Report

Feasibility Study Inactive Waste Landfill

Xerox Corporation
Webster, New York

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O'BRIEN & GERE

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FEASIBILITY STUDY
INACTIVE WASTE LANDFILL

Prepared For:

XEROX CORPORATION
WEBSTER, NEW YORK

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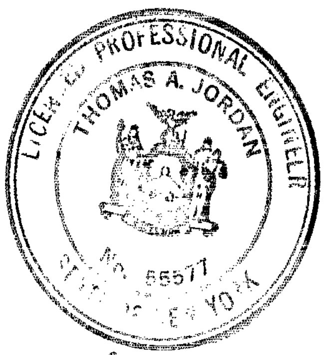
O'BRIEN & GERE ENGINEERS, INC.
SYRACUSE, NEW YORK



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EXECUTIVE SUMMARY

This report evaluates alternatives for remediating a closed landfill on the property of Xerox Corporation's Webster, New York, facility. This report is a Feasibility Study based on a Remedial Investigation (RI) performed by RECRA Research. The data contained in the RI was used to develop a Risk Assessment for the closed landfill, and the RI and Risk Assessment were then collectively used to develop and evaluate remediation alternatives.

The existing closed landfill occupies approximately 2.8 acres in the northern portion of the Xerox complex. Wastes were deposited in four-foot wide by four-foot deep trenches, approximately 50 feet on center, for a period of time between 1960 and 1971. Two types of waste were deposited - general wastes and selenium wastes. General wastes were deposited in nine-inch layers with three inches of soil cover and selenium wastes were deposited in six-inch clay-lined trenches by encapsulating three-inch layers of selenium waste with six-inch layers of clay.

The landfill is surrounded by a seven-foot high chain link fence and has dense vegetation growing over the landfill except in the northwest and southeast corners. Xerox's Building 343 is located in the southeast corner, and a gravel parking area is in the northwest corner; the gravel parking area is used to store construction materials and equipment. Two small streams run along the East and West portions of the landfill.

Wastes in the landfill include both organic and inorganic compounds. Inorganic contaminants identified are cyanide, selenium, zinc, iron, manganese, and chlorides. Organic compounds are phenolics, volatile halogenated organics, and nitrogenous organic compounds. Data analysis indicates that volatile organics have migrated from the landfill, but the contaminants are still in the proximity of the landfill.

A risk assessment evaluated two indicator parameters: zinc, and volatile halogenated organics, and two potential exposure pathways - groundwater and surface water. Estimates were made for the present and future (100 years) concentrations of the indicator parameters at exposure points in the groundwater and surface water and these values were compared with acceptable risk criteria. It was concluded that the closed landfill does not and will not pose a threat to the health and welfare of humans, wildlife, and the study area environment.

Several alternatives were initially screened using environmental, engineering, and cost criteria. As a result of the screening process, sixteen alternatives were identified and developed for further detailed evaluation. The more detailed evaluation again looked at environmental, engineering, and cost criteria. Following the detailed evaluation, the 16 alternatives were rated based on their costs and their effectiveness.

The alternatives evaluated ranged from no action to complete removal of the wastes from the landfill. Intermediate steps in the evaluation process were progressively more effective in mitigating potential impacts from the landfill. The recommended remedial action not only had to be the most cost effective but also the most environmentally sound and publicly acceptable.

The recommended remedial action for this landfill is to grade the site, provide improved site drainage, and install a low-permeability cover. All existing vegetation would be removed from the landfill and the site graded to contours that would improve the runoff characteristics of the site. Following this activity, a two-foot deep layer of low-permeable soil would be placed on top of the rough grading. Finally, six inches of topsoil would be placed on top of the low-permeable soil, and the topsoil would be seeded.

The recommended plan for remedial action performs two important functions. First, the low-permeable cover and grading will significantly reduce the amount of water which can percolate through the landfill. By reducing or eliminating the percolation through the landfill, contaminants in the landfill cannot be leached from the wastes in the landfill and groundwater mounding in the landfill will be reduced or eliminated. The groundwater mounding is the primary mechanism causing migration of wastes from the landfill because the mounding increases the hydraulic gradient which drives groundwater from the landfill. The second important function served by the recommended plan is the elimination of the potential for contaminants to leave the landfill by soil erosion. By improving the site contours and installing the low-permeability cover, rain and snow will be removed from the site without erroding the topsoil; therefore, the wastes under the cover will not be removed by erosion.

CHAPTER 1 - INTRODUCTION

1.01 INTRODUCTION

From approximately 1960 until 1971, the Xerox Corporation (Xerox) manufacturing facility in Webster, New York, used an on-site landfill to dispose of wastes. This landfill was permitted by the Monroe County Health Department. Wastes in the landfill include selenium, and waste solvents; these are inherent residues of Xerox manufacturing processes at the Webster facility.

For the purpose of this feasibility study, the landfill is defined as the area enclosed by the fence around the landfill. On-site areas are defined as those on Xerox property, but outside of the fence enclosing the landfill. All other areas are defined as off-site. Upgradient and downgradient refer to and describe areas which are either hydraulically upstream or downstream of the landfill. The site currently is completely enclosed by a seven-foot high chain link fence to prohibit unauthorized entry. Dense vegetation currently grows on the surface of the landfill with the exception of the northwest and southeast potions. The northwest area is partly paved with gravel and serves as a storage area for construction materials and equipment. Xerox Building 343 is located on the southeast portion of the landfill.

The landfill was designed as a trench-and-fill operation. During the operation of the site, trenches approximately four feet wide by four feet deep were used and were classified as either "general" waste trenches or "selenium" waste trenches. General wastes were disposed of in nine-inch layers with three inches of intermediate soil cover. Selenium wastes were disposed of by lining the trenches with six inches of clay and encapsulating three inch layers of wastes with six inches of clay. All trenches were capped with two feet of native soil.

1.02 SITE BACKGROUND

1.02.01 Topography/Hydrogeology

The landfill is located within a subcatchment of the Four-Mile Creek watershed. Water drains in a north/northwest direction and eventually discharges into Lake Ontario. The average topographic gradient north of the landfill is approximately 0.0075 ft/ft. Two streams run East and West of the landfill, joining just north of the landfill. Stormwater flow north of the landfill and plant cooling waters account for the majority of flow in these streams.

1.03 HYDROGEOLOGY

1.03.01 Previous Work

RECRA Research, Inc., conducted an investigation from 1979 through June, 1984 to characterize the hydrogeologic conditions in the vicinity of the landfill. The main purpose of the investigation was to evaluate the potential for migration of waste from the landfill through groundwater, surface water or by soil erosion. Data were collected by sampling streams and installing test pits, soil borings, piezometers and groundwater monitoring wells. The five reports issued by RECRA Research have been described below:

Phase I - "Hydrogeological Investigation, April, 1979". This work investigated the general hydrogeologic conditions of the landfill with emphasis placed on the evaluation of the potential for migration of waste constituents from the closed facility through groundwaters, surface waters, or by soils. Test pits, soil borings, piezometers and groundwater monitoring wells were installed. Samples from the borings and wells were analyzed, and together with a literature search, these data were used to develop cross-sections, plot plans, potentiometric surface maps and analytical results of water and soil samples.

Phase II - "Supplemental Hydrogeological Investigation, April, 1980". This phase was undertaken to further characterize groundwater flow directions, gradients, and quality of groundwater in the bedrock aquifer. The relationship between water table conditions in the unconsolidated materials and the bedrock aquifer was investigated to assess the potential for vertical migration of contaminants through soil and groundwater. Additional wells were installed to evaluate subsurface conditions upgradient of the landfill. Soil borings and monitoring wells were installed in both the unconsolidated material and the bedrock for the purpose of monitoring groundwater elevations, collecting additional samples, and performing chemical analyses on both water and soil samples.

Phase III - "A Preliminary Determination of Specific Water and Mass Balance, April-December, 1981". The purpose of this phase was to quantify the interactions between the landfill and groundwater, and to identify the mechanisms of groundwater inflow and outflow from the closed facility. Potential pathways for contaminant migration were also evaluated. Permeability testing on 15 wells and grain size analyses of soil samples were undertaken. Groundwater level histories for 43 locations and precipitation/percolation data were also collected. From these data, a water balance of vertical and lateral inflow and outflow was determined. Loading rates of dissolved chemical constituents were established utilizing the water balance and laboratory analytical data.

Phase IV - "Groundwater Modeling and Finalized Water and Mass Balance, March-November, 1982". This phase compiled data to refine the preliminary mass balance model and to develop an advective and dispersive contaminant transport model. Additional permeability testing was conducted and on-site precipitation was monitored. The groundwater level monitoring was continued for the duration of this project. These data were used to refine the site water and mass balance. Two dimensional qualitative and quantitative modeling was conducted to evaluate the impact of the landfill on groundwater flow and quality.

Phase V - "Refinement of Groundwater Model, October, 1983 - June, 1984". This phase characterized subsurface conditions in areas outside the landfill and integrated these new data with the previous data to refine earlier models and further develop an understanding of conditions at the landfill. Also, a new computerized mass transport model was developed to incorporate the field data. Field activities consisted of soil borings, monitoring well installations, permeability testing, geophysical surveys and groundwater level monitoring.

Based on the findings of these five reports, the following summary of hydrogeologic conditions was developed:

1.03.02 Geology

The subsurface geology of the landfill at the Xerox facility is characterized by up to 30 feet of unconsolidated deposits overlying consolidated bedrock. Understanding the nature and extent of the geologic materials beneath the site is important to characterize the groundwater flow conditions including flow rate, flow direction and contaminant migration.

Bedrock Geology

The bedrock that underlies the landfill consists of relatively thin bedded red-brown sandstone and siltstone. The bedrock is several thousand feet thick and consists of layers that dip gently to the south. Small planar openings have developed parallel and perpendicular to these layers. These openings or fractures provide the only significant avenues for groundwater movement through the bedrock. Because the bedrock fractures are highly variable in thickness and lateral extent, the permeability of the bedrock is also variable. In-situ permeability tests performed by RECRA revealed that the bedrock permeability ranges between 4×10^{-6} and 4×10^{-4} cm/sec.

The RECRA investigations have identified that the upper 0.5 to 0.9 feet of the bedrock is highly weathered and fractured. In-situ permeability data were not sufficient to determine if this fracture zone had a higher permeability than either the underlying bedrock or the overlying unconsolidated deposits.

Unconsolidated Deposits

Throughout the landfill the underlying bedrock is covered by various unconsolidated deposits that vary in thickness from 20 to 30 feet below the land surface. Three types of unconsolidated deposits have been identified at the landfill site including glacial till, glacial fluvial sand and gravel, glacial lacustrine sand and silt.

Glacial till is the most widespread unconsolidated deposit present at the landfill site. The till is a dense, unsorted mixture of rock fragments dispersed in a fine grained matrix of silt, and fine sand. Below a depth of 20 feet, the till is generally continuous across the site; however, this layer occasionally contains lenses of glacial lacustrine sand. Within the upper 20 feet of the land surface, the till is interbedded with deposits of glacial lacustrine sand and glacial fluvial sand and gravel. In-situ permeabilities within the till are generally very low ranging from 6×10^{-7} to 3×10^{-6} cm/sec.

Glacial fluvial sands and gravels are present throughout the landfill site and are variable in lateral and vertical extent. These sediments form a continuous layer within the upper 20 feet of the land surface across the south eastern portion of the landfill site but are discontinuous throughout the remainder of the site. The thickness of this deposit is variable across the landfill site but generally ranges from five to ten feet. Due to the coarse texture of this deposit, the glacial fluvial sand and gravel is assumed to have the highest permeability of the subsurface materials on-site. Permeabilities of this material may be several orders of magnitude greater than the till. However, no field tests have been performed on this deposit to determine in-situ permeabilities.

The glacial lacustrine sand and silt deposits occur as discontinuous lenses dispersed within the glacial till. The in-situ permeability of this deposit is similar to that of the till and was measured to be between 1×10^{-6} and 5×10^{-5} cm/sec.

A seismic refraction survey was performed by Dunn Geoscience at the landfill site to evaluate the variability in thickness of the unconsolidated deposits overlying the bedrock. This seismic survey was able to determine that the bedrock is shallowest within the east portion of the landfill site and deepest to the north. However, due to the heterogeneous nature of the unconsolidated deposits, there were local discrepancies between the seismic data and the borehole data. These discrepancies resulted in not using the seismic survey for a detailed thickness map of the unconsolidated deposits overlying the bedrock.

1.03.03 Groundwater Flow Conditions

Groundwater within the unconsolidated deposits occurs under unconfined conditions. The water table depth varies as a result of the mounding effects caused by the landfill site and natural seasonal fluctuations; however, groundwater generally occurs at depths ranging from two to five feet below the land surface. The groundwater surface generally slopes in a north-to-northwest direction at a very low gradient of 0.002 ft/ft. This information indicates that shallow groundwater flows in a north to northwest direction following the local topography.

Groundwater elevation data indicates that water percolation through the waste material has artificially increased the groundwater elevations beneath the landfill site creating a groundwater mound. These data indicate that mounding occurs predominantly during the wettest nine months of the year and does not occur during the three summer months. During the period of groundwater mounding, groundwater within the shallow unconsolidated deposits flows radially outward from the landfill site. The groundwater mounding also increases the hydraulic gradient to 0.01 ft/ft.

Although existing data provides information regarding the shallow natural hydraulic gradient north of the site and also characterizes the mounding beneath the waste disposal area, these data do not define the extent of the mounding or the shallow natural hydraulic gradient south of the landfill. Data south of the landfill are required to determine the natural hydraulic gradient beneath the landfill, which will define whether or not the natural groundwater table is in contact with the buried waste material.

The existing groundwater elevation data shows that the groundwater elevations within the unconsolidated deposits are higher than the groundwater elevation in the bedrock, indicating there is a downward vertical groundwater flow potential. Therefore, any contamination which might occur within the unconsolidated deposits could potentially enter the underlying bedrock aquifer. The existing data regarding the natural hydraulic gradient are insufficient to determine what effect reducing the groundwater mounding beneath the landfill site would have in reducing the vertical hydraulic gradient to the bedrock.

The rate of groundwater flow at the landfill site is dependent upon the permeability and porosity of the subsurface materials and the hydraulic gradient. Based on the range of permeabilities previously discussed and a natural hydraulic gradient of 0.002 ft/ft, it is estimated that the natural groundwater velocity within the glacial till and glacial lacustrine silts ranges from 1×10^{-5} to 8×10^{-4} ft/day. During periods of groundwater mounding, the hydraulic gradient increases to 0.01 ft/ft; the groundwater velocity is estimated to increase from the previously identified velocities to 5×10^{-5} to 5×10^{-3} ft/day. Since the glacial fluvial sand and gravel deposits may have permeabilities several orders of magnitude higher than the other deposits, the groundwater flow velocity within the sand and gravel may be much higher. Although the sand and gravel are discontinuous across the landfill, it may locally transport contaminants within the groundwater at a much higher rate than the rate within the other deposits. However, the existing data are not sufficient to determine the groundwater velocities within the glacial fluvial sand and gravel.

1.04 NATURE AND EXTENT OF SOIL AND WATER CONTAMINATION

Previous analyses of soils, soil composites and soil composite leachates have been obtained from borings within the landfill site. The borings through the landfill site indicate that the waste material contains elevated concentrations of inorganic and organic compounds. The inorganic compounds include cyanide, selenium, zinc, chlorides, iron and manganese. The organic compounds detected at elevated concentrations included phenolics, volatile halogenated organics, and nitrogeneous organic compounds.

Groundwater analyses of samples collected from shallow wells located around the perimeter of the landfill site indicate that the shallow groundwater contains elevated concentrations of the following parameters: conductivity, chlorides, zinc, iron, manganese, sulfate, methylene chloride, trichloroethylene, perchloroethylene, 1,1,1-trichloroethane, freon, benzene, toluene, and xylene.

The groundwater quality data indicates that the concentrations of the inorganic and organic compounds decrease significantly both vertically and laterally away from the landfill. The greatest reduction in concentration is associated with the inorganic compounds. This reduction is attributed to attenuation of inorganic constituents by the fine-grained soils beneath the landfill.

Analyses of organics in the groundwater show a more extensive vertical and horizontal migration than the inorganic compounds. This is attributed to the low degree of soil attenuation for these compounds. The organic compounds present at the highest concentration were the volatile halogenated organics (VHOs). The VHOs had their highest concentration in the shallow groundwater within the landfill; the concentrations decrease with depth and lateral distance away from the landfill.

Volatile halogenated organics within the landfill decrease from concentrations of 1,300 - 36,000 ppb at an average depth of seven (7) feet to 39-69 ppb at the bedrock/till interface at an average depth of 27 feet. The volatile halogenated organic concentrations detected in the till/bedrock interface wells at distances of 200 to 300 feet downgradient from the landfill were measured from undetectable to 8 ppb. These data suggest that the migration of volatile organic compounds within the till is restricted to within a few hundred feet horizontally from the landfill.

Although the volatile organic concentrations decrease with depth, the groundwater quality data shows that the bedrock aquifer contains detectable levels of volatile organics.

The volatile organic concentrations detected within the bedrock decreases from 440 ppb at monitoring well W-3, just north of the landfill, to 7 to 14 ppb at monitoring wells B-14 and B-17, at a distance of 550 feet north of the landfill.

Surface water analyses indicate that the landfill is impacting surface water quality. The chemical compounds detected at elevated levels within the surface water include: total halogenated organics, methylene chloride, trichloroethylene, perchloroethylene, 1,1,1-trichloroethane and freon. RECRA studies identified elevated concentrations of contaminants in the surface water; however, RECRA did not determine whether the elevated levels were caused by surface runoff or groundwater discharge. This information is needed to select the most effective remedial measure to minimize surface water impacts.

1.05 REPORT OBJECTIVES AND ORGANIZATION

Section 300.658(j) of the National Oil and Hazardous Substances Contingency Plan (National Contingency Plan or NCP) states that feasibility studies must identify the most cost-effective remedial action for a hazardous waste site. The NCP defines the most cost-effective option as the least-cost alternative that is technologically feasible and reliable and effectively provides adequate protection of public health, welfare and the environment. This report is developed and organized to communicate that these objectives are met.

CHAPTER 2 - INITIAL SCREENING OF REMEDIAL ACTION TECHNOLOGIES

2.01 INTRODUCTION

The screening process for selecting remedial alternatives is discussed in this Chapter. The screening process used evaluated broad categories of technologies for remediation and also evaluated the effectiveness of each technology for the landfill on the Xerox property in Webster, New York. From this evaluation process, a number of site-specific alternatives were identified for further detailed evaluation; the identification and evaluation of these alternatives are discussed in Chapters 3 and 4.

Four general categories of remediation technologies were identified to address the site conditions at Xerox's closed landfill in Webster, New York:

1. Avoidance Technologies - Avoidance alternatives provide for the separation of the receptors from areas of potential exposure.
2. Containment Technologies - These alternatives isolate contamination from transport and migration pathways, thereby, reducing the migration of contaminants off-site.
3. Groundwater Treatment Technology - These alternatives include the Containment Technology as described above and also provide for groundwater treatment.
4. Removal Technologies - This alternative includes the excavation and secure disposal of contaminated materials, which eliminates the source of contamination.

Each of these technologies are discussed in this chapter and their applicability is evaluated based on feasibility, implementability, public acceptability and cost.

2.02 DEVELOPMENT AND SCREENING OF AVOIDANCE TECHNOLOGIES

The primary exposure route associated with the Xerox landfill is through ingestion of potentially contaminated drinking water and/or through surface water contact from runoff leaving the vicinity of the landfill. Avoidance technologies which are appropriate to minimize these exposure routes are:

1. Relocation of receptors;
2. Provision of a public water supply; and
3. Restriction to access.

1. Relocation of Receptors

The extent and severity of contamination, as identified by the risk assessment in the area of the Xerox site does not warrant the relocation of receptors. Most of the surrounding community is serviced by a public water supply; therefore, the potential for ingestion through groundwater drinking wells is reduced. A new water district is scheduled for construction along Phillips Road which should further minimize the potential for ingestion of contaminated groundwater. Receptor exposure is still possible through contact with the surface water which is recharged from contaminated groundwater. However, exposure to high contaminant concentration is not expected to be a problem because of the high dilution of groundwater by surface water and because leachate generation is minimal in the summer when most receptor exposure would occur.

2. Public Water Supplies

Most residences surrounding the landfill have access to public water supplies. In a few instances, individual homeowner wells are still in use but connection to public water supplies is expected to occur in the future.

3. Access Restriction

The landfill is currently enclosed by a seven-foot high chain link fence with a locking gate. This fence prevents direct entry of personnel to the site. Dermal contact with any surface contaminants is therefore minimized.

2.03 DEVELOPMENT AND SCREENING OF CONTAINMENT TECHNOLOGIES

Containment technologies are designed to provide a partial or complete isolation of waste materials from the environment. The primary purpose of using containment technologies is either to intercept migrating contaminants or to prevent contact between hazardous materials and transport media. The hazardous properties of the material remain unchanged by containment technologies. The requirement for long-term maintenance of the site and monitoring of the groundwater aquifer must be included as part of the cost evaluation process.

The methods by which landfill wastes can be partially or completely contained and isolated from the environment are:

1. Installation of an impermeable cap or low permeability soil cover;
2. Construction of a groundwater diversion trench;

3. Construction of a groundwater cutoff wall; or

4. Complete excavation of wastes.

These methods differ greatly in their objectives, advantages, disadvantages, practicality and relationship to other technologies. A more complete discussion of these methods follows.

1. Impermeable Cap or Low Permeability Soil Cover

The use of caps to isolate waste areas can be very effective by preventing direct contact with the wastes and by reducing downward percolation and surface run-off through the waste areas. A cap or cover will reduce migration of contaminants and will, therefore, reduce exposure to off-site receptors. This is a commonly applied technology and implementation methods are well documented.

The primary disadvantages associated with this technology are the need for long-term groundwater monitoring and site maintenance; liquid wastes are not totally controlled by capping which may allow contaminants to continue migrating from the site.

Technical Feasibility:

Installation using caps or low permeability covers is a common construction technique usually implemented in several basic construction operations. The first step is to regrade the entire on-site area removing debris and existing vegetation. Trees are removed and the stumps, roots, and trunks are chipped. Spreading of chipped material under the cap or low permeability cover is possible. Next, borrow material is used to contour the landfill for drainage and to form the foundation for the capping alternative. For this site, borrow material will be on-site material with an estimated permeability of 1 x 10^{-4} cm/s to 1 x 10^{-5} cm/s; the on-site borrow material could also be used for the low permeability cover material. The capping alternative will require off-site clay soil to provide a minimum permeability of 1 x 10^{-5} cm/s.

Ability to Minimize Environmental Impact:

The use of a cap or a low permeability cover will reduce the rate of infiltration into the landfill, thereby, reducing the groundwater mounding which is the primary driving force causing the migration of contamination. Leaching of contaminants from the landfill caused by rainwater percolation will be greatly reduced. Receptor exposure to surface water contaminants will be reduced because groundwater recharging of surface water will be greatly reduced.

Environmental and Public Health Criteria:

Caps or low-permeability covers will reduce the quantity of contaminants migrating away from the site because infiltration will be reduced and therefore the leaching of contaminants from the landfill will be reduced. Some contamination will still enter the groundwater; however, the risk assessment determined no significant risk even at the contaminant concentration of the existing site. The reduced quantity of leachate generated after the installation of a cap or a cover therefore will not be a significant environmental or public health risk.

Costs:

(See Alternatives B and C in Chapter 4)

2. Groundwater Diversion Trench or Wall

The installation of diversion structures prohibits contact of groundwater with the contaminated wastes in the landfill which prevent leaching and migration of contaminants. The installation of a groundwater diversion trench or wall around the site would divert groundwater away from the landfill thus preventing migration of contamination from the landfill. Trenches are usually constructed two feet wide with varying depths depending on the depth of groundwater. The groundwater entering the trench would be diverted from traveling through the landfill by either a perforated pipe or a permeable backfill such as stone or sand. Trenches usually slope toward a discharge area downgradient of the landfill. A groundwater diversion wall is an impermeable barrier which prevents the migration of contaminants beyond the wall's boundaries.

Technical Feasibility:

Trenching and wall technologies are a developed technology and use standard construction methods. For this site, either the trench or wall would be constructed to a maximum depth of approximately 30 feet.

Ability to Minimize Environmental Impact:

The use of a diversion trench or wall would prevent groundwater from passing through the landfill. This would significantly reduce the leaching of contaminants from the landfill and eliminate the migration transport mechanism for contaminants leaving the landfill.

Environmental and Public Health Criteria:

Since the migration of contaminants will be significantly reduced by this alternative, no significant risk to the environment or public health will be present off-site, especially considering that the risk assessment has determined that no significant risk exists as a result of the existing site.

Cost:

(See Alternatives D, E, H, I, J, and K in Chapter 4.)

2.04 DEVELOPMENT AND SCREENING OF GROUNDWATER TREATMENT TECHNOLOGIES

Groundwater treatment removes contaminants from the groundwater. Treating groundwater does not eliminate the source of contamination, but treating does eliminate the contaminants from the migration source. Appropriate treatment technologies for hazardous materials depends on the contaminants and the media containing the contaminants. Volatile organics are best removed from groundwater using the following treatment mechanisms:.

1. Air stripping;
2. Activated carbon;
3. Ozone oxidation; or
4. Reverse osmosis.

Soluble metal ions are best removed from groundwater using physical-chemical processes where the pH is raised and metallic hydroxides are precipitated out of solution.

The applicability of groundwater treatment depends on the ability of groundwater pumping to constrain or recover the contaminated plume. Recovery of the plume depends on the number of wells and the characteristics of the aquifer.

After treatment, the groundwater must be discharged to surface water, groundwater, or into a sanitary sewer. Discharge permits must be obtained in either case. Permits require a specified level of treatment based the water quality criteria which are established on water use.

1. Air Stripping:

Air stripping uses a tower containing an inert packing material which maximizes the surface area of cascading water; this allows volatile organic compounds to evaporate to the atmosphere. Water flow rate and volume, tower height (i.e., packing depth), and contaminant concentration are variables affecting the removal efficiency; volatile organic concentrations can potentially be reduced to very low ppb levels. Replacing packing media is not generally required; natural metal ions in groundwater may cause a precipitate on the packing media which might require repacking of the media. Operating costs are primarily associated with the pumping costs for water.

Technical Feasibility:

Air stripping towers are state-of-the-art technology. Numerous manufacturers supply preconstructed skid-mounted units which can be easily delivered to the construction area. If multiple stripping towers or well heads need to be employed, a collection vault would be used to equalize flows to the tower(s). A system hydraulic analysis would be evaluated for systems using multiple towers or well heads.

Ability to Minimize Environmental Impacts:

An air stripper has the ability to remove volatile organic compounds from contaminated groundwater. Influent constituents and variability of inflow parameters affect the efficiency of air strippers. The removal efficiency of volatile organic compounds in groundwater typically ranges between 60 and 95 percent. Therefore, discharge from the tower to surface water, groundwater, or a public sewer will contain 5 to 40 percent of the contaminants in the groundwater. The source of contamination would be shifted from the groundwater if surface water or a public sewer were the discharge selected.

Environmental and Public Health Criteria:

Air stripping will remove a percentage of volatile organics from the groundwater. This will decrease the concentration of contaminants at the source; however, volatile organics will then be discharged to the atmosphere and those contaminants not discharged to the atmosphere will be discharged to surface water, groundwater or a public sewer. Permits will be required for air and effluent discharges. A risk assessment would be required for the air discharge, surface water discharge, or discharge to a public sewer. Reinjection of the discharge to the groundwater at the landfill would pose no significant threat because the risk assessment for the landfill shows no significant threat under existing conditions.

Costs:

(See Alternatives L, M, N and O in Chapter 4)

2. Activated Carbon

Using activated carbon for treatment of groundwater is very effective. Volatile organics and non-volatile contaminants can be removed by this process.

Activated carbon units are more difficult to operate than air stripping; they require considerable maintenance. Carbon systems are commonly fouled by bacterial growths and accumulations of solids. Fouling causes interruptions in service and require frequent backwashing or the replacement of carbon. Regeneration of carbon occurs on a routine basis; this regeneration represents a significant operational and maintenance cost.

Technical Feasibility:

Carbon units are easily adapted to a particular site. Similar to air stripping units, several manufacturers of carbon units provide portable or permanent industrial-scale activated carbon units which are readily adaptable to most in-field situations. Spent carbon can be sent to a number of firms for regeneration. The use of activated carbon for groundwater treatment is a standard technology which is easily implemented.

Ability to Minimize Environmental Impact:

Activated carbon is very effective in removing contaminants. However, the type of carbon used must be selective for the contaminant removed; therefore, several different activated carbon units would be required to remove the various contaminants associated with this landfill. Pilot plants would be required to determine the types and quantities of carbon to be used.

Environmental and Public Health Criteria:

Groundwater treatment using activated carbon would be effective in removing contaminants from groundwater. This would reduce the concentration of contaminants moving off-site in the groundwater. Groundwater treatment would not affect the source of contamination, however.

Cost:

(See Alternatives L, M, N and O in Chapter 4)

3. Reverse Osmosis

Reverse osmosis uses semi-permeable membranes to selectively concentrate chemical contaminants into an effluent stream. The process is technically complex; requires highly skilled operators; is prone to operational problems; and is expensive to purchase, operate, and maintain. It is consequently not considered feasible for use for groundwater treatment.

4. Oxidation

Several studies have shown that the use of strong oxidants for the removal of organic compounds from groundwater is not efficient or practical. Compounds found in groundwater are particularly resistant to oxidation by standard oxidants such as chlorine, permanganate, hydrogen peroxide and ozone.

5. Physical/Chemical Processes

Physical/chemical treatment processes are used extensively for removal of heavy metals from groundwater. Chemical treatment is usually accomplished in above ground tanks, and involves raising the pH, polymer addition and flocculation steps. The pH of the incoming water is raised to the point of where metals have their minimum solubility; polymer addition assists coagulation of the metal hydroxides, and flocculation promotes agglomeration of the particles to aid in settling. Metals are removed from the treatment stream by gravity settling or filtration.

Physical/chemical treatment can reduce the concentrations of metals to very low levels. Operating costs are high because of extensive operator attention and large quantities of chemicals and energy used. Sludge disposal costs are also high.

Technical Feasibility:

Packaged treatment systems are available; however, a tailored system might be required. Units are sized based on detention times, settleability characteristics of the metals, chemical addition requirements, etc. Bench-scale testing would be necessary prior to design. Physical/chemical processes are very effective for removing many heavy metals from groundwater.

Ability to Minimize Environmental Impacts:

Physical/chemical precipitation processes are limited to the removal of heavy metals. Organic contaminants would not be affected by this process.

Environmental and Public Health Criteria:

Heavy metal sludges will have to be disposed of off-site at a secure landfill. The heavy metal concentrations in the groundwater will be reduced by this method, but this method will not affect the source of contamination.nor will this method affect the leaching of contaminants into the groundwater.

Costs:

(See Alternatives L, M, N and O in Chapter 4).

2.05 DEVELOPMENT AND SCREENING OF REMOVAL TECHNOLOGIES:

The excavation and disposal of contaminated materials from the landfill to a secure landfill is a technically viable alternative. Excavation techniques that might be employed at the landfill are common construction practices.

Technical Feasibility:

Excavation of hazardous waste material is a field-proven method of waste removal. Safe working procedures are well established and the method is reliable. Site access for waste removal would require minor roadway changes. Loading procedures would be developed and transport containers would be selected to minimize any spills that would result in a risk to the environment or public health.

Environmental and Public Health Criteria:

Strict safety protocols and regular health monitoring would be required during excavation. Dust generation should be kept to a minimum by limiting site access. The removal of wastes would eliminate the source of the groundwater contamination; however, existing groundwater contamination would not be affected by excavation. Removing the source of contamination would significantly reduce the long-term potential of contaminants to migrate from the landfill which would significantly reduce risk to the environment and public health.

Costs:

(See Alternative P in Chapter 4)

2.06 INITIAL SCREENING PROCESS

Alternatives selected for a more detailed analysis were identified using a process that evaluated environmental, engineering and cost criteria to assess the feasibility of the technologies discussed previously. A worksheet for each criterion was developed to evaluate factors associated with the criterion. Each worksheet contains questions pertaining to site-specific conditions affecting constructability, human health, the environment, and costs.

The first screening worksheet entitled "Environmental Screening Criteria" lists ten objectives. Each objective is given a score ranging from one to five. The maximum score of five points is given to those goals which have the highest probability of being achieved by the alternative evaluated. Goals are to minimize groundwater contact with the wastes, to minimize contaminant migration, and to maximize public acceptability and implementability. The maximum possible score for an alternative evaluated is 50 points.

The second screening worksheet entitled "Engineering Screening Criteria" lists 12 site criteria associated with the alternative evaluated. Each criterion is given a score of one to five or one to three, based on relative importance of the criterion. Higher scores are given to those alternatives which meet the objectives of being more easily constructed and compatible with site conditions. The maximum score for an alternative based on the engineering criteria is 50 points.

The last worksheet is entitled "Remedial Action Cost". This worksheet evaluates the capital and operation and maintenance costs for each alternative using a present worth basis. This analysis is as required by 40 CFR 300.68(j), to identify the lowest cost and technically feasible alternative. Total present worth costs were developed on a conceptual design basis. Means Price Index was used to develop unit costs, and costs were adjusted for the region.

Chapter 3 discusses the evaluation of 16 alternatives that were selected for further evaluation based on the Avoidance, Containment, Treatment and Removal technologies discussed in this chapter. The non-cost basis used for evaluation was the Engineering and Environmental criteria discussed above. Chapter 4 then evaluates each of the 16 alternatives for costs.

CHAPTER 3 - DETAILED EVALUATION OF REMEDIAL ALTERNATIVES NON-COST CRITERIA ANALYSES

3.01 NON-COST CRITERIA ANALYSIS

The screening process discussed in Chapter 2 was used to develop 16 alternatives for further, more detailed evaluation. The 16 remedial alternatives, including the No Action alternative, are developed in this chapter. These alternatives are Alternative A through Alternative F. Alternative A is the No-Action alternative, and Alternative F is the complete excavation and disposal of wastes to a secure landfill; each alternative developed in this chapter becomes progressively more complex in its approach to removing and controlling contaminants in the landfill.

The purpose of this chapter is to evaluate the sixteen remedial alternatives using non-cost criteria. The criteria used are technical feasibility, environmental risk, institutional issues, and impacts on public health.

3.01.01 Alternative A - No Action:

The National Contingency Plan requires that the no-action alternative be evaluated for any hazardous waste site feasibility study. The objective of this evaluation is to determine the impacts of the landfill, now and in the future, if no remedial action is taken. No-action alternatives are appropriate when other remedial actions may cause an even greater environmental or health threat and when no impacts are identified for the existing situation or the future situation.

1. Technical Description

The No-Action alternative is a realistic alternative for the Xerox landfill based on the impacts identified in the risk assessment study. The landfill is surrounded by a chain-link fence which restricts unauthorized entry. The waste trenches are covered with an on-site material which prevents the volatilization of contaminants and eliminates migration resulting from erosion of contaminants. Contaminants do migrate from the landfill but are of such small quantity as to pose no significant risk to the environment or public health.

The major disadvantage of the No-Action alternative is that water ponds on the landfill's surface and will percolate through the landfill and cause a groundwater mound which acts as a contaminant-driving force.

2. Environmental Evaluation

The risk assessment performed concludes that the closed landfill does not and will not pose a threat to the health and welfare of humans, wildlife, and the study area environment. The risk assessment evaluated two potential migration pathways, groundwater and surface water, and two indicator parameters: zinc, and volatile halogenated organics. Estimates were made of the present and future (100 years) concentrations of the indicator parameters, and it was concluded that the concentrations of these indicator parameters are and will be below acceptable risk level concentrations.

3. Institutional Requirements

None.

4. Public Health

The risk assessment does identify potential exposure in surface water adjacent to the landfill during certain periods of the year. This is caused by groundwater recharging nearby surface water where receptors could potentially come in contact with contaminants. However, concentrations of contaminants would be below acceptable risk level concentrations.

3.01.02 Alternative B - Grading, Drainage Control, and Low-Permeability Soil Cover:

1. Technical Description

This alternative involves the installation of a low-permeability cover, designed to minimize percolation of rainwater through the wastes. The cover will use native soils located on the Xerox property; the cover material will be compacted to a specified density.

Proper grading will result in precipitation moving away from the landfill thereby reducing the ponding of water which presently occurs on the landfill's surface and thereby reducing the percolation through the landfill. The existing equipment storage area will be relocated from its present location within the confines of the landfill's security fence. Finished grade will be seeded to prevent erosion of the cover, and rip-rap will be placed at the perimeter of the cover to prevent erosion of the side slopes.

2. Environmental Evaluation

The installation of a low-permeability cover will further reduce groundwater contaminant concentrations by reducing the amount of percolation through the waste. Reducing the amount of percolation will reduce the amount of leaching of contaminants from the landfill. This will lower the concentration of contaminants in the groundwater below the already no-significant-risk-level concentration. The low-permeability cover will not prevent groundwater passing through the site during high groundwater periods from contacting contaminants in the landfill.

3. Institutional Requirements

A closure permit may be required.

4. Public Health

Contaminant concentrations are anticipated to be less than those predicted in Alternative A due to a reduction in the percolation rate.

3.01.03 Alternative C - Grading, Drainage Control, and Impermeable Cap:

1. Technical Description

This alternative is similar to Alternative B with the exception of an impermeable cap being installed instead of a low-permeability cover. The cap will have a permeability of less than 10^{-6} cm/s compared to the low-permeability cover material which would have a permeability of approximately 10^{-4} to 10^{-5} cm/s. Off-site clay materials would be transported on-site and compacted using standard construction techniques. Final grading and erosion protection will be identical to the low-permeability cover alternative.

2. Environmental Evaluation

Installation of an impermeable cap will significantly reduce the concentration of contaminants in the groundwater by essentially eliminating percolation of ponded water through the cap. Groundwater may still contact the waste during high groundwater periods causing potential leaching of contaminants from the landfill and subsequent contaminant migration.

3. Institutional Requirements

A closure permit may be required.

4. Public Health

Contaminant concentrations are expected to be reduced below the levels found in the previous alternative.

3.01.04 Alternative D - Grading, Drainage Control, Low-Permeability Soil Cover, and Groundwater Diversion Trench:

1. Technical Description

This alternative is similar to Alternative B with the addition of a groundwater diversion trench to divert upgradient groundwater away from the waste trenches. The diversion trench would be installed using standard construction techniques. The trench would be sloped away from the landfill area and backfilled with a highly permeable material and perforated pipe; the diverted groundwater would discharge downstream of the landfill.

2. Environmental Evaluation

Diversion of groundwater around the landfill will significantly reduce the potential for groundwater passing through the landfill from contacting the wastes in the landfill. This will not only reduce the potential for leaching of contaminants from the landfill but also will reduce or eliminate the migration pathway for contaminants to leave the landfill. Additional hydrogeologic studies will have to be performed to determine the physical dimensions of the diversion trench. Limited amounts of water may still percolate through the low-permeability cover which will leach contaminants from the landfill; however, the concentration of contaminants in the groundwater would be significantly reduced.

3. Institution Requirements

Discharge permits for diversion of groundwater to surface water and a closure permit might be required for this alternative.

4. Public Health

This alternative will present a lower risk to public health than any of the previously discussed alternatives.

3.01.05 Alternative E - Grading, Drainage Control, Impermeable Cap, and Groundwater Diversion Trench:

Alternative E is similar to Alternative D except that an impermeable cap will be used instead of a low-permeability cover. This will essentially eliminate percolation through the cap.

3.01.06 Alternative F - Grading, Drainage Control, Low-Permeability Soil Cover, and Groundwater Lowering via Groundwater Pumping:

1. Technical Description

Under this alternative, several wells would be installed around the perimeter of the landfill in addition to implementing the components of Alternative B. The groundwater wells would have pumps to lower the groundwater elevation below the bottom of the waste trenches. The groundwater pumping wells would be controlled off a float system so that the system would operate only during periods of high groundwater.

2. Environmental Evaluation

The discharge from the wells might have to be discharged to a sanitary sewer or be treated before being discharged to a surface water course. This alternative would reduce the percolation through the landfill as described under Alternative B. The implementation of this alternative would also significantly reduce or eliminate the leaching of contaminants from the landfill by groundwater coming in contact with the landfill during high groundwater periods. However, undesirable effects could result by establishing hydraulic gradients that could accelerate the removal of contaminants from the landfill.

3. Institutional Requirements

Implementation of this alternative could require several permits. Groundwater pumped to a sanitary sewer might require a permit from the local municipality. Groundwater discharge to a surface water course may require a state or federal permit. A closure permit may also be required.

4. Public Health

The discharge of contaminated groundwater to a surface water could increase risk by increased exposure to receptors. If this alternative were implemented, a risk assessment would be required to determine whether or not groundwater treatment would be required.

3.01.07 Alternative G - Grading, Drainage Control, Impermeable Cap, and Groundwater Lowering via Groundwater Pumping:

This alternative is similar to Alternative F except that an impermeable cap will be installed instead of the low permeability cover. The environmental risks are lower than those of Alternative F because percolation through the landfill would be essentially eliminated.

3.01.08 Alternative H - Grading, Drainage Control, Low-Permeability Soil Cover, and Upgradient Groundwater Cutoff Wall:

1. Technical Description

The installation of an upgradient groundwater cutoff wall is constructed in a fashion similar to the diversion trench. The primary difference between the trench and the cutoff wall is the composition of the backfill. The cutoff wall construction technique uses an impermeable material such as a bentonite slurry; the trenching operation uses highly permeable materials. The impermeable cutoff wall material diverts groundwater away from this landfill preventing groundwater from passing through the landfill and contacting waste materials. The bottom of the groundwater cutoff wall would be keyed into a low-permeability material to prevent groundwater from flowing under the wall and reestablished itself downstream of the wall. Additional studies need to be conducted to determine the design parameters of the cutoff wall.

2. Environmental Impact

This alternative would have essentially the same effect on the landfill as Alternative D.

3. Institutional Requirements

A closure plan may be required.

4. Public Health

This alternative will decrease the leaching of waste from the landfill by significantly reducing percolation through the landfill and by significantly reducing or eliminating contact of groundwater with wastes in the landfill. The alternative will also significantly reduce or eliminate the migration pathway of groundwater passing through the landfill.

3.01.09 Alternative I - Grading, Drainage Control, Low-Permeability Soil Cover, and Circumferential Groundwater Cutoff Wall:

This alternative is similar to Alternative H, with the exception that the groundwater cutoff wall extends completely around the perimeter of the site. By extending the wall around the site, the horizontal migration of groundwater is significantly reduced or eliminated.

3.01.10 Alternative J - Grading, Drainage Control, Impermeable Cap and Up-gradient Groundwater Cutoff Wall:

This alternative is similar to Alternative H, except the use of an impermeable cap instead of a low-permeability cover. The cap further reduces or eliminates percolation through the landfill.

3.01.12 Alternative L - Grading, Drainage Control, Low-Permeability Soil Cover, and Groundwater Collection and Treatment:

1. Technical Description

This alternative is similar to Alternative F with the addition of groundwater treatment. Treatment mechanisms were described in Chapter 2 and include physical-chemical treatment, air stripping and activated carbon-adsorption.

The volatile organic contaminants could be removed through the use of an air stripping tower. As described in Chapter 2, these units can be purchased on a skid-mounted platform which comes complete with blower and electrical connection. Winterizing of the unit must occur because the outside ambient air temperature would go below 40°F. Both the blower intake and the tower wall must be heated in order to prevent unit freeze-up. Removal efficiency of the tower is anticipated to reduce contaminant concentrations to the low parts per billion (ppb) range.

An activated carbon unit could also remove the volatile organic contaminants from the groundwater. This removal system is more complex than the air stripping unit, requiring frequent maintenance and higher initial capital cost. This unit would reduce contaminant concentrations to the low ppb range.

A physical-chemical treatment system would most likely be used to remove heavy metals from the groundwater. Typical system processes include a pH adjustment tank followed by: a flocculation tank, clarification tank and a filtration process. Various chemical feed systems would also be necessary to achieve the desired metal removal efficiency. This system operation is complex and would require a large expenditure of capital and operation and maintenance funds.

The air stripping or activated carbon processes and the physical-chemical processes would be designed for a maximum flow of 150 gpm. The groundwater collection system is discussed under Alternative F.

2. Environmental Impact

The beneficial environmental impacts of this alternative are the same as those of Alternative F. Any contaminants that might be removed on an accelerated basis due to hydraulic gradients established by perimeter wells would be treated under this alternative. Therefore, this alternative has additional benefits over those listed under Alternative F.

3. Institutional Requirements

The institutional requirements of this alternative are the same as those under Alternative F.

4. Public Health

This alternative would have the least impact on public health of all alternatives discussed thus far. Percolation through the landfill would be significantly reduced and groundwater contacting the wastes would be significantly reduced by pump action thereby significantly reducing the leaching of contaminants from the landfill. Groundwater under the landfill would be treated; therefore, discharges to surface waters would be expected to decrease the exposure potential to receptors.

3.01.13 Alternative M - Grading, Drainage Control, Impermeable Cap, and Groundwater Collection and Treatment:

This alternative is similar to Alternative L except an impermeable cap is used instead of a low-permeability cover.

3.01.14 Alternative N - Grading, Drainage Control, Low-Permeability Soil Cover, Upgradient Groundwater Cutoff Wall, and Groundwater Collection and Treatment:

This alternative is a combination of Alternatives L and H.

3.01.15 Alternative O - Grading, Drainage Control, Impermeable Cap, Groundwater Cutoff Wall, and Groundwater Collection and Treatment:

This alternative is the same as Alternative N except that an impermeable cap is used instead of a low-permeable cover.

3.01.16 Alternative P - Complete Excavation and Off-site Disposal:

1. Technical Description

Excavation of materials presently contained in the trenches could be removed with standard earth-moving equipment. Removal of waste material would require a substantial on-site construction effort which would include an office facility, decontamination area, and a loading/staging area.

Personnel safety equipment would be required due to the potential for volatilization of the wastes from the trenches and direct contact with the waste materials. An evaluation of the site would be necessary to determine the level of personnel protection.

Materials removed from the site would require containerization for shipment to a secure landfill facility. The selection of a container size and shipment destination would be determined during final design of this alternative. Excavation should be conducted during periods of low groundwater and at periods of low temperatures (just above freezing) to minimize groundwater pumping, to minimize volatilization, and to allow the wastes to freeze before shipment to minimize any risk of spills.

Upon completion of the excavation, the site should be regraded and revegetated to promote surface drainage. Regrading will minimize surface water ponding, control erosion, and maintain slope stability.

2. Environmental Evaluation

Waste excavation could adversely affect the environment and public health by releasing volatile organics contained in the trench to the atmosphere. Dilution and dispersion will help dissipate these volatile organics before receptor contact, but a further investigation should be conducted. Exposure to the wastes is significantly increased by shipping the wastes to an off-site location. A traffic accident could potentially spill all or part of the waste being hauled by the truck.

3. Institutional Requirements

Several permits will be required by regulatory agencies in order to accomplish this alternative:

1. Hazardous waste transportation and disposal requirements under RCRA;
2. Packaging and containerization in accordance with RCRA and U.S. Department of Transportation Regulations; and a
3. Closure permit.

4. Public Health

This alternative will essentially eliminate the source of contamination at the landfill. Any contaminated groundwater will have contaminant concentrations reduced over time as a result of dilution and dispersion within the groundwater.

CHAPTER 4 - DETAILED EVALUATION OF REMEDIAL ALTERNATIVES
COST CRITERIA ANALYSIS

4.01 COST CRITERIA ANALYSIS

The intent of a feasibility study is to select the lowest cost alternative which is environmentally acceptable. A conceptual design cost estimate has been prepared for all sixteen alternatives. The cost estimates were developed to provide a cost range of ±30 percent of construction costs. Estimates were prepared using 1986, Means cost data values and data from closure of similar sites.

Costs were developed on a present worth basis for capital and operation and maintenance expenditures for each remedial action alternative. In performing the cost analysis, the following methods were used:

1. Capital costs were estimated for each alternative using 1986, Means cost data guides and bids from similar projects. Capital costs included materials, labor, and equipment necessary for construction of the remedial alternative as well as indirect costs for engineering fees, legal expenses, and contingency allowances.

2. Operation and maintenance costs were developed to provide for a 30-year period. O&M costs included labor, parts, materials, chemicals, electrical power, sludge disposal costs and laboratory analysis of groundwater necessary to operate and maintain the facilities for a 30-year period.

3. A present worth analysis using the capital and operating costs for each alternative was developed to compare the costs based on current values.

A discount rate of 10 percent over a 30-year period was used for present worth calculations.

The following paragraphs describe each alternative or combinations of alternatives and the assumptions used to estimate costs. Capital and operation and maintenance costs are presented as well as the present worth costs.

4.01.01 Alternative A - No Action

The no-action alternative would limit capital expenses to the engineering fees already expended to investigate the remedial alternatives. Groundwater monitoring would be required for a 30-year period.

Capital Cost:	
Monitoring Wells (250 vlf)	$ 10,000
Contingencies (25%)	$ 2,500
Subtotal	$ 12,500
Engineering, Legal, Misc. (40%)	$ 5,000
TOTAL CAPITAL COST	$ 17,500
OPERATION & MAINTENANCE COST	
Groundwater Analysis	$ 10,000/year
PRESENT WORTH	$111,800

4.01.02 Alternative B - Grading, Drainage Control, and Low-Permeability Soil Cover

This alternative would provide a soil cover over the existing 2.8 acre landfill, to limit precipitation percolation through the site. Initial site clearing, grading and filling operations would prepare the site to receive the cover material and provide a recommended 5 percent slope for effective runoff. The cover and fill material which is assumed to be available on-site would be placed and compacted in 6-inch layers to the required density. A cover thickness of 24 inches with a 6-inch layer of topsoil above would meet the New York State requirements for a sanitary landfill. To prevent surface water runoff from penetrating beneath the soil cover, a perimeter drainage ditch would be constructed around the site. The ditch would be covered with rip-rap to prevent soil erosion.

Capital Costs:

Monitoring Wells (250 vlf)	$ 10,000
Grading (18,000 sy)	$ 13,500
Clearing (18,000 sy)	$ 5,400
Rip-Rap (916 cy)	$ 19,250
Excavation (21,000 cy)	$ 65,600
Backfill and Compaction (21,000 cy)	$ 44,550
Topsoil (18,000 sy)	$ 28,250
Seed (2.8 acres)	$ 4,300
Subtotal	$190,850
Contingencies (25%)	$ 47,650
Estimated Construction Cost	$238,500
Engineering, Legal, Misc. (25%)	$ 59,500
TOTAL CAPITAL COST	$298,000
OPERATION & MAINTENANCE COST	
Groundwater Analysis	$10,000/year
PRESENT WORTH COST	$392,300

4.01.03 Alternative C - Grading, Drainage Control, and Impermeable Cap

A cap, consisting of a 24-inch layer of clay material would be placed to cover the existing landfill site. This clay material would minimize percolation through the landfill and would provide better resistance to settlement damage and cracking than the low-permeability soil cover. Site clearing, grading, fill and cover operations would be essentially the same as addressed in Alternative B; however, it is assumed that the cover material would not be available on-site and would, therefore, need to be purchased off-site and hauled to the site. Due to the nature of the material, less compaction is assumed necessary to provide the density required to meet the New York State requirements for a sanitary landfill. As with Alternative B, construction of a perimeter drainage ditch would be incorporated to prevent surface water from entering the site.

Capital Costs:

Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Excavation (9,000 cy)	$ 28,000
Rip-Rap (916 cy)	$ 19,250
Purchase Cap Material (12,000 cy)	$ 96,000
Backfill & Compaction (21,000 cy)	$ 28,300
Hauling (12,000 cy)	$109,800
Topsoil (18,000 cy)	$ 28,300
Seed (2.8 acres)	$ 4,300
Subtotal	$343,000
Contingencies (25%)	$ 85,750
Estimated Construction Cost	$428,750
Engineering, Legal, Misc. (25%)	$107,250
TOTAL CAPITAL COST	$502,500
OPERATION & MAINTENANCE COSTS Groundwater Analysis	$10,000/year
PRESENT WORTH COST	$630,300

4.01.04 Alternative D - Grading, Drainage Control, Low-Permeability Soil Cover, and Groundwater Diversion Trench

This alternative would incorporate a groundwater diversion trench with the grading, drainage control and low permeability soil cover provisions addressed in Alternative B. The groundwater diversion trench would minimize groundwater migration through the landfill site, thereby reducing the possibility of groundwater contact with the contaminants within the landfill. The diversion trench would be constructed along three sides (south, east and west) of the site, and would consist of excavation of a 2-foot wide trench to bedrock (at approximately 25-foot depth), placement of a perforated drainage pipe, backfilling with crushed stone to a depth of 4 feet and replacement of excavated soils above the crushed stone to the surface.

To convey the groundwater off-site, the drainage pipe would continue approximately 1,000 feet until the land slope was such that the groundwater could be discharged to a surface stream.

Capital Costs:

Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Rip-Rap (916 cy)	$ 19,250
Excavation (41,000 cy)	$127,500
Backfill & Compaction (41,000 cy)	$ 85,000
Topsoil (18,000 sy)	$ 28,250
Seed (2.8 acres)	$ 4,300
Crushed Stone (310 cy)	$ 3,750
Perforated Pipe	$ 3,100
Drain Pipe (1,050 lf)	$ 3,600
Subtotal	$303,650
Contingency (25%)	$ 50,850
Estimated Construction Cost	$379,650
Engineering, Legal, Misc. (25%)	$ 94,850
TOTAL CAPITAL COST	$474,500
OPERATION & MAINTENANCE COST	
Groundwater Analysis	$10,000/year
PRESENT WORTH COST	$568,800

4.01.05 Alternative E Grading, Drainage Control, Impermeable Cap, and Groundwater Diversion Trench

This alternative would incorporate the groundwater diversion trench described in Alternative D, with the provisions for grading, drainage controls and an impermeable cap developed in Alternative C. This remedial action would divert groundwater flow away from the existing landfill site and would provide an effective cover and drainage to prevent percolation of surface water through the landfill.

Capital Costs	
Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Rip-Rap (916 cy)	$ 19,250
Excavation (29,000 cy)	$ 87,000
Backfill & Compaction (41,000 cy)	$ 61,500
Purchase Cap Material (12,000 cy)	$ 96,000
Hauling (12,000 cy)	$109,800
Topsoil (18,000 sy)	$ 28,300
Seed (2.8 acres)	$ 4,300
Crushed Stone (310 cy)	$ 3,750
Perforated Pipe (1,000 lf)	$ 3,100
Drain Pipe (1,050 lf)	$ 3,600
Subtotal	$445,500
Contingency (25%)	$111,375
Estimated Construction Cost	$556,875
Engineering, Legal, Misc. (25%)	$139,125
TOTAL CAPITAL COST	$696,000
OPERATION & MAINTENANCE COST	
Groundwater Analysis	$10,000/year
PRESENT WORTH COST	$790,300

4.01.06 Alternative F - Grading, Drainage Control, Low-Permeability Soil Cover, and Groundwater Lowering Via Groundwater Pumping

This alternative addresses groundwater pumping as a method of groundwater control around the landfill site, in addition to grading, drainage control and low-permeability soil cover provision of Alternative B. Groundwater pumping would eliminate groundwater migration through the site by lowering the groundwater table in the immediate vicinity of the landfill. Lowering of the water table would be accomplished by pumping from wells located around the perimeter, thereby creating a cone of depression of the water table at each well location. These wells would extend from the ground surface to the bedrock layer. From previous investigations in the area, it is assumed that a well yield of approximately 15 gpm (each well) would create a cone of depression extending in a 200-foot diameter circle around each well. To provide a slight overlap between depression cones around the site perimeter, an estimated 10 wells would be required. The wells would be connected to a header pipe placed underground and leading to a self-priming centrifugal pump. The groundwater would be discharged to a nearby stream or sanitary sewer. Maintaining a depressed groundwater table would prevent contact with the buried contaminated wastes.

Capital Costs:

Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Rip-Rap (916 cy)	$ 19,250
Excavation (21,600 cy)	$ 67,400
Backfill & Compaction (21,600 cy)	$ 45,450
Topsoil (18,000 sy)	$ 28,250
Seed (2.8 acres)	$ 4,300
Well Points (250 lf)	$ 25,000
Header Piping & Valves (2,000 lf)	$ 60,000
Valve Vaults (10 ea)	$ 5,000
Pump (1 ea)	$ 9,000
Pump House (LS)	$ 5,000
Subtotal	$297,550
Contingencies (25%)	$ 74,450
Estimated Engineering Cost	$372,000
Engineering, Legal, Misc. (25%)	$ 93,000
TOTAL CAPITAL COST	$465,000
OPERATION & MAINTENANCE COSTS	
Groundwater Analysis	$ 10,000
Energy	$ 5,000
Manpower	$ 5,500
TOTAL ANNUAL O&M COST	$ 20,500
PRESENT WORTH COST	$658,250

4.01.07 Alternative G - Grading, Drainage Control, Impermeable Cap, and Groundwater Lowering via Groundwater Pumping

This alternative combines the grading, drainage control and impermeable cap provisions of Alternative C with the groundwater pumping operation described in Alternative F. This remedial action would eliminate both groundwater migration and surface water/percolation through the landfill.

Capital Costs:	
Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Excavation (9,600 cy)	$ 29,900
Rip-Rap (916 cy)	$ 19,250
Purchase Cap Material (12,000 cy)	$ 96,000
Backfill & Compaction (21,600 cy)	$ 29,300
Hauling (12,000 cy)	$109,800
Topsoil (18,000 sy)	$ 28,300
Seed (2.8 acres)	$ 4,300
Well Points (250 lf)	$ 25,000
Header Piping & Valves (2,000 lf)	$ 60,000
Valve Vaults (10 ea)	$ 5,000
Pump (1 ea)	$ 9,000
Pump House (LS)	$ 5,000
Subtotal	$449,750
Contingencies (25%)	$112,500
Estimated Construction Cost	$562,250
Engineering, Legal, Misc. (25%0	$140,500
TOTAL CAPITAL COST	$702,750
OPERATION & MAINTENANCE COSTS	
Groundwater Analysis	$ 10,000
Energy	$ 5,000
Manpower	$ 5,500
TOTAL O&M COSTS	$ 20,500
PRESENT WORTH COST	$896,000

4.01.08 Alternative H - Grading, Drainage Control, Low-Permeability Soil Cover, and Upgradient Groundwater Cutoff Wall

Alternative H evaluates the cost effectiveness of a groundwater cutoff wall (or slurry trench) as a method to prevent groundwater migration through the site. The slurry trench would consist of excavation of a 2-foot wide trench to the underlying bedrock layer, then backfilling the trench with a soil-bentonite slurry to form the cutoff wall. The cutoff wall would extend approximately 1,050 feet along three sides (south, east and west) of the site to preclude any groundwater migration through the landfill.

In addition to the cutoff wall, the grading, drainage control and low permeability soil cover provision as described in Alternative B would limit the amount of surface water percolating through the landfill.

Capital Costs:

Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Rip-Rap (916 cy)	$ 19,250
Excavation (21,000 cy)	$ 65,600
Backfill & Compaction (21,000 cy)	$ 44,550
Topsoil (18,000 sy)	$ 28,250
Seed (2.8 acres)	$ 4,300
Slurry Trench Construction (26,250 vsf)	$262,500
Subtotal	$453,350
Contingencies (25%)	$113,350
Estimated Construction Cost	$566,700
Engineering, Legal, Misc. (25%)	$141,800
TOTAL CAPITAL COST	$708,500
OPERATION & MAINTENANCE COSTS	
Groundwater Analysis	$10,000/year
PRESENT WORTH COST	$802,750

4.01.09 Alternative I - Grading, Drainage Control, Low-Permeability Soil Cover, and Circumferential Groundwater Cutoff Wall

This alternative is essentially the same as Alternative H; however, improved effectiveness is achieved by extending the cutoff wall entirely around the perimeter of the site. As with Alternative H, the 2-foot wide slurry trench would extend to the bedrock layer (at a depth of approximately 25 feet). The total length of the cutoff wall would be approximately 1,400 feet. All provisions of Alternative B (grading, drainage control and soil cover) would also be incorporated.

Capital Costs:

Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Rip-Rap (916 cy)	$ 19,250
Excavation (21,000 cy)	$ 65,600
Backfill & Compaction (21,000 cy)	$ 44,550
Topsoil (18,000 sy)	$ 28,250
Seed (2.8 acres)	$ 4,300
Slurry Trench Construction (35,000 vsf)	$350,000
Subtotal	$540,850
Contingencies (25%)	$135,150
Estimated Construction Cost	$676,000
Engineering, Legal, Misc. (25%)	$169,000
TOTAL CAPITAL COST	$845,000
OPERATION & MAINTENANCE COST	
Groundwater Analysis	$10,000/year
PRESENT WORTH COST	$939,250

4.01.10 Alternative J - Grading, Drainage Control, Impermeable Cap, and Upgradient Groundwater Cutoff Wall

Alternative J combines all provisions of Alternative C with the upgradient groundwater cutoff wall described in Alternative H. This remedial action would significantly reduce or eliminate both groundwater migration and percolation through the site.

Capital Costs:

Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Excavation (9,000 cy)	$ 28,100
Rip-Rap (916 cy)	$ 19,250
Purchase Cap Material (12,000 cy)	$ 96,000
Backfill & Compaction (21,000 cy)	$ 28,350
Hauling (12,000 cy)	$109,800
Topsoil (18,000 sy)	$ 28,300
Seed (2.8 acres)	$ 4,300
Slurry Trench Construction (26,250 vsf)	$262,500
Subtotal	$605,500
Contingencies (25%)	$151,500
Estimated Construction Cost	$757,000
Engineering, Legal, Misc. (25%)	$189,250
TOTAL CAPITAL COST	$946,250
OPERATION & MAINTENANCE COST	
Groundwater Analysis	$10,000/year
PRESENT WORTH COST	$1,040,500

4.01.11 Alternative K - Grading, Drainage Control, Impermeable Cap, and Circumferential Groundwater Cutoff Wall

Alternative K combines all provisions of Alternative C with the upgradient groundwater cutoff wall described in Alternative H. This remedial action would eliminate both groundwater migration and percolation through the landfill and would also prevent any contaminated groundwater from leaving the site.

Capital Costs:

Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Excavation (9,000 cy)	$ 28,100
Rip-Rap (916 cy)	$ 19,250
Purchase Cap Material (12,000 cy)	$ 96,000
Backfill & Compaction (21,000 cy)	$ 28,350
Hauling (12,000 cy)	$109,800
Topsoil (18,000 sy)	$ 28,300
Seed (2.8 acres)	$ 4,300
Slurry Trench Construction (35,000 vsf)	$350,000
Subtotal	$693,000
Contingencies (25%)	$173,250
Estimated Construction Cost	$866,250
Engineering, Legal, Misc. (25%)	$216,500
TOTAL CAPITAL COST	$1,081,750
OPERATION & MAINTENANCE COST	
Groundwater Analysis	$10,000/year
PRESENT WORTH COST	$1,176,020

4.01.12 Alternative L - Grading, Drainage Control, Low-Permeability Soil Cover, and Groundwater Collection and Treatment

Alternative L uses groundwater collection and treatment as a method to prevent contaminated groundwater from migrating off-site. Groundwater collection would be achieved by pumping from a series of wells surrounding the site as described previously in Alternative F. The wells would extend to the bedrock layer, and would convey approximately 15 gpm each (150 gpm total) to the treatment system.

The treatment process would consist of chemical precipitation for removal of heavy metals and air stripping to reduce the levels of volatile organics. The treatment system would include: collection and pH adjustment tanks, a flocculation tank, a settling tank, and a polishing filter with chemical feed systems, and finally the air stripping operation.

Operating costs include chemicals, sludge disposal, energy and manpower.

Grading, drainage control and low-permeability soil cover provisions as described in Alternative B would limit the amount of surface water percolating through the landfill.

Capital Costs:

Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Rip-Rap (916 cy)	$ 19,250
Excavation (21,000 cy)	$ 65,600
Backfill & Compaction (21,000 cy)	$ 44,550
Topsoil (18,000 sy)	$ 28,250
Seed (2.8 acres)	$ 4,300
Groundwater Pumping System (LS)	$100,000
Chemical Treatment System	$ 50,000
Air Stripping or Carbon Equipment	$ 80,000
Building	$100,000
Subtotal	$520,850
Contingencies (25%)	$130,150
Estimated Construction Cost	$651,000
Engineering, Legal, Misc. (25%)	$162,750
TOTAL CAPITAL COST	$813,750
OPERATION & MAINTENANCE COSTS	
Groundwater Analysis	$ 10,000
Chemicals	$ 25,000
Sludge Disposal	$ 25,000
Energy	$ 10,000
Manpower	$ 15,000
TOTAL ANNUAL O&M COST	$ 85,000/year
PRESENT WORTH COST	$1,615,000

4.01.13 Alternative M - Grading, Drainage Control, Impermeable Cap, and Groundwater Collection and Treatment

Alternative M combines all components of Alternative C with the groundwater collection and treatment provisions described in Alternative L.

Capital Costs:	
Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Rip-Rap (916 cy)	$ 19,250
Excavation (9,000 cy)	$ 28,100
Purchase Cap Material (12,000 cy)	$ 96,000
Backfill & Compaction (21,000 cy)	$ 28,300
Hauling (12,000 cy)	$109,800
Topsoil (18,000 sy)	$ 28,250
Seed (2.8 acres)	$ 4,300
Groundwater Pumping System (LS)	$100,000
Chemical Treatment System (LS)	$ 50,000
Air Stripping or Carbon Equipment (LS)	$ 80,000
Building (LS)	$100,000
Subtotal	$672,900
Contingencies (25%)	$168,100
Estimated Construction Cost	$841,000
Engineering, Legal, Misc. (25%)	$210,250
TOTAL CAPITAL COST	$1,051,250
OPERATION & MAINTENANCE COSTS	
Groundwater Analysis	$ 10,000
Chemicals	$ 25,000
Sludge Disposal	$ 25,000
Energy	$ 10,000
Manpower	$ 15,000
TOTAL OPERATION & MAINTENANCE COSTS	$ 85,000
PRESENT WORTH COST	$1,852,500

4.01.14 Alternative N - Grading, Drainage Control, Low-Permeability Soil Cover, Groundwater Cutoff Wall, and Groundwater Collection and Treatment

This alternative combines the components of Alternative B with the groundwater cutoff wall provisions described in Alternative H and the groundwater collection and treatment provisions described in Alternative L.

Capital Costs:	
Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Rip-Rap (916 cy)	$ 19,250
Excavation (21,000 cy)	$ 65,600
Backfill & Compaction (21,000 cy)	$ 44,550
Topsoil (18,000 sy)	$ 28,200
Seed (2.8 acres)	$ 4,300
Slurry Trench Construction (9,450 vsf)	$ 94,500
Groundwater Pumping System (LS)	$100,000
Chemical Treatment System (LS)	$ 50,000
Air Stripping or Carbon Equipment (LS)	$ 80,000
Building (LS)	$100,000
Subtotal	$615,300
Contingencies (25%)	$153,700
Estimated Construction Cost	$769,000
Engineering, Legal, Misc. (25%)	$192,250
TOTAL CAPITAL COST	$961,250
OPERATION & MAINTENANCE COSTS	
Groundwater Analysis	$ 10,000
Chemicals	$ 25,000
Sludge	$ 25,000
Energy	$ 10,000
Manpower	$ 15,000
TOTAL OPERATION & MAINTENANCE COST	$ 85,000
PRESENT WORTH COST	$1,762,500

4.01.15 Alternative O - Grading, Drainage Control, Impermeable Cap, Groundwater Cutoff Wall, and Groundwater Collection and Treatment

Alternative O combines the components of Alternative C with the groundwater cutoff wall provisions described in Alternative H and the groundwater collection and treatment provisions described in Alternative L.

Capital Costs:	
Monitoring Wells (250 vlf)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Rip-Rap (916 cy)	$ 19,250
Excavation (9,000 cy)	$ 28,100
Backfill & Compaction (21,000 cy)	$ 28,300
Topsoil (18,000 sy)	$ 28,250
Seed (2.8 acres)	$ 4,300
Slurry Trench Construction (26,250 vsf)	$262,500
Purchase Cap Material (12,000 cy)	$ 96,000
Hauling (12,000 cy)	$109,800
Groundwater Pumping System (LS)	$100,000
Chemical Treatment System (LS)	$ 50,000
Air Stripping or Carbon Equipment (LS)	$ 80,000
Building (LS)	$100,000
Subtotal	$935,400
Contingencies (25%)	$233,850
Estimated Construction Cost	$1,169,250
Engineering, Legal, Misc. (25%)	$ 292,250
TOTAL CAPITAL COST	$1,461,500
OPERATION & MAINTENANCE COST	
Groundwater Analysis	$ 10,000
Chemicals	$ 25,000
Sludge Disposal	$ 25,000
Energy	$ 10,000
Manpower	$ 15,000
TOTAL OPERATION & MAINTENANCE COST	$ 85,000
PRESENT WORTH COST	$2,262,800

4.01.16 Alternative P - Complete Removal and Off-site Secure Disposal

Alternative P consists of removing all wastes from the landfill and transporting them off-site to a secure landfill. Locations of trenches where the contaminants were buried would be determined, followed by excavation of the trench materials. The trenches are estimated to be six feet wide, four feet deep, and 300 feet in length. The trenches are spaced approximately on 50-foot centers. Contaminated soils would be containerized and trucked to a secure landfill facility for disposal. Following contaminant removal, the site would be filled, regraded and revegetated.

Capital Costs:

Monitoring Wells (250 lf)	$ 10,000
Excavation (1,600 cy)	$ 5,000
Contaminated Soil Disposal (1,600 cy)	$250,000
Safety Provisions (LS)	$ 20,000
Dust Control (LS)	$ 50,000
Equipment Decontamination (LS)	$ 10,000
Clearing (18,000 sy)	$ 5,400
Grading (18,000 sy)	$ 13,500
Backfill and Compaction (1,600 cy)	$ 5,000
Topsoil (18,000 sy)	$ 28,200
Container Liners	$ 40,000
Seed (2.8 acres)	$ 4,300
Excavate and Containerize Contaminant Material (1,600 cy)	$ 80,000
Transportation	$ 63,000
Subtotal	$584,400
Contingencies (25%)	$146,100
Estimated Construction Cost	$730,500
Engineering, Legal, Misc. (25%)	$182,500
TOTAL CAPITAL COST	$913,000
OPERATION & MAINTENANCE COST	
Groundwater Analysis	$10,000/year
PRESENT WORTH COST	$1,007,250

CHAPTER 5 - RECOMMENDED REMEDIAL ACTION

5.01 INTRODUCTION

The alternatives discussed in the previous sections of this report were evaluated for their costs and effectiveness. The effectiveness of each alternative was evaluated using 10 environmental criteria and 12 engineering criteria. Costs were evaluated on a present worth basis, considering both capital and operation and maintenance costs. This section of the report will discuss the results of the evaluations and select a recommended remedial alternative.

5.02 SUMMARY OF COSTS AND EFFECTIVENESS

5.01.01 General

Due to the diversity of the remedial alternatives, key issues including costs, environmental concerns, and engineering criteria were evaluated based on their importance to the overall project goals. To evaluate each alternative, weighting factors were applied to the present worth costs and to the effectiveness screening criteria. The weighting factors for each of the screening criteria items are attached as Appendix A. Summarization of the weighted cost and effectiveness items allowed ranking and selection of the most cost-effective alternatives.

5.02.02 Cost Rating

A weighting factor was applied to the present worth cost of each alternative to determine a total cost rating. Since costs are a very important factor to consider in the evaluation of remedial alternatives, a weighting factor of 1.0 (on a scale of 0-1.0) was used. A summary of present worth costs is presented in Table 1. Cost ratings for each alternative were determined by multiplying the present worth cost by the weighting factor and dividing by one million to get the cost rating in a millions-of-dollars base.

5.02.03 Effectiveness Rating

Scores from the engineering and environmental criteria worksheets were weighted based on the importance of the issue involved. For example: the site is remotely located, and no future site uses are currently planned; issues involving present or future site uses were not as heavily weighted as contaminant migration issues. The more important factors involved minimization of continued contamination, receptor pathways, and legal issues. Factors such as utilization of available technology or materials, availability of products, and general site usage were considered less important. Weighting factors ranged from 0.1 for less important issues to 1.0 for issues of maximum importance.

Total effectiveness ratings were determined by multiplying the engineering and environmental criteria score by the respective weighting factor. Individual criteria were then summed to arrive at a total environmental rating and a total engineering rating for each alternative. The total environmental and engineering ratings were then summed to get a total effectiveness rating.

The highest effectiveness ratings were associated with Alternative P, Complete Removal and Off-site Disposal. The lowest effectiveness rating occurred for Alternative A, No Action.

5.02.04 Cost-Effectiveness Rating

Following compilation of the weighted cost and weighted effectiveness ratings, a summary table was prepared to allow comparison of all the alternatives on an equal basis. The most cost-effective alternatives were determined by dividing the effectiveness ratings by the cost rating for that alternative. Alternatives with the highest total ratings (effectiveness per million dollars) were judged to be the most cost-effective. A summary of this procedure is presented as Table 2.

Alternative A, No Action, was shown to have the highest cost-effectiveness rating, due to the minimal capital expenditures required. Alternatives B, D and F were the next most cost-effective alternatives with summary scores of 111.6, 83.3, and 75.6, respectively.

Variations in the interest rate used can have an effect on the estimated cost of an alternative and, therefore, on the ranking order. Following the cost-effectiveness ranking, a sensitivity analysis was performed to assess what the effect of variations in the assumed interest rate had on the present worth costs. The sensitivity analysis was performed on Alternatives A, B, D and F and used 4 percent, 7 percent and 10 percent for comparison. Changing the interest rate had no effect on the ranking of the alternatives.

5.03 RECOMMENDED ACTION

The most cost-effective remedial action is the No-Action alternative. This alternative would include the installation of monitoring wells and collecting and analyzing groundwater samples for a 30-year period. Future action at the landfill would depend on the results of the analysis of the groundwater samples which would be taken on a periodic basis throughout the year. Although the No-Action alternative is the most cost-effective, other alternatives are more environmentally and technically effective.

Alternative B is nearly twice as effective as the No-Action alternative. The grading, drainage control, and installation of a low-permeability cover would greatly reduce the percolation of water through the landfill. This would significantly reduce the leaching of contaminants in the landfill and their subsequent migration off-site. The reduction of percolation would significantly reduce or eliminate the groundwater mounding under the landfill; the groundwater mounding is the driving force which causes migration of contaminants off-site.

Alternative D is slightly more effective than Alternative B because Alternative D diverts upgradient groundwater around the landfill. By diverting the groundwater around the landfill, migration of groundwater will be significantly reduced through the landfill. During periods of high groundwater, the amount of groundwater passing through the landfill would be significantly reduced and therefore the potential for leaching of contaminants into the groundwater which might contact the wastes will be significantly reduced.

If Alternative B were selected as the recommended remedial action alternative, Alternative D could be implemented at a later date, if monitoring of the wells indicated that further action would be required. To implement Alternative D, the installation of groundwater diversion trench would be all that was necessary because the other components of Alternative D are those of Alternative B.

Alternative A, No Action, is the most cost-effective because its costs are minimal. Alternative B is nearly twice as effective as the No-Action alternative and provides a more environmentally sound, public acceptable approach to final closure of the landfill. Alternative B significantly reduces or eliminates the primary cause for contaminant migration -- leaking caused by percolation and groundwater mounding which establishes the hydraulic gradient causing migration. A higher level of protection could be provided at a later date by adding diversion trenches to Alternative B; therefore, Alternative B is a flexible alternative that is easily modified if required.

Alternative B, which includes site grading, drainage control, and the installation of a low-permeability cover is the recommended remedial action for the Xerox landfill in Webster, New York.

Figures

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FIGURE I

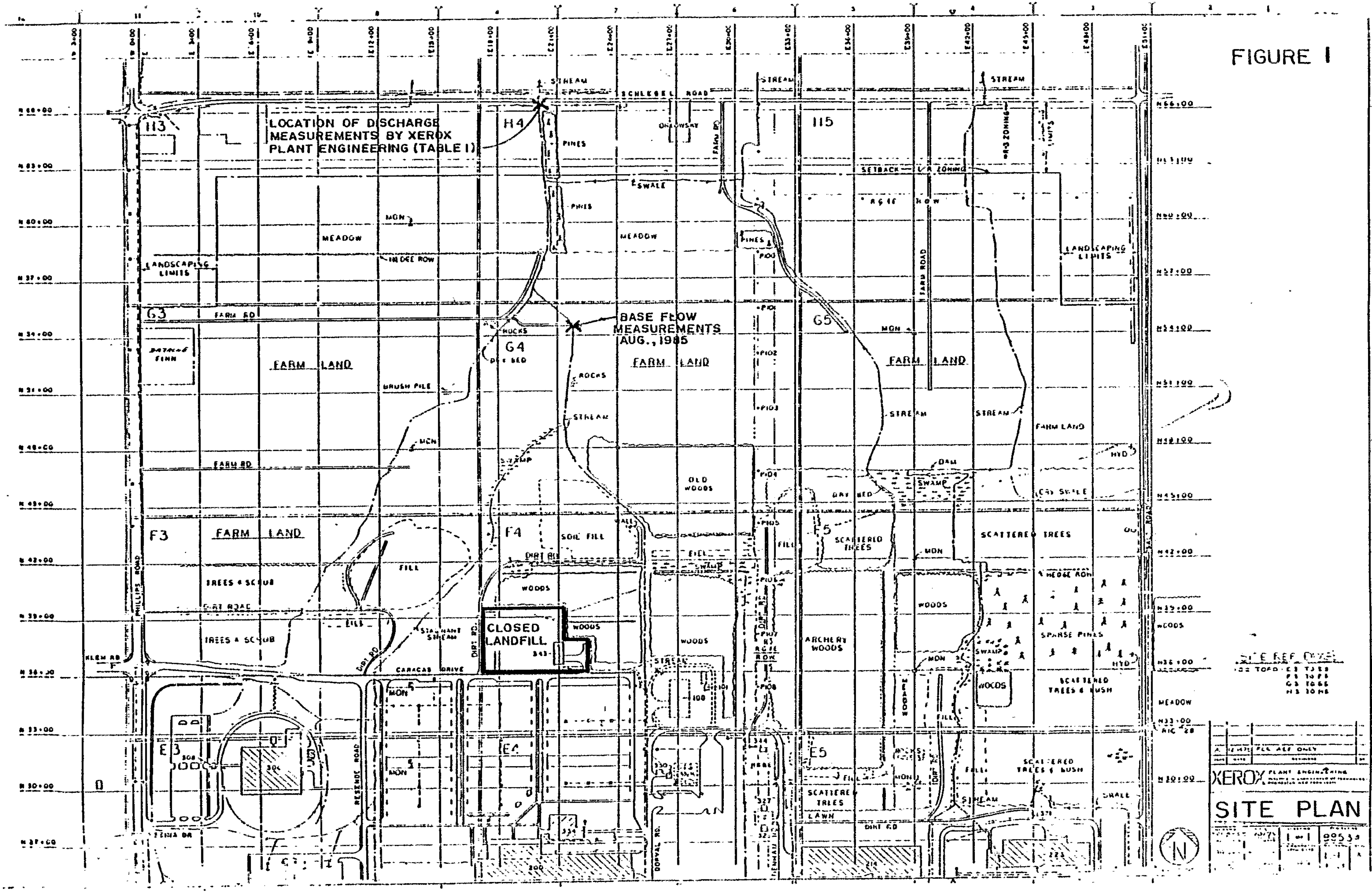
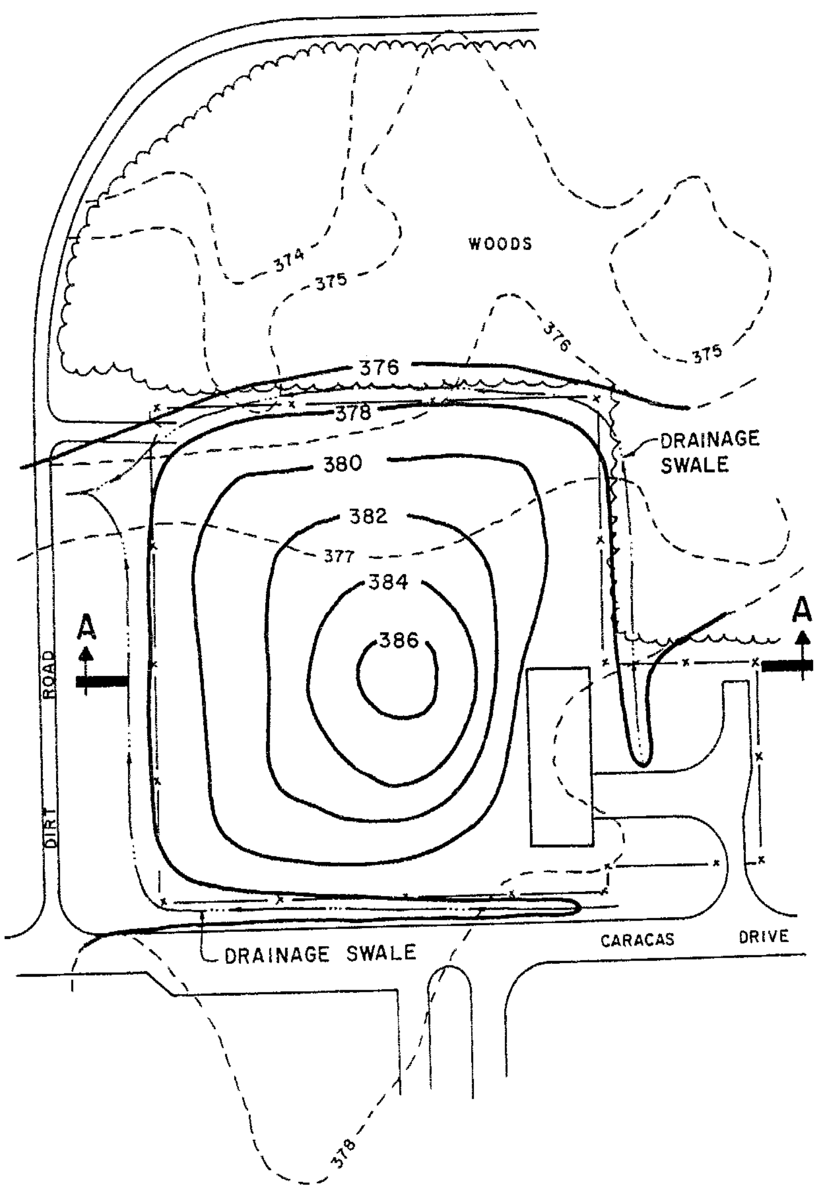
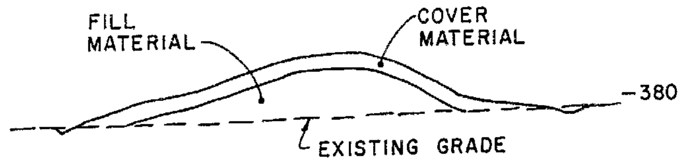

LOCATION OF DISCHARGE MEASUREMENTS BY XEROX PLANT ENGINEERING (TABLE I)
BASE FLOW MEASUREMENTS AUG., 1985
CLOSED LANDFILL
FARM LAND
MEADOW
STREAM
SCHLEGEL ROAD
PHILLIPS ROAD
CARACAS DRIVE
RESENDE ROAD
DORVAL RD.
WOODS
OLD WOODS
ARCHERY WOODS
SCATTERED TREES
SPARSE PINES
TREES & SCRUB
SOIL FILL
FILL
SWAMP
PINES
H4
H3
G3
G4
G5
F3
F4
F5
E3
E4
E5
XEROX PLANT ENGINEERING
SITE PLAN

FIGURE 2



PLAN
SCALE: 1"=100'



SECTION A
SCALE: HORIZ. 1"=100'
VERT. 1"=20'

RECOMMENDED
REMEDIAL ACTION

PLAN & SECTION

XEROX CORPORATION
WEBSTER, NEW YORK

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Tables

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TABLE 1

PRESENT WORTH COST SUMMARY

Alternative	Capital Cost	O & M Cost	Present Worth(1)	Weighting Factor	Cost Rating(2)
A	$ 17,500	$10,000	$ 111,800	1.0	0.1118
B	298,000	10,000	392,300	1.0	0.3923
C	536,000	10,000	630,300	1.0	0.6303
D	474,500	10,000	568,800	1.0	0.5688
E	696,000	10,000	790,300	1.0	0.7903
F	465,000	20,500	658,250	1.0	0.6583
G	702,750	20,500	896,000	1.0	0.896
H	708,500	10,000	802,750	1.0	0.8028
I	845,000	10,000	939,250	1.0	0.9393
J	946,250	10,000	1,040,500	1.0	1.0405
K	1,081,750	10,000	1,176,020	1.0	1.1760
L	813,750	85,000	1,615,000	1.0	1.615
M	1,051,250	85,000	1,852,500	1.0	1.8525
N	961,250	85,000	1,762,500	1.0	1.7625
O	1,461,500	85,000	2,262,800	1.0	2.2628
P	913,000	10,000	1,007,250	1.0	1.0073

(1) Present Worth determined using a Discount Rate of 10% over a 30-year life

(2) $\text{Cost rate} = \frac{\text{Present Worth x Weighting Factor}}{1,000,000}$

TABLE 2

COST EFFECTIVE EVALUATION SUMMARY

Alternative	Cost Rating (Weighted) Present Worth	Effectiveness Rating (Weighted) Envir.	Engr.	Total	Effectiveness Rating / Cost Rating	Rank
A	0.1118	9.8	13.7	23.5	210.2	1
B	0.3923	22.6	21.2	43.8	111.6	2
C	0.6303	24.0	20.3	44.3	70.3	5
D	0.5688	25.8	21.6	47.4	83.3	3
E	0.7903	27.2	20.3	47.5	60.1	6
F	0.6583	28.2	21.6	49.8	75.6	4
G	0.896	29.6	20.3	49.9	55.7	9
H	0.8028	25.8	21.6	47.4	59.0	8
I	0.9393	27.4	21.6	49.0	52.2	10
J	1.0405	27.2	20.3	47.5	45.6	11
K	1.1760	28.8	20.3	49.1	41.7	12
L	1.615	28.2	22.2	50.4	31.2	13
M	1.8525	31.4	22.0	53.4	28.8	15
N	1.7625	29.8	22.2	52.0	29.5	14
O	2.2628	33.0	21.8	54.8	24.2	16
P	1.0073	35.4	24.6	60.0	59.6	7

Appendices

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APPENDIX A

FEASIBILITY STUDY
INITIAL SCREENING WORKSHEET
SUMMARY SHEET

Project: ______________________________

Client: ______________________________

File Number: ______________ Date: ______________

Remedial Action Alternative: ______________________________

____

Prepared By: ______________________________

Checked By: ______________________________

Instructions For Use

1. Complete the attached three forms for each remedial action alternative.

2. Assign each environmental and engineering screening criteria with a value from the specified range with a one (1) indicating that the alternative does not satisfy the criteria and the highest score indicating full compliance with the criteria.

3. Note any rationale or back-ups in the "notes" section provided.

4. Total the scores and enter in the spaces below.

5. Determine an order-of-magnitude cost for each alternative and enter in the space below.

6. Utilize the scores of the initial screening process to narrow the list of remedial action alternatives to undergo detailed analysis.

Environmental Screening Score ______

Engineering Screening Score ______

Total Present Worth Cost ______

Project: ____________

Alternate: ____________

Date: ____________

By: ____________

FEASIBILITY STUDY
INITIAL SCREENING WORKSHEET
ENVIRONMENTAL SCREENING CRITERIA

Criteria	Score	Weighting Factor		Rating
1. Minimize Precipitation Percolation (1-5) Notes:	____	0.7	=	____
2. Minimize Surface Water Percolation (1-5) Notes:	____	0.7	=	____
3. Minimize Groundwater Contact with Wastes (1-5) Notes:	____	0.8	=	____
4. Minimize Contaminant Migration in Surface Water (1-5) Notes:	____	0.7	=	____
5. Minimize Contaminant Migration in Groundwater (1-5) Notes:	____	0.8	=	____
6. Minimize Existing Off-Site Contamination (1-5) Notes:	____	0.9	=	____
7. Eliminate Receptor Contact with Wastes (1-5) Notes:	____	0.9	=	____
8. Minimize Adverse Impacts Due to Alternative Implementation (1-5) Notes:	____	0.5	=	____
9. Maximize Public Acceptability (1-5) Notes:	____	0.8	=	____
10. Minimize Legal Issues Which May Affect Implementation (1-5) Notes:	____	1.0	=	____
		Total:		____

Project: ______________
Alternate: ______________
Date: ______________
By: ______________

FEASIBILITY STUDY
INITIAL SCREENING WORKSHEET
ENGINEERING SCREENING CRITERIA

	Criteria	Score	Weighting Factor		Rating
1.	Compatibility with Site Geology (1-5) Notes:	____	0.8	=	____
2.	Compatibility with Site Hydrology (1-5) Notes:	____	0.9	=	____
3.	Compatibility with Site Terrain (1-3) Notes:	____	0.7	=	____
4.	Compatibility with Meterological Conditions (1-3) Notes:	____	0.5	=	____
5.	Compatibility with Present and/or Future Site Uses (1-5) Notes:	____	0.2	=	____
6.	Compatibility with Volatile Halogenated Organics (1-5) Notes:	____	0.9	=	____
7.	Compatibility with Heavy Metal Ions (1-5) Notes:	____	0.7	=	____
8.	Constructability (1-3) Notes:	____	0.5	=	____
9.	Availability of Materials (1-5) Notes:	____	0.5	=	____
10.	Availability of Specialized Products (1-5) Notes:	____	0.4	=	____
11.	Minimize Special Safety Procedures (1-3) Notes:	____	0.4	=	____
12.	Utilization of Available Technology (1-3) Notes:	____	0.4	=	____
			Total:		____

Project: ____________________
Alternate: __________________
Date: ______________________
By: ________________________

FEASIBILITY STUDY
INITIAL SCREENING WORKSHEET
REMEDIAL ACTION COST*

Capital Costs:

Operation and Maintenance Costs:

Total Present Worth Costs:

* Use and attach additional sheets as necessary.