FEASIBILITY STUDY REPORT

Site Location:

The Aro Corporation
Life Support Division
3695 Broadway Avenue
Buffalo, New York 14227

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

LIST OF ACRONYMS

AGC	Annual Guideline Concentration
Aro	The Aro Corporation
AWQC	Federal Ambient Water Quality Criteria
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/sec	centimeters per second
DCE	dichloroethylene
EPA	Environmental Protection Agency
I-R	Ingersoll-Rand
LDRs	Land Disposal Restrictions
MCLs	maximum contaminant levels
mg/kg	milligrams/kilogram
mg/l	milligrams/liter
N/A	Not Analyzed for EPA Method 8270
NPDES	National Pollution Discharge Elimination System
NWI	U.S. Fish and Wildlife Service National Wetland Inventory
NYCRR	Codes, Rules, and Regulations of the State of New York
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSFW	New York State Freshwater Wetlands
O&M	operation and maintenance
PID	photoionization detector
POTW	publicly owned treatment works
ppb	parts per billion
RALs	Recommended Allowable Levels
RAOs	Response Action Objectives
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
s/s	stabilization/solidification
SAP	Sampling Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCGs	New York State Standards, Criteria, and Guidance Values
SITE	Superfund Innovative Technology Evaluation
SVE	soil vapor extraction
SVOCs	semivolatile organic compounds
TAL	Toxic Analyte List
TCA	1,1,2-trichloroethane
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leachate Procedure
VOC	volatile organic compound
VOCs	volatile organic compounds
μg/kg	micrograms/kilogram

1.0 INTRODUCTION

1.1 PURPOSE AND ORGANIZATION

The purpose of this feasibility study is to evaluate the results of the remedial investigation performed at The Aro Corporation (Aro) site in Buffalo, New York, develop various remedial action alternatives, evaluate these alternatives, and recommend a particular alternative for remedial action. The development and evaluation of alternatives is focused and reflects the scope and complexity of the site, as described in the remedial investigation. This Feasibility Study Report presents the results of these activities for the volatile organic compound (VOC) contaminated soils in the metal preparation room area, the former shipping and receiving area, in the sanitary/storm sewer culverts, and the associated VOC ground water plume at Aro. This study was conducted in accordance with the New York State Department of Environmental Conservation (NYSDEC) Inactive Hazardous Waste Disposal Site Program. The Aro facility is currently listed under this program as a Class 2 site. This document provides the basis for detailed development of a proposed remedial action plan for the site. In this Feasibility Study Report, remedial alternatives for soil, ground water, and surface water media are evaluated.

This report is organized into four sections. Section 1.0 presents background information on the site based on the Remedial Investigation Report (1993). Response Action Objectives (RAOs), general response actions, technology type and process screening, and alternative development and screening are presented in Section 2.0. A detailed analysis of remaining alternatives is presented in Section 3.0. The alternatives are analyzed in detail according to the following criteria:

- Threshold criterion of meeting RAOs, cleanup levels, and Applicable or Relevant and Appropriate Requirements (ARARs)
- Balancing criteria
    - Long-term effectiveness
    - Implementability
    - Short-term risks
    - Total costs
- Community acceptance

After each alternative has been assessed according to these criteria, a comparison is made for each of the criteria for the different alternatives to show which alternatives perform best for any particular criterion. Based upon the detailed analysis and consideration of the criteria for selection, a preferred remedial action alternative is recommended. A summary of the alternatives evaluation, conclusions, and recommendations is presented in Section 4.0.

1.2 SITE BACKGROUND

The Aro Corporation, Life Support Products Division facility is located on a 6.9-acre parcel of land in the town of Cheektowaga (a suburb of Buffalo), Erie County, in western New York State (Figure 1). The property is bordered to the north by Broadway Avenue (Route 130), on the east and west by private residences, and on the south by power company and railroad right-of-way. The area surrounding the site is zoned as light industrial/residential. There are residences to the east, west, and north of the site, and an operating rock quarry south of the Conrail right-of-way. The facility is owned by The Aro Corporation. However, Carleton Technologies has occupied the facility as of 1993.

During the time Aro occupied the facility, Aro manufactured life-support equipment, cryogenic storage vessels, breathing regulators, and package integrity testing equipment. Manufacturing processes included machining (product prototypes), assembling, testing, deburring (hand filing and lapping), Freon (chlorofluorocarbon) degreasing, detergent cleaning, painting, alodining (chromate conversion) passivation, arc welding, heat treating (electric oven), and hand soldering. Support operations consisted of product repair, wastewater treatment, water deionization, Freon distillation, and chemical formulation (silicone parts). Paint stripping has been discontinued at the site but was formerly conducted using a product containing methylene chloride, formic acid, phenols, and toluene. Plating activities were performed by an outside company and have never been performed on site.

The main facility building covers approximately 69,000 square feet of the property. The building is used for offices, manufacturing and related operations, and includes a metals preparation room on its west side. An approximately 4,800-square-foot, sheet-metal maintenance and storage building, separated from the main facility building, is located south of the west side of the main facility building (Figure 2). Other features on the property include a paved visitor parking area north of the main facility building; a larger, paved employee parking lot; and two delivery/pickup areas south of the building. Areas south of the employee parking lot are open fields. A storm water drainage ditch flows southward along the east property boundary and westward along the southern property boundary. A drainage ditch exits a backfilled culvert on the south side of the parking lot and flows south into the west-flowing portion of the storm water ditch. The backfilled culvert contains storm water and sanitary sewers. Surface water discharge from the property occurs near the southwest corner.

Ingersoll-Rand (I-R) commissioned several environmental assessments during the period of January 1990 through February 1991. Assessment activities generally consisted of soil sampling and analyses, installation of 13 monitoring wells (MW-1 through MW-11, MW-13, and MW-14; monitoring well MW-12 was not installed), ground water sampling and analyses, and a limited soil vapor survey.

These investigations indicated trichloroethylene (TCE) concentrations of up to 250 milligrams/kilogram (mg/kg) in soil samples obtained from beneath the concrete slab floor of the metals preparation room and TCE concentrations of up to 740 milligrams/liter (mg/l) in ground water samples obtained from a monitoring well (MW-3) installed outside the facility building, downgradient of the metals preparation room. Aro had previously used TCE as a degreasing solvent at the facility but had switched to Freon in 1985. Some additional chemicals identified in site soils and ground water were 1,2-dichloroethylene (1,2-DCE) and vinyl chloride.

The site is currently classified by the NYSDEC as a Class 2 ("significant threat to the public health or environment action required") Inactive Hazardous Waste Disposal Site (No. 9-15-147). The NYSDEC has requested that Aro conduct a remedial investigation/feasibility study at the site to investigate environmental conditions, identify potential unacceptable risks to human health and the environment, and delineate remedial measures which may be required. A draft work plan for the remedial investigation of the Aro facility was submitted to the NYSDEC on April 18, 1991. A revised work plan was submitted on August 30, 1991, and was approved by the NYSDEC with provisional comments. A remedial investigation report was submitted to NYSDEC in December 1992. In response to NYSDEC comments, a revised report was submitted in August 1993. At the request of the NYSDEC, additional remedial investigation field work was performed in July 1993 and a Remedial Investigation Supplemental Report was submitted in September 1993.

1.3 SITE GEOLOGY/HYDROGEOLOGY

The Aro facility is situated on an east-west trending till moraine, underlain by the Moorehouse Limestone Member of the Onondaga Formation. Bedrock is encountered at approximately 21 to 25 feet below the site. The overburden consists of two till layers identified as the upper and lower tills consisting of silt, clay, and sand. A culvert used for facility storm water and sanitary sewers cuts into the upper till south of the main facility building.

Near surface ground water, beneath the site, flows in a generally south-southwest direction under water table conditions. The bedrock wells (three completed into the upper bedrock) were dry and bedrock hydraulic conductivity was measured at 1×10^{-7} feet per minute. Ground water in the overburden is perched by the low-permeability bedrock. The mean hydraulic conductivity for the overburden was 1×10^{-5} feet per minute, and calculated ground water velocities were less than 1 foot per year. A ground water trough was evident in the vicinity of the culvert south of the main facility building, and a ground water mound was present to the south, where a storm water drainage ditch intersects the culvert. The culvert appears to act as a preferential pathway for ground water flow to the south, and the drainage ditch appears to be locally recharging near surface ground water.

1.4 NATURE AND EXTENT OF CONTAMINATION

A remedial investigation was performed at the Aro site in 1992 and 1993 according to provisions of the work plan, approved by NYSDEC and discussed above. Remedial investigation activities included: a limited soil-gas/shallow-water table survey, 10 soil test borings, installation of 3 bedrock and 7 overburden monitoring wells and 3 well points; analyses of 38 soil samples, 25 ground water samples, and 3 surface water samples; aquifer characterization; data reduction and evaluation; identification of natural resources near the site; and assessment of potential off-site constituent migration via the air emissions pathway. The soil and ground water samples (see Figure 2 for locations) were collected and analyzed for Toxic Compound List volatile organic compounds (VOCs), semivolatiles (sample specific), and Toxic Analyte List (TAL) metals and cyanide. Total organic carbon and hardness analyses were also performed on sediment and surface water samples, respectively. The results of these activities are summarized below.

1.4.1 Soil Contamination

Based on the results of soil analyses for VOCs and semivolatiles, only VOC contamination is a significant problem at this site and appears to be limited to the southwest area of the site property and the area around of MW-3 and MW-3R, immediately west of the metals preparation room. Figure 3 shows the interpreted extent of volatile constituents in soils.

The VOC constituents TCE, dichloroethylene (DCE), and vinyl chloride exceed New York State Toxicity Characteristic Leachate Procedure (TCLP) Alternative Guidance Values in soil samples from MW-3R, MW-16, MW-17, MW-19, MW-20, SB-101, and SB-103. Note that the TCLP Alternative Guidance Values are not regulations and are discussed only for comparison purposes. Other comparisons can be made to NYSDEC's recommended soil cleanup objectives (TAGM HWR-92-4046, November 16, 1992) for Superfund sites, and proposed Resource Conservation and Recovery Act (RCRA) Subpart S regulations. These objectives are calculated to be protective of ground water and are based on calculated leaching of soil contaminants to the ground water. The highest concentrations of VOCs and semivolatiles were found immediately west of the metals preparation room at MW-3R. Other concentrations of TCE within the property boundaries ranged from 140 micrograms/kilogram (μg/kg) to 4,900 μg/kg and were generally limited to the southwest portion of the site property. VOC constituents were found primarily in the vicinity of the storm water/sanitary sewer in the western end of the employee parking lot, in the storm water drainage ditch at the south end of the property, and in adjacent soil borings in both areas.

Based on soil results for TAL metals, metals concentrations at the site were generally within the range for natural soils or undisturbed soils in the Buffalo area. Therefore, metals were not judged to represent a problem at the site.

1.4.2 Ground Water Contamination

Ground water analytical results indicated VOCs were found in the same general areas as VOCs in soil. Figures 4, 5, and 6 show the interpreted areas of extent for TCE, DCE, and vinyl chloride in ground water, respectively. As in the soils, the primary VOC constituents in ground water were TCE, DCE, and vinyl chloride. The highest concentration of TCE was in MW-3 (1,100,000 micrograms/liter [μg/l]), but rapidly tapered off to nondetectable levels downgradient at the southern property boundary. Elevated concentrations of TCE, DCE, and vinyl chloride were mainly found in the western parking lot area, in the vicinity of the metals preparation room, adjacent to backfilled trenches for the storm water/sanitary sewers, and the storm water drainage ditch. The only semivolatile organic compounds (SVOCs) detected above New York State standards were phenols in MW-3.

Filtered and unfiltered ground water samples were analyzed for metals. Concentrations of metals in unfiltered samples were generally above New York State Ground Water Quality Standards. However, these results are biased high due to the turbidity encountered during sampling. Results of filtered samples were generally below New York State Ground Water Quality Standards. Antimony was the only TAL metal detected in filtered samples above the standards and was only detected at sample locations MW-1, MW-4, MW-7, and MW-8. Based on these results, metals in soils do not appear to be leaching to ground water.
The sewer backfill area appears to have provided a preferential pathway for ground water flow and constituent migration. The potentiometric surface map shows a mounding in the area of the south-flowing drainage ditch which would allow for constituent migration into surrounding upper till soils. The drainage ditch may have provided a preferential pathway for migration of ground water constituents exiting the culvert.

As shown in Figures 4 through 6, the lateral extent of contaminant concentrations has been delineated. Vertically, contamination is apparently limited to the overburden. The low permeability of the underlying bedrock and its lack of saturation suggests the bedrock is not being contaminated and indeed is limiting vertical migration of contaminants.

1.4.3 Surface Water Contamination

No VOCs were detected above the method detection limits in the upgradient surface water sample SW-101, obtained on the east property boundary. Only TCE and 1,2-DCE were detected in downgradient samples SW-102 and SW-103 at 203 μg/l and 190 μg/l and 40 μg/l and 26 μg/l, respectively. Detected concentrations for both constituents were above New York State Surface Water Quality Standards for Class D surface waters.

No SVOCs or metals contamination of surface water was found. Metals were generally elevated over desirable levels but did not show an increase from upgradient to downgradient, thus suggesting these metals are either naturally occurring or are from an upgradient source.

1.4.4 Sediment Contamination

DCE was detected in downgradient sediment sample Sed-103 at a trace concentration of 5 μg/kg. No DCE was detected in samples Sed-101 (upgradient) and Sed-102.

Metal concentrations in the sediment samples were generally higher then those of the on-site soils and often exceeded the New York State TCLP Alternative Guidance Values. However, they did not show a pattern of an increase from upgradient to downgradient, therefore, suggesting an upgradient source for the metals enrichment. Metals contamination will not be considered further.

Based upon previous surface water and sediment sample results, on-site sediments are not being addressed in the feasibility study at this time. However, due to the July 1993 Sed/SW-104 sample results which identified the presence of TCE and DCE, additional surface water and sediment samples will be collected.

1.4.5 Air Contamination

Exterior ambient air survey results were obtained using an HNu photoionization detector (PID). Recorded readings ranged between 2.2 to 6.0 mg/l of total VOCs. Most readings were in the 4.0 to 5.6 mg/l range. The property boundary readings were generally greater than 5.0 mg/l. The paved parking lot area in the vicinity of the buildings generally had readings between 4.0 and 4.6 mg/l. At the perimeter of the parking lots, the readings were greater than 5.0 mg/l. Based upon the exterior ambient air results, there does not appear to be an exterior ambient air quality problem.

1.4.6 Physical Setting

The majority of both the half-mile and two-mile radius areas around the Aro site is comprised of mixed urban development. Natural areas within the half-mile radius are limited to a strip of scrub-shrub and emergent wetlands north of the southernmost Conrail railroad tracks and an adjacent forested strip. Within the two-mile radius, natural areas are restricted to wood lots and undeveloped areas along Cayuga Creek and the Dr. Victor Reinstein Woods Nature Preserve in the southeastern portion of the radius circle.

The only wetlands observed within the half-mile radius were the strip of scrub-shrub and emergent wetlands described above. No wetlands are mapped for this area on either U.S. Fish and Wildlife Service National Wetland Inventory (NWI) or New York State Freshwater Wetlands (NYSFW) maps. Approximately 265 acres of wetlands are included on both NWI and NYSFW maps within the two-mile radius. Most of this acreage is forested wetland with lesser amounts of scrub-shrub and emergent wetland present. The majority of these mapped wetlands are associated with Cayuga or Scajaquada Creek.

Aquatic habitats observed within the half-mile radius consisted of four ponds and several small intermittent streams and storm water runoff conveyances. Within the two-mile radius, the main surface waters are Cayuga Creek to the south and Scajaquada Creek to the north. Although Cayuga Creek receives inflows from combined sewer overflows and urban nonpoint source pollution during storm events, records indicated that it supports a cool-water fishery. Scajaquada Creek flows through a mixed urban area, has been channelized and culverted for much of its length within the study area, and receives various pollutant inputs during storm events. It supports only limited aquatic life.

Aquatic habitats in the area 9 miles downstream of the site were also characterized. Approximately 4.25 miles downstream of the site, Cayuga Creek joins Buffalo Creek to form the Buffalo River, which eventually flows into Lake Erie. The conditions of the portions of Cayuga Creek below the 2-mile radius and the upper portions of the Buffalo river appear to be similar to those described above for Cayuga Creek within the 2-mile radius. As the Buffalo River approaches Lake Erie, however, it widens substantially and takes on the appearance of a bay of the lake. Water-quality problems exist in this slow-flowing portion of the river due to stagnant water conditions and numerous pollutant inputs.

No significant or critical habitats and no state or federally protected plant, animal, or habitats critical to these species were observed or are known to occur within the 2-mile radius area or within 9 miles downstream of Cayuga Creek.

The pathway analysis in Step II of the natural resources assessment demonstrated that significant source contaminants do not occur off site, based upon surface water sampling of drainage ditch water at the southeastern property boundary. Also, significant resources that could potentially be impacted by contaminants of concern do not exist in the vicinity of the site, and furthermore, no direct surface water pathway was identified between the Aro facility and Cayuga Creek. The findings of the pathway analysis demonstrates minimal impact with no requirement for additional analysis.

1.5 BASELINE RISK ASSESSMENT

A qualitative human health risk assessment was performed for the site and is summarized below. This assessment is divided into two sections. The first section (1.5.1) discusses potential exposure to soil, air, ground water, surface water, and sediment. It addresses environmental fate and transport of constituents detected at the site, identifies potential exposure pathways, and presents a qualitative evaluation of potential human health risks.

The second section (1.5.2) estimates the "worst-case" air exposure based on modeled emissions from soil.

1.5.1 Exposure Assessment

The primary environmental pathways for migration of chemicals detected at the Aro facility are as follows:

- Infiltration from soils to ground water
- Potential ground water discharge to surface water and sediments
- Storm water runoff from soil to surface water
- Dispersion of volatile constituents by air

Volatile organics: The primary environmental transport process for VOCs is via volatilization. In general, volatile organics have high vapor pressures indicating an increased likelihood the constituent will volatilize from soil. Additionally, these compounds may be quite mobile in soils and tend to leach to ground water. TCE was detected in ground water samples on the site, and after sufficient time and under appropriate conditions, biodegradation of this compound can yield 1,1-DCE, 1,2-DCE (total), and vinyl chloride (Davis and Allison, 1990). The following VOCs were also reported for various site media: acetone, benzene, bromodichloromethane, bromomethane, 2-butanone, carbon disulfide, chloroform, chloromethane, dibromochloromethane, 1,1-DCE, 1,2-DCE (total), ethylbenzene, 2-hexanone, 4-methyl-2-pentanone, styrene, tetrachloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, TCE, toluene, vinyl chloride, and xylene (total). However, other than TCE, 1,2-DCE, and vinyl chloride, none were at significantly elevated concentrations.

Semivolatile organics: A variety of SVOCs were detected in environmental media sampled at this site. The SVOCs detected at the Aro facility may be classified into two groups: phthalate esters and phenolic compounds.

Two phthalate esters (Bis(2-ethylhexyl)phthalate and diethyl phthalate) were detected in soils and/or ground water at the site. In general, Bis(2-ethylhexyl)phthalate is a common field and laboratory contaminant which results from the use of plastic items such as bottles or latex gloves used by the field or laboratory personnel. Water solubilities of phthalate esters range from very low to moderate, and they have physical and chemical properties which would allow moderate to strong adsorption onto suspended particles and biota. Consequently, adsorption onto soils and sediments may limit ground water migration of these compounds. Due to their low Henry's constant, phthalate esters are not expected to volatilize from water and soils. If they occur in surface waters, they will biodegrade at a moderate rate (half-life of two to three weeks). Biodegradation of these compounds also occurs in soils, but at a slightly slower rate than in water. Half-lives in soils and ground water have been estimated to range from ten days to over one year depending on pH and other site-specific conditions (HSDB, 1993).

Phenolic compounds (2,4-dimethylphenol, 4-methlylphenol, and phenol) have been detected in soil and ground water sampled at this site. If released to soil or ground water, the primary removal mechanism for phenolics is biodegradation. Despite its high solubility and poor adsorption to soils, biodegradation is typically rapid (days). If phenol is released to surface water, the primary removal process would be degradation, which occurs on the order of hours to days. In the atmosphere, phenol reacts fairly rapidly with hydroxyl radicals. Phenol would not be expected to significantly volatilize, hydrolyze, or adsorb to sediments.

Metals: Predicting the migration of metals in the environment is complicated because metals can exist in a variety of forms. For instance, metals can exist in different oxidation states. Metals can also exist as charged particles (that is ions in solution) or in an uncharged or neutral state. Metals may also interact with both organic and inorganic compounds to form a variety of different compounds. The potential for migration of metals from soil to ground water is dependent upon the solubility of these various forms in water. Metals in solution will exist in an ionic form; nonionic forms precipitate and bind to soil and sediments with limited actual transport from the site area.

The following metals were reported in various media at the Aro facility: aluminum, antimony, arsenic, barium, beryllium, calcium, cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, sodium, vanadium, and zinc. However, they were generally detected at concentrations similar to or below the available ranges for natural soils and undisturbed, native soils in Buffalo, New York.

1.5.1.1 Identification of exposure pathways

A Conceptual Site Model depicting contaminant sources, release mechanisms, exposure pathways, and potential receptors is shown in Figure 7. The potentially complete exposure pathways for the Aro facility include incidental ingestion and dermal contact with soils by utility workers or trespassers; inhalation of volatile emissions from soils by on-site workers, utility workers, off-site residents, or trespassers; and dermal contact with surface water or sediments by utility workers, off-site residents, or trespassers. The utility worker category includes the city workers that clean the drainage ditches periodically. A brief discussion of the potential exposure for each of these pathways is provided below.

Summary of exposure pathways: There are five potential exposure pathways at the Aro facility. These are exposure to soils, air, ground water, surface water, and sediments.

- Soil exposure: Direct exposure to soils for on-site workers or off-site residents is not expected to occur due to the large paved area present on site and the vegetation present in the open field south of the paved parking lot. The drainage ditches on the southern portion of the property have been maintained by the city and were cleaned on an annual or biannual basis in the past. While the potential exists for city workers to come into direct contact with soils in the ditches, exposure is not considered significant due to the low concentrations of constituents detected in soils and sediments and low frequency of exposure. Exposure to potentially contaminated soils may occur in the future if intrusive activities (excavation) or significant changes in the cover conditions take place at the site.

- Air exposure: Exposure to volatile emissions is a potentially complete exposure route for on-site workers, utility workers, and off-site residents. An air pathways assessment (see Section 1.5.2) was evaluated to estimate the "worst-case" emissions from soil, and modeled concentrations were compared to state air quality criteria. Exposure to fugitive dust emissions is not considered complete due to the lack of area without some surface cover. Site areas are either paved or vegetated, which serves to prevent dust generation on site.

- Ground water exposure: Currently there are no water-supply wells on site or the neighboring properties; therefore, exposure to ground water beneath the Aro facility is unlikely for on-site workers, utility workers, or off-site residents. All drinking and process water for the Aro facility is received through the city water supply. Residents to the west of the Aro property are not known to have private water wells, and these homes are currently supplied by the city water supply.

- Surface water and sediment exposure: Ground water discharging to the south-flowing culvert beneath the employee parking lot enters the south-flowing drainage ditch at the end of the parking lot. Some constituents have been detected in the surface water and sediment samples collected at the site. The drainage ditches have been observed by field personnel to contain small amounts of standing water. There is unrestricted access to the on-site open field area, so the potential exists for access by off-site personnel. The tall grasses and wet soil conditions make any exposure unlikely, and trespassers have not been observed by field personnel or the Aro site manager. Potential exposure to utility workers is possible but is also unlikely to occur due to protection by standard work clothes and boots.

1.5.1.2 Comparison to health-based standards/guidance

Several constituents that have the potential for causing adverse human health effects have been found in the soil, air, ground water, surface water, or sediments at the Aro facility. The potential chemical and media-specific guidance values which apply for the chemicals and exposures at this site are summarized below.

Soil criteria: Currently under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations, there are no guidelines for allowable soil concentrations. However, proposed RCRA Corrective Action Levels (Subpart S) have been proposed for soil based on human health effects due to ingestion. The NYSDEC Bureau of Spill Prevention and Response has developed TCLP Alternative Guidance Values for soils, are soil concentrations developed to be protective of ground water quality. The TCLP Alternative Guidance Values for soils establish soil concentration values at twenty times the Title 6 of the official compilation of Codes, Rules, and Regulations of the State of New York (NYCRR) Part 703 Ground Water Quality Standards and Guidance Values. The concentrations for antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, silver, sodium, zinc, 1,2-DCE, TCE, and vinyl chloride detected in soils generally exceeded the NYSDEC TCLP Alternative Guidance Values.

Air criteria: Potential ambient air concentrations were evaluated by modeling emissions for the three primary organic compounds detected in subsurface soil at the Aro facility: 1,2-DCE, TCE, and vinyl chloride. Based on the estimated emission rate calculations and using modeled "worst case" concentrations, the projected boundary concentrations of 1,2-DCE, TCE, and vinyl chloride were below applicable NYSDEC Annual Guideline Concentrations.

Ground water criteria: The National Primary Drinking Water Regulations established by the Environmental Protection Agency (EPA) provide maximum contaminant levels (MCLs) for a number of constituents in ground water. The MCLs are enforceable standards based on health effects data for specific chemicals and other concerns such as analytical detection limits, treatment technology, and economic impact. State standards are also available for these constituents. The state drinking water standards are as low or lower than the federal MCLs. Constituents detected in the ground water were compared to the drinking water standards identified in the New York State Ground Water Quality Standards and Guidance

Values (6 NYCRR Part 703). Constituents exceeding New York State Ground Water Quality Standards (and federal MCLs) included 1,2-DCE, phenol, 2,4-dimethylphenol, 4-methylphenol, TCE, and vinyl chloride.

Due to limited extent and low levels of phenols, benzene, and 1,1,2-trichloroethane (TCA) identified, these compounds are not being addressed as key constituents. However, remediation of TCE, DCE, and vinyl chloride compounds will address the removal of these compounds.

Surface water and sediment criteria: For surface water and sediment, dermal exposure is the most likely exposure pathway. The Federal Ambient Water Quality Criteria (AWQC) include human health-based surface water concentrations based on surface water and/or fish ingestion. These pathways or exposures are not expected at the Aro facility; therefore, the AWQC for the protection of human health are not appropriate. State surface water standards for Class D surface waters were exceeded only for TCE. Currently, there are no human health-based sediment standards available.

1.5.2 Air Pathways Assessment

VOCs present in the subsurface at the Aro site may travel to the surface and be emitted to the atmosphere. Therefore, potential ambient air concentrations were evaluated by estimating and modeling emissions of the three principal organic compounds discovered in the subsurface at the site: TCE, 1,2-DCE, and vinyl chloride. The purpose of this evaluation was to estimate reasonable "worst-case" emissions for the compounds and to compare calculated off-site concentrations with applicable air quality criteria.

The Industrial Source Complex Long-Term (ISCLT2) model developed for EPA was used for the assessment. Concentrations calculated (modeled) on a reasonable "worst-case" basis were compared to the NYSDEC Annual Guideline Concentration (AGC) and indicate:

- The maximum off-site concentration of TCE is approximately 50 percent of the AGC.
- The maximum off-site concentration of DCE is several orders of magnitude below its AGC.
- The maximum off-site concentration of vinyl chloride is approximately 1 percent of its AGC.

Therefore, air emissions do not represent a threat to human health near the Aro facility.

2.0 IDENTIFICATION AND SCREENING OF ALTERNATIVES

2.1 INTRODUCTION

This section of the feasibility study identifies the RAOs for the Aro site, based on the issues in the remedial investigation and identified in Section 1.0: identifies general response actions that can be used to attain these RAOs; identifies and screens technologies that can be used to meet the objectives; and finally, assembles the screened technologies into viable remedial alternatives that can be used at the site to ensure protection of human health and the environment.

The remedial alternatives developed in this section will then be further screened and analyzed in detail later in the feasibility study process to allow selection of a preferred alternative, which ultimately will be used in the Record of Decision (ROD). Each of the alternatives developed in this section will be evaluated in the detailed analysis of alternatives against the specific statutory requirements of CERCLA, as amended by Superfund Amendments and Reauthorization Act (SARA). These statutory requirements essentially state that remedial alternatives must:

- Be protective of human health and the environment
- Attain ARARs (or provide grounds for invoking a waiver)
- Be cost effective
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element or provide an explanation in the ROD as to why it does not ("Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," October, 1988)

The EPA has developed nine criteria to evaluate the remedial alternatives. These criteria are:

1. *Overall protection of human health and the environment*: Each alternative will be reviewed to see if (and how) it eliminates, reduces, or controls existing or future potential risks to human health and the environment.

2. *Compliance with ARARs*: Each alternative is assessed to ensure its compliance with all of the ARARs, and if one or more are not met, the basis for justifying one of the waivers allowed under CERCLA will be discussed. Three types of ARARs are considered:

    a. Chemical: Specific ARARs, such as MCLs and New York State Standards, Criteria, and Guidance Values (SCGs)

    b. Location: Specific ARARs, such as wetland or floodplain regulations

    c. Action: Specific ARARs, such as RCRA limitations to land disposal of certain wastes (for example, TCE).

    Additionally, compliance with advisories, criteria, or guidance that NYSDEC has included in the remedial investigation/feasibility study process (but are not considered ARARs) will be evaluated.

3. *Long-term effectiveness and permanence*: Each alternative is evaluated for the magnitude of the residual risk remaining from untreated wastes or treatment residuals after the conclusion of the remedial action, as well as the adequacy and reliability of controls used to manage these untreated wastes or treatment residuals.

4. *Reduction of toxicity, mobility, or volume through treatment*: This criterion addresses the statutory preference for those alternatives which permanently reduce toxicity, mobility, or volume of the hazardous substances.

5. *Short-term effectiveness*: Each alternative is assessed as to how it will protect workers and the community during the remedial action (that is, until cleanup targets are achieved), any potential adverse environmental impacts that may result from the remedial action, and the time required until the RAOs are achieved.

6. *Implementability*: Each alternative is evaluated as to the technical and administrative feasibility of implementing it and whether the proper materials and services will be available at the required time.

7. *Cost*: Each alternative will have a cost estimate prepared which will include capital costs, annual operation and maintenance (O&M) costs, and monitoring costs. Additionally, the costs for any potential future remedial actions must be addressed.

8. *State acceptance*: The selected alternatives will be evaluated for specific elements which may or may not be acceptable to the state.

9. *Community acceptance*: The selected alternatives will be evaluated by public comment which will determine the local community acceptance.

2.2 RESPONSE ACTION OBJECTIVES (RAOs)

In general, the RAOs for the feasibility study process are to select a remedy which will protect human health and the environment; satisfy all ARARs; provide practical, cost-effective remediation; and utilize permanent remedies which can be completed in a relatively short timeframe, if possible. Beyond these general objectives, however, specific RAOs have been developed for the various impacted environmental media at the Aro site.

2.2.1 Soil

Generally, the remedial investigation showed the soils on site to be contaminated only with VOCs (TCE; 1,2-DCE; and vinyl chloride), and then only in areas around the metals preparation room, the former loading dock on the southeast corner of the building, and the areas around the storm and sanitary sewer backfill in the southwest portion of the property. However, soil concentrations exceeded NYSDEC's Recommended Soil Cleanup Objectives to protect ground water quality (TAGM HWR-92-4046) only for TCE and 1,2-DCE. Metals contamination was not judged to be a problem because on-site concentrations compared favorably with typical Buffalo-area soils. SVOCs exceeded NYSDEC's TCLP Alternative Guidance Values only for one sample, MW-3R, but only for bis (2-ethylhexyl) phthalate, and it did not exceed the recommended soil cleanup objective for this substance.

Additionally, the remedial investigation showed that the unsaturated soils above the water table were generally free of VOC contamination. The contaminated soils were found at or below the water table.

Based on the above results, the RAOs for soil at the Aro site are:

1. Address soil contamination from VOCs (TCE and 1,2-DCE) to help ensure no further ground water contamination above ground water standards will occur:
    a. Southwest portion of the property (mainly along the sewer backfill and around the exit of the culvert to the storm water ditch)
    b. Area west of the metals preparation room (vicinity of MW-3 and MW-3R)
    c. Area southeast of the main building (around MW-17)
2. Prevent unprotected human contact with VOC contaminated soil located beneath the water table (for example, from digging or building below the water table at the site).

The only exposure routes to contaminated soils at this site are through leaching of TCE or 1,2-DCE to the ground water (and its subsequent migration to a receptor) or digging below the water table (for example, trenching or building of a basement).

2.2.2 Ground Water

The remedial investigation showed that the primary ground water contaminants at the site (above New York State Ground Water Quality Standards) were TCE, 1,2-DCE, and vinyl chloride, predominantly in the vicinity of the metals preparation room and along the sewer backfill in the western end of the employee parking lot. A small area of TCE contamination was also noted around MW-18, in the southeast portion of the parking lot. Occasional exceedances of the standards for 1,1-DCE; 1,1,1-TCA; and benzene were also noted but only in wells already contaminated with TCE or 1,2-DCE. The only SVOCs detected at levels above standards (for phenols) were in MW-3. Metals contamination was not a problem at the site.

The ground water beneath the site is part of a perched aquifer, and because of low permeabilities is not suitable for use; there are no private wells in the area. Therefore, there are no current human receptors in the vicinity of the Aro site. However, ground water contaminants may flow off site through discharge to surface waters, via a storm water drainage ditch.

Based on the above information, the ground water RAOs for the site are:

1. Prevent exposure of humans and the environment to ground water migrating from the site onto neighboring property at concentrations above acceptable risk-based levels.

2. Reduce off-site migration of ground water contaminants to levels below New York State Ground Water Quality Standards, such as: TCE $\leq$ 5.0 μg/l; 1,2-DCE $\leq$ 5.0 μg/l; vinyl chloride $\leq$ 2.0 μg/l; 1,1-DCE $\leq$ 5.0 μg/l; 1,1,2-TCA $\leq$ 5.0 μg/l; benzene $\leq$ 0.7 μg/l; and total phenols $\leq$ 1.0 μg/l.

3. Prevent ground water at levels above New York State Surface Water Standards (Class D) from entering the surface waters leaving the site (that is, the sanitary sewer backfill and storm sewers, and the drainage ditch) to the southwest. Class D standards for TCE in surface water are 11.0 μg/l.

4. Reduce ground water contaminant levels below the facility boundary to levels below the New York State Ground Water Quality Standards (see No. 2 above). This objective is a secondary one, since the ground water beneath the site is not available in sufficient quantities to be of economical use. Therefore, this is an objective mainly to aid in meeting objectives 1 through 3.

2.2.3 Surface Water

The remedial investigation has shown that surface water leaving the site was only contaminated with TCE and 1,2-DCE. Only TCE exceeded New York State Surface Water Standards for Class D waters (that is, the drainage ditch leaving the site).

Therefore, the surface water RAOs is to reduce the concentration of TCE leaving the site to less than 11.0 μg/l (the New York State Surface Water Standard for Class D waters).

2.2.4 Sediment

The remedial investigation showed that the Aro site is not causing any significant contamination of sediments. Therefore, remediation of sediments will not be considered further.

2.2.5 Air

The remedial investigation showed the Aro site is not causing any air impacts in excess of NYSDEC's AGC. Therefore, remediation of air will not be considered further.

2.3 GENERAL RESPONSE ACTIONS

2.3.1 Soil

The general response actions which can potentially be used individually, or in combination, to accomplish the RAOs for soil at the Aro site are no action, placement of access restrictions on the affected property (which would prevent contact with contaminated soils), containment actions to isolate the contaminated soils, excavation of contaminated soils followed by treatment or disposal (off site) at an approved RCRA treatment facility (or disposal of treated soils on site), or in situ treatment or stabilization of contaminated soils. These general response actions are listed in Table 1 as part of the screening of soil technologies which can be used for remediation of the Aro site.

2.3.2 Ground Water

General response actions which can be used to satisfy the RAOs for ground water are no action, monitoring of ground water, access restrictions, containment actions to prevent the spread of contaminated ground water, in situ treatment of contaminated ground water, or collection and treatment (or disposal) of ground water. These general response actions are listed in Table 2 as part of the screening of ground water technologies.

2.3.3 Surface Water

General response actions to satisfy the RAOs for surface water at the Aro site are no action, access restrictions, monitoring, containment of contaminated ground water which otherwise could enter the surface waters, and collection and treatment (or disposal) of contaminated surface waters. These general response actions are listed in Table 3 with the screening of surface water technologies.

2.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

In this section, the specific technologies and process options which are applicable to the general response actions for each media are considered. Those which cannot be technically implemented at the site will be eliminated from further consideration. The remaining technologies and process options will then be combined into alternatives for detailed analysis and eventual selection of a preferred alternative.

2.4.1 Soil

2.4.1.1 Remedial technologies

Institutional controls

Three methods of controlling access to contaminated soils are deed restrictions, acquiring the affected properties and restricting access, and fencing off the contaminated areas.

A deed restriction is a negotiated addendum to an existing deed, which until removed, indicates that soils on the property are contaminated. This notifies the existing and subsequent property owners of the contaminated soils. This is a viable option for the Aro site, but it must be noted that deed restrictions may not be enforceable.

Fencing is another possible way of controlling access to contaminated soils, both to their property and the property to the west. The method is most often used as a short-term solution (that is, restricting physical access) to contaminated soil problems because it stops only human and larger animals from coming in contact with the soils. Small animals can usually bypass fences, and soils can still cause environmental problems.

Containment

In situ stabilization: By mixing contaminated soils (saturated or dry) in the proper proportions with a portland cement mix, either alone or in combination with additives (such as bentonite clay), contaminants can be immobilized in an impermeable solid matrix. Therefore, sources of contaminants which would otherwise leach to the ground water are removed, and the soil itself is fixed in place (thus, no longer causing an exposure problem). Mixing of the cement and soils is typically accomplished mechanically using augers, though successful stabilization of soils has been reported using pressure jetting hoses in areas where auguring was not feasible. Air monitoring must be performed during this process because the heat generated during the chemical reaction may release significant concentrations of VOCs. This technology is practical in settings where the extent of contamination is not great, soils are easily mixed, and volume expansion is not a problem. This technique would be very costly and difficult to implement at the Aro site because most of the heavily contaminated soils are adjacent to, or beneath, the building.

Capping: Impermeable caps constructed over contaminated soils prevent exposure to the soils and reduce the amount of leaching of contaminants to the ground water via infiltrating precipitation. Typically, caps in industrial areas such as this are constructed of clay, concrete, or asphalt. Caps are easily installed and are a quick and lasting means of exposure and recharge control. However, this technology would not benefit the Aro site because it would only prevent exposure to the surface soils and leaching of contaminants from the unsaturated soils. At this site, the soils above the water table do not appear to be significantly contaminated; only those below the water table contain significant VOC concentrations. Caps are not effective in this situation. Additionally, the majority of the site is already capped with asphalt or buildings.

Vertical barriers: Slurry walls are usually used for hydraulic isolation of a region or to create a barrier to ground water flow to enhance other remedial techniques. They will prevent contaminants leaching from the soils and migrating off site in the ground water. They are constructed by trenching to a lower hydraulic barrier and backfilling with an effectively impermeable material, such as a bentonite slurry. Slurry walls are suited for geologic settings where the depth to the lower hydraulic barrier is moderate (typically less than 40 feet) and the formation is easily excavated. While this geologic description fits the Aro site, hydraulic isolation of the contaminated soils using slurry walls is not practical because of the presence of the manufacturing plant and access problems with adjacent properties being so close to the buildings.

Sheet pilings are used in the same manner as slurry walls and generally create the same hydraulic effect (hydraulic isolation). Sheet pilings are usually installed from the surface down to the lower hydraulic barrier and are driven into the ground using a sheet piling hammer. They suffer from the same drawbacks as slurry walls at this site.

Surface controls: Contaminated soils can be prevented from eroding by diverting surface runoff away from them by grading (installation of berms, diversion ditches, sloping, and so forth). However, for the Aro site, this diversion is not necessary for two reasons. First, the surface soils are not significantly contaminated, and second, most of the site is paved or under a building, thus not subject to surface water erosion.

Excavation

Excavation of contaminated soils at the Aro site and replacement with clean fill (or the treated soil) is a potential option at the Aro site. Contaminated soils are generally not deep and seem to be concentrated in relatively discrete areas around the metals preparation room, the former loading dock to the southeast, and the sewer backfill. Excavation could be done of either "hot spots" (around the metals preparation room and the former loading dock) or all soils contaminated above New York State Recommended Soil Cleanup Objectives. All excavated soils would require on-site treatment or off-site disposal. There are technical difficulties associated with excavation which include gaining access to areas around and beneath an active and operating facility. Additionally, several factors will significantly affect costs. These are structural problems relating to the buildings, excavating in materials below the water table, and the fact that most of the impacted area is under the facility buildings or pavement. However, due to relatively high VOC levels in certain areas, excavation may be warranted since it will remove VOC source areas for ground water contamination. This technology would have to be combined with cleanup of ground water or the fill would just be recontaminated.

In situ treatment

Biological: In situ bioremediation involves injecting (through injection wells) solutions enriched with nutrients and oxygen (that is, ammonia, hydrogen peroxide, and so forth) into the area of contaminated soils to promote the growth of the natural microflora, or introduced bacteria, which will in turn transform the contaminants into nontoxic compounds (using the contaminants as an energy source for growth). Because concentrations of nutrients may exceed ground water standards, it is often necessary to establish hydraulic control of the treatment region. This is typically accomplished via recovery wells. Bioremediation is most often done for petroleum contamination, but some successful remediation of the halogenated VOC compounds associated with the Aro site has been reported. In situ bioremediation is not considered to be a feasible remedial technique at the Aro site due to the limited capability of the water-bearing strata to transmit water and the nature of the contaminants.

Chemical: Oxidation/reduction reactions can be induced in situ to treat VOC contamination. Studies have shown that various oxidizing agents can reduce halogenated VOCs in soil and ground water, such as are present on the Aro site, into simpler nontoxic compounds. The recommended in situ treatment involves construction of a network of injection and recovery wells, which would allow injection of oxidizing agents into the contaminated area, followed by pumping to maintain hydraulic control of the area and monitor progress. This is very similar to in situ bioremediation and would suffer from the same drawbacks at this site (low formation hydraulic conductivity). This is considered an innovative technology by the EPA, and because of this, bench and/or pilot studies would have to be performed prior to full-scale implementation. Capital costs would be relatively high to start with, but operating and maintenance costs would be small. This is not considered an applicable technology for the Aro site.

Physical: Air sparging is the in situ removal/bioremediation of VOCs from soil and ground water by injecting air under pressure. The rising air not only strips the VOCs from the soil and ground water but increases the oxygen content of the water, thus enhancing natural bioremediation. Nutrients may be injected along with the air stream, if desired, to enhance bioremediation. Air sparging allows for the effective removal of VOCs without excavating soils or having to do ground water recovery or treatment. It is effective in treating chlorinated solvents with relatively large Henry's Law constants (highly volatile), such as are present on site. Typically, air sparging is done in combination with soil venting. This technique uses recovery wells fitted with vacuum pumps to extract the rising air from the unsaturated zone, collects it, and then runs the air through a treatment unit (for example, carbon filters) to remove the VOCs stripped from the soil and ground water. However, at the Aro site, migration of the air through the water-bearing strata would be hindered by the high content of silts and clays beneath the site, making this an unacceptable means of remediation for this site. Additionally, the unsaturated zone is very thin so that soil venting would be difficult.

An alternative to the above processes would be the dewatering of the site and the removal of the VOC contaminant by use of soil venting, or soil vapor extraction (SVE) technologies. Because of the low permeability of the soil due to the high content of silts and clays beneath the site, dewatering of the site would be very slow, but maintaining the dewatered area should not require removal and treatment of gross quantities of water. With the site dewatered, the SVE technologies, which may or may not include active introduction of air into the soil through air injection wells, can be applied to the site. Air fracturing of the soils may be required. This may be a relevant technology for the Aro site.

Ground water removed using this alternative would be treated or processed as required, and then discharged to either the publicly owned treatment works (POTW) or to a permitted surface discharge.

Aboveground treatment

Chemical: Soils can be treated aboveground via "soil washing." For this method, a solvent is used to "leach" VOCs off the contaminated soil, and the leachate is then treated to remove the VOCs. This is considered an innovative technology and does not have a proven track record as of yet. Therefore, bench-scale and/or pilot-scale studies would be needed. Additionally, the fine particle sizes of the tills below the site will cause problems. This is not a recommended technology for the Aro site.

Stabilization: Similar to in situ stabilization, ex situ stabilization of contaminated soils can be done by mixing with Portland cement and appropriate additives. This is a relatively simple technology but is expensive in labor and materials. Additionally, the treated fill has a greatly increased volume. The treated fill would have to be disposed of on site, which may not be practical here given space considerations, or landfilled. Trucking and disposal fees would then be incurred, and only hazardous waste landfills would be able to take the materials. This is not considered a relevant technology for the Aro site.

Incineration: Excavated soils could be incinerated on site (heated up to temperatures which would destroy the VOC contaminants) to treat the contaminants. This would involve bringing a portable incinerator on site. Depending on the resulting soil properties after treatment, the treated soils could then be reused on site as clean fill or taken off site for disposal or for use elsewhere. Total costs for using this process would include excavation, and can be quite high, however, if sufficient quantities of soil require treatment, the process may be cost effective and less expensive than off-site disposal. Permits will most likely be required, but incineration is a readily available technology which destroys the contaminants. This may be a relevant technology for the Aro site.

Low Temperature Thermal Desorption: Excavated soils could be processed by low temperature thermal desorption on site (heating of the soils to temperatures which would cause the VOC contaminants to desorp from the soil particles) to treat the contaminants. This would involve bringing a portable low temperature thermal desorption processor on site, including a system for treating of all the vapors produced by the process. Depending on the resulting soil properties after treatment, the treated soils could then be reused on site as clean fill or taken off site for disposal or for use elsewhere. Total costs for using this process would include excavation, and can be quite high, but if sufficient quantities of soil require treatment, the process may be less expensive than off-site disposal. Permits will most likely be required, but this is a readily available technology which removes the contaminants. This may be a relevant technology for the Aro site.

Disposal

On site: If the soil is treated on site, it can then be reused on site, possibly replaced in excavations or transported off site for disposal.

Off site: Disposal of contaminated soil can be accomplished by transporting it to a permitted RCRA facility. TCE and 1,2-DCE are regulated substances under EPA's Land Ban so concentrations in the soil will determine their fate and costs. If concentrations are below statutory levels (some of the soils on site fit this category), the soils can be landfilled in a hazardous waste landfill. If levels are above statutory limits, the soils must be incinerated prior to landfilling. Off-site disposal is an expensive option for large amounts of soil. This is usually a better option for small quantities of highly-contaminated wastes.

2.4.2 Ground Water

2.4.2.1 Remedial technologies

Ground water monitoring

Ground water monitoring is part of most remedial actions, and since the Aro site has ground water contamination, it will be part of any remedial action at the site. Monitoring is typically accomplished via monitoring wells. Monitoring wells can be used to gather water quality samples, measure hydraulic head, and for aquifer stress testing to gain insight on ground water flow parameters. In addition, during the installation process, geologic information is obtained. All of this information is used to predict contaminant transport at the site and in the design and periodic performance evaluations of remedial activities. Monitoring well permits with the state are required. A ground water monitoring well network is currently in place at the Aro site. Table 2 shows this and other applicable technologies and rates them for effectiveness, implementability, and cost.

Institutional controls

Three methods of controlling access to contaminated ground water are deed restrictions, well permitting restrictions, or acquiring the affected properties and restricting access fencing. A deed restriction is a negotiated addendum to an existing deed, which until removed, indicates that ground water below the property is contaminated. This notifies the existing and subsequent property owners of the contaminated ground water. Similarly, the New York State Department of Health (NYSDOH), which permits wells, can be used to screen out well permit applications which might be impacted by the site. However, neither of these mechanisms is necessary for the Aro site, since all potential downgradient receptors are on city water, and wells in these surficial materials are not practical.

Containment

Recharge control: Impermeable caps constructed over ground water contaminant source areas prevent percolation of surface waters into the ground, thereby reducing the amount of leaching of contaminants to the ground water. Typically, caps in industrial areas such as this are constructed of clay, concrete, or asphalt. Caps are easily installed and are a quick and lasting means of recharge control. However, this technology is probably not applicable to the Aro site because it would only prevent leaching of contaminants from the unsaturated soils. At this site, the soils above the water table do not appear to be significantly contaminated, only those below the water table contain significant VOC concentrations. Caps are not effective in this situation. The majority of the site is already capped with asphalt or buildings.

Vertical barriers: Slurry walls are usually used for hydraulic isolation of a region or to create a barrier to flow to enhance other remedial techniques. They are constructed by trenching to a lower hydraulic barrier and backfilling with an effectively impermeable material, such as a bentonite slurry. They usually must be combined with impermeable caps, or a "bathtub effect" will occur, and ground water will overtop the slurry wall. Slurry walls are suited for geologic settings where the depth to the lower hydraulic barrier is moderate (typically less than 40 feet) and the formation is easily excavated. While this geologic description fits the Aro site, hydraulic isolation of the contaminated region using slurry walls is not practical because of the presence of the manufacturing plant and access problems with adjacent properties being so close to the buildings. Slurry walls, serving as a flow barrier in certain areas of the property are a possible remedial method if used in combination with one or more of the other remedial technologies.

Sheet pilings are used in the same manner as slurry walls and generally create the same hydraulic effect. Sheet pilings are usually installed from the surface down to the lower hydraulic barrier and are driven into the ground using a sheet piling hammer. Because of costs and unpredictable wall integrity, sheet piling is seldom used except for temporary dewatering or other construction such as erosion protection where flowing surface waters are being intersected.

Collection

Pumping: Recovery wells are a conventional means of extracting contaminated ground water from beneath sites. The number and placement of wells is typically a function of minimizing pumping rates and cleanup time, while ensuring all contaminated ground water is recovered. The water bearing unit (tills) at the Aro site is very low yielding, having a transmissivity on the order of 0.04 feet^2 per day. Therefore, pumping wells will be impractical at this site.

Hydraulically enhanced recovery wells are installed by hydraulic fracturing of a media. This is a technique borrowed from the petroleum industry to enhance recovery wells in petroleum reservoirs. It consists of pressure injecting a granular slurry into a borehole. When the down-hole pressure exceeds the pressure of the formation, fissures or fractures are created propagating from the borehole. After the pressure is released, the granular material remains in place, preventing the fissures and fractures from closing. This significantly increases the hydraulic conductivity immediately about the well (increasing the effective radius of the well), thus allowing the well to pump greater quantities of water from low-yielding formations. This probably would not increase flow to high enough levels to be economical at this site, however, due to the formation's low hydraulic conductivity. Additionally, it may cause damage to the buildings and pavement at the site due to the shallow depth to the water-bearing layer here (injection pressure may cause soil to heave). This technology is not recommended at this site since better means of collecting ground water exist for this site.

Injection and recovery wells in combination can be used to collect ground water. By injecting clean water upgradient from a recovery well, a containment cell may be created in which the hydraulic gradient is increased, thereby allowing greater pumping rates and reducing the time required to remediate the aquifer. Care must be taken in the design of the system. If improperly designed, spreading of the contaminants will occur. Permitting of injection wells is typically quite involved. This technology is not applicable to the Aro site, due to the shallow depth to ground water and low hydraulic conductivity.

Horizontal recovery wells are installed using directional drilling techniques as developed in the petroleum industry. The standard application is for the well to be installed parallel to the axis of the contaminant plume along the top of the lower hydraulic barrier. The hydraulic effect of a horizontal recovery well is similar to that of a drain, but being at the base of the aquifer and having an active collection system, the well is able to create a larger capture zone. Horizontal wells are especially useful in settings with limited saturated thickness and a great material contrast between geologic strata. Horizontal wells may be applied at the Aro site, but the low hydraulic conductivity would cause very low yields. This technology has not been widely used and as such is very expensive. Other alternatives are available to accomplish the same purpose, and therefore this technology will not be considered further.

Subsurface drains: Interceptor trenches are widely used to collect contaminated ground water in low-permeability formations. Pumping from a sump in a trench, that is constructed from the surface down to the top of the lower hydraulic barrier, across the width of the contaminant plume, and filled with highly permeable material, would create a horizontal sink to intercept contaminated ground water flow. This active/passive collection scheme is ideally suited for use at sites with relatively shallow ground water in low-yielding formations, the contaminant plume is relatively narrow, and the depth to the lower hydraulic barrier is not great, such as the Aro site. This technology will be retained for further consideration.

Shallow drain tile networks can be installed across regions of contaminated ground water as a means of passive collection. The use of drain tiles is suited to sites with shallow ground water, and the depth to a lower hydraulic barrier is not great. While drain tiles would be an effective means to capture contaminated ground water at the Aro site, they would not ensure vertical capture of all ground water due to the depth to the lower hydraulic barrier, and therefore are not a recommended means of ground water remediation here.

Dewatering: Dewatering and maintaining a depressed water table is often necessary prior to and during the in situ treatment of contaminated soils. This technology consists of evacuating the ground water from an area and preventing upgradient infiltration through extraction wells and pumping techniques. This technology will be retained for consideration as a component of in situ soil treatment.

In situ treatment

Biological: In situ bioremediation involves injecting (through injection wells) solutions enriched with nutrients and oxygen (that is, ammonia, hydrogen peroxide, and so forth) into the aquifer to promote the growth of the natural microflora, or introduced bacteria, which will in turn transform the contaminants into nontoxic compounds (using the contaminants as an energy source for growth). Because concentrations of nutrients may exceed ground water standards, it is often necessary to establish hydraulic control of the treatment region. This is typically accomplished via recovery wells. Bioremediation is most often done for petroleum contamination, but successful remediation of the halogenated VOC compounds associated with the Aro site has been reported. In situ bioremediation is not considered to be a feasible remedial technique at the Aro site due to the limited capability of the water bearing strata to transmit water and the nature of the ground water contaminants.

Chemical: Oxidation/reduction reactions can be induced in situ to treat VOC contamination. Studies have shown that an iron-based material can reduce halogenated VOCs in ground water, such as are present on the Aro site, into simpler nontoxic compounds. The recommended in situ treatment of ground water involves construction of a trench down to the lower hydraulic barrier and backfilling with the iron-based material. This is known as a "permeable reactive wall." Ground water is allowed to flow through the trench naturally, and contaminants are reduced as it flows through the wall. It can also be aided by "funnel technology," or slurry walls, placed to funnel the ground water to the reactive wall. This technology is best suited for geologic settings in which depth to the lower hydraulic barrier is not great, or the plume does not extend to great depths. This is considered an innovative technology by the EPA. In situ oxidation/reduction is a potential remedial technique for use at the Aro site. Because it is an innovative technology, bench and/or pilot studies would have to be performed prior to full-scale implementation. Capital costs would be relatively high to start with, but operating and maintenance costs would be small.

Physical: Air sparging is the in situ removal/bioremediation of VOCs from ground water by injecting air under pressure. The rising air not only strips the VOCs from the soil and ground water but increases the oxygen content of the water, thus enhancing natural bioremediation. Nutrients may be injected along with the air stream, if desired, to enhance bioremediation. Air sparging allows for the effective removal of VOCs without ground water recovery or treatment. It is effective in treating chlorinated solvents with relatively large Henry's Law constants (highly volatile), such as are present on site. Typically, air sparging is done in combination with soil venting. This technique uses recovery wells fitted with vacuum pumps to extract the rising air from the unsaturated zone, collects it, and then runs the air through a treatment unit (that is, carbon filters) to remove the VOCs stripped from the soil and ground water. However, at the Aro site, migration of the air through the water-bearing strata would be hindered by the high content of silts and clays beneath the site, making this an unacceptable means of remediation for this site. Additionally, the unsaturated zone is very thin so that soil venting would be difficult.

Ex situ treatment

Physical: Air stripping is the process where relatively large volumes of air are mixed with contaminated water to remove volatile compounds from the water. To enhance air/water contact, the surface area of the water is maximized. This is achieved either through a packed vertical column where the water is turned into a mist or in shallow tray aerators where air is passed through the water in a vertical series of trays. A by-product of this stripping process is VOC-laden air, which may in turn have to be treated (for example, with vapor phase carbon adsorption). This method is not well suited to hard waters, as clogging may occur. Pretreatment is often required. This technique is particularly effective for compounds which have large Henry's Law constants (highly volatile), such as the VOCs present at the Aro site. The technology is well understood and readily available at moderate cost. This is an applicable means of water treatment at the Aro site and may possibly be used alone, or in conjunction with other treatment techniques.

Adsorption is another possible physical means of ex situ treatment. Organic compounds in water or air passing through granular activated carbon filters are adsorbed by the activated carbon and retained in the filter. This technology is particularly suited for removal of widely varying amounts of chlorinated solvents (from high levels, to trace amounts in certain areas), such as are present at the Aro site. These filters can adsorb only a limited amount of compounds before periodic recharging of the filter is required. This method is also prone to clogging of the filter, and pretreatment of the water may be required. This may be a useful treatment technique for use at the Aro site, especially if used in conjunction with other treatment or disposal technologies.

Disposal

On site: If the treated water contains concentrations of contaminants below the applicable standards (federal and state), it may be discharged to the storm sewer, and thus to surface waters. A National Pollution Discharge Elimination System (NPDES) permit would be required for this option. This option is applicable for most discharge rates, but is particularly cost effective when large volumes of water are being treated. Discharge of treated water to the storm sewer at the Aro site is a possible means of disposal.

Off site: Disposal of untreated or partially treated water to the local POTW is often times an attractive option, assuming the POTW has enough excess capacity and is willing to accept the water. Concentrations of VOCs in these waters would have to meet local standards and discharge rates. If extracted ground water exceeds these standards, it would have to be pretreated before discharge to the POTW. This pretreatment can be expensive, depending on the contaminants and their levels. While discharging to the POTW, the customer is assessed user fees, which usually vary depending on the flow volumes and concentrations. This method of disposal is best suited for small effluent rates, such as is expected at the Aro site, because of costs. The local POTW for the Aro site is located in the town of Cheektowaga and may be accessed via the on-site sanitary sewer. This may be a viable option for the Aro site. Use of a POTW may also have an added benefit, in that EPA has found that phenol and some related compounds (found in MW-3) do not pass through POTWs, thus making pretreatment standards for these compounds unnecessary.

Shipment of untreated water off site to a RCRA permitted treatment facility is also an option. With this option, the water does not have to undergo any pretreatment processes and is pumped directly into a licensed hazardous waste transport vehicle for delivery to the treatment plant, usually from a storage tank on site where the extracted ground water is stored until it can be transported. The user is assessed transportation and treatment fees, and costs can be quite high if large volumes of contaminated ground water must be disposed. This method usually is appropriate for small effluent rates with high concentrations of hazardous wastes, such as TCE. Because TCE is a listed hazardous waste and its reuse is unlikely, Aro may incur future liabilities should the RCRA facility dispose of it improperly. Also, transportation of contaminated ground water may cause a public perception problem, as well as cause possible liability problems if an accident occurs while transporting the wastes. Off-site disposal of water in a RCRA facility is probably not a viable option for disposal of water at the Aro site due to the nature of the contamination. VOCs are concentrated in relatively small areas, which in this formation are not amenable to pumping. Therefore, the VOCs will probably be extracted along with quantities of relatively uncontaminated ground water, making the extracted ground water relatively dilute and fairly large in quantity. Costs for shipping ground water to a RCRA facility would thus be extremely expensive and not warranted with the low concentrations.

Deep well injection

Deep well injection, involving injection of water into a subsurface strata hydraulically remote to any potable water supply, is also sometimes used as a means of water disposal. This method would require a deep well injection permit, which is usually very difficult to obtain, and may require frequent sampling of the water to be injected. Sites with low to moderate effluent rates which overlay favorable strata for disposal, such as spent oil reservoirs, are best suited for this technique. Though injection is currently legal, should a water resource be degraded in the future and linked to this disposal, Aro may be liable. Additionally, public reaction to this disposal mechanism would likely be adverse. This method of disposal is not recommended for the Aro site.

2.4.3 Surface Water

2.4.3.1 Remedial technologies

Surface water monitoring

Surface water monitoring is part of most remedial actions, and since the Aro site has surface water contamination, it will be part of any remedial action at the site. Monitoring is typically accomplished by taking grab samples directly from the surface water bodies. This information is used to predict contaminant transport at the site and in the design and periodic performance evaluations of remedial activities. Table 3 shows this and other applicable technologies and rates them for effectiveness, implementability, and cost.

Institutional/Physical controls

Two methods of controlling access to contaminated surface waters are: deed restrictions and restricting access by fencing property, similar to what may be done for ground water. However, they are even less effective for surface waters than for ground water, especially if the surface waters are flowing off site. Institutional controls are not considered a relevant technology for surface waters at this site.

Containment of contaminated ground water

Ground water is percolating into the on-site sewer backfill culvert and contaminating the surface water ditches with VOCs. This could be prevented in one of two ways. The first would be to excavate the culverts and ditches, line them with an impermeable liner (clay or a geomembrane, such as high density polyethylene), and backfill with clean fill material. The liner would prevent contaminated ground water from using these backfills as a preferential flowpath. This is a viable option at this site because the ditches are relatively short and not overly deep.

The second method would be to use pumping to lower the water table to below the level of the ditch backfill, thus preventing the ground water from infiltrating into the backfill. This would be done with several shallow wells located alongside the sewers. However, the low conductivity tills at this site make this impractical, especially with the need for treating the pumped ground water.

Collection

It is possible to divert all the contaminated surface water into a collection basin/tank for treatment and disposal. This is a relatively simple technology but would be impractical for this site for reasons of space, high costs, and the fact that most of the water collected would be storm water which is not contaminated.

More practical would be to divert clean storm water away from contaminated areas and collect only the contaminated water flowing in the sewer backfill. This water is the only water directly in contact with the contaminated ground water and is relatively small in volume. The water could be collected by constructing a sump, filled with a granular material, across and beneath the backfilled ditches near their mouth. The intercepted water could then be pumped out for treatment and disposal. This may be a viable option for the Aro site, since the sewer backfill serving as preferential flowpaths.

Treatment and disposal

Contaminated surface waters can be treated and disposed in the same way as detailed for ground water in the previous sections. Advantages would be gained (lower costs) by treating and disposing of the contaminated surface water in the same manner as the ground water, since they are contaminated with the same compounds.

2.5 EVALUATION OF TECHNOLOGIES AND PRELIMINARY SELECTION OF ALTERNATIVES

Preliminary screening of remedial technologies and process options for the various impacted media at the site was documented in the previous section. The technology screening identified potential remedial options and evaluated them for effectiveness, implementability and cost, as required by the National Contingency Plan. Tables 1, 2, and 3 give these evaluations for soil, ground water, and surface water, respectively, as well as listing screening comments relative to each option. The remedial technologies retained for consideration in choosing alternatives are those judged to best meet the RAOs for the particular media, given the effectiveness, implementability, and cost factors. These retained technologies are summarized in Table 4.

The retained technologies were then assembled into the following alternatives for remediating the Aro site. These alternatives will be carried forward for detailed analysis, and eventual selection of a preferred alternative.

2.5.1 Soil

2.5.1.1 Alternative 1 - No action

Under this alternative, no remedial action will be undertaken to remediate soils.

2.5.1.2 Alternative 2 - Limited action via institutional controls

This alternative will consist of fencing the Aro site and the two western neighboring properties to restrict access and placing deed restrictions on the properties to alert future owners that the subsurface soils may be contaminated with VOCs.

2.5.1.3 Alternative 3 - In situ stabilization of "hot spots"

This alternative will consist of in situ stabilization of two highly contaminated soil areas. The first area is around the former metals preparation room and the second is around the loading dock on the southeast corner of the building. The soil will be stabilized by the addition of Portland cement (possibly including some additives such as bentonite clay) via deep soil mixing or pressure grouting. Structural considerations pertaining to the building, the presence of the water table, and volume expansion of the stabilized soils will have to be carefully evaluated. Stabilization of these areas will prevent further leaching of TCE and 1,2-DCE to the ground water.

2.5.1.4 Alternative 4 - Excavation of "hot spots" with two treatment/disposal options

This alternative will consist of excavating portions of two highly contaminated soil areas in the vicinity of the metals preparation room and former loading dock areas to remove those soils with high levels of contamination and replacing them with clean fill. Structural considerations pertaining to the building will require careful evaluation, as well as problems associated with excavating below the water table. Actual excavation will require extensive on-site screening to identify the precise limits of contamination (keeping excavated soil to a minimum). Additionally, health and safety considerations relating to the construction workers will have to be carefully evaluated. The excavated soils will either be incinerated on site via a portable incinerator (and then disposed on site) or disposed off site via a permitted RCRA facility. If disposed off site, the soils will be landfilled if levels are below those of EPA's Land Ban or incinerated at an off-site RCRA facility and subsequently land filled if they exceed the statutory limits for landfilling. This decision will be made on the basis of relative costs, availability of permits, and so forth.

To avoid recontaminating the soils via contaminated ground water after placement of the clean fill, this alternative will require combination with a ground water collection and treatment alternative.

Excavation of the "hot spots" presents several technical and cost-related problems. From a technical perspective, a large portion of the most highly contaminated areas of the site are located under active portions of facility buildings and are therefore inaccessible. The cost associated with on-site treatment or off-site disposal of excavated materials will be significant. Other factors affecting cost include: 1) the need to support building foundations in order to excavate in and around the facility buildings near the metal preparation room and the former loading dock area and 2) excavation in low permeability materials below the water table will result in seepage into the excavation and will present material handling problems.

2.5.1.5 Alternative 5 - Excavation of all soils exceeding New York State recommended soil cleanup objectives with on-site incineration

This alternative will be similar to Alternative 4, except that all soils exceeding the New York State Recommended Soil Cleanup Objectives will be excavated and replaced with either clean fill or the treated soil. Due to the expected quantities to be treated, on-site incineration is expected to be most economical and will be accomplished via a portable incinerator. To avoid recontaminating the soils via contaminated ground water after placement of the treated soil (or clean fill), this alternative will require combination with a ground water collection and treatment alternative. The same technical and cost concerns that apply to Alternative 4 are also applicable to Alternative 5; however, these concerns will impact this alternative to a greater extent due to the increased scope of this alternative. As demolition and/or interruption of active plant facilities and operations would be involved, this alternative will be given no further consideration.

2.5.1.6 Alternative 6 - Excavation of all soils exceeding New York State recommended soil cleanup objectives with on-site low temperature thermal desorption

This alternative will be similar to Alternative 5, except that all soils exceeding the New York State Recommended Soil Cleanup Objectives will be excavated and processed on site by low temperature thermal desorption (heating of the soils to temperatures which would cause the VOC contaminants to desorp from the soil particles) to treat the contaminants. This would involve bringing a portable low temperature thermal desorption processor on site, including a system for treating of all the vapors produced by the process. Depending on the resulting soil properties after treatment, the treated soils could then be reused on site as clean fill or taken off site for disposal or for use elsewhere. Total costs for using this process would include excavation, and can be quite high, but if sufficient quantities of soil require treatment, the process may be less expensive than off-site disposal. Permits will most likely be required, but this is a readily available technology which removes the contaminants.

An obstacle in utilizing this process is that significant quantities of contamination are beneath the building and are not accessible for excavation without undue cost or destruction of portions of the building. The same technical and cost concerns that apply to Alternatives 4 and 5 are also applicable to Alternative 6. As demolition and/or interruption of active plant facilities and operations would be involved, this alternative will be given no further consideration.

2.5.1.7 Alternative 7 - Cleanup of soils in conjunction with the use of an interceptor trench

This alternative allows for clean water to enter the contaminated areas and pass by the contaminated soils with the water removing the contaminants from the soil. The water contaminated by the soils is subsequently intercepted, collected, and treated. The use of the interceptor trench in conjunction with ground water collection and treatment is discussed more fully in Section 2.5.2.4 Alternative 4 - "Ground water collection via an interceptor trench and two treatment/disposal options."

2.5.1.8 Alternative 8 - Dewatering of the site and the removal of the VOC contaminants by use of SVE

This alternative for the removal of the VOC contaminants by SVE requires that the contaminants have a high vapor pressure. This alternative also requires that the site can be dewatered and that the soil conditions at the site will allow for the passage of air through the dewatered soils.

Because of the low permeability of the soil due to the high content of silts and clays beneath the site, dewatering of the site would be very slow, but maintaining the dewatered area should not require removal and treatment of gross quantities of water. With the site dewatered, the SVE technologies, which may or may not include active introduction of air into the soil through air injection wells, can be applied to the site. Air fracturing of the soils may be required.

Ground water removed using this alternative would be treated or processed as required, and then discharged to either the POTW or to a permitted surface discharge.

2.5.2 Ground Water

2.5.2.1 Alternative 1 - No action with monitoring

Under this alternative, no remedial action would be taken to remediate ground water at the site. Ground water monitoring would be continued using the existing remedial investigation monitoring wells.

2.5.2.2 Alternative 2 - Limited action via institutional controls

This alternative will consist of purchasing the property immediately west of the metals preparation room and restricting access to it. Deed restrictions will be placed on this and the Aro property to alert future property owners of ground water contamination beneath the property. Ground water monitoring would be continued using the existing remedial investigation monitoring wells.

2.5.2.3 Alternative 3 - In situ treatment via a permeable reactive wall

This alternative would use a "permeable reactive wall" built across the downgradient end of the VOC plume to destroy VOCs in the ground water as they flow through it. The reactive wall is a totally passive system and is filled with reactive granular metal material (iron-based) to degrade VOCs as they flow through it to nontoxic by-products. It is purposely made highly conductive to allow contaminated ground water to flow through it and is completed to bedrock (the lower confining layer) to ensure the entire plume is treated. This is an EPA innovative technology.

Funnel technology, or the use of slurry walls to funnel contaminated ground water to a permeable reactive wall, will also be evaluated to achieve the optimum balance of treatment efficiency versus cost (that is, use slurry walls to funnel ground water to a relatively short reactive wall, versus using a long reactive wall with no funneling of ground water).

2.5.2.4 Alternative 4 - Ground water collection via an interceptor trench and two treatment/disposal options

An interceptor trench could be installed across the downgradient end of the VOC plume to collect contaminated ground water. The interceptor trench would be installed to bedrock (lower confining layer) with collection sumps. Ground water would be pumped from the collection sumps to a central holding system prior to treatment and discharge.

The contaminated ground water could then be treated on site via oxidation/reduction, air stripping or adsorption (using granular activated carbon), and disposed of into the storm sewer or disposed of to the local POTW, using pretreatment via one of the three methods above, if required. The decision to dispose to the POTW, or to treat and dispose to the storm sewer, would be made based on costs versus efficiency. If the decision is to dispose to the storm sewer after on-site treatment, an NPDES permit would be required.

An evaluation will also be made whether or not to include a slurry wall immediately downgradient of this interceptor trench to reduce ground water inflow from downgradient of the plume. The slurry wall would reduce inflow of uncontaminated ground water. This decision will be made based on cost, as well as avoidance of unwanted downgradient impacts to surface waters.

2.5.2.5 Alternative 5 - Ground water collection via recovery wells and two treatment/disposal options

Recovery wells could be installed within the VOC plume to collect contaminated ground water. Recovery wells would be installed to bedrock (lower confining layer) and connected to a central collection system for storage prior to ground water treatment and discharge.

Contaminated ground water which is collected from the recovery wells could be treated on site via oxidation/reduction, air stripping or adsorption (using granular activated carbon), and disposed of to the storm sewer or to the local POTW. The decision to dispose of the contaminated ground water to the POTW (possibly requiring pretreatment), or to treat and dispose of it to the storm sewer, would be made based on permit requirements and cost efficiency.

2.5.2.6 Alternative 6 - Ground water collection via SVE dewatering and two treatment/disposal options

This alternative would be a component of soil cleanup Alternative 8 - Dewatering of the site and removal of the VOC contaminants by use of SVE as discussed in Section 2.5.1.8. Ground water collection would occur as a result of dewatering activities performed during the installation and operation of an SVE system. Ground water collected during the SVE activities would be pulled from the SVE wells and collected into below grade holding tanks. These tanks would contain a system which would pump the collected ground water into a central storage tank pending treatment and discharge.

Contaminated ground water which is collected during the dewatering process could be treated on site via oxidation/reduction, air stripping or adsorption (using granular activated carbon), and disposed of to the storm sewer or to the local POTW.

2.5.3 Surface Water

2.5.3.1 Alternative 1 - No action with monitoring

Under this alternative, no remedial action will be undertaken to remediate surface waters. Surface water monitoring would be continued.

2.5.3.2 Alternative 2 - Lining of storm sewer and sanitary sewer ditches

This alternative would evaluate installation of an impermeable liner (for example, clay or geomembrane) beneath the backfill of the storm sewer and sanitary sewer on the Aro site. The drainage ditch would also be evaluated for lining. The purpose of the liners would be to prevent contaminated ground water from entering the surface water via these backfilled ditches, which are acting as ground water discharge zones at present.

2.5.3.3 Alternative 3 - Collection of influent ground water from sewer backfills with two treatment/disposal options

This alternative would collect the contaminated ground water flowing in the sanitary sewer and storm water sewer backfills (the preferential flowpaths), using sumps placed beneath and across the backfills, and treat and dispose of the collected water in one of two ways. The first way would be to treat it on site, using oxidation/reduction, air stripping or adsorption (granular activated carbon), and then disposing of it to the storm sewer (requires NPDES permit). The second way would be to dispose of it to the POTW, using pretreatment if required. The decision on how to treat and dispose of the water will be similar to what is done for ground water, assuming ground water is collected. The same system would be used to treat the surface water.

3.0 DETAILED ANALYSIS OF ALTERNATIVES

3.1 INTRODUCTION

This section presents the detailed analysis of the alternatives which were developed and screened in Section 2.0. The objective of the detailed analysis is to provide the basis for identifying a preferred alternative or combination of alternatives for preparing the proposed remedial plan. Alternatives have been evaluated using the criteria listed in Subsection 3.3.

3.2 KEY ISSUES

The key issues in the evaluation of alternatives are ground water quality and the potential risk to the environment and human health. A list of the chemicals of concern and their cleanup goals are presented in Table 5.

3.3 ALTERNATIVE ANALYSIS

This subsection details the analysis of individual alternatives for the Aro, Buffalo, New York, facility. The remaining remedial alternatives are assessed according to the criteria provided in the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" dated October 1988:

- Meeting RAOs and proposed cleanup goals

- Balancing Criteria

    - Long-term effectiveness and permanence
    - Implementability
    - Short-term risks
    - Total cost

3.4 GROUND WATER

3.4.1 Alternative 1 - Natural Attenuation - Ground Water Monitoring

3.4.1.1 Description

Under this alternative, no specific actions would be taken for ground water contamination. The ground water beneath the site would be left in its current condition, and any changes would be a direct effect of natural processes, such as biological/chemical/physical degradation, adsorption, desorption, and dispersion. A ground water monitoring program would be implemented to assess variations in the ground water contaminant concentrations. The monitoring program would consist of sampling the monitoring well network. Samples would be collected and analyzed for volatile organics (EPA Method 8240) on a quarterly basis for the first year followed by semiannual monitoring. Monitoring well sample results would be compared to proposed cleanup values and standards to assess natural attenuation. The sampling duration is assumed to be for a period of five years for cost estimating purposes. Longer term sampling would be established by a monitoring plan developed upon implementation of this alternative. With proper training, sample collection activities could be performed by facility personnel.

This alternative would require the development of a Sampling Analysis Plan (SAP). The SAP would provide detailed methodology for sample collection, handling, and shipment. The SAP would also reference the appropriate laboratory methods and would provide quality assurance requirements for the sampling effort. The SAP would be based on standard sampling practices currently used by the NYSDEC and outlined in EPA protocols SW-846.

In addition to the SAP, monitoring reports would be prepared to accompany the analytical data. The monitoring reports would discuss deviations from the SAP, note any problems encountered, summarize the analytical data, and present conclusions drawn from the data.

3.4.1.2 Threshold criteria assessment

The Risk Assessment (Section 1.5.1.1) concluded that no complete exposure pathway for ground water is present. Currently there are no water-supply wells on site or the neighboring properties; therefore, exposure to ground water beneath the Aro facility is unlikely for on-site workers, utility workers, or off-site residents. All drinking and process water for the Aro facility is received through the city water supply. Residents to the west of the Aro property are not known to have private water wells, and these homes are currently supplied by city water. Therefore, no unacceptable human health risks exist under the current use scenario.

The ground water monitoring program would allow an evaluation of changes in ground water quality. Consequently, if contaminant levels were to significantly increase, a contingency plan would be implemented.

The cleanup goals considered for ground water contamination at this site consist of meeting the general action objectives such as: TCE $\leq$ 5 μg/l; 1,2-DCE $\leq$ 5 μg/l; vinyl chloride $\leq$ 2 μg/l; 1,1-DCE $\leq$ 5 μg/l; 1,1,2-TCA $\leq$ 5 μg/l; benzene $\leq$ 0.7 μg/l; and total phenols $\leq$ 1 μg/l.

The remedial investigation showed that contaminants at the site exceeding the New York State Ground Water Quality Standards were TCE, 1,2-DCE, and vinyl chloride. These contaminants were located predominantly in the vicinity of the metals preparation room and along the sewer backfill in the western end of the employee parking lot.

In the future, through natural attenuation processes, the contaminant levels detected to date are not expected to be reduced to cleanup goals at all of the wells and thus RAOs will not be met. However, the monitoring program would detect any changes in ground water quality and assess the effectiveness of natural attenuation.

3.4.1.3 Balancing criteria assessment

Long-term effectiveness and permanence: The time to achieve long-term effectiveness and permanence of this alternative is not known. It is expected that the levels of contaminants detected in the ground water, however, would to some extent, attenuate over time. This alternative would not reduce the mobility, toxicity, or volume of contaminants in the ground water by treatment. Contaminants would be left in place and concentrations would vary only as a result of natural attenuation processes, such as those already occurring.

Implementability: Implementation of this alternative can be accomplished using local services and commercial equipment. Sampling would be performed in the same manner as during the remedial investigation. Analyses would be performed as specified in the SAP developed for the site.

Short-term risks: This alternative would effectively protect human health and the environment over a short-term period. No threats are posed by the current ground water contaminant levels and site usage, and contaminant levels are not expected to increase in the future.

Total cost: The estimated total cost of implementing this alternative is $142,000. This cost includes preparation of the SAP, sample collection, report preparation, and analytical services for sampling every three months during the first year and every six months over a five-year period.

3.4.2 Alternative 2 - Institutional Controls

3.4.2.1 Description

Under this alternative, no specific actions would be taken for the ground water contamination. The ground water beneath the site should be left in its current condition and any changes would be a direct effect of natural processes, such as biological/chemical/ physical degradation, adsorption, desorption, and dispersion. This alternative would include the ground water monitoring program described in Section 3.4.1. In addition, institutional controls would be placed on the facility and impacted neighboring properties.

Currently there are no water-supply wells on site or the neighboring properties; therefore, exposure to ground water beneath the Aro facility is unlikely for on-site workers, utility workers, or off-site residents. All drinking and process water for the Aro facility is received through the city water supply. Residents to the west of the Aro property are not known to have private water wells, and these homes are currently supplied by the city water supply. Therefore, no unacceptable human health risks exist under the current use scenario.

Two methods of controlling access to contaminated ground water are deed restrictions and well permitting restrictions. A deed restriction is a negotiated addendum to an existing deed, which until removed, indicates that ground water below the property is contaminated. This notifies the existing and subsequent property owners of the contaminated ground water. Similarly, the NYSDOH, which permits wells, can be used to screen out well permit applications which might be impacted by the site. However, these controls may not be necessary for the Aro site since all potential downgradient receptors are on city water, and wells in these surficial materials are not practical.

3.4.2.2 Threshold criteria assessment

The Risk Assessment (Section 1.5.1.1) concluded that no complete exposure pathway for ground water is present. Currently there are no water-supply wells on site or the neighboring properties; therefore, exposure to ground water beneath the Aro facility is unlikely for on-site workers, utility workers, or off-site residents. All drinking and process water for the Aro facility is received through the city water supply. Residents to the west of the Aro property are not known to have private water wells, and these homes are currently supplied by city water. Therefore, no unacceptable human health risks exist under the current use scenario.

The ground water monitoring program would allow for an evaluation of changes in ground water quality. Consequently, if contaminant levels were to increase, a contingency plan would be implemented.

The cleanup goals considered for ground water contamination at this site consist of meeting the General Action Objectives such as: TCE $\leq$ 5 μg/l; 1,2-DCE $\leq$ 5 μg/l; vinyl chloride $\leq$ 2 μg/l; 1,1-DCE $\leq$ 5 μg/l; 1,1,2-TCA $\leq$ 5 μg/l; benzene $\leq$ 0.7 μg/l; and total phenols $\leq$ 1 μg/l.

The remedial investigation showed that contaminants at the site exceeding the New York State Ground Water Quality Standards were TCE, 1,2-DCE, and vinyl chloride. These contaminants were located predominantly in the vicinity of the metals preparation room and along the sewer backfill in the western end of the employee parking lot. Therefore, this alternative will not comply with the RAOs. In the future, through natural attenuation processes, the contaminant levels detected to date are not expected to be reduced to cleanup goals at all the wells and thus RAOs will not be met. However, the monitoring program would detect any changes in ground water quality and assess the effectiveness of natural attenuation.

3.4.2.3 Balancing criteria assessment

Long-term effectiveness and permanence: The time to achieve long-term effectiveness and permanence of this alternative is not known. It is expected that the low levels of contaminants detected in the ground water, however, would to some extent attenuate over time. This alternative would not reduce the mobility, toxicity, or volume of contaminants in the ground water by treatment. Contaminants would be left in place and concentrations would vary only as a result of natural attenuation processes, such as those already occurring.

Implementability: Implementation of this alternative can be accomplished using local services and commercial equipment. Sampling should be performed in the same manner as was done during the remedial investigation. Analyses would be performed as specified in the SAP developed for the site.

Short-term risks: This alternative would effectively protect human health and the environment over a short-term period. No threats are posed by the current ground water contaminant levels and site usage, and contaminant levels are not expected to increase in the future.

Total cost: The estimated total cost of implementing this alternative is $152,000. This cost includes preparation of the SAP, legal fees, sample collection, report preparation, and analytical services for sampling every three months over a five-year period. In addition, this covers the estimated cost associated with the placement of institutional controls.

3.4.3 Alternative 3 - In Situ Treatment Via A Permeable Reactive Wall

3.4.3.1 Description

This option involves the construction of an impermeable slurry wall or sheet piling to contain and direct the flow of ground water contaminants through a permeable reactive wall. The reactive wall technology uses an iron-bearing matrix to dechlorinate the solvents passing through the wall.

The permeable wall technology is a destructive treatment method. The main advantage of an in situ destructive treatment method is that the environmental risks are eliminated or greatly reduced without transferring the contaminants to another media or incurring additional liability through off-site transportation and disposal. Also, because the construction zone can be kept outside of the area of highest contamination, potential worker exposure is reduced. The anticipated breakdown products of the process are: chloride ions, ethylene, and ethane, which all have low toxicity characteristics.

3.4.3.2 Threshold criteria assessment

The cleanup goals considered for ground water contamination at this site were discussed previously in Section 2.2.2. The anticipated ground water RAOs are: TCE ≤ 5 μg/l; 1,2-DCE ≤ 5 μg/l; vinyl chloride ≤ 2 μg/l; 1,1-DCE ≤ 5 μg/l; 1,1,2-TCA ≤ 5 μg/l; benzene ≤ 0.7 μg/l; and total phenols ≤ 1 μg/l. In reviewing previous pilot scale studies, sources with initial concentrations of TCE of between 50 and 200,000 μg/l were treated to a level of 5 μg/l. Similarly, initial vinyl chloride levels of between 24 and 800 μg/l were treated to levels of between 0.5 and 13 μg/l.

Bench and pilot scale tests would be necessary to confirm the treatment efficiency prior to full scale implementation. If the bench or pilot scale testing indicated that the prescribed treatment level was not attainable for all contaminants, a waiver would be requested.

In addition to the ground water RAOs for the known contaminants, additional standards would have to be set for the breakdown products from the reactive wall treatment method. Ground water effluent standards for a class GA fresh water source were listed for only one of the expected degradation products, chloride ions. The published standard for chloride ions is 500,000 μg/l. Standards were not published for the other two expected breakdown products.

3.4.3.3 Balancing criteria assessment

Long-Term effectiveness and permanence: The long-term effectiveness of the permeable reactive wall technology depends greatly on the ability of the in situ installation to resist fouling. Due to a number of site specific parameters, it is the opinion of the inventors of the technology that the specific characteristics of the Aro site pose a concern. Two factors that may cause fouling are the high pH and the high concentration of sulfates in the ground water at the site.

The technology relies on a mildly acidic to neutral pH to provide a supply of hydrogen ions to replace the chlorine atoms on the chlorinated hydrocarbon. To date, all trials of the permeable reactive wall technology have been conducted with a ground water pH between 6.0 and 7.5. Because the permeable reactive wall technology makes use of the available hydrogen ions, a result of this process is to raise the pH of the ground water. The initial pH of the ground water on the Aro site is between 7.2 and 9.2. Raising the pH of the ground water through the permeable reactive wall is expected to lead to the formation of insoluble metal hydroxides and mineral precipitates.

Another concern is the amount of sulfates present in the ground water. Additional testing of MW-3 and MW-20 was conducted to determine sulfate levels. These tests show sulfate levels of 400 and 240 mg/l in the two respective wells. Sulfate attack of the iron bearing matrix in the permeable wall and the formation of insoluble ferrous sulfide are two concerns over the high sulfate levels detected.

Two options were developed to improve the long-term performance of the permeable reactive wall technology. The first option is to reduce the formation of metal hydroxide and sulfate precipitants by reducing the pH of the ground water. This could be accomplished by injecting a buffering agent into the ground water through upgradient wells. The amount of buffering agent added to the ground water would have to be varied based on the ground water flow. This would require continuous monitoring of ground water flow. The measured flow would be fed into a pump controller to vary the amount of buffering agent added. This option eliminates the passive nature of the technology. Periodic maintenance and monitoring of the ground water flow meter, controller, pump, and buffering agent storage tank would be required. This option also does not address the potential attack of the iron matrix.

A second option is to assume that fouling of the permeable wall is inevitable. The design of the reactive wall would include provisions to periodically remove and replace the iron matrix. This could be accomplished by encasing the reactive wall, or gates, within a permanent screen. The iron matrix could then be removed with an auger and replaced as needed. The need to replace the iron matrix would be based on a combination of bench and pilot scale modeling data and the results of samples taken from downgradient wells.

The treatment levels achieved by the permeable reactive wall technology are very close to the proposed RAOs. Fouling or chemical attack of the iron matrix would decrease the effectiveness of this technology. As a result, the replaceable permeable reactive wall design would experience periods where the RAOs would not be met.

The permeable reactive wall technology is still undergoing field trials at this point. While the initial results of these field trials has confirmed the data developed during bench and pilot studies, long-term reliability has not yet been demonstrated. It is expected that the field trials will confirm the long-term reliability of the permeable reactive wall technology.

Confirming the concerns regarding the Aro site would require bench and pilot scale testing. The bench and pilot scale testing would be used to develop alternative engineering solutions in an effort to resolve these concerns.

Implementability: Because of the lack of correlating data between previous pilot studies using the permeable reactive wall technology and the Aro site, bench and pilot studies would be required prior to the design of a full scale in situ treatment system. The bench scale study involves treating wastewater samples from the site through a column of the iron matrix. The bench scale study would provide data on the overall effectiveness of the treatment method, degradation rates, fouling rates, and would identify degradation products. Interpretation and evaluation of the bench scale data would allow for a more accurate cost for a pilot scale study.

The pilot scale study would involve the construction of a small scale in situ treatment unit. The pilot scale treatment unit is a funnel and reactive gate system. The funnel is composed of approximately 30 feet of sheet piling on each leg of the funnel. The reactive gate is composed of a caisson, 3 feet in diameter, situated at the mouth of the funnel. Pea gravel is placed both upgradient and downgradient of the reactive gate. The caisson is filled with the iron matrix. Three monitoring wells would be installed in the pilot system. The monitoring wells would be located upgradient of the reactive gate, downgradient of the reactive gate and within the reactive gate. Additional sheet piling could be required to isolate the downgradient monitoring well from infiltration from the rest of the site. The data to be developed from the pilot scale study include site specific hydraulic conditions, presence of sulfur fixing bacteria, effects of metal hydroxide and mineral precipitants, and the effectiveness of the process.

The pilot scale system would be in operation for six months. During these six months, seven sampling events would occur. All seven sampling events would include sampling for organic materials; three of the events would include sampling for inorganic materials. A total of 252 ground water samples would be tested for organic materials and 45 samples tested for inorganic materials. The exact parameters tested would be determined following the bench scale test, but would include trichloroethylene, 1,2-dichloroethylene, vinyl chloride, ethylene, ethane, and chloride ions.

A full scale in situ treatment system design and costs would be developed from the pilot scale data. The costs developed for the full scale system would include construction, installation, and long-term operating costs.

Short-term risks: The exposure pathways expected during bench and pilot scale studies of the permeable reactive wall technology are not expected to change from the exposure pathways identified in section 1.5.1.1 of this report. Risks associated with exposure to ground water through sampling and testing would be minimized through the use of standard operating procedures designed to minimize these risks. Since the in situ pilot system would be installed downgradient from the major source of contaminants, exposure due to the installation of the pilot system would be negligible. Decommissioning of the pilot system through vibratory extraction of the sheet piling and removal of the reactive gate would also be expected to involve minimal exposure to contaminants. Depending on the location of the pilot system, it could be incorporated into the final design or abandoned in place, further reducing the risk of exposure to contaminants.

Total cost: The cost to conduct a bench scale study of the feasibility of the permeable reactive wall technology is estimated at between $20,000 and $30,000.

The cost to install and operate an in situ pilot scale permeable reactive wall treatment system for 6 months is estimated at $237,000. A present worth analysis of the cost to operate the pilot system was not necessary due to the short time period of operation. A breakdown of the costs associated with the pilot scale system are shown in Appendix A. The costs associated with a full scale system are not known at this time, but based on identified costs, it is estimated to be $3.6 million.

3.4.4 Alternative 4 - Ground Water Collection Via An Interceptor Trench And Two Treatment/Disposal Options

3.4.4.1 Description

This alternative involves the construction of an interceptor trench to collect the ground water and to prevent migration of contaminated ground water beyond the bounds of the trench. The trench is constructed using permeable materials and a collection pipe at the bottom to allow effective dewatering of the trench area. The rapid depression of the piezometric surfaces at both sides of the dewatered trench is evidence that the trench is a barrier to horizontal flow across the trench in the intercepted zones.

The interceptor trench is considered a viable means of ground water flow control because the low permeability of the native soils limits or prevents the use of conventional ground water recovery wells to effectively control the hydraulic gradient at the site. The calculated zone of influence requires that conventional wells be placed very close to each other to be effective. Such a design becomes impractical to implement and does not provide the assurance that some flow did not go between and past the conventional wells.

This alternative is desirable because it provides for control of the sources for potential contamination over a large area, and avoids the need to install and maintain a large network of well pumps, controllers, and associated piping.

This alternative can be done with readily available construction procedures. No new technologies or implementation procedures are required.

The success of using this alternative can be easily evaluated by periodic sampling and analysis of the monitoring wells downgradient and outside the boundary of the interceptor trench.

3.4.4.2 Threshold criteria assessment

The cleanup goals considered for ground water contamination at this site were previously discussed in Section 2.2.2. The anticipated ground water RAOs are: TCE $\leq$ 5 μg/l; 1,2-DCE $\leq$ 5 μg/l; vinyl chloride $\leq$ 2 μg/l; 1,1-DCE $\leq$ 5 μg/l; 1,1,2-TCA $\leq$ 5 μg/l; benzene $\leq$ 0.7 μg/l; and total phenols $\leq$ 1 μg/l.

The interceptor trench would effectively capture water flowing toward the trench and would allow that water to be processed to the required remediation standards.

The trench placement would be such that ground water downgradient and outside the boundary of the interceptor trench was within acceptable ground water quality standards.

3.4.4.3 Balancing criteria assessment

Long-term effectiveness and permanence: The long-term effectiveness of controlling the ground water depends on maintaining the integrity of the physical barrier to the migration of the ground water. The physical interruption of the normal migratory paths combined with the depression of the hydraulic head at the trench would effectively prevent migration of contaminated ground water.

Implementability: The technologies for providing effective interceptor trenches with the needed integrity control for intercepting ground water flow are well known and are being used on similar projects throughout the country, including the local Buffalo, New York, area. The integrity of the system can be evaluated by visual observation and measurement of water surfaces in the trenched area, if so required.

Because most of the construction zone is outside of the areas of highest contamination, potential worker exposure during construction is reduced.

The selection of this alternative would require the extraction of ground water, which may require treatment and disposal. However, the method of treating the ground water and the method of disposal of the treated water is a direct factor in the consideration of this alternative.

During consideration of technologies that might be applicable to this site, Section 2.5.2.4 of this report, it was stated that consideration would be given to installing a slurry wall immediately downgradient of the interceptor trench to reduce inflow of uncontaminated ground water from downgradient of the plume (and downgradient of the trench). Because of the low yield of ground water expected at this site, there appears to be no requirement for a slurry wall to be installed in conjunction with the interceptor trench. Therefore, the installation of a slurry wall is not a direct factor in the consideration of this alternative.

Furthermore, selective placement of the interceptor trench installation to retain access for a future installation of a slurry wall will allow this subject to be revisited after the interceptor trench system is operable, and if required, a slurry wall could then be installed at a later date.

Short-term risks: The exposure pathways expected during construction are not expected to increase over the exposure pathways identified in Section 1.5.1.1 of this report. Risks associated with exposure to ground water through construction would be addressed through the use of standard construction procedures designed to minimize these risks.

This alternative would effectively protect human health and the environment in the short-term. Hydraulic gradient control would prevent further migration of contaminants.

Monitoring of the air emissions during installation would be conducted to assure compliance with the applicable standards, but because of the locations selected for the trenching, air emissions are not believed to be a concern for this alternative.

Total Cost: The cost to construct the ground water interceptor trench and the associated collection (dewatering) piping and pump systems is estimated at $437,800.

To reduce the cost of disposing of the removed soil by incineration, the location of the interceptor trench would be selected to limit the amount of contamination in the soil.

The cost of treating the collected ground water by air stripping and/or carbon adsorption is estimated at $252,000. The estimated total costs for the construction of the interceptor trench and subsequent ground water treatment is $2,588,000. An operational timeframe of

30 years was used for price estimating purposes. See Appendix A for a cost breakdown on the implementation of the ground water treatment system.

The method and cost of treating the ground water, and the method and cost of disposal of the treated water is a factor in the consideration of this alternative, unless the POTW would accept the untreated ground water.

As noted above, in considering the technologies that might be applicable to this site, Section 2.5.2.4, it was stated that consideration would be given to installing a slurry wall immediately downgradient of the interceptor trench to reduce inflow of uncontaminated ground water from downgradient of the plume (and downgradient of the trench). Because of the low yield of ground water expected at this site, the cost of the slurry wall at approximately $452,000 greatly exceeds the cost of providing additional treatment capacity to handle the downgradient water flow.

3.4.5 Alternative 5 - Ground Water Recovery Wells And Two Treatment/Disposal Options

3.4.5.1 Description

Under this alternative, a ground water recovery system would be used to: 1) capture contaminated ground water, and 2) to provide gradient control to prevent further migration of contaminated ground water hydraulically downgradient of the source area(s).

Ground water recovery would be achieved through the installation of recovery wells with accompanying equipment necessary to pump, containerize, and treat (if required) the ground water prior to discharge to the POTW. This alternative would also include the monitoring plan described under Alternative 1 and the institutional controls proposed under Alternative 2.

Based upon the results of the in situ permeability testing conducted during the remedial investigation, the average hydraulic conductivity of the unconsolidated glacial till aquifer is 3.5×10^{-8} centimeters per second (cm/sec). According to U.S. EPA document number 6000/8-90/003 "Basics of Pump and Treat Ground Water Remediation Technology" unfavorable conditions exist at the facility that would make ground water extraction through pump and treat technology unfeasible. Primarily, the hydraulic conductivity is considered too low to allow a sustainable yield from the aquifer for ground water extraction. If ground water extraction cannot maintain a sustainable yield, then containment of contaminated ground water cannot be assured.

A secondary unfavorable condition is the highly heterogeneous nature of the glacial till comprising the aquifer. Under heterogeneous conditions, ground water will flow more quickly through zones of higher hydraulic conductivity and more slowly through zones of lower hydraulic conductivity. This creates difficulty in estimating the long and short-term effectiveness of the ground water recovery system. Additionally, the overall length of time will be increased under heterogeneous conditions in comparison to a more homogenous aquifer system.

If the ground water recovery well alternative was considered to be a feasible remedial alternative, it is estimated that a minimum of 68 wells would be required to provide ground water capture in the source area and a hydraulic barrier to mitigate further contaminant migration from the source area. The wells would be of a large diameter (3 feet or greater) with an estimated radius of influence of 5 feet. These wells would be expected to perform more as sumps than as continuously pumping recovery wells. The wells would be placed on 10 foot centers parallel to ground water flow in the source area adjacent to the metal prep room. The wells would extend along the property boundary parallel to ground water flow until intersecting the southern property boundary, at which point wells would be extended 200 feet to the east along the southern property boundary perpendicular to ground water flow.

The hydraulic characteristics of the glacial till reduce the radius of influence of the recovery wells in comparison to more permeable materials such as sand and gravel, hence the large number of wells that would be required to maintain hydraulic control of ground water beneath the facility. In addition to the high number of recovery wells that would be required to maintain hydraulic control, an additional drawback to this alternative is potential damage to the aquifer formation.

Damage to the aquifer formation may occur during the installation of large diameter recovery wells. The aquifer is composed of fine clays and silts with interbedded sands and gravels. Ground water movement is most active in the sand areas of less permeability. During installation of wells in fine grained sediments, it is common to "smear" the borehole with the finer grained material forming a "mudcake." This mudcake would reduce the permeability of the sandy areas where the borehole intersects these zones of higher permeability. In a higher permeability formation, ground water entering the well would aid in removing the mudcake from the borehole during development. However, in low permeability formations, ground water is slow to recharge during development, and often the mudcake cannot be effectively removed, thus the overall potential yield of the well is reduced.

Desiccation is another potential concern that may occur if the aquifer is dewatered. Desiccation could result in reducing the present permeability of the aquifer to lower levels. If this occurs, the effective yield of the recovery wells would be further reduced.

3.4.5.2 Threshold criteria assessment

As detailed in Section 3.3.1.2, the Risk Assessment concluded that no complete ground water exposure pathway exists. General action objectives for cleanup goals are desirable and could be achieved through a ground water recovery system. However, a ground water recovery system would not be as effective as other alternatives in meeting the RAOs in terms of long-term effectiveness, permanence, and total cost.

A monitoring program would accompany this alternative and be used to determine the effectiveness of the ground water recovery system. The monitoring program would be used to determine if expansion of the ground water recovery well network would be required to maintain gradient control and contaminant capture. Institutional controls would also be included under this alternative.

3.4.5.3 Balancing criteria assessment

Long-term effectiveness and permanence: The time to achieve long-term effectiveness and permanence of this alternative is estimated to be 50 or more years due to the low permeability of the aquifer, the heterogeneities, and damage to the aquifer formation which could occur during the installation of the recovery wells. The ground water recovery system would result in capture of the contaminated ground water and disposal through treatment. Gradient control could not be assured due to lack of sustainable yield from the recovery well system. Permanence can be achieved under this alternative but would exceed the time required to meet permanence under other alternatives.

Implementability: Implementation of this alternative can be accomplished using local services and commercially available equipment. The technology is well documented and requires only site specific design criteria. Operational and maintenance expense is projected as high due to the amount of equipment and the long-term operational life of the system that would be required to meet the RAOs.

Short-term risks: This alternative would not effectively mitigate the short-term risk to human health due to the low sustainable yield and unpredictability of the heterogeneities within the aquifer to a ground water recovery system. Additionally, a large amount of contaminated drill cuttings would be produced, and off-site disposal would be required.

Total Cost: The cost of a ground water recovery system was based upon a minimum of 68 recovery wells and associated equipment. The estimated cost to implement this alternative is $3,707,700. This cost does not include ground water treatment. The costs associated with ground water treatment after recovery are included under Alternative 3.4.4.

3.4.6 Alternative 6 - Ground Water Collection Via SVE Dewatering and Two Treatment/Disposal Options

3.4.6.1 Description

This alternative would be a component of soil cleanup Alternative 8 - Dewatering Of The Site And Removal Of The VOC Contaminants By Use Of SVE as discussed in Section 3.5.6. Ground water collection would occur as a result of dewatering activities performed during the installation and operation of an SVE system. Ground water collected during the SVE activities would be pulled from the SVE wells and collected into below-grade holding tanks. These tanks would contain a system which would pump the collected ground water into a central storage tank pending treatment and discharge.

Contaminated ground water which is collected during the dewatering process could be treated on site via oxidation/reduction, air stripping or adsorption (using granular activated carbon), and disposed of to the storm sewer or to the local POTW.

3.4.6.2 Threshold criteria assessment

The cleanup goals considered under this alternative concern only soil and are discussed in Section 3.5.6.2. Contaminated ground water will be removed and treated under this alternative.

3.4.6.3 Balancing criteria assessment

Long-term effectiveness and permanence: The time to achieve long-term effectiveness and permanence of this alternative is estimated at 10 - 15 years due to the low yielding aquifer and the low permeability of the soils at the site. The removal of contaminant sources from the soils and maintaining a depressed water table by utilizing an SVE/dewatering system, will decrease or eliminate the impact to the ground water at the site.

Implementability: Implementation of this alternative can be accomplished using local services and commercially available equipment. The technology is well documented and requires only site specific design criteria.

Short-term risks: As dewatering activities are a component of soil cleanup Alternative 8 - Dewatering of the site and removal of the VOC contaminants by use of SVE, the short-term risks discussed in Section 3.5.6.3 would apply.

Total Cost: The cost of dewatering the site is included in the total cost summary for soil cleanup Alternative 8 - Dewatering of the site and removal of the VOC contaminants by use of SVE and is presented in Section 3.5.6.3.

3.5 SOILS

3.5.1 Alternative 1 - No Action

3.5.1.1 Description

Under this alternative, no remedial action would be undertaken to remediate the soils. The Risk Assessment (Section 1.5.1.1) concluded that direct exposure to contaminated soil for on-site workers or off-site residents is not expected to occur due to the large paved area present on site and the vegetation present in the open field south of the paved parking lot. In addition, while the potential exists for city workers to come into direct contact with soils in the ditches, exposure is not considered significant due to the low concentrations of constituents and the low frequency of exposure.

The cleanup goals considered for soil contamination at this site were summarized previously in Section 2.2.1 and consist of meeting levels below soil cleanup objectives in three areas of the site. Currently TCE and 1,2-DCE concentrations are above the identified cleanup goals. Therefore, this alternative will not comply with the RAOs.

3.5.1.2 Threshold criteria assessment

As discussed in Section 1.5.1.1 of this report, direct exposure to soils for on-site workers or off-site residents is not expected to occur due to the large paved area present on site and the vegetation present in the open field south of the paved parking lot. A very low potential exists for city workers to come into direct contact with soils in the ditches due to the extremely low concentrations of constituents detected in soils and sediments and the low frequency of exposure. There are no imminent risks presented by the in-place and undisturbed contaminated soils.

3.5.1.3 Balancing criteria assessment

Long-term effectiveness and permanence: The time to achieve long-term effectiveness and permanence of this alternative is not known. It is expected that the low levels of contaminants detected in the soil would to some extent, attenuate over time. This alternative would not reduce the mobility, toxicity, or volume of contaminants in the soil by treatment. Contaminants would be left in place, and concentrations would vary only as a result of natural attenuation processes and infiltration of surface water, such as those already occurring.

Implementability: Implementation of this alternative does not require any services or equipment.

Short-term risks: Since there are no imminent risks presented by the contaminated soils, this option would have no beneficial short-term effects on the environment. Ground water will continue to filter through contaminated soil zones.

Total cost: There are no costs associated with implementing this alternative. This alternative does not require any report preparation, sampling, or continuing operations and maintenance.

3.5.2 Alternative 2 - Institutional Controls

3.5.2.1 Description

Under this alternative, only institutional controls will be implemented to reduce exposure to the contaminated soil; no remedial action will be undertaken to remediate the soils. Two methods of controlling access to contaminated soils are deed restrictions and by restricting access by fencing off the contaminated areas.

A deed restriction is a negotiated addendum to an existing deed, which until removed, indicates that soils on the property are contaminated. This notifies the existing and subsequent property owners of the contaminated soils. This is a viable option for the Aro site.

Fencing is another possible way of controlling access to contaminated soils on the facility and two adjacent residential properties to the west. This method is most often used as a short-term solution (that is, restricting physical access) to contaminated soil problems because it stops only humans and larger animals from coming in contact with the soils. Small animals can usually bypass fences, and soils can still cause environmental problems.

The cleanup goals considered for soil contamination at this site were summarized previously in Section 2.2.1 and consist of meeting levels below soil cleanup objectives in three areas of the site. Currently TCE and 1,2-DCE concentrations are above the identified cleanup goals. Therefore, this alternative will not comply with the RAOs.

3.5.2.2 Threshold criteria assessment

As discussed in Section 1.5.1.1 of this report, direct exposure to soils for on-site workers or off-site residents is not expected to occur due to the large paved area present on site and the vegetation present in the open field south of the paved parking lot. A very low potential exists for city workers to come into direct contact with soils in the ditches due to the extremely low concentrations of constituents detected in soils and sediments and the low frequency of exposure. There are no imminent risks presented by the in-place and undisturbed contaminated soils.

3.5.2.3 Balancing criteria assessment

Long-term effectiveness and permanence: The time to achieve long-term effectiveness and permanence of this alternative is not known. It is expected that the low levels of contaminants detected in the soil would to some extent, attenuate over time. This alternative would not reduce the mobility, toxicity, or volume of contaminants in the soil by treatment. Contaminants would be left in place and concentrations would vary only as a result of natural attenuation processes and infiltration of surface water, such as those already occurring.

Implementability: Implementation of this alternative does not require any services or equipment.

Short-term risks: Since there are no imminent risks presented by the contaminated soils, this option would have no beneficial short-term effects on the environment. Ground water will continue to filter through contaminated soil zones.

Total cost: The estimated total cost of implementing this alternative is $34,300. This does not require any report preparation, sampling, or continuing operations and maintenance.

3.5.3 Alternative 3 - In Situ Soil Treatment

3.5.3.1 Description

The alternative evaluated in this section is the in situ treatment of contaminated soils at the facility. Under this alternative there are two potential scenarios. The first is that stabilization/solidification (s/s) agents would be injected, using shallow auger mixing equipment, into the soils to reduce the mobility of the soil contaminants. The second is to use the same mixing equipment to inject hot air into the soils to volatilize the organic contaminants. Both of these scenarios are considered innovative technologies by the EPA.

This process is being considered as a means to minimize the continued leaching of contaminants from the soils in the suspected source area or areas.

The general method of implementation is that heavy drilling equipment is mobilized to the site. Large augers, from 4 to 14 feet in diameter, are drilled into the soils. The s/s reagents and/or hot air is injected into the soils using a manifold system at the bottom of the auger.

Since the source material that would be treated is located immediately adjacent to the Aro building, pretreatment activities would include a geotechnical evaluation of the load bearing capability of the soils and the design of a shoring system to protect the building structure.

For s/s processes, the reagents typically include a pozzolonic material such as fly ash and portland cement mixed in a water slurry. Additives such as bentonite or specialty polymers are used to adsorb organics. Silicates and other materials can be added to enhance the binding of inorganics and to accelerate the curing process. These reagents are mixed in a hopper and pumped to the injection ports. Typical addition rates are 10 to 15 pounds of binding agents per 100 pounds of soil. Some s/s processes conducted under the EPA Superfund Innovative Technology Evaluation (SITE) Program have used up to 100 pounds of additives per 100 pounds of soil. Soil volume increases typically run from 15 to 25 percent, with some processes well over 100 percent. While this process has been successful for metals, reported results on volatile organics have been mixed. For this reason, initial efforts would entail pilot testing of the contaminated soils with several s/s reagents.

For evaluation of the technology, soil borings are collected before and after treatment and analyzed for total and leachable contaminants. Long-term performance of the solidified mass in reducing ground water contamination will be measured using the existing monitoring well MW-3.

Dusts and chemical releases during the mixing process would be captured and treated before the air is discharged. An air permit may be necessary prior to implementation.

For volatilization processes, air is heated and injected into the ports on the bottom of the mixing auger. As the soil temperatures rise, volatile organics are driven off with the air to the surface where they are collected and discharged through a carbon bed air pollution control system. While relatively new, according to one contractor, they have used this process to reduce TCE contamination by approximately 97 percent in a region with similar soil porosities and higher contaminant levels. Contaminants were reduced from approximately 300 to 500 mg/kg to levels under 15 mg/kg with three hours of air injection per hole. The contractor has observed that most of the reduction takes place during the initial agitation, with longer periods required to remove the lower concentrations from the soils.

Executing this alternative would require pilot testing to identify any potential concerns. An air permit may be necessary prior to implementation. In addition, shoring would be required to ensure building stability during the treatment process. Costs of shoring have been included in the cost evaluation along with evaluation costs for structural stability testing prior to processing. Underground utilities would be avoided where possible rather than being relocated in order to minimize processing costs.

3.5.3.2 Threshold criteria assessment

Stabilization/Solidification

For the s/s process, while total VOC levels are not significantly affected, results on some projects indicate leachable levels of TCE may be able to be reduced to under 700 μg/kg based on TCLP testing.

The risk assessment (Section 1.5.1.1) indicates that no complete exposure pathway for soils is present.

Soil treatment would be performed on a 60 foot by 60 foot area outside of the building adjacent to the metal prep room. This area was selected based on a review of boring information. A second smaller area around the former loading dock may also be treated, if necessary, depending on negotiated cleanup levels. The costs developed for this option assumes only the treatment of the area outside of the metal preparation room.

The solidification process would be expected to provide a highly impermeable (10^{-7} cm/sec) monolith. This monolith would provide a natural barrier for intruders or utility workers conducting any excavation activities in the area of contamination. Existing underground utilities in the area would need to be relocated, and no future utilities would be able to be installed in the treated area.

The s/s process, would cause a slight increase in soil volume which is estimated to result in at least a 20 inch rise in elevations for the treated soil column from the surface to the bedrock. Approximately 3 feet of soil would be removed from the surface following treatment and 2 feet of clean fill replaced to eliminate the mounding and provide a cover to the treated soils.

This treatment would be performed on a one-time basis, and results would be obtained by taking core samples before and after analysis. Based on the results of s/s processes on organics through the EPA SITE Program, there is no guarantee that the leachable concentrations of organics would be significantly reduced through this treatment process.

One concern of the s/s process is that contaminants in the soils are not removed and could potentially serve as a long-term threat to ground water. These soils could, to some extent, leach contaminants into the ground water after the source area or areas have been addressed. The s/s process is a potential method to reduce contaminant loading of the ground water.

Air emissions would be generated during the process and would be collected and treated to minimize any impact to neighbors. The process would be completed over a two to three month period, and the raw materials would not pose any health concerns.

Soil volatilization

For the soil volatilization process, total VOC contaminant levels could be expected to be reduced to 5 to 15 mg/kg or below, assuming an approximate four hour processing time per hole. This would allow two holes to be processed per 10 hour day, for a total treatment time of the 60 foot by 60 foot area of approximately three months.

Residual soil concentrations would be above NYSDEC Recommended Allowable Levels (RALs). For this reason, this option is not seen as a method to meet RALs. This option could be used in combination with the institutional controls scenario presented in Section 3.5.2.

The soil volatilization process would leave a more permeable zone which would then be more likely to absorb water and possibly transmit contaminants through preferential pathways. This would disturb the natural ground water flow in the area. If significant contamination levels were left in the soils, they could be effectively treated through a conventional pump and treat system with one or more wells located in the treated zone. Costs for a ground water collection system are not included in this option.

Treatment would be performed on a one-time basis. As with the in situ stabilization process, there would be a soil rise associated with the process, and a top layer of soils would need to be removed and the surface regraded. The actual amount of soil rise is highly dependant on site conditions. For cost estimation purposes, a 5 percent decrease in soil density was assumed, and an additional 6 inches of topsoil would be removed and replaced with clean soil.

Since this alternative would only address the soils outside of the metal preparation room, significant levels of contaminants would be left untreated under the building. As discussed in Section 1.4.2, it appears that ground water flowing through this area has been impacted, and consequently the ground water and soils in a large area under the building and to the southeast of the building under the parking lot have low level contamination. The removal of part but not all of this source material would reduce but not eliminate the impact to these soils and ground water.

Since the process would be completed over a two to three month period, and emissions would be collected and treated using a carbon filter system, it is reasonable to expect there would be no long-term health effects of the process on neighboring properties.

3.5.3.3 Balancing criteria assessment

Long-term effectiveness and permanence: As mentioned above, the s/s process reduces the leachability of the contaminants but does not remove them from the soil. While stabilization of inorganic contaminants in soils has been performed since the 1970s in England, the long-term effectiveness in isolating organics is unknown. For this reason, there would need to be institutional controls to prevent disruption of the stabilized mass. Slow leaching of organics into the ground water over an extensive period of time could be expected. Actual levels could be approximated based on leaching tests conducted in a laboratory using a synthetic ground water which would reflect the characteristics at the site. At one site in the EPA SITE Program, leachable levels of volatile organics in soil were reduced through s/s to below 700 μg/kg.

The long-term effectiveness and permanence of the soil mixing and ventilating system would be excellent in the area of treatment, since the majority of the contaminants would be removed. Since the natural permeability of the soils would be increased, a recovery well could be installed after treatment to capture and remove ground water in the region. Based on contractor experience at similar sites, highest residual levels of TCE in the treated soils could be in the range of 5 to 15 mg/kg. Based on a similar percentage reduction, the highest total levels of DCE could be reduced to 5 to 15 μg/kg.

For both scenarios, some soils would be removed to regrade the surface, a 6-inch layer of clean fill would be replaced on top of the treated area, and institutional controls would be needed to restrict access since soil contamination levels would remain above NYSDEC guidelines. Soils under the building and outside of the treatment area would remain as sources of future ground water contamination.

Implementability: Implementing either option would require addressing a number of issues, including: obtaining access to the neighboring property; conducting a geotechnical evaluation to design an effective shoring system, if needed; conducting pilot testing; performing significant testing before and after treatment; mobilizing heavy equipment which may require upgrading the access to the neighboring property; obtaining necessary permits, and addressing neighbor concerns. These items will affect the project schedule and increase the project cost.

Short-term risks: Although the soil mixing systems have integral capture systems to control and treat the air before it is released to the environment, there is the potential for releasing dusts and volatile compounds into the atmosphere.

The use of heavy equipment presents hazards typical of industrial activities. Access to the area would be controlled through the use of fencing.

Since their are no imminent risks presented by the contaminated soils, the option would have no beneficial short-term effects on the environment.

Total costs: The estimated total cost of stabilizing/solidifying a 60 foot by 60 foot section of contaminated soils outside of the metal preparation room and a small area surrounding MW-6 is $583,000. A breakdown of these costs is provided in Appendix A. This cost does not include the cost of any institutional controls or treatment of ground water identified in Section 3.5.2.

The estimated total cost of the in situ soil volatilization (ISV) system for the same areas described above is $987,000. A breakdown of these costs is provided in Appendix A. This cost does not include the cost of any institutional controls or treatment of ground water identified in Section 3.4 and Section 3.5.2.

3.5.4 Alternative 4 - Excavation of "Hot Spots" With Two Treatment/Disposal Options

3.5.4.1 Description

This alternative involves the removal of the accessible highly contaminated areas of soil as a means of source removal to facilitate remediation of the site by eliminating the major source of the soil and ground water contamination. Selective excavation would be performed based on contaminant action levels and accessibility of the contaminated soils.

This alternative considers excavating portions of four contaminated soil areas: two contaminated areas in the vicinity of the metals preparation room and near the former loading dock areas and two areas away from the buildings that have shown soil contamination, the first in the area of MW-18 and the second in the area joined by MW-6 and MW-19.

The procedure for remediation would be to remove the contaminated soils and to replace them with clean fill. The contaminated soils would be either shipped off site for treatment and disposal or would be treated on site by incineration and reused on site as backfill.

While removal of the source of contamination is generally desirable as a remediation measure, excavation of the "hot spots" on this site presents several technical and cost-related problems limiting the alternative as a viable choice.

From a technical perspective, a large portion of the contaminated areas of the site are located under active portions of facility buildings and are therefore inaccessible. Structural considerations pertaining to the excavation next to the building requires careful evaluation as well as the problems associated with excavating below the water table. Actual excavation would require extensive on-site screening to identify the precise limits of contamination (keeping excavated soil to a minimum). Additionally, health and safety considerations relating to the construction workers would have to be carefully evaluated.

The excavated soils would either be incinerated on site via a portable incinerator (and then reused as backfill on site) or disposed off site via a permitted RCRA facility. If disposed off site, the soils would be landfilled if levels are below the EPA's Land Disposal Restrictions (LDRs) or incinerated at an off-site RCRA facility and subsequently landfilled if they exceed the statutory limits for landfilling. This decision would be made on the basis of relative costs and availability of permits.

To avoid contaminating the clean fill soils via contaminated ground water after excavation activities, this alternative would require installation of a physical barrier to restrict the ground water flow. This would include an extension to the proposed ground water collection and treatment alternative to manage the ground water flow in the remediated areas.

The cost associated with on-site treatment or off-site disposal of excavated materials would be significant. Other major factors affecting cost include: 1) the need to support building foundations near the metal preparation room and the former loading dock area during excavation activities, and 2) excavation in materials below the water table would result in seepage into the excavation and will present material handling problems and require water treatment capabilities.

Furthermore, removal of the "hot spots" would not alter the need for a ground water collection and treatment system for other areas of the site as soils below the buildings would not be removed.

3.5.4.2 Threshold criteria assessment

The cleanup goals considered for this alternative would be determined by negotiations with the State. Since it will not be possible to excavate and remove all contaminated soils because a significant portion of them are under the building, the remediation parameter objectives would be limited to reducing the level of contamination in the ground water and reducing the period of remediation.

3.5.4.3 Balancing criteria assessment

Long-term effectiveness and performance: The long-term effectiveness of removing the accessible areas of contaminated soil is limited since significant quantities of similarly contaminated soils are under the building and would not be removed.

The remaining contaminated soils are upgradient from the areas that can be removed, and ground water would move through both of the contaminated areas and a portion of the remediated areas before being captured. Attempting to control the flow of the ground water with upgradient recovery wells is not believed to be viable because of the low permeability of the soils. This results in a very small capture zone for the recovery well.

The structural shoring would be left in place as a means to redirect the ground water flow so as to not recontaminate the remediated areas.

Implementability: The technologies for providing shoring, excavation, and effective ground water control during excavation are well known and can be done with readily available construction procedures and have been used on similar projects throughout the country. No new technologies or implementation procedures are required to implement this alternative.

Implementation would require addressing a number of issues including: obtaining access to the properties neighboring the site; conducting a geotechnical evaluation to design an effective shoring system; performing significant testing before and during excavation; mobilizing heavy equipment which may require upgrading the access to the neighboring property; obtaining necessary permits and addressing neighbor concerns; and construction of the ground water collection and treatment system.

Two source areas would be excavated immediately adjacent to the Aro building. Prior to implementation a geotechnical evaluation of the load bearing capability of the soils and the design of a shoring system to protect the building structure will have to be conducted.

Because of the need to manage the ground water that would be encountered during excavation, a ground water treatment system must be in place and operating prior to beginning the excavations. Also, prior to beginning excavation of the soils near the metal preparation room, a means of collecting ground water at the perimeter of the excavations must be installed to avoid the possibility of allowing ground water contamination to migrate further beyond the excavation and, thereby, increasing the area of contamination.

The effects of the physical interruption of the normal ground water migratory paths combined with the shoring and depression of the hydraulic head at the excavation would also need to be evaluated.

Short-term risks: The agitation and exposure of contaminated soils in conjunction with excavation would release dusts and volatile compounds into the atmosphere. Because of the locations selected for excavation, air emissions are believed to be a concern of this alternative, and an air permit may be necessary prior to implementation. Monitoring of the air emissions during excavation will be conducted to assure compliance with the applicable standards.

Because most of the construction zone would be within the areas of highest contamination, potential worker exposure during construction must be considered and monitored. All OSHA requirements will be enforced.

It is expected that shoring of the building would be required, and although a geotechnical analysis and design would be performed prior to implementation, there could be some risk to the building and to the occupants from movement or failure of the shoring system.

The use of heavy equipment presents hazards typical of industrial activities. Access to the area would be controlled through the use of fencing.

As noted in the assessment of exposure pathways identified in section 1.5.1.1, there are no imminent risks presented by the in-place and undisturbed contaminated soils. Therefore, the alternative of removing a portion of the contaminated soils would have no beneficial short-term effects on the environment.

Total cost: The cost to excavate and appropriately treat and dispose of the accessible contaminated soils is in the range of $4,400,000 if on-site incineration is possible to $13,330,000 if off-site treatment and disposal is required.

In addition, the following would still be required to remediate the site: an interceptor trench (at $437,000), separation of the ground water from the surface drainage and from the sanitary sewer system (at $245,000), and a ground water treatment system (at $252,000).

3.5.5 Alternative 7 - Cleanup of Soils in Conjunction With The Use of An Interceptor Trench

3.5.5.1 Description

This alternative would allow clean ground water to enter the contaminated areas and pass through contaminated soils removing the contaminants from the soil. The ground water contaminated by the soils would be subsequently intercepted, collected, and treated. The use of the interceptor trench for ground water collection is discussed in Section 3.4.4.

3.5.5.2 Threshold criteria assessment

The cleanup goals considered for soil contamination at this site will be determined through negotiation with the State.

3.5.5.3 Balancing criteria assessment

Long-term effectiveness and performance: The long-term effectiveness of cleaning the soil through ground water flushing is dependent upon maintaining control of the ground water flow through the contaminated soils and maintaining a means of intercepting, collecting, and removing the contaminated ground water from the soils.

Because of the relatively impermeable native soils, ground water flow across the site would be slow, and the timeframe for the remediation would be quite long. The long-term effectiveness of the interceptor trench in conjunction with ground water is discussed more fully in Section 3.4.4.

Implementability: Implementation would require installation of an interceptor trench, collecting the ground water from the contaminated soils, followed by the on-site treatment and discharge of the ground water that has passed though the contaminated soils. The effects of the physical interruption of the normal ground water movement and the depression of the hydraulic head at the excavation would be evaluated prior to implementation.

Implementation of the interceptor trench in conjunction with ground water is discussed more fully in Section 3.4.4.

Short-term risks: As noted in the assessment of exposure pathways identified in section 1.5.1.1, there are no imminent risks presented by the in-place and undisturbed contaminated soils. There are no other short-term risks associated with this alternative other than those associated with the installation of the interceptor trench.

Total Cost: There are no direct costs associated with this alternative. Cost associated with the installation of the interceptor trench are discussed in Section 3.4.4.

3.5.6 Alternative 8 - Dewatering Of The Site And The Removal Of The VOC Contaminants By Use Of SVE

3.5.6.1 Description

This alternative for the removal of the VOC contaminants by SVE requires that the contaminants have a high vapor pressure. This alternative also requires that the site can be dewatered and that the soil conditions at the site will allow for the passage of air through the dewatered soils.

Because of the low permeability of the soil due to the high content of silts and clays beneath the site, dewatering of the site would be very slow, but maintaining the dewatered area should not require removal and treatment of gross quantities of water. With the site dewatered, the SVE technologies, which may or may not include active introduction of air into the soil through air injection wells, can be applied to the site. Air fracturing of the soils may be required.

Ground water removed using this alternative would be treated or processed as required, and then discharged to either the POTW or to a permitted surface discharge.

Since a large portion of the contaminated areas are located under active portions of facility buildings, disruption to the activities within a part or all of the buildings to gain access to the contaminated soil areas for construction is part of this alternative. In a like manner, disruption to the normal activities within a part or all of the buildings during the operation of this alternative due to the physical interference of installed equipment is also a part of this alternative. Property devaluation from these activities is not known at this time and, therefore, is not included as part of the cost of this alternative. However, it is important to note that they are also a real cost of this alternative.

It is proposed that the contaminated soils excavated during construction of the shallow level piping trenches be used as backfill for the trenches. An alternative is to retain the soils in piles and treat them on site by SVE for use as fill material on the site. It is also proposed that the contaminated soils excavated during construction of the soil vapor and ground water extraction wells be retained in piles and treated on site by SVE for use as fill material on the site. The State has indicated that these contaminated soil management procedures will be acceptable, and that permitting, if required, is available. The alternatives to the proposed on-site treatment are off-site disposal via a permitted RCRA facility, or incineration. The soils could be landfilled if levels were below the EPA's LDRs. If soils were above the EPA's LDRs, they would be incinerated at an off-site RCRA facility and subsequently landfilled. This decision will be made on the basis of relative costs and availability of permits.

Another factor affecting cost is the excavation below the water table which may result in seepage into the excavation and could present material handling problems and would require water treatment capabilities to be installed prior to construction.

3.5.6.2 Threshold criteria assessment

The cleanup goals considered for soil contamination at this site will be determined by negotiation with the State.

3.5.6.3 Balancing criteria assessment

Long-term effectiveness and performance: The removal of the source from the soils will decrease the impact to the ground water crossing the site after remediation is completed.

Implementability: While the use of SVE in highly permeable soils is widely used, the technologies for implementing SVE in relatively impermeable soils is still in the developmental state. Therefore, it is also proposed that a pilot operation be tested at the site to assure the viability of this alternative as an effective remedial procedure.

The technologies for the installation of the SVE system and providing effective ground water control during installation are well known and may be performed with readily available construction procedures.

Implementation would require addressing a number of issues including: obtaining access to the properties neighboring to the site, performing significant testing before and during installation, mobilizing construction equipment, upgrading the access to the neighboring property, obtaining drilling equipment capable of drilling to the bedrock depths that can be used within the existing buildings, obtaining the necessary permits, and construction of a ground water collection and treatment system.

The general method of implementation for this alternative is that drilling and excavating equipment is mobilized to the site with the drilling equipment being used for the installation of the SVE wells and the excavating equipment being used to provide trenches for routing the piping necessary to operate a SVE system. Soils that are excavated and require treatment will be loaded into trucks for transport to an on-site staging and treatment area or to an off-site facility for treatment and or disposal. Other construction equipment and trade disciplines will also be required for the construction of the ground water treatment system.

To manage the ground water that will be encountered during construction activities, a ground water treatment system must be in place and operating prior to beginning the construction.

The effects of the physical interruption of the normal ground water migratory paths and the depression of the hydraulic head at the remediation area will also need to be evaluated prior to implementation.

Short-term risks: The agitation and exposure of contaminated soils during the construction would release dusts and low level volatile compounds into the atmosphere. Monitoring of the air emissions during installation would be conducted to assure compliance with the applicable standards.

Because much of the construction zone would be within the areas of highest contamination, potential worker exposure during construction will be monitored. All OSHA requirements would be enforced.

The use of mechanical equipment presents hazards typical of construction activities. Access to the area would be controlled by fencing the affected areas.

As noted in the assessment of exposure pathways of Section 1.5.1.1, there are no imminent risks presented by the in-place and undisturbed contaminated soils. The removal of some contaminated soils during construction would have no beneficial short-term effects on the environment.

Total Cost: Based on the available site information, the cost to design and construct a SVE system is estimated at $544,000. A cost not included in this amount is for a pilot system to assure the viability of this alternative and is estimated at $60,000. Both of these costs are based on the ability to treat the contaminated soils generated during construction activities on site using SVE technology. The NYSDEC has indicated that this on-site soil treatment procedure would be acceptable.

Operating and maintenance costs for the SVE system are estimated at $28,800 a year. Costs for a duration of ten years are $288,000. In addition, a ground water treatment system, at an estimated cost of $252,000, will most likely be required to treat the removed ground water. Operating and maintenance costs for the water treatment system are estimated at $71,700 per year, for a system duration of ten years at a total cost of $717,000. It is important to note, that ground water treatment may not be necessary following the initial dewatering activities. Continued ground water treatment will be dependent upon the quality of the ground water infiltrating the capture zone while the depressed water table is maintained.

The total cost for implementing and maintaining this alternative for a ten-year period (including operation and maintenance of the water treatment system) is estimated to be $1,861,000. An increase in this cost may occur if it is necessary to treat and dispose of contaminated soils off site that have been removed during construction activities . These additional disposal and treatment costs are estimated to be in the range of $1,860,000.

3.6 SURFACE WATER

3.6.1 Alternative 1 - No Action

3.6.1.1 Description

Under this alternative, no specific actions would be taken for surface water contamination. The contaminated surface water at the site would be left in its current condition, and any changes would be a direct effect of soil or ground water remediation and natural processes, such as biological/chemical/physical degradation, adsorption, desorption, and dispersion. A surface water monitoring program would be implemented to assess variations in the surface water contaminant concentrations. The monitoring program would consist of sampling the surface water at selected locations. Samples would be collected and analyzed for volatile organics (EPA Method 8240) on a quarterly basis for the first year followed by semiannual monitoring. Surface water sample results would be compared to proposed cleanup values and standards to assess natural attenuation. The sampling duration is assumed to be for a period of five years for cost estimating purposes. Longer term sampling will be established by a monitoring plan developed upon implementation of this alternative. With proper training, sample collection activities could be performed by facility personnel.

This alternative would require the development of a SAP. The SAP would provide detailed methodology for sample collection, handling, and shipment. The SAP would also reference the appropriate laboratory methods and would provide quality assurance requirements for the sampling effort. The SAP would be based on standard sampling practices currently used by the NYSDEC and outlined in EPA protocols SW-846.

In addition to the SAP, surface water monitoring reports will be prepared to accompany the analytical data. The surface water monitoring reports would discuss deviations from the SAP, note any problems encountered, summarize the analytical data, and present conclusions drawn from the data.

3.6.1.2 Threshold criteria assessment.

The Risk Assessment (Section 1.5.1.1) concluded that a possible complete exposure pathway for surface water is present. Ground water discharging to the south-flowing culvert beneath the employee parking lot enters the south-flowing drainage ditch at the end of the parking lot. Some constituents have been detected in the surface water samples collected at the site. There is unrestricted access to the on-site open field area, so a potential exists for access by off-site personnel. The tall grasses and wet soil conditions make any exposure unlikely, and trespassers have not been observed by field personnel or the Aro site manager. Potential exposure to utility workers is possible but is also unlikely to occur due to protection by standard work clothes and boots. Therefore, no unacceptable human health risks exist under the current use scenario.

The surface water monitoring program would allow an evaluation of changes in surface water quality. Consequently, if contaminant levels were to increase, a contingency plan would be implemented.

The remedial investigation has shown that surface water leaving the site was only contaminated with TCE and 1,2-DCE. Only TCE exceeded New York State Surface Water Standards for Class D waters (that is, the drainage ditch leaving the site). The surface water RAO is to reduce the concentration of TCE leaving the site to less than 11 μg/l (the New York State Surface Water Standard for Class D waters).

Therefore, this alternative will not initially comply with the RAOs. However, in the future, through ground water and soil remediation and natural attenuation processes, the contaminant levels detected to date may be reduced to negotiated cleanup goals. The surface water monitoring program would detect any changes in surface water quality and assess the effectiveness of this alternative.

3.6.1.3 Balancing criteria assessment

Long-term effectiveness and permanence: The time to achieve long-term effectiveness and permanence of this alternative is not known. It is expected that the low levels of contaminants detected in the surface water, would be positively impacted by ground water and soil remediation performed at the site, and would, to some extent, attenuate over time. This alternative would not reduce the mobility, toxicity, or volume of contaminants in the surface water by treatment. Contaminants would be left in place, and concentrations would vary only as a result of other site remediation activities and natural attenuation processes.

Implementability: Implementation of this alternative can be accomplished using local services and commercial equipment. Sampling would be performed in the same manner as was done during the remedial investigation. Analyses would be performed as specified in the SAP developed for the site.

Short-term risks: This alternative would effectively protect human health and the environment over a short-term period. No threats are posed by the current surface water contaminant levels and site usage, and contaminant levels are not expected to increase in the future as discussed in Section 1.5.1.1.

Total cost: The estimated total cost of implementing this alternative is $67,000. This cost covers the preparation of the SAP and surface water monitoring reports, surface water sample collection, and analytical services for sampling every three months over a five-year period.

3.6.2 Alternative 2 and 3 - Separation of Uncontaminated Storm/Surface Water and Ground Water to Avoid Contamination of the Storm/Surface Water

3.6.2.1 Description

This alternative combines Alternative 2 (Lining of storm sewer and sanitary sewer ditches) and Alternative 3 (Collection of influent ground water from sewer backfills with two treatment/disposal alternatives) as listed in Section 2.5 (Evaluation of Technologies and Preliminary Selection of Alternatives). In considering the two alternatives, it became evident that the objectives of controlling the separation of the ground water from the sanitary sewer water and from the storm/surface water was best met by combining the two alternatives.

This alternative involves the following:

- Assure the integrity of the sanitary sewer drain line, and if required, reconstruct the sanitary sewer drain line to prevent infiltration of ground water into the sanitary sewer line.

- Assure the integrity of the storm sewer drain line, and if required, reconstruct the storm sewer drain line to prevent infiltration of ground water into the storm sewer line.

- Install a perforated pipe alongside the sanitary and storm water drain lines to collect and remove ground water from around the areas of the sanitary and storm sewer pipeline. This line will drain this collected ground water to a sump where it will be pumped to a ground water treatment system to remediate the contaminated ground water.

- Construct a lined storm/surface water ditch from the area of the storm sewer pipeline outfall, across the property (across the area of contaminated ground water) to beyond the area of contaminated ground water, to prevent the infiltration of ground water into the storm/surface water ditch. (Contaminated ground water infiltrating into the storm/surface water ditch would otherwise be carried off site via the ditch.)

- Assure that no infiltration can take place in the area of the lined ditch by installing a perforated pipe immediately adjacent to the lined ditch to collect and remove ground water from around the areas of the lined ditch to eliminate any positive hydraulic head from the ground water to the lined ditch. This perforated pipe will drain the collected ground water to a sump where it will be pumped to a ground water treatment system to remediate the contaminated ground water.

This alternative provides both separation and containment of the three water streams and provides for the treatment of the ground water, if required. The main advantage is that the environmental risks of potentially contaminating the surface water and potentially spreading the contamination (via the movement of the surface water) are greatly reduced or eliminated, while providing for containment of any potential contaminants on site and (if necessary) treating them with other ground water collected from the site.

This alternative is desirable because it provides for control of the source for potential contamination and avoids the need to treat large volumes of potentially low level contaminated material.

This alternative can be done with readily available construction procedures; no new technologies or implementation procedures are required.

The success of using this alternative can be easily evaluated by periodic sampling and analysis of the storm/surface waters exiting the site.

3.6.2.2 Threshold criteria assessment

The cleanup goals considered for ground water contamination at this site were summarized previously in Section 2.2.2 and consist of meeting the ground water RAOs of: TCE ≤ 5 μg/l; 1,2-DCE ≤ 5 μg/l; vinyl chloride ≤ 2 μg/l; 1,1-DCE ≤ 5 μg/l; 1,1,2-TCA ≤ 5 μg/l; benzene ≤ 0.7 μg/l; and total phenols ≤ 1 μg/l.

Maintaining separation of the three water streams will effectively eliminate contamination in the surface water runoff.

3.6.2.3 Balancing criteria assessment

Long-term effectiveness and performance: The long-term effectiveness of controlling the surface water depends on maintaining the integrity of the physical barriers separating the three water streams and/or maintaining the hydraulic gradient separation of the ground water from the two sewer lines.

Implementability: The technologies for providing pipelines and lined ditches with the needed integrity control for eliminating infiltration are well known and used in normal construction practices throughout the country, including the local areas around the site. The integrity of the existing piping system can be evaluated by visual observation and by the use of a camera in the pipe portions of the system.

If the existing sanitary sewer pipe and manhole system is believed to be in good condition, and if the existing storm sewer pipe and manhole system is believed to be in good condition, then only the piping for the collection of ground water from around the areas of the sanitary and storm sewer pipeline needs to be installed along the existing sewer lines.

The technologies for controlling the hydraulic gradient on the pipeline and the lined ditch by dewatering the horizontal area adjacent to the pipe line and the lined ditch are well known and demonstrated by local area dewatering projects and are applicable to this site since the dewatering collection pipes are placed in relatively permeable soils used as backfill in the construction of both the pipeline and the lined ditch.

Also, because most of the construction zone is outside of the areas of highest contamination, potential worker exposure during construction is reduced.

Short-term risks: The exposure pathways expected during construction are not expected to increase over the exposure pathways identified in Section 1.5.1.1. Risks associated with exposure to ground water through construction will be minimized through the use of standard construction procedures designed to minimize these risks.

This alternative would effectively protect human health and the environment in the short-term. Hydraulic gradient control would prevent further migration of contaminants.

Monitoring of the air emissions during installation will be conducted to assure compliance with the applicable standards, but air emissions are not believed to be a concern of this alternative.

Total cost: The cost to construct the ground water collection (dewatering) pipe along the storm/sanitary sewer pipeline to eliminate any positive hydraulic head from the ground water to the storm/sanitary sewer pipeline, and (if required) to re-construct the storm/sanitary sewer drain lines to prevent infiltration of ground water into the storm/sanitary sewer line is estimated at $63,700 to $90,000, depending on the integrity of the existing drain pipes.

The cost to construct a lined storm/surface water ditch through the area of contaminated ground water to prevent infiltration of ground water into the storm/surface water that will be transported by the ditch and the construction of dewatering pipes in the area immediately adjacent to the lined ditch to eliminate any positive hydraulic head from the ground water to the lined ditch is estimated at $56,100.

An allowance of $35,000 for the additional cost to construct piping to transport the collected ground water to a ground water treatment system is provided in this assessment because the method for treatment or discharge is not known.

The estimated cost to construct the complete system for separating ground water from the sanitary/storm/surface water, with ancillary sumps, pumps, controls, engineering, and so forth, is estimated at $245,200.

If required, the cost of treating the collected ground water by air stripping and/or carbon adsorption is estimated at $252,000. See Appendix A for a cost breakdown on the implementation of the ground water treatment system.

4.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

4.1 SUMMARY

The report was prepared to develop and evaluate remedial action alternatives for the Aro site in Buffalo, New York.

Results of the remedial investigation indicate there are low levels of soil and ground water contamination at the site and on the two western neighboring properties. At the site, TCE and DCE were detected in soils and ground water at levels above the MCLs. An evaluation of the geology and hydrogeology at the site indicated that migration to potential receptors is limited by slow ground water flow, sorption to organic materials, and ground water flow direction. A baseline risk assessment at the site indicates minimal risks are posed to human health or the environment by the site conditions.

Based on the findings of the remedial investigation, this feasibility study developed a range of remedial action alternatives for ground water, soil, and surface water at the site and evaluated these alternatives in accordance with CERCLA guidelines. A preferred alternative for each media at the site will be used in the development of a remedial plan for each site.

The remedial action objective is to restore all presently contaminated materials to a state that will preclude future degradation of currently clean ground water outside the area of contamination.

Based on the RAOs, general response actions were developed for soil, ground water, and surface water. General response actions are those actions taken that will satisfy the remedial action objectives. The general response actions are as follows:

- No action
- Institutional controls
- Source controls
- Removal and disposal
- Treatment

4.2 CONCLUSIONS

Several technology types and process options were identified and screened. Screening of technology types/process options were based on an evaluation of their effectiveness in meeting the remedial action objectives. Remedial action alternatives were developed from those technologies which passed technology screening. Consequently these alternatives were further evaluated and alternatives for detailed analysis chosen. At this point, all alternatives for the site were eliminated except the following:

Soil

- No Action
- Institutional Controls
    - Fencing
    - Deed restrictions
- Containment
    - In situ treatment of "hot spots"
- Excavation
    - Excavation of "hot spots"
    - Excavation of all contaminated soils
- SVE
    - In situ treatment
    - Ex situ treatment of construction soils

Ground Water

- No Action
- Institutional Controls
    - Deed restrictions
    - Ground water monitoring
- Collection
    - Interceptor trench
- Collection and Treatment as part of SVE
    - Collection by dewatering for the SVE, source removal by SVE
- In situ treatment
    - Oxidation/reduction with "permeable reactive wall"

Surface Water

- No Action

- Providing separation of sanitary/storm/surface water and ground water to avoid contamination of the sanitary/storm/surface water

- Collection and removal of contamination source as part of SVE
  - Collection by dewatering, source removal by SVE

Community acceptance: Following the NYSDEC review and approval of the feasibility study, the community will have the opportunity to review and comment on each selected treatment alternative.

4.3 RECOMMENDATIONS

A review and comparison of the threshold criteria assessments and balancing criteria assessments for the alternatives was made to determine which technologies would provide an effective means of addressing each of the site's contaminated media.

Based on the assessment of technologies, Alternative 8 - Dewatering of the site and the removal of the VOC contaminants by use of SVE (Section 2.5.1.8) is potentially the most feasible (without removing the building) for this site. However, prior to committing to a full scale system, the suitability of utilizing a SVE technology will be determined through a pilot study. Therefore, the recommendation is that the suitability and capability of SVE be tested on the site by the implementation of a pilot scale test, and that the final determination as to whether SVE is the alternative of choice be determined after the pilot operation results are evaluated.

The rationale for selecting a SVE system (including the dewatering of the site) to address both the soil and the ground water contamination is:

- The majority of soil contamination is between 12 feet and 24 feet in depth. Accessing the contamination zones does not require removal of other soils.

- The majority of the soil contamination is beneath the building. SVE can be implemented without requiring the removal of the building.

- SVE will have less impact on the facility business operations than most other alternatives. While implementing a SVE system would significantly disrupt use of portions of the building, the interruption would not be permanent and would not have as significant an impact to the business operation and facility building integrity as would addressing contaminated soils by the other alternatives.

- Dewatering the site to enable use of SVE will provide a means to collect contaminated ground water for on-site treatment.

- Because of the low permeability of the soil, dewatering of the site would be very slow but should also assist in maintaining the dewatered area without requiring the continued removal and treatment of gross quantities of water.

- The feasibility of SVE can be verified by operation of a pilot scale system without causing additional contamination to the site.

- Dewatering the site will significantly restrict the contaminant migration via ground water.

- The potential for an increase in the levels of contaminants now and in the future is considered low due to the fact that facility vapor degreasing activities have been modified to prevent future releases.

- Currently there are no water-supply wells on site or the neighboring properties that will be affected by dewatering of the site.

- Exposure to ground water beneath the Aro facility is unlikely to occur for on-site workers, utility workers, or off-site residents.

- All drinking and process water for the Aro facility is received through the city water supply.

- A restriction will be placed on the deed to the facility notifying the existing and subsequent property owners of the contaminated soils.

- Costs of other alternatives and their effectiveness do not justify their implementation.

Alternative:

If the results of the SVE pilot operation determine that SVE technology is not viable for this site, the following alternatives are recommended for this site:

- The use of institutional controls is selected to address soil contamination.
- The interceptor trench alternative with well permitting restrictions is selected to address ground water contamination.

- A modified interceptor trench strategically placed adjacent to the sanitary/storm sewer backfill is proposed to prevent contamination of surface water in the storm water ditches.

Soil:

The rationale for selecting institutional controls to address soil contamination is:

- The potential for an increase in the levels of contaminants now and in the future is considered low due to the fact that facility vapor degreasing activities have been modified to prevent future releases.
- Direct exposure to soils for on-site workers or off-site residents is not expected to occur due to the large paved area present on site and the vegetation present in the open field south of the paved parking lot.
- The majority of soil contamination is between 12 feet and 24 feet in depth.
- The majority of soil contamination is beneath the building. Addressing contaminated soils by the other alternatives considered would significantly impact the business operation and facility building integrity.
- A deed restriction will be placed on the deed to the facility notifying the existing and subsequent property owners of the contaminated soils.
- Costs of other alternatives and their effectiveness do not justify their implementation.

Ground Water/Surface Water:

The rationale for selecting an interceptor trench to address ground water and surface water contamination and placing well permitting restrictions on the affected properties is:

- It will effectively control the contaminant migration.
- It will provide a means to collect contaminated ground water for on-site treatment.
- It will not impact the facility business operations.
- The potential for an increase in the levels of contaminants now and in the future is considered low, due to the fact that facility vapor degreasing activities have been modified to prevent future releases.

- Currently there are no water-supply wells on site or on the neighboring properties.
- Exposure to ground water beneath the Aro facility is unlikely to occur for on-site workers, utility workers or off-site residents.
- All drinking and process water for the Aro facility is received through the city water supply.

5.0 CONCEPTUAL DESIGN

5.1 INTRODUCTION

This section includes the conceptual design of the recommended remedial action plan for the Aro site. Two technological alternatives are proposed for remediating the site:

- The preferred alternative proposes SVE, a technology that has not been field tested in the soils found at the site, and there is a possibility that this alternative can not achieve the required operating parameters. Per the recommendation in Section 4.3, a pilot study to evaluate the feasibility of SVE technology for this site will be performed. The SVE pilot study will determine if a full scale SVE system will be effective at the Aro site.

- In the event that SVE technology is not effective, it is proposed that an interceptor trench to capture and treat all of the contaminated ground water be installed as recommended in Section 4.3, and as discussed in Alternative 4, in Section 3.4.4.

Both of the conceptual designs have been developed in accordance with EPA, CERCLA, and NYSDEC guidelines.

The preferred alternative consists of: a series of area dewatering wells strategically positioned to remove the ground water from the contamination area, a series of SVE wells placed within the dewatered area to remove the contaminants from the soil, and an on-site treatment system for the contaminated ground water removed from the site.

Located in Appendix B, are the conceptual design figures and process flow diagrams. A description of required equipment, materials of construction, potential construction problems, discussion of permit, additional engineering data requirements, and access/right-of-way requirements are discussed in Section 5.2. Implementation, annual operation, and maintenance cost estimates are presented in Appendix B. Items in Section 5.2 include the following :

- Description of recommended remedial action
- Description of plan requirements
- Implementation schedule

The second choice alternative consists of: institutional controls to address soil contamination, an interceptor trench alternative with well permitting restrictions to address ground water contamination, a modified interceptor trench strategically placed adjacent to the sanitary/storm sewer backfill proposed to prevent contamination of surface water in the storm water ditches, and an on-site treatment system for the contaminated ground water removed from the site.

Located in Appendix B are the conceptual design figures and process flow diagrams. A general description of equipment, construction materials, potential construction problems, discussion of permit, additional engineering data requirements, and access/right-of-way requirements are discussed in Section 5.3. Capital costs, annual operation, and maintenance cost estimates are presented in Appendix A--Soil Alternative 8. Items in Section 5.3 include the following :

- Description of recommended remedial action
- Description of plan requirements
- Implementation schedule

5.2 DESCRIPTION OF PREFERRED REMEDIAL ACTION

The proposed preferred remedial action involves the following items: a series of area dewatering wells strategically positioned to remove the ground water from the contamination area, a series of SVE wells placed within the dewatered area to remove the contaminants from the soil; vacuum and pressure pumps to remove vapor from the soils; and an on-site treatment system (if necessary) for the ground water removed from the site.

The remedial system proposed for this site will prevent contaminant migration, remove the contamination from the ground water, and remove the contamination from the soil. This would be performed by the following:

- The selected remediation system would effectively dewater the contaminated areas. By removing the ground water and maintaining a depressed water table, further migration of the contamination will be prevented.

- The dewatering system will continue to operate throughout the operation of the SVE system to maintain the dewatered area and to control and remove percolating and infiltrating water at the site.

- A series of SVE wells will be placed within the dewatered area to remove the contaminants from the soil. These wells will be connected to vacuum and air pressure pumps to move air through the soils and remove the VOCs as vapors.

- The contaminated ground water, percolating water, infiltrating water, and condensate collected by these systems would be treated on site and appropriately discharged.

Surface Water

Dewatering of the soils adjacent to the storm and sanitary sewer lines will eliminate the potential for contaminated ground water to enter either of these sewer lines or from entering the surface drainage. However, consideration must now be given to these drainage lines as potential sources to the SVE system. These areas must be evaluated, as follows:

- Within the dewatered areas, the integrity of the sanitary sewer drain line system will be evaluated to prevent exfiltration from the sanitary sewer line to the ground water in the dewatered areas. (This may require reconstruction work.)

- Within the dewatered areas, the integrity of the storm sewer drain line system will be evaluated to prevent exfiltration from the storm sewer line to the ground water in the dewatered areas. Although this storm water would be removed by the dewatering system, this storm water may not be substantially different than surface water that may percolate into the dewatered area. (This may require reconstruction work.)

- The potential of water from the storm/surface water ditch infiltrating into the ground water will be evaluated. If necessary, a lined storm/surface water ditch across the dewatered area will be installed to prevent water from the storm/surface water ditch to infiltrate into the ground water.

- Ground water collected from the dewatered areas would be treated on site and appropriately discharged. The potential of problems in the treatment system as a result of leakages from the sewer systems will be evaluated.

These measures will provide for the separation and containment of the three water streams and provide for the collection of ground water for treatment, if required. The environmental risks of potentially impacting the surface water or of contaminant migration (via the movement of the surface water) are greatly reduced or eliminated by dewatering of the area.

Removal of the contamination source areas will greatly reduce or eliminate the environmental risks of potentially impacting the surface water or of contaminant migration (via the movement of the surface water) after remediation is completed.

Upon approval of this plan, specifications for evaluating the integrity of the existing sewer lines will be prepared, and if required, for the design and construction of a water separation system. All designs will be submitted to the state for approval prior to construction.

Ground Water

The proposed SVE system will be designed to remove the contaminated ground water and intercept ground water entering the dewatered area, thereby preventing further impact of the ground water and contaminant migration.

Pending the results from the pilot study and following NYSDEC approval, specifications for the design and construction of a SVE/dewatering system will be prepared.

The area to be dewatered is shown on Figure 8 and includes the area having ground water concentrations of TCE of 1,000 parts per billion (ppb) or greater. Extraction wells capable of removing ground water to the bedrock level will be installed across the entire zone. Additional extraction wells will also be installed along the perimeter of the area to limit infiltration of ground water into the dewatered area.

During the initial dewatering activities, collected ground water will be pumped to the surface for treatment and appropriate disposal. Following the initial dewatering activities, it may be possible to intercept ground water infiltrating into the contaminated area prior to any impact. Dependant upon the infiltrating ground water quality, the infiltrated ground water collected could potentially be discharged without treatment.

Soil

Pending the results from the pilot study and following NYSDEC approval, specifications for the design and construction of a SVE/dewatering system will be prepared.

The area where a SVE/dewatering system will be utilized is shown on Figure 8 and includes the area having ground water concentrations of TCE of 1,000 ppb or greater. The decision to introduce air to augment air movement through the soil will be based upon information generated during the pilot SVE pilot study and on conditions identified during construction.

It is estimated that approximately 167 SVE wells will be required, however, the actual number of wells necessary will be based on parameters determined during the SVE pilot study and on conditions identified during construction.

Condensate and ground water collected in conjunction with the operation of the SVE wells will be collected for treatment and appropriate disposal.

The cleanup goals considered for this remedial system will be determined through negotiations with the State. Since it will not be possible to remove all of the contaminants from the soils, the remediation parameter objectives could be limited to reducing the level of contamination in the ground water. Some guidance parameters for determining the capability of this system will be determined during the SVE pilot study and on conditions identified during construction.

Contaminated Water Treatment

Any remedial action system for the site would most likely require some treatment of the contaminated ground water that is collected. Actual treatment requirements are unknown at this time and will be determined in the future by permit requirements and actual ground water contaminant levels identified from within the implemented remediation system.

It is proposed that ground water contaminants be removed by air stripping and/or carbon adsorption. The processes for removal of the ground water contaminants identified at the site by air stripping and/or carbon adsorption are well known and used in every day practices throughout the country. Upon selection and approval of a remedial action system, specifications for the design and construction of the ground water treatment system will be prepared and submitted to the NYSDEC for approval prior to implementation.

The proposed treatment system is diagrammed in Appendix B--Figure B.3 and would include tankage to provide balanced flow to an air stripper and, if required, a carbon adsorption system with the appropriate tankage to provide a balanced flow to the carbon adsorption vessels. The system will include all necessary pumps, piping, control systems, safety systems, containment, and compliance testing capabilities, as required.

It is expected that the treated water will be discharged to the local POTW or to surface water under a NPDES permit. Negotiations with the appropriate agencies to secure discharge permits for the treated water will begin with the NYSDEC approval of the remedial action plan.

Air emission requirements for the operation of the ground water treatment system will also be evaluated following NYSDEC approval of the remedial action plan.

5.3 DESCRIPTION OF ALTERNATIVE REMEDIAL ACTION

In the event that SVE technology is not viable at the site, the alternative remedial action proposed involves the following items: limited action with deed restrictions for soils, installation of an intercepter trench, well permitting restrictions for ground water, and control and separation of storm/surface water from ground water.

The alternative remedial system would be designed to remove the contamination from the ground water and to prevent contaminant migration. This would be performed by the following:

- A system for collecting the contaminated ground water from along the sanitary/storm sewer backfill culvert and from storm/surface water bedding material would be installed as the bedding material may be providing a preferential pathway for ground water movement.

- An interceptor trench would be installed along the southern and western boundaries of the contamination area to collect the contaminated ground water and to control contaminant migration.

- The contaminated ground water collected by these systems would be treated on site and appropriately discharged.

Surface Water

The proposed alternate remedial system would also include the separation of ground water from the sanitary sewer drainage and from the storm/surface water drainage.

This alternative involves the following:

- Assure the integrity of the sanitary sewer drain line system. This may include reconstruction work.

- Assure the integrity of the storm sewer drain line system to prevent infiltration of ground water into the storm sewer line. This may include reconstruction work.

- Assure that no infiltration into the sanitary sewer drain line system or into the storm sewer drain line system can take place. A system for the collection and removal of ground water from the areas along the sanitary and storm sewer pipelines will be installed.

- Construct a lined storm/surface water ditch across the area of contaminated ground water to prevent the infiltration of ground water into the storm/surface water ditch which will prevent contaminated water from being transported off site via the storm/surface water ditch.

- Assure that no infiltration can take place in the area of the lined ditch. A system for the collection and removal of ground water from the area immediately adjacent to the lined ditch will be installed.

These measures would provide the separation and containment of the three water streams and provide for the collection of ground water for treatment, if required. The environmental risks of potentially impacting the surface water or of contaminant migration (via the movement of the surface water) are greatly reduced or eliminated by this work while also providing for containment of any potential contaminants on site and (if necessary) treating them with other ground water collected from the site.

Upon approval of the alternative remedial action plan, specifications for evaluating the integrity of the existing sewer lines and for the design and construction of the water separation system will be prepared.

Ground Water

The alternative remedial system will consist of a trench designed to intercept the contaminated ground water plume to prevent further contaminant migration. Specifications for the design and construction of the interceptor trench system will be prepared and approved by the NYSDEC prior to construction.

The interceptor trench would be installed from 18 inches below ground surface to the bedrock (or as close to the bedrock as it is possible to construct), approximately 24 feet below ground surface. The trench would be placed as shown in Appendix B--Figure B.1 and provide for ground water capture/control over an area as shown in Figure 4. A general cross section of the interceptor trench is shown in Appendix B--Figure B.2 with the trench being 10 to 12 inches in width and using 1/4-inch to 1/2-inch diameter gravel or stone (with less than 2 percent fines) as the permeable medium. A perforated pipe will be placed in the bottom of the trench to collect accumulated ground water and to transport the ground water to a sump (or sumps) where it will be pumped to the surface for treatment and appropriate disposal.

The number of collection sumps necessary will be determined in the field during construction and will be based on two criteria. First is the amount of water that will be captured by the trench and, secondly, the impact of ground water movement for collection purposes at locations where the direction of the trench changed.

As shown in Appendix B--Figure B.1, the interceptor trench would be placed such that the existing monitoring wells MW-9, MW-8, MW-16, MW-7, and MW-21 are on the downgradiant side of the interceptor trench and can be used to monitor the performance of the interceptor trench. The existing monitoring wells MW-15, MW-3, MW-3R, MW-10, MW-2, MW-20, MW-14, and MW-14R would be on the upgradiant side of the interceptor trench and continue to be used to monitor the ground water quality at the site.

A zone approximately 18-inch thick from the top of the interceptor trench to grade would be filled and covered with a bentonite clay cap and seeded top soil. This would prevent surface water infiltration into the interceptor trench system. The exclusion of storm water from the trench would avoid processing the storm water through the ground water treatment system.

Contaminated Water Treatment

Any remedial action system for the site would most likely require some treatment of the contaminated ground water that is collected. Actual treatment requirements are unknown at this time and will be determined in the future by permit requirements and actual ground water contaminant levels identified from within the implemented remediation system.

It is proposed that ground water contaminants be removed by air stripping and/or carbon adsorption. The processes for removal of the ground water contaminants identified at the site by air stripping and/or carbon adsorption are well known and used in every day practices throughout the country. Upon selection and approval of a remedial action system, specifications for the design and construction of the ground water treatment system will be prepared and submitted to the NYSDEC for approval prior to implementation.

The proposed treatment system for this site is diagrammed in Appendix B--Figure B.3 and would include tankage to provide balanced flow to an air stripper and, if required, a carbon adsorption system with the appropriate tankage to provide a balanced flow to the carbon adsorption vessels. The system will include all necessary pumps, piping, control systems, safety systems, containment, and compliance testing capabilities as required.

It is expected that the treated water will be discharged to the local POTW or to surface water under a NPDES permit. Negotiations with the appropriate agencies to secure discharge permits for the treated water will begin with the NYSDEC approval of the remedial action plan.

Air emission requirements for the operation of the ground water treatment system will also be evaluated following the NYSDEC approval of the remedial action plan.

5.4 IMPLEMENTATION SCHEDULE

Upon NYSDEC acceptance of the proposed remedial action plan, engineering designs, and construction specifications for a SVE pilot operation will be prepared. It is estimated that the implementation of the SVE pilot operation will take two to four months, with an additional two months to evaluate the results and to determine the viability of SVE technology at this site. Implementation and the collection of data for evaluation of the SVE pilot is limited by the low permeability of the soils and the corresponding time that is required to dewater an area to facilitate the pilot operation.

Following a viable conclusion from the pilot operation, a revised remedial action plan will be submitted to the NYSDEC. Upon NYSDEC acceptance of the revised remedial action plan, engineering designs, and construction specifications for a full scale SVE operation will be prepared. It is estimated that the implementation of a full scale SVE operation will take six to eight months. An estimate of the time needed to achieve the desired remediation will be calculated based on the results of the pilot operation and will be included in the remedial action plan. The remedial action plan will also include a task specific project schedule for the installation of a full scale SVE system.

In the event that the SVE pilot study determines that the technology is not suitable at the site, a plan for implementing the interceptor trench will be submitted to the NYSDEC. Upon NYSDEC acceptance of the interceptor trench recommendation, engineering designs, and construction specifications will be prepared. It is estimated that the proposed alternative remedial action plan implementation will take six to eight months.

6.0 REFERENCES

Capsule Environmental Engineering, Inc., Remedial Investigation Report (1993)

Technical and Administrative Guidance Memorandum (TAGM) HWR-92-4046, November 16, 1992

Davis and Allison, 1990, Predicting the fate and transport of organic compounds in water; Hazardous Materials Control, July/August 1990

HSDB (Hazardous Substance Data Bank), 1993, TOXNET files; National Library of Medicine, U.S. Department of Health and Human Services, Public Health Service, National Institute of Health, July 1993

"Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," October, 1988

TABLES

Table 1 Screening of Soil Technologies
ARO Corporation, Cheektowaga, New York

Media	Remedial Action Objectives	General Response Actions	Remedial Technology Types	Process Options	Technology Description	Effectiveness	Implementability	Cost	Screening Comments
Soil	Reduce soil contamination from VOCs to below NYS Recommended Soil Cleanup Objectives (TCE < 700 ppb and 1,2-DCE < 300 ppb) in 3 areas: 1. SW portion (mainly along sewer backfills and exit to stormwater ditch. 2. West of metals prep. room. 3. Loading dock SE of building. Prevent human contact with VOC contaminated soil located beneath the water table.	No Action	None	Not applicable	No action.	Will not meet objectives.	Not acceptable to local/state governments.	None	Does not protect human health or the environment.
		Institutional Controls	Restrict Access	Fencing	Fence off all areas overlying contaminated soils and restrict access.	Effective means if continued into the future. Does not reduce contamination.	Readily implemented. Restrictions on future land use.	Low	Does not protect environment from leaching of contaminants.
		Containment	In-situ stabilization	Portland cement alone or with additives	Mechanically mix soil with Portland cement and any additives.	Effective, but susceptible to weathering if used on near-surface soils. Best with limited areas.	Difficult to implement beneath or adjacent to buildings at site.	High	Proximity of buildings to soil contamination makes this difficult and expensive to implement.
			Capping	Impermeable or Low Permeability Cap	Install asphalt, clay, concrete, or geomembrane cap over soil to prevent leaching.	Ineffective here because contaminated soils are below the water table.	Readily implemented. Restrictions on future land use.	Low to Moderate	Majority of site already paved, so this option would not aid materially. Contaminants below water table.
			Vertical Barriers	Slurry Walls	Trench around contaminated regions and fill with bentonite slurry.	Effective in preventing contaminant migration if used in conjunction with a cap. Does not reduce contamination.	Difficult to implement beneath buildings at the site.	Moderate to High	Presence of buildings over some of the contamination makes this impractical here.
				Sheet Pilings	Drive sheet pilings around contaminated regions to form a wall.	Effective in preventing contaminant migration if used in conjunction with a cap. Does not reduce contamination.	Difficult to implement beneath buildings at the site.	Moderate to High	Presence of buildings over some of the contamination makes this impractical here.
			Surface Controls	Diversion/Collection, Grading	Prevent erosion of contaminated soils by surface runoff.	Ineffective here because contaminated soils lie beneath water table and are not subject to erosion. Area mostly paved already.	Readily implemented.	Low to Moderate	Contaminated soils lie below water table, so surface runoff doesn't influence them.
		Excavation	Excavation	Excavation of "hot spots"	Excavate highly contaminated soils around metals prep. room. Replace with clean fill.	Effective. Will require treatment or disposal.	Readily implemented, but may be difficult beneath building.	Moderate	Would remove source of future contamination. May be possible below floor. Will interfere with operations of plant.
				Excavate all contaminated soils	Excavate all soils above NYS Recommended Soil Cleanup Guidelines. Replace with clean fill.	Effective. Will require treatment or disposal.	Readily implemented, but may be difficult beneath building.	High	Would remove sources of future contamination. Would interfere with plant operations.
			Biological	Bioremediation	Use a system of injection/recovery wells to add/remove nutrients and bacteria to aquifer and soil to degrade toxic organic compounds into nontoxic by-products.	Effective method for degrading VOCs.	Deriving suitable bacteria has been a problem in the past. Wells would require permitting. Bench scale study may be required.	High capital High O&M	Clayey soils and shallow depth to groundwater at this site not conducive to this technology. Solvents are difficult to biodegrade.
		In-Situ Treatment	Chemical	Oxidation/Reduction	Use a system of injection/recovery wells to add/remove oxidizing agents to the aquifer/soil to degrade toxic organic compounds into nontoxic by-products.	Effective method for degrading VOCs.	Easily installed.	Moderate capital Moderate O&M	This is not a viable method due to extremely low transmissivity.
			Physical	Air-sparging	Inject air through a system of wells to remove volatile compounds from the soil and groundwater. Typically used in conjunction with a pumping and soil venting system.	Effective method for removing VOCs.	Readily implemented. Requires permitting.	Moderate capital Moderate O&M	Clayey soils at site are not compatible with this method.
		Aboveground Treatment	Chemical	Soil Washing	Leach VOCs off soil in an on-site soil treatment unit. Treat leachings to destroy the VOCs.	Effective, but may require more space than available at working factory. Bench-scale studies would be needed. Soils could be disposed on-site.	Readily implemented. Permits required.	Moderate to High	Necessity to treat leachate, plus fine particle nature of soils, makes this a less desirable option.
			Physical	Stabilization	Mechanically mix soil with Portland cement and possibly additional additives.	Effective, but will require subsequent disposal off site.	Readily implemented.	Moderate to High	Stabilized soil must be disposed off-site because of space considerations. Will be expensive.
			Thermal	Incineration	Incinerate contaminated soils in a portable incinerator brought on-site.	Effective. Disposal can be on or off site.	Readily implemented. Permit required.	Moderate	Treated soils can be disposed on-site. Readily available technology.
		Disposal	On-site	Not applicable	Treated soil can be disposed on-site or reused as fill.	Effective disposal means.	Readily implemented.	Low	If treatment allows quick turnaround, this will be a low-cost option.
			Off-site	RCRA facility	Truck contaminated soils to RCRA facility for disposal. Land ban criteria must be used to decide whether landfilled or incinerated.	Effective. If VOCs above statutory limits, must be incinerated, rather than landfilled.	Readily implemented.	Moderate to High	Option viable only for low quantities of contaminated soils.

able 2: Screening of Ground Water Technologies
RO Corporation, Cheektowaga, New York

Media	Remedial Action Objectives	General Response Actions	Remedial Technology Types	Process Options	Technology Description	Effectiveness	Implementability	Cost	Screening Comments
		No Action	None	Not applicable	No action.	This does not prevent contaminant migration, impacts to surface water, or restore the aquifer.	Not acceptable to local/state governments.	None	This option does not protect human health or the environment.
			Restrict Access	Deed restrictions	Deeds of relevant downgradient properties would restrict water well installations.	This is an effective means of preventing human ingestion of contaminated ground water, but does not meet the remedial objectives.	Easily implemented, though there will be ongoing legal requirements.	Low	This option does not protect the environment, but would protect humans.
		Institutional Controls				remedial objectives.			
			Monitoring	Groundwater monitoring	Monitoring wells provide information (i.e., water quality and hydraulic head) to be used for remedial design and evaluation of remedial progress.	This method is effective in monitoring ground water quali and flow direction. Alone, this does not meet any of the remedial objectives.	Permits required. To be used in conjunction with other technologies.	Low capital, moderate O&M	It is common at most Superfund sites to monitor remedial progress and migration of contaminated ground water.
			In-situ stabilization	Portland cement alone or with additives	Mechanically mix aquifer matrix with portland cement and any additives.	This is effective in stopping contaminant migration, and impacts to surface water.	Difficult to thoroughly mix at depth. Volume expansion and VOC emissions during installation have been problems in the past. Buildings will cause problems.	Very high capital, low O&M	Due to costs, this option practical only for use on discrete "hot-spots", such as beneath the plant an vicinity of the metals preparation room. Remediation may be achieved in a very timely manner. Co
		Containment	Recharge control	Low permeability cap	Install asphalt or clay cap over remaining unpaved recharge areas across the site.	This is effective in stopping recharge, though susceptible to cracks. Alone, this does not met remedial objectives.	Easily implemented. There will be restrictions on future land use.	Low capital, low O&M	This is not a relevant technology because the contaminants are below the water table.
	Prevent exposure of humans and the environment to groundwater at concentrations above acceptable risk-based levels.		Vertical barriers	Slurry Walls	Trench around contaminated regions and fill with bentonite slurry.	Effective in stopping horizontal contaminant migration if used in conjunction with cap. This will not restore the aqu	Easily implemented assuming adequate clearance. Not applicable beneath plant. Labor intensive.	High capital, low O&M	Especially applicable if used in conjunction with other collection techniques. It will take an indefinite amount of time until the aquifer is restored.
				Sheet Pilings	Drive sheet piles around contaminated regions.	Effective in stopping horizontal contaminant migration if used in conjunction with cap. This will not restore the aqu	Readily implemented outside of plant. Not applicable beneath plant.	High capital, low O&M	Especially applicable if used in conjunction with other collection techniques. It will take an indefinite amount of time until the aquifer is restored.
				Recovery wells	Install network of recovery wells to capture contaminated ground water.	This technique could prevent contaminant migration, impacts to surface water, and restore the aquifer.	Readily implemented. Requires permitting.	Moderate capital, moderate O&M	Not warranted due to extremely low transmissivity.
				Hydraulically enhanced recovery wells	Hydraulically fracture aquifer immediately about wells to enhance recovery potential.	This technique could prevent contaminant migration, impacts to surface water, and restore the aquifer.	Readily implemented. Requires permitting.	Moderate capital, moderate O&M	This method is not suitable for the site due to physical properties of the till.
	Prevent off-site migration of contaminants at concentrations above the following New York State standards : TCE <= 5 ug/l 1,2-DCE <= 5 ug/l 1,1-DCE <= 5 ug/l Vinyl Chloride <= 2 ug/l 1,1,2-TCA <= 5 ug/l Benzene <= 0.7 ug/l Total Phenols <= 1 ug/l		Pumping	Injection and recovery wells	Recirculate treated water in conjunction with recovery wells to increase hydraulic gradient and reduce flushing time.	This technique could prevent contaminant migration, impacts to surface water, and restore the aquifer.	Readily implemented. Requires permitting.	Moderate capital, moderate O&M	Not warranted due to extremely low transmissivity and shallow depth to groundwater.
		Collection		Horizontal recovery wells	Pack and screen recovery well along top of lower hydraulic barrier.	This technique could prevent contaminant migration, impacts to surface water, and restore the aquifer.	Difficult installation. Requires permitting.	Very high capital, moderate O&M	Practical method of collection. May have shallow groundwater flow breakthrough. Pumping problems due to extremely low flow rates. Long-term commitment.
GROUNDWATER			Sub-surface drains	Interceptor Trench	Trench to lower hydraulic barrier and fill with highly conductive material. Pump contaminated ground water from a sump in the trench.	This technique could prevent contaminant migration, impacts to surface water, and restore the aquifer.	Easily implemented assuming adequate clearance. Labor intensive.	Moderate capital, moderate O&M	Passive collection is practical option at this site. Hydraulic characteristics may degrade over time. This option would be a long-term commitment.
				Drain Tile	Capture contaminated ground water by installing a network of shallow drain tiles.	This technique could prevent contaminant migration, impacts to surface water, and restore the aquifer.	Easily installed.	Low capital, low O&M	Passive collection is practical option at this site. May have breakthrough of deep groundwater flow. This option would be a long-term commitment.
	Prevent groundwater at concentrations greater than the above levels from discharging to surface waters, a potential exposure route for humans and the environment.		Biological	Bioremediation	Use a system of injection/recovery wells to add/remove nutrients and bacteria to aquifer to degrade toxic organic compounds into nontoxic by-products.	Effective method for degrading VOCs. This technique could restore the aquifer.	Deriving suitable bacteria has been a problem in the past. Wells would require permitting. Bench scale study may be required.	High capital, high O&M	Clayey soils and shallow depth to groundwater at the site not conducive to this technology. Solvents are difficult to biodegrade.
		In-Situ Treatment	Chemical	Oxidation/Reduction	Trench to lower hydraulic barrier and construct highly permeable wall of reactive granular metal material (iron-based).	Bench & pilot scale applications have reduced VOC concentrations orders of magnitude to below the remedial objective standards. This is an innovative technology.	Easily implemented assuming adequate clearance. Bench scale study may be required. Labor intensive.	Very high capital, low O&M	Viable alternative, but may have regulatory problems because it's an emerging technology. This would be a long-term commitment.
	Reduce groundwater contaminant levels below the site to below the concentrations specified above.			Oxidation/Reduction	Use a system of injection/recovery wells to add/remove oxidizing agents to an aquifer to degrade toxic organic compounds into nontoxic by-products.	Effective method for degrading VOCs. This technique could restore the aquifer.	Easily installed.	Moderate capital, Moderate O&M	This is not a viable method due to extremely low transmissivity.
			Physical	Air-sparging	Inject air through a system of wells to remove volatile compounds. Typically used in conjunction with a pumping and soil venting system.	Effective method for removing VOCs.	Readily implemented. Requires permitting.	Moderate capital, moderate O&M	Clayey soils at site are not compatible with this method.
			Biological	Bioremediation	Use bacteria to degrade toxic organic compounds into nontoxic by-products.	Effective method for degrading VOCs.	Deriving suitable bacteria has been a problem in the past. Bench scale study may be required.	Moderate capital, moderate O&M	Solvents may be difficult to degrade. This treatment method is not recommended.
		Above Ground Treatment : Used with Collection and Disposal Actions	Chemical	Oxidation/Reduction	Percolate water through aboveground canisters of reactive granular metal material.	Bench & pilot scale applications have reduced VOC concentrations orders of magnitude to below the remedial objective standards. This is an innovative technology.	Easily installed. Bench scale study may be required.	Moderate capital, moderate O&M	Clogging of material may require pretreatment of collection effluent. This is a potential treatment technique for the contaminant suite in the groundwater beneath the site.
				Oxidation/Reduction	Treat contaminated water with strong oxidizing agents such as potassium permanganate in aboveground reactors.	Effective method for degrading VOCs.	Easily installed. Bench scale study may be required.	Moderate capital, Moderate O&M	May require disposal of treatment sludges. This is a potential treatment technique for the contaminant suite in the groundwater beneath the site.
			Physical	Air-stripping	Mix air and water in aerators to remove volatile compounds.	Effective method for removing VOCs.	Routing pumping effluent through low profile air-stripper can be easily accomplished.	Moderate capital, low O&M	Volatiles at this site have relatively high Henry's Constants and will strip well. Iron bacteria fouling may be a problem.
				Adsorption	Pass water/off-gas through granular activated carbon to remove volatile compounds.	Effective in treating large array of organic compounds.	Routing pumping/treatment effluent through activated carbon filters can be easily accomplished.	Moderate capital, moderate O&M	May be used as polish to stripping effluent or off-gas, or used alone. Iron bacteria fouling may be a problem.
		Disposal: Used with Collection and Potentially Treatment Actions	On-site	Storm sewer	Discharge treated ground water to on-site storm sewer.	Dependable method of discharge. Permitting required.	Treated water easily transferred to sewer. NPDES permit required.	Low capital, low O&M	Frequent effluent sampling may be required.
				POTW	Discharge treated ground water to local POTW	Dependable method of discharge.	Treated water easily transferred to POTW via sanitary	Low capital, high user fees	Pretreatment and frequent effluent sampling may be required. Costs may be higher if pretreatment needed.
			Off Site	RCRA Facility	Ship water off site to a RCRA permitted treatment facility	Dependable method of discharge.	Water easily transferred to truck for shipment off site.	Low capital, high transportation costs & user fees	The owner may inherit future liabilities.
				Deep well injection	Inject treated ground water into strata hydraulically remote from drinking water source.	Reliable method of discharge. Permitting required.	Deep injection well permits may be difficult to obtain.	Moderate Capital, low O&M	The owner may inherit future liabilities.

Table 3. Screening of Surface Water Technologies
ARO Corporation, Cheektowaga, New York

Media	Remedial Action Objectives	General Response Actions	Remedial Technology Types	Process Options	Technology Description	Effectiveness	Implementability	Cost	Screening Comments
Surface Water	Reduce concentration of TCE leaving site in surface water to less than 11 ug/l (Class D Standards).	No Action	None	Not applicable	No action.	This does not prevent contaminant migration or impacts to the environment.	Not acceptable to local/state governments.	None	This option does not protect human health or the environment.
		Institutional Controls	Restrict Access	Deed restrictions	Deeds of relevent downgradient properties would restrict use of or access to contaminated surface waters.	This is an effective means of preventing human exposure to contaminated surface water, but does not meet the remedial objectives.	Easily implemented, though there will be ongoing legal requirements.	Low	This option does not protect the environment, but would protect humans.
					Restrict access to surface water.	To contaminated surface water, but does not meet the remedial objectives.	Legal considerations.		
			Monitoring	Surface water monitoring	Surface water monitoring provides information to be used for remedial design and evaluation of remedial progress.	This method is effective in monitoring water quality. Alone, this does not meet any of the remedial objectives.	To be used in conjunction with other technologies.	No capital, low O&M	It is common at most Superfund sites to monitor progress and check on contaminant levels.
		Containment of Contaminated Ground Water	Ground Water Controls	Impermeable Liner	Line storm sewer and sanitary sewers backfill (the ditch) with an impermeable liner.	Effective means of preventing surface water/ground water interaction in lined areas. Must be combined with prevention of ground water migration off site to other surface waters.	Readily implemented.	Moderate capital, Moderate capital,	Prevents contaminated ground water from entering surface water. Relatively shallow depths and lengths of sewers make this an attractive option.
				Pumping	Lower ground water surface to below level of storm and sanitary sewer backfills to prevent ground water entering surface water.	Effective means. Must be combined with prevention of ground water migration off site to other surface waters.	Pumped ground water must be treated prior to discharge. Readily implemented.	Moderate capital, moderate O&M	Low transmissivity will hinder efforts. Necessity of treating pumped water makes this impractical, considering need for remedial action for ground water already.
		Collection	Diversion	Grading and Piping	Divert all surface water runoff from site to collection basin/tank.	Effective means, but would have to collect all storm water runoff also.	Readily implemented.	Moderate cost, high O&M	Would need to treat and dispose all storm water runoff, as well as ground water influent to the surface waters. Impractical.
				Grading and Piping	Direct storm water away and collect only groundwater influent to surface water from sewer backfills.	Effective means.	Readily implemented.	Moderate cost, low O&M	Would need to treat only contaminated waters. Recommended as long as contaminated ground water is also collected and treated to keep costs down.
		Above Ground Treatment : Used with Collection and Disposal Actions	Biological	Bioremediation	Use bacteria to degrade toxic organic compounds into nontoxic by-products.	Effective method for degrading VOCs.	Deriving suitable bacteria has been a problem in the past. Bench scale study may be required.	Moderate capital, moderate O&M	Solvents may be difficult to degrade. This treatment method is not recommended.
			Chemical	Oxidation/Reduction	Percolate water through aboveground canisters of reactive granular metal material.	Bench & pilot scale applications have reduced VOC concentrations orders of magnitude to below the remedial objective standards. This is an innovative technology.	Easily installed. Bench scale study may be required.	Moderate capital, moderate O&M	Clogging of material may require pretreatment of collection effluent. This is a potential treatment technique for the contaminants in the surface water at the site.
				Oxidation/Reduction	Treat contaminated water with strong oxidizing agents such as potassium permanganate in aboveground reactors.	Effective method for degrading VOCs.	Easily installed. Bench scale study may be required.	Moderate capital, Moderate O&M	May require disposal of treatment sludges. This is a potential treatment technique for the contaminants at the site.
			Physical	Air-stripping	Mix air and water in aerators to remove volatile compounds.	Effective method for removing VOCs.	Routing collected water through low profile air stripper can be easily accomplished.	Moderate capital, low O&M	Volatiles at this site have relatively high Henry's Constants and will strip well. Varying concentrations and flow rates may cause problem.
				Adsorption	Pass water/off-gas through granular activated carbon to remove volatile compounds.	Effective in treating large array of organic compounds.	Routing collected water through activated carbon filters can be easily accomplished.	Moderate capital, Moderate O&M	May be used as polish to stripping effluent or off-gas, or used alone. Iron bacteria fouling may be a problem, as will sediment.
		Disposal	On-site	Storm sewer	Discharge treated surface water to on-site storm sewer.	Dependable method of discharge. Permitting required.	Treated water easily transferred to sewer. NPDES permit required.	Low capital, low O&M	Frequent effluent sampling may be required.
			Off-site	POTW	Discharge treated surface water to local POTW.	Dependable method of discharge.	Treated water easily transferred to POTW via sanitary sewer.	Low capital, high user fees	Pretreatment and frequent effluent sampling may be required. Costs may be higher if pretreatment needed.
				RCRA Facility	Ship water off-site to a RCRA permitted treatment facility.	Dependable method of discharge.	Water easily transferred to truck for shipment off site.	Low capital, high transportation costs & user fees	The owner may inherit future liabilities.

Table 4
Retained Remedial Technologies for Alternative Development
ARO Corporation, Cheektowaga, New York

<u>Soils</u>

No Action
Institutional Controls
- Fencing

Containment
- In-situ stabilization of "hot spots"

Excavation
- Excavation of "hot spots"
- Excavation of all contaminated soils

Above-Ground treatment
- Incineration

Disposal
- On-site, after treatment
- RCRA facility

<u>Groundwater</u>

No Action
Institutional Controls
- Deed restrictions
- Groundwater monitoring

Containment
- In-situ stabilization of "hot spots"

Collection
- Interceptor trench

In-situ treatment
- Oxidation/reduction with "permeable reactive wall"

Above-Ground Treatment
- Oxidation/reduction
- Air stripping
- Adsorption (granular activated carbon)

Disposal
- On-site to storm sewer
- Off-site to POTW, with pretreatment, if necessary

Table 4 (Cont.)
Retained Remedial Technologies for Alternative Development
ARO Corporation, Cheektowaga, New York

<u>Surface Water</u>

No Action
Institutional Controls
  - Surface water monitoring
Containment of Contaminated Groundwater (Prevent surface water/groundwater interconnection on-site)
  - Impermeable liner for storm sewer and sanitary sewer ditches
Collection
  - Collection of groundwater influent to surface waters in sewer backfills
Above-Ground Treatment
  - Oxidation/reduction
  - Air stripping
  - Adsorption (granular activated carbon)
Disposal
  - On-site to storm sewer
  - Off-site to POTW, with pretreatment, if necessary

TABLE 5
CLEANUP GOALS FOR CHEMICALS OF CONCERN IN GROUND WATER
Aro Corporation - Buffalo, New York

Chemicals of Concern	Surface Water Cleanup Goals μg/l	Ground Water Cleanup Goals μg/l	Maximum Concentration Detected		
			Soil μg/kg	Ground Water μg/l	Surface Water μg/l
Trichloroethane	5	5	250,000	1,100,000	51
1,2-Dichloroethene	0.8	5	930	16,000	20
Vinyl Chloride	2	2	40	730 (E)	<10
1,1,2-Trichloroethane	0.6	5	<720 (1)	<2500 (2)	13(E)
Benzene	0.7	0.7	<14	<2500 (3)	<2500 (3)
Total Phenols	N/A	1	<760	186	N/A

1) Due to dilution of sample, detection limits were increased. All other samples were <6 ppb (μg/l).

2) Due to dilution of sample, detection limits were increased. The next highest detected value was 9(E) μg/l.

3) Due to dilution of sample, detection limits were increased. All other samples were <5 μg/l.

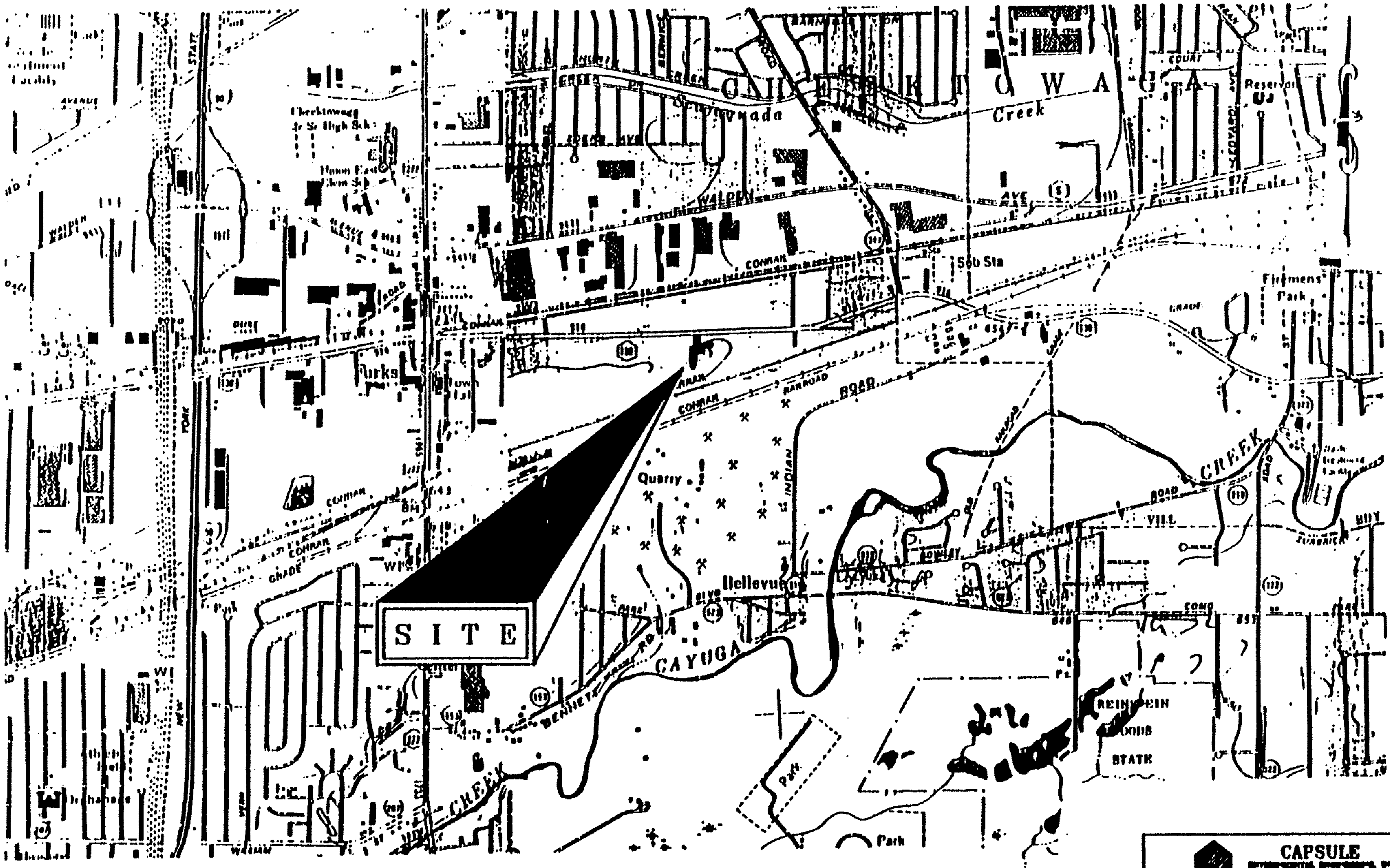
E - Estimated value due to instrument, spike and standard calibration problems.

E1 - Estimated detection limit due to instrument calibration or exceedence of holding times.

N/A - Not Analyzed for EPA Method 8270.

The proposed cleanup goals were developed utilizing the New York State Codes, Rules, and Regulations, Title 6, Chapter X, Parts 700-705.

FIGURES



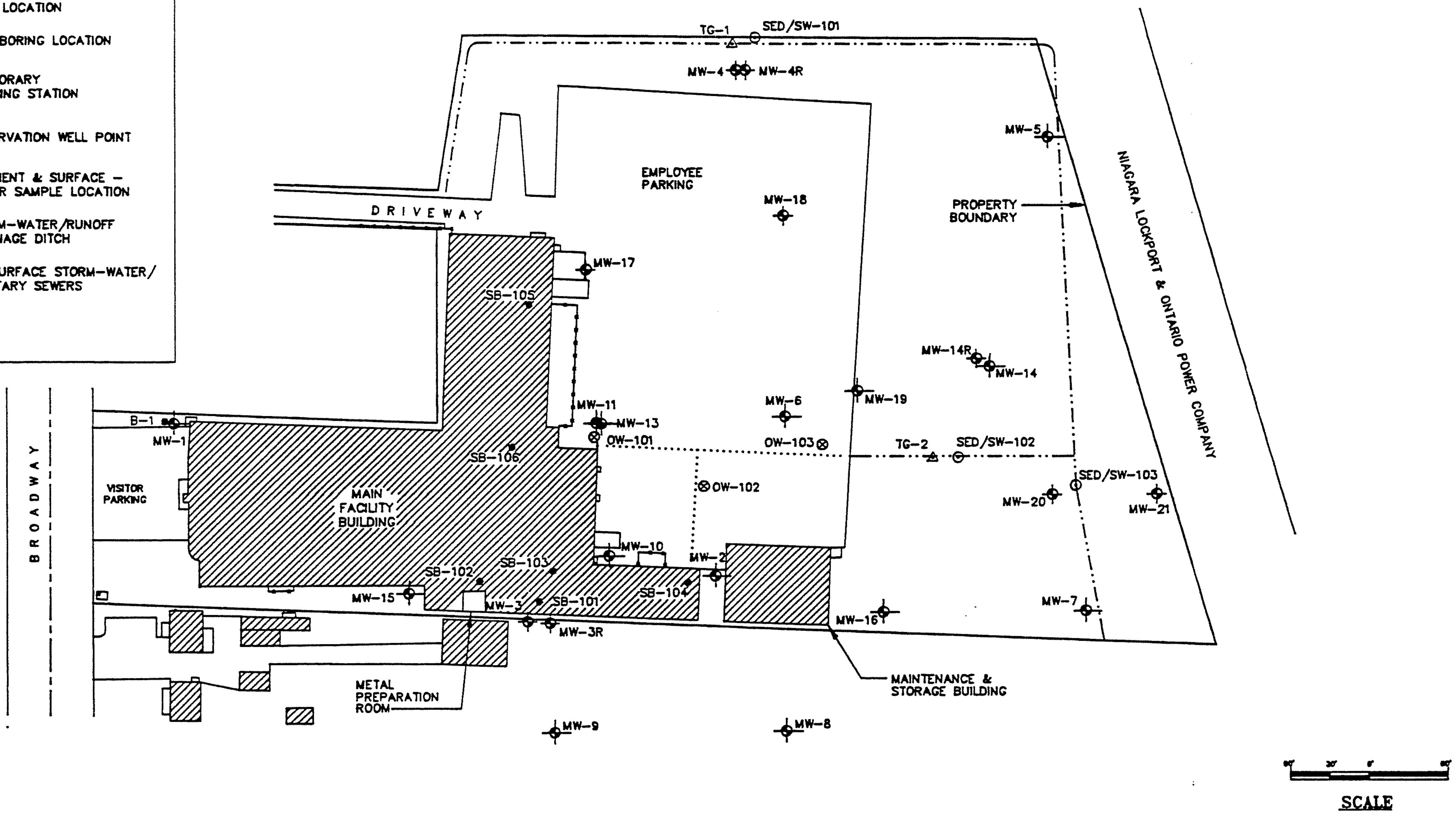
SOURCE : U.S.G.S. 7.5' QUADRANGLES, LANCASTER & BUFFALO NE (1965, PHOTOREVISED 1980)

CAPSULE
ENVIRONMENTAL ENGINEERING, INC.

TITLE

SITE LOCATION
ARO CORPORATION
BUFFALO, NEW YORK

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NTS	MEC		11/10/94	128-066	FIG 1	of



LEGEND

⌖	MONITORING WELL LOCATION
•	SOIL BORING LOCATION
△	TEMPORARY GAUGING STATION
⊗	OBSERVATION WELL POINT
⊙	SEDIMENT & SURFACE – WATER SAMPLE LOCATION
–··–··–	STORM-WATER/RUNOFF DRAINAGE DITCH
··········	SUBSURFACE STORM-WATER/ SANITARY SEWERS

NOTE

1.) ADDITIONAL SUBSURFACE UTILITIES NOT SHOWN ON THIS FIGURE, EXIST AT THE FACILITY

SOURCES :
(1.) TALLAMY, VAN KUREN, GERTIS & ASSOCIATES, Dwg. No.B-15641 (FEBRUARY 23,1981)
(2.) KREHBIEL ASSOCIATES Dwg. No.D-2300 (JUNE 23,1992)
(3.) LAW ENGINEERING: REMEDIAL INVESTIGATION REPORT (DECEMBER,1992)

REVISION	DATE	DESCRIPTION

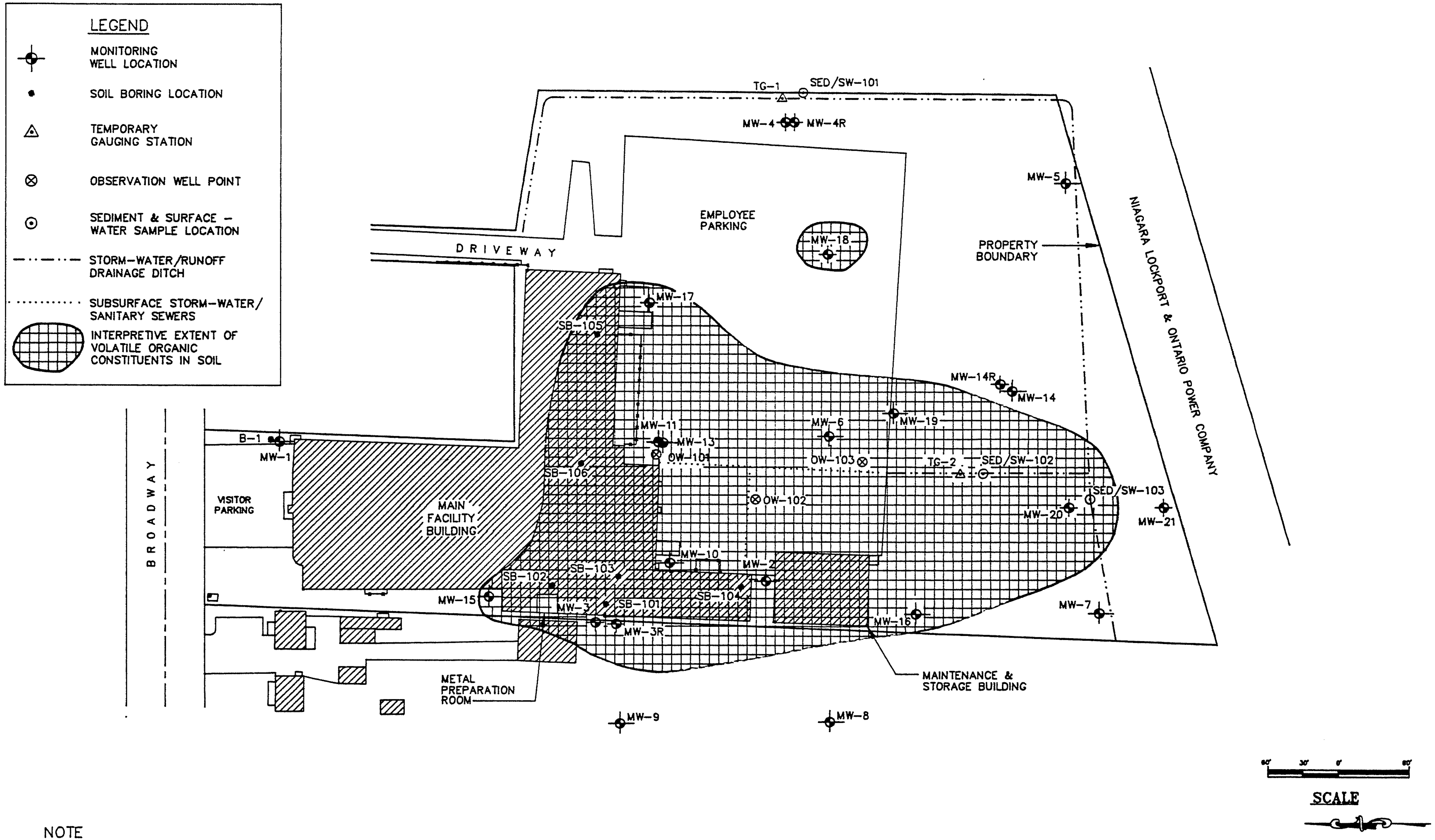
CAPSULE
ENVIRONMENTAL ENGINEERING, INC.
1970 OAKCREST AVE., SUITE 215
ST. PAUL, MINNESOTA 55113
(612) 636-2644

TITLE

SITE PLAN
ARO CORPORATION
BUFFALO, NEW YORK

SCALE	DRAWN BY	CHECKED BY	DATE	PROJECT NO.	DRAWING NO.	Sheet
	MEC		11/19/94	128-098	FIG 2	of

\28098F2 11/19/94



NOTE

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(1.) TALLAMY, VAN KUREN, GERTIS & ASSOCIATES, Dwg. No.B-15641 (FEBRUARY 23,1991)
(2.) KREHBIEL ASSOCIATES Dwg. No.D-2300 (JUNE 23,1992)
(3.) LAW ENGINEERING: REMEDIAL INVESTIGATION REPORT (DECEMBER,1992)

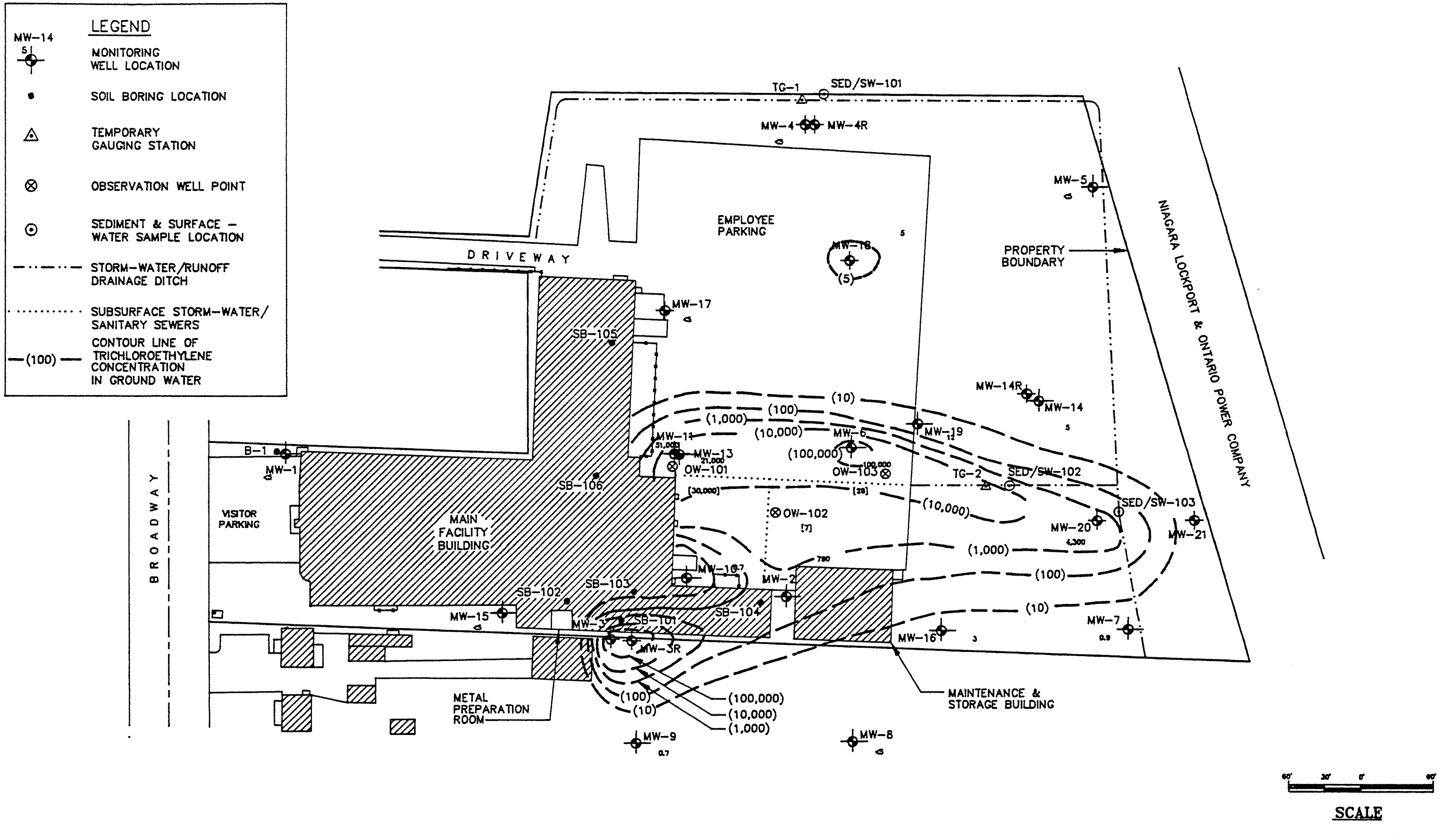
CAPSULE
ENVIRONMENTAL ENGINEERING, INC.
1970 OAKCREST AVE., SUITE 215
ST. PAUL, MINNESOTA 55113
(612) 636-2644

TITLE INTERPRETIVE EXTENT OF VOLATILE
CONSTITUENTS IN SOIL
ARO CORPORATION
BUFFALO, NEW YORK

REVISION	DATE	DESCRIPTION

SCALE	DRAWN BY	CHECKED BY	DATE	PROJECT NO.	DRAWING NO.	Sheet
	MEC		11/19/94	128-098	FIG 3.	OF

\28098F3A 11/19/94



NOTE

1.) ADDITIONAL SUBSURFACE UTILITIES NOT SHOWN ON THIS FIGURE, EXIST AT THE FACILITY

SOURCES :

(1.) TALLAMY, VAN KUREN, GERTIS & ASSOCIATES, Dwg. No.B-15641 (FEBRUARY 23,1991)

(2.) KREHBIEL ASSOCIATES Dwg. No.D-2300 (JUNE 23,1992)

(3.) LAW ENGINEERING: REMEDIAL INVESTIGATION REPORT (DECEMBER,1992)

REVISION	DATE	DESCRIPTION

CAPSULE
ENVIRONMENTAL ENGINEERING, INC.
1970 OAKCREST AVE., SUITE 215
ST. PAUL, MINNESOTA 55113
(612) 636-2644

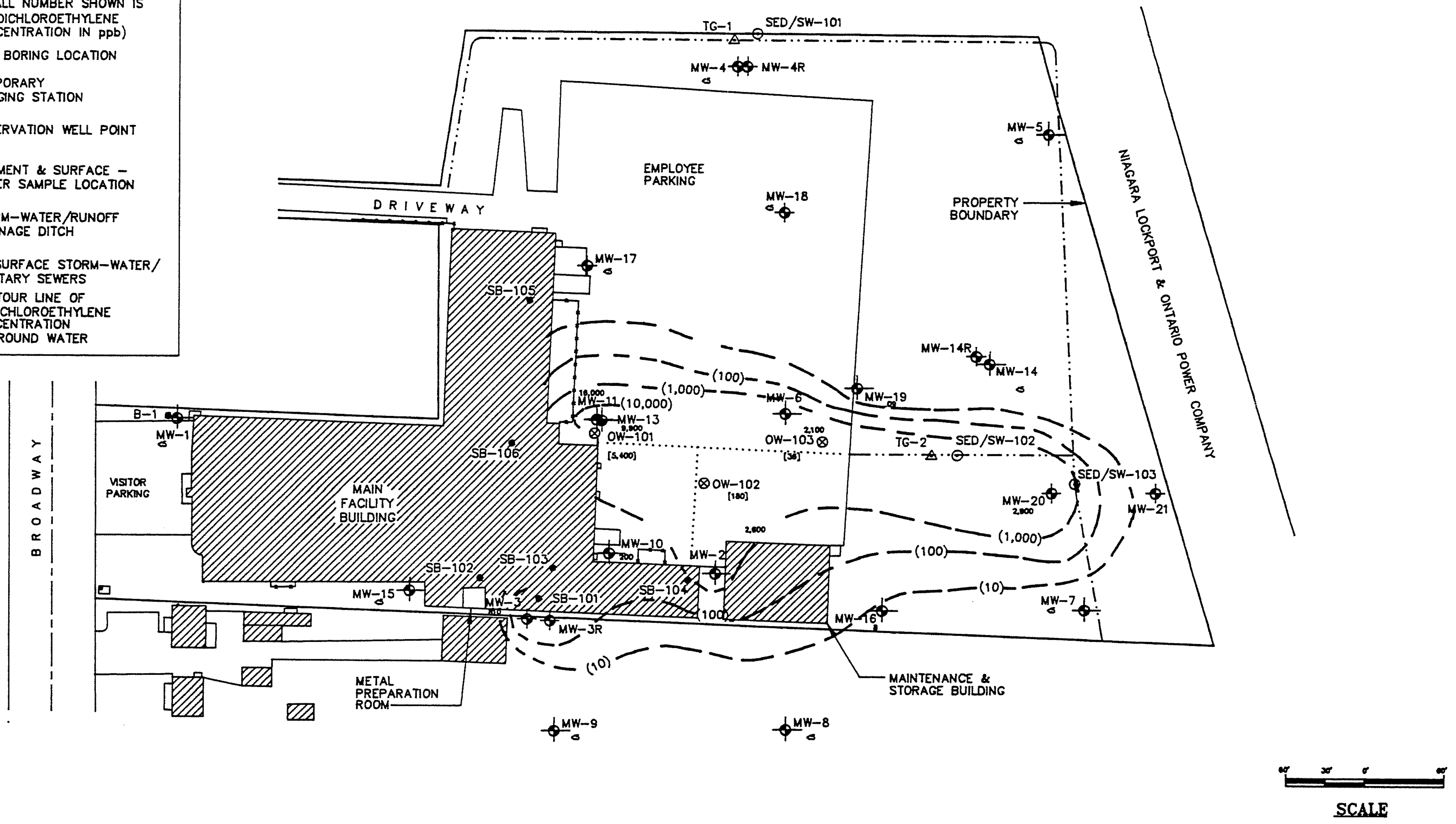
TITLE INTERPRETIVE EXTENT OF
TRICHLOROETHYLENE IN GROUND WATER
ARO CORPORATION
BUFFALO, NEW YORK

SCALE	DRAWN BY	CHECKED BY	DATE	PROJECT NO.	DRAWING NO.	Sheet
	MEC		11/19/94	128-098	FIG 4	OF

\28098F4A 11/19/94

LEGEND

MW-6 2,100	MONITORING WELL LOCATION (SMALL NUMBER SHOWN IS 1,2-DICHLOROETHYLENE CONCENTRATION IN ppb)
●	SOIL BORING LOCATION
△	TEMPORARY GAUGING STATION
⊗	OBSERVATION WELL POINT
⊙	SEDIMENT & SURFACE – WATER SAMPLE LOCATION
—··—··—	STORM-WATER/RUNOFF DRAINAGE DITCH
··········	SUBSURFACE STORM-WATER/ SANITARY SEWERS
— (10) —	CONTOUR LINE OF 1,2-DICHLOROETHYLENE CONCENTRATION IN GROUND WATER



NOTE

1.) ADDITIONAL SUBSURFACE UTILITIES NOT SHOWN ON THIS FIGURE, EXIST AT THE FACILITY

SOURCES :
(1.) TALLAMY, VAN KUREN, GERTIS & ASSOCIATES, Dwg. No.B-15641 (FEBRUARY 23,1991)
(2.) KREHBIEL ASSOCIATES Dwg. No.D-2300 (JUNE 23,1992)
(3.) LAW ENGINEERING: REMEDIAL INVESTIGATION REPORT (DECEMBER,1992)

CAPSULE
ENVIRONMENTAL ENGINEERING, INC.
1970 OAKCREST AVE., SUITE 215
ST. PAUL, MINNESOTA 55113
(612) 636-2644

TITLE INTERPRETIVE EXTENT OF
1,2-DICHLOROETHYLENE IN GROUND WATER
ARO CORPORATION
BUFFALO, NEW YORK

SCALE	DRAWN BY	CHECKED BY	DATE	PROJECT NO.	DRAWING NO.	Sheet
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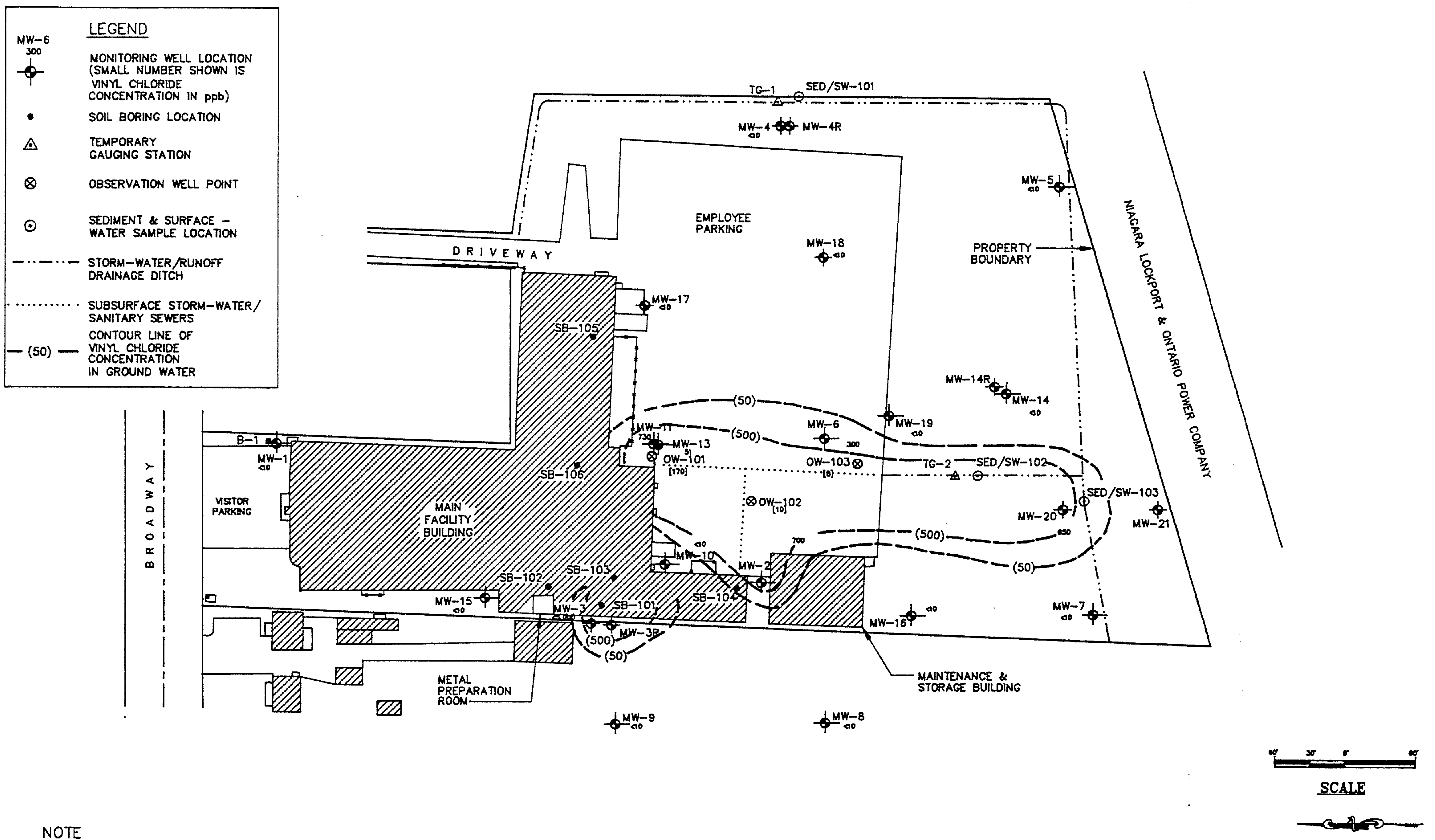
REVISION	DATE	DESCRIPTION

\28098F5A 11/19/94



NOTE

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(2.) KREHBIEL ASSOCIATES Dwg. No.D-2300 (JUNE 23,1992)
(3.) LAW ENGINEERING: REMEDIAL INVESTIGATION REPORT (DECEMBER,1992)

CAPSULE
ENVIRONMENTAL ENGINEERING, INC.
1970 OAKCREST AVE., SUITE 215
ST. PAUL, MINNESOTA 55113
(612) 636-2644

TITLE INTERPRETIVE EXTENT OF
VINYL CHLORIDE IN GROUND WATER
ARO CORPORATION
BUFFALO, NEW YORK

REVISION	DATE	DESCRIPTION

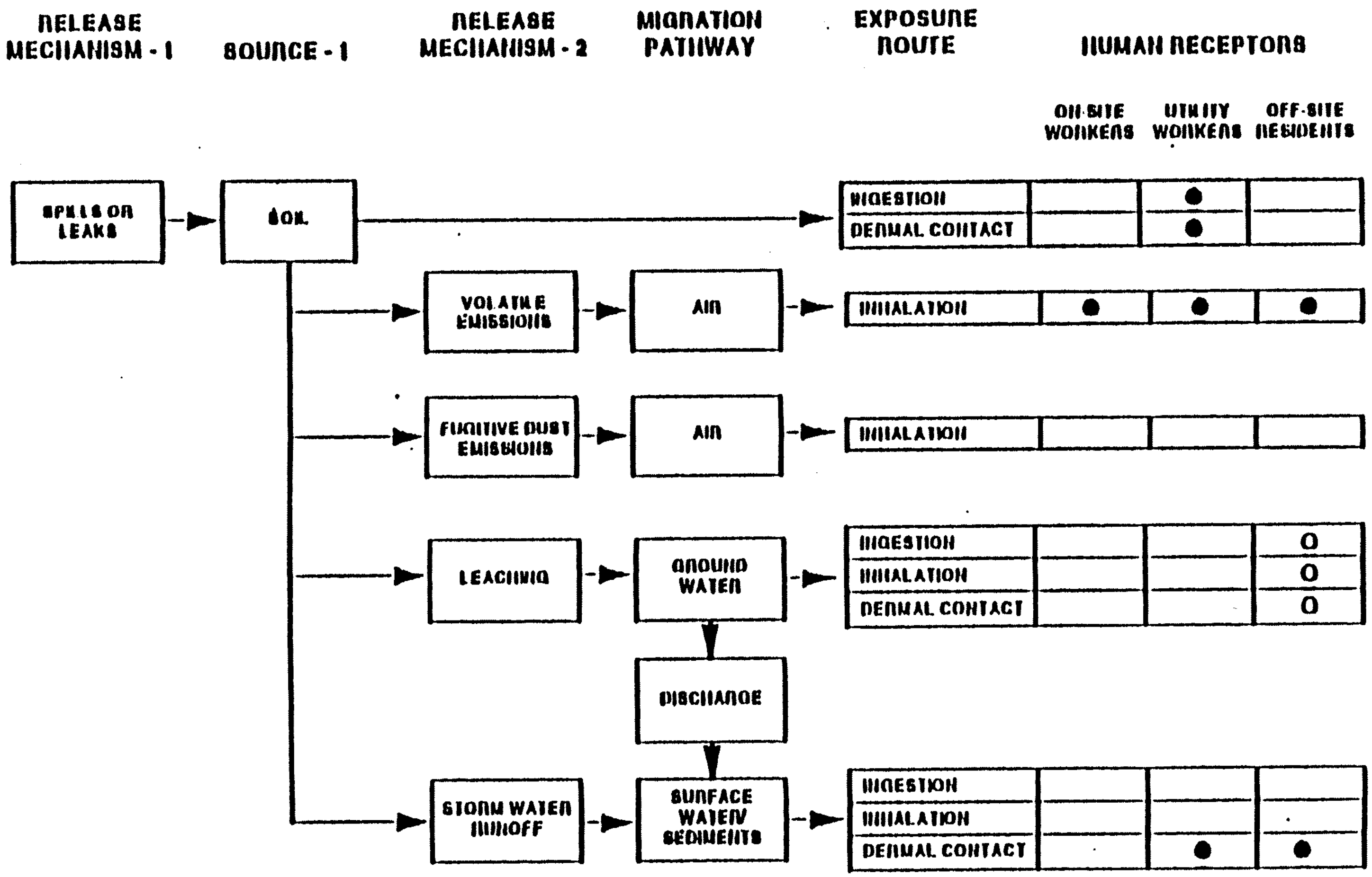
SCALE	DRAWN BY	CHECKED BY	DATE	PROJECT NO.	DRAWING NO.	Sheet
	MEC		11/19/94	128-098	FIG 6	OF

\28098F6A 11/19/94

FIGURE 7

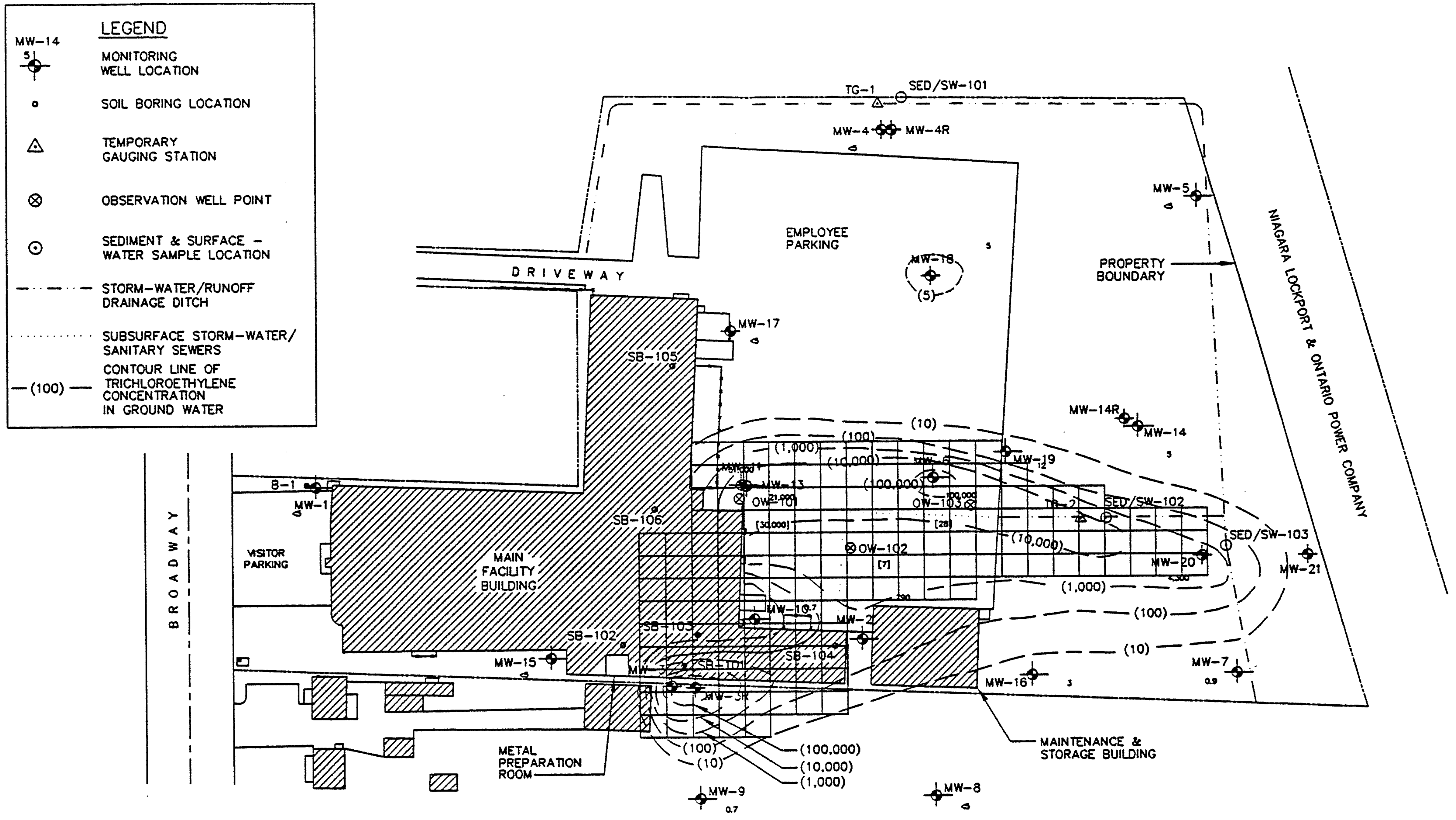
CONCEPTUAL SITE MODEL

ARO CORPORATION
CHEEKTOWAGA, NEW YORK



● CURRENT POTENTIAL EXPOSURES

O POTENTIAL EXPOSURES IF PRIVATE WELLS ARE USED AS A POTABLE WATER SOURCE



NOTE

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SOURCES :

(1.) TALLAMY, VAN KUREN, GERTIS & ASSOCIATES. Dwg. No.B-15641 (FEBRUARY 23,1991)

(2.) KREHBIEL ASSOCIATES Dwg. No.D-2300 (JUNE 23,1992)

(3.) LAW ENGINEERING: REMEDIAL INVESTIGATION REPORT (DECEMBER,1992)

REVISION	DATE	DESCRIPTION

CAPSULE
ENVIRONMENTAL ENGINEERING, INC.
1970 OAKCREST AVE., SUITE 216
ST. PAUL, MINNESOTA 55113
(612) 636-2644

TITLE
PROPOSED AREA OF
SOIL VAPOR EXTRACTION
ARO CORPORATION
BUFFALO, NEW YORK

SCALE	DRAWN BY	CHECKED BY	DATE	PROJECT NO.	DRAWING NO.	Sheet
1" =40'	MEC		11/19/94	128-098	FIG 8	OF

APPENDIX A

APPENDIX A
ALTERNATIVE COST ESTIMATES

ESTIMATED COSTS
Ground Water Alternative 1
Natural Attenuation - Ground Water Monitoring

CAPITAL COSTS	Cost
Preparation of Plans	$ 9,000
Capital Cost	
Subtotal	$ 9,000
Contingency 10%	$ 900
TOTAL CAPITAL COST	$ 9,900
OPERATION AND MAINTENANCE COSTS	
Annual Sampling	$ 2,250
Equipment, Supplies, Shipping	600
Mobilization/Demobilization	1,200
Per Diem	105
Expenses (Car, Hotel, and so forth)	375
Report Preparation	1,200
Analytical Services	
Volatiles	5,250
Total Cost per Sampling Event	10,980
Annual Sampling Costs - First Year	43,920
Annual Sampling Costs - Years 2 - 5	87,840
TOTAL COST	$141,720

ESTIMATED COSTS
Ground Water Alternative 2
Institutional Controls

CAPITAL COSTS	Cost
Preparation of Plans	$ 9,000
Legal Fees	10,000
Capital Cost	
Subtotal	19,000
Contingency 10%	1,900
TOTAL CAPITAL COST	$ 20,900
OPERATION AND MAINTENANCE COSTS	
Annual Sampling	$ 2,250
Equipment, Supplies, Shipping	600
Mobilization/Demobilization	1,200
Per Diem	105
Expenses (Car, Hotel, and so forth)	375
Report Preparation	1,200
Analytical Services Volatiles	5,250
Total Cost per Sampling Event	$ 10,980
Annual Sampling Costs - First Year	$ 43,920
Annual Sampling Costs - Years 2-5	$ 87,840
TOTAL COST	$151,720

ESTIMATED COSTS
Ground Water Alternative 3
In Situ Treatment Via a Permeable Reactive Wall

CAPITAL COSTS	Cost
Pilot System	$120,000
Sheet Piling	
3 ft. Diameter Reactive Gate	
Engineering Oversite	15,000
Monitoring Wells	12,000
Hydrogeologist Oversite/Modeling	20,000
TOTAL CAPITAL COST	$167,000
OPERATING AND MAINTENANCE COSTS	
Organics Sampling	31,500
7 Sampling Events	
36 Samples per Event	
Inorganics Sampling	6,750
3 Sampling Events	
15 Samples per Event	
Consumables	2,970
Sampling - Labor	8,820
7 Events	
16 Hours per Event	
Sampling - Travel	6,895
7 Events	
Site Management	9,450
6 Months	
20 Hours per Month	
Final Report	3,150
TOTAL O&M COST	$ 69,535

ESTIMATED COSTS
Ground Water Alternative 4
Ground Water Collection Via an Interceptor Trench and Two Treatment/Disposal Options

CAPITAL COSTS	COSTS
Implementation of Interceptor Trench	
Estimate, 800 ft. x 24 ft. Deep Interceptor Trench	$200,000
Estimate for Installing 2 Recovery Sumps (Wells)	28,000
Estimate for Installing 3 Monitoring Wells	12,000
Estimate for Well Pumps and Controls	18,000
Estimate for Manholes, Controls, and Piping to the Treatment System	35,000
Disposal, Approximately 800 Cubic Yds., (Approximately 920 Tons) Removed During Trenching Would Need to be Disposed as Nonhazardous Soil (Use $100/Ton) (Transportation Allowance In Costing of Disposal) (Also See Note Below)	92,000
Backfill Material and Placement ($3.50/yd.)	2,800
Design, Engineering, and Management	50,000
TOTAL ESTIMATED COST	$437,800

NOTE: By selecting the placement of the trench, the quality of the soil to be disposed can be selected. Since the duration of the cleanup is so long anyhow, there is no compelling reason to incur the cost of the soil disposal as hazardous waste.

If incineration disposal was required as hazardous soils, approximately 800 cubic yards, (approximately 920 tons) removed during trenching would need to be disposed at: $1,200 per ton - cost would be $1,104,000

Implementation of Slurry Wall	
Estimate, 800 ft. x 24 ft. Deep Slurry Wall	$200,000
Estimate for Slurry Wall Material	125,000
Disposal, Approximately 800 Cubic Yds., (Approximately 920 Tons) Removed During Trenching Would Need to be Disposed as Nonhazardous Soil (Use $100/Ton) (Transportation Allowance In Costing of Disposal) (Also See Note Below)	92,000
Design, Engineering and Management	35,000
TOTAL ESTIMATED COST	$452,000

NOTE: By selecting the placement of the trench, the quality of the soil to be disposed can be selected. Since the duration of the cleanup is so long anyhow, there is no compelling reason to incur the cost of the soil disposal as hazardous waste.

If incineration disposal was required as hazardous soils, approximately 800 cubic yards, (approximately 920 tons) removed during trenching would need to be disposed at: $1200 per ton - cost would be $1,104,000

Ground Water Treatment System, (Est. 15 gpm)	
Air Stripper	$ 38,000
Carbon Canisters	26,000
Tanks	12,000
Feed Pumps, Filters	8,000
Control System	17,000
Installation, Electrical, and Piping	40,000
Analytical Estimate	6,000
Building and Utilities	45,000
Design, Engineering, and Management	60,000
TOTAL ESTIMATED COST	$252,000

Estimated Operating and Maintenance Costs of Ground Water Treatment System (For 50 Years)	
Estimate for Operating Equipment Utilities (16 HP @ $0.12)	$ 10.500
Estimate for Lighting, Heating, and so forth	12.500
Estimate Maintenance for Recovery Wells	2,500
Estimate Maintenance for Treatment System	12,000
Analytical Estimate (8 wells x 4/yr. x $300)	11,200
Sampling Costs (1 day x 2 men)	1,000
Analytical Estimate (10 wells x 4/yr. x $350)	14,000
Sampling Costs (2 day x 2 men)	2,000
Estimated Engineering and Management	6,000
TOTAL ESTIMATED COST PER YEAR	$ 71.700
Times 50 Years	$3,585.000
Times 30 Years (Ref)	$2,151.000

Estimated Operating and Maintenance Costs for Site Monitoring, Other Than for the Ground Water Treatment System (For 50 Years)	
Analytical Estimate (14 wells x 4/yr. x $350)	19,600
Sampling costs (3 day x 2 men)	3,000
Estimated Engineering and Management	3.000
TOTAL ESTIMATED COST PER YEAR	$ 25.600
Times 50 Years	$1.280.000
Times 30 Years (Ref)	$ 768.000

ESTIMATED COSTS
Ground Water Alternative 5
Ground Water Recovery Wells

CAPITAL COSTS	COSTS
Design and Engineering	$ 17,000
Installation of Wells	
Recovery Wells	1,360,000
Pumps and Controllers	680,000
Drill Cuttings Disposal	250,000
Miscellaneous	150,000
Capital Costs	
Subtotal	2,457,000
Contingency @ 20%	491,000
TOTAL CAPITAL COSTS	$2,948,000
OPERATION AND MAINTENANCE COSTS	
Annual Maintenance	$ 75,000
Pump Replacement	544,000
O&M Manual Development	6,800
O&M Costs	
Subtotal	625,800
Contingency @ 20%	125,160
TOTAL O&M COSTS	$ 750,960
ANNUAL REPORT	
Report Preparation	$ 7,225
Contingency @ 20%	1,445
TOTAL REPORT COSTS	$ 8,670
TOTAL ALTERNATIVE COST	$3.707,630

ESTIMATED COSTS
Ground Water Alternative 6
Ground Water Collection Via SVE Dewatering and Two Treatment/Disposal Options

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The cost of dewatering as described in Ground Water Alternative 6 is included in the total cost summary for soil cleanup Alternative 8 - Dewatering of the site and removal of the VOC contaminants by use of SVE and is located on pages A-18 to A-21.

ESTIMATED COSTS
Soil Alternative 2
Institutional Controls

CAPITAL COSTS	COST
Preparation of Plans	$ 3,000
Legal Fees	10,000
Fencing	20,000
Capital Cost	
Subtotal	33,000
Contingency 10%	1,300
TOTAL CAPITAL COST	$34,300

ESTIMATED COSTS
Soil Alternative 3 - Option 1
In situ Soil Stabilization/Solidification

CAPITAL COSTS	COSTS
Site Work	
Treatment	$200.000
Mobilization	25.000
Air Pollution Control	20,000
Soil Disposal	
220 cubic yds.	50.000
Topsoil/Reseeding	6,000
Borings	27,000
Analytical	
On-site Gas Chromatograph	5,000
Soil Samples	54.000
Air Sampling	10.000
Access Agreement	10.000
Oversight and Reporting	
Geotechnical Design	30.000
On Site	28.000
Off Site	30.000
Reporting	50.000
Permitting	10.000
Expenses	28.000
TOTAL COSTS	$583.000

ESTIMATED COSTS
Soil Alternative 3 - Option 2
In situ Soil Volatilization

CAPITAL COSTS	COSTS
Site Work	
Treatment	$400,000
Mobilization	25,000
Sheet Piling	120,000
Air Pollution Control	50,000
Soil Disposal	
220 cubic yds.	50,000
Topsoil/Reseeding	6,000
Borings	27,000
Analytical	
On-site Gas Chromatograph	5,000
Soil samples	54,000
Air Sampling	10,000
Access Agreement	10,000
Oversight and Reporting	
Geotechnical Design	30,000
On Site	56,000
Off Site	56,000
Reporting	50,000
Permitting	10,000
Expenses	28,000
TOTAL COSTS	$987,000

ESTIMATED COSTS
Soil Alternative 4
Excavation of "Hot Spots" With Two Treatment/Disposal Options - Option 1

CAPITAL COSTS	COSTS
Next to Building, By Loading Dock	
Structural Shoring (150 ft. x 24 ft. x $85/sq. ft.)	$ 306,000
Use of Structural Trench Box (30x20x18)	40,000
Excavation and Loading (60 x 60 x 18 = 2,400 yds.) ($9.25/yd. = $8.04/Ton)	22,200
Transportation ($100/Ton) 2,760 Tons	275,000
Disposal ($1,200/Ton)	3,312,000
Bentonite Cap ($135 + $15/Ton x 153 Tons)	22,900
Backfill Material and Placement ($3.50/yd.)	8,400
TOTAL THIS AREA	3,986,500
Next to Building, By Metal Preparation Room	
Structural Shoring (150 ft. x 24 ft. x $85/sq. ft.)	306,000
Use of Structural Trench Box (60 x 60 x 24)	120,000
Excavation and Loading (60 x 60 x 24 = 3,200 yds.) ($9.25/yd. = $8.04/Ton)	29,600
Transportation ($100/Ton) 3,680 Tons	368,000
Disposal ($1,200/Ton)	4,416,000
Bentonite Cap ($135 + $15/Ton x 153 Tons)	22,900

Backfill Material and Placement ($3.50/yd.)	11,200
TOTAL THIS AREA	5,273,700
Area of MW-19 to MW-6	
Use of Structural Trench Box	N/A
Excavation and Loading (Est. 150 x 40 x 8 = 1,800 yds.) ($5.50/yd. = $4.78/Ton)	9,900
Transportation ($100/Ton) 2,070 Tons	207,000
Disposal ($1,200/Ton)	2,484,000
Bentonite Cap ($135 + $15/Ton x 255 Tons)	38,300
Backfill Material and Placement ($3.50/yd.)	6,300
TOTAL THIS AREA	2,745,500
Next to MW-18	
Use of Structural Trench Box	N/A
Excavation and Loading (Est. 40 x 40 x 8.= 474 yds.) ($5.50/yd. = $4.78/Ton)	2,600
Transportation ($100/Ton) 545 Tons	54,500
Disposal ($1,200/Ton)	654,000
Bentonite Cap ($135 + $15/Ton x 68 Tons)	10,200
Backfill Material and Placement ($3.50/yd.)	1,700

TOTAL THIS AREA	723,000
Ground Water Control During Excavation	100,000
Protection of Remediated Areas From Recontamination By Ground Water After Remediation, Estimated	500,000
TOTAL HOT SPOT EXCAVATION AND DISPOSAL (Must also add interceptor trench and ground water treatment to total cost.)	$13,328,000

ESTIMATED COSTS
Soil Alternative 4
Excavation of "Hot Spots" With Two Treatment/Disposal Options - Option 2
On-site Incineration

CAPITAL COSTS	COSTS
Next to Building by Loading Dock	
Structural shoring (150 ft. x 24 ft. x $85/sq. ft.)	$ 306,000
Use of structural trench box (30 x 20 x 18)	40,000
Excavation and loading (60 x 60 x 18 = 2,400 yds.) ($9.25/yd. = $8.04/ton))	22,200
Transportation ($3/ton, based on $65/hr charge and 2-25 tons/hr incineration rate) 2,760 tons	8,280
On-site incineration ($250/ton)	690,000
Bentonite Cap ($135 + $15/Ton x 153 Tons)	22,900
Replacement of soil ($1/ton)	2,760
TOTAL THIS AREA	$1,146,140
Next to Building, by Metal Preparation Room	
Structural shoring (150 ft. x 24 ft. x $85/sq. ft.)	$ 306,000
Use of structural trench box (60 x 60 x 24)	120,000

Excavation and loading ($9.25/yd. = $8.04/ton)	29,600
Transportation ($3/ton, based on $65/hr charge and 20-25 tons/hr incineration rate) 3,680 tons	11,040
On site incineration ($250/ton)	920,000
Bentonite Cap ($135 + $15/Ton x 153 Tons)	22,900
Replacement of soil ($1/ton)	3,680
TOTAL THIS AREA	$1,413,220
Area of MW-19 to MW-6	
Use of structural trench box	N/A
Excavation and loading (Est. 150 x 40 x 8 = 1,800 yds.) ($5.50/yd. = $4.78/ton)	9,900
Transportation ($3/ton, based on $65/hr. charge and 20-25 tons/hr. incineration rate) 2,070 tons	6,210
On-site incineration ($250/ton)	517,500
Bentonite cap ($135 + $15/ton x 255 tons)	38,300
Replacement of soil ($1/ton)	2,040
TOTAL THIS AREA	573,980
Next to MW-18	
Use of structural trench box	N/A

Excavation and loading (Est.. 40 x 40 x 8 = 474 yds.) ($5.50/yd. = $4.78/Ton)	$ 2,600
Transportation ($3/ton, based on $65/hr. charge and 2-25 tons/hr. incineration rate)545 tons	1,640
On-site incineration ($25/ton)	136,250
Bentonite cap ($135 + $15/ton x 68 tons)	10,200
Replacement of soil ($1/ton)	550
TOTAL THIS AREA	$ 151,240
Ground water control during excavation	$ 100,000
Protection of remediated areas from recontamination by ground water after remediation, estimated	500,000
Incineration mobilization	500,000
Note: Incineration mobilization could be as high as $1,200,000 if a different process is required. The figure used is the best estimate of cost based on verbal information, but pilot testing would be required to confirm that the lower prices process is viable.	
TOTAL HOT SPOT EXCAVATION AND ON-SITE INCINERATION (Must also add interceptor trench and ground water treatment to total cost.)	$4,384,580

ESTIMATED COSTS
Soil Alternative 8
Implementation of ISV with Dewatering

CAPITAL COSTS	COSTS
167 ISV Design Engineered Well, 24 ft., @ 1,000 each	$167,000
5,000 ft. (4600) Piping, Trenching @ 20/ft. @ 4 ft. Below Grade, With Installation	100,000
(4) - 6 Pump Tank Systems, to Resolve Lift Problems, With Controls, @ $7,000	42,000
Estimate for Well Pumps and Controls	18,000
Estimate for Manholes, Controls, and Piping to the Treatment System	35,000
Disposal, from Wells, Approximately 250 Cubic Yards (Approximately 325 tons)	
Approximately 200 tons as Hazardous, Manage On Site with Vapor Extraction @ $50.00/ton	10,000
Approximately 125 tons as Nonhazardous, Manage On Site Maybe with Vapor Extraction @ $20.00/ton	2,500
Disposal, from Trenching, Approximately 800 Cubic Yards (Approximately 1040 tons), say 1,100 tons	
Estimated Approximately 500 tons as Hazardous, Manage On Site with Vapor Extraction @ $50.00/ton	25,000

Approximately 600 tons as Nonhazardous, Manage On Site Maybe with Vapor Extraction @ $20.00/ton	12,000
Well Fill Material (Gravel) and Placement 250 yds. @ (est.) $12.00/yd.	3,000
Trench Back Fill Material and Placement 800 yds. @ (est.) $3.50/yd.	2,800
Vacuum/Blower and Controls, Installed in the Ground Water Treatment Building	20,000
Carbon Canisters for Off Gas Remediation	26,000
Design, Engineering, and Management	80,000
TOTAL ESTIMATED COST:	$543,300

If a "knife drag type" insertion can be done for some of the piping, soils would not be removed, and, therefore, soils disposal would be greatly reduced.

Cost Estimate for Pilot Study

Piezometer Installation:	Install 18 Piezometers to approximately 20 ft. bgl by hollow stem auger, PVC Const., 2 inch diameter, 2-10 ft. slot screens; 3 locations (6 per location)
Drilling Costs	est. $10,000
Field Supervision 50 hrs. x $85.00/day (1 person working five 10-hour days)	4,250
Travel Expenses	est. 2,000
Subtotal	16,250

Dewatering Pilot & ISV Pilot Study:	Dewater the aquifer in the three selected locations by keeping the water table depressed through the use of a submersible pump and float system. (mini-pumping test) Measure water levels in nearby piezometers. Following dewatering of the well, a vacuum would be applied, and the pressures would be monitored in the same piezometers to determine the effective radius of an operating ISV system.
Field Study 280 hrs. x $85.00 (2 persons working 14 ten-hour days)	23,800
Travel Expenses	est. 4,000
Equipment Rental	est. 4,000
Subtotal	11,230
GRAND TOTAL	$59,280

Estimated Operating and Maintenance Costs of Ground Water Treatment System (For 10-15 Years)

Estimate for Operating Equipment Utilities (16 HP @ $0.12)	$ 10,500
Estimate for Lighting, Heating, Etc.	12,500
Estimate Maintenance for Recovery Wells	2,500
Estimate Maintenance for Treatment System	12,000
Analytical Estimate (8 wells x 4/yr. x $300.00)	11,200
Sampling Costs (1 day x 2 men)	1,000
Analytical Estimate (10 wells x 4/yr. x $350.00)	14,000

Sampling Costs (2 day x 2 men)	2,000
Estimated Engineering and Management	6,000
TOTAL ESTIMATED COST PER YEAR	$ 71,700
Times a Total of 10 Years, Including 1-1.5 Years to Dewater Site	$717,000

Estimated Operating and Maintenance Costs for Site Monitoring, Other Than for the Ground Water Treatment System (For 10 Years)

Analytical Estimate (14 wells x 2/yr. x $350.00)	$ 9,800
Sampling Costs (5 days x 2 men x 2/yr.)	10,000
Air Sampling Analytical (10 x 2/yr. x $300.00)	6,000
Estimated Engineering and Management	3,000
TOTAL ESTIMATED COST PER YEAR	$28,800
Times 10 Years	$288,000

ESTIMATED COSTS
Surface Water Alternative 1
No Action

CAPITAL COSTS	COST
Preparation of Plans	$4,500
Capital Cost	
Subtotal	4,500
Contingency 10%	450
TOTAL CAPITAL COST	$4,950

ESTIMATED COSTS
Surface Water Alternatives 2 and 3
Implementation

CAPITAL COSTS	COSTS
Implementation of Storm/Surface Water Separation	
Construct 300 ft. Ground Water Collection Piping Along the Storm/Surface Water Sewer System	$ 12,000
Soil Disposal (300 x .6 x 5 = 37 yds.) 43 tons	51,600
Backfill Material and Placement ($3.50/yd.)	150
Reconstruct 450 ft. Sanitary Sewer System	15,750
Reconstruct 300 ft. Storm Sewer System	10,500
Construct 450 ft. Lined Storm/Surface Water Ditch, Along with Ground Water Collection Piping	40,500
Soil Disposal (450 x .6 x 1 = 11 yds.) 13 tons	15,600
Backfill Material and Placement ($3.50/yd.)	50
Installing 1 Recovery Sump	8,000
Installing 1 Monitoring Sump	4,000
Well Pumps and Controls	12,000
Manholes, Controls, and Piping to the Treatment System (Est.)	35,000
Design, Engineering, and Management	40,000
TOTAL ESTIMATED COST	$ 245,150

NOTE: Disposal cost is based on the need to trench to place the interceptor pick-up pipe, now based on an 8-inch wide trench, either 5 feet deep along the 300-foot area, of just 1-foot deep along the ditch to be lined. Incineration disposal was assumed required as Hazardous Soils, at $1100/Ton, plus transportation. (Use $1200/Ton)

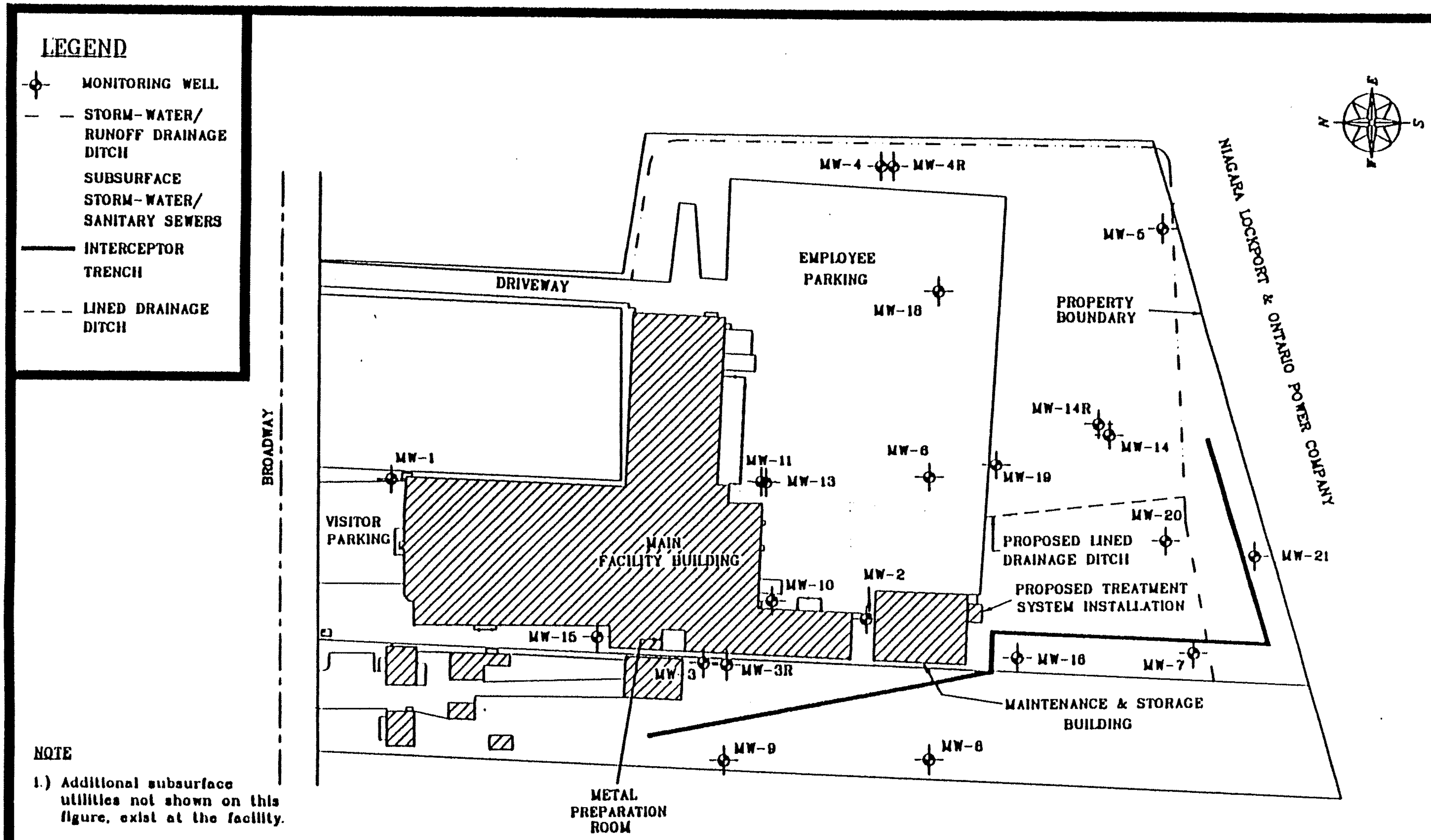
If a "knife drag type" insertion can be done, soils would not be removed, and therefore soils disposal would be greatly reduced, or almost eliminated.

ESTIMATED COSTS
Surface Water Alternatives 2 and 3
Operation and Maintenance

OPERATION AND MAINTENANCE COSTS	
Annual Sampling	$ 1,200
Equipment, Supplies, Shipping	250
Mobilization/Demobilization	1,200
Per Diem	70
Expenses (Car, Hotel, and so forth)	250
Report Preparation	1,200
Analytical Services - Volatiles	1,000
Total Cost per Sampling Event	5,170
Annual Sampling Costs - First Year	20,680
Annual Sampling Costs - Years 2 - 5	41,360
TOTAL COST	$66,490

APPENDIX B

APPENDIX B
CONCEPTUAL DESIGN



NOTE

1.) Additional subsurface utilities not shown on this figure, exist at the facility.

SOURCES:

(1) TALLAMY, VAN KUREN, GERTIS & ASSOCIATES, Dwg. No. [illegible] (FEBRUARY [illegible], 1991)

SCALE
1 INCH = 130 FEET

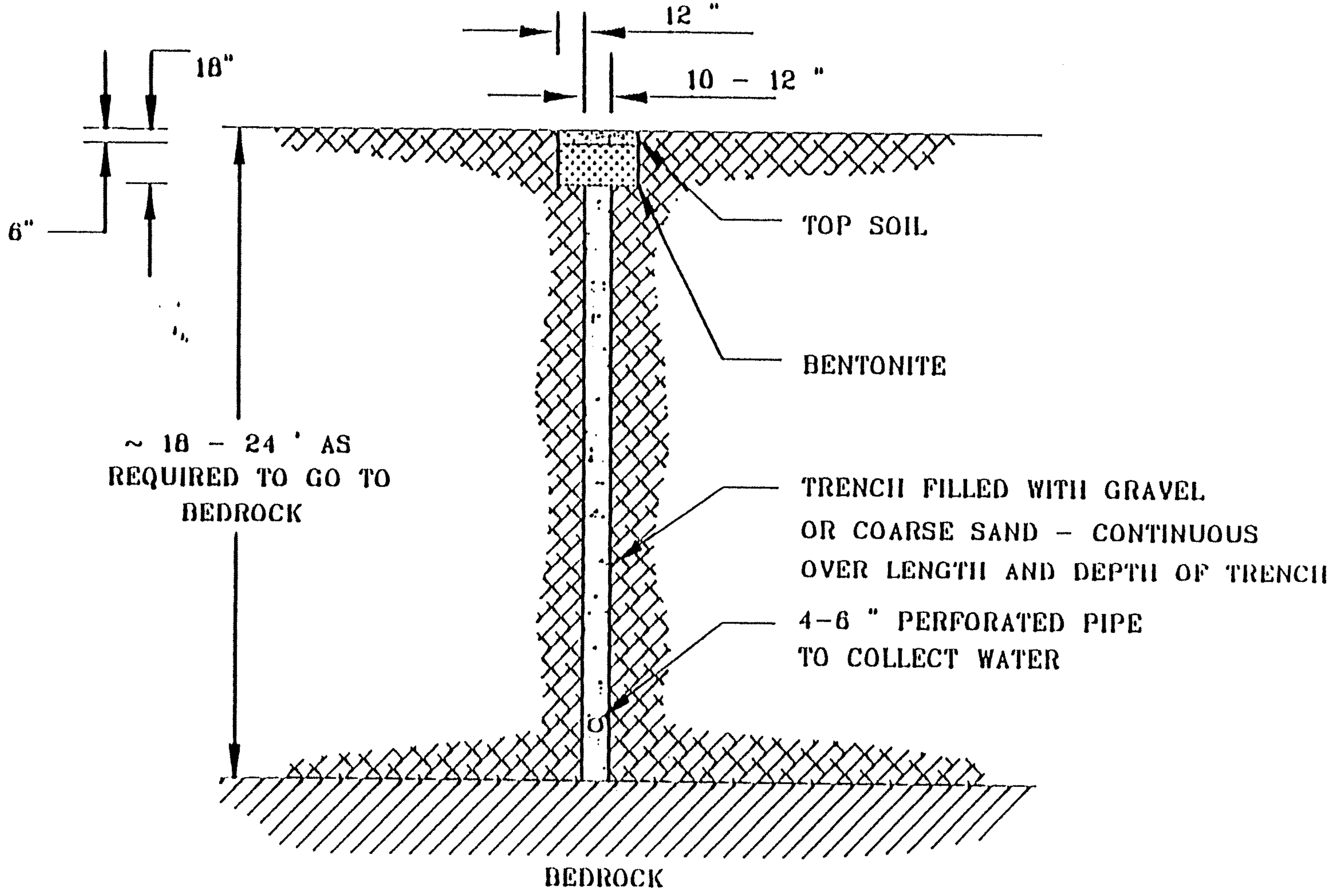
ARO CORPORATION

BUFFALO, NEW YORK

CAPSULE
Environmental Engineering Inc.
1970 OAKCREST AVENUE, SUITE 215, ST PAUL, MINNESOTA 55113
PHONE (612)636-2644 ● FAX (612)636-3106

INTERCEPTOR TRENCH
PLACEMENT

PROJECT 128-98 FIGURE B1



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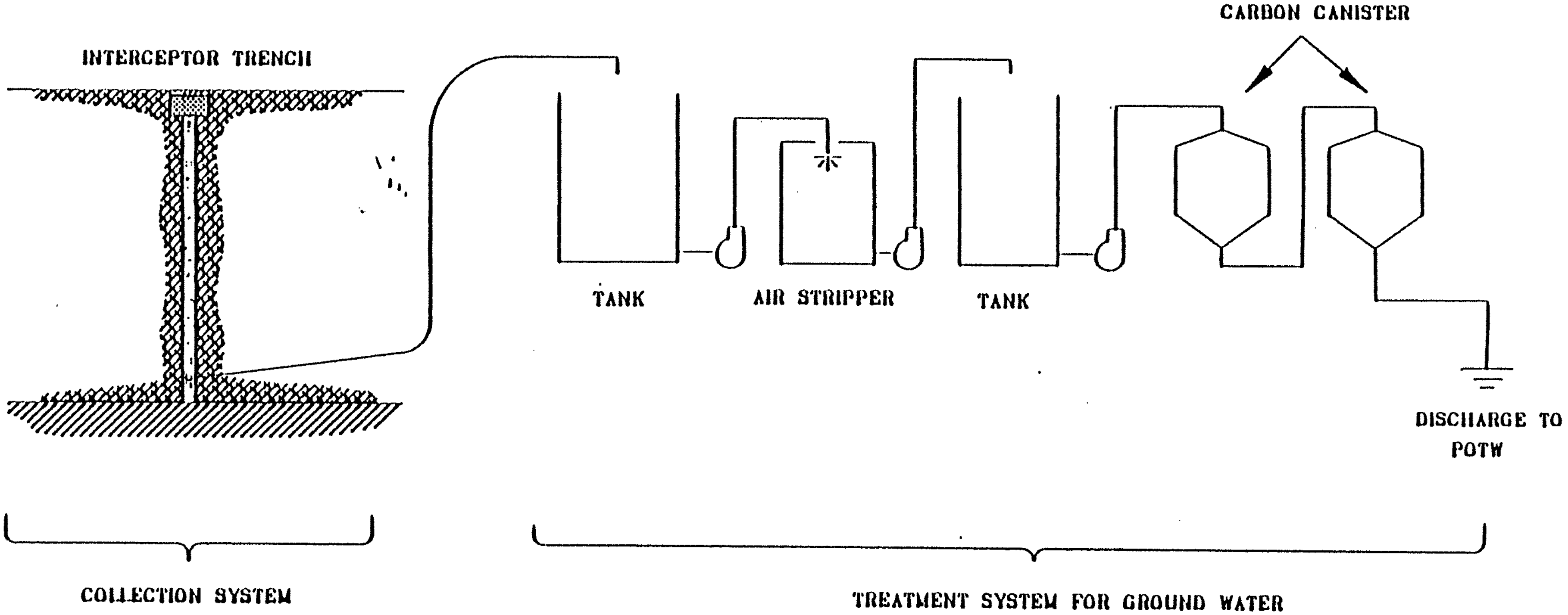
CROSS SECTION OF INTERCEPTOR TRENCH

PROJECT 128-08 FIGURE B-2



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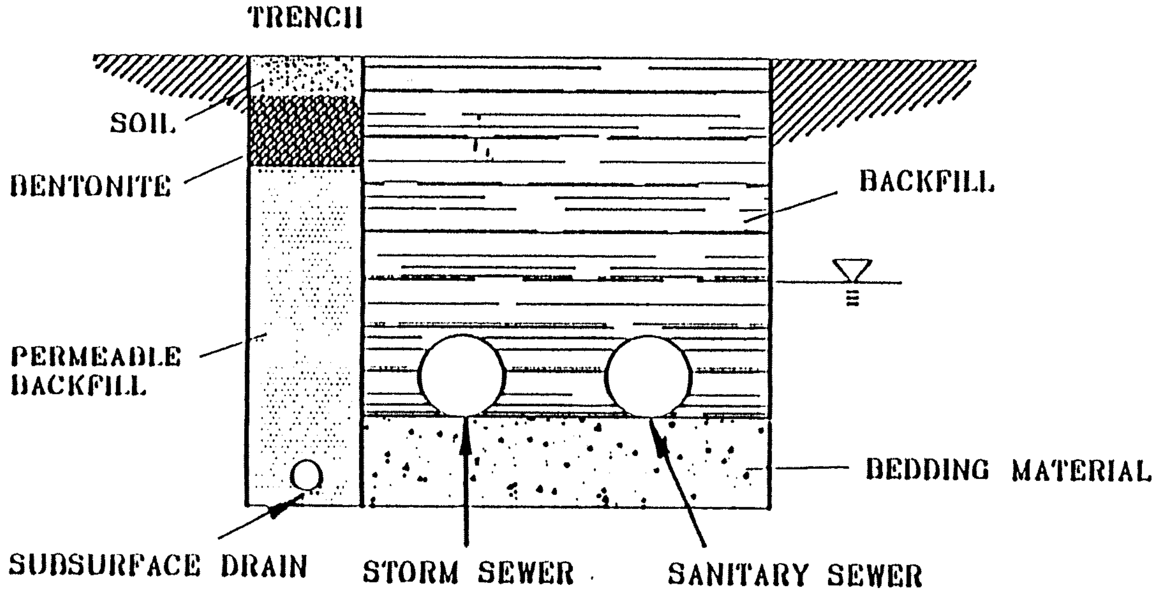
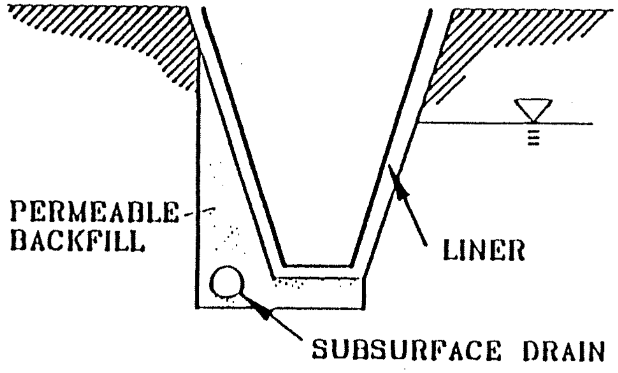
TREATMENT SYSTEM DIAGRAM

PROJECT 128-08 FIGURE B-3

SECTION: STORM/SANITARY CULVERT



SECTION: SURFACE DRAIN



ARO CORPORATION

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PHONE (612)636-2044 ● FAX (612)636-3106

CROSS SECTION OF SUBSURFACE DRAINS

PROJECT 128-98 FIGURE B-4

APPENDIX C

APPENDIX C
CORRESPONDENCE

CAPSULE
ENVIRONMENTAL ENGINEERING, INC

COPY

October 3, 1994

Mr. David Locey
Assistant Sanitary Engineer
New York State Department of
Environmental Conservation
270 Michigan Avenue
Buffalo, New York 14203

Re: The Aro Corporation
Buffalo, New York
DHWR Site #915147
Feasibility Study Response

Dear Mr. Locey:

Due to an error in the net present value (NPV) calculations which were used, values in the September 28 letter were artificially low. The enclosed documents represent the corrected values.

Please replace page 4 of the NPV comments and the NPV tables in the September 28 letter with the enclosed revisions.

If you have any questions regarding this response letter, please feel free to contact me at (800) 328-8246.

Sincerely,

CAPSULE ENVIRONMENTAL ENGINEERING, INC.

Jay Mattsfield

Jay S. Mattsfield
Manager, Remediation Technology

JSM:mmf
Enclosure
cc/enc: J. Wenker/Ingersoll-Rand, Woodcliff Lake
J. Ray/Ingersoll-Rand, Woodcliff Lake

1970 Oakcrest Avenue, Suite 215 • St. Paul, MN 55113-2624 • (612) 636-2644 • Fax (612) 636-3106
Toll Free 1-800-328-8246

Soil Alternative 4 (Off-site Incineration of Hot Spots)

Capital Costs		
Excavation and incineration	13,328,700	
Institutional controls	34,300	
Ground water treatment	252,000	
Sanitary/sewer system	245,000	
Interceptor Trench	438,000	
	14,298,000	
O&M Costs		
Ground water treatment	71,700	
Ground water monitoring	25,600	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	117,980	107,640

Soil Alternative 4 (On-site Incineration of Hot Spots)

Capital Costs		
Excavation and incineration	4,385,000	
Institutional controls	34,300	
Ground water treatment	252,000	
Sanitary/sewer system	245,000	
Interceptor trench	438,000	
	5,354,300	
O&M Costs		
Ground water treatment	71,700	
Ground water monitoring	25,600	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	117,980	107,640

Soil Alternative 4 (On-site Low Temperature Thermal Desorption)

Capital Costs		
Excavation and incineration	2,981,000	
Institutional controls	34,300	
Ground water treatment	252,000	
Sanitary/sewer system	245,000	
Interceptor trench	438,000	
	3,950,300	
O&M Costs		
Ground water treatment	71,700	
Ground water monitoring	25,600	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	117,980	107,640

Groundwater Alternative 1
No action

Year	$ Outlay
0	10000
1	44000
2	22000
3	22000
4	22000
5	22000
6	22000
7	22000
8	22000
9	22000
10	22000
11	22000
12	22000
13	22000
14	22000
15	22000
16	22000
17	22000
18	22000
19	22000
20	22000
21	22000
22	22000
23	22000
24	22000
25	22000
26	22000
27	22000
28	22000
29	22000
30	22000

Present Worth
$369,146

Groundwater Alternative 2
Institutional Controls

Year	$ Outlay
0	21000
1	44000
2	22000
3	22000
4	22000
5	22000
6	22000
7	22000
8	22000
9	22000
10	22000
11	22000
12	22000
13	22000
14	22000
15	22000
16	22000
17	22000
18	22000
19	22000
20	22000
21	22000
22	22000
23	22000
24	22000
25	22000
26	22000
27	22000
28	22000
29	22000
30	22000

Present Worth
$380,146

Groundwater Alternative 3
Reactive Wall

Year	$ Outlay
0	2981000
1	49500
2	39000
3	39000
4	39000
5	39000
6	39000
7	39000
8	39000
9	39000
10	39000
11	39000
12	39000
13	39000
14	39000
15	39000
16	39000
17	39000
18	39000
19	39000
20	39000
21	39000
22	39000
23	39000
24	39000
25	39000
26	39000
27	39000
28	39000
29	39000
30	39000

Present Worth
$3,590,526

Groundwater Alternative 4
Interceptor Trench

Year	$ Outlay
0	935000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
13	108000
14	108000
15	108000
16	108000
17	108000
18	108000
19	108000
20	108000
21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$2,604,749

Groundwater Alternative 5
Recovery Wells

Year	$ Outlay
0	3200000
1	206000
2	199000
3	199000
4	199000
5	199000
6	199000
7	199000
8	199000
9	199000
10	199000
11	199000
12	199000
13	199000
14	199000
15	199000
16	199000
17	199000
18	199000
19	199000
20	199000
21	199000
22	199000
23	199000
24	199000
25	199000
26	199000
27	199000
28	199000
29	199000
30	199000

Present Worth
$6,265,784

Groundwater Alternative 6
SVE Dewatering

Year	$ Outlay
0	855000
1	97000
2	97000
3	97000
4	97000
5	97000
6	97000
7	97000
8	97000
9	97000
10	97000
11	97000
12	97000
13	97000
14	97000
15	97000
16	97000
17	97000
18	97000
19	97000
20	97000
21	97000
22	97000
23	97000
24	97000
25	97000
26	97000
27	97000
28	97000
29	97000
30	97000

Present Worth
$2,346,128

Soil Alternative 1
No Action

Year	$ Outlay
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0
21	0
22	0
23	0
24	0
25	0
26	0
27	0
28	0
29	0
30	0

Present Worth
$0

Soil Alternative 2
Institutional Controls

Year	$ Outlay
0	34300
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0
21	0
22	0
23	0
24	0
25	0
26	0
27	0
28	0
29	0
30	0

Present Worth
$34,300

Soil Alternative 3
Stabilization

Year	$ Outlay
0	1552000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
13	108000
14	108000
15	108000
16	108000
17	108000
18	108000
19	108000
20	108000
21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$3,221,749

Soil Alternative 3
Soil Volatilization

Year	$ Outlay
0	1956000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
13	108000
14	108000
15	108000
16	108000
17	108000
18	108000
19	108000
20	108000
21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$3,625,749

Soil Alternative 4
Off-site Incineration (Hot spots)

Year	$ Outlay
0	14298000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
13	108000
14	108000
15	108000
16	108000
17	108000
18	108000
19	108000
20	108000
21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$15,967,749

Soil Alternative 4
On-site Incineration (Hot spots)

Year	$ Outlay
0	5354000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
13	108000
14	108000
15	108000
16	108000
17	108000
18	108000
19	108000
20	108000
21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$7,023,749

Soil Alternative 4
On-site LTTD (Hot Spots)

Year	$ Outlay
0	3950000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
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19	108000
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21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$5,619,749

Soil Alternative 7
Interceptor Trench

Year	$ Outlay
0	969000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
13	108000
14	108000
15	108000
16	108000
17	108000
18	108000
19	108000
20	108000
21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$2,638,749

Soil Alternative 8
Dewatering with SVE

Year	$ Outlay
0	855000
1	100500
2	100500
3	100500
4	100500
5	100500
6	100500
7	100500
8	100500
9	100500
10	100500

Present Worth
$1,631,034

Surface Water Alternative 1
No Action

Year	$ Outlay
0	5000
1	20600
2	10300
3	10300
4	10300
5	10300
6	10300
7	10300
8	10300
9	10300
10	10300
11	10300
12	10300
13	10300
14	10300
15	10300
16	10300
17	10300
18	10300
19	10300
20	10300
21	10300
22	10300
23	10300
24	10300
25	10300
26	10300
27	10300
28	10300
29	10300
30	10300

Present Worth
$173,146

Surface Water Alternatives 2&3
Line Storm/Sanitary Sewers

Year	$ Outlay
0	497000
1	92400
2	82000
3	82000
4	82000
5	82000
6	82000
7	82000
8	82000
9	82000
10	82000
11	82000
12	82000
13	82000
14	82000
15	82000
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17	82000
18	82000
19	82000
20	82000
21	82000
22	82000
23	82000
24	82000
25	82000
26	82000
27	82000
28	82000
29	82000
30	82000

Present Worth
$1,767,446

CAPSULE
ENVIRONMENTAL ENGINEERING, INC

COPY

September 28, 1994

Mr. David Locey
Assistant Sanitary Engineer
New York State Department of
  Environmental Conservation
270 Michigan Avenue
Buffalo, New York 14203

Re: The Aro Corporation
Buffalo, New York
DHWR Site #915147
Feasibility Study Response

Dear Mr. Locey:

This letter is being prepared in response to the New York State Department of Environmental Conservation (NYSDEC) feasibility study comments letter dated July 1, 1994, (hereinafter "the Department comment letter"). In response to the Department comment letter, Capsule submitted correspondence dated July 29, 1994, which addressed many of the issues raised by the Department. Subsequently, a meeting of Ingersoll-Rand, Capsule, Mr. Doster, and you was held on August 12, 1994, at the Department's offices to discuss the issues not addressed in the July 29, 1994, correspondence. Following the meeting, a telephone conversation was conducted between Capsule (Everett Milton and Jay Mattsfield) and you on September 7, 1994, in an effort to resolve the comments.

It was agreed during the September 7 telephone conversation, that the Department's comment letter, Capsule's July 29 response letter, and this letter will be attached to the Feasibility Study (FS) Report, therefore, obviating the need for any further revisions to the text of the FS Report.

The following responses are organized to correspond with the Department's comment letter.

General

1. David Flynn, Esq. submitted a letter dated September 2, 1994, on Ingersoll-Rand's behalf (enclosed) addressing this comment.

2. Based upon the telephone conversation of September 7, 1994, with Mr. Locey, combining and/or configuring the media-specific alternatives into remedial options will not be required.

3. The volume of soil and ground water that has been impacted by contamination at this site are estimated to be:

Soil	139,000 cubic yards
Ground water	10.6 acre-feet
Surface water	0.09 acre-feet

This estimate accounts for soil or ground water impacted above 1 part per billion.

The estimated time to construct/build the remedial alternative for each of the site-wide alternatives is:

Soil	2 months (pilot) 1 year (full scale system)
Ground water	2 months (pilot) 1 year (full scale system)
Surface water	2 months

As the soil and ground water remedial alternatives are both accomplished through the use of the soil vapor extraction (SVE) system, the time required to construct a system that will address both of the contaminated media is of the same duration. The construction/build estimate of one year for the full scale system is based upon a four to six month pilot scale construction and operational period to study the effectiveness of the proposed system.

4. This comment is addressed per the agreement for general comment #2 above.

5. It is Ingersoll-Rand's and Capsule's position per the letter to Mr. David Locey from Mr. David Flynn (enclosed) dated September 2, 1994, that specific soil cleanup goals and objectives for the Aro site are inappropriate and that a technology based remedy should be implemented as has been done on other NYSDEC sites. Consequently, comparisons of site-wide alternatives to cleanup levels is not deemed appropriate at this time.

6. A present net value analysis for each of the alternatives that are applicable to the site has been included as an enclosure to this letter.

Specific Comments

1. a. A copy of the most recent analytical data is included as an attachment.

   b. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

   c. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

   d. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

2. a. The facility used nitric acid and hydrofluoric acid in their passivation of stainless steel. In addition, the facility used chromic acid for the alodining.

   b. The Aro Company, a wholly-owned subsidiary of Ingersoll-Rand Company, sold certain business assets to Carleton Technologies in October 1993. The Aro/Buffalo facility was not part of the asset transfer, but Carleton, as part of the asset transfer agreement, leased the Aro/Buffalo facility from Ingersoll-Rand which owns the real property and improvements.

   c. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

   d. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

3. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

4. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment. No further response required.

5. Ingersoll-Rand has agreed to remediate the impacted sediments along the ditch. Once the sediments are removed, no further action will be required.

6. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

7. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

8. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

9. a. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

   b. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

10. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

11. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

12. This comment is addressed in specific comment #5 above.

13. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

14. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

15. Technical constraints were the principal factors used in eliminating remedial alternatives at this site. Therefore, there is no need to address this comment.

16. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

17. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

18. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

19. It is Ingersoll-Rand's and Capsule's opinion that although neither of these alternatives pursues an active remedial cleanup, they both have merit. This is based upon the following facts:

    - The aquifer that has been impacted is not considered to be a viable water bearing zone. Consequently, it is unlikely that anyone would use this aquifer for either drinking water or irrigation.

    - As the direction of ground water flow is toward the railroad right-of-way and ultimately the quarry, the probability that someone would be able to build in the area that could be potentially contaminated is unlikely. Therefore, potential for contact with the contaminated ground water is minimal.

- In the unlikely event that contaminated ground water left the site, the concentration levels would be low and ultimately the ground water would enter the quarry. Upon entering the quarry, the ground water would be naturally aerated as it descended down the quarry walls to the base of the quarry. The quarry would also act as a natural holding pond where further aeration of the water would occur.

20. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

21. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

22. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

23. Based on the telephone conversation between the NYSDEC and Capsule on September 7, 1994, no modifications to the feasibility study are required in order to address this comment.

24. Due to the discovery of dense nonaqueous phase layer (DNAPL) in MW-3 during the last sampling round, an interim remedial measure (IRM) will be instituted. A work plan addressing this issue is currently being prepared.

If you have any questions regarding this response letter, please feel free to contact me at (800) 328-8246.

Sincerely,

CAPSULE ENVIRONMENTAL ENGINEERING, INC.

Jay S. Mattsfield
Manager, Remediation Technology

JSM:mmf
Enclosure
cc/enc: J. Wenker/Ingersoll-Rand, Woodcliff Lake
J. Ray/Ingersoll-Rand, Woodcliff Lake

This document was prepared under the direction and supervision of a licensed professional engineer. It is a violation of the laws of the State of New York for any person, unless they are working under the direction of a licensed professional engineer, to alter this document in any way.

Daniel P. Reinke, P. E.
State of New York Registration Number 070781

9/29/94

DANIEL P. REINKE
070781

COMMENTS ON NET PRESENT VALUE (NPV) CALCULATIONS FOR ARO/BUFFALO

The NPV calculations for the Aro/Buffalo, New York, facility were based upon a 5% rate of return. Each of the individual alternatives include all the costs that are needed to make the system viable. For example, Soil Alternative 3 (Soil Volatilization) includes capital costs for both the soil vapor extraction (SVE) system and for a ground water treatment system. This is based upon the fact that the SVE system cannot be operated unless the ground water in the zone of influence for the SVE system is removed. In addition, the operation and maintenance (O&M) and analysis costs associated with each of the systems have been incorporated into the long-term operational costs. Therefore, the costs that have been identified include all of the costs associated with the installation and operation of a viable system.

Ground water Alternative 1 (No action)

Capital Costs	
Plan preparation	10,000
O&M Costs	
Monitoring (yr 1)	44,000
Monitoring (yr 2-30)	22,000

Ground water Alternative 2 (Institutional Controls)

Capital Costs	
Plan preparation/legal fees	21,000
O&M Costs	
Monitoring (yr 1)	44,000
Monitoring (yr 2-30)	22,000

Ground water Alternative 3 (Reactive Wall)

Capital Costs	
System	2,736,000
Sanitary sewer	245,000
	2,981,000
O&M Costs	
Monitoring (yr 1)	28,800
	20,680
	49,480
Monitoring (yr 2-30)	28,800
	10,340
	39,140

Ground water Alternative 4 (Interceptor Trench)

Capital Costs

Interceptor trench	437,800
Ground water treatment	252,000
Sanitary/sewer system	245,150
	934,950

O&M Costs

Ground water treatment	71,700	
Ground water monitoring	25,600	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	117,980	107,640

Ground water Alternative 5 (Recovery Wells)

Capital Costs

System	2,948,000
Ground water treatment	252,000
	3,200,000

O&M Costs

Annual maintenance	75,000	
Pump replacement (annualized)	18,000	
Annual report	8,670	
Ground water treatment	71,700	
Ground water monitoring	25,600	
O&M Manual (yr 1 only)	6,800	
	205,770	198,970

Ground water Alternative 6 (SVE dewatering)

Capital Costs

SVE system	543,000
Ground water treatment	252,000
Pilot test	60,000
	855,000

O&M Costs

Ground water treatment	71,700
Ground water monitoring	25,600
	97,300

Soil Alternative 1 (No Action)

No costs associated with this alternative	0

Soil Alternative 2 (Institutional Controls)

Capital Costs	
Plan preparation/legal fees	34,300
O&M Costs	
No costs	0

Soil Alternative 3 (Stabilization)

Capital Costs	
Stabilization	583,000
Institutional controls	34,300
Ground water treatment	252,000
Sanitary/sewer system	245,000
Interceptor trench	438,000
	1,552,300

O&M Costs		
Ground water treatment	71,700	
Ground water monitoring	25,600	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	117,980	107,640

Soil Alternative 3 (Soil Volatilization)

Capital Costs	
Volatilization	987,000
Institutional controls	34,300
Ground water treatment	252,000
Sanitary/sewer system	245,000
Interceptor trench	438,000
	1,956,300

O&M Costs		
Ground water treatment	71,700	
Ground water monitoring	25,600	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	117,980	107,640

Soil Alternative 4 (Off-site Incineration of Hot Spots)

Capital Costs

Excavation and incineration	13,328,700	
Institutional controls	34,300	
Ground water treatment	252,000	
Sanitary/sewer system	245,000	
Interceptor Trench	438,000	
	5,354,300	

O&M Costs

Ground water treatment	71,700	
Ground water monitoring	25,600	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	117,980	107,640

Soil Alternative 4 (On-site Incineration of Hot Spots)

Capital Costs

Excavation and incineration	4,385,000	
Institutional controls	34,300	
Ground water treatment	252,000	
Sanitary/sewer system	245,000	
Interceptor trench	438,000	
	14,298,000	

O&M Costs

Ground water treatment	71,700	
Ground water monitoring	25,600	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	117,980	107,640

Soil Alternative 4 (On-site Low Temperature Thermal Desorption)

Capital Costs

Excavation and incineration	2,981,000	
Institutional controls	34,300	
Ground water treatment	252,000	
Sanitary/sewer system	245,000	
Interceptor trench	438,000	
	3,950,300	

O&M Costs

Ground water treatment	71,700	
Ground water monitoring	25,600	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	117,980	107,640

Soil Alternative 7 (Interceptor Trench)

Capital Costs		
Institutional controls	34,300	
Interceptor trench	437,800	
Ground water treatment	252,000	
Sanitary/sewer system	245,150	
	969,250	
O&M Costs		
Ground water treatment	71,700	
Ground water monitoring	25,600	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	117,980	107,640

Soil Alternative 8 (Dewatering With SVE)

Capital Costs	
SVE system	543,000
Ground water treatment	252,000
Pilot test	60,000
	855,000
O&M Costs	
Ground water treatment	71,700
Site monitoring	28,800
	100,500

Surface Water Alternative 1 (No Action)

Capital Costs		
Plan preparation	5,000	
O&M Costs		
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340

Surface Water Alternative 2&3 (Line Storm/Sanitary Sewers)

Capital Costs		
Ground water treatment	252,000	
Sanitary/sewer system	245,150	
	497,150	
O&M Costs		
Ground water treatment	71,700	
Surface water monitoring (yr 1)	20,680	
Surface water monitoring (yr 2-30)		10,340
	92,380	82,040

Groundwater Alternative 1
No action

Year	$ Outlay
0	10000
1	44000
2	22000
3	22000
4	22000
5	22000
6	22000
7	22000
8	22000
9	22000
10	22000
11	22000
12	22000
13	22000
14	22000
15	22000
16	22000
17	22000
18	22000
19	22000
20	22000
21	22000
22	22000
23	22000
24	22000
25	22000
26	22000
27	22000
28	22000
29	22000
30	22000

Present Worth
$352,051

Groundwater Alternative 2
Institutional Controls

Year	$ Outlay
0	21000
1	44000
2	22000
3	22000
4	22000
5	22000
6	22000
7	22000
8	22000
9	22000
10	22000
11	22000
12	22000
13	22000
14	22000
15	22000
16	22000
17	22000
18	22000
19	22000
20	22000
21	22000
22	22000
23	22000
24	22000
25	22000
26	22000
27	22000
28	22000
29	22000
30	22000

Present Worth
$363,051

Groundwater Alternative 3
Reactive Wall

Year	$ Outlay
0	2981000
1	49500
2	39000
3	39000
4	39000
5	39000
6	39000
7	39000
8	39000
9	39000
10	39000
11	39000
12	39000
13	39000
14	39000
15	39000
16	39000
17	39000
18	39000
19	39000
20	39000
21	39000
22	39000
23	39000
24	39000
25	39000
26	39000
27	39000
28	39000
29	39000
30	39000

Present Worth
$3,561,512

Groundwater Alternative 4
Interceptor Trench

Year	$ Outlay
0	935000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
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24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$2,525,268

Groundwater Alternative 5
Recovery Wells

Year	$ Outlay
0	3200000
1	206000
2	197000
3	197000
4	197000
5	197000
6	197000
7	197000
8	197000
9	197000
10	197000
11	197000
12	197000
13	197000
14	197000
15	197000
16	197000
17	197000
18	197000
19	197000
20	197000
21	197000
22	197000
23	197000
24	197000
25	197000
26	197000
27	197000
28	197000
29	197000
30	197000

Present Worth
$6,092,386

Groundwater Alternative 6		Soil Alternative 1		Soil Alternative 2		Soil Alternative 3		Soil Alternative 3	
SVE Dewatering		No Action		Institutional Controls		Stabilization		Soil Volatilization	
Year	$ Outlay	Year	$ Outlay	Year	$ Outlay	Year	$ Outlay	Year	$ Outlay
0	855000	0	0	0	34300	0	1552000	0	1956000
1	97000	1	0	1	0	1	118000	1	118000
2	97000	2	0	2	0	2	108000	2	108000
3	97000	3	0	3	0	3	108000	3	108000
4	97000	4	0	4	0	4	108000	4	108000
5	97000	5	0	5	0	5	108000	5	108000
6	97000	6	0	6	0	6	108000	6	108000
7	97000	7	0	7	0	7	108000	7	108000
8	97000	8	0	8	0	8	108000	8	108000
9	97000	9	0	9	0	9	108000	9	108000
10	97000	10	0	10	0	10	108000	10	108000
11	97000	11	0	11	0	11	108000	11	108000
12	97000	12	0	12	0	12	108000	12	108000
13	97000	13	0	13	0	13	108000	13	108000
14	97000	14	0	14	0	14	108000	14	108000
15	97000	15	0	15	0	15	108000	15	108000
16	97000	16	0	16	0	16	108000	16	108000
17	97000	17	0	17	0	17	108000	17	108000
18	97000	18	0	18	0	18	108000	18	108000
19	97000	19	0	19	0	19	108000	19	108000
20	97000	20	0	20	0	20	108000	20	108000
21	97000	21	0	21	0	21	108000	21	108000
22	97000	22	0	22	0	22	108000	22	108000
23	97000	23	0	23	0	23	108000	23	108000
24	97000	24	0	24	0	24	108000	24	108000
25	97000	25	0	25	0	25	108000	25	108000
26	97000	26	0	26	0	26	108000	26	108000
27	97000	27	0	27	0	27	108000	27	108000
28	97000	28	0	28	0	28	108000	28	108000
29	97000	29	0	29	0	29	108000	29	108000
30	97000	30	0	30	0	30	108000	30	108000
Present Worth $2,275,150		Present Worth $0		Present Worth $34,300		Present Worth $3,142,268		Present Worth $3,546,268	

Soil Alternative 4
Off-site Incineration (Hot spots)

Year	$ Outlay
0	14298000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
13	108000
14	108000
15	108000
16	108000
17	108000
18	108000
19	108000
20	108000
21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$15,888,268

Soil Alternative 4
On-site Incineration (Hot spots)

Year	$ Outlay
0	5354000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
13	108000
14	108000
15	108000
16	108000
17	108000
18	108000
19	108000
20	108000
21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$6,944,268

Soil Alternative 4
On-site LTTD (Hot Spots)

Year	$ Outlay
0	3950000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
13	108000
14	108000
15	108000
16	108000
17	108000
18	108000
19	108000
20	108000
21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$5,540,268

Soil Alternative 7
Interceptor Trench

Year	$ Outlay
0	969000
1	118000
2	108000
3	108000
4	108000
5	108000
6	108000
7	108000
8	108000
9	108000
10	108000
11	108000
12	108000
13	108000
14	108000
15	108000
16	108000
17	108000
18	108000
19	108000
20	108000
21	108000
22	108000
23	108000
24	108000
25	108000
26	108000
27	108000
28	108000
29	108000
30	108000

Present Worth
$2,559,268

Soil Alternative 8
Dewatering with SVE

Year	$ Outlay
0	855000
1	100500
2	100500
3	100500
4	100500
5	100500
6	100500
7	100500
8	100500
9	100500
10	100500

Present Worth
$1,594,095

Surface Water Alternative 1
No Action

Year	$ Outlay
0	5000
1	20600
2	10300
3	10300
4	10300
5	10300
6	10300
7	10300
8	10300
9	10300
10	10300
11	10300
12	10300
13	10300
14	10300
15	10300
16	10300
17	10300
18	10300
19	10300
20	10300
21	10300
22	10300
23	10300
24	10300
25	10300
26	10300
27	10300
28	10300
29	10300
30	10300

Present Worth
$165,142

Surface Water Alternatives 2&3
Line Storm/Sanitary Sewers

Year	$ Outlay
0	497000
1	92400
2	82000
3	82000
4	82000
5	82000
6	82000
7	82000
8	82000
9	82000
10	82000
11	82000
12	82000
13	82000
14	82000
15	82000
16	82000
17	82000
18	82000
19	82000
20	82000
21	82000
22	82000
23	82000
24	82000
25	82000
26	82000
27	82000
28	82000
29	82000
30	82000

Present Worth
$1,706,973

New York State Department of Environmental Conservation
270 Michigan Avenue, Buffalo, New York 14203-2999
(716) 851-7220

Langdon Marsh
Commissioner

Post-it" Fax Note 7671

To Jay Mattsfeld	Date 9-16-94 # of pages ▶ 4
Co./Dept.	From Dave Locey
Phone #	Co.
Fax #	Phone #
	Fax #

September 16, 1994

Mr. David P. Flynn
Phillips, Lytle, Hitchcock, Blaine & Huber
3400 Marine Midland Center
Buffalo, NY 14203

Dear Mr. Flynn:

ARO Corporation-DHWR Site #915147

In response to your letter of September 2, 1994, regarding soil cleanup goals for the ARO site, this Department maintains its previous position that specific levels are required and will include them in the Proposed Remedial Action Plan. This position is consistent with the approach used at other sites and follows Federal guidance.

The USEPA document, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (1988) suggests that remedial action objectives for protecting human health and the environment should express both an acceptable contaminant level and an exposure route. Protection can be achieved by reducing exposure and/or the contaminant level.

The ROD you cited, for the Iroquois/Westwood site, describes a remedy which achieves protection by reducing exposure through containment. The remedy proposed for ARO site seeks to protect by reducing the contaminant levels.

We think it entirely appropriate to state the levels to which the contaminants must be reduced in order to achieve adequate protection and can cite other RODs where cleanup goals for soil were specified. In fact, the Feasibility Study report for the Iroquois/Westwood site stated that New York State "cleanup standards will be considered RAO's" and included a table of soil cleanup goals which were based on the NYSDEC Technical and Administrative Guidance Memorandum (TAGM) #4046. The previously stated soil cleanup goals for the ARO site are based on this same TAGM.

If, as you say, conditions at the ARO site make it physically impracticable or impossible to meet these goals, the ROD may be amended. A determination would be made as to whether or not the reduced contaminant levels actually achieved, still pose an unacceptable risk and if alternative remedial actions or institutional controls are required.

If you wish to discuss this matter further, please call me at 716-851-7220.

Sincerely,

David P Locey

David P. Locey
Environmental Engineer I

DPL/ad

cc: Mr. Jerry Wenker - I.R.
Mr. Jay Mattsfield - Capsule

PHILLIPS, LYTLE, HITCHCOCK, BLAINE & HUBER
ATTORNEYS AT LAW
3400 MARINE MIDLAND CENTER, BUFFALO, NEW YORK 14203
TELECOPIER (716) 852-6100
(716) 847-8400

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September 2, 1994

VIA TELECOPY

Mr. David Locey
Environmental Engineer I
New York State Department of
Environmental Conservation
Region 9
270 Michigan Avenue
Buffalo, New York 14203

Re: ARO Corporation

Dear Mr. Locey:

At our meeting of August 12, 1994, we discussed the appropriateness of specifying soil clean-up "goals" or "objectives" for the ARO Site. As a result of our discussions at that meeting, Ingersoll-Rand and its consultant, Capsule Environmental Engineering have reviewed the proposed remedial alternative for the Site (Soil Vapor Extraction) SVE to determine the appropriateness of specifying soil clean-up goals or objectives in the Record of Decision.

Based upon this review, we believe that rather than establishing specific soil clean-up goals or objectives for the ARO Site, a technology based remedy should be used. While we did not canvass all sites being managed by the Department, we are aware of at least one site where such an approach was followed and assume there are more. We direct your attention to the methodology set forth in the Record of Decision for the Iroquois/Westwood Site (Site number 915141). As you may know, the remedy (for soils on the main site) calls for the capping and bioremediation of soils at the site via Biosparging. The ROD recognizes that it is difficult, if not impossible, to set long-term clean-up goals and objectives for soils at the Site. Rather, the ROD is, in essence, a technology based remedy. The ROD specifies the remedial technology rather than specific clean-up goals and objectives for the soils.

For purposes of the Record of Decision for the ARO Site, we believe the approach utilized by the Department for soils at the Iroquois/Westwood Site would be appropriate for the ARO Site. This is due to the fact that the SVE technology has

JAMESTOWN OFFICE: 307 CHASE BANK BLDG., P.O. BOX 1279, JAMESTOWN, NY 14702-1279, TELECOPIER: (716) 664-4230, TELEPHONE: (716) 664-3906
NEW YORK OFFICE: 437 MADISON AVENUE, 34TH FLOOR, NEW YORK, NEW YORK 10022, TELECOPIER: (212) 308-9079, TELEPHONE: (212) 759-4888
ROCHESTER OFFICE: 1400 FIRST FEDERAL PLAZA, ROCHESTER, NEW YORK 14614, TELECOPIER: (716) 232-3141, TELEPHONE: (716) 238-2000

not yet been proven effective for the ARO Site, given the geologic conditions that are present, and the fact that even if SVE is determined to be a viable remedial option, it may be physically impractical or impossible to meet a theoretical goal or objective for the soils.

In summary, we do not believe it is appropriate to set remedial goals or objectives for soils at the ARO Site. Rather, for the reasons set forth above, we believe it is more appropriate for the Department to prepare the PRAP which does not set such goals, but rather, sets forth the remedial technology (i.e. SVE) for soils at the Site.

As discussed at our meeting, we look forward to reviewing a draft of the PRAP. If you have any questions or wish to discuss this or any other matter, please do not hesitate to contact us.

Very truly yours,

PHILLIPS, LYTLE, HITCHCOCK, BLAINE & HUBER

By David P. Flynn

WAoc
0183689

cc: Martin Doster

CAPSULE
ENVIRONMENTAL ENGINEERING, INC

FI
ID#:
SERVICE
BG, CF
CORRES ADG

July 29, 1994

CAPSULE ENVIRONMENTAL ENGINEERING, INC. FAX TRANSMITTAL		
Date: 8-1-94	Time: 11:40 a.m.	No Pages 6
To: DAVID LOCEY		From: TONY GROOMS
Co.: NYSDEC		Phone: 612/636 2644
Fax No.: 716-851-7008		Fax: 612/636-3106

Mr. David Locey
Assistant Sanitary Engineer
Region 9
New York State Department of
Environmental Conservation
270 Michigan Avenue
Buffalo, New York 14203

Re: The Aro Corporation
Buffalo, New York
DHWR Site #915147

Dear Mr. Locey:

This letter has been prepared in response to the New York State Department of Environmental Conservation (NYSDEC) feasibility study comments letter dated July 1, 1994. As per your discussion with Jerry Wenker of Ingersoll-Rand Company, we have attempted to address herein most of your office's comments, but have reserved certain issues for discussion at the project meeting scheduled for August 12, 1994.

The following responses are organized to answer the individual comments in the NYSDEC's letter in the order they were presented.

General

1. This comment will be discussed at the future NYSDEC project meeting.

2. This comment will be discussed at the future NYSDEC project meeting.

3. Capsule will develop estimates of the quantity of soil, ground water, and surface water to be treated.

4. NYSDEC Technical and Administrative Guidance Memorandum (TAGM) HWR-90-4030 is currently being reviewed specifically in regards to scoring treatment alternatives. This issue will be discussed at the future NYSDEC project meeting.

5. Capsule will prepare a summary identifying federal applicable or relevant and appropriate requirements (ARARs) and state standard criteria and guidelines (SCGs) separately.

1970 Oakcrest Avenue. Suite 215 • St. Paul. MN 55113-2624 • (612) 636-2644 • Fax (612) 636-3106
Toll Free 1-800-328-8246

6. Capsule will revise the individual alternative cost summaries to reflect a present worth basis assuming an interest rate of 5%. Operation and maintenance costs will also be computed on a present worth basis, assuming an operational period of 30 years.

<u>Specific</u>

1. Section 1.1, Purpose and Organization

    a. Capsule will revise the final Feasibility Study (FS) Report to reflect the most recent remedial investigation information available.

    b. The term remedial action objective will be used in the second paragraph.

    c. The definition of the threshold criteria will be changed to include the NYSDEC language.

    d. The additional criteria provided by the NYSDEC will be included in the report text.

2. Section 1.2, Site Background

    a. Capsule has requested additional operations data from facility personnel and will add any additional information generated to the existing report text.

    b. A statement of "Aro is a wholly owned subsidiary of Ingersoll-Rand", will be included in this section.

    c. Capsule will prepare a more comprehensive discussion of previous site investigation activities, including remedial investigation results.

    d. As discussed in 1. c., Capsule will prepare a more comprehensive discussion of previous site investigation activities.

3. This comment will be addressed by Capsule in the Revised FS Report.

4. TAGM HWR-92-4046 revisions will be reviewed to determine if it affects the project.

5. Capsule will include sediment volatile organic analysis results in the revised FS Report.

6. Capsule will modify Section 1.4.5 of the FS Report to include the NYSDEC statement regarding air contamination.

7. Capsule will revise Section 1.5.11 to include exposure to underground utility workers.

   Based upon ground water flow direction and velocity at the site, the distance of contaminated areas in relation to residential properties, and the fact that monitoring of upgradient monitoring well locations MW-1 and MW-15 has not shown the presence of contaminants. The potential of ground water infiltrating residential basements is not considered a realistic exposure pathway and, therefore, will not be considered.

8. The term SCG will replace the term ARAR in the FS Report with the understanding that it applies to both state and federal requirements.

9. a. The description provided in Section 2.2.1 Remedial Action Objectives (RAOs) - Soil of the southwest portion of the property does include the area around MW-16 and will be revised for clarification.

   b. This comment will be discussed at the future NYSDEC project meeting.

10. This comment will be discussed at the future NYSDEC project meeting.

11. This comment will be discussed at the future NYSDEC project meeting.

12. We agree that the RAO for sediments is to ensure that those sediments alone do not cause a contravention of water quality standards for the particular surface water. As the surface water in question is a Class D, the sediments will be addressed so that they do not cause a contravention of Class D standards.

    It is inappropriate to utilize the ground water GA standard to determine sediment requirements in the ditch. If the departments's rationale were used (that is, that all surface waters eventually impact ground water) there would be no basis for distinguishing any surface waters in the state.

The appropriate sediment criteria is based upon Class D surface water standards.

13. The FS Report will be revised so that Soil Alternative 3 will not pass the alternative screening.

14. The reference to the New York State Department of Health issuing permits for private drinking water wells will be removed from Section 2.4.2.1 Ground Water - Institutional Controls.

15. The state must, of course, comply with the substantive provisions of the National Contingency Plan (NCP) which is set out in 40 CFR Part 300 *et seq*. One of the criteria of the NCP for the evaluation of remedial alternatives is the cost (both construction and operation and maintenance costs) of the alternatives.

    Aro will evaluate the remedial alternatives at this site in a manner that complies with the federal regulations and the department's guidance.

16. The reference to purchasing the neighboring properties will be removed from the FS Report.

17. Ingersoll-Rand does not disagree based upon acceptance by the publicly owned treatment works.

18. The department's guidance for remediation (TAGM-HWR-90-4030) was one of the resources used in the detailed analysis of alternatives as were Environmental Protection Agency guidances and regulations (re: the NCP). The reduction of toxicity, mobility, and volume will be referenced in the evaluation of alternatives.

19. This comment will be discussed at the future NYSDEC project meeting.

20. The reference to purchasing the neighboring properties will be removed from the FS Report.

21. The geometric mean conductivity in the FS Report will be changed to 5 x 10^{-6} cm/sec.

22. A statement addressing this alternative ability to reduce the mobility, toxicity and volume of contaminants has been included in the Balancing Criteria Assessment, Long-term Effectiveness, and Permanence section. However, at the request of the NYSDEC, the FS Report will be revised to include a separate section addressing each alternative's ability to reduce the mobility, toxicity, and volume of contaminants.

23. Following careful review of Ground Water Alternative 3 - Reactive Wall, it has been decided that this alternative will not pass the alternative screening (Section 2.4) because of site conditions (local geology) and the likelihood of system fouling.

24. We will review the remedial alternatives for the site and develop "sitewide" alternatives for the final remedy selection. We will consider the several alternatives suggested by the department.

    As noted, no nonaqueous phase liquid (NAPL) has been identified on site. Until such time as NAPL is found on site, it is inappropriate to consider its "presence" in the identification and evaluation of remedial alternatives.

At your request, the results of the sediment sampling activities performed in May 1994 have been included. At this point in time, we are concerned whether the analytical results accurately reflect site conditions. As discussed with you on July 26, 1994, by telephone, a confirmation sampling event will be performed August 1 and 2, 1994.

Issues not addressed in this response letter will be discussed at the tentatively scheduled NYSDEC project meeting on August 12, 1994. However, in the interim, if you have any questions or comments to our responses regarding your July 1, 1994, letter, please call me at (800) 328-8246.

Sincerely,

CAPSULE ENVIRONMENTAL ENGINEERING, INC.

FOR

Anthony D. Grooms
Environmental Specialist

ADG:mmf
cc: D. Flynn/Phillips, Lytle, Hitchcock, Blaine & Huber, Buffalo
J. Wenker/I-R, Woodcliff Lake
J. Ray/I-R, Woodcliff Lake

New York State Department of Environmental Conservation
270 Michigan Avenue, Buffalo, New York 14203-2999
(716) 851-7220

Langdon Marsh
Acting Commissioner

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July 1, 1994

FILE
ID#:
SERVICE:
BG, CF, CO, MT, PL
CORRESPONDENCE:

Mr. Jay S. Mattsfield
Capsule Environmental Engineering, Inc.
1970 Oakcrest Avenue, Suite 215
St. Paul, MN 55113

Dear Mr. Mattsfield:

ARO Corporation, Cheektowaga, NY
Site #915147
Feasibility Study, May 1994

This Department and the New York State Department of Health Health have completed their review of the subject report and have the following comments to offer:

General

1. The recommended cleanup objectives for soils shall be based on the water-soil equilibrium partitioning model as described in the NYSDEC Technical and Administrative Guidance Memorandum (TAGM) HWR-94-4046. As discussed in this TAGM, a correction faction is used to account for the various dispersive mechanisms which change the concentration of contaminants leaching to the groundwater surface. For the ARO site, the NYSDEC recommends a correction factor of 65 for TCE and 1,2 DCE. Based on the 2% organic carbon content of the saturated soils on site, the soil cleanup objectives are: 0.9 ppm TCE, and 0.40 ppm 1,2 DCE. Vinyl chloride is a contaminant of special concern, the NYS Department of Health recommends a cleanup objective of 0.01 ppm.

2. The FS report presents alternatives which are media-specific. After the detailed analysis of the individual alternatives, the FS report should combine or reconfigure these media-specific alternatives into remedial options that address the entire site (i.e. groundwater, surface and soil combined).

3. Estimates of the quantity of soil, groundwater and surface water to be treated should be included in the description of the sitewide alternatives, as well as an estimate of the time to construct or implement each remedy.

4. The comparative analysis of sitewide alternatives should be conducted in accordance with the NYSDEC TAGM HWR-90-4030 (revised May 15, 1990) and the score for each summarized in a table attached to the FS Report.

5. Appended to the FS report should be a summary of all Federal ARARs and New York State SCGs previously identified, including the key requirements and reasons for the applicability or relevance and appropriateness of each. Each sitewide alternative should be compared to this list. A suggested format for this summary is to found in the USEPA guidance document for conducting the RI/FS (EPA/540/G-89/004, October 1988). To the list of New York State SCGs is added, the recent "Technical Guidance for Screening Contaminated Sediments, November 1993" (copy attached).

6. The total cost of each sitewide alternative should be completed on a present worth basis, assuming an interest rate of 5%. Operation and maintenance cost should also be computed on a present worth basis, assuming a operation period of 30 years. The source of information on which the item cost estimates are based should be documented in an appendix to the FS report.

<u>Specific</u>

1. Section 1.1, Purpose and Organization

   a. It is expected that the final FS report will incorporate the most recent RI information available.

   b. The commonly accepted term is <u>remedial</u> action objective or RAO (second paragraph).

   c. The definition of the threshold criteria provided is not entirely consistent with USEPA and New York State guidance documents. The National Contingency Plan (NCP) defines one of the threshold criteria as the "overall protection of human health and the environment". While the criterion stated here of "...meeting RAOs, cleanup levels...." considers the end results, the NCP definition also considers whether or not short-term risks or cross-media impacts are possible in achieving that end. The definition provided later in the report (Section 2.1 Page 13) is more accurate.

   d. The criterion of reducing the toxicity, mobility of volume of hazardous substances through treatment should be included here.

2. Section 1.2, Site Background

   a. The passivation and alodining processes should be described, in terms of the substances employed and wastes generated. The substances being treated in the wastewater treatment process should also be mentioned.

   b. Ingersoll-Rand's involvement should be explained.

   c. The maximum concentration of TCE found in the groundwater was actually 1,100 mg/L.

   d. The supplemental RI report was actually submitted in October 1993. The May 1994 Revised RI report should also be cited, with some mention of the fact that additional samples were collected that same month.

3. Section 1.3 Site Geology

The distinguishing features of the two till layers, i.e. the differences in lithology and hydraulic conductivities, should be mentioned.

4. Section 1.4.1 Nature and Extent of....Soil Contamination

Some revisions to TAGM HWR-92-4046 were made in January, 1994, a copy of the revised TAGM is attached.

5. Section 1.4.4 Sediment Contamination

The report should note the concentrations of TCE and DCE actually found at sample location SED- 104; 170 and 7 ug/kg respectively. The need for remediating the ditch sediments will be addressed when the results of the May 1994 sampling become available, and an assessment made using the most recent sediment SCGs.

6. Section 1.4.5 Air Contamination

It should be noted or clarified that HNu readings at the upwind site perimeter (background) were similar to readings on site and the downwind perimeter.

7. Section 1.5.11 Baseline Risk Assessment

Identification of Exposure Pathways. The exposure to <u>underground</u> utility worker should also be considered; dermal contact with and inhalation of volatile organics in the soil and groundwater is possible.

Given the relatively flat hydraulic gradient and proximity of private residence, a future exposure pathway might also exist from infiltration of contaminated groundwater to the basements, from fluctuations in the current flow pattern. This pathway should be considered.

8. Section 2.1 Identification and Screening of Alternatives - Introduction

The analysis of alternatives shall be conducted in accordance with the NYSDEC TAGM HWR-90-4030 (May 1990), which is actually quite similar to the cited USEPA guidance. Under this TAGM, the term SCG (Standards Criteria and Guidelines) is used to describe New York State's applicable or relevant and appropriate requirements (ARARs) as well as guidance which is "to be considered". Throughout the FS report the term SCG should be substituted for the term ARAR, with the understanding that it incorporates both State and Federal requirements.

9. Section 2.2.1 RAOs - Soil

   a. It is noted that the soil in the vicinity of monitoring well MW-16 also exceeded the recommended soil cleanup objectives outlined in TAGM-HWR-94-9406. It is assumed that the RAO of addressing soil contamination in the "southwest portion of the property" (Item 1.a) includes the area around MW-16.

   b. The State does not believe that preventing "further groundwater contamination" can be ensured unless the soils beneath the facility are remediated.

10. Section 2.2.2 RAOs - Groundwater

Item 3 implies that the RAO for groundwater within the sewer backfill will be to achieve the Class D surface water quality standards. In fact, the standards to be met here are those for Class GA groundwater.

11. Section 2.2.3 RAOs - Surface Water

For surface waters that discharge to groundwater, the RAOs are the same that apply to groundwater.

12. Section 2.2.4 RAOs - Sediment

As noted earlier (Comment #5), significant contamination <u>was</u> found in the sediments at sample location SED- 104. The RAO for sediments within the drainage ditch is to prevent contaminants from impacting the surface water to the extent that water quality standards are exceeded. If the surface water eventually discharges to groundwater, the water quality standards to be met are those for Class GA groundwater. In which case, the sediment cleanup criteria are derived in the same manner as the soil cleanup objectives, based on the level of the total organic carbon present and the GA standard.

13. Section 2.4.1.1 Identification and Screening of Technology Types...Soil-Containment

The application of solidification/stabilization technology for the treatment of VOC contaminated soil is not endorsed by the USEPA or the NYSDEC. The heat of reaction that is derived vaporizes the VOCs. This technology should not pass the screening step.

14. Section 2.4.2.1 Groundwater - Institutional Controls

The NYS Department of Health does not issue permits for private drinking water wells.

15. Section 2.5 Evaluation of Technologies...

While the NCP may indicate that technologies may be screened on the basis of cost, NYSDEC guidance (TAGM-HWR-90-4030) does not. In the FS, screening will be conducted on the basis of effectiveness and implementability only.

16. Section 2.5.1.1 Soil-Alternative 1 - Limited Action via Institutional Controls

Is it to be assumed that the neighboring properties will be purchased by ARO under this alternative?

17. Section 2.5.2.4 Groundwater Alternative 4 - ... Collection via Interceptor trench..

If on-site treatment of the groundwater will be required, discharge of treated water will be to the <u>sanitary</u> sewer.

18. Section 3.3 Detailed Analysis of Alternatives

    a. The analysis should also be conducted in accordance with the NYSDEC guidance document, TAGM-HWR-90-4030.

    b. The criterion of reducing the toxicity, mobility and volume through treatment should be included.

19. Section 3.4.1.2 Groundwater - Alternative 1 - Natural Attenuation - Short Term Risk

The State finds that this alternative is decidedly <u>not</u> effective in protecting the environment in the short term. It is likely that groundwater would continue to be impacted for a considerable period of time before the natural processes reduced contaminant concentrations to acceptable levels. The same comment applies to groundwater Alternative 2 - Institutional Controls.

20. Section 3.4.2 Groundwater - Alternative 2

In Section 2.5.2.2, the alternative's description included the purchase of the neighboring properties. Has the alternative been modified here?

21. Section 3.4.5.1 Groundwater - Alternative 5 - Groundwater Recovery Wells...

The hydraulic conductivity of the glacial till is stated here as being equal to 3.5×10^{-8} cm/sec. The RI Report indicates that geometric mean conductivities of the upper and lower tills are $2x10^{-6}$ and $7x10^{-5}$ ft/min respectively. The geometric mean conductivity of the two tills is therefore estimated to be $1x10^{-7}$ ft/min or approximately <u>$5x10^{-6}$ cm/sec.</u>

22. Section 3.4.1.3 Groundwater - Alternative 1 - Long-Term Effectiveness & Permanence

The assessment provided here does not follow the definition of the criterion as provided in the NCP, State and Federal guidance documents. Time is a factor considered under the short-term criterion. The alternative's ability to reduce the mobility, toxicity and volume of contamination through treatment is actually a separate criterion in itself.

23. Section 3.4.3.3 Groundwater - Alternative 3 - ...Reactive Wall - Balancing Criteria Assessment

Other technologies have been eliminated in the screening process on the basis of the low permeability of the soil. If a buffer needs to be injected into the formation to protect the wall, might the same concern be used to reject this alternative? There is the concern that the process might just substitute one contaminant for another; is it possible that iron may leach from the matrix, and what effect might the buffer have on the environment?

24. Section 3.4.5.3 Groundwater - Alternative 5 - Balancing Criteria

A significant factor to consider in evaluating the effectiveness of the collection and treatment alternatives is the possible presence of residual NAPL. The RI never actually found NAPL, but the extremely high level of contamination found in the groundwater near the metal preparation room suggests that it may be present.

Based on its review of the media-specific alternatives presented in this FS report, the State believes the following sitewide alternatives should be considered for detailed individual and comparative analysis:

Alternative 1:	Excavation of soil in the "hot spots" with on site treatment by low temperature thermal desorption. A groundwater interceptor trench would be installed between excavated areas and the facility. On-site sewers and drainage ditches would be lined and groundwater collected from the bedding and trench for on-site treatment and discharge to the sanitary sewer. This alternative is a combination of Groundwater Alternative 4, Surface Water Alternatives 2 an 3, and a variant of Soil Alternative 4a.
Alternative 2:	Dewatering of the site and in-situ treatment of the soil by soil vapor extraction.

Alternative 3: Excavation of all soil exceeding recommended cleanup objectives, with on site treatment by thermal desorption.

Alternative 4: Collection of groundwater via interceptor trench, combined with the lining of the sewers and drainage ditch.

Alternative 5: No Action.

It is suggested that representatives from ARO, Capsule and the State meet at the NYSDEC offices to discuss the issues raised. A tentative date for such a meeting might be July 13, 1994. Please call 716-851-7220, to discuss the matter further.

Sincerely,

David Locey

David P. Locey
Environmental Engineer I

DPL/ad

5-2-75

HWR-94-4046
January 24, 1994

mc

New York State Department of Environmental Conservation

(REVISED)

MEMORANDUM

TO: Regional Hazardous Waste Remediation Engineers, Bureau Directors and Section Chiefs
FROM: Michael J. O'Toole, Jr., Director, Division of Hazardous Waste Remediation
SUBJECT: Revised TAGM - Determination of Soil Cleanup Objectives and Cleanup Levels
DATE: JAN 24 1994

Michael J. O'Toole Jr.

Attached is the revised Division Technical and Administrative Guidance Memorandum (TAGM) on Determination of Soil Cleanup Objectives and Cleanup Levels in its final form. The changes are to the Tables of Appendix A. They are minor in nature and do not change the content of the TAGM. The changes include:

1. Alphabetizing contaminants in Table 1 through Table 4.

2. The addition of a few contaminants to Table 1 and Table 2.

3. Table 4 has been revised to indicate that background levels for lead vary widely and provide a range for undeveloped and developed areas. It also has been revised to indicate that site-specific form(s) of cyanide should be considered when establishing soil cleanup objectives for cyanide.

If you have any questions, please contact Ajay Shroff of my staff at (518)485-8792.

Attachment

cc: T. Jorling
J. Lacey
M. Gerstman
A. DeBarbieri
E. Sullivan
T. Donovan
C. Sullivan
J. Eckl
R. Davies
R. Dana
C. Goddard
C. Costopoulos
P. Counterman
J. Davis
J. Kelleher
J. Colquhoun
D. Persson
J. Printup
M. Bermingham
D. Johnson
M. Kadlecek
Regional Directors
Regional Engineers
Regional Solid and Haz. Waste Engrs.
Regional Citizen Participation Spec.

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JAN 27 1994

N.Y.S. DEPT. OF
ENVIRONMENTAL CONSERVATION
REGION 9

APPENDIX A

TABLE 1

Recommended soil cleanup objectives (mg/kg or ppm)

Volatile Organic Contaminants

Contaminant	Partition coefficient Koc	Groundwater Standards/ Criteria Cw ug/l or ppb.	a Allowable Soil conc. ppm. Cs	b ** Soil Cleanup objectives to Protect GW Quality (ppm)	USEPA Health Based (ppm) Carcinogens	Systemic Toxicants	CRQL (ppb)	*** Rec.soil Clnup Obj (ppm)
Acetone	2.2	50	0.0011	0.11	N/A	8,000	10	0.2
Benzene	83	0.7	0.0006	0.06	24	N/A	5	0.06
Benzoic Acid	54*	50	0.027	2.7	N/A	300,000	5	2.7
2-Butanone	4.5*	50	0.003	0.3	N/A	4,000	10	0.3
Carbon Disulfide	54*	50	0.027	2.7	N/A	8,000	5	2.7
Carbon Tetrachloride	110*	5	0.006	0.6	5.4	60	5	0.6
Chlorobenzene	330	5	0.017	1.7	N/A	2,000	5	1.7
Chloroethane	37*	50	0.019	1.9	N/A	N/A	10	1.9
Chloroform	31	7	0.003	0.30	114	800	5	0.3
Dibromochloromethane	N/A	50	N/A	N/A	N/A	N/A	5	N/A
1,2-Dichlorobenzene	1,700	4.7	0.079	7.9	N/A	N/A	330	7.9
1,3-Dichlorobenzene	310 *	5	0.0155	1.55	N/A	N/A	330	1.6
1,4-Dichlorobenzene	1,700	5	0.085	8.5	N/A	N/A	330	8.5
1,1-Dichloroethane	30	5	0.002	0.2	N/A	N/A	5	0.2
1,2-Dichloroethane	14	5	0.001	0.1	7.7	N/A	5	0.1
1,1-Dichloroethene	65	5	0.004	0.4	12	700	5	0.4
1,2-Dichloroethene(trans)	59	5	0.003	0.3	N/A	2,000	5	0.3
1,3-dichloropropane	51	5	0.003	0.3	N/A	N/A	5	0.3
Ethylbenzene	1,100	5	0.055	5.5	N/A	8,000	5	5.5
113 Freon(1,1,2 Trichloro-1,2,2 Trifluoroethane)	1,230*	5	0.060	6.0	N/A	200,000	5	6.0
Methylene chloride	21	5	0.001	0.1	93	5,000	5	0.1
4-Methyl-2-Pentanone	19*	50	0.01	1.0	N/A	N/A	10	1.0
Tetrachloroethene	277	5	0.014	1.4	14	800	5	1.4
1,1,1-Trichloroethane	152	5	0.0076	0.76	N/A	7,000	5	0.8
1,1,2,2-Tetrachloroethane	118	5	0.006	0.6	35	N/A	5	0.6
1,2,3-trichloropropane	68	5	0.0034	0.34	N/A	80	5	0.4
1,2,4-Trichlorobenzene	670 *	5	0.034	3.4	N/A	N/A	330	3.
Toluene	300	5	0.015	1.5	N/A	20,000	5	1.
Trichloroethene	126	5	0.007	0.70	64	N/A	5	0.
Vinyl chloride	57	2	0.0012	0.12	N/A	N/A	10	0.
Xylenes	240	5	0.012	1.2	N/A	200,000	___	1.

a. Allowable Soil Concentration Cs = f x Cw x Koc

b. Soil cleanup objective = Cs x Correction Factor (CF)

N/A is not available

* Partition coefficient is calculated by using the following equation: log Koc = -0.55 log S + 3.64, where S is solubility in water in ppm. All other Koc values are experimental values.

** Correction Factor (CF) of 100 is used as per TAGM #4046

*** As per TAGM #4046, Total VOCs < 10 ppm.

Note: Soil cleanup objectives are developed for soil organic carbon content (f) of 1% , and should be adjusted for the actual soil organic carbon content if it is known.

APPENDIX A (cont.)

TABLE 2

Recommended Soil Cleanup Objectives (mg/kg or ppm)

Semi-Volatile Organic Contaminants

Contaminant	Partition coefficient Koc	Groundwater Standards/ Criteria Cw ug/l or ppb.	a Allowable Soil conc. ppm. Cs	b ** Soil Cleanup objectives to Protect GW Quality (ppm)	USEPA Health Based (ppm)		CRQL (ppb)	Rec.soil Clnup Objct. (ppm)
					Carcinogens	Systemic Toxicants		
Acenaphthene	4,600	20	0.9	90.0	N/A	5,000	330	50.0***
Acenaphthylene	2,056*	20	0.41	41.0	N/A	N/A	330	41.0
Aniline	13.8	5	0.001	0.1	123	N/A	330	0.1
Anthracene	14,000	50	7.00	700.0	N/A	20,000	330	50.0***
Benzo(a)anthracene	1,380,000	0.002	0.03	3.0	0.224	N/A	330	0.224 or MDL
Benzo(a)pyrene	5,500,000	0.002(ND)	0.110	11.0	0.0609	N/A	330	0.061 or MDL
Benzo(b)fluoranthene	550,000	0.002	0.011	1.1	N/A	N/A	330	1.1
Benzo(g,h,i)perylene	1,600,000	5	8.0	800	N/A	N/A	330	50.0***
Benzo(k)fluoranthene	550,000	0.002	0.011	1.1	N/A	N/A	330	1.1
bis(2-ethylhexyl)phthalate	8,706*	50	4.35	435.0	50	2,000	330	50.0***
Butylbenzylphthlate	2,430	50	1.215	122.0	N/A	20,000	330	50.0***
Chrysene	200,000	0.002	0.004	0.4	N/A	N/A	330	0.4
4-Chloroaniline	43 ****	5	0.0022	0.22	200	300	330	0.220 or MDL
4-Chloro-3-methylphenol	47	5	0.0024	0.24	N/A	N/A	330	0.240 or MDL
2-Chlorophenol	15*	50	0.008	0.8	N/A	400	330	0.8
benzofuran	1,230*	5	0.062	6.2	N/A	N/A	330	6.2
benzo(a,h)anthracene	33,000,000	50	1,650	165,000	0.0143	N/A	330	0.014 or MDL
3,3'-Dichlorobenzidine	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2,4-Dichlorophenol	380	1	0.004	0.4	N/A	200	330	0.4
2,4-Dinitrophenol	38	5	0.002	0.2	N/A	200	1,600	0.200 or MDL
2,6 Dinitrotoluene	198*	5	0.01	1.0	1.03	N/A	330	1.0
Diethylphthlate	142	50	0.071	7.1	N/A	60,000	330	7.1
Dimethylphthlate	40	50	0.020	2.0	N/A	80,000	330	2.0
Di-n-butyl phthalate	162*	50	0.081	8.1	N/A	8,000	330	8.1
Di-n-octyl phthlate	2,346*	50	1.2	120.0	N/A	2,000	330	50.0***
Fluoranthene	38,000	50	19	1900.0	N/A	3,000	330	50.0***
Fluorene	7,300	50	3.5	350.0	N/A	3,000	330	50.0***
Hexachlorobenzene	3,900	0.35	0.014	1.4	0.41	60	330	0.41
Indeno(1,2,3-cd)pyrene	1,600,000	0.002	0.032	3.2	N/A	N/A	330	3.2
Isophorone	88.31*	50	0.044	4.40	1,707	20,000	330	4.40
2-methylnaphthalene	727*	50	0.364	36.4	N/A	N/A	330	36.4
2-Methylphenol	15	5	0.001	0.1	N/A	N/A	330	0.100 or MD
4-Methylphenol	17	50	0.009	0.9	N/A	4,000	330	0.9
Naphthalene	1,300	10	0.130	13.0	N/A	300	330	13.0
Nitrobenzene	36	5	0.002	0.2	N/A	40	330	0.200 or MD
2-Nitroaniline	86	5	0.0043	0.43	N/A	N/A	1,600	0.430 or MD
2-Nitrophenol	65	5	0.0033	0.33	N/A	N/A	330	0.330 or MD
4-Nitrophenol	21	5	0.001	0.1	N/A	N/A	1,600	0.100 or MD
3-Nitroaniline	93	5	0.005	0.5	N/A	N/A	1,600	0.500 or MD
Pentachlorophenol	1,022	1	0.01	1.0	N/A	2,000	1,600	1.0 or MDL
Phenanthrene	4,365*	50	2.20	220.0	N/A	N/A	330	50.0***
Phenol	27	1	0.0003	0.03	N/A	50,000	330	0.03 or MDL
Pyrene	13,295*	50	6.65	665.0	N/A	2,000	330	50.0***
,4,5-Trichlorophenol	89*	1	0.001	0.1	N/A	8,000	330	0.1

a. Allowable Soil Concentration Cs = f x Cw x Koc
b. Soil cleanup objective = Cs x Correction Factor (CF)

N/A is not available
MDL is Method Detection Limit

* Partition coefficient is calculated by using the following equation:
log Koc = -0.55 log S + 3.64, where S is solubility in water in ppm. Other Koc values are experimental values.

** Correction Factor (CF) of 100 is used as per TAGM #4046

*** As per TAGM #4046, Total VOCs < 10 ppm., Total Semi-VOCs < 500 ppm. and Individual Semi-VOCs < 50 ppm.

**** Koc is derived from the correlation Koc = 0.63 Kow (Determining Soil Response Action Levels.....
EPA/540/2-89/057). Kow is obtained from the USEPA computer database 'MAIN'.

Note: Soil cleanup objectives are developed for soil organic carbon content (f) of 1%, and should be adjusted for the actual soil organic carbon content if it is known.

APPENDIX A (cont.)

TABLE 3

Recommended soil cleanup objectives (mg/kg or ppm)

Organic Pesticides / Herbicides and PCBs

Contaminant	Partition coefficient Koc	Groundwater Standards/ Criteria Cw ug/l or ppb.	a Allowable Soil conc. ppm. Cs	b Soil Cleanup objectives to Protect GW Quality (ppm)	** USEPA Health Based (ppm)		CRQL (ppb)	*** Rec.soil Clnup Objct (ppm)
					Carcinogens	Systemic Toxicants		
Aldrin	96,000	ND(<0.01)	0.005	0.5	0.041	2	8	0.041
alpha - BHC	3,800	ND(<0.05)	0.002	0.2	0.111	N/A	8	0.11
beta - BHC	3,800	ND(<0.05)	0.002	0.2	3.89	N/A	8	0.2
delta - BHC	6,600	ND(<0.05)	0.003	0.3	N/A	N/A	8	0.3
Chlordane	21,305*	0.1	0.02	2.0	0.54	50	80	0.54
2,4-D	104*	4.4	0.005	0.5	N/A	800	800	0.5
4,4'-DDD	770,000*	ND(<0.01)	0.077	7.7	2.9	N/A	16	2.9
4,4'-DDE	440,000*	ND(<0.01)	0.0440	4.4	2.1	N/A	16	2.1
4,4'-DDT	243,000*	ND(<0.01)	0.025	2.5	2.1	40	16	2.1
Dibenzo-P-dioxins(PCDD)								
2,3,7,8 TCDD	1709800	0.000035	0.0006	0.06	N/A	N/A	N/A	N/A
Dieldrin	10,700*	ND(<0.01)	0.0010	0.1	0.044	4	16	0.044
Endosulfan I	8,168*	0.1	0.009	0.9	N/A	N/A	16	0.9
Endosulfan II	8,031*	0.1	0.009	0.9	N/A	N/A	16	0.9
Endosulfan Sulfate	10,038*	0.1	0.01	1.0	N/A	N/A	16	1.0
Endrin	9,157*	ND(<0.01)	0.001	0.1	N/A	20	8	0.10
Endrin keytone	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
gamma - BHC (Lindane)	1,080	ND(<0.05)	0.0006	0.06	5.4	20	8	0.06
gamma - chlordane	140,000	0.1	0.14	14.0	0.54	5	80	0.54
Heptachlor	12,000	ND(<0.01)	0.0010	0.1	0.16	40	8	0.10
Heptachlor epoxide	220	ND(<0.01)	0.0002	0.02	0.077	0.8	8	0.02
Methoxychlor	25,637	35.0	9.0	900	N/A	400	80	***
Mitotane	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Parathion	760	1.5	0.012	1.2	N/A	500	8	1.2
PCBs	17,510*	0.1	0.1	10.0	1.0	N/A	160	1.0(Surfac 10(sub-su
Polychlorinated dibenzo-furans(PCDF)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silvex	2,600	0.26	0.007	0.7	N/A	600	330	0.7
2,4,5-T	53	35	0.019	1.9	N/A	200	330	1.9

a. Allowable Soil Concentration Cs = f x Cw x Koc

b. Soil cleanup objective = Cs x Correction Factor (CF)

N/A is not available

* Partition coefficient is calculated by using the following equation:
log Koc = -0.55 log S + 3.64, where S is solubility in water in ppm.
All other Koc values are experimental values.

** Correction Factor (CF) of 100 is used as per TAGM #4046

*** As per TAGM #4046, Total Pesticides < 10 ppm.

Note: Soil cleanup objectives are developed for soil organic carbon content (f) of 1% (5% for PCBs as per PCB guidance document), and should be adjusted for the actual soil organic Carbon content if it is known.

APPENDIX A Rev. 12/93

TABLE 4

Recommended Soil Cleanup Objectives (mg/kg or ppm) for Heavy Metals

Contaminants	Protect Water Quality ppm	Eastern USA Background ppm	* CRDL mg/kg or ppm	***** Rec.soil Clnup Objct. (ppm)
Aluminum	N/A	33,000	2.0	SB
Antimony	N/A	N/A	0.6	SB
Arsenic	N/A	3-12 **	0.1	7.5 or SB
Barium	N/A	15-600	2.0	300 or SB
Beryllium	N/A	0-1.75	0.05	0.16(HEAST) or SB
Cadmium	N/A	0.1-1	0.05	1 or SB
Calcium	N/A	130 - 35,000 **	50.0	SB
Chromium	N/A	1.5-40 **	0.1	10 or SB
Cobalt	N/A	2.5-60 **	0.5	30 or SB
Copper	N/A	1-50	0.25	25 or SB
Cyanide	N/A	N/A	0.1	***
Iron	N/A	2,000 - 550,000	1.0	2,000 or SB
Lead	N/A	****	0.03	SB****
Magnesium	N/A	100 - 5,000	50.0	SB
Manganese	N/A	50 - 5,000	0.15	SB
Mercury	N/A	0.001-0.2	0.002	0.1
Nickel	N/A	0.5-25	0.4	13 or SB
Potassium	N/A	8,500 - 43,000 **	50.0	SB
Selenium	N/A	0.1-3.9	0.05	2 or SB
Silver	N/A	N/A	0.1	SB
Sodium	N/A	6,000 - 8,000	50.0	SB
Thallium	N/A	N/A	0.1	SB
Vanadium	N/A	1-300	0.5	150 or SB
Zinc	N/A	9-50	0.2	20 or SB

Note: Some forms of metal salts such as Aluminum Phosphide, Calcium Cyanide, Potassium Cyanide, Copper cyanide, Silver cyanide, Sodium cyanide, Zinc phosphide, Thallium salts, Vanadium pentoxide, and Chromium (VI) compounds are more toxic in nature. Please refer to the USEPA HEASTs database to find cleanup objectives if such metal salts are present in soil.

SB is site background

N/A is not available

* CRDL is contract required detection limit which is approx. 10 times the CRDL for water.

** New York State backgrond

*** Some forms of Cyanide are complex and very stable while other forms are pH dependent and hence are very unstable. Site-specific form(s) of Cyanide should be taken into consideration when establishing soil cleanup objective.

**** Background levels for lead vary widely. Average levels in undeveloped, rural areas may range from 4-61 ppm. Average background levels in metropolitan or suburban areas or near highways are much higher and typically range from 200-500 ppm.

*****Recommended soil cleanup objectives are average background concentrations as reported in a 1984 survey of reference material by E. Carol McGovern, NYSDEC.

New York State Department of Environmental Conservation
Division of Fish and Wildlife
Division of Marine Resources

Technical Guidance for Screening Contaminated Sediment

22 November 1993

This document describes the methodology used by the Division of Fish and Wildlife and the Division of Marine Resources for establishing sediment criteria for the purposes of identifying contaminated sediments. Sediments with contaminant concentrations that exceed the criteria listed in this document are considered to be contaminated, and potentially causing harmful impacts to marine and aquatic ecosystems. These criteria do not necessarily represent the final concentrations that must be achieved through sediment remediation. Comprehensive sediment testing and risk management are necessary to establish when remediation is appropriate and what final contaminant concentrations the sediment remediation efforts should achieve.

Kenneth F. Wich

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Director
Division of Fish and Wildlife

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Table of Contents

I. Executive Summary

The Department of Environmental Conservation originally proposed sediment criteria in 1989, as an appendix of a Cleanup Standards Task Force Report. These criteria were controversial because the proposed methodology, equilibrium partitioning, had not yet been endorsed by the U.S. Environmental Protection Agency (EPA) Science Advisory Board, and because the criteria themselves were perceived as remediation target concentrations. This revised sediment criteria document was prepared to incorporate scientific literature published since 1989, and to establish the purpose of sediment criteria for screening; that is, to identify areas of sediment contamination and to make a preliminary assessment of the risk posed by the contamination to human health and the environment. Criteria are developed for two classes of contaminants - non-polar organic contaminants and metals. Non-polar organic contaminant criteria are derived using the equilibrium partitioning approach, which has now been endorsed by the EPA Science Advisory Board. This approach estimates the biological impacts that a contaminant may cause based on it's affinity to sorb to organic carbon in the sediment. The concentration of biologically available contaminant is predicted and related to potential toxicity and bioaccumulation by using existing criteria established for the water column. New York State water quality standards and guidance values are used to derive sediment criteria. EPA water quality criteria are used only when New York State has not published a standard or guidance value for a particular compound. Water quality criteria for bioaccumulation proposed by the Divisions of Fish and Wildlife and Marine Resources are used when no New York State water quality standard or guidance value for bioaccumulation has been developed. Metals criteria are derived from Ministry of Ontario guidelines and NOAA data that make use of the screening level approach. This methodology measures the concentration of contaminants present in areas where ecological impacts have been noted, and correlates the contaminant concentration with the severity of the impact. Toxicity mitigating conditions such as acid volatile sulfides are not considered because with the screening level approach, the metal concentrations present are correlated directly to a measurable ecological impact. Finally, this document discusses risk management for contaminated sediment, and makes recommendations for implementing sediment criteria. Table 1 lists sediment criteria for 52 non-polar organic compounds or classes of compounds, and Table 2 lists sediment criteria for 12 metals.

II. Background and Objectives

The Department of Environmental Conservation originally proposed draft sediment criteria in December 1989 as Appendix D to the Draft Clean Up Standards Task Force Report (DEC 1991). These criteria were based on the EPA equilibrium partitioning (EP) model, which had at that time just been submitted to the EPA Science Advisory Board for review. Two problems developed relative to these criteria. The first was that the equilibrium partitioning model did not receive a complete endorsement by the EPA Science Advisory Board (EPA SAB 1990). The SAB raised questions about the degree of uncertainty, sources of variability, and applicability of EP-based sediment criteria. Secondly, the New York State sediment criteria were published in the context of a clean-up standards report for contaminated sediment remediation. The perception of the reviewers and potential users was that the criteria represented mandatory clean-up levels that must be achieved by remediation methodologies. Appendix D of the Draft Clean-up Standards Task Force Report did state that risk management decisions were necessary and appropriate in the application of the sediment criteria, but the perception remained that the low concentrations described therein were in fact the primary target levels for sediment remediation. This issue was further clouded by real-world environmental problems such as dioxin in the New York-New Jersey Harbor area. Dredging and dredge spoil disposal is necessary for continued harbor operation, but attainment of the dioxin sediment criterion described in Appendix D could be economically unachievable.

There were three objectives for revising the sediment criteria document. The first objective was simply to clarify the document, make it easier to read, and provide greater scientific documentation to support the information presented.

The second objective was to incorporate scientific literature that has been published since 1989. This revision will be based primarily upon an EPA Proposed Technical Support Document (TSD) for the Development of Sediment Quality Criteria (EPA 1991). The EPA TSD was also published verbatim in peer-reviewed scientific literature (DiToro et al., 1991). The revised sediment criteria document will also incorporate a new EPA Science Advisory Board Report that endorses the equilibrium partitioning methodology and commends the EPA for satisfactorily addressing many of the concerns noted in the original SAB review (EPA SAB 1992). Also, this revision incorporates the 1992 Ministry of Ontario Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, for metals concentrations in sediment (Persaud et al., 1992). These guidelines were only draft in 1989, when the first sediment criteria document was produced.

The final objective of the revised document was to establish the role of EP-based sediment criteria as screening criteria; that is, for identifying areas of sediment contamination, and providing an initial assessment of potential adverse impacts. While attainment of the EP-based sediment criteria will provide the maximum assurance of environmental protection, it is not necessary in all cases and at all times to achieve these criteria through remediation efforts. Risk assessment, risk management, and the results of further biological and chemical tests and analyses are vital tools for managing sediment contamination. To view sediment criteria in a one-dimensional, go/no go context is to miss potential opportunities for resource utilization through appropriately identified and managed risk.

III. Need, Basis, and Concept of Sediment Criteria

Sediments can be loosely defined as a collection of fine-, medium-, and course- grain minerals and organic particles that are found at the bottom of lakes [and ponds], rivers [and streams], bays, estuaries, and oceans (Adams et al., 1992). Sediments are essential components of aquatic [and marine] ecosystems. They provide habitat for a wide variety of benthic organisms as well as juvenile forms of pelagic organisms. The organisms in sediments are in constant contact with the sediments, and therefore, constant contact with any contaminants that may be adsorbed to the sediment particles. Potential impacts to benthic organisms include both acute and chronic toxicity with individual-, population-, and community- level affects, bioaccumulation of contaminants, and the potential to pass contaminants along to predators of benthic species (Adams, et al, 1992; Marcus, 1991; Milleman and Kinney, 1992).

Potential to harm benthic organisms is not the only adverse impact of contaminated sediments. They serve as diffuse sources of contamination to the overlying waterbody; slowly releasing the contaminant back into the water column (Marcus, 1991; DEC, 1989).

Contamination is a concept that is not always clearly defined relative to sediments. The mere presence of a foreign substance in a sediment could be construed as contamination. However, the presence of a foreign substance does not necessarily mean it is harmful. Metals can be present in naturally occurring concentrations (background levels) in species, or forms, that are not harmful to aquatic life. While there are no naturally occurring background concentrations for synthetic organic compounds, the presence of a synthetic organic compound does not necessarily imply harm. Some evaluation must be made to estimate the potential risk to aquatic life or human health that the compound will have.

The EPA has defined a contaminant as: "Any solid, liquid, semisolid, dissolved solid, gaseous material, or disease-causing agent which upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, may . . . pose a risk of or cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions . . . or physical deformations, in the organism or their offspring" (EPA, 1992). This definition clearly explains that a contaminant is not simply the presence of a foreign substance, but an element of harm to some organism, species, population, or community must be involved.

The EPA defines sediment criteria in the following manner: A sediment criterion is a specific level of protection from the adverse effects of sediment associated pollutants, for beneficial uses of the environment, for biota, or for human health . . . (EPA, 1992). A sediment criterion, then, must relate to the element of harm that the contaminant possesses by specifying an appropriate level of protection. To develop sediment criteria, it is necessary to identify the potential elements of harm to the various organisms, populations, and communities that could be affected. The criterion must then specify the level of protection necessary to balance each identified element of harm.

A corollary of the EPA definition is that if the specified level of protection is not attained, then a certain level of risk exists. The concentration of a contaminant in sediment can be compared to a number of criteria and their associated levels of protection, to determine the overall potential risk posed by that particular contaminant concentration to various exposed organisms. Only if the contaminant concentration is less than all of the available criteria can exposure to the sediment, or to organisms that inhabit the sediment, be considered to be without significant risk from those contaminants (risk could still result from other sources, such as contaminants for which criteria have not yet been derived). This is the concept of screening criteria. By comparing the contaminant concentration to various criteria and their associated levels of protection, the resource manager can begin to identify the appropriate tests, studies, and procedures to quantify and refine the level of risk; set remediation goals; prioritize remediation actions; and select risk management and communications options.

EP-based sediment criteria are tied to water quality standards, guidance values, (DEC, 1991) and criteria (EPA, 1991)[1]. Within the framework of New York State water quality regulations, five primary levels of protection are identified (6NYCRR, 1991) from which sediment criteria can be derived. These are:

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[1] Water quality standards and guidance values are New York State regulatory terms that are essentially synonymous with the EPA term criterion. A standard is a water quality criterion that has been adopted into regulation. A guidance value is a water quality criterion that has been derived in the same manner as a standard, but has not yet been adopted into regulation, or subjected to public review and comment. When referring to water quality in this document, the use of the general term criteria will mean either a New York standard or guidance value.

A. Protection of human health from acute or chronic toxicity;

B. Protection of human health from toxic effects of bioaccumulation;

C. Protection of aquatic life from acute toxicity;

D. Protection of aquatic life from chronic toxicity;

E. Protection of wildlife from toxic effects of bioaccumulation.

Other levels of protection include fish flesh tainting, and aesthetics (taste, odor, or appearance). Human health-based criteria can be further subdivided into oncogenic (cancer causing) effects and non-oncogenic effects (6NYCRR, 1991). Unfortunately, water quality standards or guidance values do not usually exist for all five levels of protection simultaneously.

This document will identify a series of screening criteria concentrations for a number of contaminants that can be used to identify areas of sediment contamination, and evaluate the potential risk that the contaminated sediment may pose to human health or the environment. A contaminated sediment can be identified as one in which the concentration of a contaminant in the sediment exceeds any of the sediment criteria for that contaminant. Once a sediment has been identified as contaminated, a site-specific evaluation procedure must be employed to quantify the level of risk, establish remediation goals, and determine the appropriate risk management actions. The site-specific evaluation might include for example: additional chemical testing; sediment toxicity testing; or sediment bioaccumulation tests.

Sediment contaminants primarily consist of heavy metals and persistent organic compounds (EPA, 1990). Sediment criteria for non-polar organic compounds are derived using equilibrium partitioning methodology (EPA, 1991, DiToro, et al., 1991). This document will derive sediment criteria for non-polar organic contaminants listed in the TOGS 1.1.1. (DoW, 1991), using the water quality standards and guidance values listed there. If a water quality criterion for a particular contaminant is not identified in TOGS 1.1.1., an EPA water quality criterion is used. These criteria are annotated with the suffix (E). Proposed water quality criteria for the protection of human health and piscivorous wildlife from bioaccumulative affects are derived using procedures identified in Appendix 1; Newell et al. (1987); and 6NYCRR Parts 702.8 and 702.13. These criteria are annotated with the suffix (P). With the exception of PCBs, these water quality guidance values are not yet listed in TOGS 1.1.1.

Sediment criteria for metals are based upon procedures and data developed by the Ministry of Ontario (Persaud et al., 1992), and the National Oceanic and

Atmospheric Agency (NOAA) (Long and Morgan, 1990). Sediment criteria for polar organic compounds are not derived. Instead, contaminant concentrations in pore water should be compared directly to surface water quality criteria; see section V. Some polar organics such as phenolic compounds behave as non-polar compounds under conditions of neutral pH. For these compounds, EP-based sediment criteria can be derived. Both the equilibrium partitioning methodology and the Ministry of Ontario procedures are discussed below.

IV. Derivation of Sediment Quality Criteria for Non-polar Organic Compounds using Equilibrium Partitioning.

A. Characteristics of Non-polar Organics

Non-polar organic compounds are substances that contain carbon, and do not exhibit a net electrical (ionic) charge (Nebergall, et al. 1968). Non-polar organic contaminants tend to be of low solubility in water. Otherwise they would dissolve and not accumulate in sediments (Manahan, 1991). Many non-polar contaminants are highly soluble in lipids, and thus can be bioaccumulated. They are persistent, meaning they do not break down or degrade rapidly, and can remain in sediments for long periods of time. The International Joint Commission defines persistent compounds as compounds with a half life greater than 56 days (IJC, 1978). Some contaminants such as pesticides can cause direct, acute toxicity to exposed benthic organisms in low concentrations. Others such as DDT, PCB, and dioxin are more insidious, and bioaccumulate over time to cause chronic toxicity affects such as reproductive failure, either in populations exposed directly to the contaminated sediment or to organisms further up the food chain (Rand and Petrocelli, 1985).

B. Fundamentals of Equilibrium Partitioning (EP)

The basis for the EP methodology for deriving sediment criteria is that the toxicity of a contaminant in a sediment is attributable to the fraction of the contaminant that dissolves in the interstitial pore water, and is considered to be freely biologically available. The EP methodology predicts the concentration of contaminant that will dissolve in the interstitial pore water from three factors: 1) the concentration of contaminant in the sediment; 2) the concentration of organic carbon in the sediment; and 3) the affinity of the contaminant for organic carbon in the sediment.

The affinity of a contaminant for sediment organic carbon can be directly measured. The sediment/water partition coefficient, or K_p is a measure of the concentration of a contaminant sorbed to the sediment divided by the concentration dissolved in water (measured in l/kg), after mixing. The K_p is only useful as a site specific measure because the K_p will vary with different sediment samples. The EPA (1991) reported that the organic carbon content of a sediment accounts for most of the variation in the uptake of the contaminant by the sediment. The K_{oc}, or sediment organic carbon/water partition coefficient is a measure of the concentration of contaminant that adsorbs to the organic carbon content of the sediment divided by the concentration dissolved in water, after mixing (measured in l/kg). When normalized for organic carbon, concentrations of a contaminant in different sediment samples are comparable. Another partition coefficient that is closely correlated with K_{oc} and is useful for predicting soil adsorption is the octanol/water partition coefficient, or K_{ow} (Kenaga, 1980). Voice, et al. (1983) citing Karickhoff (1979), reports that the relationship between the three coefficients can be described in two equations:

$$K_{oc} = K_p/f_{oc}$$

and

$$\log_{10}K_{oc} = \log_{10}K_{ow} - 0.21 \quad \text{(also in Kenaga, 1980)}$$

where f_{oc} is the fraction of solids by weight that is comprised of organic carbon.

The EPA (1991) refers to DiToro (1985) to define the relationship between K_{oc} and K_{ow} as:

$$\log_{10}K_{oc} = 0.00028 + 0.983\log_{10}K_{ow}$$

Using the DiToro (1985) relationship, the K_{oc} very nearly equals the K_{ow}. Using either relationship, it can be readily seen that the K_{oc} and K_{ow} for a given non-polar organic compound are very similar, and vary in direct proportion. In their initial review of the equilibrium partitioning methodology, the EPA SAB considered the equating of K_{oc} and K_{ow} to be a source of uncertainty (EPA SAB 1990). In their 1992 review, the EPA SAB states that uncertainties have diminished largely as a result of more accurate determination's of K_{ow}s, and that occasionally the K_{ow} may not be a good predictor of the K_{oc} (EPA SAB 1992).

When a non-polar organic contaminant enters the sediment, it will partition between the sediment and pore water in three compartments: a fraction will adsorb to the organic carbon in the sediment; another fraction will adsorb to dissolved organic carbon in the interstitial pore water; and a third fraction will dissolve in the pore water. An equilibrium will be established so that any change in the contaminant concentration in one compartment will result in a corresponding change in the contaminant concentration in other compartments. For example, if some of the contaminant dissolved in the pore water is removed, some of the contaminant adsorbed to the sediments will desorb to balance the loss from the pore water. If dissolved contaminant is added to the pore water, it will not all remain in the pore water, but some will adsorb to dissolved organic carbon and sediment organic carbon, re-establishing the equilibrium. Interestingly, the EPA (1991) noted that an increase in the volume of dissolved organic carbon in the pore water causes contaminant sorbed to the sediment to desorb and in turn sorb to the dissolved organic carbon. The freely dissolved fraction of the contaminant remains practically unchanged.

Equilibrium partitioning methodology contends that sediment toxicity is attributable to the concentration of contaminant dissolved in the interstitial pore water and considered to be biologically available (EPA 1989, EPA 1991). It can be inferred, then, that a water quality criterion developed to protect aquatic life from contaminants dissolved in the water column should also protect benthic aquatic life from contaminant concentrations dissolved in pore water. The EPA (1991) compared the sensitivity of benthic organisms to the sensitivity of water column organisms to toxicity from the same chemicals, and found that they were very similar. Therefore the prediction that exceeding a water column-based criterion in sediment pore water would harm benthic organisms was considered valid.

C. Derivation of Sediment Criteria using Equilibrium Partitioning

To derive an organic carbon normalized sediment criterion, two items of information are required:

A. An ambient water quality criterion for a particular contaminant;

B. the K_{ow} partition coefficient for the contaminant;

For example, the PCB water quality criterion (see footnote 1 on page 4) for the protection of piscivorous wildlife from bioaccumulation is 0.001 μg/l. The K_{ow} for PCB is $10^{6.14}$, or 1,380,384.3 l/kg. The organic carbon normalized PCB sediment criterion (SC_{oc}) would be:

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

$$\text{PCB } SC_{oc} = 0.001\ \mu g/l * 1{,}380{,}384.3\ l/kg * 1\ kg/1{,}000\ gOC =$$

$$1.38\ (\approx 1.4)\ \mu g/gOC$$

1 kg/1,000 gOC is a conversion factor.

The meaning of the criterion is: based on the equilibrium partitioning characteristic of PCBs, in order not to exceed the water quality criterion of 0.001 μg/l in the pore water, the concentration of PCB in the sediment must not exceed 1.4 μg for each gram of organic carbon in the sediment.

To apply this SC_{oc} on a site specific basis, the concentration of organic carbon in the sediment at the site must be known. If a sediment sample was known to contain 3% organic carbon, the site specific sediment criterion (SC) for PCB could be derived:

$$SC = SC_{oc} * f_{oc}$$

$$f_{oc} = 3\%\ \mathrm{OC/kg\ sediment} = 30\ \mathrm{gOC/kg}$$

$$\mathrm{PCB\ SC} = 1.4\ \mu\mathrm{g/gOC} * 30\ \mathrm{gOC/kg} = 42\ \mu\mathrm{g\ PCB/kg\ sediment}$$

This criterion states that: if there are less than 42 μg PCB/kg of sediment in a sediment containing $\geq$ 3% organic carbon, there is no appreciable risk to piscivorous wildlife from consuming fish or other aquatic life from the waterbody over the contaminated sediment.

D. Limitations of Equilibrium Partitioning Derived Sediment Criteria

There are several limitations to the application of EP-based criteria:

1. EP-based criteria are only applicable to non-polar organic compounds, or other substances that behave as non-polar organic compounds in the sediment and prevailing environmental conditions, such as pH.

2. EP-based criteria apply only to the specific level of protection identified in the criterion. In the example above, the 42 μg/kg PCB concentration in the 3% sediment sample does not pose appreciable risk to wildlife, however, it may or may not pose a risk to human beings. A sediment criterion derived from a human health-based water quality criterion must be compared to make that determination.

3. EP-based criteria should only be derived for sediments with organic carbon fractions between approximately 0.2 - 12% (EPA SAB, 1992). Outside of this range, other factors that the EP methodology does not account for may influence contaminant partitioning.

4. The equilibrium partitioning method should not be applied to broad classes of compounds or mixtures if one K_{ow} value is used to represent the entire class or the mixture (EPA SAB, 1992). In this respect, PCB congeners would not be considered a broad class of compounds; they are a narrow class of quite similar compounds.

5. For compounds with a K_{ow} less than 100 ($\log_{10}K_{ow} \leq 2$), the water quality criterion can be greater than the site specific sediment quality

criterion. This implies that virtually all of the contaminant is biologically available. Since the water quality criterion delineates the concentration that is harmful to aquatic life, it is not reasonable that a smaller concentration in the sediments would be harmful to benthic organisms, especially considering that some fraction of the contaminant will be sorbed to the sediment and not biologically available. For these compounds, the organic carbon normalized sediment criterion should be derived in the manner described above. However, when determining the site specific criterion, compare the product of the $SC_{oc} * f_{oc}$ with the water quality criterion, converted from a volumetric to mass units ($\mu g/l * l/kg = \mu g/kg$). If the water criterion is greater than the site specific sediment quality criterion, use the water quality criterion as the sediment criterion. For example, the $\log_{10}K_{ow}$ of benzidine is 1.4. The SC_{oc} for the protection of benthic life (chronic toxicity), based on a TOGS 1.1.1. water quality criterion of 0.1 μg/l is 0.003 μg/gOC. If the sediment contained 3% organic carbon, the site specific SC would be 0.09 μg/kg. The water quality criterion (converted from a volumetric measure to a mass measure) of 0.1 μg/kg is greater, so the site specific sediment criterion should be 0.1 μg/kg. If the site contained 5% organic carbon the site specific sediment criterion would be 0.15 μg/kg, which is greater than the water quality criterion of 0.1 μg/l. In this instance, the 0.15 μg/kg would be the appropriate criterion to use.

6. Derivation of EP-based criteria assumes that an equilibrium between the sediment/pore water compartments has been achieved. Rand and Petrocelli (1985) indicate that the sorption-desorption equilibria are achieved rapidly, usually in a few minutes to several hours. Voice et al. (1983) found that in laboratory studies, equilibria were generally achieved in about 4 hours. In investigating contamination of stable sediments with long term exposure to a contaminant, it is likely that equilibrium has been achieved. However for spill sites, and areas with unstable sediments, attainment of the equilibrium condition may be questionable. The EPA SAB (1992) recommends that EP-based criteria not be used in areas of rapid deposition or erosion (e.g. > 10 cm/yr), such as active dredge disposal areas, areas of heavy boat and barge traffic, and some river channels.

7. The EP methodology is not a highly accurate procedure in and of itself. Several related sampling and analysis procedures could introduce additional variation and uncertainty into the results. Some of these factors include: the value of the K_{ow} used and how it was derived; how the sediment sample was taken and analyzed for contaminant content; and how the organic content of the sediment sample (f_{oc}) was determined. For consistent application of sediment criteria, these factors must be considered systematically and consistently. ASTM (1993) recommendations should be followed for the proper collection, storage, and analysis techniques when

applying EP-based sediment criteria. The analysis method is particularly important for determination of sediment total organic carbon, because there are several methods available that may give variable results. The authors and EPA (1992b) recommend the use of catalytic combustion with nondispersive infrared carbon dioxide detection (Leonard, 1991) when developing total organic carbon-normalized criteria for non-polar organic compounds. However, unless the "true" K_{ow} differs by a factor of 10, or the "true" f_{oc} differs by 50 - 100% from the K_{ow} and f_{oc} values used to derive the sediment criteria, the level of imprecision introduced into the criteria calculation will be minor. An EP-based criterion applies to a single sediment sample. Results obtained from composite samples may be misleading in that the contaminant concentration at a single point or depth might be diluted with uncontaminated samples. Conversely, a contaminated sample mixed with uncontaminated samples from other points or depths might cause a greater area appear to be contaminated than actually is.

8. There are still a number of uncertainties related to equilibrium partitioning-derived sediment criteria. These include such factors as particle size, particle density, organic carbon content, K_{ow}/K_{oc} relationship, route of exposure, the impact of dissolved organic carbon, and the uncertainty of extrapolating laboratory data to field conditions (EPA, 1991; EPA SAB, 1992). Despite these uncertainties, the EPA has found that sediment toxicity from laboratory experiments generally falls within a factor of 5 of the toxicity predicted by equilibrium partitioning. EP-based criteria are considered to be valid for screening and assessment. These preliminary assessments can be followed up with further testing if necessary to more accurately quantify risk.

Table 1 lists 52 non-polar organic compounds or classes of compounds for which sediment criteria have been derived using the equilibrium partitioning methodology. The derivation procedure is the same as that recommended by the EPA (1991). The only difference is that New York State water quality standards and guidance values are used instead of EPA ambient water quality criteria. EPA criteria have been used to derive a sediment quality criterion only when a New York standard or guidance value is not available. Four criteria, corresponding to four of the five levels of protection, are listed for each contaminant whenever possible. Sediment criteria are not derived for the protection of human health from toxicity, because that type of exposure would constitute human consumption of the interstitial pore water within the contaminated area, which is an unreasonable assumption. A sediment is considered to be contaminated if the contaminant concentration exceeds <u>any</u> of the criteria listed. The table also identifies the K_{ow} and the water quality criterion used to derive the sediment criterion. Water quality criteria are from DoW TOGS 1.1.1., unless suffixed with an (E), which indicates an EPA water quality criterion. Proposed water quality criteria for the protection of human health and piscivorous wildlife from bioaccumulative effects are used when no TOGS 1.1.1. criterion for bioaccumulation has been developed. These criterion are annotated with the suffix (P), and are derived according to the method described in Appendix 1 and Newell et al. (1987).

V. Polar Organics - Application of Water Quality Criteria to Pore Water via Direct Measurement of Pore Water

For polar organics (except for phenols) no algorithms have been developed yet for sediment criteria that account for sediment characteristics which may affect substance toxicity. However, in order to screen sediments for potential impacts from polar organic compounds, interstitial (pore) water from sediment samples should not exceed existing water quality standards and guidance values for polar organics in TOGS 1.1.1.

The application of these criteria to pore water is complicated by dissolved organic carbon (DOC) in pore water that is generally much higher than DOC in the water column. DOC tends to reduce toxicity and bioaccumulation of chemicals by reducing their availability for uptake by the organism. However, even though water column DOC is usually low, water quality criteria are not modified to account for the effects of DOC. If the partitioning coeficient between DOC and water for a contaminant is known, that coefficient could be used to account for the effect of DOC on toxicity or bioaccumulation in the application of water quality criteria to pore water. The bioaccumulation of contaminants with low K_{ow} is generally not suppressed by water column DOC, indicating that the effects of DOC can probably be ignored. In any case, a conservative risk assessment is assured if the effects of DOC in pore water are ignored during a preliminary screening. In follow-on assessments, DOC affects should be evaluated. As a consequence, the water quality criteria becomes the pore water criteria, and sediment criteria per se are not derived for these compounds.

VI. Derivation of Sediment Quality Criteria for Metals

A. Characteristics of Metals as Sediment Contaminants

A wide variety of metals in a wide variety of forms can be found in marine and aquatic sediments. Some concentrations occur naturally, while others have been introduced through man's activities. Very low concentrations of most metals are required nutrients for living organisms, but in excess concentrations, metals can be harmful (Rand and Petrocelli, 1985). The properties that metals exhibit in water depend largely on the form in which the metal occurs (Manahan, 1991). In waterbodies, metals are typically found (Demayo et. al, 1978):

1. Dissolved as free ions and complexes;

2. As particulates:

    a. inorganic precipitates such as hydroxides, sulphides, carbonates, and sulphates;

    b. sorbed onto or complexed with high molecular weight organic compounds or clay particles;

3. Mixed or sorbed to bottom sediments;

4. Incorporated into the tissues of biota.

The toxicity and bioavailability of metals in water [and sediment] vary with the form of the metals (EPA 1992a). The form of the metal, and thereby the toxicity of a metal, are highly influenced by environmental conditions such as pH, alkalinity, REDOX potential, and the availability of complexing ions or ligands. Very generally, it can be said that the dissolved fraction of metals seems to account for most toxicity, however, some particulate forms of some metals also exhibit toxicity (EPA 1992a).

Metals in water can generally be measured as total (total recoverable) dissolved metal. Currently, the EPA recommends using water effects ratios for evaluating the impact of metals on surface water quality (EPA 1993). Conduct toxicity tests using water from a specified site, and compare the toxicity with reference toxicity tests in relatively pure water. The resulting "water effects ratio" can then be used to adjust either a total recoverable metal criterion or effluent limitation, or dissolved metals water quality criterion (preferred in areas of highly variable suspended solids concentrations) to account for local conditions.

In sediments, metals exhibit the same variety of forms as in water; they can dissolve as ions or soluble complexes in the interstitial pore water, precipitate as organic or inorganic compounds, or sorb to binding sites in the sediment. The complexity of metals behavior in water and sediments makes it impossible to accurately predict the levels at which toxic effects will occur. For metals, the primary concern in sediments is toxicity to benthic organisms. Metals can bioaccumulate in organisms. Bioaccumulation of metals is highly variable and dependent on the form of the metal and how it enters the organism (Doull et al., 1980). Different organs and tissues will have different affinities for different metals and species of metals. Metals can be absorbed by an organism but be bound by protiens known as metallothioneins into relatively harmless forms. Toxicity of metals are dependent on many environmental conditions and are difficult at best to predict consistantly.

B. Establishing Screening Level Concentrations

Because of the inability to predict biological affects from metals concentrations in sediment, the best alternative is to identify adverse ecological effects that are attributable to sediment-borne metals concentrations, and measure what concentration caused the adverse effect. The Ontario Ministry of the Environment issued metals guidelines derived by the "Screening Level Concentration" approach. This is an effects-based approach which uses field data on co-occurrence of benthic animals and contaminants (Persaud et al., 1992). The Ontario guidelines span background, lowest effect levels and severe effect levels. The methods used to derive these guidelines do not account for the effects of organic content, acid volatile sulfide concentration, particle size distribution or iron and manganese oxide content, or other toxicity-mitigating factors on the bioavailability of metals within the sediments, because the total metals concentration is related directly to an observed, measureable ecological effect. It is possible that this methodology might not discern toxicity from other compounds besides metals.

Long and Morgan (1990) reviewed and categorized chemical effects data in sediments according to low and median toxic effects ["Effects Range-Low (ER-L)"and "Effects Range-Median (ER-M)" concentrations] and "Overall Apparent Effects Thresholds" for benthic organisms observed in field studies across the nation. Effects levels reported were associated with bulk sediment concentrations without normalizing for any toxicity mitigating factors. For metals, effects levels in Long and Morgan (1990) may be compared with effects levels taken from Persaud et al. (1992). Both are based on a selection of observed effects from field studies, although Persaud et al. (1992) is restricted to Great Lakes data while Long and Morgan (1990) used both fresh and salt water data. For six metals (arsenic, cadmium, chromium, copper, lead and nickel), the lowest effects levels described by Persaud et al. (1992) are lower than the ER-L (effects range-low) from Long and Morgan (1990). This could be because in the relatively pure waters of Lake Ontario, fewer ligands were available to complex metal ions, so biological affects were noted at lower metals concentrations. The Long and Morgan (1990) study included more eutrophic waters, wherein, metals could be complexed to a greater extent into biologically unavailable forms. Exposed organisms were able to tolerate higher total metals concentrations because the greater fraction of metal present was biologically unavailable.

To establish screening criteria for sediments in New York State, two levels of protection as a basis sediment quality screening criteria were established, following the Ministry of Ontario Guidlines definitions. These are the Lowest Effect Level and the Severe Effect Level. The Lowest Effect Level 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 Severe Effect Level indicates the concentration at which pronounced disturbance of the sediment dwelling community can be expected (Persaud et al. 1992). The ER-L and ER-M from Long and Morgan (1990) were compared with the Lowest Effect Level and Severe Effect Level from Persaud et al. (1990). The lowest concentration in each of the two effect levels was selected as the New York sediment screening criteria. These sediment criteria for metals are listed in Table 2. If a total metals concentration in a sediment sample is less than the Lowest Effect Level listed in Table 2, the effects of the metal in the sediment are considered to be acceptable. If the concentration is greater than the lowest effect level but less than the severe effect level concentration, the sediment is considered to be contaminated, with moderate impacts to benthic life. If the concentration is greater than the severe effect level, the sediment is contaminated and significant harm to benthic aquatic life is anticipated.

Background concentrations described in Persaud et al. (1992) were not used to establish criteria. For some metals, cadmium and copper for example, Persaud lists a Lowest Effect Level that exceeds the typical background concentration. Because a metal concentration in sediment is considered to be naturally occurring, or background, does not mean that the concentration is not causing an adverse ecological effect.

As noted above, metals guidelines from Persaud et al. (1992) are based on freshwater sediments only, and effects levels in Long and Morgan (1990) reflect data from both fresh and salt water. Although differences in the bioavailability of metals in fresh and salt water sediments may be elucidated in the future, at this time, the sediment criteria identified in Table 2 are considered suitable for identifying areas of metal contaminated sediment, assessing potential risk, and identifying suitable follow-up tests, studies, and risk management options in both fresh and salt water sediments.

C. Limitations to Sediment Criteria for Metals

There are limitations to the application of the metals sediment quality criteria listed in Table 2:

1. Persaud et al. (1992) values are based on oligotrophic waters with low concentrations of metals-complexing ligands. These criteria are possibly over-protective when applied to more eutrophic waters. However, many streams and ponds in New York are oligotrophic, and the low effects concentrations are justified. These criteria are intended to be used for screening; that is, to identify potentially contaminated sites and provide a qualitative estimate of risk. Once a site is found to be contaminated with metals, further studies are necessary to quantify risk and determine if remediation actions are necessary. Remediation should not be based solely on exceedances of these criteria.

2. These criteria have limited applicability to mixtures of metals. Metals criteria are most clearly applicable to sediments with high concentrations of a single metal, or situations where one metal has a disproportionatly greater abundance in a sediment sample than any other metal. The presence of one metal can significantly affect the impact that another metal has on an organism. The effect can be synergistic, additive, or antagonistic (Eisler, 1993). A reasonable level of protection can be expected if none of the criteria are exceeded for metals that are present, however, effects may be present if the sum of the fractions of criteria over sediment concentrations exceed one, for all of the metals present. For example, in a sediment sample, four metals are detected. The concentration of each metal in the sediment sample is 0.3 of its corresponding sediment criterion. The sum of the fractions would be 1.2. In this case, further testing is warranted.

3. Total metals, or the bulk metals concentration should be measured in sediment samples.

VII. Use of Sediment Criteria in Risk Management Decisions

Once it has been determined that a sediment criterion is exceeded, more information is required to determine if remediation is necessary and what actual risks to the environment are present. The volume and location of sediment exceeding a criterion, which levels of protection are exceeded, the persistence of the contaminant, the uncertainty about the criteria, and the results of more detailed, site specific sediment tests all play a role in making decisions about how, and how much sediment to clean up in order to eliminate or minimize adverse effects. If the volume of sediment that exceeds sediment criteria is small and the sediment is fairly accessible, the remediation of all contaminated sediment may be the most expedient action. If volumes of sediment are large and/or difficult to remediate either because of accessibility, sensitivity of the impaired habitat, or lack of efficacious technology, further risk management evaluations are warranted. In general the areal extent of the contaminated sediments should be a factor in considering the need for, and method of remediation.

Once the source of contaminants to sediments is terminated, the length of time a particular area of sediments remain contaminated will depend on the persistence of the chemicals, and the site-specific characteristics of the sediment such as: rate of sedimentation; resuspension; and biological and chemical degradation. If a contaminant is not persistent (e.g. contaminant concentrations would be expected to fall to acceptable levels within six months to a year), and the effect of the contaminant is not severe, then sediment remediation may not be necessary. Even for a persistent contaminant, it may not be necessary to remediate the sediments if the contaminated area is a deposition zone, and the natural burying of the contaminated sediments beneath the zone of biological activity and availability would be expected to occur within a short time, and resuspension of the contaminants was unlikely.

EPA SAB (1992) examined a number of factors relating to the uncertainty of EP based sediment criteria, including sediment composition variability, measurement variation and K_{ow} - K_{oc} correlations and measurements. They report that all these variabilities amount to an estimated uncertainty factor of five. This suggests with good confidence that sediment criteria exceeded by a factor of five will result in the onset of toxicity. Toxicity could also result from sediment contaminant concentrations just below the sediment criterion. The EPA SAB (1992) identifies the range of concentrations from 1/5 - 5 times an EP-derived sediment criterion as a "grey" area, where observable impacts may or may not occur. Based on the statistical analysis of EP-derived sediment criteria, there is a high degree of confidence that contaminant concentrations $\leq$ 1/5 of a sediment criterion pose little or no risk. Similarly, if a contaminant concentration in sediment exceeds an EP-derived sediment criterion by a factor of 5, there is little or no doubt that adverse ecological impacts are occurring. Within the range in-between, the actual occurrence of effects is unknown. However, to avoid making the criteria excessively overprotective or underprotective, the best use of the factor of 5 is in interpreting the results of sediment screening, not to modify the criteria.

The onset of chronic toxicity may be difficult to detect in natural systems. Water quality criteria designed to prevent acute toxicity are generally about ten times greater than comparable chronic criteria. Therefore, in general, sediments with contaminants at 50 times chronic toxicity sediment criteria concentrations (a factor of five for uncertainty and a factor of ten based on acute to chronic toxicity ratios), will result in the onset of acute toxicity to benthic animals with a high degree of confidence.

It must also be noted that with this uncertainty the possibility exists that the sediment criteria may be somewhat underprotective as well as than overprotective.

Sediment criteria for metals are based on empirical evidence from both lab and field studies without an attempt to normalize for any toxicity mitigating factors in the sediment. Variability of toxicity from metals in any given sediment is evident (Appendix 2). Many of the Lowest Effect Levels from Persaud et al. (1992) are lower than the mean background concentrations in Great Lake sediments. This suggests that in some sediments relatively low levels of metals, even below mean background, are toxic, whereas in other sediments fairly high levels, up to and possibly even above background, may not be toxic. For all metals, the Severe Effect Level criteria exceeds mean background considerably; consequently, significant and noticeable toxicity is expected in all sediments that exceed that level of protection.

VIII. Implementation of Sediment Criteria for Screening

Implementation guidance can be outlined in a strategy to apply sediment criteria for screening areas suspected of sediment contamination and recommending actions to take if they are exceeded.

1. Compare sediment contaminant concentrations with sediment criteria

   a. Quantify the area and volume of sediment wherein the criteria is exceeded; determine whether biota are exposed to contaminated sediment, e.g. deeply buried sediments may be below active biological zones.

   b. Describe the significance of exceedances in terms of the predicted effects. For example, would bioaccumulation or toxicity be the predominant impact. Based on the levels of protection exceeded, evaluate whether impacts are expected to be isolated or widespread through the ecosystem of concern. Consider the potential for transport of contaminants by natural processes to other areas.

2. For naturally occurring substances such as metals, compare sediment concentrations in the area of interest with local background concentrations in areas known to be unaffected by anthropogenic sources of contamination. Evaluate sediments relative to sediment criteria to identify contaminated sites. Compare suspected contaminated sites with uncontaminated sites, looking for adverse ecological impacts.

3. If sediment concentrations of a compound are less than all of the sediment criteria for that substance, aquatic resources can be considered to be not at risk (from that compound). However, additional testing would be warranted if the concentration of numerous contaminants were just below the criteria thresholds.

4. If sediment contaminant concentrations exceed criteria, and especially if widespread in the area of interest, steps may be taken to verify the need for remediation:

   a. For sediments with non-persistent, non-polar organic contaminants that are not causing observable acute or significant chronic toxicity, further remedial investigation or sediment remediation is not necessary if the source of contamination will be eliminated and the sediment will cleanse itself. Many chemicals with $\log_{10}K_{ow} < 3$ can be expected to be non-persistent in sediments. If it is decided not to remediate sediments contaminated with non-persistent chemicals, then, assurance must be made that water quality standards in offsite waters will not be contravened, and the public is informed of risks related to the contamination.

b. For sediments exceeding criteria based on aquatic life toxicity, including metals Lowest Effect Levels:

1. Assess the degree of impairment to the benthic community; compare site specific impairment with sediment contaminant concentrations; correlate site specific level of impairment with other known level of impairments and contaminant concentrations.

2. Collect sediment samples and conduct acute and chronic toxicity tests with fish and benthic invertebrates; correlate toxicity test results with sediment contaminant concentrations. It is important to follow established toxicity identification evaluation (TIE) techniques to ensure correct identification of the cause of toxicity, e.g. ammonia is a common cause of toxicity to benthic animals that can be mistakenly attributed to other toxics. Similarly, dissolved oxygem depletion in organically enriched sites such as wetlands could be confused with acute toxicity from contaminants.

3. For non-polar organic contaminants, exceedance of sediment criteria based on aquatic life chronic toxicity by a factor of 50 in a significantly large area indicates that biota are probably impaired and to achieve restoration of the ecosystem will require remediation of organic contaminants present.

4. For metals, if Severe Effect Levels are exceeded in significant portions of the ecosystem of concern, biota are most likely impaired and to achieve restoration of the ecosystem would likely require remediation of metals present.

c. For sediments exceeding criteria based on human health concerns:

1. Collect data on residues in edible, resident biota from the areas of concern and compare with tolerances, action levels, guidance values, or 1×10^{-6} cancer risk levels, or

2. Collect sediment samples, expose representative edible biota to sediments, measure residue in biota.

d. For sediment contaminant concentrations exceeding sediment criteria for the protection of piscivorous wildlife:

1. Collect data on residues in resident prey of piscivorous wildlife and compare with fish flesh criteria for protection of wildlife.

2. Expose wildlife food supply to contaminated sediment and measure residues in the food supply; compare with food supply residue levels known to be toxic to wildlife.

If sediment concentrations and criteria are less than analytical detection limits, ecological assessments are necessary to measure toxicity of sediments or residues in organisms exposed to sediments suspected of contamination. Generally, it is reasonable to predict that some, possibly high, levels of toxicity or bioaccumulation may associated with contaminants in sediments below analytical detection.

Table 1. <u>Sediment criteria for non-polar organic contaminants.</u> Water quality criteria used are taken from Togs 1.1.1. If a water quality criterion was not listed in TOGS 1.1.1., then an EPA criterion was used. These are annotated with the suffix (E). EPA criteria were extracted from the "Water Quality Criteria Summary" chart (EPA, 1991). EPA water quality criteria for the protection of human health (bioaccumulation) were taken from the "Recalculated Values - Organisms Only" column. Wildlife (bioaccumulation) and Human Health (bioaccumulation) protection criteria were derived in Appendix 1, unless TOGS 1.1.1. (bioaccumulation) criteria already existed. Although these criteria are only proposed, they are useful as guidance for estimating potential human health risks. These criteria are annotated with a suffix (P), for "Proposed criteria values".

			Levels of Protection							
			Human Health Bioaccumulation		**Benthic Aquatic Life Acute Toxicity**		**Benthic Aquatic Life Chronic Toxicity**		**Wildlife Bioaccumulation**	
Contaminant	**LogK$_{ow}$**	**Fresh-FW Salt -SW Both -FS**	**Water Qual Criteria µg/l**	**Sediment Criteria µg/gOC**	**Water Qual Criteria µg/l**	**Sediment Criteria µg/gOC**	**Water Qual Criteria µg/l**	**Sediment Criteria µg/gOC**	**Water Qual Criteria µg/l**	**Sediment Criteria µg/gOC**
Acenapthene	4.33	FW SW						140(E)[1] 240(E)[1]		
Aldrin & Dieldrin	5.0	FS	0.001	0.1					0.0077 (P)	0.77
Azinphosmethyl	2.4	FW SW					0.005 0.01	0.001 0.003		
Azobenzene	3.82	FS	0.16 (P)	1.0						
Benzene	2.0	FS	6.0	0.6						
Benzo(a)pyrene[2]	6.04	FW SW	0.0012 0.0006	1.3 0.7						

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[1] EPA proposed sediment quality criterion for the protection of benthic organisms.

[2] These values also apply to benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-cd)pyrene, and methylbenz(a)anthracene.

			Levels of Protection							
			Human Health Bioaccumulation		Benthic Aquatic Life Acute Toxicity		Benthic Aquatic Life Chronic Toxicity		Wildlife Bioaccumulation	
Contaminant	LogK_{ow}	Fresh-FW Salt -SW Both -FS	Water Qual Criteria µg/l	Sediment Criteria µg/gOC	Water Qual Criteria µg/l	Sediment Criteria µg/gOC	Water Qual Criteria µg/l	Sediment Criteria µg/gOC	Water Qual Criteria µg/l	Sediment Criteria µg/gOC
Benzidine	1.4	FW			0.1	0.003	0.1	0.003		
Bis(2-chloroethyl) ether	1.73	FS	0.5 (P)	0.03						
Bis(2-ethylhexyl) phthalate	5.3	FW					0.6	199.5		
Carbofuran	2.26	FW			10.0	1.82	1.0	0.2		
Carbon tetrachloride	2.64	FS	1.3 (P)	0.6						
Chlordane	2.78	FW SW	0.002 0.002	0.001 0.001	2.4 (E) 0.09 (E)	1.4 0.05	0.043 (E) 0.004 (E)	0.03 0.002	0.01 (P) 0.01 (P)	0.006 0.006
Chlorobenzene	2.84	FS			50.0	34.6	5.0	3.5		
Chloro-o-toluidine	~2.0	FS	6.5 (P)	0.65						
Chlorpyrifos	5.11	FW SW			0.083 (E) 0.011 (E)	10.7 1.4	0.041 (E) 0.0056 (E)	5.3 0.72		
DDT, DDD, & DDE[1]	6.0	FW SW	0.00001 (P) 0.00001 (P)	0.01 0.01	1.1 (E) 0.13 (E)	1100 130	0.001 (E) 0.001 (E)	1.0 1.0	0.001 0.001	1.0 1.0
Diazinon	1.92	FW					0.08	0.007		
Dichlorobenzenes	3.38	FS			50.0	120.0	5.0	12.0		
1,2 Dichloroethane	1.48	FS	24.0 (P)	0.7						
1,1 Dichloroethylene	1.48	FS	0.8 (P)	0.02						

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[1] Criteria for acute and chronic benthic toxicity apply to DDT only.

			Levels of Protection							
			Human Health Bioaccumulation		Benthic Aquatic Life Acute Toxicity		Benthic Aquatic Life Chronic Toxicity		Wildlife Bioaccumulation	
Contaminant	LogK_{ow}	Fresh-FW Salt -SW Both -FS	Water Qual Criteria µg/l	Sediment Criteria µg/gOC	Water Qual Criteria µg/l	Sediment Criteria µg/gOC	Water Qual Criteria µg/l	Sediment Criteria µg/gOC	Water Qual Criteria µg/l	Sediment Criteria µg/gOC
Dieldrin	5.0	FW SW	0.001 0.001	0.1 0.1				9.0 (E)[1] 17.0 (E)		
Diphenylhydrazine	3.03	FS	0.54 (E)	0.58						
Endosulfan	3.55	FW SW			0.22 0.034	0.78 0.12	0.009 0.001	0.03 0.004		
Endrin	5.6	FW SW	0.002	0.8				4.0 (E)[1] 0.73 (E)[1]	0.0019 (P)	0.8
Fluoranthene	5.19	FW SW						1020 (E)[1] 1340 (E)[1]		
Heptachlor & Heptachlor Epoxide	4.4	FW SW	0.00003 (P) 0.00003 (P)	0.0008 0.0008	0.52 (E) 0.053 (E)	13.1 1.3	0.0038(E) 0.0036(E)	0.1 0.09	0.001	0.03
Hexachlorobenzene	6.18	FW	0.0001 (P)	0.15	6.0 (E)	9081	3.68 (E)	5570	0.008 (P)	12
Hexachlorobutadiene	3.74	FW SW	0.06 (P) 0.06 (P)	0.3 0.3	10.0 3.0	55.0 16.4	1.0 0.3	5.5 1.6	0.7 (P) 0.7 (P)	4 4

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[1] EPA proposed sediment quality criteria for the protection of benthic organisms.

			Levels of Protection							
			Human Health Bioaccumulation		Benthic Aquatic Life Acute Toxicity		Benthic Aquatic Life Chronic Toxicity		Wildlife Bioaccumulation	
Contaminant	LogK_{ow}	Fresh-FW Salt -SW Both -FS	Water Qual Criteria μg/l	Sediment Criteria μg/gOC	Water Qual Criteria μg/l	Sediment Criteria μg/gOC	Water Qual Criteria μg/l	Sediment Criteria μg/gOC	Water Qual Criteria μg/l	Sediment Criteria μg/gOC
Hexachlorocyclohexanes	3.8	FW SW	0.009 (P) 0.009 (P)	0.06 0.06	2.0 0.16	12.6 1.0	0.01 0.004	0.06 0.03	0.23 (P) 0.23 (P)	1.5 1.5
Hexachlorocyclopentadiene	3.99	FW SW			4.5 0.7	44.0 6.8	0.45 0.07	4.4 0.7		
Isodecyldiphenyl phosphate	5.4	FW			22	5526	1.7	427		
Linear Alkyl Benzene Sulfonates	3.97	FW					40	373		
Malathion	2.2	FS					0.1	0.02		
Methoxychlor	4.3	FS					0.03	0.6		
Mirex	5.83	FS	0.0001 (P)	0.07			0.001	0.7	0.0055 (P)	3.7
Octachlorostyrene	≈ 6.0	FS							0.0005 (P)	0.5
Parathion and Methyl Parathion	2.5	FW			0.065 (E)	0.02	0.008	0.003		
Pentachlorophenol	5.0	FW			1.0	100	0.4	40		
Phenanthrene	4.45	FW SW						120 (E)[1] 160 (E)[1]		
Phenols, total chlorinated	2.75	FW					1.0	0.6		

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[1] EPA proposed sediment quality criteria for the protection of benthic organisms.

			Levels of Protection							
			Human Health Bioaccumulation		Benthic Aquatic Life Acute Toxicity		Benthic Aquatic Life Chronic Toxicity		Wildlife Bioaccumulation	
Contaminant	LogK_{ow}	Fresh-FW Salt -SW Both -FS	Water Qual Criteria µg/l	Sediment Criteria µg/gOC	Water Qual Criteria µg/l	Sediment Criteria µg/gOC	Water Qual Criteria µg/l	Sediment Criteria µg/gOC	Water Qual Criteria µg/l	Sediment Criteria µg/gOC
Phenols, total unchlorinated	2.0	FW					5.0	0.5		
PCB	6.14	FW SW	0.0000006 0.0000006	0.0008 0.0008	2.0 (E) 10.0 (E)	2760.8 13803.8	0.014 (E) 0.03 (E)	19.3 41.4	0.001 0.001	1.4 1.4
2,3,7,8-TCDD	7.0	FS	0.000001	0.01					2×10^{8} (P)	0.0002
1,1,2,2-Tetrachloroethane	2.56	FS	0.7 (P)	0.3						
Tetrachloroethylene	2.88	FS	1.0	0.8						
o-Toluidine	1.4	FS	18.0 (P)	0.5						
Toxaphene	3.3	FW SW	0.009 (P) 0.009 (P)	0.02 0.02	1.6 0.07	3.2 0.14	0.005 0.005	0.01 0.01		
Trichlorobenzenes	4.26	FS			50	910	5	91		
1,1,2-Trichloroethane	2.17	FS	4.0 (P)	0.6						
Trichloroethylene	2.29	FS	11.0	2.0						
Triphenyl phosphate	4.59	FW			40	1556	4	156		
Vinyl Chloride	0.6	FS	18.0 (P)	0.07						

.able 2. Sediment Criteria for Metals. Two levels of risk have been established for metals contamination in sediments. These are the Lowest Effect Level and the Severe Effect Level. The Lowest Effect Level for each metal is the lowest of either the Persaud et al. (1992) Lowest Effect Level or the Long and Morgan (1990) Effect Range-Low. Similarly, the Severe Effect Level for each metal is the lowest of either the Persaud et al. (1992) Severe Effect Level or the Long and Morgan (1990) Effect Range-Moderate. A sediment is considered contaminated if either criterion is exceeded. If both criteria are exceeded, the sediment is considered to be severely impacted. If only the Lowest Effect Level criterion is exceeded, the impact is considered moderate. The units are µg/g, or ppm, except for iron, which is listed as a percentage. An "L" following a criterion means that it was taken from Long and Morgan (1990); a "P" following a criterion indicates that it is from Persaud et al. (1992). Complete tables from both sources can be found in appendix 2.

Metal	**Lowest Effect Level µg/g (ppm)**	**Severe Effect Level µg/g (ppm)**
Antimony	2.0 (L)	25.0 (L)
Arsenic	6.0 (P)	33.0 (P)
Cadmium	0.6 (P)	9.0 (L)
Chromium	26.0 (P)	110.0 (P)
Copper	16.0 (P)	110.0 (P)
Iron (%)	2.0% (P)	4.0% (P)
Lead	31.0 (P)	110.0 (L)
Manganese	460.0 (P)	1100.0 (L)
Mercury	0.15 (L)	1.3 (L)
Nickel	16.0 (P)	50.0 (L)
Silver	1.0 (L)	2.2 (L)
Zinc	120.0 (P/L)	270.0 (L)

Appendix 1. Basis for the Water Quality Criteria Used for Deriving Sediment Criteria for the Protection of Human and Health and Piscivorous Wildlife from Bioaccumulation Effects.

This appendix provides the basis and calculations for ambient water quality criteria in Table 1 with the suffix (P), which were developed by the Divisions of Fish and Wildlife and Marine Resources for use in calculation of sediment criteria.

Human health (bioaccumulation) based criteria in Table 1 with the (P) suffix are derived according to the method in 6NYCRR 702.8.

$$\text{Water Quality Criterion, ug/l} = \frac{\text{ADI, ug/d}}{0.033\ \text{kg/d} \times \text{BF}}$$

where

ADI, ug/d = acceptable daily intake for humans taken from fact sheets supporting drinking water standards and guidance values in TOGS 1.1.1

0.033 kg/d = the human daily intake from fish consumption cited in Part 702.8 and

BF = bioaccumulation factor

Wildlife residue based criteria in Table 1 with the (P) suffix are derived according to the method in 6NYCRR 702.13.

$$\text{Water Quality Criterion, ug/l} = \frac{\text{A, mg/kg}}{\text{BF}}$$

where

A is a fish flesh criterion for protection of
piscivorous wildlife taken from Newell et al (1987),
and BF = Bioaccumulation Factor

BFs for human health based criteria are about 3% lipid based, whereas the BCF's for wildlife based criteria are about 10% lipid based. BFs were determined as a best judgement from review of available information in EPA water quality criteria documents, EPA (1979), and other scientific literature.

Aldrin and Dieldrin

Wildlife Residue Based Criterion

$$0.0077 \text{ mg/l} = \frac{0.12 \text{ mg/kg}}{15570}$$

Azobenzene

Human Health Residue Based Criterion = 0.16 ug/l

$$0.16 \text{ ug/l} = \frac{1 \text{ ug/d}}{0.033 \text{ kg/d} \times 179}$$

Bis (2-chloro-ethyl) ether

Human Health Residue Based Criterion

$$0.5 \text{ ug/l} = \frac{0.06 \text{ ug/d}}{0.033 \text{ kg/d} \times 4}$$

Carbon tetrachloride

Human Health Residue Based Criterion

$$1.3 \text{ ug/l} = \frac{0.8 \text{ ug/d}}{0.033 \text{ kg/d} \times 19}$$

Chlordane

Wildlife Residue Based Criterion

$$0.01 \text{ ug/l} = \frac{0.5 \text{ mg/kg}}{47020}$$

Chloro-o-toluidine

Human Health Residue Based Criterion

$$6.5 \text{ ug/l} = \frac{1.4 \text{ ug/d}}{0.033 \text{ kg/d} \times 15}$$

DDT, DDD & DDE

Human Health Residue Based Criterion

$$0.00001\ \text{ug/l} = \frac{0.02\ \text{ug/d}}{0.033\ \text{kg/d} \times 53610}$$

1,2-Dichloroethane

Human Health Residue Based Criterion

$$24\ \text{ug/l} = \frac{1.6\ \text{ug/d}}{0.033\ \text{kg/d} \times 2}$$

1,1-Dichlorethylene

Human Health Residue Based Criterion

$$0.8\ \text{ug/l} = \frac{0.14\ \text{ug/d}}{0.033\ \text{kg/d} \times 2}$$

Endrin

Wildlife Residue Based Criterion

$$0.0019\ \text{ug/l} = \frac{0.025\ \text{mg/kg}}{13240}$$

Heptachlor & Heptachlor Epoxide

Human Health Residue Based Criterion

$$0.00003\ \text{ug/l} = \frac{0.018\ \text{ug/d}}{0.33\ \text{kg/d} \times 15666}$$

Hexachlorobenzene

Human Health Residue Based Criterion

$$0.0001\ \text{ug/l} = \frac{0.04\ \text{ug/d}}{0.033\ \text{kg/d} \times 12000}$$

Wildlife Residue Based Criterion

$$0.008\ \text{ug/l} = \frac{0.33\ \text{mg/kg}}{40000}$$

Hexachlorobutadiene

Human Health Residue Based Criterion

$$0.06 \text{ ug/l} = \frac{1 \text{ ug/d}}{0.033 \text{ kg/d} \times 545}$$

Wildlife Residue Based Criterion

$$0.7 \text{ ug/l} = \frac{1.3 \text{ mg/kg}}{1818}$$

Hexachlorocyclohexanes

Human Health Residue Based Criterion

$$0.009 \text{ ug/l} = \frac{0.04 \text{ ug/d}}{0.033 \text{ kg/d} \times 130}$$

Wildlife Residue Based Criterion

$$0.23 \text{ ug/l} = \frac{0.1 \text{ mg/kg}}{433}$$

Mirex

Human Health Residue Based Criterion

$$0.0001 \text{ ug/l} = \frac{0.08 \text{ ug/d}}{0.033 \text{ kg/d} \times 18100}$$

Wildlife Residue Based Criterion

$$0.0055 \text{ ug/l} = \frac{0.33 \text{ mg/kg}}{60333}$$

Octachlorostyrene

Wildlife Residue Based Criterion

$$0.0005 \text{ ug/l} = \frac{0.02 \text{ mg/kg}}{40000}$$

2,3,7,8-Tetrachlorodibenzodioxin

Wildlife Residue Based Criterion

$$2 \times 10^{-8} \text{ ug/l} = \frac{0.000003 \text{ mg/kg}}{150{,}000}$$

1,1,2,2-Tetrachloroethane

Human Health Residue Based Criterion

$$0.7\ \mathrm{ug/l} = \frac{0.4\ \mathrm{ug/d}}{0.033\ \mathrm{kg/d} \times 17}$$

0-Toluidine

Human Health Residue Based Criterion

$$18\ \mathrm{ug/l} = \frac{1.2\ \mathrm{ug/d}}{0.033\ \mathrm{kg/d} \times 2}$$

Toxaphene

Human Health Residue Based Criterion

$$0.009\ \mathrm{ug/l} = \frac{0.02\ \mathrm{ug/d}}{0.033\ \mathrm{kg/d} \times 67}$$

1,1,2-Trichloroethane

Human Health Residue Based Criterion

$$4\ \mathrm{ug/l} = \frac{1.2\ \mathrm{ug/d}}{0.033\ \mathrm{kg/d} \times 9}$$

Vinyl Chloride

Human Health Residue Based Criterion

$$18\ \mathrm{ug/l} = \frac{0.6\ \mathrm{ug/d}}{0.033\ \mathrm{kg/d} \times 1}$$

Appendix 2. The following tables are photocopied directly from Long and Morgan (1990) and Persaud et al. (1992). They are presented here to provide further information about the metals criteria developed in Table 2., and the text above.

Copied directly from Persaud et al. (1992)

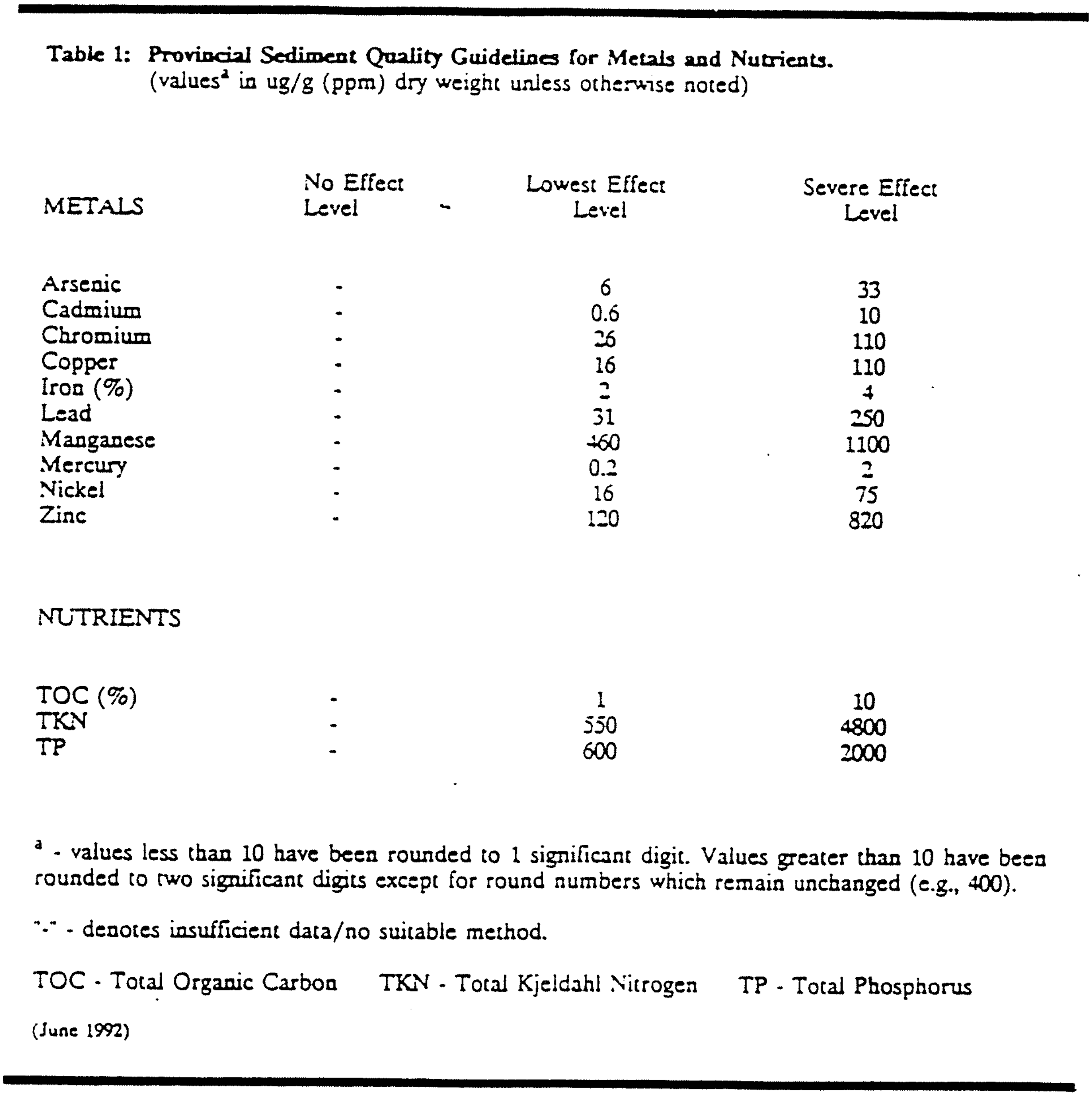

Table 1: Provincial Sediment Quality Guidelines for Metals and Nutrients.
(values[a] in ug/g (ppm) dry weight unless otherwise noted)

METALS	No Effect Level	Lowest Effect Level	Severe Effect Level
Arsenic	-	6	33
Cadmium	-	0.6	10
Chromium	-	26	110
Copper	-	16	110
Iron (%)	-	2	4
Lead	-	31	250
Manganese	-	460	1100
Mercury	-	0.2	2
Nickel	-	16	75
Zinc	-	120	820
NUTRIENTS			
TOC (%)	-	1	10
TKN	-	550	4800
TP	-	600	2000

[a] - values less than 10 have been rounded to 1 significant digit. Values greater than 10 have been rounded to two significant digits except for round numbers which remain unchanged (e.g., 400).

"-" - denotes insufficient data/no suitable method.

TOC - Total Organic Carbon TKN - Total Kjeldahl Nitrogen TP - Total Phosphorus

(June 1992)

Copied directly from Long and Morgan (1990)

Table 70. Summary of ER-L, ER-M, and overall apparent effects thresholds concentrations for selected chemicals in sediment (dry weight).

Chemical Analyte	ER-L Concentration	ER-M Concentration	ER-L:ER-M Ratio	Overall Apparent Effects Threshold	Subjective Degree of Confidence in ER-L ER-M Values
Trace Elements (ppm)					
Antimony	2	25	12.5	25	Moderate/moderate
Arsenic	33	85	2.6	50	Low/moderate
Cadmium	5	9	1.8	5	High/high
Chromium	80	145	1.8	No	Moderate/moderate
Copper	70	390	5.6	300	High/high
Lead	35	110	3.1	300	Moderate/high
Mercury	0.15	1.3	8.7	1	Moderate/high
Nickel	30	50	1.7	NSD[*]	Moderate/moderate
Silver	1	2.2	2.2	1.7	Moderate/moderate
Tin	NA	NA	NA	NA	NA
Zinc	120	270	2.2	260	High/high
Polychlorinated Biphenyls (ppb)					
Total PCBs	50	400	7.6	370	Moderate/moderate
DDT and Metabolites (ppb)					
DDT	1	7	7	6	Low/low
DDD	2	20	10	NSD	Moderate/low
DDE	2	15	7.5	NSD	Low/low
Total DDT	3	350	117	No	Moderate/moderate
Other Pesticides (ppb)					
Lindane	NA	NA	NA	NSD	NA[**]
Chlordane	0.5	6	12	2	Low/low
Heptachlor	NA	NA	NA	NSD	NA
Dieldrin	0.02	8	400	No	Low/low
Aldrin	NA	NA	NA	NSD	NA
Endrin	0.02	45	2250	NSD	Low/low
Mirex	NA	NA	NA	NSD	NA
Polynuclear Aromatic Hydrocarbons (ppb)					
Acenaphthene	150	650	4.3	150	Low/low
Anthracene	85	960	11.3	300	Low/moderate
Benzo(a)anthracene	230	1600	7	550	Low/moderate
Benzo(a)pyrene	400	2500	6.2	700	Moderate/moderate
Benzo(e)pyrene	NA	NA	NA	NSD	NA
Biphenyl	NA	NA	NA	NSD	NA
Chrysene	400	2800	7	900	Moderate/moderate
Dibenz(a,h)anthracene	60	260	4.3	100	Moderate/moderate
2,6-dimethylnaphthylene	NA	NA	NA	NSD	NA
Fluoranthene	600	3600	6	1000	High/high
Fluorene	35	640	18.3	350	Low/low
1-methylnaphthalene	NA	NA	NA	NSD	NA
2-methylnaphthalene	65	670	10.3	300	Low/moderate
1-methylphenanthrene	NA	NA	NA	NSD	NA
Naphthalene	340	2100	6.2	500	Moderate/high
Perylene	NA	NA	NA	NSD	NA
Phenanthrene	225	1380	6.1	260	Moderate/moderate
Pyrene	350	2200	6.3	1000	Moderate/moderate
2,3,5-trimethylnaphthalene	NA	NA	NA	NSD	NA
Total PAH	4000	35000	8.8	22000	Low/low

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[*] NSD = not sufficient data

[**] NA = not available

Appendix 3. Literature Cited

6NYCRR. 1991. New York Compilation of Codes, Rules, and Regulations, Volume 6, Section 703.5. The five primary levels of protection are not explicitly stated, but can be derved from table 2; Basis for Establishment of Standards.

Adams, W.J., Kimerle, R.A., and J.W. Barnett, Jr., 1992. Sediment Quality and Aquatic Life Assessment. Environmental Science and Technology 26(10):1865-1875.

ASTM, 1993. Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing (E1391-93), American Society for Testing and Materials, Philadelphia, PA.

DEC, 1989. Nonpoint Source Assessment Report. New York Department of Environmental Conservation, Division of Water, Bureau of Water Quality Management.

DEC, 1991. New York Department of Environmental Conservation, DRAFT Cleanup Policy and Guidelines, Volume II-Appendix, Appendix D: Clean-up Criteria for Aquatic Sediments. Cleanup Standards Task Force.

Demayo, A., Davis, A.R., and M.A. Forbes, 1978. Forms of Metals in Water. Scientific Series No. 87, Fisheries and Environment Canada, Inland Water Directorate, Water Quality Branch, Ottawa, Canada.

DiToro, D.M., 1985. A Particle Interaction Model of Reversible Organic Chemical Sorption. Chemosphere 14:1503-1538.

DiToro, D.M., Zarba, C.S., Hansen, D.J., Berry, W.J., Swartz, R.C., Cowan, C.E., Pavlou, S.P., Allen, H.E., Thomas, N.A., and P.R. Paquin, 1991. Technical Basis for Establishing Sediment Quality Criteria for Nonionic Organic Chemicals by Using Equilibrium Partitioning. Environmental Toxicology and Chemistry, 10(12):1541-1586.

Doull, J., Klassen, C.D., and M.O. Amdur, 1980. Toxicology: The Basic Science of Poisons. Macmillan Publishing Co., Inc., New York.

DoW, 1991. New York Department of Environmental Conservation, Division of Water, Technical and Operational Guidance Series (1.1.1.), Ambient Water Quality Standards and Guidance Values (Originator: John Zambrano) dated November 15, 1991.

Eisler, R. 1993. Zinc Hazards to Fish, Wildlife, and Invertebrates: a Synoptic Review. US Fish and Wildlife Service Biological Report 10 dated April 1993, Publications Unit, USFWA, 1849 C St., N.W., Mail Stop 130, Webb Building, Washington, D.C., 20240.

EPA, 1989. Briefing Report to the EPA Science Advisory Board on the Equilibrium Partitioning Approach to Generating Sediment Quality Criteria. US Environmental Protection Agency, EPA 440/5-89-002, Washington D.C.

EPA, 1990. Managing Contaminated Sediments. US Environmental Protection Agency, Sediment Oversight Technical Committee, EPA 506/6-90/002, Washington, D.C.

EPA, 1991. Proposed Technical Basis for Establishing Sediment Quality Criteria for Nonionic Organic Chemicals Using Equilibrium Partitioning. US Environmental Protection Agency, Office of Science and Technology, Health and Ecological Criteria Division, Washington, D.C. 20460.

EPA, 1992. Draft Outline, EPA's Contaminated Sediment Management Strategy: A Proposal for Discussion. US Environmental Protection Agency, Sediment Steering Committee.

EPA, 1992a. Interim Guidance on Interpretation and Implementation of Aquatic Life Criteria for Metals. U.S. Environmental Protection Agency, Health and Ecological Criteria Division, Office of Science and Technology.

EPA, 1992b. Sediment Classification Methods Compendium. US Environmental Protection Agency, Office of Science and Technology, Sediment Oversight Technical Committee, Washington, D.C.

EPA, 1993. Memorandum, from Martha G. Prothro, Acting Assistant Administrator for Water, subject: Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria, dated 1 Oct 93.

EPA SAB, 1990. Evaluation of the Equilibrium Partitioning (EqP) Approach for Assessing Sediment Quality. US Environmental Protection Agency Science Advisory Board, Report of the Sediment Criteria Subcommittee of The Ecological Process and Effects Committee. EPA-SAB-EPEC-90-006.

EPA SAB, 1992. An SAB Report: Review of Sediment Criteria Development Methodology for Non-Ionic Organic Contaminants. U.S. Environmental Protection Agency Science Advisory Board, Sediment Quality Subcommittee of the Ecological Process and Effects Committee. EPA-SAB-EPEC-93-002.

IJC, 1978. Great Lakes Water Quality Agreement of 1978. International Joint Commission, Canada and the United States, Ottawa, Canada.

Karickhoff, S.W., Brown, D.S., and T.A. Scott, 1979. Water Res. 13, p 241.

Kenaga, E.E., and C.A.I. Goring, 1980. Relationship Between Water Solubility, Soil Sorbtion, Octanol-Water Partitioning, and Concentration of Chemicals in Biota. in Aquatic Toxicology, Proceedings of the Third Annual Symposium on Aquatic Toxicology, Eaton, Parrish, and Hendricks, editors. ASTM STP 707, Philadelphia, Pa.

Leonard, E., 1991. Standard Operating Procedures for Total Organic Carbon Analysis of Sediment Samples. US Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Duluth, MN.

Long, E.R., and L.G. Morgan, 1990. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National States and Trends Program. National Oceanic Atmospheric Administration (NOAA) Technical Memorandum No. 5, OMA52, NOAA National Ocean Service, Seattle, Washington.

Manahan, S.E., 1991. Environmental Chemistry. Lewis Publishers, Inc., 121 South Main St., Chelsea, Michigan 48118.

Marcus, W.A., 1991. Managing Contaminated Sediments in Aquatic Environments: Identification, Regulation, and Remediation. Environmental Law Reporter, 21 ELR 10020-10032

Millemann, B. and E. Kinney, 1992. Getting to the Bottom of it: Threats to Human Health and the Environment from Contaminated Underwater Sediments. Coast Alliance.

Nebergall, W.H., Schmidt, F.C., and H.F. Holtclaw, Jr., 1968. General Chemistry. D.C. Heath and Company, Lexington, Massachusetts

Newell, A.J., Johnson, D.W., and L.K. Allen, 1987. Niagara River Biota Contamination Project: Fish Flesh Criteria for Piscivorous Wildlife. New York Department of Environmental Conservation, Division of Fish and Wildlife, Bureau of Environmental Protection, Technical Report 87-3.

Persaud, D., Jaagumagi, R., and A. Hayton, 1992. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of the Environment, Queen's Printer for Ontario.

Rand, G.M., and S.R. Petrocelli, 1985. Fundamentals of Aquatic Toxicology. Hemisphere Publishing Corporation.

Voice, T.C., Rice, C.P., and W.J. Weber, Jr., 1983. Effects of Solids Concentration on the Sorptive Partitioning of Hydrophobic Pollutants in Aquatic Systems. Environmental Science and Technology 17(9):513-517.