FEASIBILITY STUDY REPORT
MAYBROOK LAGOON SITE

TOWN OF HAMPTONBURGH
ORANGE COUNTY, NEW YORK

AUGUST 2006
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LIST OF APPENDICES

1.0 INTRODUCTION

This Feasibility Study (FS) Report has been prepared by Conestoga-Rovers & Associates (CRA) on behalf of the Maybrook and Harriman Environmental Trust (Trust) for the Former Lagoon site (Site) located in Hamptonburgh, New York. The Site location is presented on Figure 1.1. A Site Plan is presented on Figure 1.2.

The RI/FS program for the Site is being completed in accordance with Stipulation Agreement Index No. W3-0006-8102 entered into by Nepera, Inc. (Nepera) and Warner-Lambert Company (WLC) with the New York State Department of Environmental Conservation (NYSDEC). The Stipulation Agreement, signed by the NYSDEC on March 21, 1988, included the following RI/FS objectives:

1. to conduct a Remedial Investigation (RI), including a Risk Assessment (RA), to determine the nature and extent of the release or threatened release of hazardous substances, pollutants or contaminants from the Site; and
2. to perform an FS to identify and evaluate alternatives for the appropriate extent of remedial action, if any, to prevent or mitigate the migration, or the release, or threatened release of hazardous substances, pollutants, or contaminants from the Site.

In order to effectively meet the stated objectives for the Former Lagoon Site RI/FS Study Program, an RI/FS Work Plan (Work Plan) (Dames and Moore, December 1989) was prepared for the review and approval of NYSDEC. The approved Work Plan culminated in the development, review, and finalization of the following Project Plans which were prepared to aid in the effective implementation of the Work Plan:

1. Site Operations Plan (SOP);
2. Quality Assurance Project Plan (QAPP);
3. Health and Safety Plan (HASP);
4. Data Management Plan (DMP); and
5. Appropriate or Relevant and Appropriate Requirements (ARARs) Report.

All Project Plans were approved by NYSDEC prior to the initiation of Site investigative activities.

The Scope of Work (SOW) for the RI/FS is a compilation of all the work tasks to be performed during the study. A summary of the Tasks identified in the SOW is presented in Table 1.1.

The Phase I and Phase II investigations were conducted at the Site in 1991 and 1995, respectively. Additional work plans and investigations were conducted for the RI in 1996, 2001, 2002, and 2003. The results of these investigations are provided in the RI Report submitted to the NYSDEC and the United States Department of Environmental Protection (U.S. EPA) to satisfy the RI Report requirements of Task 10 of the SOW. The approved Final RI Report including the human health risk assessment (HHRA) and the ecological risk assessment (ERA) was submitted to the agencies on June 16, 2006.

This FS was prepared, based on the results of the RI, to identify, develop, and screen potential remedial alternatives for the Site which satisfy the remedial action objectives. The FS was conducted in accordance with the general outline presented in the following document, as well as relevant NYSDEC and U.S. EPA guidance:

> *"Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA", EPA/540/G-89/004, OSWER Directive 9355.3-01, October 1988 (U.S. EPA RI/FS Guidance Document).*

The remedial action objectives consist of media-specific goals for the protection of human health and the environment. The objectives are based primarily on the findings of the HHRA, ERA, and appropriate State and Federal ARARs.

1.1 REPORT ORGANIZATION

The FS report is presented in the following sections:

1.0 Introduction;
2.0 Remedial Investigation Summary
3.0 Development of Preliminary Remedial Goals
4.0 Identification and Screening of Remedial Alternatives;
5.0 Evaluation and Analysis of Remedial Alternatives for Soil;
6.0 Evaluation and Analysis of Remedial Alternatives for Groundwater;
7.0 Summary of Alternatives; and
8.0 Recommended Remedial Action.

An overview of the Site history and background is included in Section 1.0. The RI results are presented in Section 2.0. The purpose of Section 1.0 and 2.0 is to identify the basis for the FS.

The development of preliminary remediation goals (PRGs) for the Site is presented in Section 3.0.

A description of ARARs potentially applicable to the Site, the development of the media-specific remedial action objectives, and the identification and preliminary screening of potential remedial response actions, technologies, and process options is presented in Section 4.0. Each remedial response action and technology is evaluated based upon technical feasibility. Alternative process options are then screened based upon effectiveness, implementability, and cost effectiveness to select a representative process (or processes) for each technology type.

The further development and detailed analysis of remedial action alternatives utilizing the general response actions, technologies, and process options retained from the initial screening conducted in Section 4.0 is presented in Section 5.0 for soil and Section 6.0 for groundwater. The remedial action alternatives are evaluated in terms of the following criteria:

1. compliance with ARARs;
2. the overall protection of human health and the environment;
3. short-term effectiveness;
4. long-term effectiveness;
5. the reduction of toxicity, mobility, and volume of contaminants;
6. implementability; and
7. cost.

1.2 BACKGROUND

The purpose of this section is to present an overview of the Site background to provide the basis for the FS. Additional details are provided in the RI Report (CRA, June 2006).

1.2.1 SITE DESCRIPTION

The Site is located in the Town of Hamptonburgh, Orange County, New York on the southern side of Orange County Highway 4. As indicated on Figure 1.1, the Site is located approximately 1.5 miles southwest of the Town of Maybrook, New York. The 29.3-acre Site includes a portion of Beaverdam Brook and a portion of an abandoned railroad bed. The Site is surrounded by farmland and bounded on the north by Orange County Highway 4. A Site plan is presented as Figure 1.2.

Approximately five acres of the 29.3 acres total property area were affected by historical lagoon operations. Access from Orange County Highway 4 is via a gravel road leading past the former lagoon area to an abandoned railway bed. No buildings or other structures exist at the Site. Beaverdam Brook traverses the western edge of the Site flowing south to the Otter Kill just beyond the southern edge of the Site. The area of the Site where historical lagoon operations occurred is currently fenced around its perimeter (see Figure 1.2).

The Site is in an area of rolling hill topography. Two hills and a portion of a third one, with an approximate elevation of 400 feet (ft) above mean sea level (amsl), occupy the Site. The maximum local relief is on the order of 40 ft. Most of the Site is forested. The former lagoon area was originally stripped of vegetation but is now covered with grasses, wild flowers and brush.

1.2.2 SITE HISTORY

Nepera has historically been a producer of bulk pharmaceutical chemicals, hydrogels and pyridine-based industrial chemical intermediates. The plant facility located approximately 25 miles away at Harriman, New York was originally operated by the Pyridium Corporation beginning in 1942. Since that time, several other companies have owned and operated Nepera.

The Maybrook Site was purchased by the Pyridium Corporation in 1952. The Site was used for wastewater disposal in six constructed lagoons between 1953 and 1967. These lagoons were used to dispose of wastewater generated at the plant site located in Harriman, New York. No wastewater disposal has taken place at the Site since December 1967. A summary of the Site history is presented in Table 1.2.

1.2.3 SITE DEMOGRAPHY

The Site is located on undulating terrain near the confluence of Beaverdam Brook and the Otter Kill. The Site is located within the town boundaries of Hamptonburgh, Orange County, New York. However, the closest town to the Site is Maybrook, New York, which is located approximately 1.5 miles to the northeast. The area in which the Site is located is currently designated as low density rural residential/agricultural, as presented in "Master Plan, Town of Hamptonburgh, County of Orange, State of New York" (Master Plan) (adopted on November 15, 1990). As indicated in Section 1.2.2, the Site was utilized for industrial purposes between approximately 1953 and 1967.

The Site is bounded on the north by Orange County Highway 4. Three residences exist in the immediate vicinity of the Site, one just west of the southwest marsh area, and two to the north/northeast of the Site on the opposite side of Orange County Highway 4. In addition, a residential subdivision has recently been developed to the south of the Site. A Site plan is presented as Figure 1.2.

1.3 BASIS FOR REMEDIAL ACTION

Consistent with the Stipulation Agreement, the RI/FS is to be conducted in a manner consistent with the National Contingency Plan (NCP) and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Remedial action objectives for CERCLA sites are established under the CERCLA Section 121 (Cleanup Standards), as amended by the Superfund Amendment and Reauthorization Act (SARA). Remedial actions are to be in accordance with the requirements of CERCLA Section 121, and, to the extent practicable, with the NCP as codified at 40 CFR Part 300. NCP Section 300.68(i) provides that remedies selected must be cost effective and must effectively mitigate and minimize threats to and provide adequate protection of public health and welfare and the environment. SARA expanded the statutory scope of CERCLA and codified requirements which, prior to the enactment of SARA, were non-promulgated U.S. EPA policies.

The NCP provides the basis to implement the following CERCLA requirements:

- protect human health and the environment (CERCLA Section 121(b));
- comply with the applicable or relevant and appropriate requirements (ARARs) of Federal and State laws (CERCLA Section 121 (d) (2) (A)) or justify a waiver (CERCLA Section 121 (d) (4));

- be cost-effective, taking into consideration short- and long-term costs (CERCLA Section 121 (a));
- utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable (CERCLA Section 121 (b)); and
- satisfy the preference for remedies that employ treatment which permanently and significantly reduce the mobility, toxicity, or volume of hazardous substances as a principal element or provide in the Record of Decision (ROD) an explanation of why treatment was not chosen. (CERCLA Section 121 (b)).

In determining whether remedial action is warranted, based on risk assessment, the following factors must be considered (Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, OSWER Directive 9355.0-30, U.S. EPA , April 22, 1991):

- whether there is a release or threat of a release of a hazardous substance into the environment, or whether there is a release or threat of a release into the environment of a pollutant or contaminant *"which may present an imminent and substantial danger to public health or welfare;"*
- *"Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts. "*
- whether chemical-specific standards that define acceptable risk are violated;
- whether there are non-carcinogenic effects or adverse environmental impacts that warrant action;
- whether there are uncertainties in risk assessment results;
- whether there are possible potential future releases (based on quantities of material and environmental setting and reasonably foreseeable future land use); and
- whether other Site-specific conditions warrant action.

The Risk Assessment Guidance for Superfund (RAGS) states that:

- "When the cumulative current or future baseline cancer risk for a medium is within the range of 10^{-6} to 10^{-4}, a decision about whether or not to take action is a site-specific determination." (RAGS, VI, Part B).

In summary, U.S. EPA guidance generally requires that remedial actions be completed at sites where current or future human health carcinogenic risks are identified to exceed 10^{-4} (or non-carcinogenic hazard index exceeds 1.0). The guidance further recommends that once the necessity to complete remedial actions has been determined, U.S. EPA has expressed a preference for cleanups that achieve a residual carcinogenic risk level of 10^{-6} (cleanups to residual risk levels in the 10^{-4} to 10^{-6} range are determined on a site-specific basis). If the Baseline Risk Assessment does not identify unacceptable human health risks (i.e., carcinogenic risks greater than 10^{-4} or non-carcinogenic hazard index greater than 1.0), it is necessary to assess the requirements for remedial actions to be undertaken based upon the determination of unacceptable environmental risks or the exceedance of chemical-specific standards.

The current risk levels for the Site are below or within the recommended U.S. EPA target range. The exposure scenarios evaluated in the HHRA included exposures to on Site surface soils, groundwater, sediments and surface water, in addition to fish caught in the Otter Kill. As a result, the necessity to complete remediation at the Site for the existing exposures is not necessary. The potential future risk levels for the Site exceed the U.S. EPA target range for several scenarios. The highest risks are associated with future potential groundwater use on Site. Risks are also associated with future potential residential users exposed to the surface soil on Site and construction workers exposed to subsurface soils within the lagoons at the Site. It should be noted that the future use scenarios for the Site are based on highly conservative assumptions which may have resulted in over-estimated risks. Over estimation of the possible risks associated with groundwater are in part attributable to the use of TICs in the HHRA at their concentrations found in individual samples instead of at concentrations averaged across the Site. In general, the TIC concentrations are not reproducible and toxicity information is generally not available for these compounds.

The selection and necessity for remedial action must also consider the probability of the future residential land use scenario. For example, it is considered unlikely that the groundwater on Site, in particular the overburden groundwater, would be utilized for a potable water supply. In any case, existing institutional controls (e.g., NYSDEC groundwater use restrictions) would generally preclude the use of groundwater for domestic uses at these locations.

In the case of soils, the future use of the Site as a Nature Conservancy could include restriction on subsurface activities to limit exposure to construction workers. Therefore, the primary objective of a remedy for the soils on-Site will be to achieve NYSDEC Soil

Cleanup Objectives for the Site-related chemicals of concern (COCs) that are protective of groundwater at the Site.

1.4 FS SCOPE

This FS has been prepared in accordance with the approved Work Plan and Stipulation Agreement which presented the general scope of work for the FS.

The evaluation presented in this FS was conducted in accordance with the NCP, U.S. EPA guidance documents, and relevant NYSDEC guidance. The FS was conducted in accordance with the general outline presented in the U.S. EPA RI/FS Guidance Document.

In accordance with NCP (40 CFR 300), the appropriate remedy will be a "cost effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health and welfare and the environment."

2.0 REMEDIAL INVESTIGATION SUMMARY

The following investigations were conducted during the RI to primarily determine the nature and extent of contamination at the Site and to determine the human health and ecological risks:

- Phase I RI Investigation – 1991;
- Phase II RI Investigation – 1995;
- Treatability Study – 1996;
- Interim Groundwater Monitoring Program – 1997 to present;
- Additional Groundwater Sampling – 2001/2002;
- Natural Attenuation Study – 2001/2002;
- Additional Soil Investigation – 2003; and
- Wetland Delineation – 2003.

The results of these investigations are presented in the RI Report (CRA, 2006). The RI information relevant to the FS including the Site hydrogeology, chemical distribution, the results of the HHRA and ERA, and the results of the Treatability Study and Natural Attenuation Study are summarized in the following sections.

2.1 SITE HYDROGEOLOGY

The following section describes the physical characteristics of the Site based on the extensive investigations that have been undertaken at the Site continuing through the completion of the Additional Soil Sampling Program in May 2003.

2.1.1 SITE GEOLOGY

Utilizing the geologic information obtained from the current and previous investigations, a representative north-south geologic cross-section was developed. The location of the cross-section is presented on Figure 2.1, and the cross-section is presented on Figure 2.2.

The geologic units at the Site are divided into two primary units. These are:

1. Overburden:
    - Topsoil;
    - Fill; and
    - silty sand and gravel.
2. Bedrock:
    - weathered and fractured shale; and
    - shale.

The following sections briefly describe the relevant geologic features at the Site.

2.1.1.1 OVERBURDEN

The overburden soils at the Site consist primarily of fill, topsoil, and silty sand and gravel. The thickness of the overburden at the Site is presented on Figure 2.3. The figure shows that the overburden is thickest in the central area of the lagoons, and the northeast and the southern portions of the Site, where it is over 20 feet thick in some locations. The overburden is thinnest in the area immediately north of the lagoons, where the thickness is approximately 6 feet. The pattern of overburden thickness generally corresponds to the elevation of the bedrock surface, as described in the following section. The overburden composition varies both laterally and vertically across the Site. The topsoil material is generally silty and locally up to 2 feet thick. The overburden material beneath the topsoil consists of layered deposits of varying composition ranging from silt and clay till at several localities to silty sand and gravel. The overburden is composed primarily of sand with varying amounts of gravel, silt, and clay. In the vicinity of the former lagoons, the overburden and upper weathered bedrock were excavated to form the lagoons. During decommissioning of the lagoons, these overburden and bedrock materials were bulldozed into the lagoons as fill. A sand fill layer was subsequently used as backfill overlying the previously excavated fill materials.

2.1.1.2 BEDROCK

The Site lies within the Valley and Ridge physiographic province of the Appalachian Region. The Valley and Ridge physiographic province is characterized by northeast-southwest trending folds and faults. Differential erosion of resistant and soft bedrock has resulted in narrow ridges and valleys (Frimpter, 1972).

The bedrock beneath the Site is comprised of massive to bedded shale of the Middle Ordovician age Normanskill Formation. Regional crustal deformation has produced fractures, folds, and faults. The upper portion of the bedrock is generally highly fractured and weathered to depths of up to 3 feet. The shallow fractures form an interconnected network with both the overburden soils and the deeper, competent bedrock.

The surface of the bedrock at the Site is presented on Figure 2.4. The figure shows that the surface of the bedrock at the Site is roughly saddle-shaped, with two ridges trending northeast-southwest, one to either side of the lagoon area. This feature controls the overburden groundwater flow on the Site.

2.1.2 SITE HYDROGEOLOGY

2.1.2.1 CONCEPTUAL FLOW MODEL

The hydrogeologic nature of the Site is complex due to the varying nature of the overburden deposits and the irregular ground surface and bedrock topography. In general, three hydrostratigraphic units were defined at the Site, the shallow water table aquifer (Shallow Aquifer), localized overburden aquitard (silt and clay till) (Aquitard), and the bedrock aquifer (Bedrock Aquifer).

The groundwater flow at the Site is roughly divided into two aquifers, the Shallow Aquifer and the Bedrock Aquifer. The Shallow Aquifer actually comprises several feet of the weathered bedrock, and two of the bedrock wells, MW-1D-91 and MW4D-91, are included in the Shallow Aquifer. This is appropriate, as the groundwater elevations in these wells are similar to those in the nearby overburden wells.

The undulating nature of the bedrock surface at the Site also makes it likely that groundwater flows from the overburden into the weathered bedrock and back into the overburden in some areas. This can be seen on the cross-section shown on Figure 2.2. Therefore, in the preceding piezometric surfaces and the following discussion of chemistry at the Site, MW-1D-91 and MW-4D-91 will be considered as overburden wells. Groundwater infiltrates into the area of the lagoons and then flows northward and southward in the overburden, where there is likely some exchange with the weathered bedrock. A smaller component of the groundwater flow infiltrates into the bedrock, where it flows generally northward and southward with a smaller component flowing to the west and east.

2.1.2.2 OVERBURDEN

The Shallow Aquifer consists of the permeable overburden and fill deposits and the uppermost highly fractured and weathered portion of the bedrock. An east to west trending groundwater divide is present in the central portion of the former lagoons in the vicinity of Lagoon 4. The groundwater flow in the overburden follows the slope of the bedrock surface, flowing approximately northeast and southwest away from this groundwater divide.

On July 12, 2001, the overburden groundwater elevations ranged from a high of 368.96 feet AMSL at SW-4 to a low of 343.48 feet AMSL at MW-11U-01. On June 3, 2002, the overburden groundwater elevations ranged from a high of 373.08 feet AMSL at SW-4 to a low of 344.39 feet AMSL at MW-11U-01. The results from both sampling rounds indicated a similar groundwater flow pattern in the overburden that is divided into northern (north-northwest flow) and southern (southwest-southeast flow) flow components as shown on Figures 2.5 and 2.6. The second round of groundwater elevations were conducted at a time when there had been a significant amount of precipitation. Therefore, the groundwater elevations on June 3, 2002 are significantly higher than on July 12, 2001 and are considered representative of the 'wet season' conditions. The groundwater flow presented on Figures 2.5 and 2.6 is compatible with the flow from previous investigations.

The Aquitard unit is comprised of the silt and clay till, which is present outside the area of the former lagoons predominantly in the southern portion of the Site, and discontinuous in the north. Where this unit is present, the Shallow Aquifer may be perched, while the Bedrock Aquifer may be confined. The Aquitard unit varies in thickness, where present, from 3 feet (MW-7) to 13 feet (SW-9). The Aquitard unit, where present, reduces the direct vertical recharge from the Shallow Aquifer to the Bedrock Aquifer.

2.1.2.3 BEDROCK

The Bedrock Aquifer consists of the competent shale bedrock underlying the upper weathered bedrock. An east to west trending groundwater divide is also present in the

Bedrock Aquifer beneath and between Lagoons 4 and 5. Groundwater flows north-northwestward and south-southwestward with a minor westerly component.

On July 12, 2001, the bedrock groundwater elevations ranged from a high of 366.68 feet AMSL at MW-2D-91 to a low of 343.36 feet AMSL at MW-11D-01. On June 3, 2002, the overburden groundwater elevations ranged from a high of 370.29 feet AMSL at MW-2D-91 to a low of 344.07 feet AMSL at MW-11D-01. The results from both sampling rounds indicated a similar groundwater flow pattern in the bedrock that is also divided into northern (north-northwest flow) and southern (southwest flow) with a lesser component of flow to the west as shown on Figures 2.7 and 2.8. The second round of groundwater elevations were conducted at a time where there had been a significant amount of precipitation. Therefore, the groundwater elevations on June 3, 2002 are significantly higher than on July 12, 2001 and are considered representative of the 'wet season' conditions. The groundwater flow presented on Figures 2.7 and 2.8 is compatible with the flow from previous investigations.

2.1.2.4 BEAVERDAM BROOK

The surface water elevation at Beaverdam Brook was 343.38 feet AMSL on July 12, 2001 and 344.72 feet AMSL on June 3, 2002. The adjacent groundwater elevations measured at MW-11U-01 were 343.48 feet AMSL in July 2001 and 344.39 feet AMSL in June 2002. The elevations of the surface water in Beaverdam Brook and the groundwater at well MW-11U-01 are very similar indicating the close connection between Beaverdam Brook and the shallow groundwater immediately adjacent to the brook in this area.

2.2 CHEMICAL DISTRIBUTION

During the Phase I and Phase II RI and historical investigations (C.A. Rich, 1986), samples were collected from subsurface soils, surface soils, groundwater, surface water and sediment. During the Site Characterization component of the Treatability Study, conducted in November 1996, additional subsurface samples were collected from the former lagoons. As presented in the RI Report, additional groundwater sampling was conducted in 2001 and 2002 and additional soil sampling was conducted in 2003.

2.2.1 SURFACE AND SUBSURFACE SOILS

For the purpose of evaluating the detected compounds in soils for the RI, the analytical results were compared to appropriate criteria and the exceedances are presented in the following paragraphs. Organic results were compared to the NYSDEC Recommended Soil Cleanup Objectives from the document "Technical and Administrative Guidance Memorandum (TAGM): Determination of Soil Cleanup Objectives and Cleanup Levels" (TAGM #4046, NYSDEC, 1994). Soil Cleanup Objectives for the pyridine compounds were determined by the NYSDEC in a letter dated August 14, 1996.

Inorganics were compared to both the generic residential risk-based criterion (RBC) for U.S. EPA Region III (U.S. EPA, October 2004) and background soil concentrations using the methods presented in the Additional Soil Investigation Work Plan. The Additional Investigation included the collection of 32 soil samples in 2003 from the surrounding area to use as background concentrations for the parameters. Lead did not have a Region III RBC, so the U.S. EPA Region IX Preliminary Remediation Goal (PRG) for residential soil (U.S. EPA, October 2002) was used. Calcium, magnesium, potassium, and sodium do not have RBCs, as they are essential nutrients.

A summary of the VOCs and SVOCs exceedances of NYSDEC Soil Cleanup Objectives for surface soil and subsurface soil is presented in Tables 2.1 and 2.2, respectively, for the COCs for the Site.

2.2.1.2 SURFACE SOILS

Surface soil samples were collected from each of the six former lagoons and the Site access road during the Phase II RI. The eight investigative samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, cyanide, TOC and Site-specific parameters. A summary of the exceedances of NYSDEC Soil Cleanup Objectives is presented in Table 2.1 for the COCs detected in surface soil.

No COCs were detected at concentrations exceeding the Recommended NYSDEC Soil Cleanup Objectives in surface soil. Site-specific parameters such as pyridine, 2-aminopyridine, and alpha-picoline were not detected in the surface soil samples.

2.2.1.3 SUBSURFACE SOILS

Subsurface soil samples were collected during the Phase I and II RI in 1991 and 1995, the Treatability study in 1996 and for the Additional Investigation in 2003. Soil samples selected for chemical analysis were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, cyanide, and Site-specific parameters with the exception of the Additional Investigation in 2003, for which pesticides/PCBs, TAL metals, and cyanide were analyzed. Additionally, mercury speciation was performed on selected samples from the 2003 Additional Investigation.

Similarly to the surface soil samples, organic results were compared to the Recommended NYSDEC Soil Cleanup Objectives, and inorganics were compared to both U.S. EPA Region III RBCs and site-specific background soil concentrations.

A summary of the exceedances of NYSDEC Soil Cleanup Objectives is presented in Table 2.2 for the COCs detected in subsurface soil. Exceedances of NYSDEC Soil Cleanup Objectives are shown on Figure 2.9. The area of impacted soil is shown on Figure 2.10.

The lagoon soil samples exhibited the following VOC COCs that exceeded the Recommended NYSDEC Soil Cleanup Objectives:

- acetone
- benzene
- chlorobenzene
- ethylbenzene
- toluene
- xylene

SVOC COCs that exceeded the Recommended NYSDEC Soil Cleanup Objectives are the following:

- 2-aminopyridine
- 2-picoline
- pyridine
- aniline
- benzoic acid
- bis(2-ethylhexyl)phthalate
- phenol

Pesticides that were detected in the soil samples were determined not to be Site-related.

The only PCB detected above the criteria was Aroclor-1254, which was also only found in Lagoon 2.

Inorganics that were reported in soil samples at concentrations exceeding the Region III RBCs in one or more samples included arsenic, manganese, iron, mercury, aluminum, and antimony. However, with the exception of mercury, these parameters were found to be consistent with the observed range of background inorganic concentrations.

Based on the results of the mercury speciation analysis for soil, a value of 2.4 percent methylmercury was determined to represent a conservative methylmercury percentage for soil samples subjected to total mercury analysis for the purposes of calculating an exposure estimate for methylmercury in the HHRA and ERA. Based on the results of the HHRA, mercury was determined not to be a COC for the Site.

2.2.2 GROUNDWATER QUALITY

The following section presents a description of the groundwater quality in the overburden and bedrock aquifers at the Site. The description is primarily based on the July 2001 and June 2002 data. A summary of exceedances of the N.Y. State Class GA groundwater criteria is presented in Table 2.3. Overall exceedances for VOCs and SVOCs for the overburden and bedrock wells are presented on Figures 2.11 and 2.12, respectively.

2.2.2.1 VOCs

2.2.2.1.1 OVERBURDEN

Five VOCs (benzene, chlorobenzene, ethylbenzene, toluene, and xylene) were detected at levels exceeding the New York State Groundwater Criteria in samples collected from one or more monitoring wells. In July 2001, exceedances were encountered at the following monitoring well locations: benzene (MW-2, MW-3, MW-4, MW-7, MW-1U-91, MW-1D-91, SW-2, SW-3, SW-4, SW-8, and SW-9); chlorobenzene (MW-2, MW-3, MW-7, MW-1U-91, MW-1D-91, and SW-2); ethylbenzene (MW-3, MW-7, and SW-4); toluene (MW-7); and xylene (MW-3, MW-7, and SW-4). In June 2002, exceedances were encountered at the following monitoring well locations: benzene (MW-3, MW-4, MW-7, MW-1U-91, MW-1D-91, MW-8U-95, SW-2, SW-4, and SW-6); chlorobenzene (MW-3, MW-7, MW-1U-91, MW-1D-91 and SW-2); ethylbenzene (MW-3 and MW-7); toluene (MW-7); and xylene (MW-3 and MW-7).

Benzene had the most detections of the VOCs detected in the overburden groundwater. The chemical isoconcentration contours for benzene in the overburden groundwater at the Site for July 2001 and June 2002 are presented on Figures 2.13 and 2.14, respectively. The contours shown on these figures vary slightly between the dry season (July 2001) and wet season events (June 2002). This difference may be attributable to the higher groundwater levels (approximately 4 feet higher) in 2002.

2.2.2.1.2 BEDROCK

Six VOCs (acetone, benzene, chlorobenzene, ethylbenzene, toluene, and xylene) were detected at levels exceeding the New York State Groundwater Criteria in samples collected from one or more monitoring wells. In July 2001, the six VOCs exceedances were encountered at the following monitoring well locations: acetone (DW-1-95 and DW-2-95); benzene (MW-2D-91, DW-1-95, and DW-2-95); chlorobenzene (MW-2D-91); ethylbenzene (MW-2D-91); toluene (MW-5D-95); and xylene (MW-2D-91). In June 2002, five VOC exceedances were encountered at the following monitoring well locations: acetone (DW-1-95 and DW-2-95); benzene (MW-2D-91, DW-1-95, and DW-2-95); chlorobenzene (MW-2D-91); ethylbenzene (MW-2D-91); and xylene (MW-2D-91).

Similar to the overburden, benzene had the most detections of the VOCs detected in the bedrock groundwater. The chemical isoconcentration contours for benzene in the bedrock groundwater at the Site for July 2001 and June 2002 are presented on Figures 2.15 and 2.16, respectively. Similar to the overburden results, there is some variability of the benzene contours from 2001 to 2002. However, within the bedrock the variations are minimal.

2.2.2.2 SVOCs

2.2.2.2.1 OVERBURDEN

Two SVOCs (2-aminopyridine, and 4-chloroaniline) were encountered at levels exceeding the New York State Groundwater Criteria in samples collected from one or more monitoring wells. In July 2001, exceedances were encountered at the following monitoring well locations for 2-aminopyridine (MW-2, MW-3, MW-4, MW-7, MW-1U-91, MW-1D-91, MW-8U-95, SW-2, SW-4, and SW-8). In June 2002, exceedances were encountered at the following monitoring well locations for 2-aminopyridine (MW-3, MW-7, MW-1U-91, MW-1D-91, SW-2, SW-4, and SW-6). 4-Chloroaniline was detected at one well (MW-7) at a concentration exceeding New York State Groundwater

Criteria. However, 4-chloroaniline was not detected at any other location for either sampling event or in samples collected from the bedrock groundwater.

The chemical isoconcentration contours for 2-aminopyridine in the overburden groundwater at the Site for July 2001 and June 2002 are presented on Figures 2.17 and 2.18, respectively. There is some variability of the contours from 2001 to 2002, with the extent of the area above criteria larger in 2002 than in 2001 which is most likely attributable to the seasonal change in groundwater levels between the dry season and wet season events.

2.2.2.2.2 BEDROCK

Two SVOCs (2-aminopyridine and bis(2-ethylhexylphthalate) were encountered at levels exceeding the New York State Groundwater Criteria in samples collected from one or more monitoring wells. In July 2001, the exceedance for 2-aminopyridine was encountered at monitoring well MW-2D-91. In June 2002, the exceedance for 2-aminopyridine was encountered at monitoring well location DW-1-95. Bis(2-ethylhexyl) phthalate was reported at a concentration slightly exceeding the New York State Groundwater Criteria at well DW-2-95 for the sample collected in July 2001. Bis(2-ethylhexyl) phthalate was not detected at any other location for either sampling event in samples collected from the bedrock groundwater.

The chemical isoconcentration contours for 2-aminopyridine in the bedrock groundwater at the Site for July 2001 and June 2002 are presented on Figures 2.19 and 2.20, respectively. There is some variability of the contours from 2001 to 2002. However, within the bedrock the variations are minimal.

2.2.2.3 METALS

2.2.2.3.1 OVERBURDEN

Five metals (arsenic, iron, lead, manganese, and sodium) were encountered at levels exceeding the New York State Groundwater Criteria in samples collected from one or more monitoring wells. Arsenic and lead were reported at a concentration slightly exceeding the New York State Groundwater Criteria at one overburden well location each (MW-7 for arsenic and MW-4 for lead). However, arsenic and lead were not detected at any other location for either sampling event or in samples collected from the bedrock groundwater at concentrations exceeding the applicable criteria. The concentrations of arsenic, iron, lead, manganese, and sodium are considered to be representative of these naturally occurring metals in the area of the Site.

2.2.2.3.2 BEDROCK

Four metals (antimony, iron, manganese, and sodium) were encountered at levels exceeding the New York State Groundwater Criteria in samples collected from one or more monitoring wells. Antimony was reported at a concentration exceeding the New York State Groundwater Criteria at bedrock well MW-9D-01 for the July 2001 sample. However, antimony was not detected at any other location for either sampling event for samples collected from the overburden and bedrock groundwater. Following the 2001 round, a confirmatory groundwater sample was collected and analyzed for antimony from well MW-9D-01. Antimony was not detected in this confirmatory sample. The concentrations of iron, manganese, and sodium are considered to be representative of these naturally occurring metals in the area of the Site.

2.2.3 VILLAGE OF MAYBROOK SUPPLY WELLS

The Village of Maybrook currently use wells 1, 2, and 3 as their municipal water supply. These wells are monitored by the Village of Maybrook on a quarterly basis for the Site-related COCs. COCs have not been detected in the samples collected from the Maybrook supply wells to-date. Therefore, there is no indication of a Site-related impact at the Village of Maybrook supply wells based on the results of the ongoing sampling program.

2.2.4 NYSDOH RESIDENTIAL WELL SAMPLING PROGRAM

The New York State Department of Health (NYSDOH) conducts a groundwater monitoring program for the potable water supply wells for the residents closest to the Site. Currently, there are no Site-related COCs detected in the residential wells based on the results of the NYSDOH monitoring program.

2.2.5 SURFACE WATER QUALITY

Two rounds of surface water samples were collected during the 1991 Phase I investigation. All samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, cyanide, Total Petroleum Hydrocarbons, and Site-specific parameters. The first sampling round was collected during low flow conditions (period of no rainfall) and the second sampling round was collected during high flow conditions (within 48 hours of a rainfall event that produced runoff from the Site).

Three rounds of surface water samples were collected during the 1995 investigation. All samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, cyanide, hardness, chloride and Site-specific parameters. The first sampling round was collected during a period of low flow on June 5, 1995 (period of no rainfall). The second sampling round was collected during a period of relatively high water table elevations on June 14, 1995. The third round was collected during high flow conditions (within 48 hours of a rainfall event that produced runoff from the Site) on June 19, 1995.

Sample locations and analytical results are presented in the RI Report.

The surface water quality data for the Phase I and Phase II investigations indicates that the Site has no measurable impact on parameter concentrations in Otter Kill, Beaverdam Brook or the northeast marsh. Comparable concentrations of detected organics and inorganics were reported at both upstream and downstream sampling locations. Pesticides/PCBs were not detected in any of the surface water samples collected during the 1991 and 1995 investigations.

2.2.6 SEDIMENT

During the Phase I RI, sediment samples were collected from upstream, downstream and adjacent to the Site locations along Beaverdam Brook and Otter Kill, the marshy area northeast of the Site, and drainage swales in the southeast area of the Site. Samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, cyanide, TPH and Site-specific parameters.

During the Phase II RI, sediment samples were collected at two locations to investigate the sediment quality in the northeast marsh and southwest marsh, respectively. These samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, TOC, and Site-specific parameters.

Sample locations and analytical data are presented in the RI Report.

VOC results for sediment samples collected from upstream and downstream locations along Beaverdam Brook and Otter Kill in 1991 indicate no measurable Site-related impact.

Several SVOCs were detected in the sediment samples collected from the area of the Site during the 1991 investigation, with the majority of the compounds and the highest reported concentrations in samples from the northeast marsh. PAHs and phthalate esters were detected at maximum concentrations of 27,000 μg/kg and 9,600 μg/kg, respectively. These compounds were also reported at lower concentrations in the sediment sample collected from the drainage ditch immediately south of the former lagoons (Location 5).

Several of the SVOCs reported for samples from the northeast marsh were also detected at lower concentrations in the sediment sample taken from Beaverdam Brook at the southwest corner of the Site (Location 4). Results for downstream sampling Locations 6 and 7 indicate the absence of SVOCs in sediment at these locations along the Otter Kill.

Several SVOCs, primarily PAHs, were detected at similar concentrations in the two sediment samples SDII-2 and SDII-12 collected in 1995. These SVOCs were reported at concentrations ranging from 110 J μg/kg to 990 J μg/kg. The PAH concentrations were generally one order of magnitude lower at location SDII-2 compared to 1991 sampling locations located approximately 900 feet to the northwest.

Elevated levels, compared to background, were detected for the following inorganic parameters for several sediment samples collected during the 1991 investigation: antimony (256 mg/kg), cadmium (22.7 mg/kg), copper (91.6 mg/kg), silver (66.5 mg/kg), barium (221 mg/kg), lead (293 mg/kg and 293 mg/kg) magnesium (17,600 mg/kg) and manganese (3,070 mg/kg).

Inorganic parameter concentrations for samples collected from SDII-2 and SDII-12 were generally consistent with the results for the 1991 background locations 3 and 6. Beryllium and cadmium detected in the 1991 samples, were not detected in the 1995 sediment samples. Arsenic and barium were reported at lower concentrations in the sediment samples collected in 1995 compared to the 1991 samples.

Mercury was reported at concentrations ranging from 0.14 J μg/kg to 0.33 J μg/kg in sediment samples collected from SDII-2 and SDII-12 during the RI.

2.3 CHEMICAL FATE AND TRANSPORT

The potential chemical migration pathways which exist at the Site include:

- overburden and bedrock groundwater flow;
- surface water runoff;
- atmospheric dispersion from surface water and surface soils; and
- tracking of surface soils.

The pathways are discussed in further detail in the following subsections.

2.3.1 GROUNDWATER CHEMICAL MIGRATION

Site-related chemicals have been detected in the groundwater in both the overburden and bedrock aquifer units in the vicinity and downgradient of the former lagoons, as described in Section 2.2.

Transport pathways in groundwater for Site-related chemicals include the Shallow Aquifer unit and the Bedrock Aquifer unit, as discussed in Section 2.1.

2.3.1.1 SHALLOW AQUIFER UNIT

The Shallow Aquifer unit consists of the overburden and uppermost 2 to 3 feet of the fractured bedrock. Flow within this aquifer unit is controlled by the divide which runs through Lagoon 4 in an east-west orientation such that groundwater flows either to the north or south of the divide.

The shallow groundwater flow from both the north and the south areas can be calculated using Darcy's equation given by:

$$Q = KiA$$

where:

Q = the flow rate (ft^3/day)

K = average hydraulic conductivity (ft/day)

i = hydraulic gradient (ft/foot)

A = cross sectional area perpendicular to the flow path (ft^2)

The saturated thickness in the north section was estimated to range from 3 feet (dry season) to 10 feet (wet season). The saturated thickness in the south section was estimated to range from 3 feet (dry season) to 9 feet (wet season).

The length of the perpendicular cross-section flow zones for the northern and southern flow components were estimated to be 480 feet and 780 feet, respectively.

The calculated flow to the north ranges between 1,080 and 3,600 gal/day and to the south ranges between 870 and 2,600 gal/day in the Shallow Aquifer.

2.3.1.2 BEDROCK AQUIFER UNIT

The Bedrock Aquifer unit consists of the deeper fractured bedrock. Groundwater flows radially within the bedrock aquifer unit. The flow is primarily to the north and south with a minor westerly component.

The flux through the Bedrock Aquifer was estimated in the RI Report to range from 290 to 460 gal/day for the north component and from 3,090 to 4,820 gal/day for the south component.

The shallow bedrock groundwater discharges to the surface west of the Site to Beaverdam Brook, and south of the Site to Otter Kill.

The north component of shallow bedrock groundwater flow may discharge to Beaverdam Brook north of the Site.

2.3.2 CHEMICAL MIGRATION VIA SURFACE WATER

Chemicals present in surface soil and sediments are potentially subject to transport via surface water runoff. Migration may occur by physical transport of the soils or by dissolution. This section presents an evaluation of the potential for migration of chemicals off Site via this pathway.

Surface soil samples collected during the Phase II RI in 1995 indicate the presence of VOCs, SVOCs, and PCBs at very low concentrations and hence, transport of chemicals from the general Site area via surface water runoff, is considered to be minimal.

The VOCs detected in samples taken at shallow depths, exhibited relatively high aqueous solubilities and low soil adsorptivities (low K_{oc}). This indicates that these compounds have the potential to be transported via surface water runoff in the dissolved phase in addition to the physical transport of the soil particles. Pesticides and PCBs exhibit a low aqueous solubility and a high adsorptive capacity for soils (high K_{oc}) and hence, have a far less potential for transport in the dissolved phase.

Surface water generally flows across the lagoons in a southerly direction to the base of the abandoned railway grade midway between the Site. Surface water flow tends either east or west following the railway grade, to a culvert to the east, or to Beaverdam Brook to the west. Surface water which travels east either collects in the marsh area north of the culvert, or travels through the culvert to the marsh area south of the abandoned railway grade. Surface water in the marsh area will either infiltrate or evaporate. Sediments in the surface water runoff will likely be deposited in the marsh areas.

The presence of the chemicals in the drainage ditch sediments (Locations 5 and 8) indicates that chemicals are being transported via surface water runoff in the ditch south of the Site. The primary group of chemicals that were detected, PAHS, are likely attributable to the abandoned rail bed. Further transport of these chemicals may occur during significant rainfall events with ultimate discharge to Beaverdam Brook and Otter Kill. Chemicals, primarily PAHs unrelated to the Site, present in the marsh area northeast of the Site (Locations 2 and SSII-2) could also be further transported via surface water runoff for ultimate discharge to Beaverdam Brook.

Surface water flow in Beaverdam Brook and Otter Kill has the potential to transport Site-related chemicals away from the Site. Subsurface groundwater flow beneath the Site may discharge to either Beaverdam Brook or Otter Kill.

2.3.4 ATMOSPHERIC DISPERSION

The potential for atmospheric dispersion of chemicals at the Site is due to the release of chemicals from the surficial soils, exposed sediment and surface water to the atmosphere. The release of chemicals is affected by either volatilization or atmospheric entrainment of chemicals adsorbed onto particulate matter (dust).

The SVOCs detected in the surface soil at the Site, have a relatively low level of volatilization as indicated by the vapor pressure and Henry's law constants presented in the RI Report. Vapor pressures are orders of magnitude below levels for compounds considered volatile with the exception of alpha-picoline and pyridine. Alpha-picoline and pyridine were detected in the sample from TP-11a (Lagoon 1). Pyridine has a high aqueous solubility (1.0×10^6 mg/L) and a high affinity for soil, thereby minimizing the potential for volatilization.

The pesticides and PCB (Aroclor-1254) compounds detected in sample TP-41 have a very low potential for volatilization due to their low vapor pressures and high adsorption capabilities (high Koc).

Volatile compounds detected in the surface soils and exposed sediment have a relatively high potential for volatilization as indicated by the high vapor pressures (6 to 455 mm Hg) and Henry's law constants ($>10^{-5}$ $atm.m^3/mol$). However, VOCs were detected at generally low concentrations (less than 500 µg/kg) in exposed sediment and the resulting atmospheric concentrations would be negligible.

VOCs detected at location TP-11a have somewhat higher concentrations (32 µg/kg to 26,000 µg/kg) and may potentially impact the air quality in the immediate vicinity of this sampling point. However, field measurements of organic vapors taken during the test pit excavation program indicated readings at background levels in the breathing zone. During test pit excavations, the highest vapor reading measured was 7 ppm for the subsurface sludge sample submitted for analysis from location TP-11a. Based on these organic vapor results, it is concluded that atmospheric concentrations of Site-related chemicals is negligible.

The potential for atmospheric entrainment of chemicals adsorbed onto particulate matter is considered minimal. The central and east central portions of the Site where the former lagoons were located have a cover consisting primarily of grass, immature herbaceous plants and immature pioneer tree species. This cover would tend to minimize the amount of airborne particulates and stabilize the surface soils at the Site. Any particulate dispersion would be minimized by the surrounding heavily wooded area.

2.3.5 CHEMICAL MIGRATION VIA INADVERTENT TRACKING

Tracking of chemicals at the Site would be caused by trespassers or wildlife walking across soils or through surface water contaminated with Site-related chemicals or potentially by vehicular traffic through the Site. Site access from County Road 4 is restricted by a locked gate. Vehicular traffic is therefore minimized. During the Site investigation, tire tracks or any other evidence of vehicular traffic was not observed.

Although the Site is not restricted to trespassers, pedestrian traffic is considered minimal. Evidence of wildlife at the Site has been noted. Deer and rabbits may potentially track surface soils and surface water across the Site. However, the total mass of chemicals potentially transported via this pathway would be negligible.

2.4 BASELINE RISK ASSESSMENT

The HHRA was conducted as part of the RI process to evaluate the potential public health and environmental risks and/or hazards associated with chemicals in the surface and subsurface soils, groundwater, surface water, sediments, and air at the Site.

The results of the HHRA are presented in the RI Report (CRA, June 2006) and are summarized in the following subsections.

2.4.1 CHEMICALS OF POTENTIAL CONCERN

Chemicals of potential concern (COPCs) include chemicals most likely to be related to the Site, and to pose the greatest potential risk to public health. In general, detected constituents were identified as COPCs based upon their concentrations, and known toxicity characteristics. Consistent with U.S. EPA methodology, non-Site-related naturally occurring and anthropogenic chemical constituents were also included as COPCs.

For soils, a comparison to U.S. EPA Region III Risk Based Concentrations (RBCs) (U.S. EPA, 2006) was conducted for each detected chemical. The comparison of the maximum detected concentration of each chemical in soil to the human health based RBC criteria for residential land use was used as a conservative approach to identify COPCs in soil. RBC criteria for carcinogenic chemicals are based on a risk of 1×10^{-6}, while RBC criteria for non-carcinogenic chemicals are based on a hazard index (HI) of 1. The non-carcinogenic RBC criteria were reduced by an order of magnitude to reflect an HI of 0.1 to take into consideration exposure to multiple chemicals.

2.4.2 POTENTIAL EXPOSURE PATHWAYS

The current potentially exposed population includes persons who may infrequently trespass on the Site for recreational purposes. These trespassers may be hunting, hiking, or fishing. In addition, off-Site groundwater is currently used as a source of potable water by residents in the vicinity of the Site.

The intended future land use for the Site is a Nature Conservancy. The conveyance of the Site as a Nature Conservancy will ensure that the future land use is maintained and restricted to uses consistent with a park setting. Therefore, a future park user was evaluated in the HHRA. Additionally, it is possible that the development of the Site as a Nature Conservancy may necessitate that some below-grade excavation or construction be required. As a result, a future potential construction worker exposure to subsurface soils was evaluated.

A future hypothetical on-Site residential exposure scenario was included to provide baseline risks ans hazards associated with the most conservative future land use on Site.

Lagoon 6 soils were evaluated separately in the HHRA due to the isolated occurrence of the tentatively identified compound, dichlorobiphenyl isomer, detected in the surficial soils of Lagoon 6.

For both current and future conditions, the exposure scenarios that were evaluated in the HHRA are summarized as follows:

	Media of Concern	*Exposure Route*	*Current Exposure Scenario*	*Future Exposure Scenario*
1.	On-Site Surface Soil (excluding Lagoon 6)	dermal contact & incidental ingestion	trespasser/hiker	parkland user (child & adult), maintenance worker, residents (child & adult)
2.	On-Site Soils (excluding Lagoon 6)	dermal contact & incidental ingestion		construction worker
3.	On-Site Surface Soil (Lagoon 6)	dermal contact & incidental ingestion	trespasser/hiker	parkland user (child & adult), maintenance worker, residents (child & adult)
4.	On-Site Soils (Lagoon 6)	dermal contact & incidental ingestion		construction worker
5.	Sediments			
	• Northeast Marsh Area	dermal contact & incidental ingestion	occasional visitor/ hiker	
	• Southwest Marsh Area	dermal contact & incidental ingestion	trespasser/hiker	recreational user (child & adult)

	Media of Concern	*Exposure Route*	*Current Exposure Scenario*	*Future Exposure Scenario*
6.	Surface Water			
	• Northeast Marsh Area	dermal contact	occasional visitor/ hiker	
	• Beaverdam Brook	dermal contact	trespasser/hiker	recreational user (child & adult)
	• Otter Kill	dermal contact	trespasser/hiker	recreational user (child & adult)
7.	Fish			
	• Otter Kill	fish consumption		recreational anglers
8.	Air			
	• Soil-to-Air	Inhalation		
9.	Groundwater			
	• Off-Site	dermal contact, ingestion, inhalation	residents (child & adult)	
	• On-Site	dermal contact, ingestion, inhalation		residents (child & adult)

2.4.3 ESTIMATED CARCINOGENIC RISK AND NON-CARCINOGENIC HAZARD

The additional lifetime cancer risks and the non-carcinogenic hazard index were calculated for each of the potential exposure scenarios (as well as cumulative scenarios). The lifetime cancer risks were compared to the U.S. EPA target range of 1.0×10^{-6} to 1.0×10^{-4} and the non-carcinogenic hazard values were compared to the level of concern (1.0).

A summary of the calculated additional lifetime cancer risks and non-carcinogenic hazard indices for each exposure scenario for both the Central Tendency (CT) and Reasonable Maximum Exposure (RME) assumptions is presented in Table 2.4. The CT assumptions present the average or mean value for the assumptions and approximate the most probable exposure conditions. The RME presents conservative assumptions that generally utilize the 90th to 95th percentile assumptions, depending upon the available data.

The lifetime RME cancer risk for all current and future reasonable exposures were calculated to be below or within the U.S. EPA target cancer risk range of 1.0×10^{-6} to 1.0×10^{-4} with the following exceptions:

- future residents (child and adult) exposure to surface soils in Lagoon 6;
- future residents (child and adult) exposure to on-Site groundwater;
- present/future construction worker to soils; and
- future recreational anglers (child and adult) exposure to surface water in Otter Kill.

The estimated lifetime RME cancer risk values for each of the above exceptions are 1.6E-04, 1.4E-03, 1.5E-04, and 4.2E-04, respectively.

The estimated non-carcinogenic hazard indices are below the level of concern (1.0) for all potential current exposure pathways with the exception of the following:

- future resident (child) exposure to surface soil;
- future resident (child and adult) exposure to surface soils in Lagoon 6;
- future construction worker exposure to soils;
- future construction worker exposure to soils in Lagoon 6;
- future recreational user (child) exposure to sediments in the Southwest Marsh Area;
- future recreational anglers (child and adult) exposure to surface water in Otter Kill;
- current resident (child and adult) exposure to off-Site groundwater; and
- future resident (child and adult) exposure to on-Site groundwater.

The estimated RME non-carcinogenic hazard indices for the child resident exposure to surface soil and child and adult resident exposure to Lagoon 6 surface soil are 3.4, 14.1, and 1.7, respectively. For the construction worker exposure to soils on-Site and Lagoon 6 soils, the estimated hazard indices were 120 and 4.8, respectively. A hazard index of 1.3 was calculated for the recreational user (child) exposure to sediments in the Southwest Marsh Area.

The estimated hazard indices for the child and adult recreational angler exposure to surface water in Otter Kill were 11 and 7.4, respectively. The child and adult on-Site resident exposure to groundwater were 685 and 312, respectively.

The estimated RME hazard indices for the child and adult off-Site resident exposure to groundwater were 4.6 and 2.1, respectively, based on a single detection of 2-aminopyridine in off-site groundwater in September 2003. All other off-site groundwater sample locations were non-detect for this parameter. 2-Aminopyridine has not been detected at any off-Site location for the quarterly groundwater monitoring conducted by the NYSDOH since September 2003. The current human health risks associated with off-Site groundwater are, therefore, considered to be acceptable.

In addition, the Village of Maybrook has not identified any site-related parameters in their quarterly monitoring program to date in the municipal supply well immediately northeast of the Site.

2.5 ECOLOGICAL RISK ASSESSMENT

An ecological risk assessment (ERA) was conducted to evaluate the potential risks to ecological receptors exposed to site-related chemicals in on-site soil and the surface water and sediments of Beaverdam Brook, Otter Kill, and the Northeast Marsh. The ERA was conducted in three phases.

The first phase was a screening-level assessment, which consists of Steps 1 and 2 of the U.S. EPA's eight-step process for conducting ecological risk assessments (U.S. EPA, 1997). In this phase, the maximum concentrations detected for each media (soil, surface water, and sediment) were compared to conservative ecological benchmark concentrations, referred to as ecological screening values (ESVs). Constituents with maximum concentrations that exceeded their conservative benchmark concentrations were identified as chemicals of potential concern (COPCs) and carried forward to the next phase for further evaluation. Constituents that were detected in one or more samples and bioaccumulate, but lacked an ESV were also identified as COPCs. The screening-level assessment identified benzoic acid, several TIC SVOCs, Aroclor 1254, and twenty metals as COPCs in surficial soil. Chemicals identified as COPCs in the surface water of Beaverdam Brook and the Otter Kill were acetone, two phthalates (bis(2-ethylethyl)phthalate, di-n-octylphthalate), several TIC SVOCs, and nine metals. Chemicals identified as COPCs in the sediment of Beaverdam Brook and Otter Kill were acetone, six PAHS, and twenty metals. For the surface water of the Northeast Marsh, acetone, two TIC SVOCs, and seven metals were identified as COPCs. For the sediment of the Northeast Marsh, acetone, two SVOCs, and 15 metals were identified as COPCs.

The second phase of the ERA was the problem formulation for the baseline ERA. This phase is Step 3 of the eight-step U.S. EPA process. In this phase, the applicability of the ESVs to site-specific conditions was evaluated and, if appropriate, assumptions were replaced with benchmark concentrations more applicable to site-specific conditions. For metals, which are naturally occurring in the environment, background concentrations were considered. Surrogate chemicals were identified for those constituents identified as COPCs because they did not have an available ESV. The refinement process identified a dichlorobiphenyl isomer, Aroclor 1254, and mercury as COPCs in soil to be carried forward to the baseline assessment. For the surface water of Beaverdam Brook and Otter Kill, the COPCs carried forward were bis(2-ethylhexyl)phthalate and di-n-octylphthalate, and cyanide. For the sediment of Beaverdam Brook and Otter Kill, copper, selenium, and thallium were identified as COPCs carried forward to the baseline assessment. In the problem formulation step, the Northeast Marsh was eliminated as an assessment area because there is no complete pathway for the migration of site-related chemicals from source areas to the Northeast Marsh.

The third phase of the ERA was the baseline assessment. In this phase, the potential risk to soil invertebrates and terrestrial plants were evaluated considering the range of ecological benchmarks for these receptors. Risk to avian and mammalian piscivores exposed to COPCs in the surface water and sediment was evaluated using food chain models. Risk to mammalian herbivores and avian and mammalian insectivores and carnivores were also evaluated using food chain models. The baseline ERA concluded that the potential for risk to soil invertebrates and terrestrial plants was limited to isolated locations, primarily in the area of Lagoon 6. The food chain models of avian and mammalian piscivores were within acceptable limits when reasonable assumptions for area use (i.e., home range size relative to the size of the assessment area) were considered. Similarly, the potential for risk to mammalian herbivores and avian and mammalian insectivores and carnivores were within acceptable limits when reasonable assumptions for area use were considered. For mercury, the food chain models for insectivores and carnivores based on the more toxic organic form identified some potential for risk to insectivores and carnivores. Based on inorganic mercury, the predominant form on-site, the potential for risk to insectivores and carnivores is within acceptable limits.

Based on the results of the ERA, significant risks to ecological receptors exposed to Site-related chemicals were not identified for Site soils, surface water, or sediment. Surficial exposures related to the presence of PCBs and mercury in Lagoon 6 indicated a potential for risks to insectivores and small vertebrate carnivores. However, considering the population densities of potential receptors and the fact that insectivores and small vertebrate carnivores would have a much larger home range than the area of Lagoon 6 (i.e., it was assumed in the ERA that ecological receptors spend 100 percent of their time in Lagoon 6), the potential for ecological risks is negligible. The remainder of the Site poses no significant risk to ecological receptors from exposure to PCBs, mercury or any other Site-related parameter in surface or subsurface soils.

2.6 RESULTS OF THE TREATABILITY STUDY

Prior to the completion of the FS, the NYSDEC and U.S. EPA agreed to the completion of a Treatability Study in support of the SVE and bioremediation treatment technologies for the soils requiring remediation at the Site. The Soil Vapor Extraction/Bioremediation Bench Scale Treatability Study Report (Treatability Study Report) dated September 25, 1997 presents the results of the Treatability Study.

The objectives of the Treatability Study, are summarized below:

i) to assess the feasibility of the SVE and bioremediation technologies for Site-specific application, and to determine the effectiveness of these technologies to meet NYSDEC Soil Cleanup Objectives; and

ii) to further delineate the following physical and chemical characteristics of the soils in the former lagoon area to support the Remedial Design (RD) of the remedy:

- determine existing environmental conditions, air permeability, nutrient and carbon source levels, and potential future soil enhancement requirements;
- evaluate soils for the presence of indigenous microbial populations;
- evaluate the bioactivity in soils alone and in soils supplemented with nutrients and/or additional carbon source; and
- collect sufficient data to design and optimize a full-scale SVE/bioremediation system.

Phase I of the Treatability Study consisted of a literature review of the suitability of the application of SVE and/or bioremediation to the Site-related COCs.

Phase II of the Treatability Study included bench scale testing. In order to characterize the impacted soils and sludges at the Site for nutrients, indigenous microbial levels, and soil permeability, to determine whether nutrients/carbon supplements and soil amendments are required for implementing SVE or bioremediation at the Site, and to determine the rate of removal of the COCs, the bench scale treatability testing was performed in the following four stages:

- Stage I - Soil Characterization, Microbial Evaluation, and Soil Temperature Evaluation;
- Stage II - Soil Amendment Test;
- Stage III - Respirometric Testing; and

- Stage IV - Soil Column Testing.

Stage I involved the Soil Characterization and Microbial Evaluation of soil and sludge samples taken from test pits completed in the area of the former lagoons. A Soil Temperature evaluation was also conducted to determine the seasonal variation in the subsurface soil temperature and to evaluate the variation in temperature with respect to its effect on the rate of biodegradation and SVE.

Stage II involved the Soil Amendment Testing. This stage evaluated the requirements to add bulking agents to the soil/sludge mixture to optimize the application of SVE and bioremediation utilizing a biocell approach.

Stage III involved Respirometric Testing. Samples were prepared to represent the amended soil/sludge mixtures which would typically be expected at full scale. The strategy was to perform respirometric testing on optimized/amended soil/sludge samples exhibiting different levels of COCs and indigenous microorganisms.

Stage IV involved the Soil Column Testing. The Soil Column Testing was designed to evaluate the effectiveness of the SVE and bioremediation technologies to meet the NYSDEC Soil Cleanup Objectives for the Site.

During the Site Characterization component of the Treatability Study, conducted in November 1996, a total of 23 investigative samples were collected from 15 test pits within the former lagoons. Samples were analyzed for TCL VOCs, SVOCs, pesticides, and PCBs, TAL metals, cyanide, and Site-specific parameters.

The following conclusions are based on the results of the Treatability Study.

1. Based on the results of the Soil Characterization and previous investigations, the COCs for the Site are acetone, benzene, ethylbenzene, chlorobenzene, toluene, xylene, pyridine, 2-aminopyridine, and alpha-picoline.
2. The Test Pitting Program indicated a large amount of shale fragments and cobbles within the former lagoons. Based on field observations, it is estimated that approximately 90% of Lagoon 6 is comprised of shale fragments that would not require treatment in a biocell. It is conservatively estimated that 20% of the material in Lagoons 1 to 5 is fragmented shale or cobbles that would be screened out during processing prior to treatment in a biocell.
3. Based on the results of the Test Pitting Program, there is an upper layer of fill material in Lagoons 1 to 5 above a distinct black-stained fill layer encountered at

depth. Field observations and analytical results for samples collected from this upper fill layer indicate that it will, most likely, not require treatment.

4. The material to be treated at the Site is suitable for SVE/bioremediation as evident from the presence of a healthy indigenous microbial population, suitable hydraulic conductivity characteristics, and a suitable range of operating temperatures in the subsurface. Microbial activity was not inhibited by Site-related compounds.

5. Amendment with sawdust or vermiculite in the range of 2 to 4% would increase the effective hydraulic conductivity of the material to be treated.

6. Based on the results of the Respirometric Testing and Soil Column Testing, SVE/Biodegradation would be an effective treatment approach for all COCs. All VOCs were significantly reduced to non-detect levels within a period of 4 weeks. The primary removal mechanism for the VOCs was SVE with a further reduction due to biodegradation. The only SVOC COC, 2-aminopyridine, was significantly reduced by 90% within the first 4 weeks. The primary removal mechanism for 2-aminopyridine during the 4-week period was biodegradation. The rate of removal of 2-aminopyridine and the primary VOC, xylene, in the active sample during the first 4 weeks of the Soil Column Study is estimated to be approximately 457 μg/Kg/day and 924 μg/Kg/day, respectively.

7. The full-scale operation of the biocell may require nutrient support such as ammonium sulfate, urea, and tripotassium phosphate and water to function under optimum conditions.

The results of the Treatability Study indicate that SVE/bioremediation would be effective for reducing the concentrations of Site-related COCs in the soils to levels below NYSDEC Soil Cleanup Objectives. The Treatability Study results will be used in the evaluation of remedial alternatives for soils that include SVE and/or bioremediation in Sections 4.0 and 5.0.

2.7 RESULTS OF THE NATURAL ATTENUATION STUDY

A preliminary Natural Attenuation Study was conducted for the Site to evaluate the potential for Monitored Natural Attenuation (MNA) as a remedial action for groundwater. The results of the Natural Attenuation Study were presented in the report entitled Draft Natural Attenuation Study for OU-2 (CRA, 2004). The objectives of the Natural Attenuation Study were to:

1. determine the extent of natural attenuation processes occurring for COCs under current Site conditions;
2. assess how remediation of the lagoon areas may influence the natural attenuation of COCs; and
3. evaluate whether Monitored Natural Attenuation should be further evaluated in the Feasibility Study as a component of the groundwater remedy.

Based on the findings of the study, Monitored Natural Attenuation is considered to be a viable remedial option to address the identified COCs in groundwater upon source removal. The following is a summary of the preliminary findings of the Natural Attenuation Study:

- the biodegradation of site-related organic constituents derived from the lagoon area has caused strong anaerobic conditions to occur relative to the background aerobic conditions observed in groundwater outside the area of Site-related organic constituents;
- extensive biodegradation of site-related organic constituents has occurred historically, and is continuing to occur, most likely at reduced rates due to the existing anaerobic conditions;
- the aerobic bacteria required to biodegrade Site COCs have been demonstrated to occur in healthy populations in the subsurface at the Site;
- all COCs are known to readily biodegrade under aerobic conditions, and to a lesser extent under anaerobic conditions;
- remediation of the lagoon area will remove the existing source of organic compounds, and will ultimately result in the re-establishment of natural aerobic conditions in the overburden and bedrock aquifers;
- additional monitoring data are required to conduct a statistical trend analysis, which is needed to support the effectiveness of Monitored Natural Attenuation under future conditions, once the source is remediated; and
- a groundwater remedy consisting of MNA should include a monitoring program to permit further evaluation of COC and redox indicator trends after remediation of the lagoon area. As with all MNA remedies, a contingency groundwater remedial option should be designed in the event that MNA is determined to be insufficient as the sole groundwater remedy for the Site.

3.0 DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS

Preliminary Remediation Goals (PRGs) are developed for the Site-related COCs detected in soil and groundwater.

3.1 DETERMINATION OF COCs

To determine if an inorganic COPC should be considered as a COC (either Site-related or non-Site-related), the HHRA was conducted to evaluate the risks, or potential risks, posed by the Site.

If an individual inorganic COPC contributed to a carcinogenic risk greater than 10^{-6} or a non-carcinogenic HI greater than 1.0, it was retained for further consideration as a COC (either Site-related or non-Site-related) in accordance with the evaluation process described in the Additional Soil Sampling Work Plan (CRA, 2003). Any inorganic parameters that do not represent an unacceptable human health risk were not retained as COCs and will not be evaluated further in the FS process.

To summarize the HHRA with respect to the final retention of COCs, the following inorganic parameters (Site and non-Site-related) represented a carcinogenic risk greater than 10^{-6} or a non-carcinogenic HI greater than 1.0 in the HHRA and were further evaluated:

- arsenic, copper, and thallium in Otter Kill Creek surface water to fish for current/future resident/occasional visitor/trespasser;
- manganese in soil for future construction worker;
- arsenic in surface soil in Lagoon 6 for the future resident and maintenance worker;
- iron in surface soil for future resident; and
- manganese, antimony, arsenic, and lead in groundwater for future on-Site resident.

To determine if the above inorganic COCs are Site-related and thus remain as COCs, background screening was conducted for the inorganics using statistical methods to compare the lagoon area inorganic database to the background inorganic database as described in Appendix C of the Additional Soil Sampling Work Plan (CRA, 2003).

Arsenic, iron, lead, manganese, and thallium have been shown to be consistent with background levels in soil, therefore, it is concluded that there is no Site-related source for these constituents.

The background concentrations for copper in surface water are higher than copper concentrations adjacent to the Site in Beaverdam Brook and Otter Kill. Therefore, copper in surface water is being impacted by an upgradient non-Site-related source.

Antimony was not detected in any of the groundwater samples collected in July 2001 with the exception of a detection of 14.4 μg/L for well MW-9D-01. This single detection was driving the risk in the HHRA for groundwater. A confirmatory sample was subsequently collected for TAL inorganic analysis with the semi-annual groundwater monitoring program in November 2001. This result was non-detect for antimony at 4.6 μg/L. The July 2001 hit is therefore considered anomalous.

Inorganics detected at concentrations exceeding applicable criteria in soil, groundwater, surface water, and sediment were reported at similar concentrations in background samples and/or were determined not to be Site-related.

In summary, based on the HHRA and subsequent background level screening, there are no Site-related inorganics that represent an unacceptable human health risk level in any media at the Site under any exposure scenario.

The following organic compounds, detected in 5 percent or more of the samples, represented a carcinogenic risk greater than 10^{-6} or a non-carcinogenic HI greater than 1.0 in one or more exposure scenarios in the HHRA:

- 2-aminopyridine;
- aniline;
- aroclor-1254;
- benzene;
- bis(2-ethylhexyl)phthalate;
- chlorobenzene;
- toluene; and
- xylene.

Bis(2-ethylhexyl)phthalate, detected at estimated concentrations in three groundwater samples, resulted in a carcinogenic risk of 1.33×10^{-5} for the future residential use of groundwater within the range of 10^{-4} to 10^{-6}.

Although the frequency of detection of aniline in soil and groundwater samples is unknown as it has not been specifically analyzed except for samples collected in 1985, aniline will be considered a COC for the Site as it represents a non-carcinogenic HI significantly greater than 1.0 in the HHRA. Two groundwater samples were analyzed for aniline during the 1985 C. A. Rich sampling event. Aniline was detected at concentrations of 48 µg/L at well MW-5 and 140 µg/L at well T-1, exceeding its groundwater standard of 5 µg/L. Aniline was not specifically analyzed in the subsequent groundwater sampling events conducted at the Site as it was not on the parameter list. During the 2001 comprehensive round of groundwater sampling, aniline was detected as a TIC at concentrations of 12NJ at well MW-2 and 16NJ/9.2NJ at well MW-7. These concentrations were qualified with an NJ because they were estimated as the spiked sample recovery was not within control limits. These concentrations exceed the groundwater standard of 5 µg/L for aniline.

Aroclor-1254 was reported at concentrations of 14 mg/kg and 15 mg/kg for the duplicate for test pit sample RM-24 collected from a depth of approximately 4 feet from Lagoon 2 and at concentrations of 4.8 J mg/kg and 8.9 J mg/kg for the duplicate for surface soil sample SSII-6 collected from Lagoon 6. Of the 65 test pit and borehole samples collected from the Site, these are the only occurrences of an exceedance of the NYSDEC Soil Cleanup Objective of 10 mg/kg for PCBs for subsurface and 1 mg/kg for surface soils at the Site. Based on the results of the remaining soil samples at the Site, elevated concentrations of PCBs are not prevalent. These slight exceedances of the NYSDEC Soil Cleanup Objectives are considered to be an isolated occurrence and not indicative of a widespread PCB issue at the Site.

Pesticides were determined not to be Site-related.

The primary COCs for the Site based on exceedances of applicable criteria and the results of the ERA and the HHRA are as follows:

Parameter	*Soil*	*Groundwater*
VOCs		
Acetone	√	√
Aniline	√	√
Benzene	√	√
Chlorobenzene	√	√
1,2-Dichloroethane	—	√
Ethylbenzene	√	√

Parameter	*Soil*	*Groundwater*
Toluene	√	√
Xylene	√	√
SVOCs		
2-Aminopyridine	√	√
Alpha-picoline	√	√
Pyridine	√	√

Additional chemical parameters were reported at concentrations exceeding applicable criteria but were detected in less than 5 percent of the samples for a given media and/or were present at similar concentrations in background samples.

3.2 DEVELOPMENT OF SOIL PRGS

There are currently no federal or state promulgated standards for contaminant levels in soils. Therefore, To-Be-Considered Soil Cleanup Objectives for the organic COCs at the Site are based on the State of New York soil cleanup criteria published in Technical and Administrative Guidance Memorandum (TAGM) #4046 – Recommended Soil Cleanup Objectives and Cleanup Levels.

In addition to the known COCs for the Site as discussed in Section 3.1, a Soil Cleanup Objective 'Guidance' value of 400 mg/kg has been developed for the individual pyridine-based TICs that have been detected at the Site as the non-carcinogenic HI for some of these compounds has been determined to be significantly greater than 1.0 in one or more exposure scenarios in the HHRA. As presented in the May 1, 2006 correspondence from the NYSDEC, for the pyridine-related TICs, the 400 μg/kg value is a cleanup guidance value. Every effort will be made to achieve the guidance value. But as a guidance value, some leeway is permitted. If the Soil Cleanup Objectives are met for the known contaminants, but the pyridine-based TICs are above the guidance value (at a reasonably low concentration), Site cleanup will have been achieved.

The following Soil Cleanup Objectives will apply to the COCs for the Site:

Parameter	*Soil Cleanup Objective (µg/kg)*
VOCs	
Acetone	200
Aniline	1,510[1]
Benzene	60
Chlorobenzene	1,700
Ethylbenzene	5,500
Toluene	1,500
Xylene	1,200
SVOCs	
2-Aminopyridine	400 [2]
Alpha-picoline	575 [2]
Pyridine	400 [2]
TICs	
Individual Pyridine-Based TICs	400 [3]

3.3 DEVELOPMENT OF GROUNDWATER PRGS

Groundwater cleanup levels for organic COCs will be based on the more conservative of the Federal MCLs and the New York Ambient Groundwater standards and guidance values (NYSDEC TOGs 1.1.1, June 1998). The following groundwater cleanup levels are the most stringent of the two sources:

1 The soil cleanup objective for aniline has been revised from the value presented in TAGM 4046 based on correspondence from the NYSDEC dated April 7, 2006.

2 The soil cleanup objectives for the three pyridine compounds were determined by the NYSDEC in correspondence dated August 14, 1996

3 The soil cleanup objective for the individual pyridine-based TICs was determined by the NYSDEC in correspondence dated May 1, 2006. The soil cleanup objective is a guidance value. If the soil cleanup objectives are met for the known contaminants, but the TICs are above the guidance value (at a reasonably low concentration), the site cleanup objective will have been met.

Parameter	*NY State Ambient Groundwater Standards and Guidance (G) Values (µg/L)*
VOCs	
Acetone	50 (G)
Aniline	5
Benzene	1
Chlorobenzene	5
1,2-Dichloroethane	0.6
Ethylbenzene	5
Toluene	5
Xylene	5
SVOCs	
2-Aminopyridine	1 (G)
Alpha-picoline	50 [4] (G)
Pyridine	50 (G)

Final remedial goals for the Site will be based on the remedy selected and the future land use of the Site.

Additional chemical parameters were reported at concentrations exceeding applicable criteria but were detected in less than 5 percent of the samples for a given media and/or were present at similar concentrations in background samples.

Pesticides were determined not to be Site-related.

[4] Alpha-picoline does not have a standard or guidance value. Due to lack of information for this analyte, pyridine substituted as per HHRA.

4.0 IDENTIFICATION AND SCREENING OF REMEDIAL ALTERNATIVES

4.1 INTRODUCTION

This FS presents general remedial objectives for screening technologies proposed for use in the development of a remedy. As presented in Section 1.3 a remedy should:

- provide protection of public health and the environment;
- satisfy ARARs;
- provide practical, cost-effective remediation; and
- utilize permanent remedies, which are completed in a short time frame, where applicable.

The U.S. EPA guidance document entitled "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA," October 1988, states, *"remedial action objectives consist of medium-specific or operable unit-specific goals for protecting human health and the environment."* The objectives must not be so specific that the range of remedial alternatives which can be developed becomes overly limited. Remedial action objectives established to protect human health and the environment are to specify:

i) the chemicals of concern;

ii) the exposure routes and receptors; and

iii) an acceptable chemical concentration or range of concentrations for each exposure route.

Specifying remedial action objectives in this manner is deemed to be appropriate since protectiveness may be achieved by reducing exposure to receptors either separately or in conjunction with reducing chemical levels.

The guidance further states that *"because remedial action objectives for protecting environmental receptors typically seek to preserve or restore a resource, environmental objectives should be addressed in terms of the medium of interest and target cleanup levels, whenever possible."*

The remedial objectives themselves are not the motivation for initiating a remedial action. Rather, remedial objectives are a set of performance standards against which to compare remedial alternatives and aid in the NYSDEC's selection of the preferred remedy.

This section is presented as follows:

Section 4.2	Applicable or Relevant and Appropriate Requirements;
Section 4.3	Remedial Action Objectives;
Section 4.4	General Response Actions for Soils;
Section 4.5	General Response Actions for Groundwater; and
Section 4.6	General Response Actions for Surface Water/Sediments in Beaverdam Brook/Otter Kill.

A description of ARARs that are used to develop remedial action objectives and to scope and formulate remedial action technologies and alternatives is presented in Section 4.2.

The remedial action objectives for the Site based on Site-related COCs and media of interest are presented in Section 4.3. The preliminary remediation goals are established based upon risk-related factors established in the HHRA and ERA and exceedances of the chemical-specific ARARs.

General response actions for soil are developed to satisfy the remedial objectives for the Site in Section 4.4. A similar evaluation is presented for potential groundwater remedial response actions, technologies, and process options in Section 4.5. Finally, surface waters and sediments in Beaverdam Brook/Otter Kill are discussed in Section 4.6.

Potential technologies and process options applicable to each general response action are also identified. Each response action and technology is then evaluated based upon technical feasibility. Alternative process options are then screened based upon effectiveness, implementability, and cost effectiveness to select a representative process (or processes) for each technology type. The retained technologies and process options are assembled into alternatives for further evaluation in Sections 5.0 and 6.0 for soil and groundwater, respectively.

4.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ARARs are used to develop remedial action objectives and to scope and formulate remedial action technologies and alternatives. ARARs are cleanup standards, control standards or other substantive environmental limitations promulgated under federal or state law. The consideration of ARARs is made in accordance with the Comprehensive

Environmental Response, Compensation and Liability Act of 1980, as amended, (CERCLA) §121, Y2 U.S.C. §9621. CERCLA only requires the consideration of substantive requirements. However, for the purpose of this FS, guidance values are also included as potential ARARs in accordance with the current State Guidance document for selecting remedial actions at inactive hazardous waste sites (HWR-90-4030, May 15, 1990).

CERCLA/SARA requires that ARARs be identified during the RI/FS in order to aid in the preparation of a list of remedial alternatives, the evaluation of remedial alternatives under an FS, and ultimately, the selection of a remedy under the ROD.

ARARs are defined below, pursuant to SARA.

Applicable Requirements

Applicable requirements are federal and state requirements such as cleanup standards, standards of control, and other environmental protection criteria or limitations that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site.

Relevant and Appropriate Requirements

Relevant and appropriate requirements are those federal and state requirements that, while not applicable as defined above to the circumstances at a site, address problems or situations sufficiently similar to those encountered at a site that their use is well suited. The regulations provide specific criteria for determining whether a requirement is relevant and appropriate.

During the feasibility study process and in the development of remedial alternatives, relevant and appropriate requirements are accorded the same weight and consideration as applicable requirements.

Other Requirements To Be Considered

This category contains other requirements and non-promulgated documents to be considered in the CERCLA process of developing and screening remedial alternatives. The To Be Considered (TBC) category includes federal and state non-regulatory requirements, such as guidance documents, advisories, or criteria. Non-promulgated advisories or guidance documents do not have the status of ARARs. However, if no

ARARs for a contaminant or situation exist, guidance or advisories would be identified and used to ensure that a remedy is protective.

ARARs are categorized as follows:

1. chemical-specific requirements that define acceptable exposure limits and can therefore, be used in establishing preliminary remediation goals;
2. location-specific requirements that may restrict activities within specific locations such as floodplains or wetlands; and
3. action-specific requirements which may establish controls or restrictions for specific treatment and disposal activities.

Each of these ARAR types are further discussed in the following subsections.

4.2.1 CHEMICAL-SPECIFIC ARARS

Chemical-specific ARARs establish the acceptable amount or concentration of a particular chemical that may be either found in, or discharged to the ambient environment. Concentration limits provide protective site cleanup levels or may be used as a basis for estimating appropriate cleanup levels for the chemicals of concern in the various media. Chemical-specific ARARs may be used to determine treatment and disposal requirements for remedial activities and to assess the effectiveness or suitability of a remedial alternative. These values are usually based on health or risk considerations for the protection of either human health or the environment. Chemical-specific ARARs may be regulated standards or non-regulated guidance values. Guidance values may be appropriate where a standard for a particular substance is not available. If a chemical compound has more than one ARAR, the most stringent is generally required to be met.

Chemical-specific ARARs for the Site potentially apply to groundwater, surface water, soil, and sediment. There are currently no chemical-specific regulated standards for soils in New York State. However, soil cleanup objectives have been established in the State guidance document entitled "Determination of Soil Cleanup Objectives and Cleanup Levels" (TAGM HWR-94-4046, January 24, 1994).

Groundwater and Surface Water

Maximum contaminant levels (MCLs) have been established for groundwater and surface water. The most stringent values from the applicable sources are used for Class GA groundwater and Class AA surface water. The Class GA groundwater criteria are presented in Section 3.3 for the COCs.

Class GA groundwater pertains to fresh groundwater found in the saturated zone of unconsolidated deposits and consolidated rock or bedrock. The best usage of Class GA groundwater is as a source of potable water supply. It is to be noted that there are currently no users of groundwater as a potable water source at the Site. However, groundwater is used as a potable water supply in the vicinity of the Site.

Potential chemical-specific ARARs for Class GA groundwater are the most stringent of:

(1) maximum contaminant levels (MCLs) for drinking water promulgated in 10 NYCRR Subpart 5-1, Public Water Supplies;

(2) MCLs for drinking water promulgated under the Safe Drinking Water Act;

(3) water quality standards promulgated in 10 NYCRR Part 170, Sources of Water Supply; or

(4) items and specifications found in 6 NYCRR Parts 700-705, Water Quality Regulations.

Class AA surface waters are waters that will meet New York State Department of Health drinking water standards and will be considered safe and satisfactory for drinking water purposes.

Potential chemical-specific ARARs for Class AA surface water are the most stringent of:

(1) 10 NYCRR Part 170, Sources of Water Supply;

(2) 10 NYCRR Part 5, Drinking Water Supplies; or

(3) the lowest value derived using the methodologies and procedures found in 6 NYCRR Parts 702 to 703, Water Quality Regulations.

Surface and Subsurface Soils

As previously stated, chemical-specific ARARs for soils have not been promulgated in New York State. However, Soil Cleanup Objectives were determined for the COCs in surface and subsurface soil in accordance with TAGM HWR-94-4046. The Soil Cleanup Objectives are presented in Section 3.2 for the COCs.

Although the NYSDEC Soil Cleanup Objectives guideline values are not chemical-specific ARARs, they will be considered as cleanup goals for the purpose of evaluation of the soil alternatives in the FS. The final cleanup levels for soils which can actually be achieved using the preferred remedial action for soils will be fully developed during the remedial design.

The determination of Soil Cleanup Objectives for organic compounds is based on the water-soil equilibrium partition theory model which estimates the maximum chemical concentrations allowed in soil that are protective of groundwater quality. The following equation is used in the model:

$$Cs = Cw \times Koc \times foc \times At$$

where:

Cs	=	allowable concentration in soil,
Cw	=	appropriate water quality standard or guidance value for Class GA groundwater,
Koc	=	partition coefficient between water and soil media,
foc	=	fraction of organic carbon of the natural soil medium, and
At	=	attenuation factor.

The fraction of organic carbon (foc) for the overburden at the Site was assumed to be 0.1 percent. In accordance with TAGM HWR-94-4046 an attenuation factor (At) or correction factor of 100 is used.

Sediments

Chemical-specific ARARs that provide cleanup standards or objectives for sediments have not been established. However, chemical-specific ARARs for screening of sediment quality are available from the U.S. EPA and the NYSDEC.

NYSDEC guidance is available for the protection of aquatic life in Technical Guidance for Screening Contaminated Sediments, Division of Fish and Wildlife, NYSDEC, July 1994. The NYSDEC guidance is used as a screening tool to determine if sediments are contaminated. The guidance should not be used as the basis to determine if sediments require remediation. The requirement for remediation must consider sediment background levels and potential environmental impacts, as evaluated in the RI Report.

Sediment criteria are also available from Long, E.R. et al., (1995). Long, E.R. et al, (1995) established sediment criteria limits for biological effects. Sediment quality criteria are also available from the U.S. EPA for non-ionic organic compounds. Sediment criteria are further discussed and presented in the RI Report.

4.2.2 LOCATION-SPECIFIC ARARS

Location-specific ARARs are regulations that are applicable to specific physical and environmental settings. The Site is located near a designated Freshwater Wetland and Beaverdam Brook and Otter Kill. The following regulations pertain to this environmental setting:

Federal:

- Executive Orders on Floodplain Management and Wetlands Protection (CERCLA Floodplain and Wetlands Assessments) #11988 and 11990;
- 1985 Policy of Floodplains/Wetlands Management & Wetlands Protection
- RCRA Location Requirements for 100-Year Floodplains (40 CFR 264.18(b));
- Fish and Wildlife Coordination Act (16 USC 661 et seq.);
- Clean Water Act Section 404 (Evaluation of remedial alternatives with respect to wetlands) (40 CFR 230);
- Army Corps of Engineers Regulations for Construction and Discharge of Dredged or Fill Materials in Navigable Waterways (33 CFR 320-330);
- Wetlands Construction and Management Procedures (40 CFR 6, Appendix A); and
- National Historic Preservation Act (16 USC 470) Section 106 et seq. (36 CFR 800).

New York State:

- Freshwater Wetlands Law (Evaluation of remedial alternatives with respect to wetlands) (ECL Article 24, 71 in Title 23);
- New York State Freshwater Wetlands Permit Requirements and Classification (6 NYCRR 663 and 664);

- New York State Water Pollution Control Regulations Use and Protection of Waters (6 NYCRR 608);
- New York State Floodplain Management Act and Regulations (ECL Article 36 and 6 NYCRR 500);
- Endangered and Threatened Species of Fish and Wildlife Requirements (6 NYCRR 182); and
- New York State Flood Hazard Area Construction Standards (Evaluation of remedial alternatives with respect to floodplains).

4.2.3 ACTION-SPECIFIC ARARS

Action-specific ARARs are determined by the particular remedial activities that are selected to address the site cleanup. Action-specific requirements establish controls or restrictions on the design, implementation and performance of remedial activities. Following the development of the remedial alternatives, action-specific ARARs that specify performance levels, actions, technologies or specific levels for discharged or residual chemicals provide a means for assessing the feasibility and effectiveness of the remedial activities.

The federal and New York State action-specific ARARs which may be applicable to Site remediation are presented in Table 4.1.

4.3 REMEDIAL ACTION OBJECTIVES

This Section presents the development of remedial action objectives for each media of interest at the Site. The remedial action objectives consist of media-specific goals for the protection of human health and the environment. The objectives are based primarily on achieving ARARs and the findings of the HHRA and ERA.

The overall goal of Site remedial action is to ensure the protection of human health and the environment. The general remedial objectives of the FS directed at achieving this goal are to:

1. minimize the discharge of hazardous constituents off Site via groundwater flow;
2. ensure that any hazardous constituents within the soil and groundwater meet acceptable levels consistent with the anticipated use of property;

3. minimize potential human contact with waste constituents; and
4. prevent risks or adverse impacts to natural resources.

The following subsections present, on a media-specific basis, a discussion of the chemicals of interest, allowable exposures based upon the results of the HHRA, ERA, and chemical-specific ARARs, and potential remedial goals.

4.3.1 SUBSURFACE SOILS

As discussed in Section 6.1 of the RI report, Site-related chemicals were identified in subsurface soil samples collected primarily from the vicinity of the former lagoons. Although some parameters were detected in subsurface soil samples collected away from the former lagoon locations, the reported concentrations were generally an order of magnitude, or more, less than the concentrations reported in the immediate lagoon area.

As discussed in Section 3.1, the COCs for the Site soils are VOCs (acetone, aniline, benzene, ethylbenzene, chlorobenzene, toluene, and xylene) and SVOCs (alpha-picoline, 2-aminopyridine, and pyridine). Exceedances of the NYSDEC Soil Cleanup Objectives for the COCs are presented in Table 2.2.

Exposure to subsurface soils is unlikely under present conditions. The potential exposure to subsurface soils would occur only if on-Site construction requires excavation of the subsurface soils. Potential risk scenarios were developed and evaluated in the HHRA for the hypothetical future construction worker exposure to on-Site soils in the area of the Site excluding Lagoon 6 and the soils in Lagoon 6. Lagoon 6 soils were evaluated separately due to the presence of the tentatively identified compound, dichlorobiphenyl isomer in the surficial soils of this lagoon.

The estimated lifetime RME cancer risks for the construction worker exposure were calculated to be:

	RME
Site (excluding Lagoon 6)	1.5×10^{-4}
Lagoon 6	2.7×10^{-6}

The future construction worker exposure scenario risks are generally within the target cancer risk range of 1×10^{-6} to 1×10^{-4} established by the U.S. EPA. However, the estimated RME non-carcinogenic hazard index of 4.8 for Lagoon 6 and 120 for on-Site soils excluding Lagoon 6 for the construction worker exposure to Site soils is above the level of concern (1.0).

The area in the vicinity of the former lagoons contains subsurface soils with organic chemical concentrations exceeding applicable NYSDEC soil cleanup objectives as presented in Section 2.2.1.

Preliminary remedial objectives for subsurface soil at the Site will be to prevent or mitigate the migration of chemicals from the area of the lagoons that would result in groundwater contamination in excess of Class GA groundwater standards. The NYSDEC Soil Cleanup Objectives are, therefore, remedial goals for the subsurface soils. Remedial objectives, designed to reduce human health risks as a result of direct exposure to subsurface soils by construction workers are also necessary based on the results of the HHRA.

4.3.2 SURFACE SOILS

Potential risk scenarios were developed and evaluated in the HHRA for the future parkland user exposure, resident, and maintenance worker; and the current exposure scenario by trespassers to on-Site surface soils (excluding Lagoon 6) and Lagoon 6 surface soils.

For surface soils (excluding Lagoon 6), the estimated lifetime RME cancer risks were calculated to be:

	RME
Trespasser (current)	1.9×10^{-7}
Parkland User (future)	1.5×10^{-6}
Maintenance Worker (future)	3.7×10^{-6}
Resident (future)	2.7×10^{-5}

For surface soils in Lagoon 6, the estimated lifetime cancer risks were calculated to be:

	RME
Trespasser (current)	1.2×10^{-6}
Parkland User (future)	1.3×10^{-5}
Maintenance Worker (future)	2.4×10^{-5}
Resident (future)	1.6×10^{-4}

The current and future surficial soil exposure cancer risks are generally below or within the target cancer risk range of 1×10^{-6} to 1×10^{-4} established by the U.S. EPA with the exception of the future resident exposure scenario.

The estimated non-carcinogenic RME hazard indices for all exposure scenarios are below the level of concern (1.0) with the exception of the future resident exposure scenario. The estimated RME non-carcinogenic hazard index of 14 for Lagoon 6 and 3.4 for surface soils excluding Lagoon 6 for the future residential exposure to Site surface soils is above the level of concern (1.0).

The remedial goal for surface soils at the Site will be to restore surface conditions, primarily in the area of Lagoon 6, to the extent necessary, so that chemical concentrations are protective of human health.

The results of the ERA indicated that potential risks to ecological receptors by surficial exposures related to the presence of Site-related chemicals is unlikely.

4.3.3 SEDIMENTS

The requirements for sediment remediation in the Northeast Marsh Area, the Southwest Marsh Area, Beaverdam Brook, and Otter Kill are evaluated in the following paragraphs.

4.3.3.1 NORTHEAST MARSH

The results of the HHRA indicate that the current/future RME excess cancer risks associated with Site-related chemicals in sediments in the Northeast Marsh Area are well below the acceptable risk range of 10^{-4} to 10^{-6}. The non-cancer risks were determined to be well below the acceptable hazard index of 1. Therefore, based on the results of the HHRA, remedial objectives for the protection of human health are not necessary for the sediment within the Northeast Marsh Area.

The results of the ERA indicated no adverse impacts by ecological receptors to Site-related chemicals in the Northeast Marsh Area.

Detected levels of PAHs have been excluded from the evaluation of the Northeast Marsh Area sediments as NYSDEC and the U.S. EPA have agreed that the presence of PAH contamination in the Northeast Marsh Area sediments is not attributable to former Site operations. PAHs in the Northeast Marsh sediments are, therefore, considered to be unrelated to the Site. The presence of the PAHs in the Northeast Marsh Area is not considered to be Site-related because the concentrations of PAHs were higher at sediment sample location 1 located 900 feet northeast of sample location SDII-2 and 1880 feet northeast of the Site. In addition, Site-related parameters pyridine, 2-amino-pyridine and alpha-picoline were not detected for samples collected within the Northeast Marsh Area or from location 1. The chemical results coupled with the surface water drainage pattern from the Site indicate a low potential for chemical migration from the Site to the Northeast Marsh Area and a very remote potential for migration to sediment sample location 1.

The results of surface water sampling during the Phase I and II RI for varying flow conditions indicate that PAHs are not being transported in the dissolved phase from the Site. In addition, the results for the surface soil samples collected on Site during the Phase II RI (1995) indicate PAH concentrations below concentrations reported for the Northeast Marsh Area. Further deterioration of sediment quality in the Northeast Marsh Area is, therefore, unlikely, by contaminant transport in either the dissolved or particulate phase in surface water runoff from the Site.

Based on the acceptable risks to human health and ecological receptors, the possibility of contamination from a source unrelated to the Site, and the unlikelihood of further deterioration from the Site, the remediation of the Northeast Marsh Area sediments is not required (related to the Site). Remedial objectives for sediments in the Northeast Marsh Area are, therefore, not necessary.

4.3.3.2 <u>SOUTHWEST MARSH</u>

The results of the HHRA indicate that the current/future RME excess cancer risks associated with Site-related chemicals in sediments in the Southwest Marsh Area are within or below the acceptable risk range of 10^{-4} to 10^{-6}. The non-cancer risks were determined to be well below the acceptable hazard index of 1 with the exception of an HI of 1.4 for the future recreational user exposure scenario, slightly above the acceptable hazard index of 1. Therefore, based on the results of the HHRA, remedial objectives for the protection of human health are not necessary for the sediment within the Southwest Marsh Area.

The results of the ERA indicate no adverse impacts to ecological receptors by Site-related chemicals in the Southwest Marsh Area.

Based on the acceptable risks to human health and ecological receptors, remediation of the Southwest Marsh Area is not required. Remedial objectives are, therefore, not necessary for the Southwest Marsh Area.

4.3.3.3 BEAVERDAM BROOK/OTTER KILL

As presented in the HHRA, the potential for human exposure to sediments in Beaverdam Brook and Otter Kill is considered minimal. Thus, exposure to sediments in Beaverdam Brook and Otter Kill was not evaluated in the HHRA.

The sediment sampling results indicate that reported levels of organic compounds (primarily PAHs) are below all applicable criteria. Inorganic parameters detected in samples collected from Beaverdam Brook and Otter Kill were reported at higher or similar concentrations for upstream sample locations indicating a minimal Site-related impact, if any.

The results of the ERA indicate no adverse impacts to ecological receptors by Site-related chemicals in the Southwest Marsh Area.

Based on the acceptable risks to human health and ecological receptors, remediation of the sediments in the Otter Kill and Beaverdam Brook is not necessary. Remedial objectives for sediment in the Otter Kill and Beaverdam Brook are, therefore, not necessary.

4.3.4 GROUNDWATER

The HHRA evaluated the potential future on-Site residential exposure to groundwater and the potential future on-Site groundwater exposure to construction workers. There are currently no Site-related COCs detected in the off-Site residential wells or the Maybrook supply wells in close proximity to the Site so there are currently no unacceptable risks associated with groundwater off-Site.

The estimated cumulative lifetime RME cancer risks for these scenarios were calculated to be:

	RME
On-Site Resident (future)	1.4×10^{-3}
Construction Worker (future)	1.4×10^{-6}

The value for the future on-Site residential groundwater exposure scenario is above the established acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. In addition, the non-carcinogenic hazard indices ranged from 312 to 685, above the level of concern (1).

Exceedances of groundwater ARARs for the COCs are presented in Section 2.2.2 for overburden and bedrock groundwater.

Remedial goals for the groundwater at the Site are to prevent the future ingestion and exposure to groundwater with chemicals that pose carcinogenic and non-carcinogenic risks in excess of the established acceptable levels for the future on-Site residential use scenario. In addition, remedial goals for the Site groundwater are to reduce concentrations of the COCs to the applicable Class GA ARARs for the protection of human health and the environment.

4.3.5 SURFACE WATER

Potential current/future exposure scenarios to surface water were evaluated for an occasional visitor, such as, a hiker or hunter who may be wading in the Northeast Marsh Area, Beaverdam Brook, and Otter Kill and the ingestion of fish caught in Otter Kill by recreational anglers. Separate risk estimates were calculated for each of the areas in the HHRA.

The results of the HHRA indicate that the current/future RME excess cancer risks associated with Site-related chemicals in surface water in the Northeast Marsh Area, Beaverdam Brook, and Otter Kill are well below the acceptable risk range of 10^{-4} to 10^{-6}. The non-cancer risks were determined to be well below the acceptable hazard index of 1.

The estimated lifetime RME cancer risk value of 4.2×10^{-4} and the estimated RME hazard indices for the child and adult recreational angler exposure to surface water in Otter Kill of 11 and 7.4, respectively, were associated with arsenic which is not a COC for the Site.

Therefore, based on the results of the HHRA, remedial objectives for the protection of human health are not necessary for the sediment within the Northeast Marsh Area.

The results of the ERA indicate no adverse impacts to ecological receptors by Site-related chemicals in surface water in Otter Kill, Beaverdam Brook, or the Northeast Marsh Area.

Organic compounds were not detected in any of the surface water samples collected from Beaverdam Brook or Otter Kill during the Phase II RI in 1995. The organic compounds detected in downgradient samples during the Phase I RI in 1995 were reported at low concentrations similar to upgradient concentrations. Inorganic concentrations reported for surface water samples collected in 1991 and 1995 were similar for upgradient and downgradient locations indicating that the Site is not impacting the surface water quality with respect to inorganic constituents.

Remedial objectives for surface water in the Beaverdam Brook, Otter Kill, and the Northeast Marsh are not necessary due to the current and future acceptable health and ecological risks for exposure to surface water.

4.4 SOILS

4.4.1 GENERAL SOIL REMEDIAL RESPONSE ACTIONS TECHNOLOGIES AND PROCESS OPTIONS

This section presents the development of general response actions for soil. An estimation is made of the potential area or volume to which treatment, containment, or disposal technologies may be applied. Potential treatment, containment, and disposal technologies for each remedial response action and potential process options are also identified.

Although the surface and subsurface soils are evaluated separately in the RI Report for the HHRA, surface and subsurface soils are treated as one media of concern for purposes of the FS. Based upon the general evaluation presented in earlier sections, soil remedial response actions are developed to support the attainment of groundwater ARARs both on and off Site and to mitigate the potential future risks associated with contact with the soils in the area of the former lagoons.

The distribution of soils with concentrations of organic parameters exceeding the NYSDEC Soil Cleanup Objectives is presented on Figure 2.10. The volume determinations of soils requiring remediation is presented in Appendix A.

The total volume of overburden material in the area of the former lagoons is estimated to be approximately 56,810 cubic yards. Based on the results of the test pit samples collected during the Treatability Study, the upper layer of soils within Lagoons 1, 2, 3, 4, and 5 consisting of approximately 21,690 cubic yards, most likely will not require treatment as COC concentrations are expected to be below NYSDEC Soil Cleanup Objectives. However, for the purposes of the FS, it is assumed that from 0 percent to 25 percent (5,423 cubic yards) of the upper layer material will contain concentrations of COCs greater than the Soil Cleanup Objectives. For the purposes of the FS, the volume of black-stained contaminated soils with COC concentrations exceeding NYSDEC Soil Cleanup Objectives in Lagoons 1, 2, 3, 4, and 5 is estimated to range from 75 percent (26,250 cubic yards) to 100 percent (35,000 cubic yards) of the total volume. It is conservatively estimated that approximately 20 percent of the black-stained contaminated soils in Lagoons 1 to 5 consists of fragmented shale and cobbles. In addition to the material from Lagoons 1, 2, 3, 4, and 5, it is estimated that approximately 10 percent (120 cubic yards) of the material from Lagoon 6, which consists primarily of shale fragments, would require treatment. Therefore, the total volume of material requiring remediation is estimated to range from approximately 21,120 to 32,460 cubic yards or 38,020 to 58,430 tons at a density of 1.8 tons/cubic yard.

Potential general remedial response actions for addressing these soils are listed below:

1. no action;
2. limited action;
3. physical containment;
4. in situ treatment;
5. removal/treatment;
6. removal/disposal; and
7. on-Site consolidation.

Potential remedial technologies and process options associated with each of these response actions are listed in Table 4.2. A general description of each of these response actions is presented below.

4.4.1.1 NO ACTION

The NCP requires the evaluation of a no action alternative as a basis for comparison with other remedial alternatives. Under the no action response, no measures would be taken to improve environmental conditions with respect to the soils at the Site.

4.4.1.2 LIMITED ACTION

The limited action response involves restricting access to the property by installation of a fence and implementing institutional controls to reduce potential human exposure to Site-related chemicals in the soils. The institutional controls may include deed restrictions to maintain restricted access to the Site and to limit future uses of the Site.

4.4.1.3 PHYSICAL CONTAINMENT

The physical containment response action involves the use of physical means to contain/stabilize or otherwise restrict the mobility and migration of chemicals associated with the Site soils. Potential containment technologies include:

- capping the areas with soil concentrations exceeding the potential soil cleanup goals;
- chemical or physical fixation/stabilization in place; and
- surface water runoff diversion.

Alternative capping options include a composite cap constructed to RCRA design standards and a soil cap meeting NYSDEC standards for a sanitary landfill.

Surface water runoff diversion options include grading portions of the Site and construction of ditches or berms to divert surface water runoff away from the areas with soil concentrations exceeding the potential soil cleanup goal values.

4.4.1.4 IN SITU TREATMENT

This response action involves in situ treatment of the soils to achieve the soil cleanup goals. The in situ treatment process could be conducted using either the following biological or physical treatment technologies:

1. biological;
2. bioventing;
3. soil vacuum extraction; and
4. soil flushing.

Biological treatment involves the development of a bacterial colony within the soils. The bacteria are utilized to break down the chemicals to non-toxic components. Biodegradation of the chemical constituents depends on the level of saturation, levels of nutrients, the variety and concentrations of chemicals that are present, oxygen concentrations, soil characteristics, and climatic conditions. Biological treatment may be enhanced by the process of bioventing which relies on air flow through contaminated soils at rates and configurations that will ensure adequate oxygenation for aerobic biodegradation.

Treatment by vacuum extraction involves stripping the volatile organic parameters from the soil by drawing a quantity of air through the soil by vacuum. In the in situ applications, either wells or trenches with horizontal perforated pipes are installed in the desired cleanup zones. Blowers are used to draw air from the wells thereby moving air through the soils. The air removed is either reinjected (i.e., air sparging) into the soil or exhausted to the atmosphere. Treatment of the extracted air may be required prior to recirculation or exhaust to the atmosphere. The effectiveness of this system is dependent upon the type of soils, the chemicals present, and the rate at which the air is moved through the soil.

Soil flushing is very similar in principle to the vacuum extraction process except that water is used as the flushing medium. Water is flushed through the soils solubilizing chemicals from the soil. The water is collected and treated to remove chemicals and then reinjected. Again, the effectiveness of the system is dependent upon the type of soils, and the chemicals present.

4.4.1.5 REMOVAL (EX SITU)/TREATMENT

The removal/treatment action involves excavation of the soils with parameter concentrations exceeding the soil cleanup goals and treating the soils either on Site or at an off-Site facility. Potential treatment technologies include the following physical, chemical, or biological treatment options:

1. biological treatment;
2. soil vacuum extraction;
3. low temperature thermal desorption;
4. on-Site incineration;
5. off-Site incineration;
6. solvent extraction; and
7. soil washing.

Both biological treatment (which involves aeration of the soil and the addition of nutrients) and soil vacuum extraction (which involves construction of soil piles with a forced aeration system) would be conducted on an engineered treatment pad or an engineered biocell. Excavated soils would be treated to reach target cleanup levels.

Low temperature thermal desorption (LTTD) would involve excavating and placing the soils into a portable LTTD unit located on Site. Low temperature heat would be used to remove chemicals from the soil. The off-gases would be treated, as necessary, prior to discharge to the atmosphere. This technology would also require a technology specific air monitoring program to be implemented.

On-Site incineration would involve transporting a mobile incineration unit to the Site. The excavated soils would be placed into the incinerator and high temperatures (in the presence of oxygen) would be used to break down the chemical constituents to non-toxic components.

On-Site chemical treatment could be accomplished utilizing the solvent extraction treatment technology. The solvent extraction technology involves mixing the soils with an aliphatic solvent, such as triethylamine (TEA), at low temperatures in a mixing vessel. The first extraction of soil to be treated is conducted at temperatures below 40°F. At this low temperature, the TEA is miscible with water and solubilizes the hydrocarbons. The liquid phase (TEA, water, and hydrocarbons) separates from the soil and is pumped to a decanter. The solvent is then separated from the water by heating to temperatures above 130°F at which TEA becomes immiscible with water. The contaminants which remain with the solvent are then separated from the solvent using an evaporator or an evaporator combined with a distillation column. The solvent is reused and the contaminants sent off Site for treatment and disposal. Additional soil extractions, if required, are conducted at higher temperatures which increases the solubility of the organic compounds in TEA.

Soil washing is accomplished by contacting the excavated soil with water to partition the contaminants from the solid phase to the liquid phase. This technology can be enhanced by the use of surfactants which may increase the efficiency of the contaminant removal.

4.4.1.6 REMOVAL/DISPOSAL

The removal/disposal response action involves excavation of the soils with concentrations exceeding the soil cleanup goals. The excavated soil would be disposed off Site at an approved landfill disposal facility.

4.4.1.7 ON-SITE CONSOLIDATION

The on-Site consolidation response action involves consolidation of soils with concentrations exceeding the soil cleanup goals to one or more areas on Site to increase the efficiency and cost effectiveness of other remedial actions (e.g., institutional controls, in situ treatment, and capping).

4.4.2 SCREENING OF SOIL REMEDIAL RESPONSE ACTIONS, TECHNOLOGIES, AND PROCESS OPTIONS

This section presents an evaluation of the soil remedial response actions, technologies, and process options identified in Section 4.4.1. The initial screening of response actions and technologies is based upon technical feasibility. Remedial response actions and technologies which are not technically feasible are thereby eliminated from further evaluation.

Following this screening, process options for the remaining response actions and technologies are evaluated based upon effectiveness, implementability, and cost considerations. The cost comparisons applied at this stage of evaluation are based primarily upon engineering judgment and are of sufficient detail and accuracy to allow comparison of the different technologies and process options. This initial screening is used to select those technologies and process options that are considered to be most appropriate to the remedial action objectives and conditions at the Site and to eliminate the less effective or less reliable technologies and process options.

4.4.2.1 RESPONSE ACTIONS AND TECHNOLOGIES

A summary of the initial screening of potential remedial response actions and technologies for soils is presented in Table 4.3. Based upon this screening, the following technologies were eliminated from further evaluation:

- Physical Containment - chemical fixation/stabilization in-place.

This technology is eliminated from further evaluation as it would be difficult to implement on Site due to the nature of the former lagoons (e.g., six separate lagoons, each backfilled and over a relatively large area). This technology is generally suited to sites with a single well defined waste disposal area. Other, more reliable and cost-effective alternatives are retained for further evaluation.

4.4.2.2 PROCESS OPTIONS

The screening of process options is used to select the most cost effective process options for the Site, considering Site-specific conditions such as Site geology, hydrogeology, and the chemicals of interest. The process options for the various technologies are evaluated based upon effectiveness, implementability, and cost considerations. The selected process options are retained for inclusion in the development of potential remedial alternatives to be further evaluated in the FS. The following subsections present the evaluation of different capping, ex situ soil treatment, and in situ soil treatment options. Other general response actions (i.e., no action, limited action, and on-Site consolidation action) do not contain multiple process options and, therefore, are not considered in this discussion.

The following process options are discussed below in the following subsections:

Capping

1. RCRA Cap
2. New York Sanitary Landfill Cap

In Situ Soil Treatment

1. biological
2. soil vacuum extraction

3. soil flushing
4. bioventing

Ex Situ Soil Treatment

1. on-Site biological
2. on- Site soil vacuum extraction
3. on-Site low temperature thermal desorption
4. on-Site incineration
5. off-Site incineration
6. on-Site solvent extraction
7. soil washing

4.4.2.2.1 CAPPING

The capping objectives for this Site are to:

- minimize infiltration and hence reduce leaching of chemicals from the soils to the groundwater (thereby reducing chemical concentrations in the overburden and bedrock groundwater);
- eliminate the potential dermal contact by chemicals associated with surface and subsurface soils;
- minimize volatilization of chemicals in the near-surface soils to the atmosphere; and
- minimize the potential transport of chemicals in surface water runoff by eliminating surface water runoff contact with chemicals in the surface soils.

Two capping options are considered for the Site. These include a RCRA cap and a clay cap meeting NYSDEC standards for a sanitary landfill. A description of each cap design is presented below:

1. RCRA Cap (see Figure 4.1)
    - 24 inches of compacted clay;
    - high density polyethylene (HDPE) liner;
    - 12-inch drainage layer;
    - filter fabric;
    - 24 inches of compacted fill;

- 6 inches of top soil; and
- vegetative cover.

2. Clay Cap Meeting NYSDEC Sanitary Landfill Standards (see Figure 4.2)
   - 18 inches of compacted clay;
   - 24 inches of compacted fill;
   - 6 inches of top soil; and
   - vegetative cover.

Both cap designs include a minimum 2 percent slope to promote positive surface water drainage off the capped area and a maximum 33 percent slope to minimize erosion.

Effectiveness

Both capping alternatives will meet the previously stated capping objectives. The effectiveness of each cap design for reducing infiltration was evaluated using the U.S. EPA Hydrogeologic Evaluation of Landfill Performance (HELP) Computer Model. The HELP modeling results are presented in Appendix B. Five years of climatological data for Albany, New York were used in the model. A summary of the estimated leachate generation rates for each of the cap designs is presented in Table 4.4. As presented in Table 4.4, the RCRA cap is more effective for reducing leachate generation.

Implementability

Construction of either alternative cap design would utilize common construction practices. Specialized equipment is required for the placement of the synthetic liner for the RCRA cap; however, contractors are readily available with this expertise.

Costs

General costs for the capping alternatives are listed below:

1. RCRA Cap - $300,000/acre
2. Clay Cap Meeting NYSDEC Standards - $180,000/acre

Summary

Based upon this evaluation, it is determined that both of the alternative cap designs will meet the capping objectives to eliminate potential dermal contact with chemicals associated with surface soils; minimize volatilization to the atmosphere of chemicals in the near surface soils; and minimize the potential transport of chemicals in groundwater and surface water runoff. The RCRA cap is more effective for reducing leachate generation. Hence, the RCRA cap will be included in any capping alternatives.

4.4.2.2.2 IN SITU SOIL TREATMENT

Four alternative process options were identified for in situ treatment of soils at the Site. These are:

1. biological;
2. soil vacuum extraction;
3. soil flushing; and
4. bioventing.

Due to the relatively large number of alternative treatment options, a detailed evaluation of the in situ treatment technologies is presented in Appendix C. A summary of the results of the evaluation is presented in this section.

Effectiveness

Each of the four treatment technologies have varying degrees of effectiveness for treatment of the different chemicals at the Site. However, the majority of the chemicals can normally be treated with a combination of the biological and soil vacuum extraction treatment processes. Treatability and pilot tests may be required to fully evaluate the effectiveness of all in situ process options for the Site-specific conditions.

Implementability

All four of the alternative in situ treatment processes involve similar construction with installation of extraction and injection wells/trenches. Compliance with air permits may be required for discharge of treated vapors from a vacuum extraction process. Carbon adsorption may be required for treating the extracted water or vapors from the different systems prior to discharge or recirculation.

It is estimated that the soil vacuum extraction process supplemented with biological degradation, would take approximately 4 years to reach the soil cleanup levels. It is expected that biological treatment or soil flushing alone would take considerably longer.

Costs

Typical treatment costs based on treating 33,600 cubic yards of soil for the different in situ treatment technologies are listed below:

1. biological treatment - $1.8 million to $3.8 million
2. soil vacuum extraction - $0.6 million to $2.1 million
3. soil flushing - $1.8 million to $4.5 million
4. bioventing - $0.9 million to $2.4 million

Summary

Based upon this evaluation, it is concluded that soil vacuum extraction with bioventing is the most technically and cost effective in situ treatment technology for treating soils at the Site.

4.4.2.2.3 EX SITU SOIL TREATMENT

A total of seven ex situ treatment process options were identified for potential soil remediation. These process options are listed below:

1. on-Site biological;
2. on-Site soil vacuum extraction;
3. on-Site low temperature thermal desorption;
4. on-Site incineration;
5. off-Site incineration;
6. on-Site solvent extraction; and
7. on-Site soil washing.

Due to the relatively large number of alternative treatment process options, a detailed evaluation is presented in Appendix C. A summary of the results of the evaluation, presented in Appendix C, is presented below.

Effectiveness

All of the alternative process options, with the exception of solvent extraction and soil washing are considered effective and reliable treatment technologies for the chemicals at the Site. The reliability and effectiveness of solvent extraction is questionable as it is not a widely used or proven technology. The effectiveness of soil washing is dependent upon the solubility of the chemicals of concern. The biological treatment technology has a higher potential for fugitive air emissions as a large surface area of soil is exposed during the treatment process. The Treatability Study indicated that SVE coupled with biodegradation would be effective in treating the COCs at the Site.

Implementability

All of the alternative process options are readily implemented with the exception of solvent extraction, for which a limited number of mobile units are available. All of the alternative process options would permit treatment of the soils within approximately 1 to 2 years.

Cost

The following estimated costs are based on the treatment of 32,500 cubic yards of soil with COC concentrations exceeding NYSDEC Soil Cleanup Objectives:

1.	Biological Treatment	-	$1.5 million to $3.3 million
2.	Soil Vacuum Extraction	-	$1.8 million to $3.6 million
3.	Low Temperature Thermal Desorption	-	$5.4 million to $11.0 million
4.	On-Site Incineration	-	$7.7 million to $14.6 million
5.	Off-Site Incineration	-	$19.5 million to $34.0 million
6.	Solvent Extraction	-	$5.4 million to $18.0 million
7.	Soil Washing	-	$5.4 million to $11.0 million

Summary

Based upon this evaluation, it was determined that the soil vacuum extraction/ biological treatment technology is the most technically and cost-effective alternative for treating soils ex situ at the Site.

4.4.2.2.4 REMOVAL/DISPOSAL

The process options available for the disposal action are off-Site disposal at either a non-hazardous waste disposal facility or disposal at a hazardous waste facility. As some of the material in the former lagoons may potentially be classified as characteristically hazardous, both of these disposal options are retained.

4.4.2.2.5 ON-SITE CONSOLIDATION

On-Site consolidation will be retained to be used in conjunction with other remedial technologies such as capping where it may be advantageous to reduce the area to be capped by consolidating the soils with concentrations exceeding the Soil Cleanup Objectives.

4.4.2.3 SUMMARY OF SOIL SCREENING RESULTS

Based upon the results of the screening of soil remedial response actions, technologies, and process options, a total of six remedial response actions were retained for further evaluation. A listing of the retained response actions, technologies, and process options is presented in Table 4.5.

4.5 GROUNDWATER

4.5.1 GENERAL GROUNDWATER REMEDIAL RESPONSE ACTIONS, TECHNOLOGIES AND PROCESS OPTIONS

This section presents the development of general response actions for groundwater. The potential area to which treatment, containment, or disposal technologies may be applied is estimated. Potential treatment, containment, and disposal technologies for each remedial response action and potential process options are also identified.

The monitoring well locations and the exceedances of standards for Class GA groundwater are shown on Figures 2.11 to 2.20. The general areal distribution of groundwater considered for potential remediation is presented on Figures 2.13 to 2.20. Exceedances of Class GA groundwater criteria are also summarized in Table 2.3.

Potential general remedial response actions for addressing the chemicals in the groundwater are listed below:

1. no action;
2. limited action;
3. in situ treatment action;
4. physical containment action;
5. hydraulic containment action;
6. source removal action;
7. collection/disposal action; and
8. collection/treatment action.

The potential remedial technologies and process options associated with each of these response actions are listed in Table 4.6. A general description of each of these response actions is presented below.

4.5.1.1 NO ACTION

The NCP requires the evaluation of a no action alternative as a basis for comparison with other remedial alternatives. Under the no action response, no measures would be taken to improve environmental conditions with respect to the groundwater at the Site.

4.5.1.2 LIMITED ACTION

The limited action response involves implementing institutional controls to reduce the potential future human exposure to Site-related chemicals in the groundwater. The institutional controls would include initiation of deed restrictions to restrict groundwater use on the Site.

4.5.1.3 IN SITU TREATMENT ACTION

In situ treatment can be utilized to reduce chemical concentrations in the groundwater. In situ technologies/process options that could be used at the Site include:

1. biological treatment;
2. natural attenuation;
3. chemical oxidation;

4. biosparging; and
5. permeable reactive barriers.

An available and viable technology currently used for in situ treatment of groundwater is biological treatment. Biological in situ treatment of groundwater would involve development and maintenance of a bacterial culture in the groundwater under controlled conditions. The bacteria would be utilized to metabolize the chemical constituents to non-toxic components.

Natural attenuation is the term used to refer to all of the naturally occurring processes that control the fate of contaminants in soil and groundwater, and the recognition that these processes can act to naturally contain and remediate such contamination. Natural attenuation processes are those that effectively reduce contaminant mass and contaminant concentrations in soil and groundwater. The processes that control the natural attenuation of compounds in groundwater can be classified into two categories: non-destructive and destructive. Non-destructive processes which result in reductions in dissolved concentrations of compounds over distance or time include:

- dispersion and diffusion – spreading of the plume concentrations away from the centerline of the plume;
- dilution – when a chemical migrates downward from the vadose zone to an underlying aquifer;
- adsorption – binding of a compound to aquifer soil material; and
- volatilization – mass transfer from the dissolved phase to the vapor phase in the vadose zone above the water table.

Destructive natural attenuation processes which destroy the compound's structure resulting in reductions in compound mass occurs through degradation. Processes resulting in the degradation of contaminants are preferable to those that rely predominantly on non-destructive mechanisms.

Based on the results of the preliminary Natural Attenuation Study conducted for the Site, extensive biodegradation of Site-related organic constituents has occurred historically, and is continuing to occur at a reduced rate under current conditions due to the existing anaerobic conditions resulting from the utilization of oxygen for microbial metabolisim. The aerobic bacteria required to biodegrade Site COCs have been demonstrated to occur in healthy populations in the subsurface at the Site. In addition, all COCs are known to readily biodegrade under aerobic conditions and, to a lesser degree, under anaerobic conditions.

Enhanced bioremediation involves the manipulation of Site conditions to enhance in situ bioremediation of the contaminants by the indigenous microbial population. In this process, several techniques can be applied to enhance biodegradation of the Site-specific COCs, such as:

1. supplementation with suitable sources of nitrogen and phosphorus to enhance biodegradation of contaminants by indigenous microbial population;
2. manipulation of redox potential by the injection of air, oxygen, slow oxygen release compounds (ORCs), or nitrate to enhance aerobic biodegradation; and
3. injection of microbial cultures to improve the effectiveness of the microbial population in degrading the compounds of concern.

In situ chemical oxidation (ISCO) is a cost-effective method for destroying a wide range of organic aromatic and chlorinated compounds, particularly volatiles. It is used typically in source areas or hot spots. In an oxidation reaction, the oxidizing agent breaks the carbon bonds in an aromatic or chlorinated compound and converts them into non-hazardous or less toxic compounds, primarily carbon dioxide, water, and chloride. Commonly used oxidizers are potassium permanganate ($KMnO_4$), Fenton's Reagent (hydrogen peroxide in a solution of ferrous salts), ozone, and sodium persulfate.

In situ biosparging involves injection of a pressurized gas into the subsurface at very low flowrates to enhance biodegradation. Oxygen or air is injected at a low flow rate to enhance aerobic biodegradation. Injection of the gas is controlled such that vapors are not generated and do not accumulate in the vadose zone.

Permeable reactive barriers (PRBs) are an effective remedial technology for treatment of groundwater plumes. The PRB is typically installed in a trench downgradient of the groundwater plume. As the groundwater naturally flows through the PRB, the media within the PRB adsorbs and/or remediates the contaminants in the groundwater. The media used within the PRB could consist of a mixture of tree leaves or mulch, granular activated carbon (GAC) and sand/gravel. The contaminant would be adsorbed on the media and would be biodegraded by microbial activities within the barrier. The sand and gravel will aid the permeability of the PRB and reduce potential clogging. This technology is passive treatment and requires no ongoing energy requirements and limited maintenance following installation.

4.5.1.4 PHYSICAL CONTAINMENT ACTION

The physical containment response action would involve the use of physical means to contain and restrict the mobility and migration of chemicals in the groundwater. A potential physical containment technology involves construction of a barrier wall(s) either downgradient or around the source area to restrict the movement of chemicals from the Site via groundwater flow to minimize the volume of groundwater to be collected. Barrier walls can also be used with a groundwater collection/treatment system. Barrier walls can be constructed of soil/bentonite, cement/bentonite or sheet piling.

4.5.1.5 HYDRAULIC CONTAINMENT ACTION

The hydraulic containment action would involve groundwater extraction downgradient of the source area to reduce the migration of chemical constituents from the Site via groundwater flow. Hydraulic containment could be achieved by installing either groundwater extraction wells or horizontal groundwater collection drains. The collected groundwater would be either treated on Site or off Site using one of the treatment options presented in Section 4.5.1.7 and/or disposed of using one of the potential disposal options presented in Section 4.5.1.8.

4.5.1.6 SOURCE REMOVAL ACTION

The source removal response action would involve extracting groundwater throughout the source area utilizing either groundwater extraction wells or groundwater collection drains. The collected groundwater would be treated either on Site or off Site using one of the treatment options presented in Section 4.5.1.7 or disposed of using one of the potential disposal options presented in Section 4.5.1.8.

4.5.1.7 COLLECTION/TREATMENT ACTION

The collection/treatment response action would involve treating collected groundwater to acceptable standards prior to discharge. Potential treatment technologies include on-Site treatment using physical, chemical, or biological treatment options or off-Site treatment.

Physical treatment could be accomplished on Site using precipitation, filtration, carbon adsorption, air stripping, or aeration to remove contaminants from the groundwater.

Activated carbon could be used to remove dissolved contaminants from the groundwater by physical adsorption. The spent carbon would be treated/recycled or disposed of as necessary.

Air stripping involves physically stripping contaminants from the groundwater by the counter current flow of air through a packed tower media. Monitoring and treatment of the off-gas may be required.

Aeration involves physically stripping the contaminants from the groundwater by utilization of an aeration basin. Monitoring and treatment of off-gas may be required.

Chemical treatment of collected groundwater could be conducted using ultraviolet (UV) enhanced oxidation. The UV enhanced oxidation technology involves using chemical oxidizing agents such as hydrogen peroxide, or ozone combined with ultraviolet radiation to chemically oxidize organic compounds. The process decreases the toxicity of the waste by reducing contaminants to non-toxic components.

Biological treatment could be used to reduce organic concentrations in the collected groundwater. The principles of this process are essentially the same as described for bio-treatment of soils as described in Section 4.4.1.5.

Off-Site treatment technologies could include one or a combination of the identified on-Site treatment options.

4.5.1.8 COLLECTION/DISPOSAL ACTION

The collection/disposal response action would involve collection of groundwater using either the source removal and/or hydraulic containment response actions and disposal of the collected groundwater. Potential disposal technologies include discharge to Beaverdam Brook, groundwater injection or off-Site disposal at a publicly owned treatment works (POTW). Treatment utilizing one of the treatment actions identified in Section 4.5.1.7 may be required prior to disposal.

4.5.2 SCREENING OF GROUNDWATER REMEDIAL RESPONSE ACTIONS, TECHNOLOGIES, AND PROCESS OPTIONS

This section presents an evaluation of the groundwater remedial response actions, technologies, and process options. The screening process parallels the process used for screening the soil remedial alternatives (Section 4.4). The initial screening of response actions and technologies is based upon technical feasibility. Technologies which are not feasible are eliminated from further evaluation.

Following this screening, process options for the remaining response actions and technologies are evaluated based upon effectiveness, implementability, and cost considerations. The cost comparisons are based primarily upon engineering judgment and are of sufficient detail and accuracy to allow comparison of the different technologies and process options.

4.5.2.1 RESPONSE ACTIONS AND TECHNOLOGIES

A summary of the initial screening of potential remedial response actions and technologies for groundwater is presented in Table 4.7. A hydrogeologic evaluation of the Site relative to groundwater extraction alternatives is presented in Appendix E. Based upon the initial screening, the following technologies were eliminated from further evaluation:

- Physical Containment Action - barrier wall;
- Hydraulic Containment Action - overburden groundwater extraction wells;
- Source Removal Action - overburden and bedrock groundwater extraction wells;
- Collection/Disposal Action - groundwater injection;
- In situ Treatment Action – chemical oxidation; and
- In situ Treatment Action – permeable reactive barriers.

A discussion of the reasons for elimination of each of these technologies is presented in the following paragraphs:

Physical Containment Action - Barrier Wall

As discussed in Appendix E, the barrier wall construction does not provide any additional benefit for the control of off-Site migration of groundwater in the water table aquifer. Off-Site migration of groundwater would be sufficiently limited by a water table groundwater collection system.

Hydraulic Containment Action - Overburden Groundwater Extraction Wells

As discussed in Appendix E, the hydrogeologic conditions of the Site would require a multitude of groundwater extraction wells to obtain hydraulic containment for both the north and south components of the overburden groundwater flow downgradient of the former lagoon area. In addition, the limited saturated thickness of approximately 5 feet would potentially cause drawdown problems and reduce pumping efficiency. For the Site conditions, collector tile drains are considered to be more effective for hydraulic containment of the overburden groundwater. Hence the collector tile drain technology has been retained for further evaluation. Groundwater extraction wells for the hydraulic containment of the bedrock aquifer have been retained for further evaluation.

Source Removal Action - Groundwater Extraction Wells

Groundwater source extraction wells installed within the former lagoon area in both the overburden and bedrock would not be of significant benefit compared to the groundwater hydraulic containment option once the soil source is remediated. The time required to achieve groundwater MCLs for source removal is expected to be similar to the hydraulic containment option. Hence, the water table tile collection system with bedrock extraction wells has been retained for further evaluation.

Collection/Disposal Action - Groundwater Injection

Groundwater injection would be appropriate for in situ treatment technologies involving soil flushing where the recirculation of groundwater is required for effective treatment (or for increasing groundwater velocities). However, since this technology have not been retained, groundwater injection is not considered an appropriate disposal action.

In situ Treatment Action – Chemical Oxidation

Chemical oxidation will not be retained as a technology for groundwater in the FS. The low levels of the COCs in the plumes outside of the source area suggest that chemical oxidation may not be appropriate for this Site.

In Situ Treatment Action – Permeable Reactive Barriers

This technology is normally applied immediately downgradient of source areas where groundwater contamination is highest, with enhanced natural attenuation employed as a polishing step downgradient of the PRB. It is more suitable for the overburden groundwater, but not the bedrock groundwater because of the depth of the plume. However, with the source removed in the overburden under the remediation for soils, PRBs would provide little value. Therefore, this technology is not recommended and will not be retained for further evaluation in the FS.

4.5.2.2 PROCESS OPTIONS

The screening of process options is used to select the most cost-effective process options for the Site, considering Site-specific conditions such as geology, hydrogeology, and the chemicals of interest. The process options of the various technologies are evaluated based upon effectiveness, implementability, and cost considerations. The selected process options are retained for inclusion in the development of potential remedial alternatives to be further evaluated in the FS. The following sections present the evaluation of the different groundwater treatment options.

4.5.2.2.1 GROUNDWATER TREATMENT

A total of seven different process options were identified for potential groundwater treatment. The process options are listed below:

1. on-Site carbon adsorption;
2. on-Site air stripping;
3. on-Site aeration;
4. on-Site UV oxidation;
5. on-Site biological;
6. off-Site treatment at POTW; and
7. off-Site treatment at RCRA facility.

Due to the relatively large number of alternative treatment options to be evaluated, the detailed evaluation is presented in Appendix D and a summary of the results of the evaluation is presented in this section. Physical treatment such as filtration would be utilized on an as-required basis.

Effectiveness

UV oxidation, carbon adsorption, air stripping, off-Site treatment at a POTW, and off-Site treatment at a RCRA facility are considered to be effective treatment technologies for the majority of the chemicals at the Site. It is noted that UV oxidation, carbon adsorption and air stripping are partially effective for treating some of the Site compounds and less effective for other compounds. It is expected that a combination of these process options would be required to treat the varied constituents in the groundwater at the Site. Aeration is not considered effective, especially for SVOCs, due to its low efficiency in comparison to an air stripping system. Similarly, biological treatment would be ineffective for treating several chlorinated compounds present at the Site such as chlorobenzene and 4-chloroaniline, which would be expected to be present in the groundwater influent stream. Also, biological treatment would be less effective given the relatively low organic compound concentrations. Based upon the effectiveness criterion, biological treatment and aeration were eliminated from further evaluation.

Implementability

UV oxidation, carbon adsorption, air stripping and off-Site treatment at a RCRA facility are considered to be relatively easy to implement, however, pretreatment may be required to remove metals and suspended solids for the on-Site treatment options (e.g., precipitation and filtration). Chemical concentrations in the collected groundwater may preclude the feasibility of utilizing a POTW for groundwater treatment without prior pretreatment. In addition, transportation of the groundwater to the POTW may be problematic because of the volume of groundwater and distance from the Site to a suitable POTW.

Cost

Capital costs for installation of UV oxidation, carbon adsorption and air stripping systems including pretreatment are estimated to be $511,000, $230,000, and $518,000, respectively. First year annual operation and maintenance costs for treating collected water for a groundwater source treatment option (see Appendix E) are estimated to be $180,000 for UV oxidation, $75,000 for carbon adsorption, $87,000 for air stripping, and $3,000,000 for treatment at an off-Site RCRA facility. It is noted that the operating costs for a combined system (UV oxidation, carbon adsorption, and air stripping) would be lower than the sum of the aforementioned values if each of these processes were used only to treat the compounds which are readily treated by that method. A cost for the treatment at a POTW is not available.

Summary

Based upon this evaluation, it is recommended that a UV oxidation, air stripping, or carbon adsorption treatment system be included in alternatives which include groundwater collection and treatment (including precipitation/filtration, as required). These processes are much more cost effective than treatment at an off-Site RCRA facility. Treatment at an off-Site POTW may be applicable for alternatives which generate water at a very low flow rate and with low chemical concentrations. For purposes of the FS, it has been assumed that a carbon adsorption treatment system would be acceptable. The suitability of this process (or others) may only be determined during the detailed design/treatability study stage.

4.5.2.3 SUMMARY OF GROUNDWATER SCREENING RESULTS

Based upon the results of the screening of groundwater remedial response actions, technologies and process options, a total of six remedial response actions were retained for further evaluation. A listing of the retained response actions, technologies and process options is presented in Table 4.8. These alternatives represent a broad range of treatment, containment and disposal technologies which can be assembled into complete remedial alternatives for the Site for evaluation in the FS.

5.0 EVALUATION AND ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL

This section presents the development and detailed analysis of remedial alternatives for soil utilizing the general response actions, technologies, and process options retained from the initial screening conducted in Section 4. The following six alternatives for soil, presented in Table 5.1, were developed for detailed analysis:

Soil Alternative 1:

- No Action

Soil Alternative 2:

- Institutional Controls

Soil Alternative 3:

- Capping

Soil Alternative 4:

- Excavation/On-Site Biocell

Soil Alternative 5:

- In situ Soil Vacuum Extraction

Soil Alternative 6:

- Excavation/ Off-Site Disposal

The detailed analysis of alternatives consists of the evaluation of each alternative against seven evaluation criteria which encompass technical, cost, and institutional considerations; and compliance with statutory requirements. The detailed analysis presented in this section follows the outline presented in the U.S. EPA "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (May 1989).

The seven evaluation criteria used in the detailed analysis of remedial alternatives are summarized as follows:

1. overall protection of human health and the environment;
2. compliance with applicable or appropriate and relevant requirements (ARARs);
3. short-term impacts and effectiveness;

4. long-term effectiveness and permanence;
5. reduction of toxicity, mobility, and volume;
6. implementability; and
7. cost.

A list of evaluation factors to be considered under each evaluation criteria is presented in Table 5.2.

The detailed descriptions and analyses of each of the six soil alternatives is presented in Sections 5.1 to 5.6. A summary evaluation is presented in Section 7.1 and the preferred soil alternative is presented in Section 8.1.

The alternatives for soil are developed and analyzed separately from the groundwater alternatives in this section. The preferred soil and groundwater alternatives are combined in Section 8.3 where the complimentary components of the preferred remedies for soil and groundwater are discussed.

5.1 SOIL ALTERNATIVE 1: NO ACTION

The No Action alternative does not include any active remedial measures for soils. The No Action alternative would include a contingency plan for additional remedial action if conditions at the Site were identified to significantly degrade in the future. Organic chemical concentrations in the soil would be expected to reduce with time through natural attenuation processes.

5.1.1 SOIL ALTERNATIVE 1 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The No Action alternative would not reduce risks to human health and the environment associated with on-Site soils. Based upon the HHRA presented in the RI Report, the current cancer risks and non-carcinogenic hazard indices associated with surface and subsurface soil are acceptable.

The estimated cancer risks and non-carcinogenic hazard indices were below the level of concern for all potential future exposure pathways with the exception of the future residential user exposure to surface soil and the construction worker exposure to soil.

The existing conditions were determined to pose no significant risk to ecological receptors.

Under Alternative 1, future uses of the Site would not be further restricted from the present conditions.

5.1.2 SOIL ALTERNATIVE 1 - COMPLIANCE WITH ARARs

NYSDEC Soil Cleanup Objectives for soils would continue to be exceeded in the area of the former lagoons for the COCs. It is expected that the concentrations of the COCs would decrease with time as a result of natural attenuation.

5.1.3 SOIL ALTERNATIVE 1 - LONG-TERM EFFECTIVENESS AND PERMANENCE

Potential future health risks associated with the residential exposure to surface soils and the construction worker exposure to soils at the Site would be reduced over time through natural attenuation processes. Implementation of Soil Alternative 1 would not further reduce the long-term risks over what would occur through natural attenuation. A mandatory review of the remedial alternative would be conducted every 5 years to ensure that human health and the environment are being protected.

5.1.4 SOIL ALTERNATIVE 1 - REDUCTION OF TOXICITY MOBILITY, OR VOLUME THROUGH TREATMENT

Soil Alternative 1 provides no additional reduction in the toxicity, mobility, or volume of chemicals at the Site beyond what would be achieved through natural attenuation.

5.1.5 SOIL ALTERNATIVE 1 - SHORT-TERM EFFECTIVENESS

As Soil Alternative 1 involves no remedial action, there would be no additional short-term impacts to the community, workers, or the environment as a result of implementation of this alternative.

5.1.6 SOIL ALTERNATIVE 1 - IMPLEMENTABILITY

This alternative is easily implemented.

5.1.7 SOIL ALTERNATIVE 1 - COST

The costs associated with the implementation of this alternative is summarized in Table 5.3. This alternative has no capital cost or operational costs associated with it, except for Site evaluation every 5 years. On an annual basis, the Site evaluation costs are estimated to be $950. The total present worth of this alternative is estimated to be $15,000 based upon a 5.2 percent discount rate over a 30-year period.

5.2 SOIL ALTERNATIVE 2: INSTITUTIONAL CONTROLS

Soil Alternative 2 includes the implementation of institutional controls to minimize potential exposure to chemicals in the soils. Institutional controls can be utilized to effectively mitigate the potential for exposure to contaminated media and therefore, reduce risks associated with such exposures. The components of Soil Alternative 2 are presented on Figure 5.1.

Institutional controls would be comprised of deed restrictions and land use zoning changes. Deed restrictions would be placed on the Site to eliminate the potential for disturbance of the subsurface soils. Deed restrictions involve placing a notation on the property deed which makes the current and any prospective property owner aware of the property's history and the restricted land use of the property. The deed restriction would restrict the disturbance of subsurface soil and excavations and would limit property uses to open space uses only. In addition to deed restrictions, the local governments could amend land use zoning to further ensure that the property would not be developed in the future.

In addition to deed restrictions and land use zoning changes, physical controls would be used to eliminate the future potential for on-Site exposures. A perimeter security fence (with appropriate warning signs) has been constructed to restrict Site access and thereby prevent the potential exposure to chemicals present in the surface soils in the vicinity of the former lagoons. The Site security fencing and warning signs would be routinely inspected and maintained at the Site to restrict access to the Site.

5.2.1 SOIL ALTERNATIVE 2 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative would reduce the risks to human health for all future exposure scenarios associated with the potential contact with chemicals in the soils by maintaining restricted access to the Site. The potential to develop the Site in the future would be mitigated by the use of institutional controls such as deed restrictions and land use zoning changes.

5.2.2 SOIL ALTERNATIVE 2 - COMPLIANCE WITH ARARS

NYSDEC Soil Cleanup Objectives for soils would continue to be exceeded in the area of the former lagoons for the COCs. It is expected that the concentrations of the COCs would decrease with time as a result of natural attenuation.

5.2.3 SOIL ALTERNATIVE 2 - LONG-TERM EFFECTIVENESS AND PERMANENCE

Implementation of Soil Alternative 2 would reduce the potential risks due to direct contact/ingestion of soil for future uses through institutional controls. Institutional controls are considered to be reliable as a method to restrict access and possible future land uses at remote locations such as this Site. A mandatory review of the remedial alternative would be conducted every 5 years to ensure that human health and the environment are being protected.

5.2.4 SOIL ALTERNATIVE 2 - REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Soil Alternative 2 provides no additional reduction in the toxicity, mobility, or volume of chemicals at the Site beyond what would be achieved through natural attenuation.

5.2.5 SOIL ALTERNATIVE 2 - SHORT-TERM EFFECTIVENESS

As Alternative 2 involves no disturbance of any of the soils at the Site, there would be no additional short-term impacts to the community, workers, or the environment as a result of implementation of this alternative. The institutional controls could be implemented in a relatively short period of time (approximately 1 year).

5.2.6 SOIL ALTERNATIVE 2 - IMPLEMENTABILITY

Institutional controls are generally easy to implement.

5.2.7 SOIL ALTERNATIVE 2 - COST

A detailed cost breakdown for Soil Alternative 2 is presented in Table 5.4. The total capital cost is estimated to be $12,600. The annual costs for Site evaluation and maintenance are estimated to be $13,550. The total present worth of this alternative is estimated to be $217,000 based upon a 5.2 percent discount rate over a 30-year period.

5.3 SOIL ALTERNATIVE 3: CAPPING

Alternative 3 involves the construction of a cap meeting RCRA design standards (see Figure 4.1) in the area delineated on Figure 5.2. This area has soils above the water table with concentrations exceeding the NYSDEC Soil Cleanup Objectives. The cap would serve to effectively reduce chemical mass loadings to the groundwater from the former lagoon area thereby reducing the chemical concentrations beneath the former lagoons.

Prior to capping, the area would be graded to promote surface water drainage off the capped area and to conform with the maximum (33 percent) and minimum (2 percent) slope criteria.

Chemicals in the soils above the water table would be contained by the capping option. Chemicals in the soils beneath the water table and chemicals in the groundwater would be reduced with time through natural attenuation. In addition, as the Site is located on a groundwater divide, decreasing the infiltration over the former lagoon area will result in a lowering of the water table in the overburden aquifer directly beneath the Site and, hence, further reduce the chemical migration from this area via groundwater transport.

Institutional controls would be implemented to protect the capped areas from future disturbance and prevent the future development of the Site. The perimeter security fence would be maintained to restrict Site access. Institutional controls are identified in Soil Alternative 2.

5.3.1 SOIL ALTERNATIVE 3 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative would reduce the risks to human health for all exposure scenarios associated with the soils at the Site. The placement of the cap would reduce potential emissions of chemicals in the near surface soils to the atmosphere, and eliminate the potential dermal contact with chemicals in the surface soils to Site trespassers. Access to the capped area of the Site would be restricted by maintaining the Site security fence. Construction of the cap would reduce infiltration and hence lower the water table in the area of the former lagoons thereby reducing chemical migration via the overburden aquifer. This would result in reduced risks associated with exposure to chemicals in the groundwater.

5.3.2 SOIL ALTERNATIVE 3 - COMPLIANCE WITH ARARs

NYSDEC Soil Cleanup Objectives for soils would continue to be exceeded in the area of the former lagoons for the COCs. However, the NYSDEC Soil Cleanup Objectives are designed to prevent the concentrations of the COCs in the groundwater from exceeding the Class GA groundwater criteria as a result of leaching from the soils. Capping the former lagoon area would mitigate infiltration and leaching of the contaminants from the soil to the groundwater, thereby achieving the goal of the NYSDEC Soil Cleanup Objectives for the protection of groundwater.

It is expected that the concentrations of the COCs in the soils would decrease with time as a result of natural attenuation.

5.3.3 SOIL ALTERNATIVE 3 - LONG-TERM EFFECTIVENESS AND PERMANENCE

Implementation of Soil Alternative 3 would eliminate potential risks due to direct contact/ingestion of soils. Potential risks to chemicals in the ambient air and groundwater would also be reduced by the capping action. Provided that the cap is regularly maintained, the capping action is considered to have high and long-lasting reliability. Institutional controls to prevent the future disturbance of the cap are also considered to be reliable. A mandatory review of the remedial action would be required every 5 years.

5.3.4 SOIL ALTERNATIVE 3 - REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Implementation of this alternative would significantly reduce the mobility of the total volume of chemicals in the soils within the former lagoons by mitigating infiltration and lowering the water table beneath the cap. The implementation of a cap would act to reduce the mass flux into the groundwater environment which would ultimately result in reduced concentrations in the groundwater downgradient of the former lagoon area.

5.3.5 SOIL ALTERNATIVE 3 - SHORT-TERM EFFECTIVENESS

Implementation of Soil Alternative 3 would involve minimal excavation and grading of soils with chemical concentrations exceeding the NYSDEC Soil Cleanup Objectives. These activities may result in a temporary increase in dust production and chemical emissions to the atmosphere. Workers would be required to wear appropriate personal protective equipment and adhere to safe construction practices to minimize potential hazards. It is estimated that the cap could be installed within a period of approximately 3 months. The benefits of the remedial action would be obtained immediately upon installation.

5.3.6 SOIL ALTERNATIVE 3 - IMPLEMENTABILITY

Implementation of this alternative would involve common construction procedures and the services and materials are readily available. The cap would require regular maintenance to ensure its effectiveness.

5.3.7 SOIL ALTERNATIVE 3 - COST

A detailed cost breakdown for Soil Alternative 3 is presented in Table 5.5. The total capital cost is estimated to range from $1,740,000 to $2,290,000 and the estimated annual operation and maintenance cost is estimated to be $24,000. The total present worth of this alternative is estimated to range from $2,100,000 to $2,647,000 based upon a 5.2 percent discount rate over a 30-year period.

5.4 SOIL ALTERNATIVE 4: EXCAVATION/ON-SITE BIOCELL

Soil Alternative 4 would involve the excavation of the soils within the former lagoons and treatment of the soils with concentrations of COCs exceeding the NYSDEC Soil Cleanup Objectives on Site utilizing SVE and biological degradation within an engineered below-grade biocell. The biocell approach would involve excavation, soil amendment, and nutrient addition followed by the replacement of the amended soils within a below-grade biocell for the application of the SVE and bioremediation technologies.

The results of the Treatability Study, presented in Section 2.6, indicate that the COCs in the soils within Lagoons 1 to 6 can be successfully treated by SVE and biodegradation. The primary removal mechanism for the VOCs was SVE with a further reduction due to biodegradation. The primary removal mechanism for 2-aminopyridine, the only SVOC COC detected in the Treatability Study samples at significant concentrations, was biodegradation. Based on the literature review conducted for the Treatability Study, pyridine and alpha-picoline are more readily biodegradable than 2-aminopyridine. All VOCs in the Treatability Study samples were reduced to concentrations below NYSDEC Soil Cleanup Objectives after 4 weeks. 2-Aminopyridine was reduced by 90 percent within the first 4 weeks. At the end of the 16-week study, the concentration of 2-aminopyridine was 1,300 J $\mu g/kg$ and 720 J $\mu g/kg$ in the duplicate sample.

The total volume of material in the area of the former lagoons to be excavated is estimated to be approximately 56,810 cubic yards as presented in Appendix A. Based on the results of the test pit samples collected during the Treatability Study, the upper layer of soils within Lagoons 1, 2, 3, 4, and 5 consisting of approximately 21,690 cubic yards, most likely will not require treatment as COC concentrations are expected to be below NYSDEC Soil Cleanup Objectives. This upper layer of material would be excavated and segregated from the contaminated black-stained layer in separate 150 cubic yard stockpiles. Samples would be obtained by collecting a 6-point composite sample from each 150 cubic yard stockpile. Samples from the stockpiles of upper layer material would be analyzed for TCL VOCs and pyridine-based compounds to confirm that concentrations are below the applicable cleanup objectives. For the purpose of the FS, based on the above sampling program, it is assumed that 0 to 25 percent of the upper layer material (0 to 5,423 cubic yards) will contain concentrations greater than Soil Cleanup Objectives, and will, therefore, require treatment in the biocell.

The volume of black-stained contaminated soils in Lagoons 1, 2, 3, 4, and 5 is estimated to be approximately 35,000 cubic yards. However, it is conservatively estimated that approximately 20 percent of the black-stained contaminated soils in Lagoons 1 to 5 consists of fragmented shale and cobbles that would be screened out during processing prior to treatment. In addition, for the purpose of the FS, it is assumed that 75 to 100 percent of the black-stained contaminated soil will contain concentrations greater than Soil Cleanup Objectives, and will require treatment in the biocell. In addition to this volume (21,000 to 28,000 cubic yards) requiring treatment from Lagoons 1, 2, 3, 4, and 5, it is estimated that approximately 10 percent (120 cubic yards) of contaminated material from Lagoon 6, which consists primarily of shale fragments, would require treatment. Therefore, the total volume of material from the black-stained layer and lagoon 6 requiring treatment is estimated to range from approximately 21,120 to 28,120 cubic yards.

The total volume of material requiring treatment in the biocell following screening and including up to 25 percent of the upper layer material is estimated to range from 21,120 to 32,460 cubic yards.

The biocell would be constructed in the area of Lagoons 1, 2, and 3 for a total area of up to approximately 100,000 square feet as shown on Figure 3.3. The average depth to bedrock for Lagoons 1, 2, and 3 is estimated to be 9.5, 9.3, and 13.3 feet, respectively, as presented in Appendix A. It is proposed that the biocell be constructed to a depth of approximately 9 feet. The capacity of the biocell would, therefore, be designed to treat up to 33,000 cubic yards and would accommodate all of the soils to be treated at the Site. Based on the review of groundwater levels in the area of Lagoons 1, 2, and 3, presented in Appendix A, it is expected that the base of the biocell would be above the water table in the summer months. For the remainder of the year, it is expected that the water table would rise to a few feet above the base of the biocell. This groundwater would be collected by the drainage layer constructed within the base of the biocell. The results of the Treatability Study indicated the need to add water to the soils in order to increase the moisture content to optimize conditions for microbial activity. The average moisture content for the test pit samples collected from the lagoons in 1996 was estimated to be 14 percent. Therefore, groundwater would be collected and recirculated within the biocell to increase the moisture content of the soils to be treated.

No active treatment of groundwater would be conducted during the operation of the biocell. However, it is expected that the concentrations of COCs in groundwater would be reduced as the groundwater is recirculated within the biocell. Groundwater would be addressed in the remedy selection process presented in Section 6.0.

The material within the lagoons would be systematically excavated. Lagoons 1, 2, and 3 would be excavated first in order to construct the biocell. The clean upper layer from the lagoons would be stockpiled separately. As discussed, samples would be collected from this material to confirm that COC concentrations are below applicable cleanup objectives. The clean material would be backfilled in Lagoons 4, 5, and 6 following excavation of contaminated soils.

Confirmatory samples would be obtained from the excavation sidewalls to ensure that soils with COC concentrations exceeding the NYSDEC Soil Cleanup Objectives are removed. A real-time screening instrument such as an OVA meter would be used in conjunction with visual observation to guide the excavation. Once visual and real-time screening indicate the absence of contamination on the excavation sidewall, verification sampling would be conducted by collecting 6-point composite samples approximately every 50 feet around the perimeter of the excavation. Composite samples would be analyzed for TCL VOCs and pyridine-based compounds. If COCs are detected above the water table at concentrations above cleanup levels, excavation would continue into the sidewall for a few feet and additional samples would be collected.

Soils to be treated would be screened to remove shale fragments and cobbles. The soils to be treated would be amended with sawdust or vermiculite in the range of 2 to 4 percent to increase the effective hydraulic conductivity of the material to be treated. The material would be homogenized and mixed with additives such as ammonium sulfate, urea, and tripotassium phosphate to optimize conditions for biodegradation prior to placement within the biocell. Material to be treated would be placed in the biocell in two approximately 4.5-foot lifts.

The soils would be treated within the biocell by installing perforated pipes within each layer as presented on Figure 5.4. The perforated pipes would be connected to a blower unit to draw air through the piles. The air would be treated, if necessary, using carbon adsorption, prior to recirculation or exhaust to the atmosphere. Nutrients would be added to the treatment layers as required to enhance biological degradation.

In general, the biocell would be operated in two primary modes:

- SVE mode (high air flow rate); and
- bioremediation mode (low air flow rate).

During the SVE mode, the system would be operated at higher air flow rates which would be selected to optimize the removal of the VOC constituents using SVE. After the removal rate of the VOCs decreases to an asymptotic or nominal rate, the system would be switched over to the bioremediation mode. During the bioremediation mode, the system would be operated at an optimized air flow rate selected to sustain the aerobic biodegradation of the remaining VOCs and SVOCs.

Air monitoring would be conducted on a regular basis and, if required, the biocell would be covered to reduce chemical and fugitive dust emissions.

Periodic monitoring of the influent and effluent vapor-phase concentrations from the SVE system would be conducted for the COCs (TCL VOCs and pyridine-based compounds). It is proposed that monitoring of the system be conducted on a daily basis during startup for the first 4 weeks and then at a frequency of once per week. Once influent concentrations have flattened out, monitoring would be conducted every 2 weeks. The exact design of the treatment system monitoring program would be finalized during the remedial design.

For the duration of the biocell operation, quarterly reports would be prepared and submitted to the NYSDEC which would document sampling activities, present analytical results, and provide an evaluation of the data.

Once the vapor-phase influent concentrations of the COCs have been sufficiently reduced, verification sampling of the treated soils within the biocell would be performed. Samples would be collected from the treated soils within the biocell and analyzed for TCL VOCs and pyridine-based compounds. A statistically valid sampling strategy would be applied to the verification sampling process using the 95 percent upper confidence level for each COC to determine if the remediation of the soils is complete. For the purposes of the FS, it is assumed that verification sampling would be conducted every 2,500 square feet. Samples would be collected from the center of 50-foot grids at two depth intervals for a total of approximately 60 verification samples. The operation of the biocell would be terminated following the reduction of the 95 percent upper confidence level of each COC to levels below NYSDEC Soil Cleanup Objectives. A post-remediation sampling plan including a statistical approach would be developed in the Remedial Design/Remedial Action Work Plan. It is estimated that it would take 1 to 2 years to treat the COCs to levels below cleanup objectives.

A Remedial Design/Remedial Action Work Plan would be prepared for the Site detailing the protocols for handling visual contaminant hot spots, sampling for the segregation of clean soil from soil to be treated, confirmatory soil sampling during excavation, and post-remediation verification sampling within the biocell.

A Remedial Action Completion Report would be prepared following the reduction of the COC concentrations to levels below the Soil Cleanup Objectives.

5.4.1 SOIL ALTERNATIVE 4 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative would reduce the risks to human health for all exposure scenarios associated with the soils at the Site. The Biocell treatment process would remove chemicals from the soils and hence eliminate all exposures to chemicals in this medium. Access to the Site would be restricted during remediation by the maintenance of the Site security fence.

5.4.2 SOIL ALTERNATIVE 4 - COMPLIANCE WITH ARARS

NYSDEC Soil Cleanup Objectives for soils would be achieved by the removal and degradation of the COCs by SVE and biodegradation.

5.4.3 SOIL ALTERNATIVE 4 - LONG-TERM EFFECTIVENESS AND PERMANENCE

Implementation of Soil Alternative 4 would eliminate all risks associated with chemicals in the soils at the Site. The reliability of this alternative is high as no long-term operation or maintenance is required.

This alternative is considered to be permanent as the concentrations of the COCs would be effectively and permanently reduced by treatment in the biocell.

5.4.4 SOIL ALTERNATIVE 4 - REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

It is estimated that Soil Alternative 4 would remove and treat more than 90 percent of the COCs in the soils to levels below NYSDEC Soil Cleanup Objectives. The treatment processes, SVE and biodegradation for soils, are irreversible. Spent carbon from the SVE treatment processes would be sent off Site for regeneration or disposal. Low levels of chemicals would remain in the soils at concentrations below NYSDEC Soil Cleanup Objectives. However, the low levels of chemicals remaining on Site would be expected to be naturally attenuated over time. It should be noted that the mass flux of chemicals to the groundwater would be reduced by treatment of the soils resulting in reduced chemical concentrations in the groundwater beneath and downgradient of the former lagoon area.

5.4.5 SOIL ALTERNATIVE 4 - SHORT-TERM EFFECTIVENESS

Soil Alternative 4 involves extensive excavation and handling of soils with chemical concentrations exceeding the NYSDEC Soil Cleanup Objectives. These processes may result in chemical emissions to the atmosphere. Workers would be required to wear appropriate personal protective equipment and adhere to safe construction practices to minimize potential hazards.

It is estimated that this alternative would take approximately 1 to 2 years to complete.

5.4.6 SOIL ALTERNATIVE 4 - IMPLEMENTABILITY

Excavation to the depths required (approximately 10 to 20 feet bgs) is within the limits of normal construction equipment (i.e., specialized equipment would not be required). Other construction components of this alternative are relatively easy to implement. Soil with chemical concentrations exceeding the cleanup levels would not be excavated until space is available in the biocell. This would ensure that handling of this soil is minimized and hence will decrease worker exposure.

The excavation of soils will allow for the identification and handling of any hot spots.

Influent and effluent monitoring would be required for the vapor treatment system. Compliance with the requirements of RCRA and N.Y. State Air permits may be required for operation of the SVE component of the biocell treatment system.

5.4.7 SOIL ALTERNATIVE 4 - COST

A detailed cost breakdown for Soil Alternative 4 is presented in Table 5.6. The total capital cost is estimated to range from $1,474,000 to $2,388,000 and the estimated annual operation and maintenance cost is estimated range from $241,000 to $406,000. The total present worth of this alternative is estimated to range from $1,734,000 to $3,119,000 for an operating period of 1 to 2 years, respectively, based upon a 5.2 percent discount rate over a 3-year period, the expected duration of this alternative.

5.5 SOIL ALTERNATIVE 5: IN SITU VACUUM EXTRACTION

Soil Alternative 5 includes the installation of an in situ soil vacuum extraction system (ISVE) in the area identified for potential soil remediation. A drainage swale would be constructed along the edge of the treatment area to prevent surface water run-on to the treatment area. The various components of Soil Alternative 5 are presented on Figure 5.5.

As discussed previously, the ISVE system can either consist of a network of vertical wells or horizontal trenches with gravel drains and perforated pipes. Due to the relatively high permeability of the soils at the Site, it is expected that a system of extraction wells would be the preferred option, however, this determination would be based upon the results of a pre-design study which may include a pilot test. For the purpose of this evaluation, it is assumed that the system will consist of a network of extraction wells.

The soil vapor extraction wells would be strategically placed within the area of soil to be treated to ensure that airflow within the area is maximized. The extraction wells would consist of a screened section of pipe placed in a permeable packing with the top few feet of the well grouted to prevent the short circuit of airflow from the surface. An impermeable temporary cap (e.g., 40-mil HDPE liner and soil) would be placed over the treatment area to lower the water table and increase the volume of the unsaturated zone as well as to prevent short circuiting of airflow directly from the surface.

The extraction wells would be installed with vacuum and positive pressures being applied at alternating well locations to create an induced pressure gradient to move the vapors through the soil. Extracted vapors would be treated utilizing carbon filters, if required, prior to reinjection or exhaust to the atmosphere. Vapor-phase nutrients would also be injected into the soils, if required, to enhance biodegradation.

Collected groundwater and water separated from the vapor phase would be treated on Site using carbon adsorption, if necessary. The treated water would be discharged to Beaverdam Brook for which the technical requirements of a SPDES permit would have to be satisfied.

Periodic monitoring of the influent and effluent vapor-phase concentrations from the ISVE blower system would be conducted for the COCs (TCL VOCs and pyridine-based compounds). It is proposed that monitoring of the system be conducted on a daily basis during startup for the first 4 weeks and then at a frequency of once per week. Once influent concentrations have flattened out, monitoring would be conducted every 2 weeks. The exact design of the treatment system monitoring program would be finalized during the remedial design.

For the duration of ISVE operation, quarterly reports would be prepared and submitted to the NYSDEC which would document sampling activities, present analytical results and provide an evaluation of the data.

Once the vapor-phase influent concentrations of the COCs have been sufficiently reduced, verification sampling of the treated soils within the former lagoons would be performed. Samples would be collected from the treated soils within the lagoons and analyzed for TCL VOCs and pyridine-based compounds. The operation of the ISVE system would be terminated following the reduction of COC concentrations to levels below NYSDEC Soil Cleanup Objectives. It is estimated that it would take approximately 4 years to treat the COCs to levels below cleanup objectives.

Prior to final design, a pre-design ISVE pilot study would be conducted to provide refined estimates of unsaturated zone permeability, potential flow rates and equilibrium vapor concentrations. The pilot study would be completed either before or during the preparation of the preliminary remedial design. The results of the ISVE pilot study would be incorporated into the preliminary remedial design. The actual nature and scope of work for the pilot study would be presented in the Remedial Design/Remedial Action Work Plan prepared for the Site.

The ISVE pilot study would include the installation of extraction wells in representative areas of soil stratification and contamination. The wells would be screened in the soil remediation zone and be sealed. Vapor monitoring points consisting of nests of short, small diameter sections of perforated pipe would be installed at varying radial distances from each vapor extraction well. The vapor extraction well(s) would be connected to individual vacuum pumps and the system would be activated. Point measurements of vacuum reading, vapor concentrations, and time would be made at constant flow rates. The pilot test would be run until the vacuum readings stabilize and then continued until at least one pore volume of vapor was removed. Vapor readings at the start of a test are representative of equilibrium vapor concentrations while readings taken after one pore volume has been removed are indicative of expected removal rates and concentrations. The expected change in pressure distribution with time can be predicted by equations governing flow in porous media. The calculated slope of pressure distribution data plotted as a function of time on a logarithmic scale equals the soil permeability to vapor flow. This data would be used to assist in the design of the full-scale system and the prediction of expected rate of cleanup. These parameters would also be used to develop specifications for the extraction well spacing, manifolds, blower sizes, and power requirements.

A Remedial Action Completion Report would be prepared following the reduction of the COC concentrations to levels below the Soil Cleanup Objectives.

5.5.1 SOIL ALTERNATIVE 5 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative would reduce the risks to human health for all exposure scenarios associated with chemicals in the soils. The soil treatment would reduce the concentrations of chemicals in the soil and hence eliminate potential risks to chemicals in this medium. The placement of the impermeable cap would reduce potential emissions of chemicals in the near surface soils to the atmosphere, as well as eliminate the potential dermal contact with chemicals in the surface soils (to Site trespassers). Access to the Site would be restricted during remediation by the maintenance of the Site security fence.

5.5.2 SOIL ALTERNATIVE 5 - COMPLIANCE WITH ARARs

NYSDEC Soil Cleanup Objectives for soils would be achieved by the removal of the COCs by ISVE.

5.5.3 SOIL ALTERNATIVE 5 - LONG-TERM EFFECTIVENESS AND PERMANENCE

Implementation of Soil Alternative 5 would eliminate all risks associated with chemicals in the soils at the Site. Risks associated with chemicals in the groundwater would decrease with time with the removal of the source area. The reliability of this alternative is high as no long-term operation or maintenance is required.

5.5.4 SOIL ALTERNATIVE 5 - REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

It is estimated that Soil Alternative 5 would remove and treat more than 90 percent of the chemicals in the soils. The treatment process, carbon adsorption for vapor is irreversible. Spent carbon from the treatment process would be sent off Site for regeneration or disposal. Low levels of chemicals would remain in the soils at concentrations below NYSDEC Soil Cleanup Objectives. However, the low levels of chemicals remaining on Site would be expected to be naturally attenuated over time. It should be noted that the mass flux of chemicals to the groundwater would be reduced by treatment of the soils resulting in reduced chemical concentrations in the groundwater beneath and downgradient of the former lagoon area.

5.5.5 SOIL ALTERNATIVE 5 - SHORT-TERM EFFECTIVENESS

Implementation of Soil Alternative 5 would involve some worker contact with soils containing chemicals exceeding the potential cleanup levels and groundwater containing chemical constituents during installation of the ISVE system. Workers would be required to wear appropriate personal protective equipment and adhere to safe construction practices to minimize potential hazards.

ISVE construction activities could result in a temporary increase in dust production. A temporary increase in chemical emissions may also result during the treatment process. These emissions are expected to be low and hence will not result in any risks to the local community or the environment.

It is estimated that the SVE treatment would take approximately 4 years to complete.

5.5.6 SOIL ALTERNATIVE 5 - IMPLEMENTABILITY

A pilot test would be required to obtain design parameters for the ISVE system. Installation of the system involves common construction procedures. The system could be left in place for a period following remediation and be reactivated and/or expanded if necessary.

Compliance with N.Y. State air permits may be required for the operation of the treatment systems.

5.5.7 SOIL ALTERNATIVE 5 - COST

A detailed cost breakdown for Soil Alternative 5 is presented in Table 5.7. The total capital cost is estimated to range from $1,013,000 to $1,211,000 and the estimated annual operation and maintenance cost is estimated to range from $233,200 to $460,900. The total present worth of this alternative is estimated to range from $2,104,000 to $2,302,000 based upon a 5.2 percent discount rate over a 5-year period, the expected duration of this alternative.

5.6 SOIL ALTERNATIVE 6: EXCAVATION/OFF-SITE DISPOSAL

Soil Alternative 6 includes the excavation of soils within the former lagoons containing COCs at concentrations exceeding NYSDEC Soil Cleanup Objectives. The excavated soils would be disposed of off Site at an appropriate landfill. The components of Soil Alternative 6 are presented on Figure 5.6.

The total volume of material in the area of the former lagoons to be excavated is estimated to be approximately 56,810 cubic yards as presented in Appendix A. Based on the results of the test pit samples collected during the Treatability Study, the upper layer of soils within Lagoons 1, 2, 3, 4, and 5 consisting of approximately 21,690 cubic yards, most likely will not require disposal as COC concentrations are expected to be below NYSDEC Soil Cleanup Objectives. This upper layer of material would be excavated and segregated from the contaminated black-stained layer in separate 150 cubic yard stockpiles. Samples would be obtained by collecting a 6-point composite sample from each 150 cubic yard stockpile. Samples from the stockpiles of upper layer material would be analyzed for TCL VOCs and pyridine-based compounds to confirm that concentrations are below the applicable cleanup objectives. For the purpose of the FS, based on the above sampling program, it is assumed that 0 to 25 percent of the upper layer material (0 to 5,423 cubic yards) will contain concentrations greater than Soil Cleanup Objectives, and will, therefore, require disposal.

The volume of black-stained contaminated soils in Lagoons 1, 2, 3, 4, and 5 is estimated to be approximately 35,000 cubic yards. However, it is conservatively estimated that approximately 20 percent of the black-stained contaminated soils in Lagoons 1 to 5 consists of fragmented shale and cobbles that would be screened out during processing prior to disposal. In addition, for the purpose of the FS, it is assumed that 75 to 100 percent of the black-stained contaminated soil will contain concentrations greater than Soil Cleanup Objectives, and will require disposal. In addition to this volume (21,000 – 28,000 cubic yards) requiring disposal from Lagoons 1, 2, 3, 4, and 5, it is estimated that approximately 10 percent (120 cubic yards) of contaminated material from Lagoon 6, which consists primarily of shale fragments, would require disposal. Therefore, the total volume of material from the black-stained layer and lagoon 6 requiring disposal is estimated to range from approximately 21,120 to 28,120 cubic yards.

The total volume of material requiring disposal following screening and including up to 25 percent of the upper layer material is estimated to range from 21,120 to 32,460 cubic yards or 38,020 to 58,430 tons at a density of 1.8 tons/cubic yard.

The results of TCLP analysis of eight soil samples collected from the former lagoons by the U.S. EPA in November 1996, indicated the exceedance of the TCLP Regulatory Level for benzene in one sample. Therefore, for the purposes of the FS, it is conservatively assumed that from 5 to 15 percent (1,056 to 4,870 cubic yards) of the material to be disposed would be characteristically hazardous.

The material within the lagoons would be systematically excavated beginning in the area of the groundwater divide and working to the south and north. The clean upper layer from the lagoons would be stockpiled separately. As discussed, samples would be collected from this material to confirm that COC concentrations are below applicable cleanup objectives. The clean material would be backfilled in the lagoons. Additional fill material would be imported to fill in the remainder of the former lagoons.

Confirmatory samples would be obtained from the excavation sidewalls to ensure that soils with COC concentrations exceeding the NYSDEC Soil Cleanup Objectives are removed. A real-time screening instrument such as an OVA meter would be used in conjunction with visual observation to guide the excavation. Once visual and real-time screening indicate the absence of contamination on the excavation sidewall, verification sampling would be conducted by collecting 6-point composite samples approximately every 50 feet around the perimeter of the excavation. Composite samples would be analyzed for TCL VOCs and pyridine-based compounds. If COCs are detected above the water table at concentrations above cleanup levels, excavation would continue into the sidewall for a few feet and additional samples would be collected.

A Remedial Design/Remedial Action Work Plan would be prepared for the Site detailing the protocols for handling visually contaminated hot spots, sampling for the segregation of clean soil from soil to be treated, and confirmatory soil sampling during excavation.

A Remedial Action Completion Report would be prepared following the reduction of the COC concentrations to levels below the Soil Cleanup Objectives.

5.6.1 SOIL ALTERNATIVE 6 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative would reduce the risks to human health for all exposure scenarios associated with the soils at the Site. The excavation and off-Site disposal would remove the soils from the Site and hence eliminate all exposures to chemicals in this medium. Access to the Site would be restricted during remediation by the maintenance of the Site security fence.

5.6.2 SOIL ALTERNATIVE 6 - COMPLIANCE WITH ARARS

NYSDEC Soil Cleanup Objectives for soils would be achieved qt the Site by the removal of the COCs by excavation and off-Site disposal.

5.6.3 SOIL ALTERNATIVE 6 - LONG-TERM EFFECTIVENESS AND PERMANENCE

Implementation of Soil Alternative 6 would eliminate all risks associated with chemicals in the soils at the Site. The reliability of this alternative is high as no long-term operation or maintenance is required.

This alternative is considered to be permanent as the concentrations of the COCs would be effectively and permanently reduced by disposing of the soils off Site.

5.6.4 SOIL ALTERNATIVE 6 - REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

It is estimated that Soil Alternative 6 would remove more than 90 percent of the COCs in the soils at the Site to levels below NYSDEC Soil Cleanup Objectives. The low levels of chemicals remaining on Site would be expected to be naturally attenuated over time. It should be noted that the mass flux of chemicals to the groundwater would be reduced by the removal of the soils resulting in reduced chemical concentrations in the groundwater beneath and downgradient of the former lagoon area.

The mobility of the chemicals would be reduced by the placement in an appropriate engineered and permitted off-Site landfill. However, Soil Alternative 6 would not result in the reduction of toxicity or volume of the COCs through treatment.

5.6.5 SOIL ALTERNATIVE 6 - SHORT-TERM EFFECTIVENESS

Soil Alternative 6 involves extensive excavation and handling of soils with chemical concentrations exceeding the NYSDEC Soil Cleanup Objectives. These processes may result in chemical emissions to the atmosphere. Workers would be required to wear appropriate personal protective equipment and adhere to safe construction practices to minimize potential hazards.

It is estimated that this alternative would take approximately 1 year to complete.

5.6.6 SOIL ALTERNATIVE 6 - IMPLEMENTABILITY

Excavation to the depths required (approximately 10 to 20 feet bgs) is within the limits of normal construction equipment (i.e., specialized equipment would not be required). Other construction components of this alternative are relatively easy to implement. Soil with chemical concentrations exceeding the cleanup levels would not be excavated until space is available in the staging areas. This would ensure that handling of this soil is minimized and hence will decrease worker exposure.

The excavation of soils will allow for the identification and handling of any hot spots.

5.6.7 SOIL ALTERNATIVE 6 - COST

A detailed cost breakdown for Soil Alternative 6 is presented in Table 5.8. The total capital cost is estimated to range from $5,736,000 to $11,208,000 and the estimated annual operation and maintenance cost is estimated to be $22,000. The total present worth of this alternative is estimated to range from $5,756,000 to $11,228,000 based upon a 5.2 percent discount rate over a 2-year period, the expected duration of this alternative.

6.0 EVALUATION AND ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUNDWATER

This section presents the development and detailed analysis of remedial alternatives for groundwater utilizing the general response actions, technologies, and process options retained from the initial screening conducted in Section 4.0. The following five alternatives for groundwater, presented in Table 6.1, were developed for detailed analysis:

Alternative 1:
- No Action

Alternative 2:
- Monitored Natural Attenuation

Alternative 3:
- Pump and Treat

Alternative 4:
- Enhanced Bioremediation

Alternative 5:
- Biosparging

The detailed analysis of groundwater alternatives consists of the evaluation of each alternative against the seven evaluation criteria described for the evaluation of the soil alternatives in Section 5.0.

The detailed descriptions and analyses of each of the five groundwater alternatives are presented in Sections 6.1 to 6.5. A summary evaluation is presented in Section 7.2 and the recommended groundwater alternative is presented in Section 8.2.

The alternatives for groundwater are developed and analyzed separately from the soil alternatives in this section. The preferred soil and groundwater alternatives are combined in Section 8.3 where the complimentary components of the recommended remedies for soil and groundwater are discussed.

6.1 GROUNDWATER ALTERNATIVE 1: NO ACTION

The No Action alternative does not include any active remedial measures for groundwater. Organic chemical concentrations in the groundwater would be expected to reduce with time through natural attenuation processes.

A mandatory review of the remedial alternative would be conducted every 5 years to ensure that human health and the environment are being protected. The No Action alternative would include a contingency plan for additional remedial action if conditions at the Site were identified to significantly degrade in the future.

6.1.1 GROUNDWATER ALTERNATIVE 1 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The No Action alternative would not reduce risks to human health associated with on Site groundwater. Based upon the HHRA presented in the RI Report, the current cancer risks and non-carcinogenic hazard indices associated with groundwater are acceptable.

The results of the ongoing quarterly Residential Monitoring Program conducted by the NYSDOH and the quarterly monitoring conducted for the Maybrook supply wells indicate that Site-related compounds, including the COCs, are not being detected in the groundwater used for potable purposes by the residents closest to the Site.

The estimated cancer risks and non-carcinogenic hazard indices were above the level of concern for the future potential residential user exposure to groundwater on Site.

The existing conditions were determined to pose no significant risk to ecological receptors.

Under Alternative 1, future uses of the Site would not be further restricted from the present conditions.

6.1.2 GROUNDWATER ALTERNATIVE 1 - COMPLIANCE WITH ARARs

Groundwater Alternative 1 would not achieve chemical specific ARARs for Class GA groundwater at the Site beyond what would be achieved by natural attenuation processes.

6.1.3 GROUNDWATER ALTERNATIVE 1 - LONG-TERM EFFECTIVENESS AND PERMANENCE

A mandatory review of the remedial alternative would be conducted every 5 years to ensure that human health and the environment are being protected. However, should the Site be developed for residential purposes in the future, the implementation of Groundwater Alternative 1 would not further reduce the long-term risks associated with the potential future groundwater use as a potable water supply over what would occur through natural attenuation.

6.1.4 GROUNDWATER ALTERNATIVE 1 - REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Groundwater Alternative 1 provides no additional reduction in the toxicity, mobility, or volume of chemicals at the Site beyond what would be achieved through natural attenuation.

6.1.5 GROUNDWATER ALTERNATIVE 1 - SHORT-TERM EFFECTIVENESS

As Groundwater Alternative 1 involves no remedial action, there would be no additional short-term impacts to the community, workers, or the environment as a result of implementation of this alternative.

6.1.6 GROUNDWATER ALTERNATIVE 1 - IMPLEMENTABILITY

This alternative is easily implemented. A contingency plan would be in place if additional remedial actions are required at a later date.

6.1.7 GROUNDWATER ALTERNATIVE 1 - COST

The cost associated with implementation of Groundwater Alternative 1 is summarized in Table 6.2. This alternative has no capital cost or operational costs associated with it, except for Site evaluation at $5,000 every 5 years. The annual cost is estimated to be $950. The total present worth of this alternative is estimated to be $15,000 based upon a 5.2 percent discount rate over a 30-year period.

6.2 GROUNDWATER ALTERNATIVE 2: MONITORED NATURAL ATTENUATION

Groundwater Alternative 2 includes the implementation of Monitored Natural Attenuation and institutional controls.

Natural attenuation is the term used to refer to all of the naturally occurring processes that control the fate of contaminants in soil and groundwater, and the recognition that these processes can act to naturally contain and remediate such contamination. Natural attenuation processes are those that effectively reduce contaminant mass and contaminant concentrations in soil and groundwater. The processes that control the natural attenuation of compounds in groundwater can be classified into two categories: non-destructive and destructive. Non-destructive processes which result in reductions in dissolved concentrations of compounds over distance or time include:

- dispersion and diffusion – spreading of the plume concentrations away from the centerline of the plume;
- dilution – when a chemical migrates downward from the vadose zone to an underlying aquifer;
- adsorption – binding of a compound to aquifer soil material; and
- volatilization – mass transfer from the dissolved phase to the vapor phase in the vadose zone above the water table.

Destructive natural attenuation processes which destroy the compound's structure resulting in reductions in compound mass occurs through degradation. Processes resulting in the degradation of contaminants are preferable to those that rely predominantly on non-destructive mechanisms.

Based on the results of the Natural Attenuation Study conducted for the Site, extensive biodegradation of Site-related organic constituents has occurred historically, and is continuing to occur at a reduced rate under the current anaerobic conditions. The aerobic bacteria required to biodegrade Site COCs have been demonstrated to occur in healthy populations in the subsurface at the Site. In addition, all COCs are known to readily biodegrade under aerobic conditions and, to a lesser degree, under anaerobic conditions. The biodegradation of COCs in the source area of the former lagoons has caused strong anaerobic conditions to occur relative to the background aerobic conditions observed in groundwater outside the area of Site-related organic constituents.

The remediation of the soils in the area of the former lagoons will remove the existing source of organic compounds to the groundwater, and will ultimately result in the re-establishment of natural aerobic conditions in the overburden and bedrock aquifers.

It is expected that natural attenuation would be effective in treating the groundwater in a reasonable timeframe once the source area is remediated. Remediation of the source area would also reduce the concentrations of the COCs in groundwater in the area of the source. In the interim, institutional controls would be required to eliminate the future potential for on-Site exposures to groundwater by ensuring that groundwater at the Site is not used for potable purposes. Institutional controls are generally comprised of deed restrictions as well as physical controls. Deed restrictions involve placing a notation on the property deed which makes the current and any prospective property owner aware of the property's history and the restricted land use of the property. The deed restriction would restrict groundwater use on Site (i.e., establish the Site as a groundwater use exception zone). The deed restriction would limit property uses to open space uses only. In addition to deed restrictions, the local governments could amend land use zoning to further ensure that the property would not be developed in the future.

A Performance Monitoring Program would be implemented to permit further evaluation of COC and oxidation – reduction (redox) indicator trends after remediation of the lagoon area soils. The details of the monitoring program including the monitoring well network, analytical parameters, and the frequency of sampling would be provided in the Monitoring Plan which would be developed during remedial design following the treatment/removal of the source area soils. Verification monitoring of the COCs would also be conducted following the reduction of the COCs to concentrations below the applicable criteria. As part of the Performance Monitoring Program, groundwater samples would be collected from sentinel overburden and bedrock wells located around the perimeter of the Site to ensure that off-Site receptors are not being impacted.

The Performance Monitoring Program would consist of the collection and analysis of groundwater samples from overburden plume wells, bedrock plume wells, and overburden/bedrock background/sentinel wells. For the purposes of the FS, it is assumed that monitoring of the COCs would be conducted for up to 30 years. In addition, samples would be analyzed for the natural attenuation indicator parameters and geochemical parameters for the first year. Further assumptions regarding the Performance Monitoring Program are provided in Table 6.2 for the purpose of cost estimating for comparison to other alternatives.

Following source removal, a Contingency Plan would be developed for Groundwater Alternative 2 during the remedial design. The triggers requiring the implementation of the contingency would be specified in the Contingency Plan. Technologies that could be used to enhance the effectiveness of this alternative would be evaluated during the remedial design stage. The Contingency Plan would ensure that the remedy remains both effective and protective.

6.2.1 GROUNDWATER ALTERNATIVE 2 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative would reduce the risks to human health associated with the potential future use of groundwater at the Site. The potential for off-Site groundwater exposure to develop in the future would be mitigated by the use of institutional controls such as deed restrictions and land use zoning changes. Monitored natural attenuation would result in the reduction of COC concentrations in the overburden and bedrock groundwater with time.

Groundwater monitoring would ensure that there are no unacceptable risks associated with the future off-Site use of groundwater in the area of the Site. Should monitoring indicate adverse impacts to the off-Site groundwater in the future, contingencies would be implemented to mitigate any unacceptable risk.

6.2.2 GROUNDWATER ALTERNATIVE 2 - COMPLIANCE WITH ARARs

Groundwater Alternative 2 would achieve chemical-specific ARARs for Class GA groundwater at the Site by natural attenuation processes such as biodegradation. It is expected that current ARARs for Class GA groundwater would continue to be met downgradient of the Site as demonstrated by the results of the ongoing quarterly Residential Monitoring Program conducted by the NYSDOH and the quarterly monitoring conducted for the Maybrook supply wells which indicate that Site-related compounds, including the COCs, are not being detected in the groundwater used for potable purposes by the residents closest to the Site. Continued groundwater monitoring would ensure that chemical-specific ARARs are met off Site.

6.2.3 GROUNDWATER ALTERNATIVE 2 - LONG-TERM EFFECTIVENESS AND PERMANENCE

Implementation of Groundwater Alternative 2 would reduce the potential risks due to on-Site groundwater ingestion for future uses through institutional controls.

Institutional controls are considered to be reliable as a method to restrict access and possible future land uses at remote locations such as the Site. A mandatory review of the remedial alternative would be conducted every 5 years to ensure that human health and the environment are being protected.

The groundwater monitoring program would ensure that the remedy is protective in the long-term. Performance monitoring of the natural attenuation parameters would provide an indication of the effectiveness of natural attenuation in reducing the concentrations of the COCs in the groundwater at the Site.

6.2.4 GROUNDWATER ALTERNATIVE 2 - REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Natural attenuation processes such as biodegradation would provide a reduction in the volume of COCs at the Site for Groundwater Alternative 2.

6.2.5 GROUNDWATER ALTERNATIVE 2 - SHORT-TERM EFFECTIVENESS

As Groundwater Alternative 2 involves no disturbance of any of the soils or groundwater at the Site, there would be no additional short-term impacts to the community, workers, or the environment as a result of implementation of this alternative. The institutional controls to restrict groundwater use on-Site could be implemented in a relatively short period of time (approximately 1 year).

6.2.6 GROUNDWATER ALTERNATIVE 2 - IMPLEMENTABILITY

Institutional controls are generally easy to implement. The effectiveness of the remediation would be readily monitored by implementing the performance groundwater monitoring program presented in Section 6.2. A contingency plan would be in place if additional remedial actions are required at a later date dependent (and contingent) upon the results of the monitoring program.

6.2.7 GROUNDWATER ALTERNATIVE 2 - COST

A detailed cost breakdown for Groundwater Alternative 2 is presented in Table 6.3. The total capital cost is estimated to be $13,200 and the estimated annual operation and maintenance cost is estimated to range from $16,500 to $106,700. The total present worth of this alternative is estimated to range from $309,000 to $528,000 based upon a 5.2 percent discount rate over a 10 to 30-year period.

6.3 GROUNDWATER ALTERNATIVE 3 - PUMP AND TREAT

Groundwater Alternative 3 includes the installation of an overburden and bedrock groundwater collection system installed downgradient of each area with identified soil and groundwater concentrations above the potential cleanup levels. The components of this alternative are presented on Figure 6.1. This alternative would prevent the potential migration of chemicals off Site via groundwater transport. However, with the source as well as the majority of groundwater with elevated COC concentrations removed in the overburden with the implementation of the preferred soil alternative, pump and treat is expected to provide negligible organic mass removal given the expected low level residual COCs in groundwater. Alternative 3 is, therefore, considered to be a hydraulic containment remedy.

The groundwater collection system would consist of a media and tile drain for the overburden groundwater flow and extraction wells for the bedrock groundwater flow as presented in Appendix E. The tile drain would be installed two feet into the upper fractured bedrock downgradient of the north and south components of groundwater flow as presented on Figure 6.1.

A typical tile drain construction detail is presented on Figure 6.2. Each tile drain collector would drain to a sump location from which the collected water would be pumped to a groundwater treatment facility.

The bedrock groundwater collection system would consist of five extraction wells installed to the north, south, and west of the former lagoon area. Typical bedrock extraction well details are presented on Figure 6.3. Based upon the estimated flow rates for the first 2 years (70 gal/min or 100,800 gal/day as presented in Appendix E), the option of transporting this water to a POTW is considered to be impractical. In addition, chemical concentrations may exceed the levels acceptable for treatment at the POTW. Hence, an on-Site treatment system (see Appendix D for the evaluation of potential groundwater treatment process options) would be implemented (if required). The treated effluent would be discharged to Beaverdam Brook for which the technical requirements of a SPDES permit would have to be satisfied.

A Pre-Design Hydrogeological Investigation Study would be performed in support of Groundwater Alternative 3 and would include the following:

- aquifer properties testing;
- extraction system influent chemistry evaluation; and
- review of influent chemistry treatment requirements.

The pre-design studies would be completed either before or during the preparation of the preliminary remedial designs. The results of the pre-design studies would be incorporated into the preliminary remedial design. The actual nature and scope of work for the pre-design studies would be presented in the Remedial Design/Remedial Action Work Plan prepared for the Site (based upon the actual remedy selected).

Institutional controls would be implemented as described in Section 6.2 for Groundwater Alternative 2.

For the purposes of the FS, it is assumed that the groundwater pump and treatment system would operate for a period of 10 years. At the end of 10 years, COC concentrations would either be decreased to levels below applicable criteria or would be reduced to low residual concentrations above applicable criteria. For the purposes of the FS, it is assumed that the pump and treat system would not be effective in further reducing COC concentrations beyond a period of 10 years.

Groundwater monitoring of the COCs would be conducted for a period of up to 30 years. Further assumptions regarding the monitoring program are provided in Table 6.3 for the purpose of cost estimating for comparison to other alternatives.

6.3.1 GROUNDWATER ALTERNATIVE 3 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative would reduce the risks to human health for all exposure scenarios associated with the potential future use of groundwater at the Site. The potential for an on-Site groundwater exposure to develop in the future would be mitigated by the use of institutional controls such as deed restrictions and land use zoning changes. The groundwater containment system would prevent the off-Site migration of chemicals beyond the limits of the plume.

Groundwater monitoring would ensure that there are no unacceptable risks associated with the future off-Site use of groundwater in the area of the Site. Should monitoring indicate adverse impacts to the off-Site groundwater in the future, contingencies would be implemented to mitigate any unacceptable risk.

6.3.2 GROUNDWATER ALTERNATIVE 3 - COMPLIANCE WITH ARARs

It is expected that current ARARs for Class GA groundwater would continue to be met downgradient of the groundwater containment system as demonstrated by the results of the ongoing quarterly Residential Monitoring Program conducted by the NYSDOH and the quarterly monitoring conducted for the Maybrook supply wells which indicate that Site-related compounds, including the COCs, are not being detected in the groundwater used for potable purposes by the residents closest to the Site. Continued groundwater monitoring would ensure that chemical-specific ARARs are met off Site. The time to achieve groundwater ARARs on Site may be decreased by the implementation of the groundwater containment system.

6.3.3 GROUNDWATER ALTERNATIVE 3 - LONG-TERM EFFECTIVENESS AND PERMANENCE

Implementation of Groundwater Alternative 3 would reduce the potential risks due to on-Site groundwater ingestion for future uses through institutional controls. Potential future risks due to groundwater ingestion off Site would be reduced by the groundwater containment system and ongoing monitoring. The groundwater containment/treatment action has a high reliability and will result in a permanent reduction in groundwater contamination. A mandatory review of the remedial action would be conducted every 5 years.

6.3.4 GROUNDWATER ALTERNATIVE 3 - REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

The groundwater containment system implemented under Groundwater Alternative 3 would provide a permanent reduction in the volume of COCs in the groundwater. The groundwater treatment action (carbon adsorption) would result in irreversible treatment of the chemicals in the groundwater. Spent carbon from the treatment system would be sent off Site for regeneration or disposal.

6.3.5 GROUNDWATER ALTERNATIVE 3 - SHORT-TERM EFFECTIVENESS

Implementation of Groundwater Alternative 3 would involve minimal excavation and grading of soils with chemical concentrations exceeding the potential soil cleanup levels. These activities may result in a temporary increase in dust production and chemical emissions to the atmosphere. Workers would be required to wear appropriate personal protective equipment and adhere to safe construction practices to minimize potential hazards. It is estimated that this alternative could be implemented within a 1-year time period. The benefits of the elimination of off-Site migration of chemicals in the groundwater would be obtained immediately upon installation. Groundwater use restrictions would be implemented on Site until it is demonstrated that unrestricted usage is appropriate.

6.3.6 GROUNDWATER ALTERNATIVE 3 - IMPLEMENTABILITY

Implementation of this alternative would involve common construction procedures and the services and material are readily available. The groundwater containment/ treatment system would require regular maintenance to ensure its effectiveness. Additional remedial actions, such as extending the groundwater containment system, if necessary, could be readily implemented. The necessity for additional groundwater extraction components would be determined based upon the analytical results from the monitoring program.

The effectiveness of the alternative could be easily monitored by implementation of the general Site monitoring program. Additional influent and effluent monitoring would be required for the groundwater treatment system.

Compliance with the requirements of RCRA and N.Y. State Air permits may be required for the operation of the treatment system. A SPDES permit will be required for the discharge into Beaverdam Brook.

6.3.7 GROUNDWATER ALTERNATIVE 3 - COST

A detailed cost breakdown for Groundwater Alternative 3 is presented in Table 6.4. The total capital cost is estimated to range from $1,172,000 to $1,656,000 and the estimated annual operation and maintenance cost is estimated to range from $171,000 to $229,000.

The total present worth of this alternative is estimated to range from $2,635,000 to $3,339,000 based upon a 5.2 percent discount rate over a 10 to 30-year period including a 10-year operation period for the groundwater extraction/treatment system.

6.4 GROUNDWATER ALTERNATIVE 4 - ENHANCED BIOREMEDIATION

Groundwater Alternative 4 involves the manipulation of Site conditions to enhance in situ bioremediation of the COCs by the indigenous microbial population. In this process, several techniques can be applied to enhance biodegradation of the Site-specific COCs, such as:

1. supplementation with suitable sources of nitrogen and phosphorus to enhance biodegradation of contaminants by indigenous anaerobic microbial population;
2. manipulation of redox potential by the injection of air, oxygen, slow oxygen release compounds (ORCs), or nitrate to enhance aerobic biodegradation; and
3. injection of microbial cultures to improve the effectiveness of the microbial population in degrading the compounds of concern.

Enhanced bioremediation would be effective in treating the COCs in the groundwater at the Site. However, the effectiveness of this technology would be dependent upon the residual concentrations of COCs remaining in the groundwater following any remediation of the source area soils.

The concentrations of the COCs detected in the Site groundwater are not expected to be toxic or inhibitory to the indigenous microbial population. COCs such as benzene and 2-aminopyridine can be degraded slowly by anaerobic microbes, but are known to be readily degradable by aerobic microbes. The biodegradation of the compounds at the Site may currently be limited by insufficient supply of nutrients. Anaerobic biodegradation could be enhanced by the addition of nutrients and nitrate. However, sulfate reduction would be required for complete benzene biodegradation. Enhanced aerobic biodegradation could be stimulated by the addition of nutrients and electron acceptors such as oxygen.

To enhance aerobic biodegradation, treatment would involve the controlled injection of ORC or hydrogen peroxide and nutrients into the plumes, and would be applied through existing wells or additional injection points. The sandy matrix of the overburden aquifer and the natural groundwater flow, even though it is relatively slow, could slightly improve the effective radius of dispersion of the amendments in the groundwater. A pilot study would be conducted to determine the effectiveness of this technology.

The design details for enhanced bioremediation would be established following the treatment/removal of the source area soils. For the purposes of the FS, it is assumed that the treatment area would cover the area where COC concentrations are 100 ppb or higher as shown on Figure 6.4. It is assumed that 440 injection points will be required for the injection of ORC into the overburden groundwater by a 10-foot spacing between points and 50 feet between injection lines. The proposed injection points are presented on Figure 6.4.

Institutional controls and the Performance Monitoring Program for the COCs and natural attenuation parameters would be implemented as described in Section 6.2 for Groundwater Alternative 2. In addition, a Contingency Plan would be in place to ensure the long-term effectiveness of the remedy.

6.4.1 GROUNDWATER ALTERNATIVE 4 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative would reduce the risks to human health for all exposure scenarios associated with the potential future use of groundwater at the Site. The potential for an on-Site groundwater exposure to develop in the future would be mitigated by the use of institutional controls such as deed restrictions and land use zoning changes.

Groundwater monitoring would ensure that there are no unacceptable risks associated with the future off-Site use of groundwater in the area of the Site. Should monitoring indicate adverse impacts to the off-Site groundwater in the future, contingencies would be implemented to mitigate any unacceptable risk.

6.4.2 GROUNDWATER ALTERNATIVE 4 - COMPLIANCE WITH ARARs

It is expected that current ARARs for Class GA groundwater would continue to be met downgradient of the Site as demonstrated by the results of the ongoing quarterly Residential Monitoring Program conducted by the NYSDOH and the quarterly monitoring conducted for the Maybrook supply wells which indicate that Site-related compounds, including the COCs, are not being detected in the groundwater used for potable purposes by the residents closest to the Site. Continued groundwater monitoring would ensure that chemical-specific ARARs are met off Site. The time to achieve groundwater ARARs on Site may be decreased by the implementation of enhanced bioremediation.

6.4.3 GROUNDWATER ALTERNATIVE 4 - LONG-TERM EFFECTIVENESS AND PERMANENCE

Implementation of Groundwater Alternative 4 would reduce the potential risks due to on-Site groundwater ingestion for future uses through institutional controls. Potential future risks due to groundwater ingestion off Site would be reduced by the implementation of enhanced bioremediation and ongoing monitoring. Enhanced bioremediation has a high reliability and will result in a permanent reduction in groundwater contamination. A mandatory review of the remedial action would be conducted every 5 years.

The groundwater monitoring program would ensure that the remedy is protective in the long-term. Performance monitoring of the natural attenuation parameters would provide an indication of the effectiveness of enhanced bioremediation in reducing the concentrations of the COCs in the groundwater at the Site.

6.4.4 GROUNDWATER ALTERNATIVE 4 - REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

The use of ORC under Groundwater Alternative 4 to enhance the naturally occurring biodegradation processes at the Site would provide a permanent and irreversible reduction in the volume of COCs in the groundwater.

6.4.5 GROUNDWATER ALTERNATIVE 4 - SHORT-TERM EFFECTIVENESS

As Groundwater Alternative 4 involves no disturbance of any of the soils or groundwater at the Site, there would be no additional short-term impacts to the community, workers, or the environment as a result of implementation of this alternative. The institutional controls to restrict groundwater use on Site could be implemented in a 1-year time period.

6.4.6 GROUNDWATER ALTERNATIVE 4 - IMPLEMENTABILITY

Implementation of this alternative would involve common construction procedures and the services and material are readily available. Additional remedial actions, such as increasing the number of ORC injection points or extending the duration of ORC application, could be readily implemented, if necessary. The necessity for additional measures would be determined based upon the analytical results from the monitoring program.

6.4.7 GROUNDWATER ALTERNATIVE 4 - COST

A detailed cost breakdown for Groundwater Alternative 4 is presented in Table 6.5. The total capital cost is estimated to be $332,000 and the estimated annual operation and maintenance cost is estimated to range from $16,500 to $106,700. The total present worth of this alternative is estimated to range from $627,000 to $846,000 based upon a 5.2 percent discount rate over a 10 to 30-year period.

6.5 GROUNDWATER ALTERNATIVE 5 - BIOSPARGING

Groundwater Alternative 5 involves the application of in situ biosparging to inject a pressurized gas (i.e., oxygen) into the subsurface at very low flowrates to enhance aerobic biodegradation. Injection of the gas is controlled such that vapors are not generated and do not accumulate in the vadose zone.

In situ Submerged Oxygen Curtain (iSOC) is the preferred biosparging technology for the Site. It is an innovative technique whereby supersaturated oxygen is delivered to the subsurface at low flow rates such that the oxygen is infused into the groundwater without the formation of bubbles.

This technique would be very effective in treating the COCs in the groundwater plumes at the Site by aerobic degradation. The iSOC probes and or nutrient additives would be injected (placed) into the groundwater via existing wells and /or additional injection wells, if needed. These wells would be screened at each aquifer interval. The design details for biosparging would be established following the treatment/removal of the source area soils. For the purposes of the FS, it is assumed that 4 injection wells will be required as shown on Figure 6.5. Based on the technology, the contaminant types and concentrations observed in the groundwater plumes, and the low flow of oxygen that would be required, a soil vapor extraction system would not be required to collect vapor emissions.

The remediation would be expected to be completed within a relatively short timeframe. However, given the low levels of residual concentrations of COCs that would remain in the groundwater following source removal by the implementation of the preferred soil alternative, biosparging may not offer any significant advantage over natural attenuation.

Institutional controls and the Performance Monitoring Program for the COCs and natural attenuation parameters would be implemented as described in Section 6.2 for Groundwater Alternative 2. In addition, a Contingency Plan would be in place to ensure the long-term effectiveness of the remedy.

6.5.1 GROUNDWATER ALTERNATIVE 5 - OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative would reduce the risks to human health for all exposure scenarios associated with the potential future use of groundwater at the Site. The potential for an on-Site groundwater exposure to develop in the future would be mitigated by the use of institutional controls such as deed restrictions and land use zoning changes.

Groundwater monitoring would ensure that there are no unacceptable risks associated with the future off-Site use of groundwater in the area of the Site. Should monitoring indicate adverse impacts to the off-Site groundwater in the future, contingencies would be implemented to mitigate any unacceptable risk.

6.5.2 GROUNDWATER ALTERNATIVE 5 - COMPLIANCE WITH ARARs

It is expected that current ARARs for Class GA groundwater would continue to be met downgradient of the Site as demonstrated by the results of the ongoing quarterly Residential Monitoring Program conducted by the NYSDOH and the quarterly monitoring conducted for the Maybrook supply wells which indicate that Site-related compounds, including the COCs, are not being detected in the groundwater used for potable purposes by the residents closest to the Site. Continued groundwater monitoring would ensure that chemical-specific ARARs are met off Site. The time to achieve groundwater ARARs on Site may be decreased by the implementation of biosparging.

6.5.3 GROUNDWATER ALTERNATIVE 5 - LONG-TERM EFFECTIVENESS AND PERMANENCE

Implementation of Groundwater Alternative 5 would reduce the potential risks due to on-Site groundwater ingestion for future uses through institutional controls. Potential future risks due to groundwater ingestion off Site would be reduced by the implementation of biosparging and ongoing monitoring. Biosparging has a high reliability and will result in a permanent reduction in groundwater contamination. A mandatory review of the remedial action would be conducted every 5 years.

The groundwater monitoring program would ensure that the remedy is protective in the long-term. Performance monitoring of the natural attenuation parameters would provide an indication of the effectiveness of biosparging in reducing the concentrations of the COCs in the groundwater at the Site.

6.5.4 GROUNDWATER ALTERNATIVE 5 - REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

The use of biosparging (iSOC) under Groundwater Alternative 5 to enhance the naturally occurring biodegradation processes at the Site would provide a permanent and irreversible reduction in the volume of COCs in the groundwater.

6.5.5 GROUNDWATER ALTERNATIVE 5 - SHORT-TERM EFFECTIVENESS

As Groundwater Alternative 5 involves no disturbance of any of the soils or groundwater at the Site, there would be no additional short-term impacts to the community, workers, or the environment as a result of implementation of this alternative. The institutional controls to restrict groundwater use on Site could be implemented in a 1-year time period.

6.5.6 GROUNDWATER ALTERNATIVE 5 - IMPLEMENTABILITY

Implementation of this alternative would involve common construction procedures and the services and material are readily available. Additional remedial actions, such as increasing the number of iSOC injection points or extending the duration of iSOC application, could be readily implemented, if necessary. The necessity for additional measures would be determined based upon the analytical results from the monitoring program.

6.5.7 GROUNDWATER ALTERNATIVE 5 - COST

A detailed cost breakdown for Groundwater Alternative 5 is presented in Table 6.6. The total capital cost is estimated to be $191,000 and the estimated annual operation and maintenance cost is estimated to range from $16,500 to $106,700. The total present worth of this alternative is estimated to range from $519,000 to $738,000 based upon a 5.2 percent discount rate over a 10 to 30-year period.

7.0 SUMMARY OF ALTERNATIVES

7.1 SUMMARY OF EVALUATION FOR SOIL ALTERNATIVES

Each soil remedial alternative was evaluated separately in Sections 5.1 through 5.6 using the seven evaluation criteria required for the detailed analysis. An evaluation of each of the soil alternatives relative to each other is presented in this section.

Overall Protection of Human Health and the Environment

All of the soil alternatives with the exception of the No Action alternative would result in a reduction of risks to acceptable levels in the surface soils and subsurface soils for the Site. Use of the Site following remediation would be limited for Soil Alternative 1, as no physical measures would be taken to minimize potential exposures to chemicals. The potential future risks associated with a residential user exposure to surface soils and a construction worker exposure to soils was determined to be unacceptable. This risk would continue under Soil Alternative 1. Site usage restrictions (i.e., institutional controls) would be required for Soil Alternatives 2 and 3. Additional restrictions to Site usage would be required for Soil Alternative 3 in order to protect the Site cap from disturbance and restrict the future development of the Site. Following remediation, Site use would be relatively unrestricted for Alternatives 4, 5, and 6 as a large proportion of the chemicals would be removed from surface and subsurface soils. In these instances, institutional controls, such as deed restrictions, would not be required to prevent potential exposures to the soils at the Site.

Compliance with ARARs

NYSDEC Soil Cleanup Objectives for soils would continue to be exceeded in the area of the former lagoons for the COCs for Soil Alternatives 1, 2, and 3. Capping the former lagoon area (Soil Alternative 3) would mitigate infiltration and leaching of the contaminants from the soil to the groundwater, thereby achieving the goal of the NYSDEC Soil Cleanup Objectives for the protection of groundwater. It is expected that the concentrations of the COCs would decrease with time as a result of natural attenuation.

NYSDEC Soil Cleanup Objectives for soils would be achieved by the treatment of the COCs by SVE and biodegradation for Soil Alternatives 4 and 5, and by removal and off-Site disposal for Soil Alternative 6.

Long-Term Effectiveness and Permanence

Soil Alternatives 2, 3, 4, 5, and 6 would reduce the potential risk associated with chemicals in the soils. This potential risk would be reduced by Soil Alternative 2 through institutional controls and restricted Site access. The construction of the cap for Soil Alternative 3 would prevent exposure to chemicals in the surface soil and would prevent the disturbance and contact with subsurface soils. Soil Alternatives 4, 5, and 6 would permanently reduce this risk by treatment/removal of the chemical source.

Institutional controls, which are included as components of Soil Alternatives 2 and 3 are considered reliable due to the location of the Site. Soil Alternative 3 is considered to be reliable provided that the cap is maintained. Soil Alternatives 4, 5, and 6 are considered reliable as the chemical source would be removed and no long-term operation or maintenance would be required.

Soil Alternatives 1, 2, and 3 would require a mandatory review every 5 years as some residual levels of chemicals would be left untreated at the Site. Soil Alternatives 4, 5, and 6 are expected to be completed in a period of 2 years, 4 years, and 1 year, respectively and would not require ongoing 5-year reviews as COC concentrations would be reduced to levels below the Soil Cleanup Objectives within these timeframes.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Soil Alternatives 4 and 5 would result in the permanent treatment of the chemicals in the soil to concentrations below NYSDEC Soil Cleanup Objectives. Soil Alternatives 3 and 6 would reduce the mobility of the chemicals in the soils via capping and off-Site disposal, respectively. Soil Alternatives 1 and 2 do not include the remediation of soils beyond what would be achieved by natural attenuation.

Short-Term Effectiveness

Soil Alternatives 1, 2, and 5 would not have any significant short-term effects on the community, workers, or the environment. Soil Alternatives 3 involves minimal disturbance of chemicals in the soils, however, it could result in a temporary increase in dust generation as a result of grading and cap construction. Soil Alternatives 4 and 6 involve excavations into soils. These alternatives also have the highest potential for dust and chemical emissions to the atmosphere during the treatment process.

Soil Alternative 6 would increase short-term traffic-related risks associated with the increased vehicular traffic coming into and leaving the Site.

The ISVE system for Soil Alternative 5 would be less efficient in treating the soils in comparison to the biocell approach for Soil Alternative 4. The biocell approach would result in optimized soil permeability, homogeneity of soils, nutrients, and other conditions that would be conducive to SVE/biodegradation. Lower permeabilities and greater heterogeneity of the in situ soils would result in lower treatment efficiencies for Soil Alternative 5 and longer duration for treatment.

The excavation of the material within the lagoons for Alternatives 4 and 6 would allow for the examination of the material within the former lagoons to identify any hot spots that may exist.

Soil Alternatives 1 and 2 could be implemented in less than 1 year. Remediation for Soil Alternatives 3 and 6 would take approximately 1 year for completion. The biocell operating period for Soil Alternative 4 is estimated to be 1 to 2 years. It is estimated that the ISVE system for Soil Alternative 5 would require an operation period of approximately 4 years.

Implementability

Soil Alternatives 1 and 2 are easily implemented as they require no construction or operation. Soil Alternative 3 would involve common construction procedures to construct the cap. Soil Alternatives 4 and 5 would be more difficult as a pilot test would be required.

Excavation of the soils (Soil Alternatives 4 and 6) to the depths required (approximately 10 to 20 feet) would not be difficult and would not require specialized equipment.

Additional treatment, if required, could easily be incorporated into Alternatives 4 and 5. However, if additional soils require remediation based upon sidewall testing during excavation for Alternatives 4 and 6, extending the excavations could have a significant impact on the costs for these alternatives.

Services and materials are readily available for each of the alternatives.

The substantive requirements of RCRA, N.Y. State air, and SPDES permits may be required for Alternatives 3 through 6.

Costs

The costs associated with the six soil alternatives are summarized as follows:

Soil Alternative	*Capital Cost*	*Annual Operation and Maintenance Cost*	*Total Present Worth Cost*
1	$0	$950	$15,000
2	$12,600	$13,550	$217,000
3	$1,740,000 - $2,290,000	$24,000	$2,100,000 - $2,647,000
4	$1,474,000 - $2,388,000	$241,000 - $406,000	$1,734,000 - $3,119,000
5	$1,013,000 - $1,211,000	$233,200 - $460,900	$2,104,000 - $2,302,000
6	$5,736,000 - $11,208,000	$22,000	$5,756,000 - $11,228,000

7.2 SUMMARY OF EVALUATION FOR GROUNDWATER ALTERNATIVES

Each groundwater remedial alternative was evaluated separately in Sections 6.1 through 6.5 using the seven evaluation criteria required for the detailed analysis. This section presents an evaluation of each of the groundwater alternatives relative to each other.

Overall Protection of Human Health and the Environment

All of the groundwater alternatives, with the exception of the No Action alternative (Alternative 1), would result in a reduction of risks to acceptable levels in the groundwater. Groundwater Alternatives 2, 3, 4, and 5 would reduce the risks to human health for all exposure scenarios associated with the potential future use of groundwater at the Site by the use of institutional controls.

Use of the Site would be unrestricted for Groundwater Alternative 1 as no remedial measures would be taken to minimize potential exposures to COCs in the groundwater on Site. The potential future risk due to the residential use of on-Site groundwater would, therefore, continue under Alternative 1.

Groundwater monitoring would ensure that there are no unacceptable risks associated with the future off-Site use of groundwater in the area of the Site for Alternatives 2, 3, 4, and 5. Should monitoring indicate adverse impacts to the off-Site groundwater in the future, contingencies would be implemented to mitigate any unacceptable risk.

Compliance with ARARs

It is expected that current ARARs for Class GA groundwater would continue to be met for residential users of the groundwater downgradient of the Site as demonstrated by the results of the ongoing quarterly Residential Monitoring Program conducted by the NYSDOH and the quarterly monitoring conducted by the Village of Maybrook for the Maybrook supply wells which indicate that Site-related compounds, including the COCs, are not being detected in the groundwater used for potable purposes by the residents closest to the Site. Continued groundwater monitoring would ensure that chemical-specific ARARs are met off Site for Groundwater Alternatives 2, 3, 4, and 5.

It is expected that chemical-specific ARARs for Class GA groundwater may be exceeded on Site for a period of time for all groundwater alternatives. The time required to reach groundwater ARARs at the Site may be reduced for Alternatives 3, 4, and 5. However, the effectiveness of these alternatives that include enhanced bioremediation, pump and treat, or biosparging would be dependent on the concentrations of the residual COCs remaining in the groundwater following the implementation of source removal by the preferred soil alternative. Groundwater monitoring following the treatment of the source soils would provide an indication of the effectiveness of natural attenuation and the potential effectiveness of the more active groundwater alternatives.

Long-Term Effectiveness and Permanence

Implementation of Groundwater Alternatives 2, 3, 4, and 5 would reduce the potential risks due to on-Site groundwater ingestion for future uses through institutional controls. Institutional controls are considered reliable due to the location of the Site. Potential future risks due to groundwater ingestion off Site would be reduced by the implementation of natural attenuation, pump and treat, enhanced bioremediation, or biosparging and ongoing monitoring. These remedial actions have a high reliability and will result in a permanent reduction in groundwater contamination. A mandatory review of the remedial action would be conducted every 5 years.

Alternative 3 can help provide containment of the contaminant plumes provided hydraulic control can be established. With the source removed in the overburden with the remediation of soils and the low level residual COCs in groundwater, pump and treat is expected to provide negligible organic mass removal.

The groundwater monitoring program would ensure that the remedy is protective in the long-term for Alternatives 2, 3, 4, and 5.

Long-term operation and maintenance would be required for Groundwater Alternative 3 which involves groundwater extraction and treatment.

Reduction of Toxicity, Mobility or Volume Through Treatment

Natural attenuation processes such as biodegradation would provide a reduction in the volume of COCs at the Site for Groundwater Alternatives 1 and 2. The performance monitoring conducted for Alternative 2 would provide an understanding of the rate and trend in COC reduction that could be achieved by natural attenuation. The No Action Alternative 1 does not include monitoring.

The use of ORC for Groundwater Alternative 4 and iSOC for Groundwater Alternative 5 to enhance the naturally occurring biodegradation processes at the Site may result in a reduced timeframe to treat the COCs at the Site. However, any benefit to enhancing the naturally occurring biodegradative processes at the Site would be dependent upon the residual concentrations of COCs remaining in the groundwater following source removal.

Carbon adsorption (as well as other treatment processes) would be used to treat collected groundwater for Groundwater Alternative 3. These treatment processes are considered irreversible with regeneration or disposal of the carbon.

Alternatives 2, 3, 4, and 5 would provide a permanent and irreversible reduction in the volume of COCs in the groundwater.

Short-Term Effectiveness

None of the groundwater alternatives would have any significant short-term effects on the community, workers, or the environment. The benefits of the elimination of off-Site migration of chemicals in the groundwater, should it be necessary in the future, for Groundwater Alternative 3 would be obtained immediately upon installation of the pump and treat system. Off-Site migration of COCs would be mitigated as well by the implementation of Groundwater Alternatives 4 and 5.

All alternatives could be implemented in less than 1 year. Groundwater use restrictions would be implemented on Site until it is demonstrated that unrestricted usage is appropriate.

Implementability

Groundwater Alternatives 1 and 2 require no construction or operation activities. Groundwater Alternative 3 would involve common construction procedures to install a groundwater extraction/treatment system. Groundwater Alternatives 4 and 5 require minimal installation activities and operation for the injection of either ORC or iSOC.

For Groundwater Alternative 3, the groundwater containment/treatment system would require regular maintenance to ensure its effectiveness. Additional influent and effluent monitoring would be required for the groundwater treatment system for Alternative 3. In addition, the substantive requirements of RCRA, N.Y. State air, and SPDES permits may be required for Alternative 3.

All of the groundwater alternatives would be effectively monitored by implementing a groundwater monitoring program. A contingency plan would be in place for the groundwater alternatives if additional remedial actions are required at a later date dependent (and contingent) upon the results of the monitoring program.

Additional remedial actions, such as extending the groundwater containment system for Alternative 3, or increasing the number of injection or placement points for ORC and iSOC for Alternatives 4 and 5 could be readily implemented, if necessary. The necessity for additional groundwater extraction components would be determined based upon the analytical results from the monitoring program.

Costs

The costs associated with the five groundwater alternatives are summarized as follows:

Groundwater Alternative	*Capital Cost*	*Annual Operation and Maintenance Cost*	*Total Present Worth Cost*
1	$0	$950	$15,000
2	$13,200	$16,500 - $106,700	$309,000 - $528,000
3	$1,172,000 - $1,656,000	$171,000 - $229,000	$2,635,000 - $3,339,000
4	$332,000	$16,500 - $106,700	$627,00 - $846,000
5	$191,000	$16,500 - $106,700	$519,000 - $738,000

8.0 RECOMMENDED REMEDIAL ACTION

8.1 RECOMMENDED SOIL ALTERNATIVE

The recommended alternative for the remediation of soil at the Site is the biocell (Soil Alternative 4). Soil Alternative 4 addresses all of the remedial objectives for surface and subsurface soils. The results of the Treatability Study demonstrated that SVE and biodegradation would be effective technologies for the reduction of COCs to concentrations below NYSDEC Soil Cleanup Objectives within a very reasonable timeframe (estimated to be 1 to 2 years). The treatment processes, SVE and biodegradation, would be more effective using a biocell approach than ISVE for Alternative 5 as the soil could be mixed and amended to increase air permeabilities and to optimize conditions for biodegradation by the addition of nutrients and moisture, if required.

Although the capping alternative (Soil Alternative 3) would not reduce the concentrations of COCs within the former lagoons, it would result in the protection of the groundwater by reducing leaching from the source areas within the former lagoons. However, Soil Alternative 4 would permanently and effectively reduce the concentrations of the COCs to cleanup levels at a cost similar to Soil Alternative 3.

Excavation and off-Site disposal for Soil Alternative 6 is considered to be effective for the remediation of the COCs and would achieve all of the remedial objectives for the soils at the Site. However, the additional cost of up to approximately $10 million in comparison to the cost for Soil Alternative 4 is not considered cost-effective.

Soil Alternative 4 would provide an effective overall remedy for the Site soils that would be protective of human health and the environment and would achieve all of the remedial objectives for the Site.

The treatment of the soils in an engineered below-grade biocell for Soil Alternative 4 would reduce COC concentrations to levels below NYSDEC Soil Cleanup Objectives. Human health risks associated with potential exposure to surface and subsurface soils would be reduced to acceptable levels by treatment of the soils within the biocell. The reduction in chemical mass within the soils would reduce the potential for chemical loading to the groundwater, thereby, reducing the timeframe to reach groundwater ARARs. In addition, the majority of the groundwater with elevated COC concentrations would be treated in the biocell.

The excavation of the materials within the former lagoons would allow for the identification and handling of any hot spots that be present.

8.2 RECOMMENDED GROUNDWATER ALTERNATIVE

The recommended remedial alternative for groundwater at the Site is Monitored Natural Attenuation (Groundwater Alternative 2). It is expected that natural attenuation would be effective in treating the groundwater in a reasonable timeframe once the source area is remediated. The results of the groundwater Performance Monitoring Program following the removal of the source by Soil Alternative 4 would provide an indication of the effectiveness and timeframe required to reach chemical-specific ARARs in groundwater.

Institutional controls would be effective in preventing the potential future exposure to on-Site groundwater with concentrations of Site-related compounds that exceed Class GA groundwater criteria. Institutional controls, coupled with a groundwater monitoring program, would provide an overall effective approach to remedy the environmental risks associated with groundwater that have been identified at the Site.

The results of the ongoing quarterly Residential Monitoring Program conducted by the NYSDOH and the quarterly monitoring conducted for the Maybrook supply wells indicate that Site-related compounds, including the COCs, are not being detected in the groundwater used for potable purposes by the residents closest to the Site. Therefore, the implementation of a groundwater containment system (Groundwater Alternative 3) to alleviate risks associated with groundwater at the Site perimeter or more active remedial approaches such as enhanced bioremediation or biosparging are not currently warranted.

A contingency groundwater remedy could be implemented if it is determined that unacceptable groundwater concentrations are present in the future. The necessity for implementing a groundwater contingency plan would be based on triggers developed during the remedial design stage. The exact details of the rationale which would be utilized to determine the necessity to implement a groundwater contingency would be determined during the remedial design. The contingency would be dependent upon the dynamics of the situation at the time of the monitoring program.

Groundwater Alternative 2 is considered protective of human health and the environment and meets all of the remedial action objectives for groundwater at the Site. In addition, Groundwater Alternative 2 is consistent with the Site conditions which identify minimal future off Site impact, if any. Finally, this alternative is protective in itself, in that it reflects the conservative nature of the future groundwater exposure scenarios which were evaluated in the risk assessment.

Groundwater Alternative 2 is combined with the preferred soil alternative (Soil Alternative 4) for a combined overall Site remedy as presented in Section 8.3.

8.3 SUMMARY OF SITE-WIDE REMEDY

The combined alternatives for soil and groundwater, the biocell and natural attenuation presented in Sections 8.1 and 8.2, respectively, would provide an effective overall remedy for the Site that would be protective of human health and the environment and would achieve all of the remedial objectives for the Site.

The treatment of the soils in an engineered below-grade biocell (Soil Alternative 4) would effectively reduce COC concentrations to levels below NYSDEC Soil Cleanup Objectives. Human health risks associated with potential exposure to surface and subsurface soils would be reduced to acceptable levels by treatment of the soils within the biocell. The reduction in chemical mass within the soils would reduce the potential for chemical loading to the groundwater, thereby reducing the timeframe to reach groundwater ARARs on Site.

Although the potential for chemical loading to the groundwater would be significantly reduced by treatment of the soils within the biocell, it is expected that on-Site groundwater concentrations, particularly within the overburden, would remain elevated above Class GA groundwater criteria until they are naturally attenuated. However, it should be emphasized that the requirement for a groundwater remedy would be made following the treatment of the source area soils (and the groundwater within the source area) within the biocell. The residual COC concentrations in the groundwater would be investigated during the monitoring period following source removal to determine if a groundwater remedy is necessary for either the overburden, bedrock, or both. If groundwater standards are exceeded in either the overburden or bedrock groundwater following source area removal then MNA would be implemented. At that point in time, the monitoring well network, frequency of sampling, and analytical parameters would be established based on the groundwater conditions post-source treatment.

The implementation of institutional controls for Groundwater Alternative 2 would reduce the risks for all exposure scenarios associated with the potential future use of the groundwater at the Site until chemical concentrations are naturally attenuated to acceptable levels.

Currently, Site-related COCs are not present in the private and public groundwater well locations at the perimeter of the Site as indicated by the results of the NYSDOH quarterly groundwater monitoring program and the quarterly monitoring conducted by the Village of Maybrook for the Maybrook supply wells. If future monitoring indicates that unacceptable groundwater concentrations are present downgradient of the Site, a contingency plan would be implemented to evaluate appropriate solutions for the protection of public or private water supply wells. The contingency plan would be developed during the remedial design.

The total present worth cost for the overall Site remedy consisting of Soil Alternative 4 and Groundwater Alternative 2 is presented in Table 8.1. The total present worth is estimated to range from $2,054,000 to $3,629,000 dependent upon the operating period for the biocell which is estimated to be 1 to 2 years and the duration of natural attenuation.

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