Focused Ground-Water Feasibility Study for the Airco Parcel Niagara Falls, New York

Prepared for

The BOC Group
100 Mountain Avenue
Murray Hill, New Jersey 07974

Prepared by

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19 March 2003
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LIST OF ACRONYMS

ARAR	Applicable or relevant and appropriate requirements
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Constituent of concern
CVOCs	Chlorinated volatile organic compounds
EPA	(U.S.) Environmental Protection Agency
FS	Feasibility study
GRA	General Response Action
HRC	Hydrogen release compound
IIWA	Immediate Investigation Work Assignment
MCL	Maximum Contaminant Level
NCP	National Contingency Plan
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
O&M	Operation and maintenance
POTW	Publicly-owned treatment works
PRB	Permeable reactive barrier
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
SARA	Superfund Amendments and Reauthorization Act

EXECUTIVE SUMMARY

ES.1 SCOPE

This Focused Ground-Water Feasibility Study was conducted by EA Engineering, P.C. and its affiliate EA Engineering, Science, and Technology for The BOC Group. The primary objective of the Feasibility Study was to develop and evaluate potential remedial alternatives for addressing ground water that currently recharges to surface water in the southwest corner of the Airco parcel in Niagara Falls, New York (the Project). This Feasibility Study builds upon the findings of the pre-design investigation, closure plan, Interim Remedial Measure Program, and post-closure operations and facility maintenance that have been conducted since August 1999.

The Feasibility Study was conducted to be consistent with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 and Title 6 of the New York Codes, Rules, and Regulations, Part 375 et seq. The Feasibility Study does not include comprehensive human health and ecological risk assessments, but does evaluate hexavalent chromium (Cr[VI]) with respect to human health and ecological screening criteria and other applicable or relevant and appropriate requirements (ARARs).

ES.2 BACKGROUND

The Vanadium Corporation of America site in Niagara Falls, New York is currently listed as a Class 2 site in the New York State Registry of Inactive Hazardous Waste Sites (Site No. 932001). This classification indicates that the New York State Department of Environmental Conservation considers the Vanadium Corporation of America site to be a significant threat to public health or the environment, and requires remedial action. The site consists of three separate properties:

- A 25-acre Airco parcel owned by Airco Properties, Inc.
- A 37-acre parcel owned by SKW Metals and Alloys, Inc.
- A 53-acre parcel owned by Niagara Mohawk Power Corporation/New York Power Authority.

The Airco parcel is the middle of three parcels that comprise the Vanadium Corporation of America site. The Airco parcel was owned and used by the Vanadium Corporation of America from 1920 to 1964 for disposal of the following materials: stainless steel (lime) slag, ferromanganese slag, ferrochrome silicon slag and dust, and ferrosilicon dust. It is estimated that during the 44 years of operation by Vanadium Corporation of America, 600,000 tons of slag and dust and 90,000 tons of wood, brick, and ash refuse were dumped in various areas of the Airco parcel and adjacent SKW and Niagara Mohawk Power Corporation/New York Power Authority subsites.

Remedial measures were completed at the Airco Parcel during 2000, which included installation of a low permeability cap and ground-water relief system. The remedial measures received substantial completion approval on 25 October 2000, indicating remedial measures were completed. EA has been performing long-term monitoring and engineering inspections on a quarterly basis since the closure, in accordance with the Post-Closure Monitoring and Facility Maintenance Plan. Overall, the cap system is performing as expected.

ES.3 REMEDIAL GOALS FOR THE PROJECT

Federal and state ARARs were identified for developing and evaluating remedial alternatives for the Project. Preliminary Remediation Goals, which serve as potential cleanup criteria for impacted soil and ground water, were developed from the evaluation of human health risk screening, ecological risk screening, and data collected during each phase of investigation and remediation.

The following Remedial Action Objectives were developed for the Project based on results of the human health and ecological risks screenings, as well as a comparison of constituents of concern data to Preliminary Remediation Goals:

1. Minimize potential human exposure and protect the environment from constituents of concern in ground water recharging to surface water at the Project area above New York State Ambient Water Quality Criteria under the current industrial land use scenario

2. Minimize the potential migration of constituents of concern in ground water recharging to surface water beyond the Project area.

In order to achieve these Remedial Action Objectives, the following General Response Actions were evaluated:

- No action[1] (required for consideration by the National Contingency Plan as a comparative baseline)

- Institutional controls

- Containment

- Source area and ground-water removal

1. The No Action alternative refers to no remedial action for the Project area. Existing long-term monitoring and institutional controls currently performed as part of the approved Post-Closure Monitoring and Facility Maintenance Plan (EA 2000) will continue relative to the Airco parcel.

- *In situ* ground-water treatment
- *Ex situ* ground-water treatment
- Disposal.

ES.4 REMEDIAL ALTERNATIVES FOR THE PROJECT

Various traditional and innovative environmental remediation technologies that address the General Response Actions were screened based on their effectiveness and implementability for the specific conditions related to the Project. Several remedial alternatives were then developed from the technologies and process options that were retained from the initial screening. The remedial alternatives developed for the Project to meet the Remedial Action Objectives are as follows:

- Alternative 1: No Action
- Alternative 2: *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring
- Alternative 3: *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring
- Alternative 4: *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring.

Pursuant to U.S. Environmental Protection Agency guidance, the remedial alternatives were evaluated with respect to the following National Contingency Plan evaluation criteria:

1. Overall Protection of Human Health and the Environment
2. Compliance with ARARs
3. Long-Term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, and Volume through Treatment
5. Short-Term Effectiveness
6. Implementability
7. Cost
8. State Acceptance
9. Community Acceptance.

The last two National Contingency Plan evaluation criteria, State Acceptance and Community Acceptance, were not addressed in the Feasibility Study but will be addressed during public review and comment. It is anticipated that the New York State Department of Environmental

Conservation will determine whether to hold a public meeting or issue a fact sheet for community informational purposes.

ES.5 SUMMARY OF REMEDIAL ALTERNATIVES

Based on the results of quarterly ground-water monitoring, ground water beneath the Airco parcel is characterized by elevated pH and elevated concentrations of Cr(VI). The ground water in the Project area recharges to an existing wetland, which has resulted in elevated concentrations of Cr(VI) and high pH (>12) water being discharged into the wetland. The potential remedial alternatives that were developed for the Project and a summary of their analyses follow:

- **Alternative 1: No Action**—Alternative 1 would not protect human health or the environment and would not meet ARARs.

- **Alternative 2: *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring**—Alternative 2 would be protective of human health and the environment, and would immediately satisfy the ARARs by actively pumping and treating the impacted ground water prior to sewer discharge. Sewer discharge would be accomplished via a force main from an onsite treatment plant to the sewer.

- **Alternative 3: *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring**—Alternative 3 would be protective of human health and the environment, and would immediately satisfy the ARARs by actively pumping and treating the impacted ground water prior to discharge to the wetland. The discharge would require a State Pollution Discharge Elimination System permit, and would have more extensive monitoring requirements than that of Alternative 2.

- **Alternative 4: *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring**—Alternative 4 would be protective of human health and the environment, and would immediately satisfy the ARARs by aerating the ground water with carbon dioxide gas to produce carbonic acid which will neutralize the ground water to a pH of 6.5, and permeable reactive media vessels which will convert the Cr(VI) to trivalent chromium (Cr[III]) and precipitate out the hardness and some of the Cr(III). An engineered wetland would provide secondary treatment during most of the year.

The following table provides a summary of remedial alternative costs for ground water:

Alternative	Capital Costs ($)	Operation and Maintenance Costs ($)[a]	Total Costs ($)[a]
1. No Action	0	86,000	86,000
2. *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring	3,385,000	3,658,000	7,043,000
3. *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring	1,910,000	6,408,000	8,318,000
4. *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring	1,225,000	2,795,000	4,020,000

(a) Costs assume that the existing long-term monitoring and maintenance activities currently required under the Post-Closure Operations and Facility Maintenance Plan will continue concurrent to operation and maintenance costs associated with the Project. Costs shown do not include the costs associated with the existing required activities, but benefit from concurrent requirements.

ES.6 RECOMMENDED REMEDIAL ALTERNATIVE

Alternative 4: *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring—Alternative 4 would provide aggressive treatment of constituents of concern in ground water. Significant reduction of Cr(VI) would be accomplished by collecting the ground water recharging to surface, and treating it prior to release into the existing onsite drainage structures.

Bench-scale testing was performed as part of developing this Feasibility Study, and the results indicated that this technology would be effective to neutralize the high pH, and to reduce the Cr(VI) to Cr(III).

1. INTRODUCTION

This Focused Ground-Water Feasibility Study (FS) was conducted by EA Engineering, P.C. and its affiliate EA Engineering, Science, and Technology for The BOC Group. The primary objective of the FS was to develop and evaluate potential remedial alternatives for addressing ground water which currently recharges to surface water in the southwest corner of the Airco parcel in Niagara Falls, New York (the Project) (Figure 1-1). This FS builds upon the findings of the pre-design investigation, closure plan, Interim Remedial Measure Program, and post-closure operations and facility maintenance that have been conducted since August 1999. This FS, and resultant remedial actions, are being performed under the existing Order on Consent No. B9-0470-94-12, which will be amended as required for completion of this FS, and associated remedial actions resulting from acceptance of the recommendations contained within the FS.

The FS was conducted to be consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and Title 6 of the New York Codes, Rules, and Regulations Part 375 et seq. The FS does not include comprehensive human health and ecological risk assessments, but does evaluate the hexavalent chromium (Cr[VI]) and trivalent chromium (Cr[III]) with respect to human health and ecological screening criteria and other applicable or relevant and appropriate requirements (ARARs).

1.1 FEASIBILITY STUDY OBJECTIVES

1.1.1 Purpose

The purpose of the FS was to develop and evaluate potential remedial alternatives for the Project. As noted above, the existing Order on Consent will be modified to include the findings of this FS and to implement any further remedial action, and a fact sheet will be issued for community informational purposes.

1.1.2 Scope

The FS was based upon the results of long-term monitoring and the flow monitoring of the ground-water relief pipe discharge. During construction, the cap was installed with a relief pipe system to allow ground water to continue to recharge to the surface beyond the limits of the cap. It was initially believed that post-capping, the discharge would eventually dissipate. The discharge has continued in the southwest corner of the Airco parcel, and this FS is being developed to present alternatives to address that concern.

1.1.3 Report Organization

This report is divided into the following chapters:

- **Chapter 1, Introduction**—Outlines the purpose and scope of the FS and summarizes the background information and physical characteristics of the Airco parcel and the Project area. This chapter also includes a summary of relevant findings from previous investigations.

- **Chapter 2, Development of the Evaluation Process**—Provides an overview of the FS evaluation process; identifies the chemical-, location-, and action-specific ARARs; identifies Preliminary Remediation Goals (PRGs); defines the Remedial Action Objectives (RAOs); and identifies General Response Actions (GRAs) for the ground water and the identified constituents of concern (COCs).

- **Chapter 3, Identification and Screening of Technology Types and Process Options**—Presents an evaluation of potential remedial technologies and process options for remediation of COC-impacted ground water.

- **Chapter 4, Remedial Alternatives for Ground Water**—Discusses development of remedial alternatives based upon the technologies that were retained from the screening process in Chapter 3.

- **Chapter 5, Detailed Analysis of Remedial Alternatives for Ground Water**—This chapter presents a detailed evaluation and comparative analysis of each of the remedial alternatives with respect to seven of the nine National Contingency Plan (NCP) evaluation criteria.

- **Appendix A**—Presents the data collected during August 2002 in the adjacent wetland area.

- **Appendix B**—Contains the remedial alternative costing spreadsheets.

1.2 VANADIUM CORPORATION OF AMERICA SITE DESCRIPTION AND BOUNDARIES

The Vanadium Corporation of America site in Niagara Falls, New York (Figure 1-2) is currently listed as a Class 2 site in the New York State Registry of Inactive Hazardous Waste Sites (Site No. 932001). This classification indicates that the New York State Department of Environmental Conservation (NYSDEC) considers the Vanadium Corporation of America site to be a significant threat to public health or the environment, and requires remedial action. The Vanadium Corporation of America site consists of three separate properties:

- A 25-acre Airco parcel owned by Airco Properties, Inc.

- A 37-acre parcel owned by SKW Metals and Alloys, Inc.

- A 53-acre parcel owned by Niagara Mohawk Power Corporation/New York Power Authority.

The Airco parcel is the middle of three parcels that comprise the Vanadium Corporation of America site. The Airco parcel was owned and used by the Vanadium Corporation of America from 1920 to 1964 for disposal of the following materials: stainless steel (lime) slag, ferromanganese slag, ferrochrome silicon slag and dust, and ferrosilicon dust. It is estimated that during the 44 years of operation by Vanadium Corporation of America, 600,000 tons of slag and dust and 90,000 tons of wood, brick, and ash refuse were dumped throughout the Airco parcel and adjacent SKW and Niagara Mohawk Power Corporation/New York Power Authority subsites.

Remedial measures were completed at the Airco parcel during 2000, which included installation of a low permeability cap and ground-water relief system. EA has been performing long-term monitoring and engineering inspections on a quarterly basis since the closure, in accordance with the Post-Closure Monitoring and Facility Maintenance Plan. Overall, the cap system is performing as expected.

1.3 INTERIM REMEDIAL MEASURE PROGRAM

As part of the Interim Remedial Measure Program, BOC entered into Order on Consent No. B9-0470-94-12 on 17 May 2000. The terms of this Order constitute the complete and entire Order concerning the implementation of an interim remedial measure for the Airco property and demonstrates conformance with all applicable requirements of Title 6 of the New York Codes, Rules, and Regulations (NYCRR) Part 375, Environmental Conservation Law Article 27, Title 7, including 6 NYCRR Part 360 requirements pertaining to permitting, closure, and post-closure care of the landfill, and all other state plans, standards, or regulations that relate to the Interim Remedial Measure Program.

The Interim Remedial Measure Program was implemented to affect the closure of the landfill and to address the elevated pH leachate daylighting at various locations. In 2000, the landfill was capped, but the elevated pH leachate has continued to daylight in the Project area. Flow monitoring and quarterly sampling were initiated as part of post-closure operations and facility maintenance. The data collected since December 2000 indicated that the leachate was actually shallow ground-water recharging to surface water. The data also indicated that the recharge of ground water at the Project area would continue to flow seasonally. The data further indicated that elevated Cr(VI) and pH remained in excess of the ambient water quality criteria. Therefore, this FS was prepared to develop remedial alternatives to address this issue.

1.4 SUMMARY OF PREVIOUS INVESTIGATIONS

An Immediate Investigative Work Assignment (IIWA) was conducted by NYSDEC for a portion of the 150-acre parcel in August 1997. Approximately 70 acres from the Niagara Mohawk A National Grid Company and New York Power Authority parcel were investigated. During the investigation, NYSDEC determined that the Airco parcel had been used by Vanadium Corporation of America (the owners of the site from 1924 to 1964) to dispose of wood, brick, ash, lime slag, ferrochromium silicon slag, and ferrochromium silicon dust. According to the IIWA, much of the surface material consisted of fill, including fly ash, dust, slag, and cinder materials.

Analysis of the Vanadium Corporation of America site ground water during a preliminary site assessment, that was reviewed as part of the NYSDEC IIWA, indicated that surface water and ground-water standards were exceeded for Cr(VI) and pH. Based on the IIWA and other investigations, the facility has been listed as a Class 2 Hazardous Waste Site in the New York State Registry of Inactive Hazardous Waste Sites (Site No. 932001). A Class 2 listing indicates a significant threat to public health and the environment, and requires remedial action.

In addition to the PSA on IIWA, EA conducted a pre-design investigation under the Interim Remedial Measure Program to collect site-specific data in support of the Closure Plan preparation process. The Closure Plan was prepared and approved in Spring 2000.

Remedial measures were completed at the Airco parcel during 2000, which included installation of a low permeability cap and ground-water relief system. A complete description of the history of the Airco parcel, and the construction details of the landfill capping system, can be found in the Interim Remedial Measure Report (EA 2001).

1.5 PHYSICAL CHARACTERISTICS OF THE AIRCO PARCEL

This section provides a discussion of the local and regional physical characteristics of the Airco parcel based on information obtained during the closure investigation and previous investigations conducted at the Airco parcel. Descriptions of the subsurface physical features, geology, and hydrogeology are based primarily on the findings of field investigations conducted by EA and a review of geologic literature.

Descriptions of surface water hydrology, geology, and hydrogeology are provided in this section. The descriptions of the Airco parcel geology and hydrogeology are supported by the soil boring data, *in situ* electrical conductivity logging data, and water elevation gauging data collected during the investigations conducted at the Airco parcel to date. In addition, a site-specific conceptual hydrogeologic model for the Airco parcel has been developed on the basis of the geologic data and is also discussed in this chapter.

1.5.1 Surface Water Hydrology

Regionally, the Airco parcel is located in a well-developed area, therefore, the bulk of the local surface water drainage is controlled by man-made features. The ground surface at the Airco parcel lies between 600 and 630 ft above mean sea level. The most obvious potential drainage feature noted on the local topographic map is in the vicinity of the Project. The surface water in this area drains to the west-southwest. There is no indication of permanent or ephemeral streams in this area. The adjacent wetlands are most likely an artifact of predevelopment drainage. Post-construction of the cap, only limited wetland vegetation is noted within the southern drainage swale and is a result of adjacent wetland vegetation encroaching onto the Airco parcel.

Surface drainage on the landfill proper is designed to direct precipitation and runoff via drainage swales to the wetlands southwest of the Airco parcel. Precipitation infiltrates through the top soil and barrier protection layers and is removed through evapotranspiration mechanisms, or drains via the geocomposite drainage layer. Surface water that leaves the Airco parcel as surface water flow is incorporated into the combined storm and sanitary sewer system. During heavy rain fall events, the flow in the combined system may be diverted to the lower Niagara River due to capacity limitations at the publicly-owned treatment works (POTW), and a required preference for treating waste flows from more industrialized areas of the community. The Niagara River is a Class A stream that flows north toward Lake Ontario. A Class A stream is a stream that may be used: (1) as a drinking water source (with proper treatment); (2) for primary and secondary contact recreation; and (3) for fishing, fish propagation, and survival. In addition, because the Niagara River is a boundary water between the United States and Canada, it is considered a Special Class A Stream.

1.5.2 Local and Regional Geology

1.5.2.1 Airco Parcel Geology

Bedrock

The bedrock underlying the Airco parcel is the Lockport Dolomite, a calcium- and manganese-rich carbonate rock, which contains minor amounts of sulfate (as gypsum) and sulfate (pyrite, galena and sphalerite) minerals. The dolomite lies nearly flat, but does exhibit a regional dip of approximately 0.5 degrees to the south or locally approximately 30-40 ft per mi. Variations in the erosion patterns along the surface result in local differences in the dip of the bedding and contour of the bedrock surface.

Interpretation of the data relating to the depth of refusal indicates that the bedrock gently dips to the south with a pronounced low in the bedrock surface around monitoring well No. 5.

Unconsolidated Sediments and Fill

Overlying the bedrock is a layer of dense glacial clay-rich till which varies in thickness from 2 to 7 ft. This material presents an extreme range in texture, from clay and silt to gravel and occasional boulders. Soil borings completed during the December 1999 pre-design investigation indicate that the till consists of a red or gray clay-rich matrix containing some silt and clay mottling in areas.

A very compact gray silt and very fine sand, or sand and silt unit overlies the red clay at the Airco parcel. The thickness varies from approximately 1 to 12 ft. The unit contains silt lenses. A white or black fill-type material was encountered at each borehole. The texture ranges from a loose powdery slag to coarse sand and gravel-sized slag material, either loose, or very compacted, and hard to penetrate. This material was ash-like metallic material with variable color ranges including white, black, gray, green, and bluish.

1.5.3 Hydrogeology

1.5.3.1 Regional Hydrogeology

The Airco parcel is located in the Erie-Ontario Lowlands Province. This province encompasses the low flat areas lying south of Lake Erie and Lake Ontario and extends up the Black River Valley.

Overburden ground-water patterns indicate that flow is to the south. Recharge to the unconfined overburden is through direct infiltration of precipitation and runoff. Recharge to the regional bedrock (the Lockport Group) is from recharge areas along the Niagara Escarpment. Bedrock ground-water flow is to the south-southwest to regional discharge areas including local perennial streams and outcrops along the Niagara River. Localized alterations in the direction of ground-water flow in bedrock and overburden may be the result of anthropogenic effects.

1.5.3.2 Regional Ground-Water Quality

The ground water beneath the Airco parcel is classified by NYSDEC as Class GA. Class GA is the designation for ground water that occurs in areas of influence of private and potential public water supply wells. It is presumed suitable for direct human consumption without the need for treatment. However, the Airco parcel and the surrounding areas are connected to the local public water supply, and direct contact or consumption of the ground water is not anticipated.

1.5.3.3 Airco Parcel Hydrogeology

Horizontal Ground-Water Flow

Ground water is present in two distinct hydrogeologic units beneath the Airco parcel, including overburden and bedrock. Through its investigative and sampling efforts, EA has generated significant overburden ground-water data. Information regarding bedrock flow patterns is available from other sources, including professional papers completed on other locations within the area.

Figures 1-3 and 1-4 illustrate interpretations of the low and high level overburden ground-water potentiometric surface during the quarterly sampling events conducted at the Airco parcel. Figure 1-3 illustrates the interpreted low ground-water elevation observed in September 2001. Figure 1-4 illustrates the interpreted high ground-water elevation observed in March 2001. Ground-water elevations are included in Table 1-1 for each monitoring well. The overburden beneath the Airco parcel is unconfined and responds to direct precipitation.

A review of the ground-water flow patterns indicates that a ground-water divide exists beneath the Airco parcel, which is consistent with regional ground-water flow data described in the IIWA report prepared by NYSDEC. The long axis of the divide extends from a ground-water high in the northwest to the southeast. Ground-water flow flows from the crest of the divide to the northeast, southeast, and southwest.

Regional bedrock ground-water flow patterns were developed during the completion of a professional paper prepared by the U.S. Geological Survey (Yager 2000). The ground-water flow patterns of the upper weathered portions of the Lockport Group Dolostone indicate that bedrock is recharged along the Niagara Escarpment, and it discharges along local streams and the Niagara River to the south. Based on the U.S. Geological Survey data, it appears that there is a slight ground-water high in the northwest corner of the Airco parcel. This may be a reflection of the ground-water divide noted in the overburden ground water.

Vertical Ground-Water Flow between Hydrogeologic Units

Because of a lack of bedrock monitoring wells and a single overburden ground-water unit, there are no direct data available to interpret vertical ground-water flow patterns beneath the Airco parcel. However, an estimate of whether ground-water flow between the overburden and bedrock is upward or downward can be made using regional ground-water elevations (Yager 2000). In this paper, Yager illustrates bedrock ground-water elevations within the immediate area of the Airco parcel and regionally.

Using the available data, the bedrock ground-water elevations in the area appear to range from 580 to 600 ft above mean sea level. Overburden ground-water elevations range from 590 to 610 ft above mean sea level. This suggests that there is a slight downward gradient in ground-water flow between the overburden and the bedrock. Yager confirmed this downward gradient through the use of pressure transducers in overburden and bedrock monitoring wells. Although these data indicate a consistent downward hydraulic gradient from the overburden to the bedrock in this area, bedrock monitoring wells located on adjacent parcels installed as part of the IIWA, do not indicate impacts to the bedrock aquifer within the Vanadium Corporation of America site.

1.6 NATURE AND EXTENT

The only environmental concern remaining at the Airco parcel, now that the overall remedial action has been completed, consists of inorganic impacts to ground water recharging to surface water in the southwest corner of the Airco parcel. In order to determine the nature and extent of the impacts to ground water beneath the Airco parcel, EA completed a hydrogeochemical evaluation of the analytical and hydrogeologic data generated during the 2001 sampling events.

The hydrogeochemical evaluation of the ground water beneath the Airco parcel was submitted as part of the 2001 Annual Monitoring Report (EA 2002). The evaluation used various data reduction techniques (scatter plots, trend graphs, hydrographs, potentiometric surface maps, etc.) to determine the nature and extent of the inorganic impacts to ground and surface water.

The summary of analytical results indicates that there were a number of elevated concentrations of metals and other inorganic indicators observed in the ground-water relief pipe samples at the Project area. These included Cr(VI), sodium, ammonia, and pH.

Using the ground-water relief pipe samples as a baseline or initial source, it is possible to determine what effect the leachate generated within the landfill cell has on the ambient overburden ground-water chemistry, and it is possible to determine the effect of offsite sources, if present. This evaluation, coupled with known hydrogeologic characteristics, provides a picture of the nature and extent of leachate impacts to ground water beneath the Airco parcel, and at the Project area.

As noted above, the primary leachate indicators are chromium, Cr(VI), sodium, and ammonia. Of these, sodium is common to ground water found beneath the Airco parcel (Yager 2000 analytical data also indicate that sodium is common in local ground water). Therefore, sodium was eliminated as an effective leachate indicator. Silica is also monitored as part of the post-closure operations and facility maintenance. Based on the concentrations of silica identified in leachate and in the samples collected from the wells within the mixing and ambient ground-water zones, it appears that concentrations of silica are the result of offsite activities and not the result of leachate migration from the landfill cell.

Using the remaining analytes, it was determined that wells MW-1B, MW-3B, MW-5B, and MW-6B (Figures 1-3 and 1-4) have similar ground-water chemistry and are consistent with ambient or background ground-water quality. The chemistry of these wells is also similar to three of the offsite wells sampled during the IIWA (MW-103A, MW-104A, and MW-105A) (Figure 1-2), further supporting the premise that the ground-water chemistry at the wells is consistent with ambient or background ground-water quality.

Wells MW-2B, MW-4B, MW-7B, and MW-8B (Figures 1-3 and 1-4) have similar hydrogeochemical signatures when compared with ground-water relief pipe chemistry. The samples collected from these wells have concentration ratios similar to those of the ground-water relief pipe data, but at more diluted concentrations. Their chemical signatures suggest that these wells lie within a mixing zone between leachate and ambient ground water. This is supported by the ground-water flow patterns identified at the Airco parcel by NYSDEC in the IIWA report and EA in the 2001 Annual Monitoring Report (EA 2002).

Hydrogeologic and anthropomorphic changes to the area contribute to the extent of the leachate impacts in the area. Hydrogeologic data collected during the IIWA, indicate that the overburden consists of discontinuous fill overlying glaciolacustrine deposits of interbedded silty clays, clayey silts, sandy silts, and silty sands. The glaciolacustrine deposit ranges from 2 to 26 ft in thickness in the area.

A glacial till lies beneath the glaciolacustrine deposits. In the vicinity of the Airco parcel, the till deposit is characterized as a dense heterogeneous mixture of reddish-brown clay, silt, sand, gravel, and dolostone rock fragments. The till ranges in thickness from 0.6 to 14.5 ft in the vicinity of the Airco parcel.

The bedrock in the area consists of the Lockport Dolostone Group. The Lockport Group is a essentially flat-lying, weathered, dense, medium to dark gray, fine to coarse, crystalline, thin to massively bedded dolostone/limestone. The upper 45 ft of the group contains vertical fractures and weathered horizontal bedding planes.

In the IIWA, the geometric mean hydraulic conductivities of the overburden, using both the Bouwer-Rice Method and the Hvorslev Method, were 4.7×10^{-4} and 8.18×10^{-5} cm/sec respectively. Using the results of the Bouwer-Rice Method (a conservative approach), the hydraulic conductivity of the overburden can be used to determine the seepage velocity in the overburden, using the equation:

$$V = KI/n$$

where

- V = Seepage velocity (ft/day)
- K = Hydraulic conductivity (cm/sec) – 4.7×10^{-4}
- I = Hydraulic gradient – 0.006
- n = Estimated porosity – 0.33.

Using this equation, the seepage velocity was calculated to be 0.0239 ft/day or 8.72 ft/year (pre-cap conditions). The hydrogeologic conditions at the Airco parcel—relatively thick, dense, low hydraulic conductivity soils overlying massive dolostone—coupled with the landfill cap, suggest that it is unlikely that migration of leachate from the Airco parcel will be extensive.

Figure 1-5 illustrates the known areas of post-capping leachate impacts. Available data suggest that the leachate impacts to ground water are confined to the overburden in the immediate area of the Airco parcel. The most likely areas where leachate migration may be occurring are in the vicinity of monitoring wells MW-2B, MW-4B, MW-7B, and MW-8B.

1.7 ECOLOGICAL AND HUMAN HEALTH RISK ASSESSMENT

1.7.1 Screening Level Ecological Risk Assessment

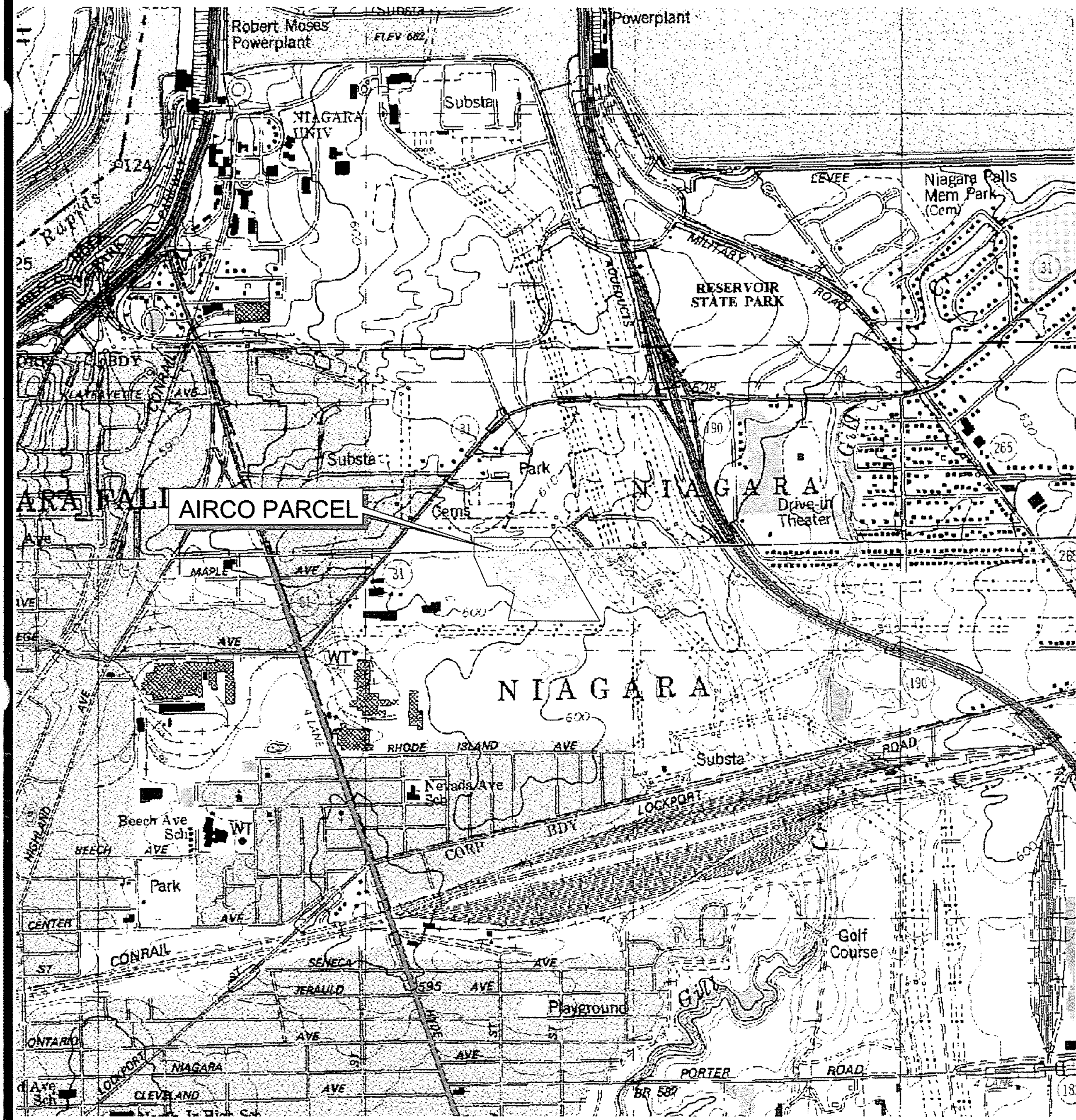
A Screening Level Ecological Risk Assessment was conducted to determine if, under expected exposure conditions, chemicals detected in surface water and wetland soil/sediment samples collected to the south and southwest of the Airco parcel are at concentrations that may cause unacceptable risk to organisms that may utilize or dwell in this habitat. Impacted ground-water discharges to surface water at the ground-water relief pipe at the Project area (Figure 1-5). The discharge appears to be seasonal, in conjunction with periods of rainfall and higher ground-water table. During extended periods of drought during the Summer of 2001, no surface discharge was observed (Figure 1-5) for short periods of time.

The area of study is a non-jurisdictional wetland including scrub/shrub, emergent, and open water habitat (Figure 1-6). The identified receptors of concern within the study area include various species of invertebrates, amphibians, reptiles, birds, mammals, and wetland plants. The emergent wetland community affected by the ground-water discharge is dominated by the common reed, *Phragmites australis*, with a fringe of cattail along the edge of open water areas.

Surface water and sediment/soil samples were collected on 22 August 2002 in support of a screening level ecological risk assessment. Samples were allocated to provide information on conditions upstream and downstream of the Project area. Samples were collected from offsite wetlands and drainage swales to the east, south, and southwest of the Project area (Figure 1-6) in order to evaluate spatial distribution of contaminants. The upper 6-10 in. of sediment/soil were sampled using a hand auger at 10 locations plus 1 duplicate. Due to prevailing drought conditions during 2001-2002, surface water elevation appeared to be approximately 1-2 ft below normal conditions. Surface water occurred only at the two most downstream locations; 2 samples plus 1 duplicate were collected. The analyte list for water and sediment/soil was the same as that used for the quarterly ground-water monitoring program for the Airco parcel; this includes the Target Analyte List metals, Cr(VI), ammonia, nitrogen, phenolics, and sulfate; total solids and total organic carbon were also determined for sediment/soil. Surface water was also analyzed in the field using a Horiba U22 multiparameter instrument to measure temperature, dissolved oxygen, conductivity, pH, and oxidation reduction potential. Environmental Laboratory Services, North Syracuse, New York conducted sediment and surface water analytical chemistry. Analysis of Cr(VI) was performed within the 24-hour hold time on 23 August 2002. All other analyses were performed between 26 August and 3 September 2002. Chain-of-custody forms and laboratory reporting forms are provided in Appendix A.

1.7.2 Human Health Risk Screening

The human health risk screening was conducted to determine if, under existing conditions and the proposed ground-water treatment program, contaminants of potential concern in surface water leaving the Project area are/will be at concentrations that may cause unacceptable risk to the health of industrial and construction workers. For screening purposes, concentrations of potential contaminants of concern in surface water were compared to PRGs for human health risk assessment (U.S. Environmental Protection Agency [EPA] Region 9). Surface water concentrations were based on quarterly monitoring at ground-water discharge pipe WRL L1 between December 2000 and March 2002, and surface water samples collected during the August 2002 ecological field survey. Section 2.3 discusses the results of this assessment.



700 0 700 1400 Feet

SOURCE MAP: USGS LEWISTON AND NIAGARA FALLS 7.5 MINUTE QUADRANGLES.

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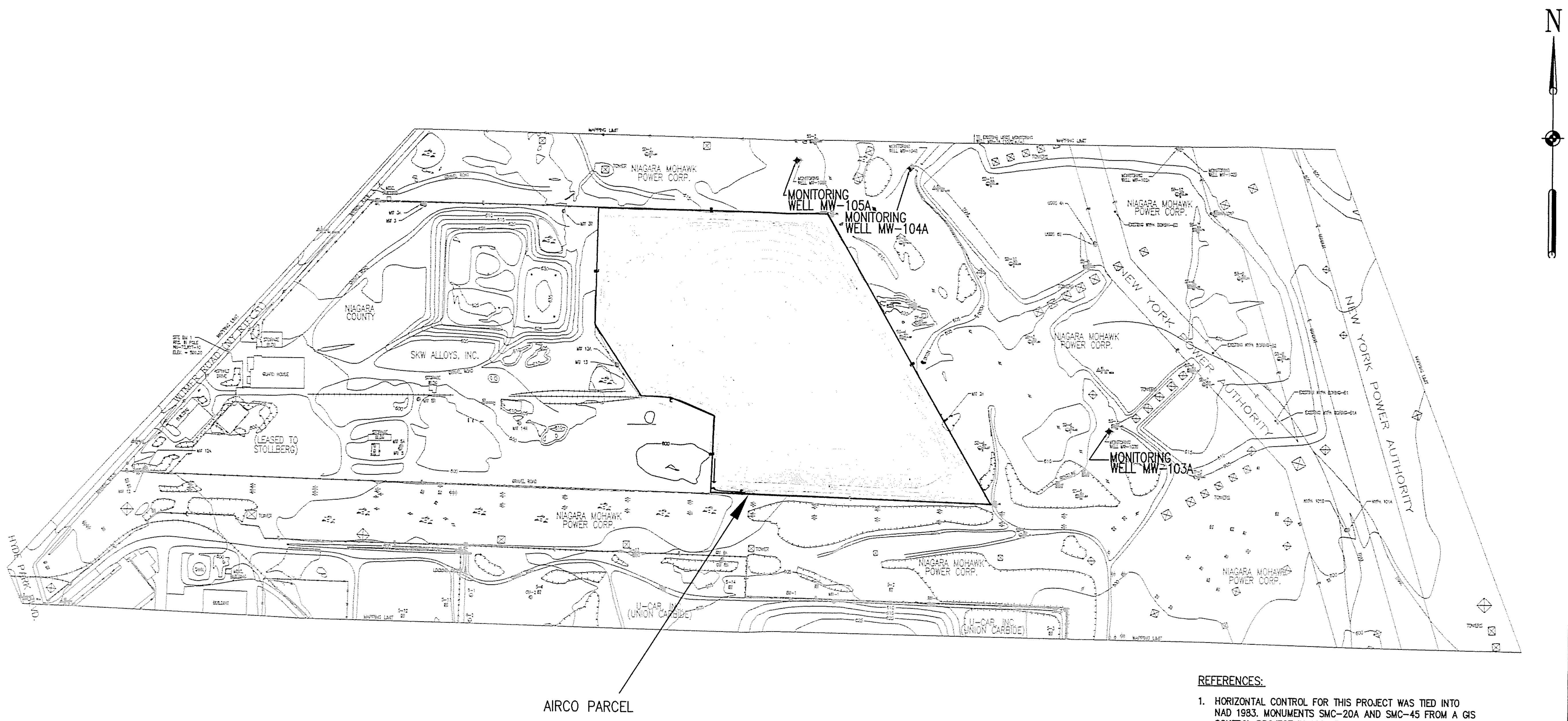
EA ENGINEERING, P.C. AND ITS AFFILIATE EA ENGINEERING, SCIENCE, AND TECHNOLOGY			AIRCO PARCEL NIAGARA FALLS, NEW YORK			FIGURE 1-1 SITE LOCATION MAP	
PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT No	FILE No
CEM	DC	DC	CEM	AS SHOWN	FEB 2003	12040.79	I:\BOC-NIAGARA\ FINAL.APR



LEGEND

- UTILITY POLE
- PROPERTY IRON PIN
- TREE LINE
- APPROX. PROPERTY LINE
- JCL SURVEY CONTROL POINT
- CHAIN LINK FENCE
- MONITORING WELL LOCATION

REFERENCES:

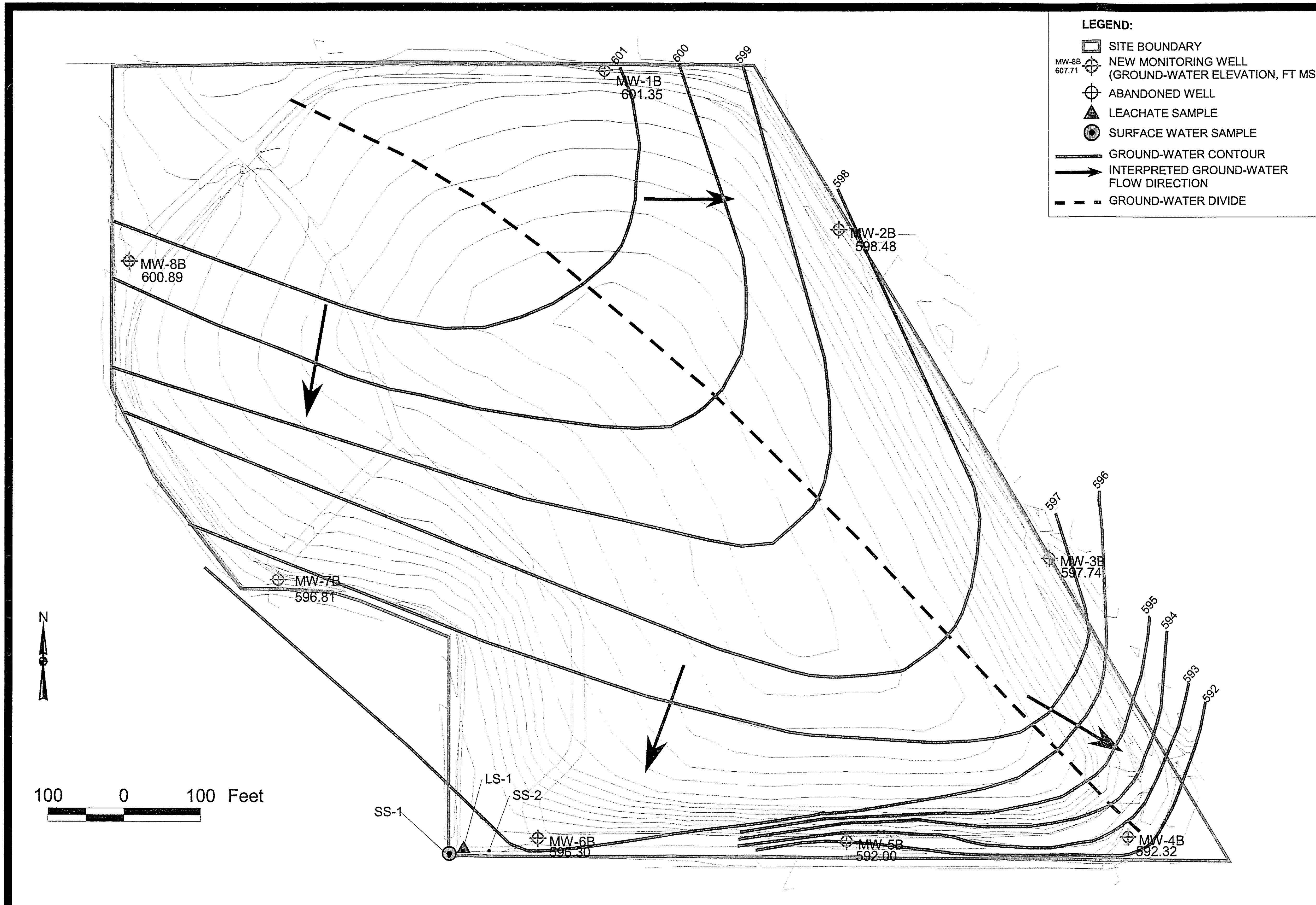
1. HORIZONTAL CONTROL FOR THIS PROJECT WAS TIED INTO NAD 1983. MONUMENTS SMC-20A AND SMC-45 FROM A GIS CONTROL PROJECT IN 1991 FOR THE CITY OF NIAGARA FALLS WAS USED.
2. VERTICAL CONTROL FOR THIS PROJECT WAS TIED INTO NGVD 1929. MONUMENT SMC-20A WITH AN ELEVATION OF 588.52 WAS USED. A SECONDARY BENCHMARK (RAILROAD SPIKE IN POLE NM-73, NYT-10) WAS SET BY LU ENGINEERS WITH AN ELEVATION OF 599.00.
3. TOPOGRAPHIC MAPPING AND 5-FT CONTOURS FOR THIS PROJECT WERE BASED ON 1"=500' PHOTOGRAPHY OBTAINED IN THE SPRING OF 1992.
4. ALL PROPERTY LINE LOCATIONS ARE APPROXIMATE. NO BOUNDARY SURVEY WAS DONE. EXISTING SURVEYS WERE UTILIZED FROM SKW ALLOYS, INC. DATED 18 FEBRUARY 1988, UNION CARBIDE LANDFILL SITE PLAN DATED 30 DECEMBER 1993, AND NEW YORK STATE POWER AUTHORITY DRAWING "NPPSKW.DWG."

400 200 0 400

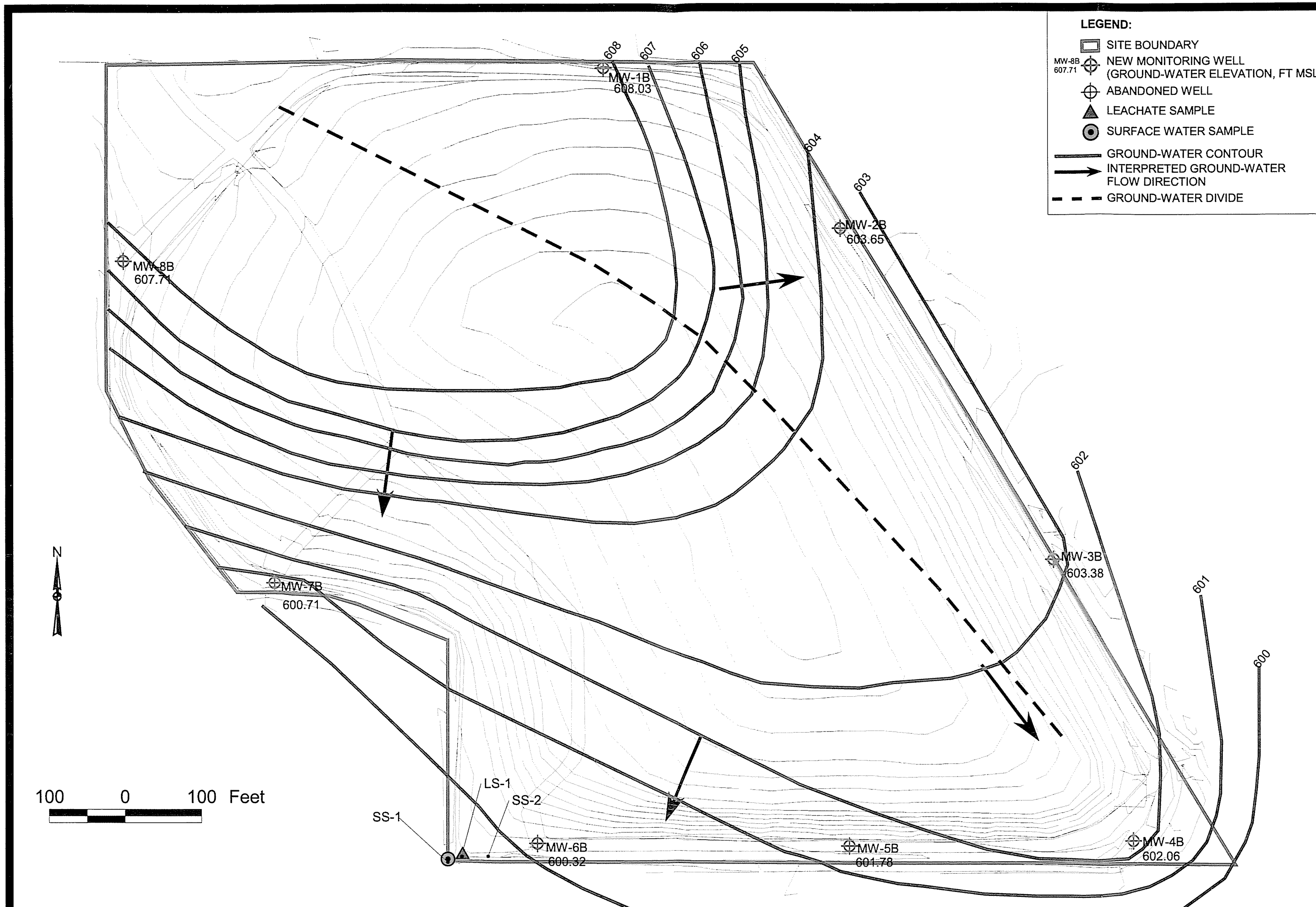
GRAPHIC SCALE IN FEET

FILE: I:\BOC-NIAGARA-GIS\CAD\FIG1-2.DWG

EA ENGINEERING, P.C. AND ITS AFFILIATE EA ENGINEERING, SCIENCE, AND TECHNOLOGY	AIRCO PARCEL NIAGARA FALLS, NEW YORK	FIGURE 1-2 VANADIUM CORPORATION OF AMERICA SITE	DESIGNED BY DC	DRAWN BY DC	DATE FEB 2003	PROJECT NO. 12040.79
			CHECKED BY CEM	PROJECT MGR. CEM	SCALE AS SHOWN	FIGURE 1-2



EA ENGINEERING PC AND ITS AFFILIATE, EA ENGINEERING, SCIENCE, AND TECHNOLOGY			AIRCO PARCEL NIAGARA FALLS, NEW YORK			FIGURE 1-3 INTERPRETED GROUND-WATER CONTOUR MAP (LOW) SEPTEMBER 2001	
PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT No	FILE No
CEM	BT/RSC	BT/RSC	SLG	AS SHOWN	12 MARCH 2002	12040.69	I:\BOC-NIAGARA-GIS\ FINAL01.APR

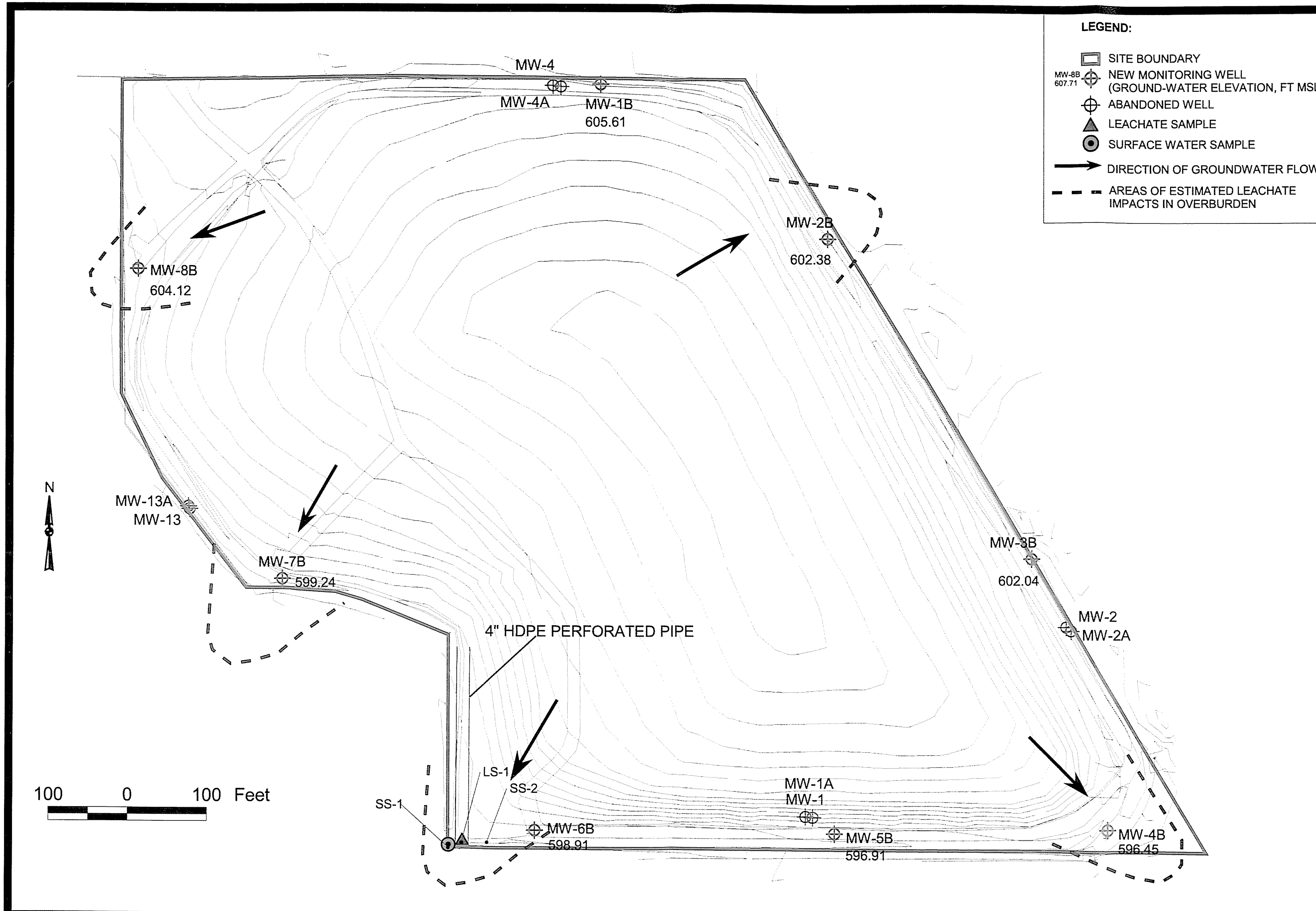


EA ENGINEERING PC AND ITS AFFILIATE,
EA ENGINEERING,
SCIENCE, AND TECHNOLOGY

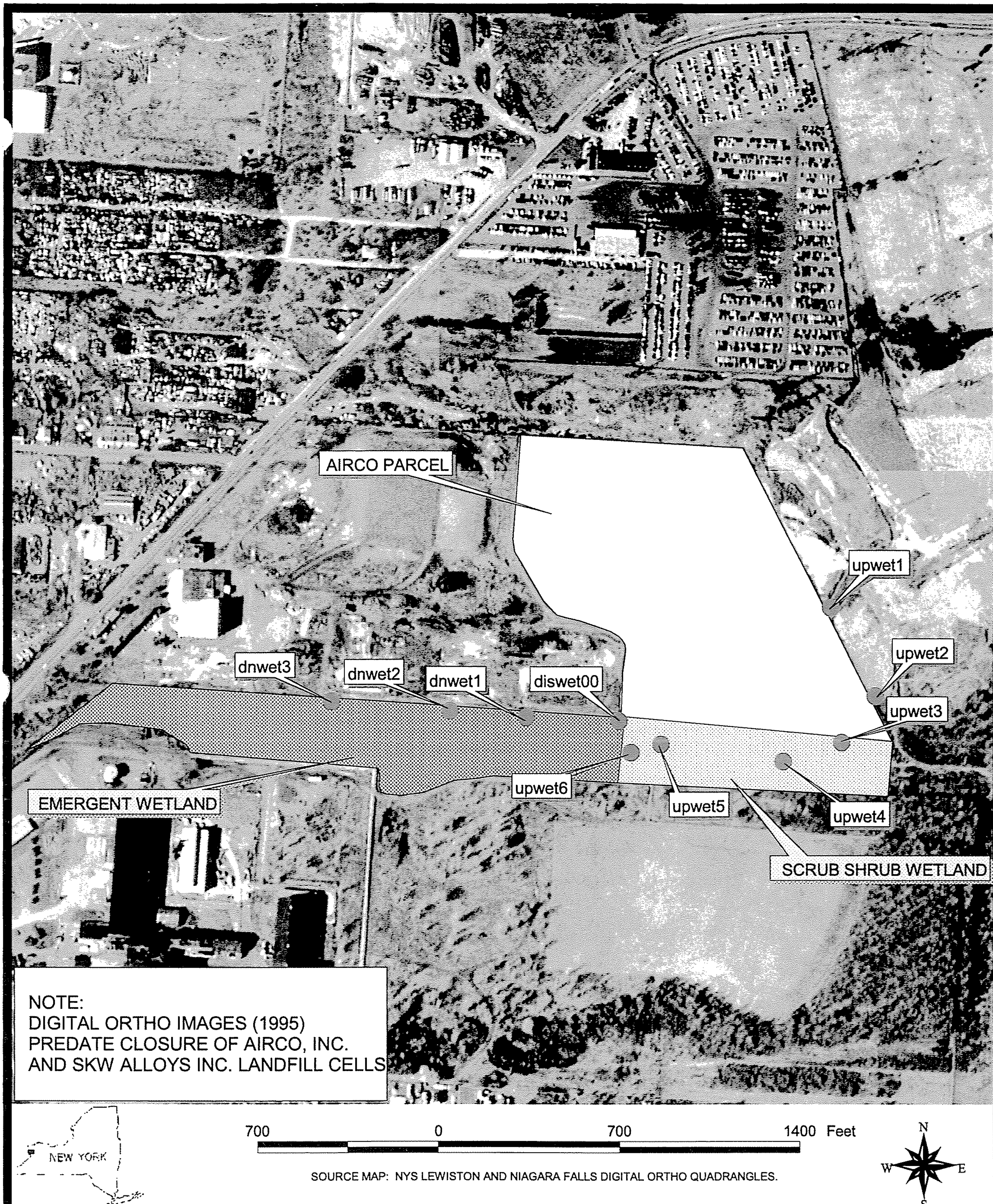
AIRCO PARCEL
NIAGARA FALLS, NEW YORK

FIGURE 1-4
INTERPRETED GROUND-WATER CONTOUR MAP (HIGH)
MARCH 2001

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT No	FILE No
CEM	BT/RSC	BT/RSC	SLG	AS SHOWN	12 MARCH 2002	12040.69	I:\BOC-NIAGARA-GIS\ FINAL.APR



EA ENGINEERING PC AND ITS AFFILIATE, EA ENGINEERING, SCIENCE, AND TECHNOLOGY		AIRCO PARCEL NIAGARA FALLS, NEW YORK			FIGURE 1-5 KNOWN EXTENT OF LEACHATE IMPACTS		
PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT No	FILE No
CEM	BT/RSC	RSC/BLH	SLG	AS SHOWN	12 DECEMBER 2002	12040.79	I:\BOC-NIAGARA-GIS\FINAL.APR



SOURCE MAP: NYS LEWISTON AND NIAGARA FALLS DIGITAL ORTHO QUADRANGLES.

EA ENGINEERING, P.C. AND ITS AFFILIATE EA ENGINEERING, SCIENCE, AND TECHNOLOGY

AIRCO PARCEL
NIAGARA FALLS, NEW YORK

FIGURE 1-6
LOCATION OF OFFSITE WETLAND AND SAMPLING LOCATIONS

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT No	FILE No
CEM	DC	DC	CEM	AS SHOWN	FEB 2003	12040.79	I:\BOC-NIAGARA\ FINAL.APR

TABLE 1-1 SUMMARY OF QUARTERLY GAUGING DATA

Gauging Date	Depth to Water (ft MSL)	Well Elevation (ft AMSL)	Water Elevation (ft MSL)
MW-1B			
05 DEC 00	15.85	617.77	601.92
21 MAR 01	09.74	617.77	608.03
12 JUN 01	11.11	617.77	606.66
18 SEP 01	16.42	617.77	601.35
04 DEC 01	12.16	617.77	605.61
14 MAR 02	9.41	617.77	608.36
11 JUN 02	10.31	617.77	607.46
05 SEP 02	15.55	617.77	602.22
10 DEC 02	14.02	617.77	603.75
MW-2B			
05 DEC 00	16.68	615.88	599.20
21 MAR 01	12.23	615.88	603.65
12 JUN 01	13.11	615.88	602.77
18 SEP 01	17.42	615.88	598.46
04 DEC 01	13.50	615.88	602.38
14 MAR 02	12.22	615.88	603.66
11 JUN 02	12.94	615.88	602.94
05 SEP 02	16.64	615.88	599.24
10 DEC 02	14.57	615.88	601.31
MW-3B			
05 DEC 00	11.20	611.22	600.02
21 MAR 01	07.84	611.22	603.38
12 JUN 01	08.67	611.22	602.55
18 SEP 01	13.48	611.22	597.74
04 DEC 01	9.18	611.22	602.04
14 MAR 02	7.81	611.22	603.41
11 JUN 02	8.63	611.22	602.59
05 SEP 02	12.34	611.22	598.88
10 DEC 02	10.09	611.22	601.13
MW-4B			
05 DEC 00	12.88	606.68	593.80
21 MAR 01	04.62	606.68	602.06
12 JUN 01	07.85	606.68	598.83
18 SEP 01	Dry	606.68	---
04 DEC 01	10.23	606.68	596.45
14 MAR 02	6.01	606.68	600.67
11 JUN 02	7.74	606.68	598.94
05 SEP 02	14.36 (Dry)	606.68	592.32
10 DEC 02	13.49 (Dry)	606.68	593.19

NOTES: MSL = Mean sea level.
AMSL = Above mean sea level.

MW-5B			
05 DEC 00	10.51	605.48	594.97
21 MAR 01	03.70	605.48	601.78
12 JUN 01	05.97	605.48	599.51
18 SEP 01	Dry	605.48	---
04 DEC 01	8.57	605.48	596.91
14 MAR 02	4.11	605.48	601.37
11 JUN 02	5.98	605.48	599.50
05 SEP 02	12.92	605.48	592.56
10 DEC 02	11.21	605.48	594.27
MW-6B			
05 DEC 00	04.80	603.47	598.67
21 MAR 01	03.15	603.47	600.32
12 JUN 01	06.76	603.47	596.71
18 SEP 01	07.17	603.47	596.30
04 DEC 01	4.56	603.47	598.91
14 MAR 02	3.41	603.47	600.06
11 JUN 02	3.74	603.47	599.73
05 SEP 02	6.25	603.47	597.22
10 DEC 02	5.11	603.47	598.36
MW-7B			
05 DEC 00	11.22	609.48	598.26
21 MAR 01	08.77	609.48	600.71
12 JUN 01	09.31	609.48	600.17
18 SEP 01	12.67	609.48	596.81
04 DEC 01	10.24	609.48	599.24
14 MAR 02	8.71	609.48	600.77
11 JUN 02	9.15	609.48	600.33
05 SEP 02	11.81	609.48	597.67
10 DEC 02	10.79	609.48	598.69
MW-8B			
05 DEC 00	09.61	611.62	602.01
21 MAR 01	03.91	611.62	607.71
12 JUN 01	05.57	611.62	606.05
18 SEP 01	10.73	611.62	600.89
04 DEC 01	7.50	611.62	604.12
14 MAR 02	5.35	611.62	606.27
11 JUN 02	5.88	611.62	605.74
05 SEP 02	10.04	611.62	601.58
10 DEC 02	8.93	611.62	602.69

2. DEVELOPMENT OF THE EVALUATION PROCESS

2.1 INTRODUCTION AND DESCRIPTION OF THE EVALUATION PROCESS

The purpose of this chapter is to assemble pertinent information that will be used in subsequent chapters for the screening, development, and evaluation of remedial alternatives at the Project area. Specific goals of this chapter are as follows:

- Identify federal and state ARARs (Section 2.2)
- Develop cleanup criteria (Section 2.3)
- Develop RAOs and identify GRAs to meet these objectives (Sections 2.4 and 2.5, respectively).

2.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

In recognition of the unique characteristics and circumstances associated with the remediation of individual sites, SARA and the NCP provide specific standards for the determination of whether a particular remedy provides sufficient cleanup at a given site. The selected remedial action for the Project area must satisfy all ARARs unless specific waivers have been granted.

The NCP (40 CFR Part 300) specifies procedures to be employed in identifying, removing, or remedying releases of hazardous substances. In particular, the NCP specifies procedures for deciding the appropriate type and extent of remedial action at the site to effectively mitigate and minimize the threat to, and provide adequate protection of, human health, welfare, and the environment.

The national goal of remedy selection is to protect human health and the environment, maintain protection over time, and minimize untreated waste (40 CFR 300.430 of the NCP [55 FR 8846]). The remedial alternative must attain ARARs under federal environmental and more stringent state environmental and facility siting laws, or provide grounds for invoking one of the waivers permitted under the statute.

2.2.1 Definition of Applicable or Relevant and Appropriate Requirements

EPA defines "applicable" and "relevant and appropriate" in the revised NCP, codified in 40 CFR 300.5 (1994) and has incorporated these definitions in its *CERCLA Compliance with Other Laws Manual* (Interim Final–EPA/540/G-89/006, Part II–EPA/540/G-89/009). Site remediation must comply with ARARs, except where a waiver is granted according to Section 121(d) of CERCLA. A requirement under CERCLA/SARA, as amended, may be either "applicable" or "relevant and appropriate" to a site-specific remedial action, but not both.

- **Applicable Requirements**—These cleanup standards are standards of control, and other substantive federal environmental and state environmental and facility siting requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a site.

- **Relevant and Appropriate Requirements**—These cleanup standards are standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law. Although not directly "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site, these requirements address problems or situations sufficiently similar to those encountered at a site that their use is well suited to the particular site. In some circumstances, a requirement may be relevant, but not appropriate, for the site-specific situation.

2.2.2 Classifications of Applicable or Relevant and Appropriate Requirements

ARARs for remedial action alternatives can be classified into one of the following three functional groups:

1. **Chemical-Specific**—Health- or risk-based numerical values or methodologies that establish cleanup levels or discharge limits for particular contaminants. Typical examples of chemical-specific ARARs include the New York State Water Quality Regulations.

2. **Location-Specific**—Requirements that restrict remedial actions based on the characteristics of the site or its immediate environs. Typical examples of location-specific ARARs include federal/state wetlands protection standards.

3. **Action-Specific—**Requirements that set controls or restrictions on the design, implementation, and performance levels of activities related to the management of hazardous substances, pollutants, or contaminants. Typical examples of action-specific ARARs include National Pollutant Discharge Elimination System requirements.

To be consistent with the NCP definition of ARARs and changes made by SARA, the following groups of ARARs were considered during the identification process:

- Federal requirements (applicable, relevant, and appropriate)
- New York State requirements.

2.2.3 To Be Considered Guidance

Federal and state guidance documents or advisories do not have the status of ARARs and are not enforceable. However, they may be considered when developing remedies that will be protective of human health and the environment.

2.2.4 Circumstances in which Applicable or Relevant and Appropriate Requirements May Be Waived

To comply with CERCLA, a remedy must either meet all identified ARAR standards or qualify for a waiver. Pursuant to Section 300.430(f)(3), there are several criteria under which an ARAR may be waived, if the standard cannot be attained.

Section 121(d)(4) of CERCLA identifies six circumstances under which ARARs may be waived:

1. The remedial action selected is only part of a total remedial action (interim remedy) and the final remedy will attain the ARAR upon its completion.

2. Compliance with the ARAR will result in a greater risk to human health and the environment than alternate options.

3. Compliance with the ARAR is technically impracticable from an engineering perspective.

4. An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach.

5. The ARAR is a State requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.

6. For Section 104 Superfund-financed remedial actions, compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

2.2.5 Identification of Applicable or Relevant and Appropriate Requirements

The following sections summarize the specific federal and state ARARs for remedial actions that may be taken at the Project area, and for the types of technologies that will be incorporated into remedial alternatives. Each ARAR has been chosen for its potential applicability, or relevance and appropriateness in accordance with the procedures identified in the *CERCLA Compliance with Other Laws Manual* (Office of Solid Waste and Emergency Response Directive 9234.1-01 [U.S. EPA 1988a]) and *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (Office of Solid Waste and Emergency Response Directive 9355.3-01 [U.S. EPA 1988b]).

2.2.5.1 Chemical-Specific Applicable or Relevant and Appropriate Requirements

Chemical-specific requirements are established using health- or risk-based numerical values or methodologies that establish cleanup levels or discharge limits in environmental media for specific substances or pollutants. The following potential chemical-specific ARARs were considered for ground water and surface water at the Project area:

- Federal Safe Drinking Water Act, Maximum Contaminant Levels (MCLs) (40 CFR 141, Subparts B, G, and I)
- New York State Water Quality Regulations (Title 6, Chapter X, Parts 700-705)
- NYSDEC Technical and Operational Guidance Series, Ambient Water Quality Standards and Guidance Values (1.1.1) (NYSDEC 1998)

Chemical-specific ARARs may be relevant and appropriate treatment requirements for remedial alternatives that include *ex situ* ground-water treatment depending on where the treated water is discharged. Chemical-specific ARARs are described below and summarized in Table 2-1.

Federal Safe Drinking Water Act, Maximum Contaminant Levels (40 CFR 141 Subparts B, G, and I)

The Safe Drinking Water Act, passed by Congress in 1974 and amended by the Safe Drinking Water Act Amendments of 1986 (Public Law 99-339), establishes national drinking water standards. Primary drinking water standards are set as MCLs. MCLs represent the maximum allowable concentrations of selected chemical constituents in public water systems. MCLs are developed by EPA based on MCL goals, which are non-enforceable health goals at which no known or anticipated adverse human health effects occur and which allow acceptable margins of safety. MCLs are as close to MCL goals as is feasible.

MCLs are legally applicable only to the quality of drinking water at the tap. For this reason, MCLs are generally considered "relevant and appropriate" to ground water that is or may be used for drinking (55 FR 8666, 8750, 9 March 1990).

The State of New York has an EPA-endorsed comprehensive Ground-Water Protection Program. NYSDEC has classified ground water beneath the Airco parcel as Class GA.

New York State Ground-Water Standards

New York State Water Quality Regulations (Title 6, Chapter X, Part 701) categorize all state ground water. The ground water beneath the Airco parcel is categorized as Class GA, fresh ground water. Class GA is the designation for ground water that occurs in areas of influence of private and potential public water supply wells. The regulations (Part 703.6) list ground-water quality standards for specific substances. The standards and guidance values, where no standards exist, are selected to be the most stringent levels based upon MCLs, or other procedures involving oncogenic and non-oncogenic effects, aesthetic considerations, and chemical correlations.

New York State Surface Water Standards

New York State Water Quality Regulations (Title 6, Chapter X, Part 701) categorize all state surface waters. The surface water adjacent to the Project area (i.e., downgradient wetland) is unclassified surface water and would be conservatively categorized as Class D. The best usage of Class D waters is fishing. Due to such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery, or stream bed conditions, the waters will not support fish propagation. These waters shall be suitable for fish survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes. The regulations (Part 703.5) list water quality standards for specific substances. The standards and guidance values, where no standards exist, are selected to be the most stringent levels based upon MCLs, or other procedures involving oncogenic and non-oncogenic effects, aesthetic considerations, and chemical correlations.

NYSDEC Technical and Operational Guidance Series, Ambient Water Quality Standards and Guidance Values (1.1.1) (NYSDEC 1998)

The primary purpose of this document is to provide ambient water quality guidance where there are no standards or regulatory effluent limitations defined in (Title 6, Chapter X, Part 703.5 or 703.6). Effluent parameters for the COCs present at the Airco parcel are defined in these documents, therefore, the guidance document will be used as reference only.

2.2.5.2 Location-Specific Applicable or Relevant and Appropriate Requirements

Location-specific ARARs may affect or restrict remedial and site activities. Location-specific ARARs are described below and summarized in Table 2-2. Generally, location-specific requirements serve to protect individual site characteristics, resources, and specific environmental features associated with unique or sensitive areas, such as wetlands, threatened or endangered species habitat, fragile ecosystems, or historic sites. The following potential location-specific ARARs were considered for the Project area:

- Federal Floodplains Protection (Executive Order No. 11988)
- Wetlands Protection—Executive Order 11990, 40 CFR Section 6.302(a) (1994) and 40 CFR Section 6, Appendix A (1994)
- Endangered Species Act (16 USC 1531 et seq.); 40 CFR 6.302(h)
- 6 NYCRR Parts 662 through 665—Freshwater Wetlands Permitting, Requirements, Classification, and Implementation.

The Airco parcel is not located within the 100-year floodplain, is not considered a historical site, and there are no federally-regulated or state-regulated wetlands located at the site. Therefore, ARARs applicable to these conditions do not apply to the Project Area. No endangered flora or fauna were identified during the ecological assessment and sampling. A request for information was made to the New York State Heritage Program, which verified that no endangered species in the vicinity of the Project area have been identified and, therefore, no ARARs will be considered.

2.2.5.3 Action-Specific Applicable or Relevant and Appropriate Requirements

Action-specific ARARs set controls or restrictions on the design, implementation, and performance levels of activities related to the management of hazardous substances, pollutants, or constituents. State laws that need to be considered when planning and conducting ground-water or surface water treatment, and/or the potential need to remove impacted soils to facilitate that treatment include the following:

- National Pollutant Discharge Elimination System
- New York State Department of Transportation Rules for Hazardous Materials Transport (49 CFR, Parts 107, 171.1-500)
- 6 NYCRR; Part 360—Solid Waste Management Facilities; Part 364—Waste Transporter Permits
- 6 NYCRR Part 370—Hazardous Waste Management System; Part 371—Identification and Listing of Hazardous Wastes; Part 372—Hazardous Waste Manifest System and Related Standards for Generators, Transporters, and Facilities
- City of Niagara POTW discharge requirements.

Action-specific ARARs may be applicable requirements for remedial alternatives depending on the treatment technologies that make up those alternatives. Alternatives that involve *ex situ* ground-water treatment and discharge to surface water will require compliance with the National Pollutant Discharge Elimination System program. Alternatives that involve excavation and disposal of waste either onsite or offsite will require compliance with the rules governing the management of that waste. Action-specific ARARs are listed in Table 2-3.

2.3 PRELIMINARY REMEDIATION GOALS

The methodology used to derive PRGs for COCs is described in the following sections. Two criteria were used to identify COCs at the Airco parcel. The first criterion used to identify COCs was the potential human health impact resulting from direct exposure to COCs in ground water recharging to surface water at the Project area. The results of the human health risk screening were used to determine whether constituents in ground water had risks exceeding EPA's published risk targets. The second criterion used to identify COCs was impact on ecological health. The results of the ecological risk screening were used to determine whether constituents in surface water had unacceptable risks.

2.3.1 Human Health Risk-Based Preliminary Remediation Goals

2.3.1.1 New York State Department of Environmental Conservation Ground-Water Criteria

Water quality criteria for ground water (GA) based on health (water source) are provided in *Water Quality Regulations, Surface Water and Groundwater Classifications and Standards* (NYSDEC 1999). These standards were used for comparison of quarterly monitoring data from the ground-water discharge between December 2000 and June 2002.

2.3.1.2 U.S. Environmental Protection Agency Preliminary Remediation Goals

PRGs are risk-based concentrations that are intended to assist risk assessors in making initial screening level evaluations of site contaminant levels and to assist the analysis of remedial alternative as initial cleanup goals. EPA Region 9 maintains a table of PRGs (URL: http://www.epa.gov/Region9/waste/sfund/prg/index.htm). These PRGs were used for comparison of quarterly monitoring data from the ground-water discharge between December 2000 and June 2002.

2.3.1.3 Selection of Constituents of Concern

Ground Water

Current onsite risk at the Project area is associated with direct contact for employees and construction workers with ground water. Samples exceeding NYSDEC Ground-Water Quality Standards, NYSDEC Surface Water Quality Standards, EPA MCLs, and EPA Region 9 PRGs are summarized in Tables 2-4, 2-5, 2-6, and 2-7, respectively.

Concentrations of chromium (total and Cr[VI]) and selenium exceed NYSDEC Ground-Water Criteria. On average, the concentration of Cr(VI) at the ground-water discharge (WRL-L1; Figure 2-1) was approximately 80 percent of total chromium, ranging from 46 to 112 percent. Chromium concentrations have typically been 8-13 times the NYSDEC Ground-Water Criteria of 50 µg/L. Selenium concentrations ranged from 20 to 26 µg/L; between 2 and 3 times the criteria value of 10 µg/L.

The concentration of chromium at the ground-water discharge was typically 5-6 times greater in quarterly monitoring samples than the MCL value of 100 µg/L. Selenium did not exceed the MCL (50 µg/L). Total thallium was below the MCL (2 µg/L) in quarterly samples collected in December 2000 and March 2001. Thallium was less than the detection limit (5 µg/L) in the five quarterly samples between June 2001 and June 2002, however, the detection limit exceeded the MCL.

The Region 9 PRGs (tap water) for Cr(VI) and Cr(III) are 110 µg/L and 55,000 µg/L, respectively. Cr(VI) has consistently exceeded the PRG. If the chromium was converted to Cr(III), the concentrations would be several orders of magnitude less than the PRG. The Region 9 selenium PRG is 180 µg/L approximately an order of magnitude higher than the observed concentrations of selenium at the ground-water discharge.

Three surface water samples collected from the offsite downstream wetland were analyzed for the same constituents as the ground-water discharge. Samples were collected approximately 200-400 ft downstream (DNWET-2 and DNWET-3) from the onsite ground-water discharge location (Figure 2-1). Duplicate samples were analyzed from the DNWET-2 location. The pH of surface water at these two offsite locations was 7.4-7.7 as compared to 11.1-11.9 for discharging ground water. The concentration of Cr(VI) at these locations was less than detection (10 µg/L); total chromium ranged from 27 to 62 µg/L. Two of three surface water samples were less than the NYSDEC Ground-Water Criteria. Therefore, it appears that the concentrations of Cr(VI) and Cr(III) dissipate within the first 200 ft of wetland.

2.3.1.4 Ground-Water Remediation Goals

NYSDEC Ground-Water Criteria (GA), NYSDEC Surface Water Standards, Federal Safe Drinking Water MCLs, and EPA Region 9 PRGs have been applied to evaluate remediation of the ground water in this GA area prior to recharge to surface water at the Project area (Table 2-8). The aquifer beneath the Airco parcel has a GA ground-water classification. Based on the above review of ground-water data at the discharge location, the primary COC for ground water is chromium; selenium and thallium appear to present minimal risk onsite based on the MCLs and Region 9 PRGs. The MCL or twice the NYSDEC GA criteria will be used as cleanup goals for chromium at the Project area to prevent potential migration offsite and impacts to human health; that is, the remediation goal for the ground water prior to recharging into the offsite wetland is 100 µg/L for total chromium. As noted above, this is a conservative approach, given the observed dissipating capacity of the wetland as noted during the August 2002 wetland sampling. In addition, the NYSDEC Water Quality Standards for a Class D surface water state that the total allowable chromium is a function of hardness within the surface water as noted in Table 2-5. Based on historic hardness data, concentrations of total chromium in the surface water leaving the site could be 15.58 times greater than the proposed 100 µg/L concentration, and remain protective of the environment. Therefore, the 100 µg/L PRG will be the target cleanup goal for ground water recharging to the surface water at the Project area as it will be protective of human health and the environment.

2.3.2 Ecological Risk-Based Preliminary Remediation Goals

Based on the screening level Ecological Risk Assessment, no risk from surface water contaminants was projected for receptors in the offsite wetlands. The open water portions of the offsite wetland area to which ground water from the Project area recharges are not classified by NYSDEC; however, comparison of offsite surface water contaminant concentrations was made to Acute Ambient Water Quality Criteria for a waterbody with a D classification. Of the analytes detected in the ground water recharging to surface water at the Project area, and selected as ground-water COCs for the Project, none of the samples collected during the August 2002 wetland sampling exceeded the Ambient Water Quality Criteria for a D Class waterbody.

2.4 REMEDIAL ACTION OBJECTIVES

Generalized, conceptual level RAOs were developed for the Project based upon post-closure quarterly monitoring data. RAOs specify COCs, media of interest, exposure pathways, and cleanup goals. These RAOs are used in Chapter 4 to develop and evaluate remedial alternatives for the protection of human health and the environment.

In order to develop remedial alternatives to address ground water recharging to surface water at the Project area, RAOs are first developed that will prevent or eliminate the complete exposure pathways associated with unacceptable risks. The primary exposure routes of concern for human health include the incidental ingestion of and direct contact with impacted ground water recharging to surface water at the Project area.

The following RAOs were developed for the Project based on results of the human health and ecological risk screenings, as well as a comparison of COC data to PRGs:

1. Minimize potential human exposure and protect the environment from COCs in ground water recharging to surface water at the Project areas above New York State Ambient Water Quality Criteria under the current industrial land use scenario

2. Minimize the potential migration of COCs in ground water recharging to surface water beyond the Project area.

2.5 GENERAL RESPONSE ACTIONS

GRAs are remedial approaches that may be used (by themselves or in combination with one or more of the others) to attain the RAOs. For the Project, the GRAs will address the RAOs by minimizing human exposure to COCs, and reducing COC concentrations in impacted ground water and surface water at the Project area.

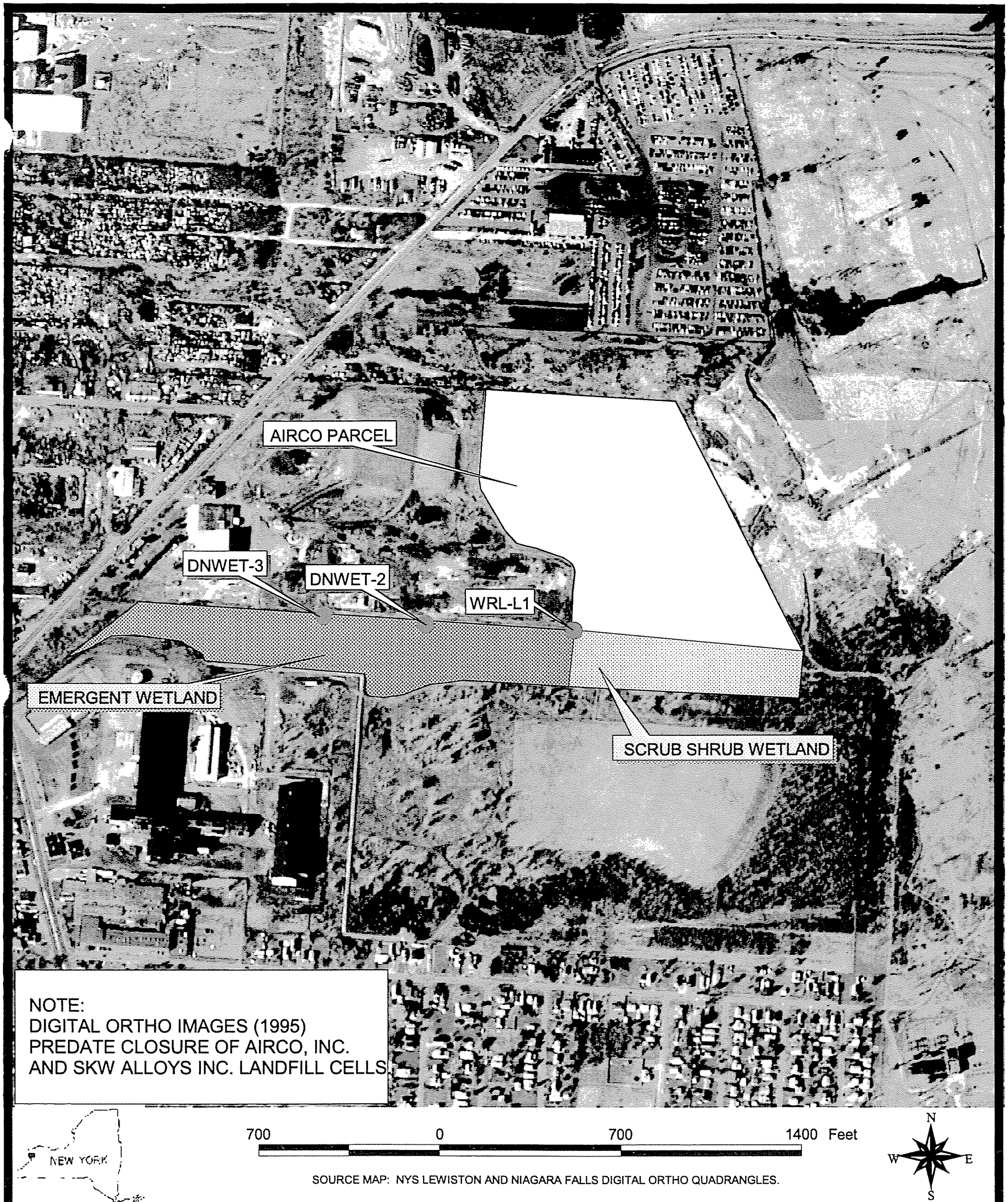
In order to achieve these RAOs, the following GRAs were evaluated:

- No action[1] (required for consideration by the NCP as a comparative baseline)
- Institutional controls
- Containment
- Source area and ground-water removal

1. The no action alternative refers to no remedial action for the Project area. Existing long-term monitoring and institutional controls currently performed as part of the approved Post-Closure Monitoring and Facility Maintenance Plan (EA 2001) will continue relative to the Airco parcel.

- *In situ* ground-water treatment
- *Ex situ* ground-water treatment
- Disposal.

The GRAs were developed to identify the technologies that have demonstrated promise in remediation of sites with conditions similar to those at the Project area. Various innovative/ emerging technologies were examined in addition to traditionally accepted remedial action technologies. These technologies are presented in Chapter 3.



EA ENGINEERING, P.C. AND ITS AFFILIATE EA ENGINEERING, SCIENCE, AND TECHNOLOGY

AIRCO PARCEL
NIAGARA FALLS, NEW YORK

FIGURE 2-1
LOCATION OF OFFSITE WATER SAMPLES COLLECTED AUGUST 2002 IN ADJACENT WETLAND

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT No	FILE No
CEM	DC	DC	CEM	AS SHOWN	FEB 2003	12040.79	I:\BOC-NIAGARA\ FINAL.APR

TABLE 2-1 SUMMARY OF CHEMICAL-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED GUIDANCE

Requirement	Citation	Status	Synopsis	Action to be Taken to Meet Applicable or Relevant and Appropriate Requirement
FEDERAL				
Maximum Contaminant Levels, Safe Drinking Water Act	40 CFR 141 Subparts B, G, and I	Relevant and Appropriate	The Safe Drinking Water Act sets forth Maximum Contaminant Levels for organic and inorganic contaminants. The Maximum Contaminant Levels were promulgated for public drinking water supplies; however, contaminant concentrations set forth in this Act are relevant and appropriate for any potential drinking water supplies.	The proposed alternatives will reduce or eliminate exposure to contaminants in ground water recharging to surface water in the Project area through remedial actions. In addition, monitoring will be performed to ensure compliance with these regulations.
STATE				
New York State Water Quality Regulations	Title 6, Chapter X, Parts 700-705	Relevant and Appropriate	These regulations establish effluent limitation criteria for surface water and ground water discharge and water quality criteria for consumptive use. Requirements are based on ground water in the area being classified by the state as a GA, and surface water being considered to be Class D.	The proposed alternatives will reduce or eliminate exposure to contaminants in ground water recharging to surface water in the Project area through remedial actions. In addition, monitoring will be performed to ensure compliance with these regulations.
New York State Department of Environmental Conservation Technical and Operational Guidance Series, Ambient Water Quality Standards and Guidance Values (1.1.1)	NYSDEC (1998)	Not Applicable	This document provides guidance for effluent limitations not found in the New York State Water Quality Regulations. The constituents of concern found at the site are regulated under the New York State Water Quality Regulations, therefore, they should take precedence.	None required.

TABLE 2-2 SUMMARY OF LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED GUIDANCE

Requirement	Citation	Status	Synopsis	Action to be Taken to Meet Applicable or Relevant and Appropriate Requirements
FEDERAL				
Floodplains Protection	Executive Order No. 11988	Not applicable	This Executive Order requires that all federally-funded actions within floodplains avoid adverse effects, minimize potential harm, and preserve beneficial values of floodplains.	The Airco parcel and the Project area are not located within a floodplain.
Wetlands Protection	Executive Order No. 11990	Not applicable	This Executive Order serves to protect wetlands and prevent, to the extent possible, the long- and short-term adverse impacts associated with the destruction or modification of wetlands.	There are no federally-regulated wetlands located at the Airco parcel or in the vicinity of the Project area.
Endangered Species Act	16 USC 1531 et seq.; 40 CFR 6.302(h)	Not applicable	This regulations intends to prohibit actions from jeopardizing threatened or endangered species or adversely modifying habitats essential to their survival.	There are currently no identified endangered species at the Airco parcel or in the vicinity of the Project area.
STATE				
Freshwater Wetlands Permitting, Requirement, Classification, and Implementation.	6 NYCRR Parts 662 through 665	Not Applicable	This set of regulation serves to preserve, protect, and conserve freshwater wetlands and the benefits derived therefrom; to prevent the despoliation and destruction of freshwater wetlands; and to regulate use and development of such wetlands to secure the natural benefits of freshwater wetlands.	There are no state-regulated wetlands located at the Airco parcel or in the vicinity of the Project area.

TABLE 2-3 SUMMARY OF ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED GUIDANCE

Requirement	Citation	Status	Synopsis	Actions to be Taken to Meet Applicable or Relevant and Appropriate Requirement
FEDERAL				
National Pollutant Discharge Elimination System		Applicable	The National Pollutant Discharge Elimination System permit program, administered by the state of New York, controls water pollution by regulating point sources that discharge pollutants into waters of the United States.	The proposed alternatives will reduce or eliminate exposure to contaminants in ground water recharging to surface water in the Project area through remedial actions. In addition, monitoring will be performed to ensure compliance with these regulations.
Transportation of Hazardous Materials	49 CFR, Part 171	Applicable	Addresses requirements for marking, manifesting, handling, and transport of hazardous materials.	Proposed alternatives that involve excavation and offsite disposal of materials will include provisions to comply with these regulations, if materials are determined to be hazardous through waste characterization.
STATE				
New York State Water Quality Regulations	Title 6, Chapter X, Parts 700-705	Relevant and Appropriate	These regulations establish effluent limitation criteria for surface water and ground water discharge and water quality criteria for consumptive use. Requirements are based on ground water in the area being classified by the state as a GA, and surface water being considered to be Class D.	The proposed alternatives will be effective in reducing or eliminating exposure to contaminants in ground water recharging to surface water in the Project area through remedial actions. In addition, ground-water monitoring and discharge monitoring will be performed to ensure compliance with these regulations.
New York State Department of Environmental Conservation Technical and Operational Guidance Series, Ambient Water Quality Standards and Guidance Values (1.1.1)	NYSDEC (1998)	Not Applicable	This document provides guidance for effluent limitations not found in the New York State Water Quality Regulations. The constituents of concern found at the site are regulated under the New York State Water Quality Regulations, therefore, they should take precedence.	None required.
Solid Waste Management and Hazardous Waste Management and Transport	6 NYCRR Part 360, 364, 370, 371, and 372	Applicable	Addresses requirements for solid waste management facilities, waste transporter permits, hazardous waste management systems, identification and listing of hazardous wastes, and hazardous waste manifest system and related standards for generators, transporters, and facilities.	Proposed alternatives that involve excavation, treatment, onsite disposal, and/or offsite disposal of materials will include provisions to comply with these regulations, if materials are determined to be hazardous through waste characterization.
City of Niagara Publicly-Owned Treatment Works Discharge Requirements		Applicable	These requirements will be established by the publicly-owned treatment works as the acceptable pre-treatment standard prior to discharge to the publicly-owned treatment works.	The water must be pre-treated to adjust the pH down to an acceptable value (6-8 pH range) prior to discharge.

TABLE 2-4 COMPARISON OF CONCENTRATION (µg/L) OF CONSTITUENTS OF PRELIMINARY CONCERN IN THE GROUND-WATER RECHARGE AT THE PROJECT AREA (WRL-L1) TO NYSDEC GROUND-WATER CRITERIA (GA)

	NYSDEC	December 2000		March 2001		June 2001	September 2001	December 2001	March 2002	June 2002
	GA Criteria	Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total
Antimony	3	<5U	<5U	<5U	<5U					
Arsenic	25	<5U	<5U	<5U	<5U					
Barium	1,000	420	430	393	387					
Beryllium	3	<5U	<5U	<3U	<3U					
Boron	1,000	<100U	<100U	<100U	<100U					
Cadmium	5	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U
Chromium	50	600	630	626	615	630	413	500	532	490
Chromium (hexavalent)	50		630		435	555	448	230	562	525
Copper	200	5	<5U	<5U	<5U					
Cyanide	200		<4U		<4U					
Iron	300	<25U	<25U	<25U	<25U	<25U	44	<25U	<25U	<25U
Lead	25	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U
Magnesium	35,000	<1,000U	<1,000U	<1,000U	<1,000U	<1,000U	<1,000U	<1,000U	<1,000U	<1,000U
Manganese	300	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U
Mercury	1	<0.2U	<0.2U	<0.2U	<0.2U					
Nickel	100	10	10	12	11					
Selenium	10	25	25	23	22	26	22	23	23	20
Silver	50	<5U	<5U	<5U	<5U					
Thallium	NA	1.9	1.5	6	2	<5U	<5U	<5U	<5U	<5U
Zinc	2,000	<5U	<5U	5	<5U	<5U	<5U	<5U	<5U	<5U

NOTE: Shaded values indicate exceedance of GA criteria.
NYSDEC = New York State Department of Environmental Conservation.
U = Indicates that concentration is less than detection limit listed.

TABLE 2-5 COMPARISON OF CONCENTRATION (µg/L) OF CONSTITUENTS OF PRELIMINARY CONCERN IN THE GROUND-WATER RECHARGE AT THE PROJECT AREA (WRL-L1) TO NYSDEC SURFACE WATER CRITERIA (CLASS D)

	NYSDEC Class D Surface Water Criteria	December 2000		March 2001		June 2001	September 2001	December 2001	March 2002	June 2002
		Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total
Arsenic	340	<5U	<5U	<5U	<5U					
Beryllium[a]	1,100	<5U	<5U	<3U	<3U					
Cadmium[a]	5.3-19.4	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U
Chromium[a]	1,511-5,800	600	630	626	615	630	413	500	532	490
Chromium (hexavalent)	16		630		435	555	448	230	562	525
Copper[a]	41.3-194	5	<5U	<5U	<5U					
Cyanide	22		<4U		<4U					
Iron	300	<25U	<25U	<25U	<25U	<25U	44	<25U	<25U	<25U
Lead[a]	13.5-66.7	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U
Mercury	1.4	<0.2U	<0.2U	<0.2U	<0.2U					
Nickel[a]	142.4-571.5	10	10	12	11					
Silver[a]	0.30-4.9	<5U	<5U	<5U	<5U					
Thallium	20	1.9	1.5	6	2	<5U	<5U	<5U	<5U	<5U
Zinc[a]	321.4-1,292.5	<5U	<5U	5	<5U	<5U	<5U	<5U	<5U	<5U

(a) Calculated value based on minimum hardness of 329 (March 2001 surface water sample) and the maximum hardness of 1,700 (December 2000 ground-water relief pipe sample.

NOTE: Shaded values indicate exceedance of Class D surface water criteria.
NYSDEC = New York State Department of Environmental Conservation.
U = Indicates that concentration is less than detection limit listed.

TABLE 2-6 COMPARISON OF CONCENTRATION (µg/L) OF CONSTITUENTS OF PRELIMINARY CONCERN IN THE GROUND-WATER RECHARGE AT THE PROJECT AREA (WRL-L1) TO FEDERAL SAFE DRINKING WATER MAXIMUM CONTAMINANT LEVELS

	Safe Drinking Water Maximum Contaminant Level (µg/L)	December 2000		March 2001		June 2001	September 2001	December 2001	March 2002	June 2002
		Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total
Arsenic	50	<5U	<5U	<5U	<5U					
Barium	2,000	420	430	393	387					
Cadmium	5	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U
Chromium	100	600	630	626	615	630	413	500	532	490
Copper	1,300	<5U	<5U	<5U	<5U					
Cyanide	200		<4U		<4U					
Lead	15	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U
Selenium	50	26	25	23	22	26	22	23	23	20
Thallium	2	1.9	1.5	2	2	<5U	<5U	<5U	<5U	<5U
Aluminum	50	9	10	15	<5U					
Iron	300	<25U	<25U	<25U	<25U	<25U	44	<25U	<25U	<25U
Manganese	50	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U
Zinc	5,000	<5U	<5U	5	<5U	<5U	<5U	<5U	<5U	<5U

NOTE: U = Indicates that concentration is less than detection limit listed.
Shaded values indicate exceedance of Maximum Contaminant Level standard.

TABLE 2-7 COMPARISON OF CONCENTRATION (µg/L) OF CONSTITUENTS OF PRELIMINARY CONCERN IN SURFACE WATER SAMPLING LOCATIONS (AUGUST 2002) IN THE WETLAND ADJACENT TO THE PROJECT AREA TO NYSDEC SURFACE WATER CRITERIA (CLASS D)

	NYSDEC Class D Criteria	DNWET-2 WRL-SS01-0802	DNWET-3 WRL-SSDUP-0802	DNWET-3 WRL-SS02-0802	Rinse Blank WRL-RB-0802
Cadmium	212,490	<5U	<5U	<5U	<5U
Chromium	5,604	27	62	45	<5U
Chromium (hexavalent)	16	<10U	<10U	<10U	<10U
Iron	300	637	2,200	1,800	<25U
Lead	13,510	<5U	13	9	<5U
Magnesium	NA	71,000	40,900	36,500	<1,000
Manganese	NA	420	1500	1500	<10
Selenium	NA	<5U	<5U	<5U	<5U
Thallium	20	<5U	<5U	<5U	<5U
Zinc	1,247	9	56	64	<2U

NOTE: NYSDEC = New York State Department of Environmental Conservation.
U = Indicates that concentration is less than detection limit listed.
NA = Not applicable.
Chromium, lead, and zinc criteria adjusted for mean hardness of 1630 mg/L using equations in NYSDEC Water Quality Regulations (1999).
Shaded values indicate exceedance of Class D criteria.

TABLE 2-8 COMPARISON OF MEAN AND MAXIMUM CONCENTRATIONS OF GROUND-WATER CONSTITUENTS OF PRELIMINARY CONCERN IN THE GROUND-WATER RECHARGE AT THE PROJECT AREA (WRL-L1) TO GROUND-WATER STANDARDS FOR PROTECTION OF HUMAN HEALTH

Constituent of Concern	New York State Department of Environmental Conservation GA	Safe Drinking Water MCL	Region 9 Preliminary Remediation Goal	N	Mean (µg/L)	Maximum (µg/L)
Chromium (hexavalent)	50	NA	110	7	484	630
Chromium (trivalent)	NA	NA	55,000	0		
Chromium, Total	50	100	NA	7	544	630
Selenium	10	50	180	7	23	26
Thallium	NA	2	2.4	7	2	3

NOTE: N = Number of samples.
NA = Not applicable.

3. IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

In this chapter, the GRAs representing technologies suitable for ground water recharging to surface water at the Project area are assembled and screened for use. The technologies are evaluated against the short-term and long-term aspects of three broad criteria: effectiveness, implementability, and cost. This screening step is used to identify the technologies to be retained for further consideration as remedial action alternatives for the Project area.

The first step in a technology screening for site remediation is to examine potential remedial technologies and to identify those technologies that warrant further consideration based on the applicability of the technology for the site-specific conditions and COC types. Potential remedial technologies are screened in this chapter for their ability to address the COCs in ground water recharging to surface water at the Project area. The primary focus of this screening evaluation is on the effectiveness and implementability of each option. A brief description of each evaluation criterion is presented as follows.

Effectiveness—The effectiveness evaluation is focused on the following elements:

- Potential effectiveness of process options in handling the estimated areas or volumes of media and in meeting the RAOs

- Potential impacts to human health and the environment during the construction and implementation phases

- Reliability and proven effectiveness of the process with respect to the COC and the site-specific conditions.

Implementability—The implementability evaluation includes both the technical and institutional (administrative) feasibility of implementing each technology or process option. This initial technology screening eliminates technology types or process options that are clearly ineffective or unworkable at the Project area. These institutional aspects include the following:

- Potential for obtaining regulatory approval
- Availability of necessary equipment and skilled workers to implement the technology
- Availability of treatment, storage, and disposal services
- Time required for implementation
- Ability to achieve the applicable remediation standards within a reasonable timeframe.

Cost—Preliminary cost estimates for the remedial technologies are presented in Chapter 5 as part of each of the remedial alternatives developed from the technologies retained in this chapter. For this screening evaluation, a qualitative cost analysis has been presented only if costs were uncommonly prohibitive or if other process options within the same technology type were comparably effective and implementable.

3.1 IDENTIFICATION AND SCREENING OF TECHNOLOGIES FOR SOIL

Process options for soil and wastes are considered here only to support implementation of ground-water alternatives.

3.1.1 Excavation

Excavation can involve removal of impacted soil and waste from the Project area associated with installation of process equipment for ground-water remediation. A backhoe, or similar type excavator, is generally used to perform the excavation. Excavated material could be placed directly onto trucks for onsite disposal under the existing cap, or, if offsite disposal is performed, transferred to a staging area prior to loading and transportation to an approved waste disposal facility.

Effectiveness—Excavation is a well-proven and highly effective method for removing impacted material from a site. Selective excavation is highly effective for the removal of well-defined, localized volumes of impacted material. Excavation options must be combined with other treatment and/or disposal options. Repairs to the cap would be required to maintain cap integrity should excavation be required within the landfill footprint.

Implementability—The required services and equipment for excavation are readily available. Selective excavation of localized volumes of soil/waste would be implementable at the Project area. Various engineering controls (e.g., dust suppression) and the use of personal protective equipment would be required during excavation.

Excavation of soil would be effective and implementable when combined with a subsequent disposal technology; therefore, this technology will be retained for further consideration.

3.1.2 Soil Disposal

Soil disposal is a necessary component of remedial alternatives that include excavation (Subsection 3.1.1). Final disposal technologies for excavated materials include both onsite and offsite options.

3.1.2.1 Engineered Disposal Cell

This option involves the disposal of wastes (e.g., excavated soil) or waste material under the existing linear low-density polyethylene geomembrane cap. The disposal cell is designed to contain the materials through the use of the low permeability liners. Advantages of disposing of wastes and/or soils into an engineered disposal cell on the Airco parcel, is that it currently exists, and only requires opening the cap, placing the wastes and/or soils, and re-closing the cap in accordance with the original design and the manufacturer's requirements.

Effectiveness—An engineered disposal cell can be an effective method for containing wastes and/or soils excavated from the Project area.

Implementability—This technology would be readily implementable since the cap currently exists. However, significant quality control and quality assurance testing will be required during cap repairs. Disposal of excavation spoils under the existing cap is an effective treatment method for large quantities of soil. Since only small quantities of soil/waste are expected to be generated, opening the existing disposal cell would not be cost effective and, therefore, will not be retained for further consideration.

3.1.2.2 Treatment, Storage, and Disposal Facility

This option involves the disposal of waste materials (e.g., excavated soil or waste) at a licensed offsite waste treatment, storage, and disposal facility. Excavated material would require characterization to determine appropriate disposal alternatives.

Effectiveness—An offsite landfill or treatment, storage, and disposal facility would be an effective method for final disposal of excavated soil and/or wastes from the Project area.

Implementability—This option is readily implementable providing an offsite landfill or treatment, storage, and disposal facility is identified that it will accept waste stream.

An offsite landfill or treatment, storage, and disposal facility would be an effective and implementable method for final disposal of impacted soil and/or wastes excavated during remedial action. Therefore, this option will be retained for further consideration.

3.2 IDENTIFICATION AND SCREENING OF TECHNOLOGIES FOR GROUND WATER

This section provides preliminary evaluations of remedial technologies that are available for treatment of contaminated ground water, which recharges to surface water at the Project area. For the purpose of selecting the remedial program best suited for the site-specific needs, a broad range of technologies is discussed here. For remedial evaluation purposes at the Project area, the ground-water interval is considered to consist of the saturated zone beginning at existing grade and extending to approximately 20 ft bgs. COCs include inorganics (Cr[VI] and Cr[III]) and elevated pH.

3.2.1 No Action

Pursuant to Section 300.430(e)(3)(ii)(6) of the revised NCP, the No Action technology is presented to provide a baseline with which to compare the other remedial technologies. No remediation would be conducted in this technology.

The No Action technology includes no additional remedial actions or institutional controls for the Project. The existing post-closure monitoring and facility maintenance being performed as part of the existing remedy would continue, but no additional activities beyond what is currently approved would be performed. In accordance with the CERCLA Section 121(c), 5-year reviews would be conducted by the NYSDEC as long as COCs remain onsite above concentrations that allow for unrestricted use and unlimited exposure.

The No Action technology is retained.

3.2.2 Institutional Controls

Institutional controls affect site management and/or activities occurring at a site. Institutional controls do not physically alter conditions at a site and do not reduce the toxicity, mobility, or volume of COCs at a site. Rather, institutional controls are used to limit the potential for exposure to COCs, primarily through restrictions to land use, water use, or site access. Depending upon the site-specific conditions, institutional controls can be used alone or in conjunction with other remedial actions.

3.2.2.1 Monitoring

Monitoring involves the collection of environmental samples to evaluate temporal trends in the quality of environmental media and receptors. Monitoring regimens can include continuous, daily, weekly, monthly, quarterly, semi-annual, annual, or less frequent collection of ground water. A monitoring program would present no adverse effects for human health or the environment.

Effectiveness—Monitoring would be an effective technique at the Airco parcel to evaluate the long-term trends of COCs and/or treatment technology performance.

Implementability—A monitoring program is currently being performed at the Airco parcel and is, therefore, readily implementable for the Project area. The required services and equipment are readily available and the existing monitoring well network could be used or expanded, as necessary. If needed, the installation of additional monitoring wells would be readily implementable. Environmental monitoring is a standard, effective, and implementable method for evaluating COC trends as well as remedial program effectiveness.

Monitoring is currently implemented at the Airco parcel, and would be readily modified for inclusion as part of a remedial alternative and will, therefore, be retained for further consideration.

3.2.2.2 Site Use Restrictions

Site use restrictions include property access controls, deed restrictions, and limitations on future site development. Control of site access can be accomplished through installation of fencing, markers, and/or warning signs, or use of facility access security measures. Deed restrictions, in the form of environmental land use restrictions, can be used to control future construction and/or residential use of a site. Deed restrictions can include zoning limitations, physical limitations on the size and weight of improvements, and installation prohibitions (e.g., preventing excavation or well installations). Site use restrictions in the form of fencing, warning signs, and deed restrictions are currently in use at the Airco parcel.

Effectiveness—Site use restrictions will be effective at minimizing exposure to ground-water COCs through the institution of environmental land use restrictions that limit subsurface construction activities and prevent residential re-use of the property. The fencing will continue to be effective for protecting non-site workers as long as the maintenance is performed to maintain the integrity of the existing fence.

Implementability—Site use restrictions are currently in use and, therefore, readily implementable at the Airco parcel. Deed restrictions and site access controls are in use and, therefore, this technology will be retained for further consideration.

3.2.2.3 Point-of-Entry/Use Treatment

Point-of-entry/use treatment technologies, typically consisting of carbon filters or ion exchange units, can be used by residences that are dependent on private wells for their drinking water. Carbon filters are used to remove organic compounds from water. Ion exchange units typically are used to reduce metal concentrations in water by using a resin bed to exchange a non-harmful metal, like sodium, for the target metal. Point-of-entry treatment is accomplished prior to tap use. The treatment units are usually located in the basement of the residence and the treated water is used by the residents for domestic water uses (e.g., drinking, bathing, and washing clothes).

Effectiveness—Point-of-entry/use treatment techniques would likely be effective in reducing human exposure to ground-water COCs if the local ground water was used as a drinking water source.

Implementability—Point-of-entry/use treatment can be difficult to implement because it requires access to private residences for the installation and long-term maintenance of treatment systems.

Point-of-entry/use treatment technologies are not required because residential dwellings are not located near the Project area, and dwellings in the general region are connected to the municipal drinking water supply system. Therefore, this technology will not be retained for further consideration.

3.2.2.4 Alternate Water Supply

Alternate water supplies, generally bottled water or municipal (i.e., piped) water, can be implemented at a site as a means of protecting the health of local residents that may be dependent on ground water for their drinking water. Providing an alternate water supply can be effective in reducing human exposure to ground-water COCs for residences depending on ground water for domestic use.

Effectiveness—Alternate water supplies can be effective in reducing human exposure to ground-water COCs if the local ground water was used as a drinking water source.

Implementability—Alternate water supplies are readily available, but can be difficult to implement because it requires private residents to be diligent in using the systems, and will require access to the residences for the installation and long-term maintenance of the systems.

Alternate water supply technologies are not required because the residential dwellings are connected to the municipal drinking water supply system. Therefore, this technology will not be retained for further consideration.

3.2.3 *In Situ* Ground-Water Remedial Technologies

In situ ground-water remedial technologies involve methods of mitigating ground-water contamination without having to extract the water from the subsurface. In some applications, these methods tend to be less labor-, equipment-, and material-intensive and have lower associated costs relative to *ex situ* treatment technologies.

3.2.3.1 Monitored Natural Attenuation

Natural attenuation pertains to the reduction of COC concentrations through naturally-occurring physical, chemical, and/or biological processes. These processes include biological degradation, dilution, sorption to soil or aquifer particles, volatilization, and/or chemical reactions with natural materials. For organic compounds (i.e., total petroleum hydrocarbons and certain chlorinated volatile organic compounds [CVOCs]), the preferred natural attenuation mechanism is biodegradation, especially if complete mineralization to carbon dioxide and water is achieved. For many organic compounds, biodegradation is the most significant natural attenuation process. Inorganic contaminants (e.g., metals) cannot be degraded but may be transformed into different chemical forms, which are non-toxic or immobile, or are physically unavailable for uptake by organisms. For example, Cr(VI) is mobile in ground water and, due to its carcinogenicity, presents a significant health risk. In subsurface environments depleted of oxygen, the oxidation state of Cr(VI) may be reduced to Cr(III), which is significantly less hazardous, and because Cr(III) binds to minerals, relatively immobile in the saturated zone.

Natural attenuation typically requires comprehensive site characterization followed by extensive monitoring to ensure that the predicted natural processes are occurring and that COC concentrations will be reduced to regulatory goals within an acceptable time period. Further, natural attenuation remedies may take longer than engineered remedies to correct a problem. Under the use of monitored natural attenuation, there should be a readily available contingent remedy for a site, in the event that natural attenuation processes do not reduce the risk within the required timeframe. In many cases, monitored natural attenuation is used at contaminated sites to document final treatment of residual COC concentrations following reduction of elevated COC concentrations via active remedial technologies.

The COCs in the ground water requiring remedial action are inorganics, including Cr(VI) and selenium.

Effectiveness—Natural attenuation will be less effective for mitigation of Cr(VI) and other metals since these elements have not been shown to biodegrade. However, as stated above, physical/chemical processes may reduce the concentration and availability of inorganics over time.

Implementability—The required services/equipment to implement and evaluate monitored natural attenuation processes are readily available. Periodic sampling would be necessary to confirm the effectiveness of the natural attenuation process. The existing monitoring well network could be utilized for collection of ground-water samples and water quality indicator parameters (necessary to evaluate natural attenuation over time). Additional monitoring wells may be required.

Monitored natural attenuation may be effective for remediating concentrations of COCs in ground water given the appropriate geochemical environment. Active remediation may be necessary to reduce COC concentrations in order for natural attenuation to be effective within an acceptable time period. Monitored natural attenuation will be retained for further consideration.

3.2.3.2 Aerobic Bioremediation

In situ biodegradation technologies for ground water are used to promote and sustain subsurface conditions in the saturated zone that are supportive of microbial degradation. These include technologies such as biosparging and oxygen enhancement with hydrogen peroxide. Generally, *in situ* biodegradation technologies are effective for remediation of dissolved-phase total petroleum hydrocarbons and several types of CVOCs. *In situ* biodegradation technologies, which operate by increasing the availability of oxygen to promote microbial degradation, are not considered to be effective for remediation of inorganics. Additionally, the establishment of increased oxidizing conditions in the subsurface has the potential to oxidize existing concentrations of Cr(III) ions to the more hazardous Cr(VI) ionic state.

Effectiveness—Aerobic bioremediation technologies are not effective for inorganics. The addition of oxidizing agents would potentially oxidize Cr(III) to the more toxic Cr(VI) state.

Implementability—The application of oxidizing agents to the subsurface would involve standard injection components and is readily implementable. The movement of oxidizing agents into the low permeability silt layer may require multiple injection points at closer spacing to ensure adequate coverage.

Due to the potential for this technology to oxidize Cr(III) to a more toxic state, and its limited effectiveness against other inorganics, aerobic bioremediation technologies will not be retained for further consideration.

3.2.3.3 Hydrogen Release Compound

Hydrogen release compound (HRC) is a proprietary polylactate ester formulated to allow the slow release of lactic acid upon hydration. HRC is injected into the saturated zone to provide a long-term, gradual release of lactic acid which indigenous anaerobic microbes metabolize into several other organic acids and, in the process, produce hydrogen. The establishment of an anaerobic, highly reducing environment may serve to reduce Cr(VI) to various less hazardous and less mobile Cr(III) species. The Cr(III) species precipitate out of the dissolved-phase and remain as sorbed-phase minerals, which do not dissolve to recontaminate the aquifer (www.regenesis.com/HRCtech/hrctb275.htm).

Effectiveness—HRC may have limited effectiveness for reducing Cr(VI) to Cr(III), as discussed above.

Implementability—HRC is a proprietary technology and would be readily implementable through a contract with Regenesis Bioremediation Products, Inc., of San Clemente, California. A treatability study would likely be required prior to full-scale HRC injection at the Project area.

HRC may not be effective for reducing Cr(VI) to Cr(III), and other technologies more applicable to treating Cr(VI) are readily available; therefore, this technology will not be retained for further consideration.

3.2.3.4 Air Sparging

Air sparging systems operate by injecting compressed air into a contaminated aquifer to volatilize dissolved-phase COCs to promote COC transfer from the ground water to soil vapor. As the sparge air travels through channels in the saturated soil, volatile COCs partition from the dissolved-phase and are released to the vadose zone with the sparged air. Air sparging systems are usually operated in conjunction with a soil vapor extraction system, which is used to recover contaminated vapors released to the unsaturated zone.

Effectiveness—Air sparging has been demonstrated at numerous sites in conjunction with soil vapor extraction systems for organic compounds. The effectiveness of air sparging was initially examined due to the natural processes occurring after the ground water recharges to surface water at the Project area (i.e., lower pH and shift in Cr[VI] to Cr[III]). However, air sparging was not shown in a bench-scale study to reduce the pH, or convert the Cr(VI) to Cr(III).

Implementability—Air sparging would be readily implementable at the Project area. However, air sparging has been shown to be ineffective at reducing the pH and converting the Cr(VI) to Cr(III), and could potentially promote oxidation of Cr(III) to the more hazardous hexavalent species; therefore, this technology will not be retained for further consideration.

3.2.3.5 Permeable Reactive Barrier

Permeable Reactive Barrier (PRB) remediation is a relatively new technology that utilizes zero valence iron filings or other media to remediate Cr(VI) contaminated ground water. A trench is excavated to the depth of an impermeable subsurface boundary and filled with the reactive media. The permeable wall must be placed in the flow path of the contaminants to promote contact between the media and COCs. Upon contact with the COCs, the zero valence iron (or other media) will begin to donate electrons to the contaminants and start breaking up chemical bonds (for organic compounds). In the case of Cr(VI), no chemical bonds are broken. Instead, the oxidation state is changed to Cr(III) species, which reduces the mobility and toxicity of Cr(VI), and facilitates precipitation onto the porous media.

Effectiveness—PRBs have proven to be effective in several different studies. PRB is considered a full-scale technology; however, its application at the Project area required bench-scale testing combined with pH and hardness reduction and was proven effective.

Implementability—The zero valence iron reactive material is readily available. The contractor who constructed the landfill cap has performed similar installations at two other facilities and is experienced in the application of the PRB technology.

PRB is a relatively new and promising technology that provides effective, low-maintenance remedial action for chlorinated solvents, total petroleum hydrocarbons, and Cr(VI). Installation costs are relatively high, but operation and maintenance (O&M) costs are minimal. This technology will be retained for further consideration.

3.2.3.6 Carbon Dioxide Aeration

This technology, examined during bench-scale study testing, utilizes carbon dioxide diffused into the ground water to generate carbonic acid for purposes of neutralizing the high pH.

Effectiveness—Carbon dioxide aeration has been proven to be effective in bench-scale studies conducted on water collected from the Project area. Carbon dioxide aeration is considered a bench-scale technology, and its application at the Project area would be innovative to treat the high pH ground water. However, this technology will be retained for further consideration coupled with other *in situ* technologies due to successful bench-scale study results.

Implementability—Carbon dioxide aeration would be readily implementable. It may require some subsurface infrastructure in the form of reaction tanks and settling tanks, but the process equipment is readily adaptable from traditional vendors of treatment equipment.

3.2.3.7 Vertical Barriers

Vertical barriers are relatively impermeable subsurface walls installed to limit lateral migration of COCs from a site or to divert ground water to limit contact with COCs. Vertical barriers may also be used to control and divert ground-water flow to a downgradient treatment location (i.e., PRB or recovery trench, etc.). These vertical barriers or walls are generally more effective when they are keyed into an impervious clay or competent bedrock layer. However, when the preferred horizontal geologic strata (i.e., a low permeable material) is not present, a partial vertical barrier can influence local hydrogeologic regimes, thus achieving partial hydraulic control of the system. Vertical barriers will not be retained for consideration since the water will be extracted prior to treatment, and horizontal hydraulic control is not required.

3.2.4 Ground-Water Extraction Technologies

Ground-water extraction technologies can include the use of extraction wells or trenches to remove ground water from the subsurface. Extracted ground water must be conveyed to a central location, treated, and discharged to an acceptable receiving body (typically a surface waterbody or a wastewater treatment facility). Ground-water extraction is designed to remove contaminants from the subsurface and to control their migration through the subsurface. Because ground-water extraction relies on the desorption of contaminants from the soil particles to remove contaminant mass, they tend to operate for long periods of time (tens of years). These technologies are typically used in conjunction with *ex situ* ground-water treatment technologies (Subsection 3.2.5).

3.2.4.1 Extraction Wells

Ground-water extraction wells are typically installed within the heart of a plume, at the downgradient plume edge, or along the boundary of a site. In general, ground water is extracted at sufficient flow rates to effect a hydraulic influence such that adequate capture is achieved. Ground-water extraction wells can also be used for source treatment remedies in conjunction with *ex situ* ground-water treatment technologies (Subsection 3.2.5).

Effectiveness—Ground-water extraction is typically used as part of a source area treatment technique (i.e., pump and treat). Extraction wells can be located at different depths in the aquifer to remove COCs. For zones of lower permeability, flow rates and capture zones are reduced, resulting in multiple wells to achieve similar capture.

Implementability—Installation of a system of extraction wells involves established construction practices. Vendors and equipment are readily available. An *ex situ* treatment system would be required for the extracted ground water. If onsite treatment is performed, then an acceptable point of discharge for the treated ground water would have to be established. Extraction wells are readily implementable.

Extraction wells are an established technology for the removal of ground water from the subsurface. Ground-water extraction would be effective in preventing further offsite migration of contaminants at the property boundary, and would be able to reverse gradients from offsite areas. Many vendors are available to install extraction wells. However, given the existing site conditions, including the interception trench, extraction wells, although effective in removing ground water, will not be retained for further consideration as they will not retrofit with the existing infrastructure easily.

3.2.4.2 Recovery Trench

Extraction trenches, or subsurface drains, are filled with a high-permeability backfill (e.g., gravel) and perforated piping which are used as conduits to convey and collect ground water via gravity flow. Recovery trenches are typically installed along the boundary of a site, hydraulically downgradient of a source area or plume. Ground water is extracted from the trenches at sufficient flow rates to achieve a hydraulic gradient flow reversal, thereby preventing migration of affected ground water from a site. Trench drains are highly effective where a continuous hydraulic barrier needs to be maintained, difficult hydrogeologic conditions exist, or low water-bearing units dominate the area. A trench drain provides a continuous hydraulic barrier that can intercept the width of the capture zone if designed to do so. Maintenance of a trench drain system is generally low because siltation does not affect a trench as much as an extraction well due to the redundancy of the design of a trench. The main disadvantage of subsurface drains is the potentially prohibitive costs of shoring, dewatering, and excavation (including handling of excavated soil containing COCs) during installation. A recovery trench is currently in place at the Project area.

Effectiveness—A recovery trench drain system would be effective in containing shallow ground water. In general, recovery trenches can be effective for collecting shallow ground water to achieve hydraulic containment. This technology would be used in conjunction with a barrier technology to limit the water contribution from adjacent properties, and to channel subsurface flow.

Implementability—This is a proven technology and the required services are readily available. Pre-design investigations may be necessary to refine specific parameters. Ground water that is extracted from a recovery trench will have to be treated prior to disposal. As discussed for extraction wells, a ground-water treatment system (*ex situ or in situ*) would have to be constructed and an acceptable point of discharge would have to be established.

The trench is currently installed, and is effective at collecting the impacted ground water; therefore, a recovery trench system will be retained for further consideration.

3.2.5 *Ex Situ* Ground-Water Treatment Technologies

Ex situ ground-water treatment technologies are used to remove dissolved-phase contaminants and/or suspended matter from extracted ground water in conjunction with operation of a pump and treat system. Ground-water treatment would be required to meet surface discharge or pre-treatment standards prior to discharge to a POTW.

Pump and treat systems operate by pumping ground water to the surface, removing the contaminants, and then either recharging the treated water to the aquifer or discharging to a surface waterbody or municipal sewage treatment plant. Once ground water has been pumped to the surface, contaminants can be removed to very low levels with established technologies used to treat drinking water and wastewater. However, pumping the contaminated water from the aquifer does not guarantee that all the contaminants have been removed from beneath a site. Contaminant removal is limited by the behavior of contaminants in the subsurface, site geology and hydrogeology, and extraction system design (Suthersan 1997).

Pump and treat systems can be designed to meet two very different objectives: containment or restoration. Pump and treat systems designed for containment of contaminated ground water generally utilize the minimum extraction rate to prevent further expansion of the contaminated zone. Therefore, these systems typically require fewer extraction wells and less costly treatment systems since the volume of extracted ground water is much less than for a similar restoration system. Pump and treat systems designed for restoration require much higher extraction rates than containment systems since clean ground water must be induced to flush through the contaminated zone from areas to which contaminant migration has not occurred.

The following technologies for treatment of extracted ground water are evaluated under the scenario in which pump and treat is selected as a ground-water remedial technology at the Project area.

3.2.5.1 Bioreactors

Bioreactors degrade organic contaminants in water with micro-organisms through attached or suspended biological systems. Suspended growth systems include activated sludge, fluidized beds, or sequencing batch reactors. In these systems, contaminated ground water is circulated in an aeration basin where the contaminants are degraded aerobically. The cells form a sludge, which is settled out and disposed of offsite. Attached growth systems include upflow fixed film, rotating biological contactors, and trickling filters. In these systems, micro-organisms attached to an inert matrix degrade organic compounds aerobically. Bioreactors are used to treat semivolatile organic compounds, petroleum compounds, and organic material. Bioreactors will not treat inorganics and will not be retained for further consideration.

3.2.5.2 Air Stripping

Air stripping is a full-scale technology that is best suited to remove volatile organic compounds from ground water by forced air contact with the contaminated water. Dissolved-phase contaminants are volatilized and removed with the forced air stream. Emission treatment may be required if off-gas contaminant concentrations exceed local, state, or federal standards. There are several different designs for air stripping, including packed tower, aeration tank, spray aeration, and other forms. Air stripping, as noted under air sparging, will not treat the elevated pH, or inorganics and will, therefore, not be retained for further consideration.

3.2.5.3 Filtration

Filtration is a full-scale technology in which solids are isolated by running a fluid stream through a porous medium. Filtration is generally used as a pre- or post-treatment process to remove suspended solids and precipitated metals from water.

Effectiveness—Success of filtration is highly dependent on the type of contaminant and the filtration method chosen. A treatability study would be required to design an effective filtration system for extracted ground water at the Project area.

Implementability—There are numerous vendors readily able to design and install a filtration system for extracted ground water at the Project area.

Cost—Filtration costs range from $1.33 to $4.56 per 1,000 gal treated.

Filtration would be a potential pre- or post-treatment method to be used in conjunction with ground-water extraction and treatment. Filtration will be retained for further consideration.

3.2.5.4 Ion Exchange

Ion exchange is a full-scale *ex situ* treatment technology in which aqueous phase ions are removed by the exchange of cations and anions between the contaminants and the exchange medium. This technology is mainly used for the removal of metals and radionuclides in aqueous solutions. The ion exchanging media may consist of resins made from synthetic materials that contain exchangeable ions, or inorganic and natural polymeric materials. Resins can be regenerated upon exhaustion.

Effectiveness—Ion exchange is effective in removal of aqueous phase metals and radionuclides and also proven to remove nitrate, ammonia, nitrogen, and silicate.

Implementability—Equipment and vendors are readily available to implement this technology. Pretreatment may be required to remove any compounds that may adversely affect the effectiveness of the ion exchange resin. A treatability study was performed utilizing ground water from the Project area, and this technology was determined to be suitable to treat the Cr(VI); however, pre-treatment to lower the pH will be required for an ion exchange system for *ex situ* ground-water treatment at the Project area.

Cost—These costs generally range from $0.30 to $0.80 per 1,000 gal of treated ground water. The major cost factors include: pretreatment requirements, resin utilization, and resin regeneration and efficiency.

This technology may be useful for the removal of Cr(VI) and other dissolved-phase inorganics at the Project area. This technology will be retained for further consideration.

3.2.5.5 Liquid-Phase Carbon Adsorption

Liquid-phase carbon adsorption is a full-scale technology in which contaminated ground water is pumped to the surface and runs through one or more vessels containing liquid-phase activated carbon. Organic contaminants are removed from the ground water by adsorption to the activated carbon. This technology will not treat inorganics and will not be retained for further consideration.

3.2.5.6 Chemical Precipitation

Chemical precipitation is the primary method for removing metals from metal-laden industrial wastewaters. This technology has been used for the removal of heavy metals in ground water. It involves pumping ground water to the surface, pH adjustment, reagent addition, mixing or flocculation of the solution, clarification or precipitation of the solids, thickening of solids, and collection of the solid material. Typically, the metals will precipitate as hydroxides, sulfides, or carbonates.

Effectiveness—Precipitation is a proven technology in both the industrial and ground-water remedial fields for the removal of heavy metals. The effectiveness of this process may be adversely affected if multiple metal species are present.

Implementability—Equipment is readily available for this treatment technology. This technology is generally used as a pretreatment process to remove metals that may adversely affect the secondary processes such as chemical oxidation or air stripping. Higher flow rates require large building and equipment footprints, and higher metals loading generates large sludge volumes that require offsite disposal. There are a number of limitations to this form of precipitation-based technology. Increasingly stringent standards will require further treatment; also metal hydroxide sludges must pass Toxicity Characteristic Leaching Procedure guidelines prior to disposal. The addition of various compounds may be required to attain desirable precipitation conditions for the solution. This can lead to further treatment of these compounds after metals removal. The treated water often requires pH adjustment prior to discharge.

Cost—Capital costs for 20- to 65-gpm packaged metals precipitation systems are approximately $35,000-$115,000. Laboratory treatability studies for metals precipitation can range from $5,000 to $20,000. Operating costs range from $0.30 to $0.70 per 1,000 gal of ground water containing 100 ppm metals. Sludge disposal may increase operating costs by $0.50 per 1,000 gal of ground water treated with actual disposal costs estimated at $300 per ton of sludge.

Precipitation is a very high cost technology that is best suited for high concentrations of metals in ground water. At the Project area, Cr(VI) and Cr(III) concentrations in the ground water are high enough to necessitate chemical precipitation. These constituents would need to be removed to meet discharge standards and/or to minimize fouling of downstream treatment processes. This technology will be retained for further consideration.

3.2.5.7 Ultraviolet Oxidation

Ultraviolet oxidation is a destructive process that oxidizes organic constituents in wastewater by the addition of strong oxidizers and irradiation with ultraviolet light. If complete mineralization is achieved, the final products of oxidation are carbon dioxide, water, and salts. The two main oxidizers utilized in this process are ozone and/or hydrogen peroxide. Typically, organic compounds with double bonds (i.e., trichloroethene, tetrachloroethene, and vinyl chloride) and some aromatic compounds (benzene, toluene, ethylbenzene, and xylenes and phenol) are rapidly oxidized with this process. This technology will not treat Cr(VI) and will not be retained for further consideration.

3.2.6 Ground-Water Discharge Technologies

Ground-water discharge technologies can include the use of injection wells, discharge to a surface waterbody, or discharge to a local POTW. Ground water must be extracted and treated to remove contaminants prior to discharge. The efficiency of contaminant removal is dictated by the type of discharge option employed and its associated discharge standards. Some standards (i.e., discharge to a POTW) may be higher than others, which may reduce treatment costs. Discharge options are affected by the flow rates they can accept relative to the extraction rates. Some options may be more amenable to higher flow rates than others. Monitoring of the treated effluent, at set intervals, is typically required to ensure that discharge standards are achieved.

Additionally, permits may need to be granted before discharge can occur. These technologies are typically used in conjunction with *ex situ* ground-water treatment technologies (Subsection 3.2.5).

3.2.6.1 Injection Wells

Injection wells are used to discharge treated ground water to the subsurface. This allows the water to recharge the aquifer, while providing hydraulic control and expediting ground-water travel times within the plume area. Hydraulic control is achieved by establishing recirculation patterns sufficient to modify the direction and/or velocity of plume migration. Injection wells can be used in conjunction with extraction wells for greater control of ground-water flow. Based on the site configuration, depth of waste within the unlined capped landfill, and ground-water flow direction, re-injection will not be retained for further consideration.

3.2.6.2 Discharge to Surface Water

Treated effluent can be discharged to surface water if an adequate surface waterbody is available in close proximity to a site. For the Project area, the wetland area to the south would be an acceptable discharge location. It is not considered "Waters of the State," but would require a State Pollutant Discharge Elimination System discharge permit.

Effectiveness—Discharge to the wetland would be effective. The current ground water daylights to this wetland, and continued discharge would not cause degradation of the wetland.

Implementability—Discharge to surface water would require installation of a discharge line from an *ex situ* ground-water treatment system. Consideration would be given to installation of this line under the existing cap, or above grade; otherwise, the discharge is readily implementable.

This option is retained for further consideration in conjunction with *ex situ* ground-water treatment systems.

3.2.6.3 Discharge to Publicly-Owned Treatment Works

Treated effluent from a ground-water treatment system can be discharged to a sanitary sewer for a local POTW. The POTW would determine pre-treatment standards that would need to be met prior to discharge, as well as maximum flow rates. A sewer connection application would be required and a permit secured prior to disposal. A sewer line that can accommodate the design flow rate would need to be constructed from the treatment building to the connection point to the local sewer. The POTW would need to be consulted to determine if adequate flow capacity is available in existing sewer lines. Effluent would need to be monitored for flow and quality. These data would need to be reported to the local sewer authority.

Effectiveness—Discharge to a POTW would be an effective method for disposing of treated effluent. The degree of treatment would be determined based on system influent concentration and POTW pre-treatment standards, which will result in less stringent treatment objectives. The

POTW indicates that only pH adjustment would be required prior to discharge to the POTW. A sewer line from the Project area to the intersection of Hyde Park and Witmer roads would be required. Additional treatment would be supplied by the POTW.

Implementability—Discharge to a POTW would require installation of a discharge line from the Project area to the intersection of Hyde Park and Witmer roads (approximately 5,000 ft). A permit application would need to be submitted and approved by the local sewer authority. Existing sewer line capacity would need to be determined and compared to total extraction flow rates to determine whether the POTW could accept the anticipated flow rates.

According to conversations with the Town of Niagara Falls, discharge to the local POTW is a viable option. This option is retained for further consideration.

3.3 SUMMARY OF TECHNOLOGY TYPE AND PROCESS OPTION EVALUATION

Based on the screening of remedial technologies, certain technologies that were not effective or implementable at the Project area have been eliminated from further consideration. The technologies that were retained will be used as a resource to develop remedial alternatives in Chapter 4. Table 3-1 summarizes the remedial technologies/approaches that were retained for soil and ground water, respectively, at the conclusion of the technology screenings presented in this chapter.

TABLE 3-1 SUMMARY OF INITIAL SCREENING OF REMEDIAL TECHNOLOGIES FOR GROUND WATER RECHARGING TO SURFACE WATER AT THE PROJECT AREA AND EXCAVATED SOIL AND WASTE

General Response Action	Remedial Technology	Process Option	Description	Status/Rationale
			GROUND WATER	
No Action	None	Not applicable	No further activities would be conducted at the site	Required for consideration by the National Contingency Plan.
Institutional Controls	Monitoring	Monitoring of impacted environmental media	Sampling of ground water as necessary to monitor remedial program performance	Retained for consideration.
	Access/Use Restrictions	Physical barriers or notices	Fencing, markers, and warning signs to restrict site access	Retained for consideration.
	Access/Use Restrictions	Environmental Land Use Restrictions	Administrative actions such as deed restrictions to restrict future site activities and site usage	Retained for consideration.
	Point-of-Entry/ Use Treatment	Treatment of ground water at point of use	Domestic/facility treatment of extracted ground water using small-scale carbon filters or ion exchange units	Not retained for further consideration because residential dwellings are connected to the local municipal system.
	Alternate Water Supply	Provide potable water	Provision of potable water supply such as bottled water or connections to a municipal system	Not retained for further consideration because residential dwellings are connected to the local municipal system.
In Situ Treatment	Natural Attenuation	Monitored natural attenuation	Long-term monitoring of COC concentrations, water quality indicator parameters, and/or microbiological parameters to evaluate rate of natural COC reduction	Retained for consideration.
	Biological	Aerobic bioremediation	Degradation of organic compounds in ground water using micro-organisms in an aerobic environment; nutrients and/or oxygen may be injected into the subsurface to promote biological activity	Not retained for further consideration since hexavalent chromium has not been shown to respond to aerobic biodegradation.
	Biological	Hydrogen release compound	Injection of a proprietary polylactate ester formulated to allow the slow release of lactic acid upon hydration, producing conditions under which reductive dehalogenation degrades chlorinated organics	Not retained for further consideration since hexavalent chromium may not respond effectively to hydrogen release compound processes.
	Physical/Chemical	Air sparging	Injection of air into ground water to transfer dissolved volatile organic compounds to the vapor phase; recovery of volatized COCs in the vadose zone using vacuum extraction wells or trenches	Not retained for further consideration since hexavalent chromium will not respond to air sparging processes.
	Physical/Chemical	Permeable reactive media	*In situ* permeable media with to reduce inorganic COC; can be combined with vertical barriers to channel impacted ground water through the treatment wall or vessel	Retained for consideration for hexavalent chromium treatment.
	Physical/Chemical	Carbon dioxide aeration	Carbon dioxide diffused into the water stream to force carbonic acid generation for neutralization of the high pH ground water.	Retained for consideration for pH reduction.

NOTE: COC = Constituent of concern.
Shaded areas indicate technology not retained for further consideration.

General Response Action	Remedial Technology	Process Option	Description	Status/Rationale
Ex Situ Treatment	Ground-Water Extraction	Extraction wells	Pumping ground water to the surface through the use of extraction wells placed to contain and/or completely remediate contaminated zones	Not retained for further consideration due to site constraints.
	Ground-Water Extraction	Recovery trench	Flow of shallow ground water through permeable fill to a central collection pipe; water flows by gravity to a sump, and then pumped from the ground.	Retained for consideration as a trench is currently in use at the site.
	Biological	Bioreactors	Utilization of aerobic microbial populations in attached or suspended growth systems to metabolize COCs in extracted ground water	Not retained for further consideration since hexavalent chromium will not respond to bioreactor processes.
	Physical/Chemical	Air stripping	Removal of volatile organic compounds from extracted ground water by forced contact with an air stream	Not retained for further consideration since hexavalent chromium will not respond to air stripping processes.
	Physical/Chemical	Filtration	Isolation and removal of suspended solids by passing extracted ground water through porous media	Retained for consideration.
	Physical/Chemical	Ion exchange	Removal of aqueous phase ions by exchange of cations and anions between contaminated ground water and an engineered exchange medium	Retained for consideration.
	Physical/Chemical	Liquid-phase carbon adsorption	Removal of organic chemicals from extracted ground water by adsorption to granular activated carbon	Not retained for further consideration since hexavalent chromium will not respond to carbon adsorption processes.
	Physical/Chemical	Metals precipitation	Removal of metals from extracted ground water by pH adjustment, reagent addition, mixing, flocculation, and sedimentation	Retained for consideration.
	Physical/Chemical	Ultraviolet oxidation	Destruction of organic COCs in extracted ground water by combined use of chemical oxidants and ultraviolet light	Not retained for further consideration since hexavalent chromium will not respond to oxidation processes.
	Ground-Water Discharge	Injection wells	Treated water is reinjected into the ground through a series of injection wells, creating a ground-water mound in the injection area	Not retained for consideration due to site constraints.
	Ground-Water Discharge	Discharge to surface water	Treated water is conveyed through a pipe that discharges to a surface waterbody	Retained for consideration.
	Ground-Water Discharge	Discharge to publicly-owned treatment works	Treated water is conveyed through a pipe to a local sanitary sewer	Retained for consideration.
EXCAVATED SOIL AND WASTE				
Containment	Capping	Geomembrane cap	Place material under the existing geomembrane cap	Not retained for further consideration.
Removal	Excavation	Selective excavation	Selective excavation and removal of impacted soil from the Project area; onsite capping or offsite disposal would be required	Retained for consideration.
Disposal	Transportation and offsite disposal of impacted soil	Transportation and offsite disposal of impacted soil	Disposal of excavated soil at a licensed, offsite disposal facility	Retained for consideration in conjunction with selective excavation.

4. REMEDIAL ALTERNATIVES FOR GROUND WATER

In this chapter, technologies retained from the initial screening (Chapter 3) are assembled into remedial action alternatives (Sections 4.1 and 4.2).

4.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES FOR GROUND WATER

As outlined in Sections 2.4 and 2.5, RAOs and GRAs for the Project area were developed to minimize potential human exposure to elevated COC concentrations in ground water recharging to surface water at the Project area, and to minimize the potential migration of COCs from the Project area. The primary COCs at the Project area, based on previous investigations and long-term monitoring, are:

- Elevated pH
- Cr(VI).

From the technologies retained from the preliminary screening in Chapter 3, the following potential remedial alternatives were developed for treatment of COCs at the Project area:

- Alternative 1: No Action[1]

- Alternative 2: *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring

- Alternative 3: *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring

- Alternative 4: *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring.

Five-year reviews would be required for all four alternatives for as long as COCs are present above acceptable concentrations. Detailed descriptions of these remedial alternatives are provided in the following sections.

1. No Action alternative refers to no remedial action for the Project area. Existing long-term monitoring and institutional controls currently performed as part of the approved Post-Closure Monitoring and Facility Maintenance Plan (EA 2001) will continue relative to the Airco parcel.

4.2 INDIVIDUAL DESCRIPTIONS OF REMEDIAL ALTERNATIVES FOR GROUND WATER

The remedial alternatives, which were outlined for ground water recharging to surface water at Project area in Section 4.1, are described individually in this section. Specific details concerning the individual characteristics of each of these alternatives will be discussed in Subsections 4.2.1 through 4.2.4.

4.2.1 Alternative 1 – No Action

Pursuant to Section 300.430(e)(3)(ii)(6) of the revised NCP, the No Action alternative is developed as a baseline for comparison against the other remedial alternatives.

4.2.1.1 Description

The No Action alternative includes no additional remedial actions, institutional controls, or monitoring beyond what is currently required under the approved monitoring plans. Impacted ground water would be left in-place and the recharge to surface water would not be addressed. No restrictions would be placed on the use of contaminated ground water at Project area, which could potentially result in human exposure to dissolved-phase COCs. This alternative is required for consideration under the NCP as a baseline comparison with other alternatives.

4.2.2 Alternative 2 – *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring

4.2.2.1 Description

Alternative 2 would address the RAOs through the following remedial components:

- Selective excavation of soil in the Project area to facilitate installation of a wetwell pump station installed and connected to the existing recovery trench
- Offsite disposal of excavated soils to a licensed, waste treatment, storage, or disposal facility
- Installation of a wetwell pump station
- Construction of a treatment system utilizing carbon dioxide aeration for pH adjustment
- Installation of a 5,000-ft long sewer discharge pipeline
- Institutional controls

- Long-term treatment system O&M
- Five-year reviews.

Descriptions of the individual components under this remedial alternative are discussed below.

Selective Excavation

Alternative 2 includes the removal of soil and waste materials encountered in the Project area during excavation for the installation of a pre-engineered pump station.

The soil and waste materials would be excavated with a large, track-mounted excavator and temporarily stockpiled onsite. Stockpiled soil would be placed on 10-mil polyethylene sheeting to prevent potential migration of COCs to non-impacted soil. Residual waste left in-place would be capped after installation of the wetwell. Capping in the Project area may include extending the existing 40-mil linear low-density polyethylene liner, or installation of an 18-in. layer of 1×10^{-7} cm/sec clay.

Safety precautions would be required during remedial excavation activities due to the disturbance and handling of contaminated soil and wastes. A staging area would be required for the temporary soil stockpile(s). Continuous air monitoring would be required, and dust control may be necessary.

Offsite Disposal

The final disposition of the excavated and stockpiled soil would include loading, transport, and disposal of the material at an offsite, licensed waste treatment, storage, or disposal facility. The acceptance of the transported material would be dependent upon the waste characterization of the material conducted prior to disposal.

Installation of a Wetwell Pump Station

This alternative includes installation of a wetwell pump station in the Project area. The pump station would be connected to the existing collection trench. The pump station would have dual pumps operated on floats, with each pump having a capacity of 100 gpm. The batch system would operate by collecting untreated water in the wetwell, and pumping approximately 8,000 gal, per batch cycle, of water up to a treatment plant located onsite. The wetwell installation would include appropriate controls and piping to connect to the treatment plant located approximately 1,500 ft to the north in the northwest portion of the Airco parcel.

Construction of a Treatment System Utilizing Carbon Dioxide Aeration for pH Adjustment

A 40-ft × 60-ft treatment building would be constructed to house two parallel process trains, with two 10,000-gal batch reactor tanks per train, a liquid carbon dioxide storage tank, and associated electrical and control systems. The process flow for the system would include connecting the wetwell to the existing relief pipe, allowing the line to drain by gravity into the wetwell. When the wetwell fills up, the pump(s) would transfer the water to the first 10,000-gal process tanks in one of the treatment trains. Once the tank is full, the control system would switch valves and start filling the primary tank of the second treatment train. The full 10,000-gal tank would undergo pH adjustment to lower the pH rapidly from 13+ to approximately 6.5 in approximately 15 minutes. A transfer pump would then transfer the water to the secondary holding tank prior to discharge via the force main to the sanitary sewer system. The treatment system will have up to 48,000 gal of total storage capacity (20,000 gal treated capacity and 28,000 process capacity) to allow for continued treatment, without discharge during periods of heavy rain. The local sewer is a combined sewer, and during periods of peak flow, no discharge would be allowed. The tanks would allow for 2 days of treated storage capacity.

Installation of a 5,000-ft Long Sewer Discharge Pipeline

A new 5,000-ft long force main that connects the new treatment system to the combined sewer, and subsequently to the Niagara Falls POTW, would be installed. It would require installation of a force main from the treatment plant, approximately 1,500 ft to Witmer Road, and an additional 3,500 ft south along Witmer Road to the closest sewer manhole. Discharge into the POTW would require integration into the combined sewer overflow alarm system to prevent discharge into the POTW system during peak rainstorm events.

Implementation of Institutional Controls

Institutional controls in the form of fencing, signage, and deed restrictions will apply. Through deed restrictions, the property owner will be restricted as follows:

- Fencing
- Signage
  - Posting of notices and signs to minimize the interference with post-closure activities
  - Signs will be posted every 100 ft around the perimeter fencing
- Deed restrictions
  - Ground-water extraction/utilization/consumption within the ground-water restriction area will not be permitted without prior testing and written approval from the New York State Department of Health

— Activities that disrupt or interfere with the post-closure activities will not be permitted

— Intrusive work within the ground-water restriction area will not be permitted without prior written approval from The BOC Group and NYSDEC.

Long-Term Treatment System Operations and Maintenance and Monitoring Program

Long-term monitoring and treatment system O&M would be required. Treatment system O&M would require sampling for discharge compliance. The system would be designed to alarm out in the event of a failure to eliminate the need for a full-time treatment plant operator. In addition to treatment system O&M, long-term monitoring of ground water would continue to be conducted at the Airco parcel to document the ground-water quality system. The existing monitoring network of wells and surface water sampling locations will be utilized and augmented by up to one additional monitoring well in the southwest corner, as required, to monitor the treatment system effectiveness. Long-term monitoring will continue at the current frequency, but may be reduced in frequency based on data collected during future sampling events.

Five-Year Reviews

In accordance with CERCLA Section 121(c), the NYSDEC would conduct 5-year reviews as long as COC concentrations remain in exceedance of levels that allow for unrestricted use and unlimited exposure. Under Alternative 2, 5-year reviews would be required because COC concentrations above the New York Alternate Ambient Water Quality Standards would remain in ground water at the Project area for periods in excess of 5 years from the date of the Record of Decision. The 5-year reviews would focus on compliance with the environmental land use restriction, the future site use (none anticipated), and would evaluate the site status through site visits and data generated during the long-term monitoring program to determine whether further action is warranted.

4.2.3 Alternative 3 – *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring

4.2.3.1 Description

Alternative 3 would address the RAOs through the following remedial components:

- Selective excavation of soil in the Project area to facilitate installation of a wetwell pump station installed and connected to the existing recovery trench

- Offsite disposal of excavated soils to a licensed waste treatment, storage, or disposal facility

- Installation of a wetwell pump station

- Construction of a treatment system utilizing traditional metals removal process equipment
- Installation of a 1,500-ft long surface water discharge line to the wetlands
- Institutional controls
- Long-term treatment system O&M monitoring program
- 5-year reviews.

Descriptions of the individual components under this remedial alternative are discussed below.

Selective Excavation

Alternative 3 includes the removal of soil and waste materials encountered in the Project area during excavation for the installation of a pre-engineered pump station.

The soil and waste materials would be excavated with a large, track-mounted excavator and temporarily stockpiled onsite. Stockpiled soil would be placed on 10-mil polyethylene sheeting to prevent potential migration of COCs to non-impacted soil. Residual waste left in-place would be capped after installation of the wetwell. Capping in the Project area may include extending the existing 40-mil linear low-density polyethylene liner, or installation of an 18-in. layer of 1×10^{-7} cm/sec clay.

Safety precautions would be required during remedial excavation activities due to the disturbance and handling of contaminated soil and wastes. A staging area would be required for the temporary soil stockpile(s). Continuous air monitoring would be required, and dust control may be necessary.

Offsite Disposal

The final disposition of the excavated and stockpiled soil would include loading, transport, and disposal of the material at an offsite, licensed waste treatment, storage, or disposal facility. The acceptance of the transported material would be dependent upon the waste characterization of the material conducted prior to disposal.

Installation of a Wetwell Pump Station

This alternative includes installation of a wetwell pump station in the Project area. The pump station would be connected to the existing collection trench. The pump station would have dual pumps operated on floats, with each pump having a capacity of 100 gpm. The batch system would operate by collecting untreated water in the wetwell, and pumping approximately 8,000 gal, per batch cycle, of water up to a treatment plant located onsite. The wetwell installation would include appropriate controls and piping to connect to the treatment plant located approximately 1,500 ft to the north in the northwest portion of the Airco parcel.

Construction of a Treatment System Utilizing Traditional Metals Removal Process Equipment

A 60-ft × 70-ft treatment building would be constructed to house traditional metals removal equipment, including chemical storage/mixing tanks, equalization tanks, a clarifier, and sludge processing equipment.

The process flow for the system would include connecting the wetwell to the existing relief pipe, allowing the line to drain by gravity into the wetwell. When the wetwell fills up, the pump(s) would transfer the water to an equalization tank. The water would proceed through a 2-step pH adjustment and metals precipitation process. Sludge would be processed routinely and would be disposed of at an approved offsite waste treatment, storage, or disposal facility. In addition to the process equipment, the system will be required to contain a minimum of 2 days worth of storage capacity. Therefore, the system will also include two 10,000-gal aboveground storage tanks to allow for continued treatment, without discharge during periods of heavy rain. The local sewer is a combined sewer, and during periods of peak flow, no discharge would be allowed. The tanks would allow for 2 days of treated storage capacity.

Installation of a 1,500-ft Long Surface Water Discharge Pipe to the Wetlands

The treated water would be pumped back down to the southwest corner and discharged under a State Pollutant Discharge Elimination System permit into the wetland. However, since this wetland drains into the combined sewer of Niagara Falls, sewer fees would still apply, treatment system storage capacity requirements would apply, and stricter discharge limits enforced under the State Pollutant Discharge Elimination System permit.

Implementation of Institutional Controls

Institutional controls in the form of fencing, signage, and deed restrictions will apply. Through deed restrictions, the property owner will be restricted as follows:

- Fencing
- Signage
    - — Posting of notices and signs to minimize the interference with post-closure activities
    - — Signs will be posted every 100 ft around the perimeter fencing

- Deed restrictions
  - Ground-water extraction/utilization/consumption within the ground-water restriction area will not be permitted without prior testing and written approval from the New York State Department of Health
  - Activities that disrupt or interfere with the post-closure activities will not be permitted
  - Intrusive work within the ground-water restriction area will not be permitted without prior written approval from The BOC Group and NYSDEC.

Long-Term Treatment System Operations and Maintenance and Monitoring Program

Long-term monitoring and treatment system O&M would be required. Treatment system O&M would require sampling for discharge compliance. The system would be designed to alarm out in the event of a failure to eliminate the need for a full-time treatment plant operator. In addition to treatment system O&M, long-term monitoring of ground-water would continue to be conducted at the Airco parcel to document the ground-water quality and the effectiveness of the treatment system. The existing monitoring network of wells and surface water sampling locations will be utilized and augmented by up to one additional monitoring well in the southwest corner, as required, to monitor the treatment system effectiveness. Long-term monitoring will continue at the current frequency, but may be reduced in frequency based on data collected during future sampling events.

Five-Year Reviews

In accordance with Comprehensive Environmental Responsibility, Compensation, and Liability Act Section 121(c), the NYSDEC would conduct 5-year reviews as long as COC concentrations remain in exceedance of levels that allow for unrestricted use and unlimited exposure. Under Alternative 3, 5-year reviews would be required because COC concentrations above the New York Alternate Ambient Water Quality Standards would remain in ground water recharging to surface water at the Project area for periods in excess of 5 years from the date of the Record of Decision. The 5-year reviews would focus on compliance with the environmental land use restriction, the future site use (none anticipated), and would evaluate the site status through site visits and data generated during the long-term monitoring program to determine whether further action is warranted.

4.2.4 Alternative 4 – *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring

4.2.4.1 Description

Alternative 4 would address the RAOs through the following remedial components:

- Selective excavation of soil in the Project area to facilitate installation of the wetwell pump station
- Offsite disposal of excavated soil and waste materials
- Construction of a treatment system utilizing *in situ* carbon dioxide aeration for pH adjustment and permeable reactive media for Cr(IV) reduction to Cr(III), iron filtration (as required to meet State Pollutant Discharge Elimination System requirements), and engineered wetlands for additional Cr(III) precipitation
- Institutional controls
- Long-term treatment system O&M and monitoring program
- 5-year reviews.

Descriptions of the individual components under this remedial alternative are discussed below.

Selective Excavation

Alternative 4 includes the removal of soil and waste materials encountered in the Project area during excavation for the installation of a pre-engineered pump station.

The soil and waste materials would be excavated with a large, track-mounted excavator and temporarily stockpiled onsite. Stockpiled soil would be placed on 10-mil polyethylene sheeting to prevent potential migration of COCs to non-impacted soil. Residual waste left in-place would be capped after installation of the wetwell. Capping in the Project area may include extending the existing 40-mil linear low-density polyethylene liner, or installation of an 18-in. layer of 1×10^{-7} cm/sec clay.

Safety precautions would be required during remedial excavation activities due to the disturbance and handling of contaminated soil and wastes. A staging area would be required for the temporary soil stockpile(s). Continuous air monitoring would be required, and dust control may be necessary.

Offsite Disposal

The final disposition of the excavated and stockpiled soil would include loading, transport, and disposal of the material at an offsite, licensed waste treatment, storage, or disposal facility. The acceptance of the transported material would be dependent upon the waste characterization of the material conducted prior to disposal.

Installation of a Wetwell Pump Station

This alternative includes installation of a wetwell pump station in the Project area. The pump station would be connected to the existing collection trench. The pump station would have dual pumps operated on floats, with each pump having a capacity of 50 gpm. The batch system would operate by collecting untreated water in the wetwell, and pumping approximately 300 gal per batch cycle of water to a treatment system. The wetwell installation would include appropriate controls and piping to connect to the treatment system located approximately 1,500 ft to the north in the northwest portion of the Airco parcel.

Construction of a Treatment System Utilizing *In Situ* Carbon Dioxide Aeration for pH Adjustment; Permeable Reactive Media Vessels to Promote Hexavalent Chromium Reduction, Trivalent Chromium, and Hardness Precipitation and Iron Filtration; and an Engineered Wetland for Continued Trivalent Chromium Precipitation

This alternative involves a 4-step treatment process. Initially, water will be collected from the existing recovery trench into a wetwell pump station. The water would be pumped and stored in a tank to promote a batch reaction process flow. The water in the influent equalization tank will be aerated, as required, with carbon dioxide to reduce the pH to an acceptable level. The water will then be hydraulically transferred to a large settling tank which will allow the calcium carbonate precipitate to settle prior to processing through vessels containing the reactive medias for Cr(VI) reduction and iron filtration. The water would exit the vessels and discharge directly into a 7,500-ft^2 engineered wetland. Water would be retained in this wetland for approximately 1 week, prior to flowing into a second wetland approximately 2,500 ft^2. The wetlands will be designed to promote further Cr(III) precipitation. The water will then leave the Project area via surface sheet flow into the offsite wetland.

The process equipment will be completely contained *in situ*, with the exception of the liquid carbon dioxide tank that will be stored above grade for accessibility during filling. Utilities will be brought to the site via approximately 11 new utility poles which will allow installation of both phone and electric service.

Implementation of Institutional Controls

Institutional controls in the form of fencing, signage, and deed restrictions will apply. Through deed restrictions, the property owner will be restricted as follows:

- Fencing
- Signage
  - Posting of notices and signs to minimize the interference with post-closure activities
  - Signs will be posted every 100 ft around the perimeter fencing
- Deed restrictions
  - Ground-water extraction/utilization/consumption within the ground-water restriction area will not be permitted without prior testing and written approval from the New York State Department of Health
  - Activities that disrupt or interfere with the post-closure activities will not be permitted
  - Intrusive work within the ground-water restriction area will not be permitted without prior written approval from The BOC Group and NYSDEC.

Long-Term Treatment System Operations and Maintenance and Monitoring Program

Long-term monitoring and treatment system O&M would be required. Treatment system O&M would require sampling for treatment system effectiveness. The system would be designed to alarm out in the event of a failure to eliminate the need for a full-time treatment plant operator. In addition to treatment system O&M, long-term monitoring of ground water would continue to be conducted at the Airco parcel to document the ground-water quality. The existing monitoring network of wells and surface water sampling locations will be utilized and augmented by up to one additional monitoring well in the southwest corner, as required to monitor the treatment system effectiveness. Long-term monitoring will continue at the current frequency, but may be reduced in frequency based on data collected during future sampling events.

Five-Year Reviews

In accordance with CERCLA Section 121(c), the NYSDEC would conduct 5-year reviews as long as COC concentrations remain in exceedance of levels that allow for unrestricted use and unlimited exposure. Under Alternative 4, 5-year reviews would be required because COC concentrations above the New York Alternate Ambient Water Quality Standards would remain in ground water recharging to surface water at the Project area for periods in excess of 5 years from the date of the Record of Decision. The 5-year reviews would focus on compliance with the environmental land use restriction, the future site use (none anticipated), and would evaluate the site status through site visits and data generated during the long-term monitoring program to determine whether further action is warranted.

5. DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUND WATER

For this chapter, alternatives developed in Chapter 4 are evaluated with respect to the NCP evaluation criteria (Section 5.1). A detailed analysis of the ground water remedial alternatives is presented in Section 5.2. A comparative analysis of the ground-water remedial alternatives is presented in Section 5.3. A summary of the ground-water remedial alternatives is provided in Section 5.4.

5.1 DESCRIPTION OF EVALUATION CRITERIA

Pursuant to EPA guidance, remedial alternatives are examined for adherence to nine criteria, as specified in the NCP. These criteria are as follows:

1. Overall Protection of Human Health and the Environment
2. Compliance with ARARs
3. Long-Term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, and Volume through Treatment
5. Short-Term Effectiveness
6. Implementability
7. Cost
8. State Acceptance
9. Community Acceptance.

The last two National Contingency Plan evaluation criteria, State Acceptance and Community Acceptance, were not addressed in the Feasibility Study but will be addressed during public review and comment. It is anticipated that the New York State Department of Environmental Conservation will determine whether to hold a public meeting or issue a fact sheet for community informational purposes.

In order to facilitate a detailed evaluation of remedial alternatives in this FS, the following rationale were applied to the remaining seven criteria:

1. Overall Protection of Human Health and the Environment

   - Reduction of risks
   - Preservation of natural resources

2. Compliance with ARARs

   - Compliance with chemical-specific, action-specific, and location-specific ARARs, as well as other To Be Considered guidances

3. Long-Term Effectiveness and Permanence

   - Magnitude of residual risk
   - Adequacy and reliability of controls

4. Reduction of Toxicity, Mobility, and Volume through Treatment

   - Treatment processes used and materials treated
   - Amount of hazardous materials destroyed or treated
   - Degree of expected reductions in toxicity, mobility, and volume
   - Degree to which treatment is irreversible
   - Type and quantity of residuals remaining after treatment

5. Short-Term Effectiveness

   - Protection of community and workers during remedial actions
   - Environmental impacts
   - Duration of time required to achieve RAOs

6. Implementability

   - Ability to construct and operate the technology
   - Availability and reliability of prospective technologies
   - Ease of undertaking additional remedial actions, if necessary
   - Ability to monitor effectiveness of remedy
   - Ability to obtain approvals from other agencies and coordination with those agencies
   - Availability of equipment and specialists and offsite treatment, storage, and disposal services

7. Cost[1]

   - Capital costs
   - O&M costs
   - 30-year net present-worth costs.

5.2 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUND WATER

5.2.1 Alternative 1 – No Action[2]

5.2.1.1 Overall Protection of Human Health and the Environment

The No Action alternative would not protect human health or the environment because ground water with elevated pH and Cr(VI) concentrations will continue to be present in the Project area.

1. Costs developed in this FS are based on 2003 dollars and are rounded to the nearest $1,000. Present-worth costs are calculated using a 5 percent discount rate over a hypothetical 30-year period of performance.
2. No Action alternative refers to no remedial action for the Project area. Existing long-term monitoring and institutional controls currently performed as part of the approved Post-Closure Monitoring and Facility Maintenance Plan (EA 2001) will continue relative to the Airco parcel.

5.2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The No Action alternative would not comply with ARARs because no action would be taken to address COC concentrations in ground water exceeding New York State Water Quality Regulations. Although natural attenuation processes within the adjacent wetland may reduce COC concentrations over time, no specialized monitoring would be conducted under the No Action alternative to verify that COCs are being naturally attenuated at acceptable rates.

5.2.1.3 Long-Term Effectiveness and Permanence

The No Action alternative would not be effective in the long-term because no remedial activities or institutional controls would be enacted for the long-term management of COC concentrations in ground water which exceed the New York State Water Quality Regulations. RAOs would not be achieved in the long-term.

Although natural attenuation processes within the adjacent wetland have been shown to reduce COC concentrations over time, no specialized monitoring would be conducted under the No Action alternative to verify that COCs are being naturally attenuated at acceptable rates.

5.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

No treatment is specified under the No Action alternative. No other controls would be implemented to address the toxicity, mobility, or volume of COCs in ground water. Although natural attenuation processes within the adjacent wetland have been shown to reduce COC concentrations over time, no specialized monitoring would be conducted under the No Action alternative to verify that COCs are being naturally attenuated at acceptable rates. Since monitoring would not be conducted, the eventual reduction of residual COC concentrations (and concurrent reduction of toxicity, mobility, and volume of impacted media) through natural attenuation would not be documented.

5.2.1.5 Short-Term Effectiveness

Because no remedial actions are specified under the No Action alternative, migration of COCs to downgradient locations (including the adjacent wetland and the combined storm/sewer system) could potentially result in human exposure and/or additional environmental contamination. None of the RAOs would be achieved and the potential development of downgradient parcels could possibly expose human receptors to COCs.

5.2.1.6 Implementability

In a technical sense, the No Action alternative would be readily implementable because no remedial actions or institutional controls are specified. Also, this alternative would not interfere or limit future remedial actions, if necessary. However, in an administrative sense, the No Action alternative will not be implementable because RAOs would not be achieved. In addition, because contamination will remain onsite (pending natural attenuation over time), 5-year reviews would be required. Since no monitoring data would be collected to document the eventual reduction of COC concentrations, the 5-year reviews would continue to be required for the foreseeable future in accordance with CERCLA Section 121(c).

5.2.1.7 Cost

There are no capital costs for Alternative 1. O&M costs include the 5-year reviews. Capital, O&M, and total 30-year net present-worth costs associated with Alternative 4 (Appendix B) are as follows:

- Estimated capital costs $ 0
- 30-year present-worth of O&M $86,000
- 30-year net present-worth costs $86,000

5.2.2 Alternative 2 – *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring

5.2.2.1 Overall Protection of Human Health and the Environment

Alternative 2 would be protective of human health through active remediation, and land use restriction to prevent future development and restrict site access. Ground-water extraction and onsite primary treatment with final treatment via the POTW, confirmed through the long-term monitoring program, would eventually eliminate the uncontrolled release of COCs to the surface water at the Project area.

The 5-year reviews would protect human health and the environment by ensuring that land use restrictions remain effective with respect to the site conditions over time, and that O&M activities are performed. Data from the monitoring program would be used to demonstrate treatment system effectiveness.

5.2.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 2 would achieve ARARs at the Project area by eliminating the recharging water via pumping, pre-treating COCs onsite prior to final treatment via the POTW. The ground water will be treated to acceptable levels using pH adjustment via carbon dioxide aeration, and then discharged via a force main to the POTW. Monitoring of the treatment system will be conducted to provide performance data, and 5-year reviews will be conducted to ensure continued compliance with ARARs.

5.2.2.3 Long-Term Effectiveness and Permanence

Alternative 2 would provide long-term effective and permanence. The treatment system would be required to operate for an indefinite period of time, as it is not designed to remediate the ground water but to prevent the offsite migration of COC at the Project area.

The 5-year reviews would provide long-term effectiveness by ensuring that applicable discharge requirements are met and that land use restrictions and monitoring are maintained. The monitoring program would be effective for evaluating the nature and extent of COC concentrations and would ensure that no change in risk status occurs without notification. Monitoring would also be effective to verify that potential migration of COCs at the Project area does not occur.

5.2.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative 2 includes a form of physical/chemical and/or biological treatment (pH pre-treatment and final treatment at the POTW) to reduce the toxicity, mobility, and volume of COCs. This is a relatively slow, long-term process that may or may not reduce COC concentrations in ground water, but will prevent offsite migration of COCs in the Project area.

5.2.2.5 Short-Term Effectiveness

Alternative 2 would provide short-term effectiveness in reducing human health risks through the continued enforcement of a land use restrictions. Enforcement of site re-use restrictions, as required by the land use restrictions, would immediately prevent use of impacted ground water, thereby protecting human health via the direct-exposure pathway. Some minor impacts during the short-term would occur until the remedial design could be implemented. These impacts are no greater than what currently exists, and no additional risks to human health or the environment will occur as a result of implementing Alternative 2.

5.2.2.6 Implementability

Alternative 2 would be readily implementable because the technology and equipment are commercially available. Some permitting issues may hamper the completion of Alternative 2 since the installation of the process equipment building will require a Town of Niagara variance for building construction due to no property frontage on Witmer Road.

5.2.2.7 Cost

Capital costs for Alternative 2 consist of treatment plant design and installation, performance monitoring, materials, and institutional controls. O&M costs include performance, monthly and annual treatment system monitoring and maintenance, and 5-year reviews. Capital, O&M, and total 30-year net present-worth costs associated with Alternative 2 (Appendix B) are as follows:

- Estimated capital costs $3,385,000
- 30-year present-worth of O&M $3,658,000
- 30-year net present-worth costs $7,043,000

5.2.3 Alternative 3 – *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring

5.2.3.1 Overall Protection of Human Health and the Environment

Alternative 3 would be protective of human health through active remediation, and land use restriction to prevent future development and restrict site access. Ground-water extraction and treatment with treated water discharge to surface water, confirmed through the long-term monitoring program, would eliminate the uncontrolled release of COCs to the surface water.

The 5-year reviews would protect human health and the environment by ensuring that land use restrictions remain effective with respect to the site conditions over time, and that O&M activities are performed. Data from the monitoring program would be used to demonstrate treatment system effectiveness.

5.2.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3 would achieve ARARs at the Project area by pumping and treating the ground water at the Project area. The ground water will be treated to acceptable levels using traditional pH adjustment and metals precipitation processes. Monitoring of the treatment system, will be conducted to provide performance data, and 5-year reviews will be conducted to ensure continued compliance with ARARs.

5.2.3.3 Long-Term Effectiveness and Permanence

Alternative 3 would provide long-term effective and permanence. The treatment system would be required to operate for an indefinite period of time, as it is not designed to remediate the ground water but to prevent the offsite migration of COC at the Project area.

The 5-year reviews would provide long-term effectiveness by ensuring that applicable discharge requirements are met and that land use restrictions and monitoring are maintained. The monitoring program would be effective for evaluating the nature and extent of COC concentrations and would ensure that no change in risk status occurs without notification. Monitoring would also be effective to verify that potential migration of COCs from the Project area does not occur.

5.2.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative 3 includes a form of physical/chemical treatment (metals removal via precipitation) to reduce the toxicity, mobility, and volume of COCs in ground water. This is a relatively slow, long-term process that may or may not reduce COC concentrations in ground water, but will prevent offsite migration of COCs at the Project area.

5.2.3.5 Short-Term Effectiveness

Alternative 3 would provide short-term effectiveness in reducing human health risks through the continued enforcement of land use restrictions. Enforcement of site re-use restrictions, as required by the land use restrictions, would immediately prevent use of impacted ground water, thereby protecting human health via the direct-exposure pathway. Some minor impacts during the short-term would occur until the remedial design could be implemented. These impacts are no greater than what currently exists, and no additional risks to human health or the environment will occur as a result of implementing Alternative 3.

5.2.3.6 Implementability

Alternative 3 would be readily implementable because the technology and equipment are commercially available. Some permitting issues may hamper the completion of Alternative 3 since the installation of the process equipment building will require a Town of Niagara variance for building construction due to no property frontage on Witmer Road.

5.2.3.7 Cost

Capital costs for Alternative 3 consist of treatment plant design and installation, performance monitoring, materials, and institutional controls. O&M costs include performance, monthly and annual treatment system monitoring and maintenance, and 5-year reviews. Capital, O&M, and total 30-year net present-worth costs associated with Alternative 3 (Appendix B) are as follows:

- Estimated capital costs $1,910,000
- 30-year present-worth of O&M $6,408,000
- 30-year net present-worth costs $8,318,000

5.2.4 Alternative 4 – *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring

5.2.4.1 Overall Protection of Human Health and the Environment

The proposed treatment system would be protective of human health and the environment through treatment of the impacted ground water recharging to surface water at the Project area. The system would prevent COCs from migrating offsite at the Project area, but would not reduce the source of ground-water contamination. Additionally, land use restrictions would eliminate ground-water use onsite while COCs remain above remediation standards.

5.2.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 4 would achieve ARARs at the Project area by treating COCs. The pH will be treated to acceptable levels via carbon dioxide aeration, and the Cr(VI) values will be reduced by the reactive media in order to meet the specific ARARs. Monitoring of the treatment system process flow will be conducted to provide performance data, and 5-year reviews will be conducted to ensure continued compliance with ARARs.

5.2.4.3 Long-Term Effectiveness and Permanence

This alternative provides long-term effectiveness at a low O&M cost. Once the carbon dioxide aeration and reactive media system is installed, it begins to remove the COCs as the ground water passes through the system. The system will be designed to have a life of 5 years due to site limitations. This means it will continue to treat contaminants in the ground water for up to 5 years, at which time, the spent zero valence iron would be changed out for new iron if contaminant concentrations are still above remediation standards. The system would provide an effective barrier to contaminants that would otherwise migrate offsite. Institutional controls would also be effective in the long-term by limiting the activities at the Airco parcel to protect human health.

Due to precipitation of Cr(III) and hardness, the reactive media vessels will need to be maintained to ensure long-term effective treatment. *In situ* ultra-sound energy could be used to dislodge precipitated metals and free up reactive media for further treatment.

5.2.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative has proven to greatly reduce Cr(VI) concentrations. The toxicity, mobility, and volume of Cr(VI) will be reduced in that it will precipitate out in the less toxic Cr(III) form. Monitoring of the treatment system process flow will indicate the levels to which the COCs are being reduced and maintained.

5.2.4.5 Short-Term Effectiveness

The treatment system will become effective upon its placement in the Project area. Site workers installing the remedial system components may come in contact with some COCs and, therefore, should be equipped with the proper personal protective equipment to minimize exposure. There are no increased risks to human health or the environment from the implementation of this alternative.

5.2.4.6 Implementability

The material, labor, contractor, and scientific data are readily available to implement this alternative. Bench scale studies have shown that the system will reduce the pH and treat the Cr(VI) to the desired levels.

5.2.4.7 Cost

Capital costs for Alternative 4 consist of carbon dioxide aeration process equipment, reactive media vessels, performance monitoring, materials, and institutional controls. O&M costs include performance, monitoring, and 5-year reviews. Capital, O&M, and total 30-year net present-worth costs associated with Alternative 4 (Appendix B) are as follows:

- Estimated capital costs $1,225,000
- 30-year present-worth of O&M $2,795,000
- 30-year net present-worth costs $4,020,000

5.3 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUND WATER

This section presents the second and final step of the Detailed Analysis of Alternatives for ground water recharging to surface water in the Project area. The remedial alternatives that were evaluated individually in Section 5.2 using the NCP evaluation criteria are compared to each other for their relative effectiveness for each of those criteria, in order to facilitate the decision-making process. As outlined in Section 5.1, two of the nine NCP criteria (State Acceptance and Community Acceptance) will be evaluated as part of the fact sheet and public meeting to be conducted by NYSDEC. A summary of the following comparative analysis is presented in Table 5-1.

5.3.1 Overall Protection of Human Health and the Environment

Alternative 1 would not be protective of human health or the environment because the elevated pH and Cr(VI) would not be addressed. Since there would be no remediation, continued migration of dissolved-phase COCs downgradient of the Project area would not be evaluated and would continue to be a threat. Alternative 1 also does not include land use restrictions and would, therefore, potentially allow future use of impacted ground water, which may result in human exposure to ground water with COC above drinking water standards.

Alternatives 2, 3, and 4 would be equally protective of human health and the environment through the implementation of land use restrictions, site restrictions, and active treatment of the ground water recharging to surface in the Project area. Long-term monitoring would be conducted to verify the treatment system efficiency.

5.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 1 would not comply with the established ARARs. Alternatives 2, 3, and 4 would each satisfy the ARARs by implementation of land and site use restrictions, active remediation, and compliance monitoring.

5.3.3 Long-Term Effectiveness and Permanence

Alternative 1 would not be demonstrably effective in the long-term because no remedial components or institutional controls would be enacted for the long-term management of risks associated with the elevated pH and Cr(VI) discharge. Although natural attenuation may eventually reduce pH and Cr(VI) residual concentrations to the ARARs within the wetlands adjacent to the Project area, no monitoring or sampling would be conducted to verify that the ARARs had been achieved.

Under Alternatives 2, 3, and 4 active remediation to control the release of elevated pH and Cr(VI) would be accomplished. Each of the three alternatives is equally effective at controlling offsite migration of COCs from the Project area.

The land and site use restrictions specified under Alternatives 2, 3, and 4, and recorded on the property deed, would be effective to prevent human exposure to COCs in the Project area (i.e., prohibiting use of impacted ground water) in the long-term. The 5-year reviews would be effective in the long-term by verifying that the land and site use restrictions continue to protect human health.

5.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative 1 does not include ground-water treatment other than potential natural attenuation, which may address impacted ground water in the Project area, but not before release of COCs to adjacent wetlands had occurred. Alternatives 2, 3, and 4 would reduce the toxicity, mobility, and volume of impacted ground water recharging to surface water in the Project area through active remedial systems. Alternative 2 would rely on final treatment of the POTW with reduction of Cr(VI) to Cr(III) and precipitation into a sludge, which will require disposal. Alternative 3 will also generate sludge, which will require disposal. Alternative 4 will generate some precipitate, significantly less than the other two processes (approximately 6,500 gal per year) with most of the reactions occurring within the reactive media bed and some precipitation.

5.3.5 Short-Term Effectiveness

Alternative 1 would not provide short-term effectiveness. Because no remedial actions or institutional controls are specified, Alternative 1 would not achieve RAOs. Alternatives 2 and 3 would be effective in the short-term, but not as protective as Alternative 4 due to the required duration to construct those two remedial alternatives. In addition, Alternative 2 would require significant disruption of traffic during force main installation.

Alternatives 2, 3, and 4 would potentially result in worker exposure to COCs during installation of subsurface remedial components (i.e., wetwell, reactive media vessels, and barrier wall) and during operation of the ground-water treatment plant.

5.3.6 Implementability

In a technical sense, Alternative 1 would be easiest to implement (because it includes no remedial actions). Alternatives 2, 3, and 4 would each require design and implementation of land and site use restrictions, treatment system, and monitoring program, and would, therefore, be equally implementable. Alternatives 2, 3, and 4 would have some significant technical design- and construction-related aspects associated with the design and installation of the remedial systems. Alternatives 2 and 3 would include more significant design, installation, and operation requirements associated with the ground-water extraction and treatment system. In particular, Alternative 2 will require the installation of a 5,000-ft force main along Witmer Road, and will present many construction- and permit-related issues.

In an administrative sense, Alternative 1 cannot be implemented because it does not achieve RAOs. The administrative implementability of Alternatives 2, 3, and 4 would each involve treatment system O&M, long-term reporting and sampling/maintenance programs, land and site use restrictions would have to be established and enforced, and 5-year reviews would be required. The required equipment and services are readily available to implement Alternatives 2 through 4.

5.3.7 Cost

The following cost estimates are based upon a preliminary review of the anticipated requirements for each alternative, as presented in Section 4.2. The cost estimates are based upon approximate design specifications, costs incurred from similar operations, and vendor quotes, where possible. In some cases, assumptions were required for unknown elements. The preliminary cost estimates are anticipated to be between -50 and +30 percent of the actual costs for completing the remedial actions. Therefore, the costs portrayed are to be used as an order of magnitude comparison. More accurate cost estimates can be obtained during the remedial design phase subsequent to construction. For the purpose of this FS, cost estimates are compared over a hypothetical 30-year performance assuming a 5 percent discount rate. Detailed cost estimates are presented in Appendix B, and are summarized in Table 5-2.

Alternative 3 (*Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring) presents the highest present-worth cost ($8,318,000). Capital costs comprise 23 percent of the present-worth cost. The remaining 77 percent of the present-worth costs includes long-term treatment system and ground-water monitoring. This alternative actively (pH adjustment/metals precipitation) treats COCs collected from the aquifer. This alternative provides for surface discharge of the treated water to the wetland adjacent to the Project area.

Alternative 2 (*Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring) presents the next highest present-worth cost ($7,043,000). Capital costs comprise 48 percent of the present-worth cost. The remaining 52 percent of the present-worth costs includes long-term treatment system and ground-water monitoring. This alternative actively (carbon dioxide aeration) treats ground water onsite prior to discharge to the POTW for final treatment. This alternative includes a 5,000-ft force main from the pre-treatment building to the nearest POTW manhole.

Alternative 4 (*In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring) presents the next highest present-worth cost ($4,020,000). Approximately 70 percent of the present-worth costs are from O&M activities.

This includes long-term treatment system and ground-water monitoring. This alternative actively (carbon dioxide aeration) and passively (reactive media and engineered wetlands) treats COCs as they migrate from the aquifer to surface.

Alternative 1 (No Action) presents the lowest present-worth cost ($86,000). No capital costs are incurred. O&M costs include 5-year reviews.

5.4 SUMMARY OF REMEDIAL ALTERNATIVES FOR GROUND WATER

Based on the results of previous investigations, the interim remedial measures program, and the long-term monitoring program, the Project area is characterized by elevated pH and Cr(VI) concentrations in ground water recharging to surface water at and in monitoring wells at various locations on the eastern and western sides of the Airco parcel. The potential remedial alternatives that were developed to prevent the offsite migration of ground water from the Project area into adjacent wetlands, and a summary of their analyses follow:

- **Alternative 1: No Action**—Alternative 1 would not protect human health or the environment and would not meet ARARs.

- **Alternative 2: *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring**—Alternative 2 would be protective of human health and the environment and meet ARARs through active pumping, pre-treatment (onsite carbon dioxide aeration) and final treatment (offsite at the POTW), land and site use restrictions and long-term monitoring.

- **Alternative 3: *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring**—Alternative 3 would be protective of human health and the environment and meet ARARs through active pumping, onsite treatment via metals removal and pH adjustment, land and site use restrictions, and long-term monitoring.

- **Alternative 4: *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring**—Alternative 4 would be protective of human health and the environment and meet ARARs through *in situ* carbon dioxide aeration for pH adjustment, passive reduction of Cr(VI) via contact with reactive media, land and site use restrictions, and long-term monitoring.

5.4.1 Recommended Remedial Alternative

Alternative 4: *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring—Alternative 4 would provide treatment of COCs in ground water recharging to surface water at the Project area. Alternative 4 is less invasive and causes less disruption to the environment and the community. Bench-scale testing indicates that the technology would be an effective treatment process and would provide hydraulic control and prevent migration of impacted water from the Project area into the adjacent wetlands. The 30-year present-worth costs are significantly lower than Alternatives 2 and 3, while being equally protective of human health and the environment.

TABLE 5-1 SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUND WATER

Criteria	Alternative 1 No Action	Alternative 2 *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring	Alternative 3 *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring	Alternative 4 *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring
OVERALL PROTECTIVENESS – HUMAN HEALTH				
Exposure to COCs in ground water	Would not address.	Through active remediation, prevention of exposure to ground water and surface water would occur. Land and site use restriction would further protect human health.	Through active remediation, prevention of exposure to ground water and surface water would occur. Land and site use restriction would further protect human health.	Through active remediation, prevention of exposure to ground water and surface water would occur. Land and site use restriction would further protect human health.
OVERALL PROTECTIVENESS – ENVIRONMENT				
Potential offsite receptors	Would not address; however, no significant risks to offsite ecological receptors were identified.	Through active remediation, offsite migration is prevented. Treated water discharged to POTW combined sewer, which requires no discharge during major rain events to prevent potential discharge of COCs into Lower Niagara River.	Through active remediation, offsite migration is prevented. Treated water discharged to surface water, which could be impacted if system fails. Water drains through the wetland into the POTW combined sewer, which requires no discharge during major rain events to prevent potential discharge of COCs into Lower Niagara River.	Through active remediation, offsite migration is prevented. Treated water discharges into engineered wetlands onsite prior to sheet surface flow into offsite wetlands.
Potential onsite receptors	Would not address; however, no significant risks to onsite ecological receptors were identified.	No potential onsite receptors identified.	No potential onsite receptors identified.	Through active remediation, water is treated and discharged into an onsite engineered wetland. Potential onsite receptors may be present after engineered wetland construction. However, the water quality exiting the reactive media vessels will be sufficiently treated to be protective.
COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS				
Chemical-specific	Would not achieve because no action specified.	Would be achieved through active pre-treatment onsite and POTW discharge.	Would be achieved through active treatment onsite.	Would be achieved through active treatment onsite.
Location-specific	Not applicable because no action specified.	Would be conducted in accordance with requirements.	Would be conducted in accordance with requirements.	Would be conducted in accordance with requirements.
Action-specific	Not applicable because no action specified.	Would be conducted in accordance with requirements.	Would be conducted in accordance with requirements.	Would be conducted in accordance with requirements.

NOTE: COC = Constituents of concern.
POTW = Publicly-owned treatment works.

Criteria	Alternative 1 No Action	Alternative 2 *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring	Alternative 3 *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring	Alternative 4 *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring
LONG-TERM EFFECTIVENESS AND PERMANENCE				
Magnitude of residual risk	Current risks would remain over time as waste is in contact with ground water. Natural attenuation of COCs in surface water may occur in the existing wetland, but would not be verified.	Current risks would remain over time as waste is in contact with ground water. This alternative will address human health and ecological receptors through remediation and controls, but will not reduce the source of contamination.	Current risks would remain over time as waste is in contact with ground water. This alternative will address human health and ecological receptors through remediation and controls, but will not reduce the source of contamination.	Current risks would remain over time as waste is in contact with ground water. This alternative will address human health and ecological receptors through remediation and controls, but will not reduce the source of contamination.
Adequacy and reliability of controls	Not applicable because no controls are specified.	Active strategy. Monitoring would verify the effectiveness of the remedial program. The land/site use restrictions would prohibit use of impacted ground water or redevelopment of the site.	Active strategy. Monitoring would verify the effectiveness of the remedial program. The land/site use restrictions would prohibit use of impacted ground water or redevelopment of the site.	Active strategy. Monitoring would verify the effectiveness of the remedial program. The land/site use restrictions would prohibit use of impacted ground water or redevelopment of the site.
REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT				
Treatment processes used and materials treated	No treatment included.	Carbon dioxide aeration (onsite) for pH neutralization, chemical treatment (POTW) to address hexavalent chromium.	Chemical treatment and precipitation onsite to address pH and hexavalent chromium.	Carbon dioxide aeration for pH neutralization, reactive media to address hexavalent chromium
Hazardous material destroyed or treated	No treatment included. Natural attenuation of COCs in surface water may occur in the existing wetland, but would not be verified.	The pH would be neutralized by carbon dioxide aeration. POTW treatment would reduce hexavalent chromium to trivalent chromium.	The pH would be neutralized by acid addition. Chemical process and precipitation would reduce hexavalent chromium to trivalent chromium.	The pH would be neutralized by carbon dioxide aeration. Reactive media would reduce hexavalent chromium to trivalent chromium.
Type and quantity of residuals remaining after treatment	No treatment included. Natural attenuation of COCs in surface water may occur in the existing wetland, but would not be verified.	Process will generate a minute increase in sludge production at the POTW, which will not be noticeable. The existing sludge characteristics will not change.	Process will generate sludge, which will require disposal.	Oxidized iron and other inert material would accumulate in the reactive media vessels.
Degree to which treatment is irreversible	No treatment included. Natural attenuation of COCs in surface water may occur in the existing wetland, but would not be verified.	After pre-treatment to neutralize pH, and chemical precipitation at the POTW for hexavalent chromium, reaction is not reversible unless additives are incorporated into the process stream.	After pH adjustment and chemical precipitation for hexavalent chromium, reaction is not reversible unless additives are incorporated into the process stream.	After pH adjustment and chemical precipitation for hexavalent chromium, reaction is not reversible unless additives are incorporated into the process stream.
Statutory preference for treatment	No treatment included. Natural attenuation of COCs in surface water may occur in the existing wetland, but would not be verified.	Treatment would reduce hexavalent chromium to trivalent chromium species, and precipitate out the trivalent chromium and other inorganic substances.	Treatment would reduce hexavalent chromium to trivalent chromium species, and precipitate out the trivalent chromium and other inorganic substances.	Treatment would reduce hexavalent chromium to trivalent chromium species, and precipitate out the trivalent chromium and other inorganic substances.

Criteria	Alternative 1 No Action	Alternative 2 *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring	Alternative 3 *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring	Alternative 4 *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring
SHORT-TERM EFFECTIVENESS				
Protection of site workers	No new risks to site workers. No restrictions would be in-place to protect potential future workers.	Safety controls would address potential risks to site workers during active remedial activities. Land/site use restrictions would restrict access to impacted ground water and surface water and limit site redevelopment.	Safety controls would address potential risks to site workers during active remedial activities. Land/site use restrictions would restrict access to impacted ground water and surface water and limit site redevelopment.	Safety controls would address potential risks to site workers during active remedial activities. Land/site use restrictions would restrict access to impacted ground water and surface water and limit site redevelopment.
Protection of community	Risk of potential downgradient migration of dissolved-phase COCs would not be addressed.	The ground-water monitoring program would verify that offsite migration of COC does not occur. Land/site use restrictions would restrict access to impacted ground water and surface water and limit site redevelopment.	The ground-water monitoring program would verify that offsite migration of COC does not occur. Land/site use restrictions would restrict access to impacted ground water and surface water and limit site redevelopment.	The ground-water monitoring program would verify that COCs do not recharge to surface in an uncontrolled environment. Land/site use restrictions would restrict access to impacted ground water and surface water and limit site redevelopment.
Time to achieve remedial goals	Remedial goals would not be achieved. Natural attenuation of COCs may occur in the existing wetland, but would not be verified.	Site cleanup would not occur quickly as the system is designed to prevent migration of COC, rather than address the source.	Site cleanup would not occur quickly as the system is designed to prevent migration of COC, rather than address the source.	Site cleanup would not occur quickly as the system is designed to prevent migration of COC, rather than address the source.
IMPLEMENTABILITY				
Ability to construct and operate	No action specified.	Readily implemented.	Readily implemented.	Readily implemented.
Ease of conducting other actions, if needed	Other actions readily implementable.	Other actions readily implementable.	Other actions readily implementable.	Other actions readily implementable.
Ability to monitor effectiveness	No monitoring included.	Effectiveness readily verified through monitoring and 5-year reviews.	Effectiveness readily verified through monitoring and 5-year reviews.	Effectiveness readily verified through monitoring and 5-year reviews.
Ability to obtain approvals and coordinate with other agencies	Unlikely to receive approval because dissolved-phase COC concentrations exceeding New York State water quality regulations would not be addressed.	Ability to receive regulatory support is uncertain. Design would require variances to local building codes, a discharge permit, and integration into the POTW controls system for major rain event notification	Ability to receive regulatory support is uncertain. Design would require variances to local building codes, a State Pollutant Discharge Elimination System discharge permit, and integration into the POTW controls system for major rain event notification	Ability to receive regulatory support is more certain. The system will require very few permits (carbon dioxide tank), is simple and *in situ*.
Availability of materials and services	Not applicable because no actions are included.	Readily available.	Readily available.	Readily available.

TABLE 5-2 SUMMARY OF REMEDIAL ALTERNATIVE COSTS FOR GROUND WATER

Alternative	Capital Costs ($)	Operation and Maintenance Costs ($)[a]	Total Costs ($)[a]
1. No Action	0	86,000	86,000
2. *Ex Situ* Ground-Water Treatment via Carbon Dioxide Aeration with a Sewer Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring	3,385,000	3,658,000	7,043,000
3. *Ex Situ* Ground-Water Treatment via Metals Precipitation with a Surface Water Discharge, Excavation, Offsite Disposal, Institutional Controls, and Monitoring	1,910,000	6,408,000	8,318,000
4. *In Situ* Carbon Dioxide Aeration, Permeable Reactive Media Vessels, Excavation, Offsite Disposal, Engineered Wetlands Construction, Institutional Controls, and Monitoring	1,225,000	2,795,000	4,020,000

(a) Costs assume that the existing long-term monitoring and maintenance activities currently required under the Post-Closure Operations and Facility Maintenance Plan will continue concurrent to operation and maintenance costs associated with the Project. Costs shown do not include the costs associated with the existing required activities, but benefit from concurrent requirements.

REFERENCES

EA Engineering, Science, and Technology. 2001. Interim Remedial Measure Report Documenting Closure of the Witmer Road Landfill, Niagara Falls, New York. January.

EA. 2002. Fourth Quarter Year 2001 Monitoring Event Report and Annual Report for 2001, Site No. 932001, Airco Properties, Inc., Witmer Road Landfill, Niagara Falls, New York. March.

New York State Department of Environmental Conservation. 1998. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations. Division of Water Technical and Operational Guidance Series (1.1.1). April.

New York State Department of Environmental Conservation. 1999. Water Quality Regulations – Surface Water and Ground-Water Classifications and Standards New York State Codes, Rules and Regulations Title 6, Chapter X Parts 700-706.

Suthersan, S.S. 1997. Remediation Engineering Design Concepts. CRC Press.

U.S. Environmental Protection Agency (U.S. EPA). 1988a. *CERCLA Compliance with Other Laws Manual* (Office of Solid Waste and Emergency Response Directive 9234.1-01]

U.S. EPA 1988b. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (Office of Solid Waste and Emergency Response Directive 9355.3-01.

Yager, Richard M. 2000. Simulated transport and biodegradation of chlorinated ethenes in a fractured dolomite aquifer near Niagara Falls, New York. U.S. Geological Survey, United States. *Water-Resources Investigations*. WRI 00-4275.