FINAL REPORT

FEASIBILITY STUDY

FOR THE

JOHNSTOWN LANDFILL

JOHNSTOWN, NEW YORK

Prepared for

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October, 1992

TABLE OF CONTENTS

EXECUTIVE SUMMARY ES-1

1. INTRODUCTION 1-1
1.1 Purpose and Organization of Report 1-1
1.2 Background Information 1-4
1.2.1 Site Description 1-4
1.2.1.1 Site Geology 1-4
1.2.1.2 Site Hydrogeology 1-8
1.2.1.3 Site Topography/Hydrology 1-13
1.2.1.4 Site Meteorology 1-14
1.2.2 Site History 1-15
1.2.3 Previous Investigations 1-16
1.2.4 Nature and Extent of Contamination 1-17
1.2.5 Fate and Transport 1-21
1.2.6 Risk Assessment Summary and Conclusions . . 1-22

2.0 IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS 2-1
2.1 Remedial Action Objectives 2-1
2.1.1 Contaminants and Media of Intest 2-1
2.1.2 Allowable Exposure Based on ARARs 2-3
2.2 General Response Actions 2-4
2.2.1 Criteria for Initial Screening of General Response Technologies 2-4
2.2.2 Identification of General Response Actions 2-4
2.3 Identification and Screening of Technology Types and Processes 2-6
2.3.1 Identification and Screening of Technologies 2-6
2.3.1.1. No Action 2-7
2.3.1.2 Limited Actions 2-7
2.3.1.3 Containment 2-9
A. Impermeable Cap 2-9
B. Vertical Barriers 2-9
C. Wells or Trenches 2-10
2.3.1.4 Removal 2-11
A. Excavation 2-11
B. In Situ Treatment of Landfilled Waste 2-16
C. Ground Water Collection 2-18
D. Ground Water Treatment 2-21
E. Treated Ground Water Discharge 2-30
F. Landfill Gas Control 2-32
G. Residential Water Supply 2-33

TABLE OF CONTENTS CONT'D.

3.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES 3-1
3.1 Development of Remedial Response Criteria 3-1
3.1.1 Use of ARARs and TBCs in Remedial Alternative Development and Evaluation 3-4
3.1.2 Identification of ARARs and TBCs 3-6
3.1.3 Listing of ARARs and TBCs 3-9
3.1.4 General Discussion of Key ARARs and TBCs . 3-9
3.2 Identification of Alternatives 3-11
3.2.1 Combination of Potentially Applicable Technologies Into Feasible Remedial Alternatives 3-11

4.0 DETAILED ANALYSIS OF ALTERNATIVES 4-1
4.1 Description of the Evaluation Process 4-4
4.1.1 Evaluation Criteria 4-5
4.2 Individual Analysis of Alternatives 4-9
4.2.1 Alternative SC 1: No Action 4-13
4.2.1.1 Description 4-13
4.2.1.2 Evaluation 4-14
4.2.2 Alternative SC 2: Limited Action, Residential Water Replacement 4-17
4.2.2.1 Description 4-17
4.2.2.2 Evaluation 4-29
4.2.3 Alternative SC 3: 6NYCRR Cap, Residential Water Replacement 4-34
4.2.3.1 Description 4-34
4.2.3.2 Evaluation 4-42
4.2.4 Alternative SC 4: RCRA Cap, Residential Water Replacement 4-47
4.2.4.1 Description 4-47
4.2.4.2 Evaluation 4-49
4.2.5 Alternative SC 5: Ground Water Collection/ Treatment/Discharge, Residential Water Replacement 4-54
4.2.5.1 Description 4-54
4.2.5.2 Evaluation 4-74
4.2.6 Alternative SC 6: 6NYCRR Part 360 Cap, Residential Water Replacement, Ground Water Collection/Treatment/Discharge 4-82
4.2.6.1 Description 4-82
4.2.6.2 Evaluation 4-83
4.2.7 Alternative SC 7: RCRA Cap, Residential Water Replacement, Ground Water Collection/ Treatment/Discharge 4-88
4.2.7.1 Description 4-88
4.2.7.2 Evaluation 4-89

TABLE OF CONTENTS CONT'D.

4.3 Comparative Analysis 4-93
4.3.1 Overall Protection of Human Health and the Environment 4-94
4.3.2 Compliance with ARARs 4-95
4.3.3 Long-Term Effectiveness and Permanence . . 4-96
4.3.4 Reduction of Toxicity, Mobility or Volume . 4-97
4.3.5 Short-Term Effectiveness 4-98
4.3.6 Implementability 4-99
4.3.6.1. Technical Feasibility 4-99
4.3.6.2. Administrative Feasibility 4-100
4.3.6.3. Availability of Services and Materials 4-101
4.3.7 Cost 4-101

LIST OF TABLES

<u>Table No.</u>

1.1	Nature and Source of Contaminants Profile Metals and Miscellaneous Inorganics - Ground Water and Surface Water
1.2	Nature and Source of Contaminants Profile Metals and Miscellaneous Inorganics - Soil Borings and Sediment Samples
1.3	Nature and Source of Contaminants TCL Volatile Organic Compounds - Ground Water and Surface Water
1.4	Nature and Source of Contaminants TCL Volatile Organic Compounds - Soil and Sediment Samples
1.5	Nature and Source of Contaminants TCL Semi-Volatile Organics and Pesticides, Ground Water and Surface Water
1.6	Nature and Source of Contaminants TCL Semi-Volatile Organics and Pesticides, Soil and Sediment Samples
2.1	Remedial Action Objectives
2.2	General Response Actions and Associated Technologies and Processes
2.3	Ground Water Treatment Parameters
2.4	Summary of Technology and Process Option Screening
3.1	Chemical Specific ARARs, Criteria and Guidance
3.2	Location Specific ARARs, Criteria and Guidance
3.3	Action Specific ARARs for Ground Water Treatment
4.1	Summary of the Detailed Evaluation Criteria
4.2	Summary of Alternative Comparison

LIST OF FIGURES

Plate 1	RI/FS Investigation Base Map
Plate 2	Preliminary Rough Grade Closure Plan
4-1	NYSDEC Landfill Cover System with Soil Liner
4-2	NYSDEC Landfill Cover System with Geomembrane Liner
4-3	RCRA Landfill Cover System
4-4	Proposed Location Well Recovery System
4-5	Physical Chemical Treatment System
4-6	Biological Treatment System

APPENDICES

A	MAJOR FACILITIES AND CONSTRUCTION COMPONENTS
B	COST ESTIMATES
B1	PROCESS COST COMPARISONS
B2	ALTERNATIVE COST COMPARISONS
C	HYDROLOGIC EVALUATION OF LINER PERFORMANCE MODEL (HELP) SUMMARY OUTPUT
D	DISCUSSION OF HYDROGEOLOGY CALCULATIONS AND MODELING

EXECUTIVE SUMMARY

The City of Johnstown, New York formerly operated a landfill located on West Fulton Street Extension in Fulton County, New York. Subsequently this Johnstown Landfill has been placed on the National Priority List of Superfund Sites by the United States Environmental Protection Agency (USEPA) and the New York State Department of Environmental Conservation (NYSDEC). In response to this action, the City of Johnstown retained the services of Thermo Consulting Engineers to conduct a Remedial Investigation and Feasibility Study (RI/FS) at the landfill in order to: investigate the physical characteristics of the site, determine the nature and extent of contamination due to landfill activities, and to assess the potential threats to human health, safety and the environment which may occur from contamination.

The objective of this Feasibility Study (FS) is to develop and screen potential alternatives to remediate environmental contamination present at the site in an effort to provide overall protection to human health and the environment. The most promising technologies are developed into potential remedial alternatives which are then evaluated utilizing a range of factors. Finally the alternatives are compared against each other. This evaluation will provide a basis for the NYSDEC to select a feasible and cost-effective solution for remediation of the site. The purpose of this report is to document the basis and procedures used in identifying, developing, screening and evaluating potential remedial alternatives which will address the contamination at the Johnstown Landfill Site.

This feasibility study was conducted subsequent to the performance of a remedial investigation at this site. The remedial investigation identified several areas of contamination which have been addressed during performance of the feasibility study.

The City of Johnstown Landfill (NY I.D. No. 518002, USEPA I.D. No. NYD980506927) operated as a sanitary landfill situated in a former gravel pit. Thirty-four acres of the 68-acre site, owned and operated by the City of Johnstown, were used as an open refuse disposal facility from 1947 to 1960 before being converted to a sanitary landfill. The landfill accepted industrial wastes from local tanneries and textile plants until mid-1977 and sludge from the Gloversville-Johnstown Joint Sewage Treatment Plant from 1973 to April, 1979. Landfill operations ceased in June, 1989. There are no records available which detail the amounts of industrial wastes accepted by the landfill. The tannery wastes disposed included chromium treated hide trimmings and other materials. Sewage sludge was disposed of for six years at the landfill, in open piles, at a rate of approximately 20,000 cubic yards per year. The sludge reportedly contained concentrations of chromium, iron, and lead.

The RI indicated that 34 acres of the 68-acre site consist primarily of mixed municipal wastes to depths ranging from 29.5 to 32 feet below the surface. Hides were found in several test pits confirming past tannery waste disposal at the landfill. The ground water surface is located approximately 14 feet below the landfilled waste. However, at two landfill borings a perched water/leachate condition was encountered within the native soils lying directly below the landfilled waste.

The active portion of the landfill consists of two terraces. The top of the upper terrace occurs at about an elevation of 920 feet and the top of the lower terrace occurs at an elevation of about 910 feet. A gravel borrow pit, approximately 30 feet deep, exists on the westward side of the landfill at the base of a steep escarpment. This pit, once used as a demolition debris and metals disposal area, when the landfill was active, is the remnant of a larger borrow pit that has been filled by the landfilled solid waste.

The area surrounding the landfill has a mixed land use of residential, agricultural and recreational. Low density residential use is located immediately north of the site on West Fulton Street Extension. Agricultural use consisting of open fields occurs to the south and west. Mixed woodlands exist between the landfill and agricultural areas to the south and adjacent to its eastern boundary. Recreational use of the forested and agricultural areas includes hunting and off-road vehicle riding.

The surface water drainage in the vicinity of the landfill flows generally to the southeast. Surface waters flow from the upland areas, north of the site, via intermittent drainage ways towards the south-southeast. The primary surface water feature in the immediate vicinity of the landfill is Mathew Creek. The headwaters of the creek (LaGrange Springs) are located approximately 1,000 to 1,200 feet southeast of the site. The creek flows southeasterly until it converges with Hall Creek prior to discharging into Cayadutta Creek. The flow of Mathew Creek is interrupted by a manmade pond (Hulbert's Pond) before it converges with Hall Creek. Cayadutta Creek ultimately discharges to the Mohawk River.

Due to differences in surface elevation, storm water runoff and drainage from West Fulton Street Extension flows onto the surface of the landfill creating ponded water near its northeastern corner. The water in this approximately one acre pond either evaporates or infiltrates into the landfilled wastes. Except for ephemeral discharges to the LaGrange Gravel Pit, there is no runoff to surface water from the landfill. The LaGrange Gravel Pit, located approximately 100 feet east of the eastern margin of the landfill, receives surface runoff from hill slopes in its immediate vicinity, minor flows from leachate seeps and occasional ephemeral runoff from the landfill surface. There are no discharges to surface water from LaGrange Gravel Pit.

Two aquifers exist beneath the site, one in the glacial till, sand, and gravel (overburden), and the other in the mid-Ordovician age calcarious Canojohane Shale (bedrock). Hydrogeologic investigations performed during the RI field program indicate that at locations southeast and south of the landfill these two aquifers may be interconnected, and that the wetland areas (LaGrange Springs and Mathew Creek) are probably a surface discharge zone for the aquifers. To the west and north of the landfill, in the low permeability section of the overburden aquifer, the extent of interconnection of the bedrock and overburden aquifers is thought to be low because of the thick, low permeability till layer that exits between the aquifers in this area and the large differences in water levels between aquifers (i.e., MW-7). To the east and south of the landfill, the overburden sands and gravels are in direct contact with the bedrock because the continuous layer is not present.

Ground water flow in the bedrock is controlled by the extent and orientation of fractures within the rock. The shale bedrock unit is described as being primarily fissile to medium bedded. The shale is reported to have low permeability, generally not suitable for water supplies greater than 20 gpm. The bedrock was found to be mildly fractured in the upper 20 feet of the unit. The bedrock surface in the eastern portion of the site slopes gently to the east and southeast while in the western and northern portions it slopes gently to the west and north. Ground water flow in the shallow bedrock is generally from a west to east direction across the study site. In contrast, the overburden ground water aquifer flows from northwest-north to south-southeast of the site, in a general direction towards LaGrange Springs and Mathew Creek.

The environmental samples collected from various media at the site provide an overview of the nature and extent of contamination that is a result of the landfill. The environmental samples were analyzed for the presence of the following parameters: 23 Target Analyte List (TAL) metals, cyanide, hexavalent chromium, 65 Target Compound List (TCL) Semi-Volatile Organics Compounds (SVOCs), 34 TCL Volatile Organic Compounds (VOCs), 20 TCL Pesticides, 7 TCL Polychlorinated Biphenyls (PCBs) and one or more miscellaneous inorganics. Several of the metal and inorganic parameters are good indicators of landfill leachate and, therefore, are useful in evaluating impacts to the environment.

Many metals and other inorganics are found naturally in background concentrations in nature. Therefore, the presence of metals and inorganics must be compared with those natural background levels in order to assess landfill impacts. Many of the metals and miscellaneous inorganics were detected at much higher concentrations at the source (soil and leachate samples) as compared to apparent background samples. The parameters aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, sodium, thallium, vanadium, zinc, cyanide, chloride, COD, TDS, bicarbonate, TOC, hardness and ammonia-nitrogen were detected at both the source and one or more samples downgradient of the landfill. Many of these were detected in sediment samples from LaGrange Pit and Mathew Creek areas at concentrations above background and landfill soil concentrations. The detection of one or more of these elevated analytes was typically at much lower concentrations in surface water and residential wells. Elevated levels were most prevalent in residential samples from Pine Tree Rifle Club, Gunnison, Hannon, and Blanket, which are located approximately one-half mile southeast of the landfill.

A total of 20 of the 34 TCL VOCs tested were detected in samples from the study site. Typically VOCs are not as prevalent in the environment as metals and inorganics. The most commonly occurring VOCs identified at the study site include ketones (acetone, 2-butanone and 4-methyl-2-pentanone) and aromatic hydrocarbons (benzene, ethylbenzene, chlorobenzene, xylene, and toluene). One or more of these were identified at the source (landfill soils and leachate) as well as downgradient sources (ground water, surface water, and sediment). Concentrations away from the source tended to be much lower. To a lesser degree, halogenated aliphatic hydrocarbons were detected more often in samples around the landfill than at the source. Also, no consistent trend was observed in the distribution of these compounds.

A total of 31 of the 65 TCL SVOCs were detected in samples from the study site. The most prevalent detected SVOCs include the phthalate ester compounds. Only four polycyclic aromatic hydrocarbons (PAH) were detected at the source (phenanthrene, fluoranthene, naphthalene, and pyrene). The PAH compounds were more prevalent in ground water and sediments downgradient of the landfill.

A total of 13 TCL pesticides were detected in samples from the study site. These include gamma-BHC, delta-BHC, endosulfan I, dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, gamma-chlordane, heptachlor, aldrin, heptachlor epoxide, and endrin. They were most prevalent in samples from the source (landfill borings and monitoring wells). Only delta-BHC and endosulfan I were detected in ground water downgradient of the site. The pesticides delta-BHC, 4,4'-DDE, 4,4'-DDD, heptachlor, and aldrin were identified in sediment samples. No PCBs were identified in any of the sampled media.

Ground water occurs in the area as a result of precipitation that percolates through the soils and underlying unconsolidated overburden deposits. Based on aquifer testing results and ground water elevation measurements, the ground water flow beneath the site is estimated to be 261,000 ft^3/day or approximately 1,360 gpm. Due to differences in surface elevation, storm water runoff and drainage from West Fulton Street Extension flows onto the landfill and infiltrates into the landfilled waste. Leachate production derived from percolation of rainfall and drainage flow onto the site is estimated to be 8,880 ft^3/day or approximately 46 gpm. The leachate percolates vertically to, and mixes with, the underlying ground water. The ground water/leachate mix migrates southeasterly from the site and discharges to the surface water at LaGrange Springs and Mathew Creek. The occurrence of LaGrange Springs is a consequence of decreasing overburden thickness and its inability to convey the ground water flow.

A health and ecological risk assessment was conducted to quantitatively and qualitatively assess the potential impacts of the landfill on human and ecological health. For the human health component of the risk assessment, both current and future residential and recreational scenarios were considered. The primary cancer and non-cancer risks were associated with the ingestion of ground water resulting in a cumulative cancer exposure risk of 5.5 E-05, and a cumulative hazard index of

6.5. The chemicals of primary concern include antimony, beryllium and tetrachloroethylene in ground water.

Based on these findings, the feasibility study includes an alternative for remediating site ground water. Remedial technologies and alternatives were not developed with regard to on-site soils and sediments because it was determined that these media did not present significant health and environmental risks and, therefore, do not require remediation. The recommended remedial action objectives for the Johnstown Landfill Site have been identified as follows:

- Prevent exposure to solid wastes by humans or potential vectors.
- Prevent the generation of leachate to comply with ARARs. If not feasible to completely eliminate leachate generation, control discharge to minimize impacts to human health and the enviroment.
- Prevent exposure to soils and sediments by humans and wildlife.
- Prevent ingestion of ground water containing contaminants in excess of ARARs.
- Restore ground water to contaminant levels which do not exceed ARARs or if not feasible, restore ground water to background contaminant levels.
- Control generation or migration of subsurface gas from the landfill in a manner that meets ARARs.
- Prevent migration of landfill gas to nearby residences.

Technologies to meet the general response actions were identified. These technologies were screened to eliminate unproven technologies, technologies which would not meet the remedial action objectives, and technologies which would be difficult to implement due to the nature of the site and/or the nature of the contaminants.

Remedial measures were identified and screened for the isolation, collection and/or treatment of the contaminated ground water. Those technologies that were considered feasible and implementable were combined to develop management of migration alternatives for the Johnstown Landfill Site.

The procedures and methods used in developing and evaluating remedial alternatives for the contaminated media are those suggested in the USEPA "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (Interim Final; October, 1988). The following are the steps followed in this feasibility study:

- General response actions were identified for each of the contaminated media based on the remedial action objectives;
- The potentially applicable technology types and process options associated with each of the general response actions were then identified and investigated;
- These technology types and process options were screened with respect to technical implementability, based on specific site conditions, contaminant pathways and risk, remedial response objectives, and nature and extent of contamination;
- The technically feasible remedial technologies identified in the previous step were grouped into potential remedial action alternatives for the

contaminated medium. Normally, if a large number of alternatives are developed, these alternatives are screened based on long-term and short-term effectiveness, technical implementability and cost considerations. However, for this report, because of the limited number of alternatives that were developed, this initial alternative screening process was omitted. All of the developed alternatives were subjected to a detailed evaluation.

- In the detailed evaluation, each remedial alternative was evaluated against nine criteria; i.e., short-term effectiveness; long-term effectiveness; reduction of toxicity, mobility and volume; implementability; cost; compliance with ARARs; overall protection; and state and community acceptance. Since the state and the public have not been provided with a formal opportunity to review the detailed analysis of the remedial alternatives, no formal comments from the state and the public are available for evaluation of the "State Acceptance and "Community Acceptance" criteria in this FS report.

The potential remedial action alternatives developed to address contaminated ground water and surface water and prevent infiltration of rainwater into the landfill waste material at the Johnstown Landfill Site are as follows:

- Alternative SC 1: No Action
- Alternative SC 2: Limited Action, Residential Water Replacement
- Alternative SC 3: 6NYCRR Part 360 Cap, Residential Water Replacement
- Alternative SC 4: RCRA Cap, Residential Water Replacement

- Alternative SC 5: Ground Water Collection Treatment and Discharge, Residential Water Replacement
- Alternative SC 6: 6NYCRR Part 360 Cap, Residential Water Replacement, Ground Water Collection Treatment Discharge
- Alternative SC 7: RCRA Cap, Residential Water Replacement, Ground Water Collection Treatment Discharge

Cost estimates were prepared for each of the potential remedial alternatives. These estimates include: construction costs, management services, and annual operating and maintenance expenses as applicable to each alternative. In order to evaluate the alternatives with respect to a total cost, present worth values were calculated as per EPA guidance, using an operating period of 30 years and a discount rate of 5.00 percent. The present worth costs for each alternative are listed below.

- Alternative 1: $ 1,859,038
- Alternative 2: $11,034,268
- Alternative 3: $16,454,248
- Alternative 4: $22,420,344
- Alternative 5: $27,159,855
- Alternative 6: $32,579,835
- Alternative 7: $38,545,032

1. INTRODUCTION

A Remedial Investigation and a Feasibility Study (RI/FS) of the Johnstown Landfill Site in the City of Johnstown, Fulton County, New York began in June, 1989. The RI was performed by Thermo Consulting Engineers for the City of Johnstown. This Feasibility Study report has been prepared in compliance with the Final RI/FS Work Plan (April, 1989) for this site approved by NYSDEC in May, 1989.

This Feasibility Study (FS) was conducted subsequent to the performance of a remedial investigation at the Johnstown Landfill Site. The RI identified several areas of contamination which have been addressed in the FS. A comprehensive report detailing the methods and results of the remedial investigation has been previously prepared (May, 1992).

1.1 Purpose and Organization of Report

The Johnstown Landfill Site FS was performed in order to assess the levels of contamination discovered at the site and to investigate the possible remediation measures that are necessary to bring the site back to acceptable standards, as identified by site ARARs, or levels of contamination to prevent unhealthful human exposure and environmental damage as defined in the site Risk Assessment. The purpose of this report is to present these findings comprehensively in terms of the various alternatives evaluated and the results of a screening process of those alternatives to aid in identifying the optimum remediation solution for the site in terms of its short-term and long-term effectiveness, technical implementability and cost.

This report consists of four sections, the contents of which are briefly described below, and four appendices which contain additional data. Documents utilized in the development of the information contained in this FS report include the EPA "Guidance on Feasibility Studies under CERCLA" (USEPA, 1985a) and the EPA "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, 1988).

This first section in addition to the above introduction, contains an abridged description of the site including its geology and hydrogeology, history of the area, regulatory actions taken and the nature and extent of the site contamination. Also provided is a summary of the baseline risk assessment. A detailed description of this information is presented in the RI/FS report for this site (May, 1992).

Section 2.0 presents the development of remedial action objectives for the soil and the ground water with regard to the allowable exposure limits for the contaminants found at the site. A description of the general response actions which have been developed for the site is provided. The quantities of materials to which remedial alternatives will be applied would be included in this section, if appropriate. Appropriate technology types and process options for the response actions will be identified and screened with regard to technical compatibility with the site conditions.

In Section 3.0 the rationale for combining various technologies and processes into a range of treatment and containment remedial alternatives, as required, is explained. The developed alternatives are then screened on a conceptual level to evaluate their effectiveness, implementability and cost.

Section 4.0 presents the results of a detailed analysis of the most viable alternatives as described in Section 3.0. This detailed evaluation consists of an assessment of each alternative with regard to its technical feasibility, environmental and public health impact, capital and operating costs, and community relations aspects. The selected remedial alternatives are then compared with each other to provide a basis for determining the most efficient and effective solution.

Appendix A contains a detailed breakdown of the major construction components of each of the identified remedial alternatives and Appendix B presents the detailed cost estimates for each alternative. Appendix C contains the summary of rainfall percolation and stormwater drainage run on calculations used to estimate leachate production rates and the output of the hydrologic evaluation of (HELP) liner performance model. A description of the hydrogeologic calculations and modeling performed to determine an optimum pumping rate for on-site ground water wells to be used for a collection system and estimates of time required for contamination to dissipate are provided in Appendix D.

1.2 Background Information

1.2.1 Site Description

The active portion of the landfill consists of two, generally flat, terraces (Plate 1). The top of the upper terrace occurs at an elevation of 920 feet and the top of the lower terrace occurs at an elevation of 910 feet. A gravel borrow pit, approximately 30 feet deep, exists on the westward side of the landfill at the base of a steep escarpment. This pit, once used as a demolition debris and metals disposal area, when the landfill was active, is the remnant of a larger borrow pit that has been filled by the landfilled solid waste.

The area surrounding the landfill has a mixed land use of residential, agricultural and recreational. Low density residential use is located immediately north of the site on West Fulton Street Extension. Agricultural use consisting of open fields occurs to the south and west. Mixed woodlands exist between the landfill and agricultural areas to the south and adjacent to its eastern boundary. Recreational use of the forested and agricultural areas includes hunting and off-road vehicle riding.

1.2.1.1 Site Geology

The surficial geology of the Johnstown area has been previously mapped by the New York State Geological Survey and is summarized in the Hudson-Mohawk sheet of the Surficial Geologic Map of New York (1987). The Johnstown Landfill is located in an area which has been mapped as a kame deposit which includes kames, eskers, kame terraces and kame deltas. These landforms are formed by the deposition of fluvially transported sediments in the immediate vicinity of a glacier either supraglacially or subglacially. These deposits typically consist of stratified fine to coarse sand and/or gravel. These kame deposits were deposited during the retreat of the Wisconsinan ice sheet at the margin of a section of stagnant ice. During the retreat of the Wisconsinan ice sheet stagnant ice filled the lowlands in the vicinity of present day Great Sacandaga Lake. Meltwater from the ablating ice transported sediments along the margins of the ice sheet to a discharge point south of the landfill. The duration of the stagnant ice appears to have been significant enough for the formation of a kame moraine, which has been mapped immediately south of the landfill.

Based upon the results of seismic geophysical surveys performed along the eastern and southern property lines, the thickness of the sand and gravel deposits appears to decrease from the northwest to the southeast. Although the thickness of the sand and gravel deposits decreases along this southerly trend, the elevation of the bedrock surface appears to be relatively flat lying with several isolated areas of bedrock lows and highs. In the bedrock lows, the thickness of the sand and gravels locally thicken.

During the RI drilling program, a lodgement till deposit consisting of a dense, poorly sorted mixture of silt, clay, sand, gravel and occasional boulders was encountered overlying the bedrock at boring clusters MW-1, MW-3, MW-4, MW-5, MW-6, MW-7, MW-12, MW-13, and MW-14. The thickness of the till ranged from 8.5 feet (MW-13) to 79 feet (MW-7) and appeared to decrease along an easterly and southerly trend across the site.

The overburden material overlying either the bedrock or lodgement till at the study site are sand and gravel deposits consisting of an upper stratified sand unit and a lower stratified sand and gravel unit. The upper sand unit consists of moderately to well sorted fine to medium sands with some gravel and interbedded silts. The thickness of this unit ranges from 10 feet (MW-4D) to 52 feet (MW-6D) and is primarily found along the northern portion of the landfill. The sand and gravel unit varies in thickness from 12 feet (MW-6D and MW-8D) to 46 feet (MW-1D) and appears to thicken in a southerly trend across the site within the landfill boundary. This unit thins appreciably to the southeast beyond the landfill boundary as evidenced in the boring logs for MW-2, MW-10, MW-8, and MW-15.

The sand and gravel deposits found at the Johnstown Landfill are part of a kame terrace which was formed along the margin of stagnant ice. The stratified sand and gravels were deposited either subglacially or along the stagnant ice by meltwater streams. The stratigraphy of the sands and gravels can be viewed in a former sand and gravel borrow pit located west of the landfill. An upper sand unit is observed to overlie a lower sand and gravel unit. Within the upper sand unit several cut and fill structures may be observed. These features were formed by streams which may have flowed along the margin of the stagnant ice. Several areas of slumping were also identified in the sand and gravels. These slump structures may have been formed during the ablation of the stagnant ice which had provided support for these sediments during their deposition.

Surficial deposits identified at borings located within the active landfill boundary generally consisted of household refuse (i.e., wood, plastic, paper, cloth) mixed with a cover material of brown loamy sand with gravel. The interface of the landfilled waste with the native soils was encountered at depths ranging from approximately 29 feet (MW-17 and MW-19) to 32.5 feet (MW-16 and MW-18) below ground surface. Based on known approximate surface elevations, the elevation of the bottom of the landfilled waste was determined by the four borings to range from 893.29 feet (MW-16) to 901.83 feet (MW-19). The borings did not encounter ground water in contact with landfill refuse. The ground water surface is located approximately 14 feet below the landfilled waste in the vicinity of MW-17 and MW-19. However, at boring MW-16, a narrow band of wet native material was identified just below the landfill/native soil interface. This may represent a perched water and/or leachate condition caused by a local low-permeable strata of native material.

The bedrock geology of the region has been mapped by the New York State Geological Survey and is summarized on the Hudson-Mohawk sheet of the New York State Geology Map (Fisher et al., 1970). The immediate area of the landfill is underlain by the Canojoharie Shale, a mid-Ordovician age, calcarious shale with occasional pyrite lobes. The shale is described as being primarily fissile to medium bedded in the eastern region and becomes more massive to the west. The shale unit is claystone to siltstone in texture and developed from the accumulation of finer detritus from young orogenic area with vigorous erosion, rapid transport and speedy deposition. The unit has been reported to display vertical jointing, however, orientations locally are not known. The shale is reported to have low permeability, generally not suitable for water supplies greater than 20 gpm, and reportedly has high total dissolved solids. West and northwest of the site is a major northeast-southwest normal fault which forms the boundary between precambrian igneous rocks to the west and younger sedimentary rocks to the east.

The bedrock contours indicate that the bedrock in the eastern portion of the property slopes gently to the east and southeast. The bedrock in the western and northern portions of the property slopes gently to the west and north. South of the landfill property, are some topographically elevated hill regions. The bedrock rises steeply in this area to a bedrock high (865 feet mean sea level) as determined by the seismic study. The bedrock then slopes in a southeasterly direction toward LaGrange Springs - Mathew Creek areas, which again approximates the topographic slope in the hill regions. Another feature evident from the bedrock contours is a bedrock trough (low area) along aline from MW-1 to MW-9.

1.2.1.2 Site Hydrogeology

Ground water occurs in the area as a result of precipitation that percolates through the surficial soils and the unconsolidated overburden deposits to the underlying bedrock.

In general, ground water in the overburden flows from areas northwest and north of the site to areas south of the site towards LaGrange Springs and Mathew Creek. This flow pattern typically corresponds with the general topography of the area. Some seasonal fluctuations in the water table elevations are evident. Higher water elevations were observed in the spring months (around April) and then decreased during the relatively dryer months of summer and winter season. Seasonal ground water level changes did not induce changes in the ground water flow direction. The overburden ground water flows from uplands to the northwest of the site to its discharge point at LaGrange Springs, headwaters of Mathew Creek, to the southeast of the landfill. The overburden thickness above bedrock and depth to ground water generally decrease in the downgradient direction across the site (northwest to southeast). The occurrence of LaGrange Springs is a consequence of the decreasing overburden thickness and its inability to convey the ground water flow beneath the ground water surface. LaGrange Springs and Mathew Creek occur because of the intersection of the ground water table with the ground surface.

The shale bedrock is moderately fractured to a depth of 20 feet below its surface. A till unit isolates the bedrock from the overlying unconsolidated geologic materials at regions north and west of the landfill, and extending below the landfill to regions just beyond the eastern and northern property lines (MW-1 and MW-13, Plate 1). At downgradient well locations MW-2, MW-8, MW-10, MW-9, MW-11, and MW-15 (Plate 1), the overburden surficial deposits (sands and gravel) are in direct contact with the bedrock surface, with no observable confining layers identified from the borings. Therefore, the shallow bedrock aquifer in these regions may be hydraulically connected to the overburden aquifer.

The bedrock ground water flows generally in a direction from west to east across the site. This is in contrast to a more north to south flow pattern of the shallow water table aquifer. The flow pattern in the shallow bedrock is generally consistent with the bedrock surface contours. Potentiometric head elevations determined from the four bedrock wells (MWs 1D, 2D, 3D, and 7D) have been observed to show the largest deviations in seasonal measurements as well as difference in head as measured in the overburden aquifer wells. The potentiometric head elevations measured in MWs 1D, 3D, and 7D were generally lower than the water table elevation of the overburden aquifer at these locations. In contrast, the potentiometric head elevation measured in the remaining bedrock well (MW-2D) was closer to the water table elevation measured in the shallow overburden aquifer well (MW-2S). In some instances, the water elevations measured in MW-2D were higher than that measured in MW-2S. The absence of a till unit above the bedrock at MW-2 may explain this difference. It was observed during pumping and purging operations of MW-2D, the recovery occurred more rapidly than in the other bedrock wells. This may be indicative of a hydraulic connection between the overburden aquifer and the bedrock aquifer at MW-2.

With the exception of MW-3, MW-7 and MW-15, vertical ground water gradients are very small or weak. Well clusters MW-3 and MW-7 indicate downward ground water gradients and cluster MW-15 indicates an upward ground water gradient exists in these areas. Borings for these wells, with the exception of MW-15, encountered a fine grained, low permeability lodgement till isolating the overburden and bedrock. This till unit is either nonexistent or does not isolate the overburden and bedrock ground water zones at many of the other monitoring wells, thus water level differences and vertical gradients are small. Weak or small vertical gradients also occur when the horizontal gradient (or slope) of the ground water surface is small and as the overburden thickness above bedrock is reduced.

Hydraulic conductivity (or permeability) of the site soils was determined from slug tests conducted within 20 of the monitoring wells. The results from 14 of the 20 wells tested were of acceptable quality for computer analysis. The hydraulic conductivity of the surficial deposits and bedrock at the site ranged from 4.5 ft/day to 307 ft/day. The lowest hydraulic conductivities were measured in the glacial till (4.5 to 31 ft/day) and fine sand (8.6 to 81 ft/day). The highest hydraulic conductivities from slug tests were measured in the sand and gravels (58 to 307 ft/day).

Aquifer testing via pump tests was also performed on MW-10D. Analysis of the test data provided hydraulic conductivities ranging between 516 and 1,056 ft/day in the unconfined sands and gravels. The aquifer test values were greater than slug test values possibly because a rainfall event occurred during the aquifer test. Rainfall infiltration may have infiltrated to the shallow ground water during the test reducing the drawdown which would result in higher calculated hydraulic conductivities. Bedrock permeability was estimated to be 192 ft/day.

The total ground water flow beneath the site was calculated using a flow net and Darcy's Law. To determine the ground water flow rate, the flow net was subdivided into nine separate flow tubes or segments. The weighted average hydraulic conductivity of each segment was determined based on the geologic cross sections and the results of permeability testing of each stratigraphic unit. These calculations indicate that the total ground water discharge beneath the site is about 261,000 cubic feet per day (ft^3/day) or approximately 1,360 gpm. This discharge estimate is based on the ground water levels measured on April 1, 1991 and ground water surface gradients derived from that data. Ground water discharge is expected to vary proportionally as seasonal ground water gradients and water surface elevations increase during wetter seasons and decrease during dryer seasons. An average ground water velocity estimate of 40 ft/day was derived using the data described above and an assumed porosity of 0.2.

Estimates of the percolation of rainfall and drainage from West Fulton Avenue Extension through the landfilled waste were used to develop the leachate production rate. Two methods were used to estimate leachate rates due to percolation on the site; a basic water balance calculation and the U.S. Army Corps of Engineers Hydrologic Evaluation of

Landfill Performance (HELP) computer model. HELP is a two dimensional model of water movement across, into, through and out of landfills that accounts for effects of surface storage, runoff, infiltration, percolation, evapotranspiration, soil moisture storage and lateral drainage. Both methods yielded similar results; leachate production due to percolation of precipitation onto the landfill is 4,120 ft^3/day or about 21 gpm. Leachate production due to percolation of runoff onto the site was estimated using water balance procedures. This calculation estimates percolation of water running onto the site to be 4,760 ft^3/day or about 25 gpm. Therefore, the total leachate production due to percolation is estimated to be 8,880 ft^3/day or 46 gpm.

1.2.1.3 Site Topography/Hydrology

The topography of the area surrounding the Johnstown Landfill reflects both the character of the underlying bedrock and the surficial geologic processes that have formed the existing landscape. The landscape in the vicinity of the landfill consists of rounded uplands of moderate relief. In general, the topography slopes from the upland areas northwest of the landfill to lowlands located to the southeast. The elevation of the land surface in the area ranges from approximately 1,100 feet above mean sea level in the uplands to 800 feet in the lowlands.

The surface water drainage in the vicinity of the landfill flows generally to the southeast. Surface waters flow from the upland areas, north of the site, via intermittent drainage ways towards the south-southeast. The primary surface water feature in the immediate vicinity of the landfill is Mathew Creek. The headwaters of the creek (LaGrange Springs) are located approximately 750 feet southeast of the site. The creek flows southeasterly until it converges with Hall Creek prior to discharging into Cayadutta Creek. The flow of Mathew Creek is interrupted by a man-made pond (Hulbert's Pond) before it converges with Hall Creek. Cayadutta Creek ultimately discharges to the Mohawk River.

Due to differences in surface elevation, storm water runoff and drainage from West Fulton Street Extension flows onto the surface of the landfill creating ponded water near its northeastern corner. The water in this approximately one acre pond either evaporates or infiltrates into the landfilled wastes. Except for ephemeral discharges to the LaGrange Gravel Pit, there is no surface water runoff from the landfill. The LaGrange Gravel Pit, located approximately 100 feet east of the eastern margin of the landfill, receives surface runoff from hill slopes in its immediate vicinity, minor flows from leachate seeps and occasional ephemeral runoff from the landfill surface. There is no surface water runoff from LaGrange Gravel Pit.

1.2.1.4 Site Meteorology

The Johnstown Landfill is situated within south central Fulton County, New York, in the north central aspect of the Mohawk River Valley. The site is located south of a major drainage divide that bisects Fulton County. In general, the hydrology of the region is based on the precipitation of the area and the interaction of the precipitation with the surficial and bedrock geology. The county receives approximately 43.2 inches of rain annually, with the heaviest precipitation occurring in the months of June through September. The average annual snowfall has been reported to be approximately 84 inches, occurring from October to April. Mean daily air temperatures remain below 32°F (0°C) three to four months per year from December to March on average.

1.2.2 Site History

The City of Johnstown, New York operated a landfill located off West Fulton Street Extension in Fulton Country, New York. The Johnstown Landfill was placed on the National Priority List of Superfund sites by the United States Environmental Protection Agency (USEPA) and the New York State Department of Environmental Conservation (NYSDEC). In response to this action, the NYSDEC and New York State Department of Law (NYSDOL) requested that the City start work at the landfill to remediate any potential contamination which may pose a threat to human health, safety and the environment.

The City of Johnstown Landfill (NY I.D. No. 518002, USEPA I.D. No. NYD980506927) operated as a sanitary landfill situated in a former gravel pit. Thirty-four acres of the 68-acre site, owned and operated by the City of Johnstown, were used as an open refuse disposal facility from 1947 to 1960 before being converted to a sanitary landfill. The landfill accepted industrial wastes from local tanneries and textile plans until mid-1977, and sludge from the Gloversville-Johnstown Joint Sewage Treatment Plant from 1973 to April,

1979. Landfill operations ceased in June, 1989. There are no records available which detail the amounts of industrial wastes accepted by the landfill. Much of the tannery wastes have been disposed as chromium treated hide trimmings and other materials. Sewage sludge was disposed of for six years at the landfill, in open piles, at a rate of approximately 20,000 cubic yards per year. The sludge reportedly contained concentrations of chromium, iron, and lead.

1.2.3 Previous Investigations

A file review, data review and on-site visits had been previously conducted during the scoping for the RI/FS Work Plan. Based on the existing data sources (NYSDEC, NYSDOL, NYSDOH), the existing conditions do not appear to pose an imminent danger to public health. However, since the site was recently an active landfill, it was not possible to use existing data to characterize the various industrial wastes disposed at the site because these have been covered.

The previous investigations completed at the site and in the vicinity of the landfill include the following:

1. Preliminary Investigation of the Johnstown Landfill, Phase I Summary Report, Ecological Analysts, Inc., November, 1983.

2. Report on the Status of Ground Water Contamination in the Vicinity of the Johnstown Landfill, Paul A. Rubin, September, 1984.

3. Ammonia Toxicity and Chemical Analysis in Relation to Mathew Creek, Johnstown, NY, New York State

Department of Environmental Conservation, July, 1987.

Investigation 1 included the installation of ground water monitoring wells at the landfill, 1 and 2 included sampling of the wells. Additionally, surface water sampling was conducted at selected locations along Mathew Creek. Investigation 3 focused entirely on the water quality of Mathew Creek.

The ground water quality data collected prior to the initiation of this RI was nearly five years old and was not collected following current NYSDEC Contract Lab Program protocols. In addition, the existing monitoring wells at the site were not constructed to current NYSDEC-approved standards. Therefore, additional ground water monitoring wells were installed and ground water samples were collected by Thermo Consulting Engineers under this RI/FS.

In addition, the existing database was inadequate to support the DQO's of sound defensible decisions concerning remedial action selection. Previous sampling efforts had been inconsistent in the selection of sample sites and analytical parameters. Different media had been sampled at different times making comparison over time or distance very tenuous. The RI activities were intended to provide consistent data for all affected media on-site and off-site.

1.2.4 Nature and Extent of Contamination

The hydrogeological investigation determined that two aquifers exist beneath the Johnstown Landfill. Ground water flow through the overburden is generally towards the southeast and south from the landfill following surface drainage patterns. However, ground water flow through the shallow bedrock aquifer is generally from west to east across the site. Ground water in both the overburden and shallow bedrock aquifers appears to discharge into the wetlands area of LaGrange Springs and Mathew Creek located southeast of the Johnstown Landfill site.

Environmental samples collected to characterize the extent of contamination found at the site included soil, landfill leachate, surface water, sediment, and ground water. These included samples from background, on-site, downgradient and residential well locations. A summary of the levels of the nature and extent of contamination profiles is presented in Tables 1-1 through 1-6 at the end of the chapter.

Native soils located beneath the landfill site exhibited the majority of the soil contamination at the Johnstown Landfill Site. Eight TCL volatile compounds were detected in the landfill soil samples. Landfill soil boring, MW-16, was observed to have the highest concentration of most of these compounds. Benzoic acid, phthalate, and polycyclic aromatic hydrocarbons (PAH) compounds comprised most of the semi-volatile contamination detected in landfill soil zones, with phthalate esters observed to have the highest range of concentration (42 mg/kg to 1,100 mg/kg). Eighteen TAL metals were detected in soil samples from landfill soil borings. However, only eight (antimony, calcium, chromium, lead, magnesium, sodium, aluminum and zinc) exceeded background values. Downgradient soil metal contamination included detections of iron, manganese, thallium, and zinc in soil samples. Eleven TCL pesticides were detected in soil samples from landfill borings.

Thirteen TCL VOCs comprised the volatile contamination detected in the overburden downgradient ground water aquifer. Concentration of these contaminants ranged from 0.2 μg/L to 62.0 μg/L, with the highest VOC concentration of toluene (62 μg/L) detected in MW-3S. Semi-volatile contamination was limited to phthalate ester compounds, polycyclic aromatics, methylphenol and benzoic acid. Metal samples obtained during this effort were not filtered as per the Field Sampling Plan requirements. Twenty TAL metals were detected in overburden wells downgradient of the landfill at levels often exceeding background levels. Eight TAL metals exceeded USEPA and/or NYSDEC standards in downgradient monitoring wells.

The results indicate that acetone and bis(2-ethylhexyl) phthalate were the primary contaminant detected within the bedrock aquifer at concentrations typically much greater than that found at the source (landfill wells). In addition, the highest concentration of acetone was detected in the upgradient bedrock well MW-7D (2,900 μg/L). The highest concentration of bis(2-ethylhexyl) phthalate was detected in MW-3D, located just south east of the landfill. The majority of the other parameters were detected at typically lower concentrations within the bedrock as compared to the overburden aquifer.

The primary contaminants found in residential well samples (ground water) were mainly metals, TDS, and ammonia-nitrogen. Limited contamination with VOCs and SVOCs (mainly phthalate esters) were observed in residential wells. NYSDEC and/or USEPA standards for total dissolved solids, iron, manganese, sodium, and zinc were exceeded in one or more residential samples.

The highest level of organic compound contamination at the Johnstown Landfill Site surface waters were observed at sampling locations in the vicinity of the landfill which included the man-made LaGrange Gravel Pit which receives surface runoff from the landfill. Six VOCs were detected in LaGrange Pit and Mathew Creek samples which is consistent with those compounds detected in ground water downgradient of the landfill. Semi-volatile organic compound (SVOC) contamination was mainly comprised of phthalate esters at both LaGrange Pit and Mathew Creek locations. Additional SVOCs which include phenol, benzyl alcohol, 4-methyl-phenol, and benzoic acid were detected at LaGrange Pit. Of all the TCL pesticides/PCBs compounds analyzed for none were detected in any of the surface water samples from Mathew Creek or LaGrange Pit. In addition to the few organic compounds detected, 15 TAL metals were detected at LaGrange Pit and Mathew Creek locations. High concentrations of ammonia-nitrogen was also widespread. Concentrations of three metals (iron, manganese, and selenium) and ammonia-nitrogen exceeded NYSDEC Class "A" surface water standards in one or more samples.

Sediment contamination included metals, ammonia-nitrogen, VOCs, SVOCs, and pesticides at concentrations typically higher than concentrations detected in soils from landfill borings. Concentrations for arsenic, cadmium, chromium, copper, manganese, mercury, nickel, lead, and zinc exceeded Lowest Observable Effect Levels (LOEL) of the NYSDEC Sediment Criteria Guidance Values in one or more sediment samples from Mathew Creek and LaGrange Pit. The Limit of Tolerance (LOT) of the NYSDEC Guidance Values was exceeded once (1 out of 16 samples in Round 3) for arsenic and five times for manganese (1 out of 8 samples, Round 1; 2 out of 8 samples, Round 2; 2 out of 16 samples, Round 3) in Mathew Creek and LaGrange Pit. The single LOT exceedance for arsenic occurred in a sample from the LaGrange Pit.

1.2.5 Fate and Transport

Generally low levels of VOCs were detected in subsurface soils, ground water, and sediment. The primary mechanism by which these VOCs naturally attenuate is through volatilization. The principle VOCs detected at the site, acetone, is more mobile, due to its higher solubility and low organic carbon-water partition coefficient (K_{oc}). Other VOCs detected on site (e.g., ethylbenzene, benzene, and xylenes) were not detected at significant levels downgradient of the site, and are more persistent in the environment because they have lower solubilities and higher K_{oc} values.

SVOCs were detected at higher levels within the subsurface soils below the landfill and sediments (LaGrange Pit and Mathew Creek) as compared to less frequent detection and lower concentrations within ground water at isolated downgradient sites. In the environment, SVOCs tend to adsorb onto soils and particles. They are persistent in the environment, due to their low solubilities and high K_{oc} values.

Pesticides were primarily detected in the subsurface soils and leachate (MW-16) within the landfill limits as well as the sediments sampled along Mathew Creek and LaGrange Pit. Pesticides tend to be very persistent and less mobile in the environment, due to their low solubilities and high K_{oc} values.

Numerous inorganic compounds (particularly metals) were detected in all sampled media at the site, for which many are leachate indicator parameters. Inorganics have a wide range of solubilities and K_{oc} values. Some compounds, such as lead and chromium, tend to adsorb to organic matter or soils and this is their predominant fate process. High concentrations were detected in ground water and sediments (LaGrange Pit and Mathew Creek) downgradient of the landfill. Ammonia-nitrogen was widespread, particularly in ground water and surface water of Mathew Creek. It is a very mobile parameter, with a high water solubility and low K_{oc}.

1.2.6 Risk Assessment Summary and Conclusions

The risk assessment quantitatively analyzed the contribution of 46 different chemicals (21 inorganic, 16 volatile organics, 8 base/neutral organics, 1 pesticide) to lifetime incremental cancer risk and non-cancer health effects (Hazard Index Ratio). Only six metals (all essential nutrients) and methane were discarded from the analysis. The assessment quantitated exposure and risk to potential receptors in the current use/recreational/residential scenarios (adults and children), and in the future residential/recreational scenarios (adults and children). Exposure was modeled for the most likely pathways: ingestion of tap water (residential scenario), ingestion of soil (all scenarios), dermal contact with soil (all scenarios), inhalation of compounds volatilized from tap water (residential scenario), inhalation of dust-borne compounds (residential scenario), dermal contact with tap water during showering (residential scenario), and dermal and ingestion exposures to surface water (recreation scenario).

Risk levels at the site were elevated above the range of acceptable cancer risk (1E-04 to 1E-06) and above the acceptable hazard ratio (1E+00) in several cases. The greatest cancer risk levels and hazard index ratios were for the current residential scenario. The total cancer risk for all chemicals and all pathways in this scenario is 5.5E-05. The total hazard index ratio is 6.5E+00. Cancer risk levels and hazard index ratios in the recreation scenario were generally much less than those derived in the residential scenario. The risk level and hazard index ratios for the recreational scenario are significant only for the high exposure assumptions.

The most important exposure pathways are ingestion of chemicals in drinking water (derived from ground water). Beryllium and tetrachloroethylene were found in ground water at levels that substantially increase cancer risk. The analytical data collected for the site used in the Risk Assessment included detectable concentrations of beryllium found in samples from both monitoring wells and residential wells. Highest concentrations of beryllium were indicated in ground water samples from the landfill wells and downgradient wells. Beryllium was detected in all three rounds in ground water around the site. Beryllium concentrations typically much lower than those from monitoring wells were found in 4 of 17 samples taken from residential wells in Round 2. No detectable concentrations of beryllium were indicated in residential wells during sampling Rounds 1 and 3. The concentrations of beryllium in residential wells may be indicative of background levels based on the data. The analytical data for the site used in the Risk Assessment included a single occurrence of tetrachloroethylene in a water quality sample from the residence of LaGrange (daughter's dug well). The detected concentration of 3 ppb did not exceed the NYSDOH standard for public water supplies. A confirmatory sample of this well did not indicate any detection of tetrachloroethylene. Tetrachloroethylene was not detected in soil or water quality samples from the landfill. Therefore the calculated risk for tetrachloroethylene is based on limited and possibly isolated minimal contamination event, and not on landfill impacts.

The primary contributor to hazard index ratio is ingestion exposure of residents to antimony in drinking water. It should be noted that antimony was not detected in any downgradient wells or landfill wells, but was detected on two occasions at upgradient wells. Antimony was detected in eight residential well samples during Round 2. Non-detectable concentrations were indicated in residential samples during Rounds 1 and 3. Based on this data, the landfill does not appear to be source of antimony. Also, concentrations of antimony appear to be higher in background ground water as compared to ground water beneath and downgradient of the landfill. Therefore, the calculated risk for antimony is likely based on background water quality, rather than on landfill impacts.

In conclusion, beryllium and tetrachloroethylene and antimony concentrations in ground water were the major driving forces in producing elevated cancer risk and hazard index ratios in the residential and recreational use scenarios. Based on the analytical data, the elevated cancer risk and hazard index ratios calculated for these compounds represent a very conservative risk for the study site, with no adjustment made for statistical and/or background screening. Of these compounds, it appears that the calculated risks for beryllium may be site related. However, analytical data gathered as part of the RI field study indicated elevated levels of leachate indicator parameters (i.e., iron, manganese, TDS, ammonia, bicarbonate, and chloride) in residential well samples. Based on this, NYSDOH will require alternate water supply for residences in study area. As a result, the Risk Assessment calculations will not be rerun using site related ground water conditions.

Table 1-1: Nature and Source of Contaminants Profile
Metals and Miscellaneous Inorganics
Groundwater and Surface Water
Johnstown Landfill, Johnstown, New York

	GROUND WATER UPGRADIENT WELLS				GROUND WATER LANDFILL WELLS				GROUND WATER DOWNGRADIENT WELLS			
Parameter	FREQ	LOW	HIGH	MW	FREQ	LOW	HIGH	MW	FREQ	LOW	HIGH	M
METALS (μg/L)												
Aluminum	27/27	67	43,200	5S	3/3	13,300	55,800	16	51/51	83.8	104,000	1
Antimony	2/27	15.8	26.3	14D	0/3				0/51			
Arsenic	22/27	1.1	16.0	5S	3/3	11.9	35.7	16	44/51	0.8	49.5	3
Barium	26/27	18.4	425	13D	3/3	17.7	1,080	16	51/51	41.6	594	1
Beryllium	7/27	0.23	3.3	13D	3/3	2.4	6.0	16	51/51	0.37	9.2	1
Cadmium	16/27	1.3	53.0	7D	3/3	2.5	77.6	16	22/51	1.1	11.4	3
Calcium	27/27	42,700	796,000	13D	3/3	327,000	1,430,000	16	51/51	35,300	1,610,000	3
Chromium(T)	25/27	3.5	187	13D	3/3	145	2,330	16	46/51	2.6	229	1
Cobalt	13/27	2.4	69	5S	3/3	20.6	61.2	16	29/51	2.2	121	1
Copper	19/27	3.5	269	13D	3/3	104	259	16	39/51	6.8	286	3
Iron	27/27	651	124,000	5S	3/3	45,800	130,000	16	51/51	58.0	202,000	3
Lead	26/27	1.0	65.3	5S	3/3	34.0	487	16	45/51	1.0	454	2
Magnesium	27/27	5,210	86,600	5S	3/3	36,800	82,900	16	51/51	4,960	80,400	2
Manganese	27/27	24	4,630	5S	3/3	1,350	2,570	18	51/51	7.9	57,300	1
Mercury	2/27	0.20	0.40	5S	3/3	0.21	10.6	16	9/51	0.25	0.49	1
Nickel	18/27	6.9	247	13D	3/3	91.7	445	16	46/51	7.6	332	3
Potassium	27/27	701	13,100	5S	3/3	7,100	206,000	16	50/51	1,070	19,500	3
Selenium	0/27				0/3				0/51			
Silver	0/27				0/3				0/51			
Sodium	27/27	1,890	89,800	6D	3/3	13,300	423,000	16	51/51	1,790	166,000	1
Thallium	0/27				1/3		1.9	16	2/51	1.0	2.7	1
Vanadium	21/27	3.7	163	13D	2/3	49.9	131	18	35/51	4	270	15
Zinc	27/27	10.8	798	13D	3/3	215	2,730	16	50/51	3.6	479	1S,
Cyanide	0/27				1/3		73	16	1/51		10.2	1
Hexchrome	2/27	30	30	5S,M	0/3				3/51	20	40	1
INORG. (mg/L)												
Sulfate	20/27	7.41	103	5M	3/3	11.5	13.2	19	36/51	11.9	51.8	3
Chloride	25/27	6.30	112	6D	3/3	25.3	699	16	46/51	3.17	215	3
COD	14/27	11.2	668	13D	3/3	19.3	852	18	29/51	10.3	672	10
TDS	27/27	101	634	5S	3/3	286	2,100	16	51/51	134	1,330	3
Bicarbonate	27/27	84.4	522	5S	3/3	411	2,890	16	51/51	74.4	760	3
Carbonate	0/11				0/3				0/23			
TOC	11/11	1.4	105	7D	3/3	16.1	178	16	22/23	0.64	68.7	15
Hardness	11/11	81.0	550	5S	3/3	251	700	16	23/23	108	448	4
Ammonia–N	10/11	0.05	15.9	5M	3/3	33.8	472	16	23/23	0.08	64.5	15S,

Notes:

FREQ = Frequency of analyte detected above sample detection limits

LOW = Lowest concentration detected in each sampling category

HIGH = Highest concentration detected in each sampling category

MW,RESIDENCE,STAT# = Sample location where highest concentration of analyte was detected

UPG

DOW

LAN

	GROUND WATER RESIDENTIAL WELLS				SURFACE WATER MATHEW CREEK				SURFACE WATER LaGRANGE PIT		
IW	FREQ	LOW	HIGH	RESIDENT	FREQ	LOW	HIGH	STAT#	FREQ	LOW	HIGH
1S	34/52	16.0	1,410	Gunnison	11/12	34.9	363	#2R	2/2	192	357
	8/52	13.6	21.4	Palmateer	1/12		13.9	#1	1/2		17
S	11/52	0.30	1.6	LaGrange	0/12				1/2		1.6
S	41/52	2.1	555	Gunnison	12/12	27	72.6	#1	2/2	22.9	32.4
1S	4/52	0.21	0.45	Hulbert	0/12				0/2		
D	0/52				0/12				0/2		
S	51/52	87.8	121,000	Pine Tree	12/12	49,900	111,000	#1	2/2	64,900	88,200
S	1/52		3.4	Blanket	4/12	3.7	7.2	#4	2/2	34	40.6
S	0/52				1/12		3.7	#1	0/2		
S	22/52	3.1	30.5	Gunnison	0/12				0/2		
S	43/52	53.0	6,840	Gunnison	12/12	63.7	4,940	#4	2/2	1,410	6,330
S	18/52	0.4	5.6	Pine Tree	1/12		5.9	#4	1/2		2.2
S	51/52	33.9	26,100	LaGrange	12/12	6,480	15,000	#2	2/2	8,070	11,100
S	46/52	0.72	7,990	Gunnison	12/12	29.3	557	#1	2/2	93.9	944
S	0/52				0/12				0/2		
S	5/52	5.9	13.6	Pine Tree	3/12	9.2	12	#4	1/2		12.6
S	43/52	518	13,500	Blanket	12/12	2,980	5,420	#1	2/2	9,790	23,000
	10/52	0.5	1.4	Forrester	2/12	1.2	1.4	#2R	0/2		
	1/52		2.5	Wintermute	0/12				0/2		
S	52/52	2,200	258,000	Hannon	12/12	14,700	70,900	#2	2/2	33,000	97,300
S	6/52	0.7	1.6	Schreppel	0/12				0/2		
S	2/52	6.5	7.2	Wheeler	0/12				2/2	5.9	8
3S	38/52	4.2	750	Pine Tree	3/12	3.5	20.4	#4	2/2	16.8	283
D	2/52	16.0	29.2	Wager	2/12	34.8	41.0	#3	0/2		
S	0/52				0/12				0/2		
D	45/52	10.3	57.9	Wager	10/12	11.1	58.9	#1	2/2	18.9	29.2
	34/52	3.1	154	Pine Tree	12/12	22.2	88.8	#2	2/2	40.3	136
B	5/52	12.7	36.7	Hulbert	6/12	10.4	41	#3	2/2	25.2	219
G	52/52	82.0	1,160	Wheeler	12/12	202	463	#1	2/2	322	738
S	52/52	67.5	590	Pine Tree	12/12	140	409	#1	2/2	245	315
	12/35	0.02	2.4	LaGrange	0/4				0/1		
D					4/4	4.70	11.2	#3	1/1		8.15
S	17/17	74	328	Pine Tree	4/4	198	279	#1	1/1		197
9D	8/8	0.010	5.5	Pine Tree	4/4	2.72	33.5	#1	1/1		11.2

RADIENT WELLS : CLUSTER MWs 5,6,7,13,14

NGRADIENT WELLS : CLUSTER MWs 1,2,3,4,8,9,10,11,12,15

DFILL WELLS : MWs 16,18,19

Table 1-2: Nature and Source of Contaminants Profile
Metals and Miscellaneous Inorganics
Soil Boring and Sediment Samples
Johnstown Landfill, Johnstown, New York

	SOIL SAMPLES UPGRADIENT BORINGS				SOIL SAMPLES LANDFILL BORINGS				SOIL SAMPLES DOWNGRADIENT BORINGS			
Parameter	FREQ	LOW	HIGH	MW	FREQ	LOW	HIGH	MW	FREQ	LOW	HIGH	MW
METALS (mg/Kg)												
Aluminum	2/2	3,860	5,710	14D	3/3	4,000	6,480	16	4/4	3,050	11,200	11D
Antimony	0/2				1/3		4.2	17	0/4			
Arsenic	2/2	0.7	1.4	14D	3/3	0.43	1.1	16	4/4	0.5	1.0	12D
Barium	2/2	14.4	21.3	14D	3/3	16.0	23.9	16	4/4	11.3	21.0	9D
Beryllium	2/2	0.39	0.53	14D	3/3	0.23	0.39	17	4/4	0.31	0.43	9D
Cadmium	0/2				0/3				0/4			
Calcium	2/2	12,800	63,400	13D	3/3	18,900	72,000	18	4/4	1,230	39,200	10D
Chromium(T)	2/2	5.9	11.8	14D	3/3	6.3	30.0	16	4/4	5.2	11.5	11D
Cobalt	2/2	1.9	3.0	14D	3/3	2.2	3.0	16	4/4	1.6	4.0	11D
Copper	2/2	4.5	10.1	14D	3/3	5.0	7.1	17	4/4	4.3	9.1	10D
Iron	2/2	4,890	9,710	14D	3/3	6,290	9,280	16	4/4	4,660	11,100	9D
Lead	2/2	1.7	3.8	14D	3/3	2.6	7.8	16	4/4	1.7	3.6	12D
Magnesium	2/2	3,100	5,780	14D	3/3	1,500	6,660	17	4/4	704	2,060	10D
Manganese	2/2	106	188	14D	3/3	120	188	17	4/4	78.5	224	12D
Mercury	0/2				0/3				0/4			
Nickel	2/2	4.4	10.9	14D	3/3	4.5	7.1	16	4/4	4.0	6.6	9D
Potassium	2/2	1,080	1,610	14D	3/3	864	1,030	18	4/4	303	786	11D
Selenium	0/2				0/3				0/4			
Silver	0/2				0/3				0/4			
Sodium	2/2	346	395	14D	3/3	343	507	17	4/4	239	365	10D
Thallium	1/2		0.21	14D	0/3				2/4	0.23	0.26	10D
Vanadium	2/2	7.1	17.3	14D	3/3	10.3	15.1	16	4/4	6.6	16.2	11D
Zinc	2/2	12.5	18.9	14D	3/3	13.5	32.6	16	4/4	11.3	22.3	9D
Cyanide	NT				0/3				NT			
Hexchrome	0/2				0/3				0/4			
INORG. (mg/Kg)												
Sulfate	NT				1/3		250	17	0/4			
COD	NT				3/3	5,420	80,800	17	4/4	2,810	11,000	12D
TOC	NT				NT							
Ammonia-N	NT				NT							

Notes:
FREQ = Frequency of analyte detected above sample detection limits
LOW = Lowest concentration detected in each sampling category
HIGH = Highest concentration detected in each sampling category
MW,STATION = Sample location where highest concentration of analyte was detected
NT = Not tested

UPGRADIENT BO
DOWNGRADIENT
LANDFILL BORIN

	SEDIMENT–ROUNDS 1 & 2 MATHEW CREEK				SEDIMENT–ROUND 3 MATHEW CREEK				SEDIMENT–ROUNDS 2 & 3 LaGRANGE PIT		
/	FREQ	LOW	HIGH	STATION	FREQ	LOW	HIGH	STATION	FREQ	LOW	HIGH
)	16/16	1,940	16,100	#1,0–6"	16/16	1,590	20,200	BD#2,6–12"	6/6	2,600	3,660
	0/16				0/16				0/6		
)	16/16	0.58	12.2	#1,6–12"	16/16	0.76	91.0	2R,0–6"	6/6	0.30	2.2
'	16/16	12	316	#1,0–6"	16/16	19.3	158	2R,0–6"	6/6	9.9	25.4
	13/16	0.06	0.83	#3INLET	5/16	0.17	0.58	2R,0–6"	3/6	0.21	0.29
	3/16	0.93	3.7	#1,0–6"	16/16	0.50	2.7	BD#2,6–12"	6/6	0.29	0.84
	16/16	1,740	56,300	#1,0–6"	16/16	3,020	22,900	SD(A),0–6"	6/6	17,400	106,000
	16/16	1.9	33.8	#1,0–6"	16/16	2.8	18.5	#3IN,0–6"	6/6	29.3	1,820
	14/16	2.5	39.3	#1,0–6"	16/16	1.7	13.1	2R,0–6"	5/6	2.2	8.5
	15/16	1.4	43.2	#3INLET	15/16	0.61	26.4	#3IN,0–6"	6/6	5.4	17.2
	16/16	6,100	121,000	#1,0–6"	16/16	5,290	39,700	2R,0–6"	6/6	5,840	8,640
)	16/16	2.7	17.8	#1,0–6"	16/16	2.8	62.4	#4,6–12"	6/6	3.3	53.4
,	16/16	602	3,910	#1,0–6"	16/16	536	3,510	MP,0–6"	6/6	1,590	2,880
)	16/16	41.6	4,220	#1,6–12"	16/16	79.4	2,640	2R,0–6"	6/6	71.5	155
	0/16				6/16	0.10	0.43	#3IN,0–6"	2/6	0.14	0.22
	14/16	1.6	50.5	#1,0–6"	16/16	3.0	21.6	#1,6–12"	6/6	4.4	8.2
	16/16	279	1,790	#1,0–6"	16/16	160	817	SD(A),0–6"	6/6	276	594
	6/16	0.43	1.8	#1,6–12"	1/16		0.71	#1,6–12"	1/6		0.33
	0/16				2/16	0.86	2.2	SD(A),0–6"	0/6		
	16/16	105	666	#1,0–6"	16/16	53.4	356	SD(A),0–6"	6/6	82.2	269
	1/16		0.3	#1,6–12"	0/16				1/6		0.24
	16/16	7.1	45.7	#1,0–6"	16/16	4.9	29.8	BD#2,6–12"	6/6	4.9	10.0
	16/16	13.1	95.7	#1,0–6"	16/16	12	190	BD#2,6–12"	6/6	24.7	108
	3/16	1.1	1.4	#2,0–6"	1/16		5.7	#3IN,0–6"	0/6		
	2/16	0.06	0.66	#1,0–6"	1/16		0.71	#1,0–6"	0/6		
	12/16	81.8	577	#2,6–12"	0/16				3/6	274	337
	16/16	8,360	347,000	#1,0–6"	16/16	10,700	456,000	BD#2,0–6"	6/6	2,000	62,500
	NT				11/16	7,370	>80,000	BD,SD	4/4	8,740	58,850
	NT				16/16	18.6	987	2R,0–6"	4/4	23.8	36.3

'INGS : MWs 5,6,7,13,14
'ORINGS MWs 1,2,3,4,8,9,10,11,12
GS : MWs 16,17,18

Table 1-3 : Nature and Source of Contaminants Profile
TCL Volatile Organic Compounds
Groundwater and Surface Water
Johnstown Landfill, Johnstown, New York

	GROUND WATER UPGRADIENT WELLS				GROUND WATER LANDFILL WELLS				GROUND WATER DOWNGRADIENT W		
Parameter	FREQ	LOW	HIGH	MW	FREQ	LOW	HIGH	MW	FREQ	LOW	HIGH
VOC's (µg/L)											
Acetone	12/27(B)	2	2,900	7D	1/3		130	16	22/51(B)	2	1,700
Methylene Chloride	8/27(B)	2	75	7D	1/3		26	16	14/51(B)	0.8	44
Trichloroethylene	0/27				0/3				0/51		
1,1,1 Trichloroethane	1/27		3	5S	0/3				0/51		
Chloroform	4/27(B)	0.8	3	7D	0/3				9/51(B)	0.5	10
Vinyl Chloride	1/27		30	7S	0/3				1/51		3
Xylene	2/27	2	12	6D	2/3	5	230	16	5/51	0.3	4
Benzene	1/27		0.8	6D	2/3	0.9	9	16	7/51	0.2	2
Ethylbenzene	2/27	0.7	2	6D	2/3	7	110	16	4/51	0.6	2
Chlorobenzene	1/27		1	6D	0/3				2/51	0.7	2
2-Butanone	0/27				0/3				1/51		41
4-Methyl-2-Pentanone	0/27				0/3				1/51		7
Vinyl Acetate	1/27		0.7	5D	0/3				0/51		
1,1-Dichloroethane	0/27				0/3				2/51		0.2
Styrene	0/27				0/3				2/51	1	2
Carbon Disulfide	1/27		2	6D	0/3				5/51	0.1	2
Toluene	4/27	0.6	6	6D	0/3				5/51	0.7	62
Tetrachloroethylene	0/27				0/3				0/51		
1,1-Dichloroethylene	0/27				0/3				0/51		
1,2-Dichloroethylene	1/27		2	6S	0/3				0/51		

Notes:
FREQ = Frequency of analyte detected above sample detection limits
LOW = Lowest concentration detected in each sampling category
HIGH = Highest concentration detected in each sampling category
MW,RESIDENCE,STAT# = Sample location where highest concentration of analyte was detected
(B) = Flag indicates analyte was detected in method blanks for one or more of the samples

'ELLS	GROUND WATER RESIDENTIAL WELLS				SURFACE WATER MATHEW CREEK				SURFACE WATER LaGRANGE PIT		
MW	FREQ	LOW	HIGH	RESIDENCE	FREQ	LOW	HIGH	STAT#	FREQ	LOW	HIGH
1D	6/52(B)	3	6	Gunnison	4/12(B)	12	24	#2	1/2		120
2D	3/52(B)	1	2	PTRC,Gunnison	3/12(B)	2	3	#1	1/2(B)		8
	1/52		2	LaGrange	1/12		1	#3	0/2		
	1/52		3	Schreppel	0/12				0/2		
1M	0/52				0/12				0/2		
3D	0/52				0/12				0/2		
3S	0/52				0/12				0/2		
3S,8D	0/52				0/12				1/2		2
3S	0/52				0/12				0/2		
3S	0/52				1/12		0.7	#4	0/2		
1D	0/52				0/12				1/2		250
3S	0/52				0/12				1/2		49
	0/52				0/12				0/2		
15D,3S	0/52				0/12				0/2		
3M	0/52				0/12				0/2		
3M,D	4/52	0.3	3	LaGrange	0/12				0/2		
3S	1/52		2	Schreppel	4/12(B)	1	2	#1,2R	1/2		18
	0/52				1/12		7	#3	0/2		
	0/52				0/12				0/2		
	0/52				0/12				0/2		

JPGRADIENT WELLS : CLUSTER MWs 5,6,7,13,14

)OWNGRADIENT WELLS : CLUSTER MWs 1,2,3,4,8,9,10,11,12,15

.ANDFILL WELLS : MWs 16,18,19

Table 1-4 : Nature and Source of Contaminants Profile
TCL Volatile Organic Compounds
Soil and Sediment Samples
Johnstown Landfill, Johnstown, New York

	SOIL BORINGS UPGRADIENT WELLS				SOIL BORINGS LANDFILL WELLS				SOIL BORINGS DOWNGRADIENT		
Parameter	FREQ	LOW	HIGH	MW	FREQ	LOW	HIGH	MW	FREQ	LOW	HIGH
VOC's (µg/Kg)											
Acetone	5/5(B)	5	160	7S	3/3(B)	13	440	16	9/9(B)	7	75
Methylene Chloride	3/5(B)	2	6	13D	3/3(B)	4	7	16	7/9(B)	2	5
Trichloroethylene	0/5				0/3				2/9	7	9
1,1,1 Trichloroethane	0/5				0/3				2/9	4	5
Chloroform	3/5	1	1	5,6,7	0/3				1/9		1
Vinyl Chloride	0/5				0/3				0/9		
Xylene	0/5				2/3	10	15	16	2/9	3	9
Benzene	0/5				1/3		13	16	1/9		0.6
Ethylbenzene	0/5				2/3	3	5	17	2/9	1	2
Chlorobenzene	0/5				0/3				0/9		
2-Butanone	3/5(B)	2	4	5D	2/3(B)	7	350	16	3/9(B)	2	3
4-Methyl-2-Pentanone	0/5				1/3(B)		14	16	0/9		
Vinyl Acetate	0/5				0/3				0/9		
1,1-Dichloroethane	0/5				0/3				0/9		
Styrene	0/5				0/3				0/9		
Carbon Disulfide	0/5				0/3				0/9		
Toluene	3/5(B)	0.5	2	14D	2/3	10	51	16	5/9	0.6	2
Tetrachloroethylene	1/5		3	7S	0/3				5/9	0.7	2
1,1-Dichloroethylene	0/5				0/3				2/9		0.9
1,2-Dichloroethylene	0/5				0/3				0/9		

Notes:
FREQ = Frequency of analyte detected above sample detection limits
LOW = Lowest concentration detected in each sampling category
HIGH = Highest concentration detected in each sampling category
MW,STATION = Sample location where highest concentration of analyte was detected
(B) = Flag indicates analyte was detected in method blanks for one or more of the samples

WELLS	SEDIMENT MATHEW CREEK ROUNDS 1 & 2				SEDIMENT MATHEW CREEK ROUND 3				SEDIMENT LaGRANGE PIT ROUNDS 2 & 3		
MW	FREQ	LOW	HIGH	STATION	FREQ	LOW	HIGH	STATION	FREQ	LOW	HIGH
1D	16/16(B)	14	380	#1,0-6"	16/16(B)	18	130	#3INLET	6/6(B)	16	99
2D	15/16(B)	2	28	#1,0-6"	15/16(B)	6	23	#3INLET	5/6(B)	4	8
12D	0/16				1/16		18	SD(B),6-12"	0/6		
10D	0/16				0/16				0/6		
1D	4/16(B)	0.8	2	#1,6-12"	0/16				0/6		
	0/16				0/16				0/6		
12D	0/16				0/16				0/6		
2D	1/16		3	#2,0-6"	0/16				0/6		2
12D	0/16				0/16				0/6		
	0/16				0/16				0/6		
12D	8/16	6	100	#3 INLET	11/16(B)	2	32	#3INLET	3/6(B)	3	96
	0/16				0/16				1/6		15
	0/16				0/16				0/6		
	0/16				0/16				0/6		
	0/16				0/16				0/6		
	1/16		31	#3 INLET	1/16				0/6		
3D	3/16	2	3	#1,#3IN.	2/16	4	5	#4,0-6"	2/6	3	23
1D,3D	0/16				0/16				0/6		
3D,11D	0/16				0/16				0/6		
	0/16				0/16				0/6		

UPGRADIENT BORINGS : MWs 5,6,7,13,14
DOWNGRADIENT BORINGS : MWs 1,2,3,4,8,9,10,11,12
LANDFILL BORINGS : MWs 16,17,18

Table 1-5 : Nature and Source of Contaminants Profile
TCL Semi-Volatile Organics and Pesticides
Groundwater and Surface Water
Johnstown Landfill, Johnstown, New York

	GROUND WATER UPGRADIENT WELLS				GROUND WATER LANDFILL WELLS				GROUND WATER DOWNGRADIENT WE	
Parameter	FREQ	LOW	HIGH	MW	FREQ	LOW	HIGH	MW	FREQ	LOW
SVOC's (μg/L)										
Phenol	0/19				0/3				0/37	
Benzyl alcohol	0/19				0/3				0/37	
1,2-Dichlorobenzene	0/19				1/3		2	16	0/37	
4-Methylphenol	0/19				0/3				1/37	
Benzoic acid	0/19				2/3	2	6	19	7/37	2
Naphthalene	1/19		0.6	6D	2/3	1	21	16	0/37	
2-Methylnaphthalene	0/19				1/3		2	16	0/37	
Dimethylphthalate	1/19		0.7	6S	0/3				1/37	
Diethylphthalate	6/19(B)	0.8	2	5S,D	1/3		2	19	15/37(B)	0.6
N-Nitrosodiphenylamine(1)	0/19				0/3				1/37	
Phenanthrene	0/19				1/3		1	16	2/37	0.5
Anthracene	0/19				0/3				2/37	0.6
Di-n-butylphthalate	6/19(B)	0.5	3	5D	2/3	1	2	16	16/37(B)	0.4
Fluoranthene	0/19				1/3		2	16	2/37	0.7
Pyrene	0/19				1/3		2	16	2/37(B)	1
Butylbenzylphthalate	2/19	0.2	0.4	6D	0/3				4/37(B)	0.3
3,3'-Dichlorobenzidine	0/19				0/3				1/37	
Benzo(a)anthracene	0/19				0/3				2/37	0.8
Chrysene	0/19				0/3				2/37	1
bis(2-Ethylhexyl)phthalate	18/19(B)	2	33	6S	3/3(B)	9	24	16	37/37(B)	2
Di-n-octylphthalate	4/19	0.3	4	5M	1/3		0.6	19	8/37(B)	0.3
Benzo(b)fluoranthene	0/19				0/3				2/37(B)	0.6
Benzo(k)fluoranthene	0/19				0/3				1/37(B)	
Benzo(a)pyrene	0/19				0/3				2/37(B)	0.7
Indeno(1,2,3-cd)pyrene	0/19				0/3				1/37(B)	
PESTICIDES (μg/L)										
delta-BHC	0/19				0/3				1/37	
Endosulfan 1	0/19				0/3				1/37	
Dieldrin	0/19				1/3		0.01	16	0/37	
4,4'-DDE	0/19				1/3		0.19	16	0/37	
4,4'-DDD	0/19				1/3		0.35	16	0/37	
4,4'-DDT	0/19				1/3		0.03	16	0/37	
alpha-Chlordane	0/19				1/3		0.06	16	0/37	
gamma-Chlordane	0/19				1/3		0.05	16	0/37	
gamma-BHC	0/19				0/3				0/37	
Heptachlor	0/19				0/3				0/37	
Aldrin	0/19				0/3				0/37	
Heptachlor Epoxide	0/19				0/3				0/37	
Endrin	0/19				0/3				0/37	

Notes:
FREQ = Frequency of analyte detected above sample detection limits
LOW = Lowest concentration detected in each sampling category
HIGH = Highest concentration detected in each sampling category
MW,RESIDENCE,STAT# = Sample location where highest concentration of analyte was detected
(B) = Flag indicates analyte was detected in method blanks for one or more of the samples

LS		GROUND WATER RESIDENTIAL WELLS				SURFACE WATER MATHEW CREEK				SURFACE WATER LaGRANGE PIT		
HIGH	MW	FREQ	LOW	HIGH	RESIDENCE	FREQ	LOW	HIGH	STAT#	FREQ	LOW	HIGH
		0/39				0/8				1/1		41
		0/39				0/8				1/1		4
		0/39				0/8				0/1		
4	3S	0/39				0/8				1/1		10
4	15S,9	0/39				0/8				1/1		190
		0/39				0/8				0/1		
		0/39				0/8				0/1		
.4	2S	0/39				0/8				0/1		
6	11D	1/39		2	Forester	7/8(B)	0.4	1	#1,3	1/1(B)		21
4	11D	0/39				0/8				0/1		
3	11D	0/39				0/8				0/1		
[illegible]	11D	0/39				0/8				0/1		
1	11D	6/39(B)	0.8	2	Forester	5/8(B)	0.4	0.7	#4	1/1(B)		2
7	11D	0/39				0/8				0/1		
7	11D	0/39				0/8				0/1		
7	11D	0/39				0/8				1/1		0.2
7	11D	0/39				0/8				0/1		
4	11D	0/39				0/8				0/1		
2	11D	0/39				0/8				0/1		
150	3D	34/39(B)	2	66	Palmateer	7/8(B)	0.7	16	#1	1/1(B)		9
8	11D	5/39	3	16	Paul	0/8				1/1		0.2
5	11D	0/39				0/8				0/1		
0.8	15S	0/39				0/8				0/1		
4	11D	0/39				0/8				0/1		
	11D	0/39				0/8				0/1		
0.04	9S	0/39				0/8				0/1		
0.05	11D	0/39				0/8				0/1		
		0/39				0/8				0/1		
		0/39				0/8				0/1		
		0/39				0/8				0/1		
		0/39				0/8				0/1		
		0/39				0/8				0/1		
		0/39				0/8				0/1		
		0/39				0/8				0/1		
		0/39				0/8				0/1		
		0/39				0/8				0/1		
		0/39				0/8				0/1		
		0/39				0/8				0/1		

UPGRADIENT WELLS : CLUSTER MWs 5,6,7,13,14

DOWNGRADIENT WELLS : CLUSTER MWs 1,2,3,4,8,9,10,11,12,15

LANDFILL WELLS : MWs 16,18,19

Table 1-6 : Nature and Source of Contaminants Profile
TCL Semi-Volatile Organics and Pesticides
Soil and Sediment Samples
Johnstown Landfill, Johnstown, New York

	SOIL BORINGS LANDFILL WELLS				SEDIMENT SAMPLES MATHEW CREEK ROUND 1		
Parameter	FREQ	LOW	HIGH	MW	FREQ	LOW	HIG
SVOC's (µg/Kg)							
Acenaphthene	0/3				0/3		
Dibenzofuran	0/3				0/3		
Fluorene	0/3				0/3		
Acenaphthylene	0/3				0/3		
Benzoic acid	2/3	120	380	16	6/8	32	4,5
Naphthalene	1/3		410	16	0/3		
2-Methylnaphthalene	0/3				0/3		
Dimethylphthalate	0/3				0/3		
Diethylphthalate	1/3		700	16	2/8	80	82
N-Nitrosodiphenylamine(1)	0/3				0/3		
Phenanthrene	0/3				2/8(B)	31	160
Anthracene	0/3				0/3		
Di-n-butylphthalate	1/3		760	16	1/8(B)		67
Fluoranthene	0/3				3/8(B)	40	370
Pyrene	0/3				4/8(B)	21	210
Butylbenzylphthalate	1/3		700	17	0/8		
3,3'-Dichlorobenzidine	0/3				0/8		
Benzo(a)anthracene	0/3				1/8(B)		170
Chrysene	0/3				1/8(B)		17
bis(2-Ethylhexyl)phthalate	3/3(B)	400	1,100	18	8/8(B)	44	18
Di-n-octylphthalate	1/3		42	16	1/8		15
Benzo(b)fluoranthene	0/3				2/8(B)	16	15
Benzo(k)fluoranthene	0/3				0/8		
Benzo(a)pyrene	0/3				1/8		15
Indeno(1,2,3-cd)pyrene	0/3				1/8		8
Benzo(g,h,i)perylene	0/3				0/8		
Isophorone	0/3				0/8		
PESTICIDES (µg/Kg)							
gamma-BHC	1/3		4.1	18	0/8		
delta-BHC	1/3		4.5	18	1/8		13
Endosulfan 1	1/3		14	18	0/8		
Dieldrin	1/3		17	18	0/8		
4,4'-DDE	2/3	11	25	16	4/8	2.1	9.8
4,4'-DDD	1/3		37	16	0/8		
4,4'-DDT	2/3	14	18	16	0/8		
alpha-Chlordane	0/3				0/8		
gamma-Chlordane	0/3				0/8		
Heptachlor	1/3		4.4	18	0/8		
Aldrin	1/3		5.8	18	0/8		
Heptachlor Epoxide	1/3		14	18	0/8		
Endrin	1/3		21	18	0/8		

Notes:
FREQ = Frequency of analyte detected above sample detection limits
LOW = Lowest concentration detected in each sampling category
HIGH = Highest concentration detected in each sampling category
MW,STAT# = Sample location where highest concentration of analyte was detected

		SEDIMENT SAMPLES MATHEW CREEK ROUND 2				SEDIMENT SAMPLES LaGRANGE PIT ROUNDS 1 & 2		
GH	STAT	FREQ	LOW	HIGH	STAT	FREQ	LOW	HIGH
		0/3				1/2		44
		0/3				1/2		48
		0/3				2/2	15	91
		1/8		12	#4,6–12	2/2	11	42
00	#1,0–6	7/8	28	480	#1,6–12	0/2		
		1/8		15	#4,6–12	2/2	170	1,400
		1/8		9	#4,6–12	2/2	40	320
		1/8		18	#3,OUT	0/2		
	#4,6–12	6/8(B)	19	58	#1,0–6	2/2(B)	52	71
		0/3				0/2		
	#1,0–6	4/8	37	220	#4,6–12	2/2	56	170
		3/8	20	51	#4,6–12	2/2	16	51
	#4,6–12	8/8(B)	23	90	#1,0–6	1/2(B)		41
	#1,0–6	8/8	16	260	#4,6–12	2/2	69	150
	#1,0–6	6/8(B)	16	210	#4,6–12	2/2	71	150
		3/8(B)	9	35	#3,IN	0/2		
		0/8				0/2		
	#1,0–6	4/8	22	93	#4,6–12	2/2	46	84
0	#1,0–6	4/8	22	110	#4,6–12	2/2	45	99
0	#4,6–12	8/8(B)	69	140	#3,IN	2/2(B)	430	850
5	#4,6–12	8/8	12	190	#3,IN	2/2(B)	45	270
0	#1,0–6	3/8	48	75	#4,0–6	2/2	43	240
		2/8	56	59	#3,OUT	1/2		160
	#4,6–12	3/8	48	70	#4,6–12	1/2		43
	#4,6–12	0/8				0/2		
		1/8		4	#4,6–12	0/2		
		2/8	7	8	#3,OUT	0/2		
		0/8				0/2		
	#3,IN	0/8				0/2		
		0/8				0/2		
		0/8				0/2		
	#1,0–6	4/8	2.5	12	#1,0–6	2/2	38	170
		0/8				2/2	13	69
		0/8				0/2		
		0/8				0/2		
		0/8				0/2		
		0/8				1/2		3.7
		0/8				1/2		1.8
		0/8				0/2		
		0/8				0/2		

UPGRADIENT BORING : MWs 5,6,7,13,14
DOWNGRADIENT BORING : MWs 1,2,3,4,8,9,10,11,12
LANDFILL BORING : MWs 16,17,18
(B) = Flag indicates analyte was detected in method blanks for one or more of the samples

2.0 IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

This chapter will discuss the development of the remedial action objectives (RAOs) and the general response actions that may be required to meet the RAOs. The selected objectives and actions will then be used for an initial screening of the available technologies and options. This initial screening shall eliminate those options that cannot be implemented for physical or technical reasons, or would not be useful for meeting the RAOs.

2.1 Remedial Action Objectives

2.1.1 Contaminants and Media of Interest

For a mixed waste disposal site such as the Johnstown Landfill, the list of objectives of a remediation project is varied. The remedial action objectives for the site are displayed in Table 2.1. For the waste disposal area itself, solid waste, ground water, and subsurface gas objectives apply. The LaGrange Gravel Pit in the southeast corner of the site is considered to be on-site. On-site contaminants of concern include the full range of leachate parameters due to the heterogeneous nature of the wastes. Off-site parameters of concern are primarily metals dissolved in ground water and surface water or contained in the stream sediments, specifically ammonia, iron, manganese, trivalent chromium, and lead. Several volatile organic compounds have been inconsistently detected in the ground water and are considered in the review of treatment options at this time to correspond with the Risk

TABLE 2.1

REMEDIAL ACTION OBJECTIVES
JOHNSTOWN LANDFILL

MEDIA OF CONCERN	REMEDIAL ACTION OBJECTIVES
Solid Waste On-site Soils Sediments	• Prevent exposure to solid waste by humans or potential vectors. • Prevent erosion of contaminated soil through surface water runoff. • Prevent the generation of leachate to comply with ARAR. If not feasible to completely eliminate leachate generation, control discharge to minimize impact on human health and the environment. • Prevent exposure to on-site soils and sediments by humans or wildlife.
Ground Water	• Prevent ingestion of ground water containing contaminants in excess of ARARs. • Restore ground water aquifer to contaminant levels which do not exceed ARARs, or if not feasible, to restore ground water to background contaminant levels.
Subsurface Gas	• Control generation and prevent migration of subsurface gas in a manner that meets ARARs. • Prevent migration of gas into nearby residences.

Assessment that also included these parameters. The only volatile organic compound that has been consistently detected at high levels is acetone. This compound has been consistently detected in the upgradient bedrock well 7D, at higher levels than it has been detected in the landfill or the downgradient bedrock wells. Since it is unclear what the source of this contamination is, options for treatment of the acetone are also considered.

2.1.2 Allowable Exposure Based on ARARs

The following potential ARARs have established concentrations for the contaminants of concern in the ground water. These standards or criteria are for drinking water or are for ground water or surface water discharges.

1. Federal Water Quality Criteria (Quality Criteria for Water 1986, EPA 440/5-86-001, May 1 1986)

2. Resource Conservation and Recovery Act, Maximum Contaminant Levels 40 CFR 264 Subpart F

3. Safe Drinking Water Act Maximum Contaminant Levels (40 CFR 141.11-16)

4. Safe Drinking Water Act Maximum Contaminant Level Goals, 40 CFR 141.50

5. New York State Pollution Discharge Elimination System Regulations; 6 NYCRR 750 et seq.

6. Ambient Water Quality Standards and Guidance; Technical and Operations Guidance Series (TOGS) 1.1.1, April 1, 1987

7. Surface Water and Ground Water Classifications and Standards; NYCRR Title 6, Chapter X, Parts 700-705

8. New York State Department of Health; Bureau of Public Water Supply; Standards Limiting Organic Contamination in Drinking Water, 1988

9. NYSDOH Chapter 1 State Sanitary Code, Part 5, Subpart 5-1

The ARARs above are further discussed later.

2.2 General Response Actions

2.2.1 Criteria for Initial Screening of General Response Technologies

Several general response actions and associated technologies are potentially applicable to the Johnstown Landfill Site. The technologies and process options shall be screened based upon their ability to address the RAOs, and their ability to protect public health and the environment. The feasible technologies and process options shall be combined to develop the remedial alternatives for the site.

2.2.2 Identification of General Response Actions

Based upon the RAOs, site conditions, and waste characteristics, potential general response actions were developed and preliminarily screened. Table 2.2 lists the general response actions, and the technologies and processes appropriate for each action in each media.

TABLE 2.2

GENERAL RESPONSE ACTIONS
AND ASSOCIATED TECHNOLOGIES AND PROCESSES

GENERAL RESPONSE ACTION	TECHNOLOGY OR PROCESS	MEDIA
NO ACTION	PUBLIC AWARENESS MONITORING	ALL SURFACE WATER/GROUND WATER
LIMITED ACTION	RESTRICTED ACCESS SITE SECURITY SITE MONITORING ALTERNATIVE WATER SUPPLY REGRADE	ALL ALL ALL GROUND WATER SOILS
CONTAINMENT	IMPERMEABLE CAP VERTICAL BARRIER WELLS OR TRENCHES	SOILS/SEDIMENTS/SURFACE & GROUND WATER GROUND WATER GROUND WATER
REMOVAL	EXCAVATE & DISPOSE OFF SITE EXCAVATE & TREAT IN SITU TREATMENTS COLLECT AND TREAT VENTING	PIT AND CREEK SEDIMENTS/LANDFILL SOILS PIT AND CREEKSEDIMENTS/LANDFILL SOILS SOILS GROUND WATER/GAS GAS
RESIDENTIAL WATER SUPPLY	POINT-OF-USE TREATMENT REPLACEMENT WELLS COMMUNITY SYSTEM BOTTLED WATER CITY WATER	GROUND WATER

These technologies and options will be further refined and screened in the next section.

2.3 Identification and Screening of Technology Types and Processes

2.3.1 Identification and Screening of Technologies

The FS process consists of identifying the applicable categories of remedial technologies associated with each response action. The feasibility of determining the RAOs using these technologies will then be established.

The screening of remedial technologies is based upon the RAOs, site specific conditions, waste characteristics, and the extent of contamination. Waste characteristics include physical properties (e.g., volatility, solubility etc.), specific chemical constituents, and properties that affect the performance of the technology. Site characteristics gathered during the RI are reviewed to determine any limiting or favorable conditions for specific options. Technologies whose use is clearly precluded by waste or site characteristics are eliminated from further consideration.

In order to develop treatment schemes and evaluate various technologies, a compilation of the compounds that require treatment, their influent and allowable effluent levels must be determined. Table 2.3 lists the influent levels based upon the highest concentration reported in downgradient wells as defined in the RI, levels based upon the lowest level reported in the wells to the north and west of the landfill from the RI, and the appropriate discharge standard from the ARARs.

Table 2.3 is followed by descriptions and initial screenings of the general response actions and the appropriate technologies and process options. This initial screening will be summarized in Table 2.4.

2.3.1.1. <u>No Action</u>. The no action alternative would provide no remediation of the landfill. The activities that would take place would be a public awareness program, and continued site monitoring.

<u>Initial Screening</u>. This option is required to be included as a baseline for comparison to other alternatives. The public awareness program and monitoring program will be required for any final alternative, but will not provide any remediation or meet the ARARs.

2.3.1.2 <u>Limited Actions</u>. Limited actions include site access control by fencing, deed restrictions, alternative water supplies, continued site monitoring and regrading.

<u>Initial Screening</u>. Security fencing and deed use restrictions would prevent access to the hazardous materials on site by the public and prevent future uses that may pose a threat to the public. This would be a useful part of any remediation plan, but provides no actual cleanup. Alternative water supplies such as bottled water, replacement wells, provision of city water, or point of use treatment would be useful if landfill contaminants are detected in any private

TABLE 2.3

JOHNSTOWN LANDFILL SITE
GROUND WATER TREATMENT PARAMETERS

CONTAMINANT	INFLUENT CONCENTRATION μg/L	BACKGROUND CONCENTRATION μg/L	DISCHARGE GOAL μg/L
Iron	202,000[4]	8,240	300[1]
Manganese	57,300[4]	273	300[1]
Ammonia	59,600[4]	LTS	2.1[2]
Lead	135[4]	LTS	10[2]
Chrome	229[4]	LTS	50[1]
Acetone	1,700[5]	2,900	50[3]
Toluene	62[4]	LTS	5[3]

LTS = Less than Standard

[1] 6NYCRR Parts 700-705, Class A Surface Water Standard. Health (Water Supply) Standard.

[2] 6NYCRR Parts 700-705, Class A Surface Water Standard Aquatic Life Standard, based on Water Quality reported for LaGrange Springs.

[3] 10NYCRR Subpart S-1 NYSDOH Drinking Water Standard.

[4] Influent concentration derived from maximum concentration detected at any downgradient overburden well at any sampling event.

[5] Influent concentration derived from maximum concentration detected at any downgradient well during any sampling event.

water supplies. Regrading would prevent the ponding presently occurring on site, protect the public from coming into direct contact with the buried wastes, and prevent leachate seeps.

This action would not meet the ARARs, but would be a necessary precursor to any further action. This option is retained for further analysis.

2.3.1.3 Containment. There are three basic technologies used for containing the wastes on site; placement of an impermeable cap, placement of interception wells or trenches, or a vertical barrier.

A. Impermeable Cap. Further reduction in leachate production can be achieved by the use of an impermeable cap. In general, these capping systems consist of a gas vent layer, an impermeable layer typically either a geosynthetic or clay, a protective soil layer that also acts as a drainage layer, and a topsoil layer to support vegetation.

Initial Screening. Typical caps of this type can reduce the leachate generation by over 90 percent, and are a requirement of the New York State regulations 6 NYCRR Part 360 and RCRA regulations (40 CFR 264.110-264.120) for hazardous waste facilities. Therefore, this option will be given a detailed analysis.

B. Vertical Barriers. One method of containing the contaminated ground water on the site is to construct a slurry wall partially or completely around the site. A partial wall upgradient of the site could be used to divert ground water from entering the site. Along with an impermeable cap, the rate of shallow ground water flow could be severely reduced. A partial wall downgradient could be used as a containment mechanism for shallow ground water combined with ground water pumping and treatment. A fully encapsulating wall could be used to minimize the leachate production from the site. Cutoff walls can be constructed of soil bentonite, cement bentonite, sheet piles, or grouts. Cutoff walls are most effective for containing ground water moving in the upper aquifer, as opposed to contaminants in a deep bedrock aquifer. Effectiveness of the barrier is a function of how well the barrier can be keyed into an impermeable layer such as the deeper tills or bedrock.

Initial Screening. An upgradient or fully encapsulating wall would require easements, or purchasing of some adjacent property. Since the ground water level is below the landfilled wastes, an upgradient barrier would not change the production of leachate caused by percolation. Therefore, this option will not be discussed further. A downgradient wall may be useful to prevent the collection of ground water that has not been contaminated by leachate or aid the interception of contaminated ground water depending upon its location. Therefore, this option will be analyzed as part of the removal General Response Action analysis for ground water.

C. Wells or Trenches. Wells or trenches can be used in the same manner as a vertical barrier. Upgradient wells or trenches would intercept and convey ground water causing it to bypass the landfill. Downgradient wells or trenches would collect any water passing under the landfill that has been contaminated by leachate, and would have to be treated before discharge.

Initial Screening. Upgradient trenches have the same easement and structure problems that vertical barriers do. Given that the landfilled material does not intercept the ground water table, it does not appear likely that reducing the clean water flowing below the site would effectively reduce the movement of contaminants from the site. Therefore, this option will not be discussed further. The use of downgradient wells or trenches will be more fully discussed under the removal section.

2.3.1.4 Removal. Removal options are the ultimate source control in that the contaminants of concerned are removed from the site either physically or by chemical transformation. Removal options for soils include excavation and removal or treatment, and in situ treatment options such as bioremediation, soil flushing, and vacuum extraction. Options for ground water are broken into three phases collection (wells or trenches): treatment (physical, chemical, or biological), and discharge (POTW, surface water, ground water). While all three phases are requirements for any ground water removal scheme, they will be analyzed separately. Landfill gas removal options include venting, collection and treatment, and collection and utilization.

A. Excavation. Remediation options for the handling of the on-site materials that include excavation as one of the steps pose potential risks in that the majority of the wastes at the landfill are too heterogeneous to fully characterize. Significant health risks could be posed to the personnel involved in the excavation work and possibly to the general public if fugitive emissions were released from the excavation processes. However, the advantage of excavation is that it would allow a more detailed characterization of the materials on site, and would allow for the destruction and/or removal of any potentially hazardous materials.

The Remedial Investigation detected sediment concentrations of arsenic, cadmium, chromium, copper, manganese, mercury, nickel, lead and zinc above the Lowest Observable Effects Levels (LOEL) of the NYSDEC Sediment Criteria Guidance Values. Only manganese in sediment from Mathew Creek exceeded the Limit of Tolerance (LOT) value. Excavation of stream sediments would allow a more detailed characterization of these contaminants and their distribution and allow for their removal from the aquatic system. Sediments could be excavated using equipment such as backhoes, front end loaders, clamshells, draglines, hydraulic shovels, and cutterhead hydraulic or vacuum dredges.

Initial Screenings.

A.1. Off-Site Disposal of Landfilled Waste. One remediation option is to excavate the disposed materials and to dispose of them at a proper facility. This option is appropriate where the wastes are well defined and relatively homogeneous. Facilities for the proper disposal of the buried tires, abandoned tanks, and some of the construction debris could be found. Disposal of the less well characterized municipal wastes, which contains widely scattered sludges, tannery wastes, hides, and possibly other hazardous materials would be more difficult. The problem of safe transport of the material excavated would also have to be addressed, since a spill of hazardous materials would probably pose a more immediate health risk to the general public than the handling of the materials on-site. The high costs associated with excavation, sampling transport and disposal of the large volume of these wastes at a RCRA facility render the off-site disposal option inappropriate. With the exception of the handling the sediments at LaGrange Pit, this option will not be further analyzed.

Off-site Disposal of Stream Sediments. The LOEL values are generally based on bioassay results using the most sensitive test species. These levels cannot be generally applied to other aquatic (or terrestrial) organisms. Although exceedance of LOEL values may suggest some sublethal effects to the most sensitive aquatic species they do not suggest that the entire aquatic community and especially, more tolerant, higher order organisms, are being affected. Manganese, a naturally occurring abundant metal, exceeded the LOT only 5 times out of 31 samples from Mathew Creek with 3 of these exceedances occurring in samples collected near LaGrange Springs.

Lowest observed effect levels (LOELs) are determined from the results of laboratory chronic and subacute toxicity tests of one or a few lab animal species, usually "sensitive" species. An uncertainty factor (ranging from 0.1 to 1.0) is used to adjust the laboratory-based LOELs to compensate for the unknown ranges of inter- and intra-specific sensitivities.

This results in a new, estimated, lower value called the no observable effect level (NOEL).

The USEPA recommended, in their Health Effects Assessment Guidelines (EPA 1980 cited in Newell et al., 1987), that a higher value uncertainty factor be used for severe effects (such as liver cell necrosis). Lower uncertainty factors are suggested for less severe effects such as fatty infiltration of the liver. In NYSDEC's Fish Flesh Criteria for Piscivorous Wildlife (Newell et al., 1987) an uncertainty factor of 0.2 was used to convert LOEL to NOEL.

The limit of tolerance level is defined as the concentration which would be detrimental to the majority of species, potentially eliminating most (NYSDEC, 1989). This threshold value is derived from analysis of field data, examining the correlation between benthic communities and metals concentrations (Arthur Newell, NYSDEC, personal communication).

It is difficult to accurately predict the effects of site contaminants on an ecosystem from laboratory studies on a few species. Different species and individuals within a species vary in their tolerance to contaminants. Many factors in the ecosystem (such as organic carbon content of the sediments, pH of the water, etc.) affect the bioavailability of contaminants to organisms. Laboratory toxicity studies and field studies that examine the correlations between contaminants and aquatic community parameters (species composition, population sizes, etc.) can be used, but predictions must be interpreted cautiously. Cause-effect relationships are difficult to prove. Criteria such as LOELS, NOELS, and LOTS are used by

NYSDEC as guidelines based on information available from laboratory and field studies.

Excavation of the stream sediments will cause excessive siltation, mobilization of the sediments that are buried, significant streambed alterations and major impacts to aquatic life. Siltation and mobilization of the sediments can be reduced by dewatering the excavated area and diverting the stream. The dewatering flows would require treatment prior to their discharge into Mathew Creek downstream of the excavation. Both the treatment equipment and the area required for the stream channel diversion would cause significant impacts to the wetlands adjacent to the creek. Further wetlands impacts could be expected related to providing heavy equipment access to and along the creek channel.

Because a significant risk from the sediments is not apparent, excavation is not warranted. This option will not be analyzed further for the stream sediments.

A.2 Excavate, Treat, and Replace Landfilled Waste. There are a number of treatment options for contaminated soils that have been excavated, but do not require the removal of the soils from the site. Treatment options include soil washing, soil incineration, chemical fixation, vitrification, and bioremediation. Each of these options have advantages and disadvantages depending upon the contaminants to be remediated. However, the heterogenous nature of the site would make selection of an appropriate technology difficult. Furthermore, the amount of material that would require handling (over 1.6 million cubic yards), thereby incurring costs and creating the safety hazards described above, is too large for this to be a cost effective option. This option will not be analyzed further.

Excavate, Treat and Replace Stream Sediments. The excavation step of this remedial option poses significant impacts to the aquatic environment as described in A.1. This option will not be considered further for the stream sediments.

B. In Situ Treatment of Landfilled Waste. A number of technologies are available to treat or contain wastes in situ. The primary advantage of in situ treatment is the costs for excavating and handling the waste materials are greatly reduced if not eliminated. However, monitoring the systems for optimal treatment is more difficult in situ, particularly for a heterogenous waste typical of landfill sites.

B.1 Soil Flushing. Soil flushing consists of the addition of a solvent or surfactant to the contaminated soil in order to mobilize the contaminant. The contaminant would then be removed by some form of ground water collection system and treated.

<u>Initial Screening</u>. This method will permanently remove the contaminant from the site, but creates a more contaminated ground water that must be contained and treated to remove the mobilized contaminant and the flushing agent. Removal of the contaminants from the soil is difficult to monitor, making determination of the time required for treatment difficult to estimate. Furthermore, heterogeneities

in the soil may create pockets where the flushing agent does not enter, thereby leaving some contaminants in place. Costs will be difficult to estimate as they will be dependant upon the flushing agent, the contaminants flushed, and the treatment thereby required. Therefore, since the effectiveness and costs of the method cannot be evaluated without further studies, this option will not be further evaluated in the FS.

B.2 Bioremediation. Many contaminants can be treated biologically, if the conditions are correct. Typical subsurface environmental parameters that can be altered to improve bioremediation include, water content, oxygen content, nutrients, and pH. Under aerobic conditions non-chlorinated organics can be effectively destroyed by biologic activity. Chlorinated hydrocarbons are best remediated in anaerobic environments.

Initial Screening. The difficulties in monitoring degradation are the same as the soil flushing option. Also the potential exists for partial degradation to a more mobile contaminant, rather than complete destruction. Pilot studies would be required to determine the requirements for adding oxygen and other parameters, both in quantities and for the delivery system. Because of the unknowns of effectiveness and cost this option will not be further evaluated in this FS.

B.3 Vacuum Extraction. Highly volatile contaminants can be removed from the site in the vapor phase by forced air extraction. If the soil is permeable enough, contaminated air can be removed from the soils and be replaced with clean air. Volatile contaminants would desorb into the gaseous phase and be removed. The extracted air would probably have to be treated, and the difficulties with monitoring and heterogeneities remain. This process can also be used with bioremediation in some cases as a means of delivering oxygen, some moisture, and some nutrients.

Initial Screening. As in bioremediation, this option will require pilot studies to determine costs and effectiveness. Furthermore, the principal contaminants of concern are metals that are not volatile and thereby amenable to treatment by vacuum extraction. Therefore, this option will not be further analyzed in the FS.

C. Ground Water Collection

C.1 Vertical Wells. A system of vertical wells may be used to collect water from any depth for collection and treatment.

Initial Screening. This technology is readily available and well understood. It is energy intensive, particularly if ground water is to be intercepted over a large lateral area, and in relatively impermeable soils. Vertical wells can be installed within unconsolidated overburden deposits and within bedrock. However, these wells are much more effective interceptors of ground water flow in more permeable deposits than impermeable deposits. This is because the effective capture radius (radius of drawdown) can be generally greater in zones of higher permeability than in lower permeability zones. The effectiveness of interception wells in low permeability bedrock such as the shale beneath the site, is lessened because of the highly variable location of ground water transmitting fractures or fracture zones. These bedrock fractures can be detected in some cases through geophysical or aerial photograph interpretation techniques. Unfortunately the overburden thickness and lack of bedrock outcrops preclude any effective siting of the interception wells in bedrock fractures at this site.

Review of the well development and purging operations (RI Sections 2.5.5 and 2.5.6) indicate that bedrock wells MW-1D, 3D, and 7D went dry and had poor recovery rates that necessitated collection of small volume ground water quality samples over a several day period. In contrast, bedrock well MW-2D recovered slowly but sufficiently to allow normal purging and sampling procedures to be followed. These differing bedrock well responses to development and purging are indicative of the highly variable permeability caused by the variable fracture locations. Slug tests indicate that the hydraulic conductivity of the bedrock and overburden deposits underlying the site range from 4.5 to 307 ft/day. Pump tests yielded permeabilities up to 1056 ft/day in the overburden and estimated values of 192 ft/day in the bedrock. The approximately 40 fold range between the 4.5 and 192 ft/day hydraulic conductivity values further attest to the highly heterogeneous nature of the bedrock beneath the site.

Because of the bedrock fracture heterogeneity, it is impossible to be certain that bedrock transport of contaminants has been effectively intercepted. Bedrock monitoring of interception effectiveness is uncertain at best because it is impossible to verify that no pollutant transmitting fractures have been missed. Due to the great expense and uncertain effectiveness of interception and monitoring, ground water interception in bedrock is dropped from further review. This option applied to the overburden deposits is retained for further analysis.

C.2 Drains or Trenches. Drains and trenches can be used to collect for treatment any contaminated ground water existing in shallow water tables. Trenches can be readily constructed to a depth of 25 feet with a maximum depth of about 40 feet. Vertical barriers can be used to reduce the amount of water removed by the drains.

<u>Initial Screening</u>. Trenches have the advantage over wells in that they can collect ground water completely over a linear area (up to the depth of the trench) with a minimum of pumping, and can be particularly cost effective in low permeability soils, where large numbers of vertical wells would have to be spaced close together to create a hydraulic barrier. This technology applied to the overburden deposits will be kept for further evaluation.

C.3 Horizontal Wells. Using technology from the petroleum and/or utility industry, it is possible to drill and install a horizontal well, as an alternative to drains and trenches. This technology can be used to place wells directly under the landfill in order to collect ground water as close to the contamination source as possible. The technology could also be used to assist in vacuum extraction, bioremediation, and soil flushing operations.

Initial Screening. The primary disadvantage to horizontal well drilling is its relative newness as a technology, cost, and the unknowns related to effective construction. Horizontal wells can be constructed over 500 feet in length and at depths up to 500 feet. This option does not appear to provide any advantages over trenches for the Johnstown Landfill, and therefore will not be further evaluated in this FS.

C.4 Vertical Barriers. Vertical barriers such as grout walls and/or soil bentonite slurries, may be useful to improve the collection efficiency of any ground water collection system.

Initial Screening. Cut off walls would require extensive excavation and installation of impermeable materials such as soil bentonite, and would be difficult to monitor their effectiveness particularly at the soil/bedrock interface. Furthermore, plans for handling the ground water if the collection system is shut down for temporary maintenance, or as part of the operating plan, would have to be devised, such that the cut off wall would not cause ground water seeps to be created at the surface. Therefore, due to cost, operational difficulties, and the limited improvement in collection efficiency that is anticipated, cutoff walls will not be further evaluated.

D. Ground Water Treatment. Any ground water removed will have to be treated and disposed. For disposal to the sanitary sewer the contaminants of concern, (metals and ammonia), must be removed in compliance with the local sewer use ordinance before being disposed of in the sewer, thereby reducing the need for any further treatment. The other disposal options, (ground water or surface water) will also have discharge limitations that must be met. This section will quickly review available treatment technologies.

D.1. Neutralization. Neutralization is the process of adjusting the pH of the ground water, either for process enhancement, or to meet discharge limitations. The process typically requires the addition of a base such as lime, calcium hydroxide, caustic, or soda ash to raise pH; or the addition of an acid such as sulfuric, hydrochloric, or nitric acid to lower the pH. This operation is typically achieved in a mixing tank and can be operated in a batch or continuous flow mode as required. Chemical handling and byproduct reactions can be a concern for this process.

Initial Screening. Neutralization is a common and well understood treatment process, and a necessary precursor to many treatment methods. Therefore, it is retained for further evaluation.

D.2. Precipitation. Soluble metals are typically removed by adjusting the pH of the water, to promote the formation of a precipitate. The specific form of the dissolved metal influences the solubility of the metal. Therefore, precipitants are chosen to allow for the best removal of the metal, often in a hydroxide, sulfate, or carbonate form. The precipitants are added in a mixing tank as described in the neutralization process. Often flocculating agents are also added at the same time. The next step is a gentle mixing, to allow the particles to form. This process is called flocculation and is often done in a separate tank. The final step of the process is settling where the water is left in a quiescent state to allow the flocculent particles to settle to the bottom of the tank where it can be removed as sludge. Again this can be done in a separate tank. Chemical handling, sludge disposal and byproduct reactions can be of concern for this process.

Heavy metals are easily removed from solution in this manner. Each metal, however, has a specific pH value where it exhibits minimal solubility, and maximum ability to form an insoluble precipitate, and for removal from solution. For solutions containing a mixture of heavy metals, selection of the optimum pH and precipitant to be used is a function of best overall reduction of metals in solution and the effluent targets desired for each separate metal. In these instances some compromises are made in order to reach the best effluent.

Initial Screening. Precipitation processes are commonly used for metals removal and well understood. Therefore, this option is retained for further evaluation.

D.3. Flotation. Some contaminants can be removed from water by flotation. The simplest process is the removal of contaminants that are immiscible in water and have a specific gravity less than 1.0, such as many oils. These can be separated in a process similar to sedimentation except that the contaminant floats to the top and is skimmed off. Dissolved air flotation (DAF) involves the bubbling of air through the water. The air bubbles attach to particles, and if the combined specific gravity is less than 1.0, the particle floats and is skimmed off. DAF would typically be used for flocculated particles with a specific gravity too close to unity to quickly float or settle.

Initial Screening. Flotation is typically only appropriate with wastes and sludges anticipated to have a specific gravity less than 1.0. Metals sludges are not typically in this range, therefore, this option will not be further evaluated.

D.4. Oxidation/Reduction. The chemical state a contaminant is in can effect its ability to be removed by precipitation, ion exchange, biological processes, etcetera. Oxidation/reduction are the typical processes by which the chemical state is changed to a form more suitable for treatment. The process flow is similar to that of the precipitation process in that chemicals are added in a rapid mix tank and are allowed to react. Typical oxidizing agents include oxygen, ozone, hydrogen peroxide, chlorine, calcium and sodium hypochlorite, chlorine dioxide, and potassium permanganate. The process can also be enhanced by the use of ultraviolet light or a catalyst. Typical reducing agents include sulfur dioxide, sodium sulfites, and sodium borohydrate. Chemical handling, sludge disposal and byproduct reactions can be of concern for this process.

Initial Screening. Chemical oxidation and reductions processes are reasonably common and well understood. However, the effects of interfering or byproduct reactions are common problems with complex waters as would be expected from the Johnstown Landfill. However, since the ground water is very high in iron and manganese, these processes may be needed to remove these metals, prior to the removal of other contaminants. Therefore, this option shall be kept.

D.5. Air or Steam Stripping. Volatile contaminants can be transferred from the ground water into air or steam by the process of stripping. Typical stripping devices include diffused aerators, mechanical surface aerators, coke tray aerators, spray towers, and packed towers; with countercurrent packed towers being the most common method. Primary design concerns are the volatility of the contaminants and the handling and treatment of the off gases.

Initial Screening. Air or Steam Stripping are not effective for the removal of metals, with the exception of their use as an oxidation process typically for iron and manganese removal. A side benefit of this process is aeration removes VOCs. This process will be kept primarily as a pretreatment option for iron and manganese and for VOC removal.

D.6. Filtration. Filtration occurs whenever water passes through a porous medium media such as sand. Contaminants can either be captured if they are too large to pass through the media (straining), or are attracted to the media in a manner that allows attachment of the contaminant to the media (adsorption). Other processes that can occur in the media include flocculation and sedimentation which can change the contaminants form to improve straining or adsorption. A wide variety of media are used in filtration including sand,

and anthracite coal. Filtration can be upflow, downflow, rapid, slow, or even pressurized. Choice of filter method is highly specific to the contaminant, process, and desired level of removal. Filters are maintained through backwashing the media to remove entrained materials and restor filtering capability. The backwash water is handled as a waste product, or treated prior to disposal.

Initial Screening. Filtration is a well understood process for the removal of small amounts of solids. This may be appropriate for the Johnstown Landfill as a finishing step. Therefore, this process will be evaluated further.

D.7. Adsorption. Adsorption is a process similar in configuration to filtration. Adsorption processes rely on the ability of a specific material (adsorbent) to attract and retain the compound or contaminant to be removed (adsorbate). The attraction is the result of Van de Waal's forces (affinity) exerted by one molecule for another. Adsorbents may be matched to the specific compound or contaminant based on their relative affinities. Activated carbon, because of its unique properties, is an adsorbent with affinities for a wide range of compounds, and is commonly used as the adsorbent in pollution treatment systems. Activated carbon is a good adsorbent due to its micropore structure (high specific area) which allows more of its molecules to come in contact with the solution, and provide more adsorption sites because of its surface area. Various types of techniques for carbon adsorption include small canister, fixed bed, expanded bed, and moving beds, with the fixed bed and canister types being the most common. The carbon filters can be equipped to allow backwashing, however, it is more common to use carbon on waters that will not strain many particles. When the adsorption sites on the carbon are occupies by the adsorbate, carbon must be replaced and/or regenerated.

Initial Screening. Carbon adsorption is typically only used for volatile organic compounds not metals. However, it is effective for the removal of ammonia and as a final polishing step for metal removal. It may also be required for the treatment of the off gases from an aeration process, and will therefore be kept.

D.8. Ion Exchange. Ion exchange is the process by which ions in solution are preferentially removed from a process wastestream by exchanging site with another ionic substance and retained on the surface of a specially prepared resin. Because there is a limited capacity directly related to the ionic concentration of the solution, ion exchange resins become saturated, or exhausted. When the capacity of the resin is exhausted, it is regenerated with solution containing acid or base solutions.

Ion exchange resins are plastic or gel beads contained in columns. These columns are usually sized as a function of the ratio of wastewater flow rate to resin volume. Recommended loading rates range from 2-4 gpm/ft^3 of resin. Most commercial ion exchangers are synthetic plastic materials and can vary from loosely cross-linked polymers which are slightly soluble in water to tightly cross-linked resins, which would be insoluble but more difficult to use due to restricted access to exchange sites. The resins are reacted with acid or base solutions. The disassociated groups from these solutions attach themselves to each nucleus in the skeleton of the resin to provide an exchange site. Depending on the structure of the resin, it will have more or less of these sites. The resin capacity for exchange is a function of the number of sites, and is measured in equivalents per unit volume. The constituents of the ground water can be measured in equivalents per unit volume as well, and the length of time to exhaustion of the resin (exchange capacity reached) can be estimated.

Initial Screening. Ion exchangers are common and well known technology for the removal of relatively small amounts of specific anions or cations. However the ground water at the Johnstown Landfill has such high iron and manganese concentrations, that it would not be cost effective to remove these metals from the waste stream. Therefore, this option will not be further considered.

D.9. Ultrafiltration/Reverse Osmosis. Ultrafiltration and reverse osmosis use semipermeable membranes to separate the contaminants from the water. Semipermeable membranes are permeable to water but less permeable to dissolved solids. Ultrafiltration uses membranes with pores that range in size from 0.001 to 0.02 um. Reverse osmosis membranes would have pores smaller than 0.001 um. Under pressure, water flows through these membranes leaving the contaminants behind. Without pressure water would flow into the contaminated side. Ultrafiltration operates at lower pressures and thereby at less cost.

Initial Screening. Reverse osmosis and ultrafiltration are highly complex energy intensive treatment methods. They are extremely efficient at removing contaminants from the water stream, but have a significant waste stream that would have to be treated and/or disposed. It is not anticipated that treatment of the waste stream from either ultrafiltration or reverse osmosis would produce enough savings over treating the water directly to be cost effective. Therefore, this option will be not considered further.

D.10. Sludge Dewatering. A variety of methods exist for the dewatering of sludge including drying beds, gravity thickeners, pressure filters, vacuum filters, and centrifuges.

Initial Screening. Depending on the treatment stream, sludge thickening may be required. Choice of method is highly dependant upon the amounts and characteristics of the sludge. Therefore, this technology will be kept for further analysis.

D.11. Biological Treatment. Many contaminants can be broken down and/or removed from the environment by biological processes. Biological treatment systems can include, suspended growth systems such as activated sludge, attached growth systems such as rotating biological contact units, treatment ponds and lagoons, and wetland systems. Selection of the type of system is dependant upon the waste stream to be treated, desired levels of treatment, and the available landspace.

Initial Screening. In general biological systems are not efficient at the removal of metals when compared to physical chemical methods, primarily due to the biotoxicity of the metals. However, several European water treatment plants are using biological methods for the oxidation of iron and manganese. Biological processes are also efficient at the removal of ammonia. Therefore, these options will be further analyzed.

E. Treated Ground Water Discharge. Any treated ground water will have to be discharged. Treatment systems typically discharge either to a surface water, ground water, or to a sanitary sewer leading to a publicly owned treatment works (POTW).

E.1. Surface Water. The nearest surface water is Mathew Creek which originates at LaGrange Springs. Ditching or a sewer outfall would have to be constructed.

Initial Screening. Any surface water discharge would be subject to NPDES regulations and NYS surface water standards but would not change the water balance of the wetland areas near Mathew Creek. This option will be further analyzed.

E.2. Ground Water. The ground water discharge could be placed in an infiltration pond, injection wells, or land applied to return it to the ground water environment. Presently, the stormwater from the site infiltrates in several areas in natural or manmade (unintentionally) basins. It may be suitable to combine the treated ground water discharge with the stormwater in one of these areas.

Initial screening. A ground water discharge by way of infiltration basin appears feasible based upon present storm water handling and does not change the water balance of wetland areas near Mathew Creek. This option will be retained for further analysis.

E.3. Publicly Owned Treatment Works (POTW). Contaminated ground water would be extracted and discharged to a municipal sanitary sewer system for treatment and disposal.

Initial Screening. There is no sewer system or POTW close to the site; all residences in the area utilize small septic systems. In addition, the Johnstown Regional Treatment Plant requires source control criteria to be met prior to release of any wastewater to their facility. Because of the large ground water discharge rates beneath the site, a high capacity on-site treatment process to meet the POTW source control criteria is required on site. Currently the POTW source control limit for lead (100 μg/L) is below the estimated ground water lead concentration of 135 μg/L (Table 2.3) thus pretreatment would be required. In addition, the POTW is having difficulty meeting its SPDES restriction of ammonia (7 mg/L) for discharge to a Class D receiving water. It is expected that the receiving water will be upgraded to Class C, further increasing ammonia discharge restrictions thus on-site pretreatment for ammonia would also be necessary. An on-site treatment plant capable of meeting these POTW source control requirements would be of similar configuration and cost to a treatment plant designed for on-site disposal. Disposal to a POTW would involve considerable additional costs related to the construction of a sewer main to the site. In addition, transport and disposal of treated ground water off-site will reduce the ground water recharge to the LaGrange Springs and wetlands of Mathew Creek. Because of these additional sewer main costs and similar treatment plant costs and wetlands impacts, this alternative is dropped from further consideration.

F. Landfill Gas Control. The Johnstown landfill has landfill gas migrating out of it. This gas has been analyzed and contains a mixture of methane, carbon dioxide, nitrogen, and oxygen. Most of this gas can be expected to migrate up out of the landfill and be dispersed in the air to trace amounts, below detection levels. The primary concern with landfill gas is the possibility of its buildup, particularly in buildings on adjacent properties, thus creating a explosion hazard due to its methane content. It also creates a nuisance problem in the form of occasional odors.

Treatment of the landfill gas can include perimeter collection and treatment (passive or active), gas venting, gas collection and treatment and/or utilization. Perimeter collection would be used if off-site migration was determined to be extensive and the risk to adjacent property holders was high. Gas venting is the minimum requirement for the ARAR's when a landfill is capped. Gas collection and treatment or utilization would be used if large volumes of gas was anticipated, and the energy recovered from utilization would offset the added cost of construction. Utilization is more economically viable if a large energy user were adjacent to the landfill.

Initial Screening. Gas venting is a requirement for the landfill and will be built into the rough grading costs. There is presently no indication that perimeter vents, or active collection and treatment are required because extensive off-site gas migration was not detected. Off-site soil gas measurements were high in a limited area beyond the eastern limits of the landfill near LaGrange Gravel Pit. It is likely that these levels are caused by off gassing of the leachate that surfaced from the landfill embankment and flowed to the pit in this area. Perimeter monitoring after capping will be used to determine the necessity for active collection and treatment of migrating gas. Therefore, these options will not be pursued. Collection and utilization would require further pilot studies to determine viability. Therefore it will not be further considered in the FS.

G. Residential Water Supply. At present, the impact of the landfill leachate on the private water supplies is unclear. Some residential wells exceed ammonia nitrogen, iron, manganese, sodium and zinc above NYSDEC standard for Class GA ground water. Given the apparent high levels of many of these compounds naturally (except ammonia), it is difficult to separate the natural water quality levels that could be expected from the water quality levels due to any impacts caused by the landfill. At the federal level the standards for these compounds (except ammonia) are secondary standards based on aesthetics. Sodium is a health concern for people on a sodium restricted diet and is a NYSDEC standard. Ammonia nitrogen, a health concern and constituent of landfill leachate, also has a NYSDEC standard.

G.1. Point-of-Use Treatment. Many of the private residences already rely on iron and manganese treatment systems. The technology required to remove contaminants from the residential water supply would involve a reverse osmosis or granular activated carbon unit in addition to currently used metals removal techniques. In addition, sampling and analyses would be required to insure treatment is effective.

Initial Screening. Point-of-use treatment systems would have to be provided, maintained, and installed by the municipality and could entail significant legal and administrative concerns. Monitoring would be required on a regular basis to verify the systems were operating effectively. In addition, the NYSDOH considers point-of-use treatment to be unacceptable if a permanent solution is available. Therefore, this option will not be considered further.

G.2. Replacement Wells. New wells would be drilled to replace existing residential water supply wells.

Initial Screening. Replacement wells would have to be drilled deeper than existing wells and would penetrate the bedrock. Because of the discontinuity and unpredictability of the bedrock fractures, it is uncertain if satisfactory amounts of drinking water quality could be consistently obtained and its quality cannot be evaluated in advance. Continued monitoring would be required for all wells to avoid their potential contamination by the landfill. Because this may not be a permanent solution this option will not be considered further.

G.3. Community Water System. A community water system consists of a suitable water source, potentially a treatment plant and a water distribution system.

Initial Screening. A community system relying on a surface water source would be prohibitively expensive due to the distances involved to any suitable surface water source. A ground water source could not be used in the area due to concerns related to leachate contamination described above. Exploration for a suitable ground water supply outside of the impacts of the site would be expensive and would require monitoring and a distribution system. Because this may not result in a satisfactory solution and because it may not be a long-term solution it will not be considered further.

G.4. Bottled Water. Bottled water would be provided by private companies to each residence for drinking and cooking purposes.

Initial Screening. This alternative does not address exposure to ground water used for bathing and washing purposes and does not eliminate the potential for ingestion of the ground water by the private residences. Therefore, this option will not be considered further.

G.5. City Water Service. Providing city water requires extension of the city water lines and a booster station.

Initial Screening. At least 24,600 feet of water line will be required to extend the city system to the residences in the landfill vicinity. In addition, many institutional issues related to extension of a city system outside of city boundaries into the Town of Johnstown exist. Issues related to establishing service contracts, a water district, a permissive use district or annexation of the area to be served into the City of Johnstown must be dealt with prior to initiating this alternative. This alternative does achieve a permanent solution and is acceptable to NYSDOH so it will be retained for further analysis.

TABLE 2.4 JOHNSTOWN LANDFILL
SUMMARY OF TECHNOLOGY AND PROCESS OPTION SCREENING

TECHNOLOGY OR PROCESS	EVALUATE	ELIMINATE
NO ACTION		
PUBLIC AWARENESS	X	
MONITORING	X	
LIMITED ACTIONS		
SECURITY FENCE	X	
DEED RESTRICTIONS	X	
ALTERNATIVE WATER SUPPLY	X	
REGRADE	X	
CONTAINMENT		
IMPERMEABLE CAP	X	
WELLS AND TRENCHES		X
VERTICAL BARRIERS		X
REMOVAL		
EXCAVATION		
OFF SITE DISPOSAL		X
TREAT AND REPLACE		X
IN SITU SOIL TREATMENT		
BIOREMEDIATION		X
SOIL FLUSHING		X
VACUUM EXTRACTION		X
GROUND WATER COLLECTION		
VERTICAL WELLS	X	
TRENCHES	X	
HORIZONTAL WELLS		X
VERTICAL BARRIERS		X
GROUND WATER TREATMENT		
NEUTRALIZATION	X	
PRECIPITATION	X	
FLOTATION		X
OXIDATION/REDUCTION	X	
AIR/STREAM STRIPPING	X	
FILTRATION	X	
ADSORPTION	X	
ION EXCHANGE		X
ULTRAFILTRATION/REVERSE OSMOSIS		X
SLUDGE DEWATERING	X	
BIOLOGICAL TREATMENT	X	
GROUND WATER DISCHARGE		
POTW		X
SURFACE WATER	X	
GROUND WATER	X	
SURFACE WATER TREATMENT		X
SEDIMENT		
DREDGING		X
MONITORING	X	
LANDFILL GAS CONTROL		
GAS VENTING	X	
PERIMETER VENTING		X
COLLECTION/TREATMENT		X
RESIDENTIAL WATER SUPPLY REPLACEMENT		
POINT-OF-USE		X
REPLACEMENT WELLS		X
COMMUNITY WATER		X
BOTTLED WATER		X
CITY WATER SERVICE	X	

3.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

This chapter discusses the development of potential remedial alternatives by combining the technologies and processes determined previously to be feasible for implementation at the Johnstown Landfill Site.

Potential remedial alternatives are developed by a two-phase process. Initially, criteria must be established to evaluate the acceptability of the environmental and public health impacts, and performance of each alternative. This step will identify the applicable or relevant and appropriate requirements (ARARs) and other criteria to be considered (TBCs), and develop the performance requirements and potential risks associated with implementing each remedial action. After the ARARs are identified, the potentially applicable technologies previously identified are used to develop comprehensive remedial alternatives on the basis of operation and performance compatibility, and the use of good engineering practice.

3.1 Development of Remedial Response Criteria

The development of alternatives must comply with the requirements of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended, and to those of the National Contingency Plan (NCP). Section 300.68 of the NCP specifically refers to ARARs in the development of alternatives. CERCLA Section 121(d) requires that Superfund remedial actions must attain ARARs or other regulations that are more stringent than Federal requirements to the extent that they are applicable to the project and are identified to the USEPA in a timely manner.

CERCLA, as amended, identifies the following statutory preferences when developing and evaluating potential remedial alternatives:

- Remedial actions involving treatments permanently and significantly reducing the volume, toxicity, or mobility of the contaminants of hazardous substances are preferred.
- Remedial actions using permanent solutions, alternative treatment technologies, or resource recovery technologies shall be assessed.
- Off-site transport and disposal of hazardous substances or contaminated materials without treatment is considered the least-favored alternative remedial action where practical treatment technologies are available.

USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988b) provides guidance regarding implementation of CERCLA amendments during the remedy selection process. The guidance states that the range of treatment alternatives should be developed from an alternative that, to the maximum degree possible, would eliminate the need for long-term management (including monitoring) at the site, to alternatives involving treatment that would reduce toxicity, mobility, or volume as their principal element. The guidance also indicates that a containment option (involving little or no treatment) and a No Action alternative should be developed, if at all possible.

Based on these statutory preferences and the general response actions developed previously, remedial alternatives were developed to meet the following criteria to the best extent practicable:

- The remedial alternative is protective of human health and the environment.
- The remedial alternative attains chemical-specific ARARs and can be implemented in a fashion consistent with location and action-specific ARARs.
- The remedial alternative uses permanent solutions and alternative treatment technologies to the maximum extent practicable.
- The alternatives developed are capable of achieving a remedy in a cost-effective manner.

As specified in the NCP, remedial alternatives are classified either as source control (SC) or management of migration (MM) remedial actions.

Source control remedial actions primarily address situations where hazardous substances remain at or near the areas where they were originally located and are not adequately contained to prevent migration. The purpose of SC remedies is to prevent or minimize migration of hazardous substances from the source material. These remedies seek to remove, stabilize, and/or contain the hazardous substances, and are primarily applied in cases where contaminants are in the solids/soils matrix.

Management of migration remedial actions address situations in which hazardous substances have migrated from the original source of contamination and pose a threat to the public health and welfare and/or the environment. These MM alternatives include ground water and/or sediment response actions where contaminated ground water still exists on-site as a result of former site activities, and also may be responsible for contaminating downgradient water resources.

3.1.1 Use of ARARs and TBCs in Remedial Alternative Development and Evaluation

In this section, the approach used to identify ARARs for the Johnstown Landfill Site is discussed and ARARs for site-specific conditions are identified.

Section 121(d) of the Superfund Amendments and Reauthorization Act (SARA) and the NCP (40 CFR Part 300; 1990) require that remedial actions taken under CERCLA comply with Section 121(d)(2)(c) of SARA, if they are legally enforceable and consistently enforced statewide. ARARs are used to determine the appropriate extent of site cleanup, to scope and formulate remedial action alternatives, and to govern the implementation and operation of the selected action. According to SARA, requirements may be waived by USEPA under six conditions, provided the protection of human health and the environment is still assured. These conditions include the following:

- The selected remedial action is an interim remedy or portion of a total remedy that will attain the standard when complete;

- Compliance with such requirements will result in greater risk to human health and the environment than alternative options;
- Compliance with such requirements is technically impracticable from an engineering perspective;
- The selected remedial action will provide a standard of performance equivalent to the standard required by the ARAR;
- The requirement is a state requirement that has been inconsistently applied; and
- The alternative will not provide a balance between public health and the environmental welfare and the availability of funds to respond to existing or potential threats at other sites, taking into account the relative immediacy of the threats.

A requirement under CERCLA as amended may be either "applicable" or "relevant and appropriate" to a site-specific remedial action, but not both.

Applicable Requirement: Those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

Relevant and Appropriate Requirements: Those cleanup standards, standards of control, and other environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. In some circumstances, a requirement may be relevant but not appropriate for the site-specific situation.

Other Requirements To Be Considered: Federal and State guidance documents or criteria that are not generally enforceable but are advisory that do not have the status of potential ARARs. Guidance documents or advisories to be considered in determining the necessary level of cleanup for protection of human health or the environment may be used where no specific ARARs exist for a chemical or situation, or where such ARARs are not sufficient to be protective.

3.1.2 Identification of ARARs and TBCs

The ARARs for remedial action alternatives at the Johnstown Landfill Site can be generally classified into one of the following three functional groups:

- Chemical specific requirements that set protective cleanup levels for the chemicals of concern.
- Location specific requirements that restrict remedial actions based on the characteristics of the site or its immediate environs.
- Action specific requirements that set controls or restrictions on the design, implementation, and performance levels of activities related to the management of hazardous substances, pollutants, or contaminants.

Chemical specific requirements set health or risk based concentration limits or ranges in various environmental media for specific hazardous substances. These requirements provide protective site cleanup levels as a basis for calculating cleanup levels for the chemicals of concern in the designated media. Chemical specific ARARs are also used to indicate an acceptable discharge limit or water quality to determine treatment and disposal requirements resulting from a remedial activity, and to assess the effectiveness of the remedial alternative.

Location specific requirements set restrictions on the types of remedial activities performed based on site specific characteristics. Remedial action alternatives may be restricted or precluded based on Federal and State citing laws for hazardous waste facilities, proximity to wetlands or floodplains, or to man-made features such as existing landfills. Location specific requirements provide a basis for assessing restrictions during the formulation and evaluation of potential remedies.

Action specific requirements are triggered by the particular remedial alternatives that are selected. After remedial alternatives are developed, action specific ARARs that specify levels of residual chemicals for discharge provide a basis for assessing the remedies. These action specific ARARs may include, for example, surface water discharge standards, and site construction regulations.

Consideration of ARARs

ARARs were considered in the study through a two-step process. Step one consisted of the identification of chemical specific and location specific ARARs. These ARARs were used during the identification of remedial response objectives, screening of technologies and development of remedial alternatives. An inventory of potential ARARs for each category was prepared to ensure that all ARARs were considered. The list of potential ARARs was narrowed based on whether each requirement is legally enforceable at the site, or whether it would be reasonable to apply the requirement to site conditions if the site or remedial action was under its jurisdiction.

Step two consisted of the identification of action specific ARARs that will control the implementation and/or operation of remedial actions identified for the site, so that the feasibility and effectiveness of the remedy can be assessed.

Regulations identified as chemical specific and location specific ARARs for existing site conditions are presented in Table 3.1. To be consistent with the NCP definition of ARARs and changes made by SARA, the following groups of ARARs were considered during the identification process:

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

- Federal criteria, advisories and guidance documents
- New York State criteria, advisories and guidance documents.

3.1.3 Listing of ARARs and TBCs

The Federal, State and local ARARs and other regulatory requirements to be considered (TBCs) for the Johnstown Landfill Site are presented in Tables 3.1, 3.2 and 3.3.

3.1.4 General Discussion of Key ARARs and TBCs

Chemical specific ARARs - Groundwater at the Johnstown Landfill Site is designated as Class "GA" in accordance with the New York State Water Classification System. The "GA" designation is used to classify water quality suitable for potential drinking water supply. Several Federal and New York State regulations govern the quality, usage and discharge of ground water.

Action specific ARARs - Many of the action-specific ARARs are common to all the alternatives. Most of the RCRA ARARs and the OSHA rules are common to each alternative. They require that wastes be identified, manifested and properly monitored. The Air Pollution Control regulations apply specifically to site construction activity. In addition to these regulations, surface water quality standards will be applied to any discharge of the treated ground water to Matthew Creek, a Class A water body. The water quality standards for a Class A surface water body will be complied with for any discharge to Matthew Creek.

Location specific ARARs - This section identifies the ARARs that address the conduct of the remedial actions in particular locations suggested by the circumstances of the Johnstown Landfill Site. If work does impact Matthew Creek, there will be wetlands requirements. In general, there may also be concerns regarding the potential for the discovery of endangered species and cultural resources in the areas.

Wetlands - Clean Water Act 404, Executive Order 11990 - Protection of Wetlands; New York Freshwater Wetlands Permit Requirements and Classifications. Each of these laws and regulations set forth various requirements for activities in a wetland. If the cleanup of the site is going to have any effect on the wetland, they must be considered in the feasibility study.

Cultural Resources - The National Historic Preservation Act sets forth the requirements for the protection of cultural resources. It requires a review for all items which may be eligible for the National Historic Register.

Endangered Species - The FS must consider the possibility of endangered species being found at the site and the impact they will have on the alternative selection process. The Endangered Species Act, the Fish and Wildlife Coordination Act, and the Endangered and Threatened Species of Fish and Wildlife Requirements all require that the FS provide for protection of endangered species, limiting of the destruction of the natural habitat and mitigating any damage done by the remedial action.

These items were all evaluated during the performance of the RI for this site and no significant impacts were found to be present. The wetland areas near the landfill were studied during the remedial investigation with regard to potential impacts from implementation of remedial actions. Any construction activities on and around the wetlands (Matthew Creek) would occur only if the creek is chosen as a discharge point for leachate collection. These activities would be limited and would have to be implemented using great care so as not to disturb the wetlands.

All remediation activities are anticipated to take place within the landfill or adjacent areas where gravel mining operations have occurred. Previously undisturbed areas will remain so. Therefore, the impact on any cultural resources within the Johnstown Landfill Site is considered minimal.

There is no record of the site or the landfill as being the home of any endangered species at this time. These location-specific ARARs will not effect the implementation of any potential remedial alternative at the site.

3.2 Identification of Alternatives

3.2.1 Combination of Potentially Applicable Technologies Into Feasible Remedial Alternatives

A review of the RI results and the technology screening presented previously indicates that four basic potential remedial actions, with various technologies, exist for the situation of this site:

1) No Action
   a. Public Awareness
   b. Monitoring
      i. Ground Water
      ii. Surface Water
      iii. Stream Sediments

2) Limited Action
   a. Security Fence
   b. Deed Restrictions
   c. Alternative Water Supply
   d. Regrade

3) Containment
   a. Impermeable Cap
      i. NYCRR Cap
      ii. RCRA Cap

4) Removal, Treatment and Disposal of Contaminated Material
   a. Ground Water Collection
      i. Vertical Wells
      ii. Trenches and Drains
   b. Ground Water Treatment
      i. Neutralization
      ii. Precipitation
      iii. Oxidation/Reduction
      iv. Filtration
      v. Adsorption
      vi. Biological Processes
      vii. Sludge Dewatering
   c. Ground Water Discharge
      i. Surface Water
      ii. Ground Water
   d. Landfill Gas Control

5) Residential Water Supply
   a. City Water Service

These technologies can be combined into the following Remediation Alternatives:

SC 1	No Action
SC 2	Limited Action, Residential Water Replacement
SC 3	6NYCRR Part 360 Cap, Residential Water Replacement
SC 4	RCRA Cap, Residential Water Replacement
SC 5	Ground Water Collection Treatment and Discharge, Residential Water Replacement
SC 6	6NYCRR Part 360 Cap, Residential Water Replacement, Ground Water Collection Treatment Discharge
SC 7	RCRA Cap, Residential Water Replacement, Ground Water Collection Treatment Discharge

While some specific technologies remain to be defined in each of these alternatives, the basic alternatives will not be affected. Because each of the basic alternatives do not differ significantly within itself they will not be preliminarily screened by effectiveness, implementability or cost. These alternatives will be analyzed in further detail.

TABLE 3.1 JOHNSTOWN LANDFILL SITE
CHEMICAL SPECIFIC ARARs, CRITERIA, AND GUIDANCE

REGULATORY LEVEL	ARAR IDENTIFICATION	STATUS	REQUIREMENT SYNOPSIS	FS CONSIDERATION
Federal	CWA Water Quality Criteria (WQC) for protection of Human Health and Aquatic Lives	Relevant and Appropriate	Contaminant levels regulated by WQC are provided to protect human health for exposure from drinking water and from consuming aquatic organisms (primarily fish) and from fish consumption alone.	The promulgated values are compared to the maximum contaminant levels at Site to determine levels of contamination. Note that WQC are also relevant and appropriate to evaluation of surface water discharge acceptability.
Federal	RCRA Maximum Concentration Limits (MCLs)	Relevant and Appropriate	Provides standards for 14 toxic compounds and pesticides for protection of ground water. These standards are equal to the MCLs established by the SDWA.	The promulgated values are included in the SDWA MCLs (Refer to SDWA below). The combined standards are compared with the maximum contaminant levels at site to determine the level of contamination. See SDWA below.
Federal	SDWA Maximum Contaminant Levels (MCLs)	Relevant and Appropriate	Provides standards for 30 toxic compounds, including the 14 compounds adopted as RCRA MCLs, for public drinking system.	Metallic species were identified in ground water contamination. The SDWA MCLs, in conjunction with NY Ambient Quality Standards and guidance values, will be used to select indicator chemicals and as treatment.
Federal	SDWA MCL Goals	Relevant and Appropriate	EPA has promulgated 9 contaminants and has proposed 40 others for the public water system. The MCLGs are non-enforceable health goals and are set at levels that would result in no known or anticipated adverse health effects with an adequate margin of safety.	Since the MCLGs are non-enforceable goals, they are used as reference values to indicate treatment system performance only.
New York	6 NYCRR NY State Pollution Elimination Discharge System Part 750 et seq	Applicable	Provides effluent limitations for discharge to surface water.	Effluent limitations for specific waste stream may allow discharge at a higher level of contamination which is technologically feasible based on this standard.
New York	Ground Water Quality Regulations 6 NYCRR Part 703.5	Applicable	Provide quality standards for ground water. Certain contaminant levels are specified.	The concentrations of contaminants in ground water at site were compared to these standards to determine treatment requirements.
New York	Ambient Surface Water Quality Standards 6 NYCRR Part 701	Applicable	Provide quality standards for discharge to surface water.	The concentrations of contaminants in ground water at site will be compared to these standards to determine treatment requirements. Discharge water will be treated as close as possible to these levels prior to discharge to a surface water body.
New York	Ambient Water Quality Standards and Guidance Technical and Operations Guidance Series (TOGS) 1.1.1, April 1, 1987	To be considered	Provide quality standards for ground water and discharges to surface water.	The concentration of contaminants in the ground water at site will be compared to these standards to determine treatment requirements. Discharge water will be treated as close as possible to these levels prior to discharge to a surface water body.
New York	NYCRR Part 5, and 170 State Sanitary Codes Public Water Supplies	Applicable	Provides water quality standards for drinking water supplies.	The concentration of contaminants in the ground water at site will be compared to these standards to determine treatment requirements.

TABLE 3.2

JOHNSTOWN LANDFILL SITE
LOCATION SPECIFIC ARARs, CRITERIA AND GUIDANCE

	ARARs	STATUS	REQUIREMENTS SYNOPSIS	FS CONSIDERATIONS
Federal	Clean Water Act 404 33 USC 466	Applicable	Details Federal requirements with regard to activities in a wetland	Must coordinate with the USACOE regarding dredging and filling in wetlands area. Consider additional requirements of and cost of activities in wetland when determining alternatives.
Federal	Fish and Wildlife Coordination Act 16 USC 661	Relevant and Appropriate	Details requirements with regard to the protection of fish and wildlife.	Must consider effects of alternatives on endangered species.
Federal	Wetland Executive Order 11990	Applicable	Details requirements for the preservation of wetlands.	Must consider effects of alternatives on wetlands.
Federal	USEPA/USACOE Memorandum of Agreement on No Net Loss	Applicable	Details requirements for the preservation of wetlands.	Must consider effects of alternatives on wetlands.
Federal	Endangered Species Act 16 USC 1531	Relevant and Appropriate	Details the requirements for the protection of endangered species.	Must consider effects of alternatives on endangered species.
Federal	National Historic Preservation Act 16 USC 470	Relevant and Appropriate	Sets forth requirements for the preservation of items of cultural or historical value.	Must consider effects of alternatives or cultural resources in the area.
New York	NYS Freshwater Wetlands Law ECL Article 24, 71 in Title 23	Applicable	Sets forth the needs and goals for the preservation of wetlands in New York State.	Must consider effects of alternatives on wetlands.
New York	NYS Freshwater Wetlands Permit Requirements and Classification 6 NYCRR 663 and 664	Applicable	Details requirements for activities in a wetland in New York State.	Must consider effects of alternatives on wetlands.
New York	NYS Endangered and Threatened Species of Fish and Wildlife Requirements 6 NYCRR 182	Relevant and Appropriate	Details requirements for the protection of endangered species in New York State.	Must consider effects of alternatives on endangered species.

TABLE 3.3

JOHNSTOWN LANDFILL SITE
ACTION SPECIFIC ARARs, CRITERIA AND GUIDANCE

REMEDIAL ACTION	ARARs	STATUS	REQUIREMENT SYNOPSIS
A. Common to All Alternatives	OSHA - General Industry Standards (29 CFR 1910)	Applicable	These regulations specify the 8-hour time-weighted average concentration for worker exposure to various organic compounds. Training requirements for workers at hazardous waste operations are specified in 29 CFR 1910.120.
	OSHA - Safety and Health Standards (29 CFR 1926)	Applicable	This regulation specified the type of safety equipment and procedures to be followed during site remediation.
	OSHA - Record Keeping, Reporting and Related Regulations (29 CFR 1904)	Applicable	This regulation outlines the record keeping and reporting requirements for an employer under OSHA.
	USEPA Ground Water Protection Strategy - USEPA Policy Statement, August 1984	To Be Considered	Identifies ground water quality to be achieved during remedial actions based on the aquifer characteristics and use.
	RCRA - Standards for Generators of Hazardous Waste (40 CFR 262.1)	Relevant and Appropriate	General generator requirements outline manifest record keeping and transporting requirements.
	RCRA - Standards for Transporters of Hazardous Waste (40 CFR 263)	Applicable	General transportation requirements.
	RCRA - Standards for Owners/Operators of Permitted Hazardous Waste Facilities (40 CFR 264.10-264.18)	Relevant and Appropriate	General facility requirements outline general waste analysis, security measures, inspections, and training requirements.
	RCRA - Preparedness and Prevention (40 CFR 264.30-264.31)	Relevant and Appropriate	This regulation outlines the requirements for safety equipment and spill control.
	RCRA - Contingency Plan and Emergency Procedures (40 CFR 264.50-264.56)	Relevant and Appropriate	This regulation outlines the requirements for emergency procedures to be used following explosions, fires, etc.
	RCRA - Ground Water Protection (40 CFR 264.90-264.109)	Relevant and Appropriate	This regulation details requirements for ground water monitoring program to be installed at the site.
	RCRA - Miscellaneous Units (40 CFR 264.00-264.999)	Relevant and Appropriate	These standards are applicable to miscellaneous units not previously defined under existing RCRA regulations for treatment, storage, and disposal units.
	RCRA - Closure and Post-Closure (40 CFR 264.110-264.120)	Relevant and Appropriate	The regulation details specific requirements for closure and post-closure of hazardous waste facilities.
	DOT Rules for Transportation of Hazardous Materials (49 CFR Parts 107, 171.1-172.558)	Applicable	This regulation outlines procedures for the packaging, labeling, manifesting, and transporting of hazardous materials.
	New York Hazardous Waste Manifest System Rules (6 NYCRR 372)	Relevant and Appropriate	This regulation outlines NY State manifest requirements.
	New York Hazardous Waste Treatment, Storage and Disposal Facility Permitting Requirements (6 NYCRR 370 and 373)	Relevant and Appropriate	This regulation outlines general waste facility requirements, outlines general waste analyses, security measures, inspections and training requirements.
	New York State Solid Waste Management Facilities (6 NYCRR 360)	Relevant and Appropriate	Establishes landfill closure requirements.
	New York Industrial Code (12 NYCRR 753)	Relevant and Appropriate	Establishes construction and notification requirements for buried pipelines.
	New York Rules for Inactive Hazardous Waste Disposal Sites (6NYCRR 375)	Applicable	Applies to development and implementation of inactive hazardous waste site remedial program under authority of Environmental Conservation Law

TABLE 3.3 CONT'D.

REMEDIAL ACTION	ARARs	STATUS	REQUIREMENT SYNOPSIS
B. Ground Water Treatment	40 CFR 122.44	Relevant and Appropriate	Requires to use best available technology (BAT) to control toxic and nonconventional pollutants; use of best conventional pollutant control technology (BCT) for conventional pollutants. Technology-based limitations may be determined on a case by case basis.
	40 CFR 122.41	Relevant and Appropriate	Provides monitoring requirements.
	40 CFR 12.100 and 40 CFR 125.104	Relevant and Appropriate	Requires to develop and implement a Best Management Practices program to prevent the release of toxic constituents to surface water.
	40 CFR 136.1-136.4	Relevant and Appropriate	Approved test methods for waste constituents to be monitored must be followed. Detailed requirements for analytical procedures and quality control are provided. Sample preservation procedures, container materials, and maximum allowable holding times are prescribed.
	CWA Water Quality Criteria (WQC) for Protection of Human Health and Aquatic Lives	Relevant and Appropriate	Contaminant levels regulated by WQC are provided to protect human health from exposure from drinking water and from consuming aquatic organisms (primarily fish) and from fish consumption alone.
	RCRA Maximum Concentration Limits (MCLs)	Relevant and Appropriate	Provides standards for 14 toxic compounds and pesticides for protection of ground water. These standards are equal to the MCLs established by NPDWS. This regulation also provides basis for application of a site specific basis.
	SDWA Maximum Contaminant Levels (MCLs)	Relevant and Appropriate	Provides standards for 30 toxic compounds, including the 14 compounds adopted as RCRA MCLs, for public drinking system.
	SDWA MCL Goals	Relevant and Appropriate	EPA has promulgated 9 contaminants and has proposed 40 others (50 FR 46936) for the public water system. The MCLGs are non-enforceable health goals and are set at levels that would result in no known or anticipated adverse health effects with an adequate margin of safety.
	Ground Water Quality Standards (6 NYCRR Part 703.5)	Applicable	Provide quality standards for ground water. Certain contaminant levels are specified.
C. Discharge of Treated Ground Water to Surface Water	Ambient Surface Water Quality Standards (6 NYCRR Part 701 and Appendix 31)	Applicable	Provide quality standards for discharge to surface water.
	NYS Pollution Discharge Elimination System (SPDES) 6 NYCRR 750	Applicable	Provide effluent limitations for discharge to surface water.
	NY TOGS 1.1.1 April, 1987	To Be Considered	Provides contaminant levels guidance for discharge of treated ground water.
D. Site Work	New York Guidelines for Soil Erosion and Sediment Control	Relevant and Appropriate	Provides guidelines for developing a soil erosion and sediment control plan and describes various techniques for achieving compliance.
	National Emission Standards for Hazardous Air Pollutants (NESHAP)	Applicable	These standards provide acceptable limits for emissions of specific chemicals. Requirements address operational aspects; record keeping, and general emission standards that apply to particulate matter from pumps, valves, compressors and vessels.
	New York State General Prohibitions on Fugitive Air Emissions (6 NYCRR 211)	Applicable	This regulation restricts the emission of air contaminants associated with particulate matter, fumes, mist and smoke as well as other visible emissions.
	New York Air Guide - I September, 1991	Relevant and Appropriate	Provides guidelines for the control of emissions of toxic air contaminants.

4.0 DETAILED ANALYSIS OF ALTERNATIVES

This chapter contains a discussion of the detailed evaluation and assessment of the potential remedial alternatives developed for the Johnstown Landfill Site. Nine evaluation criteria have been developed identifying the important technical and policy considerations for selecting among potential alternatives. These nine evaluation criteria serve as the basis for conducting the detailed analyses and identifying a preferred alternative. These nine criteria are:

1) Overall protection of human health and the environment
2) Compliance with ARARs
3) Long term effectiveness
4) Reduction of toxicity, mobility or volume
5) Short term effectiveness
6) Implementability
7) Cost
8) State acceptance
9) Community acceptance

A summary description of these evaluation criteria and the factors considered for each is presented in Table 4-1.

Based on the statutory preferences and the remedial action objectives developed in Section 2.0, remedial alternatives shall meet the following requirements during evaluation and selection:

- Protection of human health and the environment (CERCLA Section 121(b)).
- Attainment of the applicable or relevant and appropriate requirements (ARARs) of Federal and State laws (CERCLA Section 121(d)(2)(A)) or warranting a waiver under CERCLA Section 121(d)(4).
- Reflection of a cost-effective solution, taking into consideration short-term and long-term costs (CERCLA Section 121(a)).
- Use of permanent solution and treatment technologies or resource recovery technologies to the maximum extent practicable (CERCLA Section 121(b)).
- Satisfaction of the preference for remedies that permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances as a principal element, or explanation of reasons why such remedies were not selected (CERCLA Section 121(b).

TABLE 4-1
JOHNSTOWN LANDFILL SITE
SUMMARY OF THE DETAILED EVALUATION CRITERIA

OVERALL PROTECTION

- How risks are eliminated, reduced or controlled

COMPLIANCE WITH ARARs

- Compliance with chemical-specific ARARs
- Compliance with action-specific ARARs
- Compliance with location-specific ARARs
- Compliance with appropriate criteria, advisories and guidances

LONG-TERM EFFECTIVENESS AND PERMANENCE

- Magnitude of residual risks
- Adequacy of controls imposed after remedial action completed
- Reliability of controls imposed after remedial action completed

REDUCTION OF TOXICITY, MOBILITY OR VOLUME

- Treatment process and remedy
- Amount of hazardous material destroyed or treated
- Reduction in toxicity, mobility or volume of hazardous material
- Irreversibility of the treatment
- Type and quantity of treatment residuals

SHORT-TERM EFFECTIVENESS

- Protection of community during remedial actions
- Protection of workers during remedial actions
- Time until remedial action objectives are achieved
- Environmental impacts

IMPLEMENTABILITY

- Ability to construct technology
- Reliability of technology
- Ease of undertaking additional remedial action, if necessary
- Monitoring consideration
- Coordination with other agencies
- Availability of treatment, storage capacity, and disposal services
- Availability of necessary equipment and specialists
- Availability of prospective technologies

COST

- Capital costs
- Annual operating and maintenance costs
- Present worth analysis

STATE ACCEPTANCE

- Preferences among alternative
- Concerns about alternatives

COMMUNITY ACCEPTANCE

- Preferences among alternatives
- Concerns about alternatives

4.1 Description of the Evaluation Process

The extent to which the alternatives are analyzed during this stage of the FS is influenced by the available data, the number and types of alternatives being evaluated and the degree to which the alternatives were previously analyzed.

This assessment compares the potential remedial alternatives and identifies the key tradeoffs among them. This approach to analyzing alternatives is designed to provide decision makers with sufficient information to adequately compare the alternatives, select an appropriate remedy for the site, and demonstrate satisfaction of the CERCLA remedy selection requirements in the Record of Decision.

The detailed analysis of alternatives includes the following steps:

- Further definition of each alternative with respect to the volumes and areas of contaminated media to be addressed, the technologies to be employed and any performance requirements associated with those technologies;
- The assessment of each alternative against the previously described nine evaluation criteria; and,
- A comparative analysis among the alternatives to assess the relative performance of each one with respect to each of the evaluation criteria.

4.1.1 Evaluation Criteria

The nine evaluation criteria listed above encompass statutory, technical, cost, and institutional considerations that have been determined to be appropriate for a thorough evaluation. A brief description of each of the nine is presented below.

Overall Protection of Human Health and the Environment: This criterion provides an overall assessment of protection based on a composite of factors such as long-term and short-term effectiveness, and compliance with ARARs. Evaluations of the overall protectiveness address:

- How a specific site remedial action achieves protection over time,
- How site risks are reduced, and
- How each source of contamination is to be eliminated, reduced, or controlled for each remedial action.

This criterion also considers whether an alternative poses any unacceptable short-term or cross-media impacts.

Compliance with ARARs: This criterion is used to determine how each remedial action complies with applicable or relevant and appropriate Federal and State requirements as defined in CERCLA Section 121.

Each alternative is evaluated in detail for:

- Compliance with contaminant-specific ARARs (e.g., MCLs),
- Compliance with action-specific ARARs (e.g., RCRA minimum technology standards),
- Compliance with location-specific ARARs (e.g., preservation of historic sites), and
- Compliance with appropriate criteria, advisories, and guidances (i.e., "To Be Considered" material).

<u>Long-Term Effectiveness and Permanence</u>: This criterion addresses the results of the remedial action in terms of the risk remaining at the site after the action objectives have been met, particularly the effectiveness of the controls that will be applied to manage the risks posed by the residuals of the treatment process and/or untreated wastes. The components of this criterion include the magnitude of the remaining risks measured by numerical standards such as cancer risk levels; the adequacy and suitability of controls used to manage treatment residuals or untreated wastes; and the long-term reliability of management controls for providing continued protection from residuals, i.e., the assessment of potential failure of the technical components.

<u>Reduction of Toxicity, Mobility or Volume</u>: This criterion addresses the statutory preference that treatment is used to reduce the principal threats of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. Factors to be evaluated include the treatment process

employed; the amount of hazardous material destroyed or treated; the degree of toxicity reduction, mobility, or volume expected; and the type and quantity of treatment residuals.

Short-Term Effectiveness: This criterion addresses the impacts of the action during the construction and implementation phase until the remedial action objectives are met. Factors to be evaluated include protection of the community during the remedial actions, protection of workers during the remedial actions, environmental impacts resulting from the implementation of the remedial actions, and the time required to achieve protection.

Implementability: This criterion addresses the technical and administrative feasibility of implementing a remedial action including the availability of various required services and materials. Technical feasibility factors include construction and operational difficulties, reliability of technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy. The administrative feasibility includes the ability and time required for permit approval and for activities needed to coordinate with other agencies. Factors utilized to evaluate the availability of services and materials include availability of treatment, storage, and disposal services with required capacities; availability of equipment and specialists; and availability of proposed technologies for competitive bid.

Cost: The types of costs that will be addressed include capital costs, and operation and maintenance (O & M) costs.

Capital costs consist of direct and indirect costs. Direct capital costs include expenditures for the equipment, labor, and materials necessary to install remedial actions. Indirect capital costs include expenditures for engineering, financial, and other services required to complete the installation of remedial alternatives. O & M costs include labor, materials, chemicals, and energy, disposal of residues, purchased services, administrative costs, insurance, taxes, license costs, maintenance reserve and contingency funds, rehabilitation costs, and costs for periodic site reviews.

The costs associated with each of the remedial actions is prepared on the basis of present worth. Present worth analysis allows remedial actions to be compared as a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. An operating performance period of 30 years and a discount rate of 5.00 percent is assumed for a base calculation. The "study estimate" costs provided for the remedial actions are intended to reflect actual costs with an accuracy of -30 to + 50 percent.

<u>State Acceptance</u>: This assessment is intended to evaluate the technical and administrative issues and concerns the State of New York (State) may have regarding each of the remedial actions. The factors to be evaluated include features of the actions that the State supports, that the State has reservations about, or the State opposes. The New York State Department of Environmental Conservation (NYSDEC) is the State agency charged with reviewing these remedial

actions and will indicate its preference in the proposed plan.

Community Acceptance: This assessment is intended to incorporate public input into the analysis of the remedial actions. Factors of community acceptance to be discussed include features of the supportiveness, reservations and opposition of the community.

Since the State and public have not been provided with a formal opportunity to review the detailed analysis of the remedial actions, no formal comments are available for evaluation of the "State Acceptance" and "Community Acceptance" criteria in this FS Report. It is anticipated that the formal comments from the public will be provided during the public comment period for the RI/FS Report and proposed plan. These comments will then be addressed in the ROD and responsiveness summary. Therefore, only the first seven evaluation criteria were used to evaluate the potential remedial alternatives.

4.2 Individual Analysis of Alternatives

This section will present descriptions of the potential remedial alternatives developed for the Johnstown Landfill Site and their individual evaluations as compared with the above mentioned criteria.

Source Control Alternatives include:

SC 1 No Action

Under this alternative no physical remedial action would be taken. Ground water, surface water and stream sediment monitoring and public awareness and education program would be implemented.

SC 2 Limited Action, Residential Water Replacement

This alternative is composed of the following components:

- Ground water, surface water and stream sediment monitoring,
- Site access restrictions, deed restrictions,
- Residential connections to City water system,
- Drainage improvements to eliminate storm drainage water flows onto the site and
- Regrading to eliminate ponding of storm water on the site.

SC 3 6NYCRR Part 360 Cap, Residential Water Replacement

This alternative is composed of the following components:

- Ground water, surface water, stream sediment and landfill gas monitoring,
- Site access and deed restrictions
- Residential connections to City water system,
- Drainage improvements
- Regrading
- 6NYCRR Cap.

SC 4: RCRA Cap, Residential Water Replacement

This alternative is composed of the following components:

- Ground water, surface water, stream sediment and landfill gas monitoring,
- Site access and deed restrictions,
- Residential connections to City water system,
- Drainage improvements,
- Regrading
- RCRA Cap.

SC 5 Ground Water Collection/Treatment/Discharge, Residential Water Replacement

- Ground water, surface water, stream sediment monitoring,
- Site access and deed restrictions,
- Residential connections to City water system,
- Drainage improvements
- Regrading and
- Ground water collection/treatment/disposal.

SC 6 6NYCRR Part 360 Cap, Residential Water Replacement, Ground Water Collection/Treatment/Discharge

The following components are included in this alternative:

- Ground water, surface water, stream sediment and landfill gas monitoring,

- Site access and deed restrictions,
- Residential connections to City water system,
- Drainage improvements
- Regrading
- 6NYCRR Part 360 Cap
- Ground water collection/treatment/discharge

SC 7 RCRA Cap, Residential Water Replacement, Ground Water Collection/Treatment/Discharge

The following components are included in this alternative:

- Ground water, surface water, stream sediment and landfill gas monitoring,
- Site access and deed restrictions,
- Residential connections to City water system,
- Drainage improvements,
- Regrading
- RCRA cap,
- Ground water collection/treatment/discharge

In addition to the previously mentioned documents utilized for the identification and initial screening of remedial technologies and process options, the following literature was used to enhance the development and descriptions of the potential remedial alternatives presented above:

- Requirements for Hazardous Waste Landfill Design, Construction and Closure (USEPA, 1988);
- Covers for Uncontrolled Hazardous Waste Site (USEPA, 1985);
- Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites (USEPA, 1988);
- Compendium of Costs of Remedial Technologies (USEPA, 1987).

4.2.1 Alternative SC 1: No Action

4.2.1.1 Description. The no action remedial alternative consists of a long-term ground water monitoring program in order to provide data for the assessment of the impact of leaving contaminated materials on-site on the underlying ground water. This response action does not include any physical remedial measures that address the problem of contamination at the site. The ground water monitoring program would utilize 30 of the wells installed during the remedial investigation at this site. Water samples would be taken on a quarterly basis from upgradient, on-site and downgradient monitoring wells and five surface water locations on Matthew Creek. Five sediment sample stations will be established on Mathew Creek and two samples (6-inch and 12-inch depths) will be collected at each station on a quarterly basis. Parameters to be sampled and analyzed are to be in accordance with 6NYCRR Part 360 baseline and routine parameters.

The no action response also includes the development and implementation of a public awareness and education program for the residents in the area surrounding the Johnstown Landfill Site. This program would include the preparation and distribution of informational press releases and circulars and the convening of public meetings. These activities will serve to enhance the public's knowledge of the conditions existing at the site. This alternative will also require the involvement of local government, and various health departments and environmental agencies.

Because this alternative does not include contaminant removal, the site will have to be reviewed every five years for a period of 30 years per CERCLA requirements, as amended. These five year reviews would include the reassessment of human health and environmental risks due to the contaminated material left on-site, using data obtained from the ground water sampling program.

4.2.1.2 Evaluation

Overall Protection of Human Health and the Environment. The no-action alternative does not include provisions for the treatment, removal or containment of on-site contaminated materials. Therefore, it would not provide adequate protection of human health and the environment since there would be no immediate reduction in the toxicity, mobility or volume of the contaminants. This response action does not include any measures to reduce the quantity of leachate generated by precipitation infiltrating the landfill, and contaminating the nearby surface water. In addition, contaminated ground water flowing through the landfilled materials will continue to migrate unimpeded and untreated downgradient to off-site locations. The no action alternative does not address the reduction of the potential health risk to residents via ingestion of contaminated ground water. For these reasons, this alternative does not meet any of the remedial action objectives. It is included in the detailed analysis as required, only to provide a baseline against which all other potential remedial alternatives may be compared.

Compliance with ARARs. This alternative fails to eliminate the source of contamination or remediate the ground water to acceptable health based standards. It does not satisfy any of the ARARs or TBCs.

Long-Term Effectiveness and Permanence. Because this alternative does not address the reduction of the mobility or concentration of the contaminants in the landfill mound at the site, and does not provide for ground water treatment, it does not satisfy the remedial action objectives developed for the site. For these reasons, the implementation of this potential remedial alternative will adversely impact the environment and public health, and is not considered to be an effective or permanent solution.

Reduction of Toxicity, Mobility or Volume. This alternative does not involve any containment, removal, treatment or disposal actions. It would leave the landfill mound intact. Migration of contaminants into ground water would continue by natural processes. Implementation of the no action alternative would not result in the reduction in the toxicity, mobility or volume (TMV) of contaminants which may exist in materials presently buried within the landfill mound.

Short-Term Effectiveness. This alternatives does not include any construction or other physical site activity. As a result, there would be no short-term threats to neighboring communities and no significant impacts on the environment or public health during its implementation. Implementation of this alternative would not result in any improvement over current site conditions.

Implementability.

Technical Feasibility. This alternatives does not require the installation of any additional equipment. The sampling of the existing ground water monitoring wells, surface water and sediment and subsequent laboratory analysis of the samples is readily implementable. The public education and awareness program, consisting of mailing printed notices to advise all private residences, businesses, and public agencies of the status of the site and convening public meetings, could easily be implemented. The services and materials required to successfully utilize this program are readily available in the region. Vendors would be available for competitive bids.

Administrative Feasibility. Implementation of this alternative would require a considerable amount of institutional management. The long-term monitoring program, public education program and the five-year site status reviews would require administrative and regulatory attention from local and State agencies on a periodic basis to ensure adequate information is being utilized and distributed.

Cost. The total present worth of this alternative is estimated to be approximately $1,859,038. This cost includes an annual cost of $119,150 which includes the quarterly sampling program. The convening of public meetings on a periodic basis (dependent upon public interest), newspaper submittals and literature distribution, and the site status review every five years is budgeted at $5,000 per review. The detailed information used to calculate these costs is contained in Appendices A and B.

4.2.2 Alternative SC 2: Limited Action, Residential Water Replacement

4.2.2.1 Description. The limited action alternative combines a program of ground water, surface water, and stream sediment monitoring with site access and land and ground water use restrictions. Additional actions would include alternative residential water supplies and regrading work for drainage improvements. The monitoring program would be the same as in SC 1. The analytical results of the ground water samples would be evaluated to determine the degree of natural attenuation taking place. A public awareness program would be implemented as described in Alternative SC 1 to ensure that the nearby residents are familiar with all aspects of this response action.

Site Access Restrictions. The site access restriction portion of this alternative consists of surrounding the entire landfill mound with approximately 6,800 feet of conventional chain-link fencing. Along the fence, at appropriate intervals, various warning signs would be placed that would identify the site as a Superfund site with limited access. One locked access gate would be provided to provide access for ground water sampling, turf maintenance, and review purposes by authorized personnel. In addition to the access restrictions, institutional controls will be implemented to restrict the use of the land because of the threat of contamination. This may occur in the form of local ordinances or deed restrictions.

Alternative Drinking Water Options. Along with the land use restrictions, City water would be supplied for any downgradient private water supplies impacted by the landfill.

Providing City water would require the extension of the City's water lines, and a booster pump station requiring major construction.

At least 24,600 feet of water line would have to be constructed to provide City water to all the residences potentially impacted. The capital cost of this option would be approximately $2,464,010. Assuming an operation and maintenance cost of $25,000 per year, a 30-year total present worth project cost of $2,848,321 would be anticipated.

Drainage Improvements and Regrading. As part of the Limited Action the landfill should be regraded to prevent stormwater from ponding on the landfill mound, and to allow rapid runoff from the site while minimizing soil erosion.

There are presently five locations where stormwater from the site is collecting. These areas are shown on Plate 1 (map pocket) and designated as E1, E2, E3, E4, and E5. The handling of each of these areas is discussed below, developing a preferred option for each area. This preliminary design work is required to adequately cost the regrading option. The area specific option discussion is followed by a discussion of the regrading requirements for the entire landfill site. All stormwater management options retain the water within the watershed by discharges to infiltration ponds (ground water discharge) upgradient of LaGrange Springs or discharges to Mathew Creek at LaGrange Springs. As a result, the existing water balance is maintained and impacts to wetlands are avoided.

Subcatchment area E1, in the northeast corner of the landfill, encompasses an area that has been landfilled. Stormwater ponds here from precipitation onto the landfill and runoff from Fulton Street Extension. Preliminary runoff estimates based upon the U.S.G.S. topography of the adjacent land, assuming 18 inches of runoff per year (National Water Summary, 1985), estimate that stormwater would pond at E1 from approximately 28 acres collecting an average of 13 million gallons per year. Since any water which collects at E1 must either leach through the waste or evaporate, rerouting this ponded water to another location will significantly reduce the leachate production of the landfill. Stormwater can be routed from this area by filling this low area, creating a stormwater ditch, constructing a gravity storm sewer, and/or building a pump station and force main.

Allowing the low area to continue to collect stormwater would continue to effectively handle stormwater flows, but would not reduce the leachate production. Filling the low area would cause the stormwater to pond on Fulton Street Extension, potentially creating a public nuisance. A diversion ditch, storm sewer, or pump station would effectively eliminate stormwater ponding.

Creating a diversion ditch would require excavation work. If the shortest route to lower ground is taken, the ditch would run across the landfill approximately 500 feet. At a minimum slope of four percent (per 6NYCRR Part 360), a vertical drop of 20 feet would be required between Fulton Street Extension and the discharge point. This would require the construction of a 20 foot deep v-trench, with sides of 33 percent (per 6NYCRR Part 360). Over 13,000 cubic yards of material, mostly landfilled waste, would have to be excavated during this construction. Given the health and safety issues involved in the excavation of heterogeneous waste material, this is not an acceptable option. Other ditch alignments would require even more excavation, and would not be able to stay within the present landfill property limits. Therefore, a ditch in this area would not be implementable.

Construction of a gravity storm sewer could be done at a more nearly flat slope such as 0.5 percent minimizing the excavation required. However, if the shortest alignment were used, some waste excavation would still be required. Furthermore, the high likelihood of the waste continuing to settle, would threaten the structural integrity of the storm sewer, potentially damaging the sewer causing it to leak. A leak could become a source of leachate production or if waste were above the sewer, leachate could enter the storm sewer and be transported with the stormwater. Therefore, the preferred alignment would keep the storm sewer outside the area of waste disposal as shown on Plate 1. This alignment would take the stormwater from the E1 area, and send it by gravity to a lower area either E5 or, with additional ditching, to E4. Maximum excavation depth would be approximately 20 feet, at the manhole in the northeast corner. The excavation to that depth would be minimized by the use of standard shoring techniques, and backfilled to grade upon construction.

A pump station could deliver water along the same route without the deep excavation work, and is easily implementable. A pumping station and force main would cost approximately the same as a storm sewer but would have much higher annual operating and maintenance costs, including electricity, and periodic maintenance of the pump. Failure of the pump station would cause the remaining low area to fill, potentially flooding Fulton Street Extension. Therefore, a storm sewer alignment outside of the landfilled wastes is the preferred method of handling this low area.

Subcatchment E2 is located west of and adjacent to E1, immediately upgradient to an area that has been landfilled. Stormwater ponds here from the landfill, and from Fulton Street Extension. Preliminary runoff calculations estimate that stormwater would pond on E2 from an approximately 12-acre watershed collecting an average of 5 million gallons each year. Stormwater can be routed from this area by filling this low area, creating a drainage ditch, constructing a gravity storm sewer, and/or building a pump station and force main.

Filling the low area would cause the stormwater to pond and leach into the soils further from the landfill. However, to be certain that no wastes were impacted, it would be necessary to allow ponding to occur only at a significant distance from the landfilled area or, at an elevation below that of the bottom of the waste (approximately 890). The nearest location meeting the elevation requirement is the gravel pit which receives the stormwater from subcatchment E3.

Filling the low area such that stormwater runs to the gravel pit would require extensive fill, but is implementable. Less fill would be required to move the area of ponding further from the landfilled wastes, but still a significant amount of clean fill would be required. Creating a diversion ditch would require extensive excavation work. If the shortest path to lower ground is taken, the ditch would run next to the landfill for a distance of approximately 600 feet. The maximum cut would be required about 200 feet from the present low area, and would have to be eight feet below the low area grade, thereby requiring an 18 foot deep cut, about 108 feet wide. This excavation would intercept the buried waste material. Given the health and safety issues involved in the excavation of waste material, this is not a preferable option. Other ditch alignments would require even more excavation, and would not remain within the present landfill property limits.

Construction of a gravity storm sewer at a more nearly flat slope such as 0.5 percent would minimize the excavation required. It should also be possible to align the sewer such that it is not placed over waste and only a minimum amount of waste excavated and removed, such as shown on Plate 1. This alignment would take the stormwater from the E2 area, and send it by gravity to a lower area at E3. A pump station could deliver water along the same route without the deep excavation work, and could be easily implemented. A pumping station and force main would be more expensive than the storm drain in this case since the amount of excavation saved would probably not equal the capital cost of the pumping station. Therefore, a storm sewer to area E3 is the preferred alternative for this area.

Drainage subcatchment E3, presently receives drainage from over 100 acres, only three of which are from the landfilled area. Over 49 million gallons per year would be expected to be handled in this area. The gravel pit acts as an infiltration basin where the surface water seeps into the soils and reaches the ground water. From the test pit work, ground water is approximately ten feet below the bottom of the gravel pit. There is no indication that any ground water, mounded by the infiltration in the gravel pit, intercepts the waste disposed of in the landfill.

The alternative to maintaining the gravel pit as an infiltration basin is to collect the ground water and transfer it by gravity or by pumping to another discharge area, the nearest being E4. The gravel pit is presently acting effectively as an infiltration basin. Given the elevations, it is unlikely that any water that collects and/or infiltrates there would come into direct contact with the landfilled wastes. Transferring the collected runoff to an area downgradient of the landfill could effect the ground water flow pattern of the area.

Using the gravel pit as an infiltration basin would be self-implementing. Extensive construction would be required for any other option given the 25+ foot embankment between the subcatchments E3 and E4. A ditch would be extremely difficult to construct in this area given the existing topography. A storm sewer would require significant excavation, and/or horizontal boring to run a pipe under/through the existing embankment. A pump station would be able to pump stormwater above the bank, but would be subject to extensive operating and maintenance requirements. Therefore, use of the gravel pit as an infiltration basin is effective, implementable, and the lowest cost option. There is no apparent advantage to the other options.

Drainage subcatchment E4, presently drains approximately 59 acres, 8 of which are from the landfilled area. The low area by the gravel access road apparently acts as an infiltration basin since no culvert has been found leading under the road. This area would be expected to handle approximately 29 million gallons per year. This area is hydraulically downgradient of the landfill. There is no indication that any ground water, mounded by the infiltration in the low area, intercepts the waste disposed of in the landfill.

The alternative to maintaining this area as an infiltration basin is to collect the stormwater and transfer it by gravity or by pumping to another discharge area, the nearest being Mathew Creek at the LaGrange Springs. Any of these options would provide effective stormwater management and would maintain the present water balance of the wetlands. Some construction would be required for any transfer option, however, the present topography appears suitable for relatively easy ditch or sewer construction. A pump station and force main is also feasible. Construction easements and/or purchase of the affected lands would be required. Wetlands issues may impact the outfall location and construction.

Maintaining this area as an infiltration area would be the least cost option, with only occasional cleaning required. A ditch or gravity sewer would be an additional cost since a sedimentation pond would have to be constructed in the infiltration area to minimize the transfer of sediments to the wetland. A pump station and force main would not provide any additional savings relative to the ditch or sewer construction. Continued use of this area as an infiltration basin is effective, easily implemented, and least cost option. Discharge to Mathew Creek offers no apparent advantage unless combined with treated ground water discharge as will be described in Alternative SC 5.

Drainage subcatchment E5, presently drains approximately 20 acres with an estimated annual runoff of 10 million gallons per year. The low area by the gravel access road is referred to as the LaGrange Gravel Pit and acts as both an infiltration basin and a ground water seep. This area is hydraulically downgradient of the landfill, with the lower elevations at or below the ground water detected in MW-3. Therefore, some leachate from the landfill seeps into the LaGrange pit. Since there is no outlet this ground water, along with the stormwater which collects here, must evaporate or seep back into the ground water.

Water quality data collected from the pit during RI field investigations indicated ARARs for several parameters were exceeded. Water quality samples collected in Round 2 exceeded both the NYSDEC surface water standards and the NYSDOH drinking water standards for iron, manganese, phenol, and 4-methylphenol. NYSDOH drinking water standards for total dissolved solids, acetone, methylene chloride, toluene, 2-butanone, and benzoic acid were exceeded in samples from Round 2. However in Round 3, NYSDEC surface water standard for iron and NYSDOH drinking water standards for iron and manganese were exceeded in water quality samples from the pit. Therefore, leaving this area to act as a ground water seep and infiltration basin presents a potential health risk due to the possibility of contact with landfill leachate parameters in the ground water.

An alternative to leaving the pit in place is to fill the pit with clean fill to an elevation four feet above the apparent seasonal high ground water elevation. This filled area could still be used as an infiltration basin, and/or an area to collect the stormwater and transfer it by gravity or by pumping to another discharge area, the nearest being E4.

This would effectively prevent the public or any vectors from coming into contact with any leachate seeps.

The pit would be excavated to increase its storage capacity and to remove fine sediments to enhance the infiltration rates. In addition, excavation would remove contaminants from the pit. All excavated sediments would be placed on the existing landfill and covered. The proposed topography appears suitable for sewer construction, but difficult for a ditch. A pump station would provide some potential construction savings over sewer construction, but has the operations and maintenance problem.

Sediment removal prevents contact with contaminants and allows use of the area as an infiltration basin to handle stormwater. Transferring the stormwater to another basin does not provide any advantages and may create impacts to wetlands by effecting the water balance.

Regrading. The landfill must be regraded such that stormwater will drain positively by gravity. In order to accomplish this a minimum slope of 4 percent is recommended. For slope stability a maximum slope of 33 percent is recommended by NYSDEC. Additionally, interception ditches are needed for every 20 feet of vertical drop on the banks for erosion control. Plate 2 (map pocket) shows a preliminary rough grading plan that can meet these requirements, and handles the existing subcatchments as discussed above. This plan changes the subcatchments somewhat, and thereby labels the "final" subcatchment F1, F2, F3, F4, and F5 respectively. This preliminary plan first attempts to minimize the amount of waste excavated for health and safety reasons. The second priority is to minimize the amount of fill required. Regrading and diverting the stormwater from area E1 would reduce the leachate production by about 36 percent. This equates to a reduction in the average annual leachate production from 24.2 million gallons (46 gpm) to 15.5 million gallons (29 gpm).

An alternative plan minimizing the cut and fill required for the site could be developed, however, a significant additional amount of landfilled waste would have to be moved creating potential health and safety issues. Costs for this type of plan would be difficult to estimate due to the potential requirement to operate in a high level of protection (level B or higher) for unknown periods of time and the increased potential for discovering localized wastes (i.e., drums) that would have to be characterized, and probably disposed of off site at a high cost. For these reasons, preliminary costs will be developed for the preliminary cut plan and not for the minimum cut and fill alternative.

Passive gas vents would be placed during the rough grading part of the work, and extended through the landfilled waste if an impermeable cap is later placed. If the impermeable cap is not to be immediately placed, the roughly graded landfill would have to be covered with six inches of loam, and the required permanent erosion controls (ditches, treatment swales, infiltration basins) placed. As part of the Limited Action Alternative, 18 inches of soil cover meeting a maximum of 1×10^{-5} cm/sec permeability would be placed over the landfill mound and six inches of top soil would be placed over the soil cover.

As stated previously in Alternative SC 1, a review of the site status would have to be conducted every five years for 30 years because there will be contamination remaining on-site. The five year reviews would include evaluation of sampling analytical data, reassessment of human health and environmental risks, and addressing public compliance with the institutional controls.

4.2.2.2 Evaluation

Overall Protection of Human Health and the Environment. This Limited Action alternative includes provision of partial containment of on-site contaminated landfill materials. However, no materials would be treated or removed from the landfill. Therefore, it would provide only limited protection of human health and the environment since there would be no immediate reduction in the toxicity or volume of the contaminants. The landfill materials would remain in place and the leaching of contamination into the ground water via infiltration of precipitation will continue at a somewhat reduced rate. This alternative consists of the installation of a fence to isolate the site and the use of institutional controls to restrict the future use of the property and ground water in the vicinity of the site, thereby preventing exposure to solid waste by humans or other vectors. By providing City water to the nearby residences, this alternative will minimize the risk of contaminated ground water ingestion and inhalation. It will minimize the risk of direct contact with contaminated landfill material, prevent the addition of more materials being added to the existing mound by restricting site use and access, and provide more information to the public regarding the ground water contamination. The discharge of stormwater runoff within the drainage basin would maintain the existing water balance conditions and avoid impacts to wetlands.

Compliance with ARARs. This alternative fails to eliminate the source of contamination to ground water or remediate the ground water to acceptable health based standards. It does not satisfy any of the New York State ARARs or TBCs. The proposed soil cover would meet 40 CFR 258, also known as Subtitle D, which is the Federal criteria for Municipal Solid Waste Landfills.

Long-Term Effectiveness and Permanence. This alternative only partially satisfies the remedial action objectives developed for the site because it does not address the reduction of the concentration of the contaminants in the landfill materials at the site. It provides no means for lowering the existing levels in the aquifer ground water to those levels required by New York State standards due to the slightly reduced leachate production and natural attenuation. The potential for contaminant migration into the ground water will still exist although at a reduced rate. The use of City water will reduce potential health impacts due to ingestion and inhalation of ground water. Therefore, the implementation of this limited action alternative could still adversely impact the environment and although potential public health impacts would be eliminated, it is considered to be ineffective. The limited action would require on-going monitoring and maintenance.

<u>Reduction of Toxicity, Mobility or Volume</u>. The limited action alternative only provides limited containment of the contamination at the site. It does not include any measures to provide removal, treatment or disposal of the contamination at the site. It would leave the contaminated landfill mound intact. Migration of contaminants into ground water would continue via natural transport processes albeit at a reduced rate. The limited action alternative would not result in the reduction in the toxicity or volume of contaminants but would somewhat reduce their mobility by the reduced leachate from regrading. This alternative does provide a means for eliminating contamination by replacing ground water from residential wells with City water for domestic purposes.

<u>Short-Term Effectiveness</u>. This alternative does include some substantial construction activity primarily in the regrading work to be done at the site. There would be some minimal short-term threats to neighboring communities consisting primarily of increased traffic, noise, and related dust, but no significant impacts on the environment or public health during the implementation of these limited activities is anticipated. The workers performing the remediation work consisting of fence installation, sampling, site inspection activities and regrading may potentially be exposed to contaminated materials. However, these personnel will be trained for work at hazardous waste sites and in the use of proper protective equipment for this site. This training will

minimize the risk of direct contact with contaminated ground water, soil and sediment. Implementation of this alternative would result in a substantial improvement over current site conditions. Eighteen to 24 months would be required to design, permit, bid, and construct the regrading plan.

Implementability

Technical Feasibility. The installation of the new security fence is an easily implementable task. The sampling of the existing ground water monitoring wells, surface water, and sediment, and subsequent analysis of the samples, and the five-year site status reviews could also be accomplished with little difficulty. The regrading work will require substantial construction effort but is readily achievable with standard construction techniques.

Monitoring the effectiveness of this alternative would be accomplished by the evaluation of the analytical results of the all samples and the reassessment of the risks associated with the site during the five-year reviews. In order to ensure compliance with the access and use restrictions enacted for the property, periodic surveillance of the site and residences would be conducted by local agencies. Extension of City water to replace private water supplies currently in use is readily achievable with standard construction techniques.

Availability of Services and Materials. The services and materials required to successfully implement this alternative are readily available in the area. The initial work required to install the fence could be completed in a short period of time. Installation of the City water system could be readily accomplished to serve the local site area. Numerous local contractors would be available to submit competitive bids for the performance of the work related to this alternative. The regrading work will require standard construction equipment. Contractors are readily available with the equipment and skills required. Health and safety training would be required for all workers. Specialty firms are available to do this work and/or training could be provided specifically for the site workers.

Administrative Feasibility. Implementation of this alternative would require significant long-term institutional management. Local law enforcement agencies may be enlisted to perform visual site inspection on a periodic basis to ensure the integrity of the security fence. The use restrictions on the property would require the attention of local municipal planning and zoning authorities to be enacted and enforced. Administrative issues related to the decision between establishing service contracts, water district, permissive use district or annexation of the area to extend City water services must be evaluated prior to implementing private water supply replacement. In addition, the public education program, the monitoring program and the five-year site status reviews would require administrative and regulatory attention from local and State agencies on a periodic basis to ensure adequate information is being utilized.

<u>Cost</u>. The total present worth of this alternative is estimated to be approximately $11,034,268. This cost includes capital cost of $8,342,622 for replacement of private

water supplies, the installation of the new fence, regrading, and the implementation of use restrictions, and an annual cost of $174,191. The annual costs for this alternative include the ground water, surface water, and sediments sampling and laboratory analysis, and maintenance of the fence and warning signs. The public education program and the site status review every five years are budgeted at $5,000 every five years. The detailed information used to calculate these costs is provided in Appendices A and B.

4.2.3 Alternative SC 3: 6NYCRR Cap, Residential Water Replacement

4.2.3.1 Description

The major features of this alternative include the construction of a multi-layer closure cap over the landfill mound, supply of City water to replace existing private wells, monitoring and erection of a security fence. The replacement of private water sources with City water, monitoring, use restrictions, fencing, public education and status reviews components are identical to those described in Alternative SC 2 and will not be repeated here. Prior to construction of the cap, the landfill mound would have to be regraded and compacted to provide a stable foundation for placement of the various layers of the cap and to provide positive drainage as described in SC 2. The cap is constructed of four layers; gas venting, barrier, drainage and topsoil.

Gas Venting Layer. The gas vent layer is used to collect any landfill gas that passes through the existing soil cover, and may collect under the impervious barrier layer. It also provides a smooth foundation for the barrier layer. The gas vent layer is typically a granular soil and 6NYCRR Part 360 requires that it be a minimum of 12 inches thick, contain less than 5 percent fines, and have a permeability greater than 1×10^{-3} centimeters per second. Alternatively a non-woven geosynthetic fabric could be used to provide the needed permeability and smoother foundation for the barrier layer. Gas vents are required at a spacing of approximately one per acre, and are to enter at least three feet into the landfilled waste. Given typical landfill construction, where the waste is placed in cells and covered with soil daily, and closed out areas are given a second "intermediate" cover, lenses of impermeable soils would be expected at various locations in the landfill. These lenses could prevent the gas from migrating up out of the landfill, unless the gas vents fully penetrate the landfilled waste. Accordingly the gas vents presented here are fully penetrating.

The results from the combustible gas survey at the landfill, indicate that gas venting is required. Use of a geosynthetic layer may be cost effective compared to providing the specified granular soil layer particularly if the existing cover soils or additional soils used for regrading are suitable to allow horizontal gas movement. However, the geosynthetic may have a low friction angle in relation to an impermeable geomembrane, thereby requiring flatter slopes and more fill material. The most cost effective method would have to be determined during the actual design phase. If a soil gas venting layer is used, 6NYCRR Part 360 requires it to be bounded on its upper and lower surfaces with a filter layer.

If the impervious barrier layer is a soil, the upper gas vent layer filter would be necessary to prevent fines from migrating into the gas vent layer, possibly clogging it. If the barrier were a geomembrane, the upper gas vent filter layer would not be necessary. The lower boundary gas vent filter provides permanent separation between the gas venting layer and the landfill cover materials. While some of the gas venting layer can be expected to be pressed into the cover material during construction, once the layer is placed and compacted, the amount of material that would continue to mix with the cover material is minimal. Therefore, the gas vent layer could be placed without the lower filter with only minimal additional risk to the vent layer, if the subgrade is adequately compacted, and of suitable granular material.

Barrier Layer. The impermeable barrier layer must be a permeability of less than 1 x 10^{-7} cm/sec. This is achieved typically by using either a geomembrane or a soil layer. If a geomembrane is used, it is required by 6NYCRR Part 360 to be at least 40 mils thick. The liner would be placed and overlapping seams would be "welded" together. Each seam would then have to be tested to make certain it was tight. Design concerns with a geomembrane include slope stability, anchoring, and adequate tensile strength. A soil barrier layer is generally clay, or a soil bentonite mixture, however, some wastewater sludges (specifically from the paper processing industry) have been successfully used. NYCRR requires a soil barrier to be at least 18 inches thick after compaction. It should be noted that reports on the effectiveness of soil liners indicate that liners less than

2.0 feet thick have a high probability of not meeting the 1 x 10^{-7} cm/sec standard (Daniel, 1990).

Extensive quality control is required for the placement of a soil cover. The material must meet the required permeability requirements. Furthermore, it must be broken into small clods (0.2 inches), and be within the required moisture content range. The material is then placed in approximately eight-inch lifts and compacted to six inches in thickness. The permeability and compaction is then field tested before the liner is accepted and the next lift is placed.

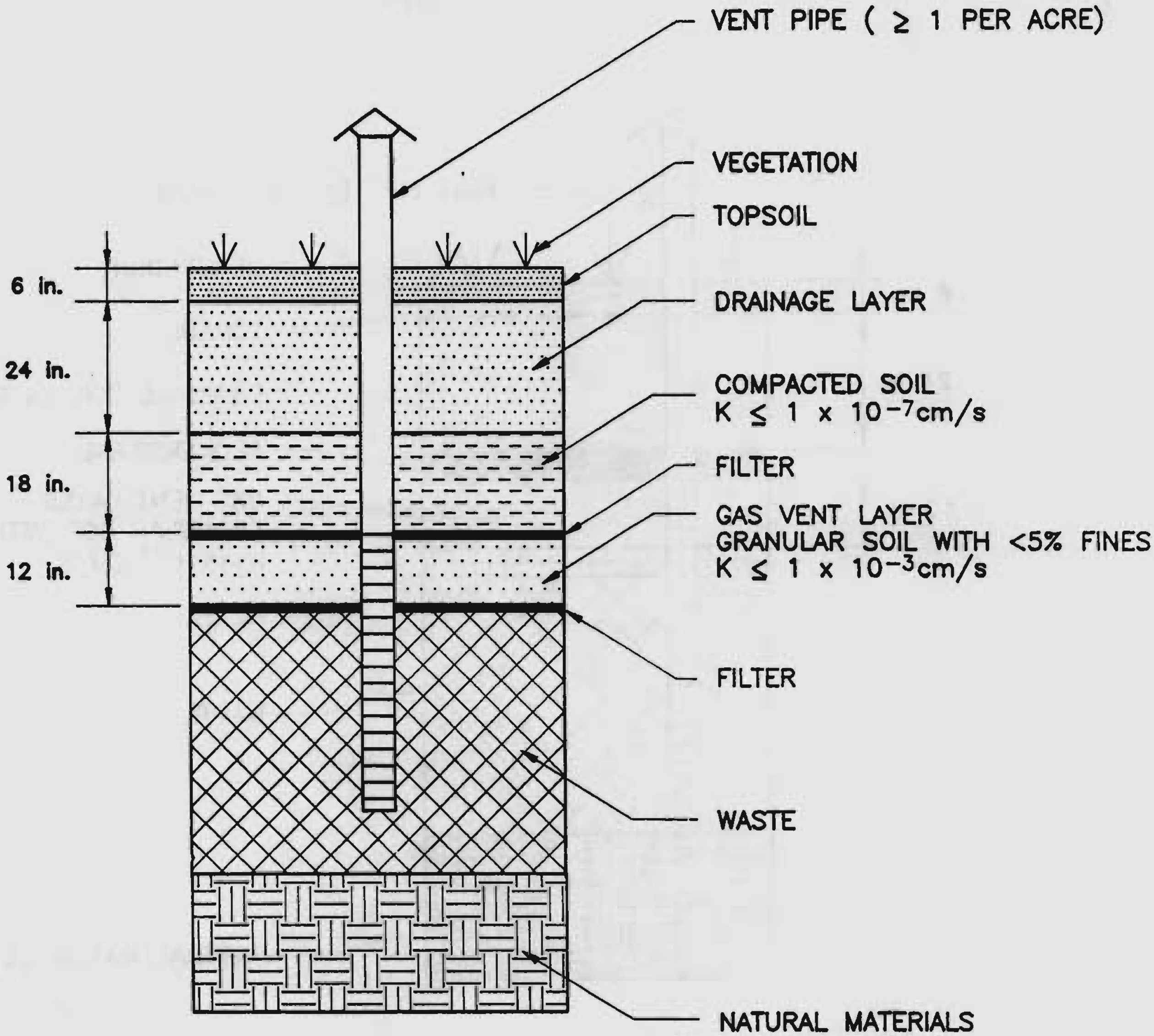
Drainage and Topsoil Layers. Water infiltrating through the upper layers of the cap will migrate to the barrier layer. A high permeability layer is required just above the barrier layer to carry the infiltrated water horizontally off the landfill site. The drainage layer also provides protection for the barrier layer from roots, frost, and any equipment that may be used over the cap.

Drainage can be accomplished either with a geotextile net, fabric, or composite, or with a high permeability soil. A geotextile can be placed without heavy equipment, and with minimal risk of damaging the liner. Soil will still be required to provide protection from roots, etc. 6NYCRR Part 360 requires the drainage layer above the liner to be 24 inches thick and the topsoil layer above that to be six inches thick. Preliminary calculations using the Hydrologic Evaluation of Landfill Performance Model (HELP Version I) indicate that an 18-inch drainage layer and a six inch topsoil layer above the liner would be the minimum requirement to prevent soil water from totally saturating the liner.

Depth of the protective layer required depends upon the need for frost protection, the vegetation used on final cover, and the final use of the site. A clay barrier layer can be damaged by freeze/thaw effects, whereas a geomembrane is not generally affected if appropriate quality control is observed. Therefore, a deeper protective layer would be required for a soil liner than a geomembrane. Using the Modified Berggren Program for determining the depth of freeze or thaw in layered soil systems from the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), a maximum frost depth of approximately ten inches would be expected. Therefore, 12 inches of drainage soils (with fines less than 15 percent) would be the minimum requirement to prevent the formation of ice lenses that could damage the cap.

A cap meeting the specific requirements of 6NYCRR Part 360 would consist of a filter fabric, 12 inches of gas vent layer, a 40 mil geomembrane (or 18 inches of clay), 24 inches of drainage material and six inches of topsoil (Figures 4-1 and 4-2).

Based on preliminary estimates using HELP, the NYCRR clay cap will reduce leachate to 1.46 million galls per year (2.8 gpm) or about 6 percent of the current 24.2 million gallons per year leachate rate. A well installed geomembrane NYCRR barrier could reduce leachate production to 4,188 gallons per year (.008 gpm) or about .02 percent of the current 24.2



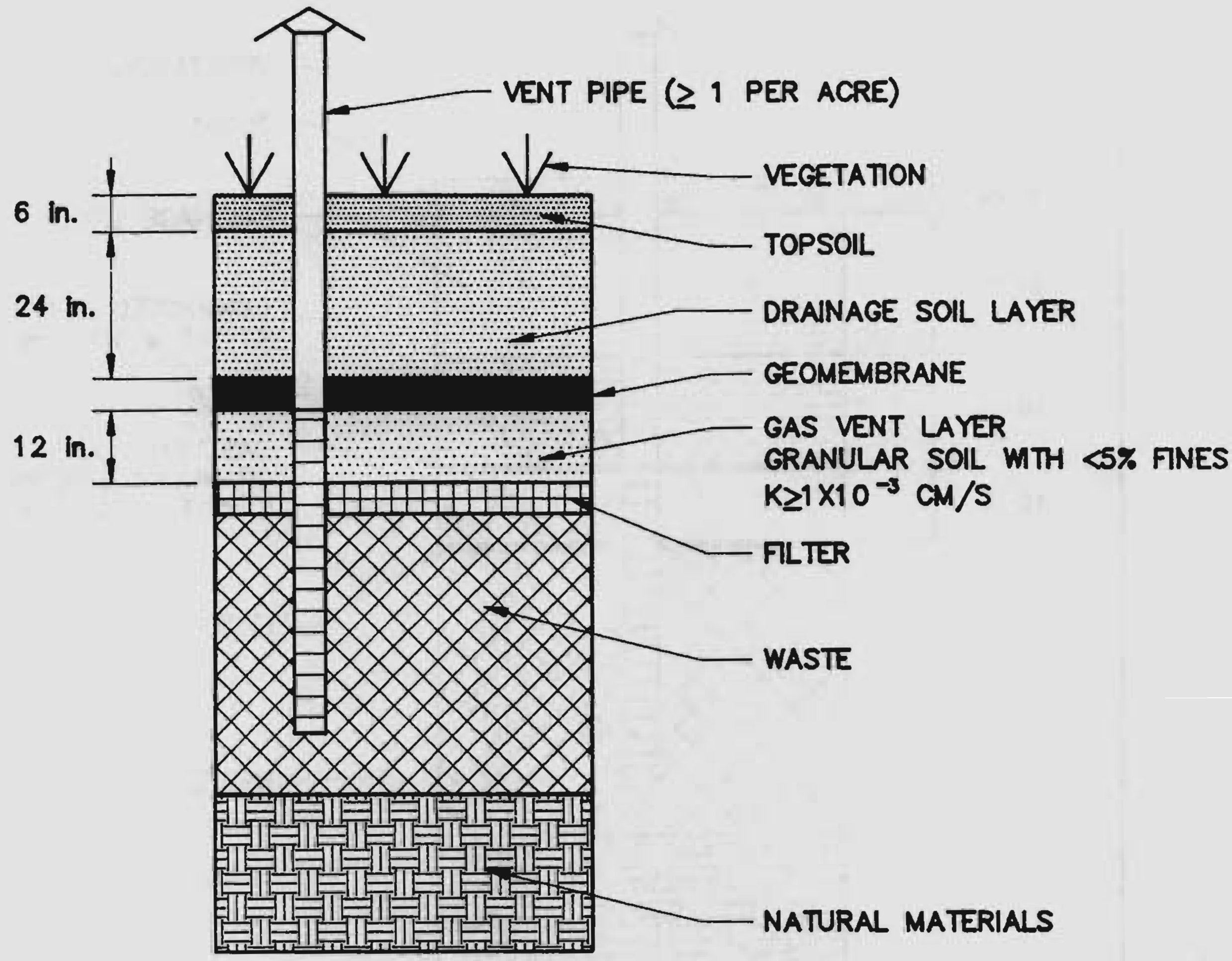
CITY OF JOHNSTOWN
JOHNSTOWN, NEW YORK

FIGURE 4-1

NYDEC LANDFILL COVER SYSTEM
WITH SOIL LINER

Thermo Consulting Engineers
10 Ferry Street, Box 7, Concord, NH 03301

0C3424-1
PLOT DATE: 8/27/92



CITY OF JOHNSTOWN
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FIGURE 4-2

NYS DEC LANDFILL COVER SYSTEM
WITH GEOMEMBRANE LINER

0C343-24/3-8
PLOT DATE: 5/18/92

Thermo Consulting Engineers
10 Ferry Street, Box 7, Concord, NH 03301

million gallons per year leachate rate. It should be realized, however, that the extremely low leachate rates predicted for the NYCRR cap with a synthetic liner are a consequence of the assumptions used in the HELP model for these liners. It is assumed that the liner is placed in a manner to avoid any leaks, tears or pulled seams, therefore, the leakage fraction is very, very small (.000001 in this case).

The NYCRR geomembrane system would cost approximately $200,000 per acre. This cost does not include the preliminary regrading work, but does include engineering and contingency.

Since the Johnstown Landfill was not designed or operated for hazardous wastes, and the RI found primarily municipal solid wastes, New York State regulations for municipal landfills would best apply to the closure requirements. Furthermore, a review of Table 2.3, shows that only a 15 percent reduction of leachate is required to lower the ground water concentrations below the highest observed background level. The leachate reductions brought about by capping can be expected to bring downgradient ground water concentrations in the same range as the upgradient levels. This reduction would meet the lowest levels found in the upgradient wells for all contaminants except iron and manganese, the only parameters that would be expected to exceed NYSDEC Ground Water Standards.

Therefore, for Alternative SC 3 a NYCRR cover will be assumed with a closure cost of approximately $200,000 per acre, not including the required regrading work.

4.2.3.2 Evaluation

Overall Protection of Human Health and the Environment. This alternative provides a level of protection superior to SC 2. The on-site soils remain in place, but are contained by an impermeable cap. The cap along with the security fence will prevent contact between humans or vectors and the contaminants in the soils. The impermeable cap will reduce the leachate production by over 94 percent. The contaminated ground water will not be removed or treated in any way. City water will replace private wells to protect human health from contact by ingesting ground water.

Compliance with ARARs. There are no New York State soil action ARARs or cleanup levels that pertain to this site. Therefore, no soil remediation levels or ARARs are applicable for the Johnstown Landfill Site.

This alternative does not provide an effective measure for reducing the level of contamination in the ground water aquifer other than by natural attenuation and reduction of leachate generation. This alternative would enable drinking water MCLs to be met at the ground water point-of-use by the replacement of private wells with City water as in Alternative SC 2. Capping does provide a means for reducing health risks by significantly reducing the contaminated leachate seeps due to stormwater infiltration. It is expected that all applicable action-specific and location-specific ARARs would be complied with during the design and implementation of this remedial action.

Long-Term Effectiveness and Permanence. This alternative could substantially satisfy the remedial action objectives identified for the Johnstown Landfill Site because it significantly reduces infiltration of precipitation into the landfill mound and may thereby reduce the mobility of the contaminants within the landfill materials. A properly designed and constructed closure system would provide a means of eliminating leachate formation as surface seeps, and improve ground water quality by reducing the quantity of leachate entering the ground water table. The use of City water is an effective method for eliminating any contamination in drinking and cooking water used in the household.

Reduction of Toxicity, Mobility or Volume. Implementation of the capping alternative could effectively reduce the mobility of the contaminants within the landfill materials, but would not reduce the toxicity or volume of these contaminants. Significant reduction of the rainfall infiltration will minimize the quantity of contaminated leachate generated from the landfill and would minimize the source of contamination due to seeps from within the landfill mound. This alternative provides no means for aquifer remediation other than natural attenuation. The capping option does not include any measures for reducing the toxicity, mobility or volume of the contaminated ground water. The use of City water at the point-of-use will reduce the risk from any landfill related contamination in the ground water that was used as a drinking water source.

Short-Term Effectiveness. The identifiable short-term risks associated with this alternative include on-site worker safety and environmental risks. Because constructing a cap over the landfill mound involves a significant amount of earthwork and will require the use of heavy earthmoving equipment, there is potential for work related accidents to occur. The use of proper operational procedures and construction techniques will minimize the risk of any on-site accidents. The short-term impacts on the environment would be the traffic problems and an increase in noise levels due to the construction activity. Because of the enormous quantities of material required for construction of the closure cap, it is estimated that over 10,000 truckloads will be delivered to the site. As a result, the additional traffic that is generated would cause noise and air pollution, a potential increase in accidents, and also put a strain on the existing roadways and traffic patterns.

An appropriate local traffic control plan would be implemented to manage trucks and other vehicles and reduce accidents, noise and airborne particulate matter. Proper dust control measures, such as water spray, would be provided to minimize particulate emissions. A soil erosion prevention and sediment control plan would be developed and employed during the remedial activities. The period for implementation of this remedial alternative is estimated to be 24-30 months.

<u>Implementability</u>.

Technical Feasibility. Preparation of the site would require the use of standard construction procedures and equipment for grading and compaction. These traditional earthworking operations and equipment are readily available in the local area. Health and safety training may require specialty crews. After the landfill mound has been regraded and compacted, the closure cap, including installation of gas vents and monitoring wells, may be easily constructed using standard, commercially available earthworking technology and equipment. The materials required for installation of the closure system, including sand, geosynthetic, topsoil and vegetation should be readily available. Installation of the monitoring wells and gas vents involves conventional well-drilling technology and can be accomplished by contractors in the region. The supply and installation of the geomembrane, or fabric filter, and the synthetic liner is available from numerous vendors. The supply and installation of the security fence is also readily available service and is easily accomplished. The extension of City water services to private homes is a technically reliable and effective method of replacing the existing drinking water source.

Availability of Services and Materials. All of the services and materials required for implementation of this alternative including supply and installation of the water treatment units, security fence and construction of the closure capping system are readily available. Numerous contractors are available for competitive bidding to perform the work included with this potential remedial alternative. All the work on the project may be performed by one contractor, or individual contracts could be developed for small portions of the project.

Administrative Feasibility. Implementation of this alternative would involve a fair amount of institutional administration. Construction activities may require coordination with local public safety agencies to regulate the additional traffic and to ensure public safety by restricting access to the site. Significant long-term management of an inspection and maintenance program to ensure the structural and functional integrity of the cap would be required. Administrative issues related to the formation of a water district, a permissive use district, establishing service contracts or annexation must be resolved to replace residential water supplies with City water.

The development and implementation of the monitoring program and subsequent five-year site status reviews would require the involvement of several concerned environmental agencies, such as USEPA and NYSDEC.

Cost. The total capital cost and annual operation and maintenance costs for implementation of this remedial alternative are estimated to be approximately $13,762,602 and $174,191, respectively. The total present worth of this alternative is approximately $16,454,268. Direct capital costs for this project include construction services and materials required for installation of the landfill cap, gas control vent system, City water services and security fence. Indirect capital costs consist of contingency costs, engineering and design services, and administrative services for management and procurement. Annual operating and maintenance costs include periodic inspection of the fence and cap and any necessary repairs, quarterly sampling and analysis. Costs for performing the five-year site status reviews is also included. The details of development of these costs are contained in Appendices A and B.

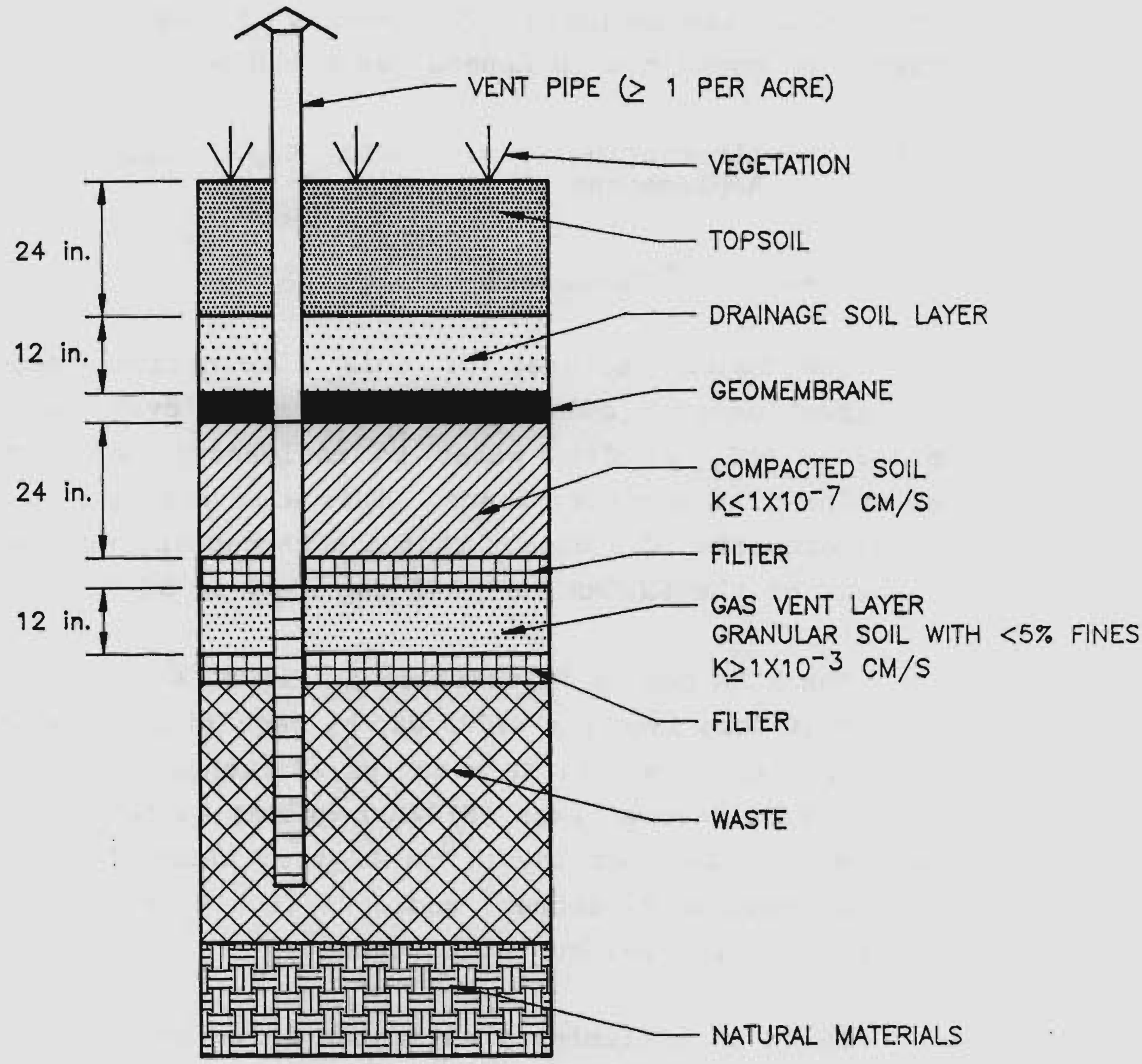
4.2.4 Alternative SC 4: RCRA Cap, Residential Water Replacement

4.2.4.1 Description

The major features of this alternative include the construction of a multi-layer closure cap over the landfill mound, supply of City water to residences, monitoring and erection of a security fence. This alternative is identical to Alternative SC 3 except that a RCRA capping system is used instead of the 6NYCRR Part 360 cap used in SC 3.

The RCRA cap is illustrated in Figure 4-3. This capping system differs from the NYCRR cap by requiring a 24-inch thick soil barrier layer (NYCRR requires 18 inches if soil is used) and a 40 mil geomembrane (NYCRR requires either the membrane or the soil barrier layer), a 12-inch thick drainage layer (NYCRR requires 24 inches) and a 24-inch thick topsoil layer (NYCRR requires 6-inch thick topsoil).

Based on preliminary estimates using HELP, the RCRA cap would reduce leachate to nearly zero or less than one percent of the current million galls per year leachate rate. It must be realized, however, that the negligible leachate prediction is a consequence of the HELP model's assumptions of zero permeability for synthetic liners. Actual leachate production may be greater depending upon leaks, tears or pulled seams.



CITY OF JOHNSTOWN
JOHNSTOWN, NEW YORK

FIGURE 4–3

RCRA LANDFILL COVER SYSTEM

0C343-22/3-8
PLOT DATE: 5/27/92

Thermo Consulting Engineers
10 Ferry Street, Box 7, Concord, NH 03301

The RCRA liner system cost is estimated to be $345,000 per acre (as compared to $200,000 per acre for the NYCRR system). This cost does not include preliminary regrading but does include engineering and contingency.

4.2.4.2 Evaluation

Overall Protection of Human Health and the Environment. This alternative provides a level of protection superior to SC 2 or SC 3. The on-site soils remain in place, but are contained by an impermeable cap. The cap along with the security fence will prevent contact between humans or vectors and the contaminants in the soils. The impermeable cap will reduce the leachate production by over 99 percent. The contaminated ground water will not be removed or treated in any way. City water will replace private wells to protect human health from contact by ingesting ground water.

Compliance with ARARs. There are no New York State soil action ARARs or cleanup levels that pertain to this site. Therefore, no soil remediation levels or ARARs are applicable for the Johnstown Landfill Site.

This alternative does not provide an effective measure for reducing the level of contamination in the ground water aquifer other than by natural attenuation and reduction of leachate generation. This alternative would enable drinking water MCLs to be met at the ground water point-of-use by the replacement of private wells with City water as in Alternative SC 2. Capping does provide a means for reducing health risks by significantly reducing the contaminated leachate seeps due to stormwater infiltration. It is expected that all applicable action-specific and location-specific ARARs would be complied with during the design and implementation of this remedial action.

Long-Term Effectiveness and Permanence. This alternative could substantially satisfy the remedial action objectives identified for the Johnstown Landfill Site because it significantly reduces infiltration of precipitation into the landfill mound and may thereby reduce the mobility of the contaminants within the landfill materials. A properly designed and constructed closure system would provide a means of eliminating leachate formation as surface seeps, and will improve ground water quality by reducing the quantity of leachate entering the ground water table. The use of City water is an effective method for eliminating any contamination in drinking and cooking water used in the household.

Reduction of Toxicity, Mobility or Volume. Implementation of the capping alternative could effectively reduce the mobility of the contaminants within the landfill materials, but would not reduce the toxicity or volume of these contaminants. Significant reduction of the rainfall infiltration will minimize the quantity of contaminated leachate generated from the landfill and would minimize the source of contamination due to seeps from within the landfill mound. This alternative provides no means for aquifer remediation other than natural attenuation. The capping option does not include any measures for reducing the toxicity, mobility or volume of the contaminated ground water. The use of City water at the point-of-use will reduce the risk from any landfill related contamination in the ground water that was used as a drinking water source.

Short-Term Effectiveness. The identifiable short-term risks associated with this alternative include on-site worker safety and environmental risks. Because constructing a cap over the landfill mound involves a significant amount of earthwork and will require the use of heavy earthmoving equipment, there is potential for work related accidents to occur. The use of proper operational procedures and construction techniques will minimize the risk of any on-site accidents. The short-term impacts on the environment would be the traffic problems and an increase in noise levels due to the construction activity. Because of the enormous quantities of material required for construction of the closure cap, it is estimated that over 10,000 truckloads will be delivered to the site. As a result, the additional traffic that is generated would cause noise and air pollution, a potential increase in accidents, and also put a strain on the existing roadways and traffic patterns.

An appropriate local traffic control plan would be implemented to manage trucks and other vehicles and reduce accidents, noise and airborne particulate matter. Proper dust control measures, such as water spray, would be provided to minimize particulate emissions. A soil erosion prevention and sediment control plan would be developed and employed during the remedial activities. The period for implementation of this remedial alternative is estimated to be 24-30 months.

Implementability.

Technical Feasibility. Preparation of the site would require the use of standard construction procedures and equipment for grading and compaction. These traditional earthworking operations and equipment are readily available in the local area. Health and safety training may require specialty crews. After the landfill mound has been regraded and compacted, the closure cap, including installation of gas vents and monitoring wells, may be easily constructed using standard, commercially available earthworking technology and equipment. The materials required for installation of the closure system, including sand, geosynthetic, topsoil and vegetation should be readily available. Installation of the monitoring wells and gas vents involves conventional well-drilling technology and can be accomplished by contractors in the region. The supply and installation of the geomembrane, or fabric filter, and the synthetic liner is available from numerous vendors. The supply and installation of the security fence is also readily available service and is easily accomplished. The extension of City water services to private homes is a technically reliable and effective method of replacing the existing drinking water source.

Availability of Services and Materials. All of the services and materials required for implementation of this alternative including supply and installation of the water treatment units, security fence and construction of the closure capping system are readily available. Numerous contractors are available for competitive bidding to perform the work included with this potential remedial alternative. All the work on the project may be performed by one contractor, or individual contracts could be developed for small portions of the project.

Administrative Feasibility. Implementation of this alternative would involve a fair amount of institutional administration. Construction activities may require coordination with local public safety agencies to regulate the additional traffic and to ensure public safety by restricting access to the site. Significant long-term management of an inspection and maintenance program to ensure the structural and functional integrity of the cap would be required. Administrative issues related to the formation of a water district, a permissive use district, establishing service contracts or annexation must be resolved to replace residential water supplies with City water.

The development and implementation of the monitoring program and subsequent five-year site status reviews would require the involvement of several concerned environmental agencies, such as USEPA and NYSDEC.

Cost. The total capital cost and annual operation and maintenance costs for implementation of this remedial alternative are estimated to be approximately $19,728,699 and $174,191, respectively. The total present worth of this alternative is approximately $22,420,344. Direct capital costs for this project include construction services and materials required for installation of the landfill cap, gas control vent system, City water services and security fence. Indirect capital costs consist of contingency costs, engineering and design services, and administrative services for management and procurement. Annual operating and maintenance costs include periodic inspection of the fence and cap and any necessary repairs, quarterly sampling and analysis. Costs for performing the five-year site status reviews is also included. The details of development of these costs are contained in Appendices A and B.

4.2.5 Alternative SC 5: Ground Water Collection/ Treatment/Discharge, Residential Water Replacement

4.2.5.1 Description

The major features of this alternative include regrading with a two-foot soil cover as described in Alternative SC 2, ground water collection, treatment and discharge, residential water replacement by City water, security fencing, and a monitoring program. The ground water treatment system would be located permanently at the Johnstown Landfill Site. Details of these processes and other unit operations required for a complete treatment system are presented below. The contaminant level in the treated ground water will comply with the surface water discharge standards for this site even though discharge to ground water is percolation ponds may be implemented. The discharge standards will be established by NYSDEC and regulated through a discharge permit (SPDES).

This remedial alternative includes provisions for interception, pumping, and collection of ground water, treatment of ground water, and discharge to surface water or ground water via percolation ponds, with a performance monitoring program. The major goal of this remedial alternative is to remove contaminants from the ground water leaving the site. The only downgradient receptors currently are primarily private residences who rely on the ground water for their potable water needs. These private ground water supplies will be replaced by City water thus no downgradient receptors will remain.

The contaminants of concern identified from monitoring well data are primarily heavy metals, and volatile organic compounds (VOCs). A review of ARARs has provided the criteria to identify those contaminants and develop treatment objectives for them, which will meet discharge requirements and reduce risk of exposure to acceptable levels. These contaminants identified at the landfill site as causing unacceptable risk include: lead, chromium, zinc, beryllium, and acetone. In private wells the primary contaminants of concern have been identified as beryllium, antimony, and tetrachloroethylene (PCE). Treatment for VOCs includes all those detected because it is expected they all will be removed by aeration because of their low concentrations.

Background concentrations of other water quality parameters indicate the ground water quality is marginal from an aesthetic viewpoint without any impact from the landfill. Many private well owners currently utilize point-of-entry/point-of-use (POE/POU) home treatment units to reduce unpleasant effects (taste/odor) due to elevated concentrations of the following:

- iron (Fe(II))
- manganese (MN (II))
- alkalinity (bicarbonate)
- pH

Elevated concentrations of these parameters are indicative of an extremely hard water, a water which, when used as a potable water supply, is likely to exhibit undesirable taste and odor characteristics, and cause staining of plumbing fixtures, and laundry. While these constituents do not necessarily endanger health, and as such, do not have primary drinking water standards, they are problematic. The presence in the ground water of unregulated constituents at concentrations orders of magnitude higher than the contaminants of concern will cause interference with removal of the regulated contaminants. The proposed ground water treatment system is evaluated on its ability to remove these secondary constituents out of necessity, in order to then accomplish removal of contaminants of concern.

The objectives of the ground water collection and treatment system are as follows:

- intercept the plume of contaminants leaving the site;
- treat the collected ground water to reduce the concentrations of constituents in the ground water to meet surface water standards.

It is possible that discharge to ground water via percolation ponds upgradient of LaGrange Springs maybe implemented. However, this option requires further analysis through pilot testing to size the ponds. It is expected that the cost differences between surface and ground water discharge are insignificant compared to treatment and interception costs. The surface water discharge location, if implemented, is assumed for this analysis to be the LaGrange Springs, an area where the water bearing formation thins to the extent that the shallow ground water aquifer flows out on the ground in the form of a stream. This stream forms the headwaters of Mathew Creek which flows easterly to Cayadutta Creek through the City of Johnstown and eventually to the Mohawk River. The stream is classified by the NYSDEC as a Class A surface water, and the water quality limits of this classification are used for the treatment objectives. The major features of Alternative SC 5 to accomplish the stated objectives follows below.

<u>Ground Water Extraction and Collection</u>. Based on results of aquifer tests and analysis of aquifer permeability, there are two options for ground water extraction that are

possible at the Johnstown Landfill Site. Because each of the options are technically feasible, conceptual cost estimates have been prepared for each option to ascertain which is more cost effective and complies more closely with ARARs.

The options are extraction utilizing drilled extraction wells and submersible turbine pumps, or, passive extraction utilizing a specially excavated and prepared interception trench with buried, perforated collection pipe. In theory, each of these options are capable of intercepting contaminated ground water plumes. The extraction wells and pumps manage this feat through induced ground water flow to the wells by drawdown development. The entire ground water flow leaving the site is collected by the creation of overlapping zones of influence of the extraction wells. With the trench, an interception barrier to ground water flow is created by excavating a trench perpendicular to ground water flow, and installation of a perforated pipe at the bottom. The trench is then backfilled with a porous, coarse granular material, such as crushed stone, or pea stone, which will allow the ground water to flow straight to the perforated pipe, to be carried away by gravity to a collection point.

In practice, although performing a similar function, the two options are markedly different in their implementation. Extraction wells are drilled and installed with minimum disturbance of the surface and the water table without any special measures. The installation of a pump introduces the mechanical aspect with associated operation and maintenance concerns. The pumps also require electrical power. Electrical service must be provided to the site from a distance, and distributed to each well. Bringing ground water to the surface for conveyance adds the requirement of cold and adverse weather protection to the conveyance system.

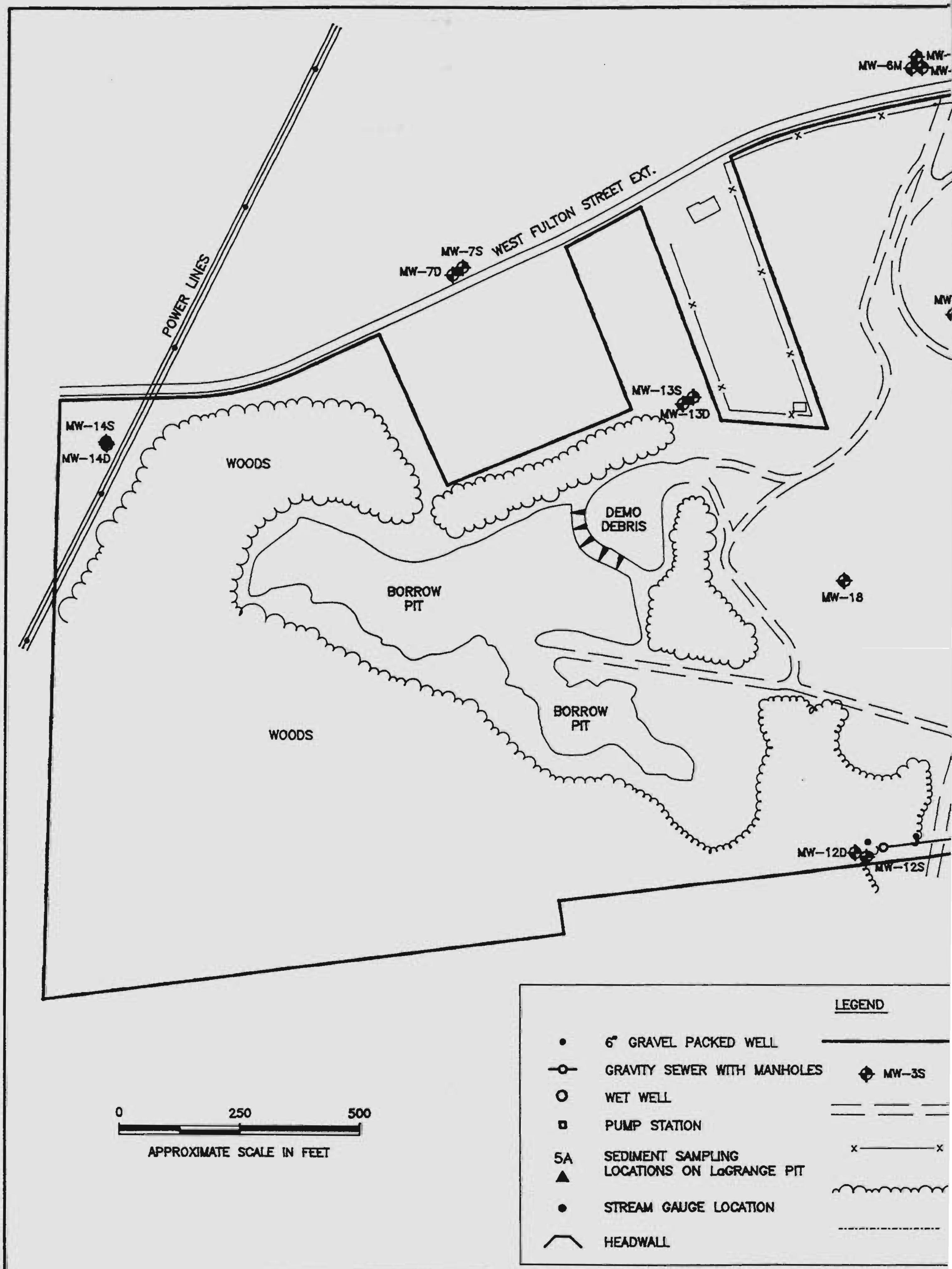
The obvious advantages of interceptor trench collection are that the mechanical aspect is eliminated, along with the need for a power supply and any operation or maintenance activity. The extraction system is a conveyance system as well. Trench excavation is necessarily intrusive, however and complicated at this site. Although specialty contractors have perfected the technique of excavating, placing the pipe, and backfilling in a continuous process, minimizing the disturbed area under construction, the need for trench bracing, shoring, dewatering, and excavation soils disposal remain as disadvantages. The handling and disposal of dewatering discharge and excavated soils is likely to be complicated by the presence of contamination. This issue in some instances cannot be reconciled with ARARs and remedial objectives.

In general, experience has shown that trench installation is more cost effective than wells if extraction well spacing must be closer than 100 feet. The practical limit on trench depth because of the machinery currently employed is 22 feet deep. At the Johnstown landfill, the shallow aquifer extends to bedrock, 33 feet below the surface. Pumping tests and ground water flow modeling have determined that a well spacing of 200 feet would be sufficient to intercept the plume. In order to construct the interceptor trench, preliminary excavations would be performed to get the pipe placing equipment to an appropriate working elevation. This preliminary excavation would amount to approximately 27,000 cubic yards of soil, possibly contaminated with heavy metals. In addition, the ARARs identified for this site would force the treatment of dewatering water prior to discharge. Even with conservative well spacing of 100 feet, the preliminary cost estimate for trench construction is the same as the estimated cost of extraction wells before adding in the trench dewatering and excavated soil disposal costs. Based upon this evaluation, the installation of a collector trench is ruled out from further analysis.

In order to develop a conservative cost estimate and assure that the entire plume of contamination is contained and/or recovered, 20 extraction wells placed at 100 feet horizontal spacing are proposed on the easterly and southerly borders of the landfill. The proposed arrangement is delineated in Figure 4-4.

Each of the wells discharges to the common collection line which runs parallel to the line of extraction wells on two sides of the landfill. The collection lines, essentially gravity sewers, convey the contaminated ground water to a collection sump. A pumping station mounted over the sump transfers the ground water from the sump to the ground water treatment system. From computer-assisted analysis, the estimated ground water recovery rate is 700 gpm.

Ground Water Treatment. As stated, the ground water treatment system has been studied for feasibility in meeting objectives corresponding to primary drinking water standards for lead, chrome, zinc, ammonia and VOCs. In order to accomplish this, the ground water must first undergo an

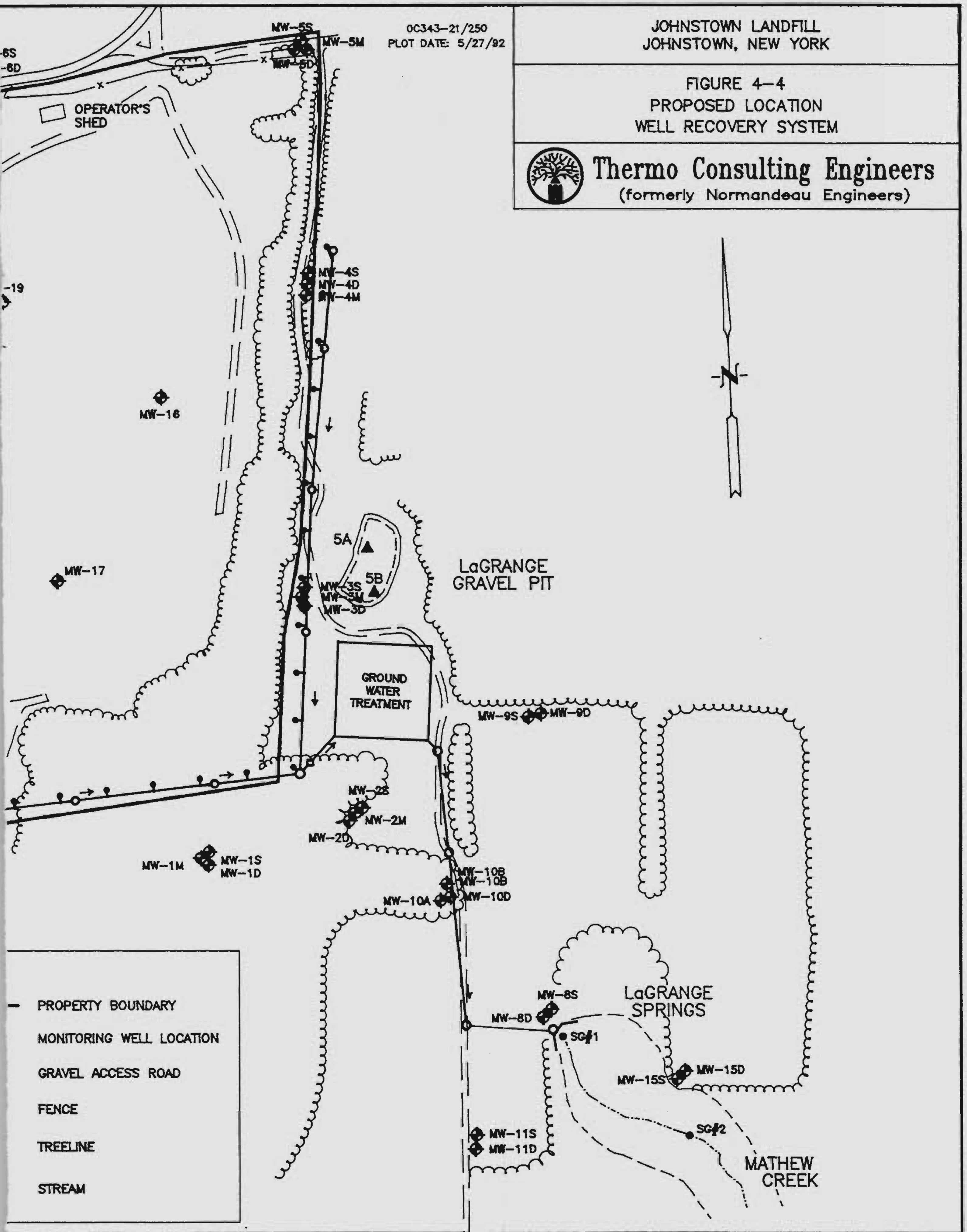


MW-6M
MW-7S
MW-7D
WEST FULTON STREET EXT.
POWER LINES
MW-13S
MW-13D
MW-14S
MW-14D
WOODS
DEMO DEBRIS
BORROW PIT
MW-18
BORROW PIT
WOODS
MW-12D
MW-12S
0
250
500
APPROXIMATE SCALE IN FEET
LEGEND
6" GRAVEL PACKED WELL
GRAVITY SEWER WITH MANHOLES
WET WELL
PUMP STATION
5A
SEDIMENT SAMPLING LOCATIONS ON LaGRANGE PIT
STREAM GAUGE LOCATION
HEADWALL
MW-3S

JOHNSTOWN LANDFILL
JOHNSTOWN, NEW YORK

FIGURE 4-4
PROPOSED LOCATION
WELL RECOVERY SYSTEM

Thermo Consulting Engineers
(formerly Normandeau Engineers)



extensive level of treatment to reduce the concentrations of iron, manganese, ammonia, and other inorganic constituents that will interfere with lead, chrome, and zinc removal.

In order to reduce lead, chrome, and zinc to meet discharge standards, an estimated ninety-five (95) percent reduction from influent concentrations is required. The most common and effective means of accomplishing the removal of dissolved heavy metals from solution is through pH adjustment, and chemical precipitation, as either a hydroxide (with caustic addition) or a carbonate (with lime addition) precipitate.

Because each metal has a different pH value at which it's insolubility is greatest, effective removal of mixtures of heavy metals is a compromise solution. Because of this, and also because clarifiers are not generally 95 percent efficient in capturing solids, a polishing step is needed. For this application, filters using granular activated carbon (GAC) media are considered. In addition to capturing coagulated metal colloids, the adsorptive ability of the carbon will be utilized to remove the remaining soluble fraction of heavy metals and will remove VOCs. This ability to remove metals can be further enhanced by adding chelating agents to solution to hold dissolved metals (especially the different soluble species of lead) in solution. The chelating agents are more adsorbable than the dissolved metal species and their removal by the carbon bed will optimize removal of any dissolved heavy metals.

A chemical precipitation step requires pH adjustment in order to promote precipitation. The expected pH of the ground water is likely to be above 7.5 S.U. (standard units). The pH of greatest insolubility for chromium hydroxide is about 8.5 S.U., and for lead hydroxide it is reported to be in the range from 7.5 to 9.0 S.U. The relatively high pH of the extracted ground water will help to minimize the amount of caustic added to drive the pH up and cause precipitate to form.

At pH greater than 8.2 to 8.4, carbonate ions will begin to be measurable and exert their influence, especially on dissolved lead. The solubility of the various lead carbonate species varies with respect to a number of water quality conditions, i.e. pH, alkalinity, and the presence of competing ligands, such as natural humic substances and other metal ions. Lead hydroxide and carbonate species have very narrow ranges for optimizing their removal in a precipitation system. The optimum pH for removal of lead and for removal of chrome is close enough that they can be optimized through pilot testing or simple bench-scale jar tests. If zinc must also be removed due to its presence in extracted ground water at levels in excess of what can be discharged, coprecipitation of all three of these metals becomes problematic.

The pH associated with greatest insolubility of zinc hydroxide is well over 9.0 S.U., a level which will resolubilize lead and may tend to oxidize Cr(III) to Cr(VI), increasing its solubility and reverting this metal to its more toxic form. The presence of carbonate alkalinity, fulvic and humic substances, and natural silicates from the ground water, complicates the precipitation of these metals into insoluble hydroxide or carbonate species will be a compromise solution, and not be completely effective for removal of all metals. Recognizing this, a polishing filter, usually employed following precipitation, will not in itself be completely effective. It will remove carry-over suspended solids from the clarification step. Soluble metals, complexed metals and VOCs remaining in solution (sequestered) will require a specific separation step if treatment objectives are to be met. The proposed process will utilize granular activated carbon in a deep bed gravity filter. The bed of carbon shall be of sufficient volume to provide 15 minutes of empty bed contact time. The carbon will also provide particle filtration and entrainment of carry-over solids from the precipitation process. Other adsorption media (i.e., activated alumina) or natural zeolites exist which have high capacity to remove dissolved metal ions. The activated carbon is suggested due to its ability to adsorb ammoniated compounds, VOCs and its demonstrated ability as an all purpose adsorbent.

Unfortunately, although a membrane process or ion exchange process would undoubtedly be more effective as a removal process for these dissolved metal ions of concern, the presence of competing ions (i.e., sodium, calcium, and carbonate) in higher concentrations makes application of these processes unfeasible. The use of high technology separation processes would require treatment of the ground water to levels much cleaner than required by the discharge standards.

The combination of the metal precipitation and carbon adsorption steps are proposed to remove the heavy metal and VOC contamination from the ground water prior to discharge. These two treatment processes are at the end of the treatment train, however, due to the extremely high concentrations of dissolved iron, manganese, and ammonia present in the ground water. These contaminants, along with severe hardness, must be dealt with initially prior to focusing on removal of heavy metals and VOCs.

Due to the flowrate expected (700 gpm) several types of proven high volume, high load iron and manganese removal systems were briefly evaluated. These include

- lime/soda-ash softening
- manganese greensand
- iron oxidation/degassification
- iron coprecipitation

A rather new, innovative, and low-tech alternative was also evaluated, biological removal of iron and manganese.

Although most of these technologies are proven, some have decided drawbacks. A softening process, while having advantages such as being able to coprecipitate all metals (i.e., lead, chrome, and zinc) in solution in one step, has the disadvantage of requiring large quantities of lime, or soda ash (up to 3000 pounds per day), and producing up to 8,000 pounds per day of sludge. The quantities are vast and would required several trucks per day entering and leaving the site. A suitable disposal site for this sludge is not available within a two-hour drive of the site because it is anticipated to be a RCRA waste. Actual classification of the sludge would be done during pilot testing and prior to its shipment off-site (assuming ground water treatment is implemented).

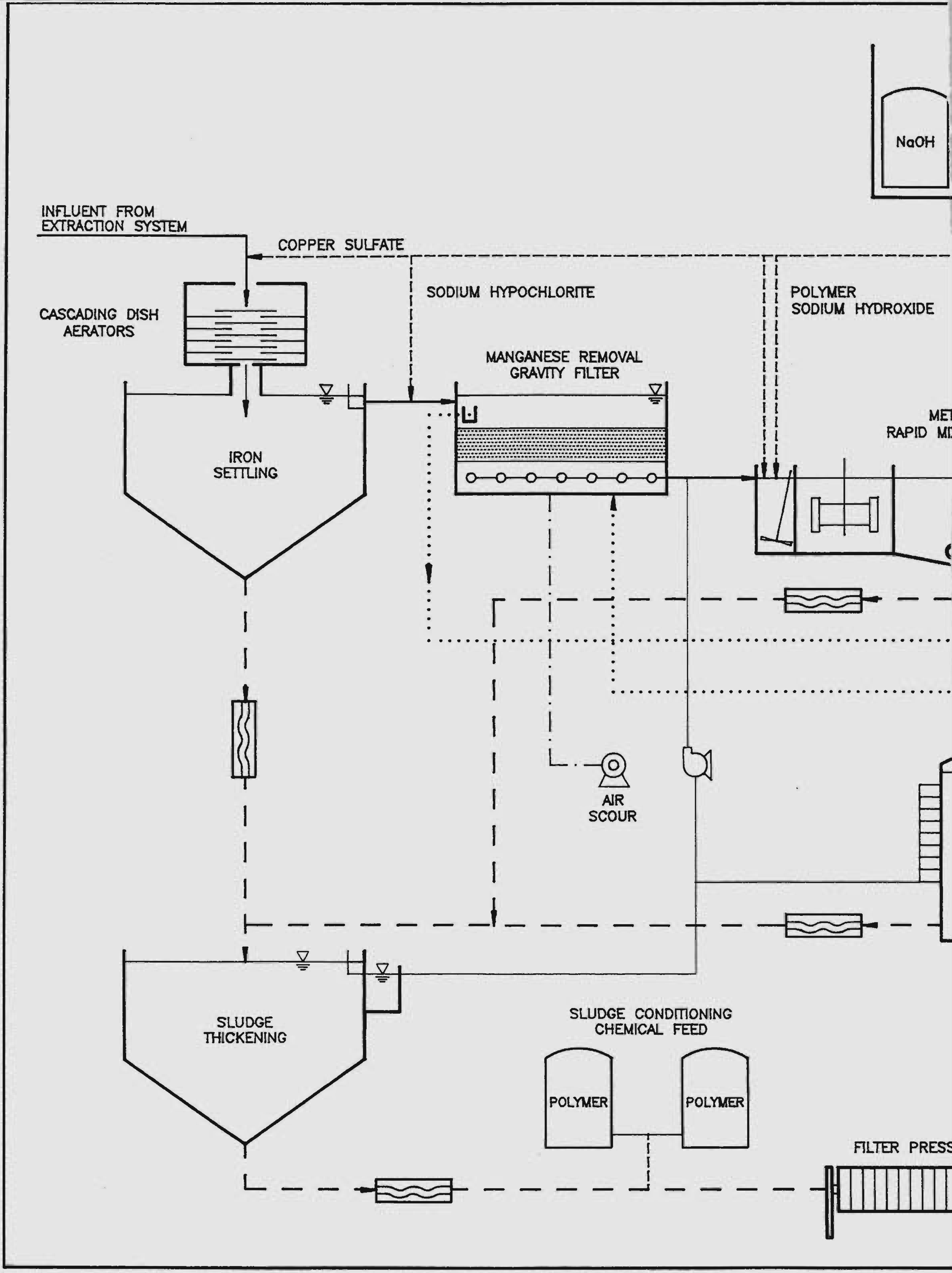
A manganese greensand process is primarily used in pressure filters, and would be preceded by a patented iron oxidation and filtration step (Aqua-Ferrox), also utilized in a pressure filter. These processes have the disadvantage of requiring pumping, and at the loadings anticipated, would require backwashing too frequently to avoid high head loss build-up and subsequent breakthrough.

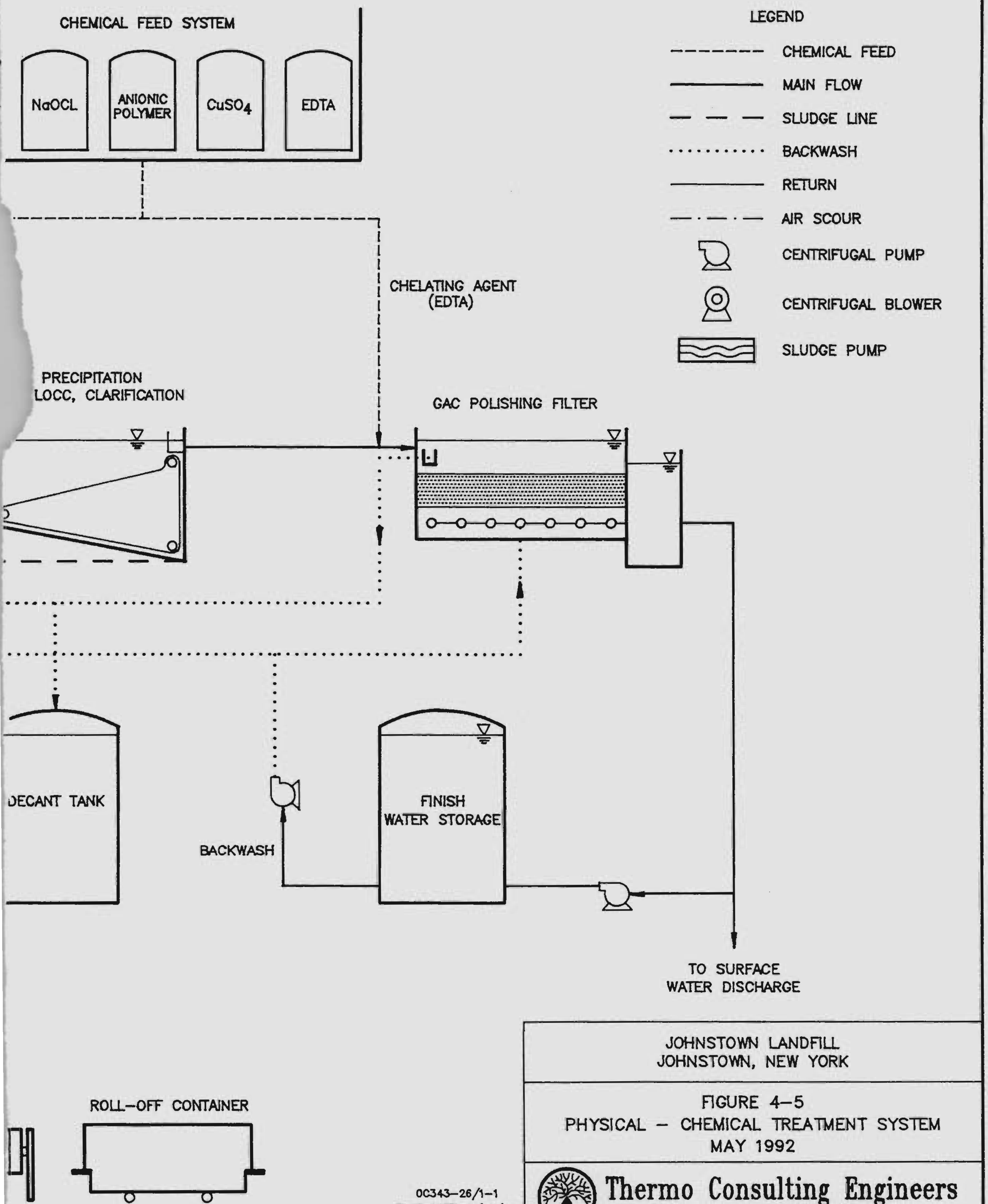
Dissolved gasses such as hydrogen sulfide, and carbon dioxide are not present in this ground water due to elevated pH. However, degassification, cascading dish, or tray aerators are considered to be an effective means of completely oxidizing the dissolved iron in the ground water and would also contribute to VOCs removal. Following this passive aeration step, a clarifier is utilized to accomplish passive removal of iron. In the tray aerator VOCs are volatilized via air stripping and soluble iron is converted (thru oxidation) to its ferric form, which forms an insoluble precipitate, ferric hydroxide in the presence of the excess hydroxyl ions in solution at pH over 7.5 S.U. This initial step will passively remove almost 3,000 pounds per day of ferric hydroxide sludge, easing the burden on downstream processes.

Following removal of the gross iron concentration, the next step is designed to reduce MN(II) concentration. Although iron and manganese are often found together in ground water, their chemistries, and subsequently processes for their removal differ. Manganese is oxidized rapidly by oxygen at pH greater than 9.5. Because raising pH to 9.5 is impractical, a stronger oxidant is required. Sodium hypochlorite is chosen as the oxidant for this feasibility study due to its chlorinating aspects as well as serving as an oxidant. The addition of chlorine in sufficient amounts to produce a residual concentration to oxidize manganese will also form chloramines from dissolved ammonia. The chloramines and any remaining VOCs are adsorbable on GAC as discussed previously. Once free chlorine is available after the "breakpoint" reaction is satisfied, it's concentration is increased stoichiometrically to oxidize the MN(II) to MN(IV). A weight ratio of 1.29 mg Cl per mg MN(II) is required to oxidize the manganese. A dose of 6.45 mg/L is needed at the estimated MN(II) concentration of 5 mg/L for oxidation. A dose of 38 mg/L is estimated to reach breakpoint. The total dose of 44.45 mg/L corresponds to approximately 300 gpd of 15 percent sodium hypochlorite solution. Because of the quantity of sodium hypochlorite involved, testing and evaluation of other oxidants may be warranted.

Once oxidized, the typical method of forming a precipitate with hydroxide would require raising the pH to approximately 8.5. Since this would require large quantities of caustic, and the concentration of MN(IV) is so high, a passive removal process is recommended. In practice, it has been found that manganese dioxide (black precipitate), when allowed to build-up as a coating on sand media, acts as an adsorbent for preferential removal of more MN(IV) from solution. Studies of filters in operation at water treatment plants have shown the ability to remove 0.5 moles MN(II) per mole of $MNO_{x(s)}$ coating at pH values above 7.0. This removal is accomplished in two mechanistic pathways. Soluble MN(II) is adsorbed on the surface of the oxide coating. Since it is only adsorbed, the process is rapid and limited only by the number of adsorption sites present. The potential for desorption exists, however, if the pH or surface chemistry of the $MNO_{x(s)}$ changes. In the presence of free chlorine, MN(II), following adsorption is oxidized to $MNO_{x(s)}$ forming additional coating and regenerating adsorption sites. The filter is backwashed with air and water occasionally to remove the oxide coating. This backwashing is performed in response to head-loss development. The use of air scour introduces the necessary energy to create collisions in the fluidized media bed and further removes VOCs through air stripping. The collisions and abrasions between the grains of media loosen the oxide coatings so they may be carried out by the backwash water.

This physical-chemical option for VOCs, iron, manganese and ammonia removal is depicted in Figure 4-5 in combination with the metal precipitation and activated carbon adsorption processes. The physical-chemical process described herein has been focused primarily on the removal of VOCs, iron, manganese, ammonia, and heavy metal contaminants. Excluding the VOCs this list of constituents exists in ground water at concentrations orders of magnitude higher than other constituents. There does exist in the ground water trace


NaOH
INFLUENT FROM
EXTRACTION SYSTEM
COPPER SULFATE
SODIUM HYPOCHLORITE
POLYMER
SODIUM HYDROXIDE
CASCADING DISH
AERATORS
MANGANESE REMOVAL
GRAVITY FILTER
IRON
SETTLING
AIR
SCOUR
SLUDGE
THICKENING
SLUDGE CONDITIONING
CHEMICAL FEED
POLYMER
POLYMER



JOHNSTOWN LANDFILL
JOHNSTOWN, NEW YORK

FIGURE 4-5
PHYSICAL – CHEMICAL TREATMENT SYSTEM
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levels of several VOCs. Water quality data from monitoring wells indicate ARARs for several VOCs were exceeded, which includes the compounds of benzene, vinyl chloride, acetone, methylene chloride, toluene, xylene, ethylbenzene, and chloroform. However, other than acetone, the detection of many of these VOCs has been inconsistent and often at concentrations much lower than concentrations of acetone. It is expected that treatment of ground water to the discharge standards of acetone would effectively eliminate levels of the other VOCs that might be present in the pumped ground water. With aeration steps at the beginning and activated carbon at the end of the treatment system, maintaining levels of these compounds below discharge standards seems assured.

An alternative to the complete physical-chemical treatment system described above is biological treatment for removal of iron, ammonia, and manganese prior to heavy metal precipitation and activated carbon adsorption/filtration. Although not a common approach in this country, application of biological treatment is gaining favor in Europe, especially in France on ground waters containing relatively high quantities of dissolved iron (Fe(II) >1 ppm) and manganese (MN(II) >0.1 ppm).

The application of biological treatment makes use of the family of anaerobic bacteria that utilize the energy released from oxidation of Fe(II) and MN(II) (an exothermic reaction) to reduce CO_2 and metabolize carbon as food source. These same bacteria are commonly a nuisance in the operation of production wells, and are removed when their profligate populations create clogging problems in the well screen. In the biological iron removal process, the bacteria's growth is encouraged.

The iron removal rate is impressive, and this process works extremely well at high rates owing to the phenomenon that almost 600 moles of Fe^{++} is needed to assimilate one mole of carbon. The bacteria that are suited to this environment adsorb dissolved iron from solution and oxidize it with absorbed dissolved oxygen, in order to capture the energy intracellularly. The species of bacteria are typically filamentous organisms that collect the oxidized and precipitated iron compounds on the stalks and filaments associated with their growth.

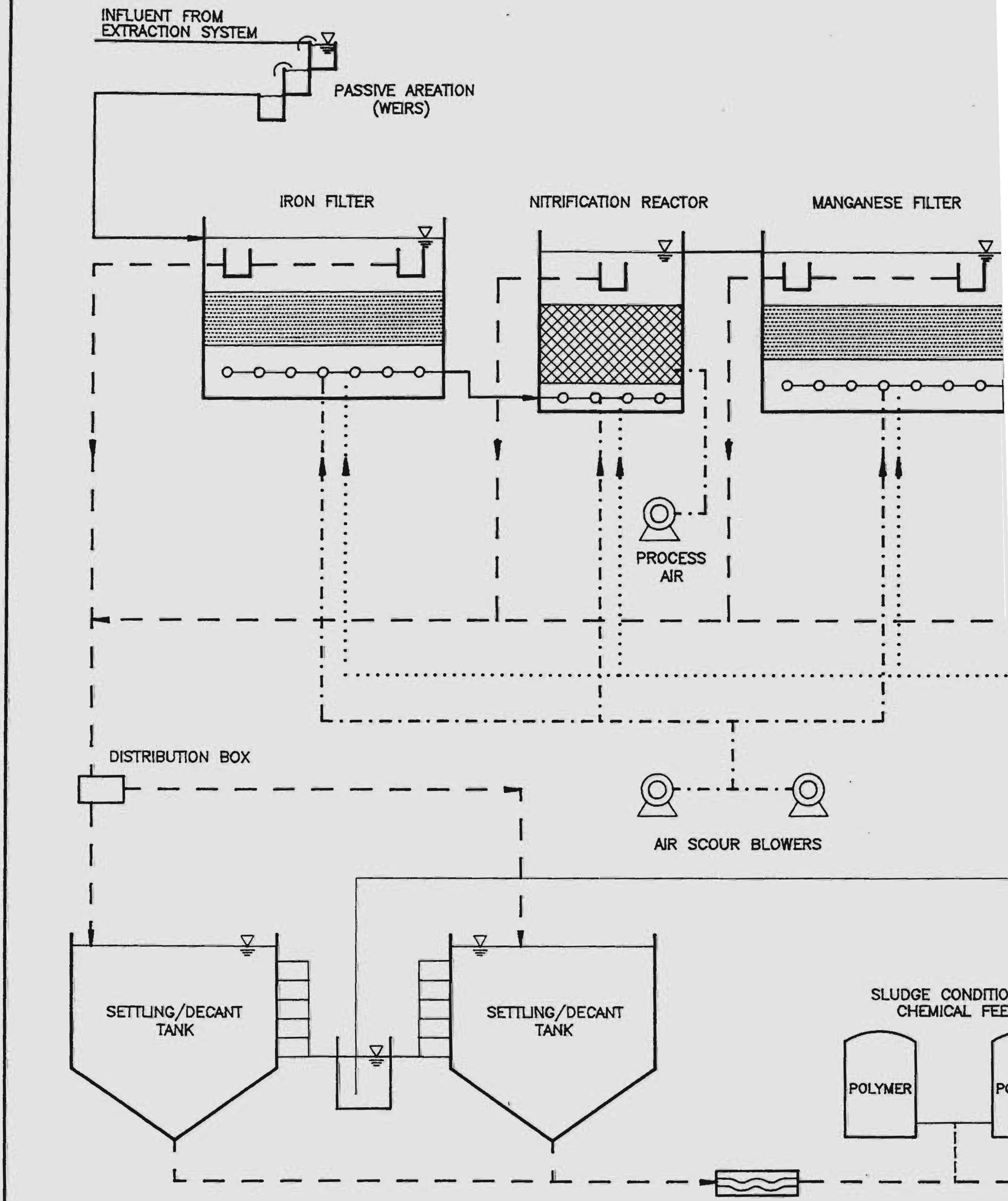
The feasibility of the biological iron removal process is ultimately determined by the correct relationship between pH and Eh (redox potential). The oxygen requirement for this process is precise and confined to a certain range. Oxygen is generally added passively, through simple surface transfer when falling over weirs. In acidic waters (pH <6) even intensive aeration is unlikely to raise the value of Eh to the desired range. In overly alkaline waters (pH >7.5) physical-chemical phenomena predominate over biological (i.e., iron is rapidly oxidized by all available oxidizing agents).

Biological manganese removal is accomplished with similar principles but by different bacteria and under higher pH conditions required for oxidation by oxygen. Because of these differences, manganese and iron removal are typically performed in separate reactors by different cultures. When water contains ammonia, complete nitrification must be accomplished because of the necessary adjustment of the Eh parameter.

All of the process units, the iron and manganese filters, and the nitrification biofilter, are all backwashed to remove excess biological solids (wasting). The nitrification process requires air supplied by a blower through diffusers. The biological process for removal of iron, manganese and ammonia is shown in Figure 4-6. If raw water conditions are right, the bacteria will remove these constituents without chemicals, and produce less sludge.

Because of it's limited availability at present, and lack of pilot data, it is not possible to even conceptually size reactors for this process, or to generate cost estimates. As the application of this process becomes more widespread, further investigation into its use and piloting.

Ground Water Discharge. The treated ground water can be discharged either by returning it to the ground water, or by discharging to a stream, the nearest being Mathew Creek. Discharge to ground water is preferable to surface water discharge because wetlands impacts can be avoided. Both surface water and ground water discharge options retain the intercepted ground water within the drainage basin and maintain the existing water balance of Mathew Creek, thus wetlands impacts are minimized. Presently stormwater is handled by infiltration, therefore, it is reasonable to assume that the treated ground water could be discharged to an infiltration gallery or basin, or injection wells. Permeability studies in the location of the infiltration basin



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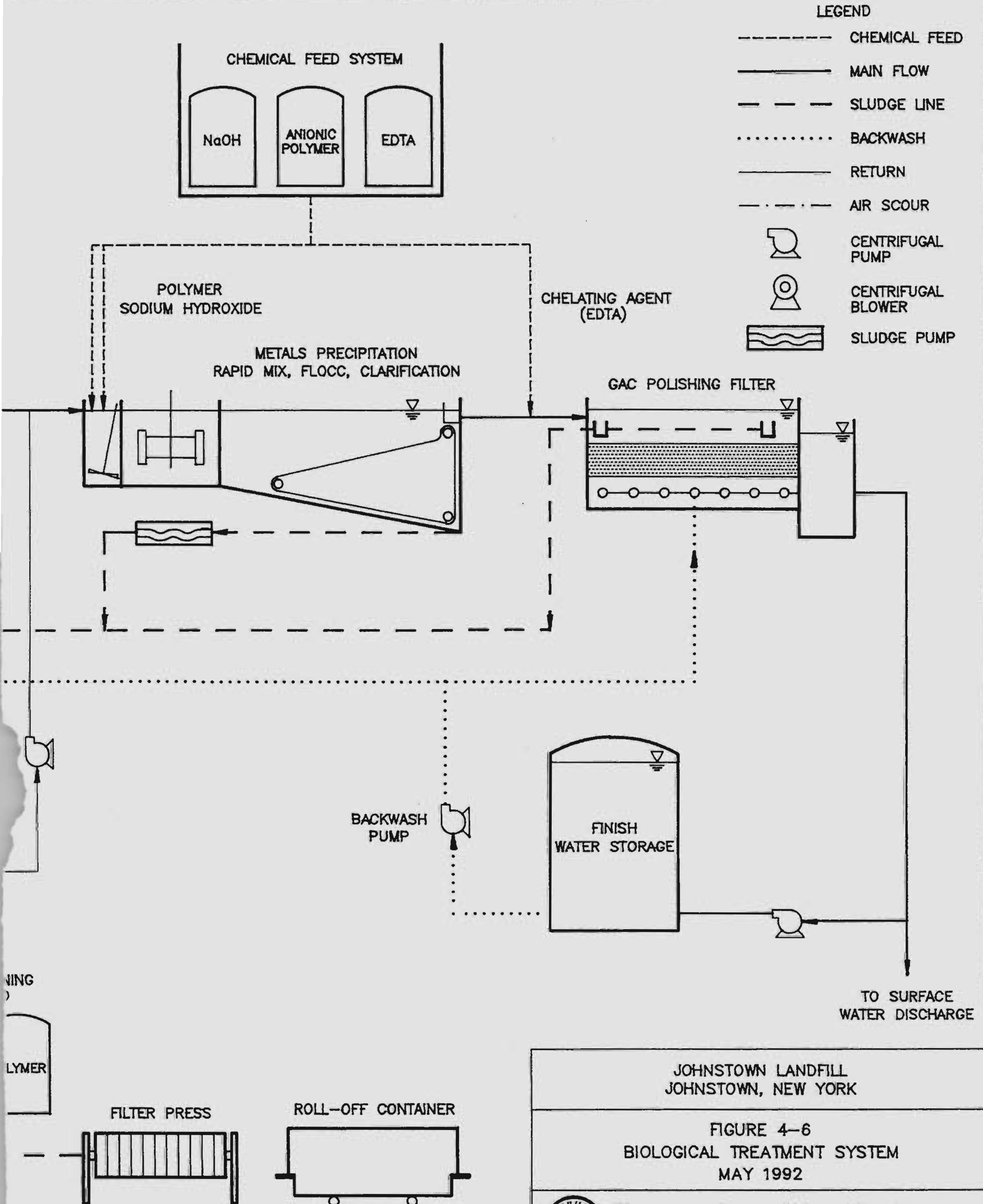

JOHNSTOWN LANDFILL
JOHNSTOWN, NEW YORK

FIGURE 4-6
BIOLOGICAL TREATMENT SYSTEM
MAY 1992

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would have to be conducted to determine the necessary size of such structures and a complex manifold would have to be designed to properly distribute the discharge. The location of the infiltration structures would have to be determined to prevent interfering with the collection wells. Surface infiltration techniques would probably require a large land area which would have to be obtained from adjoining properties. Injection wells would also have to be placed on adjacent properties, but would require far less construction.

Alternatively, a discharge line could be constructed to Mathew Creek. Such a line would be effective and easily implemented, but would require the acquisition of a permanent easement for the line, and the acquisition of wetlands permits for the outfall. The outfall would be distributed to diffuse the discharge over a wide area similar to the present ground water seeps in order to minimize hydraulic changes at the stream's headwaters.

Given the uncertainties involved with discharge permits and land/easement acquisition neither system has a clear cost advantage. However, for the purpose of this alternative ground water discharge is preferred.

4.2.5.2 Evaluation

Overall Protection of Human Health and the Environment. Alternative SC 5 would remove the contamination from the aquifer beneath the landfill, and would ultimately eliminate downgradient migration of contaminated ground water. Implementation of the pump and treat option would reduce the toxicity, mobility and volume of contaminants present in the landfill leachate and ground water by removing them completely from the aquifer. This treatment could be continued as long as necessary to control the spread of contamination generated by the leaching landfill materials, and ensure ground water quality. The treated effluent will meet applicable surface water discharge standards. The SPDES permit will be the regulatory standard to ensure that standards are met.

Compliance with ARARs. The ground water extraction and treatment processes in this alternative would achieve all MCLs and health based clean-up levels for ground water. The ground water treatment operations will be engineered to effectively reduce heavy metal, VOCs, and ammonia concentrations to below Federal and New York State standards. The treated ground water will subsequently be discharged to the LaGrange Springs area to maintain the existing water balance and minimize wetlands impacts, and the release of this effluent will be conducted in accordance with New York SPDES requirements and all other applicable surface water quality regulations. It is expected that most identified action-specific and location-specific ARARs would be complied with during implementation of this remedial alternative. NYCRR's requirement for an impermeable cap would not be met. The pumping and treatment system will be designed, constructed, operated and closed in conformance with Federal and State RCRA facility standards and OSHA standards for worker protection. All site construction activity will be conducted to prevent fugitive emissions and adverse impacts to the environment and wildlife. Further, all treatment residuals would be treated to comply with the Land Disposal Regulation requirements. Any waste which is classified as RCRA characteristic waste will be so labeled and marked to comply with federal and state hazardous waste transportation requirements and disposed of at an appropriate facility.

<u>Long-Term Effectiveness and Permanence</u>. This alternative would satisfy most of the remedial action objectives identified for the site, which included prevention of precipitation infiltration into the landfill and reduction of ground water contaminant concentrations. The regrading and soil cover would reduce stormwater and snowmelt percolation through contaminated materials, and the ground water extraction and treatment system provides a means of removing aquifer contamination. The remediation would continue until the concentrations of the contaminants of concern in the ground water influent to the treatment facility are equal to or below applicable MCLs and health-based cleanup levels or are statistically equivalent to levels detected upgradient of the landfill. For purposes of this feasibility study, it is assumed that the operational time period will be at least 30 years. This is because of the uncertainty of the affects of the aging and decay process on the landfilled materials.

Potential public health risks and adverse environmental impacts could be mitigated by proper design, engineering, and construction during the implementation phase of the project. Health hazards to treatment plant workers exist as a result of the use of the various reagents and chemicals for the processes, however, the development and enforcement of safe operating procedures, training and precautions will greatly reduce this risk.

Dewatered clarifier sludge containing mostly precipitated metallic hydroxide sludge would be disposed at an off-site facility. Moderate risk to the community from increased traffic during transportation of treatment residuals is expected along with the increased hazard of transporting potentially hazardous materials and the associated potential of accidental spill due to truck accidents along the transportation route. Implementation of a traffic control program including a specified trucking route should minimize this concern.

All the components of the treatment system are commercially available and have been used for similar ground water treatment processes. The process residuals such as sludge from precipitation could be handled by an off-site RCRA disposal facility. Regular performance monitoring to maintain long-term effectiveness would include checking for metal removal efficiency.

Reduction of Toxicity, Mobility or Volume. This alternative would offer an overall reduction of the toxicity, mobility and volume of the contaminants of concern by extracting and treating the contaminated ground water from the aquifer below the landfill. The pumping system would control the mobility of the contaminants by collecting ground water immediately downgradient of the landfill. This contaminated ground water would be treated for compounds present above surface water quality requirements, thus reducing the toxicity of this ground water.

The metals precipitated and settled out of suspension would be taken off-site as a dewatered sludge for further treatment, such as solidification to minimize their leachability, and ultimate disposal.

VOC removal is anticipated to be largely accomplished by air stripping created during the aeration processes of the treatment train. It is anticipated that releases of the VOCs to the atmosphere will be within acceptable limits. However, pilot testing will be necessary to determine VOC release rates to the atmosphere and the need for exhaust treatment.

Short-Term Effectiveness. Potential risks of on-site workers during implementation of this remedial alternative consist mainly of construction hazards and accidents due to the nature of the site work. The installation of the ground water extraction wells has the potential for worker exposure to contaminated ground water. Construction activities such as grading and compacting for placement of the soil cap could cause dust. Excavation for pipeline installation and building foundations could expose workers to contaminated materials. These types of hazards and exposure risks will be minimized through the employment of proper construction techniques and practices, and the utilization of effective dust control measures, such as water spray. A soil erosion and sediment control plan would be implemented to prevent off-site migration of potentially contaminated materials.

Health and safety training and the use of personnel protective equipment will ensure worker safety. The site area will be surrounded by a secure fence and traffic controls would be instituted in the area to maintain public safety. The traffic concerns and noise impacts due to the construction activity as described in the evaluation of Alternative SC 2 would be addressed in a similar manner. The total time required for implementation of this alternative including additional testing, design, contract procurement and site work is estimated to be four to five years. The soil cover could be placed within two years but the additional treatment system pilot design and permitting would require additional time even if the work proceeded concurrently.

Implementability. This discussion will focus on the ground water extraction, treatment and discharge portion of this alternative. The implementability of the regrading and soil cover cap was described in the evaluation of Alternative SC 2 and will not be repeated.

Technical Feasibility. The conventional unit operations included with this alternative such as pumping, aeration, chemical precipitation, clarification, and filtration have been used extensively to treat ground water contaminated with metals and VOCs. This treatment scheme has been employed at hazardous waste sites and also incorporated into normal operations at many industrial facilities. All the components of this alternative are well developed, commercially available and have easily adjustable operating parameters. The selection of this equipment is not expected to cause any major technical problems which could lead to schedule delays. Construction of the facility and equipment installation involves standard techniques and can be accomplished by local contractors. Land area at the site to locate the treatment facility, including a building and any ancillary equipment that may be required and the discharge line, will require a land easement or purchase.

Routine operation and maintenance procedures for the process equipment are required to ensure achievement of the treatment goals. During the operation of the system, its effectiveness would be monitored by periodic analysis of the contaminant concentrations in the treated ground water before discharge. Ground water sampling and analysis is readily available and involves standard procedures.

Availability of Services and Materials. The treatment systems for this alternative are conventional wastewater treatment processes and can be readily fabricated. Several suppliers are available for every type of equipment or technology required for this alternative. Competitive bids can thus be obtained from more than one vendor. Similarly, specialists are available for the design, construction and operation of this alternative as required. The process residuals generated from the alternative could be transported to an approved off-site RCRA disposal facility. Local contractors could be utilized during the implementation of this alternative for a major portion of the work.

Administrative Feasibility. The administrative requirements for this alternative include those described earlier as part of the evaluations for Alternative SC 2. This potential remedial alternative would require extensive institutional management to ensure its proper operation, maintenance and overall execution. It must be in compliance with Federal, State and local environmental and transportation regulations with regard to storage, handling and disposal of the process residual wastes, such as sludge and spent carbon. Discharge of the treated ground water to the nearby LaGrange Springs would necessitate obtaining a SPDES from the NYSDEC and compliance with its effluent limitations. Periodic monitoring of the discharge, and reporting of analytical results is a condition of this permit.

Long-term ground water monitoring would be required to measure the performance of the treatment system and the cap. Five-year reviews would be essential in assessment of the effectiveness of this alternative in terms of contaminant concentration reductions by ground water extraction and to implement appropriate alterations in the treatment process. Although time consuming, the tasks associated with coordinating the management of this alternative are feasible and implementable.

Cost. The total construction cost of this potential remedial alternative is estimated to be approximately $12,754,017 including materials and construction services, and also indirect costs such as engineering services and management. The annual costs associated with operation of this alternative are approximately $762,025. This cost includes operating and maintenance expenses for the treatment system equipment, institutional management such as sampling and analysis. The total present worth of this alternative is $27,159,855. The details of these costs are presented in Appendices A and B.

4.2.6 Alternative SC 6: 6NYCRR Part 360 Cap, Residential Water Replacement, Ground Water Collection/Treatment/Discharge

4.2.6.1 Description

This alternative consists of the following: construction of a multi-layer NYCRR closure cap over the landfill mound as in Alternative SC 3; treatment of extracted ground water followed by discharge preferably to ground water as in Alternative SC 5 (to be implemented if monitoring does not show rapid declines in contaminant concentrations after capping and during treatment system pilot testing); supplying City water to local residents; implementing ground water, surface water, sediment and landfill gas monitoring programs; and erecting a security fence around the landfill as in Alternative SC 2.

A full description of each action is found in the appropriate alternatives. It is expected that this alternative would be implemented in phases. Construction of the multi-layer closure cap over the landfill mound and replacement of residential water with City water would occur initially. The extension of City water to residences to replace private well water sources eliminates the principal health risk identified by the Risk Assessment. The ground water extraction and treatment component of this alternative would be done at a later date after pilot testing is completed if monitoring results do not demonstrate contaminant concentrations are declining. As described in Section 4.2.3, Alternative SC 3, the impermeable cap will reduce leachate production to the extent that eventual ground water quality downgradient of the site will be similar to the upgradient quality. Because the rate of contaminant decrease cannot be predicted with certainty (see Appendix D for discussion) monitoring would be performed to document the expected declining trends. Reviewing the effectiveness of this alternative and the need for ground water treatment would be accomplished by the evaluation of the monitoring results, assessment of ground water quality trends and reassessment of risks related to the site during the five-year reviews. If the trend of contaminant decline is too slow, the ground water extraction and treatment system would be constructed after pilot testing is completed and operated. This alternative becomes identical to Alternative SC 3 if ground water extraction and treatment is not implemented.

4.2.6.2 Evaluation

Overall Protection of Human Health and the Environment. The capping portion of this alternative is discussed fully as Alternative SC 3. In brief, capping would reduce the amount of contaminants discharged to the aquifer below the landfill by significantly reducing percolation of precipitation. This measure would also reduce the source of surface water contamination from landfill leachate seeps.

Mobility, toxicity and volume of overburden would be reduced via the ground water pump and treat system if monitoring indicates contaminant concentrations are not declining following capping. Extension of the City water system would provide residents with an uncontaminated potable water supply.

Compliance with ARARs. There are no soil remediation levels or New York State ARARs that pertain to the Johnstown site. A study of the site soils and sediments shows that there is no health risk associated with these media, and, therefore, no soil or sediment remediation actions have been proposed.

As in Alternative SC 5, the ground water extraction and treatment processes would enable achievement of all MCLs and health-based cleanup levels for ground water. The supply of City water to residences will ensure a potable water supply that is in compliance with chemical-specific ARARs. It is expected that all design and implementation activities will comply with both action-specific and location-specific ARARs as described in Alternative SC 5. Unlike SC 5, NYCRR's requirement for an impermeable cap would be met.

Long-Term Effectiveness and Permanence. This alternative could satisfy all of the remedial objectives for the Johnstown Landfill Site as described in Alternative SC 5. Ground water extraction and treatment if needed provides a means of removing aquifer contamination. The remediation would continue until the concentrations of the contaminants of concern in the ground water influent to the treatment facility are equal to or below applicable MCLs and health-based or background cleanup levels. This alternative may provide a permanent solution for ground water contamination, depending upon the design and construction of the cap. The City water provided to affected area residences will avoid exposure to organic and inorganic contamination from the ground water. Since the impermeable cap will further reduce the amount of leachate passing through the landfilled materials, it is anticipated that treatment would be required for a shorter period of time than under Alternative SC 5, however, this potential difference in time period cannot be estimated due to the available information and the heterogeneity of the wastes.

Reduction of Toxicity, Mobility or Volume. Reductions in toxicity, mobility and volume of contaminants in ground water are achieved by the pump and treat system in this alternative. Leachate seeps originating within the landfill would be eliminated by the cap. The City water supplied to nearby homes will avoid the organic and inorganic contamination.

Short-Term Effectiveness. Short-term impacts due to implementation of this alternative could effect on-site worker safety, local traffic patterns, air/dust emissions and environmental impacts to the wetlands. The use of proper operational procedures and construction practices will minimize the risks to on-site workers; air monitoring will also be performed to determine possible exposure to landfill fumes and off-site emissions. Due to the operation of heavy machinery necessary for grading, excavation and other earthwork, as well as delivery of materials, a traffic control plan will be implemented. A soil erosion and sediment control plan would also be developed. The impermeable cap can be placed in three to four years. The ground water treatment system will take four to five years.

Implementability.

Technical Feasibility. Standard equipment and techniques would be employed for the preparation of the site, specifically grading and compacting. The construction of the closure cap and installation of ground water extraction wells and treatment system wells and gas vents are also accomplished using readily available technologies and machinery. Means to extend City water to replace residential sources are available and reliable.

Availability of Services and Materials. The services and materials required for site grading/compacting, cap construction and are readily available. Contractors are available for competitive bidding to perform the work, which may be divided into separate tasks. Equipment and materials for the extension of City water to the individual residences are readily available through numerous vendors.

Administrative Feasibility. The administrative aspects of this potential remedial alternative are similar to those discussed with regard to Alternative SC 5. Construction activities involved in the implementation of this alternative would require coordination between local public safety agencies, State/Federal regulator agencies and the contractors. Long-term management of the site would be necessary for the proper execution of the surface water, sediments, ground water and landfill gas monitoring programs and inspection of the cap. The implementation of the site status reviews would require the involvement of several concerned environmental agencies, including the USEPA and NYSDEC.

Cost. The total capital cost and annual operation and maintenance cost for implementation of this remedial alternative are estimated to be $18,173,997 and $762,025, respectively if ground water extraction and treatment are required. The total present worth of this alternative is $32,579,835 if ground water extraction and treatment are required. These costs become the same as those listed for Alternative SC 3 if ground water remediation is not required. Direct capital costs for this project include construction services and materials required for installation of the landfill cap, ground water extraction and treatment system, gas control vent system, City water extension, and security fence. Indirect capital costs consist of contingency costs, engineering and design services, and administrative services for management and procurement. Annual operating and maintenance costs include periodic inspection of the fence and cap and any necessary repairs, quarterly surface water, sediments, ground water and landfill gas sampling and analyses. Performing the five-year site status reviews is an additional expense. The details of development of these costs are contained in Appendices A and B.

4.2.7 Alternative SC 7: RCRA Cap, Residential Water Replacement, Ground Water Collection/ Treatment/Discharge

4.2.7.1 Description

This alternative consists of the following: construction of a multi-layer RCRA closure cap over the landfill mound as in Alternative SC 4; treatment of extracted ground water followed by discharge preferably to ground water as in Alternative SC 5 (to be implemented if monitoring does not show rapid declines in contaminant concentrations after capping and during treatment system pilot testing); supplying City water to local residents; implementing ground water, surface water, sediment and landfill gas monitoring programs; and erecting a security fence around the landfill as in Alternative SC 2.

A full description of each action is found in the appropriate alternatives. It is expected that this alternative would be implemented in phases. Construction of the multi-layer closure cap over the landfill mound and replacement of residential water with City water would occur initially. The extension of City water to residences to replace private well water sources eliminates the principal health risk identified by the Risk Assessment. The ground water extraction and treatment component of this alternative would be done at a later date after pilot testing is completed if monitoring results do not demonstrate contaminant concentrations are declining. As described in Section 4.2.4, Alternative SC 4, the impermeable cap will reduce leachate production to the extent that eventual ground water quality downgradient of the site will be similar to the upgradient quality. Because the rate of contaminant decrease cannot be predicted with certainty (see Appendix D for discussion) monitoring would be performed to document the expected declining trends. Reviewing the effectiveness of this alternative and the need for ground water treatment would be accomplished by the evaluation of the monitoring results, assessment of ground water quality trends and reassessment of risks related to the site during the five-year reviews. If the trend of contaminant decline is too slow, the ground water extraction and treatment system would be constructed after pilot testing is completed and operated. This alternative becomes identical to Alternative SC 4 if ground water extraction and treatment is not implemented.

4.2.7.2 Evaluation

Overall Protection of Human Health and the Environment. The capping portion of this alternative is discussed fully as Alternative SC 4. In brief, capping would reduce the amount of contaminants discharged to the aquifer below the landfill by significantly reducing percolation of precipitation. This measure would also reduce the source of surface water contamination from landfill leachate seeps.

Mobility, toxicity and volume of overburden would be reduced via the ground water pump and treat system if monitoring indicates contaminant concentrations are not declining following capping. Extension of the City water system would provide residents with an uncontaminated potable water supply.

Compliance with ARARs. There are no soil remediation levels or New York State ARARs that pertain to the Johnstown site. A study of the site soils and sediments shows that there is no health risk associated with these media, and, therefore, no soil or sediment remediation actions have been proposed.

As in Alternative SC 5, the ground water extraction and treatment processes would enable achievement of all MCLs and health-based cleanup levels for ground water. The supply of City water to residences will ensure a potable water supply that is in compliance with chemical-specific ARARs. It is expected that all design and implementation activities will comply with both action-specific and location-specific ARARs as described in Alternative SC 5. Unlike SC 5, the RCRA requirement for an impermeable cap would be met.

Long-Term Effectiveness and Permanence. This alternative could satisfy all of the remedial objectives for the Johnstown Landfill Site as described in Alternative SC 5. Ground water extraction and treatment if needed provides a means of removing aquifer contamination. The remediation would continue until the concentrations of the contaminants of concern in the ground water influent to the treatment facility are equal to or below applicable MCLs and health-based or background cleanup levels. This alternative may provide a permanent solution for ground water contamination, depending upon the design and construction of the cap. The City water provided to affected area residences will avoid exposure to organic and inorganic contamination from the ground water. Since the impermeable cap will further reduce the amount of leachate passing through the landfilled materials, it is anticipated that treatment would be required for a shorter period of time than under Alternative SC 5, however, this potential difference in time period cannot be estimated due to the available information and the heterogeneity of the wastes.

Reduction of Toxicity, Mobility or Volume. Reductions in toxicity, mobility and volume of contaminants in ground water are achieved by the pump and treat system in this alternative. Leachate seeps originating within the landfill would be eliminated by the cap. The City water supplied to nearby homes will avoid the organic and inorganic contamination.

Short-Term Effectiveness. Short-term impacts due to implementation of this alternative could effect on-site worker safety, local traffic patterns, air/dust emissions and environmental impacts to the wetlands. The use of proper operational procedures and construction practices will minimize the risks to on-site workers; air monitoring will also be performed to determine possible exposure to landfill fumes and off-site emissions. Due to the operation of heavy machinery necessary for grading, excavation and other earthwork, as well as delivery of materials, a traffic control plan will be implemented. A soil erosion and sediment control plan would also be developed. The impermeable cap can be placed in three to four years. The ground water treatment system will take four to five years.

Implementability.

Technical Feasibility. Standard equipment and techniques would be employed for the preparation of the site, specifically grading and compacting. The construction of the closure cap and installation of ground water extraction wells and treatment system wells and gas vents are also accomplished using readily available technologies and machinery. Means to extend City water to replace residential sources are available and reliable.

Availability of Services and Materials. The services and materials required for site grading/compacting, cap construction and are readily available. Contractors are available for competitive bidding to perform the work, which may be divided into separate tasks. Equipment and materials for the extension of City water to the individual residences are readily available through numerous vendors.

Administrative Feasibility. The administrative aspects of this potential remedial alternative are similar to those discussed with regard to Alternative SC 5. Construction activities involved in the implementation of this alternative would require coordination between local public safety agencies, State/Federal regulator agencies and the contractors. Long-term management of the site would be necessary for the proper execution of the surface water, sediments, ground water and landfill gas monitoring programs and inspection of the cap. The implementation of the site status reviews would require the involvement of several concerned environmental agencies, including the USEPA and NYSDEC.

Cost. The total capital cost and annual operation and maintenance cost for implementation of this remedial alternative are estimated to be $24,139,194 and $762,025, respectively if ground water extraction and treatment are required. The total present worth of this alternative is $38,545,032 if ground water extraction and treatment are required. These costs become the same as those listed for Alternative SC 3 if ground water remediation is not required. Direct capital costs for this project include construction services and materials required for installation of the landfill cap, ground water extraction and treatment system, gas control vent system, City water extension, and security fence. Indirect capital costs consist of contingency costs, engineering and design services, and administrative services for management and procurement. Annual operating and maintenance costs include periodic inspection of the fence and cap and any necessary repairs, quarterly surface water, sediments, ground water and landfill gas sampling and analyses. Performing the five-year site status reviews is an additional expense. The details of development of these costs are contained in Appendices A and B.

4.3 Comparative Analysis

This section contains discussions of key factors of each of the potential remedial alternatives and differences among them relative to each of the seven evaluation criteria used at this state of the feasibility study. Table 4-2 presents a condensed summary of the individual evaluations of all the developed alternatives.

4.3.1 Overall Protection of Human Health and the Environment

Alternatives SC 1 and SC 2 do not fully address the remedial action objectives developed for the Johnstown Landfill Site and do not contain any measure for mitigation of ground water. Alternative SC 2, however, would reduce ground water exposure risk to local residences via residential water supply replacement.

The soil cover or closure cap systems of Alternatives SC 2, SC 3 and SC 4 provide a partial solution to the problems at the site because they will significantly reduce run-on and infiltration of rainfall or snowmelt into the landfill, thus reducing the quantity of water percolating through the landfill materials and leaching out contaminants. This alternative will also prevent the formation of the contaminated surface leachate seeps emanating from the landfill mound and flowing to LaGrange Gravel Pit. Alternative SC 3 (NYCRR impermeable cap) would provide about a 94-99 percent reduction in leachate production and Alternative SC 4 (RCRA impermeable cap) would provide greater than 99 percent reduction in leachate production , while Alternative SC 2 (soil cover) would achieve approximately a 36 percent reduction. None of these alternatives include any direct ground water control or remediation measures; therefore, the contaminated ground water will remain unaffected except for reduced leachate production allowing ground water contaminant levels to decline. However, extension of City water services proposed in these alternatives would reduce the risk associated with contaminated ground water ingestion and exposure.

The extraction and treatment system of Alternative SC 5 will provide control of the movement and toxicity of the contaminated landfill leachate ground water by pumping and treating this water and preventing its downgradient migration. Reduction of leachate production would be accomplished by a soil cover as in SC 2, as would the risk of ground water ingestion by extension of City water services.

Alternatives SC 6 and SC 7 include the closure cap systems of Alternatives SC 3 and SC 4 respectively, City water service and ground water extraction and treatment as in Alternative SC 5. SC 6 and SC 7 thereby further reduce the volume of ground water coming into contact with the contaminant source possibly reducing the remediation time in comparison with Alternative SC 5.

4.3.2 Compliance with ARARs

The provisions of Alternative SC 1 will not enable any of the chemical-specific ARARs to be met because it does not include any contaminant mitigation or control measures. Alternatives SC 2, SC 3 and SC 4 include direct ground water remediation only in terms of water supply replacement, thereby providing compliance with drinking water standards. These alternatives will not comply with other chemical-specific

ARARs for ground water quality other than through natural attenuation.

The ground water pumping, treatment and discharge system of Alternatives SC 5, SC 6 and SC 7 would allow compliance with all chemical-specific ARARs with respect to ground water, and will also successfully meet the action-specific ARARs for surface water discharge. All applicable location-specific ARARs would be complied with during implementation of any of the alternatives. Alternatives SC 3, SC 4, SC 6 and SC 7 would meet or exceed NYCRR's requirements for an impermeable cap.

4.3.3 Long-Term Effectiveness and Permanence

Alternative SC 1 provides no long-term controls for handling the on-site contamination or the ground water contamination. Alternative SC 2 would minimally reduce the rate of leachate production, thereby limiting direct contact with the contamination. Human health would be protected by the replacement of residential water supplies as needed. Ground water contamination would be monitored and handled by natural attenuation. Alternatives SC 3 and SC 4 would provide greater reduction in leachate production than Alternate SC 2, thereby reducing the time period for natural attention to remediate the ground water. However, most of the contaminants in the landfill mound would remain in place and could potentially leach if the impermeable cap were to fail. Alternative SC 5 would provide some leachate reduction from the soil cap, the contamination would be contained by the ground water collection and treatment system. The collection and treatment system would be operated until background levels of the contaminants was achieved. Alternatives SC 6 and SC 7 would combine Alternatives SC 3 and SC 5 and SC 4 and SC 5, respectively, thus reducing the period of treatment necessary but not eliminating the source of leachate in the landfill. The closure cap is a permanent technology that must be maintained at regular intervals to ensure its structural integrity and impermeability. Failure of the cap in the future could cause leachate to be generated again.

4.3.4 Reduction of Toxicity, Mobility or Volume

The no action (SC 1) alternative does not contain any remedial measures which would reduce the toxicity, mobility or volume of the ground water contamination. The limited action alternative (SC 2) addresses measures for reduction of ground water exposure risk to residents via water supply replacement. Furthermore, risk of leachate seeps and some leachate reduction is achieved through the regrading plan.

Alternatives SC 3 and SC 4 provides further reduction of the volume of contaminated ground water by further reducing the amount of water infiltrating the landfill. These alternatives also eliminate the formation of contaminated leachate seeps. Finally, these alternatives employ replacement of existing water supplies with City water for reduction of public health risks.

Implementation of Alternatives SC 5, SC 6 and SC 7 would reduce the toxicity, mobility and volume of the contaminated ground water, extracting the ground water beneath the landfill mound, and subjecting it to treatment. These alternatives will remove the contaminated ground water from the aquifer, reduce or eliminate the hazardous compounds to below applicable ARARs, and discharge the water. These actions will prevent downgradient migration of the contaminated ground water. As in Alternative SC 2, these alternatives eliminate surface leachate seeps and provide for the extension of the City water service.

Alternative SC 5 reduces the leachate production using a soil cap. Alternatives SC 6 and SC 7 further reduce leachate with an impermeable cap. Alternative SC 5 would leach some contaminants from the landfill mound but at a slower rate, therefore, greater dilution would be achieved and treatment could probably be ceased after a relatively short period. Alternatives SC 6 and SC 7 would cease almost all leachate production and, thereby, provide shortest treatment period. However, leachate production would restart if the impermeable cap were to fail. Data is not presently available concerning the effective life of a landfill cap.

4.3.5 Short-Term Effectiveness

Alternative SC 1 does not include any physical construction measures and, therefore, does not present a risk to the community as a result of its implementation.

The remaining alternatives involve major construction activities at the site and the use of heavy earthmoving equipment. Potential hazards to the surrounding community and environment would include adverse traffic conditions, airborne dust and particulate emissions, an increase in noise levels, and adverse impacts to the wetlands area. All of the impacts due to implementation of Alternative's SC 2, SC 3, SC 4, SC 5, SC 6 or SC 7 could be mitigated in part through the employment of proper construction techniques and operational procedures. In addition to risks to the public, the potential for on-site accidents and worker exposure to contaminated media is greater as a result of the amount of construction activity taking place. These risks would be minimized by the use of proper health and safety training and personal protective equipment.

The treatment systems of Alternatives SC 5, SC 6 and SC 7 would require storage and handling of possibly dangerous materials, such as process reagents and residuals. All of these activities may be accomplished with minimal health risk to workers by the development and implementation of safe operating and maintenance practices and precautions. Compliance with applicable regulations would ensure proper hazardous waste transportation procedures and disposal of drummed process sludge at an approved off-site RCRA Subtitle C facility.

4.3.6 Implementability

4.3.6.1. Technical Feasibility. Alternative SC 1 involves minimal on-site activity. Public information programs and monitoring are easily implemented. Supply of City water to nearby residents is readily achievable. The construction procedures, materials and earthworking equipment required for the implementation of Alternatives SC 2, SC 3, SC 4, SC 5, SC 6 and SC 7 are conventional and are used extensively in standard commercial and industrial applications. The treatment systems of Alternatives SC 5, SC 6 and SC 7 utilize standard unit operations and water treatment equipment that are well suited for this application and are technically reliable. Transportation and disposal of the dewatered process sludge involves easily implementable practices and the use of commercially available facilities.

4.3.6.2. Administrative Feasibility. All of these alternatives involve some degree of institutional management. Alternative SC 1 requires administrative coordination of the monitoring program and the five-year site status reviews, along with the development of the public education program. Alternative SC 2 requires a similar level of control those activities, and also for maintenance of the security fence and administrative issues related to extension of the City water system to residents and associated maintenance.

The administrative requirements of Alternatives SC 3, SC 4, SC 5, SC 6 and SC 7 include the ground water, surface water and sediments monitoring program, and the security fence inspection. In addition to these activities, the structural integrity and impermeability of the closure cap, as applicable, must be maintained through a program of periodic surveillance and necessary repairs. Because of the large land area of the landfill, this item could be fairly substantial.

Alternatives SC 5, SC 6 and SC 7 also require an extensive monitoring program for the operation and maintenance of the ground water treatment facility. The administrative elements of this are extensive because they include equipment maintenance schedules, system effluent monitoring to comply with the SPDES permit and to adjust operating parameters, and transportation and disposal of hazardous process residuals in compliance with regulations.

4.3.6.3. Availability of Services and Materials. Most services and materials required for implementation of any of these potential remedial alternatives are readily available. Standard construction equipment and practices can be employed for the fence installation and the extensive site work activities of Alternatives SC 2, SC 3, SC 4, SC 5, SC 6 and SC 7. Most of the materials and equipment required for these alternatives may be locally obtained.

Contractors to provide the construction services are also available in the Fulton County area. Because the work will be taking place on a Superfund Site, all on-site personnel must have approved health and safety training. Many companies are available to provide this training to contractors. The engineering and design services required for implementation of Alternatives SC 2, SC 3, SC 4, SC 5, SC 6 and SC 7 may be obtained from many vendors. Hazardous waste transportation and disposal for treatment residuals in Alternatives SC 5, SC 6 and SC 7 is also commercially available.

4.3.7 Cost

Cost estimates were developed for each of the potential remedial alternatives. The quantities of materials and equipment sizes utilized for these estimates are considered to be conservative due to data limitations and are biased toward equipment sizes utilized for these estimates are considered to be conservative due to data limitations and are biased toward the high side. These parameters may change during the performance of the remedial design phase due to further refinement of the information required.

The details of the cost estimates for capital and annual expenses are presented in Appendix B of this report. The present worth costs are calculated as per EPA guidance using a discount rate of 5 percent and a 30-year time interval. The estimated present worth costs for each of the alternatives are as follows:

Alternative	Present Worth
SC 1	$ 1,485,333
SC 2	$11,034,268
SC 3	$16,454,248
SC 4	$22,420,344
SC 5	$27,159,855
SC 6	$32,579,835*
SC 7	$38,545,032**

*Cost is reduced to that of SC 3 if ground water remediation is not implemented.

**Cost is reduced to that of SC 4 if ground water remediation is not implemented.

JOHNSTO
SUMMARY OF A

CRITERIA	ALTERNATIVE 1 No Action	
Key Components	Long term ground water monitoring, public awareness and education program, 5-year site reviews over a 30-year period	Monitoring, site a residential water cover.
1) Overall Protection of Human Health and the Environment	There is no reduction in toxicity or volume of contaminants. Risk from contaminant migration is monitored but not reduced. Future exposure is not prevented.	Institutional cont fencing will provi Regrading will re Toxicity and volu exposure is reduc
2) Compliance With ARARs	This alternative fails to remediate aquifer ground water to acceptable health-based levels.	Same as Alternat allow compliance Reduced leachate natural remediati levels.
3) Long-Term Effectiveness and Permanence	Source has not been removed; existing risk will remain.	Same as Alternat reduction in leac
4) Reduction of Toxicity, Mobility or Volume	No reduction in toxicity, mobility or volume of contaminants in aquifer would result from this alternative.	Mobility of conta reduced. Toxicit same. Water tre at point-of-use.
5) Short-Term Effectiveness	No construction involved; therefore, no impacts to the community or environment during implementation. No substantial improvement would result from this alternative.	Earthworking act impact traffic in measures would Dust control mea minimize particul
6) Implementability • Technical Feasibility	No construction or equipment installation required. Both site review and public awareness programs easily implementable.	Installation of se implemented tas damage easily ac equipment and p the regrading.
• Administrative Feasibility	Some coordination involved for site review and ground water monitoring, as well as the implementation of public awareness program.	Same as Alterna fence inspection coordination. Lo involved in regra
• Availability of Services and Materials	All facilities and materials necessary for implementation are available locally.	Same as Alterna are available for
7) Cost • Total Capital Cost	$ 13,500	
• Annual Operation and Maintenance Cost	$ 119,150	
• Present Worth Value	$1,859,038	

TABLE 4-2

WN LANDFILL SITE
LTERNATIVE COMPARISON

ALTERNATIVE 2 Limited Action	ALTERNATIVE 3 NYCRR Impermeable Capping	ALTERNATIVE 4 RCRA Impermeable Capping
ccess and use restriction, replacement. Regrading and soil	Construction of multi-layer closure cap, installation of gas control system, monitoring, site access restriction, residential water replacement.	Construction of multi-layer closure cap, installation of gas control system, monitoring, site access restriction, residential water supply replacement
rols will restrict site usage, and de site access restrictions. luce leachate production. me is not reduced. Future :ed.	Contaminated materials remain on-site. Leaching of contaminants into aquifer could be significantly reduced. Lateral movement of untreated contaminated ground water treated downgradient to downgradient receptors would continue.	Contaminated materials remain on-site. Leaching of contaminants into aquifer could be significantly reduced. Lateral movement of untreated contaminated ground water treated downgradient to downgradient receptors would continue.
ive 1. Point-of-use treatment will with drinking water ARARs. : concentration may allow some ɔn to eventually meet health based	Attainment of chemical-specific ARARs for ground water could be hastened due to significantly reduced leaching. Point-of-use treatment would allow attainment of chemical-specific ARARs. Action- and location-specific ARARs will be complied with during implementation.	Attainment of chemical-specific ARARs for ground water could be hastened due to significantly reduced leaching. Point-of-use treatment would allow attainment of chemical-specific ARARs. Action- and location-specific ARARs will be compiled with during implementation.
ve 1. Risk sensitivity reduced by ıate volume.	Leaching of contaminants from upper portion of landfill into ground water could resume if containment system fails. This alternative may not be a permanent solution.	Leaching of contaminants from upper portion of landfill into ground water could resume if containment system fails. This alternative may not be a permanent solution.
ninants would be slightly ' and volume would remain the ıtment units would reduce toxicity	Mobility of contaminants would be reduced; toxicity and volume in aquifer and landfill would remain the same.	Mobility of contaminants would be reduced; toxicity and volume in aquifer and landfill would remain the same.
vities required could negatively he area. Protection and safety ɔe employed for on-site workers. sures would be provided to te emissions.	Same as Alternative 2.	Same as Alternative 2.
urity fencing is an easily . Repair of fence in case of :omplished. Conventional ocedures would be involved for	Conventional equipment and procedures are involved for both cap construction and vent system installation.	Conventional equipment and procedures are involved for both cap construction and vent system installation
ve 1. Institutional controls and equire further interagency ıg term construction management ing.	Long term management involved in construction, maintenance and inspection, as well as monitoring and site reviews.	Long term management involved in construction, maintenance and inspection, as well as monitoring and site reviews.
ve 1. Numerous local contractors ompetitive bidding.	Standard construction practices are utilized, and numerous contractors are available for competitive bidding on this work.	Standard construction practices are utilized, and numerous contractors are available for competitive bidding on this work.
$ 8,342,622	$13,762,602	$19,728,699
$ 174,191	$ 174,191	$ 174,191
$11,034,268	$16,454,268	$22,420,344

TABLE

CRITERIA	ALTERNATIVE 5 Ground Water Pumping/ Ground Water Treatment/Discharge
Key Components	Construction of soil cover; ground water pumping, treatment via chemical precipitation, and discharge; residential water replacement; and performance monitoring.
1) Overall Protection of Human Health and the Environment	Contaminants would be removed from the aquifer. Toxicity, mobility and volume of contaminants would reduced. Further migration of contaminants to downgradient receptors eliminated. Point-of-use treat would reduce ground water risks to local residents.
2) Compliance With ARARs	Health-based cleanup levels and MCLs for ground wat would be achieved. Many action- and location-specifi ARARs will be complied with during implementation. However, 6NYCRR Part 360 requires impermeable ca
3) Long-Term Effectiveness and Permanence	Treatment would continue until MCLs are achieved. Precipitation percolation through landfill would be red Estimated treatment period would be over 30 years.
4) Reduction of Toxicity, Mobility or Volume	Toxicity, mobility and volume of contaminants would reduced via pumping and treatment. Residuals would disposed of off-site in an approved RCRA facility.
5) Short-Term Effectiveness	Same as Alternative 2. In addition, installation of extraction wells and operation of treatment facility p the risk of worker exposure. Personnel protective equipment and health and safety training for on-site workers would be provided.
6) Implementability	
• Technical Feasibility	Same as Alternative 3. Conventional equipment and procedures are involved for ground water extraction, treatment and discharge.
• Administrative Feasibility	Long term management involved in construction, maintenance and inspection, and monitoring.
• Availability of Services and Materials	Same as Alternative 3. Standard equipment and serv are available for ground water pump and treat systen
7) Cost	
• Total Capital Cost	$12,754,017
• Annual Operation and Maintenance Cost	$ 762,025
• Present Worth Value	$27,159,855

4-2 Cont'd.

	ALTERNATIVE 6 . NYCRR Impermeable Cap/Ground Water Pumping/ Ground Water Treatment/Discharge/ Residential Water Replacement	ALTERNATIVE 7 RCRA Impermeable Cap/Ground Water Pumping/ Treatment/Discharge/ Residential Water Replacement
	Construction of impermeable cap with vent system; ground water pumping, treatment and discharge; residential water replacement; and performance monitoring.	Construction of impermeable cap with vent system; ground water pumping, treatment and discharge; residential water replacement; and performance monitoring.
be :ment	Same as Alternative 5.	Same as Alternative 5.
er c ɔ.	Same as Alternative 5. 6NYCRR Part 360 would be met.	Same as Alternative 5. 6NYCRR Part 360 would be met or exceeded.
ɩced.	Same as Alternative 5. Remediation time may be reduced since impermeable cap would reduce the volume of ground water requiring treatment. Cap failure could resume leachate production.	Same as Alternative 4. Remediation time may be reduced since impermeable cap would reduce the volume of ground water requiring treatment. Cap failure could resume leachate production
lbe be	Same as Alternative 5.	Same as Alternative 5.
·ses	Same as Alternative 5.	Same as Alternative 5.
	Same as Alternative 5.	Same As Alternative 5.
	Same as Alternative 5.	Same As Alternative 5.
ices ı.	Same as Alternative 5.	Same as Alternative 5.
	$18,173,997 $ 762,025 $32,579,835	$24,139,194 $ 762,025 $38,545,032

APPENDIX A

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

TABLE A-1

ALTERNATIVE 1: NO ACTION

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. GROUND WATER MONITORING PROGRAM	30	Develop and perform a ground water monitoring program consisting of sampling 30 existing wells and five surface water locations and 10 sediment locations and analyzing samples for NYSDEC baseline and routine parameters.
SURFACE WATER	5	
SEDIMENTS	10	
II. PUBLIC AWARENESS PROGRAM	LS	Convene public meetings, develop information handouts for nearby residential community, prepare press releases and public relations literature.

TABLE A-2
ALTERNATIVE 2: LIMITED ACTION
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. GROUND WATER MONITORING PROGRAM SURFACE WATER SEDIMENTS		Same as Alternative 1 - Item I
II. PUBLIC AWARENESS PROGRAM	LS	Convene public meetings, develop informational handouts for nearby residential community, prepare press releases and public relations literature.
III. GROUND WATER/LAND USE RESTRICTIONS	LS	New York State and local agencies, in conjunction with USEPA, to establish appropriate requirements for installation of new domestic wells, such as permitting and testing. Local agencies to develop and enforce plan to prevent ground water use for sanitary purposes, and to develop ordinances for preventing future use of the land.
IV. PRIVATE WATER SUPPLY REPLACEMENT	80	Extend City water system to replace private and domestic supply at 80 sites.
V. ACCESS RESTRICTION		
1. Security Fence	6,800 linear ft	8 ft. high chain link, double strand barbed wire, 2 access gates. Appropriate warning signs posted.
2. Warning Signs	35	2 ft. x 3 ft. PVC signs posted on perimeter fence.
VI. SUPPORT FACILITIES		
Office Trailer	2	One USEPA, NYSDEC, and engineering office; One construction office; Lease for one year
Decontamination Trailer	2	Health and Safety trailers with shower facility Lease for one year
VII. ROUGH GRADING & COMPACTION	160,000 CY	Clean fill required to be moved from on-site or imported.
VIII. STORM SEWER	1600 LF	Corrugated metal pipe 24 inch
MANHOLES	3 Ea.	4 Foot diameter
HEADWALLS	4 Ea.	Concrete or stone headwalls
IX. GAS VENTS	33 Ea.	4-inch PVC piping, 200 feet a part - average Installed depth approximately 40 feet
X. SOIL CAP		
Soil Layer	87,120 CY	18 Inches of soil with permeability less than 1×10^{-5} cm/sec
Topsoil	29,260 CY	6 Inches of topsoil

[illegible]

TABLE A-3

ALTERNATIVE 3: NYCRR IMPERMEABLE CAP
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. SUPPORT FACILITIES		Same as Alternative 2 - Item VI
II. SECURITY FENCING/SIGNS	6,800 linear ft.	Same as Alternative 2 - Item V
III. ROUGH GRADING & COMPACTION		Same as Alternative 2 - Item VII
IV. DRAINAGE STRUCTURES		Same as Alternative 2 - Item VIII
V. MULTILAYER CAP	36 acres	
1. Geosynthetic - 40 mils	1,580,000 SF	Impermeable geosynthetic
2. Sand Soil	175,560 CY	Two-foot thick sand/soil layer on top of the liner for drainage One-foot thick sand/soil below liner for gas venting
3. Topsoil Cover	29,260 CY	Six-inch thick topsoil cover on top of sand/soil layer
4. Seeding	36 acres	Seed and mulch topsoil
5. Filter Fabric	1,580,000 SF	Filter fabric to separate soil layers
VI. PASSIVE LANDFILL GAS CONTROL SYSTEM 1. Landfill Gas Vents	33	Same as Alternative 2 - Item IX
VII. PRIVATE WATER SUPPLY REPLACEMENT	30	Same as Alternative 2 - Item IV
VIII. SITE MONITORING PROGRAM Ground Water Surface Water Sediments		Same as Alternative 1 - Item I

TABLE A-4

ALTERNATIVE 4: RCRA IMPERMEABLE CAP
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. SUPPORT FACILITIES		Same as Alternative 2 - Item VI
II. SECURITY FENCING/SIGNS	6,800 linear ft.	Same as Alternative 2 - Item V
III. ROUGH GRADING & COMPACTION		Same as Alternative 2 - Item VII
IV. DRAINAGE STRUCTURES		Same as Alternative 2 - Item VIII
V. MULTILAYER CAP	36 acres	
1. Geosynthetic - 40 mils	1,580,000 SF	Impermeable geosynthetic
2. Sand Soil	175,560 CY	Two-foot thick sand/soil layer on top of the liner for drainage One-foot thick sand/soil below liner for gas venting
3. Vegetative Support Layer	87,778 CY	1.5 foot thick layer above drainage layer
4. Topsoil	29,259 CY	Six-inch thick layer above vegetative support layer
5. Seeding	1,580,000 SF	Seed and mulch topsoil
6. Clay Layer	117,037 CY	Two-foot thick impermeable soil liner
7. Filter Fabric	3,160,000 SF	Filter fabric to separate soil layers
VI. PASSIVE LANDFILL GAS CONTROL SYSTEM		
1. Landfill Gas Vents	33	Same as Alternative 2 - Item IX
VII. PRIVATE WATER SUPPLY REPLACEMENT	30	Same as Alternative 2 - Item IV
VIII. SITE MONITORING PROGRAM Ground Water Surface Water Sediments		Same as Alternative 1 - Item I

[illegible]

TABLE A-5

ALTERNATIVE 5: GROUND WATER, PUMPING/TREATMENT/DISCHARGE TO SURFACE WATER
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. SUPPORT FACILITIES		
1. Office Trailer	2	Same as Alternative 2 - Item VI
2. Decontamination Trailer	2	
II. SECURITY FENCE/SIGNS	6,800 linear ft.	Same as Alternative 2 - Item V
III. ROUGH GRADING, DRAINAGE IMPROVEMENTS, AND SOIL CAP	21.6 ACRES	Same as Alternative 2 - Items VII, VIII, IX and X
IV. GROUND WATER EXTRACTION		
1. Extraction Wells	20	6-Inch diameter gravel packed, average depth 35+ ft.
2. Pumps	20	1.5 hp submersible, 35 gpm @ 40 ft. TDH
3. Misc. Equipment/Piping	20	2-inch galvanized steel with 2-inch pitless-SS adaptor. Well cap and level sensing
V. GROUND WATER COLLECTION		
1. Collection System	1900 ft.	12-inch gravity PVC sewer with seven manholes
2. Lift Station	1	Wet well mounted. Two 7.5 hp pumps, 20,000 gal. wet well, 100 feet of force main
VI. IRON REMOVAL		
1. Cascading Dish Aerators	2	10 Foot diameter, aluminum
2. Settling Tank	1	40 foot diameter, steel tank with sludge removal system
3. Sludge Pumps	2	100 gpm progressing cavity pumps
4. Chemical Feed System	1	Copper sulfate mix tank, storage tank, two chemical feed pumps
VII. MANGANESE REMOVAL		
1. Gravity Filter	1	Approximately 300 SF filter broken into four cells
2. Blowers	2	Air scour to aid in backwash
3. Chemical Feed System	1	Bulk sodium hypochloride storage tank, two chemical feed pumps

TABLE A-5 CONT'D.

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
VIII. METALS REMOVAL		
1. Metal Precipitation	2	Rapid mix, floc tank, and clarification tank
2. Chemical Feed Systems	2	Bulk sodium hydroxide and anionic polymer storage, each with two pumps
3. Sludge Pumps	2	25 gpm progressing cavity pumps
IX. POLISHING FILTER		
1. Gravity Filter	1	Approx. 400 SF filter with 3.5 foot deep bed of granular activated carbon.
2. Chemical Feed System	1	Mix tank, storage tank, and two chemical feed pumps for chelating agent.
X. SLUDGE HANDLING		
1. Sludge Thickener	1	35 Foot diameter gravity thickening tank
2. Chemical Feed System	1	Polymer storage tanks and feed pumps
3. Sludge Dewatering	1	0.7 meter wick filter press with roll-off container
4. Sludge Pumps	2	100 gpm progressing cavity pumps
5. Supernatant Pumps	2	Centrifugal return pumps
XI. WATER STORAGE/BACKWASH		
1. Finish Water Storage Tank	1	80,000 gallon steel tank
2. Decant Tank	1	80,000 gallon steel tank, decant ports and sludge withdrawal
3. Backwash Pumps	2	750-1500 gpm horizontal base plate mounted
4. Sludge Pump - Decant Tank	2	Progressing cavity pumps
5. Finish Water Fill Pump	2	Centrifugal, base plate mounted
XII. SITE MONITORING PROGRAM		Same as Alternative 1 - Item I
XIII. PRIVATE WATER SUPPLY REPLACEMENT	80	Same as Alternative 2 - Item IV

TABLE A-6

ALTERNATIVE 6: NYCRR IMPERMEABLE CAP/GROUND WATER, PUMPING/TREATMENT/DISCHARGE TO SURFACE WATER
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. SUPPORT FACILITIES		
1. Office Trailer	2	Same as Alternative 2 - Item VI
2. Decontamination Trailer	2	
II. SECURITY FENCE/SIGNS	6,800 linear ft.	Same as Alternative 2 - Item V
III. ROUGH GRADING, DRAINAGE IMPROVEMENTS, AND IMPERMEABLE CAP	21.6 ACRES	Same as Alternative 3 - Items III, IV, V and VI
IV. GROUND WATER EXTRACTION		
1. Extraction Wells	20	6-Inch diameter gravel packed, average depth 35+ ft.
2. Pumps	20	1.5 hp submersible, 35 gpm @ 40 ft. TDH
3. Misc. Equipment/Piping	20	2-inch galvanized steel with 2-inch pitless-SS adaptor. Well cap and level sensing
V. GROUND WATER COLLECTION		
1. Collection System	1900 ft.	12-inch gravity PVC sewer with seven manholes
2. Lift Station	1	Wet well mounted. Two 7.5 hp pumps, 20,000 gal. wet well, 100 feet of force main
VI. IRON REMOVAL		
1. Cascading Dish Aerators	2	10 Foot diameter, aluminum
2. Settling Tank	1	40 foot diameter, steel tank with sludge removal system
3. Sludge Pumps	2	100 gpm progressing cavity pumps
4. Chemical Feed System	1	Copper sulfate mix tank, storage tank, two chemical feed pumps
VII. MANGANESE REMOVAL		
1. Gravity Filter	1	Approximately 300 SF filter broken into four cells
2. Blowers	2	Air scour to aid in backwash
3. Chemical Feed System	1	Bulk sodium hypochloride storage tank, two chemical feed pumps

TABLE A-6 CONT'D.

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
VIII. METALS REMOVAL		
1. Metal Precipitation	2	Rapid mix, floc tank, and clarification tank
2. Chemical Feed Systems	2	Bulk sodium hydroxide and anionic polymer storage, each with two pumps
3. Sludge Pumps	2	25 gpm progressing cavity pumps
IX. POLISHING FILTER		
1. Gravity Filter	1	Approx. 400 SF filter with 3.5 foot deep bed of granular activated carbon.
2. Chemical Feed System	1	Mix tank, storage tank, and two chemical feed pumps for chelating agent.
X. SLUDGE HANDLING		
1. Sludge Thickener	1	35 Foot diameter gravity thickening tank
2. Chemical Feed System	1	Polymer storage tanks and feed pumps
3. Sludge Dewatering	1	0.7 meter wick filter press with roll-off container
4. Sludge Pumps	2	100 gpm progressing cavity pumps
5. Supernatant Pumps	2	Centrifugal return pumps
XI. WATER STORAGE/BACKWASH		
1. Finish Water Storage Tank	1	80,000 gallon steel tank
2. Decant Tank	1	80,000 gallon steel tank, decant ports and sludge withdrawal
3. Backwash Pumps	2	750-1500 gpm horizontal base plate mounted
4. Sludge Pump - Decant Tank	2	Progressing cavity pumps
5. Finish Water Fill Pump	2	Centrifugal, base plate mounted
XII. SITE MONITORING PROGRAM		Same as Alternative 1 - Item I
XIII. PRIVATE WATER SUPPLY REPLACEMENT	80	Same as Alternative 2 - Item IV

TABLE A-7

ALTERNATIVE 7: RCRA IMPERMEABLE CAP/GROUND WATER, PUMPING/TREATMENT/DISCHARGE TO SURFACE WATER
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. SUPPORT FACILITIES		
1. Office Trailer	2	Same as Alternative 2 - Item VI
2. Decontamination Trailer	2	
II. SECURITY FENCE/SIGNS	6,800 linear ft.	Same as Alternative 2 - Item V
III. ROUGH GRADING, DRAINAGE IMPROVEMENTS, AND IMPERMEABLE CAP	21.6 ACRES	Same as Alternative 4 - Items III, IV, V and VI
IV. GROUND WATER EXTRACTION		
1. Extraction Wells	20	6-Inch diameter gravel packed, average depth 35+ ft.
2. Pumps	20	1.5 hp submersible, 35 gpm @ 40 ft. TDH
3. Misc. Equipment/Piping	20	2-inch galvanized steel with 2-inch pitless-SS adaptor. Well cap and level sensing
V. GROUND WATER COLLECTION		
1. Collection System	1900 ft.	12-inch gravity PVC sewer with seven manholes
2. Lift Station	1	Wet well mounted. Two 7.5 hp pumps, 20,000 gal. wet well, 100 feet of force main
VI. IRON REMOVAL		
1. Cascading Dish Aerators	2	10 Foot diameter, aluminum
2. Settling Tank	1	40 foot diameter, steel tank with sludge removal system
3. Sludge Pumps	2	100 gpm progressing cavity pumps
4. Chemical Feed System	1	Copper sulfate mix tank, storage tank, two chemical feed pumps
VII. MANGANESE REMOVAL		
1. Gravity Filter	1	Approximately 300 SF filter broken into four cells
2. Blowers	2	Air scour to aid in backwash
3. Chemical Feed System	1	Bulk sodium hypochloride storage tank, two chemical feed pumps

TABLE A-7 CONT'D.

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
VIII. METALS REMOVAL		
1. Metal Precipitation	2	Rapid mix, floc tank, and clarification tank
2. Chemical Feed Systems	2	Bulk sodium hydroxide and anionic polymer storage, each with two pumps
3. Sludge Pumps	2	25 gpm progressing cavity pumps
IX. POLISHING FILTER		
1. Gravity Filter	1	Approx. 400 SF filter with 3.5 foot deep bed of granular activated carbon.
2. Chemical Feed System	1	Mix tank, storage tank, and two chemical feed pumps for chelating agent.
X. SLUDGE HANDLING		
1. Sludge Thickener	1	35 Foot diameter gravity thickening tank
2. Chemical Feed System	1	Polymer storage tanks and feed pumps
3. Sludge Dewatering	1	0.7 meter wick filter press with roll-off container
4. Sludge Pumps	2	100 gpm progressing cavity pumps
5. Supernatant Pumps	2	Centrifugal return pumps
XI. WATER STORAGE/BACKWASH		
1. Finish Water Storage Tank	1	80,000 gallon steel tank
2. Decant Tank	1	80,000 gallon steel tank, decant ports and sludge withdrawal
3. Backwash Pumps	2	750-1500 gpm horizontal base plate mounted
4. Sludge Pump - Decant Tank	2	Progressing cavity pumps
5. Finish Water Fill Pump	2	Centrifugal, base plate mounted
XII. SITE MONITORING PROGRAM		Same as Alternative 1 - Item I
XIII. PRIVATE WATER SUPPLY REPLACEMENT	80	Same as Alternative 2 - Item IV

APPENDIX B

COST ESTIMATES

B1. PROCESS COST COMPARISONS

B2. ALTERNATIVE COST COMPARISONS

B1 PROCESS COST COMPARISONS

ALTERNATIVE WATER SUPPLYS

BOTTLED WATER

ANNUAL COSTS					
FAMILY OF 4 USING 5 GPD					
BOTTLED WATER	80	UNITS	$1,826	$146,100	
DISPENSER	80	UNITS	$120	$9,600	
ANNUAL WELL SAMPLING	80	SAMPLES	$520	$41,600	
SAMPLING LABOR	1	RND	$2,000	$2,000	
		ANNUAL COST		$199,300	
			PRESENT WORTH		$3,063,729
		TOTAL ALTERNATIVE COST			$3,063,729

POINT OF USE TREATMENT

INSTALL FE REMOVAL (HOUSE),					
UNDERSINK GAC,RO	80	UNITS	$3,000	$240,000	
MONTHLY TESTING					
INFLUENT,AND EFFLUENT	1920	SAMPLES	$220	$422,400	
SAMPLING LABOR	12	RND	$2,000	$24,000	
TOTAL DIRECT CONSTRUCTION COST				$686,400	
20 % CONTINGENCY				$137,280	
10 % ENGINEERING				$68,640	
5 % ADMINISTRATION				$34,320	
		TOTAL CAPITAL COST			$926,640
OPERATION AND MAINTENANCE					
REPLACE FILTERS, MEMBRANE	80	UNITS	$300	$24,000	
SEMIANNUAL TESTING					
INFLUENT AND EFFLUENT	160	SAMPLES	$520	$83,200	
SAMPLING LABOR	2	RND	$2,000	$4,000	
		ANNUAL COST		$111,200	
			PRESENT WORTH		$1,709,417
		TOTAL ALTERNATIVE COST			$2,636,057

ALTERNATIVE WATER SUPPLYS, CONT.

PROVIDE CITY WATER

8 INCH WATER MAIN	22600	LF	$30	$678,000	
6 INCH WATER MAIN	2000	LF	$25	$50,000	
HYDRANT ASSEMBLY	47	EA	$2,000	$94,000	
8-INCH GATE VALVES	34	EA	$800	$27,200	
HOUSE SERVICES	75	EA	$2,000	$150,000	
TEMP TRENCH PAVEMENT	24600	SY	$9	$227,550	
PERM TRENCH PAVEMENT	32718	SY	$12	$376,257	
BOOSTER PUMP STATION	1	LS	$157,000	$157,000	
TOTAL DIRECT CONSTRUCTION COST				$1,760,007	
20 % CONTINGENCY				$352,001	
10 % ENGINEERING				$176,001	
10 % ADMIN/LEGAL				$176,001	
TOTAL CAPITAL COST					$2,464,010
OPERATION AND MAINTENANCE	1	YR	$25,000	$25,000	
PRESENT WORTH					$384,311
TOTAL ALTERNATIVE COST					$2,848,321

CAPITAL COST ESTIMATES IMPERMEABLE CAPPING OPTIONS

NYCRR CAP

FILTER FABRIC	1,580,000	SF	$0.56	$884,800
GAS VENT LAYER 12″	58,519	CY	$18.00	$1,053,333
GEOSYNTHETIC 40 MILS	1,580,000	SF	$0.50	$790,000
DRAINAGE LAYER 24″	117,037	CY	$18.00	$2,106,667
TOPSOIL 6″	29,259	CY	$19.20	$561,778
GAS VENTS	33	EA	$3,000.00	$99,000
SUBSURFACE DRAINAGE	15,000	LF	$16.00	$240,000
DRAINAGE DITCHES	15,000	LF	$2.00	$30,000
SEEDING	1,580,000	SF	$0.05	$79,000
	TOTAL DIRECT CONSTRUCTION COST			$5,844,578
	20	% CONTINGENCY		$1,168,916
	10	%ENGINEERING/PLANNING		$584,458
	5	% LEGAL/ADMINISTRATIVE		$292,229
		TOTAL ALTERNATIVE COST		$7,890,180
		COST PER 36 ACRES		$219,172

RCRA CAP

GAS VENT LAYER 12″	58,519	CY	$18.00	$1,053,333
FILTER FABRIC	1,580,000	SF	$0.56	$884,800
CLAY LAYER 24″	117,037	CY	$22.00	$2,574,815
GEOSYNTHETIC 40 MILS	1,580,000	SF	$0.50	$790,000
DRAINAGE LAYER 12″	117,037	CY	$18.00	$2,106,667
FILTER FABRIC	1,580,000	SF	$0.50	$790,000
VEGETATIVE SUPPORT LAYER 18″	87,778	CY	$12.00	$1,053,333
TOPSOIL 6″	29,259	CY	$19.20	$561,778
GAS VENTS	33	EA	$3,000.00	$99,000
SUBSURFACE DRAINAGE	15,000	LF	$16.00	$240,000
DRAINAGE DITCHES	15,000	LF	$2.00	$30,000
SEEDING	1,580,000	SF	$0.05	$79,000
	TOTAL DIRECT CONSTRUCTION COST			$10,262,726
	20	% CONTINGENCY		$2,052,545
	10	%ENGINEERING/PLANNING		$1,026,273
	5	% LEGAL/ADMINISTRATIVE		$513,136
		TOTAL ALTERNATIVE COST		$13,854,680
		COST PER 36 ACRES		$384,852

COLLECTION SYSTEMS, COST COMPARISIONS

TRENCH DRAINS

EXCAVATE TO 18 FEET					
1:1 SLOPE, 20 FT WIDE	25000	CY	$5.00	$125,000	
TRENCH AND PLACE PIPE	1900	LF	$200.00	$380,000	
2 PUMP STA. @ 200 GPM	2	EA	$120,000.00	$240,000	
	TOTAL DIRECT CONSTRUCTION COST			$745,000	
	20	%CONTINGENCY		$149,000	
	10	% ENGINEERING/PLANN		$74,500	
	5	%LEGAL/ADMIN		$37,250	
			TOTAL CAPITAL COST		$1,005,750
POWER	76000	KWH/YR	$0.07	$5,320	
YEARLY MAINTENANCE				$12,000	
			TOTAL O&M	$17,320	
ASSUME 30 YEARS AT 5%		PRESENT WORTH		$266,251	
			TOTAL PROJECT		$1,272,001

VERTICAL WELLS

DRILL WELLS	20	EA	$4,000.00	$80,000	
INSTALL PUMPS	20	EA	3000	$60,000	
RUN ELECTRICAL	2000	LF	22	$44,000	
12″ COLLECTION SEWER	1900	LF	65	$123,500	
MANHOLES	7	EA	3000	$21,000	
PUMP STATION	1	LS	125000	$125,000	
	TOTAL DIRECT CONSTRUCTION COST			$453,500	
	20	%CONTINGENCY		$90,700	
	10	% ENGINEERING/PLANN		$45,350	
	5	%LEGAL/ADMIN		$22,675	
			TOTAL CAPITAL COST		$612,225
POWER	205000	KWH/YR	$0.07	$14,350	
YEARLY MAINTENANCE				$22,675	
			TOTAL O&M	$37,025	
ASSUME 30 YEARS AT 5%		PRESENT WORTH		$569,165	
			TOTAL PROJECT		$1,181,390

B2 ALTERNATIVE COST COMPARISONS

ALTERNATIVE SC 1 NO ACTION

CAPITAL COSTS

PUBLIC AWARENESS PROGRAM	1	LS	$10,000.00	$10,000

TOTAL DIRECT CONSTRUCTION COST		$10,000
20	% CONTINGENCY	$2,000
10	%ENGINEERING/PLANNING	$1,000
5	% LEGAL/ADMINISTRATIVE	$500
TOTAL CAPITAL COST		$13,500

OPERATION AND MAINTENANCE COSTS
ASSUMED 5 PERCENT INTEREST, 30 YEAR PERIOD

LONG TERM MONITORING				
30 WELLS, 5 SURFACE WATERS, 10 SEDIMENT				
BASELINE (1X PER YR)	45	SP	$670.00	$30,150
ROUTINE (3X PER YEAR)	135	SP	$400.00	$54,000
LABOR AND MATERIALS	4	QTR	$5,500.00	$22,000
REPORT	4	RPTS	$2,000.00	$8,000
ADMIN./RECORDKEEPING	1	LS	$5,000.00	$5,000
		ANNUAL COST		$119,150
			PRESENT WORTH COST	$1,831,628

SITE STATUS REVIEWS	1	EA	$5,000.00	$5,000
EVERY 5 YEARS	YEARS 5, 10, 15, 20, 25, 30			
			PRESENT WORTH COST	$13,910
			TOTAL PRESENT WORTH COST	$1,859,038

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ALTERNATIVE SC2 LIMITED ACTION

CAPITAL COSTS

PUBLIC AWARENESS/ LAND USE RESTRICTIONS	1	LS	$10,000.00	$10,000
RESIDENTIAL WATER SUPPLY REPLACEMENT	1	LS	$1,760,000	$1,760,000
SITE PREPARATION				
CONSTRUCTION OFFICES	1	LS	$30,000.00	$30,000
CLEAR AND GRUB	18	AC	$5,000.00	$90,000
SECURITY FENCE	6,800	LF	$15.90	$108,120
ROUGH GRADING				
CUT AND FILL	160,000	CY	$14.00	$2,240,000
STORM SEWERS	1,600	LF	$65.00	$104,000
MANHOLES	3	EA	$3,000.00	$9,000
SOIL COVER				
SOIL LAYER 12"	58,500	CY	$14.00	$819,000
TOPSOIL 6"	29,250	CY	$19.20	$561,600
GAS VENTS	33	EA	$3,000.00	$99,000
SUBSURFACE DRAINAGE	15,000	LF	$16.00	$240,000
DRAINAGE DITCHES	15,000	LF	$2.00	$30,000
SEEDING	1,580,000	SF	$0.05	$79,000

TOTAL DIRECT CONSTRUCTION COST	$6,179,720
20 % CONTINGENCY	$1,235,944
10 %ENGINEERING/PLANNING	$617,972
5 % LEGAL/ADMINISTRATIVE	$308,986
TOTAL CAPITAL COST	$8,342,622

OPERATION AND MAINTENANCE COSTS
ASSUMED 5 PERCENT INTEREST, 30 YEAR PERIOD

LONG TERM MONITORING				
30 WELLS, 5 SURFACE WATER, 10 SEDIMENT				
BASELINE (1X PER YR)	45	SP	$670.00	$30,150
ROUTINE (3X PER YEAR)	135	SP	$400.00	$54,000
LABOR AND MATERIALS	4	QTR	$5,500.00	$22,000
REPORT	4	RPTS	$2,000.00	$8,000
ADMIN./RECORDKEEPING	1	LS	$5,000.00	$5,000
MOWING, 8TIMES/YR	12,545	MSF	$2.00	$25,091
DITCH CLEANING	15,000	LF	$0.33	$4,950
WATER SYSTEM O & M	1	ANNUAL	$25,000.00	$25,000

ANNUAL COST	$174,191
PRESENT WORTH COST	$2,677,736

SITE STATUS REVIEWS	1	EA	$5,000.00	$5,000
EVERY 5 YEARS	YEARS 5, 10, 15, 20, 25, 30			

PRESENT WORTH COST	$13,910
TOTAL PRESENT WORTH COST	$11,034,268

ALTERNATIVE SC3 NYCRR IMPERMEABLE CAP

CAPITAL COSTS

PUBLIC AWARENESS/ LAND USE RESTRICTIONS	1	LS	$10,000.00	$10,000
RESIDENTIAL WATER SUPPLY REPLACEMENT	1	LS	$1,760,000	$1,760,000
SITE PREPARATION				
CONSTRUCTION OFFICES	1	LS	$30,000.00	$30,000
CLEAR AND GRUB	18	AC	$5,000.00	$90,000
SECURITY FENCE	6,800	LF	$15.90	$108,120
ROUGH GRADING				
CUT AND FILL	160,000	CY	$14.00	$2,240,000
STORM SEWERS	1,600	LF	$65.00	$104,000
MANHOLES	3	EA	$3,000.00	$9,000
NYCRR CAP				
FILTER FABRIC	1,580,000	SF	$0.56	$884,800
GAS VENT LAYER 12"	58,500	CY	$18.00	$1,053,000
GEOSYNTHETIC 40 MILS	1,580,000	SF	$0.50	$790,000
DRAINAGE LAYER 24"	117,000	CY	$18.00	$2,106,000
TOPSOIL 6"	29,250	CY	$19.20	$561,600
GAS VENTS	33	EA	$3,000.00	$99,000
SUBSURFACE DRAINAGE	15,000	LF	$16.00	$240,000
DRAINAGE DITCHES	15,000	LF	$2.00	$30,000
SEEDING	1,580,000	SF	$0.05	$79,000

TOTAL DIRECT CONSTRUCTION COST		$10,194,520
20	% CONTINGENCY	$2,038,904
10	%ENGINEERING/PLANNING	$1,019,452
5	% LEGAL/ADMINISTRATIVE	$509,726

TOTAL CAPITAL COST	$13,762,602

OPERATION AND MAINTENANCE COSTS
ASSUMED 5 PERCENT INTEREST, 30 YEAR PERIOD

LONG TERM MONITORING				
30 WELLS, 5 SURFACE WATERS, 10 SEDIMENT				
BASELINE (1X PER YR)	45	SP	$670.00	$30,150
ROUTINE (3X PER YEAR)	135	SP	$400.00	$54,000
LABOR AND MATERIALS	4	QTR	$5,500.00	$22,000
REPORT	4	RPTS	$2,000.00	$8,000
ADMIN./RECORDKEEPING	1	LS	$5,000.00	$5,000
MOWING, 8TIMES/YR	12,545	MSF	$2.00	$25,091
DITCH CLEANING	15,000	LF	$0.33	$4,950
WATER SYSTEM O & M	1	ANNUAL	$25,000.00	$25,000
		ANNUAL COST		$174,191

PRESENT WORTH COST	$2,677,736

SITE STATUS REVIEWS	1	EA	$5,000.00	$5,000
EVERY 5 YEARS	YEARS 5, 10, 15, 20, 25, 30			

PRESENT WORTH COST	$13,910
TOTAL PRESENT WORTH COST	$16,454,248

[illegible]

ALTERNATIVE SC4 RCRA IMPERMEABLE CAP

CAPITAL COSTS

PUBLIC AWARENESS/ LAND USE RESTRICTIONS	1	LS	$10,000.00	$10,000
RESIDENTIAL WATER SUPPLY REPLACEMENT	1	LS	$1,760,000	$1,760,000
SITE PREPARATION				
CONSTRUCTION OFFICES	1	LS	$30,000.00	$30,000
CLEAR AND GRUB	18	AC	$5,000.00	$90,000
SECURITY FENCE	6,800	LF	$15.90	$108,120
ROUGH GRADING				
CUT AND FILL	160,000	CY	$14.00	$2,240,000
STORM SEWERS	1,600	LF	$65.00	$104,000
MANHOLES	3	EA	$3,000.00	$9,000
RCRA CAP				
GAS VENT LAYER 12″	58,519	CY	$18.00	$1,053,342
FILTER FABRIC	1,580,000	SF	$0.56	$884,800
CLAY LAYER 24″	117,037	CY	$22.00	$2,574,814
GEOSYNTHETIC 40 MILS	1,580,000	SF	$0.50	$790,000
DRAINAGE LAYER 24″	117,037	CY	$18.00	$2,106,666
FILTER FABRIC	1,580,000	SF	$0.50	$790,000
VEGETATIVE SUPPORT LAYER 18″	87,778	CY	$12.00	$1,053,336
TOPSOIL 6″	29,259	CY	$19.20	$561,773
GAS VENTS	33	EA	$3,000.00	$99,000
SUBSURFACE DRAINAGE	15,000	LF	$16.00	$240,000
DRAINAGE DITCHES	15,000	LF	$2.00	$30,000
SEEDING	1,580,000	SF	$0.05	$79,000

TOTAL DIRECT CONSTRUCTION COST		$14,613,851
20	% CONTINGENCY	$2,922,770
10	%ENGINEERING/PLANNING	$1,461,385
5	% LEGAL/ADMINISTRATIVE	$730,693
TOTAL CAPITAL COST		$19,728,699

OPERATION AND MAINTENANCE COSTS
ASSUMED 5 PERCENT INTEREST, 30 YEAR PERIOD

LONG TERM MONITORING				
30 WELLS, 5 SURFACE WATERS, 10 SEDIMENT				
BASELINE (1X PER YR)	45	SP	$670.00	$30,150
ROUTINE (3X PER YEAR)	135	SP	$400.00	$54,000
LABOR AND MATERIALS	4	QTR	$5,500.00	$22,000
REPORT	4	RPTS	$2,000.00	$8,000
ADMIN./RECORDKEEPING	1	LS	$5,000.00	$5,000
MOWING, 8TIMES/YR	12,545	MSF	$2.00	$25,091
DITCH CLEANING	15,000	LF	$0.33	$4,950
WATER SYSTEM O & M	1	ANNU	$25,000.00	$25,000
		ANNUAL COST		$174,191
		PRESENT WORTH COST		$2,677,736

SITE STATUS REVIEWS	1	EA	$5,000.00	$5,000
EVERY 5 YEARS	YEARS 5, 10, 15, 20, 25, 30			
		PRESENT WORTH COST		$13,910
		TOTAL PRESENT WORTH COST		$22,420,344

ALTERNATIVE SC5 GROUNDWATER COLLECTION/TREATMENT/DISCHARGE
CAPITAL COSTS

PUBLIC AWARENESS/ LAND USE RESTRICTIONS	1	LS	$10,000.00	$10,000
RESIDENTIAL WATER SUPPLY REPLACEMENT	1	LS	$1,760,000	$1,760,000
SITE PREPARATION				
CONSTRUCTION OFFICES	1	LS	$30,000.00	$30,000
CLEAR AND GRUB	18	AC	$5,000.00	$90,000
SECURITY FENCE	6,800	LF	$15.90	$108,120
ROUGH GRADING				
CUT AND FILL	160,000	CY	$14.00	$2,240,000
STORM SEWERS	1,600	LF	$65.00	$104,000
MANHOLES	3	EA	$3,000.00	$9,000
SOIL COVER				
SOIL LAYER 12"	58,500	CY	$14.00	$819,000
TOPSOIL 6"	29,250	CY	$19.20	$561,600
GAS VENTS	33	EA	$3,000.00	$99,000
SUBSURFACE DRAINAGE	15,000	LF	$16.00	$240,000
DRAINAGE DITCHES	15,000	LF	$2.00	$30,000
SEEDING	1,580,000	SF	$0.05	$79,000
GROUNDWATER COLLECTION				
DRILL WELLS	20	EA	$4,000.00	$80,000
INSTALL PUMPS	20	EA	$3,000.00	$60,000
RUN ELECTRICAL	2,000	LF	$22.00	$44,000
12" COLLECTION SEWER	1,900	LF	$65.00	$123,500
MANHOLES	7	EA	$3,000.00	$21,000
PUMP STATION	1	LS	$125,000.00	$125,000
GROUNDWATER TREATMENT				
PROVIDE 3 PHASE	2,000	LF	$15.35	$30,700
PREFAB STEEL BUILDING	20,000	SF	$15.00	$300,000
IRON REMOVAL	1	EA	$165,000.00	$165,000
MN FILTER	1	EA	$150,000.00	$150,000
METALS PRECIPITATION	1	EA	$500,000.00	$500,000
GAC POLISHING FILTER	1	EA	$200,000.00	$200,000
SLUDGE THICKENING	1	EA	$100,000.00	$100,000
SLUDGE HANDLE/DEWATER	1	EA	$250,000.00	$250,000
CHEMICAL FEED SYSTEMS	6	EA	$15,000.00	$90,000
FINISH WATER TANK	1	EA	$80,000.00	$80,000
DECANT TANK	1	EA	$80,000.00	$80,000
PUMPS	10	EA	$5,000.00	$50,000
LAB EQUIPMENT	1	LS	$20,000.00	$20,000
BUILDING ELECTRICAL	1	LS	$500,000.00	$500,000
STARTUP	1	LS	$200,000.00	$200,000
GROUNDWATER DISCHARGE				
SEWER	1,200	LF	$65.00	$78,000
MANHOLES	6	EA	$3,000.00	$18,000
HEADWALL	1	EA	$2,500.00	$2,500

TOTAL DIRECT CONSTRUCTION COST	$9,447,420
20 % CONTINGENCY	$1,889,484
10 %ENGINEERING/PLANNING	$944,742
5 % LEGAL/ADMINISTRATIVE	$472,371
TOTAL CAPITAL COST	$12,754,017

ALTERNATIVE SC5 GROUNDWATER COLLECTION/TREATMENT/DISCHARGE, CONT.

OPERATION AND MAINTENANCE COSTS
ASSUMED 5 PERCENT INTEREST, 30 YEAR PERIOD

LONG TERM MONITORING					
30 WELLS, 5 SURFACE WATERS, 10 SEDIMENTS					
BASELINE (1X PER YR)	45	SP	$670.00	$30,150	
ROUTINE (3X PER YEAR)	135	SP	$400.00	$54,000	
LABOR AND MATERIALS	4	QTR	$5,500.00	$22,000	
REPORT	4	RPTS	$2,000.00	$8,000	
ADMIN./RECORDKEEPING	1	LS	$5,000.00	$5,000	
MOWING, 8TIMES/YR	12,545	MSF	$2.00	$25,091	
DITCH CLEANING	15,000	LF	$0.33	$4,950	
WATER SYSTEM O & M	1	ANNUAL	$25,000.00	$25,000	
		ANNUAL COST		$174,191	
			PRESENT WORTH COST		$2,677,736
SITE STATUS REVIEWS	1	EA	$5,000.00	$5,000	
EVERY 5 YEARS	YEARS 5, 10, 15, 20, 25, 30				
			PRESENT WORTH COST		$13,910
GROUNDWATER COLLECTION					
POWER	205,000	KWH/YR	$0.07	$14,350	
YEARLY MAINTENANCE	1	ANN,	$22,675.00	$22,675	
GROUNDWATER TREATMENT					
CHEMICALS	1	LS	$90,000.00	$90,000	
SLUDGE DISPOSAL	550	TONS/YR	$300.00	$165,000	
POWER	1,000,000	KWH/YR	$0.07	$70,000	
REPLACE GAC	2	PER/YEAR	$50,000.00	$100,000	
OPERATORS – LABOR	4	EA	$50,000.00	$200,000	
MAINT./OPERATIONS ALLOWANCE	1	LS	$100,000.00	$100,000	
		ANNUAL COST		$762,025	
			PRESENT WORTH COST		$11,714,192
		TOTAL PRESENT WORTH COST			$27,159,855

ALTERNATIVE SC6 NYCRR IMPERMEABLE CAP/GW COLLECTION/TREAT/DISCHARGE

CAPITAL COSTS

PUBLIC AWARENESS/				
LAND USE RESTRICTIONS	1	LS	$10,000.00	$10,000
RESIDENTIAL WATER SUPPLY REPLACEMENT	1	LS	$1,760,000	$1,760,000
SITE PREPARATION				
CONSTRUCTION OFFICES	1	LS	$30,000.00	$30,000
CLEAR AND GRUB	18	AC	$5,000.00	$90,000
SECURITY FENCE	6,800	LF	$15.90	$108,120
ROUGH GRADING				
CUT AND FILL	160,000	CY	$14.00	$2,240,000
STORM SEWERS	1,600	LF	$65.00	$104,000
MANHOLES	3	EA	$3,000.00	$9,000
NYCRR CAP				
FILTER FABRIC	1,580,000	SF	$0.56	$884,800
GAS VENT LAYER 12"	58,500	CY	$18.00	$1,053,000
GEOSYNTHETIC 40 MILS	1,580,000	SF	$0.50	$790,000
DRAINAGE LAYER	117,000	CY	$18.00	$2,106,000
TOPSOIL 6"	29,250	CY	$19.20	$561,600
GAS VENTS	33	EA	$3,000.00	$99,000
SUBSURFACE DRAINAGE	15,000	LF	$16.00	$240,000
DRAINAGE DITCHES	15,000	LF	$2.00	$30,000
SEEDING	1,580,000	SF	$0.05	$79,000
GROUNDWATER COLLECTION				
DRILL WELLS	20	EA	$4,000.00	$80,000
INSTALL PUMPS	20	EA	$3,000.00	$60,000
RUN ELECTRICAL	2,000	LF	$22.00	$44,000
12" COLLECTION SEWER	1,900	LF	$65.00	$123,500
MANHOLES	7	EA	$3,000.00	$21,000
PUMP STATION	1	LS	$125,000.00	$125,000
GROUNDWATER TREATMENT				
PROVIDE 3 PHASE	2,000	LF	$15.35	$30,700
PREFAB STEEL BUILDING	20,000	SF	$15.00	$300,000
IRON REMOVAL	1	EA	$165,000.00	$165,000
MN FILTER	1	EA	$150,000.00	$150,000
METALS PRECIPITATION	1	EA	$500,000.00	$500,000
GAC POLISHING FILTER	1	EA	$200,000.00	$200,000
SLUDGE THICKENING	1	EA	$100,000.00	$100,000
SLUDGE HANDLE/DEWATER	1	EA	$250,000.00	$250,000
CHEMICAL FEED SYSTEMS	6	EA	$15,000.00	$90,000
FINISH WATER TANK	1	EA	$80,000.00	$80,000
DECANT TANK	1	EA	$80,000.00	$80,000
PUMPS	10	EA	$5,000.00	$50,000
LAB EQUIPMENT	1	LS	$20,000.00	$20,000
BUILDING ELECTRICAL	1	LS	$500,000.00	$500,000
STARTUP	1	LS	$200,000.00	$200,000
GROUNDWATER DISCHARGE				
SEWER	1,200	LF	$65.00	$78,000
MANHOLES	6	EA	$3,000.00	$18,000
HEADWALL	1	EA	$2,500.00	$2,500

TOTAL DIRECT CONSTRUCTION COST	$13,462,220
20 % CONTINGENCY	$2,692,444
10 %ENGINEERING/PLANNING	$1,346,222
5 % LEGAL/ADMINISTRATIVE	$673,111
TOTAL CAPITAL COST	$18,173,997

ALTERNATIVE SC6 NYCCR IMPERMEABLE CAP/GW COLLECTION/TREAT/DISCHARGE, CONT.

OPERATION AND MAINTENANCE COSTS
ASSUMED 5 PERCENT INTEREST, 30 YEAR PERIOD

LONG TERM MONITORING				
30 WELLS, 5 SURFACE WATERS, 10 SEDIMENTS				
BASELINE (1X PER YR)	45	SP	$670.00	$30,150
ROUTINE (3X PER YEAR)	135	SP	$400.00	$54,000
LABOR AND MATERIALS	4	QTR	$5,500.00	$22,000
REPORT	4	RPTS	$2,000.00	$8,000
ADMIN./RECORDKEEPING	1	LS	$5,000.00	$5,000
MOWING, 8TIMES/YR	12,545	MSF	$2.00	$25,091
DITCH CLEANING	15,000	LF	$0.33	$4,950
WATER SYSTEM O & M	1	ANNUAL	$25,000.00	$25,000
		ANNUAL COST		$174,191
			PRESENT WORTH COST	$2,677,736

SITE STATUS REVIEWS	1	EA	$5,000.00	$5,000
EVERY 5 YEARS	YEARS 5, 10, 15, 20, 25, 30			
			PRESENT WORTH COST	$13,910

GROUNDWATER COLLECTION				
POWER	205,000	KWH/YR	$0.07	$14,350
YEARLY MAINTENANCE	1	ANN,	$22,675.00	$22,675
GROUNDWATER TREATMENT				
CHEMICALS	1	LS	$90,000.00	$90,000
SLUDGE DISPOSAL	550	TONS/YR	$300.00	$165,000
POWER	1,000,000	KWH/YR	$0.07	$70,000
REPLACE GAC	2	PER/YEAR	$50,000.00	$100,000
OPERATORS – LABOR	4	EA	$50,000.00	$200,000
MAINT./OPERATIONS ALLOWANCE	1	LS	$100,000.00	$100,000
		ANNUAL COST		$762,025
			PRESENT WORTH COST	$11,714,192
		TOTAL PRESENT WORTH COST		$32,579,835

ALTERNATIVE SC7 RCRA IMPERMEABLE CAP/GW COLLECTION/TREAT/DISCHARGE

CAPITAL COSTS

PUBLIC AWARENESS/				
LAND USE RESTRICTIONS	1	LS	$10,000.00	$10,000
RESIDENTIAL WATER SUPPLY REPLACEMENT	1	LS	$1,760,000	$1,760,000
SITE PREPARATION				
CONSTRUCTION OFFICES	1	LS	$30,000.00	$30,000
CLEAR AND GRUB	18	AC	$5,000.00	$90,000
SECURITY FENCE	6,800	LF	$15.90	$108,120
ROUGH GRADING				
CUT AND FILL	160,000	CY	$14.00	$2,240,000
STORM SEWERS	1,600	LF	$65.00	$104,000
MANHOLES	3	EA	$3,000.00	$9,000
RCRA CAP				
GAS VENT LAYER 12"	58,519	CY	$18.00	$1,053,342
FILTER FABRIC	1,580,000	SF	$0.56	$884,800
CLAY LAYER 24"	117,037	CY	$22.00	$2,574,814
GEOSYNTHETIC 40 MILS	1,580,000	SF	$0.50	$790,000
DRAINAGE LAYER 24"	117,000	CY	$18.00	$2,106,000
FILTER FABRIC	1,580,000	SF	$0.50	$790,000
VEGETATIVE SUPPORT LAYER 18"	87,778	CY	$12.00	$1,053,336
TOPSOIL 6"	29,259	CY	$19.20	$561,773
GAS VENTS	33	EA	$3,000.00	$99,000
SUBSURFACE DRAINAGE	15,000	LF	$16.00	$240,000
DRAINAGE DITCHES	15,000	LF	$2.00	$30,000
SEEDING	1,580,000	SF	$0.05	$79,000
GROUNDWATER COLLECTION				
DRILL WELLS	20	EA	$4,000.00	$80,000
INSTALL PUMPS	20	EA	$3,000.00	$60,000
RUN ELECTRICAL	2,000	LF	$22.00	$44,000
12" COLLECTION SEWER	1,900	LF	$65.00	$123,500
MANHOLES	7	EA	$3,000.00	$21,000
PUMP STATION	1	LS	$125,000.00	$125,000
GROUNDWATER TREATMENT				
PROVIDE 3 PHASE	2,000	LF	$15.35	$30,700
PREFAB STEEL BUILDING	20,000	SF	$15.00	$300,000
IRON REMOVAL	1	EA	$165,000.00	$165,000
MN FILTER	1	EA	$150,000.00	$150,000
METALS PRECIPITATION	1	EA	$500,000.00	$500,000
GAC POLISHING FILTER	1	EA	$200,000.00	$200,000
SLUDGE THICKENING	1	EA	$100,000.00	$100,000
SLUDGE HANDLE/DEWATER	1	EA	$250,000.00	$250,000
CHEMICAL FEED SYSTEMS	6	EA	$15,000.00	$90,000
FINISH WATER TANK	1	EA	$80,000.00	$80,000
DECANT TANK	1	EA	$80,000.00	$80,000
PUMPS	10	EA	$5,000.00	$50,000
LAB EQUIPMENT	1	LS	$20,000.00	$20,000
BUILDING ELECTRICAL	1	LS	$500,000.00	$500,000
STARTUP	1	LS	$200,000.00	$200,000

ALTERNATIVE SC7 RCRA IMPERMEABLE CAP/GW COLLECTION/TREAT/DISCHARGE, CONT.

GROUNDWATER DISCHARGE				
SEWER	1,200	LF	$65.00	$78,000
MANHOLES	6	EA	$3,000.00	$18,000
HEADWALL	1	EA	$2,500.00	$2,500
TOTAL DIRECT CONSTRUCTION COST				$17,880,885
20 % CONTINGENCY				$3,576,177
10 %ENGINEERING/PLANNING				$1,788,088
5 % LEGAL/ADMINISTRATIVE				$894,044
TOTAL CAPITAL COST				$24,139,194

OPERATION AND MAINTENANCE COSTS
ASSUMED 5 PERCENT INTEREST, 30 YEAR PERIOD

LONG TERM MONITORING				
30 WELLS, 5 SURFACE WATERS, 10 SEDIMENTS				
BASELINE (1X PER YR)	45	SP	$670.00	$30,150
ROUTINE (3X PER YEAR)	135	SP	$400.00	$54,000
LABOR AND MATERIALS	4	QTR	$5,500.00	$22,000
REPORT	4	RPTS	$2,000.00	$8,000
ADMIN./RECORDKEEPING	1	LS	$5,000.00	$5,000
MOWING, 8TIMES/YR	12,545	MSF	$2.00	$25,091
DITCH CLEANING	15,000	LF	$0.33	$4,950
WATER SYSTEM O & M	1	ANNUAL	$25,000.00	$25,000
		ANNUAL COST		$174,191
PRESENT WORTH COST				$2,677,736

SITE STATUS REVIEWS	1	EA	$5,000.00	$5,000
EVERY 5 YEARS	YEARS 5, 10, 15, 20, 25, 30			
PRESENT WORTH COST				$13,910

GROUNDWATER COLLECTION				
POWER	205,000	KWH/YR	$0.07	$14,350
YEARLY MAINTENANCE	1	ANN,	$22,675.00	$22,675
GROUNDWATER TREATMENT				
CHEMICALS	1	LS	$90,000.00	$90,000
SLUDGE DISPOSAL	550	TONS/YR	$300.00	$165,000
POWER	1,000,000	KWH/YR	$0.07	$70,000
REPLACE GAC	2	PER/YEAR	$50,000.00	$100,000
OPERATORS – LABOR	4	EA	$50,000.00	$200,000
MAINT./OPERATIONS ALLOWANCE	1	LS	$100,000.00	$100,000
		ANNUAL COST		$762,025
PRESENT WORTH COST				$11,714,192
TOTAL PRESENT WORTH COST				$38,545,032

APPENDIX C

HYDROLOGIC EVALUATION OF LINER PERFORMANCE MODEL (HELP) SUMMARY OUTPUT

JOHNSTOWN LANDFILL
CONTOUR AND REGRADE, NO CAP

GOOD GRASS

LAYER 1 (TOP SOIL)

VERTICAL PERCOLATION LAYER		
THICKNESS	=	6.00 INCHES
EVAPORATION COEFFICIENT	=	4.500 MM/DAY**0.5
POROSITY	=	0.5210 VOL/VOL
FIELD CAPACITY	=	0.3770 VOL/VOL
WILTING POINT	=	0.2210 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.88199991 INCHES/HR

LAYER 2 (DRAINAGE LAYER)

LATERAL DRAINAGE LAYER		
SLOPE	=	5.00 PERCENT
DRAINAGE LENGTH	=	500.0 FEET
THICKNESS	=	18.00 INCHES
EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
POROSITY	=	0.3665 VOL/VOL
FIELD CAPACITY	=	0.1903 VOL/VOL
WILTING POINT	=	0.0920 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.02750000 INCHES/HR

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	80.59
TOTAL AREA OF COVER	=	1580000. SQ. FT
EVAPORATIVE ZONE DEPTH	=	14.00 INCHES
EFFECTIVE EVAPORATION COEFFICIENT	=	4.268 MM/DAY**0.5
UPPER LIMIT VEG. STORAGE	=	6.0580 INCHES
INITIAL VEG. STORAGE	=	2.9232 INCHES

CLIMATOLOGIC DATA FOR SCHENACTADY NEW YORK

MONTHLY MEAN TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
23.67	25.72	33.86	45.90	58.63	68.62
73.20	71.15	63.01	50.96	38.24	28.25

MONTHLY MEANS SOLAR RADIATION, LANGLEYS PER DAY

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
126.58	182.27	264.80	352.05	420.64	452.19
438.25	382.56	300.03	212.78	144.19	112.64

LEAF AREA INDEX TABLE

DATE	LAI
1	0.00
114	0.00
131	1.23
149	2.01
166	2.01
184	2.01
201	2.01
218	2.01
236	1.81
253	1.31
271	0.64
288	0.34
366	0.00

GOOD GRASS

WINTER COVER FACTOR = 1.20

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JOHNSTOWN LANDFILL
CONTOUR AND REGRADE, NO CAP
PAGE 3

AVERAGE MONTHLY TOTALS FOR 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	3.01	1.98	3.59	3.67	3.71	4.61
	6.32	4.98	5.35	3.91	3.29	3.54
RUNOFF (INCHES)	0.000	0.000	0.163	0.356	0.081	0.020
	0.479	0.178	0.502	0.117	0.020	0.000
EVAPOTRANSPIRATION (INCHES)	0.855	1.172	2.207	2.478	3.539	4.007
	4.075	4.214	3.056	2.028	1.157	0.817
PERCOLATION FROM BASE OF COVER (INCHES)	0.0000	0.0000	2.8284	4.1960	1.3534	0.3203
	0.9399	0.7624	1.4629	1.8089	1.5553	0.5681
DRAINAGE FROM BASE OF COVER (INCHES)	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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AVERAGE ANNUAL TOTALS FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	47.97	6316049.	100.00
RUNOFF	1.917	252386.	4.00
EVAPOTRANSPIRATION	29.607	3898221.	61.72
PERCOLATION FROM BASE OF COVER*	15.7958	2079781.	32.93
DRAINAGE FROM BASE OF COVER	0.000	0.	0.00

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*Annual leachate production

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PEAK DAILY VALUES FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.90	513500.0
RUNOFF	1.186	156129.9
PERCOLATION FROM BASE OF COVER	0.5608	73839.2
DRAINAGE FROM BASE OF COVER	0.000	0.0
HEAD ON BASE OF COVER	0.0	
SNOW WATER	8.27	1088689.6

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4241
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1473

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JOHNSTOWN LANDFILL
NYCRR CAP
CLAY BARRIER

GOOD GRASS

LAYER 1 (TOP SOIL)

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
EVAPORATION COEFFICIENT	=	4.500 MM/DAY**0.5
POROSITY	=	0.5210 VOL/VOL
FIELD CAPACITY	=	0.3770 VOL/VOL
WILTING POINT	=	0.2210 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.88199991 INCHES/HR

LAYER 2 (DRAINAGE LAYER)

LATERAL DRAINAGE LAYER

SLOPE	=	5.00 PERCENT
DRAINAGE LENGTH	=	100.0 FEET
THICKNESS	=	24.00 INCHES
EVAPORATION COEFFICIENT	=	3.300 MM/DAY**0.5
POROSITY	=	0.3890 VOL/VOL
FIELD CAPACITY	=	0.1990 VOL/VOL
WILTING POINT	=	0.0660 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	6.61999989 INCHES/HR

LAYER 3 (CLAY CAP)

BARRIER SOIL LAYER

THICKNESS	=	18.00 INCHES
EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.4500 VOL/VOL
WILTING POINT	=	0.3600 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.00014200 INCHES/HR

LAYER 4 (GAS VENT LAYER)

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
POROSITY	=	0.3083 VOL/VOL
FIELD CAPACITY	=	0.1657 VOL/VOL
WILTING POINT	=	0.0660 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY*	=	0.33100000 INCHES/HR

***Model default value used, does not change leachate estimate.**

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	80.59
TOTAL AREA OF COVER	=	1580000. SQ. FT
EVAPORATIVE ZONE DEPTH	=	14.00 INCHES
EFFECTIVE EVAPORATION COEFFICIENT	=	4.301 MM/DAY**0.5
UPPER LIMIT VEG. STORAGE	=	6.2380 INCHES
INITIAL VEG. STORAGE	=	2.8540 INCHES

CLIMATOLOGIC DATA FOR SCHENACTADY NEW YORK

MONTHLY MEAN TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
23.67	25.72	33.86	45.90	58.63	68.62
73.20	71.15	63.01	50.96	38.24	28.25

MONTHLY MEANS SOLAR RADIATION, LANGLEYS PER DAY

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
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LEAF AREA INDEX TABLE

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149	2.01
166	2.01
184	2.01
201	2.01
218	2.01
236	1.81
253	1.31
271	0.64
288	0.34
366	0.00

GOOD GRASS

WINTER COVER FACTOR = 1.20

JOHNSTOWN LANDFILL
NYCRR CAP
CLAY BARRIER
PAGE 3

AVERAGE MONTHLY TOTALS FOR 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	3.01	1.98	3.59	3.67	3.71	4.61
	6.32	4.98	5.35	3.91	3.29	3.54
RUNOFF (INCHES)	0.000	0.000	0.136	0.349	0.068	0.014
	0.430	0.138	0.341	0.078	0.013	0.000
EVAPOTRANSPIRATION (INCHES)	0.856	1.173	2.208	2.452	3.368	3.103
	3.169	2.956	2.562	1.648	1.053	0.814
PERCOLATION FROM TOP BARRIER (INCHES)	0.0832	0.0179	0.0848	0.1752	0.1472	0.1317
	0.1400	0.1464	0.1425	0.1495	0.1374	0.1283
PERCOLATION FROM BASE OF COVER (INCHES)	0.0834	0.0184	0.0834	0.1755	0.1474	0.1317
	0.1398	0.1465	0.1425	0.1494	0.1376	0.1285
DRAINAGE FROM TOP BARRIER (INCHES)	0.159	0.004	1.148	3.968	2.059	1.347
	1.650	1.944	1.946	2.124	1.677	1.052
DRAINAGE FROM BASE OF COVER (INCHES)	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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JOHNSTOWN LANDFILL
NYCRR CAP
CLAY BARRIER
PAGE 4

AVERAGE ANNUAL TOTALS FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	47.97	6316049.	100.00
RUNOFF	1.567	206332.	3.27
EVAPOTRANSPIRATION	25.362	3339270.	52.87
PERCOLATION FROM TOP BARRIER	1.4841	195410.	3.09
PERCOLATION FROM BASE OF COVER*	1.4840	195391.	3.09
DRAINAGE FROM TOP BARRIER LAYER	19.081	2512308.	39.78
DRAINAGE FROM BASE OF COVER	0.000	0.	0.00

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PEAK DAILY VALUES FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.90	513500.0
RUNOFF	1.160	152689.8
PERCOLATION FROM TOP BARRIER	0.0094	1231.4
PERCOLATION FROM BASE OF COVER	0.0088	1153.6
DRAINAGE FROM TOP BARRIER LAYER	0.291	38327.6
DRAINAGE FROM BASE OF COVER	0.000	0.0
HEAD ON TOP BARRIER LAYER	28.4	
HEAD ON BASE OF COVER	0.0	
SNOW WATER	8.27	1088689.6

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4319
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1324

*Annual leachate production

JOHNSTOWN LANDFILL
NYCRR CAP
GEOSYNTHETIC BARRIER

GOOD GRASS

LAYER 1 (TOP SOIL)

VERTICAL PERCOLATION LAYER		
THICKNESS	=	6.00 INCHES
EVAPORATION COEFFICIENT	=	4.500 MM/DAY**0.5
POROSITY	=	0.5210 VOL/VOL
FIELD CAPACITY	=	0.3770 VOL/VOL
WILTING POINT	=	0.2210 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.88199991 INCHES/HR

LAYER 2 (DRAINAGE LAYER)

LATERAL DRAINAGE LAYER		
SLOPE	=	5.00 PERCENT
DRAINAGE LENGTH	=	100.0 FEET
THICKNESS	=	24.00 INCHES
EVAPORATION COEFFICIENT	=	3.300 MM/DAY**0.5
POROSITY	=	0.3890 VOL/VOL
FIELD CAPACITY	=	0.1990 VOL/VOL
WILTING POINT	=	0.0660 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	6.61999989 INCHES/HR

LAYER 3 (SYNTHETIC CAP)

BARRIER SOIL LAYER WITH LINER		
THICKNESS	=	12.00 INCHES
EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
POROSITY	=	0.3083 VOL/VOL
FIELD CAPACITY	=	0.1657 VOL/VOL
WILTING POINT	=	0.0660 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY *	=	0.33100000 INCHES/HR

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	80.59
TOTAL AREA OF COVER	=	1580000. SQ. FT
EVAPORATIVE ZONE DEPTH	=	14.00 INCHES
LINER LEAKAGE FRACTION	=	0.000001
EFFECTIVE EVAPORATION COEFFICIENT	=	4.301 MM/DAY**0.5
UPPER LIMIT VEG. STORAGE	=	6.2380 INCHES
INITIAL VEG. STORAGE	=	2.8540 INCHES

*Model default value, does not change leachate estimate.

JOHNSTOWN LANDFILL
NYCRR CAP
GEOSYNTHETIC BARRIER
PAGE 2

CLIMATOLOGIC DATA FOR SCHENACTADY NEW YORK

MONTHLY MEAN TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
23.67	25.72	33.86	45.90	58.63	68.62
73.20	71.15	63.01	50.96	38.24	28.25

MONTHLY MEANS SOLAR RADIATION, LANGLEYS PER DAY

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
126.58	182.27	264.80	352.05	420.64	452.19
438.25	382.56	300.03	212.78	144.19	112.64

LEAF AREA INDEX TABLE

DATE	LAI
1	0.00
114	0.00
131	1.23
149	2.01
166	2.01
184	2.01
201	2.01
218	2.01
236	1.81
253	1.31
271	0.64
288	0.34
366	0.00

GOOD GRASS

WINTER COVER FACTOR = 1.20

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JOHNSTOWN LANDFILL
NYCRR CAP
GEOSYNTHETIC BARRIER

AVERAGE MONTHLY TOTALS FOR 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	3.01	1.98	3.59	3.67	3.71	4.61
	6.32	4.98	5.35	3.91	3.29	3.54
RUNOFF (INCHES)	0.000	0.000	0.137	0.367	0.068	0.014
	0.431	0.138	0.341	0.078	0.013	0.000
EVAPOTRANSPIRATION (INCHES)	0.856	1.173	2.210	2.451	3.371	3.106
	3.169	2.957	2.561	1.648	1.053	0.814
PERCOLATION FROM BASE OF COVER (INCHES)	0.0002	0.0002	0.0003	0.0005	0.0004	0.0003
	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
DRAINAGE FROM BASE OF COVER (INCHES)	0.251	0.059	1.193	4.096	2.201	1.479
	1.786	2.091	2.087	2.274	1.816	1.185

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AVERAGE ANNUAL TOTALS FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	47.97	6316049.	100.00
RUNOFF	1.586	208823.	3.31
EVAPOTRANSPIRATION	25.369	3340211.	52.88
PERCOLATION FROM BASE OF COVER*	0.0043	560.	0.01
DRAINAGE FROM BASE OF COVER	20.518	2701576.	42.77

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*Annual leachate production

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PEAK DAILY VALUES FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.90	513500.0
RUNOFF	1.160	152701.5
PERCOLATION FROM BASE OF COVER	0.0000	3.6
DRAINAGE FROM BASE OF COVER	0.291	38331.9
HEAD ON BASE OF COVER	28.7	
SNOW WATER	8.27	1088689.6

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4347
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1324

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JOHNSTOWN LANDFILL
RCRA CAP

GOOD GRASS

LAYER 1 (TOP SOIL)

VERTICAL PERCOLATION LAYER		
THICKNESS	=	24.00 INCHES
EVAPORATION COEFFICIENT	=	4.500 MM/DAY**0.5
POROSITY	=	0.5210 VOL/VOL
FIELD CAPACITY	=	0.3770 VOL/VOL
WILTING POINT	=	0.2210 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.88199991 INCHES/HR

LAYER 2 (DRAINAGE LAYER)

LATERAL DRAINAGE LAYER		
SLOPE	=	5.00 PERCENT
DRAINAGE LENGTH	=	100.0 FEET
THICKNESS	=	12.00 INCHES
EVAPORATION COEFFICIENT	=	3.300 MM/DAY**0.5
POROSITY	=	0.3890 VOL/VOL
FIELD CAPACITY	=	0.1990 VOL/VOL
WILTING POINT	=	0.0660 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	6.61999989 INCHES/HR

LAYER 3 (CLAY AND SYNTHETIC CAP)

BARRIER SOIL LAYER WITH LINER		
THICKNESS	=	24.00 INCHES
EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.4500 VOL/VOL
WILTING POINT	=	0.3600 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY	=	0.00014200 INCHES/HR

LAYER 4 (GAS VENT LAYER)

VERTICAL PERCOLATION LAYER		
THICKNESS	=	12.00 INCHES
EVAPORATION COEFFICIENT	=	3.100 MM/DAY**0.5
POROSITY	=	0.3083 VOL/VOL
FIELD CAPACITY	=	0.1657 VOL/VOL
WILTING POINT	=	0.0660 VOL/VOL
EFFECTIVE HYDRAULIC CONDUCTIVITY*	=	0.33100000 INCHES/HR

*Model default value, does not change leachate estimate.

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	80.59
TOTAL AREA OF COVER	=	1580000. SQ. FT
EVAPORATIVE ZONE DEPTH	=	14.00 INCHES
LINER LEAKAGE FRACTION	=	0.000001
EFFECTIVE EVAPORATION COEFFICIENT	=	4.500 MM/DAY**0.5
UPPER LIMIT VEG. STORAGE	=	7.2940 INCHES
INITIAL VEG. STORAGE	=	4.1860 INCHES

CLIMATOLOGIC DATA FOR SCHENACTADY NEW YORK

MONTHLY MEAN TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
23.67	25.72	33.86	45.90	58.63	68.62
73.20	71.15	63.01	50.96	38.24	28.25

MONTHLY MEANS SOLAR RADIATION, LANGLEYS PER DAY

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
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438.25	382.56	300.03	212.78	144.19	112.64

LEAF AREA INDEX TABLE

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288	0.34
366	0.00

GOOD GRASS

WINTER COVER FACTOR = 1.20

JOHNSTOWN LANDFILL
RCRA CAP
PAGE 3

AVERAGE MONTHLY TOTALS FOR 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	3.01	1.98	3.59	3.67	3.71	4.61
	6.32	4.98	5.35	3.91	3.29	3.54
RUNOFF (INCHES)	0.000	0.000	0.171	0.612	0.086	0.016
	0.470	0.161	0.412	0.111	0.023	0.000
EVAPOTRANSPIRATION	0.856	1.173	2.206	2.475	3.735	3.763
(INCHES)	3.798	3.986	2.982	1.904	1.096	0.814
PERCOLATION FROM TOP	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BARRIER (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION FROM BASE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OF COVER (INCHES)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DRAINAGE FROM TOP	0.240	0.057	1.139	3.599	2.283	1.280
BARRIER (INCHES)	1.107	1.233	1.172	1.752	1.532	1.083
DRAINAGE FROM BASE OF	0.000	0.000	0.000	0.000	0.000	0.000
COVER (INCHES)	0.000	0.000	0.000	0.000	0.000	0.000

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AVERAGE ANNUAL TOTALS FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	47.97	6316049.	100.00
RUNOFF	2.063	271574.	4.30
EVAPOTRANSPIRATION	28.788	3790438.	60.01
PERCOLATION FROM TOP BARRIER	0.0000	0.	0.00
PERCOLATION FROM BASE OF COVER*	0.0000	0.	0.00
DRAINAGE FROM TOP BARRIER LAYER	16.476	2169318.	34.35
DRAINAGE FROM BASE OF COVER	0.000	0.	0.00

PEAK DAILY VALUES FOR 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.90	513500.0
RUNOFF	1.173	154460.4
PERCOLATION FROM TOP BARRIER	0.0000	0.0
PERCOLATION FROM BASE OF COVER	0.0000	0.0
DRAINAGE FROM TOP BARRIER LAYER	0.228	30073.7
DRAINAGE FROM BASE OF COVER	0.000	0.0
HEAD ON TOP BARRIER LAYER	35.6	
HEAD ON BASE OF COVER	0.0	
SNOW WATER	8.27	1088689.6

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5172

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2210

*Estimated annual leachate production

JOHNSTOWN LANDFILL
WATER BALENCE CALCULATIONS

STORMWATER DRAINAGE FLOWS TO LANDFILL (runon)

RUNON TO LANDFILL

Catchment	Total Drainage Area (Acres)	Yearly Runoff (inches)	Yearly Accumulation (Cubic ft/year)
E-1	28	18	1,829,520

POND EVAPORATION

Catchment	Ponded Area (acres)	Pond Evaporation (inches)	Yearly Loss (cubic ft/year)
E-2	1	25	90,750

Total Runon Infiltration 1,738,770 ft^3/yr
4764 ft^3/day
24.75 gpm

Notes
Drainage area estimated from USGS topographic map
Annual runoff and evapotranspiration from USGS
1985 National Water Summary

Rainfall Percolation Through Landfill

Total Landfill area 34 acres

Landfill area draining to other catchments

E 3 3 acres

E 4 8 acres

Area remaining 23 acres

Percolation = 23 acres × 18 in/yr => 1,502,820 ft^3/yr

4,117 ft^3/day

21.4 gpm

Notes

Percolation estimate based on flat non vegetated condition of landfill surface

Area based on site topographic map (Plate 1)

APPENDIX D

DISCUSSION OF HYDROGEOLOGY CALCULATIONS AND MODELING

APPENDIX D

I. INTRODUCTION

This appendix contains the following sections: II, a description of the computer model used to size the ground water extraction system component of remedial Alternative SC 5; III, computer modeling of contaminant transport to estimate the rate of contaminant decline after capping; IV, an analytical estimate of the rate of contaminant decline and the mass of chromium produced after capping; V, a discussion of the validity of using the retardation equations to model contaminant transport at the Johnstown Landfill; and VI, conclusion and recommendations.

II. ANALYTICAL MODELING OF GROUND WATER EXTRACTION SYSTEM

A computer version of an analytical solution for the modeling of ground water flow was used to evaluate the alternatives for the extraction of contaminated ground water downgradient of the Johnstown Landfill. The RESSQC option of the USEPA WHPA model (USEPA, 1991) was used for this analysis. The RESSQC code is a slightly modified version of the RESSQC code developed by Javandel et al. (1984). The RESSQC model simulates ground water flow in a two dimensional uniform flow field. The major assumptions in using this model are: 1) the aquifer is homogeneous, isotropic and of constant saturated thickness and 2) the flow of ground water in the aquifer is two dimensional in a horizontal plane at steady state.

Input to the computer model includes: transmissivity of the aquifer, regional hydraulic gradient, angle of ambient ground water flow, aquifer porosity and aquifer saturated thickness. As predicated by the governing assumptions of the flow model, each of the input values represent constant values in both time and space.

The estimated transmissivity of the aquifer was calculated by multiplying the lowest estimated hydraulic conductivity of the aquifer by the lowest estimated saturated thickness. Based upon the results of in-situ permeability tests performed in five of the shallow monitoring wells installed in the vicinity of the landfill the hydraulic conductivity of the sand unit ranges from 79 ft/day to 232 ft/day. Based upon the seismic geophysical surveys performed at the site the saturated thickness of the unconfined aquifer ranges from 29 to 33 feet. To provide a conservative estimate for the transmissivity of the unconfined aquifer at the site, the lowest value of hydraulic conductivity (79 ft/day) was multiplied by the lowest value of the saturated thickness (29 ft) to estimate the transmissivity (2,300 ft^2/day) of the unconfined aquifer.

The hydraulic gradient of ground water flow at the site was estimated using the average ground water elevations in the shallow monitoring wells recorded during 1991. The average ground water elevations were then contoured and three flow lines were delineated. For each flow line the hydraulic head was divided by the length of the flow line to estimate the hydraulic gradient. The hydraulic gradient of the three flow lines were added and the average hydraulic gradient was calculated. An average hydraulic gradient of 0.017 ft/ft was used for the model.

The angle of ambient ground water flow was estimated by visually fitting a line perpendicular to the average ground water elevation contours. An angle of 317° (northwest to southeast) was input for the angle of ambient ground water flow in the model.

The porosity of the unconfined aquifer was estimated from the textural descriptions of soil samples collected from 14 soil borings drilled in the vicinity of the landfill. Based on the soil samples the unconsolidated deposits consist of sand with varying amounts of gravel. Based upon the investigation by Johnson (1967) the porosity of these deposits may range from 25 to 35 percent. An average value of 30 percent was used for the model.

The number of ground water wells to be used in the extraction system and their rate of discharge was fitted by trial and error. The objective of the fitting procedure was to utilize a sufficient number of wells pumping at a moderate flow rate to create a capture zone which would include the Johnstown Landfill. The findings of this analysis suggested that a minimum of 13 to 14 wells pumping at a rate of 50 gallons per minute (gpm) would be required to create a capture zone large enough to encompass the footprint of the landfill (Figure 1).

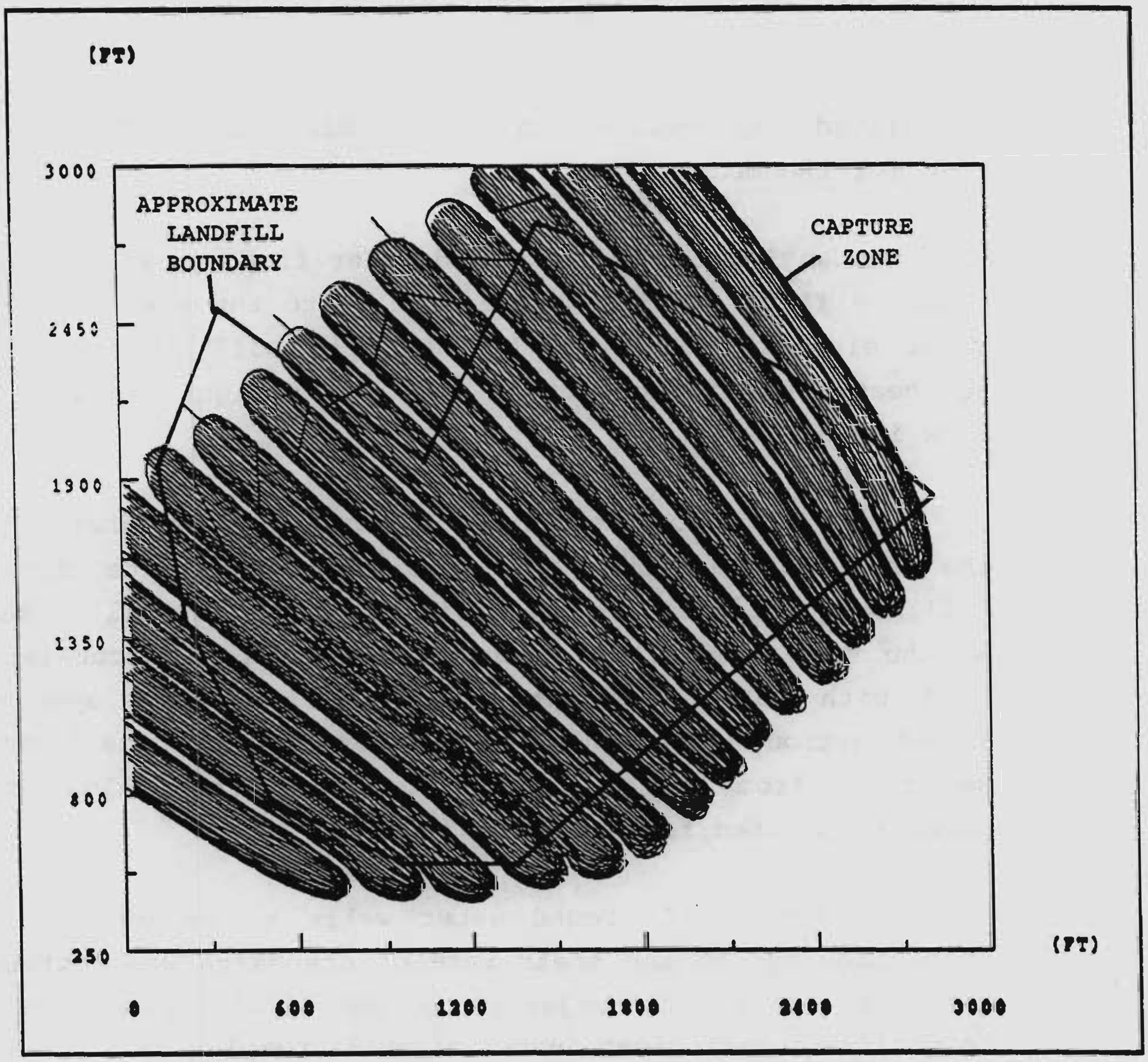


FIGURE 1 Capture zones for 14 extraction wells pumping at 50 gpm with aquifer transmissivity equal to 2,300 ft^2/day.

The results of this analysis are extremely conservative because the analytical model does not consider variations in the transmissivity of the unconsolidated deposits and the nonuniform nature of the ground water flow field at the site. Based upon the water quality and ground water flow direction information collected from the monitoring wells at the site, the contaminant plume appears to be concentrated in the southeast corner of the landfill. As a result, the number of extraction wells required to intercept the plume may be considerably less than the 13 or 14 wells suggested by the analytical model.

III. NUMERICAL GROUND WATER FLOW AND CONTAMINANT TRANSPORT MODEL

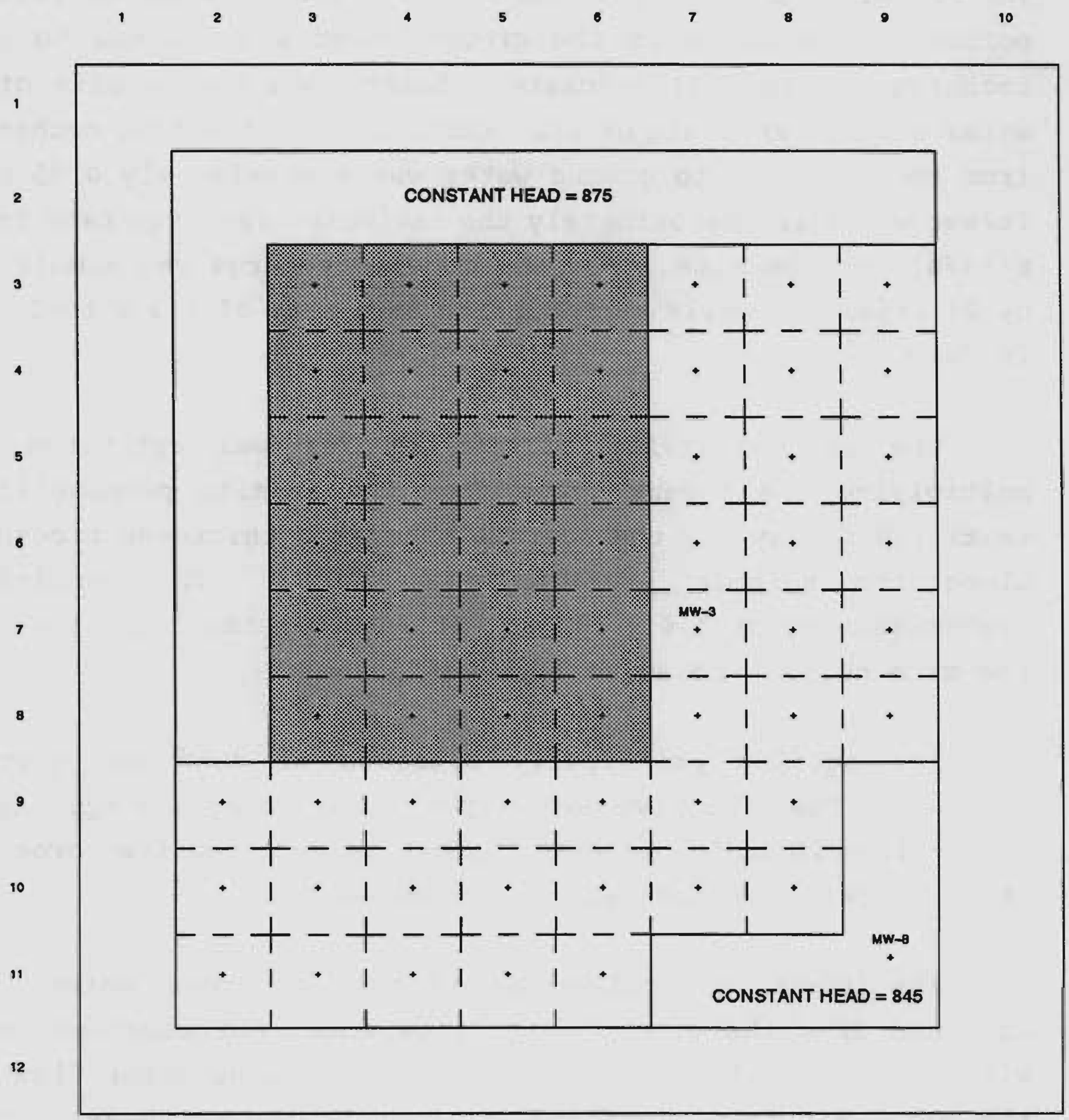
As part of the evaluation of the feasibility of the remediation of the contamination at the Johnstown landfill, a numerical computer program was used to simulate the migration of contaminated ground water from the landfill. The objective of the simulations was to preliminarily evaluate the time required for a conservative and non-conservative contaminant to move from the landfill to a downgradient monitoring well.

The USGS Method of Characteristics (MOC) ground water flow and contaminant transport computer program was used for this analysis. The MOC model is based upon a finite difference ground water flow model originally developed by Trescott, Pinder and Larson (1984) This flow model was modified by Konikow and Bredehoeft (1984) for the simulation of one or two dimensional problems involving steady or transient ground water flow conditions and the transport of conservative contaminants by convective transport, hydrodynamic dispersion and mixing. The program was further modified by Goode and Konikow (1989) to incorporate decay and equilibrium controlled sorption or ion exchange. The modified version of the MOC model was used in this analysis.

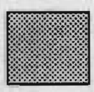
The predominant migration pathway for the leachate contaminated ground water at the site is via ground water flow in the unconfined aquifer. The unconfined aquifer occurs in the sand and gravel deposits which underlie the site. Based upon ground water elevations recorded in the monitoring wells at the site the direction of ground water flow is horizontal and from recharge areas to the north and west of the landfill to the southeast towards the Lagrange Spring. Considering that ground water flow at the site is predominantly horizontal, a two dimensional model was assumed to adequately represent the ground water flow system.

The first step of the modeling process was to construct the model grid. The model was constructed from a 10 x 12 grid of cells which included the landfill and the area between the landfill and the Lagrange Spring (Figure 2). A constant head boundary was established to the north and to the west of the landfill. This constant head boundary was set equal to 875 feet, which reflects the ground water elevation recorded in this area in April, 1991. A second constant head boundary was established southeast of the landfill in the vicinity of monitoring well MW-8S. This constant head boundary was set at 845 feet, which reflects the ground water elevation at monitoring well MW-8S recorded in April, 1991.

FIGURE 2 : GRID FOR MOC SIMULATION OF JOHNSTOWN LANDFILL



LEGEND



LANDFILL

MW-3 + OBSERVATION WELL

The ground water flow model also requires input values for recharge, aquifer thickness, transmissivity and effective porosity. Recharge to the ground water was limited to the recharge of landfill leachate. Based upon the results of a water balance analysis of the landfill, the effective recharge from the landfill to ground water was approximately 0.05 cu. ft/sec which is approximately the estimated recharge rate from rainfall on the site. For the model, recharge was simulated by 24 injection wells each pumping at a rate of 2.3 x 10-3 cu. ft./sec.

The transmissivity of the aquifer was estimated by multiplying the lowest value from the in-situ permeability tests (79 ft/day) by the average saturated thickness recorded along the seismic profiles (33 feet). The resulting transmissivity of 2.6×10^{-2} sq. ft./sec was input for each of the grid cells. No anisotropy was assumed.

The aquifer principally consists of sand and gravel deposits. The effective porosity of these materials typically ranges from 20 to 50 percent. An estimated effective porosity of 30 percent was assumed for the model.

The direction, gradient and velocity of ground water flow obtained from the ground water flow model corresponded well with observed values. The direction of ground water flow in the model was from the north and west to the southeast. The gradient of ground water flow ranged from 0.012 to 0.02 while the observed gradients ranged from 0.013 to 0.016. The velocity of ground water flow is dependent upon the hydraulic conductivity and the effective porosity of the aquifer material. Assuming an effective porosity of 30 percent, a hydraulic conductivity of 79 ft/day, a minimum gradient of 0.013 and a maximum gradient of 0.016 the velocity of ground water at the site would range from 3.4 to 4.2 ft/day. The maximum simulated ground water velocity was 6.9 ft/day.

To model the transport of contaminants via ground water flow, several additional physical and chemical characteristics of the aquifer must be known and input in the model. These characteristics include the aquifer dispersivity and the type of physical/chemical reaction that occurs with the contaminant of interest. The aquifer dispersivity is scale dependent and can be estimated as 10 percent of the length of the flow line. A longitudinal dispersivity of 160 feet was estimated based upon the length of a flow line from the center of the landfill to the Lagrange Spring.

To monitor the concentration of the contaminants migrating from the landfill an observation well was input in the model in the vicinity of monitoring well MW-3S. During each model run a printout was obtained which listed the time, the contaminant concentration and the static water level. The contaminant concentrations at the observation well were then compared with the laboratory results obtained at MW-3S to see if the modeling results were similar to observed values.

Chloride was selected to represent the conservative contaminant to be modeled. Based upon the results of numerous hydrochemical investigations chloride does not physically or chemically interact with aquifer materials or other contaminants. As a result its movement through the aquifer is unretarded. In the MOC model the no reaction option was selected for this analysis.

Based upon a sample collected from monitoring well MW-16 the concentration of chloride in the landfill leachate was 699 mg/L. For the model, a source concentration of 700 mg/L was assumed to the discharged at each of the 24 cells representing the landfill. A background concentration of 10 mg/L was used based upon the average concentration of chloride recorded in several of the monitoring wells not impacted by the landfill.

The MOC model was run with five years of recharge followed by five years with no recharge, to simulate the capping of the landfill. A peak concentration of 97.7 mg/L was observed within the five year pumping period (Figure 3). The actual concentration of chloride recorded at MW-3S has ranged from 109 to 215 mg/L during three sampling rounds. The model results would suggest that a higher source strength (concentration and/or rate of recharge) may be required to simulate field concentrations although these results are considered to be adequate for the purposes of this discussion.

After the five year recharge period, the recharge to ground water (and the source of chloride) was eliminated to simulate the capping of the landfill. As a result, the concentration of chloride was found to decline rapidly to background concentrations within three years (Figure 3). The model results would suggest that the concentration of any conservative contaminants in the leachate contaminated ground water will rapidly decline, once the source of the leachate is

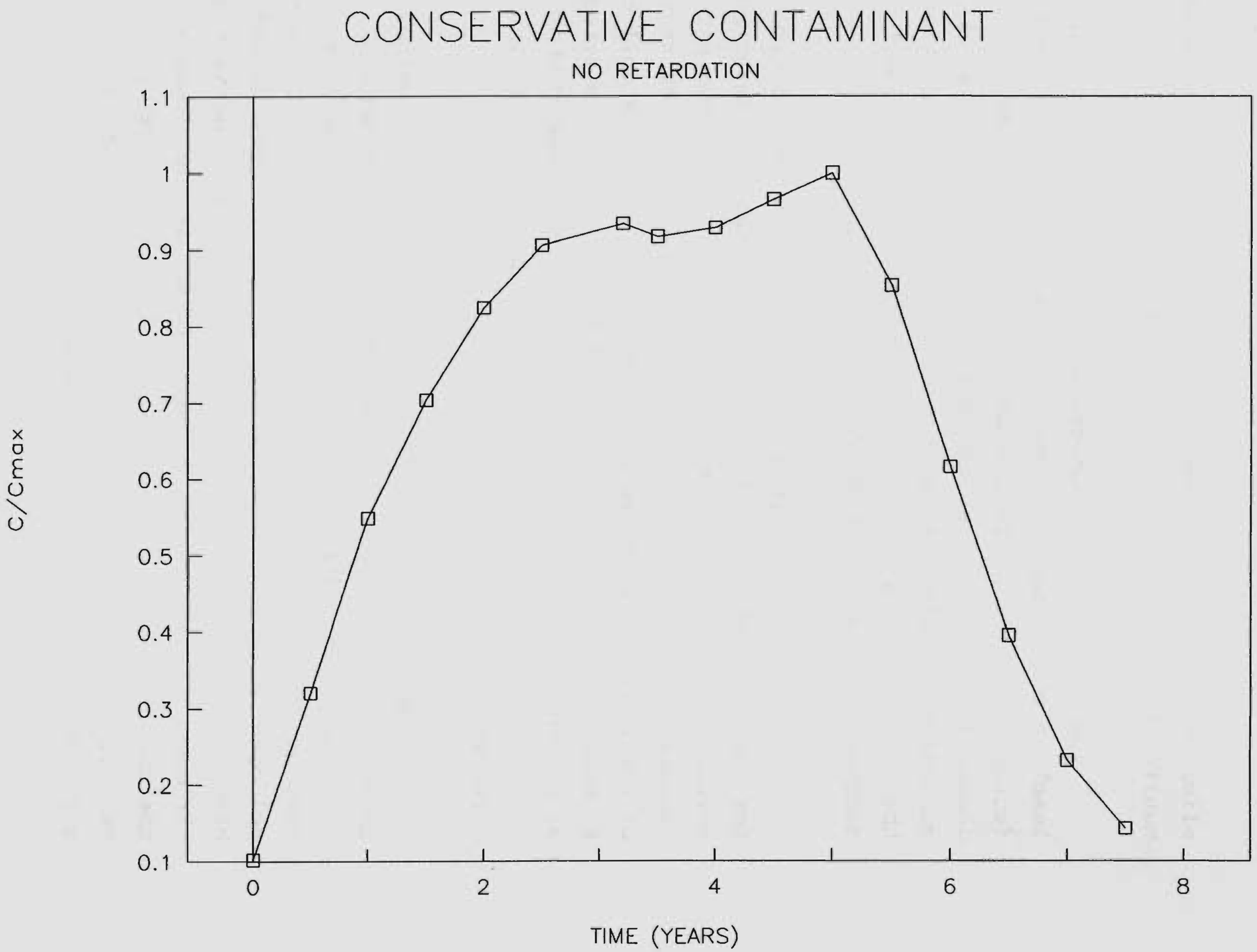


Figure 3 - Plot of the ratio of contaminant concentration to maximum contaminant concentration for a conservative contaminant.

eliminated. This trend should be observed in the ground water monitoring program after the landfill is capped.

The migration of non-conservative contaminants in the leachate contaminated ground water is dependent upon several factors including: the concentration of the contaminant, the chemical state of the contaminant, the reactions of the contaminants with the aquifer material, co-precipitation of the contaminants onto the aquifer material and the decomposition or decay of the contaminants.

Chromium was selected as a non-conservative contaminant for this evaluation. Trivalent chromium has been detected in several of the ground water monitoring wells at the site at concentrations exceeding 100 μg/L. The highest concentration of chromium was detected in the sample of leachate collected at monitoring well MW-16. At this well chromium was detected at a concentration of 2,330 μg/ and this value was used as the source concentration. The background concentration of chromium at the site is 40 μg/L.

Chromium is considered a non-conservative contaminant because it will typically sorb onto aquifer material. The sorption of chromium onto the aquifer material decreases its concentration in the ground water and decreases its overall velocity relative to ground water flow. The amount of chromium sorbed onto the aquifer material is dependent upon the concentration of the chromium present in the ground water, the amount of chromium sorbed onto the aquifer material, the rate of ground water flow and the chemical characteristics of the contaminant plume. In general, the ratio of the mass sorbed versus the mass in solution is expressed by the distribution coefficient (K_D). The higher the distribution coefficient the greater the amount of contaminant sorbed onto the aquifer. The difference in the rate of movement between the contaminant and ground water is expressed by the retardation factor (R). If the chromium is readily sorbed onto the aquifer material (high K_D) the resulting retardation of its movement in the ground water will be considerable.

To evaluate the migration of a non-conservative contaminant, such as chromium, in the ground water at the site, the MOC model was run using the linear sorption reaction option. A range of distribution coefficients (2, 5 and 10) were used since no value is available for the aquifer materials at the Johnstown Landfill.

The linear sorption option also requires estimates of the bulk density of the aquifer material and a half life of the contaminant if decay is to be considered. A bulk density of 1.86 was used for the model and a half life of thirty years was assumed (no substantial decay).

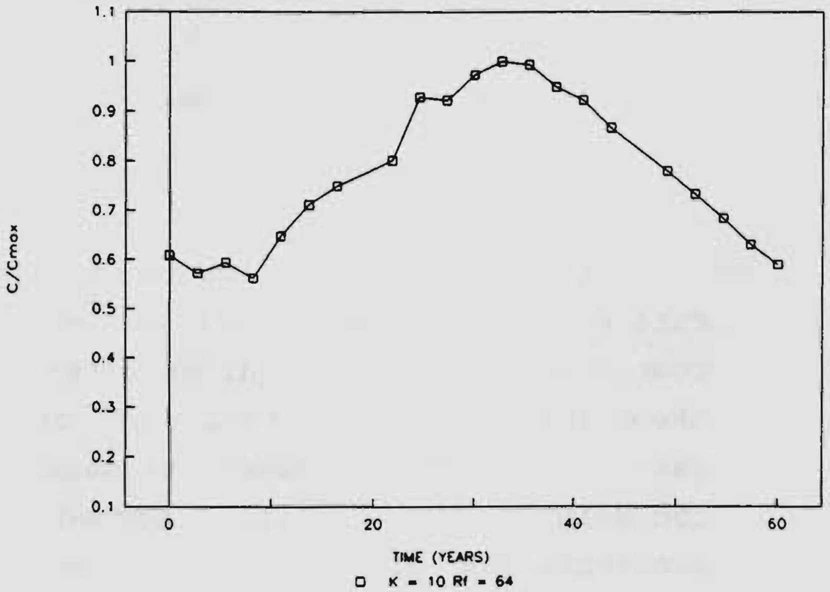
Due to the retardation of the contaminants, the run time of the model had to be increased from 5 years to 30 years so that the estimated concentration of chromium would be similar to the values recorded in the field. The 30-year run time also roughly corresponds to the length of time that the landfill had operated.

As shown in Figure 4, as the distribution coefficient and the retardation factor are increased, the maximum contaminantconcentration decreases. This is due to the increased sorption of the contaminant onto the aquifer material. Based upon the model results the maximum estimated concentration of chromium decreases from 207 µg/L when K_D=2 to 66 µg/L when K_D=10. These range of values are similar to the range of concentrations observed at monitoring well MW-3S. Historically the concentration of chromium at monitoring well MW-3S has ranged from 47 to 163 µg/L.

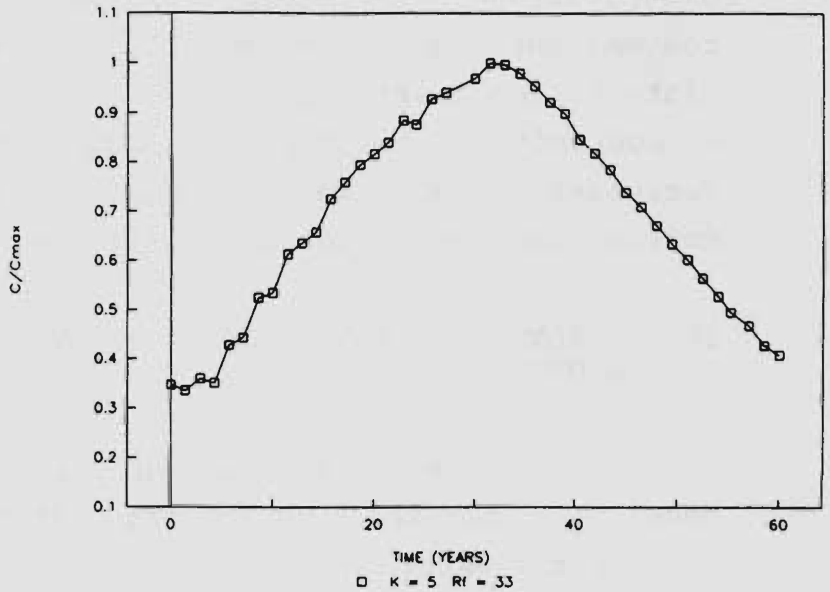
Due to sorption, the concentration of the non-conservative contaminant is attenuated as it migrates with ground water flow. The attenuation of the contaminant concentration may reduce the time required for the contaminant to decrease to a target concentration (i.e., drinking water standard). For example, if chromium was the regulated contaminant modeled, the time required for its concentration to decline to the proposed USEPA MCL of 100 µg/L ranges from approximately 14 years when K_D = 2 to approximately 9 years when K_D = 5. In the case where K_D = 10, the concentration of chromium never exceeds the MCL. This would suggest that K_D is less than 10 at the site.

In summary, the results of the preliminary ground water modeling indicate that conservative contaminants such as chloride may migrate rapidly from the landfill. Once the landfill is capped and their source eliminated the concentration of the conservative contaminants will rapidly decline to near background values.

a)



b)



c)

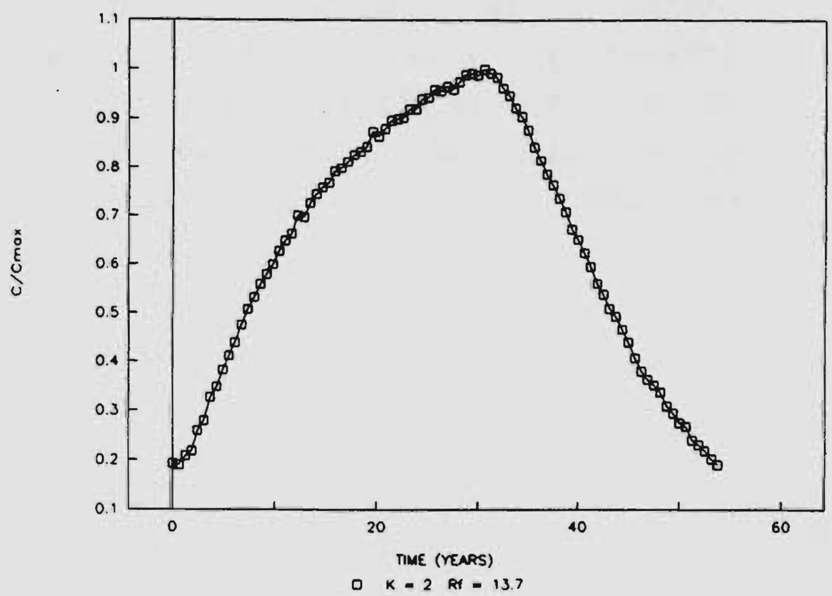


Figure 4 - Plot of the ratio of contaminant concentration to the maximum contaminant concentration where a) K=10 b) K=5 and c) K=2.

For a non-conservative contaminant, such as chromium, the rate of migration will be dependent upon the reaction of the contaminant with the aquifer materials. The retardation of the contaminant will directly effect its concentration and the rate at which is moves through the aquifer. If the contaminant is linearly sorbed onto the aquifer the concentration of the contaminant will decline. As the distribution coefficient (K_D) is increased, the resulting contaminant concentration will decrease. Over a range of distribution coefficients (2, 5 and 10) the time required for a contaminant to reach a target concentration actually decreased as K_D increased due to the attenuation of the contaminant and reduction of its maximum concentration.

IV. ANALYTICAL EVALUATION OF CONTAMINANT TRANSPORT RATES AND AMOUNTS

The previous discussion illustrates, via computer modeling, that the time required after capping for the levels of ground water contamination to decline to acceptable standards is dependent on the retardation factor (R) (presently unknown) and K_D (dispersion coefficient). This concept is also illustrated by Zheng et al. (1992) through an analytical solution of a version of the general transport equation:

$$-\rho_b \, \Delta V \frac{dC_b}{dt} - QC_w = n \, \Delta V \frac{dC_w}{dt} \quad . \qquad (1)$$

This differential equation relates dissolved contaminant mass to time, aquifer volume that is being flushed, flow rate and sorbed contaminant mass (Zheng et al., 1992). Their solution is:

$$PV = -R \ln \frac{C_{wt}}{C_{wo}} \quad ;where \qquad (2)$$

PV is the number of pore volumes to reduce the initial contaminant concentration (C_{wo}) to an acceptable concentration (C_{wt}) at time interval t and R is the retardation factor. If the analytical results for chrome (163 μg/L) in monitoring well MW-3 are used to represent C_{wo} and C_{wt} is set at 100 μg/L of chrome, Equation (2) becomes:

$$PV = -R \ln \frac{100}{163} \quad ; \text{which leads to:}$$

$$PV = 0.49\ R \qquad (3)$$

Equation (3) is converted from number of pore volumes (PV) to time, by multiplying both sides by t_p, the ground water travel time per pore volume, and recognizing that the elapsed time $t = t_p \times PV$. The time per pore volume is calculated by

$t_p = \frac{L}{V}$ where L is the ground water travel length under the landfill and $V = \frac{Ki}{\Phi}$ where K is the hydraulic conductivity (ft/day), i is the gradient and ϕ is the porosity of the aquifer materials. Therefore, Equation (3) can be rewritten as:

$$t = 0.49\, R\, \frac{L}{V} = 0.49\, \frac{RL\Phi}{Ki} \quad . \qquad (4)$$

Using K = 79 ft/day (representative of the sand units as described previously), i = .017, ϕ = .30 and L = 1200 ft, Equation (4) becomes:

$$t\ (days) = 131\, R \quad . \qquad (5)$$

Therefore, for the Johnstown Landfill, Equation (5) predicts that the time for chrome concentrations to recede to 100 μg/L without ground water treatment is approximately 0.4, 5, 12, or 23 years after capping for R values of 1, 13.7, 33 or 64, respectively that were derived from K_D's used in the computer model. These results differ from the model's results because this analytical method ignores dispersion and assumes that the maximum chrome concentrations of 163 μg/L are present in MW-3 regardless of R.

Prior to selecting remedial Alternative SC 5, SC 6 or SC 7, that incorporate ground water extraction and treatment, it is worthwhile to estimate the contaminant mass that is currently being released from the landfill as well as the mass that would be released after capping without treatment (based on the R values used above). The current production of chrome is estimated using Darcy's Law and the chrome concentration for MW-3:

$$M_{Cr} = Q \times t \times C_{wo} = KiA \times t \times C_{wo}$$

$= 79$ ft/d x .017 x 39,460 ft^2 x 1 d x 163 10^{-9} gm/L x 28.3 L/ft^3

= .24 gm/d = .19 pounds chrome per year (currently).

In terms of pore volumes, the mass released per pore volume is:

$$M_{Cr\ PV} = .24\ gm/d \times \frac{L}{V} = .24\ gm/d \times \frac{L\Phi}{Ki}$$

= .24 x 1200 x .30 ÷ 79 ÷ .017

= 64 grams or .14 pounds chrome per pore volume (currently).

Calculation of the chrome mass released after capping, without ground water extraction and treatment, must take into account the various R values and the associated rate of contaminant concentration decline over time. Rearranging Equation (2) and taking its exponent yields:

$C_{wt} = C_{wo}\, e^{-\frac{PV}{R}}$ which becomes

$$C_{wt} = C_{wo}\, e^{-\frac{tKi}{L\Phi R}} = C_{wo}\, e^{-\frac{.00373t}{R}} \tag{6}$$

using the previously described relationships between pore volumes (PV) and time (t) and inserting the values used before.

Equation (6) is an exponential decay curve relating the contaminant concentration (C_{wt}) at time t to R and the initial concentration. The average concentration ($\overline{C_{wt}}$) over the time (t) required after capping to reach chrome concentrations of 100 μg/L can be determined by taking the integral of (6) to get the area under the curve and dividing the result by t. From tables:

$$Area = \int_0^t C_{wo}\, e^{-\frac{.00373t}{R}}\, dt = C_{wo}\left[-\frac{R}{.00373}\, e^{-\frac{.00373t}{R}}\right]_0^t$$

$$= C_{wo}\left\{\frac{R}{.00373} - \frac{R}{.00373}\, e^{-\frac{.00373t}{R}}\right\} .$$

From the definition of $\overline{C_{wt}}$:

$$\overline{C_{wt}} = \frac{C_{wo}}{t}\left\{\frac{R}{.00373} - \frac{R}{.00373}\, e^{-\frac{.00373t}{R}}\right\} \qquad (7)$$

From Equation (5) we can substitute R for t in (7) yielding:

$$\overline{C_{wt}} = .79C_{wo} = .79 \times 163\ \mu g/L = 129\ \mu g/L$$

The mass of chrome produced after capping without ground water treatment is simply:

$$M_{Cr} = Q \times t \times \overline{C_{wt}}$$

$$= KiA \times 131R \times \overline{C_{wt}}\ .$$

Substituting for these parameters as before and converting units yields:

$$M_{Cr} = 25.3\ R\ (grams).$$

The mass of chrome produced after capping without ground water treatment is summarized below:

R	t (yrs)	M_{Cr} grams	M_{Cr} pounds
1	.4	25	.06
13.7	5	347	.77
33	12	835	1.9
64	23	1619	3.6

In other words, if capping is done but ground water treatment is not implemented, .06 to 3.6 pounds of chrome could be released from the landfill during the .4 to 23 years time required for chrome concentrations to recede to 100 $\mu g/L$ (for R equal to 1 or 64, respectively).

V. DISCUSSION OF CONTAMINANT TRANSPORT ANALYSES

Although the above computer model and analytical methods rely on the use of K_D's and R values to evaluate contaminant sorption-desorption reactions, many researchers question their validity in conditions such as those encountered at the Johnstown Landfill. Valocci (1984) states "The validity of the K_D approach rests upon the linear equilibrium relationship expressed by [assuming the linear isotherm is valid]. Implicit also in this approach is the assumption that K_D is a constant in both space and time (for a homogeneous porous medium).". Nielsen et al (1986), point out that in actuality K_D's may have different values for adsorption as compared with desorption and these processes are nonlinear and are dependent upon the presence of competing dissolved constituents. Miller and Benson (1983) observed that the degree of contaminant sorption was affected by the overall concentration of dissolved constituents in a solution thus the value of K_D cannot be assumed to be constant. They state"...the tendency of an ion to be sorbed depends on its concentration in the aqueous phase relative to the concentrations of other sorbable ions, the selectivity of the sorptive substrate for an ion relative to other ions, and the number of sites on the sorptive substrate.". In other words K_D values will change as the concentration and make up of the dissolved constituents in the solution changes. Reardon (1981) succinctly stated "Distribution coefficients to describe...reactions then would not be use in landfill leachate studies...where the contaminant water will have significantly different chemistry than the natural ground water...". This is because contaminant migration problems are in a dynamic chemical evolution as concentrations and the suite of dissolved constituents change following installation of the cap. Due to the changing concentrations brought about through leachate interception by capping, the conditions for using constant K_D's or R's are not met because the sorption reactions can be expected to vary over time and space until steady state conditions are reached.

Research indicates sorption-desorption processes are further complicated by colloidal transport of metals (Ryan, 1990 and Mills et al, 1991) that greatly reduces retardation rates. Ryan (1990) concludes anoxic conditions are responsible for releasing colloids bound to aquifer materials through the depletion of iron oxide coatings and that the presence of organic humic acids maintains their mobility.

Ryan also states colloids may be removed when ground water samples are filtered which implies analytical results of filtered versus unfiltered metals samples should have significant differences. Table 1 presents a comparison of analytical results for filtered and unfiltered metals samples collected from selected monitoring wells. It is clear from the table that metals concentrations differ by several orders of magnitude between the filtered and unfiltered samples indicating colloidal transport of metals is occurring at the Johnstown Landfill. Analyses of monitoring wells MW-8S and 15S indicate colloidal transport continues to Mathew Creek where the ground water discharges. Since colloidal transport is responsible for mobilization of metals at the site (including chrome and lead) the dispersion coefficients and retardation rates are lowered thus metals migration from the landfill is rapid. The low retardation and rapid migration rates suggest contaminant levels will rapidly decline after the landfill is capped.

VI. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, projections based on analytical or computer modeling techniques that incorporate retardation should not be the basis for accepting or rejecting remedial alternatives at the Johnstown Landfill. In fact, "...evaluating the dispersion coefficient for the whole system with conventional approaches is futile." (Bouwer, 1991). Instead in consideration of the small quantities of chrome that may be released after capping, the best approach is to monitor ground water quality after the cap is in place (Alternative SC 3). After a monitoring period of three to five years, contaminant trends can be evaluated and the need for ground water interception and treatment (Alternatives SC 5, SC 6 or SC 7) can be determined based on actual data instead of assumptions.

Table 1 : Summary Laboratory Results For TAL Metals, Cyanide, and Hexavalent Chromium
Comparison of Filtered and Unfiltered Samples
Ground Water Monitoring Well Sampling, Round 3
Johnstown Landfill, Johnstown, New York, April 1991

Parameter	MW-1S UNFILT.	MW-1S FILTERED	MW-2S UNFILT.	MW-2S FILTERED	MW-3S UNFILT.	MW-3S FILTERED	MW UNF
Aluminum	7,090	<14.0	5,790	<14.0	9,590	<14.0	4,4
Antimony	<25.0	<25.0	<25.0	25.2	<25.0	<25.0	<2
Arsenic	2.9	<1.0	2.4	<1.0	49.5	<1.0	2.
Barium	65.2	29.0	73.1	61.8	391	62.7	79
Beryllium	<1.0	<1.0	<1.0	<1.0	4.5	<1.0	<1
Cadmium	<2.0	<2.0	3.5	<2.0	6.4	<2.0	<2
Calcium	216,000	86,500	133,000	99,700	303,000	88,300	107,
Chromium (T)	38.7	<3.0	77.4	3.8	47.2	6.9	11.
Cobalt	14.2	4.1	15.0	6.3	23.3	5.6	5.
Copper	24.4	<14.0	22.6	<14.0	58.4	<14.0	17.
Iron	20,500	148.0	18,100	<54.0	198,000	5,710	11,4
Lead	6.0	<1.0	51.1	<1.0	15.9	<1.0	7.
Magnesium	17,100	5,410	21,900	12,000	29,400	12,100	12,7
Manganese	856	48	1,090	926	1,760	839	71
Mercury	<0.20	<0.20	<0.20	<0.20	0.25	<0.20	<0.
Nickel	41.1	95.0	65.8	14.8	163	17.3	27.
Potassium	3,660	3,030	7,890	7,600	14,000	13,400	4,5
Selenium	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<1.
Silver	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.
Sodium	7,260	8,010	29,000	39,400	73,700	72,700	12,7
Thallium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.
Vanadium	32.1	<6.0	20.3	<6.0	78.2	<6.0	17.
Zinc	99.1	<14.0	78.4	15.5	134	<14.0	67.

All concentrations and standards expressed in micrograms/liter (ppb)

-8S	MW-8S	MW-9S	MW-9S	OB-10B	OB-10B	NYSDOH/USEPA	NYSDEC
ILT.	FILTERED	UNFILT.	FILTERED	UNFILT.	FILTERED	D.W.S.	G.W.S.
90	<14.0	12,100	<14.0	48,500	<14.0		
5.0	<25.0	<25.0	<25.0	<25.0	<25.0		
9	<1.0	5.8	3.9	14.9	<1.0	50 (p)	25
.3	53.9	105	66.4	401	38.1	1,000(p)	1,000
.0	<1.0	1.1	<1.0	6.2	<1.0		
.0	<2.0	<2.0	<2.0	5.4	<2.0	10 (p)	10
000	80,200	98,800	80,200	1,340,000	86,400		
8	<3.0	101.0	6.0	167	<3.0	50 (p)	50
2	<3.0	12.1	7.6	92.4	<3.0		
4	<14.0	45.8	<14.0	212	<14.0	1,000(s)	200
00	74.5	32,500	12,400	146,000	<54.0	300 (s)	300
[illegible]	<1.0	6.2	<1.0	77.0	<1.0	50 (p)	25
00	6,960	12,100	9,690	59,500	7,360		
5	245	1,630	1,210	5,590	65.0	50 (s)	300
20	<0.20	<0.20	<0.20	0.46	<0.20	2 (p)	2
0	<9.0	67.3	<9.0	252	<9.0		
00	4,410	8,640	9,600	13,400	2,610		
0	<2.0	<2.0	<2.0	<2.0	<2.0	10 (p)	10
0	<3.0	<3.0	<3.0	<3.0	<3.0	50(p)/100(s)	50
00	12,100	44,500	52,400	10,500	8,850		20,000
0	<1.0	<1.0	<1.0	<1.0	<1.0		
1	<6.0	35.6	<6.0	175	<6.0		
5	<14.0	72.9	16.9	433	<14.0	5,000 (s)	300

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JOB 0C 342.13
SHEET NO. 1 OF
CALCULATED BY JB DATE 3/10/92
CHECKED BY DATE
SCALE

Ground Water Discharge Calculation *

Flow Tube Number [1]	Sat Thickness [2] (ft) S	Width [3] (ft) W	$\bar{K}$ [4] ft/d K	Gradient i	Q per flow tube (ft³/d)	V [5] ft/d
1	17	120	230	.015	8,445	20.7
2	34	120	290	.014	16,564	29.3
3	45	180	440	.013	46,332	28.6
4	42	200	800	.013	87,360	52.0
5	40	130	590	.014	42,952	41.3
6	38	75	410	.015	16,359	30.8
7	37	50	400	.014	10,360	28.0
8	37	90	310	.017	17,549	26.4
9	38	100	280	.017	18,088	23.8

Total Area = 39,460 ft²

Total Q : 264,009 ft³/d

= 1,974,787 gpd

= 1371 ~ 1,370 gpm

$* Q_{tube} = S \times W \times K \times i$

1) see flow net p3

2) see pp 4+5

3) from flow net, p3

4) weighted average, see p 3

5) $V = \frac{\bar{K} i}{n_e}$

$$\bar{V} = \frac{\sum_{i=1}^{9} S_i \times W_i \times V_i}{\sum_{i=1}^{9} S_i \times W_i} = 33.5 \text{ ft/d}$$

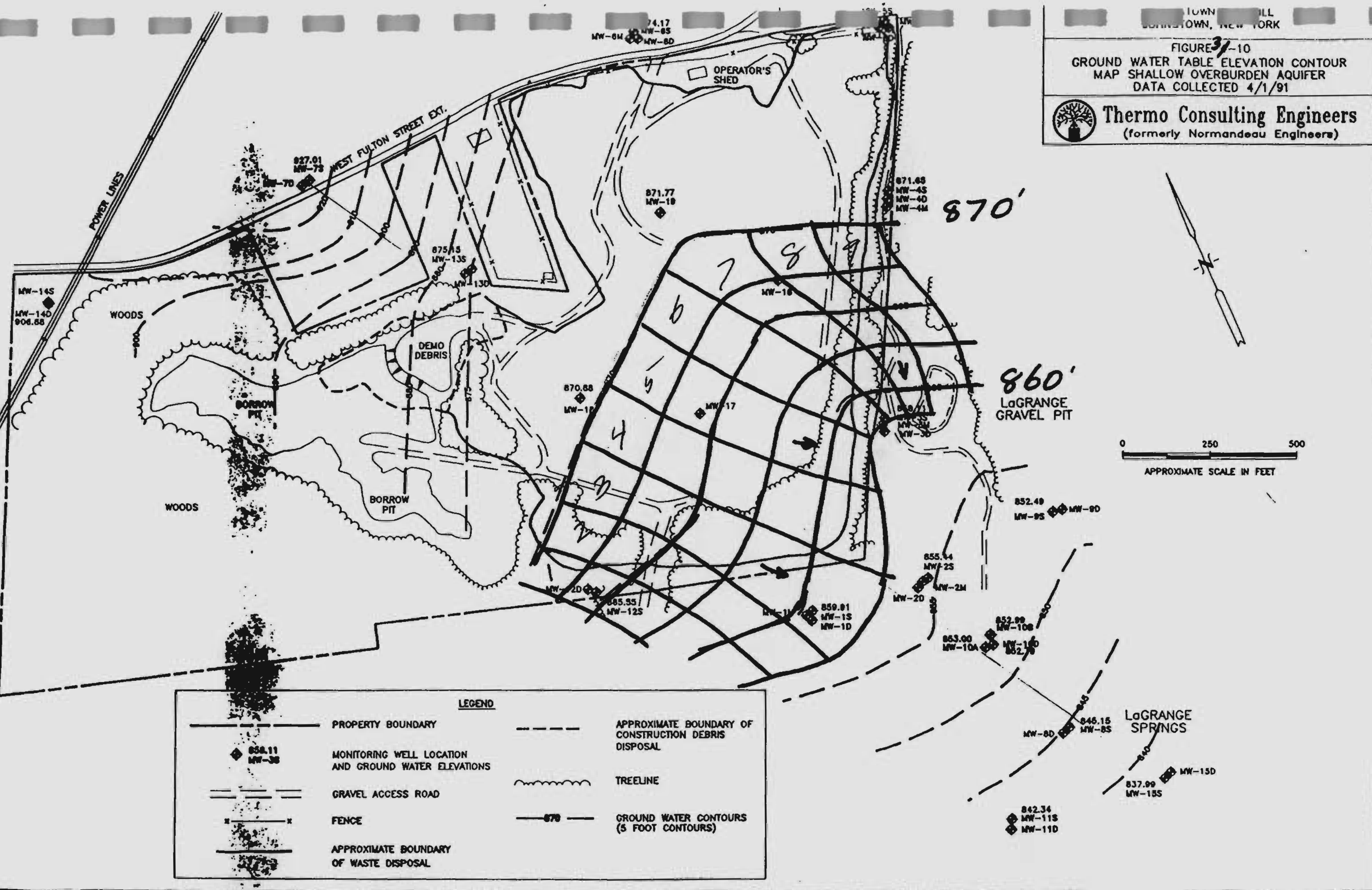


FIGURE 3-10
GROUND WATER TABLE ELEVATION CONTOUR MAP SHALLOW OVERBURDEN AQUIFER
DATA COLLECTED 4/1/91
Thermo Consulting Engineers
(formerly Normandeau Engineers)
WEST FULTON STREET EXT.
POWER LINES
OPERATOR'S SHED
WOODS
DEMO DEBRIS
BORROW PIT
LaGRANGE GRAVEL PIT
LaGRANGE SPRINGS
870'
860'
0 250 500
APPROXIMATE SCALE IN FEET
N
MW-14S
MW-14D 906.88
927.01 MW-7S
MW-7D
875.15 MW-13S
MW-13D
871.77 MW-19
870.88 MW-18
MW-17
MW-16
871.65 MW-4S MW-4D MW-4M
MW-6M MW-6S MW-6D
852.49 MW-9S MW-9D
855.94 MW-2S MW-2M MW-2D
859.91 MW-1S MW-1D
885.35 MW-12S
MW-12D
852.99 MW-10S MW-10D
863.00 MW-10A
845.15 MW-8S MW-8D
837.99 MW-15S MW-15D
842.34 MW-11S MW-11D
LEGEND
PROPERTY BOUNDARY
MONITORING WELL LOCATION AND GROUND WATER ELEVATIONS
GRAVEL ACCESS ROAD
FENCE
APPROXIMATE BOUNDARY OF WASTE DISPOSAL
APPROXIMATE BOUNDARY OF CONSTRUCTION DEBRIS DISPOSAL
TREELINE
GROUND WATER CONTOURS (5 FOOT CONTOURS)

Flow Net

Thermo
Consulting Engineers
10 Ferry Street Box 7 Concord, NH 03301
Phone (603) 224-5770 FAX (603) 224-4128

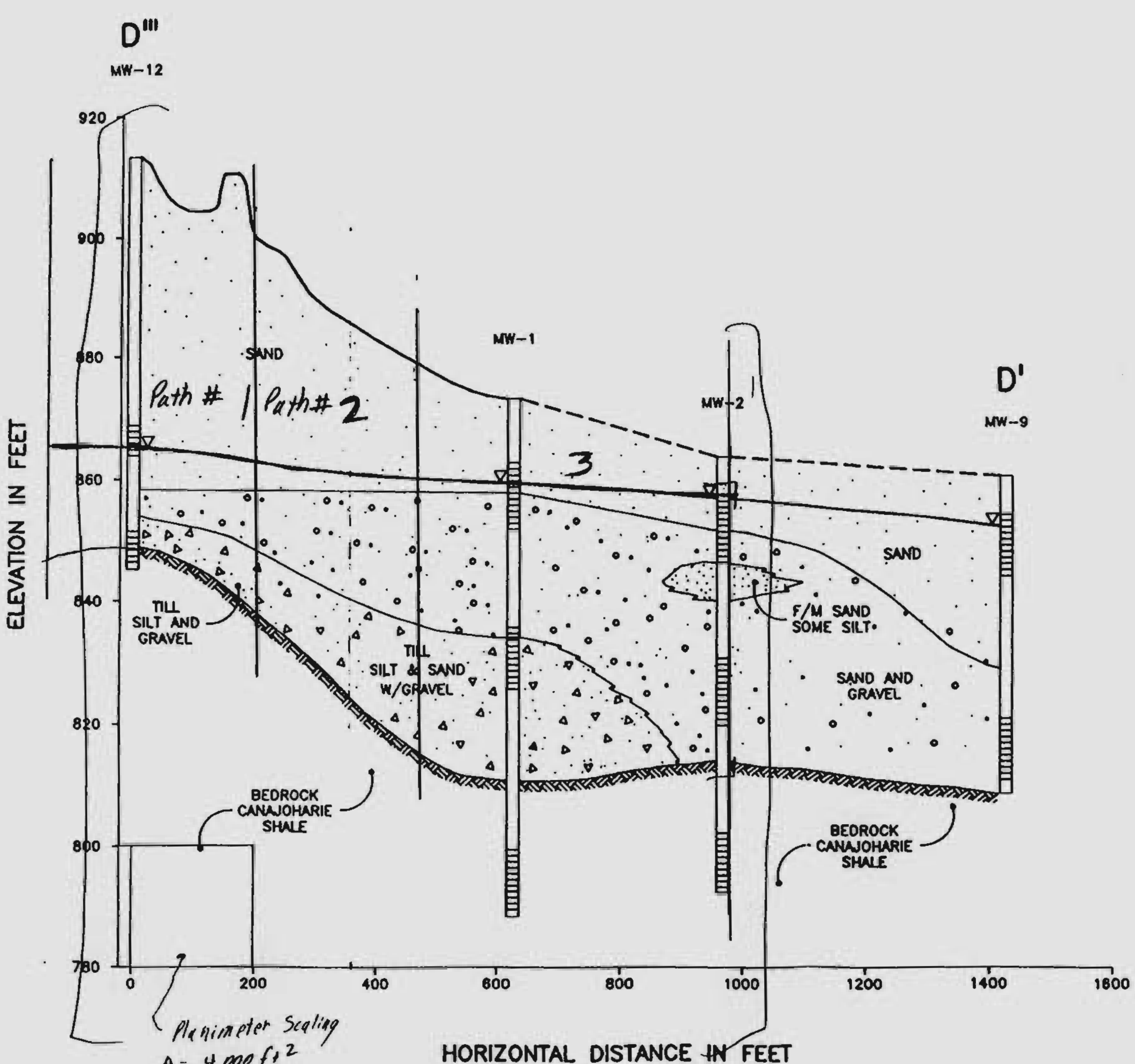
JOB
SHEET NO. 3 OF
CALCULATED BY DATE
CHECKED BY DATE
SCALE

Hydraulic Conductivity (weighted Ave)

Flow Tube Number	Saturated Materials Encountered (% per flow tube)[1]: sand	sand + Gravel	fine sand + silt	coarse sand + till	till	$\overline{K}$ (ft/d)[3]
1	.33	.33			.34	231
2	.10	.46			.44	286
3	.08	.72			.20	440
4	.10	-		.90	-	802
5	.05	-	.20	.65	.10	589
6	-	-	.32	.44	.24	406
7	-	-	.30	.43	.27	397
8	-	-	.25	.33	.42	306
9	.10	-	-	.31	.59	283
Nominal K for each material type[2]	100	600	60	950	.4	

1) Percent of area of each flow tube (pp 4+5)
2) Selected from aquifer tests and permeability tests
3) Example calc for Tube #1:

$$\overline{K}_1 = (.33)(100) + (.33)(600) + (.34)(.4) = 231$$



Planimeter Scaling
A = 4,000 ft²
Plan Read = 1.13 in²
1.09
1.14
PR 1.12
x Factor = A/PR = 3571

LEGEND

OUTWASH–ICE CONTACT DEPOSITS

- STRATIFIED SAND, FINE SAND AND SILT
- SAND AND GRAVEL

LODGEMENT TILL

- SILT, SAND AND GRAVEL

BEDROCK

- CANAJOHARIE SHALE
- NO TOPOGRAPHIC DATA AVAILABLE
- MW-8 SOIL/BEDROCK BORING AND MONITORING WELL IDENTIFICATION WITH SLOTTED SCREEN SECTION SHOWN
- GROUNDWATER TABLE ELEVATION RECORDED APRIL 1, 1991

JOHNSTOWN LANDFILL
JOHNSTOWN, NEW YORK

FIGURE 3-7

GEOLOGIC CROSS SECTION OF SURFICIAL DEPOSITS AND BEDROCK ALONG TRANSECT D'''–D' LOCATED SOUTH OF THE JOHNSTOWN LANDFILL

FEBRUARY 1992

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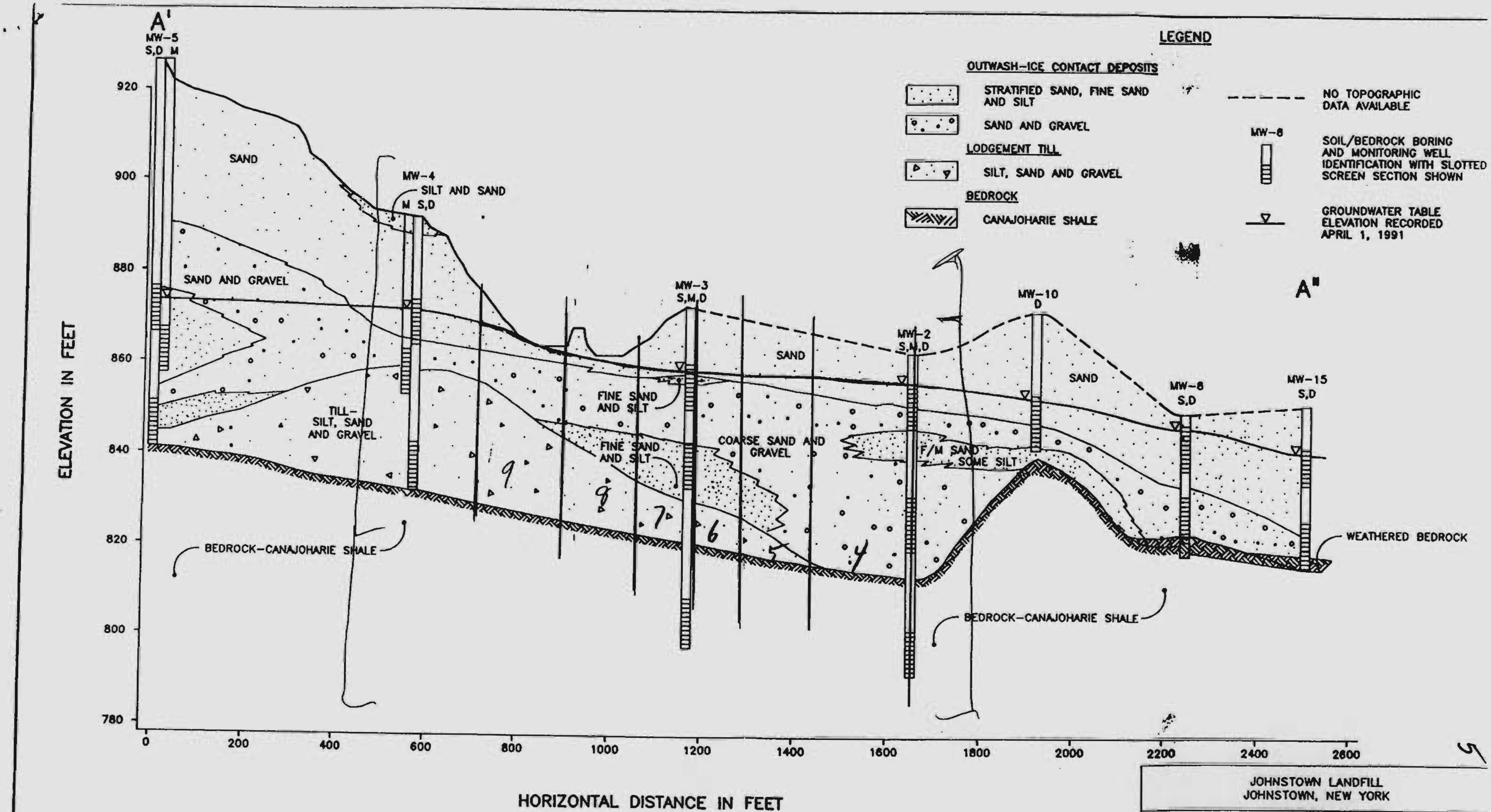
0C3424-8



5

JOHNSTOWN LANDFILL
JOHNSTOWN, NEW YORK

FIGURE 3A-3

GEOLOGIC CROSS SECTION OF SURFICIAL DEPOSITS AND BEDROCK ALONG TRANSECT A' – A" LOCATED EAST OF THE JOHNSTOWN LANDFILL

FEBRUARY 1992

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0C3424-2