET LEVELS FOR ALL ON-SITE SOILS

Parameter	Max. Conc. Detected in On-Site Soil	Tier 2 SSTL Utility Worker-Soil	Max. Conc. Detected in On-Site Soil Exceeds Tier 2 SSTL	Tier 2 SSTL Utility Worker-Inhalation	Max. Conc. Detected in On-Site Soil Exceeds Tier 2 SSTL
Pesticides/PCBs (mg/kg)					
Aldrin	2.60E-02	1.69E+00		7.13E+05	
Aroclor 1254	1.60E+00	8.76E-01	X		
Aroclor 1260	1.90E+00	8.76E-01	X		
beta-BHC	1.10E-02	1.45E+01		1.81E+05	
delta-BHC	2.70E-01				
4,4'-DDD	2.80E-01	1.41E+02			
4,4'-DDE	7.50E-02	9.93E+01			
4,4'-DDT	3.80E-01	8.58E+01		3.91E+08	
Dieldrin	2.40E-02	1.79E+00		4.56E+05	
Endosulfan 1	1.80E-01	2.90E+03			
Endosulfan sulfate	4.40E-02				
Endrin	6.00E-02	1.45E+02			
Endrin ketone	2.00E-01				
Heptachlor epoxide	5.60E-01	3.13E+00		4.62E+05	
Methoxychlor	3.70E-01	2.41E+03			
Inorganic Compounds (mg/kg)					
Arsenic	4.92E+01	2.02E+01	X	N/A	
Barium	4.39E+02	4.48E+02		N/A	
Cadmium	9.87E+01	3.52E+01	X	N/A	
Chromium	2.49E+03	5.22E+05		N/A	
Lead	1.74E+04			N/A	
Mercury	4.00E+00	2.72E+02		N/A	
Selenium	3.01E+01	2.61E+03		N/A	
Silver	1.05E+01	2.61E+03		N/A	

Notes:
N/A = Not Applicable

TABLE 2-10

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY

Parameter	Max. Conc. Detected in Groundwater	Tier 2 SSTL Utility Worker Contact	Max. Conc. Detected in Groundwater Exceeds Tier 2 SSTL	Tier 2 SSTL Utility Worker-Inhalation Outdoors	Max. Conc. Detected in Groundwater Exceeds Tier 2 SSTL	Tier 2 SSTLAdult Resident-Inhalation Indoor Groundwater	Max. Conc. Detected in Groundwater Exceeds Tier 2 SSTL	Tier 2 SSTLChild Resident-Inhalation Indoor Groundwater	Max. Conc. Detected in Groundwater Exceeds Tier 2 SSTL
Volatile Organic Compounds (mg/ll)									
Chloroform	1.90E-02	1.96E+01		3.02E+01		4.38E-02		8.45E-02	
cis-1,2-Dichloroethene	4.20E+00	1.58E+01							
Tetrachloroethene	6.00E-01	1.14E+01							
Trichloroethene	1.60E+00								
Vinyl chloride	1.10E+00	6.46E-02	X	1.94E+00		1.94E-03	X	3.74E-03	X
Xylenes	4.30E-02	4.02E+02							
Semivolatile Organic Compounds (mg/l)									
Anthracene	1.00E-03	1.83E+01							
Benzo(a)anthracene	6.00E-04	1.44E-02							
Benzo(b)fluoranthene	2.00E-04	8.90E-03							
Benzo(k)fluoranthene	2.00E-04	8.90E-02							
bis(2-Ethylhexyl)phthalat	2.10E-01	2.68E-01							
Butylbenzylphthalate	7.00E-04	4.99E+01							
Chrysene	2.00E-04	1.44E+00							
Diethylphthalate	8.00E-03	2.57E+03							
Di-n-butylphthalate	2.00E-03	2.24E+01							
Di-n-octylphthalate	4.00E-04	7.73E-02							
Fluoranthene	2.00E-03	5.95E+00							
Fluorene	3.00E-03	6.64E-02							
2-Methylnaphthalene	8.00E-03								
Naphthalene	1.60E-02								
N-nitrosodimethylamine	3.00E-03								
Phenanthrene	3.00E-03								
Pyrene	2.00E-03	8.46E+01							
Pesticides/PCBs (mg/l)									
4,4'-DDT	1.00E-05	5.89E-03		1.79E+03		1.28E+01		2.47E+01	
Inorganic Compounds (mg/l)									
Arsenic	8.26E-02	7.53E-01		N/A		N/A		N/A	
Barium	1.99E+01	1.13E+03		N/A		N/A		N/A	
Cadmium	2.44E-02	8.07E+00		N/A		N/A		N/A	
Chromium	4.18E+01	1.61E+04		N/A		N/A		N/A	
Lead	9.89E-01			N/A		N/A		N/A	
Selenium	1.77E-02	8.07E+01		N/A		N/A		N/A	

Notes:
N/A = Not Applicable

TABLE 2-11

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF SSTLs

Parameter	Soils								Groundwater		
	NYSDEC TAGM 4046 Value (mg/kg)	RFI Adjusted TAGM 4046 Value * (mg/kg)	NYSDEC Soil Cleanup Criteria for Perfection Plating (mg/kg)	On-Site Surface Soil SSTL (mg/kg)	All On-Site Soil SSTL (mg/kg)	Off-Site Surface Soil/Sediment SSTL (mg/kg)	Soil Saturation Concentration (mg/kg)	Average Site Specific Background Concentration (mg/kg)	NYS Class GA Water Quality Standard (mg/l)	Groundwater SSTL (mg/l)	Water Solubility Limit (mg/l)
Volatile Organic Compounds											
Benzene	0.06	0.48			3.24E+01		5.55E+03		0.0007		1.75E+03
2-Butanone	0.3	3.2		9.98E+03	7.20E+03				0.005		
Carbon disulfide	2.7	2.4			4.56E+02		4.06E+03		N/A		1.19E+03
Chloroform	0.3	5.6		5.03E+00	1.39E+01		2.35E+04		0.007	4.38E-02	7.92E+03
1,2-Dichloroethene	0.3	0.8			2.62E+03		3.71E+03		0.005	1.58E+01	3.50E+03
Methylene chloride	0.1	11.2		6.46E+01	7.71E+02		1.64E+05		0.005		1.30E+04
Tetrachloroethene	1.4	12		2.02E+03	2.62E+03		2.92E+03		0.005	1.14E+01	2.00E+02
Toluene	1.5	44		1.81E+03	2.84E+03		5.75E+03		0.005		5.26E+02
Trichloroethene	0.7	9.6					1.79E+03		0.005		1.10E+03
Vinyl chloride	0.2	4.8			2.92E-01		4.70E+03		0.002	1.94E-03	2.76E+03
Xylenes	1.2	8		> SSC	> SSC		3.11E+03		0.005	> WS	1.61E+02
Semivolatile Organic Compounds											
Acenaphthene	50 a	400		> SSC	> SSC	> SSC	1.56E+03		0.02		4.24E+00
Acenaphthylene	41	328							N/A		
Anthracene	50 a	400		> SSC	> SSC	> SSC	4.90E+01		N/A	> WS	4.34E-02
Benzidine	N/A	N/A		1.57E-04	7.46E-03				0.005		
Benzo(a)anthracene	0.224 or MDL			3.15E+00	4.63E+01	9.90E-01	1.04E+03		0.000002	> WS	9.40E-03
Benzo(b)fluoranthene	1.1	8.8		3.15E+00	4.63E+01	9.90E-01	6.60E+01		0.000002	> WS	1.50E-03
Benzo(k)fluoranthene	1.1	8.8		3.15E+01	> SSC	9.90E+00	3.52E+01		0.000002	> WS	8.00E-04
Benzo(a)pyrene	0.061 or MDL			3.15E-01	4.63E+00	9.90E-02	5.04E+01		0.000002		1.62E-03
Benzo(g,h,i)perylene	50 a	400							N/A		
bis(2-Ethylhexyl)phthalate	50 a	400		1.64E+02	2.41E+03	5.16E+01	3.02E+03		0.05	2.68E-01	3.40E-01
Butylbenzylphthalate	50 a	400		> SSC	> SSC	> SSC	1.23E+04		0.05	> WS	2.69E+00
Chrysene	0.4	3.2		> SSC	> SSC	> SSC	2.56E+01		0.000002	> WS	1.60E-03
Dibenz(a,h)anthracene	0.014 or MDL			3.15E-01	4.63E+00	9.90E-02	6.57E+02		N/A		2.49E-03
Diethylphthalate	7.1	56.8		> SSC	> SSC	> SSC	2.49E+04		0.05	> WS	1.08E+03
Di-n-butylphthalate	8.1	64.8		> SSC	> SSC		3.05E+04		0.05	> WS	1.12E+01
Di-n-octylphthalate	50 a	400		1.64E+04	9.65E+03		1.34E+05		N/A	> WS	2.00E-02
Indeno(1,2,3-cd)pyrene	3.2	25.6		> SSC	> SSC	9.90E-01	2.82E+00		0.00002		2.20E-05

TABLE 2-11

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF SSTLs

	Soils								Groundwater		
Parameter	**NYSDEC TAGM 4046 Value (mg/kg)**	**RFI Adjusted TAGM 4046 Value * (mg/kg)**	**NYSDEC Soil Cleanup Criteria for Perfection Plating (mg/kg)**	**On-Site Surface Soil SSTL (mg/kg)**	**All On-Site Soil SSTL (mg/kg)**	**Off-Site Surface Soil/Sediment SSTL (mg/kg)**	**Soil Saturation Concentration (mg/kg)**	**Average Site Specific Background Concentration (mg/kg)**	**NYS Class GA Water Quality Standard (mg/l)**	**Groundwater SSTL (mg/l)**	**Water Solubility Limit (mg/l)**
Fluoranthene	50 a	400		> SSC	> SSC	> SSC	1.78E+03		0.05	> WS	2.06E-01
Fluorene	50 a	400		> SSC	> SSC	> SSC	1.15E+03		0.05	6.64E-02	1.98E+00
2-Methylnaphthalene	36.4	291.2							N/A		
Naphthalene	13	104					3.21E+02		0.01		3.10E+01
Phenanthrene	50 a	400							0.05		
Phenol	0.03 or MDL	0.24				3.72E+04	1.98E+05		0.001		8.28E+04
Pyrene	50 a	400		> SSC	> SSC	> SSC	4.10E+02		0.05	> WS	1.35E-01
Pesticides/PCBs											
Aldrin	0.041			4.83E-02	1.69E+00		3.53E+04		N/A		1.80E-01
Aroclor 1254	1/10 b			2.04E-01	8.76E-01				0.0001		
Aroclor 1260	1/10 b			2.04E-01	8.76E-01				0.0001		
beta-BHC	0.2	1.6		4.56E-01	1.45E+01		1.07E+02		N/A		2.40E-01
delta-BHC	0.3	2.4							N/A		
4,4'-DDD	2.9			3.42E+00	1.41E+02		7.14E+03		ND		9.00E-02
4,4'-DDE	2.1			2.41E+00	9.93E+01		4.24E+04		ND		1.20E-01
4,4'-DDT	2.1			2.41E+00	8.58E+01		5.26E+03		ND	5.89E-03	2.50E-02
Dieldrin	0.044			5.13E-02	1.79E+00		2.96E+03		N/A		1.95E-01
Endosulfan 1	0.9	7.2		2.46E+02	2.90E+03		4.37E+02		N/A		5.10E-01
Endosulfan sulfate	1	8							N/A		
Endrin	0.1	0.8		2.46E+02	1.45E+02		1.88E+03		ND		2.50E-01
Endrin ketone	N/A	N/A							N/A		
Heptachlor epoxide	0.02	0.16		9.02E-02	3.13E+00		1.32E+03		ND		2.00E-01
Methoxychlor	c	c		> SSC	2.41E+03		3.55E+02		0.035		4.50E-02
Inorganic Compounds											
Arsenic	10.5 d	23	23	<SSB	2.02E+01	<SSB		10.5	0.025	7.53E-01	
Barium	300			7.90E+04	4.48E+02			118	1	1.13E+03	
Cadmium	1	39	39	1.13E+03	3.52E+01			0.23	0.01	8.07E+00	
Chromium	20.7 d	390	390	> 1E+06	5.22E+05			21	0.05	1.61E+04	
Lead	186 d	500	500	4.00E+02 e		4.00E+02 e		186	0.025		
Mercury	0.54 d			> 1E+06	2.72E+02			0.54	0.002		

TABLE 2-11

EXPOSURE ASSESSMENT
CORRECTIVE MEASURES STUDY
SIBERIA AREA - WATERVLIET ARSENAL

SUMMARY OF SSTLs

Parameter	Soils								Groundwater		
	NYSDEC TAGM 4046 Value (mg/kg)	RFI Adjusted TAGM 4046 Value * (mg/kg)	NYSDEC Soil Cleanup Criteria for Perfection Plating (mg/kg)	On-Site Surface Soil SSTL (mg/kg)	All On-Site Soil SSTL (mg/kg)	Off-Site Surface Soil/Sediment SSTL (mg/kg)	Soil Saturation Concentration (mg/kg)	Average Site Specific Background Concentration (mg/kg)	NYS Class GA Water Quality Standard (mg/l)	Groundwater SSTL (mg/l)	Water Solubility Limit (mg/l)
Selenium	3.1 d			5.65E+03	2.61E+03			3.1	0.01	8.07E+01	
Silver	ND d			0.00E+00	2.61E+03			ND	0.05		

Notes:
N/A = None Available
ND = Not Detected
MDL = Method Detection Limit
* = Adjusted TAGM values from the *RCRA Facility Investigation Report, Siberia Area, Watervliet Arsenal, Watervliet, NY*. Malcolm Pirnie, Inc., December 1997.
a = As per TAGM#4046, individual semi-volatile compounds <50 mg/kg.
b = Policy Based: For surface soil (1 mg/kg) and subsurface soil (10 mg/kg).
c = As per TAGM 4046, total pesticides < 10 mg/kg.
d = Site Background Value
e = A soil screening level of 400 mg/kg in soil at residential properties has been set (USEPA, 1998, 1994).
> SSC = SSTL is greater than the soil saturation concentration.
> WS = SSTL is greater than the water solubility limit.
< SSB = SSTL is less than the site specific background concentration.