FEASIBILITY STUDY OF REMEDIAL ALTERNATIVES
MOREAU SITE
II - CERCLA - 30201

prepared for:

GENERAL ELECTRIC
Schenectady , New York

prepared by:

Dunn Geoscience Corporation

August 1985

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EXECUTIVE SUMMARY

This Feasibility Study of remedial alternatives was conducted for the General Electric Company, Schenectady, New York by Dunn Geoscience Corporation, Latham, New York. Prior to this Feasibility Study, a Remedial Investigation consisting of an in-depth geohydrologic study of the area surrounding the Moreau site located in the Town of Moreau, Saratoga County, New York, was performed by Dunn Geoscience Corporation. The initial Remedial Investigation report, dated October, 1984, and the March, 1985 Remedial Investigation Report Addendum were submitted to the EPA Region II office.

The purpose of the Remedial Investigation was to characterize the extent of contamination at the site with the objective of using the information obtained for the preparation of this Feasibility Study of remedial alternatives. The Remedial Investigation included test drilling, installation of 72 monitoring wells, collection of water level measurements, collection and analysis of over 200 groundwater monitoring well samples and sample collection and analysis from 190 private residential wells. As of August 9, 1985, thirty-four rounds of surface water samples had been collected and analyzed.

Although surface water sample analyses indicate that none of the four Village of Fort Edward surface water reservoirs is contaminated, analyses indicate Reardon Brook and its tributaries are contaminated with trichloroethylene and trans -1,2- dichloroethylene. The stream had been diverted by the Village of Fort Edward to bypass New Reservoir in 1984. A record of Reardon Brook flow was obtained with a V-notch weir equipped with a stilling well and water level recorder. During the 69 days of weir operation, average stream discharge was 287 gallons per minute.

The site is underlain by the Moreau sand aquifer. The aquifer consists of up to 88 feet of glaciodeltaic sand overlying up to 28 feet of upper glaciolacustrine medium to fine sand with some silt. The aquifer is underlain by a confining bed consisting of up to 25 feet of lower glaciolacustrine varved silt and clay with glacial till overlying dark gray argillaceous limestone bedrock.

The major factor influencing groundwater flow in the area is the topographic scarp southeast of the site that marks the edge of the Moreau sand aquifer. Near this area the gradient is up to 0.035 ft/ft and directs the principal flow of groundwater to the southeast.

The areal extent of groundwater contamination of trichloroethylene in concentrations greater than 100 parts per billion (ppb) occurs in an essentially southeast trending plume approximately 4800 feet long and about 2000 feet wide at its widest point. The overall orientation of the plume follows the direction of groundwater flow and the downgradient limit is controlled by groundwater discharge to springs and streams having their head waters at the foot of the escarpment.

Five hundred thirty-three soil samples collected from 512 different locations were analyzed for PCBs. Ninety-nine samples representing 76 different locations showed signs of PCB contamination. Contaminated soils were found at the ground surface and deeper, but none were found below 25 inches. The total volume of PCB-contaminated or potentially contaminated soil was estimated to be approximately 8,600 cubic yards.

Several remediation activities have already taken place at the site:

- o Early in 1984, there was an indication that Reardon Brook, which supplies water to New Reservoir, had become contaminated with trichloroethylene. In response, the Village of Fort Edward constructed a channel to divert Reardon Brook so as to bypass New Reservoir.

- Whole house treatment systems, employing two canister carbon filtration and ultraviolet disinfection, have been installed at six impacted residences in the plume area.
- In order to contain the source of groundwater contamination, a soil-bentonite cut-off wall was constructed around the former disposal site.

This Feasibility Study identifies and evaluates potential remedial alternatives for the Moreau site and recommends the most cost-effective actions for mitigating the impact of the contamination on the environment and public health. The Feasibility Study was prepared in accordance with the requirements set forth in the National Oil and Hazardous Substances Contingency Plan (NCP).

As outlined in the NCP, a three phased process for the selection of the most appropriate remedial actions at the site was utilized. First, a limited number of remedial action alternatives were selected based on the site problems as defined in the remedial investigation. Second, an initial screening of the potential remedial action alternatives was performed. The initial screening was performed in order to reduce the number by eliminating alternatives that were obviously infeasible, inappropriate or environmentally unacceptable. The results of the initial screening are contained in sections 4.3 and 4.4 of this report.

The third phase of the remedial alternative selection process involves a detailed analysis of the alternatives passing the initial screening. As outlined in the NCP, the detailed evaluation consisted of refinement and specification of alternatives in detail, evaluation in terms of engineering implementation, analysis of methods for mitigating impacts and a detailed cost estimation. In Section 5.3 of this report, each remedial action alternative passing the initial screening was evaluated with respect to technical feasibility, public health effects, institutional requirements, environmental effects and cost. The results of the detailed analysis form the recommended remedial action for the Moreau site.

The overall recommended remedial plan includes the following actions:

- Air stripping treatment of Reardon Brook;

  Air stripping is the most cost-effective method of returning Reardon Brook to the Village of Fort Edward Water Supply. This technology has all the benefits and none of the disadvantages associated with the carbon adsorption alternative.

- Providing water supply pipeline to Bluebird Road impact area and other adjacent areas;

  Installation of the pipeline provides maximum isolation of residents affected by, or who could in the future be affected by, groundwater contamination from the site.

- Aquifer restoration by source containment, monitoring and air-stripping Reardon Brook;

  Analysis shows that source containment, consisting of cutoff wall and cap, and treatment of the plume of contamination by air stripping Reardon Brook is the cost-effective method of aquifer restoration.

Monitoring groundwater would allow detection of changes in groundwater quality and measure the degree of actual flushing of the aquifer.

- Excavation and on-site disposal of contaminated soil. Compared with in-place sealing, this alternative has the advantage of more effectively isolating the contaminated soil. The on-site disposal option is also much more cost-effective than the off-site disposal option while reducing potential exposure during transportation of contaminated soil and avoiding utilization of limited off-site land burial capacity.

1.0 INTRODUCTION

This feasibility study of the development and selection of remedial alternatives to perform off-site remedial action at the Moreau site was prepared for the General Electric Company, Schenectady, New York, by Dunn Geoscience Corporation, Latham, New York. The feasibility study was conducted in response to Part III of Administrative Order No. II-CERCLA-30201 and was prepared in accordance with the requirements of 300.68(a)-(j) of the National Oil and Hazardous Substances Contingency Plan (NCP) published pursuant to Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

The successive Sections of this report address the following major subjects.

Site background	- location, size, history, site conditions
Nature and extent of problem	- discussion and summary of remedial investigation activities and findings - discussion and summary of accomplished remediation activities
Statement of remedial objectives	- delineation of problem areas requiring remedial action and statement of remedial objectives
Remedial alternatives	- development and screening of prospective remedial alternatives
Detailed analyses of alternatives	- detailed analyses of remedial alternatives passing initial screening

Summary of alternatives and recommendations	- tabulation and summary of remedial alternatives and recommendation for remedial action

2.0 SITE BACKGROUND

2.1 Site Location

The Moreau site is located in the Town of Moreau, Saratoga County in upstate New York. The study area for the remedial investigation of off-site conditions consists of approximately 1,900 acres.

The site is within a broad sand plain area of low relief, stretching from the Luzerne Mountains west of the study area, east to the Hudson River. The Hudson River meanders across a relatively wide floodplain and flows in a general southwest to northeast direction. At Hudson Falls, the river abruptly turns south toward Fort Edward and continues south until it reaches New York Harbor. Located within the study area are four small surface water reservoirs: New, Sanderspree, Dority, and Christie. These reservoirs, located within the Town of Moreau, provide water to the Village of Fort Edward Water District.

2.2 Site History

Between the years of 1958 and 1968, the Moreau site was reportedly used as a disposal site for approximately 452 tons of industrial waste. In 1978, Town of Moreau and State officials began testing the air, soil, surface and groundwater at and near the disposal site. In December 1978, the Town of Moreau removed approximately 100 cubic yards of contaminated material and had it transported to a secure landfill.

In May of 1979, through a joint effort by the New York State Department of Environmental Conservation (DEC), the New York State Department of Transportation (DOT), and the Town of Moreau, a temporary cap was placed on the "evaporation pit" area.

In September 1980, in a negotiated agreement with the DEC, General Electric agreed to take remedial action at the Moreau site.

On December 8, 1980, the General Electric Company engaged O'Brien & Gere Engineers, Inc. to perform the studies at the Moreau site. O'Brien & Gere Engineers installed five permanent monitoring wells and defined groundwater flow paths beneath the site. After evaluating four alternative remedial programs, O'Brien & Gere recommended in-place containment for the evaporative lagoon site.

During July and August 1982, the Town of Moreau tested 151 private wells in the vicinity of the Moreau site for volatile organic compounds. In August 1982, the Town of Moreau contracted C.A. Rich Consultants to conduct a geohydrologic investigation of the extent of chemical contamination of the aquifer. As part of the investigation, a total of thirteen test wells were installed. The results of the investigation are contained in the April 1983 Hardick/Rich report entitled "Investigation of Groundwater Contamination in the Vicinity of the GE Moreau (Caputo) Site".

The Moreau site was proposed for the EPA Superfund list in December 1982, and was marked Number 141 nationally (out of 400), and Number 7 in New York State (out of 26). In the summer of 1983, the United States Environmental Protection Agency (EPA) initiated negotiations with the General Electric Company to address the off-site contamination problems at the Moreau site. The negotiations resulted in an order on consent whereby GE would conduct a Remedial Investigation/Feasibility Study and take necessary corrective action pursuant to Administrative Order No. II CERCLA-30201.

2.3 Remedial Investigation Objectives

In accordance with Section II of Administrative Order II-CERCLA-30201, Dunn Geoscience Corporation conducted a remedial investigation of off-site conditions at the Moreau site.

The remedial investigation was designed to provide sufficient information to develop remedial alternatives as described in the NCP. As outlined in the Administrative Order, the remedial investigation included the following elements:

- geohydrologic setting of the site including a characterization of the soils and definition of aquifer characteristics;
- groundwater gradients, velocity, and quality within the area of concern;
- location and influence of pumping wells on the movement of groundwater;
- modeling of the drinking-water aquifer to predict both rate and extent of groundwater contamination;
- determination of the vertical and lateral extent of contamination in soil, air, surface water, and groundwater; and,
- appropriate health and safety plans for conducting the remedial investigation.

The remedial investigation field work was initiated on May 2, 1984 and a Remedial Investigation Report dated October, 1984 was prepared. Subsequent to this report, additional studies were requested by the EPA. The results of the additional investigations, as well as new data obtained since the preparation of the October, 1984 report, were compiled into a March, 1985 Remedial Investigation Report Addendum.

3.0 SUMMARY OF REMEDIAL INVESTIGATION ACTIVITIES AND FINDINGS

This section of the report presents a summary of the Remedial Investigation activities and findings. A detailed presentation of the Remedial Investigation activities and findings are contained in the October, 1984 Remedial Investigation Report and the March, 1985 Report Addendum.

3.1 Summary of Investigation Activities

3.1.1 Surface Water Investigation

Located within the study area are four small surface water reservoirs: New, Sanderspree, Dority and Christie. These reservoirs provide water to the Village of Fort Edward Water District. As part of the remedial investigation, a water sampling program for the reservoirs and eight other surface water sources was implemented. Thirty-four rounds of samples were collected and analyzed for volatile organic compounds as of August 9, 1985.

In order to measure the volume of surface water flow in the Reardon Brook, a V-notch weir equipped with a stilling well and water level recorder was installed in a diversion ditch which had been dug by the Village of Fort Edward in 1984. This installation provided a continuous and reliable record of stream flow discharge over a period of approximately two months.

3.1.2 Subsurface Investigation

Seventy-two monitoring wells were installed at 30 locations near the site. The wells were arranged in sequentially numbered clusters and were installed in three phases over the May 2 to November 15, 1984 drilling period. With the exception of one borehole, all test borings were advanced utilizing mud-rotary drilling techniques. Depths and well installation details were determined by subsurface hydrologic data obtained during drilling. With the exception of clusters DGC 1, 2 and 3, the well clusters are constructed to screen the entire saturated portion of the aquifer above the basal glaciolacustrine clayey silts.

Standard five foot interval and continuous soil samples were collected following ASTM standards for the split-barrel method. As part of the first phase drilling program, split spoon samples were screened for volatile organic compounds. Draeger detector tubes and an HNU photoionization analyzer were used for the field screening. Selected soil boring samples were subsequently analyzed for volatile halogenated hydrocarbons by gas chromatography.

During the period between June 25, 1984 and February 18, 1985, seven rounds of groundwater samples were collected and analyzed for volatile organic compounds from the new and previously installed monitoring wells. Samples were obtained from selected wells during each round. Six major rounds of residential well water sampling were conducted between April 1984 and August, 1985. More frequent periodic sampling was performed on a monthly or bi-monthly basis at selected residences.

Fifteen rounds of water level measurements were obtained from the newly installed monitoring wells between July 11, 1984 and

August 1, 1985. Additionally, Town of Moreau, Moreau on-site and New York State Department of Transportation wells were measured as appropriate.

To determine the influence of pumping wells on the movement of groundwater, a continuous recording water level recorder was installed on monitoring wells DGC-12S, 12I and 25Ib. In addition, a water budget and groundwater model for the area near the site were developed.

3.1.3 Soil Investigation

Five hundred thirty-three soil samples were analyzed with a McGraw-Edison PCB field test kit. The 533 samples were obtained from 512 different locations, considering the various depths at which samples were collected as different locations. Each sampling site had, as a minimum, one sample collected from a depth at 6(+/- 2) inches. Many sites were sampled at different levels ranging from surface soil to horizons more than four feet below ground surface.

Samples were collected in accordance with a protocol dated September 28, 1984 and accepted by the United States Environmental Protection Agency. Quality assurance was provided by performing replicate field kit analyses and by comparing kit results with results on samples submitted to an approved chemical laboratory employing gas chromatographic techniques (EPA Method 8.08, SW-846).

3.2 Summary of Remedial Investigation Findings

3.2.1 Surface Water Investigation

As of August 9, 1985, thirty-four rounds of surface water samples had been collected and analyzed. Stream contamination in the wooded area downgradient of the topographic escarpment and leading to the Fort Edward reservoirs was found to be fairly constant over time.

Reardon Brook and its tributaries begin as seeps from the escarpment and gain volume as they move downstream toward New Reservoir. Trichloroethylene levels of up to 900 ppb were measured in the feeder springs located at the base of the escarpment. Relatively low levels of trans-1,2-dichloroethylene were also detected. Reardon Brook shows a pattern of contaminant concentrations in which contaminant levels decrease downstream from the source. This can be attributed to two factors; the stream gaining uncontaminated groundwater, and volatilization of contaminants.

Early in 1984, there was an indication that Reardon Brook, which supplies water to New Reservoir, was contaminated with trichloroethylene. The stream was diverted by the Village of Fort Edward to bypass New Reservoir. In order to measure the volume of water diverted, a V-notch weir, equipped with a stilling well and water-level recorder, was installed in the diversion ditch. A reliable record of stream flow discharge was obtained from the weir/recorder. During the 69 days of weir operation, average stream discharge was 287 gallons per minute.

conductivity tests were also conducted for the glaciodeltaic deposits. The calculated horizontal hydraulic conductivities range from 2.4 x 10^{-3}cm/sec to 2.1 x 10^{-2}cm/sec, with an average of 7.4 x 10^{-3}cm/sec (21 ft/day). Calculated vertical hydraulic conductivities in the glaciodeltaic deposit range from 4.4 x 10^{-6} to 2.0 x 10^{-2}cm/sec with an average of 1.6 x 10^{-3} cm/sec.

Groundwater elevation data indicates that a groundwater mound exists in proximity to the Moreau Site causing gradients from the disposal site toward the west, southwest, south, and southeast. The major factor influencing groundwater flow in the study area is the northeast-southwest trending topographic scarp located about four-fifths of a mile south of the GE Moreau Site. Hydraulic gradients to the west and southwest are very slight, in the 0.0001 to 0.002 ft/ft range. The groundwater gradients near the scarp are high -- .035 ft/ft and direct groundwater to the southeast. Groundwater equipotential lines based on monitoring well measurements indicate that flow lines toward the west and southwest in the immediate vicinity of the mound change direction to the south and southeast.

Vertical head distributions in the well clusters indicate that, in general, the area surrounding the Moreau Site is a zone of groundwater recharge. In contrast, the areas next to, and south of, the topographic scarp are groundwater discharge areas as indicated by higher water levels in the deeper wells than associated shallower wells. Discharge is further indicated by numerous seeps and springs at the scarp base and the presence of a flowing well (FE-1). Based on field measurements of hydraulic gradients, hydraulic conductivities and estimates of aquifer porosity, the calculated average linear groundwater velocity is about 0.67 feet/day for the upper portion of the aquifer, and about 0.27 feet/day for the lower portion. Therefore, the time of travel is about 18 years for groundwater flowing entirely within the upper portion of the aquifer from the Moreau Site to a discharge point at the erosional escarpment, a distance of approximately 4800 feet.

During the remedial investigation, over 200 groundwater samples were collected and analyzed for volatile organic compounds, from the new and previously installed monitoring wells. The sampling was accomplished in seven rounds dating from June 25, 1984 to February 18, 1985. Analyses were performed in accordance with EPA Methods 601 and/or 624. Figure 1 shows the approximate areal extent of groundwater contamination. The map was prepared by considering the highest level of trichloroethylene (TCE) found in any well cluster or in any individual well that is not part of a cluster. Although, groundwater contaminants include a variety of organic compounds, TCE is most prevalent and, therefore, was chosen to be an indicator of overall contamination. The areal extent of contamination representing TCE concentrations greater than 100 ppb occur in an essentially southeast trending plume approximately 4800 feet long and about 2000 feet wide at its widest point. The plume has its origin at the Moreau disposal site and its overall orientation follows the direction of groundwater movement. The plume extends southeastward to the erosional escarpment. Maximum organic levels occur in a relatively narrow, essentially southeast trending band which coincides with groundwater flow paths south of the Moreau site. Dispersion is responsible for lateral spreading of the contaminants as they migrate in response to groundwater flow; however, its influence on the migration of contaminants is much less than that of advection. TCE concentrations tend to be highest at intermediate and deep levels within the aquifer.

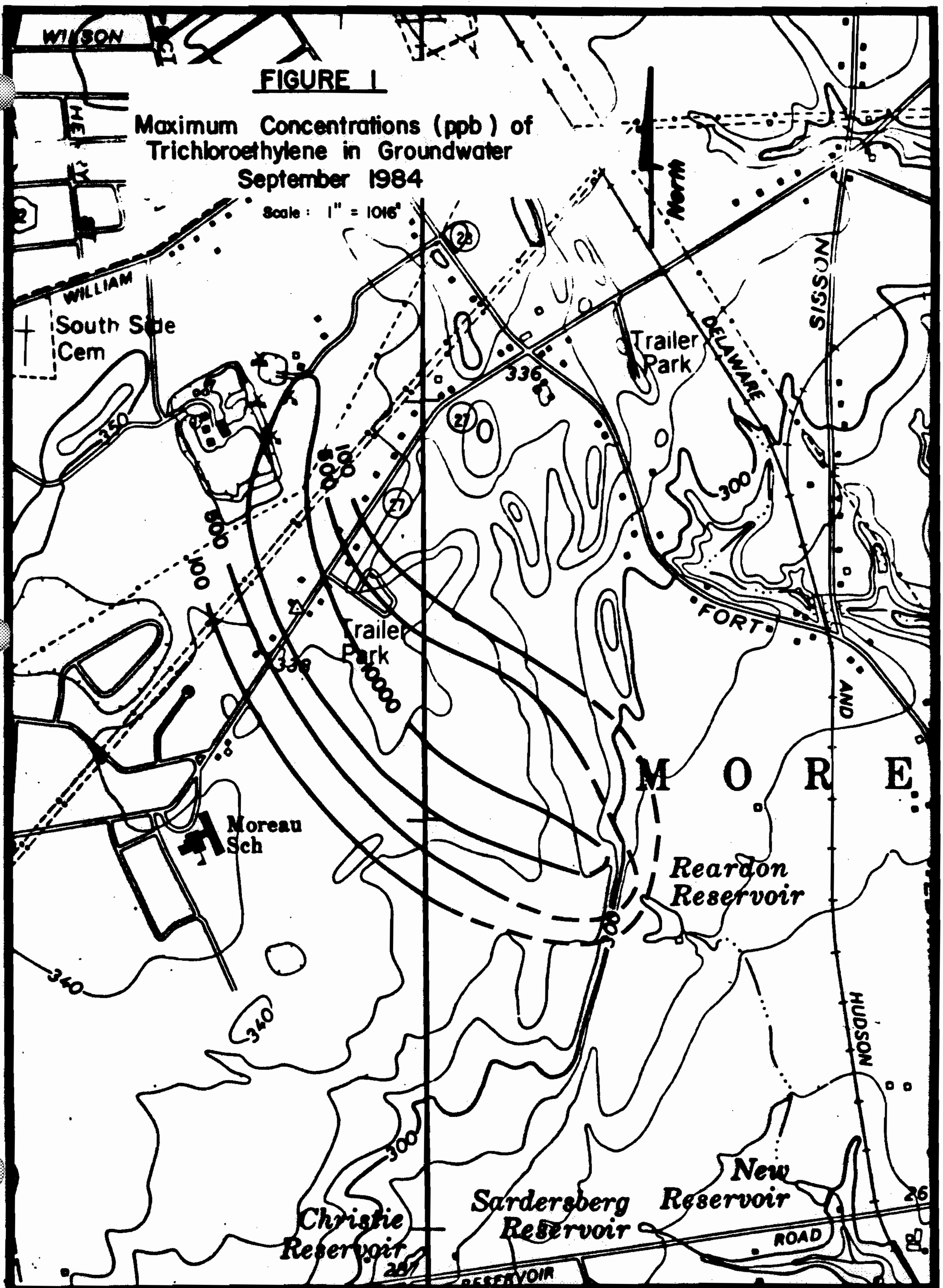

FIGURE 1

Maximum Concentrations (ppb) of Trichloroethylene in Groundwater September 1984

Scale : 1" = 1016'

Field observations indicate that the Bluebird Terrace Trailer Park pumping well has no significant influence on nearby water levels. Due to the high aquifer transmissivity, the distributed nature of the Cheryl and Terry Drive private well pumping, and the distance of well DGC-25 from the nearest pumping well (approximately 100 ft.), no influence from pumping is expected at DGC-25.

3.2.3 Soil Investigation

Five hundred thirty-three soil samples were collected from 512 different locations and analyzed for PCBs using the McGraw-Edison Test Kit. Ninety-nine samples showed kit responses indicating PCB contamination at or above the kit detection limit. These 99 samples represent 76 different locations.

Of the 76 locations, 54 are directly on, or adjacent to, a driveway and a path which leads to the former dump site. Contaminated soils were found at the ground surface and deeper, but none were found below 25 inches.

Eight of the 76 contaminated locations are south and west of a house on the property. In no case was contamination detected at depths greater than 6 inches below ground level in these eight samples. Contamination detected by kit probe response showed 12 sites along the former dump site to be affected. The total volume of PCB-contaminated or potentially contaminated soil is estimated to be approximately 8,600 cubic years.

3.3 Summary of Accomplished Remediation Activities

3.3.1 Diversion of Reardon Brook

Early in 1984, there was an indication that Reardon Brook, which supplies water to New Reservoir, had become contaminated with trichloroethylene. The Village of Fort Edward constructed a channel to divert Reardon Brook so as to bypass New Reservoir. Data collected by Dunn Geoscience in the summer of 1984 indicates the average flow rate of Reardon Brook to be approximately 287 gpm.

The diversion of Reardon Brook has been effective in preserving the water quality of New Reservoir. However, diversion is not a long-term solution as it may result in a water shortage during low precipitation periods.

3.3.2 Residential Whole-House Treatment Systems

Treatment units employing two-canister carbon filtration and ultraviolet disinfection have been installed by General Electric at six residences in the Bluebird Road area. These domestic water supplies were chosen because monitoring results exceeded a predetermined action level as set forth in the November 1983 EPA Administrative Order.

The system utilized two canisters containing activated carbon, followed by an ultraviolet disinfection lamp, all assembled in series. The units are monitored monthly from the inlet and outlet of the upstream canister to determine adsorption efficiencies and breakthrough criteria. As of this time, the units have proven to be very effective.

3.3.3 Cutoff Wall

In order to contain the source of groundwater contamination, a soil-bentonite cutoff wall was constructed around the former disposal area. Construction of the cutoff wall began on June 18, 1984 and was completed on September 4, 1984.

The water-table aquifer at the Moreau site is underlain by lacustrine sediments, largely glacial varved silts and clays. These deposits are relatively impermeable with an estimated hydraulic conductivity of 5 x 10^{-7}cm/sec (compared to 7.4 x 10^{-3}cm/sec for the Moreau aquifer) and form an extensive aquitard which has protected the underlying bedrock aquifer from contamination. Thus, natural groundwater flow in the unconsolidated sands is largely horizontal above the lacustrine clays which range from 88 to 105 feet deep.

Like the lacustrine clays, the soil-bentonite slurry wall is relatively impermeable to water, having an engineered hydraulic conductivity less than 1 x 10^{-7}cm/sec. Various laboratory tests on the slurry wall materials indicate a hydraulic conductivity as low a 1 x 10^{-8}cm/sec. The slurry wall has a circumference of approximately 1600 feet and a minimum thickness of 30 inches.

The slurry wall totally surrounds the contaminant source and is keyed a minimum of 6 feet into the underlying natural clays and effectively prevents groundwater flow into or out of the contained Moreau site.

The containment system represents a barrier to the natural flow of groundwater in the water-table aquifer which will now be directed around the containment system. Water levels can be expected to rise slightly immediately upgradient and lower slightly immediately downgradient from the site to allow for groundwater flow around the system. However, the extremely weak gradients in the vicinity of the site (0.0006 from OBG-3 to TMB and 0.0002 from OBG-3 to DGC-18 for 9/26/84) preclude any significant head changes that might be caused by emplacement of the containment system.

In support, hydrographs have been developed for various wells from water level data from early July 1984 to late May 1985 (i.e. from the beginning of cutoff wall construction to the present). When superimposed, hydrographs from wells immediately upgradient from the site (OBG 2 and 3) closely match those from more distant wells in aquifer recharge areas (DGC 6 and 7) indicating that construction of the slurry wall has not caused groundwater levels to fluctuate to any greater or lesser extent than other areas more distant from the cut off wall.

Because the slurry cutoff wall prevents further release of contaminants from the site, aquifer restoration should proceed unhindered. The natural flow of uncontaminated groundwater from upgradient areas around the site toward the topographic scarp to the southeast will provide for a flushing of contaminants from the Moreau aquifer. Although the remedial effects of the cut-off wall will develop slowly, the extent of the contaminant plume will decrease with time.

3.4 Statement of Remediation Objectives

The remedial investigation findings in the areas of groundwater, surface water and soil, identified four subjects to be considered for remediation. The off-site migration of chemicals within the groundwater regime has:

(1) adversely impacted the well water supplies of those residents along Bluebird Road in the vicinity of the zone of concentration downgradient of the original disposal area, and has raised concerns about effects on residential well groundwater in the vicinity of the Cheryl, Terry and Myron Road area in the future.

(2) created an arcuate shaped plume within the unconfined aquifer approximately 2,000 feet in width, 4,800 in length; and

(3) contributed measurable levels of trichloroethylene (up to 900 ppb) and relatively low levels of trans 1, 2-dichloroethylene in groundwater discharge feeder springs to Reardon Brook which supplies the Village of Fort Edward waterworks.

(4) In addition, some members of the public are concerned that soils that contain high levels of PCBs may pose a threat to the health and welfare of the public and to the environment.

The remediation objectives are as follows:

1. To provide plume - impacted Bluebird Road residences with water supplies that meet present New York State and Federal drinking water standards.

2. To insure that residents in the Cheryl, Terry and Myron Road area are not affected by the plume in the future.

3. To remediate Reardon Brook water, so as to meet present New York State and Federal drinking water standards.

4. To manage the groundwater system in those areas where continued migration of existing plume constituents could, in the future, present unacceptable levels of human exposure or adverse impact on the environment.

5. To satisfactorily reduce potential pathways of human exposure to soils that contain unacceptable levels of PCBs.

4.0 PRELIMINARY REMEDIAL ALTERNATIVES EVALUATION

This section presents an identification of alternatives that may be appropriate for off-site remediation at the Moreau site.

4.1 Methodology of Remedial Alternative Evaluation

This section is a summary of the National Oil and Hazardous Substances Contingency Plan (NCP) outline of the three-phased process for the selection of the most appropriate remedial actions at a given site. Under subsection 300.68 (g) of the NCP, remedial technologies are initially identified and developed. This process involves the following steps:

1. Identify site problems and pathways of contamination (remedial investigation).

2. Identify general response actions that address site problems and meet cleanup goals and objectives.

3. Screen the identified technologies implied by each general response action to initially eliminate inapplicable and infeasible technologies.

4. Assemble technologies into operable units based on the remaining feasible technologies. (remedial alternative development)

Second, as specified in 300.68 (h) of the NCP, additional screening of remedial alternatives is performed in order to reduce the number by eliminating infeasible, inappropriate or environmentally unacceptable alternatives. Three broad criteria are used in this screening process;

1. Cost -

   The cost of installing or implementing the remedial action is considered, including operation and maintainance costs. An alternative that far exceeds the cost of other alternatives evaluated and that does not provide substantially greater health or environmental benefit should be excluded from further consideration.

2. Effects of the Alternative -

   Effects of each alternative are evaluated in two ways: whether the alternative or its implementation has any adverse environmental effects; and, whether the alternative is likely to effectively mitigate and minimize the threat of harm to public health, welfare or the environment.

3. Engineering Acceptability -

   Alternatives must be feasible for the location and conditions at the site, applicable to the problem, and represent a reliable means of addressing the problem. The level of technological development will also be considered.

The third phase, as described in 300.68 (i) of the NCP, involves a detailed analysis of the limited number of alternatives which have passed the initial screening.

4.2 Identification of Remedial Response Actions and Remedial Action Technologies

Remedial response actions and technologies have been identified for the Moreau site, and are summarized in Table 1. These technologies are those that passed the identification process of Section 4.1.

TABLE 1

GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

General Response Action	Technologies
No Action	None.
Monitoring	Sampling and analyses.
Containment	Capping; groundwater containment barrier walls; grout curtains.
Pumping	Groundwater pumping.
Diversion	Stream diversion.
Complete/partial removal	Soil excavation and disposal.
On-site Treatment	Incineration; wet oxidation; solidification; land treatment; biological, chemical, and physical treatment.
Off-site Treatment	Incineration; biological, chemical, and physical treatment.
In situ Treatment	Permeable treatment beds; biological degradation; soil flushing.
Off-site Disposal	Landfills.
On-site Disposal	Designed containment areas.
Alternative Water Supply	Bottled water; cisterns; aboveground tanks; deeper or upgradient wells; municipal water system; individual treatment devices.

4.3 Initial Screening of Remedial Action Alternatives

The remedial action technologies have been assembled into a list of remedial alternatives organized according to the site problems they are intended to mitigate. These alternatives are summarized in Table 2 and have been evaluated and screened in the remainder of Section 4.3 using the following criteria:

Technical Feasibility
Cost Effectiveness
Implementation Time Frame
Environmental Effectiveness
Institutional Considerations
Safety

Table 2

Potential Remedial Action Alternatives
At the Moreau Site

SURFACE WATER

- No Action
- Diversion
- Treatment
    - Carbon adsorption
    - Air stripping
    - Resin adsorption
    - Ion exchange
    - Reverse osmosis

RESIDENTIAL WATER SUPPLY

- No Action
- Monitoring
- Groundwater Pumping and Recharge
- Individual Whole-House treatment
- Alternate Water Supply (pipeline from existing municipal system)
- New Wells
- Cisterns
- Bottled Water

AQUIFER RESTORATION

- No Action
- Containment Barriers
- Source Containment, Groundwater Monitoring and Air Stripping of Groundwater Discharge
- Source Containment, Groundwater Pumping and Recharge
- Permeable Treatment Beds

SOIL REMEDIATION

- No Action
- Sealing
- Excavation and Removal
- Treatment
    - Incineration
    - Wet Air Oxidation
    - Biological Degradation
    - Chemical Treatment

4.3.1 Surface Water

4.3.1.1 No Action

General Description

Under this alternative no effort would be made to mitigate the contamination problem in Reardon Brook.

Application to the Moreau Site

Water in Reardon Brook contains trichloroethylene and trans-1,2-dichloroethylene contaminants. In view of the use of Reardon Brook to supply part of the Village of Fort Edward's water needs, remedial alternatives must be considered. Thus, the no action alternative is eliminated

4.3.1.2 Diversion

General Description

Early in 1984, Reardon Brook was diverted so as to bypass New Reservoir. Under this alternative, the present diversion would be maintained.

Application to the Moreau Site

Based on data accumulated in a 69-day period during the summer of 1984, it is estimated that approximately 287 gpm is diverted from the stream, which is about 40 percent of the total water works output. Under the present system, it is recognized that during extended periods of low precipitation, total demand may exceed the amount of water available to the water works. Thus, stream diversion as a long term remedy is eliminated because it could lead to a drinking water shortage problem.

4.3.1.3 Treatment

General Description

Separating synthetic, volatile organic chemicals from water is best performed by taking advantage of the chemical and physical characteristics of the contaminants; technologies suited to this are adsorption, filtration and purging. These three technologies share the common property of selective chemical removal.

Application to the Moreau Site

Carbon Adsorption

Activated carbon treatment has the advantage of high adsorption potential, tolerance of fluctuation in concentrations and flow, and has high flexibility in operation and design.

Isotherm data from a commercial carbon producer indicates that the carbon adsorption capacity for TCE is 28 mg/gm (1). For a 400 gpm, 100 ppb TCE contaminated surface water source, this would result in the adsorption of:

$$\frac{400\ \text{gal}}{\text{min}} \times \frac{60\ \text{min}}{\text{hr}} \times \frac{24\ \text{hr}}{\text{day}} \times \frac{3.785\ \text{liter}}{\text{gal}} \times \frac{100\ \text{ug TCE}}{\text{liter}} \times \frac{1\ \text{gm}}{10^6\ \text{mg}}$$

$=218$ gm TCE/day

This would require:

$$\frac{218 \text{ gm TCE}}{\text{day}} \times \frac{1 \text{ gm carbon}}{0.028 \text{ gm TCE}} \times \frac{1 \text{ lb}}{454 \text{ gm}} = 17 \text{ lbs. carbon/day}$$

or about 6200 pounds per year.

This is a minimum estimate based on clean standard hydrocarbon solutions. However, activated carbon will remove other organic compounds such as natural humic materials and has the disadvantage of being intolerant of high suspended solids levels. Competition for adsorption sites is a problem in multi-component contaminant systems, as is microbial growth which is known to occur on activated carbon. Often carbon adsorption requires pre-treatment of influent water.

Air Stripping

Air stripping can provide an effective means of treating the levels of trichlorethylene in Reardon Brook water.

An air stripping unit was designed for installation adjacent to the Reardon Brook diversion site, in compliance with Superfund program guidelines for implementing initial remedial measures prior to selection of a final remedy (Section 300.68 (e) of the National Contingency Plan). This action received NYSDEC approval for supplying the Village of Fort Edward with acceptable drinking water from Reardon Brook. The water treatment facility was designed by Blasland & Bouck (Syracuse, NY) for General Electric and is scheduled to begin operating in August 1985.

The basis of design of the Reardon Brook water treatment facility and its acceptability will be discussed in the detailed analysis of this alternative.

Resin Adsorption

Resin adsorption is another effective treatment for water containing organic contaminants. Although laboratory results have shown that various classes of organic compounds are adsorbable, this method is not widely used due to the difficulty of selecting the appropriate adsorbent/regeneration combination for a particular waste stream. Resin adsorption technology is not as well developed as carbon adsorption, but applications for the removal of color, phenol and other dissolved organics have been developed.

One disadvantage of resin adsorption is the high initial cost. Another is that its adsorption capacity is lower than activated carbon due to the smaller surface area of the resin. Because of these disadvantages, resin adsorption is eliminated from future consideration as a remedial action for Reardon Brook.

Ion Exchange

The basic mechanism of ion exchange is the reversible interchange of ions between an insoluble salt (the ion exchange material), and a solution of electrolyte in contact with the ion exchange material.

Ion exchange is a process with a history of use as a final polishing treatment technique where it is necessary to remove dissolved species: it will remove dissolved salts, organic salt, and a limited number of organics from aqueous solutions. The technique has been employed to remove heavy metals, toxic ions, and some organics from water and waste water.

Ion exchange is not a process that would normally receive consideration as a primary treatment consideration, and it is not well suited as a treatment for chlorinated, aliphatic hydrocarbon removal. The non-polar compounds found in Reardon Brook are not well suited to this technology. Therefore, ion-exchange treatment is eliminated from further consideration.

Reverse Osmosis

Reverse osmosis is a relatively new process which has been used for waste purification and to concentrate industrial waste effluents. It has shown potential in the treatment of both organic and inorganic contaminants, especially heavy metals and low molecular weight organics.

Reverse osmosis employs a force to drive certain components of a solution through a semi-permeable membrane. The application of a pressure gradient results in the driving of contaminants from the dilute solution to the more concentrated solution. The popular cellulose acetate membranes are expensive and require high pressure differentials for effective treatment.

Any use of reverse osmosis on a full scale basis would require extensive bench and pilot testing to ascertain the compatibility of the waste chemistry and the reverse osmosis procedure. Other disadvantages include the need for pre-treatment to remove colloidal and suspended solids, membrane fouling due to precipitation of insoluble salts, and the necessity for rigid pH control. At this time the method is generally limited to polishing operations following more conventional treatment procedures and is eliminated as a remedy for Reardon Brook.

4.3.2 Residential Water Supply

4.3.2.1 No Action

General Description

Under this alternative, no efforts would be made to mitigate the residential well problem at the Moreau Site.

Application to the Bluebird Road Area

Concentrations of trichloroethylene (TCE) found in some of the residential wells in the Bluebird Road area exceed the 10 ppb quality standard established by New York State for class GA groundwater designated for use as a potable water supply. For this reason the no action alternative is eliminated.

Application to Areas Adjacent to Plume

The plume is close enough to the Cheryl, Terry, Myron Road area and residents of that area have expressed concern about the possibility of future impact. Although the no action alternative would not provide positive steps for either monitoring or mitigating the possibility of future contamination, the no action alternative will be discussed in the detailed evaluation of alternatives.

4.3.2.2 Monitoring

General Description

The monitoring alternative would involve periodic sampling and analysis of residential wells in the plume contaminated area.

Application to the Bluebird Road Area

Groundwater analyses have shown that some residential wells in the plume impacted area on Bluebird Road contain contamination levels that exceed groundwater quality standards established for class GA waters designated for use as a potable water supply. For this reason, the monitoring alternative for residential wells in this area was eliminated from further consideration as a potential remedial action.

Application to Areas Adjacent to Plume

The possibility that residential wells in the Cheryl, Terry, Myron Road area could become impacted by the plume in the future has been taken into account. As part of this alternative, groundwater monitoring wells upgradient of this area would be periodically sampled and analyzed in order to evaluate whether groundwater standards in the area are maintained. If groundwater standards in the area are contravened, then some other action would be required. This alternative will be considered in the detailed evaluation of alternatives.

4.3.2.3 Groundwater Pumping and Recharge

General Description

Groundwater pumping involves the active withdrawal of groundwater to control plume migration. Plume management by groundwater pumping is applicable to prevent the eventual contamination of wells and streams or to hasten aquifer rehabilitation by recovering and treating contaminated water.

Application to the Bluebird Road Area

Groundwater analyses have shown that some residential wells in the plume impacted area on Bluebird Road contain contamination levels that exceed groundwater quality standards established for Class GA waters designated for use as a potable water supply. Implementation of this alternative would require many years of treatment before the groundwater in this area can be used as an untreated drinking water source. For this reason, the groundwater pumping and recharge option was eliminated from further consideration as a potential remedial action in the Bluebird Road impacted area.

Application to Areas Adjacent to Plume

The possibility that residential wells in the Cheryl, Terry, Myron Road area could become impacted by the plume in the future has been taken into account. Groundwater pumping in this area may be applicable to meet two objectives: alter groundwater flow paths to eliminate the threat of contaminant migration from the Moreau site into the Cheryl, Terry, Myron Road area and to rehabilitate the contaminated portion of the aquifer in the vicinity of the Cheryl, Terry, Myron Road area. Based on this initial screening, a more detailed analysis of the groundwater pumping and recharge alternative adjacent to the Cheryl, Terry, Myron Road area will be considered further.

4.3.2.4 Individual Whole House Treatment

General Description

As discussed in the 1982 interim report on point-of-use activated carbon treatment systems issued by the NYS Department of Health(2), these systems are being used to remove the by-products of chlorination on public water systems as well as on private water supplies. According to the NYS DOH report, in 1982 over 1,500 activated carbon point-of-use treatment systems had been installed in New York State on private wells to remove toxic organic compounds including trichloroethylene.

In-line whole house units are placed on the water line coming into the house so that all water is treated.

Application to the Moreau Site

Activated carbon adsorption is a well developed technology which has a wide range of potential waste treatment applications. It is especially well suited for the removal of mixed organic contaminants from aqueous wastes and no serious environmental impacts are associated with carbon adsorption systems. Based on the above, the use of activated carbon whole house treatment units will be considered in the detailed evaluation of alternatives.

4.3.2.5 Alternate Water Supply (Pipeline)

General Description

An alternate water supply to residents whose wells do not meet prevailing water quality standards may be accomplished by extending a pipeline from a nearby municipal water system. The residential wells not in compliance with groundwater standards are thereby replaced by a municipal water source.

Application to the Moreau Site

Providing an alternate water supply passed the initial screening and will be considered in the detailed evaluation of alternatives for several reasons. This alternative effectively mitigates the contamination problem in affected residential wells, and is technically feasible. Existing municipal water distribution systems could be easily extended to supply water to the affected area.

4.3.2.6 New Domestic Wells

General Description

The installation of new domestic wells is an option that has occasionally been used to provide an alternate drinking-water supply to affected residences. Wells are typically completed at new locations, at different depths within the contaminated aquifer, or in a different aquifer located above or below the affected one. Replacement well design, materials, and installation methods are usually very similar to those used in drilling the original wells. However, special attention is given to positioning the screen at the proper interval within the aquifer.

Application to the Moreau Site

This option is eliminated from further consideration at the Moreau site due to the following:

- The contaminants are distributed throughout the entire thickness of the unconfined aquifer. Consequently, changing the well depth at these locations will not provide potable water.

- New wells completed in the bedrock aquifer would yield potable water. However, well installation would necessitate penetrating the confining layer that separates the bedrock aquifer from the Moreau sand aquifer. Disturbing the integrity of the confining bed could provide a pathway for the movement of contaminants into the bedrock.

Additionally, even in those areas where wells could be successfully installed, implementation of this option would ultimately involve some degree of uncertainty relative to the quality of the water being pumped. Therefore, an integral element of this option would include an on-going program of water-quality monitoring.

4.3.2.7 Cisterns

General Description

Cisterns have long been used in rural areas to supplement inadequate supplies of well water. Under this alternative rain water from the roof is collected in gutters and conducted to a tank in the basement or underground. Cisterns can be equipped with filters to remove dust, dirt, and other particulate matter washed off the roof. The cistern needs a tight, rodent-proof cover and should be frequently disinfected.

Application to the Moreau Site

The use of cisterns is eliminated from further consideration as a potential remedial action at the Moreau site for a number of reasons. The amount of water collected in the cisterns is not of sufficient quantity to supply the average home. The systems would be difficult to keep sanitary and as a whole are not a viable solution to the residential water-supply question.

4.3.2.8 Bottled Water

General Description

The use of bottled water has long been recognized as a short-term solution to water supply problems. In this method, commercially available bottled water is delivered for home use on a regular basis. The water is used for cooking, cleaning, bathing, and human consumption.

Application to the Moreau Site

The use of bottled water as the primary water supply is eliminated from consideration as a potential remedial action at the Moreau site. Based on a water usage of 150 gallons per day, the average residence would require 210 five-gallon containers of water a week. Additionally, the use of bottled water would require a system for pumping it through the house distribution system.

4.3.3 Aquifer Restoration

4.3.3.1 No Action

General Description

The no action alternative, with respect to aquifer restoration, is basically a dilution/attenuation alternative. The alternative relies upon the aquifer's natural capacity to dilute or remove the contaminants, and upon the tendency of site geohydrology to constrain the plume in a defined position.

Application to the Moreau Site

Data collected and evaluated during the remedial investigation indicate that the concentration of contaminants in groundwater undergoes some natural reduction between the Moreau site and discharge points near Reardon Brook. The downgradient limit of the plume is controlled by groundwater discharge at the foot of the escarpment which serves as an aquifer boundary. In the absence of source control, contamination migration would continue from the former disposal area and natural flushing of the aquifer would not be effective. For this reason, the no action alternative was eliminated from further consideration.

4.3.3.2 Containment Barriers

General Description

Containment barriers represent a technology for encapsulating an area to restrict the movement of contaminated groundwater. Barriers are typically installed with a circumferential placement or downgradient of the suspected contaminant source.

They may be constructed using a variety of materials and methods. Some materials used in the past include:

- soil-bentonite slurry walls
- cement-bentonite slurry walls
- vibrated beams, curtains or thin walls
- compacted clay
- grout curtains
- steel, wood, or concrete sheet piling
- synthetic membranes

In this method, a low permeability material is installed and keyed into an underlying confining strata. The purpose of the containment barrier is to divert groundwater flow and restrict contaminant migration in the subsurface.

The most common type of containment barrier is the slurry wall. Under this alternative, slurry trench containment barriers are constructed and extended into the underlying confining clay layer. A bentonite water mixture is introduced into the trench during excavation providing side wall support. After the trench has been excavated to its required depth, a soil-bentonite or cement-bentonite mixture is placed into the trench displacing the bentonite water slurry. The resulting low permeability mixture acts as a barrier to groundwater movement.

<u>Application at the Moreau Site</u>

Except for source containment purposes at the area of the original disposal site, containment barriers are eliminated from further consideration as potential remedial actions downgradient of the Moreau site. Off-site containment barriers are not feasible to remediate contaminated groundwater for several reasons.

Future migration of the plume is presently controlled by the hydrogeologic conditions which result in plume discharge to Reardon Brook at the base of the escarpment . The escarpment therefore represents the effective limit of both the aquifer and subsurface contaminants. The existing cutoff wall around the former disposal area has eliminated discharge to the aquifer; therefore, it is anticipated that the size of the plume will diminish naturally. While an off-site containment barrier could prevent the discharge of contaminated groundwater to the Reardon Brook area, it would also prevent or impede the natural flushing action of the aquifer. Aquifer remediation is more appropriately addressed by other alternatives, and the discharge to Reardon Brook can be remediated by more effective means.

Additionally the cost of installation of a barrier wall would be high due to the anticipated average depth (70 feet) and the great length required to be effective. The length of a barrier wall necessary to completely encircle the plume of contamination would be in excess of two miles.

For the above reasons, off-site containment barriers are eliminated from further consideration as practical, cost effective remedial actions.

4.3.3.3 Source Containment, Groundwater Monitoring and Air Stripping Groundwater Discharge

General Description

This alternative combines the technologies of containment barriers, groundwater monitoring and air stripping of groundwater discharges as an aquifer restoration alternative at the Moreau site. Source containment barriers represent a technology for encapsulating an area to restrict the movement of contaminated groundwater. They may be constructed using a variety of materials, the most common type is the slurry wall.

Groundwater monitoring involves periodic groundwater sampling and analysis of selected monitoring wells. The results of these analyses would be used to regularly assess the degree of aquifer restoration.

Treatment of groundwater discharges in the area south of the topographic escarpment would be accomplished by air stripping. Air stripping is a mass transfer process in which a substance in solution in water is transferred to solution in a gas. There are several basic equipment configurations used for air stripping. The countercurrent packed column is considered to be the most appropriate configuration for treating contaminated groundwater(3).

Application to the Moreau Site

As discussed previously in Sections 3.3.3 and 4.3.3.2, a soil-bentonite slurry wall with a circumference of approximately 1600 feet and a minimum thickness of 30 inches has been constructed around the former disposal area. The slurry wall prevents further release of contaminants from the site and is an effective source control measure. With the contaminant source cut off, natural flushing of the aquifer will occur. Groundwater monitoring will be used to chart the progress of groundwater cleanup.

Air stripping can provide a cost effective means of treating the relatively low levels of trichlorethylene found in groundwater discharges from the aquifer. For the reasons outlined above, this remedial alternative passes the initial screening and will be considered in the detailed evaluation of alternatives.

4.3.3.4 Source Containment, Groundwater Pumping and Recharge

General Description

Groundwater pumping involves the withdrawal of groundwater to clean up a plume or to control plume migration. Plume management by groundwater pumping is applicable to prevent the eventual contamination of wells and streams or to hasten aquifer rehabilitation by recovering and treating contaminated water.

Recovery well systems utilized in this alternative directly control the movement of groundwater, and thereby, control the movement of contaminants within the radius of influence of a recovery well or a series of wells. The design and operation of the recovery system is influenced by the following constraints:

- the total discharge of the recovery system must be large enough to produce flow lines which create a capture zone equal to, or greater than, the widest part of the plume;

- the maximum drawdown produced in the recovery wells cannot exceed the aquifer thickness; and,

- if complete capture is required, the recovery system must be located near enough to the downgradient boundary of the plume to reverse the hydraulic gradient at the boundary.

In all cases where water-bearing sands occur at a depth greater than 10 feet below land surface, or the anticipated drawdown is greater than 10 to 15 feet below land surface, submersible or jet pumps should be used. Well points are limited to applications involving only shallow aquifers.

Groundwater pumping may be conducted in one of two alternative operations:

- recovery of contaminated groundwater followed by treatment and discharge to the surface; and,
- recovery of contaminated groundwater followed by treatment and return to the aquifer through recharge wells or seepage basins.

In order to eliminate replenishment of contaminants from the source to the aquifer, the soil-bentonite cutoff wall discussed in Section 3.3.3 is utilized.

Application to the Moreau Site

The areal extent of contamination, as represented by TCE concentrations greater than 100 ppb, occurs as a plume approximately 4800 feet long and up to 2,000 feet at its widest point. The plume originates at the Moreau disposal site and extends southward to the escarpment which is the downgradient boundary for the unconfined aquifer. The downgradient limit of the plume is controlled by groundwater discharge to springs and streams having their headwaters at the foot of the escarpment.

An analytical model of the aquifer suggests that a recovery system pumping at a rate of about 400 to 500 gpm could alter groundwater flowpaths and successfully capture contaminated groundwater for discharge and/or treatment.

The first pumping alternative involves recovery, treatment and discharge to the surface. Generally, however, recovery without recharge is acceptable only when small volumes of water are involved and when no water supplies are dependent on the aquifer. Therefore, this alternative is not considered feasible because of the volume of water ultimately discharged and possible adverse change in the distribution of water flowing to the Village of Fort Edward reservoirs.

The second alternative, involving recovery, treatment, and recharge may be feasible. Appropriate technology exists to treat the recovered water and to return it to the aquifer through seepage basins or recharge wells. Seepage basins require a high degree of maintenance to prevent a reduction in their porosity, and hence, in their capability to allow recharge. Consequently, the basins are not always practical in cases where several basins are required to adequately handle the discharge or where adequate maintenance cannot be assured. Therefore, the use of recharge wells may be preferred over the use of seepage basins. Based on this initial screening, a more detailed analysis of the groundwater pumping alternative utilizing source containment, recovery wells, treatment, and recharge wells will be considered in the detailed evaluation of alternatives.

4.3.3.5 Permeable Treatment Beds

General Description

Permeable treatment beds represent a technology for the in-situ treatment of contaminated groundwater. Installation of the beds is accomplished by excavating a trench to intercept the flow of contaminated groundwater, filling the trench with appropriate materials, and capping the trench. Relatively few materials can be employed in permeable beds to control contaminated groundwater. These materials include:

Limestone or crushed shells
Activated carbon
Glauconitic greensands or zeolites
Synthetic ion exchange resins

The trench should be long enough to intercept the plume of contaminated groundwater and deep enough to stop the groundwater from flowing underneath. Typically, the depth of the bed is the distance from the ground surface to an underlying low permeability confining bed.

Application to the Moreau Site

The use of permeable treatment beds is eliminated from further consideration as a potential remedial action downgradient of the Moreau site for a number of reasons. The underlying confining layer at the site is at a depth (100 feet) which may be prohibitive for installation. The cost of activated carbon, the only material commonly used for organic contamination, is very high. Plugging of the bed may occur and removal of spent activated carbon is difficult and possibly hazardous. In general, the use of activated carbon permeable treatment beds would not be cost effective and would be difficult to implement at the Moreau site.

4.3.4 Soil Remediation

4.3.4.1 No Action

General Description

Under this alternative, no effort will be made to mitigate the exposure to PCB contaminated soils at the Moreau site.

Application to the Moreau Site

The no action alternative would not alleviate the possibility of public exposure. Accordingly, the no action alternative is eliminated from further consideration.

4.3.4.2 Excavation and Removal

General Description

This alternative involves the excavation and removal of PCB contaminated soils.

Application to the Moreau Site

Excavation of PCB contaminated soils, followed by removal to a less environmentally sensitive area or engineered disposal facility is an appropriate alternative. The only local disposal option is the Moreau site containment. The excavated material, approximately 8600 cubic yards, could be placed within the source containment cutoff wall and the cap replaced over the contaminated soil.

Off-site disposal in a secure land burial facility is another option. The material could be excavated and trucked (bulk) to facilities in western New York.

The on-site disposal option in the source containment area has several positive aspects. The material would not need to be hauled by trucks over 300 miles of highway, and the secured containment system (slurry wall) has already been established.

The technology exists and is well defined for both disposal options. Both options are feasible and applicable, and will be considered in the detailed evaluation of alternatives.

4.3.4.3 Sealing

General Description

Surface sealing, or capping, is the process by which contaminated sites are covered to prevent surface water infiltration, control erosion, and isolate and contain contaminated wastes. A variety of impermeable cover materials and sealing techniques are available for such purposes.

Natural soils used as cover material must be relatively impermeable and erosion resistant. Fine-grained soils such as clays and silty clays have low hydraulic conductivity values and are, therefore, best suited for capping purposes because they resist infiltration of water. Concrete or mortar can be mixed with water and spread over well-compacted bases to cover and seal some disposal sites. Paving asphalt with a sealer coat is often used to prevent volatilization and resist contact with underlying sediments. Synthetic membranes such as PVC and HDPE are often used as a capping media.

Application to the Moreau Site

The use of surface sealing or capping is a viable alternative for reducing the possibility of contact with PCB contaminated soils. Based on the anticipated effectiveness and cost considerations, the use of natural soils, asphalt sealers and synthetic membranes will be considered in the detailed evaluation of alternatives.

4.3.4.4 Treatment

Incineration

Incineration is the preferred treatment method for materials containing more than 500 ppm PCBs. Average concentrations of PCB contaminated soil at the site fall far short of this figure. Given the relatively low average PCB concentrations and the high cost of this potential alternative, incineration either on-site or off-site would not be a cost effective alternative and was eliminated from further consideration.

There are few methods other than incineration that are available on a commercial basis for the destruction of PCBs. At this time none of the alternative methods proposed meet the destruction efficiency requirements of the PCB regulations. Extensive laboratory bench and pilot scale experimentation would be required to apply an alternate treatment method for the disposal of PCBs. Alternate treatment methods of wet air oxidation, biological degradation and chemical treatment, are discussed below.

Wet Air Oxidation

Wet air oxidation decomposes materials by applying air or oxygen at elevated temperatures and pressure. IT Enviroscience (ITE) Inc. has developed a catalysed wet air oxidation process for the destruction of PCBs. PCBs are oxidized by air or oxygen in an acidic, aqueous medium at high temperatures. The catalyst reduces the heat and pressure requirements that would normally be necessary. The method can be used for the destruction of PCBs in organic material in a liquid solution, organic liquid residues and different types of sludges and solid residues.

Research on the ITE system is not complete, but laboratory analysis has shown that 90% of PCBs were repeatedly destroyed by oxidation at 523° K for 2 hours. Destruction efficiency of 99+% is possible by leaving unreacted PCBs in the reactor unit until destroyed.

Little information is available on the cost effectiveness of this method. It is expected that due to its developmental nature and the high initial costs, this option is not suitable for application at the Moreau site and is eliminated from further consideration.

Biological Degradation

Biological degradation is based on the ability of microorganisms to degrade organic chemicals. Most commercial applications are to aqueous streams containing relatively small amounts of organic compounds. Two biological processes, activated sludge treatment and the trickling filter method have been proposed as possible procedures for the treatment of PCBs.

Activated sludge treatment is an aerobic process in which a microbial solution is suspended in a liquid medium containing dissolved oxygen. Trickling filters consist of crushed rocks, slag, or stone which provide a surface for microbial growth, and passages for liquid and air.

Laboratory studies indicate that Aroclor mixtures can be degraded but that degradation rates are inversely related to increasing chlorine substitution on the biphenyl molecule(3). It is not believed that either activated sludge treatment or the trickling filter methods are technologically applicable to the degradation of PCBs in soils. Due to the refractory nature of PCBs, only small amounts can be fed into a commercial scale biological system, and even these small amounts would not undergo complete destruction. These limitations make it doubtful that this type of biological process will be capable of destruction efficiencies equivalent to high efficiency boilers or incinerators.

In addition, biological degradation requires transport to a commercial facility or costly development of on-site treatment. These are not considered cost-effective for a project of this scope and are eliminated from further consideration.

Chemical Treatment

Several chemical treatment techniques for the removal of PCBs from contaminated soils are available. Such treatment methods include:

- Extraction by the controlled washing of contaminants with a suitable aqueous or non-aqueous, non-polluting solvent. The concentrate collected from this "solution mining" is treated in an appropriate manner.
- Soil additives to :
  1. increase adsorption sites and induce greater biodegradation,
  2. catalyze the promotion of free-radical oxidation, or reduction and dehalogenation,

3. add proton donors to enhance photodecomposition.

- Adding a chemical analog of a hazardous compound to induce microbial co-metabolism of the contaminant.

Prior to implementation of any of the above treatments, bench-scale and pilot-scale studies to evaluate the technical and practical feasibility would be necessary. The delay in determining the assimilative capacity of the soil in the application of this technology and the high cost of laboratory studies, do not provide a time or cost-effective remedial alternative for treating contaminated soil at the site.

4.4 Summary of Inital Screening Results

Using the screening process previously discussed in Section 4.1, the remedial alternatives that were initially developed were screened to eliminate infeasible or non cost-effective alternatives.

The following list presents the alternatives which passed the initial screening phase. These alternatives are categorized into groups according to which site problems the remedy addresses (i.e., aquifer remediation, residential water supply).

Surface Water

- Treatment
    - Carbon Adsorption
    - Air Stripping

Residential Water Supply

- No Action
- Monitoring
- Groundwater Pumping and Recharge
- Individual Whole-House Treatment
- Alternate Water Supply (pipeline from existing system)

Aquifer Restoration

- Source Containment, Groundwater Monitoring and Air Stripping Groundwater Discharge
- Source Containment, Groundwater Pumping and Recharge

Soil Remediation

- Excavation and Removal
- Sealing

5.0 DETAILED EVALUATION OF ALTERNATIVES

5.1 Methodology for Evaluation of Alternatives

After completion of the initial screening, a detailed evaluation of alternatives passing the initial screening was conducted. Each of the alternatives identified in Section 4.4 was evaluated in compliance with Section 300.68(i) of the National Oil and Hazardous Substances Contingency Plan (NCP). As outlined in the NCP, the detailed evaluation consisted of the following:

- Refinement and specification of alternatives in detail, with emphasis on the use of established technology...
- Evaluation in terms of engineering implementation, or constructability...
- An assessment in terms of public health protection...
- An analysis of methods for mitigating (adverse environmental) impacts...
- Detailed cost estimation, including distribution of costs over time

5.2 Criteria for Evaluation of Alternatives

In compliance with Section 300.68 (i) each alternative passing the initial screening was evaluated in detail. In order to assure compliance, each alternative was evaluated for the following:

- Technical feasibility
- Public health effects
- Institutional requirements
- Environmental effects
- Cost

The technical feasibility of a remedial action was evaluated for performance, reliability, implementability, safety and level of technological development. Two aspects of performance determine desirability on the basis of performance: effectiveness and useful life. Effectiveness refers to the degree to which the action will prevent or minimize substantial danger to public health, welfare, or the environment. The useful life is the length of time this level of effectiveness can be maintained. The cost of installing and operating remedial alternatives, and the importance of protecting public health and the environment make reliability an important concern. The frequency and complexity of operation and maintenance are considered in evaluating the reliability of alternatives. Technologies requiring frequent or complex operation and maintenance activities are regarded as less reliable than technologies requiring little or straightforward operation and maintenance.

An important aspect of remedial alternatives is implementability, or the relative ease of installation and the time required to achieve a given level of response. The time requirements are generally classified according to the time required to implement a technology and the elapsed time before results are actually realized.

Each remedial alternative was also evaluated with regard to safety. This evaluation considered threats to the safety of nearby communities and environments as well as those to workers during implementation. The major risk considered was exposure to hazardous substances.

Technologies involved in a remedial alternative are either proven and widely used, or experimental when applied to hazardous waste sites. Generally, a proven and widely used technology was rated high for technological development, and experimental technologies lower.

In addition to being technologically feasible and reliable, a remedial action must adequately protect public health. Remedial actions were evaluated with respect to the degree to which they mitigate health and environmental impacts, and in terms of how well they attain relevant public health and environmental standards. For each remedial alternative evaluated, any negative environmental effects resulting from the implementation of that alternative were identified. Alternatives requiring Federal, State or Local permits are also identified.

As specified in Section 300.68(i)(2)(B) of the NCP, remedial alternative cost estimates, including distribution of costs over time were developed. In developing detailed cost estimates, the following steps were performed:

1. Estimated capital and operation and maintenance costs for remedial action alternatives.

2. Present worth analysis was calculated assuming 10 percent interest and 5 percent inflation. This analysis allows evaluation of expenditures that occur over a length of time by discounting all future costs to the present. This allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money, that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over a thirty year life.

5.3 Evaluation of Alternatives

5.3.1 Surface Water

From the initial screening of alternatives, activated carbon adsorption and air stripping are the two remedial actions retained for further consideration for the treatment of Reardon Brook. Both of these technologies could provide corrective action that: 1) would not cause any adverse environmental impact, 2) would mitigate or minimize any threat of harm to public health, welfare or the environment.

5.3.1.1 Carbon Adsorption

The carbon adsorption process employs direct contact of a waste stream with carbon. The carbon selectively adsorbs materials by physical and chemical forces. When the carbon reaches its ultimate capacity for adsorption, it is replaced and the spent carbon is removed for disposal or regeneration.

Technical Feasibility

In a 1981 New York State Department of Health report entitled Organic Chemicals and Drinking Water (4), carbon adsorption and aeration stripping were the only two technologies considered and evaluated for the treatment of organic chemical contamination in public drinking water. Carbon adsorption is technically feasible for the treatment of volatile organics in water in general, as well as for the specific requirements of the Reardon Brook remediation. Carbon adsorption is an available technology with standard implementation requirements.

The suitability of any treatment of contaminated water depends upon the influent characteristics, the extent of pre-treatment and the required effluent quality. Critical design criteria for carbon adsorption are organic load, hydraulic load, contacting method, contact time and regeneration/disposal requirements.

Isotherm data indicate that the carbon adsorption capacity for trichloroethylene and trans-1,2-dichloroethylene is 28 mg/gm and 3.1 mg/gm, respectively(1). Assuming a stream flow of 400 gpm and a concentration of 100 ug/L trichloroethylene and 3 ug/L trans-1,2-dichloroethylene, the rate of carbon usage is calculated to be approximately 22 pounds per day.

Standard carbon units are available (e.g. Calgon) in a size sufficient to hold 20,000 pounds of carbon. Based on a hydraulic loading of 5 gpm per ft.^{2}, the unit would be adequate for a flow rate of 400 gpm, with a life span of 2.5 years if only trichloroethylene and trans-1,2-dicloroethylene were to be removed from the stream.

Public Health Protection

The post-treatment water quality will easily meet or exceed the New York State guidelines for potable water derived from surface water sources as described in the ambient water quality standards of Title 6, NYCRR, Part 701 (NYSDEC).

Institutional Requirements

New York State Department of Environmental Conservation permits would be required for the construction and operation of a carbon adsorption treatment facility.

Environmental Effects

There is no significant risk or detrimental environmental impact associated with carbon adsorption when properly installed and maintained.

Cost Evaluation

Costs have been estimated for a carbon adsorption treatment facility with a capacity of 20,000 pounds of carbon. The costs have been broken down into capital costs and annual operation and maintenance (O & M) costs. The O & M costs are also converted to a 30-year present worth (assuming 10 percent interest and 5 percent inflation). Estimated site costs are presented below.

	Costs (Thousands of Dollars)			
	Capital	Annual O & M	30 year O & M Present Worth	Total
Carbon Adsorption	600	150	2,306	2,906

Evaluation

Carbon adsorption is an available proven technology. However, carbon treatment has several significant disadvantages including:

- A critical design criteria to handle variations in total organic load, contacting method and contact time.

- Competition for adsorption sites on the carbon from natural organics such as algae and aquatic plants, as well as microbial growth, can significantly reduce the useful life of the carbon, possibly requiring pre-treatment.

- Replacement, regeneration and/or disposal of the carbon.

5.3.1.2 Air Stripping

Most volatile compounds dissolved in water can be removed readily from solution by contacting the water with air. The relatively high vapor pressure of these volatile compounds compared to that of water causes an enrichment in air and these compounds can be "stripped" from solution. Both trichloroethylene and trans-1,2-dichloroethylene each have relatively high vapor pressures and therefore can be removed from solution by air stripping. A relatively large air-to-water volume ratio must be used. The conventional method for providing this large volume is by gravity flow through a packed stripping column. Air blown into the base of the column, flows out of the top after contacting the descending liquid. The counterflow operation promotes relatively high efficiencies.

Technical Feasibility

Air stripping is a well proven and readily available technology for the treatment of volatile organics in water. Air stripping is capable of treating the concentrations of trichloroethylene observed in Reardon Brook to output levels not exceeding 1 ug/l. Risks from systems failure are minimized by influent/effluent monitoring, the incorporation of sensor alarm systems to detect any mechanical or electrical breakdown and the provision of secondary, backup treatment units where necessary (including spare parts at the treatment facility).

In order to remove volatile chemicals from Reardon Brook, an air stripping treatment facility is being constructed at a site below the junction of the diverted stream and the former flow path of Reardon Brook. This site is approximately 500 feet from the existing water treatment plant and therefore readily accessible to electrical power and operator attention. A copy of the Basis of Design document for this installation is attached as Appendix A.

Public Health Protection

The post-treatment water quality will easily meet or exceed the New York State guidelines for potable water derived from surface water sources as described in the ambient water quality standards of Title 6, NYCRR, Part 701 (NYSDEC).

Institutional Requirements

A permit to construct this facility for the Village of Fort Edward Water Works has been granted by Region 5 of the New York State Department of Environmental Conservation. This initial remedial measure of early construction of the stripping facility complies with Section 300.68 (e) of the National Contingency Plan whereby remedial activities may be instituted prior to formal completion of an approved feasibility study.

Environmental Effects

There is no significant risk or detrimental environmental impact associated with the air stripping facility being constructed at the Village of Fort Edward Water Works.

Cost Evaluation

The basis of design and construction criteria for the air stripping treatment facility have been described in existing documents prepared by Blasland and Bouck Engineers, P.C., in March 1985. The air stripping tower costing $90,000 is the main unit of the $500,000 treatment facility. Estimated costs as presented below include capital costs and annual operation and maintenance (O & M) costs. The O & M costs are also converted to a 30-year present worth (assuming 10 percent interest and 5 percent inflation.

	Cost (Thousands of Dollars)			
	Capital	Annual O & M	30 Year O & M Present Worth	Total
Air Stripping	500	16	246	746

Evaluation

Air stripping is a proven, technically feasible and available method for the removal of volatile organics from drinking water. The reliability of air stripping systems is greater than for technologies involving selective adsorption using bulky, fixed adsorbents requiring much time consuming maintenance.

Comparison of Alternatives for Surface Water Treatment

Carbon adsorption and air stripping are both technically feasible and available alternatives for treatment of Reardon Brook water. However, carbon adsorption has several significant disadvantages as presented in Section 5.3.1.1. The total cost of carbon adsorption, $2,906,000, is also much greater than the cost of air stripping, $746,000 for the same degree of effectiveness.

5.3.2 Residential Water Supply

From the initial screening of alternatives, five drinking water options were retained for further consideration. These options are:

- No Action (areas of potential future impact only)
- Monitoring (areas of potential future impact only)
- Groundwater Pumping and Recharge (areas of potential future impact only)
- Individual Whole House Treatment
- Alternate Water Supply (pipeline from existing system)

The evaluation of alternatives to provide clean potable water to residents near the Moreau site, focuses on the area currently impacted by the plume and other adjacent areas.

5.3.2.1 Plume Impacted Area

5.3.2.1.1 Individual Whole House Treatment

This alternative involves installing in-line whole house treatment units on residential wells where drinking water contamination attributed to the Moreau site is detected. The units consist of two activated carbon filtration canisters deployed in series followed by an ultraviolet unit. Also included under this alternative would be a quality assurance program where four samples, three for organics detection and one for bacteria, would be obtained monthly and analyzed from each residence where the filters are installed. In the scoping of this alternative it is also assumed that filters for each affected residence would be changed at least annually and that residents adjacent to plume impacted homes will be monitored periodically.

Technical Feasibility

In terms of performance, reliability, implementability, safety and level of technological development, the whole house treatment alternative is feasible. Data collected on the six treatment units currently in use at the site indicate that no breakthrough of the dual carbon filters has occurred.

The whole house treatment units are relatively easy to install and achieve a high level of decontamination very quickly. The level of technological development and safety during implementation is very high.

Public Health Effects

The whole house treatment alternative would effectively mitigate risks to public health. Although the whole house treatment units effectively remove all the contaminants from the groundwater, this action only partially isolates the residents from the contaminated groundwater.

Institutional Requirements

No institutional requirements have been identified for the whole house treatment alternative.

Environmental Effects

No adverse environmental effects can be attributed to the whole house treatment alternative. Proper regeneration and or disposal of spent carbon from the whole house treatment units should avoid any adverse environmental impact. This alternative would not cause negative impacts on the hydrology, geology, air quality, or biology at the area.

Cost Evaluation

The costs presented below are broken down into capital costs and annual operation and maintenance (O & M) cost. The O & M costs are converted to a 30 year present worth (assuming 10 percent interest and 5 percent inflation). For the purposes of this cost estimation, eight whole house treatment units are considered, but costs for more units would be directly proportional.

	Costs (Thousands of Dollars)			
	Capital	Annual O & M	30 year O & M Present Worth	Total
Whole House Treatment	24	32	492	516

If at some point in the future, new homes are constructed in currently unoccupied lands overlying the plume, or residential wells adjacent to the plume become contaminated, these residences would likely each require an individual whole house treatment unit. Depending on how many additional units would need to be installed, the total cost over a 30 year period could be significantly higher than the cost calculated above.

Evaluation

Although whole house treatment units are technically feasible, they do not completely isolate the residents from the contaminated ground water. The possibility of breakthrough will be minimized by the monthly sampling protocol.

5.3.2.1.2 Alternate Water Supply

This alternative involves installation of a potable water pipeline to residents in the plume impacted area on Bluebird Road. The pipeline option would not require any ongoing residential well monitoring and would effectively isolate the residents from the contaminated groundwater. Under this alternative, a pipeline from an existing nearby water distribution system (Town of Moreau or Village of South Glens Falls) would be extended to include areas affected by plume constituents. Transmission lines can be sized so as to be compatible with future expansion in the plume impacted area. Under this alternative, potable water could be supplied to currently undeveloped lands which overlie the plume. Should these currently undeveloped parcels require water in the future, distribution line(s), servicing currently undeveloped lands could be connected to the Bluebird Road transmission line. In the scoping of this alternative, it was assumed that water usage fees and/or ad valorem taxes collected by the municipality would be used to cover the operation and maintenance costs for the pipeline.

Technical Feasibility

In terms of performance, reliability, implementability, safety, and level of technological development, the alternate water supply (pipeline) alternative is feasible. The level of technological development and safety during implementation is very high. Assuming an alternate water supply which is free of contaminants, performance and reliability characteristics of the pipeline would be very good.

Public Health Effects

The pipeline alternative would effectively isolate the residents from contaminated groundwater, thereby effectively mitigating any risks to public health.

Institutional Requirements

Permits to install the alternate water supply pipeline may be required, however, these permits should not be difficult to secure. At a minimum, a street opening permit from the Town of Moreau will be necessary. New York State Department of Health approval will also be required.

Environmental Effects

No adverse environmental effects can be attributed to the alternate water supply (pipeline) alternative. The pipeline would not create a negative impact on the hydrology, geology, air quality or biology of the area.

Cost Evaluation

The costs presented below are broken down into capital costs and annual operation and maintenance (O & M) costs. The O & M costs are converted to a 30 year present worth (assuming 10 percent interest and 5 percent inflation).

	Cost (Thousands of Dollars)			
	Capital	Annual O & M	30 Yr. O & M Present Worth	Total
Water Pipeline	463-692*	0	0	463-692

- The pipeline alternative capital cost varies according to pipeline sizing and degree of compatibility with the Town of Moreau Water Service Comprehensive Plan. Calculated costs do not reflect future connection charges.

Evaluation

An alternate water supply pipeline is a proven, frequently used and technically feasible method of mitigating the drinking water problem in the plume impact area. This alternative effectively isolates the affected residents from the contaminated groundwater. Relative to whole house treatment units, the pipeline would take more time to achieve a given level of response. This effect can be minimized by maintaining the whole house treatment units until the pipeline alternative is implemented.

Comparison of Alternatives for Plume Impacted Residential Wells

In terms of technical feasibility and public health protection, the alternate water supply pipeline alternative is rated higher. The pipeline would isolate residents from the contaminated groundwater and the risk of failure, producing a possible health threat is minimal. The costs for the pipeline is approximately equal to the cost of the whole house treatment units when operation and maintenance costs are projected over a 30 year period.

5.3.2.2 Areas Adjacent to Plume

A potential exists for chemicals to migrate toward residential wells in the Cheryl, Terry, Myron Road area, and other areas adjacent to the contaminant plume. Five potential remedial alternatives are discussed with reference to drinking water in the areas of potential future impact: No-Action, Groundwater Monitoring, Groundwater Pumping and Recharge, Individual Whole House Treatment and Alternate Water Supply (pipeline).

5.3.2.2.1 No-Action

The no-action alternative is essentially a dilution/attenuation alternative. It depends, primarily, on groundwater flow to constrain the plume in its present position. The alternative also depends upon dilution and/or attenuation to prevent low levels of the chemicals from dispersing into new areas creating a possible future impact on drinking water wells.

Technical Feasibility

Not Applicable.

Public Health Effects

The no-action alternative does nothing to mitigate any potential future impact.

Institutional Requirements

Not applicable.

Environmental Effects

Assuming geohydrologic conditions remain relatively unchanged, and the plume is constrained to its present location, no additional adverse environmental effects are anticipated for the no-action alternative.

Cost Evaluation

The no-action alternative has no capital or annual operation and maintenance costs associated with it.

Evaluation

If the geohydrologic conditions at the site remain relatively unchanged and the plume constrained to its present location, no adverse environmental or public health effects are anticipated for this alternative. However, implementation of this alternative would not provide verification that the plume has remained unchanged.

5.3.2.2.2 Groundwater Monitoring

In the scoping of this alternative it was anticipated that wells upgradient of the Cheryl, Terry, Myron Road area of potential impact would be sampled for volatile organics quarterly. The monitoring well network will act as an early warning system. Should unacceptable levels of contaminants be detected in these monitoring wells, some additional action would be required. For the area of potential impact east of the plume, sampling from four existing monitoring wells for volatile organics will be done semi-annually.

Technical Feasibility

The technical feasibility of groundwater monitoring is well established. This option is well suited for the Moreau site considering the geohydrologic conditions.

Public Health Effects

The monitoring alternative would effectively monitor groundwater quality upgradient of the Cheryl, Terry, Myron Road area and be an effective early warning system, should a problem begin to develop. If unacceptable levels of contaminants are detected in the monitoring wells some other action would be required.

Institutional Requirements

Easements would be required to assure access to the monitoring wells.

Environmental Effects

No adverse environmental impacts can be attributed to the groundwater monitoring alternative. Implementation of this alternative would not have negative impact on the hydrology, geology, air quality, or biology of the area.

Cost Evaluation

The costs presented below are broken down into capital costs and annual operation and maintenance (O & M) cost. The O & M costs are converted to a 30 year present worth (assuming 10 percent interest and 5 percent inflation). For the purposes of this cost estimation, the following is anticipated:

Operation and maintenance - quarterly sampling and analysis of eighteen monitoring wells

	Cost (Thousands of Dollars)			
	Capital	Annual O & M	30 Yr. O & M Present Worth	Total
Monitoring	0	22	338	338

Evaluation

Implementation of the groundwater monitoring alternative would create an effective early warning system. However, this alternative would not provide any control on groundwater movement but rather provides the capability to detect undesirable changes in time to react to them.

5.3.2.2.3 Groundwater Pumping and Recharge

The groundwater pumping and recharge alternative would be implemented to provide a hydraulic barrier between the Moreau site and the area of potential future impact. The purpose of the system would be to intercept groundwater flowing toward the area of potential future impact, provide treatment, and return the treated water to the aquifer. Therefore, the recovery system would primarily serve a plume management function and would hasten aquifer restoration only secondarily.

The system, as conceptualized from numerical computer model simulation, would have a lower pumping and treatment capacity than a system intended to capture and remove the plume downgradient of the Moreau site. The proposed scenario would include four pumping wells located approximately midway between the Moreau site and the Cheryl, Terry, Myron Road area. The wells would be configured in a north-south line and spaced about 200 feet apart. Each well would pump 50 gpm for a combined pumping rate of 200 gpm. The system would also include a total of eight recharge wells for returning water from the treatment plant to the aquifer. Recharge wells would be located southeast of the pumping wells.

Technology for treating the recovered groundwater would be an air stripping tower capable of providing greater than 98 percent organic removal. The treatment system would be similar to the tower intended for Reardon Brook.

The final element in implementing this technology would be periodic monitoring of selected observation wells.

Technical Feasibility

The groundwater pumping and recharge alternative utilizes well established, commonly used technology. In terms of performance, reliability, safety and implementability, the groundwater pumping and recharge alternative is feasible. This option is suited for this site considering the geohydrologic conditions and existing groundwater monitoring system.

Public Health Effects

Implementation of the groundwater pumping and recharge option would provide a hydraulic barrier between the Moreau site and the area of potential future impact. This hydraulic barrier should effectively reduce the potential for contamination of wells in the Cheryl, Terry, Myron Road area.

Institutional Requirements

With respect to the groundwater pumping and recharge option, land would need to be purchased or right-of-ways obtained to provide site access. Permitting considerations may include obtaining local building permits and complying with the requirements of Underground Injection Control and Clean Air Act permits, as well as permits to construct and operate a treatment plant.

Environmental Effects

The groundwater pumping and recovery system would mitigate potential degradation of residential well water quality by providing a hydraulic barrier to the migration of organic chemicals. Secondly, it would hasten aquifer restoration to some extent. Disadvantages associated with the pumping and recharge system could include the following:

- Significant drawdown in the water-table which may impact wells in the area;
- Formation of groundwater sinks and mounds which might adversely alter the direction of groundwater flow in adjacent areas;
- Drawing plume constituents closer to the area of potential future impact in an attempt to intercept them; and
- Introducing contamination to the area of potential future impact from undiscovered and unrelated sources.

Cost Evaluation

The estimated costs shown below are separated into capital costs and annual operation and maintenance (O & M) costs. O & M costs are also presented as a 30-year present worth calculated by assuming 10 percent interest and 5 percent inflation. The pumping and recharge capital cost includes materials and labor to install the pumping and recharge wells, transmission lines, and the air stripper for treating the recovered water. It does not include the price of any land which might be purchased. O&M includes electrical cost, re-development costs, replacement parts, and miscellaneous maintenance. It also includes quarterly sampling of selected monitoring wells.

	Cost (Thousands of Dollars)			
	Capital	Annual O & M	30 Yr. O & M Present Worth	Total
Pumping and Recharge	1,100	74	1,144	2,244

Evaluation

The groundwater pumping and recharge alternative is a widely used, well developed and proven technology. This option would provide a hydrologic barrier but has several possible adverse impacts. The estimated cost for implementation over a 30 year period is in excess of $2,200,000, making this alternative one of the least cost effective.

5.3.2.2.4 Individual Whole House Treatment

This alternative involves installing in-line whole house treatment units on residential wells in the potential future impact area where drinking water contamination attributed to the Moreau site is detected.

The units used would be the same as described in Section 5.3.2.1.1 and subjected to the same quality assurance program discussed in that Section.

Technical Feasibility

In terms of performance, reliability, implementability, safety, and level of technological development, the whole house treatment alternative is technically feasible. Data collected on the six treatment units currently in use and the site indicate that no breakthrough of the dual carbon filters has occurred. The whole house treatment units are relatively easy to install and achieve a given level of response very quickly. The level of technological development and safety during implementation is very high.

Public Health Effects

The whole house treatment alternative would effectively mitigate risks to public health. Although the whole house treatment units effectively remove all the contaminants from the groundwater, this action only partially isolates the residents from the contaminated groundwater.

Institutional Requirements

No institutional requirements have been identified for the whole house treatment alternative.

Environmental Effects

No adverse environmental effects can be attributed to the whole house treatment alternative. Proper regeneration and/or disposal of spent carbon from the whole house treatment units should not produce any adverse environmental impact. This alternative would not have any negative impacts on the hydrology, geology, air quality, or biology at the area.

Cost Evaluation

The costs presented below are broken down into capital costs and annual operation and maintenance (O & M) costs. The O & M costs are converted to a 30-year present worth (assuming 10 percent interest and 5 percent inflation). For the purposes of estimating costs, capital and annual O & M expenditures are calculated for 22, 44, 66 and 110 homes requiring treatment, including monthly quality assurance sampling at affected residences.

	Cost (Thousands of Dollars)			
	Capital	Annual O & M	30 Yr. O & M Present Worth	Total
Whole house treatment				
22 residences	63	72	1,107	1,170
44 residences	126	144	2,214	2,340
66 residences	189	216	3,320	3,519
110 residences	315	360	5,534	5,859

Evaluation

Although individual whole house treatment units are technically feasible, if a contamination problem should develop in the area, the treatment units would not completely isolate the residents from the contaminated groundwater. The cost of this option progressively increases with the number of residences affected. Should the potential for contamination in this area be realized, the cost for this alternative could be in excess of 5.5 million dollars and is clearly the least cost effective alternative considered.

5.3.2.2.5 Alternate Water Supply (pipeline)

This alternative involves installation of a potable water pipeline to residents in the area of potential future impact. The pipeline option would not require any ongoing residential well monitoring and would effectively isolate the residents from the contaminated groundwater. Under this alternative, a pipeline from an existing nearby water distribution system (Town of Moreau or Village of South Glens Falls) would be extended to include areas of potential future impact. In the scoping of this alternative, it was assumed that water usage fees and/or ad valorem taxes collected by the municipality would be used to cover the operation and maintenance costs for the pipeline.

Technical Feasibility

In terms of performance, reliability, safety, and level of technological development, the water supply (pipeline) alternative is technically feasible. The level of technological development and safety during implementation is very high. Assuming an alternate water supply which is free of contaminants, performance and reliability characteristics of the pipeline would be very good.

Public Health Effects

The pipeline alternative would effectively isolate the residents from contaminated groundwater thereby effectively mitigating any possible risks to public health.

Institutional Requirements

Permits to install the alternate water supply pipeline may be required, however, these permits should not be difficult to obtain. At a minimum, a street opening permit from the Town of Moreau will be necessary. New York State Department of Health approval will also be required.

Environmental Effects

No adverse environmental effects can be attributed to the water supply (pipeline) alternate. The pipeline would not create any negative impacts on the hydrology, geology, air quality, or biology of the area.

Cost Evaluation

The costs presented below are broken down into capital costs and annual operation and maintenance (O & M) costs. The O & M costs are converted to a 30 year present worth (assuming 10 percent interest and 5 percent inflation). For the purposes of this cost estimation, it was assumed that water usage fees and/or ad valorem taxes collected by the municipality would be used to cover operation and maintenance costs for the pipeline.

	Cost (Thousands of Dollars)			
	Capital	Annual O & M	30 Yr. O & M Present Worth	Total
Pipeline	527-755*	0	0	527-755*

- The pipeline alternative capital costs vary according to pipe sizing and degree of compatibility with the Town of Moreau Water Service Comprehensive Plan. Calculated costs do not reflect future connection charges.

If water supply pipelines to the plume impacted area and the Cheryl, Terry, Myron Road area were to be designed and installed concurrently, a significant cost savings can be realized. Depending on the transmission line sizing and the degree of compatibility of the Town of Moreau Water Service Comprehensive Plan, a water supply pipeline can be installed in both the Bluebird Road and the Cheryl, Terry, Myron Road areas concurrently for 695,000 - 974,000 dollars.

Evaluation

An alternate water supply pipeline is a proven, frequently used and technically feasible method of mitigating the threat to drinking water in the area of potential future impact. This alternative would effectively isolate residents from the potential groundwater contamination problem.

Comparison of Alternatives for Residential Wells in the Areas Adjacent to Plume

A total of five remedial alternatives were evaluated with respect to residential wells in areas adjacent to the plume: No-Action, Groundwater Monitoring, Groundwater Pumping and Recharge, Individual Whole House Treatment Units, and an Alternate Water Supply (pipeline) option. Each of the alternatives represent technically feasible, well established technologies. The No-Action option has the disadvantage in that there is a potential for undetected degradation of the quality of drinking water. However, monitoring the groundwater upgradient of potentially affected areas would clearly detect any such undesirable changes. The groundwater pumping and recharge has several disadvantages, as presented in Section 5.3.2.2.3, which offset its advantages. The most significant disadvantage is the high cost. The individual whole-house treatment alternative is potentially the most costly alternative evaluated. In terms of technical feasibility and public health protection, the water supply pipeline alternative is rated high. The pipeline option provides the greatest degree of isolation from potentially contaminated drinking water.

5.3.3 Aquifer Restoration

Two remedial alternatives have passed the initial screening for aquifer restoration and will be analyzed in detail:

- Source Containment, Groundwater Monitoring and Air Stripping Groundwater Discharge
- Source Containment, Groundwater Pumping and Recharge

A plume of contaminated groundwater is present within the lower two-thirds of the Moreau aquifer with dimensions approximately 4,800 feet long and up to 2,000 feet wide. The plume extends from the original disposal site to an escarpment at the southern boundary of the aquifer. The compounds migrate along groundwater flowpaths primarily by the process of advection. The downgradient limit of the plume is controlled at the escarpment by groundwater discharge through springs and seeps, and as baseflow to Reardon Brook and its tributaries. Aquifer restoration alternatives will be considered with respect to the area affected by this well-defined plume.

5.3.3.1 Source Containment, Groundwater Monitoring, and Air Stripping Groundwater Discharge

Under this alternative, the soil-bentonite cutoff wall constructed around the former disposal area in 1984 is utilized to contain the source of off-site groundwater contamination. The soil-bentonite slurry wall has a hydraulic conductivity of less than 1×10^{-7} cm/sec. The slurry wall has a circumference of approximately 1600 feet and a minimum thickness of 30 inches. The slurry wall totally surrounds the contaminant source and is keyed a minimum of 6 feet into the underlying natural clay confining layer and effectively prevents groundwater flow into or out of the former disposal area. Because the slurry wall prevents further release of contaminants from the site, aquifer restoration will proceed unhindered by recharge of new contaminants to the plume.

Source containment eliminates contaminant input into the aquifer and initiates the process of aquifer restoration via natural flushing. The processes which most strongly influence flushing (i.e., solute transport) are advection, dispersion, sorption, and degradation. The current understanding of these fundamental processes as they occur in the natural environment is not complete.

Trichloroethylene is moderately hydrophobic and hence is retarded only slightly by sorption during subsurface movement. It also is believed to degrade slowly or not at all in the subsurface environment(5). As such, trichloroethylene is transported rapidly through subsurface environments. The time required to naturally flush the TCE plume from the Moreau aquifer system is difficult to estimate --any estimate will contain a range of uncertainty. The duration of natural flushing will likely be on the order of decades . Additionally, the number of pore volume changes necessary to remove the contaminants has been estimated to range from as low as one and one half to as many as fifteen(6,7). For trichloroethylene removal, the number of pore volume exchanges would be at the lower end of this range.

An important component of this alternative is the regular sampling and analysis of groundwater samples. The purpose of this monitoring would be to measure the degree to which flushing of the aquifer has proceeded and to determine if the direction of plume migration changes with time. In the scoping of this alternative it was anticipated that the following 18 wells would be sampled and analyzed for the compounds of interest on a semi-annual basis:

DGC - 2 S, I, D
DGC - 15 S, I, D
DGC - 16 S, D
DGC - 18 S, I, D
DGC - 25 Ia, Ib
TM - 2
TM - 5
TM - C
TM - G
FE - 1

The third element of this remedial alternative is the treatment of groundwater discharge south of the topographic escarpment. Reardon Brook and its tributaries begin as seeps and springs at the base of the escarpment. The results of thirty-four rounds of surface water sampling indicate that relatively low levels of trichloroethylene and trans-1,2- dichloroethylene are present in Reardon Brook.

Air stripping is a mass transfer process in which a substance in solution in water is transferred to air. Most volatile compounds in water can be removed readily from solution by contacting the water with air. In order to remove volatile chemicals from Reardon Brook, an air stripping treatment facility is currently under construction. This air stripping unit will be used for the treatment of groundwater as it is discharged from the aquifer.

Technical Feasibility

The source containment, monitoring and air stripping alternative utilizes well established and commonly used technologies. Since each of three elements of the alternative are either in place or soon will be, the alternative can be implemented rapidly.

Public Health Effects

Implementation of this alternative would enhance restoration of the aquifer.

Institutional Requirements

A permit to construct the air stripping facility has been granted by Region 5 of the New York State Department of Environmental Conservation. This initial remedial measure of early construction of the stripping facility complies with Section 300.68 (e) of the National Contingency Plan whereby remedial activities may be instituted prior to formal approval of a feasibility study.

Prior to installation of the soil-bentonite cutoff wall, easements from three property owners were obtained. New York State Department of Environmental Conservation approval was obtained prior to installation of the slurry wall.

Environmental Effects

Since treatment is provided at groundwater discharge points and it is anticipated that the plume direction will not change, no adverse environmental effects are anticipated with this alternative.

A

Cost Evaluation

The costs are broken down into capital costs and annual operation and maintenance (O & M) costs. The O & M costs are also converted to a 30-year present worth (assuming 10 percent interest and 5 percent inflation). For the purposes of this cost estimation, the following estimates were used:

Capital costs -
- installation of air stripping facility to treat Reardon Brook water
- installation of a 1600 foot slurry wall around the former disposal area, includes engineered clay cap

Operation and maintenance
- semi-annual sampling and analysis of eighteen monitoring wells
- operational and maintenance requirements for the air stripping facility
- maintenance and monitoring of containment area

	Cost (Thousands of Dollars)			
	Capital	Annual O & M	30 yr O & M Present Worth	Total
Source Containment, Monitoring and Air Stripping	2,600	40	615	3,215

Evaluation

This remedial alternative utilizes well established technology and has several advantages which include the following:

- Eliminates further releases into the aquifer
- Capability to measure the degree to which flushing of the aquifer is occuring
- Capability to determine if the direction of plume migration changes with time
- Capability to detect undesirable changes in groundwater quality in time to react to them.
- Provides treatment of contaminated groundwater discharges

5.3.3.2 Source Containment, Groundwater Pumping and Recharge

The groundwater pumping and recharge alternative as conceptualized in the initial screening included a series of pumping wells for recovering contaminated groundwater, a system for treating the recovered water, and a series of recharge wells for returning the treated water to the aquifer. The theory behind the operation of the system is based on constraining the plume within a capture zone that is typically delineated by the radius of influence of the well system. Therefore, the design of an effective recovery system depends on the ability to predict the drawdown and radius of influence produced by the operation of a given system as well as the ability to predict the transport of dissolved chemical species in the groundwater. The theory of superposition and general equations describing well hydraulics that govern drawdown and the radius of influence is well understood and can be found in most standard hydrology texts. The general theory of solute transport can be found in most hydrology texts but the current understanding of the sorption, dispersion, and degradational processes occurring in the natural environment is not complete.

Groundwater flow beneath the study area was simulated to investigate the effectiveness of various well field configurations and locations to expedite aquifer restoration. Specifically, the simulations were used to determine the discharge rate and well spacings associated with different system scenarios. The simulations were conducted using the USGS two-dimensional, finite-difference flow model described in the remedial investigation report. Further calibration was performed to eliminate groundwater mounding predicted in the earlier simulations, before the various scenarios were evaluated.

After five scenarios involving pumping and recharge were simulated, the following conclusions were developed:

- wells oriented parallel to the longitudinal axis of the plume create the greatest impact on the flow regime and collect the chemical constituents most effectively;
- wells spaced less than 200 feet apart cannot be pumped at more than 40 gpm without de-watering the aquifer;
- wells spaced more than 200 feet apart can be pumped at 50 gpm.

Based on these conclusions, the optimum flow scenario tested included nine recovery wells located along the longitudinal axis of the plume and spaced 400 feet apart. The combined pumping rate of the system was 390 gpm with individual well discharge rates ranging between 30 and 50 gpm. The system also included a total of 21 recharge wells to return water from the treatment plant to the aquifer. The recharge wells were located on either side of, and parallel to, the pumping wells and outside the limit of the plume.

The technology chosen for the treatment of Reardon Brook is also appropriate, with some modification, for the treatment of the recovered groundwater. Therefore, in the conceptual design, groundwater would be piped from the recovery wells to an air stripper for treatment.

Under this alternative the soil-bentonite cutoff wall constructed around the former disposal area is utilized to contain the source of off-site groundwater contamination.

An integral part of the option includes periodic monitoring of existing observation wells. Data collected from the wells would be used to measure the effectiveness of the restoration and adjust the operation of the system, if necessary.

Technical Feasibility

The technical feasibility of source containment, groundwater pumping and recharge is well established. This option is suited for this site considering the geohydrological conditions and existing groundwater monitoring system.

Public Health Effects

Implementation of the source containment, groundwater pumping and recharge option would restore the aquifer and aid in plume management.However, pumping the contaminated water above ground for transmission to a treatment plant increases the potential for human contact, especially through leaks and spills, and during maintenance.

Institutional Requirements

With respect to the source containment, groundwater pumping and recharge option, land would need to be purchased or right-of-ways obtained to provide site access. Permitting considerations may include obtaining local building permits and complying with the requirements of Underground Injection Control and Clean Air Act permits, as well as permits to construct and operate a treatment plant. The aestetics of the wells, transmission lines, and treatment structures also may be problematic in terms of public acceptance.

Environmental Effects

The groundwater pumping and recharge system would help mitigate the effects of the plume by removing contaminated groundwater, treating it, and returning the clean water to the aquifer. As mentioned in Section 5.3.3.1, it is difficult to predict with any certainty the time required to restore the Moreau aquifer to its former quality (or an alternate concentration deemed safe). For the pumping and injection system just described, restoration of the Moreau aquifer is likely to be on the order of decades. This is true for both natural flushing and induced flushing.

The processes of advection, dispersion, sorption, and degradation are simply not well defined in natural environments. The benefits to be gained from applying advection - dispersion - retardation models for predicting aquifer restoration are indeed questionable because of the difficulty associated with determining the appropriate dispersion and sorption parameters and the greater difficulty of applying the equations(8).

The feasibility of aquifer restoration is strongly dependent on the magnitude of dispersion and retardation; choosing to neglect these phenomena could lead to serious predictive misjudgements concerning aquifer clean-ups. Choosing a dispersivity (d) or dispersion coefficient (D); or a retardation factor (R), a distribution coefficient (K_d), an octanol: water partition coefficient, or an organic carbon distribution coefficient (Koc) provides no added certainty. Even small retardations can result in the need to remove much greater volumes of water than that already contaminated within the aquifer. In addition, uncertainties in the well spacings and screen settings for maximizing capture of clean aquifer water further complicate predictions concerning the efficiency and operational period of a withdrawal/recharge remedial alternative.

Possible environmental impacts associated with the pumping and recharge system could include the following:

1 - Significant drawdown in the water-table which may impact wells in the area;

2 - Formation of groundwater mounds which might alter the direction of groundwater flow in some areas; and

3 - Possible reduction in the discharge of groundwater to Reardon Brook.

Cost Evaluation

The costs are broken down into capital costs and annual operation and maintenance (O & M) costs. The O & M costs are

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also converted to a 30-year present worth (assuming 10 percent interest and 5 percent inflation). The source containment, pumping and recharge capital cost includes materials and labor to install the pumping and recharge wells, transmission lines, and the treatment facility as well as the cost of the existing containment structure. It does not include the price of any land which might be purchased. O & M includes electrical cost, re-development costs, replacement parts, and miscellaneous maintenance. It also includes semi-annual sampling and analysis of selected monitoring wells.

	Cost (Thousands of Dollars)			
	Capital	Annual O & M	30 Year O & M Present Worth	Total
Source Containment, Pumping and Recharge	4,251	240	3,689	7,940

Evaluation

This alternative will slightly enhance the restoration of the aquifer and constrain the plume to its present position.

Groundwater pumping and recharge has several major disadvantages however. The most significant is the following:

- Very high cost associated with the initial capital investment and the long-term operation and maintenance costs when considered in light of the minimal benefits.

Additional disadvantages include the following:

- A significantly effective system will require nine recovery wells and up to 21 recharge wells. This in itself would produce an unsightly operation in an otherwise rural setting;

- Significant drawdown in the water-table which may impact wells in the area;

- Formation of groundwater mounds which might alter the direction of groundwater flow in some areas;

- Possible reduction in the discharge of groundwater to Reardon Brook;

- A long-term commitment to monitoring and O & M requirements;

- A projected decades long operational period to restore the aquifer; and

- Permit requirements of Underground Injection Control and Clean Air Act, as well as permits to construct and operate a treatment plant.

Comparison of Alternatives for Aquifer Restoration

Both the Source Containment/Monitoring/Air Stripping and Source Containment, Groundwater Pumping and Recharge alternatives are technically feasible. The Source Containment, Groundwater Pumping and Recharge altenative has several disadvantages, as presented in Section 5.3.3.2, which offset its advantages. The most significant disadvantage is the high cost of implementation and operation.

The Source Containment/Monitoring/Air Stripping remedial alternative takes advantage of the natural flushing of the aquifer as a restoration technique. This alternative also has the advantage of containing the source and monitoring the groundwater for any undesireable changes in groundwater quality.

Both of the alternatives provide for treatment of contaminanted groundwater. The total cost of the source containment, groundwater pumping and recharge alternative is estimated to be $7,940,000 versus $3,215,000 for the source containment/monitoring/air stripping alternative.

5.3.4 Soil Remediation

5.3.4.1 Excavation/On-Site Disposal

This alternative involves the excavation of the total volume of PCB contaminated or potentially contaminated surface soil. The volume of material is estimated to be 8,600 cubic yards in four major areas. The contaminated surface soil is at a depth of 6 to 24 inches deep. The soil would be loaded, transported, and placed within the on-site source containment area.

Technical Feasibility

The alternative includes the well established and commonly used techniques of excavation, transportation and placement of materials. The alternative can be implemented rapidly and is reliable. The installation of the cap is presently being performed, and this alternative does not increase those requirements nor the requirements for cap maintenance.

Public Health Protection

This alternative achieves a high degree of public health protection as the soils are effectively isolated from public exposure. Public exposure during excavation, transportation and placement can be well controlled, and is minimized by the proximity of the excavation areas to the source containment area.

Institutional Requirements

The alternative will require federal and state approvals prior to implementation.

Environmental Effects

The most significant environmental effect of this alternative is the unrestricted future land use of the presently contaminated soil areas. The alternative of in place sealing would include future restrictions on the use of these areas.

Cost Evaluation

The costs presented below are broken down into capital costs and annual operation and maintenance (O & M) costs. The O & M costs are converted to a 30 year present worth (assuming 10% interest and 5% inflation). For the purposes of this cost estimation, the excavation/on-site disposal alternative is considered as having no annual operation and maintenance cost.

	Cost in Thousands of Dollars			
	Capital	Annual O & M	30 Year O & M Present Worth	Total
Excavation/ On-site	500	0	0	500

Evaluation

This alternative is a well established and commonly used alternative that can be implemented rapidly. The reliability is high, and the material is isolated from public exposure. Land presently contaminated will be available for future unrestricted land use.

5.3.4.2 Excavation/Off-Site Disposal

This alternative is similar to the alternative presented above, except that the contaminated soil is transported to an off-site commercial, secure land burial facility, in the western New York area.

Technical Feasibility

This alternative involves the well established and commonly used techniques of excavation, transportation and placement of materials. The alternative can be implemented in a timely fashion. The reliability of this alternative is dependent on the operators of the commercial facility.

Public Health Protection

This alternative achieves a high degree of public health protection as the soils are effectively isolated from public exposure.

This alternative has the additional disadvantage of public exposure during the approximately 300 mile trip to the commercial disposal facility.

Institutional Requirements

The alternative will require federal and state approvals prior to implementation.

Environmental Effects

The environmental effects of the excavation/off-site disposal alternative are the same as the excavation/on-site disposal alternative; future land use will be unrestricted.

Cost Evaluation

The costs presented below are broken down into capital costs and annual operation and maintenance (O & M) costs. The O & M costs are converted to a 30-year present worth (assuming 10% interest and 5% inflation).

	Cost (Thousands of Dollars)			
	Capital	Annual O & M	30 Year O & M Present Worth	Total
Excavation/ Off-site	2,500	0	0	2,500

Evaluation

This alternative uses well established and commonly used techniques and can be implemented in a timely fashion. The advantages of this alternative are equivalent to the excavation/ on-site disposal alternative. The excavation/off-site alternative has the disadvantage of potential public exposure during transportation of the soil and the avoidable use of limited disposal capacity at permitted sites. The cost of the excavation/off-site disposal alternative, $2,500,000, is much greater than the cost of the excavation/on-site disposal, $500,000, for otherwise essentially equivalent alternatives.

5.3.4.3 Surface Sealing

Three options of this alternative have been considered. These include surface sealing with natural soils, asphalt sealers, and a combination of soil/synthetic membrane.

Surface sealing or capping is the process by which contaminated soils are covered to prevent the infiltration of surface water and precipitation, control of erosion and transport by wind and water, and prevention of human and animal contact and exposure. Each of these options includes fencing off the sealed areas to restrict access.

Technical Feasibility

The performance of each of the three the sealing options should be comparable assuming proper operations and maintenance is performed. The reliability of the sealing options should be adequate, with routine seasonal operation and maintenance.

The sealing options can be implemented in a timely fashion. The safety during implementation is possibly slightly greater for the sealing option than for the other alternatives, because sealing eliminates problems associated with excavation.

Public Health Effects

The sealing options are comparable to each other. The excavation/removal alternatives are rated higher as they will more effectively isolate the soils from public exposure.

Institutional Requirements

This alternative will require federal and state approvals prior to implementation.

Environmental Effects

The sealing alternative would result in restricted land use if implemented. The excavation/removal alternatives would allow for unrestricted land use, and are therefore rated higher.

Cost Evaluation

The costs presented below are broken down into capital costs and annual operation and maintenance (O & M) cost. The O & M costs are converted to a 30-year present worth (assuming 10% interest and 5% inflation).

	Cost (Thousands of Dollars)			
	Capital	Annual O & M	30 Year O & M Present Worth	Total
Sealing/ Soil	160	8	123	283
Sealing/ Asphalt	286	14	215	501
Sealing/ Synthetic	230	12	185	415

Evaluation

The three surface sealing options are considered to have essentially equal technical merit. However, this alternative has some disadvantage in that the contaminated soil remains in place and future land use is restricted.

Comparison of Alternatives for Soil Remediation

The excavation/removal alternatives have the advantage of more effectively isolating the contaminated soils. An additional advantage of the excavation/removal alternatives over the sealing alternative is that the land is available for future use.

The benefits of the two excavation/removal alternatives are comparable as evaluated in the preceding sections of this report. However, the cost (present worth) of the excavation/off-site disposal alternative, $2,500,000, is much greater than the cost of the on-site disposal alternative, $500,000.

6.0 Summary of Alternatives, Evaluations and Recommendations

From the evaluations presented in section 5.3, an overall remedial action plan for the Moreau site can now be formulated. The various site problems along with the recommended remedial alternatives for each, are presented below:

- Surface Water
  - Treatment of Reardon Brook by air stripping
- Residential Water Supply
  - Provide water supply pipeline to Bluebird Road impact area and adjacent areas
- Aquifer Restoration
  - Provide source containment via a soil-bentonite slurry wall, monitor groundwater in order to detect undesireable changes and to measure the degree of actual flushing of the aquifer, treat groundwater discharge by air stripping
- Soil Remediation
  - Excavation and on-site disposal

The estimated costs associated with this overall action plan are presented below:

Action	Cost (Thousands of Dollars) Capital	30 Year O & M Present Worth	Total
Air stripping Reardon Brook	500	246	746
Water supply pipeline to Bluebird Road and adjacent areas	695-974	0	695-974
Soil-bentonite cut off wall	2,100	231	2,331
Groundwater monitoring	0	138	138
Excavation and on-site disposal of contaminated soil	500	0	500
Total Estimated Costs for Recommended Actions	3,795-4,074		4,410-4,689

The remedial plan as presented in this section is the most cost-effective solution to the problems identified at the

Moreau site. The recommended plan provides maximum protection of residents affected by, or potentially affected by, groundwater contamination from the site. Air stripping of Reardon Brook is a cost-effective method of returning Reardon Brook to the Village of Fort Edward Water Supply and treating contaminated groundwater discharge.

By combining effective source containment with the proposed treatment of Reardon Brook, natural flushing of the aquifer with proper monitoring is a cost-effective method of aquifer restoration. Coupled with the installation of the potable water pipeline, this alternative minimizes public exposure to contaminants. Groundwater monitoring will measure the degree of natural flushing of the aquifer and insure detection of changes in groundwater quality. Since treatment is provided at groundwater discharge points, there are no adverse environmental effects associated with this option.

Excavation and on-site disposal of contaminated soils can be implemented rapidly and with high reliability. Compared with in place sealing, this alternative has the advantage of more effectively isolating the contaminated soil. The on-site disposal option is much more cost effective ($500,000 vs. $2,500,000) than off-site disposal and reduces potential exposure during transportation of the soil and does not use up limited land burial facilities.

The remedial program outlined is a logical, cost effective method of meeting the remediation objectives outlined earlier in this report. The program utilizes positive, easily implemented and proven techniques for mitigating identified and potential public health risks associated with the site.

References Cited

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APPENDIX A

REARDON BROOK
WATER TREATMENT FACILITIES

BASIS OF DESIGN

March, 1985

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SECTION 1: INTRODUCTION

SECTION 2: WATER TREATMENT SYSTEM

SECTION 3: FACILITY OPERATION AND MAINTENANCE

SECTION 1

INTRODUCTION

1.01 Background

In January of 1984, officials of the Village of Fort Edward reported the presence of Trichloroethylene (TCE) in the Village drinking water system. Investigations conducted by the General Electric Company (GE) indicated that the TCE may have entered the groundwater system from beneath a former industrial waste disposal site and migrated with groundwater flow. This groundwater eventually surfaces and feeds a stream known as Reardon Brook which, in turn, feeds the Village of Fort Edward Water System.

Reardon Brook, which normally empties into New Reservoir (one of four reservoirs that provide water to the Village of Fort Edward Water System), was diverted in early 1984 and the Village water supply has been free of TCE since that time. In order to restore Reardon Brook as a source of water to the Village water system, GE has proposed to provide air stripping water treatment facilities to remove TCE from the waters of Reardon Brook before it enters New Reservoir.

This report provides the Basis of Design for the Reardon Brook air stripping water treatment facilities. Engineering Plans and Specifications prepared by Blasland & Bouck Engineers, P.C. and dated March, 1985 were utilized during the preparation of this report.

1.02 General Facility Description

The Reardon Brook Water Treatment Facilities will be installed at a site in the Town of Moreau in Saratoga County, New York. Access to the site is from Reservoir Road, approximately 800 feet west of the intersection with Fort Edward Road. The general location is shown on Figure 1. The facility will be located adjacent to Reardon Brook, approximately 700 feet upstream from its normal discharge point in New Reservoir.

The Water Treatment Facility is designed to remove volatile organic compounds (VOCs), mainly trichloroethylene (TCE), from Reardon Brook. The TCE enters Reardon Brook with groundwater which surfaces at an escarpment approximately 1800 feet from the treatment facility.

Water flow in Reardon Brook will vary with seasonal variations in groundwater flow and surface runoff resulting from precipitation. Water flow rate data collected prior to design showed a range of water flows between 200 and >1200 gallons per minute (gpm). The Treatment Facility is designed to treat water flows between 150 and 400 gpm.

TCE concentrations at the Treatment Facility location have ranged from 5 to 15 parts per billion (ppb). To allow for possible fluctuations caused by variations in stream TCE levels, the treatment facility is designed to process influent water with TCE levels up to 100 ppb, treating to a maximum level of 1 ppb in effluent water.

SECTION 2

WATER TREATMENT SYSTEM

2.01 Basis of Design

The Reardon Brook Treatment Facility is designed for continuous, year-round operation. To allow for seasonal variations in operating conditions, the following criteria were used as a basis of design:

1. Water Characteristics:

Maximum Flow	400 gpm
Minimum Flow	150 gpm
Temperature	32°F and above
Maximum Influent TCE Concentration	100 ppb
Maximum Effluent TCE Concentration	1 ppb

2. Ambient Air Characteristics:

Temperature	-20°F and above

2.02 Process Description

A process flow diagram for the Water Treatment Facilities is shown in Figure 2. The influent channel is positioned at approximately grade level in the stream bed to intercept the entire flow of Reardon Brook. Water will pass through the influent channel to a grit removal facility where flow velocities will be reduced to 0.06 feet per second (fps) at 400 gpm. At this velocity, sand and gravel type material will be removed from influent flows. Water will then discharge to a pumping basin where it will be pumped to the top of the air stripping tower for treatment.

The influent channel is designed to handle periodic high stream flow rates such as those experienced during spring runoff or storm events. Stream flows up to 16,000 gpm (estimated 10-year storm flow) will be directed to the existing Reardon Brook diversion ditch via an overflow channel positioned in the influent channel just prior to the grit removal facility.

The stripping tower will be a 42' tall (approx.), 5' diameter (approx.) cylindrical tank filled with plastic packing media. Influent water will be distributed over the full diameter of the packing bed by a distribution plate at the top of the tower. The water will fall via gravity over and through the media to the bottom of the tower. Simultaneously, large volumes of air will be blown into the base of the tower and will pass up through the packing media, exiting at the top of the tower. It is during this exposure to air that volatile compounds in the water, such as TCE, will be removed from the water and discharged with the air. Maximum TCE levels in the stripping tower exit air stream will be within New York State Air Quality Standards. Treated water will discharge from the base of the stripping tower through a 6" effluent pipe to Reardon Brook and, eventually, flow to New Reservoir.

A pilot study has been conducted by Hydro Group, Inc. to establish the size of the tower facilities required to meet the design criteria. A permit application to construct and operate the facility has been submitted to the New York State Department of Environmental Conservation regional office. A basis of design for system components is included in Appendix A.

SECTION 3

FACILITY OPERATION AND MAINTENANCE

3.01 Normal Operation

The Reardon Brook Treatment Facility is designed to run continuously with a minimum of supervision and maintenance. A detailed description of the operation of facility components, including design parameters, is presented below.

1. Influent Flow Channel

The 3' wide x 15' long Influent Flow Channel (reinforced concrete) is designed to handle water flow rates up to 16,000 gpm (estimated 10-year storm flow rate). Prior to entering the channel, water will pass through a 3' x 3' rack constructed from vertical 3/8" steel bars spaced on 2 3/8" centers designed to remove large objects such as sticks or branches. Flows up to 400 gpm will pass directly to the grit removal chamber. That fraction of flow which exceeds 400 gpm will discharge over a 5' long concrete weir located in the side of the influent channel to the existing Reardon Brook diversion ditch. The overflow channel is designed to discharge overflows up to 16,000 gpm.

The influent channel is covered with removable steel grating for inspection and maintenance.

2. Grit Removal Facility

The grit removal facility consists of a 6' wide x 10' long x 7' deep reinforced concrete tank designed to reduced influent flow velocity from 2 fps to 0.06 fps at 400 gpm. At this velocity, sand and gravel type material will be removed from the influent flow prior to discharge to the pumping basin.

Sand and gravel material which build up over time in the grit removal basin will require periodic removal. To accommodate this, the grit chamber is equipped with a 2' wide bypass channel to allow uninterrupted operation during grit removal operations. Grit removal will be accomplished by isolating the grit chamber by inserting aluminum stop plates at the inlet and outlet of the grit chamber and removing aluminum stop plates located in the bypass channel. Maintenance personnel will then use portable pumps to remove the water in the chamber to the elevation of the grit. The grit will then be removed manually using the jib crane provided at the southwest end of the grit chamber. The grit chamber is covered with removable steel grating for inspection and maintenance.

3. Pump Station

The pump station consists of a 16' wide x 7' long x 11.4' deep precast concrete pump basin and three constant speed vertical turbine pumps (one standby). The pumps have been arranged to provide a continuous water supply to the air stripper over a range of water flows from 150 to

400 gpm. The pump basin is equipped with a system of baffles to minimize suction interferences between pumps. The pumps are located in a common pumping basin and are manifolded to a common 6" diameter ductile iron discharge pipe. Each pump discharge is equipped with a manually operated flow control ball valve to allow for changing pump flow rates and a check valve to prevent pump back flow.

Pump flow will be controlled by a combination of pump discharge valve settings and pump basin level controls. The lead pump will be throttled down using the manually controlled ball valve on the pump discharge to handle low system flow rates (to 150 gpm). The lag pump, in combination with the lead pump, is designed to handle system flow rates up to 400 gpm. The third pump will serve as a standby for the first two pumps.

As water flows into the pumping basin, a series of switches will close in response to changing water level. When the level of water in the pumping basin reaches 251.50', the lead pump will start and pump approximately 150 gpm. If the water level continues to rise to an elevation of 253.75', the lag pump will start and remain on until the water level drops to 249.50'. The lead/lag pump combination will accommodate flows up to 400 gpm. A further rise in water level above elevation 255.00' (flows >400 gpm) will result in an overflow to the existing Reardon Brook diversion ditch. As the water level drops in the pumping basin, level switches in the pumping basin will respond by shutting off the pumps in the reverse of the sequence by which they were turned on. The lag pump will shut off at elevation 249.50' and the lead pump will shut off at 248.50'. If the water level drops below elevation 248.00, both pumps will be off and an alarm will notify the system operator of the shutdown. The Pump Station pumping basin is covered with removable steel grating for inspection and maintenance.

4. Air Stripping System

Water from the pump station is pumped to the top of the air stripper through a 6" ductile iron pipe. The pipe is equipped with a meter to continuously monitor system flows.

The air stripping system is comprised of an air stripping tower, an air supply system consisting of two blowers (one standby), a propane fired duct heater and connecting air ducts.

The stripping tower is 42' tall (approx.) x 5' diameter (approx.) with a 33' depth of packing media. The air stripping system is started when the air supply blower turns on in response to the lead pump being started. Water enters the tower and is distributed evenly over the top of the packing by an orifice plate distributor. As water flows over the packing, the air supply system blows air into the bottom of the tower at a minimum air-to-water ratio of approximately 60:1 (at water flow rate of 400 gpm). The air flow rate is constant at 3200 ACFM. TCE is stripped from the water as it flows through the packing past the rising air. After passing through the packing media, the water will collect in the bottom of the tower and discharge through a 6" ductile iron pipe to the existing Reardon Brook stream bed. The stripping tower will remain in operation as long as one of the water pumps is on. The air supply blower will remain on for approximately 3 minutes after all pumps are turned off. The stripping tower is designed to reduce levels of TCE in influent water (up to a maximum of 100 ppb) to less than 1 ppb over a flow range of 150 to 400 gpm.

The stripping system is equipped with temperature controls necessary for continuous operation during expected seasonal variations in climate and stream temperature conditions. During winter conditions, it is expected that water temperatures may drop as low as 32°F while ambient air temperatures may reach -20°F. System temperature controls have been employed, therefore, to reduce the risk of freezing in the stripping system.

A propane-fired air heater will be installed at the discharge of the air blower. Water and air temperature sensors will provide signals for the temperature control system. If the water temperature drops below 32°F, the air heater will turn on in two stages in response to air temperature control settings determined in the field during the first year of operation. The stripping tower shell and influent piping will be insulated to minimize heat loss.

The air supply system is equipped with high and low air pressure sensors to alert operating personnel of system malfunctions such as blower failure (low pressure) or plugging of stripping tower packing (high pressure).

5. Control Building

A treatment system control building is provided to house the following pieces of equipment:

a. Auxiliary Power Generator
b. Motor Control Center
c. Air Compressor
d. Instrument Control Panel

The control building is a 27.3' long x 17.3' wide x 10' tall concrete block structure located approximately 60' south of the treatment system pump station. The building is fully enclosed and insulated.

3.02 Backup Systems

The following system backups will be provided:

- A standby pump.

- A standby air blower.

- An auxiliary diesel fired generator.

3.03 System Alarms

An automatic telephone dialer system will be installed to notify operating personnel of the following system conditions:

1. Water Pump Shutoff
2. Low Pumping Basin Water Level
3. Loss of Electric Power
4. Stripping Tower Shutdown
5. High Stripping Tower Air Pressure
6. Low Stripping Tower Air Pressure
7. Low Propane Gas Pressure (For Air Heater)
8. Auxiliary Generator Running

3.04 System Modifications

Provisions have been made in the design of the Reardon Brook Facilities to accommodate possible future fluctuations in water flow rates and variations in concentrations of TCE or the presence of other VOCs. Specifically, the system layout will allow the installation of a second air stripping tower.

3.05 Maintenance

A maintenance manual for the Water Treatment Facility will be prepared prior to startup.

APPENDIX A

BASIS OF DESIGN

Water Treatment System

1. Influent Channel

Number of Units:	1
Length:	15' (inside)
Width:	3' (inside)
Depth:	3' (inside)
Characteristics:	Reinforced Concrete With 3' x 3' steel bar rack at inlet. 3/8" vertical bars, 2-3/8" O.C.
Design Water Flow Rate:	400 gpm
Maximum Water Flow Rate:	16,000 gpm (10 Yr. Storm)

2. Overflow Channel

Number of Units:	1
Length:	4'
Width:	5' (inside)
Depth:	3' (inside)
Characteristics:	Reinforced Concrete
Design Water Flow Rate:	16,000 gpm (10 Yr. Storm)

3. Grit Chamber

Number of Units:	1
Length:	10' (inside)
Width:	6' (inside)
Depth:	7.4' (inside)
Characteristics:	Reinforced Concrete
Auxiliary Equipment:	Jib Crane for Grit Removal

4. Pump Station

a. Pump Basin

Number of Units:	1
Length:	7' (inside)
Width:	16' (inside)
Depth:	11.4' (inside)
Characteristics:	Reinforced Precast Concrete

b. Water Supply Pumps

Number Required:	3 (1 Standby)
Type:	Vertical, short-coupled, centrifugal.
Capacity:	100 gpm @ 72' TDH 200 gpm @ 55' TDH
Motor:	5 HP, 230/460 Volt, 3 Phase, 60 Hz

APPENDIX A

BASIS OF DESIGN

Water Treatment System (Cont'd.)

5. Air Stripping System

a. Tower Shell

Number Required:	1
Height:	41.5'
Diameter:	5' (inside)
Characteristics:	1/8" minimum thickness, structural aluminum, free standing with 6" diameter water inlet nozzle.

Operating Parameters:

Water Flow	
Minimum:	150 gpm
Maximum:	400 gpm
Water Temperature:	32°F and above
Air Flow:	3200 ACFM
Ambient Air Temperature:	-20°F and above
TCE Concentration	
Inlet:	100 ppb (max.)
Outlet:	1 ppb (max.)

Shell Insulation:

Type:	Polyurethane Foam with Vinyl Jacket
Thickness:	1-1/2"
Service Temperature:	-60°F to 220°F

b. Packing

Type:	Jaeger Tripacks^{R}
Nominal Size:	2"
Packing Bed Depth:	33'
Characteristics:	Polypropylene Material

c. Packing Support Plate

Number Required:	1
Type:	Fiberglass Grating
Size:	To fit 5' inside diameter shell
Capacity:	Support of 33' packing bed plus normal liquid holdup
Characteristics:	1-1/2" square openings

APPENDIX A

BASIS OF DESIGN

Water Treatment System (Cont'd.)

d. **Water Distributor**

Number Required:	1
Type:	Orifice-plate
Size:	To fit 5' inside diameter shell
Capacity:	150 to 400 gpm
Characteristics	Constructed from structural grade aluminum

e. **Mist Eliminator**

Number Required:	1
Type:	Polypropylene Mesh
Thickness:	6"
Capacity:	3200 ACFM
Characteristics:	Self-supporting

7. Air Supply System

a. **Air Blower**

Number Required:	2 (One stand-by)
Type:	Centrifugal Blower
Capacity:	3200 ACFM @ 2.4" W.C.
Motor:	2 HP, 230/460 Volt, 3 Phase, 60 Hz, Open drip proof with weather cover

b. **Air Preheater**

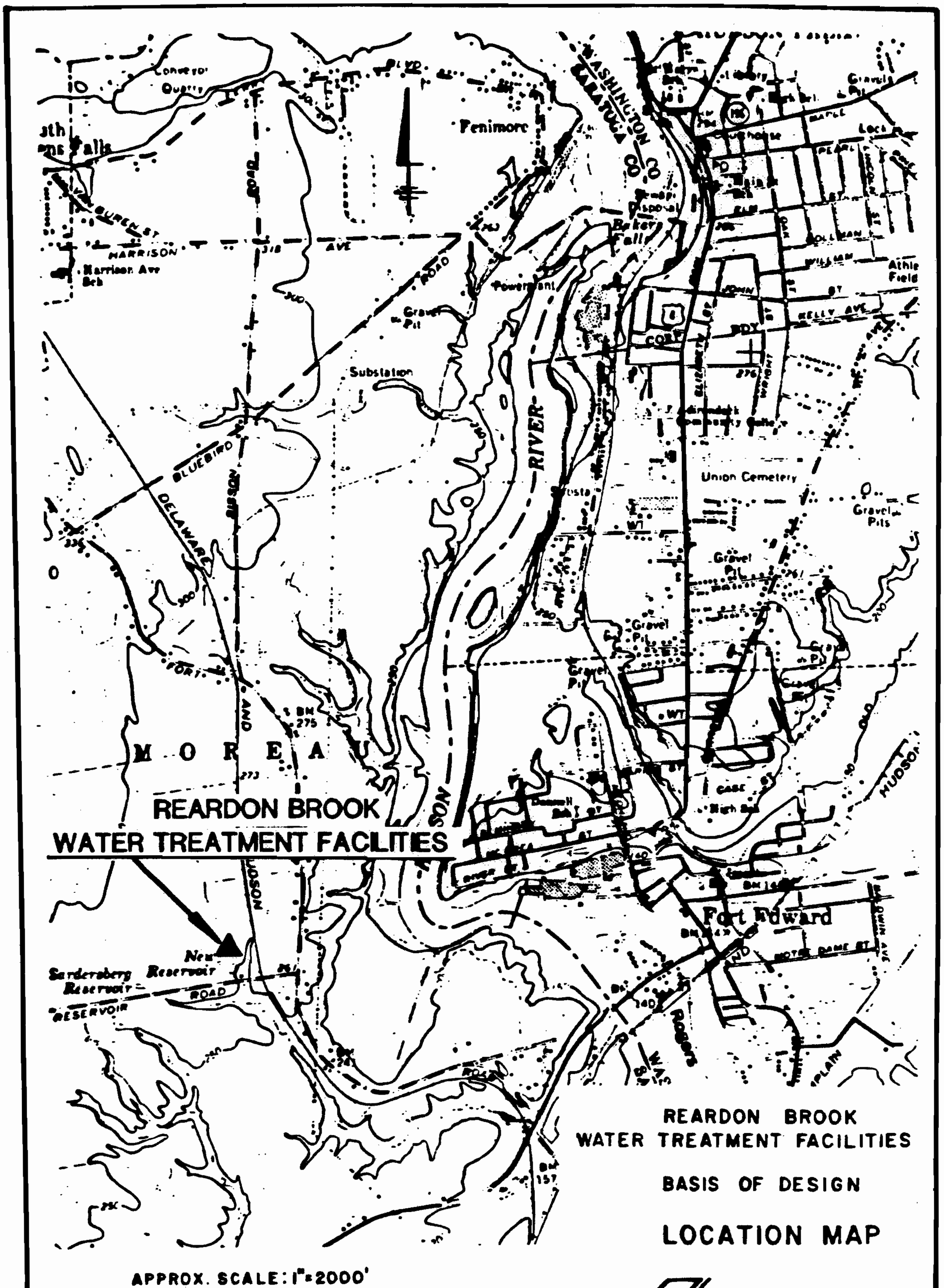
Number Required:	1
Type:	Propane Gas Heater
Capacity	
Low fire:	125,000 BTU/hr.
High fire:	250,000 BTU/hr.
Performance:	Heat 3200 ACFM of air from -20°F to 35°F (high fire)
Pressure Drop:	0.20" W.C. @ 3200 ACFM air flow
Characteristics:	Designed for outdoor installation
Electrical Requirements:	115V, Single phase, 60 Hz

APPENDIX B

SOURCES OF INFORMATION

1. Reardon Brook Water Treatment Facilities Contract Documents, Blasland & Bouck Engineers, P.C., Syracuse, New York, March, 1985.

FIGURE 1



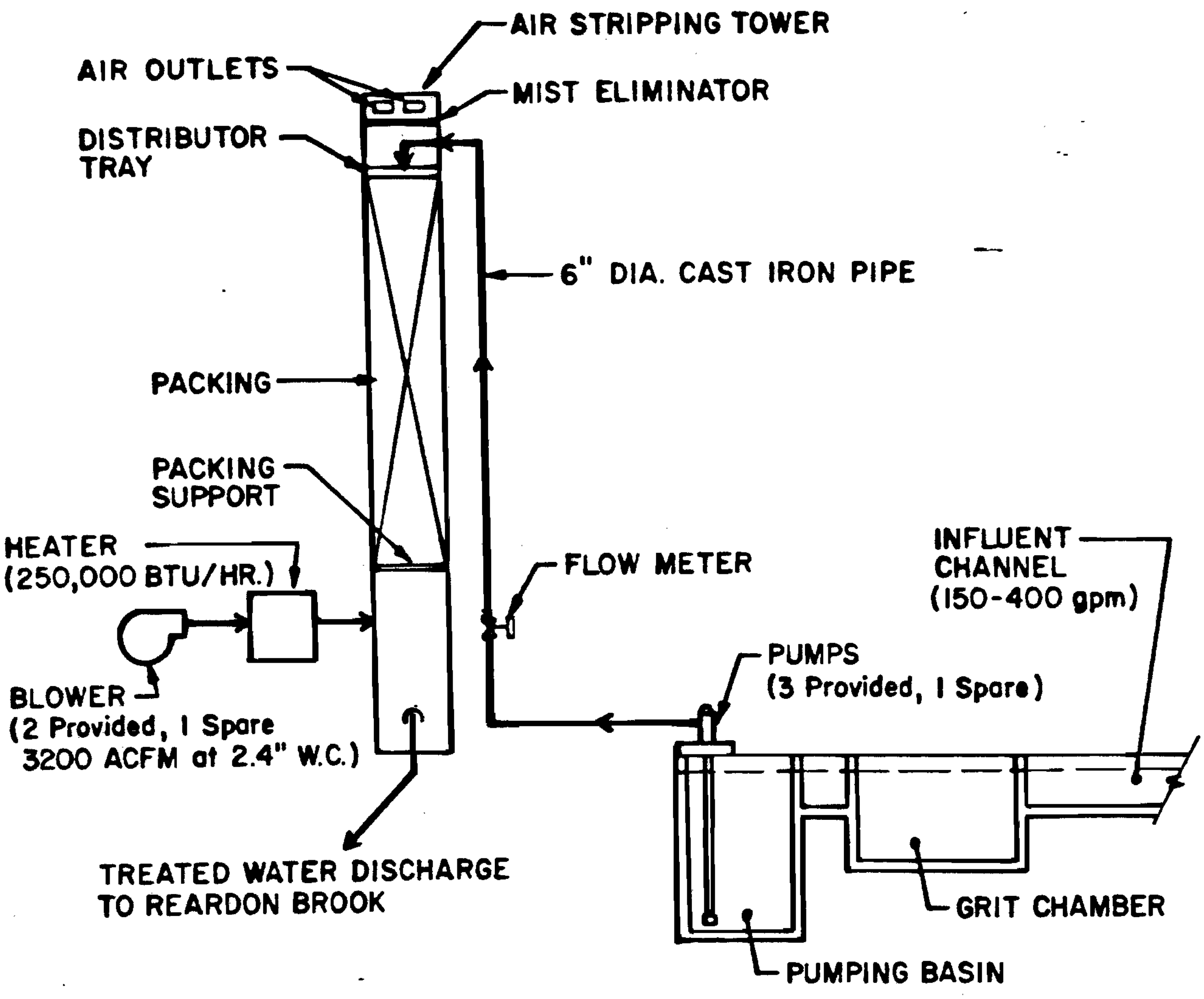
REARDON BROOK
WATER TREATMENT FACILITIES

BASIS OF DESIGN

LOCATION MAP

APPROX. SCALE: 1"=2000'

FIGURE 2



DESIGN CONDITIONS

Water Flow Rate: 150-400 gpm
Water Temperature: 32°F

Air Flow: 3200 ACFM
Air Temperature: -20°F

Trichlorethylene Concentration
Inlet (max.): 100 ppb
Outlet (max.): 1 ppb

REARDON BROOK
WATER TREATMENT FACILITIES

BASIS OF DESIGN

TREATMENT SYSTEM FLOW SCHEMATIC

BLASLAND & BOUCK