

FINAL
CORRECTIVE MEASURES STUDY AND
REMEDIAL INTERIM MEASURES REPORT
XEROX CORPORATION
JOSEPH C. WILSON CENTER FOR TECHNOLOGY
WEBSTER, NEW YORK
IIRCRA-3008 (h)-88-02043
EPA I.D. NO. NYS002211324

by

H&A of New York
Rochester, New York

for

Xerox Corporation
Webster, New York

File No. 7580-56
October 1992





Geotechnical Engineers &
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5 October 1992
File No. 7580-56

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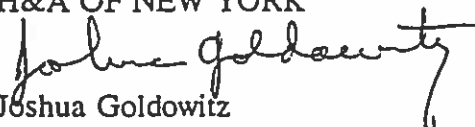
Subject: Final Corrective Measures Study
and Remedial Interim Measures Report
Salt Road Investigation
Xerox Corporation
Webster, New York
II RCRA-3008 (h)-88-0204
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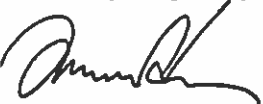
Gentlemen:

H&A of New York is pleased to submit the Final Corrective Measures Study and Remedial Interim Measures Report for the Xerox Corporation Salt Road Complex. This report follows the general organization of the Revised Corrective Measures Study Plan submitted to the U.S. Environmental Protection Agency (USEPA) in January 1991, and fulfills the Corrective Measures Study requirements described in the Corrective Action Order for this site, dated 18 April 1988. The final report incorporates EPA comments dated 18 August 1992.

It has been a pleasure working with you on this project. If you have any questions or comments regarding this report, please do not hesitate to call.

Sincerely yours,
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I. INTRODUCTION

This document presents the Final Corrective Measure Study and the Remedial Interim Measures (RIM) Report performed for the Xerox Corporation Facility located in Webster, New York as shown in Figure 1-1. The Corrective Measure Study is required under the Corrective Action Order, Docket No. II RCRA-3008(h)-88-0204, dated 18 April 1988; specifically, Part VI-Order, Section B - Corrective Measures Study (CMS) Phase, Paragraph 1- Corrective Measure Study. The purpose of the Corrective Measures Study is to identify and evaluate alternative Corrective Measure Technologies for remediation of soil and groundwater contamination previously identified on site. The goal of this study is to make a selection of Corrective Measures Option(s) that are best suited to environmental conditions at the site. This report also includes a summary of the RIM implemented by Xerox on the site.

The technical approach and rationale used for the selection of Corrective Measures Option(s) was described and documented in "Corrective Measures Study Plan (CMSP), Xerox Corporation, Joseph C. Wilson Center for Technology, Webster, New York" dated January 1990 and approved by USEPA in November 1990. A copy of the CMSP approval is presented in Appendix A.

In general, the format of this document follows the work tasks identified in the CMSP and addresses the items listed under Part VI-Order, Section B-Corrective Measures Study (CMS) Phase, Paragraph 2 - Corrective Measures Study (CMS) Report. In addition to the outline presented in the CMSP, chapters were added to this CMS report to describe the results of previous technology screening and to discuss the effectiveness of previously implemented RIMs. As such, the document is structured as follows:

- o Chapter II provides a review of the site history, a description of the regulatory and technical background of the site in terms of the Consent Order, and an overview of the RIMs instituted to date;
- o Chapter III summarizes existing environmental conditions;
- o Chapter IV identifies the Corrective Action Objectives to be achieved through remediation;

- o Chapter V provides a detailed description of the findings of bench scale and technology screening studies conducted at the site to date;
- o Chapter VI describes the effectiveness of existing RIM in terms of percentage reduction in chemical concentrations and the mass of chemicals removed from groundwater, and provides an updated status of contamination summary;
- o Chapter VII assesses the human health and environmental impact taking into account the effect of the RIM on the status of contamination and serves as the basis for determining the need for additional Remedial Measures. The chapter identifies the areas of the site requiring additional action to abate impacts to human health and/or the environment.
- o Chapter VIII presents the screening process used to evaluate alternative Corrective Measure Technologies to mitigate impacts and results; and
- o Chapter IX describes the evaluation of the Corrective Measure Options, and identifies the most favorable option.
- o Chapter X discusses the impact site conditions are likely to have on clean-up times and discusses the likelihood of an asymptotic or "zero-slope" condition.
- o Chapter XI discusses long-term monitoring needs and performance evaluation methods.

These Chapters are supported by Tables, Figures and Appendices where applicable.



II. BACKGROUND

2.1 SITE HISTORY

Manufacturing of supplies associated with electrostatic copying machines is presently conducted at the Salt Road complex. In the past, hazardous waste resulting from the manufacturing process was released at or near the vicinity of Bldgs. 224/225 located as shown on Figure 2-1. The Bldg. 224 courtyard is bounded at the north end by a former steel shot reclaim process which was dependent on trichloroethene. Adjacent to the south end is a toner developer manufacturing process which required toluene. Other hazardous wastes that have been identified with the manufacturing operations which may have been released into the environment include 1,1,1-trichloroethane and tetrachloroethylene. Xylene, benzene and a portion of the toluene detected at the site may have resulted from a 14,000 gallon No. 2 fuel oil spill from an oil storage tank west of Bldg. 225 in January 1980. The majority of the spill was cleaned up by Xerox shortly after it occurred.

In November 1982, Xerox pressure-tested two underground toluene spill tanks in the 224/225 courtyard for leakage. Results from these tests indicated a likelihood that the tanks had leaked. Xerox initiated a soil sampling and analysis program to define the extent of contamination. Analyses from 20 core samples from the courtyard indicated the presence of toluene and trichloroethylene. Upon notification of these results, Xerox removed the contaminated soils, the two toluene spill tanks and the trichloroethylene and toluene sumps.

In October 1984, during the excavation for Bldg. 224E, located in the central portion of the courtyard, red colored, solvent-smelling groundwater was encountered at the overburden/bedrock interface in areas adjacent to the east courtyard passageway. Contamination of the groundwater beneath the site by volatile organic compounds (VOCs) was confirmed after sampling soil and groundwater.

Since the discovery of contamination in 1984, Xerox Corporation has been conducting hydrogeologic investigations at the site in order to determine the nature and extent of the contamination and has implemented extensive remedial measures to mitigate the contamination.

On 18 April 1988, Xerox Corporation (Xerox) entered into an Administrative Consent Order with the U. S. Environmental Protection Agency (USEPA) involving a portion of the Joseph C. Wilson Center for Technology in Webster New York. This portion of the Joseph C. Wilson Center for Technology is referred to as the Salt Road Complex. The Salt Road Complex includes the portion of Building 224 that contains the developer operation, the portion of Building 225 that contained the steel-shot reclamation operation, and the contaminated portions of contiguous or associated properties, including property owned by Xerox Corporation east of Salt Road.

In addition to the Solid Waste Management Units (SWMUs) located in the Building 224/225 Courtyard, several additional SWMUs exist at the Salt Road site as summarized in Appendix D. All of the SWMUs previously present have been removed or replaced. The information in Appendix D indicates all of the SWMUs are being addressed by the RIM. The SWMU in the northeast corner of Bldg. 223 is currently being investigated, as described in a correspondence from Xerox to EPA dated 22 September 1992. The findings of this investigation will not materially alter the implemented remedial system.

The initial work task outlined under the Consent Order was the performance of a RCRA Facility Investigation (RFI). The RFI was submitted to USEPA, and subsequently approved on 30 August 1989. This investigation resulted in the H&A of New York report titled "Revised RCRA Facility Investigation (RFI) Report-Salt Road Remedial Investigation, Webster New York, July 1989." The RFI summarizes the hydrogeologic and soils investigations conducted at the site and the effect of Remedial Interim Measures performed by Xerox on the mitigation of contamination.

Based on information contained in the RFI and in subsequent quarterly reports, groundwater contamination at the site occurs within the shallow and intermediate water bearing zones at the site. A water bearing zone was identified below the intermediate zone and has been shown not to be impacted by the Salt Road contamination. Accordingly, only the shallow and intermediate zones are evaluated by this CMS.

In accordance with the conditions of the Consent Order, Xerox Corporation is required to perform a Corrective Measures Study (CMS) to identify, screen and propose a Corrective measure option(s) to remediate contamination at the site as identified in the RFI. Prior to performing the CMS, a plan



describing the technical approach and rationale to be followed during the screening of potential corrective measures technologies and subsequent evaluation of corrective measure option(s) was developed and submitted to USEPA for approval. The Corrective Measures Study Plan was submitted to USEPA in January 1990 and approved by USEPA on 9 November 1990.

2.2 REMEDIAL INTERIM MEASURES

Xerox has undertaken substantial Remedial Interim Measures (RIM) to mitigate groundwater contamination at the site and to mitigate possible impacts of the contamination on human health and the environment, including the furnishing of public water, the purchase of land and the installation of a groundwater recovery and treatment system. This CMS was performed by first evaluating the effectiveness of the Remedial Interim Measures which have already been implemented at the site or previously pilot tested. The results are described in detail in Chapters V and VI.

III. OVERVIEW OF SITE ENVIRONMENTAL CONDITIONS

As discussed in Chapter II, a RCRA Facility Investigation (RFI) was performed at the Salt Road site to summarize the hydrogeologic and soil investigations performed to delineate the extent of contamination. The RFI also discussed the effectiveness of Remedial Interim Measures in mitigating of contamination. The following section provides an overview of the hydrogeologic conditions, groundwater and soil contamination, and RIM implemented to date as described in the document entitled "Revised RCRA Facility Investigation (RFI) Report-Salt Road Remedial Investigation Webster New York" dated July 1989 and in various subsequent studies. This information forms the basis for the Corrective Measure Study.

3.1 SUMMARY OF RCRA FACILITY INVESTIGATION

The hydrogeologic and soils investigations undertaken by Xerox since 1985 have resulted in the delineation of subsurface conditions and the horizontal and vertical extent of contamination at the site in both soil and groundwater. Results from these studies indicate soils at the site consist of lacustrine sand, glacial till and fill overlying bedrock. Overburden thickness typically ranges from about 2 to 17 feet and average less than 5 feet. Bedrock encountered at the site is the Grimsby Sandstone. A broad, shallow bedrock ridge is present in the Salt Road Complex below the overburden and appears to influence groundwater flow conditions in the site vicinity.

Due to the shallow nature of the surface soil, the majority of the contamination occurs in bedrock and is being transported by groundwater flow mechanisms below the bedrock/soil interface. Groundwater contamination has been detected in two distinct water bearing zones below ground surface at the site. The first zone is composed of the overburden and fractured upper bedrock surface and the second zone consists of an intermediate bedrock flow system which occurs at a depth of about 15 to 25 feet below the top of bedrock. A stratigraphic profile through bedrock below the Xerox facility is shown in Figure 3-1.

Direction and gradient of groundwater flow in the shallow bedrock system closely follows the surface topography, and is regionally northward toward Lake Ontario and locally northward or towards surface drainage ways. Within the courtyard vicinity, shallow groundwater flow is primarily northwestward toward the small surface drainage channel which separates the Salt Road Complex from Bldg. 214 to the west. Groundwater flow to the east of the courtyard is northeastward toward the small surface stream which trends in a northeasterly direction through the open lands east of Salt Road.

Groundwater flow direction in the intermediate bedrock system follows the directions of the nearly vertical fractures that extend through the bedrock. Fractures that have been mapped on site extend north-south or southwest-northeast. A groundwater flow divide is present between Buildings 214 and 225 and is probably controlled by the bedrock ridge described above. West of Buildings 224/225, the direction of groundwater flow is generally to the north-northwest. The direction of groundwater flow under natural flow conditions in the area east of Salt Road is to the northeast.

Based on four years of regular analytical testing of the 118 monitoring wells and 14 pumping wells, and numerous analyses of soil samples obtained from several areas of the site, it is evident the chemical constituents detected have been consistent with concentrations diminishing since the inception of subsurface investigations in 1985. Figure 2-1 depicts locations of the monitored wells.

The principal organic contaminants detected in the groundwater at the site include toluene, trichloroethene, 1,1,1-trichloroethane, tetrachloroethene and the biodegradation/decay products trans 1,2-dichloroethene and vinyl chloride. Analyses for metals have also been performed on groundwater for the Salt Road site. Although detectable levels of metals have been identified in groundwater, data from the surrounding Rochester area indicate the metal concentrations found at the site are within the same range distribution as found elsewhere in the area and are not a concern. A more detailed description of the comparison of metal concentrations for the Salt Road site with regional data is provided in Appendix B.

Tables 3-1 and 3-2 present the constituents found at the site along with ranges of concentrations of the constituents in both groundwater and soil, respectively. The shallow and intermediate groundwater areas for which data is tabulated in Table 3-1 are shown graphically in Figures 3-2 and 3-3. Several compounds were identified in the RFI, in addition to those included on Table 3-1 and

3-2, as having been detected in lab analyses at least once. These compounds include: bis(2-ethylhexyl) phthalate, a component of vacuum pump oil which is a common lab contaminant; chloroform and bromodichloromethane, which occur as a result of chlorination of public water supplies; carbon tetrachloride, a solvent which has no record of use on the site; and chloroethane, which appears as breakdown components of the trichloroethane; 1,1-dichloroethene which is a breakdown component of perchlorethene and occurs in monitoring wells north of Bldg. 209, its probable source; and 1,1,2-trichloroethane, and its breakdown component 1,2-dichloroethane, which was used in the northeast corner of Building 223 and is associated with the SWMU at that location.

Bis(2-ethylhexyl) phthalate has only been detected in one sampling round out of over 50 and is believed to be a laboratory contaminant. The trihalomethanes chloroform and bromodichloromethane are only consistently detected in the sump in the basement of Bldg. 225 which is near a washdown area which uses public water, and in wells adjacent to a public water supplied firemain north of Building 214. The analytical results for the last two years for these commonly not-detected compounds are included in Appendix B. None of the compounds listed above has ever been detected in the influent to the Ultrox treatment system, and the present treatment system is capable of removing these compounds from water, if present. Therefore, these compounds are not considered to be of significant concern of this site. The effectiveness of the RIM in reducing chemical concentrations is discussed in Chapter VI.

The transport of groundwater contamination appears to be controlled by preferred jointing patterns and fractures in bedrock which are not generally aerially continuous. These structural features and bedrock permeability are the dominant factors influencing contaminant transport rather than the direction and gradient of the groundwater surface. As a result, contaminants may be moving to an area of lower elevation, not necessarily migrating with groundwater flow direction.

The horizontal and vertical extent of groundwater contamination has been defined. East of the Bldg. 224 courtyard area, the primary route for contaminant migration has been along a depression in the top of bedrock surface located southeast of Bldg. 224 trending east-northeast toward the open lands east of Salt Road. West of the courtyard, contamination has migrated to the west and northwest. Contaminant transport in this area has probably been facilitated by utility lines blasted into bedrock that run north-south along the east side of Bldg. 214 and east-west along the north side of Bldg. 214,



and also the northwesterly groundwater flow direction which exists in this area. The joint and fracture pattern control on groundwater flow is superimposed upon the hydrogeologic controls mentioned above. Figure 3-4 shows the horizontal extent of groundwater contamination in the shallow and intermediate zones.

3.2 CMS GOALS

Based on the results of the RCRA Facility Investigation for the Salt Road site, the following goals were adopted for this study:

1. Evaluate the need for additional remedial action at the site in order to inhibit further migration of groundwater contaminants.
2. Evaluate the need for and alternatives to remediate contaminated soils.
3. Establish cleanup goals for groundwater and soil at the site.
4. Establish a program to allow monitoring of the remediation system performance.

IV. CORRECTIVE ACTION OBJECTIVES

This section of the CMS presents the Corrective Action Objectives to be achieved for groundwater and soil remediation. The corrective action objectives are numerical clean-up goals in the form of chemical concentrations for each of the contaminant found at the Salt Road site. In addition, this section presents a listing of corrective action technologies reviewed as potential options for the remediation of groundwater and soil.

4.1 CORRECTIVE ACTION OBJECTIVES

The corrective action objectives for groundwater are based on current New York State policy. This policy requires groundwater to be cleaned up to the most stringent applicable Federal or State standards. Consistent with this policy, the most stringent regulatory standard for organic contaminants in groundwater is found in Part 703. Using these standards, the corrective action objectives for groundwater under the Corrective Measure Study have been set at a clean-up goal of a maximum of 5 ug/l for trichloroethylene (TCE) and 1,2-Dichloroethylene (DCE), and at 2 ug/l for vinyl chloride. Table 4-1 presents a summary of the constituents detected in groundwater and corresponding corrective action objective level. The cleanup goals for compounds associated with the SWMU's which are not frequently detected but not considered to be laboratory contamination related are included on Table 4-1. The potential for failure to meet these goals due to an asymptotic or "zero-slope" condition is discussed in Chapter X.

The clean-up goals for soils under the corrective action objective have been set at the health-based criteria as described in EPA's document entitled "RCRA Facility (RFI) Guidance Interim Final May 1989, Section 8-Health and Environmental Assessment. Constituents detected in soil are listed in Table 3-2 of this document.

In addition to the health-based criteria, the potential for leaching of contaminants from soil to groundwater is considered under the corrective action objective. As a result, clean-up goals for soils are based on not only the RCRA health-based criteria, but also on the Toxicity Characteristic Leaching Procedure as described in EPA Method 1311, SW-846. Soils remaining in-place will be required to meet this objective as a measure to minimize the impact to groundwater quality as a

result of soil leaching unless the groundwater impacted by the leachate is dealt with by other groundwater remedial measures.

4.2 IDENTIFICATION OF CORRECTIVE MEASURE TECHNOLOGIES

As described in the CMSP, the purpose of this study is to identify and screen potential corrective measure technologies that may be effective in the containment, treatment, remediation and/or disposal of contamination at the Salt Road site. The CMSP identifies the contaminants to be addressed in the groundwater and soil at the site as listed in Tables 3-1 and 3-2.

The initial aspect of the screening process is to evaluate the broad list of potential corrective measure technologies as presented in the CMSP. The majority of these technologies were researched and screened to assess suitability with regard to site conditions, waste characteristics, technology limitations, and economic impact as part of the RIM as discussed in Chapter V. Additional screening of technologies was performed as part of the CMS as described in detail in Chapter VIII of this document.

The purpose of the screening in Chapter VIII is to determine if one or more of the listed technologies employed individually or in combination will be more effective in achieving the corrective measure objectives than the currently implemented RIM. The technologies presented in Tables 4-2 and 4-3 were evaluated for potential application at the Salt Road site during the RIM and CMS programs.



V. PREVIOUS TECHNOLOGY SCREENING AND
(BENCH AND PILOT SCALE STUDIES)

5.1 REMEDIAL INTERIM MEASURES OBJECTIVES

In order to abate the potential threat to human health and the environment, Xerox established the following objectives for the RIM:

1. Provide water from the public supply system to all of its neighbors.
2. Acquire offsite property to facilitate access for remedial activities.
3. Removal of courtyard soils which could have acted as an ongoing source for groundwater contamination.
4. Abatement of further contaminant migration.
5. Reduction of contaminant levels.
6. Accelerate site remediation relative to that possible under the RFI/CMS/CMI process.

Objectives 1 and 3 were implemented by Xerox in 1985. Objective 2 was implemented by Xerox between 1986 and 1991 with the acquisition of four dwellings and 81.4 acres of land.

Xerox conducted extensive technology screening and bench and pilot scale studies as part of the remedial interim measures conducted at the site to date to achieve Objectives 4, 5, and 6. The results of this screening process conducted during the RIM are summarized in Tables 5-1 and 5-2 and discussed in the following sections.

5.2 RIM TECHNOLOGY SCREENING

The technologies screened as potential RIM included:



- o In-situ groundwater treatment
- o Groundwater Containment
- o Groundwater pumping
- o Vacuum extraction for soil and groundwater
- o Above ground soil treatment
- o Groundwater treatment

The screening process included a literature review to identify vendors providing commercially available technology systems and then pilot testing of various systems.

5.2.1 In-situ Treatment Technologies

The potential for using in-situ groundwater treatment technologies for the remediation of the contamination at the Salt Road site was evaluated between 1987 and 1988. DuPont Biosystems, Inc., now a service of DuPont Remediation Services, Inc., was contacted in 1987 relative to the feasibility of using an enhanced biological processes for the in-situ destruction of a groundwater contamination. Information on the site hydrogeology and contaminants was provided to DuPont Biosystems for their review. It was concluded the bioremediation technique would most likely not be feasible at the Salt Road site primarily because of the difficulty associated with injecting nutrients into the fractured rock aquifer system. The bedrock at the site exhibits low permeability and the majority of the contaminant migration occurs in isolated fracture systems. It was concluded that the ability to maintain hydraulic containment during the injection of the nutrients essential for biodegradation could probably not be assured. In addition, the use of bioremediation techniques for cleanup of chlorinated solvent contamination has yet to undergo a reliable full scale demonstration. As a result of this review, Xerox elected not to pursue bioremediation as a remedial alternative for the Salt Road site.

5.2.2 Groundwater Containment Technologies

One of Xerox's primary goals in conducting the RIM was to abate further migration of the contaminant plume at the site. Accordingly, H&A of New York investigated the use of containment technologies as part of the overall remedial program.

Based on the analytical data and groundwater flow conditions identified between 1985 and 1987, the primary direction of groundwater contaminant migration from the Xerox's property was to the northeast. H&A of New York evaluated the potential for constructing a low permeability cut-off barrier in bedrock at the northern property line on the east side of Salt Road. Two types of low permeability barriers were considered. The first consisted of a narrow (approximately 1 ft. width) slot cut into bedrock and backfilled with a cement bentonite grout to below the depth of known contamination along the northern boundary of the area east of Salt Road. The technology for cutting slotted trenches in rock was developed in Europe and is not currently available in the United States. In addition, the technology could potentially produce a large volume of contaminated bedrock as a result of trench excavation which would have required treatment or disposal. Therefore, this technology was not pursued.

The second technique considered for construction of a low permeability barrier was the construction of a grout curtain along the northern property line. The grout curtain would be formed by drilling three rows of drillholes on 5 ft. centers to below the known depth of contamination and pressure grouting the holes in sequence. Initially, two rows of holes would be drilled 10 ft. apart parallel to the northern fence line. A third row would be added between the two initial rows to complete the barrier wall.

The barrier technology was not pursued when it was demonstrated that hydraulic containment could be achieved by pumping wells installed in fractured rock trenches in the area east of Salt Road. Water levels obtained from long term pumping indicated that the zone of capture of the pumping wells extended beyond the northern property boundary of Xerox's lands east of Salt Road. Therefore, low permeability barriers were not required. In addition, grout curtains and cement cutoff walls are generally only effective in reducing



permeability to the 10^{-5} to 10^{-7} cm/sec range. This is not significantly different than the natural bedrock permeability along the northern fence line. These technologies were not pursued further for the remediation of the Salt Road contamination.

5.2.3 Groundwater Pumping and Enhancement Technologies

Groundwater pumping was the first alternative evaluated by Xerox for remediation of the Salt Road contamination. A series of four pumping wells were installed in late 1985 after the discovery of the contamination by Xerox Corporation. Recovery Wells 1, 2 and 3 were located along Salt Road east of the Salt Road Complex to intercept eastward migration of groundwater contamination. Recovery Well 4 was installed immediately east of the courtyard area to intercept contamination in the source area. Pumping of these wells between March and October 1986 was routed to an air stripper installed in the treatment building at Building 348.

The initial pumping wells were installed with 3-1/2 in. diameter casings and equipped with jet pumps. Because of the small diameter and narrow pump clearance, the wells were susceptible to fouling by iron bacteria and iron precipitation and were removed from service in early 1987. The initial pumping wells were capable of rates ranging between about 0.1 and 4.5 gallons per minute.

A test well was installed in the vicinity of observation well OS-29 in 1987 to evaluate the potential for using groundwater pumping wells to intercept the contaminant plume on the lands east of Salt Road. The well was tested for a period of about 24 hours at a flow rate of less than one gallon per minute. The cone of depression of the pumping well extended less than 50 ft. from the well. Based on the results of the pump test and on the information obtained from the initial four pumping wells, it was concluded that large differences in bedrock permeability existed on the site, primarily dependent on the existence of vertical joint sets in the bedrock. Bedrock jointing patterns were mapped based on lineations from aerial photography and orientations of surface streams. The bedrock joints were found to be discontinuous and randomly spaced.



The average pumping rate of the four initial pumping wells and the test well was about 1 gallon per minute. Based on this average flow rate and the average zone of capture of the pumping wells, it was concluded that more than 50 individual pumping wells would be required to capture the extent of contamination in the lands east of Salt Road. Accordingly, technologies for enlarging the zone of capture of individual pumping wells were evaluated.

Ranney Wells

The Ranney Division of Hydro-Group, Inc. was contacted relative to the potential for construction of Ranney collector wells in the bedrock formation. A Ranney well consists of an approximately 6 to 10 ft. diameter drop shaft installed to the desired depth of influence, in this case the known depth of contamination. Individual collector drains are then installed through the drop shaft in a radial fashion extending out from the shaft. Although the Ranney Division considered the concept to be technically feasible, they concluded it was not cost effective when compared to individual pumping wells because of the high costs associated with dropping a shaft in bedrock with contaminated groundwater. Therefore, this alternative for increasing the radius of influence of individual pumping wells was not evaluated further.

Permeability Enhancement Through Blasting

The concept of increasing bedrock permeability through the use of explosives was evaluated for use at the site. Groundwater contamination at the site was known to migrate along zones of preferred orientation associated with the regional joint patterns. Previous attempts at encountering these high permeability near vertical structures with individual pumping wells were only marginal successful. The blasting program would consist of drilling blast shotholes on 5 ft. centers in lines oriented perpendicular to the primary joint orientations which were known to be acting as zones of preferred contaminant migration. The detonation of explosives in the shotholes would interconnect the natural fracture systems and allow for an increased radius of influence from the pumping wells.



This technique had been employed at a Black and Decker facility in Brockport, New York in the Grimsby Sandstone, which is also the rock unit which underlies the Salt Road site. Although the actual pumping of wells in the blasted trench had not occurred at the time the technology was considered, the blasting contractor utilized at the Black and Decker site reported that the program was successful in creating a higher permeability continuous trench in rock as evidenced by the hydraulic communication between shotholes during fracturing. This technology was carried on to pilot testing and implementation at the Salt Road site, as described in Section 5.3.2.

The use of explosives for fracturing bedrock imparts significant vibrations to the ground surrounding the fractured trench. Accordingly, the technology cannot be used in close proximity to vibration sensitive operations and structures. Therefore, it was not considered to be a practical technology for increasing the permeability of the bedrock formations near the courtyard source area.

Hydraulic Fracturing

In order to evaluate alternative technologies for permeability enhancement, H&A of New York gathered information and obtained contractor estimates for performing hydraulic fracturing in the courtyard area.

Northeast Water Production, Inc. of Sterling, Massachusetts was contacted in February 1989 with regard to using hydraulic fracturing to increase bedrock permeability. A scope of work and proposal was developed to evaluate the suitability of this process at the Salt Road site. The hydraulic fracturing would have been accomplished in a manner similar to blasting, with drillholes advanced to the known depth of contamination on 5 ft. centers. The contractor would have attempted to fracture the bedrock using high water pressure.

The depth to rock over much of the Salt Road site is generally less than 5 ft. The majority of the contamination in the courtyard area occurs at the bedrock/overburden interface and in the upper few feet of bedrock. In order to successfully hydraulically fracture a formation, a steel casing must be seated several feet into rock to ensure against short



circuiting of the system by removal of casing from its socket in rock during the pressurizing process. In addition, the blasting program was successful because it was able to interconnect pumping wells with zones of higher permeability in the bedrock. Pumping tests conducted in the vicinity of the courtyard area indicated a consistent low permeability exists throughout a wide area. Accordingly, it was concluded the hydraulic fracturing process would likely provide no beneficial improvement in the rate of contaminant recovery in the source area.

Radio Frequency Rock Fracturing

The use of radio frequency energy for the fracturing of rock to increase bedrock permeability was considered as a means of accelerating contaminant recovery in the courtyard area. Research funded by the oil shale industry and the federal government in the late 1970's and early 1980's resulted in the development of several processes for utilizing radio frequency energy for the fracture of rock for enhanced kerogen recovery from oil shales. Demonstration programs conducted in Colorado and Utah in the early 1980's were successful in demonstrating the ability to fracture rock and generate temperatures of several hundred degrees centigrade through the application of RF energy applied in deep boreholes.

KAI Technologies of Woburn, Massachusetts has applied for a patent on the application of RF technologies for fracturing bedrock for enhanced recovery of groundwater contamination. H&A of New York and KAI Technologies prepared a work plan for a pilot test program to evaluate the applicability of the RF technology for accelerated recovery of contamination at Salt Road.

Several obstacles were identified during the development of the work plan. The heating required to fracture rock typically results in temperatures in the formation of a few hundred degrees centigrade. The presence of high concentrations of volatile organics including vinyl chloride, a known carcinogen, beneath the operating areas of the plant was of concern to Xerox Corporation. If the volatiles were liberated during heating, the introduction of high levels of solvent vapors in the operating areas of the facility would



have been possible. Access to the facility for the installation of a vapor recovery or vapor control system is severely limited by in-plant operations critical to Xerox's business. In addition, the technology had not been applied anywhere for fracturing of rocks at depths similar to those at the Salt Road site. Groundwater recovery conducted at the site since 1987 has resulted in substantial reductions in the concentration of volatile organic compounds in onsite monitoring wells, as discussed in Section VI. As a result of these factors, Xerox Corporation elected to not proceed with pilot testing of this technology at this time.

Groundwater Flushing

The potential for enhancing the rate of contaminant recovery in the courtyard source area using groundwater flushing was evaluated in 1989 and 1990. It is believed the contaminants in the source area have diffused into the pore spaces of the bedrock underlying the courtyard. Accelerated recovery through enhanced recharge was pilot tested at the site as discussed in Section 5.3.1.

Status of Enhancement Technologies

At present, no other technology is available for the enhancement of bedrock permeability which has been proven feasible by actual demonstration. Likewise, there are no feasible technologies for accelerating the rate of diffusion of volatile contaminants from bedrock into groundwater. Accordingly, a review of new and emerging technologies should be performed on an annual basis to periodically determine if applicable technologies exist for accelerating contaminant recovery. Bench or pilot programs should be considered if cost effective technologies are developed.

5.2.4 Vacuum Extraction

Xerox Corporation has conducted extensive research on the use of vacuum extraction for the remediation of contaminated soil and groundwater at its facilities throughout the United States. As a result of this research, Xerox Corporation currently has operational



vacuum extraction systems at facilities around the world. In addition, Xerox Corporation was awarded a patent for a dual phase vacuum extraction process in 1991. The system is capable of withdrawing vapor and groundwater from a single well under high vacuum rates. As a result, a two pump system is not required and a large radius of influence of the vacuum extraction system can be achieved.

The use of vacuum extraction was evaluated for the Salt Road site in 1988. The vacuum extraction process is successful in soil with low permeabilities due to the increase in permeability resulting from desiccation cracks induced by the vacuum process. The low permeability bedrock in the Salt Road site area is not susceptible to desiccation cracking and therefore, the vacuum extraction process has limited applicability at Salt Road unless the bedrock permeability can be enhanced using the techniques outlined in Section 5.2.3.

A trial of a vacuum extraction system in the Grimsby Sandstone at a facility in Rochester, New York was unsuccessful in recovering methylene chloride contamination in rock. The radius of influence in the vacuum extraction well was reportedly inhibited by the low permeability of the sandstone formations and operation of the system was suspended after about a one year trial. Similar performance is anticipated if the system is applied to the Grimsby Sandstone at the Salt Road site.

Vacuum extraction was considered as a remedial alternative for the soil contamination north of Building 214. Given the relatively small quantity of contaminated soil identified, however, it was not considered to be cost effective when compared to the other soil treatment technologies identified in Section 5.2.5.

5.2.5 Aboveground Soil Treatment Technologies

The consent order for the Salt Road site distinguishes between source soils and affected soils by identifying source soils as those which may contribute to groundwater contamination. Affected soils are those soils which were contaminated as a result of contact with contaminated groundwater or through the de-volatilization of contaminants out of groundwater underlying the soil. The courtyard soils contaminated by the releases

from the underground spill containment tanks were removed as described in Section 4. It is not probable that soils trapped underneath Buildings 223, 224, and 225 are source soils since these soils most likely were not directly exposed to releases of contaminants. The contamination in these soils resulted from the volatilization from groundwater below the building floor slab. The EPA and DEC indicated in a 18 August 1992 correspondence that these soils are inaccessible and their presence is not an issue at this time, as long as the effects of their presence are being addressed through ongoing groundwater corrective measures.

The only other soils identified on site which could be considered source soils are the contaminated soils identified north of Building 214. Several technologies for the remediation of these soils have been evaluated between 1987 and present. The vacuum extraction process identified in Section 5.2.4 was not considered feasible due to cost considerations and the small quantity of contaminated soils.

5.2.6 Groundwater Treatment Technologies

Xerox has evaluated various groundwater treatment technologies for use at the Salt Road site since installation of the initial groundwater recovery wells in early 1986. The initial groundwater treatment system consisted of an air stripper connected to four pumping wells. In addition to the air stripper, Xerox has evaluated the following groundwater treatment technologies:

- o Biological treatment
- o Granular activated carbon filtration
- o Airstripping plus granular activated carbon
- o Catalytic incineration with concentration
- o PEROXSIV system
- o Peroxidation systems Perox-Pure Process
- o Ultrox International
- o Solarchem Environmental Systems
- o Radiation Disposal Systems, Inc.



Airstripping

Xerox concluded airstripping is not a suitable stand alone technology for treatment of the contaminated water at the site because of the presence of vinyl chloride in the groundwater and Xerox's goal of reducing atmospheric conditions. Accordingly, Xerox elected to pursue technologies which would result in the onsite destruction or concentration of the contamination.

Biological Treatment

H&A of New York contacted DETOX, Inc. of Ithaca, New York in 1987 regarding the use of biological treatment for the Salt Road groundwater. DETOX concluded the technology was not appropriate for the Salt Road site because of the large variations in flow rates anticipated, presence of chlorinated compounds, the size of system required relative to Bldg. 348 space availability and the range of contaminants present. Accordingly, this technology was not pursued further.

Activated Carbon Based Systems

H&A of New York retained the Environmental Products Division of Hydro-Group, Inc. in 1988 to evaluate liquid phase carbon, airstripping plus vapor phase carbon and airstripping plus off-gas treatment as groundwater treatment alternatives. Hydro-Group concluded technologies using liquid or vapor phase carbon were not practical for site application because of the presence of vinyl chloride in the groundwater. Vinyl chloride is not easily adsorbed by carbon and the carbon system required for abatement would have resulted in substantially increased treatment costs over those of other technologies Xerox was considering at the same time.

Airstripping Plus Offgas Treatment

Hydro-Group concluded airstripping plus a new off-gas treatment technology might be a feasible technology for groundwater treatment. The air-phase treatment technology

evaluated by Hydro-Group consisted of concentration of organics on a bed of molecular sieves developed by the Union Carbide Corporation. The treatment process would run on a concentration mode until approximately 90% of the sieve material had been saturated with the vapor phase contaminants. At this time, the volatile organic compounds would be liberated from the molecular sieves using hot air. The hot air would be routed over a catalytic incinerator to destroy the volatile organic compounds in the air stream. Although the technology appeared to be feasible, Xerox elected not to pursue it further because of concurrent research being conducted at the site on oxidation technologies, as discussed below.

Oxidation Technologies

In keeping with its goal of evaluating onsite contaminant destruction technologies for the Salt Road site, Xerox Corporation began to evaluate oxidation technologies for groundwater treatment in late 1987. H&A of New York contacted Union Carbide and FMC which had developed the PEROXSIV process for onsite destruction of contaminants. The process utilized molecular sieves to absorb volatile organic contaminants from water. The absorption process is run for a period of weeks until the molecular sieve bed is near breakthrough. The sieves are then backflushed with a hydrogen peroxide solution. Trace elements in the molecular sieves catalyze the disassociation of hydrogen peroxide to two OH-radicals which accomplish oxidation of the organic contaminants on the sieve bed. The effluents of the system are carbon dioxide and water, with chloride ions resulting if chlorinated solvents were present on the sieve bed. Bench scale and field scale pilot testing of the PEROXSIV process was accomplished at the Salt Road site in early 1988 as summarized in Section 5.3.

In addition to the PEROXSIV process, Xerox evaluated four other oxidation technologies for use at the Salt Road site. These consisted of: the Perox-Pure process developed by Peroxidation Systems, Inc. of Tucson, Arizona; the Ultrox process developed by Ultrox International of Santa Anna, California; the Rayox System developed by Solarchem Environmental Systems of Toronto, Canada; and an oxidation system under development by Radiation Disposal Systems, Inc. of North Carolina. The Peroxidation Systems, Inc. and

Rayox units consisted of a reaction chamber where contaminated groundwater is mingled with hydrogen peroxide in the presence of ultraviolet light. The ultraviolet light disassociates the hydrogen peroxide into two OH-radicals and excites the bonding structure of organic compounds. As a result, the OH-radicals oxidize the organic compounds to carbon dioxide, water and chloride ions. The Ultrox system is similar to the Solarchem and Peroxidation units but also includes ozone as an additional oxidant in the reaction chamber. The ultraviolet light decomposes the ozone to an oxygen singlet and O₂. The organic contaminants in groundwater are oxidized in a manner similar to the peroxidation systems Rayox units. Each of these three UV oxidation systems were pilot tested at the Salt Road site as discussed in Section 5.3.

H&A of New York evaluated an oxidation system under development by Radiation Disposal Systems for use at the Salt Road site. The unit consisted of an ozone generator which provided ozone to a reaction chamber with ultraviolet light. The treatment system was at a substantially lower stage of development than the other units evaluated and onsite pilot testing of this system was not conducted.

5.3 BENCH AND PILOT SCALE STUDIES

As discussed in Section 5.2, Xerox conducted bench and pilot scale studies as part of the RIM process for the following technologies:

- o Groundwater flushing
- o Permeability enhancement through blasting
- o Oxidation technologies for groundwater treatment

The results of the pilot and bench scale studies performed during the RIM are summarized in the following sections.

5.3.1 Groundwater Flushing

Xerox pilot tested a groundwater flushing system during January of 1990. The goal of the



system was to use treated groundwater injected at the top of rock in the source area to flush contaminants from the source towards the extraction wells, thus enhancing the rate of recovery of the contamination. A reinjection system was constructed with a metered water line taking treated water from the groundwater treatment system in Building 348 and discharging it to the groundwater in the courtyard source area via a perforated PVC line located along the top of rock. The New York State DEC expressed concern relative to the potential for reinjection of groundwater which could be considered a listed waste under the "contained in" rule. As a result, the system was reconstructed to allow for injection of potable water from the municipal supply systems serving the Salt Road complex.

The injection system was tested beginning on 3 January 1990 with the injection of 7 gpm of potable water. Water levels were monitored in wells near the courtyard and in recovery wells 4 and 5. The injection was continued until 8 January when ponded water was found in the courtyard above ground surface.

Water levels in monitoring wells adjacent to the courtyard did not respond throughout the test, and the pumping rates at recovery wells 4 and 5 were not increased due to the injection of the potable water. The water level in the gravel backfill in the courtyard declined over several days following the test, indicating the bedrock underlying the courtyard was only capable of accepting recharge at a low rate. Based on this trial, it was concluded groundwater flushing through artificial injection was not a viable technology for accelerating the rate of recovery of contaminants in the source area.

It should be noted the roof drainage from nearby buildings is routed into the gravel backfill of the courtyard so that the area receives an increased rate of recharge. This probably has some beneficial impact on the rate of flushing of contaminants in the source area and should be continued.

5.3.2 Permeability Enhancement Through Blasting

H&A of New York conducted a test blasting program to evaluate the suitability of blasting for increasing bedrock permeability in the area east of Salt Road. The test blasting



program was conducted between 23 and 24 November 1987 by Nothnagle Enterprises, Inc. of Scottsville, New York.

The pilot blasting program was intended to establish the charge weight and firing delays necessary to accomplish fracturing of the rock, while at the same time minimizing vibrations to nearby structures and to manufacturing operations at the Salt Road complex. The initial pilot program consisted of drilling approximate 2 in. diameter shotholes on 5 ft. centers near the Test Well 2 location. The initial group of 8 holes were loaded as follows:

1. 7.5 lbs. of extra jel explosive (3 sticks) was placed in the bottom of the hole and connected to a 25 millisecond delay.
2. 2.5 ft. of stemming stone consisting of 3/8 minus crushed stone was placed above the lower charge.
3. A second set of 7.5 lbs. of extra jel explosive with a 25 millisecond delay was placed and covered with 2.5 ft. of stemming stone.
4. A final charge of 7.5 lbs. of extra jel explosives with a 25 millisecond delay was placed and stemming stone was extended to ground surface.

The depth to bedrock from ground surface in the area of the pilot test program averaged approximately 6 ft. Seismographs were placed at various locations to record vibrations during the blasting operations. One seismograph was located within 100 ft. of the shothole; another within 500 ft.; and two at remote locations, near the houses along Salt Road and next to the building foundation at the Salt Road complex. The shotholes were detonated individually and vibration readings were obtained.

The hydraulic communication between the shotholes was evaluated by visually observing water spouting from adjacent shotholes during the pilot test. Water was observed being ejected from all of the shotholes during the detonation of the final single shothole during the first pilot round.



No volatile organic compounds were detected in the work area during the pilot blasting program. In addition to the organic vapor analyzers and Hnu meters used for air monitoring, the construction and monitoring personnel performing the blasting operation were equipped with carbon canisters which sampled air in the breathing zone throughout the eight hour work days.

A second round of shotholes was detonated by loading the holes with two separate delays of 12.5 lbs. of explosives each. A third round of shotholes was detonated with a single delay per hole and 25 lbs. of explosives per delay. The vibrations induced by blasting of the various shotholes were plotted vs. charge weight and distance on a scaled distance plot. This plot can be used to estimate the vibration induced at any distance from a shothole for any charge weight at the same rock formation.

Based on the results of the pilot blasting program, it was concluded the pilot blasting was effective in achieving hydraulic interconnection between the shotholes drilled during the pilot round. In addition, groundwater was observed spouting from the Test Well 2 cluster as the pilot blasting advanced to within 10 ft. of the pumping well. Therefore, it was concluded the blasting was effective and the full scale production blasting program was implemented. Data from the scaled distance relationship was used to size charge weights so that vibrations at the nearby structures and in the manufacturing operations were kept below predetermined levels. Production blasting was begun on 25 November 1987 and was completed at 10 December 1987 for the blasted trenches at Recovery Wells 6 and 7.

A blasted trench was installed for Recovery Well 10 along the northside of the area east of Salt Road in 1988 and for Recovery Well 14 near the northwest corner of Salt Road and Mitcheldean Drive in 1990. Information developed from the pilot program for the scale distance relationship was used during the blasting at these two locations to establish the charge weight necessary to minimize impacts on existing structures and manufacturing operations.



5.3.3 Oxidation Technologies

Xerox Corporation conducted bench and pilot scale testing of four oxidation technologies between late 1987 and 1990. The results of these studies are summarized below:

5.3.3.1 PEROXSIV System

The PEROXSIV system developed by Union Carbide Corporation and FMC Corporation was evaluated for groundwater treatment at the Salt Road site. Samples of the Salt Road groundwater were provided to Union Carbide in January 1988 for laboratory testing. Test results indicated the laboratory scale testing achieved complete destruction of the contaminants present in the Salt Road groundwater.

Union Carbide and FMC submitted a proposal for a field test at the Salt Road site on 12 February 1988. The field trial was intended to determine the following:

1. Evaluate the performance of two alternative high silica zeolites for use as the absorbent. One of the zeolites operated at ambient temperatures, the other required heating to approximately 130° - 150°F during the regeneration step.
2. Identify the maximum achievable effluent purity during the absorptive phase of the treatment process.
3. Determine the rate of hydrogen peroxide consumption during the regeneration phase.
4. Determine the regeneration characteristics including backflow rate of the peroxide solution, the optimization of the regeneration solution by the inclusion of additives to inhibit premature decomposition, and the evaluation of the regeneration time required to oxidize the organics on the sieve bed.

5. Evaluate the variability of ambient temperatures on regeneration.
6. Evaluate the impact of numerous absorption and regeneration cycles on the performance of the molecular sieves.

Field Tests

The field trial was performed on water at the Webster site using a skid mounted test unit constructed by Union Carbide and FMC. The unit contained four packed bed columns, each 6 ft. long by 3 inches in diameter. The columns were equipped with sample taps for measuring water quality to determine contaminant breakthrough at various locations along the column. In addition, the columns were also equipped with thermocouples to monitor the heat of reaction during the regeneration step. Flow meters are mounted on the inlet of each column to measure the total volume of water treated. The system could be run either in series or in parallel depending on the length of the absorption step desired.

The absorption step during the field trials typically lasted from three to six days, depending on the type of absorbent in the bed. After each absorbent step was completed, the unit was regenerated by backflushing with a hydrogen peroxide solution. One of the molecular sieves operated at ambient temperatures during regeneration. The other required external heat to temperatures of 130 to 150°F. The spent regeneration solution was fed back into the groundwater influent line to the absorption bed during the next absorptive step in the event any contaminants remained in the solution.

The field trial was conducted at the Webster site between 1 March and 15 April 1988. A Photovac model 10S50 portable gas chromatograph was maintained on site throughout the duration of the field trial to measure the organic concentration of the influent water, at various locations within the sieve bed, and the effluent. Additional analyses for organic contaminants were performed by General Testing Corporation using EPA Methods 601, 602 and 624. The detection limits for these



methods range between 1 and 10 ppb, depending on the compound.

Results

The results of the PEROXSIV field trial may be summarized as follows:

1. The absorbent which required the addition of heat during regeneration was superior in its absorptive capability for the contaminants at the Salt Road site.
2. Both the ambient temperature and the heated absorbent were able to remove the volatile organic compounds to below the method detection limit in the site groundwater, as summarized below:

| <u>Compound</u> | Influent | Effluent |
|-------------------------|---------------|---------------|
| | Concentration | Concentration |
| | <u>ug/L</u> | <u>ug/L</u> |
| Vinyl Chloride | 342 | <10 |
| 1,1-DCE | 12 | < 5 |
| 1,1-DCA | 20 | < 5 |
| Trans 1,2-DCE | 3450 | < 5 |
| 1,1,1-TCA | 135 | < 5 |
| Carbon Tetrachloride | 17 | < 5 |
| TCE | 2750 | < 5 |
| Toluene | 40 | < 5 |



3. No by-products other than CO₂, H₂O and Chloride Ions were generated during the PEROXSIV process.
4. Metals in the site groundwater, particularly iron and calcium, were detrimental to the PEROXSIV system. These metals resulted in plugging of the bed which reduced the absorptive capacity. The metals also resulted in the premature catalyzation of the peroxide which increased the amount of peroxide acquired. The deposition of metals in the sieve bed was not observed during laboratory testing. Pretreatment for metals, primarily iron and calcium would be required in order for the system to be effective.

As a result of the Salt Road trial, Union Carbide Corporation notified Xerox on 17 June 1988 that it had decided not to commercialize the PEROXSIV process for application at the Salt Road site because of high system costs due to the metals fouling problem. Accordingly, the technology was not further considered.

Union Carbide Corporation and FMC Corporation made a joint presentation to the EPA and the DEC at the EPA Region 2 office in New York City on 12 May 1988. A copy of the field test report prepared by Union Carbide Corporation was provided to the EPA at that time.

5.3.3.2 Peroxidation Systems, Inc.

The Peroxidation Systems, Inc. (PSI) Perox-Pure process was pilot tested at the Salt Road site between July 1988 and March 1989. Prior to the pilot testing, Xerox provided samples of the Salt Road groundwater to PSI for laboratory analyses in June 1988. Results of the laboratory testing indicated that destruction of more than 90% of the volatile organic compounds in the Salt Road groundwater could be achieved.

The PSI unit tested at the Salt Road site was LV60 system which contained four 15,000 watt lamps and a reactor capacity of 80 gallons. The system has a hydraulic



capability of treating up to 180 gpm of flow. The actual flow rate is dependent on the residence time required to affect destruction of the organic contaminants.

The system as tested was equipped with adjustable power settings to each of the four lamps. The lamps could individually be turned off, or run on low or high power. Parameters evaluated during the field trial included:

1. Variations in organic loading.
2. Variations in influent peroxide concentration.
3. Various lamp settings.
4. Wavelength of UV light.
5. Pretreatment for iron.
6. Evaluation of maintenance frequency.

Initial field trials of the PSI unit indicated that it was capable of destroying more than 98% of the volatile organic contaminants present in groundwater at the Salt Road site. The trials were conducted at organic concentrations ranging from about 1 ppm to near 100 ppm total volatiles. Although the system design was intended to run at a peroxide loading equal to about 3 times the organic loading on a molar basis, wide variations in organic concentrations observed during the testing indicated the system was not overly sensitive to peroxide concentration. For the instances in which the peroxide loading fell well below the 3:1 recommended ratio, destruction efficiencies of over 90% could still be achieved.

Throughout the pilot trial, it was evident the destruction efficiency for the saturated organic compounds 1,1,1-TCA and 1,1-DCA were not as high as those of the unsaturated compounds such as Trichloroethylene. Research conducted by Dr. William Glaze at UCLA, partially funded by Xerox, indicated the destruction efficiency for TCA could be improved if the wavelength of UV light emitted by the lamps in the reactor vessels was more on the order of 210 nanometers than that of standard mercury UV lamps, which have a peak output closer to 260 nanometers. PSI installed new lamps in the reactor vessel during the pilot trials which reportedly



produced more UV light at the lower wavelength. Trials conducted after the installation of these lamps indicated generally lower overall destruction efficiency for all of the compounds present at the site and all the lamps were subsequently replaced with the original bulbs.

The unit was particularly susceptible to fouling by iron during the pilot trial. The ambient iron concentration in the groundwater at Salt Road ranges up to about 6 ppm. Upon entering the reaction chamber, the iron is precipitated on the quartz sleeves which shield the UV lamps. As a result, the amount of UV light entering the reaction chamber is substantially reduced. The field trial indicated the quartz sleeves would require cleaning at a frequency of about once a week in order to maintain destruction efficiency above 95%.

In order to solve the iron precipitation problem, Xerox experimented with alternative metals pretreatment systems. A sand filter was installed by Peroxidation Systems, Inc. but was not hydraulically capable of handling the quantity of flow necessary to conduct the pilot trial. The iron prefilter system was not resolved prior to the end of the pilot trial.

Detailed information on the trial of this system, the Ultrox system and the Solarchem system was presented to a meeting at the American Chemicals Society at the HAZMAT Conference on 4 June 1990 in Atlantic City. A paper entitled "Oxidation Technologies for Groundwater Treatment" was published in "Emerging Technologies and Hazardous Waste Management, Volume 2" by the American Chemical Society in August 1991. A copy of the article is included in Appendix C.

5.3.3.3 Ultrox System

The Ultrox treatment system was pilot tested at the Salt Road site between March 1989 and March 1991. The model 725 system contained seventy-two 65 watt lamps and a reactor volume of 725 gallons. The system includes hydrogen peroxide and ozone in the treatment process. The parameters evaluated during the field trial

included:

1. Organic loading
2. Flow rate
3. Iron pretreatment
4. Variations in peroxide in ozone concentrations
5. Maintenance frequency

The pilot program indicated the system was capable of achieving destruction efficiencies of more than 98% of the total volatiles present. The destruction efficiency for the saturated chlorinated organics 1,1,1-TCA and 1,1-DCA was on the order of 70%. The system was less susceptible to fouling by iron precipitation, most likely due to the lower intensity UV lamps installed in the process. The reaction time for groundwater in the unit was on the order of 24 minutes.

Further detail on the field trial and discussion of the Ultrox results is contained in the article included in Appendix C.

5.3.3.4 Solarchem Environmental Systems

The Solarchem Environmental Systems Rayox unit was pilot tested between February and March 1990. The system tested consisted of a unit with a single 6 kilowatt lamp with a reactor capacity of 15 gallons. The system was also constructed with a mechanical wiper to clean the outside of the quartz sleeve to reduce the impacts of mineral scaling.

The Rayox system was tested for an approximately 2 week period and sufficient time was not allotted or optimization of oxidation process. The destruction efficiencies achieved for the system were generally in excess of 90%, but most likely could have been improved with further pilot testing. Based on the short duration test however, it appeared the mechanical cleaning device installed to clean the outside of the quartz sleeve was effective at minimizing the impact of iron



precipitation on destruction efficiency. Further detail on the pilot trial and results of pilot testing of the Rayox system are discussed in the article in Appendix C.

VI. SUMMARY OF REMEDIAL INTERIM MEASURES

Xerox Corporation began conducting remedial interim measures (RIM) coincident with the discovery of contamination in the Salt Road Courtyard. As stated in Section V, Xerox's objectives in performing the RIM activities have been:

1. Furnishing of public water to property owners surrounding Xerox.
2. Purchase of 81.4 acres of land and four residential dwellings.
3. Removal of source material.
4. Abatement of migration of contaminants from the source area.
5. Abatement of further migration of dissolved phase contamination.
6. Reduction of groundwater-borne contaminate levels.

In order to accomplish these goals, Xerox Corporation has undertaken RIM activities for the remediation of soil contamination in the Salt Road source area, groundwater pumping over the extent of contaminant plume, and on-site treatment of the contaminated groundwater. The RIM activities in each of these areas are summarized in the following sections.

6.1 FURNISHING PUBLIC WATER

After discovery of the contamination along Salt Road, Xerox Corporation arranged with Monroe County Water Authority to provide a municipal water supply to residents of Phillips, Schlegel, Salt and Basket Roads who had previously relied on well water. All of the residences were connected to the public supply by 1986, at an expense of approximately \$300,000 to Xerox.



6.2 LAND ACQUISITION

Xerox acquired four dwellings along Salt Road and 81.4 acres of land in transactions between 1986 and 1991. The lands acquired are lands east of Salt Road indicated on Figure 2-1 .

6.3 SOIL REMEDIATION

The soils in the courtyard at the Salt Road site were the only on-site soils exposed directly to contaminants as a result of the release from the underground spill containment tanks in the courtyard area. Other soils within the site area may have been contaminated as a result of contact with contaminated groundwater or as a result of the volatilization of contaminants from groundwater underlying the soil. Contaminated soil has been identified north of Building 214 which does not appear to result either from the direct release of contaminants associated with the Salt Road operations or contamination by groundwater. The source of this contamination is unknown.

Xerox undertook the remediation of the soils in the Building 223 and 224 courtyard in 1984 and 1985. Xerox contracted the excavation of approximately 525 cu. yds. of soil from the northern half of the Building 224 courtyard in 1984. This soil was transported to the Model City Landfill in Niagara Falls, New York for disposal. The soil from ground surface to the top of bedrock was removed and replaced with 1-1/2 to 2 in. diameter gravel.

Xerox contracted for the excavation of approximately 100 yards of soil from the southern portion of the courtyard near the northeast corner of Building 224 east of the toluene storage tanks in June 1985. The soil was disposed of at a secure landfill. This second phase of soil removal constituted the removal of the remaining soil in the courtyard areas. Both the northern and southern half of the Building 224 courtyard have been backfilled with gravel.

6.4 GROUNDWATER EXTRACTION MEASURES

Groundwater extraction as a RIM activity began in 1986 with the installation of Recovery Wells 1, 2, 3 and 4 by O'Brien & Gere of Syracuse, New York. Recovery wells 1, 2, and 3 were located east of the Salt Road facility along the western side of Salt Road and were intended to inhibit further



offsite migration of the contamination. Recovery well 4 is located to the west of the Building 224 courtyard and was intended to capture contamination migrating from the source area.

The initial groundwater recovery wells were installed with casing diameters approximately 3-1/2 inches. The wells were equipped with jet pumps and were capable of producing water at flow rates ranging from about 0.1 to 4.5 gpm. The wells were operational for about a 6 month period until maintenance problems caused their shutdown. Iron bacterial growth and iron precipitation had plugged the wells, the pumps and the 1 inch discharge line to the air stripper in Building 348. As a result, the groundwater pumping system was not effective at recovering contamination.

H&A of New York was retained in early 1987 to develop a groundwater remediation system for the Salt Road site. After groundwater pumping was selected as the desired course of action by Xerox based on a technology review by H&A, as summarized in Section 5, the following objectives were defined for the groundwater pumping system:

1. Provide a hydraulic barrier to further groundwater contaminant migration.
2. Reduce contaminant levels to drinking water standards, with initial focus being on the areas east of Salt Road.
3. Abate further migration of groundwater-borne contaminants from the source area.

The current groundwater remediation system at Salt Road consists of 14 pumping wells. A chronology of the installation of the wells along with information such as the maximum pumping rate and the average total organic concentration is included in Table 6-1. Four of the pumping wells are installed in fractured rock trenches and pump the majority of the contaminated groundwater on the site to the Building 348 treatment center. Wells 12, 13 and 8 were installed near the blasted trenches associated with the utility lines installed for Building 214. As a result, these wells are also capable of pumping water at rates higher than wells constructed in the surrounding unfractured bedrock would have individually yielded. The recovery wells, the blast fractured trenches and the groundwater transmission lines are shown in Figure 6-1.



6.5 GROUNDWATER TREATMENT REMEDIAL INTERIM MEASURES

Xerox Corporation installed an airstripper in Building 348 in early 1986 to treat the groundwater from the initial four pumping wells. The air discharge from the stripper was permitted by the New York State DEC. The initial airstripper was designed to treat up to a maximum of 150 gpm of groundwater flow with a 98% removal efficiency. Due to the iron fouling problems with the initial recovery wells, the actual quantity of water routed through the airstripper prior to the replacement of the four pumping wells was less than 1 million gallons.

Because of the presence of vinyl chloride in the groundwater waste stream and Xerox's desire to reduce overall air emissions, Xerox pursued other treatment technologies for groundwater as discussed in Chapter V. The groundwater pumping throughout the 1988 to 1990 period was routed through the various pilot-scale treatment units at the Salt Road site and then subsequently routed through the airstripper for further treatment. Accordingly, the site groundwater received varying amounts of pre-treatment prior to entering the airstripper during this time period.

In an effort to reduce the influence of dissolved iron on the efficiency of the pilot oxidation systems, an iron pre-treatment system was installed in Building 348. The system consists of a Ronningen-Petter 5 micron automatic backwash microfilter. The majority of the iron in the Salt Road groundwater precipitates during the approximate 20 minute transmission time in the groundwater transmission lines. The filter system installed consists of a 5 micron self backwashing filter and is capable of removing about 90% of the iron in the groundwater.

Xerox began installation of a 250 gpm capacity Ultrox treatment system in Building 348 in November of 1990. The system is currently in operation has been consistently demonstrated to achieve greater than 95% destruction of the organic contaminants in the groundwater at Salt Road.

6.6 EFFECTIVENESS OF REMEDIAL INTERIM MEASURES

The basis for the evaluation of any future remedial action at the Salt Road site will be determined by evaluating the effectiveness of the remedial interim measures conducted to date. An evaluation of the effectiveness of the measures related to soil and groundwater are summarized below.

6.6.1 Soil Remedial Interim Measures

The contaminated soils in the source area were removed and disposed of by Xerox Corporation as defined in Section 6.2. With the exception of the soils at the north end of Building 214, the need for additional remediation of soil will not be evaluated until the Salt Road groundwater has been remediated, in accordance with consent order provisions. The need for remedial action on the soils north of Building 214 is evaluated in Chapter VII.

6.6.2 Effectiveness of Groundwater Extraction Remedial Interim Measures

As stated in Chapter III, the long term goals of the remediation at Salt Road are to minimize impact to human health and the environment and to restore groundwater quality at the site. The effectiveness of the present groundwater extraction system in meeting these goals can be evaluated by reviewing the performance of the remediation system since installation in 1988.

6.6.2.1 Contaminant Mass Reduction

As a measure of system effectiveness, the reduction in contaminant mass resulting from the groundwater extraction system has been evaluated using three methods:

- o Chemical concentration contour plots
- o Concentrations polygons/mass calculations

o Volume/concentration of treated groundwater

Xerox Corporation has performed more than 50 rounds of chemical testing on the monitoring wells at the Salt Road Site since 1985. Seasonal trends in concentrations are evident in the data, as discussed in the RFI. The maximum concentration in groundwater occurs in the fall and is reflected in the October sampling round data. In order to accurately represent the mass reduction resulting from the remedial interim measures, the change in concentration with time was evaluated using data from the October sampling round of each year since implementation of the RIM, with the exception of 1992, for which October data is not yet available. Data from April 1992 was utilized for comparison purposes.

Contour Method

The intermediate zone contour plots generated using the October 1988, 1990 and April 1992 data are included in Figures 6-2, 6-3 and 6-4. The plots do not include the portion of the plume west of Bldg. 214 because recovery well 15 was not installed until 1991 and no measurable contaminant reduction was occurring prior to its installation. The dissolved phase contaminant mass for each year was estimated from the contour plans by calculating the area contained in each contour and multiplying it by the mid point concentration of the contour interval, a saturated thickness of the aquifer of 10 ft. and an aquifer porosity of 10 percent. As an example, the mid-point concentration between the 100 parts per billion and 1,000 parts per billion (or 1 ppm) contour interval was assumed to be 500 ppb. Using this method, the estimated dissolved phase contaminant mass in the intermediate aquifer (with the exception of the western edge of the plume) was as follows:

| Contaminant Mass | |
|------------------|------------------|
| <u>Year</u> | <u>in Pounds</u> |
| 1988 | 4500 |
| 1989 | 1105 |



| | |
|------|-----|
| 1990 | 825 |
| 1992 | 410 |

The estimated intermediate zone dissolved phase contaminant reduction between 1988 and 1992 using this method is approximately 92 percent. The contour plots indicate the area encompassed by the 10 ppb contour line has been reduced by about 25% since 1988.

Contour plots for the shallow zone are included as Figures 6.5, 6.6 and 6.7 for 1988, 1990 and 1992, respectively. The plots indicate over 45 percent of the shallow aquifer plume identified in the 1988 data had been brought below drinking water standards (5 ppb) by 1992.

Polygon Method

The contaminant mass reduction since 1988 was also calculated using the polygon method and the October analytical data for 1988, 1989, and 1990. Figure 6-8 shows the influence polygons calculated for the intermediate aquifer at the Salt Road site. The contaminant mass within each influence polygon was calculated for each of the four years and the data is summarized in Table 6-2. The method results in an estimated reduction and dissolved phase contaminant mass in the intermediate aquifer of from (4620 lbs. in 1988 to 665 lbs. in 1990, or approximately 85 percent).

Treated Contaminant Mass

Xerox has maintained records of the volume and concentrations of contaminated water entering Building 348, as presented in Figure 6-9. Based on this information, the calculated dissolved phase contaminant mass recovered between 1988 and September 1992 equals approximately 4000 pounds. Contaminant mass recovery was calculated for the Building 348 treatment system, and for the individual wells independently. These calculations yielded similar results. This value agrees well with the estimated contaminant mass removed calculated using concentration



contours and the polygon method particularly when natural volatilization and biodegradation are considered.

6.6.2.2 Zone of Capture

In addition to the percentage contaminant mass reductions, the zone of capture is also a measure of the effectiveness of the Remedial Interim Measures. Figure 3-4 presents the zone of capture of the 15 pumping wells at the Salt Road site relative to the known extent of contamination as documented by available data. Based on this information, nearly the entire shallow groundwater plume is contained within the zone of capture of the pumping well system. Following the installation of a blast-fractured trench located north of Building 215, the zone of capture expanded to encompass nearly the entire plume in the intermediate zone. The expanded portion of the zone constitutes the small area of the plume located north of Building 210 which was previously not contained.

6.6.2.3 Effectiveness of Groundwater Treatment RIM

Based on the results of the 2-1/2 years of pilot testing of Advanced Oxidation Processes discussed in Chapter V, Xerox Corporation installed a 250 gpm Ultrox treatment system beginning in November 1990. The system is currently running on a routine basis with approximately 90% up time, and approximately 95% destruction efficiency.

The effluent from the Ultrox system is routed to the airstripper previously installed at the site. The airstripper was modified by reconfiguration of the distributor ring to accommodate a flow of up to 200 gpm. The effluent from the ultrox system is routed to the airstripper at flow rates of up to 200 gpm. Ultrox effluent in excess of 200 gpm is routed to the sanitary sewer system.

The effluent from the airstripper was routed to the sanitary sewer until September of 1992 when Xerox obtained a SPDES discharge permit to discharge the effluent



from the treatment building to the surface swale south of Building 348. The results of the Advanced Oxidation Process installed in Building 348, indicate the air emissions are substantially reduced.



VII. HUMAN HEALTH AND ENVIRONMENTAL ASSESSMENT

This section presents the results of a human health and environmental assessment conducted as part of the CMS according to the procedures outlined in the EPA RCRA Facility Investigation Guidance document (1989). The objectives of this section are to determine the potential pathways and routes for human health and environmental exposure that may exist presently at the Salt Road site and in the foreseeable future, and to identify the need for remedial action to abate potential exposures, in addition to actions already implemented as RIM.

The assessment is based on the conditions that exist at the site at present, following implementation of the RIM activities and as represented by the analytical data from the most recent sampling rounds. Potential exposure pathways via groundwater, soil and surface water may have existed prior to the implementation of the RIM activities. However, this assessment addresses only those exposure pathways that have not been mitigated by the RIM.

7.1 IDENTIFICATION OF CHEMICAL COMPOUNDS OF CONCERN

Chemicals of potential concern, as defined in EPA's Risk Assessment Guidance Manuals (1989), are chemicals that are potentially site related and for which analytical data are of sufficient quality for use in a quantitation risk assessment.

A number of studies have been conducted at the Salt Road site by H&A of New York and others. In addition to site characterization studies, data have been collected to evaluate the groundwater remedial program and soil excavations undertaken at various locations at the site.

Due to the phased approach of the site characterization and remediation, analytical data span about seven years of sample collection and analyses. Data for the site were gathered from available sources and reviewed for inclusion in this human health and environmental assessment. Analytical data spanning the most recent full year for which it was available was chosen to best represent current conditions for groundwater. Results were obtained from Quarterly Reports 10, 11, 12 and 13, reflecting sampling that occurred in 1990.



Compounds of concern detected in groundwater are chloroethane, 1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, tetrachloroethene, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethene and vinyl chloride (Table 7-1).

Samples were collected from the stream and pond located to the east of Salt Road in March of 1991. The sampling event and results are discussed in the Quarterly Report. No compounds were detected in the Study Area 3 stream or pond. Therefore, the surface stream is not considered to contain compounds of concern.

Soils containing solvent compounds which may be considered "Source Soils" are located to the north of Building 214. The source of the contamination is unknown and is not considered to be related to the Salt Road operations. Analytical data for soils from Building 214 reflect samples collected and reported in progress report No. 10 November 1989 to February 1990, Salt Road Remedial Investigation Wester, New York by H&A of New York, dated February 1990. Compounds of concern detected in soil are shown in Table 3-2 and include: benzene, chloroform, 1,2-dichloroethane, 1,2-dichloroethene, ethylbenzene, tetrachloroethene, toluene and xylene.

7.2 EXPOSURE ASSESSMENT

The exposure assessment is a process in which possible routes are evaluated by which humans may come in contact with compounds identified at the site. These include incidental ingestion dermal absorption and inhalation. First, pathways of exposure for these routes are evaluated for each medium affected at the site. Potential exposures during current site use conditions and foreseeable future use conditions are included. Next, potential concentrations at which exposure could occur are derived for each medium and use conditions.

The current use condition is defined as a condition at the site which may result in an exposure based on the current use of the site. Future use conditions are a set of hypothetical conditions based on a foreseeable future use of the site.

7.2.1 Groundwater

As indicated in Section VI, the groundwater contamination at the Salt Road site is contained within the zone of capture created by the pumping wells installed during the RIM program. The potential pathways of exposure for groundwater contamination typically include migration into drinking water wells, basements, and surface streams. Based on the available data, groundwater contamination at the Salt Road site is considered to be contained within lands owned by Xerox Corporation. Xerox is supplied water by the Monroe County Water Authority and no water supply wells are present on the facility. In addition, groundwater in the Salt Road area contains high levels of natural sodium and chloride, hence the name "Salt Road", which make it unacceptable for potable or industrial uses without extensive treatment. Therefore, no potential exposure pathway for human exposure is considered to exist for the Salt Road groundwater while the groundwater extraction system is operating.

As a result of the pumping of the recovery wells, the water table in the Salt Road aquifers is depressed below the level of the surface streams. Accordingly, discharge to surface waters of contaminated groundwater at the Salt Road site is highly unlikely. Consequently, no pathway exists for surface water discharge from groundwaters.

Xerox Corporation acquired the four residential dwellings east of Salt Road that were within the known extent of contamination of the Salt Road plume. No other residential dwellings exist within the area of contamination, and further migration of the contamination has been abated by the installation of the groundwater pumping system. Therefore, no exposure pathway for groundwater migration into basements exists at the Salt Road site.

7.2.2 Soil

The source soil north of Building 214 is within the fenceline of the Building 214 restricted area. ^{RESTRICTED} Access to this area is controlled by Xerox security. ^{DEP} Because of the location of the contaminated soil ^{IS ADJACENT TO A WAREHOUSE FACILITY} relative to Xerox operations, ~~groundskeepers or maintenance personnel are the only individuals with the potential for exposure to soils near Building 214.~~



SEE POTENTIAL
P

HSP diet prob required
monitoring VOCs!

The primary potential exposure route through which humans encounter compounds in soil is by incidental ingestion. Compounds in soil may also be available for human contact/exposure following intermedia transfer to air or groundwater. Ambient air monitoring for organic vapors conducted during numerous site investigations did not indicate the presence of volatile organic compounds in ambient air above the known area of contamination. Therefore, the transfer of volatile contaminants from soil to ambient air is not considered a potential exposure pathway for the Building 214 soils.

The contaminants in the soils north of Building 214 may be leachable into groundwater. However, the location of the contaminated soils is within the zone of capture of recovery wells 8 and 12, ^{and potentially 12.} as indicated on Figure 3-4. Any contaminants leaching from the soils in this area are expected to be intercepted by the groundwater pumping system. Accordingly, the potential exposure pathway from the soil to groundwater has been mitigated by the RIM. In summary, the potential for ingestion of contaminated soils north of Building 214 is the only potential route of exposure identified for the Salt Road contamination that requires an evaluation of risk for human health.

7.2.3 Air

The Ultrox unit destroys over 95% of the contamination in groundwater prior to discharge to the air stripper. The constituents remaining after the oxidation process are discharged to the air via the air stripper. The air stripper is at a height of approximately 44 feet above ground level and the concentrations of the organic constituents are greatly reduced by dispersion before contacting the ground surface in the site vicinity. Xerox operates under a NYSDEC air permit, and has historically emitted significantly lower quantities than the air permit allows. With the Ultrox system in operation, the air stripper emits less than one pound of volatiles per week to the atmosphere. A copy of the air permit is included in Appendix E.

7.3 EXPOSURE CONCENTRATIONS

This section describes how the potential concentrations at which exposure could occur were obtained. The first part describes how exposure concentrations were selected or derived and the



second part describes the exposure concentration (level) calculations for the pathway and route of exposure.

7.3.1 Source Media Contaminant Concentrations

One exposure pathway was identified in Section 7.2 and this originates from soils within the site boundaries. Compound levels that were detected at least once in surface soil samples from the Building 214 area of the site have been used to calculate the potential exposure concentrations (levels). The maximum detected concentration (levels) for each compound in surficial samples were used as the reasonable maximum exposure concentration (levels); the average detected concentration is considered the likely exposure concentration (levels) as included in Table 7-2. Since sample quantification limits for the analytes were low enough to allow for detection of contaminant levels above toxicity reference values, sample detection limits were not used as surrogate concentrations.

Chemicals that were detected in only one sample were considered as a reasonable maximum exposure scenario at the concentration (levels) identified, rather than by averaging over the total number of samples analyzed.

7.3.2 Exposure Estimation Methods

Exposure estimates based on human health criteria require certain assumptions for the intake of contaminated soil. The Building 214 contaminated soils are contained within an area of restricted access which is also an industrial Free Trade Zone. Access to the area is limited by an 8-foot high chain link fence topped with barbed wire. Access to the site is only available through a security gate, manned 24-hours per day along Mitcheldean Drive. In addition, the area is patrolled on a regular basis by Xerox security.

Building 214 is used primarily as a warehouse operation. The area north of Building 214 which contains the contaminated soils is part of the landscaping buffer of the building. Routine access to this area is limited to Xerox groundskeeping and maintenance staff. Xerox Corporation intends to continue the current site usage for an indefinite period of time.

Based on the site access restrictions and the future site usage, the potential exposure scenario for the Building 214 soils is limited to non-intentional, intermittent ingestion of contaminated surficial (less than 2-ft. depth) soils. Groundskeeping and maintenance activities to the north of Building 214 are limited to the summer months between May and October.

The oral intake assumption assumed in this assessment for carcinogens is 100 milligrams of soil per day, for a 70-Kg adult and for systemic toxicants, 200 mg of soil per day, based on 5-year exposure period for a 16-Kg child.

7.3.3 Exposure Levels

The maximum exposure levels for Building 214 contaminated soils are considered to be the maximum concentrations detected in the surface soils (less than 2-ft. depth). The likely exposure level is considered to be the average concentration of the ten surficial samples. The compounds detected and their maximum and average levels in surface soils are as follows:

| <u>Compound</u> | <u>Maximum Levels</u> <u>(Micro grams per Kilogram)</u> | <u>Average</u> <u>Levels</u> |
|--------------------|--|---------------------------------|
| 1,2-dichloroethene | 452 | 51.9 |
| Chloroform | 18.7 | 2.8 |
| trichloroethene | 356 | 40.3 |
| tetrachloroethene | 27800 | 4250 |

7.4 TOXICITY ASSESSMENT

The toxicity assessment is composed of an identification of potential adverse health effects that may be associated with exposure to the compounds identified (hazard assessment), and identification of toxicity values for assessing the potential for adverse effects to occur resulting from the exposure (indices of toxicity).

7.4.1 Hazard Assessment

The hazard assessment describes the potential toxic properties of chemicals of concern in the Building 214 soils. Exposure concentrations which may be associated with adverse effects are discussed below.

Chloroform

Chloroform is in the group of compounds referred to as trihalomethanes which are formed from the interaction of chlorine with organic materials found in water. Several case-control studies suggest a positive correlation between drinking chlorinated water and the incidence of several human cancers, particularly bladder, rectal and colon cancer.

The studies considered exposure to a mixture of compounds including chloroform which is considered to be a probable human carcinogen, thus the data are considered inadequate for assessing individual components of the trihalomethane group.

Chloroform has produced central nervous system depression and hepatic and renal teratogenic and carcinogenic effects at oral dose levels ranging from 30 to 350 mg/kg.

1,2-Dichloroethene (1,2-DCE) ✓

1,2-DCE is a synthetic organic chemical which most likely occurs in the 214 soils as a degradation product of perchloroethene and trichloroethene. There are two forms of 1,2-DCE, the cis-1,2-DCE and trans-1,2-DCE isomers which may occur separately or as a mixture. Inhalation of high levels of 1,2-DCE can cause nausea, drowsiness, and may result in death. Liver, heart, and lung damage were observed in laboratory animals after short- or long-term exposure to 1,2-DCE in air or food. Humans exposed to 1,2-DCE vapors reported nausea, fatigue, dizziness, and intracranial pressure at vapor concentrations greater than 4.8 ppm. The relative potencies of the cis- and trans- isomers have not been adequately evaluated.

Tetrachloroethene (Perchloroethene, PCE) ✓

PCE is a synthetic organic chemical which is widely used for dry cleaning fabrics, for metal-degreasing operations, and in the manufacture of other chemicals. Humans may be exposed to PCE by breathing air or ingesting food or water which have been contaminated with it. Exposure to high concentrations in air, particularly in confined areas, can cause central nervous system effects which may be expressed as dizziness, headache, sleepiness, confusion, nausea, and possible unconsciousness and death. Animal studies, conducted with concentrations much higher than those usually encountered in the environment, suggest that PCE can cause liver and kidney damage, developmental effects on fetuses, toxicity to pregnant animals, liver cancer, and leukemia. Based on the evidence from animal studies, PCE is considered a probable human carcinogen.

Minimum Risk Levels (MRLs) have been derived based on noncarcinogenic effects for long-term oral exposure. The MRL for long-term oral exposure is 0.125 mg/kg/day. At concentrations above the MRL, liver and kidney toxicity and shortened life span may occur based on effects observed in laboratory animal studies.

Trichloroethene (TCE) ✓

TCE is used as a cleaning agent and solvent for degreasing operations. TCE may cause adverse health effects following exposure via inhalation, ingestion, or skin or eye contact. TCE may cause drowsiness, dizziness, headache, blurred vision, lack of coordination, mental confusion, flushed skin, tremors, nausea, vomiting, fatigue, and heart arrhythmia. Exposure of laboratory animals to TCE has been associated with an increased incidence of a variety of tumors and TCE is considered a probable human carcinogen. MRLs for noncarcinogenic effects have been derived for oral exposure. The MRL for ingestion of TCE is 0.125 for ppm short-term and 0.1 ppm for long-term exposures.

7.4.2 Indices of Toxicity

Indices of toxicity are derived by the EPA for use in assessing the potential for the adverse effects described in Section 7.4.1 to occur. These values are also used in the EPA RFI Guidance document for deriving the health-based criteria and may be used as a benchmark for comparison to levels humans may encounter in the environment. For potential carcinogens, the value is the slope factor (SF), for noncarcinogens the value for oral exposure is the reference dose (RfD). SFs and RfDs include adjustments to reflect human variability and, where appropriate, the uncertainty of extrapolating from laboratory animal data to humans.

Compounds identified in the surficial soils at Building 214 at the site are considered either non-carcinogenic; probable or possible carcinogens; or not classifiable. To assess the carcinogenic potential of each compound, a risk of developing cancer of 1×10^{-6} or 1×10^{-5} is used to derive the health-based criteria. As used here, the term carcinogen means any chemical for which there is sufficient evidence that exposure may result in continuing uncontrolled cell division (cancer) in humans and/or animals. These definitions are not static, rather compounds may be reclassified when additional evidence becomes available which shifts the weight-of-evidence.

The classification of chemicals at the site and the RfDs and/or SFs derived for each are presented in Tables 7-2 and 7-3. Recognizing that the indices of toxicity and carcinogenicity classification are subject to change based on current toxicity data, the latest available values are presented in the tables. These values may supercede those contained in the RFI Guidance document for deriving health-based criteria.

7.5 DERIVATION AND USE OF HEALTH-BASED CRITERIA

7.5.1 Health-Based Criteria

Using the indices of toxicity discussed in Section 7.3.2, health-based criteria for the Xerox Salt Road site were derived using procedures specified in the RFI Guidance document. For noncarcinogens, criteria were calculated in the following manner:



$$C_i = (RfD)(W/I)$$

where:

C_i = Criterion level for constituent of interest (mg/Kg);

RfD = Reference Dose (mg/Kg/day);

W = Adult Body Weight (70Kg); and

I = Ingestion Rate (0.1 gm/day of soil to 70 Kg person).

For carcinogens, criteria were calculated using the equation:

$$C_i = (R/q_1^*)(W/I)$$

where:

C_i = The criterion concentration for the constituent of interest; and

R = The specified risk level (1×10^{-6} for Class A and B carcinogens and 1×10^{-5} for Class C carcinogens.

q_1^* = The carcinogen slope factor (SF) in (mg/kg/day) developed by the Carcinogen Assessment Group (CAG) of the EPA, Office of Health and Environmental Assessment, or the Agency's Carcinogen Risk Assessment Verification Endeavor (CRAVE) workgroup;

W = The assumed weight of the exposed individual (16 Kg); and

I - Ingestion rate (0.2 g/day of soil based on a 5 year period for a 16 Kg child).

Carcinogen and systemic toxicant health-based criteria for ingestion of compounds of concern in soil are presented in Table 7-4, along with maximum and average detected compound soil levels for comparison. The maximum soil levels represent a reasonable maximum exposure scenario. The average soil levels represent a likely exposure scenario.

7.5.2 Criteria Comparison

Assuming ingestion of soil would be limited to the upper two feet because the area is a landscape buffer with restricted access, none of the compounds of concern had average or maximum concentrations that exceeded the health-based criteria for carcinogens and systemic toxicants. The highest concentration of perchloroethylene (121 ppm) was from a sample from the two to four feet depth in one of the borings. Because the foreseeable future use of the site is the same as the current use and because of the restricted access of the area, the occurrence of this elevated concentration at depth does not present a reasonable exposure scenario for comparison with human health based criteria.

VIII. SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES

The purpose of this section is to identify areas of the site requiring remedial action in light of the Corrective Measure Goals outlined in Section IV, the effectiveness of the remedial interim measures conducted at the site to date described in Section 6.4, and the human health and environmental assessment presented in Section 7.0. In light of this information, the following conclusions can be drawn:

1. Groundwater contamination at the Salt Road Site is contained in the zone of influence of the groundwater recovery wells installed during the remedial interim measures.
2. The remedial interim measures have been effective at removing more than 80 percent of the intermediate zone dissolved phase groundwater contamination at this site since 1988. In addition, more than 40 percent of the shallow zone contamination has been brought to within the cleanup goals since 1988. The majority of the area which has been brought below drinking water standards lies east of Salt Road or the lands acquired by Xerox. Accordingly, the potential risk to human health or the environment resulting from this shallow contamination has been abated in these areas.
3. The Ultrox oxidation system for groundwater treatment installed during the remedial interim measures program will be effective at reducing air emissions by over 95 percent as compared to conventional air stripping technology.
4. Although contaminated soils exist north of Building 214, they are within the zone of capture of the groundwater pumping system. Therefore, leachate generated by storm water infiltration is captured by the existing pumping system. Under the probable exposure scenario for the continuation of the existing site use into the foreseeable future, the concentrations of contaminants in the surface soils are below health-based ingestion levels. Therefore, remedial action, other than continuation of restricted access and operation at the groundwater pumping system currently installed, is not required to abate impacts to human health or the environment resulting from these soils.



The area in question north of Bldg. 214 is within a secure fenced, guarded portion of the Xerox property. Xerox will maintain the current level of security for the area. If residual contaminants are detected in the soil following groundwater remediation, Xerox will review the need for remediation of these soils based on standards in effect at that time with the EPA and DEC. If Xerox elects not to remediate the soils at some future date with concurrence of the EPA and DEC, a notification will be incorporated into the deed of the portion of the Xerox property in question, or on a similar instrument which is normally examined during title search that will, in perpetuity, notify any potential purchaser of the property that the land had been used to manage hazardous waste or hazardous constituents.

8.1 SCREENING OF GROUNDWATER CORRECTIVE MEASURES

Because the contaminants at the site is within the zone of capture at the pumping system installed during the RIM, no additional groundwater corrective measures were screened.

8.2 SCREENING OF SOURCE AREA ENHANCEMENT TECHNOLOGIES

The screening of enhancement technologies for accelerating the rate of contaminant recovery is presented on Table 5-1. None of the identified enhancement technologies pass all of the five screens. Therefore, none of the technologies are retained as corrective measures technologies.

8.3 GROUNDWATER TREATMENT TECHNOLOGY SCREENING

The screening of groundwater treatment technologies is presented in Table 5-1. None of the technologies evaluated match the performance of the Ultrox system which is currently installed on the site. Therefore, the Ultrox treatment system and air stripper polishing unit is retained as the groundwater treatment system for the current pumping wells.

IX. IDENTIFICATION OF CORRECTIVE MEASURE OPTIONS

Screening of Corrective Measure Technologies (CMTs) presented in Chapter VIII identified technologies applicable for remediation of groundwater at the Salt Road site. The purpose of this chapter is to determine which of the short-listed technologies should form the Corrective Measure Options (CMOs). The currently employed Remedial Interim Measures (RIMs) are groundwater pumping enhanced with blast-fractured trenches, and Ultrox volatile organic oxidation followed by air stripping. A technology will supplant the existing RIM as the preferred CMO only if it is demonstrably better than the RIM. Alternatively a technology may become part of the CMO if it will enhance the operation of the RIM or another CMO.

9.1 SELECTION CRITERIA

Technologies on the CMT short list have been evaluated in terms of projected performance, projected reliability, projected implementability, and projected safety and health effects. Technologies were evaluated with regard to these characteristics and compared to the RIMs. The selection criteria were:

- o Performance - effectiveness in achieving Corrective Action Objective, and useful life of the system components.
- o Reliability - acceptable operating and maintenance costs and consistent operation at similar sites.
- o Implementability - ease of installation or implementation, time to install, and time to achieve significant contaminant reduction.
- o Safety and Health - affects on the safety and health of Xerox and contractor employees, nearby communities and nearby environments during the implementation and lifetime of the technology.

9.2 IDENTIFICATION OF THE GROUNDWATER CORRECTIVE MEASURE OPTION

Based on the above-mentioned criteria, the following is a description of the entire groundwater Corrective Measure Option.

Groundwater Pumping

Groundwater pumping as an RIM has decreased the average VOC concentration in groundwater below the site by over 80% in two years, and therefore is an effective technology. This and the permanent nature of the pumping wells gives groundwater pumping a high performance rating. Reliability of the pumping system can be maintained, as proven by the more than 70 million gallons of water pumped since 1988, by an effective maintenance program. Implementability is good due to availability of materials and personnel, and because it is a known technology. There are no safety and health effects on workers or offsite populations aside from the physical hazards of well installation. This technology is selected as part of the CMO.

Blasted Trench Permeability Enhancement

This technology involves increasing the permeability of the bedrock in the vicinity of recovery wells to increase their capture zone and groundwater recovery rate. The performance of this technology has proven to be extremely high. The technology is efficient in increasing permeability, producing a ten-fold increase (H&A of New York, 1991), and in increasing groundwater recovery rate. The useful life of the technology is measured in geologic time, in that the permeability of the blasted zone is permanently increased. Reliability is high in that there is no operation or maintenance costs. Implementability is good in that four recovery wells are currently located in blasted trenches. The constraint on installing additional blasted trenches in the vicinity of the source is the shock and pressure waves caused by blasting, which may be damaging to sensitive computer equipment within Building 225. The only safety and health concerns are the physical hazards associated with well drilling and subsurface blasting, which are mitigated by safe field practices. This technology is selected as a CMO enhancement option.



Ultrox-UV, Chemical Oxidation

This technology has been employed to reduce air emissions by over 95 percent since 1988. The Ultrox system destroys chlorinated VOCs by chemical and ultraviolet light oxidation, producing chloride ions, CO₂, and water. The high continued efficiency, minimal negative effect on the environment and the projected long useful life gives this system a high performance rating. Pilot scale testing of this system has shown it to have long-term reliability and acceptable operation and maintenance costs. Implementability is completed, in that the system is already in place. The only health and safety concern is for workers within the treatment building due to possible elevated ozone levels. This is mitigated by continuous ozone monitoring and an automatic high ozone alarm system. This technology is selected as part of the CMO.

Air Stripper

This was the first groundwater treatment system employed at the Salt Road site, and is currently used as secondary treatment, or "polishing" of treated effluent from the Ultrox system. The system is extremely effective in removing the low levels of VOCs from the Ultrox effluent. The system has been operating continuously for approximately four years and has a long projected service life. The system is reliable and has minimal operation and maintenance costs. Implementability is good in that the system is in place and the air emissions are permitted. Safety and health concerns are minimal, and are associated with the emissions of stripped VOCs to the atmosphere. These concerns are minimal in that the concentrations are kept within permitted levels. This technology is selected as part of the CMO.

Treated Groundwater Reinjection

This technology enhances contaminated groundwater recovery in the courtyard area by flushing contaminants toward recovery wells 4 and 5. Surfactant or hot water flushing is an efficient technique in sandy aquifers (Abdul et al, 1990). The existing reinjection system and a pilot test of this system is described in Chapter V. This system was found to be ineffective during pilot testing in that the injected water filled the courtyard to the level of the top of the gravel. The ponded water did eventually infiltrate, and it was concluded the recharge afforded by the discharge of roof



drainage to the courtyard would sufficiently accomplish the flushing process. Reliability is good in that operation and maintenance costs are nonexistent if roof runoff is used. Implementability is good in that the basic system is installed. There are no safety or health concerns associated with this system. This system is selected as a ongoing CMO enhancement technique.

9.3 ENHANCEMENT TECHNOLOGIES

No feasible technologies were identified for the acceleration or enhancement of contaminant recovery at the Salt Road source area. Accordingly, as part of the CMI, Xerox should perform an annual review of available technologies for consideration in the source area. Bench or pilot testing may be warranted if feasible enhancement technologies are identified in the future.

X. PROJECTED EFFECTIVENESS OF GROUNDWATER CORRECTIVE MEASURES

10.1 INTRODUCTION

The selected corrective measure options for remediation of the groundwater contamination at the Salt Road site have proven to be effective in reducing the mass of dissolved phase contamination in groundwater at the Salt Road site. Analytical solutions have been developed by various authors to allow prediction of the time needed to achieve contaminant reduction to required levels. The analytical solutions require information on aquifer properties including diffusivity, dispersion and organic carbon present in the aquifer (Vangeunchten Alves, 1982). These aquifer properties are difficult to measure and are subject to a high degree of variability.

The analytical solution can be used to predict the rate of contaminant reduction and the time required to achieve a certain concentration. Xerox Corporation has obtained analytical data from the four years of groundwater pumping at the Salt Road site which can be used to demonstrate the actual rate of reduction in contaminant mass due to pumping without knowing the specific aquifer properties. Accordingly, the actual contaminant mass of reduction data has been used to develop equations for predicting the times required to achieve contaminant mass reduction.

Based on the continuing observations of the extent and degree of contamination several conclusions regarding the rate of reduction in contaminant mass:

1. The areas of the plume which occur at concentrations of less than a few parts per million of total volatile organics have experienced significant reductions in contaminant concentration. In these areas, it appears possible to reduce contaminant levels to below drinking waters standards in a relatively short time. This is evidenced by the reduction in contaminant concentrations in the vicinity of pumping wells 7, 10 and 11 as shown on Figure 6-4. Concentrations have been reduced from a few parts per million to a few parts per billion near recovery well 7; from several hundred parts per billion to less than a few parts per billion (ppb) in the vicinity of recovery well 10 and to below drinking water standards (5 ppb) in the vicinity of recovery well 11 since the inception of pumping. In addition, the areal extent of shallow contamination above



drinking water standards has been reduced by more than 40 percent since 1988.

2. The concentrations of contaminants in the source area at the Salt Road site have been reduced from near solubility levels (1100 ppm in the case of TCE) to concentrations on the order of 100 ppm since the inception of pumping. When the pumping wells in the source area shut down for maintenance reasons, the concentrations in those wells would be expected to increase slowly. Dense, non-aqueous phase liquids (DNAPL) have never been identified in more than 50 rounds of monitoring at the source area. It is likely, however, solvents permeated the bedrock and occupied dead end joints in the bedrock and pore spaces of the rock matrix. The rate of diffusion of this material into groundwater through solubilization has been shown to be extremely slow (USEPA 540/4-89-005, 1989). Matrix diffusion probably accounts for a portion of the increase in contaminant levels when the source area pumping wells are shut down. Accordingly, the analytical solutions for predicting contaminant reduction times are not applicable to the Salt Road source area. Also, no technologies exist which have been proven to be effective at accelerating the removal of solvent contamination from bedrock.
3. Given the high concentrations of contaminants in bedrock in the Salt Road source area, the rate of contaminant reduction at the site will probably achieve some type of asymptotic or "zero-slope" condition.
4. Given the conditions outlined above, it will be necessary to establish a procedure for determining when various portions of the site have achieved the cleanup goals, or when additional pumping or remedial measures will not be effective in further reduction of contaminant levels.

10.2 CONTAMINANT REDUCTION PROJECTIONS

Historical data were used to prepare contaminant reduction projections for the non-source areas of the Salt Road plume using historical data and the polygon method as described in Section VI. Contaminant reduction diagrams for TCE and 1,2-DCE for wells in the downgradient portion of the plume are shown in Figure 10-1. The time required to achieve drinking water standards in the downgradient portion of the plume is on the order of a few years. This projection is supported by

the fact that more than 40 percent of the shallow plume and more than 25 percent of the internal plume has been reduced to below drinking water standards since 1985. The majority of this reduction has occurred in the area east of Salt Road.

The actual time required to achieve drinking water standards in the entire plume area will depend on the rate of recharge, well pumping rates, the continued biodegradation of the contaminants, and other factors.

10.3 DETERMINATION OF COMPLIANCE WITH CLEANUP GOALS

It is envisioned the individual pumping wells at the Salt Road site will achieve differing levels of contaminant reduction at different times. Therefore, individual pumping wells can be shut down once the area of the plume within the zone of capture of that pumping well has achieved the cleanup goals. The procedure for determining compliance with the cleanup goals is outlined in this section.

10.3.1 Compliance With Drinking Water Standards

The areas of influence for the individual pumping wells based on water level data are shown in Figure 10-2. If all of the selected monitoring wells within the zone of influence of each pumping well are found to be below drinking water standards for eight consecutive quarters, a review of current technologies to further reduce the concentration of contaminants in the groundwater will be conducted. If the results of the review demonstrate that an alternate technology is not feasible nor available, a Termination Petition will be submitted to the Agencies for approval prior to shut off of any pumping well within that area. In the event that very low or non-detectable levels of contaminants are found, Xerox may submit a Termination Petition after four quarters. The determination of compliance with drinking water standards will be assessed through the use of Statistical Method Performance Standards as selected by Xerox and approved by the Agencies. Water quality within the capture zone of that pumping well will be monitored on a regular basis for 4 additional quarters. If the contaminant concentrations in groundwater remain below drinking water standards throughout the 4 consecutive quarters, that area of the plume will be considered remediated and semi-annual monitoring will be performed for a period of two years.

Following review and evaluation of the groundwater data, the EPA and the New

York State DEC will inform Xerox of its decision to allow termination of the groundwater corrective measures implementation program.

Based on the well shut-off procedure outlined above it is envisioned the pumping wells at the Salt Road site will be decommissioned beginning first with the downgradient-most pumping wells. The time required to achieve cleanup goals for the pumping wells within the interior of the plume are expected to be significantly greater than those on the periphery.

10.3.2 Asymptotic or "Zero-Slope" Condition

It is likely the contaminant concentrations for certain pumping wells, particularly those closest to the source area, will achieve an asymptotic or zero-slope condition at a concentration above drinking water standards. Once this condition is achieved, Xerox Corporation may petition the USEPA and the DEC if it concludes there is no alternate remedial technology capable of meeting the cleanup standards or further reducing concentration of organic compounds at the site. The procedure for determining when this condition has been met is described below.

The zero-slope condition occurs when the slope of the concentration vs. time plots for selected monitoring wells within the area of capture of individual pumping wells is determined to be essentially zero. This determination will be based on plotting the results of eight consecutive quarterly monitoring rounds. The regression model will be used to plot time versus concentration utilizing all well monitoring data by individual well and contaminant.

If the curve which best fits the data is linear, then a straight line using a least squares regression will be fitted to the data and the slope of the fitted line will be computed and designated as the estimated slope. If the data points are non linear, then an exponential curve will be fit using a least squares regression. The estimated slope will be the first derivative of the curve at a value of time halfway between the last two sample intervals. The slope will be determined to be zero if it is essentially equal to zero, or the yearly reduction in the total volatile organic concentration in the well is less than the average overall precision of the analytical methods used for the analysis.



The average overall precision, S_A , is calculated as follows:

$$S_T = \sqrt{\sum(S_1)^2}$$

where:

S_T = overall precision for the compounds in a single sampling episode

S_1 = overall precision for individual constituent in a single sampling episode

$$S_A = \frac{(\sum S_T/N)}{[\sum (X-\bar{X})^2]^{1/2}}$$

where $\sum S_T/N$ = arithmetic mean of precisions for all sampling episodes

S_A = average overall precision

\bar{X} = $\sum X/N$

where X = sampling period

N = number of sampling periods

*This factor = 1.62 for 8 consecutive quarters of sampling.

Upon determination by Xerox of a zero slope condition, and further determination by Xerox that no additional remedial technology which has been proven to be technologically feasible will be capable of meeting the regulatory standards or substantially further reducing levels of contamination in the groundwater, Xerox Corporation will petition the EPA and the New York State DEC to decommission the pumping well (S) for which the determination of zero slope has been made.

The USEPA and the New York State DEC have presented comments regarding the achievement of an asymptotic condition into a Draft Corrective Measures Study Report response letter dated 18 August 1992 and addressed to Xerox Corporation.

Xerox is in agreement with the conditions set forth by the Agencies, such that the Agencies will consider termination of the groundwater corrective measures implementation program prior to achieving State and Federal Groundwater Quality Standards if Xerox can demonstrate that:

- a. The drinking water standards for contaminants attributable to Xerox are met at all wells near Xerox's property boundary;
- b. The presence of any on-site groundwater contaminants does not pose an unacceptable risk to human health and the environment;
- c. The residual groundwater contaminants are not incompatible with future use of the Xerox property and adjacent property; and
- d. A "zero-slope" has been reached with regard to groundwater quality improvement (i.e., continued pumping will not result in any noticeable decrease in the concentration of groundwater contaminants).

After termination, Xerox will be required to monitor the groundwater to demonstrate that the levels of residual contamination are within an acceptable range. Also, a formal notification will be required on the deed of the portion of the Xerox property containing contaminant levels which are above state and federal groundwater quality standards, or on some other instrument which is normally examined during title search that will, in perpetuity, notify any potential purchaser of the property that the land had been used to manage hazardous waste.

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TABLE 3-1

SUMMARY OF DETECTED CONSTITUENTS IN GROUNDWATER

| COMPOUND | RANGE AREA 1 Upgradient | RANGE AREA 1 Downgradient | RANGE AREA 2 | RANGE AREA 3 |
|--------------------------|-------------------------------|---------------------------------|-----------------|-----------------|
| <u>SHALLOW ROCK</u> | | | | |
| Trichloroethene | 0-0 | 0-0 | 0-65 | 0-50,000 |
| 1,2-Dichloroethene | 0-4 | 0-0 | 0-90 | 0-15,000 |
| Toluene | 0-0 | 0-0 | 0-0 | 0-100,000 |
| 1,1,1-Trichloroethane | 0-0 | 0-0 | 0-0 | 0-9,500 |
| 1,1-Dichloroethane | 0-0 | 0-0 | 0-2 | 0-4,800 |
| Tetrachloroethene | 0-0 | 0-0 | 0-0 | 0-1,200 |
| Vinyl Chloride | 0-0 | 0-0 | 0-10 | 0-220 |
| <u>INTERMEDIATE ROCK</u> | | | | |
| Trichloroethene | 0-1 | 0-20 | 0-240 | 0-39,000 |
| 1,2-Dichloroethene | 0-0 | 0-70 | 0-3,000 | 0-20,000 |
| Toluene | 0-0 | 0-0 | 0-0 | 0-1,900 |
| 1,1,1-Trichloroethane | 0-0 | 0-1 | 0-40 | 0-170 |
| 1,1-Dichloroethane | 0-0 | 0-3 | 0-70 | 0-340 |
| Tetrachloroethene | 0-2 | 0-0 | 0-260 | 0-90 |
| Vinyl Chloride | 0-0 | 0-8 | 0-910 | 0-1,800 |

Notes:

- All concentrations are in ug/L and reflect chemistry of the annual sampling event, November 1990.
- Area delineation is shown on Figures 3-2 and 3-3.

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TABLE 3-2
SUMMARY OF SOIL CHEMICAL DATA
BUILDING 214

| ug/kg | # Detects | Max. | Location, Depth of Maximum |
|----------------------|--------------|---------|-------------------------------|
| Benzene | 4 | 6,420 | R-80, 3.0 - 4.5' |
| Chloroform | 3 | 1,329 | R-80, 3.0 - 4.5' |
| 1,2-Dichloroethane | 1 | 29 | 214 BS3, 4 - 6' |
| 1,2-Dichloroethylene | 27 | 2,859 | 214 DS3, 4 - 6' |
| Ethylbenzene | 1 | 35 | 214 BS3, 4 - 6' |
| Tetrachloroethylene | 38 | 121,000 | 214A-S2, 2 - 4' |
| Toluene | 29 | 22,530 | R-80, 3 - 4.5' |
| Xylene | 19 | 2,094 | R-80, 4.5 - 6.0' |

Notes:

- # Detects refers to the number of samples with concentrations above detection limits.

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TABLE 4-1

**DETECTED CONSTITUENT LEVELS IN GROUNDWATER VS.
CORRECTIVE ACTION OBJECTIVES**

| CONSTITUENT | Maximum Detected Concentration in Groundwater | Groundwater Corrective Action Objective |
|-----------------------|---|---|
| Trichloroethene | 50,000 | 5 |
| 1,2-Dichloroethene | 20,000 | 5 |
| Toluene | 100,000 | 5 |
| 1,1,1-Trichloroethane | 9,500 | 5 |
| 1,1-Dichloroethane | 4,800 | 5 |
| Tetrachloroethene | 1,200 | 5 |
| Vinyl Chloride | 1,800 | 2 |
| 1,1-Dichloroethene* | 60 | 5 |
| 1,2-Dichloroethane* | 270 | 5 |
| Chloroform* | 5,900 | 7 |
| Chloroethane* | 130 | 5 |
| Benzene* | 10 | 0.7 |
| Carbon Tetrachloride* | 60 | 5 |
| Bromodichloromethane* | 3 | 7 |
| Ethylbenzene* | 12 | 5 |

Notes:

1. Groundwater concentrations are in ug/L.
2. Groundwater detected concentrations reflect chemistry of the annual sampling event, November, 1990.
3. Groundwater Corrective Action Objectives based on New York State Sanitary Codes, Part 703, maximum concentration levels.
4. Groundwater detected concentrations for compounds with asterisks reflect the highest detected concentration between May 1990 and April 1992.

TABLE 4-2
 POTENTIAL GROUNDWATER CORRECTIVE REMEDIAL TECHNOLOGIES

LIMITED/NO ACTION

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|-------------------------------|-----------|--|--|
| Limited/No Action Groundwater | — | No action is taken to impede the flow of groundwater or contaminants. Contaminant levels in groundwater are monitored. | Applicable to non-mobile contaminants, or where natural processes are effectively remediating groundwater. |

CONTAINMENT

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|---------------------------------|-----------|---|---|
| Active Containment Groundwater | — | Groundwater flow velocity and direction is controlled by a series of extraction and/or injection wells. The wells create hydraulic barriers that prevent contaminated groundwater from travelling off-site. | Applicable to granular aquifers where groundwater movement can be accurately predicted and controlled. |
| Passive Containment Groundwater | — | Groundwater and/or contaminant migration is controlled by emplacement of a low conductivity slurry wall, either surrounding, upgradient from or downgradient from the contaminated area, depending on-site characteristics. | Applicable to granular aquifers where the slurry walls can be keyed into a low permeability horizon at depth. |

TREATMENT

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|---------------|-----------|---|---|
| Air Stripping | — | Volatile chemicals are transferred from the water phase to the air phase via diffusion. In the most efficient form, air stripping takes place in a tower packed with high surface area porous spheres. Air is pumped upward through the column. Contaminated water enters from the top, flows downward, and exits as treated water at the bottom. | Water contaminated with volatile organic chemicals. |

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TABLE 4-2
 POTENTIAL GROUNDWATER CORRECTIVE REMEDIAL TECHNOLOGIES
 (CONTINUED)

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|--------------------------------------|---------------|---|--|
| Air Stripping with Carbon Adsorption | -- | Same as above with the effluent air being treated by adsorption of volatile chemicals by activated carbon filters. | Water contaminated with volatile organic chemicals. Activated carbon filters must be replaced periodically. |
| Biological Aqueous Treatment System | Biotroll Inc. | Contaminated water enters a mixing tank where the pH is adjusted and inorganic nutrients are added. The water is heated, and then flows to the reactor where the contaminants are biodegraded, either under aerobic or anaerobic conditions. The contaminants are degraded to carbon dioxide, water and chloride ion. | Applicable to aqueous streams contaminated with organic compounds and other hydrocarbons. Not applicable for removal of metals. |
| Biological Treatment | -- | Organic chemicals in water are oxidized by aerobic bacteria in an above ground activated sludge process. Groundwater is pumped first to an aerated reaction tank where the bacterial digest the organic chemicals, forming sludge, then to a clarifier where the sludge settles. Alternately biological treatment can take place in a trickling filter. | Groundwater contaminated with organic chemicals. |
| In-Situ Bioremediation | -- | Organic chemicals in soil or groundwater are oxidized by aerobic bacteria within the ground to carbon dioxide, water and chloride. This process is enhanced by the injection of nutrients into the ground to stimulate bacterial growth. | Soil and groundwater contaminated with organic chemicals. Soil and aquifer material must be porous and have a resident bacterial population. |
| Carbon Adsorption | -- | Dissolved organic chemicals are transferred from the water phase to granular organic carbon (GAC) phase by the process of adsorption. Groundwater remediation is usually done in a series of GAC columns. | Water contaminated with organic chemicals, and less than 50 ppm suspended solids. GAC columns must be regenerated periodically. Water with >50 ppm suspended solids needs prefiltration. |

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TABLE 4-2
POTENTIAL GROUNDWATER CORRECTIVE REMEDIAL TECHNOLOGIES
(CONTINUED)

TREATMENT CONT.

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|--|---------------------------------|---|--|
| Cross-Flow Pre evaporation System | Wastewater Tech. Center | This technology utilizes semi-permeable membranes to separate organic materials from contaminated water. The contaminated water flows on one side of the membrane while a vacuum is applied on the opposite side. The membrane is nearly impervious to water, but allows organic compounds to diffuse through. | |
| Freezing Separation | Freeze Technologies Corporation | In this freeze crystallization process, refrigerant is injected into the waste and ice crystals are recovered and washed with pure water to remove any adhering contaminants. Air strippers are used to remove the refrigerant from the purified water. | This technology will remove both organic and inorganic as well as ionic and non-ionic species from contaminated aqueous streams. |
| In-Situ Vacuum Extraction | Terra Vac, Inc. Xerox Corp. | A process of removing and venting volatile organic compounds from the unsaturated zone of soils. A well is used to extract subsurface organic contaminants. The extracted contaminant stream passes through a vapor/liquid separator, and the resulting off-gases are treated through activated carbon before being released to the atmosphere. | Organic compounds that are volatile or semivolatile at ambient temperatures in soils and groundwater. Contaminants with a Henry's Law constant of .001 or higher. |
| Integrated Vapor Extraction & Steam Vacuum Stripping | AWD Technologies Inc. | The Aqua Detox/SVE system consists of two basic processes: an Aqua Detox moderate vacuum stripping tower that uses low-pressure steam to treat groundwater; and a soil gas vapor extraction/reinjection process to treat contaminated soil. | This technology removes VOC's including chlorinated hydrocarbons in soil and groundwater. Sites with contaminated groundwater or soil containing TCE, PCE or other VOC's are suitable. |
| Microfiltration and Chemical Oxidation | Union Carbide and FMC | Molecular sieves remove organic chemicals from groundwater. Sieves are periodically backflushed with peroxide (H ₂ O ₂) which removes organic chemicals from the sieves and oxidizes them. | Applicable to groundwater contaminated with organic chemicals. |
| Ultraviolet Light, Peroxide, and Ozone Oxidation | Ultrax Int. | Organic chemicals in water are oxidized by UV light, H ₂ O ₂ , and O ₃ in a reaction chamber. The organic chemicals are oxidized to carbon dioxide, water and chlorid ion. | Applicable to groundwater contaminated with organic chemicals. |

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TABLE 4-2
 POTENTIAL GROUNDWATER CORRECTIVE REMEDIAL TECHNOLOGIES
 (CONTINUED)

TREATMENT CONT.

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|--|---|--|---|
| Ultraviolet Light and Peroxide Oxidation | Peroxidation and Solarchem | Organic chemicals in water are oxidized by UV light and H ₂ O ₂ in a reaction chamber. The organic chemicals are oxidized to carbon dioxide, water and chloride ion. | |
| Ion Exchange | — | Ionic contaminant species dissolved in water are exchanged with non-contaminations on a solid media, such as clay, zeolite, or synthetic resins. Groundwater is pumped through a packed column or a bed of ion exchange material where the exchange takes place. | Groundwater contaminated with ionic species such as metals, halides, cyanides etc. Ion exchange media must be back flushed and regenerated. The backflush water may be hazardous and require treatment/disposal as a hazardous waste. |
| Laser Stimulated Photochemical Oxidation | Energy & Environmental Engineering Inc. | Contaminated groundwater is pumped through a filter unit to remove suspended particles. The filtrate is fed into the reactor and irradiated with laser light. The water is then sent to a degassing unit, where volatiles are treated prior to release to the atmosphere. Part of the groundwater is reinjected into the ground, and the rest is recycled to wash the particulate matter separated in the filtration unit. | This technology can be applied to groundwater and industrial wastewater containing organics. |
| PACT/Wet Air Oxidation | Zimpro/Passavant Inc. | The PACT system uses powdered activated carbon (PAC) combined with biological treatment to treat liquid waste containing toxic organic contaminants. The wet air oxidation technology regenerates the PAC for reuse in the PACT system. | Contaminated groundwater, industrial wastewaters and leachates containing halogenated solvents, phenol pesticides, PCB's and other organic compounds. |
| Surfactant Flushing | USEPA | Insoluble or slightly soluble contaminants are released from soil or aquifer material by flushing with surfactant (detergent). Surfactants can be injected or allowed to infiltrate through the surface to enhance the delivery of adsorbed contaminant or free phase contaminant to a recovery well. | Applicable to contaminated soil or aquifer material. This technology is in the development phase, but probably requires porous aquifer material. |

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TABLE 4-3
POTENTIAL SOIL CORRECTIVE REMEDIAL TECHNOLOGIES

LIMITED/NO ACTION

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|------------------------|-----------|---|--|
| Limited/No Action Soil | — | No action is taken to remove contaminants or lower the contaminant level in soil. Human contact with the affected soil is prevented by access control such as fencing, guards, and posted warnings. | Applicable where access can be controlled, contaminants are unremediable, or where remediation activities pose an unacceptable environmental threat. This may also be applicable where natural processes and remediating soil at an acceptable rate. |

CONTAINMENT/DISPOSAL

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|-------------------|-----------|--|----------------------------------|
| Impermeable Cover | — | An impermeable cover material such as pavement or geotextile is placed over the area of contaminated soil to prevent the infiltration of water, the escape of fugitive dust, or human contact with the soil. | Applicable to contaminated soil. |
| Off-site Disposal | — | Excavate soils and dispose as hazardous waste/special waste; backfill/revegetate. | Applicable to contaminated soil. |
| On-site Disposal | — | Excavate soils and dispose in on-site landfill. | Applicable to contaminated soil. |

TREATMENT

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|---|----------------|--|---|
| Batch Steam Distillation/ Metal Extraction | IT Corporation | Volatile organics are separated from the soil by steam injection. The resulting vapors are condensed and decanted to separate organic liquids from the aqueous phase. After the volatiles are separated, heavy metals are removed from the soil slurry using hydrochloric acid. Heavy metals are precipitated as hydroxide salts, and drawn off as sludge for off-site disposal or recovery. | This process is applicable to soils contaminated with both organics and heavy metals. |

FIGURE 7580-56

TABLE 4-3
POTENTIAL SOIL CORRECTIVE REMEDIAL TECHNOLOGIES
(CONTINUED)

TREATMENT CONT.

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|--------------------------------------|------------------------------|--|--|
| Circulating Fluidized Bed Combustor | Ogden Environmental Services | Waste material and limestone are fed into a combustion chamber along with the recirculating bed material from a hot cyclone. The limestone neutralizes acid gases. The treated ash is transported out of the system by an ash conveyor. Hot gases produced during combustion pass through a convective gas cooler and bag-house before being released to the atmosphere. | This technology is suitable for treating halogenated and non-halogenated organic compounds in soils, sludges and slurries. |
| In-Situ Bioremediation | — | Organic chemicals in soil or groundwater are oxidized by aerobic bacteria to carbon dioxide, water and chloride. This process is enhanced by the injection of nutrients into the ground to stimulate bacterial growth. | Soil and groundwater contaminated with organic chemicals. Soil and aquifer material must be porous and have a resident bacterial population. |
| Ex-Situ Vapor Extraction | Xerox Corp. | Excavated soil is placed in a covered roll-off container. The roll-off is equipped with a series of porous pipes below the soil. A vacuum applied to the pipes removes volatile organics from the soil. | Soil contaminated with volatile organic chemicals. |
| Stream Injection & Vacuum Extraction | Toxic Treatments Inc. | Steam is used to heat the area to be remediated, increasing the vapor pressure of the volatile contaminants and thereby increasing the rate at which they can be stripped. Both the air and steam carry the contaminants to the surface. At the surface the volatile contaminants and the water vapor are removed from the off-gas stream by condensation. | Applicable to organic contaminants such as hydrocarbons and solvents with sufficient partial pressure in the soil. |
| | Solvent Services | Steam is forced through the soil, via injection wells to thermally enhance the vacuum extraction process. Recovered gaseous contaminants are then either condensed and processed along with recovered liquids, or trapped by activated carbon filters. | The technology is used to treat soil contaminated with volatile organic compounds and semivolatile organic compounds in total concentrations ranging from 10 ppb to 100,000 ppm by weight. |

7580-56

TABLE 4-3
 POTENTIAL SOIL CORRECTIVE REMEDIAL TECHNOLOGIES
 (CONTINUED)

TREATMENT CONT.

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|--|--|--|--|
| In-Situ Vacuum Extraction | Terra Vac, Inc. | A process of removing and venting volatile organic compounds from the unsaturated zone of soils. A well is used to extract subsurface organic contaminants. The extracted contaminant stream passes through a vapor/liquid separator, and the resulting off-gases is treated using activated carbon before being released to the atmosphere. | Organic compounds that are volatile or semivolatile at ambient temperatures in soils and groundwater. Effective for contaminants with Henry's Law constant of .001 or higher. |
| In-Situ Vitrification | Battelle Northwest | Contaminated soil is converted into a chemically inert glass-like substance. Electrodes are buried in the soil and are subject to an electrical potential. The natural resistance of the soil causes it to heat to above its melting point. Organic chemicals are destroyed during vitrification and metallic or radioactive contaminants are encapsulated in the glass. in the glass. | |
| Integrated Vapor Extraction & Steam Vacuum Stripping | AWD Technologies Inc. | The Aqua Detox/SVE system consists of two basic processes: an Aqua Detox moderate vacuum stripping tower that uses low-pressure steam to treat groundwater; and a soil gas vapor extraction/reinjection process to treat contaminated soil. | This technology removes VOC's including chlorinated hydrocarbons in soil and groundwater. Sites with contaminated groundwater or soil containing TCE, PCE or other VOC's are suitable. |
| Low temperature thermal desorption | Chemical Waste Management | The pilot-scale system is mounted on two trailers and has a capacity of treating 5 tons of material per day. The first trailer contains a rotary dryer used to heat contaminated materials and drive off water and organic contaminants. The second trailer contains a gas treatment system that condenses and collects the contaminants driven from the soil. | Applicable for volatile and semivolatile organics. and PCB's. |
| Pyretron Oxygen Burner | American Combustion Technologies, Inc. | The Pyretron technology involves an oxygen-air-fuel burner, and uses advanced fuel injection and mixing concepts to burn wastes. | Technology not suitable for processing aqueous wastes or inorganic wastes. |

7580-56

TABLE 4-3
 POTENTIAL SOIL CORRECTIVE REMEDIAL TECHNOLOGIES
 (CONTINUED)

TREATMENT CONT.

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY |
|---------------------|-----------------------------|--|--|
| Soil Flushing | MTA Remedial Resources Inc. | Injection of a solvent or surfactant solution to enhance contaminant solubility, which results in increased recovery of contaminants in the groundwater. The system includes extraction wells drilled in the contaminated soils zone, reinjection wells upgradient of the contaminated area and a wastewater treatment system. | Soils contaminated with only a few specific chemicals. Uniform soils with high permeability are necessary. |
| Surfactant Flushing | USEPA* | Insoluble or slightly soluble contaminants are released from soil or aquifer material by flushing with surfactant (detergent). Surfactants can be injected or allowed to infiltrate through the surface to enhance the delivery of adsorbed contaminant or free phase contaminant to a recovery well. | Applicable to contaminated soil or aquifer material. This technology is in the development phase, but most likely requires porous materials. |

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TABLE 5-1
SCREENING OF POTENTIAL GROUNDWATER CORRECTIVE REMEDIAL TECHNOLOGIES

| LIMITED/NO ACTION METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|-------------------------------|-----------|--|--|---|
| Limited/No Action Groundwater | -- | No action is taken to impede the flow of groundwater or contaminants. Contaminant levels in groundwater are monitored. | Applicable to non-mobile contaminants, or where natural processes are effectively remediating groundwater. | The mobility of the waste constituents and groundwater velocity at the site make this an unacceptable option. |

| CONTAINMENT METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|---------------------------------|-----------|---|---|---|
| Active Containment Groundwater | -- | Groundwater flow velocity and direction is controlled by a series of extraction and/or injection wells. The wells create hydraulic barriers that prevent contaminated groundwater from travelling off-site. | Applicable to granular aquifers where groundwater movement can be accurately predicted and controlled. | The unpredictable nature of groundwater flow directions in the site's fractured bedrock aquifers makes this technique unacceptable. The large size of the plume makes this technique economically & practically feasible. |
| Passive Containment Groundwater | -- | Groundwater and/or contaminant migration is controlled by emplacement of a low conductivity slurry wall, either surrounding, upgradient from or downgradient from the contaminated area, depending on-site characteristics. | Applicable to granular aquifers where the slurry walls can be keyed into a low permeability horizon at depth. | As with the above technique the fractured bedrock flow regime and the size of the plume make this an unacceptable option. |

| TREATMENT METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|--------------------------------------|---------------|---|--|---|
| Air Stripping | -- | <p>Volatile chemicals are transferred from the water phase to the air phase via diffusion. In the most efficient form, air stripping takes place in a tower packed with high surface area porous spheres. Air is pumped upward through the column. Contaminated water enters from the top, flows downward, and exits as treated</p> | <p>Water contaminated with volatile organic chemicals.</p> | <p>This is a proven, effective technique for VOC contaminated water when used in combination with a groundwater extraction system. Its operation is relatively inexpensive.</p> |
| Air Stripping with Carbon Adsorption | -- | <p>Same as above with the effluent air being treated by adsorption of volatile chemicals by activated carbon filters.</p> | <p>Water contaminated with volatile organic chemicals. Activated carbon filters must be replaced periodically</p> | <p>This technology has similar results for the site, waste, and technical screens as air stripping, but is more expensive to operate and maintain.</p> |
| Biological Aqueous Treatment System | Diatroll Inc. | <p>Contaminated water enters a mixing tank where the pH is adjusted and inorganic nutrients are added. The water is heated, and then flows in the reactor where the contaminants are biodegraded, either under aerobic or anaerobic conditions. The</p> <p>The contaminants are degraded to carbon dioxide, water and chloride ion.</p> | <p>Applicable to aqueous streams contaminated with organic compounds and other hydrocarbons. Not applicable for removal of metals.</p> | <p>This is a proven effective technique for VOC contaminated water when used in combination with a groundwater extraction system.</p> |
| Biological Treatment | -- | <p>Organic chemicals in water are oxidized by aerobic bacteria in an above ground activated sludge process. Groundwater is pumped first to an aerated reaction tank where the bacteria digest the organic chemicals, forming sludge, then to a clarifier where the sludge settles. Alternately biological treatment can take place in a trickling filter.</p> | <p>Groundwater contaminated with organic chemicals.</p> | <p>This technology has similar results for the site, waste, technology, and economic screens as Biological Aqueous Treatment System.</p> |

TREATMENT

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|----------------------------------|------------------------------------|--|--|---|
| In-Situ Bioremediation | -- | Organic chemicals in soil or groundwater are oxidized by aerobic bacteria within the ground to carbon dioxide, water and chloride. This process is enhanced by the injection of nutrients into the ground to stimulate bacterial growth. | Soil and groundwater contaminated with organic chemicals. Soil and aquifer material must be porous and have a resident bacterial population. | This method is ineffective in low conductivity soil and fractured bedrock flow regimes as found at the site. |
| Carbon Adsorption | -- | Dissolved organic chemicals are transferred from the water phase to granular organic carbon (GAC) phase by the process of adsorption. Groundwater remediation is usually done in a series of GAC columns. | Water contaminated with organic chemicals, and less than 50 ppm suspended solids. GAC columns must be regenerated periodically. Water with >50 ppm suspended solids needs prefiltration. | This is a proven effective method for VOC removal when used in combination with a groundwater extraction system. This method is unacceptable because of the high cost of regenerating GAC and because of the high treatment rates needed at the site. |
| Cross-Flow Evaporation System | Wastewater Tech. Center | This technology utilizes semi-permeable membranes to separate organic materials from contaminated water. The contaminated water flows on one side of the membrane while a vacuum is applied on the opposite side. The membrane is nearly impervious to water, but allows organic compounds to diffuse through. | This technology will remove both organic and inorganic as well as ionic and non-ionic species from contaminated aqueous streams. | This method may not achieve a high percentage reduction in contaminants at the low concentrations found on site. Membrane fouling is likely due to iron precipitation on the membrane due to the drop in pressure. |
| Freezing Separation | Freeze Technologies Corporation | In this freeze crystallization process, refrigerant is injected into the waste and ice crystals are recovered and washed with pure water to remove any adhering contaminants. Air strippers are used to remove the refrigerant from the purified water. | | This method produces wash water contaminated with the original VOCs and purified water contaminated with refrigerant. |

TREATMENT

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|--|----------------------------|---|--|--|
| In-Situ Vacuum Extraction | Terra Vac, Inc. | A process of removing and venting volatile organic compounds from the unsaturated zone of soils. A well is used to extract subsurface organic contaminants. The extracted contaminant stream passes through a vapor/liquid separator, and the resulting off-gases are treated through activated carbon before being released to the atmosphere. | Organic compounds that are volatile or semivolatile at ambient temperatures in soils and groundwater. Contaminants with a Henry's Law constant of .001 or higher. | This method will remove VOC's from areas of poor access such as from below building pads. It is a proven effective technology that is applicable to VOC contamination. |
| Integrated Vapor Extraction & Steam Vacuum Stripping | AWD Technologies Inc | The Aqua Detox/SVE system consists of two basic processes: an Aqua Detox moderate vacuum stripping tower that uses low-pressure steam to treat groundwater; and a soil gas vapor extraction/reinjection process to treat contaminated soil. | This technology removes VOC's including chlorinated hydrocarbons in soil and groundwater. Sites with contaminated groundwater or soil containing TCE, PCE or other VOC's are suitable. | This may be an effective method for the site if soil gas vapor extraction/reinjection is possible in a low conductivity environment. At present this is a relatively unknown technology. |
| Microfiltration and Chemical Oxidation | Union Carbide and FMC | Molecular sieves remove organic chemicals from groundwater. Sieves are periodically backflushed with peroxide (H ₂ O ₂) which removes organic chemicals from the sieves and oxidizes them. | Applicable to groundwater contaminated with organic chemicals. | This method is not applicable to the site groundwater because the molecular sieves are subject to fouling by iron and other metal species. |
| Ultraviolet Light, Peroxide, and Ozone Oxidation | Ultrax Int. | Organic chemicals in water are oxidized by UV light, H ₂ O ₂ , and O ₃ in a reaction chamber. The organic chemicals are oxidized to carbon dioxide, water and chloride ion. | Applicable to groundwater contaminated with organic chemicals. | This is a proven effective method for VOC destruction which is suitable for the site when used in combination with a groundwater extraction system. |
| Ultraviolet Light and Peroxide Oxidation | Peroxidation and Solarchem | Organic chemicals in water are oxidized by UV light and H ₂ O ₂ in a reaction chamber. The organic chemicals are oxidized to carbon dioxide, water and chloride ion. | | Same as above, but economically and technically inferior. |

TREATMENT

| METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|--|---|--|---|--|
| Ion Exchange | --- | Ionic contaminant species dissolved in water are exchanged with non-contaminations on a solid media, such as clay, zeolite, or synthetic resins. Groundwater is pumped through a packed column or a bed of ion exchange material where the exchange takes place. | Groundwater contaminated with ionic species such as metals, halides, cyanides etc. Ion exchange media must be back flushed and regenerated. The backflush water may be hazardous and require treatment/disposal as a hazardous waste. | This technology is not applicable to organic solvents. |
| Laser Stimulated Photochemical Oxidation | Energy & Environmental Engineering Inc. | Contaminated groundwater is pumped through a filter unit to remove suspended particles. The filtrate is fed into the reactor and irradiated with laser light. The water is then sent to a degassing unit, where volatiles are treated prior to release to the atmosphere. Part of the groundwater is reinjected into the ground, and the rest is recycled to wash the particulate matter separated in the filtration unit. | This technology can be applied to groundwater and industrial wastewater containing organics. | Not a proven technology. |
| PACT/Vet Air Oxidation | Zimpro/Passavant Inc. | The PACT system uses powdered activated carbon (PAC) combined with biological treatment to treat liquid waste containing toxic organic contaminants. The wet air oxidation technology regenerates the PAC for reuse in the PACT system. | Contaminated groundwater, industrial wastewaters and leachates containing halogenated solvents, phenol pesticides, PCD's and other organic compounds. | High carbon cost and proven effectiveness of in-place oxidation system makes technology not appropriate. |
| Surfactant Flushing | USEPA | Insoluble or slightly soluble contaminants are released from soil or aquifer material by flushing with surfactant (detergent). Surfactants can be injected or allowed to infiltrate through the surface to enhance the delivery of adsorbed contaminant or free phase contaminant to a recovery well. | Applicable to contaminated soil or aquifer material. This technology is in the development phase, but probably requires porous aquifer material. | Not applicable to low permeability bedrock. |

TABLE 5-2
SCREENING OF POTENTIAL SOIL CORRECTIVE REMEDIAL TECHNOLOGIES

| LIMITED/NO ACTION | | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|-------------------|------------------------|-----------|---|--|--|
| METHOD NAME | Limited/No Action Soil | -- | No action is taken to remove contaminants or lower the contaminant level in soil. Human contact with the affected soil is prevented by access control such as fencing, guards, and posted warnings. | Applicable where access can be controlled, contaminants are unremediable, or where remediation activities pose an unacceptable environmental threat. This may also be applicable where natural processes and remediating soil at an acceptable rate. | This method is appropriate for the Salt Road Site in that soil contamination areas have controlled access, and the contaminants are relatively immobile in soil. |

| CONTAINMENT/DISPOSAL | | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|----------------------|-------------------|-----------|--|----------------------------------|---|
| METHOD NAME | Impermeable Cover | -- | An impermeable cover material such as pavement or geotextile is placed over the area of contaminated soil to prevent the infiltration of water, the escape of fugitive dust, or human contact with the soil. | Applicable to contaminated soil. | This method is not appropriate because contaminated soil is covered by building pads (Bldg. 224/224 area) or is found at 3 to 6 feet below ground surface (Bldg. 214 area). |
| | Off-site Disposal | -- | Excavate soils and dispose as hazardous waste/special waste; backfill/revegetate. | Applicable to contaminated soil. | This method is unnecessarily expensive, and is not applicable to soils below Bldgs. 224 and 225. |
| | On-site Disposal | -- | Excavate soils and dispose in on-site landfill. | Applicable to contaminated soil. | This method is not applicable to soils below Buildings 224 and 225, and offers little advantage over leaving soils in place at Building 214. |

| TREATMENT | | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|---|------------------------------|-----------|--|--|---|
| METHOD NAME | | | | | |
| Batch Steam Distillation/ Metal Extraction | IT Corporation | | Volatile organics are separated from the soil by steam injection. The resulting vapors are condensed and decanted to separate organic liquids from the aqueous phase. After the volatiles are separated, heavy metals are removed from the soil slurry using hydrochloric acid. Heavy metals are precipitated as hydroxide salts, and drawn off as sludge for off-site disposal or recovery. | This process is applicable to soils contaminated with both organics and heavy metals. | The low intrinsic permeability of site soils, lack of metals contamination and questionable use of steam injection below Bldgs. 224/225 all make this an unacceptable method. |
| Circulating Fluidized Bed Combustor | Ogden Environmental Services | | Waste material and limestone are fed into a combustion chamber along with the recirculating bed material from a hot cyclone. The limestone neutralizes acid gases. The treated ash is transported out of the system by an ash conveyor. Hot gases produced during combustion pass through a convective gas cooler and baghouse before being released to the atmosphere. | This technology is suitable for treating halogenated and non-halogenated organic compounds in soils, sludges and slurries. | Poor access to soils below Bldgs. 224/225, and high cost make this an unacceptable method. |
| In-Situ Bioremediation | -- | | Organic chemicals in soil or groundwater are oxidized by aerobic bacteria to carbon dioxide, water and chloride. This process is enhanced by the injection of nutrients into the ground to stimulate bacterial growth. | Soil and groundwater contaminated with organic chemicals. Soil and aquifer material must be porous and have a resident bacterial population. | Although the waste constituents and technology are well suited, the low intrinsic permeability of on-site soils make this an unacceptable technology. |
| Ex-Situ Vapor Extraction | Xerox Corp. | | Excavated soil is placed in a covered roll-off container. The roll-off is equipped with a series of porous pipes below the soil. A vacuum applied to the pipes removes volatile organics from the soil. | Soil contaminated with volatile organic chemicals. | This experimental technology is acceptable for soils with good access, such as in the Building 214 area. |

TREATMENT

| TREATMENT METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|--------------------------------------|-----------------------|---|--|---|
| Stream Injection & Vacuum Extraction | Toxic Treatments Inc. | Steam is used to heat the area to be remediated, increasing the vapor pressure of the volatile contaminants and thereby increasing the rate at which they can be stripped. Both the air and steam carry the contaminants to the surface. At the surface the volatile contaminants and the water vapor are removed from the off-gas stream by condensation. | Applicable to organic contaminants such as hydrocarbons and solvents with sufficient partial pressure in the soil. | The soils low intrinsic permeability coupled with its high specific heat and relatively low temperature will lead to condensation of steam and an increase in the soils moisture content. This will lead to a decrease in the soils air permeability. |
| In-Situ Vacuum Extraction | Solvent Services | Steam is forced through the soil, via injection wells to thermally enhance the vacuum extraction process. Recovered gaseous contaminants are then either condensed and processed along with recovered liquids, or trapped by activated carbon filters. | The technology is used to treat soil contaminated with volatile organic compounds and semivolatile organic compounds in total concentrations ranging from 10 ppb to 100,000 ppm by weight. | Same as above technology. |
| In-Situ Vacuum Extraction | Terra Vac, Inc. | A process of removing and venting volatile organic compounds from the unsaturated zone of soils. A well is used to extract subsurface organic contaminants. The extracted contaminant stream passes through a vapor/liquid separator, and the resulting off-gases is treated using activated carbon before being released to the atmosphere. | Organic compounds that are volatile or semivolatile at ambient temperatures in soils and groundwater. Effective for contaminants with Henry's Law constant of .001 or higher. | This is a proven effective technology. Currently the cost of activated carbon regeneration makes this an unacceptable method. |
| In-Situ Vitrification | Battelle Northwest | Contaminated soil is converted into a chemically inert glass-like substance. Electrodes are buried in the soil and are subject to an electrical potential. The natural resistance of the soil causes it to heat to above its melting point. Organic chemicals are destroyed during vitrification and metallic or radioactive contaminants are encapsulated in the glass in the place. | | This technology is destructive of the subsurface environment, and is not appropriate to the site. Areas of soil contamination at the site are associated with areas of underground utilities. |

| TREATMENT METHOD NAME | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|--|--|--|--|--|
| Integrated Vapor Extraction & Steam Vacuum Stripping | AWD Technologies Inc | The Aqua Detox/SVE system consists of two basic processes: an Aqua Detox moderate vacuum stripping tower that uses low-pressure steam to treat groundwater; and a soil gas vapor extraction/reinjection process to treat contaminated soil. | This technology removes VOC's including chlorinated hydrocarbons in soil and groundwater. Sites with contaminated groundwater or soil containing TCE, PCE or other VOC's are suitable. | This may be an effective method if soil gas vapor extraction/reinjection is possible in a low intrinsic permeability soil. At present this is a relatively unknown technology. |
| Low temperature thermal desorption | Chemical Waste Management | The pilot-scale system is mounted on two trailers and has a capacity of treating 5 tons of material per day. The first trailer contains a rotary dryer used to heat contaminated materials and drive off water and organic contaminants. The second trailer contains a gas treatment system that condenses and collects the contaminants driven from the soil. | Applicable for volatile and semivolatile organics, and PCB's. | This system may be applicable to the Bldg. 214 area where soil access is good. |
| Pyretron Oxygen Burner | American Combustion Technologies, Inc. | The Pyretron technology involves an oxygen-air-fuel burner, and uses advanced fuel injection and mixing concepts to burn wastes. | Technology not suitable for processing aqueous wastes or inorganic wastes. | The high cost and applicability to only accessible soils makes this an unacceptable method. |
| Soil Flushing | MTA Remedial Resources Inc. | Injection of a solvent or surfactant solution to enhance contaminant solubility, which results in increased recovery of contaminants in the groundwater. The system includes extraction wells drilled in the contaminated soils zone, reinjection wells upgradient of the contaminated area and a wastewater treatment system. | Soils contaminated with only a few specific chemicals. Uniform soils with high permeability are necessary. | The low intrinsic permeability of soils on site make this an inappropriate technology for Bldg. 214 soils, but it may be applicable to country and area soils and unsaturated top of rock. |

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| TREATMENT | | DEVELOPER | SYNOPSIS OF METHOD | APPLICABILITY | SCREENING RESULTS |
|-------------|--|-----------|---|--|--|
| METHOD NAME | | USEPA* | Insoluble or slightly soluble contaminants are released from soil or aquifer material by flushing with surfactant (detergent). Surfactants can be injected or allowed to infiltrate through the surface to enhance the delivery of adsorbed contaminant or free phase contaminant to a recovery well. | Applicable to contaminated soil or aquifer material. This technology is in the development phase, but most likely requires porous materials. | The low intrinsic permeability of soils on site make this an inappropriate technology for Bldg. 214 soils, but it may be applicable to country and area soils and unsaturated top of rock. |

TABLE 6-1

GROUNDWATER EXTRACTION SYSTEM CHRONOLOGY

| Well | Installation Date | Type | Flow Rate (gpm) | Cumulative Flow (gal. x 10 ⁻⁶) | Typical Total Volatiles (ppb) |
|-------|-------------------|-------------|-----------------|--|-------------------------------|
| REC1 | | Single well | | Not Operable | |
| REC1A | 12/88 | Single well | | Not Operable | |
| REC2 | 11/87 | Single well | 5 | 5.7 | 10,000 |
| REC3 | 10/87 | Single well | 7 | 5.9 | 500 |
| REC4 | 11/87 | Single well | .5 | .5 | 50,000 |
| REC5 | 11/87 | Single well | 2 | 2.0 | 100,000 |
| REC6 | 12/87 | In Trench | 50 | 2.5 | 300 |
| REC7 | 12/87 | In Trench | 40 | 22 | 50 |
| REC8 | 8/88 | Single well | 7 | 7.0 | 1,000 |
| REC9 | 12/88 | Single well | | Not Operable | |
| REC10 | 1/89 | In Trench | 60 | 2.0 | 100 |
| REC11 | 1/89 | Single well | 1 | .8 | 10 |
| REC12 | 4/89 | Single well | 6 | 4.1 | 30 |
| REC13 | 4/89 | Single well | 1 | .7 | 400 |
| REC14 | 8/90 | In Trench | 35 | 6.4 | 15,000 |
| REC15 | 8/91 | In Trench | 2.5 | .3 | 3,000 |
| R25 | 11/89* | Single well | .5 | .6 | 10,000 |
| R26 | 11/89* | Single well | .5 | .7 | 500 |

*Wells R-25 and R-26 were converted to recovery wells during November of 1989.

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TABLE 6-2
CONTAMINATION MASS REDUCTION CALCULATION BY POLYGON METHOD
INTERMEDIATE AQUIFER

| WELL | AREA (SQ FT) | THICKNESS (FT) | POROSITY | SAT VOLUME (CUBIC FT) | SAT VOLUME (GAL) | 1988 TOTAL VOL CONC (PPB) | 1988 TOT VOL (GAL VOL) | 1990 TOTAL VOL CONC (PPB) | 1990 TOT VOL (GAL VOL) |
|------|-----------------|-------------------|----------|--------------------------|---------------------|---------------------------------|------------------------------|---------------------------------|------------------------------|
| R18 | 146300 | 10 | 0.1 | 146300 | 1094470 | 4400 | 4.8 | 1249 | 1.4 |
| R19 | 127500 | 10 | 0.1 | 127500 | 953828 | 1154 | 1.1 | 2853 | 2.7 |
| R21 | 158800 | 10 | 0.1 | 158800 | 1187983 | 16160 | 19.2 | 4058 | 4.8 |
| R23 | 161300 | 10 | 0.1 | 161300 | 1206685 | 462 | 0.6 | 399 | 0.5 |
| R26 | 125000 | 10 | 0.1 | 125000 | 935125 | 1297 | 1.2 | 1105 | 1.0 |
| R35 | 60000 | 10 | 0.1 | 60000 | 448860 | 11401 | 5.1 | 2295 | 1.0 |
| R36 | 161300 | 10 | 0.1 | 161300 | 1206685 | 0 | 0.0 | 4 | 0.0 |
| R37 | 73800 | 10 | 0.1 | 73800 | 552098 | 0 | 0.0 | 0 | 0.0 |
| R39 | 237500 | 10 | 0.1 | 237500 | 1776738 | 2230 | 4.0 | 269 | 0.5 |
| R55 | 80000 | 10 | 0.1 | 80000 | 598480 | 151000 | 90.4 | 90 | 0.1 |
| R59 | 111300 | 10 | 0.1 | 111300 | 832635 | 189 | 0.2 | 42 | 0.0 |
| R6 | 142500 | 10 | 0.1 | 142500 | 1066043 | 85300 | 90.9 | 34300 | 36.6 |
| R60 | 208800 | 10 | 0.1 | 208800 | 1562033 | 0 | 0.0 | 0 | 0.0 |
| R66 | 176300 | 10 | 0.1 | 176300 | 1318900 | 31650 | 41.7 | 66 | 0.1 |
| R72 | 181300 | 10 | 0.1 | 181300 | 1356305 | 46582 | 63.2 | 2645 | 3.6 |
| R74 | 100000 | 10 | 0.1 | 100000 | 748100 | 61000 | 45.6 | 752 | 0.6 |
| R76 | 187500 | 10 | 0.1 | 187500 | 1402688 | 2436 | 3.4 | 145 | 0.2 |
| OR38 | 157500 | 10 | 0.1 | 157500 | 1178258 | 2345 | 2.8 | 319 | 0.4 |
| OR52 | 108800 | 10 | 0.1 | 108800 | 813933 | 0 | 0.0 | 0 | 0.0 |
| OR61 | 212500 | 10 | 0.1 | 212500 | 1589713 | 7 | 0.0 | 4 | 0.0 |
| OR62 | 200000 | 10 | 0.1 | 200000 | 1496200 | 422 | 0.6 | 274 | 0.4 |
| OR63 | 150000 | 10 | 0.1 | 150000 | 1122150 | 1416 | 1.6 | 363 | 0.4 |
| OR68 | 226300 | 10 | 0.1 | 226300 | 1692950 | 32 | 0.1 | 25 | 0.0 |
| OR69 | 202500 | 10 | 0.1 | 202500 | 1514903 | 172 | 0.3 | 2 | 0.0 |
| OR70 | 315000 | 10 | 0.1 | 315000 | 2506135 | 2 | 0.0 | 16 | 0.0 |
| OR71 | 233800 | 10 | 0.1 | 233800 | 1749058 | 0 | 0.0 | 0 | 0.0 |

1988 CONTAMINANT MASS = 4620 LB 1990 CONTAMINANT MASS = 667 LB

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TABLE 7-1
SUMMARY OF ANALYTICAL DATA
GROUNDWATER SALT ROAD STUDY AREA

| Compound (ug/L) | Intermediate Rock (R) | | | Shallow Rock (S) | | |
|-----------------------|-----------------------|---------|-------------|------------------|--------|-------------|
| | Range | Mean | #N Loc. Max | Range | Mean | #N Loc. Max |
| 1,1-Dichloroethene | 1.2-258000 | 7093 | 191 Rec5 | 1.14-371000 | 15725 | 62 SR4 |
| 1,2-Dichloroethene | 1.09-20700 | 1253.41 | 59 R6 | 1.0-14700.00 | 916.57 | 30 SR4 |
| Tetrachloroethene | 2.32-11800.0 | 899.92 | 108 OR104 | 2.0-474 | 66.78 | 27 SR16 |
| Toluene | 1.0-7550.0 | 263.13 | 86 OR106 | 1.34-9570 | 522.31 | 20 SR5 |
| 1,1,1-Trichloroethane | 1.5-62500 | 4549. | 193 OR106 | 1.21-37800 | 1635 | 47 SR16 |
| Trichloroethene | 2-13800 | 1421 | 45 RECS | 2.93-109000 | 13749 | 8 SR5 |
| Vinyl Chloride | 1.28-539 | 115 | 41 R74 | 1.5-2900 | 282 | 20 SR12 |
| Chloroethane* | 2.88-2.88 | 2.88 | 1 Rec6 | 6.5-32.5 | 18.7 | 7 OS109 |
| 1,2-Dichloroethane* | 5.32-17.5 | 11.4 | 2 R18 | 4.14-4.14 | 4.14 | 1 OS32 |

Notes:

1. Summary of data from 1990 sampling events.
2. All concentrations in ug/L.
3. #N = Number of times detected at the site.
4. Mean concentration is the average of all detectable compound concentration data.
5. Range: Is the range of all detectable compound concentration data.
6. Starred compounds are infrequently detected.

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TABLE 7-2
 TOXICITY VALUES: POTENTIAL CARCINOGENIC EFFECTS
 CHEMICAL CLASSIFICATION AND SLOPE FACTORS

| Chemical | Oral Slope Factor (SF) (mg/kg-day) | Weight of Evidence Classification | Type of Cancer | SF Basis/SF Source |
|---------------------|------------------------------------|-----------------------------------|----------------|----------------------|
| Chloroform | 0.0061 | B2 | Kidney | Drinking Water/HEAST |
| Tetrachloroethylene | 0.051 | B2 | Liver | Gavage/HEAST |
| Trichloroethylene | 0.011 | B2 | Liver | Gavage/HEAST |

1. SF Basis/SF Source – cites the study from which slope factors were derived and the reference it is cited in.

2. HEAST: Health Effects Assessment Summary Tables.

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TABLE 7-3
 CHRONIC TOXICITY VALUES: POTENTIAL NONCARCINOGENIC EFFECTS
 ORAL EXPOSURE

| Chemical | Chronic RfD mg/kg-day | Critical Effect | RfD Basis/ RfD Source | Uncertainty (UF) and Modifying (MF) Factors |
|------------------------|--------------------------|---------------------------|--------------------------|---|
| Chloroform | 0.01 | Liver lesions | Ingest./HEAST | 1000 |
| 1,2-c-Dichloroethylene | 0.01 | Blood changes | Gavage/HEAST | 3000 |
| 1,2-t-Dichloroethylene | 0.02 | Blood chemistry change | Drinking water/ HEAST | 1000 |
| Tetrachloroethylene | 0.01 | Liver toxicity | Ingest./HEAST | 1000 |

1. RfD: Reference Dose
2. Critical Effect: Effect associated with chemical exposure.
3. RfD Basis/RfD Source: Refers to how chemical administered in laboratory study used to derive reference dose, and source of RfD.
4. HEAST: Health Effects Assessment Summary Tables.

sfL29

FILE NO. 7580-56

TABLE 7-4

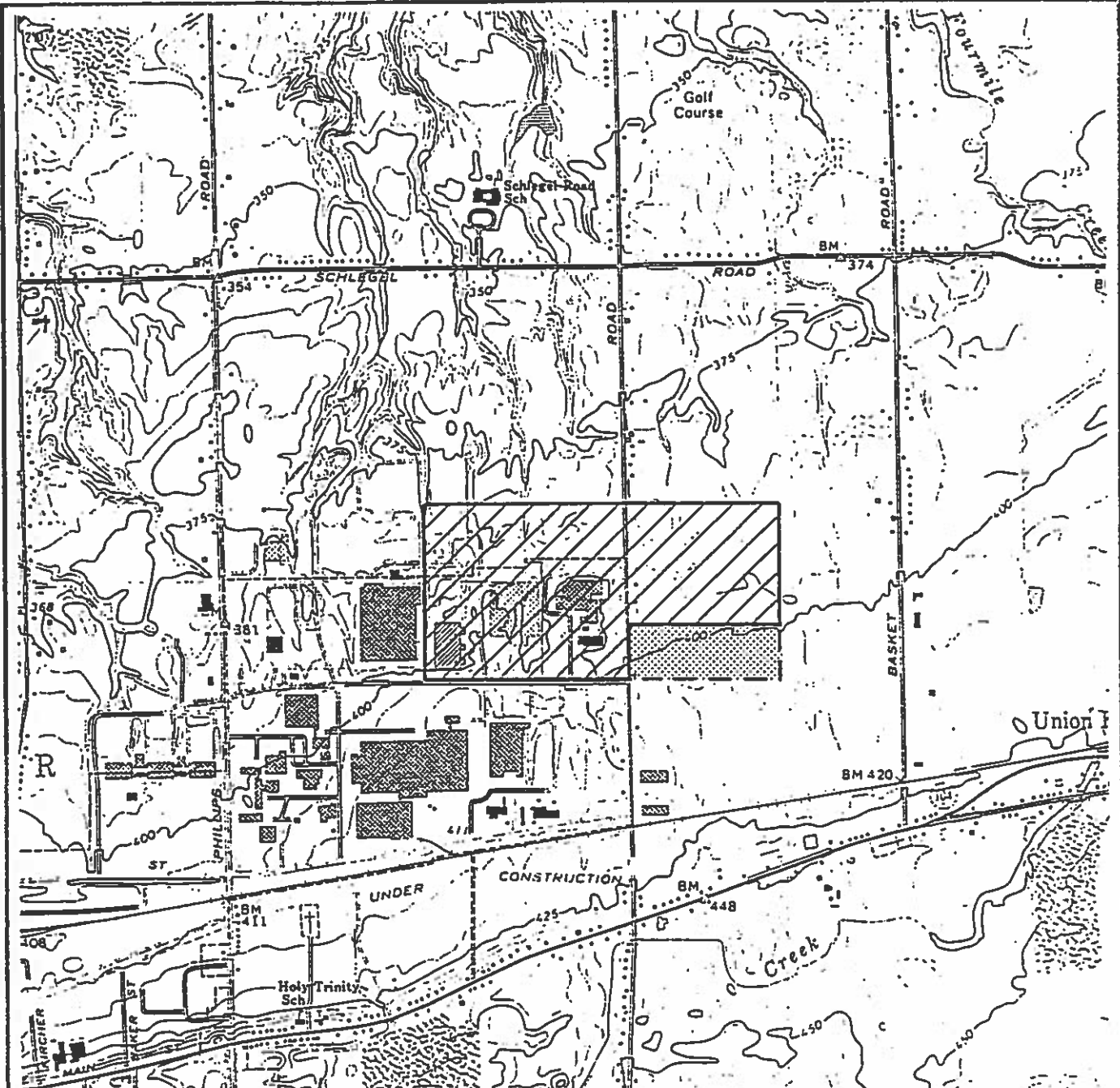
COMPARISON OF HEALTH-BASED SOIL INGESTION CRITERIA
WITH SOIL CONTAMINANT LEVELS FOR BUILDING 214

| Chemicals | Health-Based Criteria for Ingestion of Soil (mg/Kg) | | Soil Contaminant Levels (mg/Kg) | |
|----------------------|---|--------------------|---------------------------------------|---------|
| | Carcinogens | Systemic Toxicants | Maximum | Average |
| Chloroform | 110 | 800 | 0.0187 | 0.003 |
| Tetrachlorethene | 14 | 800 | 27.80 | 4.25 |
| Trichloroethene | 64 | NA | 0.356 | 0.040 |
| 1,2-c-Dichloroethene | NA | 800 | 0.452 | 0.052 |
| 1,2-t-Dichloroethene | NA | 1600 | 0.452 | 0.052 |



Notes:

NA - Not Applicable

jg7580-62/Ty7-4



LEGEND:

-  XEROX OWNED PROPERTY COVERED UNDER SALT ROAD CONSENT ORDER.
-  704 SALT ROAD PROPERTY RECENTLY ACQUIRED BY XEROX CORPORATION



QUADRANGLE LOCATION

USGS QUADRANGLE: WEBSTER, N.Y.

AOA H & A of New York
 Consulting Geotechnical Engineers, Geologists and Hydrogeologists

XEROX CORPORATION
 CORRECTIVE MEASURES STUDY
 SALT ROAD COMPLEX

PROJECT LOCUS

SCALE: 1 IN. = 2000 FT.

AUGUST 1991

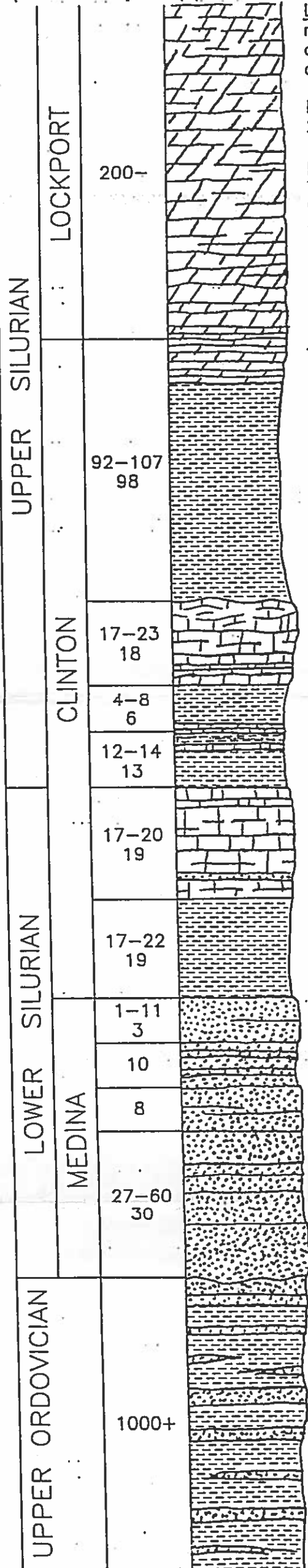
FILE NO. 7580-56

CHARRETTE

FIGURE 1-1

GENERAL STRATIGRAPHIC PROFILE

AGE GROUP THICKNESS RANGE AND AVERAGE (FT.) LITHOLOGY



FORMATION DESCRIPTION:

LOCKPORT DOLOMITE - Light to medium gray, fine to medium-grained, thin to medium-bedded, siliceous DOLOMITE with stylolites, very close to moderately close argillaceous partings, and vugs and cavities often lined with secondary dolomite, calcite, aragonite and quartz.
 Includes three members: Oak Orchard Dolomite (over 100 ft. thick in western New York), Penfield Dolomite (about 75 ft. thick), and Decew Dolomite (approximately 22 ft. thick).
 Oak Orchard is uppermost unit. Underlying Penfield contains wavy and uneven partings in lower 20 ft. Partings may slope at high angles, may appear as 1/8 - to 1/4-in. thick silty bands, and are frequently slickensided. Some cross-bedding observed. Basal Decew Member contains very thin clay partings in the basal few ft. Secondary gypsum seams in closely spaced partings occur throughout the Decew.
 Contact with underlying Rochester Shale is gradational. Usually marked only by increasing dolomitic mudstone between increasingly thinner dolomite beds in the Decew.

ROCHESTER SHALE - Light to dark gray, fine-grained, fossiliferous, dolomitic MUDSTONE with interbeds of dolomite and limestone, and secondary gypsum seams in closely to very closely spaced partings.
 Upper 8 to 12 ft. called the Gates Dolomite Member and consists of thin to very thin dolomite beds. Very thin limestone beds occur from 15 to 25 ft. below top of Rochester and increase in thickness and frequency downward... They grade into the adjacent mudstone and contain fine quartz silt. Infrequently, weathered clay partings and clay beds observed. Pits and vugs occur in trace amounts in the upper Rochester and their frequency decreases downwards. Gypsum nodules present in trace amounts throughout the formation.
 Upper contact with Lockport Dolomite is gradational. Marked by upwardly increasing frequency and thickness of dolomite beds in the Rochester.

IRONDEQUOIT LIMESTONE - Light to medium gray, fine to medium-grained, thin to medium-bedded, fossiliferous LIMESTONE with thin interbeds of dark gray, dolomitic shale, trace pits and vugs, gypsum nodules, and secondary gypsum seams at partings. Limestone bedding wavy. Shale beds thickest in lowest quarter of formation.

WILLIAMSON SHALE - Dark greenish gray SHALE with trace fossils, a few thin limestone beds and dark gray, very thin shale beds containing graptolite fossils at the base.

LOWER SODUS SHALE - Dark greenish gray to grayish brown SHALE with trace fossils. Upper part contains several light gray, thin, close to moderately close limestone beds containing abundant brachiopod fossils. Sometimes weathered zone is present at the upper contact.

REYNALES LIMESTONE - Light to medium gray, fine to medium-grained, thin-bedded, fossiliferous, crystalline LIMESTONE with dark gray, very thin dolomitic shale interbeds. Thin siliceous zones (chert or chalcedony and fine-grained quartz siltstone) observed. Trace stylolites, secondary gypsum seams at partings, and a persistent, red, oolitic, fossiliferous, hematitic limestone bed ((Seneca Park Hematite Member) present.

MAPLEWOOD SHALE - Light greenish gray argillaceous SHALE.

KODAK SANDSTONE - Light gray to greenish gray, fine to medium-grained, medium to thick-bedded SANDSTONE. Bioturbated? Historically referred to as the Thorold Sandstone, which is now recognized to be older (see below).

CAMBRIA FORMATION - Reddish brown, fine-grained, medium to thin-bedded shaley SILTSTONE with gray mottling and bioturbation? This formation has historically been considered the top portion of the Grimsby Sandstone (see below).

THOROLD SANDSTONE - Reddish brown and light gray mottled, fine-grained, medium-bedded SANDSTONE, with bioturbation? Once thought to be equivalent to, or synonymous with, the Kodak Sandstone (see above).

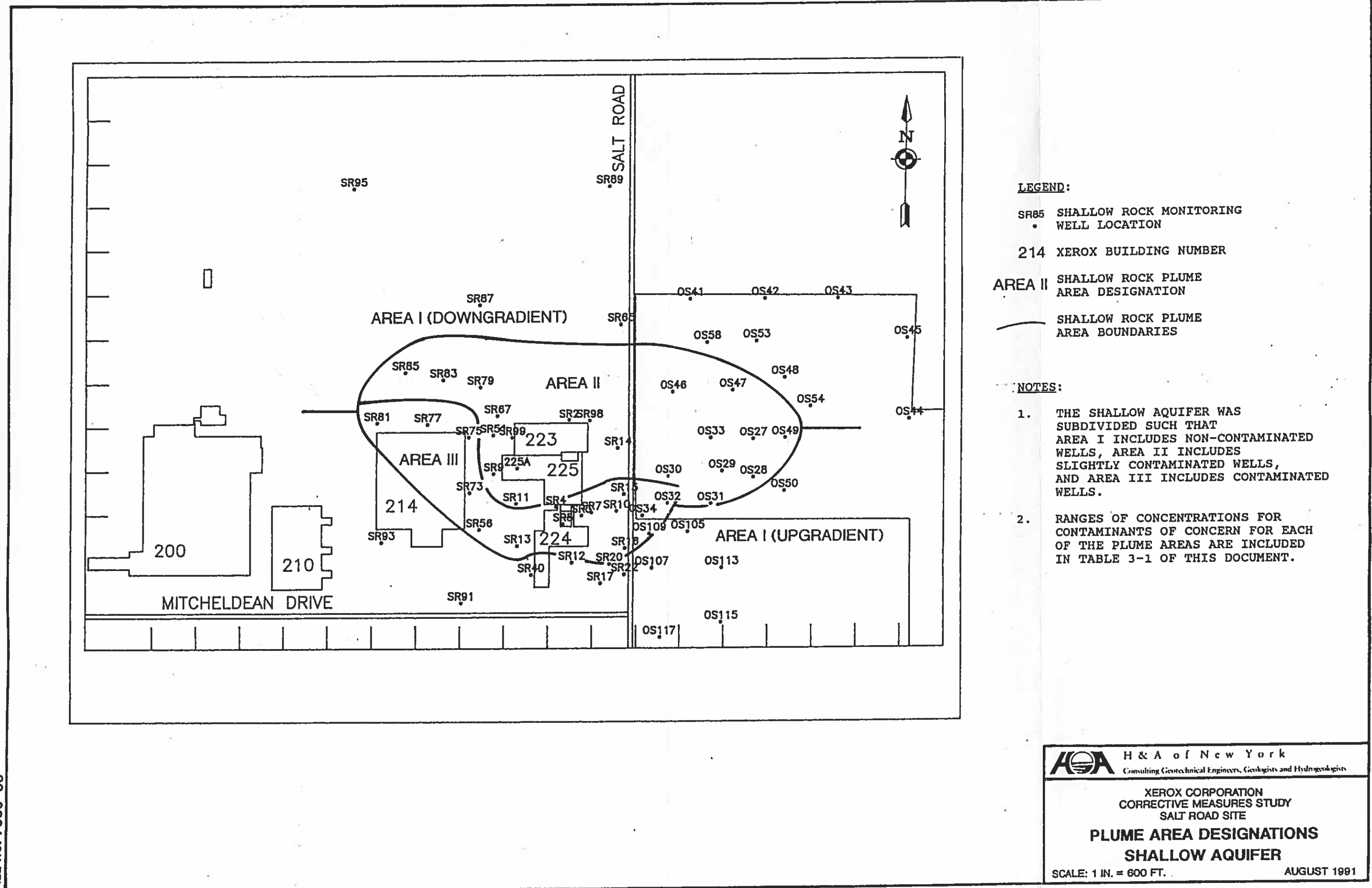
GRIMSBY SANDSTONE - Reddish brown, fine to medium-grained, thin to thick-bedded SANDSTONE. Gray and greenish gray color mottling in upper half.. Closely to widely spaced, argillaceous partings with occasional gypsum seams. Bioturbated? in the upper half. Lower half is massive, has shallow cross-bedding, and has largest grain size in formation. Basal contact is sharp and undulating; an unconformity in Rochester area, frequently marked by weathered shaly or clay parting.

QUEENSTON FORMATION - Reddish brown, fine-grained, thin to thick-bedded SANDSTONE, with some greenish gray to light gray mottling and very thin color banding. Close to moderately close argillaceous partings, some of which have secondary gypsum seams. Lithology grading laterally and vertically, including sandstone, siltstone, mudstone and very thin limestone beds.

NOTES:

1. Rock descriptions and thicknesses obtained from available test borings drilled for Monroe County Department of Engineering sewer tunnel project, modified with new formation names, descriptions and relationships proposed by geology staff at University of Rochester and accepted by New York state geologist.
2. Profile not to scale.
3. Swirly bedding caused by activity of marine worms.

GENERAL STRATIGRAPHIC PROFILE
 ROCHESTER, NEW YORK
 H&A OF NEW YORK Rev. MAY 1991



LEGEND:

SR85 SHALLOW ROCK MONITORING WELL LOCATION

214 XEROX BUILDING NUMBER

AREA II SHALLOW ROCK PLUME AREA DESIGNATION

— SHALLOW ROCK PLUME AREA BOUNDARIES

NOTES:

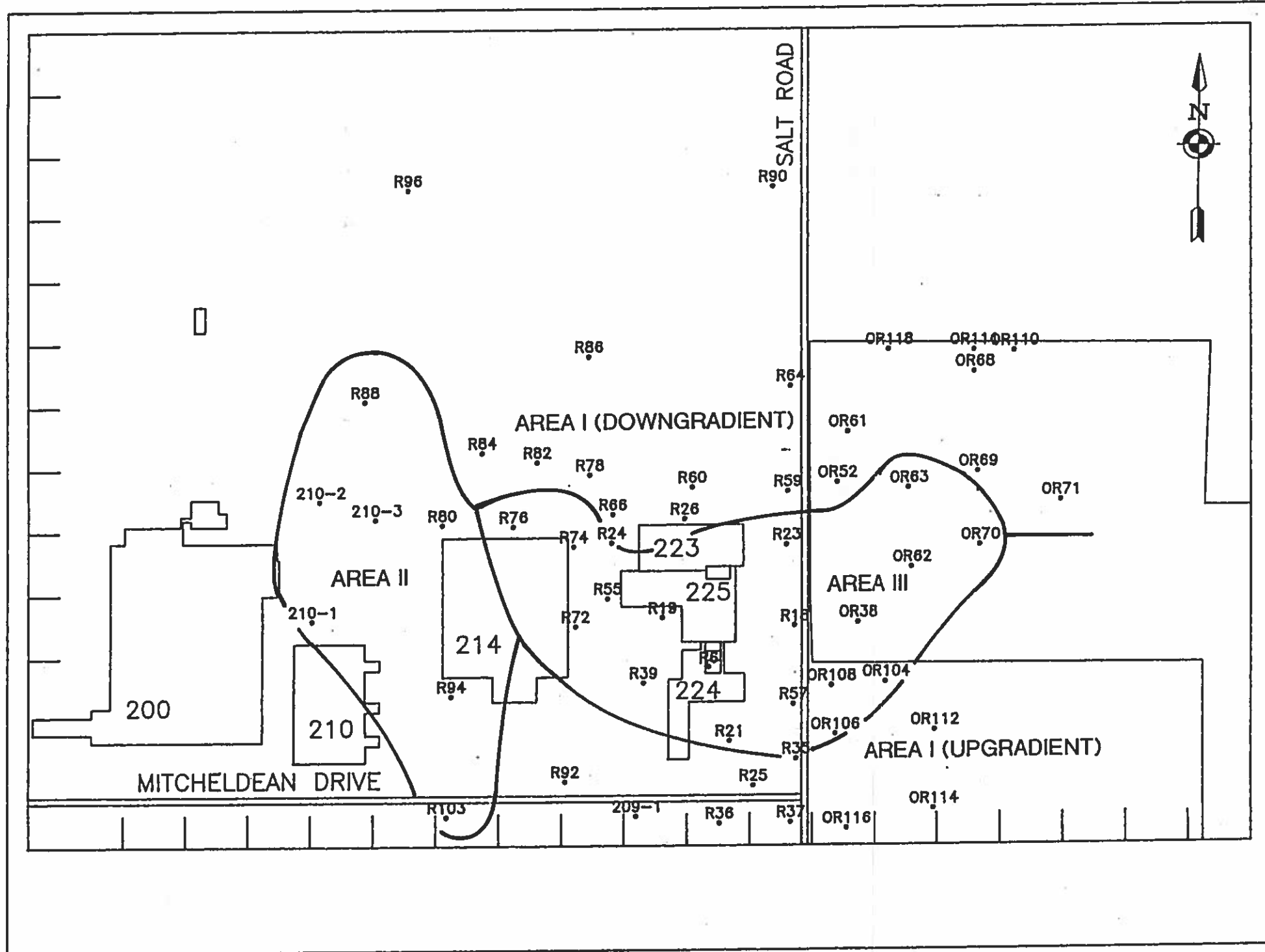
1. THE SHALLOW AQUIFER WAS SUBDIVIDED SUCH THAT AREA I INCLUDES NON-CONTAMINATED WELLS, AREA II INCLUDES SLIGHTLY CONTAMINATED WELLS, AND AREA III INCLUDES CONTAMINATED WELLS.
2. RANGES OF CONCENTRATIONS FOR CONTAMINANTS OF CONCERN FOR EACH OF THE PLUME AREAS ARE INCLUDED IN TABLE 3-1 OF THIS DOCUMENT.

H&A of New York
 Consulting Geotechnical Engineers, Geologists and Hydrogeologists

XEROX CORPORATION
 CORRECTIVE MEASURES STUDY
 SALT ROAD SITE
**PLUME AREA DESIGNATIONS
 SHALLOW AQUIFER**

SCALE: 1 IN. = 600 FT.

AUGUST 1991



LEGEND:

- OR61 INTERMEDIATE ROCK MONITORING WELL LOCATION
- 214 XEROX BUILDING NUMBER
- AREA II INTERMEDIATE ROCK PLUME AREA DESIGNATION
- INTERMEDIATE ROCK PLUME AREA BOUNDARIES

NOTES:

1. THE INTERMEDIATE AQUIFER WAS SUBDIVIDED SUCH THAT AREA I INCLUDES NON-CONTAMINATED WELLS, AREA II INCLUDES SLIGHTLY CONTAMINATED WELLS, AND AREA III INCLUDES CONTAMINATED WELLS.
2. RANGES OF CONCENTRATIONS FOR CONTAMINANTS OF CONCERN FOR EACH OF THE PLUME AREAS ARE INCLUDED IN TABLE 3-1 OF THIS DOCUMENT.

FILE NO. 7580-56

CHAPRETTE

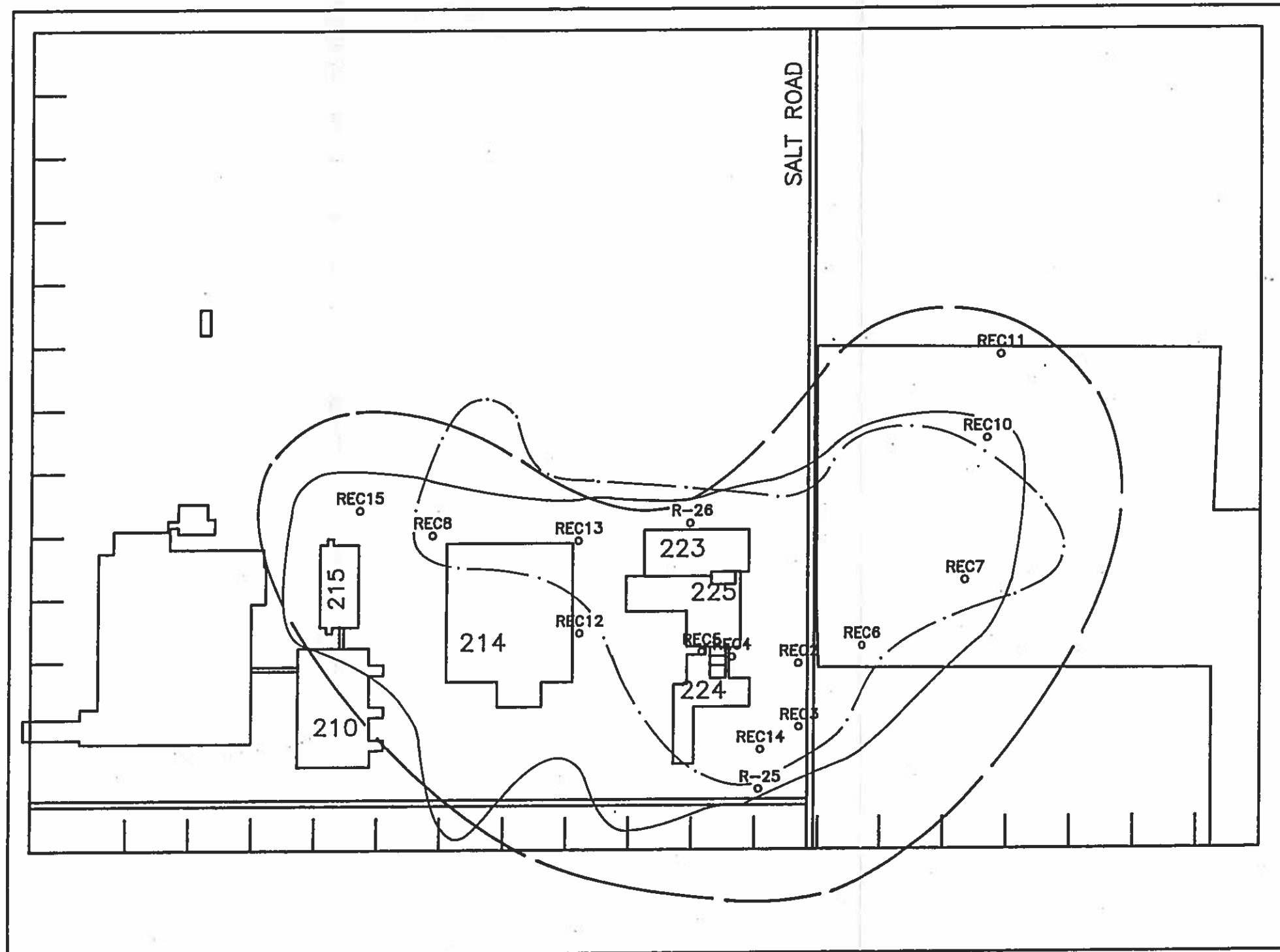
H&A of New York
 Consulting Geotechnical Engineers, Geologists and Hydrogeologists

XEROX CORPORATION
 CORRECTIVE MEASURES STUDY
 SALT ROAD SITE

**PLUME AREA DESIGNATIONS
 INTERMEDIATE AQUIFER**

SCALE: 1 IN. = 600 FT. AUGUST 1991

FIGURE 3-3



LEGEND:

- 223 XEROX BUILDING NO.
- R-26 ○ RECOVERY WELL
- ESTIMATED EXTENT OF INTERMEDIATE PLUME
- - - ESTIMATED EXTENT OF SHALLOW PLUME
- · - · ZONE OF CAPTURE

NOTE:

1. ESTIMATED EXTENT OF INTERMEDIATE PLUME ENCOMPASSES ALL INTERMEDIATE WELLS WHICH HAVE HAD DETECTABLE LEVELS OF CONTAMINANT WITHIN 1992 ABOVE DRINKING WATER STANDARDS.
2. ESTIMATED EXTENT OF SHALLOW PLUME ENCOMPASSES ALL SHALLOW WELLS WHICH HAVE HAD DETECTABLE LEVELS OF CONTAMINANT WITHIN 1992 ABOVE DRINKING WATER STANDARDS.
3. PROJECTED FUTURE ZONE OF CAPTURE IS BASED ON INTERMEDIATE AQUIFER GROUNDWATER CONTOUR MAPS FROM THE 17TH THROUGH 20TH QUARTERS.


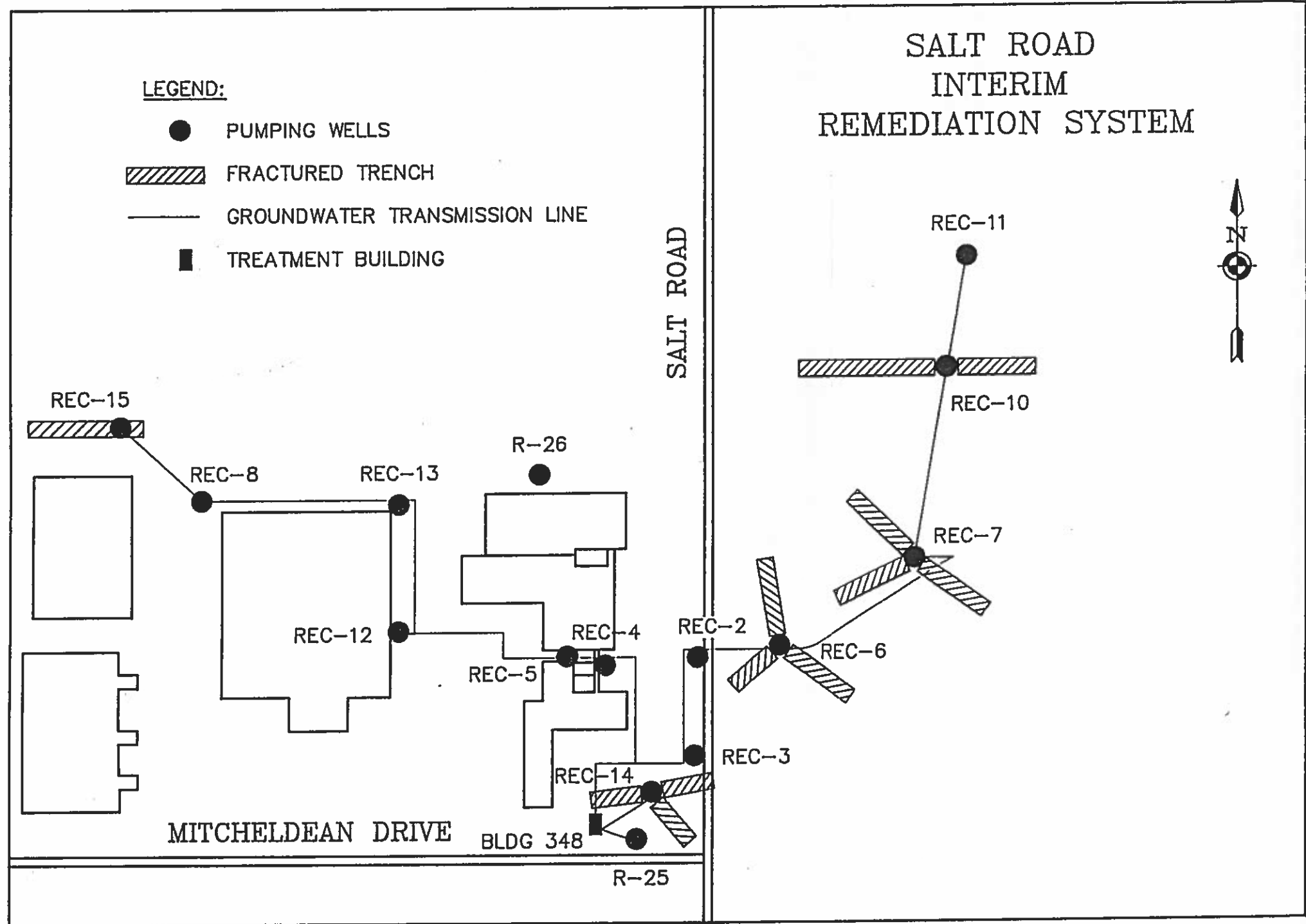
| | |
|---|--|
| H & A OF NEW YORK | |
|  | Geotechnical Engineers & Environmental Consultants |
| XEROX CORPORATION CORRECTIVE MEASURES STUDY SALT ROAD COMPLEX | |
| EXTENT OF PLUME AND GROUNDWATER CAPTURE ZONE | |
| SCALE: 1IN. = 600 FT. | OCTOBER 1992 |

FIGURE 3-4

SALT ROAD INTERIM REMEDIATION SYSTEM

LEGEND:

- PUMPING WELLS
- ▨ FRACTURED TRENCH
- GROUNDWATER TRANSMISSION LINE
- TREATMENT BUILDING



AOA H & A O F N E W Y O R K
Geotechnical Engineers & Environmental Consultants

XEROX CORPORATION
CORRECTIVE MEASURES STUDY
SALT ROAD COMPLEX

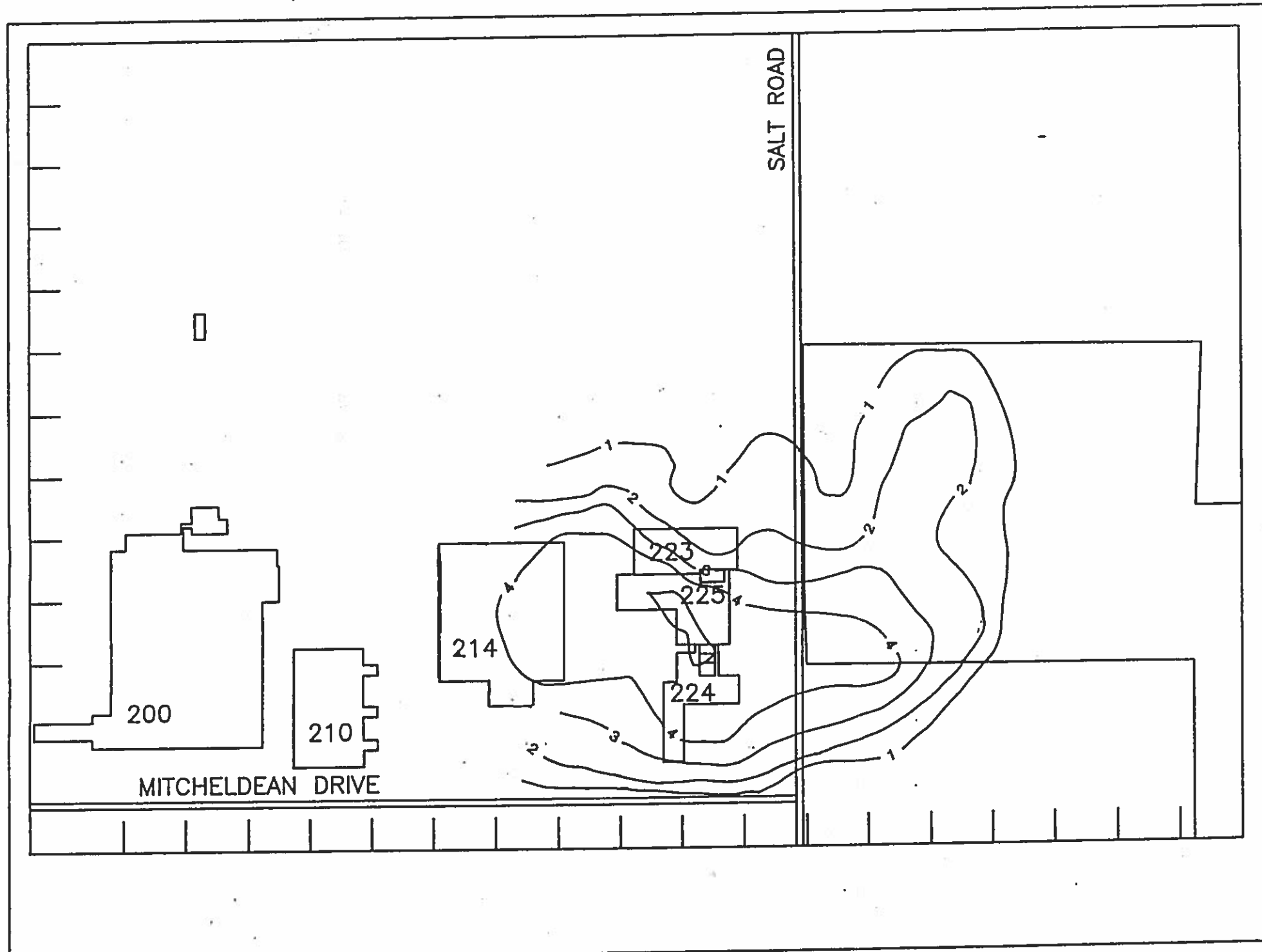
GROUNDWATER RECOVERY SYSTEM

SCALE: 1 IN. = 600 FT.

OCTOBER 1992

FIGURE 6-1

FILE NO. 7580-56



LEGEND:

223 XEROX BUILDING NO.

2 EQUAL CONCENTRATION CONTOURS OF THE LOG OF TOTAL VOLATILE CONCENTRATION (PPB)

NOTE:

1. CONTOURS BASED ON TOTAL VOLATILE ORGANIC CONCENTRATIONS DETERMINED DURING THE 1988 ANNUAL SAMPLING AND ANALYSIS EVENT CONDUCTED DURING NOVEMBER 1988.

FILE NO. 7580-56

CHARRETTE

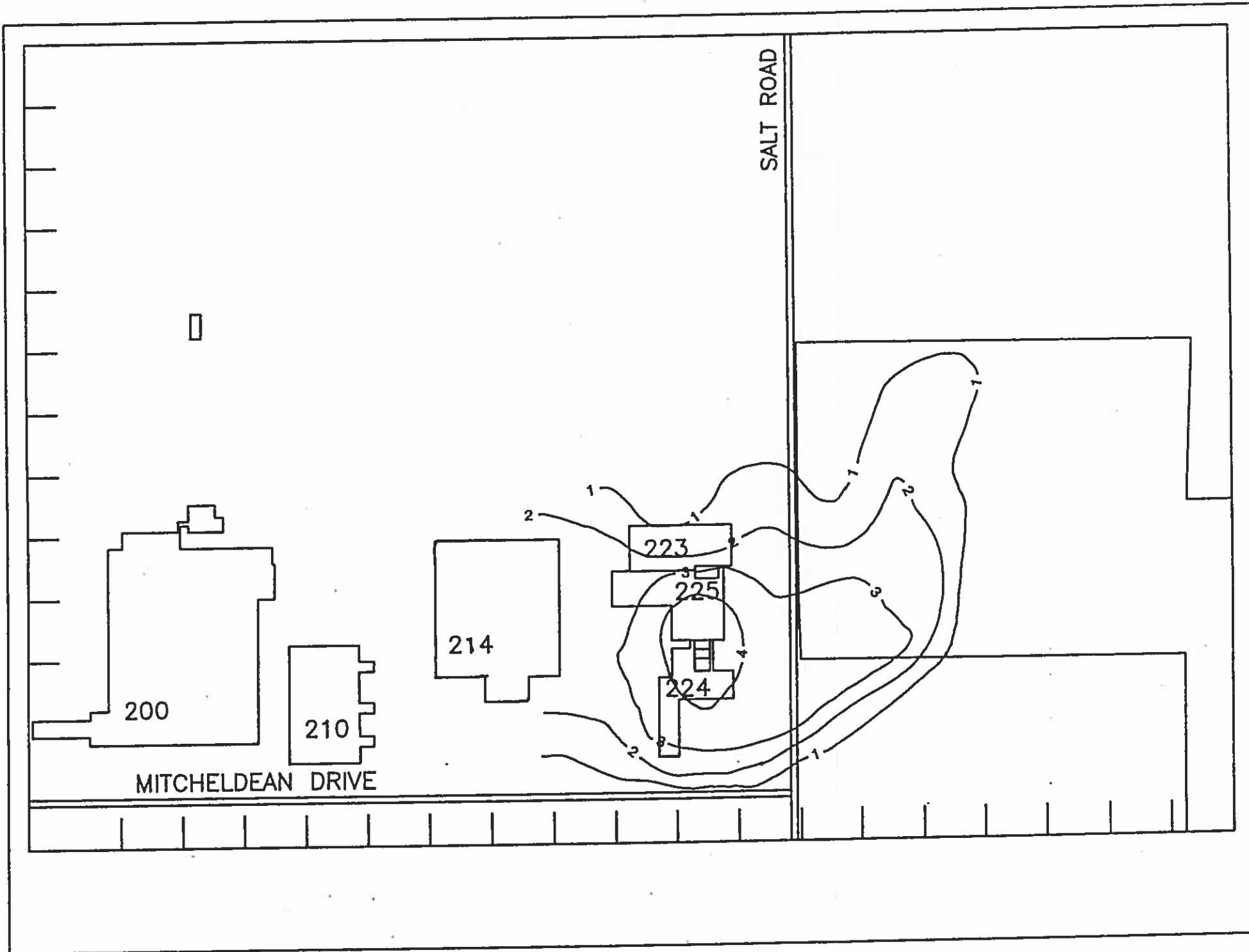
AOA H & A of New York
 Consulting Geotechnical Engineers, Geologists and Hydrogeologists

XEROX CORPORATION
 CORRECTIVE MEASURES STUDY
 SALT ROAD COMPLEX
 TOTAL VOLATILE ORGANIC CONCENTRATION
 INTERMEDIATE ZONE
 NOVEMBER, 1988

SCALE: 1 IN. = 600 FT.

AUGUST 1991

FIGURE 6-2



LEGEND:

223 XEROX BUILDING NO.

2 EQUAL CONCENTRATION CONTOURS OF THE LOG OF TOTAL VOLATILE CONCENTRATION (PPB)

NOTE:

1. CONTOURS BASED ON TOTAL VOLATILE ORGANIC CONCENTRATIONS DETERMINED DURING THE 1990 ANNUAL SAMPLING AND ANALYSIS EVENT CONDUCTED DURING NOVEMBER 1990.

FILE NO. 7590-56

CHARPETTE

AOA H & A of New York
 Consulting Geotechnical Engineers, Geologists and Hydrogeologists

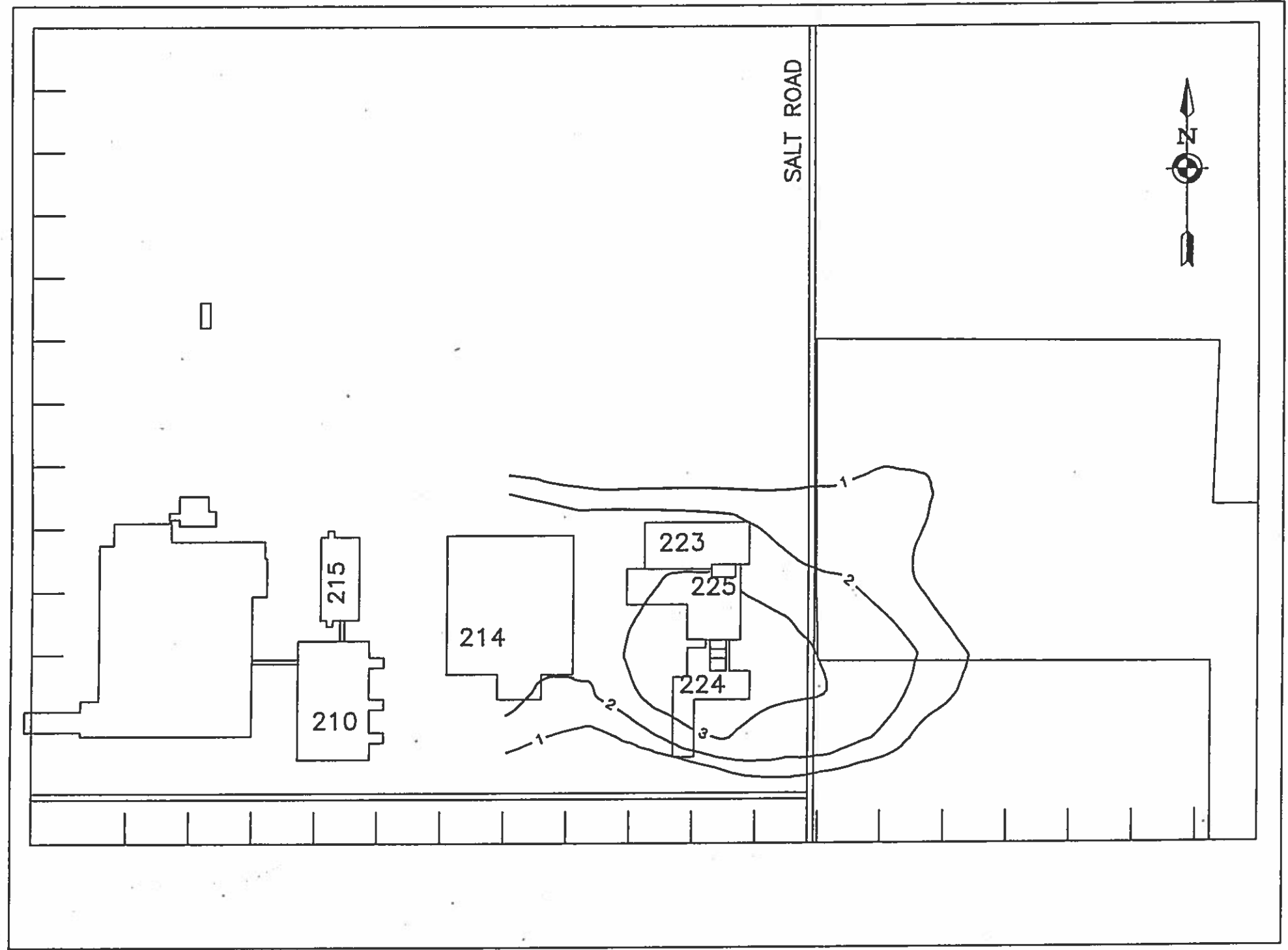
XEROX CORPORATION
 CORRECTIVE MEASURES STUDY
 SALT ROAD COMPLEX
**TOTAL VOLATILE ORGANIC CONCENTRATION
 INTERMEDIATE ZONE
 NOVEMBER, 1990**

SCALE: 1 IN. = 600 FT.

AUGUST 1991

FIGURE 6-3

109009



LEGEND:

223 XEROX BUILDING NO.

— 2 — EQUAL CONCENTRATION CONTOURS OF THE LOG OF TOTAL VOLATILE CONCENTRATION (PPB)

NOTE:

1. CONTOURS BASED ON TOTAL VOLATILE ORGANIC CONCENTRATION DETERMINED DURING THE SAMPLING AND ANALYSIS EVENT CONDUCTED DURING APRIL 1992.

FILE NO. 7580-62

MAKEPEACE


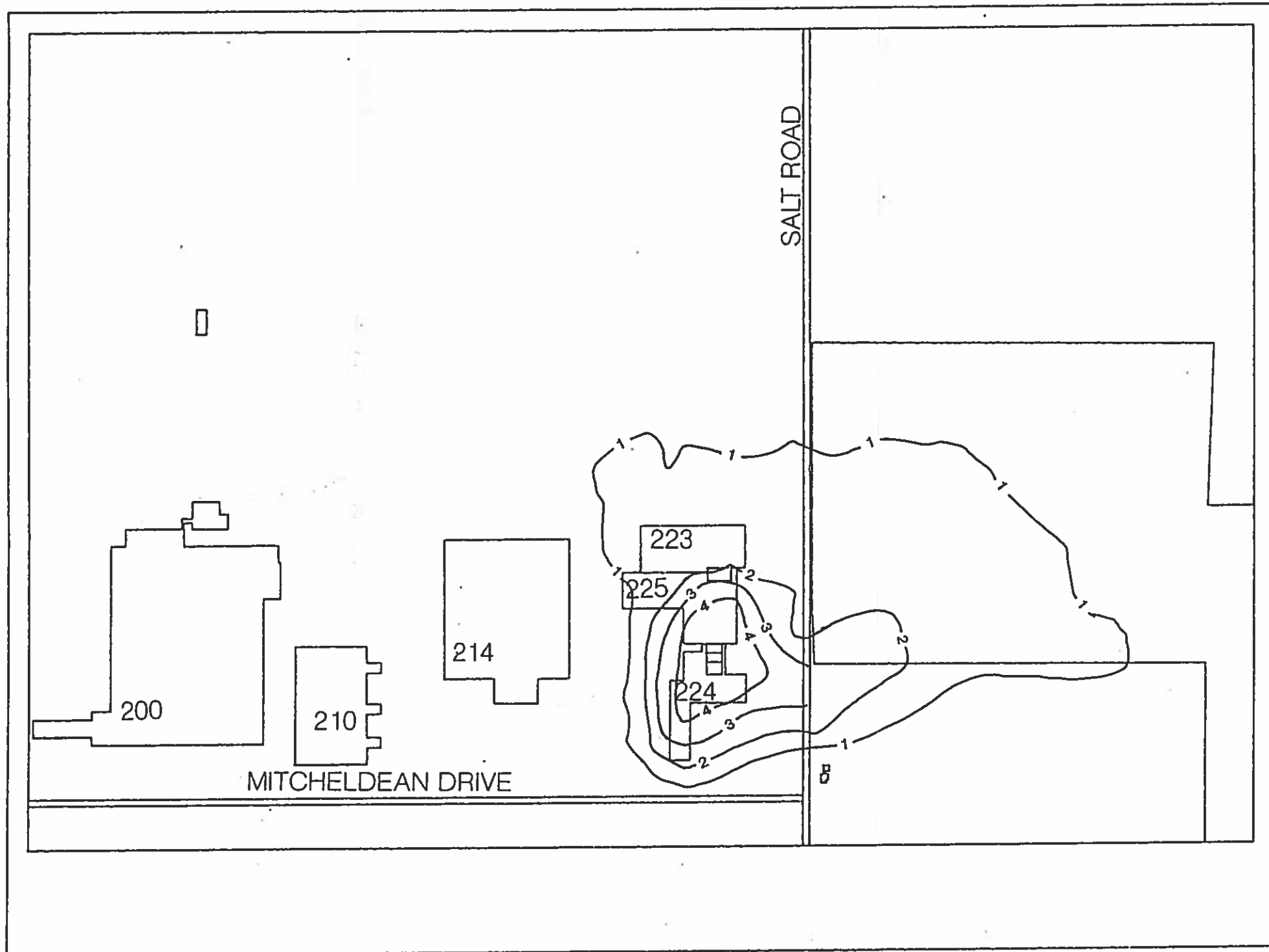
| | |
|---|--|
| H & A OF NEW YORK | |
|  | Geotechnical Engineers & Environmental Consultants |
| XEROX CORPORATION CORRECTIVE MEASURES STUDY SALT ROAD COMPLEX | |
| TOTAL VOLATILE ORGANIC CONCENTRATION INTERMEDIATE ZONE — APRIL, 1992 | |
| SCALE: 1 IN. = 600 FT. | OCTOBER 1992 |

FIGURE 6-4



LEGEND:

223 XEROX BUILDING NO.

— 2 — EQUAL CONCENTRATION CONTOURS OF THE LOG OF TOTAL VOLATILE CONCENTRATION (PPB)

NOTE:

1. CONTOURS BASED ON TOTAL VOLATILE ORGANIC CONCENTRATIONS DETERMINED DURING THE 1988 ANNUAL SAMPLING AND ANALYSIS EVENT CONDUCTED DURING NOVEMBER 1988.

FILE NO. 7580-62

CHARRETTE

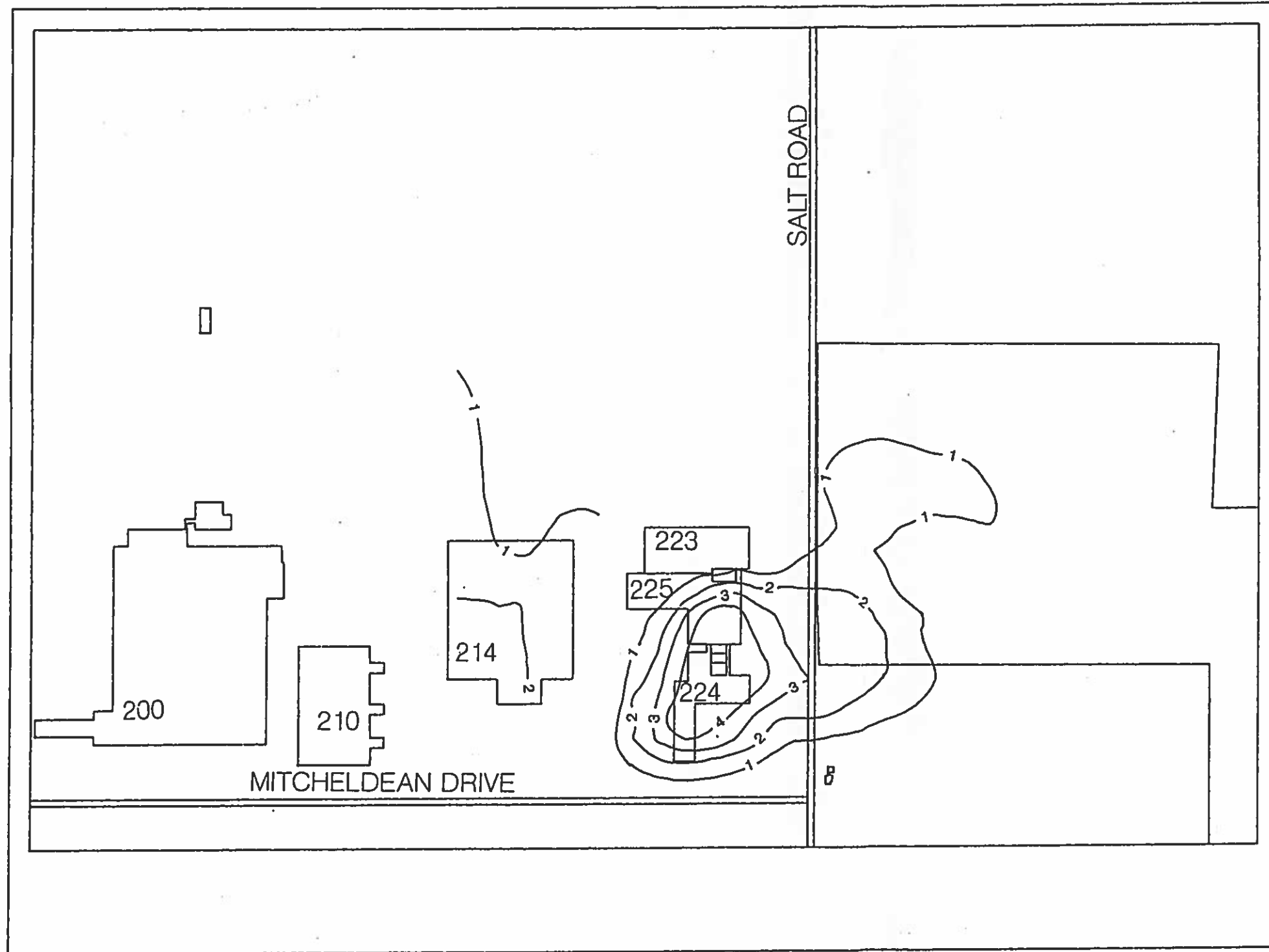
H&A H & A of New York
 Consulting Geotechnical Engineers, Geologists and Hydrogeologists

XEROX CORPORATION
 CORRECTIVE MEASURES STUDY
 SALT ROAD COMPLEX
**TOTAL VOLATILE ORGANIC CONCENTRATION
 SHALLOW ZONE
 NOVEMBER, 1988**

SCALE: 1 IN. = 600 FT.

SEPTEMBER 1991

FIGURE 6-5



LEGEND:

223 XEROX BUILDING NO.

— 2 — EQUAL CONCENTRATION CONTOURS OF THE LOG OF TOTAL VOLATILE CONCENTRATION (PPB)

NOTE:

1. CONTOURS BASED ON TOTAL VOLATILE ORGANIC CONCENTRATIONS DETERMINED DURING THE 1990 ANNUAL SAMPLING AND ANALYSIS EVENT CONDUCTED DURING NOVEMBER 1990.

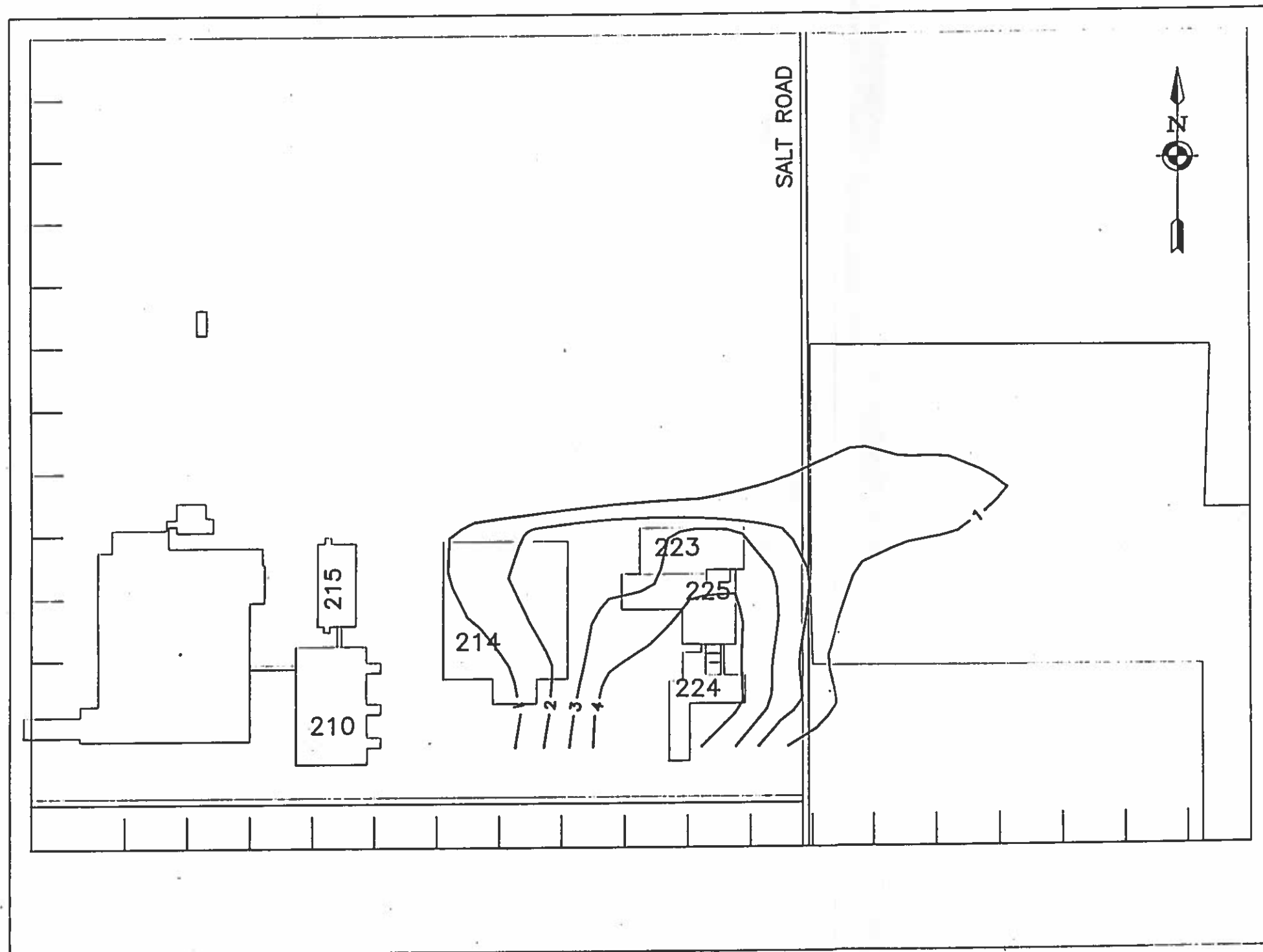
FILE NO. 7580-62

CHARRETTE

H&A H & A of New York
 Consulting Geotechnical Engineers, Geologists and Hydrogeologists

XEROX CORPORATION
 CORRECTIVE MEASURES STUDY
 SALT ROAD COMPLEX
**TOTAL VOLATILE ORGANIC CONCENTRATION
 SHALLOW ZONE
 NOVEMBER, 1990**
 SCALE: 1 IN. = 600 FT. SEPTEMBER 1991

FIGURE 6-6




LEGEND:

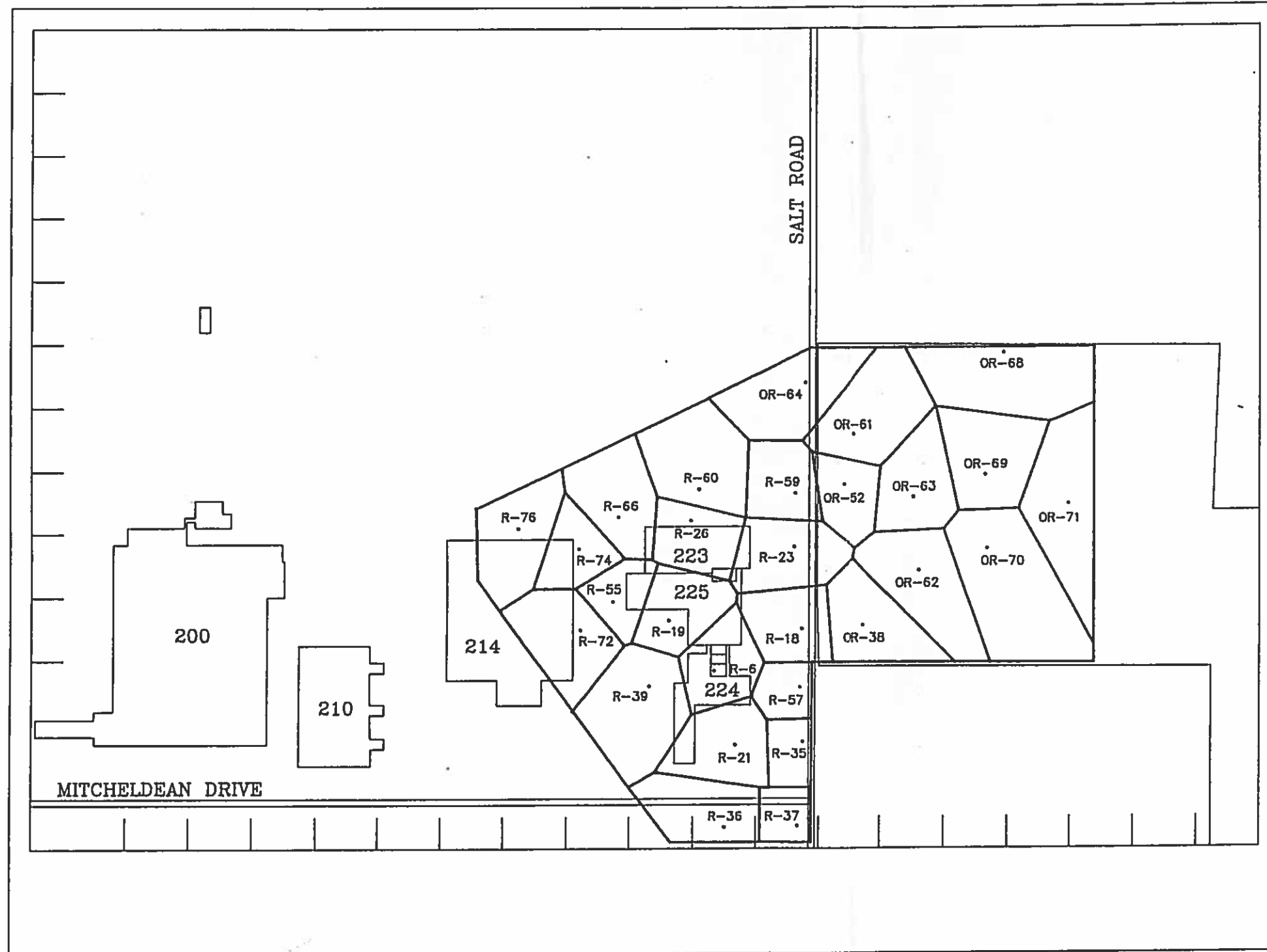
223 XEROX BUILDING NO.

2 — EQUAL CONCENTRATION CONTOURS OF THE LOG OF TOTAL VOLATILE CONCENTRATION (PPB)

NOTE:

1. CONTOURS BASED ON TOTAL VOLATILE ORGANIC CONCENTRATION DETERMINED DURING THE SAMPLING AND ANALYSIS EVENT CONDUCTED DURING APRIL 1992.

| | |
|---|--|
| H & A OF NEW YORK | |
|  | Geotechnical Engineers & Environmental Consultants |
| XEROX CORPORATION CORRECTIVE MEASURES STUDY SALT ROAD COMPLEX | |
| TOTAL VOLATILE ORGANIC CONCENTRATION SHALLOW ZONE - APRIL 1992 | |
| SCALE: 1 IN. = 600 FT. | OCTOBER 1992 |



LEGEND:

- OR-38 MONITORING WELL LOCATION
- 200 XEROX BUILDING NUMBER

NOTES:

1. INFLUENCE POLYGONS DRAWN USING THE THEISSEN METHOD.
2. SEE TABLE 6-2 FOR CONTAMINANT MASS REDUCTION BASED ON THESE POLYGONS.
3. WELL INCLUDED IN THIS MAP ARE ALL INTERMEDIATE AQUIFER WELLS IN EXISTENCE IN 1988, AND SAMPLED DURING THE 1988 ANNUAL SAMPLING ROUND.

FILE NO. 7580-62

CHARRETTE

H&A of New York
 Consulting Geotechnical Engineers, Geologists and Hydrogeologists

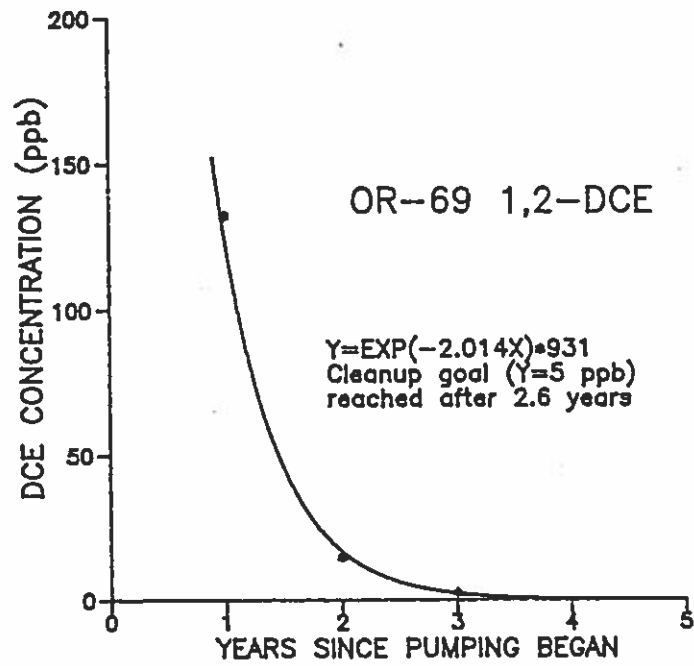
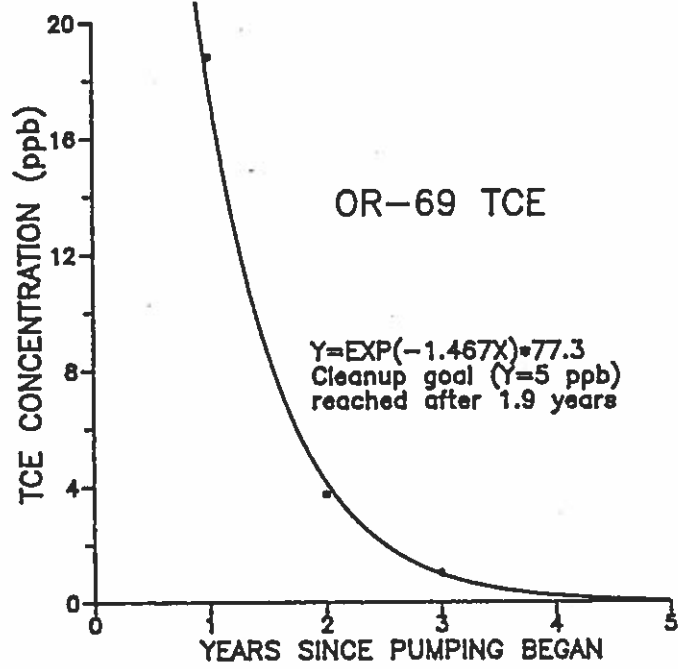
XEROX CORPORATION
 CORRECTIVE MEASURES STUDY
**INFLUENCE POLYGONS
 INTERMEDIATE WELLS**

SCALE: 1 IN. = 600 FT.

AUGUST 1991

FIGURE 6-8

FIGURE 10-1
PROJECTED CONTAMINANT REDUCTION DIAGRAMS



FILE NO. 7580-56

APPENDIX A

**Revised Corrective Measures Study Plan
Approval Letter**





UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION II
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10278

NOV - 8 1990

Dr. Robert Heeks, Ph.D.
Xerox Corporation
800 Salt Road
Building 843
Webster, NY 14580

RE: Conditional Approval of Corrective Measures Study Plan
Xerox Corporation - Salt Road Complex
NYD002211324

Dear Dr. Heeks:

This letter transmits changes requested for incorporation into the Corrective Measures Study Plan (CMSP) for the Xerox Salt Road Complex, submitted to EPA January 1990 pursuant to Consent Order II-RCRA-3008(h)-88-0204. Pending review and incorporation by Xerox of the enclosed changes into the CMSP, conditional approval of the (revised) CMSP is granted.

The effectiveness of the remedial interim measures employed at the Salt Road site are well documented at this time. It is our opinion that subsequent to screening of available technologies with the goal of determining those technologies, or combinations of technologies, which are potentially more effective than currently employed, the Corrective Measures Study may focus on the enhancement of the existing remedial technologies, given that no more effective technologies are found. This may be achieved through engineering modifications and/or use of additional technologies in a direct or phased manner.

Please be advised that EPA reserves the right to require incorporation into the CMSP of technologies for remediation of metals contamination at the Salt Road site, pending receipt and review by EPA of on-site and off-site (local) historical metals data. Further, it should be noted that the referenced guidance documents for health based standards (for soil and groundwater) are subject to modification as additional research and health related information becomes available.

1

Text enclosed is intended to replace corresponding sentences in the referenced paragraphs:

IV. Corrective Action Objectives - (page 9, paragraph 1)

...Consistent with this policy, the most stringent regulatory standard for organic contaminants is found in the New York State Groundwater Protection Concentrations, which incorporates the Part 5 Drinking Water Supplies of the New York State Sanitary Code, Subpart 5-5.51 Maximum Contaminant Levels.

IV. Corrective Action Objectives - (page 9, paragraph 3)

...As a result, clean-up goals for soils will also be based on the Toxicity Characteristic Leaching Procedure as described in EPA Method 1311, SW-846 (Appendix C).

Section 4.1 - (page 10, paragraph 2)

...The primary screening of potential technologies will be to determine whether the technology, employed either individually or in combination with other technologies, will be more effective in achieving the corrective measure objectives than the currently implemented measure.

V. Laboratory and Bench scale Studies Plan and Implementation - (page 12, paragraph 1)

...A review of the potential corrective action technologies identified in Section 4.1 indicates the implementation of bench scale studies will, for the most part, not be necessary, with the exception of groundwater treatment technologies involving oxidation and technologies (or combinations of technologies) employed to enhance groundwater treatment technologies involving oxidation. Where preliminary evaluation of a potential corrective measure option, however, indicates performance exceeding that of the currently employed measure, or where implementation of a particular technology is waste specific, as in bioremediation, bench scale or pilot studies will be conducted, as appropriate, to determine the effectiveness of the corrective measure. However, should sufficient data exist which documents the implementation of a given technology under similar conditions to those at the Salt Road site (whether simulated or actual), such information may be utilized as a substitute to bench scale and/or pilot studies.

V. Laboratory and Bench Scale Studies Plan and Implementation - (page 12, paragraph 2)

...In addition, the findings from previous technology screening studies will be described in full as part of the CMS.

VI. Summary of Effectiveness of Existing Interim Remedial Measures - (page 14)

...Potential corrective measure technologies that do not offer additional benefits in contaminant reduction when compared to existing technologies will not be given further consideration, with the exception of technologies employed in conjunction with existing remedial technologies to enhance effectiveness.

VII. Screening of Corrective Measures Technologies - (page 16, Benefit Comparison)

...benefits offered by a technology do not provide a higher degree of contaminant reduction when compared to existing remedial measures, or generate cross media contamination or by-products which necessitate further remediation.

Section 8.1.10 - Overall Technical Assessment - (page 25, Performance, paragraph 2)

...in Section 8.1.1.

Section 8.1.10 - Overall Technical Assessment - (page 27, Implementability, paragraph 3)

...Beneficial results will be considered in terms of the reduction in levels of contamination necessary to attain applicable corrective action objectives; where possible, the achievement of intermediate, as well as final corrective action goals will be evaluated for each of the proposed corrective measures options.

Section 8.1.10 - Overall Technical Assessment - (page 27, Safety and Health)

Replace existing section with the following:

The corrective measure option(s) will be evaluated with regard to impacts on the safety and health of nearby communities, environments, and workers during implementation of the measure. This evaluation will consider the health impacts of end products

which may be produced as a result of implementation of the corrective measure, as well as the potential for release of by-products to the environment.

Section 8.1.11 - Overall Technical Assessment - (page 26, Environmental Assessment)

Replace existing section with the following:

An assessment of the short-term and long-term environmental effects, both beneficial and adverse, of implementation of the corrective measure option(s) will be made. The environmental assessment will include an evaluation of the facility conditions and pathways of contamination specifically addressed by the corrective measure option(s) and an analysis of the capability of the measure for mitigating adverse environmental effects.

Section 8.1.12 - Overall Technical Assessment - (page 25, Human Health Assessment)

Replace existing section with the following:

An assessment will be made to determine the extent that the corrective measure option(s) mitigates the short-term and long-term potential exposure to any residual contamination and protects human health during and after implementation. The assessment will identify and describe potential exposure routes, affected population, levels of exposure to contaminants, and predicted exposure reduction afforded by the measure over time.

Section 8.1.14 - Background vs. Alternate Contaminant Concentrations (page 29)

Replace existing section with the following:

The capability of the corrective measure option(s) to ensure that releases to soils, and ground water are remedied to specified corrective action levels will be assessed. If the determination that the specified corrective action levels cannot be reached is made, either as a result of the Corrective Measures Study or during Corrective Measures Implementation, alternate concentration levels (ACL) will be proposed at such time, subject to EPA approval.

FROM U.S. EPA 0134

12/11/90 14:24 P. 2

Please call me at (212) 254-4669 if you have any questions or comments on this matter.

Sincerely,



Leonard Grossman
Project Coordinator

cc: S. Kaminsky, NYSDEC
D. Radke, NYSDEC
E. Miles, NYSDEC
V. Mincha, NYSDEC
D. Rollins, NYSDEC
C. Richmond, NYSDEC
C. Amento, NYSDOH

APPENDIX B

**Metals Concentration in Groundwater
Salt Road Site, Letter Report**

**Summary of Analytical Data for Other
Organic Compounds Detected in Groundwater**



28 June 1990
File No. 7580-54

Xerox Corporation
800 Salt Road
Building 843
Webster, New York 14580

Attention: Dr. Robert Heeks

Subject: Review of Metals Concentrations in
Groundwater - Salt Road Site

Gentlemen,

This letter presents the results of H&A of New York's review of existing data regarding the presence of metals in groundwater at the Salt Road site. Xerox requested this review as a result of discussions with USEPA during the 11th Quarter Meeting held on 30 May 1990. USEPA questioned why metals are not included in the ongoing groundwater sampling and analysis activities, or in the remediation program. The purpose of our review was to determine the rationale for elimination of metals analysis and remediation activities.

Metals analyses were conducted on groundwater samples from the Xerox site collected in 1983, 1985, and 1986. More recently, metals analyses were conducted on four groundwater samples collected during 1989. In addition, approximately 200 Webster wells were included in a Monroe County Health Department study of arsenic during 1986. The analytical database for metals that was reviewed for this investigation, which includes on-site and off-site sampling locations is as follows:

- o 15, 16, 17 November 1983 RECRA Env. Labs.
Test pit and building 225-A Sump
- o 19 December 1985 General Testing Corporation
56 Salt Road Monitoring Wells

189 North Water Street
Rochester, NY 14604
716/242-7300

Affiliate
Haley & Aldrich, Inc.
Cambridge, Massachusetts
Glastonbury, Connecticut
Scarborough, Maine
Bedford, New Hampshire

- o 8 January 1986 General Testing Corporation
23 Salt Road Monitoring Wells
- o 2 February 1986 General Testing Corporation
24 Salt Road Monitoring Wells
- o 20 February 1986 General Testing Corporation
54 Salt Road Monitoring Wells, Bldg. 225-A Sump
- o 1 April 1986 General Testing Corporation
58 Salt Road Monitoring Wells, Bldg. 225-A Sump
- o 1, 2 May 1986 General Testing Corporation
58 Salt Road Monitoring Wells, Bldg. 225-A Sump
- o 25 January 1989 General Testing Corporation
SR-9, R-19, and R-55

In addition the following reports contain data and information that are referenced in this letter:

- Ref. 1 Eisler R. 1985. Selenium Hazards to Fish, Wildlife, and Invertebrates. A Synoptic Review. U.S. Fish and Wildlife Service.
- Ref. 2 H&A of New York, 1981. Report on Geologic Conditions, Combined Sewer Overflow Abatement Program, Phase II.
- Ref. 3 Monroe County Health Department, 1986. Final Report, Re: Webster Groundwater Contamination.
- Ref. 4 Sheneman, R.S. 1986. Arsenic Contamination of Groundwater in Webster, New York. Senior Thesis, University of Rochester.

In the mid 1980's, Xerox Corporation had determined that groundwater contamination had occurred on site, and had begun installing and sampling wells to determine the areal extent and severity of the problem. In that the chemical nature of the plume had yet to be defined, groundwater samples were analyzed for a wide range of organic chemicals and metals.

During the same time period an intensive study of arsenic levels in the soil, groundwater, and rock underlying Webster was being conducted by the Monroe County Health Department (MCHD). The MCHD, along with the Town of Webster, NYSDEC, Xerox Corporation, Monroe County Cooperative Extension Service, SUNY Geneseo Geology Department and Cornell University Department of Agriculture and Life Science, collected hundreds of samples for arsenic analysis.

The results of this joint effort indicated that high levels of arsenic were found in groundwater throughout Webster, including areas that are remote from the Xerox Webster site. Elevated levels of arsenic were also detected in samples of Grimsby sandstone from Webster (Reference 3). The patterns and distribution of arsenic levels led to the conclusions that the naturally occurring high levels of arsenic were due to the mineralogy of the Grimsby Sandstone below Webster, and that additional arsenic had been added to local soil and water when lead arsenate and cuprous arsenate were used as pesticides on local orchards.

The MCHD study and final report were completed in late May of 1986. The final round of sampling and analysis for metals in water samples from Xerox wells occurred in June of 1986. It is possible that the Xerox metals analyses were curtailed after it was determined that elevated arsenic and lead levels in water were wide spread in the Webster area, and not related to the activities of Xerox Corporation.

A previous study, the 1981 Combined Sewer Overflow Abatement Project (CSOAP) performed by Lozier Laboratories, involved collection and analysis of 26 groundwater samples locally from CSOAP wells constructed in the Grimsby Sandstone. Samples were analyzed for metals including arsenic, lead, and selenium. Elevated levels of arsenic, lead, and selenium were detected in samples from areas that are remote from the Xerox Webster site.

A review of the metals concentrations found in water samples from Xerox Salt Road monitoring wells, and CSOAP wells supports the conclusions of the MCHD report, that elevated metals concentrations are ubiquitous in this area and are related to previous agricultural practices and regional geochemistry. Table 1 presents the range and mode of metals concentrations found in the CSOAP investigation and at the Xerox site. The most stringent applicable standard and percent exceedances of the standard is also included.

Arsenic, lead, and selenium were found at levels above the applicable NYS standards at the Xerox site. Nickel exceeded the standard on only one occasion at one well by approximately 1%. Copper concentrations were consistently lower than the applicable standard.

In its study the MCHD had found that arsenic levels for most wells in Webster were in the 0.015 to 0.025 ppm range, with two above 0.050 ppm, the EPA drinking water standard. Water samples collected from the Grimsby Sandstone as part of the CSOAP study were found to have arsenic levels ranging from 0.003 to 0.22 ppm, with 8% of the wells having arsenic levels exceeding the EPA drinking water standard (Reference 3). Of the 277 groundwater samples collected from the Salt Road site by Xerox Corporation during 1986 and submitted for metals analysis, approximately 3% had arsenic levels above the current New York State standard of 0.025 ppm, similar to that observed for the CSOAP wells.

Elevated levels of lead in groundwater was found to be ubiquitous at the Salt Road site. Approximately 80% of the groundwater samples collected during 1986 had lead levels above the current New York State standard of 0.025 ppm. The elevated lead levels reflect either natural conditions for this area, or residue from the local historical use of lead arsenate as a pesticide. This argument is supported by the finding that elevated lead levels were measured in upgradient wells, cross gradient wells, and perimeter wells (i.e. R-36, R-37, OS-44, OS-45, and OS-58). Additionally, 81% of the water samples from the Grimsby Sandstone wells analyzed during the CSOAP study had lead levels above the New York State Standard, similar to that observed for Salt Road.

Selenium levels exceeded the drinking water standard only at SR-10 and SR-15, and consistently exceeded the standard only at SR-10. Of the 277 groundwater samples collected from the Salt Road Site by Xerox Corporation during 1986, approximately 3% had selenium levels above the current New York State standard of 0.010 ppm. Selenium levels found during the CSOAP study ranged from less than 0.005 to 0.016 ppm, with 4% of the wells having selenium levels above the current New York State standard similar to that observed for the Salt Road site. It is possible that elevated selenium levels are related to past agricultural practices, in that selenium has also historically been used as a pesticide to control mites on apples (Reference 1).

All of the analytical results mentioned in the above discussion were obtained from non-filtered water samples. These results reflect the metal concentrations of suspended particles in the water samples as well as the dissolved concentration. Filtered groundwater samples from the Xerox Salt Road site would provide chemical results more representative of groundwater metals concentrations as they occur in the aquifers.

In summary, there are two overriding facts which must be considered when reviewing groundwater metals concentrations at the Xerox Salt Road site:

1. The reported metals concentrations for the Xerox Salt Road site are total metals rather than dissolved metals. Therefore, the reported metals concentrations are probably higher than the true concentration of metals in groundwater below the site.
2. The range and distribution of metals concentrations, and the percentage exceeding groundwater standards at Xerox wells is nearly identical to the range and distribution of metals concentrations, and the percentage exceeding groundwater standards for CSOAP wells. This indicates that Xerox groundwater samples are within the same chemical population as the CSOAP wells, and that the metals concentrations at Xerox wells have not been affected by industrial activity.

Sincerely yours,
H&A OF NEW YORK,

Joshua Goldowitz
Staff Hydrogeologist

Lawrence P. Smith
Assistant Manager



TABLE 1
 ARSENIC, LEAD, AND SELENIUM CONCENTRATIONS
 AT XEROX, WEBSTER AND MONROE COUNTY

| | XEROX DETECTION LIMIT | CSOAP DETECTION LIMIT | XEROX MAXIMUM | CSOAP MAXIMUM | XEROX PERCENT EXCEEDENCE | CSOAP PERCENT EXCEEDENCE | MOST STRINGENT APPLICABLE STANDARD |
|----------|-----------------------------|-----------------------------|------------------|------------------|--------------------------------|--------------------------------|--|
| ARSENIC | 0.002 | 0.003 | 0.180 | 0.220 | 3 | 8 | 0.025 |
| LEAD | 0.050 | 0.020 | 0.850 | 0.880 | 80 | 81 | 0.025 |
| SELENIUM | 0.002 | 0.005 | 0.030 | 0.016 | 3 | 4 | 0.010 |

- Notes: 1) All concentrations are in milligrams per liter.
 2) Xerox % exceedence based on 277 samples collected during 1986,
 CSOAP % exceedence based on 26 samples collected during 1981.
 3) % Exceedence refers to the percent of samples exceeding
 applicable drinking water standards.



CORRECTIVE ACTION CHEMICAL PROGRESS 9/29/92 TLW

() = WELL NUMBER

ANALYTICAL RESULTS = UG/L = PPB

| CHEMICAL | MAY 1990 | JULY 1990 | OCT. 1990 | JAN. 1991 | APRIL 1991 | AUG. 1991 | NOV. 1991 | FEB. 1992 | APRIL 1992 |
|--------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|--------------|
| 1,1 DCE | 21.3(R-19) | 5.88(OS-34) | 34.8(R-94) | 41.3(R-94) | 22(OR-108) | 12.1(SR-3) | 3.06(R-35) | 28.5(SR-16) | 1.3(210-1) |
| | 1.99(R-57) | 1.09(R-55) | 16.5(R-103) | 34.0(R-103) | 59.9(R-103) | 33.7(R-103) | 32.9(R-103) | 41.6(R-103) | 42(R-103) |
| | 26.9(R-94) | 30.6(R-94) | 4.02(OS-109) | | 1.07(210-1) | 19.2(R-94) | 16.8(R-94) | 8.00(R-94) | 36(R-94) |
| | 25.8(R-103) | 28.6(R-103) | | | 5.24(210-2) | 1.40(210-1) | 4.23(OS-109) | 1.3(210-1) | |
| | 42.7(OR-106) | 3.60(OS-109) | | | | | 2.18(210-1) | 13.2(OR-104) | |
| | 9.03(OR-108) | 10.2(210-3) | | | | | | | |
| | | 27.1(OR-108) | | | | | | | |
| | 38.7(OR-104) | | | | | | | | |
| CHEMICAL | MAY 1990 | JULY 1990 | OCT. 1990 | JAN. 1991 | APRIL 1991 | AUG. 1991 | NOV. 1991 | FEB. 1992 | APRIL 1992 |
| 1,2 DCA | 4.14(OS-32) | 1.39(REC.1A) | 17.5(R-18) | 3.64(REC.1A) | 2.44(REC.1A) | 1.63(REC.1A) | 4.52(REC.1A) | 1.91(REC.1A) | 1.7(REC.1A) |
| | | | 5.32(R-23) | | 17.1(R-18) | 1.93(OR-63) | 4.35(SR-2) | 270(R-6) | |
| | | | 1.02(OR-68) | | | 1.16(SR-85) | 23.2(R-18) | 2.94(OR-63) | |
| | | | | | | 2.49(210-1) | 7.36(R-23) | | |
| | | | | | | 21.4(R-18) | 1.18(R-59) | | |
| | | | | | | 1.24(R-94) | | | |
| CHEMICAL | MAY 1990 | JULY 1990 | OCT. 1990 | JAN. 1991 | APRIL 1991 | AUG. 1991 | NOV. 1991 | FEB. 1992 | APRIL 1992 |
| CHLOROFORM | 2.67(OR-69) | 570(SR-12) | 6.75(B225A-S) | 10.3(B225A-S) | 16.6(B225A-S) | 17.2(B225A-S) | 8.14(B225A-S) | 6.40(B225A-S) | 6.0(B225A-S) |
| | | 6.90(REC.3) | 4.64(REC.13) | 4.33(REC.13) | 5.14(REC.13) | 16.6(REC.8) | 8.90(REC.8) | 56(SR-7) | 5.6(REC.8) |
| | | | | 3.46(R-74) | 7.22(R-74) | | | | 1.1(REC.12) |
| | | | | | 3.01(OS-29) | | | | |
| | | | | 5870(SR-4) | | | | | |
| CHEMICAL | MAY 1990 | JULY 1990 | OCT. 1990 | JAN. 1991 | APRIL 1991 | AUG. 1991 | NOV. 1991 | FEB. 1992 | APRIL 1992 |
| CHLOROETHANE | 32.4(OS-109) | 22.1(OS-109) | 17.5(OS-109) | 20.2(OS-32) | 13.6(REC.3) | ND | 8.61(R-35) | 5.6(R-35) | 11(REC.3) |
| | | 8.68(SR-81) | 21.8(OS-34) | 54.3(OS-34) | | | 7.12(OS-34) | 2.32(OR-63) | 130(REC.15) |
| | | 22.1(OS-34) | 2.88(REC.6) | | | | 30.3(SR-20) | | |
| | | 6.54(OS-32) | | | | | 2.16(OR-70) | | |
| | | | | | | 3.45(SR-81) | | | |
| | | | | | | 2.08(DR-102) | | | |
| | | | | | | 2.56(OR-112) | | | |
| CHEMICAL | MAY 1990 | JULY 1990 | OCT. 1990 | JAN. 1991 | APRIL 1991 | AUG. 1991 | NOV. 1991 | FEB. 1992 | APRIL 1992 |
| BENZENE | ND | 12.6(SR-75) | ND | 2.99(OS-34) | ND | ND | ND | 2.50(SR-81) | ND |
| | | 3.10(OS-109) | | | | | | 10.6(210-2) | |

| | | | | | | | | | |
|----------------------|----------|-------------|-------------|-----------|---------------|---------------|-------------|-----------|------------|
| CHEMICAL | MAY 1990 | JULY 1990 | OCT. 1990 | JAN. 1991 | APRIL 1991 | AUG. 1991 | NOV. 1991 | FEB. 1992 | APRIL 1992 |
| CARBON TETRACHLORIDE | ND | 3.08(REC.3) | 1.07(SR-14) | ND | ND | ND | 56.2(R-21) | ND | ND |
| CHEMICAL | MAY 1990 | JULY 1990 | OCT. 1990 | JAN. 1991 | APRIL 1991 | AUG. 1991 | NOV. 1991 | FEB. 1992 | APRIL 1992 |
| BROMODICHLOROMETHANE | ND | ND | ND | ND | 2.42(REC.8) | 1.53(B225A-S) | 1.50(REC.8) | ND | ND |
| CHEMICAL | MAY 1990 | JULY 1990 | OCT. 1990 | JAN. 1991 | APRIL 1991 | AUG. 1991 | NOV. 1991 | FEB. 1992 | APRIL 1992 |
| ETHYLBENZENE | ND | 11.9(SR-75) | ND | ND | 1.97(B225A-S) | ND | ND | ND | ND |

APPENDIX C

"Oxidation Technologies for Groundwater Treatment"



Chapter 7

Oxidation Technologies for Groundwater Treatment

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Xerox Corporation has pilot tested three UV / Oxidation processes for the treatment of contaminated groundwater containing chlorinated and non-chlorinated organic solvents. The technologies pilot tested included the ULTROX system developed by ULTROX International, the perox-pure process of Peroxidation Systems, Inc. and the Rayox process by Solarchem Environmental Systems. The three processes use a combination of ultraviolet light and hydrogen peroxide to oxidize organic solvents in water. The ULTROX system includes ozone as part of the treatment. Data gathered during pilot testing demonstrated that these processes are effective in the destruction of organic contaminants in groundwater. These results are discussed in regard to applicability to the groundwater remediation at the Xerox Facilities in Webster and Blauvelt, New York.

Over the past few years, Xerox Corporation has been aggressively investigating innovative technologies for treatment of contaminated groundwater. Those technologies that result in the destruction of contaminants rather than the transfer from one physical state to another such as the case with air stripping or activated carbon were of particular interest. As a result, chemical oxidation technologies involving combinations of ultraviolet radiation, hydrogen peroxide and ozone were evaluated as a method for groundwater treatment. The evaluation of oxidation as an emerging technology for treatment of contaminated groundwater involved field trials of the ULTROX system developed by ULTROX International, the perox-pure process by Peroxidation Systems, Inc. and the Rayox process by Solarchem Environmental Systems.

Each of these groundwater treatment systems was tested at the Xerox Facility in Webster, New York referred to as the Salt Road Site. The perox-pure system was also tested at the Xerox Facility in Blauvelt, New York. It is the intent of this paper to describe the results of testing of these units by Xerox for the treatment of contaminated groundwater.

History

State of the art groundwater remediation activities have been evaluated and tested by Xerox Corporation over the past several years at the Xerox facilities in Webster and Blauvelt, New York as well as other sites not discussed in this paper. Activities at both sites have involved extensive hydrogeologic investigations resulting in the installation of over one hundred monitoring wells along with groundwater interim remediation systems which continue to operate today.

The Xerox Facility referred to as the Salt Road site is a 400 acre complex of manufacturing buildings and open space located in the northeast section of the Xerox manufacturing facility in Webster, New York. The Salt Road facility manufactures xerographic toner, developer and photoreceptors. During additional construction in the mid-1980's, it was discovered that underground containment tanks for Trichloroethene (TCE) and Toluene had leaked and contaminated surrounding soils. Subsequent investigations indicated that the groundwater quality in the vicinity had also been affected. Notification and coordination with the U.S. Environmental Protection Agency (EPA) and the New York State Department of Environmental Conservation (NYSDEC) has led to the implementation of a groundwater recovery and treatment system based on air stripping technology as an interim measure.

The Blauvelt site is located in Blauvelt, New York and at one time was used by Xerox as a refurbishing center for copier machines. The refurbishing process involved the use of such solvents as TCE and toluene. Today, the facility is used for the storage of copier parts. Groundwater contamination was discovered at the Blauvelt site in 1980. As in the case of Salt Road, the source of contamination at this site was leakage from underground tanks containing chlorinated solvents and toluene. Subsequent groundwater remediation activities at this site have included the installation of a groundwater recovery and treatment facility using air stripping followed by activated carbon as a polishing step.

Both the Salt Road and Blauvelt site have had extensive involvement with State and Federal regulatory agencies. This involvement has led to the negotiation of a Consent Order for the Salt Road site with EPA. A Consent Order under NYSDEC was recently signed for the Blauvelt site.

The investigation and remedial activities including the testing of UV / Oxidation systems have been performed in close consultation and cooperation with the regulatory agencies.

Remedial Measures To Date

The aerial and vertical dimensions of the contaminant plumes as well as chemical profile have been determined at the Salt Road and Blauvelt sites. Table I presents a profile of the groundwater quality at these sites.

Interim remediation measures implemented at the Salt Road site included the removal and off-site disposal of 500 cubic yards of contaminated soil from the source area. These activities were conducted shortly after the contamination was discovered. Since that time, over 100 monitoring wells of various depths have been installed at the Salt Road site along with 13 recovery wells and an air stripper for groundwater treatment. At the Blauvelt site, 25 monitoring wells as well as 10 recovery wells have been installed as part of groundwater remediation efforts.

Continued interim remediation measures at the Salt Road and Blauvelt sites have included the pilot-testing of UVOxidation technologies. Oxidation techniques for the treatment of contaminated groundwater were selected by Xerox for evaluation based on their potential to destroy specific chemical compounds, thereby minimizing contaminant concentrations in effluent discharges. The ULTROX and Peroxidation units were evaluated over a period of approximately ten (10) months each. The Solarchem Rayox process was not identified until the end of the testing sequence. Therefore, relatively few test points were obtained and it should not be considered that the unit was fully optimized in operation during this test period. The results of these units are discussed in detail.

Oxidation As An Emerging Technology

The oxidation technologies pilot tested at the Xerox facilities have involved the use of combinations of ultraviolet radiation, hydrogen peroxide and in one unit, ozone. The basic principal of oxidation technologies is the generation of the hydroxyl radical which promotes the destruction of organic compounds. Hydrogen peroxide, and ozone under the influence of ultraviolet radiation have greater oxidizing capabilities when compared to other common oxidants because of their potential to generate the hydroxyl radical in the presence of water. (Ref. 1,2,3,4,5, 6). Approaches to utilizing this principle for the purification of water have been embodied in the equipment provided by the three vendors studied at Xerox as described in this paper.

General Theory

When the oxidation of organic constituents in water is carried out to completion, the by products generated are carbon dioxide and water. If halogens are present, these are converted to the corresponding inorganic halides. Although ultraviolet light alone does have some destructive power, the hydroxyl radical is a superior oxidizing agent only to be surpassed by fluorine when compared to common chemical oxidants as is shown in Table II.

Table I

Range Of Organic Chemical Constituent Concentrations Entering Groundwater Treatment

| Contaminant | Salt Road (ppb) | Blauvelt (ppb) |
|---|--------------------|-------------------|
| Trichloroethene (TCE) | 374-10600 | 1490-2380 |
| 1,2 Dichloroethene (Cis and Trans) (1,2 DCE) | 138-8730 | 3020-6860 |
| 1,1,1 Trichloroethane (1,1,1 TCA) | ND-466 | 2440-4270 |
| Toluene | ND-1980 | ND-134 |
| Vinyl Chloride | ND-470 | ND |
| Tetrachloroethene (PCE) | ND-57 | 4540-7760 |
| 1,1 Dichloroethene (1,1 DCE) | ND-5 | ND-165 |
| 1,1 Dichloroethane (1,1 DCA) | ND-334 | ND-220 |
| Methylene Chloride | ND | ND-177 |

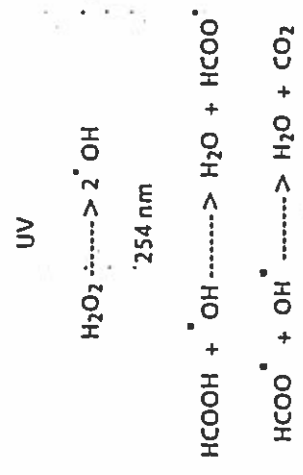
ND - NOT DETECTABLE

Table II
Oxidation Potential Of Oxidants

| Relative Oxidation Power Chlorine = 1.0 | Species | Oxidative Potential (volts) |
|---|-------------------------|-----------------------------|
| 2.23 | Fluorine | 3.03 |
| 2.06 | Hydroxyl Radical | 2.80 |
| 1.78 | Atomic Oxygen (singlet) | 2.42 |
| 1.52 | Ozone | 2.07 |
| 1.31 | Hydrogen Peroxide | 1.78 |
| 1.25 | Perhydroxyl Radical | 1.70 |
| 1.24 | Permanganate | 1.68 |
| 1.17 | Hypochlorous Acid | 1.59 |
| 1.15 | Chlorine Dioxide | 1.57 |
| 1.10 | Hypochlorous Acid | 1.49 |
| 1.07 | Hypoiodous Acid | 1.45 |
| 1.00 | Chlorine | 1.36 |
| 0.80 | Bromine | 1.09 |
| 0.39 | Iodine | 0.54 |

The literature (Ref. 1,4,5) identifies paths or steps by which hydrogen peroxide or hydrogen peroxide and ozone in the presence of UV energy form hydroxyl radicals which attack organic compounds in water. An example is the reaction of formic acid with hydrogen peroxide which has been catalyzed by UV.

General Theory



As with other chemical reactions, UV/Oxidation processes are dependent upon a number of reaction conditions which affect both performance and cost. These variables include the following.

- Type and concentration of organic contaminant
- Light transmittance of the water
- Type and quantity of dissolved salts such as iron and carbonates
- UV dosage
- Residence time

- Ozone and/or peroxide dosage
- pH

While the UV/Oxidation process is based on known chemistry, the equipment to carry out this process is continuously undergoing development. The challenge of the UV/Oxidation equipment producers today is to utilize the information that is being generated to maximize the power and reliability of the process while minimizing costs for long term use in purification of effluents with low contaminant concentrations.

Specification

The Xerox specification for a UV / Oxidation process provided to each vendor was 95 percent reduction of TCE at a throughput rate of 250 gpm and 99 percent reduction of TCE at a throughput rate of 125 gpm. Additionally, an up time target of 90 percent calculated on a quarterly basis would, if not met, require penalties from the vendor unless the down time is under Xerox control. The validity of specification depends upon incoming groundwater quality and quantity conforming to the Xerox projection. Additionally, specific preventative maintenance actions must be taken to maintain equipment up time.

Equipment Description

The UV / Oxidation processing units tested are described in the following paragraphs. Each process requires a stock feed of 50 percent hydrogen peroxide in water. The concentration of hydrogen peroxide, in the case of the ULTROX unit, for example was in the order of 0.002% during the processing. Peroxide is stored in polyethylene or aluminum tanks and is fed by chemical metering pumps directly into the incoming water stream. ULTROX uses ozone as a source of hydroxyl radical production in addition to hydrogen peroxide. Ozone for the ULTROX unit was produced on site by an ozone generator process involving a conventional spark gap method. The three processes use UV lamps of varying power with the principle wavelength being 254 nanometers. Some of the more unique characteristics of these devices are discussed in the following descriptions.

Peroxidation Systems. The Peroxidation unit tested was the perox-pure LV60 (Figure 1) (7). The reactor is rectangular with an 80 gallon capacity. There are four UV lamps stacked horizontally within the reactor. These lamps are protected from the water by quartz sleeves. The UV lamps can be controlled individually to provide variations in the number of lamps as well as power to the lamps. The LV60 unit used in this test contains four lamps, with a potential to produce 15 kW of energy per lamp.

Incoming water was mixed with hydrogen peroxide and entered into the bottom of the oxidation chamber. It then flowed upward over the UV lamps to exit from the top of the unit. The design of the flow pattern assures adequate mixing is obtained. For the Xerox Salt Road application, Peroxidation Systems included a sand filter in an attempt to remove precipitated iron from incoming groundwater. The complete unit has alarms, automatic shutdown and controls to allow automatic

operation. The Peroxidation Systems LV60 was tested at both the Salt Road and Blauvelt sites.

Ultrax International. The ULTRAX International model 725 unit was tested at the Salt Road site (Figure 2) (3). This unit has a capacity of 725 gallons. The reactor chamber contains 72 UV lamps, each having a 65 watts capacity. The lamps are placed vertically and protected by quartz sleeves.

This unit includes ozone in the treatment process. A generator is used to produce ozone on-site from dry air. Ozone is fed into the groundwater in the reaction chamber. There is an exit port for off gassing to the atmosphere. This contains a heated catalyst placed in the line to destroy ozone prior to entering the ambient air. The unit is equipped with an ozone monitoring device which reads the level of ozone and can be adapted to sound an alarm when an unacceptable level of ozone is encountered in the ambient air. The unit is designed to operate automatically.

Solarchem Environmental Systems. Late in the testing program a decision was made to test the Solarchem Environmental Systems, Rayox pilot unit at the Salt Road site (Figure 3) (8). The device obtained was a cylindrical reaction chamber containing a vertical 6 kW UV lamp protected by a quartz sleeve. Within the reaction chamber there was a mechanical cleaner which transversed the quartz sleeve automatically at a predetermined time interval to maintain cleanliness of the sleeve. Reactor volume was approximately 15 gallons.

Solarchem also makes provision for the addition of chemicals to catalyze the decomposition of hydrogen peroxide into the hydroxyl radical. This fluid, called ENOX™, is fed into the incoming groundwater stream in a matter similar to the hydrogen peroxide. The additive was not considered by Solarchem to be useful for the Salt Road groundwater. Solarchem as well as Peroxidation Systems have explored a variety of UV wavelengths to optimize absorption for more complete or higher rate of destruction of specific chemicals.

Process Methodology

The goal of the pilot trials was to determine the capability of the selected oxidation process units to meet the Xerox specification when operated under optimized conditions. Additionally, the ability of the unit to maintain a high degree of performance with continued operation was also evaluated along with relative cost of operation. Information was obtained to scale up to a unit capable of 250 gpm throughput.

Performance of the UV/Oxidation units was evaluated by measuring contaminant concentrations in the groundwater influent and effluent. Initial phase of the trial period focused on the adjustment of the unit to achieve optimum treatment of the incoming ground water. Real time measurements were taken by collecting influent and effluent samples which were screened for volatile organic compounds using a portable gas chromatograph. At start up, samples were submitted daily to an

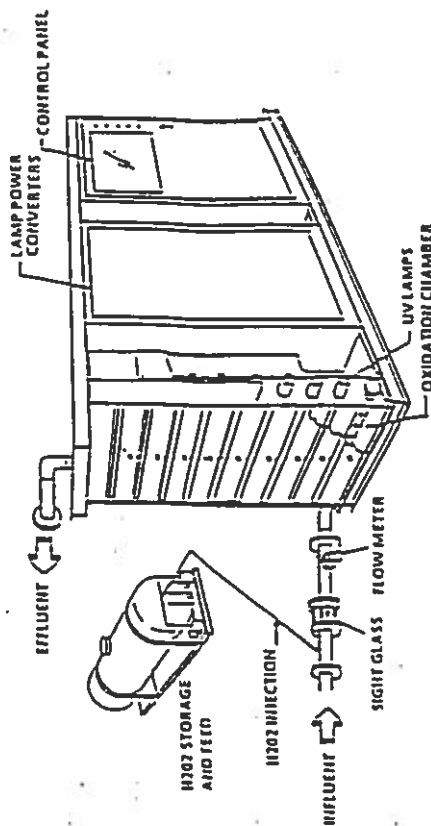


Figure 1. Peroxidation systems.

analytical laboratory for volatile organic compound analysis using EPA methods 8010/8020 to substantiate the screening results.

Establishment of optimum unit operation conditions was dependent upon proper adjustment of hydrogen peroxide flow, residence time of the water in the reaction chamber, ultraviolet radiation and in the case of the Ultrax unit, dosage of ozone. After ideal conditions were established, sampling for laboratory analysis was performed weekly to monitor the contaminant elimination efficiency. The test period for the Peroxidation Systems and Ultrax unit was approximately ten months each. As noted previously, the Solarchem unit was only evaluated for the period of about one week near the end of the test period.

Results

Results of the three UV/Oxidation processes pilot tested are summarized in Tables III through XI, where near optimized conditions are presented. The data are typical of performance achievable under routine operating conditions. In a few instances, particularly with saturated compounds, the influent stream contained a compound below the detection limit while in the effluent stream, concentration was slightly above the detection limit. These occurrences are not counted in the percent reduction averages. However, the data are presented in the Tables. The initials "ND" are used throughout this article to signify a compound was not present in quantity above the analytical method detection limit. Detection limits for influent ranged from 50 to 100 ppb and for effluent, from one to ten ppb. These ranges were affected by contaminant concentrations in the streams. It should be noted the pH of the incoming groundwater was measured intermittently and found to be near seven with some excursions falling between six and eight.

Peroxidation Systems, Inc. Tables III and IV show the perox-pure LV60 trial results obtained at the Salt Road site. Optimized conditions were found to exist at a flow rate of 50 gpm which corresponds to 1.6 minutes residence time. Influent hydrogen peroxide level was optimized at 80 mg/l of 50% solution. The LV/60 contained four UV lamps, 15 kW each. Greatest reliability occurred when all four lamps were operated at their specified power of 15 kW. The LV60 as well as all the units tested were placed before an air stripper in the process line. At Blauvelt, some trials also were performed with the air stripper placed before the LV60 in the process.

As can be seen in the Tables, the perox-pure LV60 was very efficient in removing vinyl chloride, 1,2 DCE, TCE, toluene and PCE. The destruction of saturated compounds, 1,1 DCA and 1,1,1 TCA was achieved only to 73.0 percent and 17.7 percent, respectively. Difficulty in destruction of saturated compounds was common through out the trials for all units tested. However, owing to the chemical composition of the groundwater being purified, the overall total volatile organic reduction reached near 95 percent.

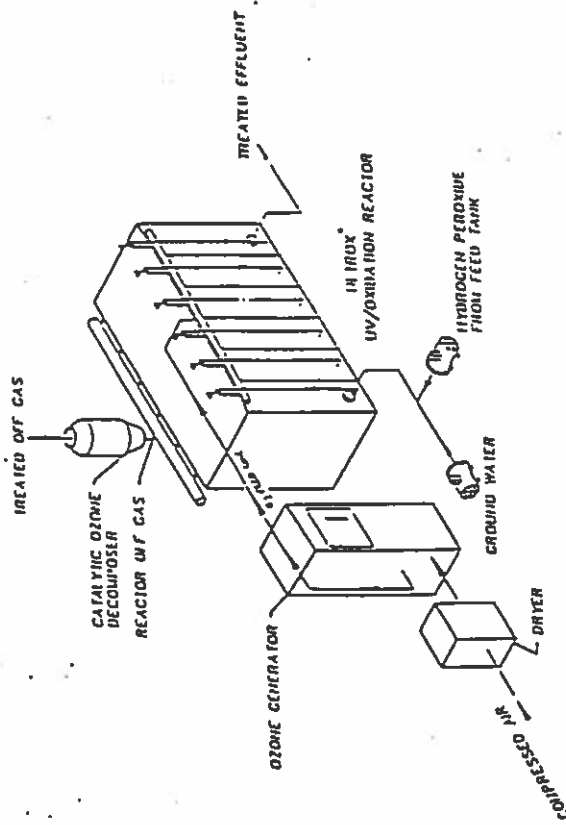


Figure 2. Isometric view of Ultrax International Model 725 unit.

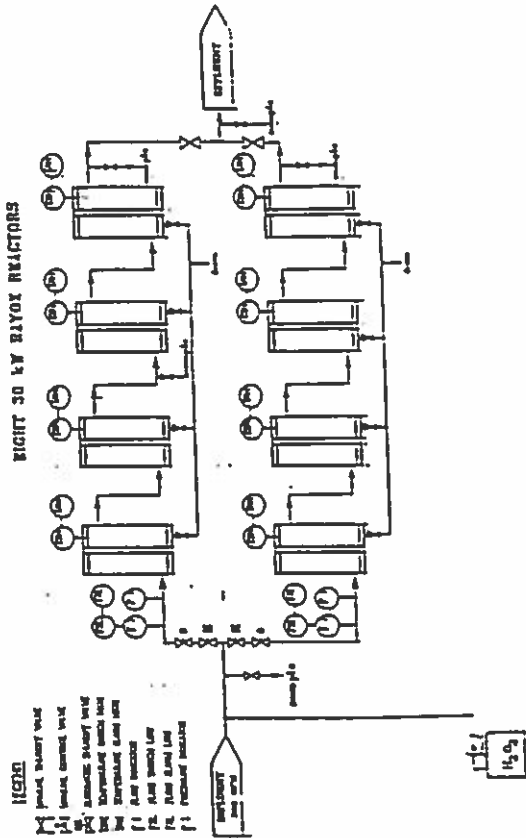


Figure 3. Solarchem Environmental Systems, Raynox pilot plant.

Table III. Perox-Pure LV60 Trial Results at Salt Road Site

| Day | 1 | | 2 | | 3 | | 4 | | 5 | |
|-----------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) |
| Residence Time (Min.) | 0.85 | | 1.0 | | 1.4 | | 1.6 | | 1.6 | |
| Vinyl Chloride | 163.0 | ND | 49.0 | ND | ND | ND | ND | ND | 198.0 | ND |
| 1,1-DCA | 67.3 | 40.4 | 117.2 | 43.9 | ND | 36.0 | 250.5 | 31.2 | 105.0 | 30.5 |
| 1,2-DCE | 1643.8 | 25.5 | 933.0 | 15.9 | 731.5 | 15.9 | 2750.0 | 6.9 | 1627.0 | 16.7 |
| 1,1,1-TCA | ND | 182.0 | 75.7 | 76.8 | 85.1 | 74.8 | 127.5 | 85.7 | ND | 102.0 |
| TCE | 4200.0 | 964.0 | 789.5 | 27.2 | 6895.0 | 114.5 | 11550.0 | 73.5 | 2680.0 | 23.9 |
| Toluene | 434.0 | 13.9 | 227.5 | 1.3 | 272.5 | 1.7 | 642.5 | ND | 404.0 | ND |
| PCE | 309.0 | 21.2 | ND | ND | ND | ND | ND | ND | 242.0 | 4.4 |
| Total | 6857.1 | 1251.0 | 2191.9 | 165.0 | 7984.1 | 242.9 | 15320.5 | 197.3 | 6251.0 | 177.5 |
| % Removal | | 81.8% | | 92.5% | | 97.0% | | 98.7% | | 97.2% |

Test Conditions:

- Sand and bag filters ahead of LV-60
- Quartz tubes cleaned and remained clean during test.
- Lamp #223 (5id) used. 15 kW
- Influent H₂O₂ approximately 80 mg/l. (50%)
- Four lamps on days 2-5
Two lamps on day one

Table IV. Average Scores on Perox-Pure LV60 Trials at Salt Road Site

| Contaminant | Average Influent (ppb) | Average Effluent (ppb) | % Removal (\leq) |
|----------------|------------------------|------------------------|-------------------------------|
| Vinyl Chloride | 82 | ND | 100.0 |
| 1,1 DCA | 135.0 | 36.5 | 73.0 |
| 1,2 DCE | 1544.1 | 16.2 | 99.0 |
| 1,1,1 TCA | 96.1 | 79.1 | 17.7 |
| TCE | 5422.9 | 241.4 | 95.6 |
| Toluene | 396.1 | 3.4 | 99.1 |
| PCE | 110.2 | 5.1 | 95.4 |
| Total | 7786.4 | 381.7 | 95.1 |

During the trials of the perox-pure unit, the iron content of the water began to fluctuate with intermittent slugs of high concentrations coming into the system. In time, the quartz sleeves surrounding the UV lamps became coated with iron resulting in decreased efficiency of the lamps. This effect caused decreased performance of the unit. After cleaning of the sleeves, efficiency returned to its prior level of 95 + % reduction of total volatiles. However, after about three weeks the iron coatings repeated and again, performance decreased to an unacceptable level. Peroxidation Systems placed a sand filter in the influent line which appeared to alleviate the problem to a large extent. The conclusion from these trials was that the perox-pure LV60 is capable of removing an average of over 95% total volatiles from Salt Road groundwater at flow rates from 50 to 75 gallons per minute. However, the need to properly design and operate a pretreatment system was indicated for removal of iron from the water supply. The scaled up unit projected by Peroxidation Systems to meet the specification included the perox-pure 360 equipment which has a holding tank of 480 gallons capacity with energy input of twenty-four, 15 kW lamps. Peroxidation Systems also included the need for an adequate filtration system to purify the water prior to entry into the reaction chamber to minimize scaling of the quartz tubes surrounding the lamps.

At the Blauvelt site, the perox-pure LV60 system first was tested using influent groundwater after it had been processed through an air stripper to obtain highly purified water effluent. A second trial was conducted with the perox-pure unit placed prior to the air stripper. Tables V and VI describe the results of these trials.

Optimum conditions at Blauvelt included a residence time of 2.5 minutes, 4 UV lamps operating at their specified power 15kW and a flow rate of 50% concentration hydrogen peroxide at 40 mg/l. Although influent concentrations were greatly different using streams before and after processing through the air stripper, reduction efficiency of organic constituents was persistently in the range of 90%. As in prior studies of UV/Oxidation techniques, TCA demonstrated strong resistance to destruction with efficiency of removal of 28%. The unsaturated compounds as found in other trials, demonstrated removal efficiencies near 100%. It should be noted the problem of iron coating the quartz sleeves was not pronounced at the Blauvelt site indicating low iron concentrations in the groundwater. The perox-pure LV60 could accommodate adequate capacity to fulfill Blauvelt's requirement. Therefore, a perox-pure LV60 was leased by Xerox for use at its Blauvelt site.

Table V. Perox-Pure LV60 Trial Results at Blauvelt Site

| Day | Influent (ppb) | | Effluent (ppb) | | Residence Time (Min.) | 1,2-DCE | 1,1,1-TCA | TCE | PCE | Total | % Removal | |
|-----|----------------|----------------|----------------|----------------|-----------------------|---------|-----------|-----|------|-------|-----------|--|
| | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | | | | | | | | |
| 1 | | | | | 2.5 | ND | 9.1 | ND | 6.3 | ND | 89.9 | |
| 2 | | | | | 2.5 | ND | 9.1 | ND | 6.3 | ND | 89.9 | |
| 3 | | | | | 2.5 | ND | 6.3 | ND | 15.1 | ND | 88.5 | |
| 4 | | | | | 2.5 | ND | 6.3 | ND | 15.1 | ND | 90.1 | |
| 5 | | | | | 2.5 | ND | 5.7 | ND | 16.1 | ND | 87.6 | |
| 6 | | | | | 2.5 | ND | 5.7 | ND | 16.1 | ND | 88.0 | |

Test Conditions:

- Day 1 - 5 Ground water flowed through air stripper prior to the Peroxidation unit, LV60 used as polisher.
- Day 6 - Ground water flowed through LV60 prior to air stripper. Stripper used as polisher.
- Influent of H₂O₂ (50%) - 40 mg/l
- Four bulbs on during test. Standard #223 bulbs used, 15 kW.

Ultrax International. The greatest amount of data obtained during these trials was from the ULTROX International F-725 pilot unit. As noted previously, this device contained seventy-two 65 watt lamps as opposed to some of the competitive systems that used fewer but higher energy lamps. Tables VII and VIII demonstrate that optimized conditions for processing were near 24 minutes residence time or 30 gallons per minute at a hydrogen peroxide flow of 40 mg/l and an ozone flow of 58 mg/l. Some trials were run under the same conditions but using 14.5 minutes residence time relating to flow rate of 50 gpm. This appears to be a borderline condition for this unit because removal fell below 95 percent. On the tenth test day, hydrogen peroxide was reduced from 40 to 20 mg/l with other conditions remaining constant. Although prior trials indicated the hydrogen peroxide flow level of 20 mg/l to be excessively low, the data for day ten show little sensitivity to peroxide level in that particular test. It is considered desirable to reduce the hydrogen peroxide as far as possible to avoid obtaining the constituent in the effluent stream. Referring to Table IX it is seen that DCA and TCA follow the trend of low removal efficiency when under going UV/Oxidation treatment with removal efficiencies of 55.0 and 57.5 percent, respectively. The groundwater at Salt Road contains relatively small quantities of these saturated chlorinated hydrocarbons. Therefore, total removal efficiency in excess of 95 percent still can be achieved.

The USEPA, in a comprehensive evaluation of ULTROX equipment under its Superfund Innovative Technology Evaluation (SITE) Program, established the fully configured ULTROX system emitted no volatile organic compounds into the atmosphere. The EPA observed that the great majority of volatile organic compound destruction occurred in the water phase. A very small percentage of the volatile organic compound destruction, especially for saturated compounds such as TCA and DCA, occurred in the DECOMPOZON/D-TOX off gas control device. The EPA's findings are consistent with those found at Xerox. Using a unit without the D-TOX catalyst Xerox in its pilot runs detected trace quantities of organic materials in the effluent air stream on an intermittent basis. The full scale ULTROX system is to have the DECOMPOZON/D-TOX off gas device to ensure total volatile organic compound control. In the case of the Salt Road Application, the ULTROX machine will be placed in the line prior to a permitted air stripper presently in operation.

During the ULTROX trials a five micron filter was placed in the influent line to remove suspended particulate matter in the water. The ULTROX unit did not show a high tendency towards scaling of the quartz sleeves surrounding the UV lamps. After about five months running, some deterioration was noted. However, this was solved by use of a weak acid rinse. The unit performed on a high level of efficiency on a consistent basis.

Table VI. Average Scores on Perox-Pure LY60 Trials at Blauvelt Site

| Contaminant | Perox-Pure After Air Stripper | | % Removal (\leq) |
|-------------|-------------------------------|------------------------|-------------------------|
| | Average Influent (ppb) | Average Effluent (ppb) | |
| 1,2 DCE | 9.7 | ND | 100.0 |
| 1,1,1 TCA | 4.6 | 3.3 | 28.2 |
| TCE | 3.2 | ND | 100.0 |
| PCE | 15.0 | ND | 100.0 |
| Total | 32.5 | 3.3 | 89.8 |

| Contaminant | Perox-Pure Before Air Stripper | | % Removal (\leq) |
|-------------|--------------------------------|------------------------|-------------------------|
| | Average Influent (ppb) | Average Effluent (ppb) | |
| 1,2 DCE | 3480 | ND | 100 |
| 1,1,1 TCA | 1980 | 1430 | 27.8 |
| TCE | 1480 | ND | 100 |
| PCE | 4990 | ND | 100 |
| Total | 11930 | 1430 | 88.0 |

Table VII. F-725 Pilot Unit Trial Results, Days 1-5

| Day | 1 | | 2 | | 3 | | 4 | | 5 | |
|---------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) |
| Residence Time Min. | | 14.5 | | 14.5 | | 14.5 | | 14.5 | | 14.5 |
| Vinyl Chloride | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 1,1-DCA | ND | 25.9 | ND | 10.1 | ND | 21.0 | ND | 14.9 | ND | 14.6 |
| 1,2-DCE | 1220.0 | ND | 835.0 | 2.3 | 1030.0 | 4.61 | 733.0 | 28.9 | 681.0 | 23.5 |
| 1,1,1-TCA | 61.3 | 21.5 | 66.9 | 18.1 | 52.5 | 37.2 | 16.3 | 20.4 | 14.3 | 13.7 |
| TCE | 2710.0 | 8.2 | 3930.0 | 23.4 | 1960.0 | 14.7 | 4290.0 | 211 | 2290.0 | 151.0 |
| Toluene | ND | ND | ND | ND | 71.3 | ND | 56.0 | ND | 29.5 | ND |
| PCE | 65.4 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Total | 4056.7 | 63.4 | 4831.9 | 53.9 | 3113.8 | 80.51 | 5095.3 | 275.2 | 3014.8 | 202.8 |
| % Removal | | 98.4 | | 98.9 | | 97.4 | | 94.6 | | 93.3 |

Test Conditions:

- 5 Micron bag filters ahead of F-725.
- Influent H₂O₂ approximately 40 mg/L except day 10.
- Ozone flow 58 mg/l

Table VIII. F-725 Pilot Unit Trial Results, Days 6-10

| Day | 6 | | 7 | | 8 | | 9 | | 10 | |
|---------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) |
| Residence Time Min. | | 14.5 | | 24.0 | | 24.0 | | 24.0 | | 24.0 |
| Vinyl Chloride | 20.4 | ND | ND | ND | 303.0 | ND | ND | ND | 60.4 | ND |
| 1,1-DCA | ND | 13.8 | 78.7 | 38.6 | 97.5 | 27.8 | 52.1 | 31.5 | 72.3 | 37.4 |
| 1,2-DCE | 958.0 | 33.6 | 1250.0 | 7.6 | 2260.0 | ND | 1470.0 | 4.1 | 1660.0 | 13.2 |
| 1,1,1-TCA | 128.0 | 21.9 | 47.2 | 29.0 | ND | 24.2 | ND | 27.6 | 44.6 | 21.2 |
| TCE | 3970.0 | 211.0 | 1500.0 | 14.2 | 1790.0 | 6.8 | 1650.0 | 22.0 | 2190.0 | 39.9 |
| Toluene | 60.4 | ND | 118.0 | ND | 671.0 | ND | 337.0 | ND | 118.0 | ND |
| PCE | ND | 1.1 | ND | ND | ND | ND | ND | 1.0 | 22.8 | 2.0 |
| Total | 5136.8 | 281.4 | 2993.9 | 89.4 | 5121.5 | 58.8 | 3509.1 | 86.2 | 4164.1 | 113.7 |
| % Removal | | 94.5 | | 97.0 | | 98.9 | | 97.5 | | 97.3 |

Test Conditions:

- 5 Micron bag filters ahead of F-725.
- Influent H₂O₂ approximately 40 mg/L except day 10.
Day 10 Influent H₂O₂ approximately 20 mg/L.
- Ozone flow 58.0 mg/l

Table IX. Average Scores of Trials with F-725 Pilot Unit

| Contaminant | Average Influent (ppb) | Average Effluent (ppb) | % Removal (<) |
|-----------------|------------------------|------------------------|---------------|
| Vinyl Chloride | 38.3 | ND | 100.0 |
| 1,1 DCA | 75.1 | 33.8 | 55.0 |
| 1,2 DCE | 1209.7 | 11.8 | 99.0 |
| 1,1,1 TCA | 53.9 | 22.9 | 57.5 |
| TCE | 2628.0 | 70.2 | 97.3 |
| Toluene | 146.1 | ND | 100.0 |
| PCE | 44.1 | 1.0 | 97.7 |
| Total Volatiles | 4195.2 | 138.7 | 96.7 |

Solarchem Environmental Systems. Optimum operating conditions for groundwater treatment with the Rayox unit at Salt Road involved the use of a 6 kW lamp with a two minute residence time in the reaction chamber and the addition of 24 mg / l of 50% hydrogen peroxide. Since this was a small pilot unit, flow through the unit was limited to 10 gpm. However, Solarchem stated sufficient data were available to scale up to a 250 gpm capacity unit.

The Rayox reactor was successful in destroying unsaturated organic compounds such as TCE and toluene. Destruction efficiencies were less for the saturated organic compounds, TCA and DCA, as has been the case with other reactors tested. As can be seen in Tables X and XI, removal of total contamination could be achieved to a level of up to 95.5 percent. Solarchem has stated that at other groundwater remediation sites, the Solarchem unit has achieved greater than 99.9 percent destruction of DCA and TCA using a larger unit than that employed at Salt Road. Competitive systems such as ULTROX and Peroxidation also have noted some success in destruction of saturated compounds such as DCA and TCA at other sites using different operating conditions.

Although sufficient time was not available to complete the testing of the Rayox unit, Solarchem personnel reported that twice the normal dose of UV energy was required for destruction of organic contamination in the Salt Road groundwater due to unusually high loading of inorganic salts. Use of a proprietary additive, ENOX, was considered not to be significantly beneficial to justify its use in these trials. In limited testing there was no evidence of stripping of contamination by volatilization from the groundwater in the unit. Based upon this relatively short trial,

Table X. Rayox Reactor Trial Results

| Day | 1 | | 2 | | 3 | | 4 | | 5 | |
|---|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) | Influent (ppb) | Effluent (ppb) |
| Residence Time (Min.) | 2.0 | | 2.0 | | 2.0 | | 2.0 | | 1.0 | |
| Influent H ₂ O ₂ (50%) mg/l | 24 | | 24 | | 24 | | 0 | | 30 | |
| Vinyl Chloride | ND | ND | 49.0 | ND | ND | ND | 68.1 | 14.4 | ND | ND |
| 1,1-DCA | ND | 17.0 | 40.3 | 15.0 | 30.9 | 21.5 | ND | 11.2 | ND | 20.6 |
| 1,2,DCE | 554.00 | 43.0 | 346.0 | 7.6 | 791.0 | 264.0 | 528.0 | 156.0 | 678.0 | 84.9 |
| 1,1,1 - TCA | 18.2 | 11.2 | 10.4 | 12.5 | 25.4 | 22.1 | 125.0 | 21.6 | ND | 13.1 |
| TCE | 1070.0 | 73.6 | 853.0 | 22.2 | 2050.0 | 225.0 | 3000.0 | 292.0 | 1880.0 | 177.0 |
| Toluene | 94.3 | ND | 27.2 | ND | 36.0 | 10.0 | 45.4 | 7.1 | ND | ND |
| PCE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Total | 1736.5 | 144.8 | 1276.5 | 57.3 | 2933.3 | 542.6 | 3766.5 | 502.5 | 2558.0 | 295.6 |
| % Removal | | 91.7 | | 95.5 | | 81.5 | | 86.7 | | 88.4 |

a scaled up unit was conceived to consist of eight separate reactors each with a single lamp. This unit would have a foot print of 10' X 16' in an area which would be relatively small compared to some competitive units. Solarchem produced impressive progress with the time that was allotted to them in demonstrating their approach to UV/Oxidation technology.

Table XI. Average Scores of Trials with Rayox Reactor

| Contaminant | Average Influent (ppb) | Average Effluent (ppb) | % Removal (\leq) |
|-----------------|------------------------|------------------------|----------------------|
| Vinyl Chloride | 23.4 | 2.9 | 87.6 |
| 1,1 DCA | 35.6 | 18.2 | 48.7 |
| 1,2 DCE | 579.4 | 111.1 | 80.1 |
| 1,1,1 TCA | 44.8 | 16.0 | 62.4 |
| TCE | 1770.6 | 158.0 | 91.1 |
| Toluene | 40.6 | 3.4 | 91.6 |
| Total Volatiles | 2494.4 | 310.4 | 87.4 |

Cost Estimate

Except for the Solarchem Rayox unit, sufficient information was generated to obtain cost estimates for the processing of 250 gpm flow rate of Xerox groundwater with 95% TCE removal. Information also was obtained to enable calculation of cost data at a flow rate of 25 gpm. Cost estimates were designed to be fully loaded, i.e., inclusive of all equipment, operating and maintenance cost.

Although variation among vendors does exist, average cost per thousand gallons of groundwater processed was determined at a flow rate of 250 gpm to be \$1.57. In reducing flow rate to 25 gpm and down sizing equipment, cost increased to beyond \$5.00 per thousand gallons processed. This cost data emphasizes the merits of processing greater flow rates of water where fixed costs can be spread over large volumes of water processed per unit time.

Conclusions

Based upon the studies of the pilot units described, the following conclusions were drawn:

- UV/Oxidation technology is applicable on a commercial scale for the purification of groundwater containing the unsaturated compounds of TCE, DCE, PCE, Vinyl Chloride and Toluene.
- The processes evaluated were less efficient in the destruction of saturated compounds such as DCA and TCA. This is the subject of additional work by the equipment developers.

- The commercial units available rely upon similar technology. However, each application requires optimization of the process for destruction of specific organic compounds as well as adaptation to handle inorganic salts in the water that interfere with the process. Constituents in the groundwater that would not usually be considered toxic such as iron or bicarbonate, can influence the efficiency of a UV/Oxidation process to a significant extent.
- Cost per unit quantity of ground water processed can vary significantly depending upon total volume per unit time. Some variation among different vendors should be anticipated. However, trials at Xerox suggest a cost range from \$1.57 to near \$5.00 for thousand gallons processed in progressing from a throughput rate of 250 down to 25 gallons per minute.

Discussion

Based upon the results of these trials, Xerox leased a Peroxidation, LV60 unit for its facility in Blauvelt, New York. The intent is to polish water after being processed by an air stripper to a high purity level for effluent to a storm sewer. At the Webster, Salt Road site an ULTROX system was ordered to accommodate full scale flow of 250 gallons per minute. The Salt Road groundwater will be processed first through the ULTROX unit to be followed by an air stripper. The intent is to provide highly purified water to a storm sewer system with levels of contamination being significantly below permitted both in the effluent air and water levels. Due to time constraints the Solarchem Rayox System was not fully optimized or performance tested in depth in this work. However, the results obtained were presented for completeness since sufficient information on the process was obtained to demonstrate this process will accomplish the cleaning of groundwater. The trials at the Xerox locations were specifically designed to purify water with characteristics present at those locations. The results presented in this paper are not intended to recommend or discourage the testing of any commercial system discussed.

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Literature Cited

1. William H. Glaze, Joon - Wun Kang & Douglas H. Chapin, *Ozone Science & Engineering*, Volume 9 pp. 335-352.
2. David B. Fletcher, *Water World News*, Volume 3, No. 3.
3. Norma M. Lewis, *USEPA Site and Demonstration Bulletin*, EPA / 540 / M5-89/012.
4. D. G. Hager and C. E. Smith, *Proceedings of the Haztech International Conference and Exhibition*, Institute for International Research, Denver, Colorado, pp. 215 - 231.
5. R. D. Samuel Stevens, "Application of Rayox for the remediation of chlorinated ground water," presented at the Hazmat Central Conference, Chicago, March, 1990.
6. Norma Lewis, Kirankumar Topudurti and Robert Foster, *HMC*, pp. 42-44, March/April 1990.
7. Carl Loven, Chris Giggly, Presented at *AWWA Annual Conference and Exposition*, Orlando, Florida June 19-23, 1988.
8. Dr. Samuel Stevens, Personal correspondence with Dr. Robert Heeks dated April 3, 1990.

APPENDIX D

Status of SWMU's



Solid Waste Management Units (SWMU's) Status

A review of the SWMUs at the Salt Road site relative to the status and contamination investigations conducted during the course of the RCRA facility investigation and other studies is summarized below.

Building 223

Underground Spill Containment Tank, Northeast Corner

Located near the northeast corner of the building, the underground spill containment tank (USCT) was designed to contain solvent spills from Bldg. 223. The tank was constructed in 1982 and was removed and replaced in 1992 under a DEC approved closure plan. RCRA waste types that were contained in the tank are F002 (spent chlorinated solvents). Testing of soil and water taken during the tank replacement indicated concentrations of 1,1,2-trichloroethane and methylene chloride. Xerox notified EPA of these findings on 18 September 1992 and submitted a plan for investigation of the area on 22 September 1992. The SWMU is within the zone of capture of the RIM. ✓

Underground Spill Containment Tank, Northwest Corner

Located near the northwest corner of the building, the USCT was constructed in 1975 to contain solvent spills from Building 223. RCRA waste type that may have been contained in the tank are F002 (spent chlorinated solvents), F003 (spent non-chlorinated solvents), F005 (other spent non-chlorinated solvents), and D001 (ignitable). A temporary stainless steel above ground tank was installed in June 1986 to replace the USCT. The tank was removed in 1991 under an NYSDEC approved closure plan. Testing of the excavation during removal did not detect contamination and the area will continue to be monitored by existing wells. No further action is required on this unit.

Building 224

TCE Transfer Sump (new)

Located in the northern portion of the 224/225 courtyard, the aboveground transfer sump was installed in 1984 and used to contain solvent spills associated with the developer reclaim process. The sump was excavated in March 1989 under a formal closure plan. Extensive investigation has already occurred in this area, as documented in the quarterly reports and hydrogeologic investigation (8). It has been determined by the NYSDEC that there is no evidence of releases of hazardous waste or constituents that threaten human health or the environment from this unit, and therefore this SWMU has been placed on the list of SWMU's with a no action requirement.

Toluene Transfer Sump (new)

Located in the southern portion of the 224/225 courtyard, this unit was installed in September 1984 and is presently active and is being used for containing Methyl Ethyl Ketone (MEK). The unit consists of a stainless steel aboveground sump inside a concrete vault equipped with high liquid level alarms. It has been determined by the NYSDEC that there is no evidence of releases of hazardous waste or constituents that threaten human health or the environment. This SWMU has been placed on the list of SWMU's with a no action requirement.

TCE Transfer Sump (old)

Located in the northern portion of the 224/225 courtyard, the sump was installed in 1975, and was designed to store spent trichloroethene used in the steel shot reclaim process prior to discharge into a bulk waste storage tank. The SWMU was excavated in October 1984 during the construction activities associated with building 224E. Approximately 900 cubic yards were excavated and backfilled with #2 stone. The extent of contamination resulted from this unit has been defined during the RFI process and therefore no additional investigation is required.

Toluene Transfer Sump (old)

Located in the southern portion of the 224/225 courtyard, this sump was installed in 1975 and was last used on or about January 24, 1984 which was the last date on which toluene was required in the manufacturing process. The unit was excavated in October 1984. The extent of contamination resulted from this unit has been defined during the RFI process and therefore no additional investigation is required.

Underground Spill Containment Tank East (new)

Located on the Bldg. 224 east lawn, this unit was installed in 1984 and is constructed of a 55 gallon steel drum contained in a concrete vault. This unit is partially below and aboveground with aboveground piping open for inspection. The unit is currently operational and is designed to contain MEK from the lacquer mix operation. It has been determined by the NYSDEC that there is no evidence of releases of hazardous waste or constituents that threaten human health or the environment from this unit, and therefore this SWMU has been placed on the list of SWMU's with a no action requirement.

Courtyard Underground Spill Containment Tank South

The USCT was installed in 1975 to contain spills from the lacquer mix operation. The unit was excavated in 1984, and has been replaced with the USCT East (new). The extent of contamination resulting from the unit has been defined during the RFI process and therefore no additional investigation is required. This SWMU has been placed on the list of SWMU's with a no action requirement.

Courtyard Underground Spill Containment Tank

The USCT was excavated and the extent of contamination resulting from the unit has been defined during the RFI process and therefore no additional investigation is required. This SWMU has been placed on the list of SWMU's with a no action requirement.

Waste MEK Tank

Located southwest of Bldg. 224A, this tank is currently in use and has a secondary containment system. Extensive soil vapor testing and soil sampling have been conducted in the immediate vicinity of the tank and no evidence of contamination resulting from the unit has been identified. No further action is required.

Soil Contamination (west side)

The soil contamination on the west side of Bldg. 224 was observed during installation of cooling tower sumps. It has been determined by NYSDEC there is no evidence of releases of hazardous waste or constituents that threaten human health or the environment from this unit, and therefore no additional investigation is required. This SWMU has been placed on the list of SWMU's with a no action requirement.

Building 225

Waste TCE Tank

Located southwest of Bldg. 225 the tank was constructed in 1977 to contain spent solvents from the steel shot reclamation distillation process. RCRA waste types that may have been contained in the tank are F002 (spent chlorinated solvents). Previously in September 1984, soil around the sump/transfer tank was removed and backfilled with crushed stone. In March 1989, the unit was closed and underwent excavation and additional backfilling. No additional investigation is required.

1980 Oil Spill

In January 1980, approximately 14,000 gallons of #2 fuel oil spilled from a storage tank west of Bldg. 225 and approximately 6000 to 7000 gallons were recovered. Xylene, benzene, and a portion of the toluene detected at the site may have resulted from this source. The extent of groundwater contamination resulting from this spill has been defined in the RFI investigation, and therefore no additional investigation is required. This SWMU has been placed on the list

of SWMU's with a no action requirement.

Scuppers Bldg. 225 Nickel Wastewater

Releases through scuppers (openings in the wall through which water can drain from a floor) were identified. The scuppers were in operation from 1977-1984. Investigations conducted by Xerox and approved by NYSDEC did not detect nickel above action levels. No further action is required in this SWMU.

Tanker Truck Transfer Area

Accidental spillage of nickel sulfamate during loading operations occurred southeast of Bldg. 225A. In 1985, approximately 175 cubic yards of contaminated soil were removed to a depth of approximately 2.3 feet and a transfer station was constructed. Several soil borings and test pits were installed in the vicinity and analytical testing indicated that nickel contamination is below action levels. No further action is required.

APPENDIX E
Salt Road Air Permit



CONTAINED IN FORM 7611-12 BEFORE ANSWERING ANY QUESTION

PROCESS, EXHAUST OR VENTILATION SYSTEM APPLICATION FOR PERMIT TO CONSTRUCT OR CERTIFICATE TO OPERATE

| | | | | | | | | |
|---|--|---|---|---|--|--|-----------------------------------|------------------------------|
| S E C T I O N | 1 NAME OF OWNER / FIRM Xerox Corporation | 9 NAME OF AUTHORIZED AGENT Day Engineering, P.C. | 10 TELEPHONE (716) 292-1090 | 19 FACILITY NAME (IF DIFFERENT FROM OWNER / FIRM) | | | | |
| | 2 NUMBER AND STREET ADDRESS 604 Phillips Road | 11 NUMBER AND STREET ADDRESS 2144 Brighton Henrietta Townline Road | 20 FACILITY LOCATION, NUMBER AND STREET ADDRESS | | | | | |
| | 3 CITY - TOWN - VILLAGE Webster | 4 STATE NY | 5 ZIP 14550 | 12 CITY - TOWN - VILLAGE Rochester | 13 STATE NY | 14 ZIP 14623 | 21 CITY - TOWN - VILLAGE | 22 ZIP |
| | 6 OWNER CLASSIFICATION A <input type="checkbox"/> COMMERCIAL <input type="checkbox"/> UTILITY <input type="checkbox"/> MUNICIPAL <input type="checkbox"/> RESIDENTIAL B <input type="checkbox"/> INDUSTRIAL <input type="checkbox"/> FEDERAL <input type="checkbox"/> EDUC INST <input type="checkbox"/> OTHER | 7 NAME & TITLE OF OWNER'S REPRESENTATIVE Joseph J. Stubb, P.E. | 8 TELEPHONE (716) 422-3831 | 15 NAME OF ARCHITECT OR ENGINEER Clark K. P.E. | 16 P.E. LICENSE NO. 62446 | 17 TELEPHONE (716) 292-1090 | 23 BUILDING NAME OR NUMBER 348 | 24 FLOOR NAME OR NUMBER 1 |
| 18 SIGNATURE OF OWNER'S REPRESENTATIVE OR AGENT WHEN APPLIED FOR A PERMIT TO CONSTRUCT OR CERTIFICATE TO OPERATE <i>Joseph J. Stubb</i> 12/19/91 | | | 25 START UP DATE 10 / 91 | 26 DRAWING NUMBERS OF PLANS SUBMITTED 348-01-2 | 27 PERMIT TO CONSTRUCT A <input type="checkbox"/> NEW SOURCE B <input type="checkbox"/> MODIFICATION | 28 CERTIFICATE TO OPERATE A <input type="checkbox"/> NEW SOURCE C <input type="checkbox"/> EXP-AG B <input checked="" type="checkbox"/> MODIFICATION | | |

| | | | | | | | | | | | | | | |
|----------------------|---------------------------|----------------------------------|-----------------------|---------------------------|-------------------|---------------------------|---------------------------|----------------|------------|------------|--|----|----|----|
| 29 EMISSION POINT ID | 30 GROUND ELEVATION (FT.) | 31 HEIGHT ABOVE STRUCTURES (FT.) | 32 STACK HEIGHT (FT.) | 33 INSIDE DIMENSIONS (IN) | 34 EXIT TEMP (°F) | 35 EXIT VELOCITY (FT/SEC) | 36 EXIT FLOW RATE (ACF/M) | 37 SOURCE CODE | 38 WRS DAY | 39 DAYS/YR | 40 % OPERATIONAL SEASON Winter Spring Summer Fall | | | |
| 01 | 402 | 12 | 44 | 8 | 60 | 74 | 1550 | 2218 | 24 | 365 | 25 | 25 | 25 | 25 |

| | | | | | | | |
|---------------------------------|--|----|----|----|----|----|----|
| S E C T I O N | 41 DESCRIBE PROCESS OR UNIT Packed column air stripper. | 42 | 43 | 44 | 45 | 46 | 47 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

| | | | | | |
|----------------------------------|-----------------|---|--------------------|--------------------------------|----------------|
| 48 EMISSION CONTROL EQUIPMENT ID | 49 CONTROL TYPE | 50 MANUFACTURER'S NAME AND MODEL NUMBER | 51 DISPOSAL METHOD | 52 DATE INSTALLED MONTH / YEAR | 53 USEFUL LIFE |
| 01 | 38 | Citrox UV/Oxidation Unit | 07 | 10 / 91 | 20 |

CALCULATIONS
The modification involves the installation of a UV/oxidation system prior to the air stripper for the treatment of contaminated groundwater.
See attached calculations sheets.

| S E C T I O N | CONTAMINANT | | INPUT OR PRODUCTION | UNIT | ENV RATING | EMISSIONS | | | | % CONTROL EFFICACY | POLY EMISSIONS (LBS/YR) | | ANNUAL EMISSIONS (LBS/YR) | | |
|---------------------------------|-----------------------|------------|---------------------|------|------------|-----------|------|---------|-------------|--------------------|-------------------------|--------|---------------------------|---------------|------|
| | NAME | CAS NUMBER | | | | ACTUAL | UNIT | HOW SET | PERMISSIBLE | | APP | ACTUAL | ACTUAL | % PERMISSIBLE | |
| 54 | toluene | 00108-88-3 | 56 | gal | 58 | 74.6 | 2 | 74.6 | 62 | 50 | 0.749 | 0.75 | 3607 | 0 | 3607 |
| 59 | tetrachloroethylene | 00127-18-4 | 71 | lb | 72 | 0.015 | 1 | 0.015 | 77 | 90 | 0.015 | 0.015 | 169 | 0 | 169 |
| 64 | 1,1,1-trichloroethane | 00011-55-0 | 86 | lb | 87 | 52.6 | 2 | 52.6 | 91 | 35 | 0.653 | 0.653 | 333 | 0 | 333 |
| 69 | methylene chloride | 00075-09-2 | 101 | lb | 102 | 5.4 | 2 | 5.4 | 107 | 35 | 0.0054 | 0.0054 | 39 | 0 | 39 |
| 114 | 1,1-dichloroethane | 00075-34-3 | 116 | lb | 117 | 0.017 | 1 | 0.017 | 122 | 35 | 0.017 | 0.011 | 123 | 0 | 123 |
| 129 | trichloroethylene | 00075-01-0 | 131 | lb | 132 | 0.296 | 1 | 0.296 | 137 | 90 | 0.296 | 0.296 | 1426 | 0 | 1426 |

| | | | | | | | | | | |
|----------|------------------------|---------|----------|---|---------|----------|---------------------------|------------|---------------------|---------------------|
| 144 TYPE | 145 SOLID FUEL TONS/YR | 146 % S | 147 TYPE | 148 LIQUID FUEL THOUSANDS OF GALLONS/YR | 149 % S | 150 TYPE | 151 GAS THOUSANDS OF CFYR | 152 STU/CF | 153 APPLICABLE RULE | 154 APPLICABLE RULE |
| | | | | | | | | | 212 | |

Upon completion of construction sign the statement below and forward to the appropriate local representative. THE PROCESS, EXHAUST OR VENTILATION SYSTEM HAS BEEN CONSTRUCTED AND WILL BE OPERATED IN ACCORDANCE WITH STATED SPECIFICATIONS AND IN CONFORMANCE WITH ALL PROVISIONS OF EXISTING REGULATIONS.

155 SIGNATURE OF AUTHORIZED REPRESENTATIVE OR AGENT: *Joseph J. Stubb* 12/19/91

| | | | | | | | |
|-------------------|---------------------|-------------|-------------|----------------|------------------------|------------------------|-----------------|
| 156 LOCATION CODE | 157 FACILITY ID NO. | 158 UTM (E) | 159 UTM (N) | 160 SIC NUMBER | 161 DATE APPL RECEIVED | 162 DATE APPL REVIEWED | 163 REVIEWED BY |
| 21454000 | 0191915 | 310327 | 816213 | 2001 | 12/19/91 | 12/19/91 | |

| | | | | |
|---------------------|---------------------|-------------------------|---------|--|
| PERMIT TO CONSTRUCT | | | | 164 |
| 164 DATE ISSUED | 165 EXPIRATION DATE | 166 SIGNATURE OF APPROV | 167 FEE | 168 DEVIATION FROM APPROVED APPLICATION SHALL VOID THIS PERMIT |
| 1/1/92 | 1/1/96 | <i>Clark K. P.E.</i> | 30 | THIS IS NOT A CERTIFICATE TO OPERATE |
| | | | | 169 TESTS AND/OR ADDITIONAL EMISSION CONTROL EQUIPMENT MAY BE REQUIRED PRIOR TO THE ISSUANCE OF A CERTIFICATE TO OPERATE |

| | | | | |
|------------------------|---------------------|-------------------------|---------|---|
| CERTIFICATE TO OPERATE | | | | 173 |
| 169 DATE ISSUED | 170 EXPIRATION DATE | 171 SIGNATURE OF APPROV | 172 FEE | 173 INSPECTED BY |
| 01/23/92 | 03/01/96 | <i>Clark K. P.E.</i> | | DATE |
| | | | | 174 INSPECTION DISCLOSED DIFFERENCES AS BUILT VS PERMIT CHANGES INDICATED ON FORM |
| | | | | 175 ISSUE CERTIFICATE TO OPERATE FOR SOURCE AS BUILT |
| | | | | 176 APPLICATION FOR C/O DENIED |
| | | | | DATE |
| | | | | INITIALED |

| | |
|------------------------|-----|
| 174 SPECIAL CONDITIONS | 175 |
| | |
| | |
| | |
| | |

CONTAINED IN FORM 26-1112 BEFORE ANSWERING ANY QUESTION

PROCESS, EXHAUST OR VENTILATION SYSTEM APPLICATION FOR PERMIT TO CONSTRUCT OR CERTIFICATE TO OPERATE

YELLOW - APPLICANT

| | | | |
|---|--|--|--|
| 1 NAME OF OWNER - FIRM Xerox Corporation | 2 NAME OF AUTHORIZED AGENT Day Engineering, P.C. | 10 TELEPHONE (716) 292-1090 | 19 FACILITY NAME IF DIFFERENT FROM OWNER, FIRM |
| 2 NUMBER AND STREET ADDRESS 200 Phillips Road | 11 NUMBER AND STREET ADDRESS 2144 Brighton Henrietta Townline Road | 20 FACILITY LOCATION (NUMBER AND STREET ADDRESS) | |
| 3 CITY - TOWN - VILLAGE Webster | 4 STATE NY | 5 ZIP 14560 | 21 CITY - TOWN - VILLAGE |
| 6 STATE NY | 7 ZIP 14560 | 12 CITY - TOWN - VILLAGE Rochester | 13 STATE NY |
| 14 ZIP 14022 | 15 STATE NY | 16 ZIP 14022 | 22 ZIP |
| 4 NUMBER OF ESTABLISHMENT A <input type="checkbox"/> COMMERCIAL C <input type="checkbox"/> UTILITY F <input type="checkbox"/> MUNICIPAL I <input type="checkbox"/> RESIDENTIAL B <input type="checkbox"/> INDUSTRIAL D <input type="checkbox"/> FEDERAL G <input type="checkbox"/> EDUC INST J <input type="checkbox"/> OTHER | 5 NAME OF ESTABLISHMENT Oper. Mgr., Env. Engineering | 17 NAME OF ARCHITECT OR ENGINEER Joseph J. Skuld, P.E. | 18 TELEPHONE (716) 422-3831 |
| 19 NAME & TITLE OF OWNER'S REPRESENTATIVE Joseph J. Skuld, P.E. | 20 TELEPHONE (716) 422-3831 | 21 NAME OF APPLICANT Day Engineering, P.C. | 22 TELEPHONE (716) 292-1090 |
| 23 START UP DATE MO / YR | 24 DRAWING NUMBERS OF PLANS SUBMITTED | 25 PERMIT TO CONSTRUCT A <input type="checkbox"/> NEW SOURCE B <input type="checkbox"/> MODIFICATION | 26 CERTIFICATE TO OPERATE A <input type="checkbox"/> NEW SOURCE C <input type="checkbox"/> EXISTING SOURCE B <input type="checkbox"/> MODIFICATION |



| | | | |
|----------------|------------|--------------|---|
| 27 SOURCE CODE | 28 -MS DAY | 29 DAYS / YR | 30 % OPERATING SEASONS Winter Spring Summer Fall |
|----------------|------------|--------------|---|

DESCRIBE PROCESS OR UNIT

| EMISSION CONTROL EQUIPMENT ID | CONTROL TYPE | MANUFACTURER'S NAME AND MODEL NUMBER | DISPOSAL METHOD | DATE INSTALLED MONTH / YEAR | USEFUL LIFE |
|-------------------------------|--------------|--------------------------------------|-----------------|-----------------------------|-------------|
| 42 | 43 | 44 | 45 | 46 | 47 |
| 48 | 49 | 50 | 51 | 52 | 53 |

CALCULATIONS

| CONTAMINANT | NAME | CAS NUMBER | INPUT OR PRODUCTION UNIT | ENV DATA | EMISSIONS | | | | HOURLY EMISSIONS (LBS/HR) | | ANNUAL EMISSIONS (LBS/YR) | | |
|-------------|----------------------|------------|--------------------------|----------|-----------|------|---------------|------------------|---------------------------|--------|---------------------------|---------------|-----|
| | | | | | ACTUAL | UNIT | % PERMISSIBLE | CONTROL EFF. CTY | ERP | ACTUAL | ACTUAL | % PERMISSIBLE | |
| 54 | 1,2-dichloroethylene | 00156605 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 |
| | | | | | 0.527 | 1 | 15.27 | 50 | 0.527 | 2539 | 0 | 2537 | |
| 68 | vinyl chloride | 00075014 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 |
| | | | | | 18.2 | 2 | 18.3 | 50 | 0.019X | 83 | 0 | 88 | |
| 84 | xylene | 01330207 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 |
| | | | | | 1.9 | 2 | 1.9 | 50 | 0.0055 | 9 | 0 | 9 | |
| 99 | chlorine | 07782505 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 |
| | | | | | 0.075 | 1 | 0.075 | 0 | 0.095 | 0.095 | 832 | 0 | 832 |

| TYPE | SOLID FUEL TONS / YR | LIQUID FUEL THOUSANDS OF GALLONS / YR | GAS THOUSANDS OF CF / YR | APPLICABLE RULE |
|------|----------------------|---------------------------------------|--------------------------|-----------------|
| 144 | 145 | 146 | 147 | 148 |

UNDER CERTIFICATION OF CONSTRUCTION WITH THE STATEMENT HEREON AND THEREIN TO THE SECRETARY'S AND REPRESENTATIVE'S THE PROCESS EXHAUST OR VENTILATION SYSTEM HAS BEEN CONSTRUCTED AND WILL BE OPERATED IN ACCORDANCE WITH STATED SPECIFICATIONS AND IN CONFORMANCE WITH ALL PROVISIONS OF EXISTING REGULATIONS

154 LOCATION CODE 157 FACILITY ID NO 158 UTM (E) 159 UTM (N) 160 SIG NUMBER 161 DATE APPL RECEIVED 162 DATE APPL REVIEWED 163 REVIEWED BY

PERMIT TO CONSTRUCT

164 DATE ISSUED 165 EXPIRATION DATE 166 SIGNATURE OF APPROVAL 167 FEE

1 DEVIATION FROM APPROVED APPLICATION SHALL VOID THIS PERMIT
2 THIS IS NOT A CERTIFICATE TO OPERATE
3 TESTS AND/OR ADDITIONAL EMISSION CONTROL EQUIPMENT MAY BE REQUIRED PRIOR TO THE ISSUANCE OF A CERTIFICATE TO OPERATE

CERTIFICATE TO OPERATE

169 DATE ISSUED 170 EXPIRATION DATE 171 SIGNATURE OF APPROVAL 172 FEE

173 INSPECTED BY _____ DATE _____
174 INSPECTION DISCLOSED DIFFERENCES AS BUILT VS PERMIT CHANGES INDICATED ON FORM
175 ISSUE CERTIFICATE TO OPERATE FOR SOURCE AS BUILT
176 APPLICATION FOR C/O DENIED _____ DATE _____ INITIALED _____

SPECIAL CONDITIONS

APPLICANT ONLY

EMISSIONS CALCULATIONS - FF01

In an effort to reduce the amount of contaminants transferred from the liquid phase to the gaseous phase, Xerox has installed an Ultrox UV/oxidation system upstream of the existing groundwater air stripping system. This system utilizes the chemical oxidation properties of ultraviolet radiation, hydrogen peroxide and ozone as a method for groundwater treatment.

In the Ultrox system, groundwater is injected with hydrogen peroxide from an outside storage tank prior to entering a UV/oxidation reactor. The reaction chamber has a 3900 gallon capacity and contains 432 UV lamps. A generator is used to produce ozone on site from dry air. The ozone is fed into the groundwater in the reaction chamber. Excess ozone is routed from the reactor to a heated catalyst which destroys the ozone before it is emitted to the atmosphere. An isometric sketch of the Ultrox system is included with this submittal.

Groundwater contaminant concentrations and air stripper efficiencies were extrapolated by the Xerox Process Manager from extensive analytical records maintained for the process. The Ultrox system efficiency for destroying the various groundwater contaminants was derived from analytical data collected by Xerox personnel during a 12 month pilot study conducted at the Xerox Webster facility.

The Ultrox system requires a minimum volume of groundwater flow to remain operational. Xerox engineers anticipate that the system will be operational approximately 50% (4380 hrs/yr) of the time. According to the manufacturer, the Ultrox system will destroy approximately 90% of the groundwater contamination with the exception of 1,1,1-trichloroethane, 1,1-dichloroethane, methylene chloride and chlorine. Estimated efficiency of destruction is approximately 35% for the first three compounds and 0% for chlorine. Following treatment in the Ultrox system, the treated groundwater will be routed to the air stripper. The air stripper removal efficiency is 100% for chlorine and approximately 95% for the remaining groundwater contaminants.

Approximately 50% (4380 hrs/yr) of the time, the Xerox process engineers anticipate that there will be insufficient groundwater flow to operate the Ultrox system. During this period, the groundwater will be routed directly to the air stripper.

Since the Ultrox system will not be operating continuously, the DEC has requested that:

1. the actual emissions blocks (i.e. blocks 59, 74, 89, etc) and the ERP emissions blocks (i.e. 64,79,94, etc) on the air permit application form be completed using the anticipated emissions when the Ultrox system is not operating, and
2. the actual hourly emissions blocks (i.e. blocks 65, 80, 95, etc) on the air permit application be completed using the anticipated emissions when the Ultrox system is operating.

According to the Xerox Process Manager, the groundwater contaminants and the maximum concentrations of these contaminants encountered by the process are as follows:

| <u>Contaminant</u> | <u>Max. Concentration (lb/hr)</u> | <u>Air Stripper Eff. (%)</u> | <u>Ultrox Eff. (%)</u> |
|-----------------------|---------------------------------------|----------------------------------|----------------------------|
| toluene | 0.788 | 95 | 90 |
| tetrachloroethylene | 0.0368 | 95 | 90 |
| 1,1,1-trichloroethane | 0.0556 | 95 | 35 |
| methylene chloride | 0.0057 | 95 | 35 |
| 1,1-dichloroethane | 0.018 | 95 | 35 |
| trichloroethylene | 0.3114 | 95 | 90 |
| 1,2-dichloroethylene | 0.5545 | 95 | 90 |
| vinyl chloride | 0.0193 | 95 | 90 |
| xylene | 0.002 | 95 | 90 |
| chlorine | 0.095 | 100 | 0 |

The estimated emissions for each contaminant will be calculated as follows:

- ERP = the estimated hourly emission when the Ultrox system is not operational

$$\text{ERP Emission} = [(\text{avg. groundwater concentration}) \times (\text{air stripper removal efficiency})]$$
- Actual = the estimated hourly emission when the Ultrox system is operational

$$\text{Actual Emission} = [(\text{avg. groundwater concentration}) \times (1 - \text{Ultrox removal efficiency})] \times (\text{air stripper removal efficiency})]$$
- Annual Emission = $[(\text{Actual Emission} \times 4380 \text{ hrs/yr}) + (\text{ERP Emission} \times 4380 \text{ hrs/yr})]$

Toluene Emissions:

$$\begin{aligned} \text{ERP} &= 0.788 \text{ lb/hr} \times 0.95 = 0.7486 \text{ lb/hr} \\ \text{Actual} &= (0.788 \text{ lb/hr} \times 0.10) \times (0.95) = 0.07486 \text{ lb/hr} \\ \text{Annual} &= (0.07486 \text{ lb/hr} \times 4380 \text{ hrs/yr}) + (0.7486 \text{ lb/hr} \times 4380 \text{ hrs/yr}) \\ &= 327.89 \text{ lbs/yr} + 3278.87 \text{ lbs/yr} = 3606.76 \text{ lbs/yr (round to 3607 lbs/yr)} \end{aligned}$$



Tetrachloroethylene Emissions:

$$\begin{aligned} \text{ERP} &= 0.0368 \text{ lb/hr} \times 0.95 = 0.035 \text{ lb/hr} \\ \text{Actual} &= (0.0368 \text{ lb/hr} \times 0.10) \times (0.95) = 0.0035 \text{ lb/hr} \\ \text{Annual} &= (0.0035 \text{ lb/hr} \times 4380 \text{ hrs/yr}) + (0.035 \text{ lb/hr} \times 4380 \text{ hrs/yr}) \\ &= 15.33 \text{ lbs/yr} + 153.30 \text{ lbs/yr} = 168.63 \text{ lbs/yr (round to 169 lbs/yr)} \end{aligned}$$

1,1,1-trichloroethane Emissions:

$$\begin{aligned} \text{ERP} &= 0.0556 \text{ lb/hr} \times 0.95 = 0.0528 \text{ lb/hr} \\ \text{Actual} &= (0.0556 \text{ lb/hr} \times 0.65) \times (0.95) = 0.0343 \text{ lb/hr} \\ \text{Annual} &= (0.0343 \text{ lb/hr} \times 4380 \text{ hrs/yr}) + (0.0528 \text{ lb/hr} \times 4380 \text{ hrs/yr}) \\ &= 150.23 \text{ lbs/yr} + 231.26 \text{ lbs/yr} = 381.50 \text{ lbs/yr (round to 382 lbs/yr)} \end{aligned}$$

Methylene chloride Emissions:

$$\begin{aligned} \text{ERP} &= 0.0057 \text{ lb/hr} \times 0.95 = 0.0054 \text{ lb/hr} \\ \text{Actual} &= (0.0057 \text{ lb/hr} \times 0.65) \times (0.95) = 0.00352 \text{ lb/hr} \\ \text{Annual} &= (0.00352 \text{ lb/hr} \times 4380 \text{ hrs/yr}) + (0.0054 \text{ lb/hr} \times 4380 \text{ hrs/yr}) \\ &= 15.42 \text{ lbs/yr} + 23.65 \text{ lbs/yr} = 39.07 \text{ lbs/yr (round to 39 lbs/yr)} \end{aligned}$$

1,1-dichloroethane Emissions:

$$\begin{aligned} \text{ERP} &= 0.018 \text{ lb/hr} \times 0.95 = 0.017 \text{ lb/hr} \\ \text{Actual} &= (0.018 \text{ lb/hr} \times 0.65) \times (0.95) = 0.011 \text{ lb/hr} \\ \text{Annual} &= (0.011 \text{ lb/hr} \times 4380 \text{ hrs/yr}) + (0.017 \text{ lb/hr} \times 4380 \text{ hrs/yr}) \\ &= 48.18 \text{ lbs/yr} + 74.46 \text{ lbs/yr} = 122.64 \text{ lbs/yr (round to 123 lbs/yr)} \end{aligned}$$

Trichloroethylene Emissions:

$$\begin{aligned} \text{ERP} &= 0.3114 \text{ lb/hr} \times 0.95 = 0.296 \text{ lbs/hr} \\ \text{Actual} &= (0.3119 \text{ lbs/hr} \times 0.10) \times (0.95) = 0.0296 \text{ lb/hr} \\ \text{Annual} &= (0.0296 \text{ lb/hr} \times 4380 \text{ hrs/yr}) + (0.296 \text{ lbs/hr} \times 4380 \text{ hrs/yr}) \\ &= 129.65 \text{ lbs/yr} + 1296.48 \text{ lbs/yr} = 1426.13 \text{ lbs/yr (round to 1426} \\ &\quad \text{lbs/yr)} \end{aligned}$$



1,2-dichloroethylene Emissions:

$$\text{ERP} = 0.5545 \text{ lb/hr} \times 0.95 = 0.527 \text{ lb/hr}$$

$$\text{Actual} = (0.5545 \text{ lb/hr} \times 0.10) \times (0.95) = 0.0527 \text{ lb/hr}$$

$$\begin{aligned} \text{Annual} &= (0.0527 \text{ lb/hr} \times 4380 \text{ hrs/yr}) + (0.527 \text{ lb/hr} \times 4380 \text{ hrs/yr}) \\ &= 230.83 \text{ lbs/yr} + 2308.26 \text{ lbs/yr} = 2539.09 \text{ lbs/yr (round to 2539 lbs/yr)} \end{aligned}$$

Vinyl chloride Emissions:

$$\text{ERP} = 0.0193 \text{ lb/hr} \times 0.95 = 0.0183 \text{ lb/hr}$$

$$\text{Actual} = (0.0193 \text{ lb/hr} \times 0.10) \times (0.95) = 0.00183 \text{ lb/hr}$$

$$\begin{aligned} \text{Annual} &= (0.00183 \text{ lb/hr} \times 4380 \text{ hrs/yr}) + (0.0183 \text{ lb/hr} \times 4380 \text{ hrs/yr}) \\ &= 8.02 \text{ lbs/yr} + 80.15 \text{ lbs/yr} = 88.17 \text{ lbs/yr (round to 88 lbs/yr)} \end{aligned}$$

Xylene Emissions:

$$\text{ERP} = 0.002 \text{ lb/hr} \times 0.95 = 0.0019 \text{ lb/hr}$$

$$\text{Actual} = (0.002 \text{ lb/hr} \times 0.10) \times (0.95) = 0.00019 \text{ lb/hr}$$

$$\begin{aligned} \text{Annual} &= (0.00019 \text{ lb/hr} \times 4380 \text{ hrs/yr}) + (0.0019 \text{ lb/hr} \times 4380 \text{ hrs/yr}) \\ &= 0.83 \text{ lbs/yr} + 8.32 \text{ lbs/yr} = 9.15 \text{ lbs/yr (round to 9 lbs/yr)} \end{aligned}$$

Chlorine Emissions:

$$\text{ERP} = \text{actual emissions} = 0.095 \text{ lb/hr} \times 1.0 = 0.095 \text{ lb/hr}$$

$$\text{Annual} = 0.095 \text{ lb/hr} \times 8760 \text{ hrs/yr} = 832.20 \text{ lbs/yr (round to 832 lbs/yr)}$$