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FINAL REPORT

CORRECTIVE MEASURES IMPLEMENTATION PLAN OFFSITE SYSTEM

BELL AEROSPACE TEXTRON WHEATFIELD PLANT

Bell Aerospace TEXTRON
Division of Textron Inc.

Prepared by:
Golder Associates Inc.
Buffalo, New York

913-9014

MARCH 1992

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Golder Associates

FINAL REPORT ON

CORRECTIVE MEASURES IMPLEMENTATION PLAN OFF-SITE SYSTEM BELL AEROSPACE TEXTRON WHEATFIELD PLANT

Submitted to:

Bell Aerospace Textron
2221 Niagara Falls Boulevard
Niagara Falls, New York 14304

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REGION 9

March 1992

913-9014

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Golder Associates

March 11, 1992

913-9014

Bell Aerospace Textron
2221 Niagara Falls Boulevard
Niagara Falls, New York 14304

Attention: Mr. Brian Smith

RE: FINAL REPORT ON
CORRECTIVE MEASURES IMPLEMENTATION PLAN
OFF-SITE SYSTEM
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT

Gentlemen:

Please find attached the Final Report on the Corrective Measures Implementation Plan (CMI) for the off-site system at the Bell Aerospace Textron (BAT) Wheatfield Plant in Niagara Falls, New York.

Golder Associates Inc. (Golder Associates) appreciates the opportunity to provide continuing engineering services to BAT. If you should have any questions regarding this document, please do not hesitate to call.

Very truly yours,

GOLDER ASSOCIATES INC.

Anthony L. Grasso

Anthony L. Grasso, P.G.
Senior Hydrogeologist

ALG:cr

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1.0 INTRODUCTION

1.1 General

Bell Aerospace Textron (BAT) investigated ground water degradation emanating from the Wheatfield Plant Facility in Niagara Falls, New York (see Figure 1), in order to comply with Consent Order No. RCRA 85-010-91, Index No. 051485 issued by the New York State Department of Environmental Conservation (NYSDEC). The ground water degradation was associated with release of chlorinated solvents from a Neutralization Pond Solid Waste Management Unit (SWMU) located at the BAT facility. The pond has since been closed. Investigation of the ground water contamination was performed as a five phase investigation, culminated by submission of the RCRA Facility Investigation (RFI) report (Golder Associates Inc., 1991a). The RFI report was accepted by the NYSDEC and the United States Environmental Protection Agency (USEPA) on June 7, 1991.

The investigation included sampling of soils, bedrock and ground water, with subsequent analytical chemistry analyses performed on representative samples to define the presence of hazardous materials. In addition, analysis and testing of subsurface aquifer systems were undertaken to determine aquifer characteristics and local ground water flow patterns. Subsequent to these investigations, a Corrective Measures Study (CMS) was performed and the results were submitted to the NYSDEC and the USEPA for review and approval (Golder Associates Inc., 1991b). The CMS included an evaluation of remedial alternatives and related actions, and provides a basis for determining final remedial measures. The NYSDEC and the USEPA accepted the CMS on June 7, 1991.

The CMS contains a conceptual remedial program which the NYSDEC and USEPA have determined to be appropriate for remediation of the contaminant plumes emanating from the site. The corrective measures involve extraction wells, configured into both an off-site and on-site system, to withdraw water from area soils and bedrock and deliver the water to treatment facilities. In addition, the CMS proposed modification of the storm water drainage system along Walmore Road and the placement of two clay plugs in the Walmore Road sanitary sewer trench adjacent to the BAT Facility. These modifications to the storm sewer were completed in June 1991 (Golder Associates Inc., 1991c).

1.2 Post Closure Permits

BAT is currently negotiating with the NYSDEC and USEPA to obtain a 6NYCRR Part 373 Permit (Part 373 Permit) (from NYSDEC) and a Hazardous and Solid Waste Amendments Permit (HSWA Permit) from the USEPA, for post closure care and remediation of the closed Neutralization Pond SWMU located at the BAT facility. Draft versions of the two permits were issued to BAT in 1991. The draft permits require BAT to submit a Corrective Measures Implementation Plan (CMI) for the remedial systems.

The NYSDEC and USEPA have determined that the most effective and timely way to achieve remediation of the contaminant plumes is to separately implement on-site and off-site remedial systems. Due to the less complex nature of the off-site plume remediation system (see Figure 2), the NYSDEC and USEPA determined that implementation of the off-site corrective measures will take precedence over the on-site corrective measures and should proceed as soon as possible. Therefore, this CMI is specifically aimed at the off-site system. A CMI for the on-site system will be submitted to the NYSDEC and USEPA as a separate document at a later date.

This document constitutes BAT's CMI for the off-site remedial system. This plan presents the off-site extraction system and the requirements for reporting and monitoring of the system's effectiveness and performance. If the off-site system specified herein does not meet anticipated remedial goals, BAT may be required to modify the system.

This off-site CMI contains a design package for the extraction system, monitoring plans and a data collection plan to gauge system performance (physical/chemical), reporting criteria, clean-up standards, termination protocols, sampling methodology, and analysis plans. Acceptance of this document also depends on acceptance of the Solute Transport Modeling Study (see Appendix E), along with issuance of the final Part 373 and HSWA Permits. The Health and Safety Plan, included as Appendix D of this plan, has previously been submitted to and accepted by the NYSDEC and the USEPA, as stated in a letter dated January 7, 1992, from the NYSDEC to BAT.

1.3 Site Background

A complete discussion of site history and previous investigations and studies are contained in the RFI report (Golder Associates Inc., 1991a).

1.4 Design Scope

A general description of the off-site remedial system and design components are presented in Section 2.0 of this plan. A detailed design package for the off-site remedial system, including design specifications is presented as Appendix F to this plan.

1.5 Project Schedule

Within 30 days of the NYSDEC and the USEPA approval of the off-site CMI, weather permitting, BAT shall commence the activities for construction of the off-site remedial system.

1.6 Treatment System and Capacity

BAT has received an Industrial Waste Permit, dated February 1, 1992 (Permit No. 92-07), from the Niagara County Sewer District No. 1 to discharge off-site extracted ground water directly to the Walmore Road sanitary sewer. The anticipated pollutant discharge levels to the sewer are based on concentrations and loading values generated during the modeling of hydrogeologic conditions (see Appendix E, Solute Transport Model). The permit discharge loading values are based on the results of this modeling effort. The permit states that the off-site extraction systems will be connected to the sanitary sewer system at Manhole 9-3 (see Figure 3). Discharge to the sewer will commence during system start up procedures.

1.7 System Monitoring and Modifications

Monitoring of the installed system will be subdivided into three categories: effectiveness; termination; and post termination. A data collection plan will also be implemented as part of monitoring of the system. The monitoring programs provide for both physical and chemical evaluation of the installed system and the data to be collected will include, but not be limited to:

- Well pumping rates;
- Ground water elevations;
- Meteorologic information (from Niagara Falls International Airport Weather Station);
- Ground water chemistry information; and
- Operational activities.

Dependent upon the information collected, BAT will make minor modifications to the system. BAT will make modifications to the pumping rates, as required, to create the desired level of drawdown (i.e., fine tune the system) and regulate the discharge to the Niagara County sanitary sewer. These modifications to the system will be presented in quarterly reports, which will be submitted to the NYSDEC and the USEPA. All other modifications to either system configuration or operation will require written approval from the NYSDEC and the USEPA.

2.0 OFF-SITE REMEDIAL SYSTEM DESIGN

2.1 General

This section presents the a generalized description of the off-site remedial system design. The off-site system was designed primarily by Conserva-Tech Engineering Services, under subcontract to Golder Associates Inc. The design includes a ground water extraction system consisting of six ground water extraction wells to be placed within the Niagara Mohawk utility easement, located south of the BAT facility. The extraction wells are designed to primarily extract ground water from the Zone 1 aquifer to remediate the aquifer of dissolved phase contaminants present in the ground water system. The extracted ground water will be transferred via a pipeline network to a sanitary sewer inlet. Once the extracted ground water enters the sewer it will be transferred via the sewer line to a local publicly owned treatment works (POTW) facility for treatment. Appendix F presents the detailed design package, including design specifications, for the off-site remedial system.

2.2 System Components

The layout of the off-site system is based on results of ground water modeling completed as part of the CMS (Golder Associates Inc., 1991b) and on results of the solute transport model (see Appendix E of this plan). The number of wells, spacing of the wells, anticipated ground water extraction rates, anticipated drawdown, and anticipated reduction in ground water contaminants resulting from operation of the off-site system, based on these modeling efforts, are presented in Appendix E.

Each extraction well has been designed to be capable of extracting about 5 gallons per minute (gpm) to 14 gpm. The well head will be recessed, installed in a vault buried below the ground surface. A buried double walled pipeline network, fitted with a leak detection device, will transmit the extracted ground water as a force main to the sewer inlet. The pipeline system has been over designed to accommodate the maximum flow volume from the six extraction wells, and additional flow volume from extraction wells that may be added to the system in the future.

A 3-inch diameter pipe, consisting of polypropylene material will serve as the carrier pipe; a six-inch diameter pipe, consisting of fiberglass material will serve as the containment pipe. These piping materials are chemically compatible with the contaminants previously reported in ground water samples obtained from the Zone 1 aquifer.

The vaults will consist of polymerized concrete materials and will allow access to sample the extracted ground water at each well. The vaults will also house an expansion loop for the 3-inch diameter carrier pipe. The expansion loop has been designed to facilitate expansion and contraction of the carrier pipe under normal operating conditions. The six-inch diameter fiberglass containment pipe does not require an expansion loop due to the low coefficient of expansion of the fiberglass material.

The water level in each extraction well will be maintained between prescribed elevations by using water level control switches to activate and deactivate the pump based on the water level in the well. Further, the pumping rate for each well will be controlled by adjusting two butterfly valves at the well head to establish the desired flow rate. The elevation settings for the water level switches and pumping rate for each well will be established after the extraction wells are installed.

The off-site system has been designed to be monitored from the BAT facility. The system will be manually operated at each well head, with operational data sent via a telephone line to the BAT facility, and will indicate the basic operational status of the system (i.e. flow rate and flow volume at each well).

3.0 PERFORMANCE MONITORING SYSTEM

3.1 Introduction

As required in the draft Part 373 and HSWA Permits, monitoring of ground water will be necessary throughout and beyond the operation of the off-site extraction system to evaluate the effectiveness of the corrective measures. The effectiveness of the corrective measures will be evaluated through both impact on the local hydrogeologic systems and quality of ground water at selected monitoring well locations and the quality of the ground water extracted by the extraction wells. The measurement of piezometric heads and sampling and analysis of the ground water will occur with set frequencies (detailed in the following sections) with the results presented in the quarterly reports. The information derived from these analyses will be compared to baseline data presented in the RFI report (Golder Associates Inc., 1991a) in order to demonstrate that containment (inward gradients) and cleanup (reduced concentrations) of the contaminated ground water is occurring.

This section is also considered as the Data Collection Plan that will be used to characterize the performance of the off-site system during the first 12 months of system operation. The data collection protocols presented herein will provide sufficient information about the operation of the system to allow BAT to develop a final Operation and Maintenance Program for the off-site system.

3.2 Hydraulic Monitoring Criteria

3.2.1 Hydraulic Gradient Criteria

Measurement of the drawdown developed due to pumping of the extraction wells will be used to evaluate the effectiveness of the system for establishing a zone of capture. As discussed in the Solute Transport Model (see Appendix E), the anticipated drawdown pattern is roughly trough-shaped, trending north to south along the Niagara Mohawk Power utility easement, and extending to the northeast at the northern end. Ground water elevations will be measured from the defined monitoring points presented in Table 1 and from the three monitoring wells to be installed in the vicinity of the proposed extraction wells (see Figure 3). The ground water data will be used to determine hydraulic gradients created by the extraction system and to estimate the extent and geometry of the capture zone. Measurement of ground water elevations will be performed on a periodic basis throughout start up and continued operation of the extraction system at the frequencies specified in Table 1. A single channel datalogger, connected to pressure transducers, will be installed in one of the three new monitoring wells and in monitoring well 87-17(1) to monitor ground water elevations at these wells.

A stable configuration of the cone-of-depression (i.e., near steady-state conditions), due to operation of the off-site system, is not expected to develop until after a minimum of 12 months of operation, depending on seasonal fluctuations. After this 12-month period, if water level measurements indicate the observed drawdown is not producing an effective capture zone, then operation of the system may be modified (e.g. adjusting the pumping rate or depth of pump actuation within a well) or additional pumping wells will be added. Field measurements will be referenced to geodetic datum.

3.2.2 Monitoring Well Criteria/New Monitoring Well Locations

Monitoring wells installed as part of this CMI will be constructed in general accordance with the previously approved protocol. This protocol is detailed in "Phase V, Monitoring Well Installation Specifications, Bell Aerospace Textron," submitted to NYSDEC in September, 1989 (Golder Associates Inc., 1989). The locations of the proposed three new monitoring wells, shown on Figure 3, are based on the results of the modeling performed for the Solute Transport Model (Appendix E). The final location of these three new monitoring wells will be dependant on BAT's ability to gain access to appropriate locations.

3.2.3 System Performance

Following start-up of the off-site extraction system, data pertinent to changes in ground water elevation, chemistry, and system operation will be collected and evaluated as described in this plan. Also, meteorological data from the Niagara Falls International Airport and discharge data from Atlantic Research Corporation located at the BAT facility will be evaluated. Furthermore, other hydraulic related sources that may be affecting the system, if identified, may also be evaluated.

3.3 Ground Water Quality Monitoring

Monitoring of off-site ground water quality has been conducted at the BAT site since 1985 and has indicated the presence of dissolved phase contaminants. This baseline information has been summarized in the RFI report (Golder Associates Inc., 1991a). Monitoring of off-site ground water quality will be evaluated for different sets of contaminants, from different wells, depending on the stage of monitoring being performed (i.e., effectiveness, termination, or post termination) throughout and following the operation of the off-site system.

The purpose of the respective monitoring programs is to evaluate the effectiveness of the corrective measures as instituted, determine when the prescribed clean-up levels have been met, and provide a method for determining a system shut off date. No allowance for an alternative basis for system shutdown has been established at this time. Each phase of the monitoring protocol will utilize several different well types. These well types are referred to as:

- Internal Monitoring Wells (INT Wells)

  Wells within the presently existing plume, whether existing or proposed, that will provide both chemical and water level data;

- Perimeter Monitoring Wells (PMW Wells)

  These wells will be located near or outside the existing plume area, as defined in the RFI report; and

- Supplemental Wells (SUPP Wells)

  These wells will be considered as the extraction wells for the off-site system.

The analytes of concern in the off-site extraction system are presented in Tables 2, 3, and 4. Table 2 provides a list of Volatile Organic Compounds (VOCs), the associated Ground Water Protection Standard, and the detection limits associated with different analytical methodologies for VOCs. Tables 3 and 4 provide the same information for the Semi-Volatile Organic Compounds (Semi-Volatiles), Polychlorinated Biphenyls (PCBs) and Inorganic analytes.

For all phases of monitoring, samples will be collected in general accordance with the Ground Water Sampling Plan described in Section 5.0. Analyses will be conducted in accordance with the Laboratory Analysis Plan described in Section 6.0 and the Sampling and Analysis protocols set forth in the Ground Water Monitoring Plan (GWMP) for Bell Aerospace Textron Wheatfield Plant, dated February 1992 (Golder Associates Inc., 1992).

3.3.1 Effectiveness Monitoring

Effectiveness monitoring is designed to show that the system, as planned and constructed, is performing as expected. The goal of effectiveness monitoring is to demonstrate that clean-up is occurring (i.e., targeted at a 50-percent average reduction in hazardous waste constituents within 10 years and a 75-percent average reduction within 15 years for the off-site system, as defined in the draft Part 373 and HSWA Permits). Effectiveness monitoring will begin with system initiation and continue until termination monitoring commences. The effectiveness monitoring program will consist of analyses for the VOCs listed in Table 2. The first four quarters of data collected for the newly installed extraction wells will be used to establish baseline concentrations of constituents for such wells. Historical data collected during the RFI will be used to establish baseline concentrations for the existing wells. Effectiveness monitoring trends will be measured from these baseline concentrations.

Table 5 shows the analytical scheme to be employed during effectiveness monitoring. The six SUPP Wells, eight PMW Wells, six existing INT Wells, and the three new monitoring wells (INT Wells) will be sampled on a quarterly basis (four sampling events per year) or on an annual basis for VOCs by SW-846 Methods (Method 8240 and/or Method 8260), and/or EPA Methods 601 and 602. As the constituents in the dissolved phase plume decrease in concentration, Method 8260 will be used because of the lower achievable detection limits. It should be noted that, if a well is to be sampled for the quarterly and annual programs, the quarterly list of parameters will be analyzed three times per year while the annual list will be analyzed once per year.

When it can be demonstrated, based on the analytical data from a well(s), that the concentrations of VOCs do not exceed the Ground Water Protection Standards, the well(s) will be considered for Termination Monitoring. Prior to Termination Monitoring, the wells will be analyzed for VOCs using the methodologies described above or the Contract Laboratory Program (CLP) methodologies in existence at that time. The laboratory will be allowed to report the Method Detection Limits (MDLs) rather than the Contract Required Reporting Limits, providing that the MDLs do not exceed Ground Water Protection Standards. The laboratory will provide a data package which conforms to the specifications described in the Appendix B. The purpose of this sampling event will be to provide data that are defensible and demonstrates that the off-site termination criteria have been achieved for VOCs prior to entering termination monitoring. If the listed goals are not met within the time frames specified in the draft Part 373 and HSWA Permits, BAT will submit a plan to the NYSDEC and the USEPA stating its strategy to achieve the defined clean-up criteria.

3.3.2 Termination Monitoring

Once it has been demonstrated that the off-site termination criteria have been achieved for VOCs in all or part of the off-site system, BAT will implement the termination monitoring program 60 days after submittal of a Termination Monitoring Plan (TMP) to the NYSDEC and the USEPA. The TMP will describe the wells to be monitored and the analytical scheme to be employed during termination monitoring. Based on the Solute Transport Model (see Appendix E), it is envisioned that termination monitoring will occur at different times for the various zones of plume capture; hence, monitoring of the ground water chemistry in the wells will occur on a phased approach. Table 6 illustrates a conceptual monitoring scheme for the termination of the off-site extraction system; this conceptual scheme is described below.

On a quarterly basis, a select group of the termination monitoring wells will be analyzed for VOCs using Method 8260 to insure that termination criteria are met. Similarly, on an annual basis, Semi-Volatiles and PCBs will be analyzed using SW-846 Method 8270, and Method 8080, respectively. The laboratory will report the MDLs as opposed to the Practical Quantitation Limits (PQLs) for Semi-Volatiles because the PQLs may be greater than the Ground Water Protection Standards. Moreover, samples will be collected annually for inorganic analysis. The laboratory will use appropriate SW-846 methodologies for the analysis of the inorganic analytes such that the detection limits do not exceed the greater of the Ground Water Protection Standards or background values. Tables 2, 3, and 4 show the analytes which will be analyzed during termination monitoring. This analytical scheme will be employed for a minimum of eight consecutive quarters. In addition to meeting the Ground Water Protection Standards on a per well basis, as set forth in Tables 2, 3, and 4, BAT will need to demonstrate, through termination monitoring, that the total concentration of all organic compounds is not greater than 100 parts per billion (ppb), and no single organic compound concentration exceeds 50 ppb.

The analytical data collected will be evaluated to determine the mean concentration for each constituent. Since the primary indicators at the BAT site are VOCs, the mean concentration will be determined by using the arithmetic mean of the analytical results of VOCs from eight consecutive quarterly monitoring events during termination monitoring. Alternately, data for the other analytes will be evaluated on an annual basis. If the mean concentration of each constituent in ground water samples taken from designated monitoring wells within the capture zone of a recovery well is less than the Ground Water Protection Standards and the criteria for total organic compounds (described above) is met, then the off-site termination criteria will have been achieved for that recovery well. In accordance with the draft Part 373 Permit, "constituents that can be demonstrated as not attributable to releases from the Bell Aerospace Textron site may be excluded from the data evaluation used to determine whether the termination criteria have been met." BAT will notify the NYSDEC and the USEPA that these analytes are not being used and provide justification for excluding the data.

3.3.3 Post Termination Monitoring (PTM)

Upon demonstrating the off-site termination criteria described in Section 3.3.2, BAT will petition the NYSDEC and the USEPA for shut down of all or part of the off-site remedial system. A program for PTM will be submitted for approval to the NYSDEC and the USEPA, and will include a description of which well or wells BAT is intending to shut down and which wells will be utilized for post termination ground water monitoring. At that time, a revised Ground Water Sampling and Analysis Plan will be submitted by BAT to the NYSDEC and the USEPA. The revised plan will fully detail decommissioning procedures, analytical methodologies and any other pertinent information. PTM will continue for a minimum of three years following plan approval.

As part of the data evaluation procedure established for PTM, a method for establishing the average overall precision of analytical data will be developed by BAT and approved by the NYSDEC and the USEPA. In the event that one of the following events occur during PTM, BAT will notify the NYSDEC and USEPA:

- Two successive quarterly monitoring results from any designated monitoring well located in the discontinued portion of the system exceed the termination criteria by an amount greater than the average overall precision of the analytical data; or

- The yearly average results of quarterly monitoring from any designated monitoring well located in the discontinued portion of the system exceed the termination criteria.

Also, if during PTM, analytical results of a sample from a discontinued portion of the system indicates that the concentration of total organic compounds to be greater than ten times the off-site termination criteria, the well will be resampled within 30 days. The results of this resampling event will be submitted to the NYSDEC and the USEPA.

3.3.4 Data Verification and Resampling

In the event that, during any of the specified monitoring programs, a result from the analytical laboratory is deemed suspect by BAT, then BAT, at its discretion, may order a resampling of the suspect well or wells. Prior to resampling, BAT may request that the laboratory validate its data. If no errors are found, BAT will notify the NYSDEC and the USEPA and resample the suspect well or wells. Each sample will be collected in duplicate with both duplicates being analyzed for the appropriate monitoring program and the average result presented to the NYSDEC and the USEPA for evaluation. Upon NYSDEC and the USEPA approval, BAT will submit the averaged values into a database developed by BAT with either a reference note or footnote.

3.4 Monitoring of Discharge to Sewer

The Industrial Waste Discharge Permit BAT received from Niagara County Sewer District #1 requires BAT to monitor the discharge into the sewer. The monitoring criteria established by the Permit includes recording discharge flow volumes, and weekly, monthly, and quarterly sampling of the extracted ground water that is discharged to the sewer (for details on monitoring requirements, refer to the Permit). Results of the monitoring will be compared to the daily discharge levels established by the Permit. In the event that pollutant discharge levels exceed daily limits, BAT shall initiate a detailed study of sources, and methods of reducing discharge quantities. A report on the said study shall be submitted to the Niagara County Sewer District #1, within 60 days of the discharge occurrence.

3.5 Reporting Summary

3.5.1 Construction Certification Report

Within 60 days after completion of construction of the off-site system, BAT will submit to the NYSDEC and USEPA a construction certification document detailing the materials and activities utilized in the construction of the off-site system. This report will contain an executive summary of construction activities, daily field inspection reports, certification documents, including as-built documentation, quality assurance/quality control (QA/QC) records and a listing of all approved changes, with substantiating documentation. The report will also include the date and time the system began continuous operation, the initial pumping rates for each of the extraction wells, modifications made to those pumping rates, observations regarding the development of the induced hydraulic gradients, and appropriate figures, graphs and tabulated analytical data.

3.5.2 Quarterly Reports

Beginning with the first quarter following initiation of the off-site system, BAT will submit a quarterly report to the NYSDEC and the USEPA which describes results of sampling events and ground water elevation measurements obtained during the previous quarter. The report will also characterize system operations for the previous quarter and provide tabulated flow data, average pumping rates, with detailed descriptions of any system down times encountered and/or modification of operational protocols required to improve system operational characteristics. Further, copies of analytical data will be provided in both hard copies and an acceptable digital format such as 5¼-inch, 1.2 MB diskette, comma delimited ASCII file in DOS format.

3.5.3 Annual Reports

BAT will submit to the NYSDEC and the USEPA an annual report of the previous years activities prepared in accordance with the guidelines and requirements of 6NYCRR 373-3.6(e). The annual report shall be due by April 1 of each year and shall contain a summary of all pertinent data and evaluations as required for quarterly reports. In addition, the following information should be included in the annual report:

- Determination of ground water flow rate and direction of ground water flow in Zone 1; and
- A proposal for any changes to the Ground Water Monitoring Plan.

3.5.4 Down Time Reporting

The ground water extraction system will be operated on an essentially continuous basis, excepting periods of planned maintenance or unscheduled mechanical or electrical failures. If any part of the system fails and renders the system inoperable for a period longer than five consecutive days, or more than ten days in a 30-day period, BAT will notify the NYSDEC and USEPA, in writing. All such notification will explain the occurrence, the actions which have been taken to restore the system, and activities or modifications which will be undertaken to possibly prevent a repetition of the failure.

3.5.5 System Performance Reporting

Two reports describing the performance of the off-site system will be submitted to the NYSDEC and the USEPA, and will include pertinent data that has been collected. The first report will be entitled "Interim System Performance Report," and will be submitted following a period of six months of continuous operation of the off-site system. A second report entitled "Final System Performance Report," will be submitted following a period of 12 months of continuous operation of the off-site system. This second report will include a proposal for a final Operation and Maintenance Program for the off-site system. If appropriate, this second performance report may be submitted as part of the annual report.

3.6 System Modification

3.6.1 Adjustments Due to Drawdown Development

At BAT's discretion, and without prior NYSDEC and the USEPA approval, adjustments will be made to pumping rates or depths of pump actuation within each well which will enhance overall system performance. Any such adjustment will be reported to the NYSDEC and USEPA in the next scheduled quarterly report. All other changes, whether to the physical system or to an operational protocol, will be considered a system modification and will require written approval from the NYSDEC and the USEPA.

3.6.2 Adjustments Due to Ground Water Quality

BAT, following receipt of analytical data from a sampling event, may modify the overall pumping rate of the off-site system to maintain compliance with Niagara County Sewer District No. 1 Discharge Permit. These modifications include increases or decreases to an extraction well(s) pumping rate, or adjusting the depth of pump actuation within an individual extraction well(s). Any such adjustment will be reported to the NYSDEC and the USEPA in the next scheduled quarterly report.

4.0 TERMINATION OF GROUND WATER REMEDIATION

4.1 General

Termination of ground water extraction activities may only occur after the conditions in Section 3.3.3 have been met and the appropriate notifications have been submitted. Based on the modeling performed for the Solute Transport Model (see Appendix E), it is estimated that off-site extraction activities may continue for a period of 21 years. As discussed previously, a specific PTM plan will be submitted to the NYSDEC and the USEPA. This plan will be based on conditions which actually develop and the general guidelines outlined below.

4.1.1 Clean-Up Standards

After a minimum of eight quarters of termination monitoring, successful clean-up of the off-site plume will be considered to have occurred, on a per well basis when:

- All analytes remain below the limits listed in Table 2;
- After three years of PTM, the analytes remain below the values specified in Tables 2, 3, and 4; and
- The total concentration of volatile organic compounds is below 100 ppb, with no single constituent concentration exceeds 50 ppb.

4.1.2 Clean-Up Guidelines

A listing of off-site specific analytes targeted for remediation is presented in Tables 2, 3, and 4. The guideline concentrations associated with each chemical constituent are based on values promulgated by USEPA and/or the NYSDEC. If, however, it is determined that these guidelines are inappropriately low, due either to technological constraints or hydrogeologic conditions, BAT may petition the NYSDEC and/or the USEPA for a variance.

4.2 Termination Criteria

In the event that all standards and guidelines are met or BAT has obtained and met Alternate Concentration Limits, BAT may petition the NYSDEC and/or the USEPA to terminate the operation of a single well, multiple wells or the entire system. The petition will include all pertinent analytical data, and tabulations of analyzed data reflecting compliance with termination criteria, and rationale for the request.

5.0 GROUND WATER SAMPLING PLAN

5.1 Introduction

The following protocols provide methods for ground water level measurement, well purging prior to sampling, and sample collection and will be followed during ground water sampling events. BAT will notify the NYSDEC and the USEPA, in writing, of any modification of these protocols or the procedures set forth in the Standard Operating Procedures included in Appendix A.

5.2 Sampling Preparation

5.2.1 Checklist

Prior to any sampling event, the following steps will be taken by personnel responsible for sampling:

- Review the sampling procedures, well records, and logs;
- Assemble and inspect field equipment necessary for sample collection, verify that equipment is clean and in proper working order;
- Calibrate equipment to manufacturers specifications;
- Examine shipping containers, bottles, and preservatives; contact laboratory immediately if any problems are found;
- Confirm sample delivery time and method of sample shipment with the laboratory;
- Establish a sampling team of at least two people; and
- Establish a well purging and sampling schedule.

5.2.2 Tracking and Authorization

All individuals involved in the sampling will have read the Sampling Plan, be technically qualified for the required sampling, and follow the sampling plan whenever ground water samples are obtained.

5.3 Sampling Equipment and Procedures

The following is a step-by-step listing of the procedures for obtaining ground water samples from the wells (see Appendix A for Standard Operating Procedures, Appendix B for the Quality Assurance Project Plan (QAPP), and Appendix C for Methodology Modifications and Related Quality Assurance Information):

- Inspect the well for damage or inadvertent entry. Note any such evidence on the Chain-of-Custody Record and in the field notebook;
- Open the well cap or plug and monitor the air quality at the well head using an air monitoring detector (i.e., OVA or OVM). If the concentration of organic vapors are detected at over 5 ppm above background levels, for more than a brief peak, refer to the health and safety protocols outlined in the Ground Water Monitoring Plan (Golder Associates Inc., 1992). Air monitoring data must be recorded by the sampling contractor;
- Before and after use, triple rinse the water level sounding probe and the bottom two feet (or more) of cable with distilled water;
- Measure and record in the field notebook the depth to the water surface in the well from the top of the inner casing using the water level sounding probe;
- Calculate and record the volume of water in each well. Purge each well by removing three to five times this volume, or if the well yield is low, by removing water to within a nominal 6-inches of the bottom of the well (i.e., purged "dry");
- A vacuum dewatering system (peristaltic pump) or a bailer will be used to purge the wells.
  a. The vacuum dewatering system will consist of a polyethylene tube connected to two 5-gallon bottles in series and a portable vacuum pump. Each well will have a dedicated length of tubing to prevent possible cross-contamination between the wells. The lower end of the tube will be positioned just below the water surface and lowered, as necessary, during pumping. This process will allow stagnant water to be removed from the well and allow representative formation water to flow into the well.

  b. The bailer dewatering system will consist of a stainless steel or Teflon bailer attached to a new polypropylene rope. The bailer will be lowered slowly into the water in the well to minimize disturbance of the water. The volume of water removed from each well will be measured and recorded and the purge water will be stored at the BAT facility for proposal disposal.

- Immediately after purging, the wells will be sampled. Wells with slow recovery will be sampled for VOCs within three hours of purging, if possible. Recovery of the low yield wells will be monitored so that sampling for volatiles can be done as quickly as practicable (i.e., sufficient volume of water available to fill the containers). Proper documentation of the delay, if any, will be provided;

- Ground water samples for analysis will be obtained from the wells by bailing using dedicated bailers (when possible). Bailers used to obtain samples from more than one well will be decontaminated before use. New polypropylene rope will be used for each well;

- When sampling, the bailer will be lowered slowly into the well to minimize disturbance of the water in the well. The bailer will be used to obtain samples from the bottom of the well. The initial sample could have been subject to some degassing, so this sample will not be used for volatile organic analyses. The first bailer volume removed will be used for field measurements of pH, specific conductance and temperature;

- A glass beaker will be filled with water from the well for measuring temperature, pH and specific conductance. The pH and specific conductance meters' probes will be triple rinsed with distilled water before and after use. A minimum of four measurements will be made for each parameter. The temperature data will be used to correct specific conductance data to the 25-degree centigrade standard condition (a minimum of one set of field parameters shall be taken per well volume purged);

- Temperature, pH and specific conductance measurements will be recorded in a field notebook and on the Chain-of-Custody Record, if possible;

- After obtaining the field measurement samples, the required volume of water for the volatile organic samples (about 40 mL for each VOC vial) will be bailed from the well. The laboratory-prepared container will be filled to overflowing and covered with a Teflon septa and capped so that no air bubbles will be present in the sample;

- Sample container labels will be affixed to the sample container and the samples will be placed in an insulated container so that they can be kept cool, but not frozen (approximately 4-degrees centigrade (refer to Section 5.3.3));

- Chain-of-Custody documentation will be completed (refer to Section 5.4); and

- Samples will be stored in a cooler with ice and will be shipped to the laboratory by courier service on the day of sampling. The laboratory involved will be notified by the Sampling Team Project Manager prior to sampling to ensure capability of the laboratory to meet all holding times (refer to Section 5.3.2).

A table denoting the QA/QC sampling requirements and protocol for a ground water monitoring event, including the required number of field duplicates, field blanks, and trip blanks per sampling event, and the analytical method to be used (See Section 5.6) will be submitted upon finalization of the sampling program.

5.3.1 Sample Containers

All sample containers will be precleaned and contaminant free. The cleanliness of a batch of containers will be verified by the laboratory prior to use. Containers will be cleaned based on the analyte(s) of interest. Cleaning procedures will be as follows:

Metals Analyses

New plastic (metal) or borosilicate glass bottles (1 liter minimum) and caps that are:

- Detergent (non-phosphate) washed with hot water;
- Tap water rinsed, three times with hot water;
- Acid washed (1:1 nitric);
- Deionized water rinsed, three times with ASTM Type 1 water;
- Air dried; and
- Capped when dry.

VOCs

New 40 mL borosilicate vials with PFTE lined septa and screw caps that are:

- Detergent (non-phosphate) washed with hot water;
- Tap water rinsed, three times with hot water;
- Deionized water rinsed, three times with ASTM Type 1 water;
- Oven dried at 110-degrees centigrade for one hour; and
- Capped while still hot, making sure that PFTE side is facing the interior of the vial.

Extractable Organic Analyses (Phenols, BNAs, PCBs, Pesticides)

New amber glass bottles (1-liter minimum capacity) with PFT lined screw caps from which cardboard cap liners have been removed and rinsed with methanol. Caps and teflon cap liners should then be:

- Detergent (non-phosphate) washed with hot water;
- Tap water rinsed, three times with hot water;
- Deionized water rinsed, three times with ASTM Type 1 water;
- Rinsed with methylene chloride; and
- Oven dried at 110-degrees centigrade for one hour.

Once cleaned, sample bottles should be capped and stored in a clean environment. When samples bottles are received by the sampling team, all labels will be inspected to insure proper sample identification.

5.3.2 Holding Times and Laboratory Protocols

The holding times for samples are outlined below:

- All VOC samples are to be analyzed following the procedures set forth in the Ground Water Analysis Plan. Due to the potential presence of carbonate materials the samples will not be preserved with acid and will be refrigerated (4-degrees Celsius). The samples will be analyzed within seven days of collection; and

- Please refer to Appendix B-1 of Appendix B in this plan for holding times related to other constituents.

5.3.3 Sample Preservation and Shipment

Immediately following collection of the samples, they will be placed in a cooler with ice packs in order to maintain sample integrity. Any preservatives required will be added during sampling as directed by the analytical laboratory and applicable methodology. Sample bottles to be used for VOC analyses will be filled to capacity to minimize any headspace. The samples will be shipped by overnight courier to the laboratory to ensure holding times are met.

The shipping container used will be designed to prevent breakage, spills and contamination of the samples. Tight packing material will be provided around each sample container and any void around the ice packs. The container will be securely sealed, clearly labeled, and accompanied by a Chain-of-Custody Record. Separate shipping containers will be used for clean and heavily contaminated samples.

5.4 Sample Custody

The Chain-of-Custody Record will be filled out by the sample collector for each sample point. Additionally, information will be recorded in the field notebooks. The Chain-of-Custody Records will be provided as an attachment or appendix to each Technical Sampling Report. The following information is to be documented:

- Site name (BAT), sample ID, and other identifiers;
- Date, time and elapsed hours from sample start to sample finish;
- Information regarding purging the well prior to sampling;
- Field test results including pH, temperature and specific conductance;
- Sampling method used, such as bailer, vacuum pump, etc. Note the construction material of equipment in margin;
- Type of sample and information which appears significant (i.e., sampled in conjunction with regulatory authorities or auditing personnel);
- Field observations/sampling conditions (i.e., weather);
- Appearance of sample, such as color, turbidity, sediment, oil on surface, DNAPL, etc.; and
- Sampler's identity and signature.

In order to maintain the integrity of the ground water samples, strict chain-of-custody procedures will be followed. To ensure that the samples have not been altered from the time the sample is collected until the sample is in the custody of the analytical laboratory, the samples will be:

- In the sampler's possession;
- In the sampler's view, after being in their possession;

- In the sampler's possession and is then locked in a designated, secure area to prevent tampering; or
- In a shipping container sealed with a tamper proof chain-of-custody seal.

A written Chain-of-Custody Record of the transference of samples will be maintained. The Chain-of-Custody Record will be attached to the sample container at the time the sample is collected. All sample bottles will be properly labeled. When transferring the possession of samples, the person making the transference will sign and record the date and time on the record. The number of custodians in the chain of possession will be as few as possible.

The Chain-of-Custody Record form will be sealed in the shipping container and transported to the laboratory. Upon receipt by the laboratory, the seal will be broken, and the condition of the samples, temperature of the container, date and time of receipt will be recorded on the form by the person receiving the sample. The Chain-of-Custody Record form will be included in the technical analytical reports prepared by the laboratory.

5.5 Health and Safety

Personnel performing the sampling will adhere to all Health and Safety requirements for contractors and/or visitors of the BAT facility. Personnel performing the sampling will, at a minimum, wear suitable field boots, and protective gloves and safety glasses. Other safety equipment which is deemed necessary as the program progresses will be used by sampling personnel, as outlined in the Ground Water Monitoring Plan (Golder Associates Inc., 1992).

5.6 Sampling Quality Assurance and Quality Control (QA/QC)

5.6.1 Blank and Duplicate Samples

Blank and duplicate samples will be obtained during a sampling event to assess conditions existing in the field and during sample shipment. They are critical in the overall integrity and QA/QC of a sampling and analysis plan.

- <u>Trip Blank</u>

  A trip blank will be prepared by the laboratory for each sampling event. If sampling of the monitoring network takes more than one day, trip blanks will be prepared for each day's sample set. The trip blank will be created by filling each type of sampling container that will be used for samples with analyte free water, transporting the containers to the site and to each sampling location, and should be packed in the cooler in the same manner as the samples are packed. Trip blanks will be analyzed for the same set of parameters as the samples.

- <u>Equipment Blank</u>

  Each day that samples are collected using non-dedicated equipment, at least one equipment blank will be prepared. The equipment blank will be prepared by filling one of the sampling devices with distilled water and subsequently transferring the water to the appropriate sampling bottles. Equipment blanks will be analyzed for the same suite of parameters as the samples.

- <u>Field Blank</u>

  Field blanks are used to determine if contamination is being introduced by the sampling environment during sample collection. Field blanks will be prepared when equipment blanks are not necessary (i.e., dedicated equipment is used for sample collection). The field blank will be prepared at one of the sampling points by exposing distilled water to the air and transferring the water to a set of sampling bottles. Field blanks will be analyzed for the same suite of parameters as the samples.

- <u>Duplicate Samples</u>

  At least one duplicate suite of samples will be collected and analyzed each time the monitoring network is sampled. It is recommended that the duplicate sample be obtained at a different well for each sampling event.

5.6.2 <u>Split Samples</u>

Split samples are used in a sampling program to assess the replication of results from the same analysis between two laboratories. In this case, the NYSDEC and the USEPA have the right to split samples with BAT and have all or a portion of the analytical parameters tested by their laboratory of choice. If split samples are to be collected, the following procedure is to be used:

- Ground water will be placed directly from the bailer into two 40 mL vials for VOC analyses; and
- Ground water will be placed directly from the bailer into a larger glass jar (greater or equal to one gallon) and will be cleaned in the same manner as the sample bottles. The ground water in the glass jar will then be thoroughly mixed (composited) and poured directly into individual sample bottles.

The split samples will be from select monitoring wells in which the ground water has been analyzed as having less than 1,000 μg/l Total Organics (the sum of the organic constituents analyzed), during the previous year of sampling.

5.7 Sampling Completion (Clean-Up, Security, and Well Records)

The area in the vicinity of the well being sampled will be cleaned and the well will be locked and secured before proceeding to the next well. Well Records will be updated at the termination of each sampling event (last sample taken from last well and post sampling procedures complete). The well record will contain all pertinent information regarding well integrity, volumes purged, and water level measurements.

6.0 LABORATORY ANALYSIS PLAN

6.1 Introduction

As described in Section 2.0 of this plan, the draft Part 373 and HSWA Permits require ground water monitoring throughout and following the operation of the off-site extraction system. Due to the expected duration of the performance monitoring necessary for the permits, different laboratories may be used during the life of the permits. As such, the laboratory analysis plan presented herein is described in general terms. Individual laboratories will have different QA/QC programs. However, at a minimum, the laboratory performing the ground water analyses will perform the QA/QC specified in this section and follow the approved GWMP (Golder Associates Inc., 1992) and the QAPP (see Appendix B). The analytical laboratory chosen to perform the analyses will maintain certifications in the programs necessary for this project. This section describes QA/QC protocols for the ground water analysis.

Enseco-Rocky Mountain Analytical Laboratory (RMAL) has performed the ground water monitoring analyses for the Site in the past. RMAL is qualified to perform work using USEPA methodologies and CLP protocols. The QAPP presented in Appendix B, which is approved by the NYSDEC and USEPA, is a general description of the QA/QC program employed by RMAL as well as specifics for the work performed at the Site.

As stated previously, BAT reserves the right to engage different laboratories at its choosing for completion of analytical work. The chosen laboratory will perform work in accordance with the approved GWMP and QAPP. As the draft Part 373 and HSWA Permits require work be performed in accordance with this approved QAPP, a new laboratory-specific QAPP will not be written unless otherwise directed by the NYSDEC and/or USEPA. However, any modifications to the QAPP will be submitted to the NYSDEC and USEPA for approval.

It should also be noted that over the course of time, specific items in the methodologies themselves may change (i.e., MDLs, analytical procedures and/or requirements may change due to improvements). These items can not be foreseen and are beyond BAT's control.

6.2 Methodology

Ground water samples will be analyzed using methodologies specified in SW-846 "Test Methods for Evaluating Solid Waste," 3rd Edition (1986), and Update I (1989). VOCs will be analyzed using Method 8240 and Method 8260. Semi-Volatiles will be analyzed using Method 8270. PCBs will be analyzed using Method 8080. Specific metals will be analyzed using Method 6010 by Inductively Coupled Plasma or appropriate methods for Graphite Furnace Atomic Absorption. In order to achieve the Ground Water Protection Standards specified in the off-site termination criteria (see Table 3) for Semi-Volatiles, the laboratory will report the MDLs as opposed to the PQLs, as necessary.

In certain cases, ground water samples may be analyzed using CLP methodologies for specific analytes. The laboratory will use the most current Statements of Work (SOWs) to perform these analyses. The current SOWs are document OLM01.1 (March 1990, revised December 1990) for Organic analyses and document ILM01.0 (March 1990) for inorganic analyses.

6.3 Documentation

Documentation of all activities as they pertain to ground water analysis is a critical aspect of laboratory performance. Chain-of-Custody Records for the samples will be maintained by the laboratory. All tasks involved in the preparation and/or analysis of the samples, preparation of standards, calibration procedures, data reduction and reporting procedures, and preventative maintenance procedures will be documented by the laboratory in notebooks or the equivalent. The laboratory will maintain files containing records for method validation studies, performance evaluation studies, internal QC studies, audits and corrective actions. The data will be accessible to BAT, the NYSDEC, and the USEPA in the event of an audit.

6.4 Laboratory Quality Control (QC)

The laboratory contracted to perform the required analyses will have a QA and QC program which conforms to that specified in SW-846, 3rd Edition. The QA/QC program can be used to evaluate the accuracy and precision of the data measurements in order to assess the data quality. The program also provides information which can be used as an indication of the need for corrective action and as an indication of the effectiveness of corrective action.

The laboratory will analyze QC samples for each analytical batch and at the frequency dictated by the specific methodologies. An analytical batch is a group of environmental samples of similar composition which are analyzed together with the same method sequence and the same lots of reagents and standards within the same time period or in continuous sequential time periods. For organic analyses, the analytical batch size is usually restricted to 20 environmental samples. The laboratory will provide all QA/QC information in the analytical report for the environmental samples for data evaluation purposes. The reporting requirements, including QA/QC information, are described in the draft Part 373 Permit, Appendix III-A, dated March 19, 1991. A copy of these requirements has been included in Appendix C of this document.

6.4.1 Laboratory Blanks

Laboratory (method) blank samples are used to monitor the possible introduction of target analytes into the analytical process. The laboratory blank is an aliquot of reagent-grade (analyte-free) water or solvent which is prepared and analyzed using the same procedures as the environmental samples. The results of the laboratory blanks are used to assess whether the analytical system is "in-control" with regard to possible introduction of contaminants which might lead to the reporting of elevated concentration levels or false positives in the environmental samples.

A laboratory blank will be analyzed with each batch of samples processed. The results of the laboratory blank will be evaluated, as well as other batch QC information, to determine analytical batch acceptability. In the event that laboratory blank results are unacceptable, the analytical batch will be re-prepared and/or re-analyzed.

6.4.2 Reference Standards

In order to generate quality data, it is necessary to assure the purity and traceability of the standard solutions and reagents used in the analytical procedures. Primary reference standards and standard solutions should be obtained from the USEPA repository or other reliable commercial sources. All standards and standard solutions should be documented in a laboratory notebook which identifies the supplier, lot number, purity/concentration, analytes, receipt/preparation date, preparer's name, method of preparation, expiration data, and any other information pertinent to the standard.

6.5 Analytical Spikes

Spiked samples are aliquots of a sample to which predetermined quantities of specific target analytes are added prior to sample preparation and/or analysis. When an aliquot of reagent-grade water is used, the resultant QC check sample is used to evaluate the laboratory's performance of routine analytical procedures. When an aliquot of an environmental sample is used, the resultant matrix spike (MS) sample is used to evaluate the effect of the matrix on the accuracy of the analysis as well as the laboratory's performance of routine analytical procedures.

6.5.1 Analyte Spikes

For each analytical batch or for each 20 environmental samples, the laboratory will analyze a MS sample containing the appropriate target analytes specified in the methods. For the organic analyses, the laboratory will also analyze a matrix spike duplicate (MSD) sample. The MS/MSD recoveries will be compared to the recovery ranges specified in the methods and used to evaluate the effect of the matrix on the accuracy and precision of the analysis.

For each analytical batch or for each 20 environmental samples, the laboratory will analyze a QC check sample containing the appropriate target analytes specified in the methods. The QC check sample recovery criteria specified in the individual methodologies will be used to monitor the laboratory's performance of routine analytical procedures. The laboratory will keep updated records of the accuracy data and develop laboratory acceptance criteria based upon method performance. The QC check sample recoveries will be compared to the laboratory acceptance criteria to determine if the analyses are in-control. If the analyses are determined to be out-of-control, the analysts will take corrective action in order to eliminate procedural errors.

6.5.2 Surrogate Spikes

Surrogates are organic compounds which have similar chemical composition and characteristics (extraction and chromatographic) to the analytes of interest but which are not normally found in environmental samples. These compounds are spiked into all blanks, standards, samples and spiked samples prior to preparation and/or analysis. Percent recoveries are calculated for each surrogate compound. The surrogate recoveries are used to monitor the effect of the matrix on the accuracy of the analysis as well as the laboratory's performance of routine analytical procedures. The surrogate compounds to be used and the associated recovery ranges may be found in the individual methodologies. As presented previously, other field QA/QC samples will be required as part of the QA/QC protocol, including trip blanks, equipment blanks (if appropriate), and field blanks.

6.6 Laboratory Reporting

The laboratory will provide hard copy and diskette deliverables of all analytical results. The minimum analytical data which will be reported is outlined in the draft Part 373 Permit, Appendix III-A, dated March 19, 1991. A copy of these requirements is included in Appendix C of this document. In some cases, the laboratory may be required to produce a "CLP-type" data package. This data package will contain all information required by Appendix III-A as well as any additional information required by the CLP. In these cases, the analytical data for environmental and QA/QC samples would be evaluated using existing federal and/or regional data validation guidelines developed for the CLP or the specific methodologies (if they exist).

7.0 SUMMARY

The document presented herein constitutes BAT's CMI for the off-site remedial system. This plan contains a detailed drawing package and construction specifications for the off-site remedial system, monitoring and performance plans, and reporting requirements.

The off-site remedial system consists of a ground water extraction system to be installed south of the BAT facility. Six extraction wells will be installed within the Zone 1 aquifer and extract water from this zone which will be transferred via a double-contained pipeline to an off-site facility for treatment. The system has been designed to reduce the concentration of dissolved phase contamination present in the Zone 1 aquifer.

Ground water monitoring and data collection plans presented herein will be used to evaluate the effectiveness of the off-site system. Based on the results of the monitoring programs, the system may be adjusted to enhance the overall system performance. Ground water monitoring of the off-site system will be evaluated for different sets of contaminants, from different wells, depending on the stage of monitoring being performed during the operation of the system.

The reporting requirements include quarterly reports describing the results of monitoring, pertinent data collected, adjustments made to the system, problems encountered, and general operational activities. An annual report is also required and will include a summary of pertinent data, evaluation of the system, a presentation of the ground water flow rate and direction in the off-site system, and proposed changes to the ground water monitoring plan. Other reporting requirements include reports presenting the performance of the system, and a construction certification report documenting construction of the off-site system.

Within 30 days of the NYSDEC and the USEPA approval of this off-site CMI, weather permitting, BAT shall commence the activities for construction of the off-site remedial system.

GOLDER ASSOCIATES INC.

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Principal

ALG/RCFK:cr

REFERENCES

1. Golder Associates Inc., September 1989, "Phase V, Monitoring Well Installation Specifications, Bell Aerospace Textron."
2. Golder Associates Inc., June 1991a Volumes I and II, "Final Report, RCRA Facility Investigation, Neutralization Pond, Bell Aerospace Textron, Wheatfield Plant."
3. Golder Associates Inc., June 1991b, "Final Report, Corrective Measures Study, Bell Aerospace Textron, Wheatfield Plant."
4. Golder Associates Inc., August 1991c, "Final Report on the Walmore Road Storm Drainage Improvement Project at Bell Aerospace Textron."
5. Golder Associates Inc., February 1992, "Final Report on Ground Water Monitoring Plan, Bell Aerospace Textron, Wheatfield Plant, Niagara Falls, New York."
6. SW-846, 3rd Edition (1986) and Update I (1989), "Test Methods for Evaluating Solid Waste."

TABLE 1
PERFORMANCE MONITORING
(OFF-SITE EXTRACTION SYSTEM)
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

FREQUENCY OF GROUND WATER LEVEL MEASUREMENTS

MONITORING WELL IDENTIFICATION		WELL TYPE		STARTUP			COMMENTS
			0 - <3 MONTHS	3 MONTHS - <1 YEAR	+1 YEAR		
87-19(1)		INT	Biweekly	Quarterly	Quarterly/Annually		
87-20(1)		INT	Biweekly	Quarterly	Annually	(t)	
87-21(1)		INT	Biweekly	Quarterly	Annually	(t)	
89-04(1)		INT	Biweekly	Quarterly	Quarterly/Annually		
89-05(1A)		INT	Biweekly	Quarterly	Quarterly/Annually		
89-05(1B)		INT	Biweekly	Quarterly	Quarterly/Annually		
92-01(1)	*	INT	Biweekly	Quarterly	Annually	(t)	
92-02(1)	*	INT	Hourly	Daily	Annually	(t)	Automated datalogger drawdown
92-03(1)	*	INT	Biweekly	Quarterly	Quarterly/Annually		
89-03(1)		PMW	Biweekly	Quarterly	Annually	(t)	
89-06(1)		PMW	Biweekly	Quarterly	Annually	(t)	
89-07(1A)		PMW	Biweekly	Quarterly	Annually	(t)	
89-07(1B)		PMW	Biweekly	Quarterly	Annually	(t)	
89-08(1)		PMW	Biweekly	Quarterly	Annually	(t)	
89-16(1)		PMW	Biweekly	Quarterly	Annually	(t)	
89-17(1)		PMW	Biweekly	Quarterly	Annually	(t)	Automated datalogger drawdown
89-18(1)		PMW	Biweekly	Quarterly	Annually	(t)	

NOTES:

* = Proposed monitoring well
(t) = Minimum frequency of elevation measurement, taken when well is sampled.

F/N: TABLE1.WK1

TABLE 2
PERFORMANCE MONITORING PROGRAM
(OFF-SITE EXTRACTION SYSTEM)
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

ANALYTES OF CONCERN - VOLATILE ORGANIC COMPOUNDS

PARAMETER	UNITS	CAS NUMBER	GROUND WATER PROTECTION STANDARD	MCLs	METHODOLOGY			
					8260 PUBLISHED MDL **	8260 RL-RMAL	8240 PQL	601/602 PUBLISHED MDL
VOLATILE ORGANIC COMPOUNDS								
Methylene Chloride	ug/l	75-09-2	5.0	---	0.03	1.0	5	0.25
Trichloroethylene (TCE)	ug/l	79-01-6	5.0	5.0	0.19	1.0	5	0.12
1,1,1-Trichloroethane	ug/l	71-55-6	5.0	200.0	0.08	1.0	5	0.03
Acetone	ug/l	67-64-1	5.0	---	--- *	2.0	100	---
1,2-Dichloroethylene (total) (DCE)	ug/l	540-59-0	5.0	---	---	1.0	---	---
cis-1,2-Dichloroethylene	ug/l	156-59-4	---	70	0.12	---	---	---
trans-1,2-Dichloroethylene	ug/l	156-60-5	---	100	0.06	---	5	0.10
Vinyl Chloride	ug/l	75-01-4	2.0	2.0	0.17	2.0	10	0.18
Carbon Disulfide	ug/l	75-15-0	50	---	--- *	1.0	5	---
1,1-Dichloroethylene (DCE)	ug/l	75-35-4	5.0	7.0	0.12	1.0	5	0.13
1,1-Dichloroethane	ug/l	75-34-3	5.0	---	0.04	1.0	5	0.07
Xylene (total)	ug/l	1330-20-7	5.0	10000	---	1.0	5	---
1,2-Xylene	ug/l	95-47-6	---	---	0.11	---	---	--- *
1,3-Xylene	ug/l	108-38-3	---	---	0.05	---	---	--- *
1,4-Xylene	ug/l	106-42-3	---	---	0.13	---	---	--- *
Chloroform	ug/l	67-66-3	50	100 ***	0.03	1.0	5	0.05
Toluene	ug/l	108-88-3	5.0	1000	0.11	1.0	5	0.2
Benzene	ug/l	71-43-2	ND	5.0	0.04	1.0	5	0.2
Ethylbenzene	ug/l	100-41-4	5.0	700	0.06	1.0	5	0.2
Trichlorofluoromethane	ug/l	75-69-4	5.0	---	0.08	1.0 *	--- *	IND
Chloromethane	ug/l	74-87-3	5.0	---	0.13	2.0	10	0.08
Tetrachloroethylene	ug/l	127-18-4	5.0	5	0.14	1.0	5	0.03
2-Hexanone	ug/l	591-78-6	50	---	--- *	2.0	50	---

NOTES:

*	Additional compound to published list.
**	Method 8260 PQL is 1 ug/l for compounds listed in method; may not be achievable by all laboratories.
***	Total Trihalomethan MCL = 100 ug/l.
---	Not available.
IND	MDL not determined.
MCL	Maximum Contaminant Level - Drinking water standards currently in effect and/or finalized 01/30/91 (FR 3526).
MDL	Method Detection Limit as published in method; may not be achievable by all laboratories.
ND	Not detected using the approved methodology.
PQL	Practical Quantitation Limit
RL	Reporting Limit, specific to Enseco RMAL Laboratory
601/	602 are GC methods for volatile organics published in EPA document "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," July 1982, amended June 1986.
8240	and 8260 are GC/MS methods for volatile organics published in EPA document "Test Methods for Evaluating Solid Waste," (SW-846) 3rd Edition (1986), Update 1 (1989).

F/N: TABLE2.WK1

TABLE 3
PERFORMANCE MONITORING PROGRAM
(OFF-SITE EXTRACTION SYSTEM)
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

ANALYTES OF CONCERN – SEMI-VOLATILE ORGANIC COMPOUNDS

PARAMETER	UNITS	CAS NUMBER	GROUND WATER PROTECTION STANDARD	METHODOLOGY		
				MCLs	625 PUBLISHED MDL	8270 PQL
SEMIVOLATILE ORGANICS						
Acid Extractable:						
2,3,4,6-Tetrachlorophenol	ug/l	58-90-2	50	—	— *	— *
2,4-Dimethylphenol	ug/l	105-67-9	50	—	2.7	10
2-Chlorophenol	ug/l	95-57-8	5.0	—	3.3	10
Phenol	ug/l	108-95-2	50	—	1.5	10
Base Neutral Extractable:						
1,2,4,5-Tetrachlorobenzene	ug/l	95-94-3	5.0	—	— *	— *
Naphthalene	ug/l	91-20-3	50	—	1.6	10
Di-n-octyl phthalate	ug/l	117-84-0	50	—	2.5	10
o-Dichlorobenzene	ug/l	95-50-1	4.7	600	1.9	10
p-Dichlorobenzene	ug/l	106-46-7	4.7	75	4.4	10
Anthracene	ug/l	120-12-7	50	—	1.9	10
Benzo (a) anthracene	ug/l	56-55-3	ND	—	7.8	10
Benzo (b) fluoroanthene	ug/l	205-99-2	20	—	4.8	10
Benzo (a) pyrene	ug/l	50-32-8	ND	—	2.5	10
bis (2-Ethyl hexyl) phthalate	ug/l	117-81-7	50	—	2.5	10
Chrysene	ug/l	218-01-9	0.2	—	2.5	10
Acenaphthene	ug/l	83-32-9	50	—	1.9	10
Acenaphthylene	ug/l	208-96-8	50	—	3.5	10
Benzo (ghi) perylene	ug/l	191-24-2	50	—	4.1	10
Fluorene	ug/l	86-73-7	50	—	1.9	10
Phenanthrene	ug/l	85-01-8	50	—	5.4	10
Pyrene	ug/l	129-00-0	50	—	1.9	10
Di-n-butyl phthalate	ug/l	84-74-2	50	—	2.5	10
Fluoranthene	ug/l	206-44-0	50	—	2.2	10
4-Nitroquinoline-1-oxide	ug/l	56-57-5	5.0	—	—	—
Methapyriline	ug/l	91-80-5	50	—	—	—
Indeno (1,2,3-cd) pyrene	ug/l	193-39-5	0.4	—	3.7	10
1,2,4-Trichlorobenzene	ug/l	120-82-1	5.0	—	1.9	10
2-Methylnaphthalene	ug/l	91-57-6	50	—	—	10

NOTES:

*	Additional compound to published list.
—	Not available.
MCL	Maximum Contaminant Level – Drinking water standards currently in effect and/or finalized 01/30/91 (FR 3526).
MDL	Method Detection Limit as published in method; may not be achievable by all laboratories.
ND	Not detected using the approved methodology.
PQL	Practical Quantitation Limit
625	is a GC/MS method for semivolatile organics published in EPA document "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," July 1982.
8270	is a GC/MS method for semivolatile organics published in EPA document "Test Methods for Evaluating Solid Waste," (SW-846), 3rd Edition (1986), Update 1 (1989).

TABLE 4
PERFORMANCE MONITORING SYSTEM
(OFF-SITE EXTRACTION SYSTEM)
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

ANALYTES OF CONCERN - PESTICIDES, PCBs, AND INORGANIC COMPOUNDS

PARAMETER	UNITS	CAS NUMBER	GROUND WATER PROTECTION STANDARD	MCLs	METHODOLOGY 608 PUBLISHED MDL	METHODOLOGY 8080 PUBLISHED MDL
Pesticides and PCBs						
PCB-1254	ug/l	11097-69-1	100 **	0.5 **	IND	IND
PCB-1260	ug/l	11097-82-5	100 **	0.5 **	IND	IND

PARAMETER	UNITS	CAS NUMBER	GROUND WATER PROTECTION STANDARD	MCLs	METHODOLOGY ICP EST. DL	METHODOLOGY FURNACE AA EST. DL
Inorganics						
Lead	ug/l	7439-92-1	25	50	42	1
Zinc	ug/l	7440-66-6	300	5000 ***	2	---
Barium	ug/l	7440-39-3	1000	1000	2	---
Selenium	ug/l	7782-49-2	10	10/50	75	2
Arsenic	ug/l	7440-38-2	25	50	53	1
Cadmium	ug/l	7440-43-9	5.0	10/5.0	4	---
Chromium	ug/l	7440-47-3	50	50/100	7	---
Nickel	ug/l	7440-02-0	100	---	7	---
Vanadium	ug/l	7440-62-2	250	---	8	---

NOTES:

* Additional compound to published list.
** Total PCB concentration cannot exceed this value.
*** Value is the Secondary Maximum Contaminant Level (SMCL) - Drinking water standards currently in effect.
— Not available.
Cadmium MCL currently in effect is 10 ug/l. When the MCLs finalized 01/30/91 (FR 3526) become effective on 07/30/92, the Cadmium MCL will be 5.0 ug/l.
Chromium MCL currently in effect is 50 ug/l. When the MCLs finalized 01/30/91 (FR 3526) become effective on 07/30/92, the Chromium MCL will be 100 ug/l.
Furnace AA Estimated Detection Limits (DL) are published in the methodologies as guidance.
ICP Estimated Detection Limits (DL) are published in the methodologies as guidance.
IND MDL not determined
MCL Maximum Contaminant Level - Drinking water standards currently in effect and/or finalized 01/30/91 (FR 3526).
MDL Method Detection Limit as published in method; may not be achievable by all laboratories.
Selenium MCL currently in effect is 10 ug/l. When the MCLs finalized 01/30/91 (FR 3526) become effective on 07/30/92, the Selenium MCL will be 50 ug/l.
The Lead value pertains to EPA method 239.2 and SW-846 method 7421; the Selenium value pertains to EPA method 270.2 and SW-846 method 7740;
the Arsenic value pertains to EPA method 206.2 and SW-846 method 7060.
Values pertain to EPA method 200.7 and SW-846 method 6010 for analysis of metals by Inductively Coupled Plasma.

F/N: TABLE4.WK1

TABLE 5
PERFORMANCE MONITORING WELLS
(OFF-SITE EXTRACTION SYSTEM)
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

EFFECTIVENESS MONITORING

MONITORING WELL IDENTIFICATION	WELL TYPE	FREQUENCY Q (4x)	FREQUENCY QM (VARIES)	FREQUENCY A (1x)	METHODOLOGY Q	METHODOLOGY QM	METHODOLOGY A
92-01(1)	INT		X			8240/8260//CLP	
92-02(1)	INT		X			8240/8260//CLP	
92-03(1)	INT	X			8240/8260//CLP		
87-19(1)	INT	X			8240/8260//CLP		
87-20(1)	INT		X			8240/8260//CLP	
87-21(1)	INT		X			8240/8260//CLP	
89-04(1)	INT	X			8240/8260//CLP		8260//CLP
89-05(1A)	INT	X			8240/8260//CLP		8260//CLP
89-05(1B)	INT	X			8240/8260//CLP		8260//CLP
89-03(1)	PMW			X			8260//CLP
89-06(1)	PMW			X			8260//CLP
89-07(1A)	PMW			X			8260//CLP
89-07(1B)	PMW			X			8260//CLP
89-08(1)	PMW			X			8260//CLP
89-16(1)	PMW			X			8260//CLP
89-17(1)	PMW			X			8260//CLP
89-18(1)	PMW			X			8260//CLP

EXTRACTION WELLS	WELL TYPE	FREQUENCY Q (3x)	FREQUENCY A (1x)	METHODOLOGY Q	METHODOLOGY A
EW-1	SUPP **	X	X	601/602/8240	8240/8260
EW-2	SUPP **	X	X	601/602/8240	8240/8260
EW-3	SUPP **	X	X	601/602/8240	8240/8260
EW-4	SUPP **	X	X	601/602/8240	8240/8260
EW-5	SUPP **	X	X	601/602/8240	8240/8260
EW-6	SUPP **	X	X	601/602/8240	8240/8260

NOTES:

*	Proposed Monitoring Well
**	Will also be used to assess discharge to sewer.
INT	Internal Well
PMW	Perimeter Monitoring Well
SUPP	Supplemental Well

PROGRAMS:

A	Annual Program.
M	Monthly program.
Q	Quarterly program.
QM	Modified Quarterly Program – quarterly (4 times a year) for approximately two years/annually after two years.
W	Weekly program.

METHODOLOGY:

CLP	Contract Laboratory Program.
601 – 602	EPA Wastewater Methods.
8240 – SW846	(3rd ed.) Wastewater Methods.
8260 – SW846	(3rd ed.) Low Level Concentration Method.

F/N: TABLE5.WK1

TABLE 6
PERFORMANCE MONITORING WELLS
(OFF-SITE EXTRACTION SYSTEM)
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

PROPOSED TERMINATION MONITORING

TERMINATION WELL IDENTIFICATION	PREDICTED WELL IDENTIFICATION	WELL TYPE	FREQUENCY TOTAL OF EIGHT QUARTERS		METHODOLOGY	
			Q (3 TIMES/YEAR)	A (1 TIME/YEAR)	Q	A
EW-6	91-03(1)	INT	X	X	8260	8260, 8270, 8080, Ing
EW-5	EW-6	INT	X	X	8260	8260, 8270, 8080, Ing
EW-4	89-05(1A)	INT		X		8260, 8270, 8080, Ing
	89-05(1B)	INT		X		8260, 8270, 8080, Ing
	EW-5	INT	X	X	8260	8260, 8270, 8080, Ing
EW-3	EW-4	INT	X	X	8260	8260, 8270, 8080, Ing
EW-2	EW-3	INT	X	X	8260	8260, 8270, 8080, Ing
	91-02(1)	INT		X		8260, 8270, 8080, Ing
EW-1	EW-2	INT	X	X	8260	8260, 8270, 8080, Ing
	87-21(1)	INT		X		8260, 8270, 8080, Ing

NOTES:

INT	Interal Well
Predicted	Well Identification will monitor termination criteria for recovery wells using a phased approach.

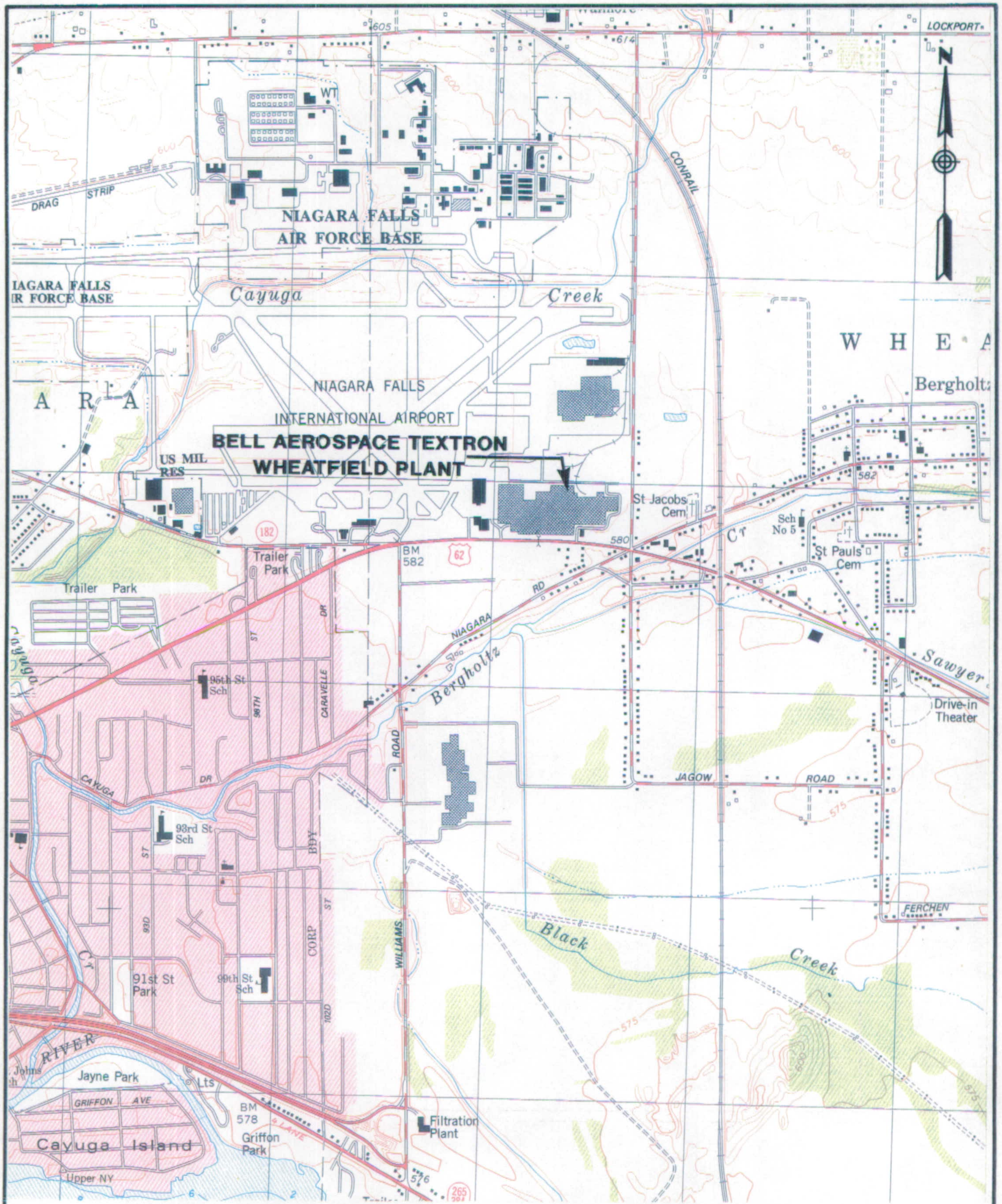
PROGRAMS:

A	Annual Program
Q	Quarterly Program

METHODOLOGY:

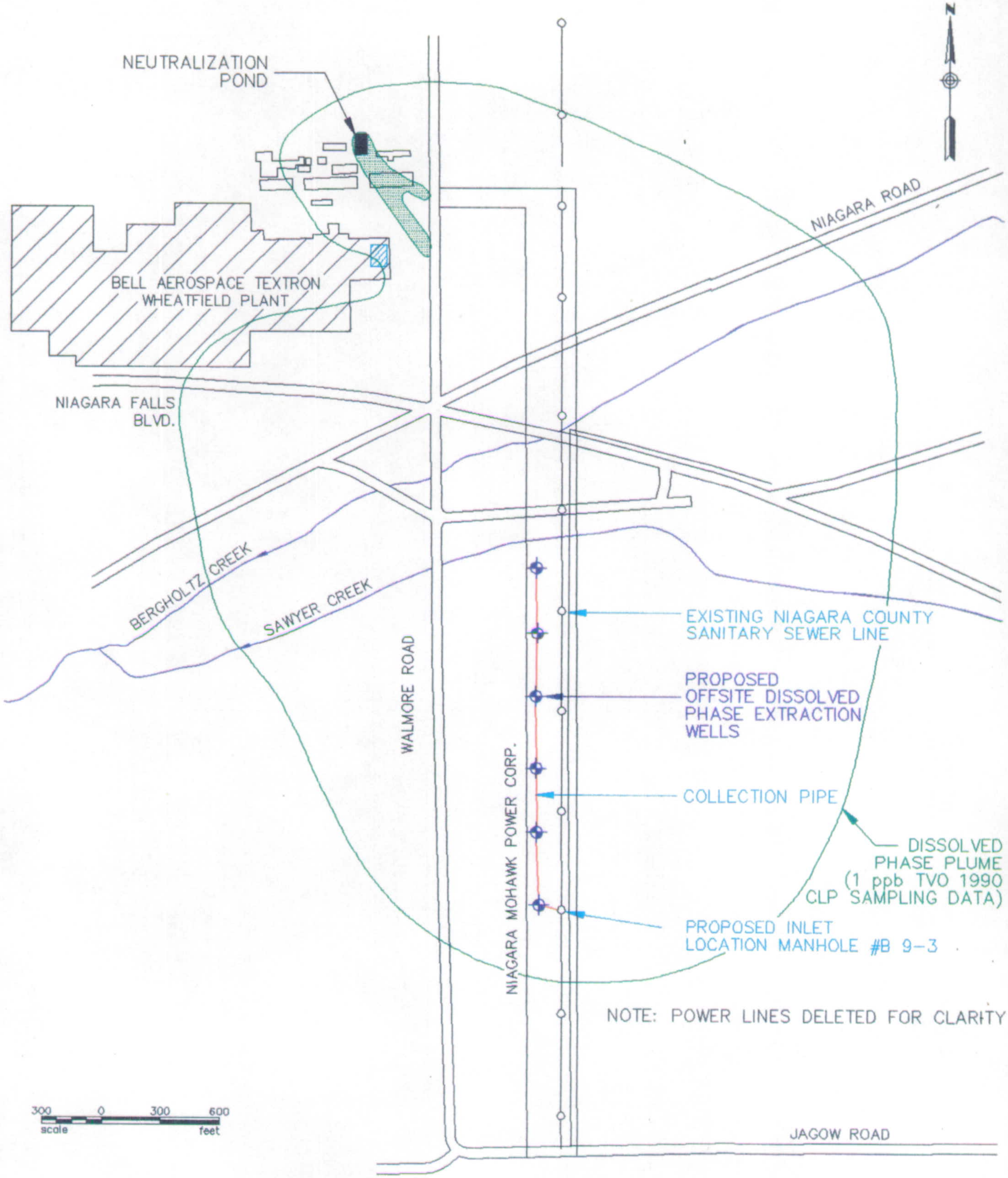
8260 - SW846	(3rd ed.) Low Level Concentration Method.
8270 - SW846	(3rd ed.) Wastewater Methods.
8080 - SW846	(3rd ed.) Wastewater Methods.
Ing	Inorganic parameters - SW846 (3rd ed.)

F/N: TABLE6.WK1



SOURCE: TOWANDA WEST QUADRANGLE, NEW YORK, 7.5' SERIES, DATED 1980

JOB No.:	913-9014	SCALE:	1"=2000'	
DRAWN:	LAS	DATE:	08/14/91	**SITE LOCATION MAP**
CHECKED:	ALS	DWG. No.:	NY01-281	
				BELL AEROSPACE TEXTRON — FIGURE 1



JOB No.: 913-9014

SCALE: AS SHOWN

DRAWN: MJZ

DATE: 08/14/91

CHECKED:

DWG. No.: NY01-275

Golder Associates

OFFSITE CORRECTIVE MEASURES

BELL AREOSPACE TEXTRON

FIGURE 2

APPENDIX A

Standard Operating Procedures

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1.0 STANDARD OPERATING PROCEDURE FOR THE INITIAL DECONTAMINATION OF DEDICATED BAILERS

The following is the decontamination procedure for the bailers that will be used as dedicated sampling equipment at the Bell Aerospace Textron (BAT) facility.

- Wear disposable gloves (e.g. latex) while cleaning bailer to avoid contamination and change gloves as needed;
- Prepare a non-phosphate, laboratory grade detergent solution with distilled water in a bucket;
- Disassemble bailer (if applicable) and scrub each part with the detergent solution using a brush;
- Rinse bailer with potable water;
- Rinse bailer with distilled or deionized water and reassemble bailer;
- Rinse bailer with distilled or deionized water;
- Rinse bailer with methanol (to remove volatile organic compounds);
- Allow to bailer air dry;
- Rinse with distilled or deionized water;
- Wrap bailer in aluminum foil (non-coated side against bailer) and then place bailer in dedicated plastic sheath; and
- Collect all cleaning solutions and rinse water in a container for proper disposal.

Dedicated bailers will be used, therefore, this decontamination procedure should be used only before the initial use of the bailer. Prior to a sampling event, rinse the bailer with distilled or deionized water and collect all rinsate in a container for disposal by BAT. Preferably, the dedicated bailers will be stored in the well casing to avoid bailer contamination.

2.0 STANDARD OPERATING PROCEDURE FOR SAMPLING GROUND WATER MONITORING WELLS

2.1 Materials and Equipment

The following items may be required for monitoring well sampling and data collection:

- Appropriate bailer(s) (i.e. constructed of stainless steel or Teflon® materials);
- Non-absorbent cord (e.g., polypropylene);
- Pre-measured plastic bucket(s);
- Plastic sheeting;
- Water level indicator (i.e. M-scope, electronic water level indicator);
- Tape measure (steel - tenth of a foot measurement increments) and chalk;
- Pen knife;
- Field forms/field notebook;
- Well location map;
- Pump and associated materials such as:
  1. Teflon tape;
  2. Appropriate tubing (e.g. polyethylene) if using peristaltic pump; and
  3. Portable generator if using peristaltic pump.

- Calculator;
- Hard hat (if required on location);
- pH meter;
- Conductivity meter;
- Buffer/calibration solutions;
- Thermometer;
- Paper towels, clean rags;
- Black pen and pencil;
- Wet ice and/or blue packs;
- Sample jars, codes, and labels;
- Electrical tape;
- Pipe wrench;
- Screwdriver, hammer;
- Cooler(s);
- Water jugs;
- Disposable gloves;
- Well keys;
- Masking and packing tape;
- Water-proof marker;
- Well sampling form(s);
- Non-phosphate, laboratory-grade detergent;
- Distilled/deionized water;
- Chain-of-Custody form(s);
- Custody seal(s); and,
- Extra batteries (meters, thermometer).

2.2 Procedure

- Daily sampling activities shall be documented in the field notebook;

- All non-dedicated sampling equipment shall be decontaminated and calibrated before use, with the exception of new precleaned equipment such as rope and disposable gloves.

- Document well identification and presampling information in the field notebook as needed;

- Inspect the protective casing of the well and note any items of concern such as a missing lock or bent casing;

- Place plastic sheeting around the well to protect sampling equipment from potential contamination;

- Remove the well cap or plug and check the ambient air quality in the immediate vicinity of the well head using an air monitoring detector (i.e. organic vapor detector). Should readings exceed 5 ppm in the breathing zone at the well, implement requirements for Level C protection, and follow the health and safety protocols included in the Ground Water Monitoring Plan. Document activity in the field notebook and on air monitoring forms.

- Clean the top of the well off with a clean rag. Place the cap or plug on plastic;

- Measure the depth to water using the water level indicator. Document in field notebook;

- Measure the depth of the well with a steel tape or obtain information from construction diagram. Calculate and record the volume of water in the well in the field notebook;

- Prior to sampling, the well should be pumped or bailed to remove a minimum of three casing volumes if the recharge rate is adequate to accomplish this within a reasonable amount of time. The well should not be pumped or bailed dry. If the well produced little water, at least one well volume must be purged. The well will be sampled after the water level has stabilized;

- Record the temperature, pH, conductivity, and physical appearance of the water in the field notebook (e.g., color, turbidity, odor, etc.) as it is pumped or bailed, a minimum of three times. Generally, the field parameters should be taken after a well volume has been purged;

- Flush the dedicated bailer several times with distilled/deionized water, and collect and discard (in an appropriate manner) three bails of well water before collecting the sample;

- Using a non-absorbent cord (e.g., polypropylene), lower the bailer into the well and collect the sample;

- Quality Control/Quality Assurance samples to be collected during the sampling program include field duplicates and field blanks. Trip blanks (provided by the analytical laboratory) shall be included in each shuttle sent to the analytical laboratory during the sampling program. The following procedures shall be employed to obtain field duplicates and field blanks:

  a. When collecting field duplicate samples for volatile organic compound (VOC) analysis, the water from the bailer will be distributed first to fill one VOC container and then followed by the filling of the second duplicate VOC container. A sufficient quantity of water should be collected in the bailer such that both VOC containers can be filled completely from the same bail of water; and,

  b. Field blanks shall be obtained by pouring organic free water into the appropriate sampling containers.

  Dedicated bailers will be used for sampling, therefore, equipment blanks will not be required. However, in the event that dedicated equipment is not used, equipment blanks will be collected as described in the Ground Water Monitoring Plan.

- Place samples in the prelabeled containers and store on ice (wet ice or blue packs);

- After sample collection is complete, collect a sufficient quantity of water in a beaker to allow for the measurement of field parameters. Measure and record the temperature, conductivity, pH, and physical appearance of the water, and record in the field notebook;

- Wipe the well cap with a clean rag, replace the cap and protective cover (if present). Lock the protective cap;

- Verify that each sample is placed in an individual "zip-lock" bag, wrapped with "bubble wrap," and placed in its appropriate container (holder) in the shuttle, and that the shuttle has sufficient ice (wet ice or blue packs) to preserve the samples for transportation to the laboratory;

- Complete the Chain-of-Custody forms. One copy of the Chain-of-Custody form is retained. Secure the shuttle with sufficient packing tape and a Custody Seal. Forward the samples via overnight (express) mail or hand deliver to the designated laboratory preferably within 24 hours but no later than 48 hours after sampling. Notify the laboratory that samples have been shipped, and make special arrangements if Saturday delivery is necessary; and

- Wrap dedicated sampling equipment (bailers and hoses) with a suitable material (e.g., aluminum foil or plastic bags). Discard the cord, rags, gloves, etc. in a manner consistent with the Health and Safety Plan.

3.0 STANDARD OPERATING PROCEDURE FOR MEASURING WATER TEMPERATURE

3.1 Calibration

- Calibration of thermometers will be performed before entering the field and checked upon return to the office;

- Thermometers will be calibrated against a National Bureau of Standards (NBS) - traceable thermometer;

- The thermometer must read within 1-degree to 1.5-degrees centigrade of the NBS - traceable thermometer. If the thermometer does not read within this range and the thermometer cannot be calibrated, then it will not be used for temperature measurements and will be disposed of in an appropriate manner. If the thermometer does not read within this range and the thermometer can be calibrated, then the thermometer will be calibrated to the NBS - traceable thermometer; and

- The following information is documented in the calibration logbook at the time of calibration:

  a. Date
  b. Thermometer Identification
  c. Initials
  d. Calibration Data.

3.2 Procedure

- The thermometer is immersed in water until the temperature equilibrates. The temperature is read in Celsius; and

- Temperature data are recorded in the field notebook, initialed (of the sampler) and dated.

4.0 STANDARD OPERATING PROCEDURE FOR MEASURING THE pH OF WATER SAMPLES

4.1 Calibration

- Calibration of the pH meter is to be performed prior to its use each day at the end of the day, and at least every four hours;

- Recalibration must occur if:

  a. The pH of the samples being measured is outside the previous calibration range; or

  b. The battery is replaced.

- Two buffer calibrations bracketing the expected pH range of samples are to be performed prior to the meters use each day. Three pH buffers (4.0, 7.0, and 10.0) are read after standardization at pH of 7.0 to evaluate the linearity and electrodes. The samples and buffers are to be measured at the same temperature; and

- The following information is documented in the calibration logbook at the time of calibration:

  a. Date;
  b. pH meter identification;
  c. Initials (of the sampler); and
  d. Calibration results using pH standards.

4.2 Procedure

- The pH electrode must be kept moist;

- The electrodes must be carefully rinsed with deionized water before each measurement;

- Follow manufacturer's operating instructions;

- The pH readings are documented in the field notebook, initialed (of the sampler) and dated;

- The electrodes are rinsed with deionized/distilled water and the unit stored properly. The electrodes are not to be stored in tap water or deionized/distilled water.

5.0 STANDARD OPERATING PROCEDURE FOR MEASURING THE CONDUCTIVITY OF WATER SAMPLES

5.1 Calibration

- Calibration is in accordance with the manufacturer's specific directions, and the following information is documented in the calibration logbook:

  a. Date;
  b. Conductivity meter identification;
  c. Calibration results; and
  d. Initials (of the sampler).

- Calibration is performed at the beginning and end of the day, and at least every four hours.

5.2 Procedure

- The probe is immersed in a water sample until the meter equilibrates;

- In reading the conductivity meter scale, one or more of the following may have to be considered:

  a. The reading may have to be multiplied appropriately (e.g., the reading is expressed in x1, x10, x100 scales);

  b. If the conductivity meter is not capable of compensating for temperature differences, then note that the conductance measurements are not temperature compensated and document the temperatures of the standards and samples; and

  c. If the conductivity meter can be compensated for temperature, then adjust the temperature control before reading the conductance measurement.

- Conductivity measurements and any other relevant information are recorded in the field notebook, initialed (of the sampler) and dated.

6.0 STANDARD OPERATING PROCEDURE FOR MEASURING WATER LEVELS USING AN ELECTRONIC WATER LEVEL METER

6.1 Procedure

- The probe of the water level meter must be precleaned (decontaminated) using a non-phosphate, laboratory-grade solution and distilled/deionized water before use. The wire should be rinsed with distilled water;

- The manufacturer's model should be noted because some have switches, lights, beepers, or a combination of the above. If a test switch is available, test the light or beeper prior to use;

- The water-level measurement is taken by lowering the probe into the well until the instrument-specific detection method (e.g., light, beeper, or both) is activated by contacting the water. Avoid lowering the probe below the water surface;

- Measurements will be taken accurately and to the nearest 0.01 foot to the top of the inner casing; and

- The depth to water from the measuring point (top of the inner casing), the elevation of the outer protective casing and inner well casing, will be documented in the field notebook and initialed and dated.

F/N: APPENDIX.A

APPENDIX B

Laboratory Quality Assurance Project Plan

QUALITY ASSURANCE PROJECT PLAN
TASK 4

PHASE V

BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

March 1992

913-9014

Golder Associates

NOTE

This plan is a reproduced version of the original plan, dated January 1990, which was submitted to and accepted by the New York State Department of Environmental Conservation and the United States Environmental Protection Agency.

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1.0 PROJECT DESCRIPTION

1.1 Introduction

This Quality Assurance Project Plan (QAPP) has been prepared in support of the additional field investigations to be completed at the Bell Aerospace Textron (BAT) Wheatfield Plant in Niagara, New York. This document outlines and describes the policy, organization, functional activities, and specific quality assurance/quality control (QA/QC) elements necessary to achieve the data quality objectives (DQOs) that will support decisions regarding corrective measure activities.

This plan was prepared in accordance with the following EPA documents:

- Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans (EPA-600/4-83-004) February 1983;
- DQOs for Remedial Response Activities - Development Process (OSWER Directive 9355.0-7B) March 1987;
- Superfund Remedial Design and Remedial Action Guidance (OSWER Directive 9355.0-4A) June 1986;
- Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (OSWER Directive 9355.3-01 Interim Final) October 1988;
- User's Guide to the Contract Laboratory Program (USEPA) December 1986; and
- NYS Department of Environmental Conservation Division of Hazardous Substances Regulation (Guidelines) Revised August 1989.

1.2 Site History, Location, Description, and Previous Investigations

Golder Associates Inc. (Golder Associates) was retained by BAT to complete a series of hydrogeology studies at the Wheatfield Plant, Niagara Falls, New York. These studies have been conducted in four phases and have provided information regarding the extent and nature of groundwater containing chlorinated organic solvents plus relatively limited information regarding the presence of PAH and polychlorinated biphenyls (PCBs) compounds.

The Phase I and II investigations were carried out between November 1986 and February 1987 and defined the extent of volatile organic compounds (VOCs) within the overburden, on the basis of Organic Vapor Analysis (OVA) data, and defined the bedrock hydrostratigraphic conditions beneath the site. The final Phase I and II report, discussing this work, was submitted in May 1987.

The Phase II bedrock plume definition study was completed between August 1987 and May 1988 and was based on the results of the Phase I and II work. The Phase III study involved the installation of 37 monitoring wells, both on and off the BAT property, to extend the information regarding groundwater containing VOCs in the overburden, Zone 1 bedrock and Zone 3 bedrock. An interim status report for the Phase III studies was submitted in July 1988 and a revised Phase III report was submitted in October, 1989.

The Phase IV site investigation studies were completed between March 14, 1989 and June 13, 1989 and determined the southern extent of the Zone 1 dissolved phase plume, identified the presence of a Zone 1 bedrock dissolved phase plume off the property, and resulted in the development of the Phase IV investigation program. A status report submitted in August 1989 provided the information obtained from the work and the interpretation of this data. This report also outlined the additional work required to finalize the definition of the extent of the Zone 1 dissolved phase plume and the DNAPL plume and the Zone 3 dissolved phase plume.

In summary, the present understanding of the hydrogeological conditions indicate that the groundwater containing chlorinated solvents originated from the Neutralization Pond adjacent to the Rocket Test Facility. Although one continuous plume, the groundwater plume, extending downgradient from the Neutralization Pond, may be considered as four plumes for convenience.

- A limited area of overburden containing organic solvents around the Neutralization Pond;

- A Dense Non Aqueous Phase Liquid (DNAPL) plume in the Zone 1 aquifer (upper most strata of the bedrock) stretching about 800 feet to 1,000 feet to the southeast of the Neutralization Pond;
- A dissolved phase plume in the Zone 1 bedrock stretching about 5,000 feet to the southeast of the pond, roughly pear shaped, about 3,000 feet to 4,000 feet wide; and
- A dissolved phase plume of limited extent in the Zone 3 bedrock stratum, beneath the DNAPL plume.

The location of the Wheatfield Plant, the Zone 1 DNAPL and the Zone 1 dissolved phase plume are shown in the Field Sampling Plan.

2.0 PROJECT MANAGEMENT

2.1 Project Team

Golder Associates has been retained by BAT to perform the RCRA Facility Investigation (RFI) for the Neutralization Pond studies at the Wheatfield Plant, in Niagara Falls, New York. In order to provide the most appropriate corrective measure project team, Golder Associates is subcontracting portions of the work to qualified specialty firms. Golder Associates is the primary consultant and is responsible for the technical competency, schedule, quality, cost, and completeness of the investigation and the related reports. Further, Golder Associates will provide the results of this Corrective Measures Investigation (CMI) and will be responsible for ensuring that the investigations meet the objectives of this Sampling and Analysis Plan (SAP). The contact addresses of each team member are give in Table B-1. A summary of the project team and their responsibilities is as follows:

2.1.1 Golder Associates Inc. (Golder Associates)

Golder Associates is a specialist firm of geotechnical and environmental engineers and scientists providing services related to geotechnical engineering and solid/hazardous waste management. Corrective measures design of the Wheatfield Plant will be managed and performed out of the Golder Associates' office in Buffalo, New York.

Golder Associates will manage the Pre-Design project team and:

- Provide a single point of accountability for results;
- Provide day to day direction, communications, and coordination within the project team;
- Communicate project status on a regular and frequent basis to BAT, and communicate with the United States Environmental Protection Agency/New York State Department of Environmental Conservation (USEPA/NYSDEC) as appropriate;
- Review and approve project documents, and in particular, ensure that the work products of the team members are coordinated;

- Implement the SAP, assure compliance with the SAP objectives, schedule, and technical content, for work by Golder Associates and other members of the project team;

- Monitor overall progress and take necessary actions to comply with the Consent Decree and intermediate schedules as they apply to the SAP;

- Monitor overall costs, and financial aspects of the SAP; and

- Review, assess, and approve Contract Laboratory Program (CLP) data packages.

2.1.2 Frontier Technical

Frontier Technical is a technical firm specializing in sampling procedures. For this project, Frontier Technical's prime responsibility will be to sample the designated wells and take the necessary QA/QC samples in the manner as outlined in the Field Sampling Plan. Equipment calibration, groundwater sampling, and decontamination procedures will be adhered to via the Standard Operating Procedures (SOPs). Any deviation by Frontier Technical from the outline procedures will be verified, prior to implementation, with the project director or project manager at Golder Associates.

2.1.3 Enseco Incorporated

Enseco, Inc. is a network of environmental laboratories equipped to handle a variety of projects nationwide. The Enseco Rocky Mountain Analytical Laboratory (RMAL) holds a contract for analysis of water and soil samples for organics, inorganics, and dioxins under the Federal USEPA CLP. Further, the RMAL facility is certified to perform analysis of environmental samples according to the NYSDEC. This laboratory will be performing the analytical work for this study. RMAL is required to adhere to all requirements as outlined in this QAPP, as well as the USEPA Statement of Work for CLP, organic analysis. Any deviation from the above shall not be acceptable unless clarified with the project director at Golder Associates prior to modification.

3.0 QUALITY ASSURANCE (QA) OBJECTIVES

3.1 Introduction

The overall objectives of the Quality Assurance (QA) Program are to ensure that the samples and the analytical results which describe these samples are precise, accurate, representative, comparable, and complete (PARCC parameters). To this end, a series of specific objectives is set forth for each step of collecting, handling, preparing, analyzing, and documenting the samples collected for this project. The basis of the QA program is the establishment of methods to be followed while collecting a sample and producing a valid analytical result for this sample.

The QA program encompasses field operations (i.e., field measurements, sampling, sample handling) and laboratory operations (i.e., sample custody, sample analysis). The field QA program will include the use of well-trained field sampling personnel, standardization of field methods for sampling and measurements, and collection of QA samples. The laboratory QA program will include the use of specific parameters for analysis; standardization of analytical methods and instrumentation; and standard laboratory operating procedures and techniques.

QA samples, spikes, and standards calibration will be used to monitor analytical data quality in the field and chemical laboratory. Recommended changes in methods will be reported with reasons and QA results suitable to support the change. This will include, when appropriate, verification or validation of data.

3.2 Accuracy

Accuracy is defined as the degree of agreement of a measurement or average of measurements with an accepted reference or true value, for the execution of a method in a particular laboratory. Accuracy for chemical laboratory testing will be assessed by means of reference samples and percent recoveries of spiked samples. In general, the accuracy goals for this project are to use reference materials of known purity for calibrations and spiking so that:

- Errors due to instrument response can be determined;

- incomplete preparation recoveries can be determined; and
- the primary uncertainties in the analytical data are due to random errors not exceeding those appearing on the reference in Table B-2 and Table B-3.

The accuracy of analysis will be monitored by the percent recovery of known constituent additions on a minimum of 5-percent of the analyzed samples.

Accuracy limits will be determined for both absolute and relative recovery. Recovery is the degree of agreement of a measurement or average of measurements of a field sample to which a known amount of analyte has been added (i.e., this will be added at the level specified in the method) compared to the sum of the measurement of the analyte in the field sample before addition and the amount of analyte added. Absolute recovery is based upon the addition of spikes to blanks and relative recovery is based upon the addition of spikes to samples. Generally, absolute recoveries are most indicative of method/control verification. Relative recovery, on the other hand, is indicative of analytical/analyst control and/or matrix effects.

3.3 Precision

Precision is defined as a measure of mutual agreement among individual measurements of the sample property. Precision will be assessed by means of field duplicate and laboratory replicate samples. A final QA objective is that the precision of the analysis be within the limits specified in the references in Table B-2 and Table B-3.

The precision (reproducibility) of the analytical results from the chemical laboratory will be based upon laboratory replicate analysis of a minimum of 5-percent of the samples analyzed by the laboratory. In addition, the program will include a minimum of 5-percent field duplicates. Replicate samples provide an estimate of laboratory variability and field duplicates provide an estimate of total system (field plus laboratory) variability. Precision will be expressed as percent relative standard deviation (percent-RSD). Relative standard deviation is defined as the standard deviation divided by the average value times 100-percent.

3.4 Completeness

Completeness expresses the measure of confidence with which the data resulting from a data collection activity meets the specific objectives of the activity. It is the measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct normal conditions. Completeness will be evaluated to determine that the total amount of valid data obtained is sufficient to satisfy the DQOs for each activity.

3.5 Representativeness

Representativeness expresses the extent to which data define an environmental condition. Representativeness will be evaluated to determine that in situ measurements are made and/or physical samples are collected at such locations and in such a manner to result in data reflecting the media measured and/or sampled. Representativeness is best addressed by making certain that sampling locations are properly selected and sufficient number of samples are collected. These decisions require that the Field Sampling Plan be based on sound technical judgement and experience.

3.6 Comparability

Comparability expresses the measure of the confidence with which data are equivalent. Comparability will be evaluated so that data sets can be considered equivalent in regard to the measurement of a specific parameter and/or groups of parameters. The ability to compare data sets is particularly critical when a set of data for a specific parameter is compared to historical data for determining trends. Comparability will be a very important element in data interpretation for this project due to the extensive chemical database for the various sample points.

3.7 Method Detection Limit (MDL)

Method Detection Limit (MDL) is the quantitative expression of the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the true value, corresponding to a single measurement, is above zero. The method detection limit is normally expressed as a concentration of a substance in standard units of measure.

MDLs are generally method specific. However, method detection can be affected by the sample matrix, dilutions, and other interferences.

3.8 Standard Reference Material (SRM)

In addition to precision and accuracy determinations, other control measures will be employed to ensure interlaboratory quality control. One of these will be the use of standard reference materials (SRMs). All reference material used as calibration standards or surrogate compounds will be of known purity (>98-percent), commercially available, and will be certified by the supplier.

SRMs will be extracted and analyzed periodically. The results of these analyses will be reviewed by the laboratories relative to established control limits with each matrix.

3.9 Field QA Samples

Field activity protocols are addressed in the Field Sampling Plan. In general, collection of field duplicates, field blanks, equipment blanks, and trip blanks will be based on a minimum of 5-percent of the total number of samples taken per matrix. In this case, the only matrix will be groundwater.

3.9.1 Field Duplicates

Field duplicates will be used to assess consistency of sampling, sample homogeneity and laboratory analysis. Field duplicate samples are two separate samples taken from the same sampling point in the field. They are submitted to the laboratory in separate containers and analyzed independently. A field duplicate sample be collected for each sampling trip or for every 20 samples, whichever is greater.

3.9.2 Blank Samples

Field blanks, equipment blanks and trip blanks will be used to assess sample container cleanliness, decontamination effectiveness, and the potential for sample contamination. Field blanks will be water which is as free of the analyte as possible and is transferred from a container to a sample bottle at the sampling site and preserved with the appropriate reagents. Equipment blanks will be water that is as free of the analyte as possible and is transported to the site, opened in the field and poured over or through the sample collection device after the decontamination procedure is complete, collected in a sample container and returned to the laboratory. Trip blanks will be used for volatile organics. Trip blanks will be water which is as free of the analytes as possible and is transported to the sampling site and returned to the laboratory without being opened. This serves as a check on sample contamination originating from sample transport, shipping, and from the site conditions. Field QA samples are also discussed in the Field Sampling Plan.

Additionally, in accordance with the NYSDEC, if field decontamination of sample collection equipment needs to be performed, an equipment blank per day will be done on one piece of equipment per batch of equipment type cleaned. Trip blanks are required so to maintain a 1:20 ratio of blanks to samples. For this project, every shipment cooler will contain a trip blank but only one of 20 will be analyzed for CLP volatile organics.

3.10 Other Control Measures

Minimally, other quality control measures include, but are not necessary limited to the following:

- Daily establishment of calibration curves;
- Periodic analysis of a midrange standard (check standard) to verify maintenance of linearity and consistency of standard curve;
- Reinjection and gas chromatograph interpretation of samples analyzed after any sample which significantly exceeded 50-percent of the analytical range in order to guard against ghosting;

- Verification of the absence of contaminants and/or interference in extraction (or cleaning) solvents when new lots are started;
- Daily performance checks for each instrument; and
- Analysis of method blanks with the following frequency; one blank every 20 samples or one blank on each set of analysis if less than 20 samples in a batch/set.

The following sections of the QAPP (Sections 4.0 - 14.0) are based on the Revised 3.3, May 1989 version of the Enseco Incorporated Quality Assurance Program Plan for Environmental Chemical Monitoring.

4.0 SAMPLING PROCEDURES

The generation of quality data begins with the collection of the sample, and therefore, the integrity of the sample collection process of concern to the laboratory. Samples will be collected in such a way that no foreign material is introduced into the sample and no material of interest escapes from the sample prior to analysis. To ensure sample integrity, the following will be considered:

- Samples will be collected in appropriate containers;
- The sample containers will be properly cleaned to ensure that the sample is not contaminated during the collection process;
- Samples will be preserved appropriately to minimize the loss of materials of interest due to adsorption, chemical or biological degradation, or volatilization;
- Appropriate volumes of samples will be collected to ensure that the required detection limits are met and quality control samples analyzed; and
- Samples will be properly shipped to the laboratory, in the appropriate time frame, to ensure that holding times for the analyses are met.

4.1 Sample Containers and Preservatives

This SAP includes Enseco's Sample Safe program which is designed by the laboratory to ensure sample collection integrity. This program consists of a set of sample containers that are properly cleaned and preserved for use in sample collection. Appropriate containers and preservatives, and minimum sample volumes required for analyzing routine organic, metal, and conventional parameters are listed in Appendix B-1. Specific information pertaining to this project is listed in Table B-4.

4.2 Holding Times

USEPA has established holding time requirements for some analyses. These holding time requirements are listed in Appendix B-1, along with container and preservative requirements. As indicated in Table B-4, holding time requirements differ depending on the regulatory program. Enseco will follow the CLP holding times (see Table B-4). For

CLP, the date of sample receipt initiates the first day of hold time for a given set of samples.

Enseco will initiate preparation and/or analysis of the sample within holding times if sample delivery acceptance occurs within 72 hours of sampling or before ½ of the holding time period has expired, whichever is less.

Due to the potential for high levels of contamination in some of the wells, samples may require dilution for some fractions analyzed. For this project, a sample that requires dilutions must be run within the holding times as outlined in Table B-4. In the event a holding time is exceeded, Enseco has committed to contacting the client, Golder Associates, immediately so to carry out resampling events expeditiously. Costs incurred from resampling in the field due to missed hold times will be assumed by Enseco.

5.0 SAMPLE CUSTODY

Upon receipt by Enseco, samples will proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and its documentation.

All samples will be received by Enseco's Sample Control Group and will be carefully checked for label identification, and completed, accurate, Chain-of-Custody Records. Photographs document the condition of samples and each sample will then be assigned a unique laboratory identification number through a computerized Laboratory Information Management System (LIMS) that stores all identifications and essential information. The LIMS system tracks the sample from storage through the laboratory system until the analytical process is completed and the sample is returned to the custody of the Sample Control Group for disposal. This process is summarized in Figure B-1. Access to all Enseco laboratories is restricted to prevent any unauthorized contact with samples, extracts, or documentation. Lastly, final evidence files will include all originals of laboratory reports and will be maintained under document control in a secure area.

When accounting for sample custody, the following will be considered:

- A sample or an evidence file is under custody if:

  a. It is in your possession;
  b. It is in your view, after being in your possession;
  c. It was in your possession and is now placed in a spare area; or
  d. It is in a designated secure area.

An example of the Enseco Chain-of-Custody Record used to transmit samples from the client to the laboratory is given in Figure B-2. The Chain-of-Custody Record (Interlaboratory Analysis Form) used to transmit samples between laboratories within Enseco is given in Figure B-3.

6.0 CALIBRATION PROCEDURES

6.1 Standard/Reagent Preparation

A critical element in the generation of quality data is the purity and traceability of the standard solutions and reagents used in the analytical operations. Enseco continually monitors the quality of reagents and standard solutions through a series of well-documented procedures.

To ensure the highest purity possible, all primary reference standards and standard solutions used will be obtained from the National Institute of Standards and Technology, the USEPA Repository or other reliable commercial sources. All standards and standard solutions will be logged into a database that identifies the supplier, lot number, purity/concentration, receipt/preparation date, preparer's name, method of preparation, expiration date, and all other pertinent information.

6.1.1 Standard Solutions

Standard solutions will be validated prior to use. Validation procedures can range from a check for chromatographic purity to verification of the concentration of the standard using a standard prepared at a different time or obtained from a different source. Stock and working standards will be checked regularly for signs of deterioration, such as discoloration, formation of precipitates, or change in concentration. Care will be exercised in the proper storage and handling of standard solutions, and all containers will be labeled as to compound, concentration, solvent, expiration date, preparation date, and initials of preparer.

6.1.2 Reagents

Reagents will be examined for purity by subjecting an aliquot or subsample to the analytical method in which it will be used; for example, every lot of methylene chloride (for volatile organics) is analyzed for undesirable contaminants prior to use in the laboratory.

A database is used to store essential information on specific standards or reagents. The system is designed to serve various functions (i.e., the system issues warnings on expiration dates and allows chemists to obtain a list of all working standard solutions prepared from the same stock solution). The program also facilitates the management and auditing of reagents and standards.

6.2 Instrument Calibration and Tuning

Calibration of instrumentation will be required to ensure that the analytical system is operating correctly and functioning at the proper sensitivity to meet established reporting limits. Each instrument will be calibrated with standard solutions appropriate to the type of instrument and the linear range established for the analytical method. The frequency of calibration and the concentration of calibration standards is determined by the manufacturer's guidelines, the analytical method, or the requirements of special contracts. For this project, strict adherence to USEPA CLP Protocols will be followed regarding calibration and tuning of instruments.

6.2.1 Gas Chromatography/Mass Spectrometry (GC/MS)

Each day prior to analysis of samples, the instrument will be tuned with bromofluorobenzene for volatile compounds and decafluorotriphenylphosphine for semivolatile compounds (according to the tuning criteria specified in the USEPA CLP). No samples will be analyzed until the instrument has met tuning criteria.

The instrument will then be calibrated for all target compounds. An initial calibration curve is produced and certain key compounds referred to as System Performance Calibration Compounds and Continuing Calibration Compounds will be evaluated on a daily basis to ensure that the system is within calibration. If the daily standard does not meet the established criteria, the system will be recalibrated.

6.2.2 Chromatography

The field of chromatography involves a variety of instrumentation and detection systems. While calibration standards and acceptance criteria vary depending on the type of system and analytical methodology required for a specific analysis, the general principles of calibration apply uniformly. Each chromatographic system is calibrated prior to performance of analyses. Initial calibration consists of determining the linear range, establishing limits of detection, and establishing retention time windows. The calibration will be checked on a daily basis to insure that the system remains within specifications. If the daily calibration check does not meet established criteria, the system will be recalibrated and samples will be reanalyzed since the last acceptable calibration check.

6.3 Calibration of Field Instruments

Field monitoring equipment will be calibrated according to the manufacturers' procedures. This usually involves the use of calibration/standardization materials. Calibration of field equipment will be performed at the beginning and end of each day and at least every four hours. Field calibration will be documented in the field notebooks. Refer to the Field Sampling Plan portion of this document for further details.

7.0 ANALYTICAL PROCEDURES

Most analyses performed by Enseco will be driven by regulatory concerns. Therefore, methods used at Enseco predominantly originate from regulatory agencies. Generally the methods used will be those specified by the USEPA and other federal agencies, state agencies, and professional organizations, as provided in the following references:

- Current USEPA (CLP) protocols for the analysis of organic and inorganic hazardous substances including chlorinated dioxins and furans;
- "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act," 40 CFR, Part 136;
- "Methods for Chemical Analysis of Water and Wastes," USEPA-600/4-79-020 (revised March, 1983);
- "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," USEPA-600/4-82-057 (July, 1982);
- "Test Methods for Evaluating Solid Waste" (SW-846), 2nd Edition (revised), Update I (1984), Update II (1985), 3rd Edition (1986), Update I (1989), Office of Solid Waste and Emergency Response, USEPA;
- "Standard Methods for the Examination of Water and Wastewater," 16th Edition, American Public Health Association, American Water Works Association, Water Pollution control Federation, Washington, DC (1985);
- "Official Methods of Analysis," 14th Edition, Association of Official Analytical Chemists, Arlington, VA (1984);
- "Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water," USEPA, Environmental Monitoring and Support Laboratory - Cincinnati (September, 1986);
- "Annual Book of ASTM Standards," Volumes 11.01 and 11.02, American Society for Testing and Materials (ASTM), Philadelphia, PA (1987); and
- "Techniques of Water Resources Investigations of the United States Geological Survey (USGS), Book, 5, Laboratory Analysis," USGS, Washington, DC (1979).

7.1 Method Choice

The choice of method will be dependent on the objectives of the study in terms of qualitative certainty, quantitative sensitivity, precision and accuracy, and the type of matrix to be analyzed. Each method used routinely will be documented in the form of an SOP. The SOP contains detailed instructions concerning both the use and the expected performance of the method. Any deviations from published methodology will be documented and explained in the SOP. A description of the contents of laboratory SOPs is given below. See Appendix B-2 for SOP Formatting.

7.1.1 Standard Operating Procedures (SOPs)

Details of analytical and QC protocols will be contained in SOPs. SOPs will be documents that contain detailed information on the requirements for the correct performance of a laboratory procedure. Enseco has four categories of laboratory SOPs:

- SOPs for Performance of an Analytical Method;
- SOPs for Preparation of Standards and Reagents;
- SOPs for Equipment Operation, Calibration, and Maintenance; and
- SOPs for General Laboratory Procedures.

The formats for these SOPs can be located in Appendix B-2.

All SOPs will be approved by the QA Department before being implemented. The distribution of current SOPs and archiving of outdated ones will be controlled through the QA department at Enseco.

7.2 Method Validation

Before any methods will be routinely used to generate analytical data, the method will be validated. Validation criteria consist of:

- Method selection by a senior staff member;

- Documentation of the method in an SOP. This includes a summary of the method, detailed description of the analytical procedure, calculations, reporting formats, safety concerns, and special remarks;

- Testing of the method to verify detection limits and linear range, establish reporting limits, and precision and accuracy criteria; and

- Establishment of data acceptance criteria that will be approved by a senior staff member and the Divisional QA Director.

7.3 CLP Protocol

In regard to this particular project, the current USEPA CLP protocol for Organic Analysis will be followed as outlined in Enseco's Statement of Work Revised September 1988. CLP organic analyses include volatiles, semivolatiles and polychlorinated biphenyls (PCBs).

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

8.1 Data Reduction and Validation

All analytical data generated within Enseco laboratories will be extensively checked for accuracy and completeness. The data validation process consists of data generation, reduction, and three levels of review, as follows (also see Figure B-4).

8.1.1 Level 1 Review

The analyst who generates the analytical data will have the prime responsibility for the correctness and completeness of the data. All data will be generated and reduced following protocols specified in laboratory SOPs. Each analyst will review the quality of his or her work based on an established set of guidelines. The analyst reviews the data package to insure that:

- Sample preparation information will be correct and complete;
- Analysis information will be correct and complete;
- The appropriate SOPs will be followed;
- Analytical results will be correct and complete;
- QC samples will be within established control limits;
- Blanks will be within appropriate QC limits;
- Special sample preparation and analytical requirements will be met; and
- Documentation is complete (i.e., all anomalies in the preparation and analysis will be documented, Out-of-Control forms (if required) will be complete; holding times will be documented, etc.).

The data reduction and validation steps will be documented, signed and dated by the analyst. This initial review step, performed by the analyst, will be designated Level 1 review. The analyst then passes the data package to an independent reviewer, who performs a Level 2 review.

8.1.2 Level 2 Review

Level 2 review will be performed by a supervisor or data review specialist whose function will be to provide an independent review of the data package. This review will also be conducted according to an established set of guidelines and will be structured to ensure that:

- Calibration data will be scientifically sound, appropriate to the method, and completely documented;
- QC samples will be within established guidelines;
- Qualitative identification of sample components will be correct;
- Quantitative results will be correct;
- Documentation will be complete and correct (i.e., anomalies in the preparation and analysis have been documented; Out-of-Control forms (if required) will be complete; holding times will be documented, etc.);
- **The** data will be ready for incorporation into the final report; and
- The data package will be complete and ready for data archive.

Level 2 review is furthered structured so that all calibration data and QC sample results will be reviewed and all of the analytical results from 10-percent of the samples will be checked back to the bench sheet. If no problems are found with the data package, the review will be complete. If any problems are found with the data package, an additional 10-percent of the samples will be checked to the bench sheet. The process continues until no errors are found or until the data package has been reviewed in its entirety.

An important element of Level 2 review will be the documentation of any errors that have been identified and corrected during the review process. The laboratory believes that the data package submitted by the analyst for Level 2 review should be free of errors. Errors that are found will be documented and transmitted to the appropriate supervisor. The cause of the errors will then be addressed with additional training or clarification of procedures to ensure that quality data will be generated at the bench.

Level 2 data review will also be documented and the signature of the reviewer and the date of review recorded. The reviewed data will then be approved for release and a final report will be prepared.

8.1.3 Level 3 Review

Before the report is released to the client, the Program Administrator who is responsible for interfacing directly with Golder Associates, reviews the report to ensure that the data meet the overall objectives of the client, Golder Associates, as understood by the Program Administrator. The review will be labeled Level 3 review.

Each level of this review process will involve evaluation of data quality based on both the results of the QC data and the professional judgement of those conducting the review. This application of technical knowledge and experience to the evaluation of the data will be essential in ensuring that data of high quality will be generated consistently.

8.1.4 Additional Review

In addition to the three levels of review discussed previously, the Divisional QA department will randomly audit 5-percent of all projects reported. The QA audit will include verifying that holding times have been met, calibration checks are adequate, qualitative and quantitative results are correct, documentation is complete, and QC results are complete and accurate. During the review, the QA department will check the data from 20-percent of the samples back to the bench sheet. If no problems are found with the data package, the review will be complete. If any problems are found with the data package, an additional 10-percent of the samples will be checked to the bench sheet. The process continues until no errors are found or until the data package has been reviewed in its entirety.

8.2 Data Reporting - CLP Deliverables Package

For CLP samples, both hard copy and diskette deliverables will be provided to Golder Associates in accordance with Enseco's CLP SOW (9/88).

9.0 INTERNAL QUALITY CONTROL (QC) CHECKS

9.1 Introduction

The laboratory QA/QC program will monitor data quality with internal QC checks. Internal QC checks will be used to answer two questions:

- Are laboratory operations in control, (i.e., operating within acceptable QC guidelines), during data generation?; and
- What effect does the sample matrix have on the data being generated?

The first question is answered by Laboratory Performance QC. Laboratory performance QC will be based on the use of a standard, control matrix to generate precision and accuracy data that will be compiled, on a daily basis, to control limits. This information, in conjunction with method blank data, will be used to assess daily laboratory performance.

The second question is addressed with Matrix-Specific QC. Matrix-Specific QC will be based on the use of an actual environmental sample for precision and accuracy determinations and commonly relies on the analysis of matrix spikes, matrix duplicates, and matrix spike duplicates. This information, supplemented with field blank results, will be used to assess the effect of the matrix and field conditions on analytical data.

Laboratory Performance QC will be provided as a standard part of every routine Enseco analysis. Matrix-specific QC is available as an option to the client and should be specified based on the types of matrices to be analyzed and the DQOs and regulatory requirements of the project. According to USEPA CLP Protocol, Matrix-Specific QC will be implemented for this sampling event. Therefore, specific samples will be designated as matrix spike and matrix spike duplicates.

A complete discussion of the Enseco Internal QC Check program follows.

9.2 Laboratory Performance QC Program

Laboratory Performance QC will be provided as a standard part of every routine analysis. The main elements of Laboratory Performance QC will be:

- The analysis of Laboratory Control Samples (LCS), which include Duplicate Control Samples (DCS), Single Control Samples (SCS), and method blanks; and
- The generation of daily calibration data.

9.2.1 Laboratory Control Samples (LCS)

LCS will be well characterized, laboratory generated samples used to monitor the laboratory's day-to-day performance of routine analytical methods. Certain LCS will be used to monitor the precision and accuracy of the analytical process, independent of matrix effects. Other LCS will be used to identify any background interference or contamination of the analytical system which may lead to the reporting of elevated concentration levels or false positive data.

The results of the LCS will be compared to well defined laboratory acceptance criteria to determine whether the laboratory system is in control. Controlling laboratory operations with LCS (as opposed to matrix spike/matrix spike duplicate samples), offers the advantage of being able to differentiate low recoveries due to procedural errors from those due to matrix effects. As a result, procedural errors will be identified and corrected by the analyst at the bench, without waiting for extensive senior level review or costly and time consuming reanalysis of the sample.

Three types of LCS are routinely analyzed: DCS, SCS, and Method Blanks. Each of these LCS are described below:

Duplicate Control Samples (DCS)

DCS will be used to monitor the precision and accuracy of the analytical system on a continuous basis. Each DCS will consist of a standard control matrix that is spiked with a group of target compounds representative of the method analytes. A DCS pair will be analyzed for every 20 samples processed by the method. DCS are analyzed with environmental samples to provide evidence that the laboratory is performing the method within accepted QC guidelines for accuracy and precision.

Accuracy (average recovery of each in the DCS pair) and precision (Relative Percent Difference (RPD) between each analyte in the DCS pair) data will be compared to control limits that have been established for each of the analytes contained in the DCS. Initially, control limits for analytes spiked into the DCS are taken directly from the CLP program. If CLP limits are not available, laboratory historical data are used to set the control limits. As sufficient laboratory data become available, the control limits will be redefined based upon the most recent nine months of DCS data. Control limits for accuracy for each analyte will be based on the historical average recovery (mean of the average recoveries of the DCS pairs) plus or minus three standard deviation units. Control limits for precision for each analyte are based on the historical RPD and range from zero (no difference between DCS results) to the average RPD plus three standard deviation units. Calculated control limits tend to be tighter than CLP limits because of the use of a control matrix. However, if the calculated limits are broader than the CLP limits, the CLP limits are used to control the laboratory. For this SAP, CLP control limits will be used.

Analytical data that are generated with a DCS pair which falls within the established control limits will be judged to be in control. Data generated with a DCS pair which falls outside of the control limits will be considered suspect and are repeated, or reported with qualifiers. The procedure used to evaluate data from control samples is given in Figure B-5. The protocols include examination of instrument performance and preparation and analysis information, consultation with the supervisor, and finally a decision path for determining whether reanalysis is warranted.

DCS have been established for each routine analytical method. Reagent water will be used as the control matrix for the analysis of aqueous samples. The DCS compounds will be spiked into reagent water and carried through the appropriate steps of the analysis. The control matrix for solids samples is standard Ottawa sand, an ASTM approved material for use in highway construction, due to its fine degree of homogeneity. The DCS compounds will be spiked into the Ottawa sand and carried through the appropriate steps of the analysis.

As stated previously, DCS will be analyzed at a frequency of no less than one DCS pair per 20 samples. The DCS program will be supplemented with the SCS program to ensure that Laboratory Performance QC is available with each batch of samples processed (see following subsection).

DCS precision and accuracy data will be archived in the LIMS. In addition, the associated DCS data will be reported with each set of sample results to enable Golder Associates to make a quality assessment of the data.

Single Control Samples (SCS)

As stated above, a DCS pair will be analyzed with every 20 samples to measure the precision and accuracy of an analysis on a continuous basis. However, samples may be analyzed in lots of less than 20, due to holding time or turnaround time requirements. Since it is necessary to have a measure of laboratory performance with each batch of samples processed, Enseco has instituted the SCS program.

An SCS will consist of a control matrix that is spiked with surrogate compounds appropriate to the method being used. In cases where no surrogate is available, (e.g, metals or conventional analyses) a single DCS serves as the control sample. An SCS will be prepared for each sample lot for which the DCS pair is not analyzed. Recovery data generated from the SCS are compared to control limits that have been established for each of the compounds being monitored. Initially, CLP control limits or laboratory historical data are used to set the control limits. When sufficient SCS data are available, control limits will be redefined based on the most recent nine months of data. Control limits for SCS components will be based on the historical average recovery in the SCS plus or minus three standard deviation units. For this sampling plan, CLP control limits will be implemented.

Analytical data that are generated with an SCS which falls within the control limits are judged to be in control. Data that are generated with an SCS which falls outside of acceptance criteria will be considered suspect and are reanalyzed, or reported with qualifiers. The protocols for evaluating SCS are identical to those established for DCS (see Figure B-5).

SCS recovery (accuracy) data will be archived in the LIMS. In addition, the associated SCS data will be reported with each set of sample results which will enable Golder Associates to make a quality assessment of the data.

Method Blank

Method blanks, also known as reagent, analytical, or preparation blanks, will be analyzed to assess the level of background interference or contamination which exists in the analytical system and which might lead to the reporting of elevated concentration levels or false positive data.

As part of the standard laboratory program, a method blank will be analyzed with every batch of samples processed. A method blank consists of reagents specific to the method which are carried through every aspect of the procedure, including preparation, cleanup, and analysis. The results of the method blank analysis will be evaluated, in conjunction with other QC information, to determine the acceptability of the data generated for that batch of samples.

Ideally, the concentration of target analytes in the blank should be below the Reporting Limit for that analyte. In practice, however, some common laboratory solvents and metals are difficult to eliminate to the parts-per-billion (ppb) levels commonly reported in environmental analyses. Therefore, criteria for determining blank acceptability will be based on consideration of the analytical techniques used, analytes reported, and Reporting Limits required.

For organic analyses, the concentration of target analytes in the blank will be below the Reporting Limit for that analyte in order for the blank to be considered acceptable. An exception will be made for common laboratory contaminants (methylene chloride, acetone, 2-butanone, toluene, and bis(2-ethylhexy)phthalate) which may be present in the blank at up to 5 times the Reporting limit and still be considered acceptable. This policy will be consistent with the CLP policy and has been established in recognition of the fact that these compounds are frequently found at low levels in method blanks due to the materials used in the collection, preparation, and analysis of samples for organic parameters.

If the blank does not meet acceptance criteria, the source of contamination will be investigated and appropriate corrective action will be taken and documented. Investigation includes an evaluation of the data to determine the extent and effect of the contamination on the sample results. Corrective actions may include reanalysis of the blank, and/or repreparation and reanalysis of the blank and all associated samples.

For organic analyses, method blank results will be reported with each set of samples results. Sample results are not corrected for blank contamination. Occasionally, due to limited sample volume or other constraints, the laboratory will report data associated with an unacceptable blank. In these cases, the Reporting Limit for each analyte contained in the blank will be raised to the level found in the blank.

9.3 Matrix-Specific QC

Matrix Specific QC will be used to assess the effects of a sample matrix or field conditions on the analytical data. The main elements of Matrix-Specific QC are:

- The analysis of matrix spikes, matrix duplicates, and matrix spike duplicates;
- Monitoring the recovery of surrogate compounds from environmental samples;
- Monitoring the results of standard additions in environmental samples;
- The analysis of field blanks; and
- The determination of MDLs in a specific matrix.

Different regulatory programs have different requirements in terms of Matrix-Specific QC. In order to ensure that the data generated meet all DQOs, Matrix-Specific QC will be included for this SAP. For this project, current USEPA CLP protocols for Matrix QC will be followed. A discussion of the different elements of Matrix-Specific QC is below.

9.3.1 Matrix Spikes, Matrix Duplicates, and Matrix Spike Duplicates

A Matrix Spike (MS) will be an environmental sample to which known concentrations of analytes have been added. The MS will be taken through the entire analytical procedure and the recovery of the analytes will be calculated. Results will be expressed as percent recovery. The MS will be used to evaluate the effect of the sample matrix on the accuracy of the analysis.

A Matrix Duplicate (MD) is an environmental sample that is divided into two separate aliquots. The aliquots will be processed separately and the results will be compared to determine the effects of the matrix on the precision of the analysis. Results will be expressed as RPD.

A Matrix Spike Duplicate (MSD) is an environmental sample that is divided into two separate aliquots, each of which will be spiked with known concentrations of analytes.

The two spiked aliquots will be processed separately and the results compared to determine the effects of the matrix on the precision and accuracy of the analysis. Results will be expressed as RPD and percent recovery.

Further, Table B-3 contains the Quality Control Limits for the Matrix Spike and Matrix Spike Duplicates of the analytical parameters which will arise in this investigation. CLP PCBs will be controlled via the Pesticides QC Limits.

9.3.2 Surrogate Recoveries and Standard Additions

Surrogates are organic compounds which are similar to the analytes of interest in chemical behavior, but which are not normally found in environmental samples. Surrogates will be added to samples to monitor the effect of the matrix on the accuracy of the analysis. Results will be reported in terms of percent recovery.

Enseco will routinely add surrogates to samples requiring GC/MS analysis and reports these surrogate recoveries to the client. However, the laboratory does not control its operations based on surrogate recoveries in environmental samples. As discussed earlier (see Section 9.2), the laboratory will control its operations based on the results of LCS. The surrogate recoveries will be primarily used by the laboratory to assess matrix effects. However, obvious problems with sample preparation and analysis (e.g. evaporation to dryness, leaking septum, etc.) which can lead to poor surrogate spike recoveries will be ruled out prior to attributing low surrogate recoveries to matrix effects. Regardless, strict adherence to USEPA CLP acceptance criteria will be followed by the laboratory.

9.3.3 Other Blanks

Field blanks are check samples that will monitor contamination originating from the collection, transport or storage of environmental samples. One example of a field blank is an equipment blank. An equipment blank is blank water that will be poured through the sample collection device to check the adequacy of the cleaning procedures for the sampling equipment. Another type of blank sample is a trip blank. A trip blank is a laboratory control matrix (distilled/deionized water) which is sent to the field in an appropriate sample container, remains unopened in the field, and then is sent back to the laboratory. The purpose of the trip blank will be to assess the impact of field and shipping conditions on the samples. The results from field blanks are reported to the client as samples in the same concentration units as the samples themselves. No correction of the analytical data will be performed in the laboratory based on the analysis of the mentioned blanks. Refer to Section 3.9 for field discussion of blanks.

9.3.4 Matrix-Specific Detection Limits

MDLs determined on a specific sample matrix will be called Matrix-Specific Detection Limits. In accordance with USEPA CLP protocol, quantitation limits will be used for this project. See Section 12.0 for a discussion of detection, reporting, and quantitation limits.

10.0 PERFORMANCE AND SYSTEM AUDITS

The Enseco network of laboratories participate in a variety of federal and state certification programs, (including the USEPA CLP), that subject each of the laboratories to stringent system and performance audits on a regular basis. A system audit is a review of laboratory operations conducted to verify that the laboratory has the necessary facilities, equipment, staff and procedures in place to generate acceptable data. A performance audit verifies the ability of the laboratory to correctly identify and quantitative compounds in blind check samples submitted by the auditing agency. The purpose of these audits will be to identify those laboratories that are capable of generating scientifically sound data.

In addition to external audits conducted by certifying agencies or clients, the laboratory will regularly conduct the following internal audits:

- Quarterly systems audits conducted by the Divisional QA Director;
- Periodic (at least yearly) audits conducted by the Corporate QA Office; and
- Special audits by the Divisional QA Director or Corporate QA Office when a problem will be suspected.

Enseco laboratories will also routinely analyze check samples as described below:

- LCS (DCS, SCS, and method blanks) will be analyzed at a frequency equal to at least 10-percent of the total number of samples analyzed (see Section 9.2);
- All Enseco laboratories will participate in the analyses of USEPA check samples provided under the Water Supply (WS) and Water Pollution (WP) Performance Evaluation Studies. The results of these PE samples are tabulated by the Corporate QA Office to identify performance trends within the Enseco laboratories;
- The majority of the Enseco laboratories are CLP labs and thus analyze organic and/or inorganic CLP PE samples on a quarterly basis. The results of these analyses will also be tabulated and evaluated by the Corporate QA Office;
- The laboratories participate in multiple state certification programs (including New York, New Jersey, and California) which require that PE samples be analyzed periodically; and

- Blind check samples from an independent commercial firm will be sent to the laboratories periodically by the Corporate QA Office. The frequency and type of samples sent is based on problem areas identified by evaluation of tabulated PE results.

The results of these check samples will be used to identify areas where additional training is needed or clarification of procedures is required within the Enseco laboratories.

11.0 PREVENTIVE MAINTENANCE

To minimize downtime and interruption of analytical work, preventive maintenance will be routinely performed on each analytical instrument. Designated laboratory personnel are trained in routine maintenance procedures for all major instrumentation. When repairs are necessary, they will be performed by either trained staff or trained service engineers employed by the instrument manufacturer.

Each Enseco laboratory has detailed SOPs on file that describe preventive maintenance procedures and schedules. The laboratory will also maintain detailed logbooks documenting the preventive maintenance and repairs performed on each analytical instrument.

Further, Field Sampling Coordinators and Laboratory Supervisors will maintain an adequate stock of spare parts to minimize an inefficient use of time.

12.0 DATA ASSESSMENT PROCEDURES/REPORTING LIMITS

12.1 Data Quality Assessment

As mentioned in Section 3.0, QA Objectives, the effectiveness of a QA program is measured by the quality of data generated by the laboratory. Data quality will be judged in terms of its precision, accuracy, representativeness, completeness and comparability. These terms are described as follows.

12.1.1 Precision

Precision is the degree to which the measurement will be reproducible. Precision will be assessed by replicate measurements of DCS, reference materials, or environmental samples. Enseco will routinely monitor precision by comparing the RPD between DCS measurements with control limits established at plus three standard deviations from the mean RPD of historical DCS data.

Precision is frequently determined by comparison of replicates. The standard deviation of "n" measurements of "x" is commonly used to estimate precision.

Standard deviation (S) will be calculated as follows:

$$S \quad = \quad \frac{\overset{n}{1}}{n_{-1}3} \qquad - \quad i \quad = \quad (X_1 - X)^2$$

where a quantity "x" (i.e., a concentration) is measured "n" times.

The relative standard deviation (or sample coefficient of variation, CV), which expresses standard deviation as a percentage of the mean, is generally useful in the comparison of three or more replicates (although it may be applied in case of $n = 2$).

$$RSD = 100\,(s/X)$$

or

$$CV = 100\,(s/X)$$

where: RSD = relative standard deviation

CV = coefficient of variation

s = standard deviation

X = mean

In the case of duplicates, the RPD between the two samples will be used to estimate precision.

$$\text{RPD} = \frac{|D_1 - D_2|}{(D_1 + D_2)/2} - \quad X\ 100$$

12.1.2 Accuracy

Accuracy is a determination of how close the measurement is to the true value. Accuracy will be assessed using LCS, SRMs, or spiked environmental samples. Unless specified otherwise in special contracts, Enseco will monitor accuracy by comparing LCS results with control limits established at plus or minus three standard deviation units from the mean of historical LCS results.

The determination of the accuracy of a measurement requires a knowledge of the true or accepted value for the signal being measured. Accuracy will be calculated in terms of percent recovery as follows:

$$\text{Percent Recovery} = X \quad 100 \; \frac{X}{I}$$

where: X = the observed value of measurement

T = true value

12.1.3 Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Analytical data should represent the sample analyzed regardless of the heterogeneity of the original sample matrix. Enseco will try to accommodate all sample matrices. Some samples may require analysis of multiple phases to obtain representative results.

12.1.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount that is expected to be obtained under normal conditions.

To be considered complete, the data set will contain all QC check analyses verifying precision and accuracy for the analytical protocol. In addition, all data will be reviewed in terms of stated goals in order to determine if the database will be sufficient.

When possible, the percent completeness for each set of samples will be calculated as follows:

$$\text{Completeness} = \frac{\text{valid data obtained}}{\text{total data planned}} \text{ X 100-percent}$$

12.1.5 Comparability

Comparability expresses the confidence with which one data set can be compared to another data set measuring the same property. Comparability will be ensured through the use of established and approved analytical methods, consistency in the basis of analysis (wet weight, volume, etc.), consistency in reporting units (ppm (mg/l), ppb (ug/l), etc.), and analysis of SRMs.

12.2 Reporting Limits

Assuring the validity of quantitative measurements at low concentrations is an extremely difficult technical problem. As regulatory action levels are pushed lower and lower, the validity of any given measurement becomes even more important. The consequences of false positive or false negative data will be significant.

A number of terms have been used, by the USEPA and other technical groups, to express the lowest concentration of an analyte which can be measured. For USEPA protocol, Contract Required Quantitation Limits (CRQLs) will be used.

The laboratory takes very seriously its responsibility to report technically defensible data. Therefore, Enseco has established a Reporting Limit (RL) for each analyte in each method. The RL represents the value above which the laboratory believes it to be reliable data that can be routinely obtained.

12.2.1 History

These Reporting Limits were established by collecting MDL data for organic analyses and Instrument Detection Limit (IDL) data for metals analyses from each Enseco laboratory. The MDL data were collected using the procedures described in 40CFR136 Appendix B-1. IDL data were calculated using the procedures outlined in the USEPA CLP Statement of Work Dated 12/87. The MDL/IDL data were then compared to various limits published in USEPA methods and in the regulations. For example, for Volatile Organics, the MDL data generated in Enseco laboratories were compared to the Practical Quantitation Limits (PQLs) published in SW-846 Method 8240; the PQLs contained in the July 9, 1987, Federal Register Final Rulemaking on Appendix IX; the Contract Required Quantitation Limits (CRQLs) in the CLP Method for Volatile Organics; and the MDLs in Method 624. Following, a Reporting Limit for each analyte was established which considered all of this information. Using this procedure, the Reporting Limits established are generally between two to five times the laboratory MDL/IDL. This range is consistent with the American Chemical Society definition for the Limit of Quantitation (LOQ).

13.0 CORRECTIVE ACTION

The need for corrective actions is based on predetermined limits for acceptability.

13.1 Laboratory Corrective Actions

When errors, deficiencies, or out-of-control situations exist, the QA program will provide systematic procedures to resolve problems and restore proper functioning to the analytical system.

Laboratory personnel will be alerted that corrective actions may be necessary if:

- QC data are outside the acceptable windows for precision and accuracy;
- Blanks, DCS, or SCS contain contaminants above acceptable levels;
- Undesirable trends are detected in spike recoveries or RPD between duplicates;
- There are unusual changes in detection limits;
- Deficiencies are detected by the QA department during internal or external audits or from the results of performance evaluation samples; or
- Inquiries concerning data quality are received from clients.

Corrective action procedures will be handled at the bench level by the analyst, who reviews the preparation or extraction procedure for possible errors, checks the instrument calibration, spike and calibration mixes, instrument sensitivity, etc. If the problem persists or cannot be identified, the matter will be referred to the laboratory supervisor and/or manager and the QA department for further investigation. By enacting standard quality control procedures or conducting system and performance audits, the QA Officer will determine if the data is acceptable. The QA Officer will be responsible for ensuring that the following steps are taken, if necessary:

- Identification and definition of the problem;
- Assignment of responsibility for investigating the problem;
- Investigation and determination of the cause of the problem;

- Determination of a corrective action to eliminate the problem;
- Assigning and accepting responsibility for implementing the corrective action;
- Implementing the corrective action and evaluating its effectiveness; and
- Verifying that the corrective action has eliminated the problem.

Furthermore, for each analytical method employed in this program the Laboratory Interface and Laboratory Supervisor will regularly track precision by the percent-RSD of field duplicate and laboratory replicate analyses. Accuracy will be tracked by percent of recovery from spiked samples. If the accuracy or the precision of sample analysis fails to fall within the limits specified by Table B-2 and Table B-3 and the applicable analytical procedures, the Laboratory Supervisor will take immediate corrective action. The Laboratory Supervisor will fully document the problem, action taken and results incurred in a report to the QA Officer. In addition, the data validation specialist will immediately notify the laboratory of any deficiencies in CLP deliverable packages and request submission of corrected or missing items.

13.2 Field Corrective Actions

If during the system or performance audits of the field activities, weakness or problems are uncovered, corrective action, after approval by the Golder Associates' QA Officer and Project Manager, will be initiated immediately by the Field Technicians. The Technical Project Manager will fully document the problem, actions taken and results incurred in a report to the QA Officer.

14.0 QUALITY ASSURANCE (QA) REPORTS

Timely submission of QA reports is essential to the successful completion of this project. Further, the reporting system will be a valuable tool for measuring the overall effectiveness of the QA program. It serves as an instrument for evaluating the program design, identifying problems and trends, and planning for future needs. Divisional QA Directors submit extensive monthly reports to the Vice President of QA and the Divisional Director. These reports include:

- The results of internal systems audits including any corrective actions taken (performance/system audits);
- Performance evaluation scores and commentaries;
- Results of site visits and audits by regulatory agencies and clients;
- Performance on major contracts, (example CLP);
- Problems encountered and corrective actions taken;
- Holding time violations;
- Comments and recommendations; and
- A summary of the 5-percent QA data audits conducted.

The Vice President of QA Enseco will submit weekly reports to the CEO and regularly reports on the status of the QA Program to the Enseco Management Committee and each Divisional Director. These reports will summarize the information gathered through the laboratory reporting system and contain a thorough review and evaluation of laboratory operations throughout Enseco.

REFERENCES

1. Data Quality Objectives for Remedial Response Activities - Development Process (OSWER Directive 9355.0-7B) March 1987.

2. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (OSWER Directive 9355.3-01 Interim Final) October 1988.

3. Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans (EPA-600/4-83-004) February 1983.

4. NYS Department of Environmental Conservation Division of Hazardous Substances Regulation (Guidelines) Revised August 1989.

5. Superfund Remedial Design and Remedial Action Guidance (OSWER Directive 9355.0-4A) June 1986.

6. USEPA (1983). Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans. EPA-600/ 4-83-004. U.S. EPA, Washington, D.C., February 1983.

7. USEPA (1986). Superfund Remedial Design and Remedial Action Guidance. OSWER Directive 9355.0-4A. U.S. EPA, Washington, D.C. June 1986.

8. USEPA (1987). Data Quality Objectives for Remedial Response Activities (Development Process). OSWER Directive 9355.0-7B. U.S. EPA, Washington, D.C., March 1987.

9. USEPA (1988a). Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Interim Final. OSWER directive 9355.3-01. U.S. EPA, Washington, D.C., October 1988.

10. USEPA (1988b). Region I Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses, U.S. EPA Hazardous Site Evaluation Division, Data Review Workgroup, February 1988, modified by Region I November, 1988.

11. USEPA (1989a). Industri-Plex Site Consent Decree, Civil Action 89 0196-MC, April 1989.

12. USEPA (1989b). Region I Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses, U.S. EPA Hazardous Site Evaluation Division, Data Review Workgroup, June 1988, modified by Region I February, 1989.

13. User's Guide to the Contract Laboratory Program (USEPA) December 1986.

TABLE B-1
CONTACT ADDRESSES
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

1.	Bell Aerospace Textron 2221 Niagara Falls Boulevard Niagara Falls, New York 14304	Contact: Telephone Number: Facsimile Number:	Brian Smith (716) 298-6754 (716) 298-6981
2.	New York State Department of Environmental Conservation 50 Wolf Road Albany, New York 12233	Contact: Telephone Number: Facsimile Number:	William Wertz (518) 457-9255 (518) 457-1088
3.	Golder Associates Inc. 210 John Glenn Drive Suite One Amherst, New York 14228	Contact: Telephone Number: Facsimile Number:	Anthony Grasso (716) 691-1156 (716) 691-5109
4.	Frontier Technical 8675 Sheridan Drive Buffalo, New York 14221	Contact: Telephone Number: Facsimile Number:	Mike Trelecky (716) 634-2293 N/A
5.	Enseco - Rocky Mountain Analytical Laboratory 4955 Yarrow Street Arvada, Colorado 80002	Contact: Telephone Number: Facsimile Number:	Craig Huff (303) 421-6611 (303) 431-7171

F/N: TABLEB-1.WK1

TABLE B-2
ANALYTICAL METHODS AND PARCC DATA FOR WATER SAMPLES
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

MEASUREMENT PARAMETER		REFERENCE	PRECISION (b)(d)	ACCURACY (c)(d)	METHOD COMPLETENESS (d)
Volatile Organics:	TCL (a)	EPA-CLP	See Table B-3	See Table B-3	85
Base Neutrals/Acids:	Semi-Volatiles	EPA-CLP	See Table B-3	See Table B-3	85
PCBs:	TCL	EPA-CLP	See Table B-3	See Table B-3	85
Pesticides:	TCL	EPA-CLP	See Table B-3	See Table B-3	85

NOTES:

(a) TCL - Target Compound List, see CLP Statement of Work.
(b) Precision expressed as percent relative standard deviation.
(c) Accuracy expressed as percent recovery of matrix spike.
(d) Precision and accuracy for CLP samples given in Table B-3.
(e) Comparability and completeness are non-quantitative parameters.

F/N TABLEB-2 WK1

TABLE B-3
WATER MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY FOR CLP SAMPLES
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPOUNDS	QC LIMITS	
	RPD	REC
Volatile		
1,1-Dichloroethene	14	61 - 145
Trichloroethene	14	71 - 120
Benzene	11	76 - 127
Toluene	13	76 - 125
Chlorobenzene	13	75 - 130
Semi-Volatile		
Phenol	42	12 - 89
2-Chlorophenol	40	27 - 123
1,4-Diclorobenzene	28	36 - 97
N-Nitroso-di-n-propylamine	38	41 - 116
1,2,4-Trichlorobenzene	28	39 - 98
4-Chloro-3-methylphenol	42	23 - 97
Acenaphthene	31	46 - 188
4-Nitrophenol	50	10 - 80
2,4-Dinitroluene	38	24 - 96
Pentachlorophenol	50	9 - 103
Pyrene	31	26 - 127
Pesticides		
Lindane	15	56 - 123
Heptachlor	20	40 - 131
Aldrin	22	40 - 120
Dieldrin	18	52 - 126
Endrin	21	56 - 121
4,4'-DDT	27	38 - 127

NOTES:

REC Acceptable Recovery

RPD Maximum Acceptable Relative Percent Difference

F/N: TABLEB-3.WK1

TABLE B-4
METHOD REFERENCES, CONTAINER TYPES, PRESERVATION, HOLDING TIMES FOR GROUND WATER SAMPLES
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

MEASUREMENT PARAMETER			REFERENCE	CONTAINER TYPE	METHOD PRESERVATION (a)	HOLDING TIMES	
Volatile Organics:	TCL	(c)	EPA-CLP	Amber-glass	4-Degrees Centigrade	10 Days	
Base Neutrals/Acids:	Semi-Volatiles		EPA-CLP	Amber-glass	4-Degrees Centigrade	5/40 Days	(b)
Pesticides/PCBs:	TCL	(d)					

NOTES:

(a) Sample preservation is performed by the sampler immediately upon sample collection.

(b) 5 days for extraction/40 days for analysis after extraction date.

(c) TCL - Target Compound List (see USEPA CLP list - Table B-5)

(d) Only PCBs (TCL) will be reported for this project.

(e) Comparability and completeness are non-quantitative parameters.

F/N TABLEB-4 WK1

TABLE B-5
TARGET COMPOUND LIST (TCL) AND CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)*
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

		QUANTITATION LIMITS	
COMPOUNDS	CAS NUMBER	WATER UG/L	LOW SOIL/ SEDIMENT UG/KG (a)
Volatiles			
Chloromethane	74-87-3	10	10
Bromomethane	74-83-9	10	10
Vinyl Chloride	75-01-4	10	10
Chloroethane	75-00-3	10	10
Methylene Chloride	75-09-2	5	5
Acetone	67-64-1	10	10
Carbon Disulfide	75-15-0	5	5
1,1-Dichloroethene	75-35-4	5	5
1,1-Dichloroethane	75-34-3	5	5
1,2-Dichloroethene (total)	540-59-0	5	5
Chloroform	67-66-3	5	5
1,2-Dichloroethane	107-06-2	5	5
2-Butanone	78-93-3	10	10
1,1,1-Trichloroethane	71-55-6	5	5
Carbon Tetrachloride	56-23-5	5	5
Vinyl Acetate	108-05-4	10	10
Bromodichloromethane	75-27-4	5	5
1,2-Dichloropropane	78-87-5	5	5
cis-1,3-Dichloropropene	10061-01-5	5	5
Trichloroethene	79-01-6	5	5
Dibromochloromethane	124-48-1	5	5
1,1,2-Trichloroethane	79-00-5	5	5
Benzene	71-43-2	5	5
trans-1,3-Dichloropropene	10061-02-6	5	5
Bromoform	75-25-2	5	5
4-Methyl-2-pentanone	108-10-1	10	10
2-Hexanone	591-78-6	10	10
Tetrachloroethen	127-18-4	5	5
Toluene	108-88-3	5	5
1,1,2,2-Tetrachloroethane	79-34-5	5	5
Chlorobenzene	108-90-7	5	5
Ethyl Benzene	100-41-4	5	5
Styrene	100-42-5	5	5
Xylenes (Total)	1339-20-7	5	5

NOTES:

(a) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Volatile TCL Compounds are 125 times the individual Low Soil/Sediment CRQL.

(b) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Semi-Volatile TCL Compounds are 60 times the individual Low Soil/Sediment CRQL.

(c) TCL Pesticides will not be analyzed for this project.

(d) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Pesticide/PCB Compounds are 15 times the individual Low Soil/Sediment CRQL.

* Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

** Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

F/N: TABLEB-5.WK1

TABLE B-5
TARGET COMPOUND LIST (TCL) AND CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)*
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPOUNDS	CAS NUMBER	QUANTITATION LIMITS WATER UG/L	QUANTITATION LIMITS LOW SOIL/ SEDIMENT (a) UG/KG
Semi-Volatiles			
Phenol	108-95-2	10	330
bis (2-Chloroethyl) ether	111-44-4	10	330
2-Chlorophenol	95-57-8	10	330
1,3-Dichlorobenzene	541-73-1	10	330
1,4-Dichlorobenzene	106-46-7	10	330
Benzyl Alcohol	100-51-6	10	330
1,2-Dichlorobenzene	95-50-1	10	330
2-Methylphenol	95-48-7	10	330
bis (2-Chloroisopropyl) ether	108-60-1	10	330
4-Methylphenol	106-44-5	10	330
N-Nitroso-di-n-dipropylamine	621-64-7	10	330
Hexachloroethane	67-72-1	10	330
Nitrobenzene	98-95-3	10	330
Isophorone	78-59-1	10	330
2-Nitrophenol	88-75-5	10	330
2,4-Dimethylphenol	105-67-9	10	330
Benzoic acid	65-85-0	50	1600
bis (2-chloroethoxy) methane	111-91-1	10	330
2,4-Dichlorophenol	120-83-2	10	330
1,2,4-Trichlorobenzene	120-82-1	10	330
Naphthalene	91-20-3	10	330
4-Chloroaniline	106-47-8	10	330
Hexachlorobutadiene	87-68-3	10	330
4-chloro-3-nethylphenol (para-chloro-meta-cresol)	59-50-7	10	330
2-Methylnaphthalene	91-57-6	10	330
Hexachlorocyclopentadiene	77-47-4	10	330
2,4,6-Trichlorophenol	88-06-2	10	330
2,4,5-Trichlorophenol	95-95-4	10	1600
2-Chloronaphthalene	91-58-7	10	330
2-Nitroaniline	88-74-4	50	1600
Dimethyphthalate	131-11-3	10	330
Acenaphthylene	208-96-8	10	330
2,6-Dinitrotoluene	606-20-2	10	330
3-Nitroaniline	99-09-2	50	1600

NOTES:

(a) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Volatile TCL Compounds are 125 times the individual Low Soil/Sediment CRQL.

(b) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Semi-Volatile TCL Compounds are 60 times the individual Low Soil/Sediment CRQL.

(c) TCL Pesticides will not be analyzed for this project.

(d) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Pesticide/PCB Compounds are 15 times the Individual Low Soil/Sediment CRQL.

* Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

** Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

TABLE B-5
TARGET COMPOUND LIST (TCL) AND CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)*
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPOUNDS	CAS NUMBER	QUANTITATION LIMITS WATER UG/L	QUANTITATION LIMITS LOW SOIL/ SEDIMENT (a) UG/KG
Semi-Volatiles (Continued)			
Acenaphthene	83-32-9	10	330
2,4-Dinitrophenol	51-28-5	50	1600
4-Nitrophenol	100-02-7	50	1600
Dibenzofuran	132-64-9	10	330
2,4-Dinitrotoluene	121-14-2	10	330
Diethylphthalate	84-66-2	10	330
4-chlorophenyl-phenyl ether	7005-72-3	10	330
Flourene	86-73-7	10	330
4-Nitroaniline	100-01-6	50	1600
4,6-Dinitro-2-methylphenol	534-51-1	50	1600
N-nitrosodiphenylamine	86-30-6	10	330
4-Bromophenyl-pheylether	101-55-3	10	330
Hexachlorobenzene	118-74-1	10	330
Pentachlorophenol	87-86-5	50	1600
Phenanthrene	85-01-8	10	330
Anthracene	120-12-7	10	330
Di-n-butylphthalate	84-74-2	10	330
Fluoroanthene	206-44-0	10	330
Pyrene	129-00-0	10	330
Butylbenzylphthalate	85-68-7	10	330
3,3-Dichlorobenzidine	91-94-1	20	660
Benzo (a) anthracene	56-55-3	10	330
Chrysene	218-01-9	10	330
bis (2-Ethylhexyl) phthalate	117-81-7	10	330
Di-n-octyphthalate	117-84-0	10	330
Benzo (b) fluoroanthene	205-99-2	10	330
Benzo (k) fluoranthene	207-08-9	10	330
Benzo (a) pyrene	50-32-8	10	330
Indeno (1,2,3-cd) pyrene	193-39-5	10	330
Dibenz (a, h) anthracene	53-70-3	10	330
Benzo (g, h, i) perylene	191-24-2	10	330

NOTES:

(a) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Volatile TCL Compounds are 125 times the individual Low Soil/Sediment CRQL.

(b) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Semi-Volatile TCL Compounds are 60 times the individual Low Soil/Sediment CRQL.

(c) TCL Pesticides will not be analyzed for this project.

(d) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Pesticide/PCB Compounds are 15 times the individual Low Soil/Sediment CRQL.

* Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

** Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

F/N: TABLEB-5.WK1

TABLE B-5
TARGET COMPOUND LIST (TCL) AND CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)*
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

		QUANTITATION LIMITS	
COMPOUNDS	CAS NUMBER	WATER UG/L	LOW SOIL/ SEDIMENT (a) UG/KG
Pesticides/PCBs			
alpha-BHC	319-84-6	0.05	8.0
beta-BHC	319-85-7	0.05	8.0
delta-BHC	319-86-8	0.05	8.0
gamma-BHC (Lindane)	58-89-9	0.05	8.0
Heptachlor	76-44-8	0.05	8.0
Aldrin	309-00-2	0.05	8.0
Heptachlor epoxide	1024-57-3	0.05	8.0
Endosulfan I	959-98-8	0.05	8.0
Dieldrin	60-57-1	0.10	16.0
4,4'-DDE	72-55-9	0.10	16.0
Endrin	72-20-8	0.10	16.0
Endosulfan II	33213-65-9	0.10	16.0
4,4'-DDD	72-54-8	0.10	16.0
Endosulfan sulfate	1031-07-8	0.10	16.0
4,4'-DDT	50-29-3	0.10	16.0
Methoxylchlor	72-43-5	0.5	80.0
Endrine ketone	53494-70-5	0.10	16.0
alpha-Chlordane	5103-71-9	0.5	80.0
gamma-Chlordane	5103-74-2	0.5	80.0
Toxaphene	8001-35-2	1.0	160.0
Aroclor-1016	12674-11-2	0.5	80.0
Aroclor-1221	11104-28-2	0.5	80.0
Aroclor-1232	11141-16-5	0.5	80.0
Aroclor-1242	53469-21-9	0.5	80.0
Aroclor-1248	12672-29-6	0.5	80.0
Aroclor-1254	11097-69-1	1.0	160.0
Aroclor-1260	11096-82-5	1.0	160.0

NOTES:

(a) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Volatile TCL Compounds are 125 times the individual Low Soil/Sediment CRQL.

(b) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Semi-Volatile TCL Compounds are 60 times the individual Low Soil/Sediment CRQL.

(c) TCL Pesticides will not be analyzed for this project.

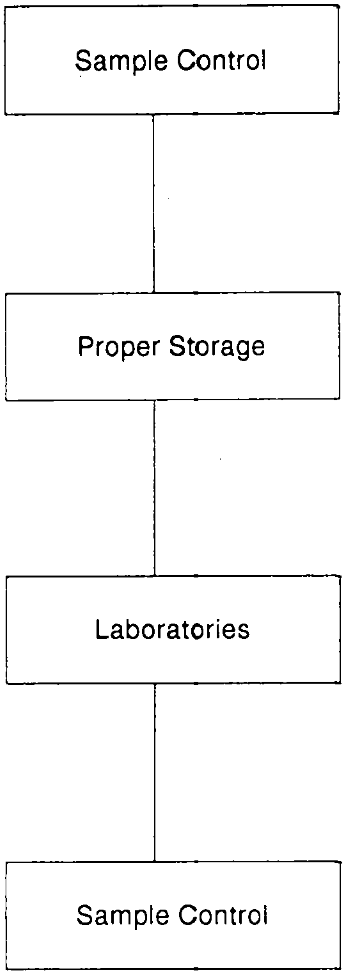
(d) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Pesticide/PCB Compounds are 15 times the individual Low Soil/Sediment CRQL.

* Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

** Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

F/N: TABLEB-5.WK1

FIGURE B-1
ENSECO SAMPLING PROCESSING FLOW CHART
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK



Check and document physical condition of sample.
Verify documentation and parameter assignment.
Log into LIMS.
Send acknowledgement letter to client.

Store sample according to preservation guidelines.
Transfer sample to lab with proper documentation.

Document analytical work.
Return unused samples to Sample Control.

Return sample to client or arrange for sample disposal.

F/N: FIGB-1.WK1

Enseco - Rocky Mountain Analytical

4955 Yarrow Street
Arvada, Colorado 80002
303/421-6611 Facsimile: 303/431-7171

CHAIN OF CUSTODY

No. 5068

Attn: ____________________

Enseco Client ____________________

Project ____________________

Sampling Co. ____________________

Sampling Site ____________________

Team Leader ____________________

SAMPLE SAFE™ CONDITIONS

1. Packed by: ____________________ Seal # __________
2. Seal Intact Upon Receipt by Sampling Co.: Yes No
3. Condition of Contents ____________________
4. Sealed for Shipping by: ____________________
5. Initial Contents Temp : __________ °C Seal # __________
6. Sampling Status: Done Continuing Until ____________________
7. Seal Intact Upon Receipt by Laboratory Yes No
8. Contents Temperature Upon Receipt by Lab: __________ °C
9. Condition of Contents: ____________________

Date	Time	Sample ID/Description	Sample Type	No. Containers	Analysis Parameters	Remarks

CUSTODY TRANSFERS PRIOR TO SHIPPING

	Relinquished by (signed)	Received by (signed)	Date	Time
1				
2				
3				

SHIPPING DETAILS

Delivered to Shipper by

Method of Shipment Airbill #

Received for Lab Signed Date/Time

Enseco Project No

FIGURE B-2

FIGURE B-3

Page ______ of ______
File Index ______

Enseco
INTERLABORATORY ANALYSIS

SHIP TO: *(circle one)*

CAL ERCO CLE GAS MAR HOU

Attention:

SEND RESULTS TO:
Rocky Mountain Analytical Laboratory
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611 FAC: (303) 431-7171

Attention:

CLIENT NAME

PROJECT NO.

Relinquished by: *(Signature)*	Received by: *(Signature)*	Date	Time
Relinquished by: *(Signature)*	Received by: *(Signature)*	Date	Time

Import Lab ID	Enseco ID	Client ID	Matrix (a, s, w)	Date Sampled	Date Rec'd	Date Auth.	Analysis Requested/ P.L. Item #	Sample Condition Upon Receipt

a. Written results required by (date): ______ Verbal results required by (date): ______

b. QC: ☐ Standard Enseco ☐ CLP Protocol ☐ Project-Specific ______

c. Sample Disposal: ☐ Enseco ☐ Return to Client ☐ Phone RMAL

d. Raw Data Copies Needed: ☐ Yes ☐ No

e. Detection Limits: ☐ Standard Product ☐ Other*

f. Holding Times: ☐ Enseco ☐ EPA-CLP ☐ Other*

g. *Special Instructions: ______

**h. Intercompany Rebate: *(circle one)* 0% 5% 10%

i. P.O. Number ______

FIGURE B-4

DATA VALIDATION SCHEME

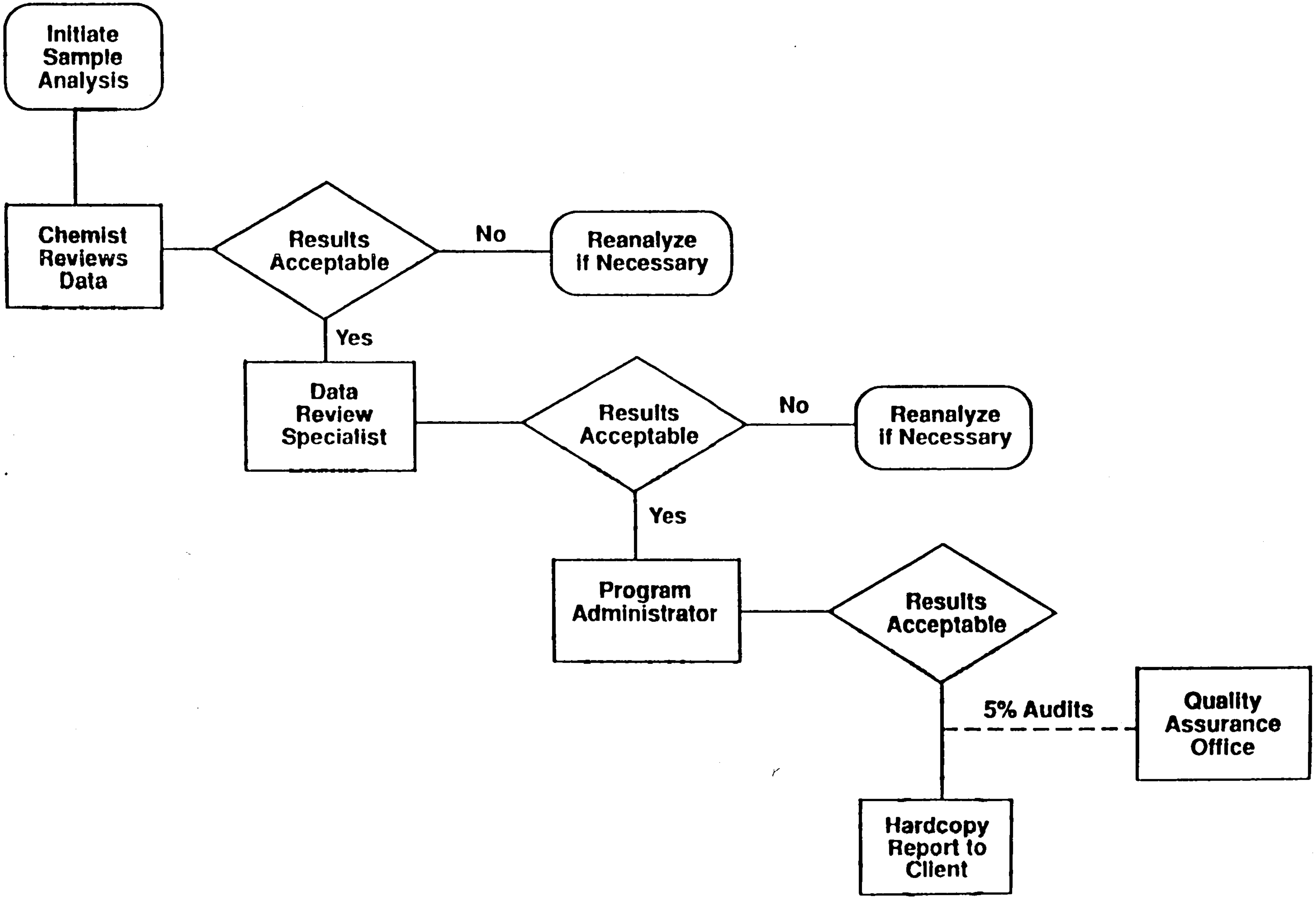
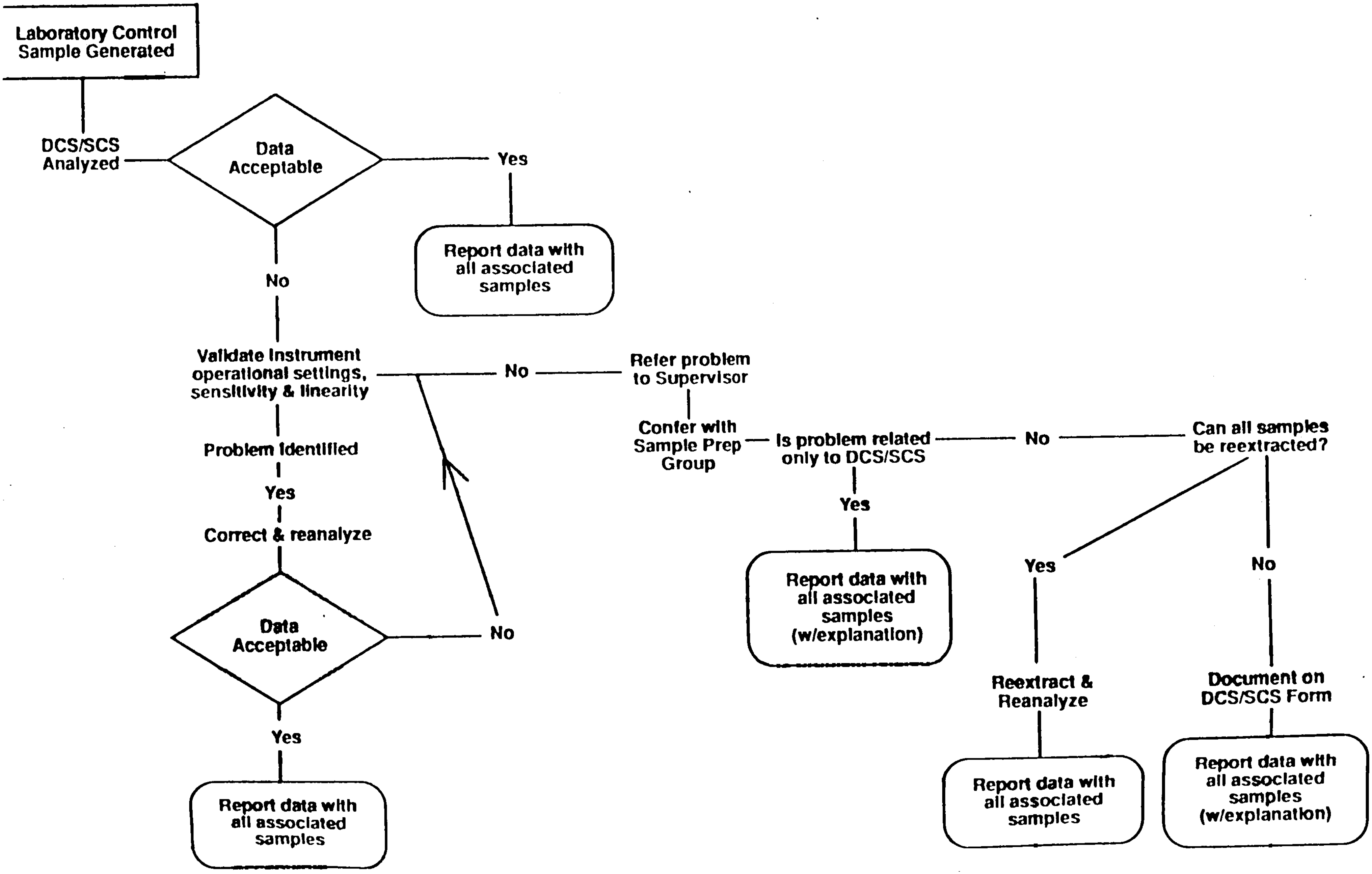


FIGURE B-5

SAMPLE EVALUATION PROCEDURE



Appendix B-1

Recommended Holding Times, Sample Collection/Preservation Information (Enseco)

A. VOLATILE ORGANICS

Matrix	Container	Minimum Sample Size	Preservative	Holding Time (From Date Sampled)
Water Samples				
No Residual Chlorine Present	3 40 mL vials with Teflon lined septum caps	40 mL	4 drops conc. HCl, 4°C	14 days
Residual Chlorine Present	3 40 mL vials with Teflon lined septum caps	40 mL	4 drops of 10% sodium thiosulfate, 4 drops conc. HCl, 4°C	14 days
Acrolein and Acrylonitrile	3 40 mL vials with Teflon lined septum caps	40 mL	Adjust to pH 4-5, 4°C	14 days
Soil/Sediments and Sludges	Glass jar with Teflon liner or core tube	10 g	4°C	14 days
Concentrated Waste Samples	Glass jar with Teflon liner or core tube	10 g	None	14 days

The above information applies to the following parameters and methods:

Parameter	Method
Volatile Halocarbons	601/8010 (GC)
Volatile Aromatics	602/8020 (GC)
Volatile Organics	624/8240/8260 (GC/MS)
Acrolein/Acrylonitrile	603/8030 (GC)

B. SEMIVOLATILE ORGANICS

Matrix	Container	Minimum Sample Size	Preservative	Holding Time (From Date Sampled)
Water Samples				
No Residual Chlorine Present	1 liter glass with Teflon liner	1 liter	4°C	Samples must be extracted within 7 days and analyzed within 40 days of extraction.
Residual Chlorine Present	1 liter glass with Teflon liner	1 liter	Add 3 mL 10% sodium thiosulfate per gallon, 4°C	Samples must be extracted within 7 days and analyzed within 40 days of extraction.
Soil/Sediments and Sludges	Glass jar with Teflon liner or core tube	50 g	4°C	Samples must be extracted within 14 days and analyzed within 40 days of extraction.
Concentrated Waste Samples	Glass jar with Teflon liner or core tube	50 g	None	Samples must be extracted within 14 days and analyzed within 40 days of extraction.

The above information applies to the following parameters and methods:

Parameter	Method
Phenols	604/8040 (GC)
Phthalate Esters	606/8060 (GC)
Organochlorine Pesticides/PCBs	608/8080 (GC)
Polyaromaltic Hydrocarbons	610/8310 (HPLC)
Organophosphate Pesticides	614/8140 (GC)
Phenoxy acid Herbicides	615/8150 (GC)
Semivolatile Organics	625/8270 (GC/MS)
Carbamate & Urea Pesticides	632 (HPLC)

C. OTHER ORGANICS

Parameter	Method No.	Matrix	Holding Time[a] (from Date Sampled)	Container	Preservative	Min. Sample Size
Dioxins/Furans	8280	Water	30 days extn. 45 days anal.[b]	One liter glass	4°C	1000 ml
		Soil/Waste	30 days extn. 45 days anal.[b]	core tube or glass jar	4°C	50 g
Petroleum Hydrocarbons as Gasoline	TPH-Gasoline Purge & Trap (LUFT manual)	Water	14 days	3 40 mL vials with Teflon liners	4°C, HCl to pH < 2	40 mL
		Soil/Waste	14 days	Core tube or glass jar	4°C	50 g
Petroleum Hydrocarbons as Gasoline	TPH-Gasoline Extractable (LUFT manual)	Water	14 days extn. 40 days anal.	One liter glass	4°C, HCl to pH < 2	500 mL
		Soil/Waste	14 days extn. 40 days anal.	Core tube or glass jar	4°C	50 g
Petroleum Hydrocarbons as Diesel	TPH-Diesel Extractable (LUFT manual)	Water	14 days extn. 40 days anal.	One liter glass	4°C	500 mL
		Soil/Waste	14 days extn. 40 days anal.	Core tube or glass jar	4°C	50 g
Petroleum Hydrocarbons (TPH)	TPH-IR (418.1)	Water	28 days	One liter glass	4°C, H_2SO_4 to pH < 2	1000 mL

(a) extn: extraction anal: analysis
(b) from date of collection

D. METALS

Parameter	Method No.	Matrix	Holding Time (from Date Sampled)	Container	Preservative(a)	Min. Sample Size
Metals (ICP)	200.7/6010	Water	6 months	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	6 months	core tube/glass jar	$4^{\circ}C$	10 g
Arsenic (GF-AA)	206.2/7060	Water	6 months	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	6 months	core tube/glass jar	$4^{\circ}C$	10 g
Mercury (CV-AA)	245.1/7470	Water	28 days	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	28 days	core tube/glass jar	$4^{\circ}C$	10 g
Selenium (GF-AA)	270.2/7740	Water	6 months	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	6 months	core tube/glass jar	$4^{\circ}C$	10 g
Thallium (GF-AA)	279.2/7841	Water	6 months	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	6 months	core tube/glass jar	$4^{\circ}C$	10 g
Lead (GF-AA)	239.2/7421	Water	6 months	Poly	HNO_3 to pH < 2.0	100 ml
		Soil/Waste	6 months	core tube/glass jar	$4^{\circ}C$	10 g
Chromium (III/VI)	220.7/218.4/ 312B/7197	Water	24 hours	Poly	$4^{\circ}C$	100 ml
		Soil/Waste	24 hours extn. (b)	core tube/glass jar	$4^{\circ}C$	10 g
Silica	200.7/6010	Water	28 days	Poly	$4^{\circ}C$	100 ml
		Soil/Waste	28 days	core tube/glass jar	$4^{\circ}C$	10 g

(a) Listed preservative is for total metals. Dissolved or suspended metals require filtration prior to pH adjustment.

(b) extn: extraction

E. CONVENTIONALS

Parameter	Method No.	Matrix	Holding Time[(a)] (from Date Sampled)	Container	Preservative	Min. Sample Size
Color	110.2	Water	48 hours	Poly	4^oC	100 ml
Oil and Grease	413.1/ 413.2	Water	28 days	Glass	4^oC, H_2SO_4 to $pH < 2$	1000 ml
Specific Conductance	120.1	Water	28 days	Poly	4^oC	50 ml
Acidity	305.1	Water	14 days	Poly	4^oC	50 ml
pH	150.1	Water	ASAP	Poly	4^oC	50 ml
Alkalinity	310.1	Water	14 days	Poly	4^oC	50 ml
Hardness	200.7/ 314A/314B	Water	6 months	Poly	HNO_3 to $pH < 2$	50 ml
Biochemical Oxygen Demand	405.1	Water	48 hours	Poly	4^oC	200 ml
Chemical Oxygen Demand	410.4	Water	28 days	Glass	4^oC, H_2SO_4 to $pH < 2$	100 ml
Organic Carbon (TOC)	415.1	Water	28 days	Glass	4^oC, H_2SO_4 to $pH < 2$	100 ml

C. CONVENTIONALS (Cont.)

Parameter	Method No.	Matrix	Holding Time[(a)] (from Date Sampled)	Container	Preservative	Min. Sample Size
Orthophosphate	365.3	Water	48 hours	Poly	4°C	100 ml
Total Phosphorus	365.3	Water	28 days	Glass	H_2SO_4 to pH < 2	100 ml
Total Kjeldahl Nitrogen	351.2	Water	28 days	Glass	4°C, H_2SO_4 to pH < 2	100 ml
Ammonia	350.1	Water	28 days	Glass	4°C, H_2SO_4 to pH < 2	50 ml
Nitrite	354.1	Water	48 hours	Poly	4°C	50 ml
Nitrate	353.2/300.0	Water	48 hours	Poly	4°C	50 ml
Nitrite plus Nitrate	353.2	Water	28 days	Glass	4°C, H_2SO_4 to pH < 2	50 ml
Total Solids	160.3	Water	7 days	Poly	4°C	100 ml
Total Suspended Solids	160.2	Water	7 days	Poly	4°C	100 ml
Total Dissolved Solids	160.1	Water	7 days	Poly	4°C	100 ml

C. CONVENTIONALS (Cont.)

Parameter	Method No.	Matrix	Holding Time[(a)] (from Date Sampled)	Container	Preservative	Min. Sample Size
Total Volatile Solids	160.4	Water	7 days	Poly	4°C	100 ml
Turbidity	180.1	Water	48 hours	Poly	4°C	50 ml
Sulfate	300.0	Water	28 days	Poly	4°C	50 ml
Sulfite	377.1	Water	ASAP	Poly	4°C	100 ml
Sulfide	376.2	Water	7 days	Poly	4°C, NaOH to pH > 9 $Zn(C_2H_3O_3)2$	100 ml
Cyanide	335.1/ 335.2/335.3	Water	14 days	Poly	4°C, NaOH to pH > 12	250 ml
Coliform, Total & Fecal	909A/ 909C	Water	6 hours	Sterile poly	4°C, $Na_2S_2O_3$	100 ml
Bromide	Dionex	Water	28 days	Poly	4°C	50 ml
Chloride	300.0	Water	28 days	Poly	4°C	50 ml
Chlorine, residual	330.1	Water	ASAP	Poly	4°C	100 ml

C. CONVENTIONALS (Cont.)

Parameter	Method No.	Matrix	Holding Time[(a)] (from Date Sampled)	Container	Preservative	Min. Sample Size
Fluoride	340.2	Water	28 days	Poly	4°C	50 ml
Iodide	Dionex	Water	28 days	Poly	4°C	50 ml
Organic Halogen (TOX)	9020	Water	28 days	Glass	4°C, H_2SO_4 to pH < 2	200 ml
Phenolics	420.1/ 420.2	Water	28 days	Glass	4°C, H_2SO_4 to ph < 2	100 ml
Surfactants (MBAS)	425.1	Water	48 hours	Poly	4°C	100 ml
Gross Alpha, Beta and Radium	9310/ 9315	Water	6 months	Poly	HNO_3 to ph < 2	2000 ml
Odor	140.1	Water	ASAP	Glass	4°C	1000 mL

a) Parameters with holding times of 24 hours or less are analyzed on the day of receipt in the laboratory. Parameters with holding times between 24 and 48 hours are analyzed within one day of receipt in the laboratory.

F. CLP HOLDING TIMES

Parameter	Matrix	Holding Time(a) (from Date Received)	Container	Preservative	Min. Sample Size
Volatile Organics	Water	10 days	2 40 mL vials with Teflon lined caps	4°C	40 mL
	Soil	10 days	Glass jar with Teflon liner or core tube	4°C	10 g
Extractable Organics	Water	5 days extn. 40 days anal.	1 liter glass with Teflon liner	4°C	1000 mL
	Soil	10 days extn. 40 days anal.	Glass jar with Teflon liner or core tube	4°C	50 g
Metals (other than Mercury)	Water	180 days	P,G (b)	HNO_3 to pH < 2	100 mL
	Soil	180 days	P,G	4°C	10 g
Mercury	Water	26 days	P,G	HNO_3 to pH < 2	100 mL
	Soil	26 days	P,G	4°C	10 g
Cyanide	Water	14 days	P,G	0.6 g ascorbic acid,(c) NaOH to pH >12, 4°C	100 mL
	Soil	14 days	P,G	4°C	10 g

(a) Holding times calculated from date of receipt in laboratory
(b) Polyethylene (P) or glass (G)
(c) Only used in the presence of residual chlorine

Appendix B-2

Formats for Standard Operating Procedures

FORMAT FOR SOP - LABORATORY, ANALYTICAL METHOD

Title (includes method number)

1. Scope and Application
    - 1.1 Analytes
    - 1.2 Detection limit (instrument and method)
    - 1.3 Applicable matrices
    - 1.4 Dynamic range
    - 1.5 Approximate analytical time (i.e., 5 minutes, 2 days)

2. Summary of Method
    - 2.1 Generic description of method and chemistry behind it (i.e., extract with slvent, convert to methyl ester, analyze by electron-capture gas chromatography).

3. Comments
    - 3.1 Interferences
    - 3.2 Helpful hints

4. **Safety** Issues (specific to the method)

5. Sample Collection, Preservation, Containers, and Holding Times

6. Apparatus

7. Reagents and Standards

8. Procedure (detailed step-by-step)
    - 8.1 Sample preparation
    - 8.2 Calibration
    - 8.3 Analysis

9. QA/QC Requirements
    - 9.1 QC samples
    - 9.2 Acceptance criteria (precision and accuracy, % of multi-component QC analytes which must be within windows)
    - 9.3 Corrective action required (reference current QC manual)

10. Calculations

11. Reporting

    11.1 Reporting units
    11.2 Reporting limits
    11.3 Significant figures
    11.4 LIMS data entry

12. References

    12.1 Method source
    12.2 Deviations from source method and rationale

FORMAT FOR SOP - LABORATORY, STANDARDS AND REAGENTS

Title

1. Reagent/Standard Name
2. Type (reagent, calibration standard, DSC, SCS, stock solution, etc.)
3. Constituents/concentration
4. Solvent
5. Safety Issues (specific to the reagent or standard)
6. Shelf Life
7. Procedure
    - 7.1 Preparation
    - 7.2 Documentation (purchase date, open date, labeling, etc.)
    - 7.3 Verification

FORMAT FOR SOP - LABORATORY, EQUIPMENT OPERATION, CALIBRATION, AND MAINTENANCE

Title

1. Purpose

2. Safety Issues (applicable to the specific equipment)

3. Procedure

    3.1 Initial start-up
    3.2 Calibration and performance documentation
    3.3 Example output
    3.4 Shut-down
    3.5 Maintenance and maintenance records

4. Responsibilities

5. Comments

6. Definitions

FORMAT FOR SOP - LABORATORY, PROCEDURAL

Title

1. Purpose
2. Policies
3. Safety Issues
4. Procedure
5. Responsibilities
6. Comments
7. Definitions

APPENDIX C

Methodology Modifications
and
Related Quality Assurance Information

METHODOLOGY MODIFICATIONS

METHOD 524.2 MODIFICATIONS

As per Enseco Rocky Mountain Analytical Laboratory (RMAL) letter from Craig Huff, Project Administrator, on May 8, 1990, RMAL performs Method 524.2 with the following modifications:

1. RMAL does not spike the entire target compound list as specified in the method. RMAL spikes only the following compounds[1]:

    Benzene
    Toluene
    Chlorobenzene
    Ethylbenzene
    1,3-Dichlorobenzene
    1,1-Dichloroethane
    Chloroform
    Bromodichloromethane
    Trichloroethene
    Hexachlorobutadiene

2. RMAL analyzes samples on a 12-hour calibration curve, as opposed to an 8-hour curve.

3. RMAL follows the internal standard criteria as stated in the United States Environmental Protection Agency's (USEPA) Corrective Laboratory Program (CLP) Statement of Work (SOW) dated February 1988.

4. Hydrochloric acid will be added to ensure preservation of the volatile compounds. As stated in SW-846, 3rd Edition, preserved volatiles will have a holding time of 14 days.

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[1] To date, RMAL has not received the quality assurance/quality control (QA/QC) requirements for this program. We will, therefore, follow the guidelines in RMAL's Quality Assurance Project Plan (QAPP) for QA/QC unless otherwise specified.

Table 1. 524.2 (Modified) Component List

Component List	Reporting Limit ug/L
Chloromethane	2.0
Bromomethane	2.0
Vinyl chloride	2.0
Chloroethane	2.0
Methylene chloride	5.0
1,1-Dichloroethene	1.0
1,1-Dichloroethane	1.0
1,2-Dichloroethene (cis/trans)	1.0
Chloroform	1.0
1,2-Dichloroethane	1.0
1,2,3-Trichlorobenzene	1.0
1,2,4-Trichlorobenzene	1.0
1,1,1-Trichloroethane	1.0
Carbon tetrachloride	1.0
Bromodichloromethane	1.0
1,2-Dichloropropane	1.0
1,3-Dichloropropane	1.0
2,2-Dichloropropane	1.0
1,1-Dichloropropene	1.0
Trichloroethene	1.0
Chlorodibromomethane	1.0
cis-1,3-Dichloropropene	1.0
trans-1,3-Dichloropropene	1.0
1,1,2-Trichloroethane	1.0
Benzene	1.0
Bromoform	1.0
1,1,1,2-Tetrachloroethane	1.0
1,1,2,2-Tetrachloroethane	1.0
Tetrachloroethene	1.0
Toluene	1.0
Chlorobenzene	1.0
Ethylbenzene	1.0
Styrene	1.0
Xylenes (total)	1.0
n-Propylbenzene	1.0
1-Methylethylbenzene	1.0
p-Isopropyltoluene	1.0
1,2,4-Trimethylbenzene	1.0
1,3,5-Trimethylbenzene	1.0
n-Butylbenzene	1.0
sec-Butylbenzene	1.0
tert-Butylbenzene	1.0
1,4-Dichlorobenzene	1.0
1,2-Dichlorobenzene	1.0
1,3-Dichlorobenzene	1.0
2-Chlorotoluene	1.0
4-Chlorotoluene	1.0
Bromobenzene	1.0
Hexachlorobutadiene	1.0
Naphthalene	1.0
DBCP (1,2-Dibromo-3-chloropropane	1.0
EDB (1,2-Dibromoethane)	1.0

Table 1. 524.2 (Modified) Component List

(Continued)

Component List	Reporting Limit (ug/L)
Dibromomethane	1.0
Dichlorodifluoromethane	1.0
Trichlorofluoromethane	1.0
1,2,3-Trichlorpropane	1.0
Bromochloromethane	1.0

Table 2. 624 Compounds and Reporting Limits

Component List	Reporting Limit (ug/L)
Chloromethane	10
Bromomethane	10
Vinyl chloride	10
Chloroethane	10
Methylene chloride	5.0
1,1-Dichloroethene	5.0
1,1-Dichloroethane	5.0
1,2-Dichloroethene (cis/trans)	5.0
Chloroform	5.0
1,2-Dichloroethane	5.0
1,1,1-Trichloroethane	5.0
Carbon tetrachloride	5.0
Bromodichloromethane	5.0
1,2-Dichloropropane	5.0
trans-1,3-Dichloropropene	5.0
Trichloroethene	5.0
Chlorodibromomethane	5.0
1,1,2-Trichloroethane	5.0
Benzene	5.0
cis-1,3-Dichloropropene	5.0
2-Chloroethyl vinyl ether	10
Bromoform	5.0
1,1,2,2-Tetrachloroethane	5.0
Tetrachloroethene	5.0
Toluene	5.0
Chlorobenzene	5.0
Ethylbenzene	5.0

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Volatile Organics^Target Compound List (TCL)

8260

Component	Reporting Limit (ug/L)
Chloromethane	2.0
Acetone	2.0
Bromomethane	2.0
Vinyl chloride	2.0
Chloroethane	2.0
Methylene chloride	1.0
1,1-Dichloroethene	1.0
1,1-Dichloroethane	1.0
2-Hexanone	2.0
1,2-Dichloroethene^(cis/trans)	1.0
Chlorobenzene	1.0
4-Methyl-2-pentanone^(MIBK)	2.0
Chloroform	1.0
1,2-Dichloroethane	1.0
2-Butanone (MEK)	2.0
Carbon disulfide	1.0
1,1,1-Trichloroethane	1.0
Carbon tetrachloride	1.0
Bromodichloromethane	1.0
1,2-Dichloropropane	1.0
Trichloroethene	1.0
Dibromochloromethane	1.0
cis-1,3-Dichloropropene	1.0
trans-1,3-Dichloropropene	1.0
1,1,2-Trichloroethane	1.0
Benzene	1.0
Bromoform	1.0
1,1,2,2-Tetrachloroethane	1.0
Tetrachloroethene	1.0
Toluene	1.0
Ethylbenzene	1.0
Styrene	1.0
Xylenes (total)	1.0
Vinyl acetate	2.0
trichlorofluoromethane	1.0

LABORATORY CERTIFICATION STATUS

FEB 15 1991

Enseco, Inc.

Certifications and Government Contracts

Enseco, Inc. is certified by a number of federal and state agencies to perform environmental testing. The certification process, although differing in detail for each regulatory agency, relies on a combination of system and performance audits of the laboratory. The systems audit consists of an evaluation of the laboratory operation based on the analytical equipment available to the laboratory, the experience of the staff, and the availability of detailed operational and quality assurance procedures. Performance audits are conducted by submission of blind QC samples to the laboratory for analysis. The laboratory results for these QC samples are compared, by the certifying agency, to known values. Analytical results falling within established guidelines are considered acceptable. If the requirements of the systems and performance audits are met, the laboratory is "certified" by the agency as being qualified to perform environmental testing. A list of certifications held by the Enseco laboratories is attached.

ENSECO FEDERAL AND STATE CERTIFICATIONS/CONTRACTS

AGENCY	PROGRAM	CAL	CRL	EAST	ERCO	RMAL
USEPA	CLP-ORGANIC CONTRACT	C	-	C	C	C
	CLP-INORGANIC CONTRACT	-	-	-	-	C
	CLP-DIOXIN, SAS-ELIGIBLE	C	-	-	-	-
	DMR-QA	C	C	C	C	C
US DEPT OF ENERGY	HAZWRAP	C	-	C	P	C
US AIR FORCE	ENVIRONMENTAL ANALYSES	-	-	-	-	C
US ARMY	CORPS OF ENGINEERS	C	-	P	P	-
US ARMY	USATHAMA	-	-	-	-	C
US NAVY	NEESA	C	-	-	-	C
USDA	SOIL IMPORT PERMIT	C	C,C/V	C	C	C
ALABAMA	SDWA	-	-	-	C	-
ARIZONA	HAZARDOUS WASTE REGISTRATION	D	-	-	-	-
CALIFORNIA	SDWA	C	C,C/V	-	-	-
	HAZARDOUS WASTE	C	C,C/ML C/V,C/S	-	-	C
	AQUATIC TOX	-	C/V	-	C/M	-
	WASTEWATER	C	-	-	-	-
	CDFA	C	-	-	-	-
COLORADO	SDWA	-	-	-	-	C
CONNECTICUT	SDWA	-	-	P	C	-
	WASTEWATER	-	-	P	C	-
DELAWARE	SDWA	-	-	P	C	-
FLORIDA	SDWA	-	-	C	C	C
	WASTEWATER	-	-	C	C	C
ILLINOIS	SDWA	-	-	P	-	-
KANSAS	SDWA	-	-	-	P	C
	RCRA	-	-	-	P	C
	CWA	-	-	-	P	C

ENSECO FEDERAL AND STATE CERTIFICATIONS/CONTRACTS (CONT.)

AGENCY	PROGRAM	CAL	CRL	EAST	ERCO	RMAL
MAINE	SDWA	-	-	-	C	-
MARYLAND	SDWA	-	-	P	-	-
AGENCY	PROGRAM	CAL	CRL	EAST	ERCO	RMAL
MASSACHUSETTS	CHEMICAL ANALYSIS	-	-	C	C	-
NEVADA	ENVIRONMENTAL ANALYSES	C	-	-	-	-
NEW HAMPSHIRE	SDWA	-	-	-	C	-
	WASTEWATER	-	-	-	C	-
NEW JERSEY	ECRA	C	-	C	C	C
	SDWA	-	-	C	C	C
	WASTEWATER, CHEMISTRY	P	C/ML	C	C	C
	WASTEWATER, BIOASSAY	-	-	-	P/M	-
	RI/FS	C	-	P	C	C
NEW YORK	DOHS DW	-	-	C	C	C
	DOHS WASTEWATER/WASTE	-	-	C	C	C
	DOHS AIR AND EMISSIONS	-	P/A	-	-	-
	DEC CONTRACT	-	-	C	C	C
NORTH CAROLINA	WASTEWATER	-	-	C	-	-
NORTH DAKOTA	SDWA	-	-	-	-	C
	RCRA	-	-	-	-	C
	CWA	-	-	-	-	C
OKLAHOMA	NPDES	-	-	-	-	C
PENNSYLVANIA	SDWA	-	-	C	C	-
RHODE ISLAND	SDWA	-	-	C	C	-
	WASTEWATER	-	-	C	C	-
SOUTH CAROLINA	CHEMICAL ANALYSIS	-	-	C	C	C
TENNESSEE	SDWA	-	-	C	C	C
UTAH	SDWA	-	-	-	-	C
	CWA/RCRA	-	-	-	-	C
VIRGINIA	SDWA	-	-	C	C	C
WEST VIRGINIA	SDWA	-	-	C	-	-
	WASTEWATER	-	-	C	-	-
WISCONSIN	ENV ANALYSES	-	-	-	C	C

LEGEND

C - Lab is certified, approved, or contracted.
C/H - Certification held by Enseco-Houston.
C/M - Certification held by Enseco-Marblehead.
C/ML - Certification held by Enseco-Mobile Labs.
C/S - Certification held by Enseco-Santa Maria
C/V - Certification held by Enseco-Ventura
D - Arizona maintains directory of labs which perform environmental analysis.
L - Letter on file in Corporate QA office from Joan Fisk stating that CRL and EAST have demonstrated capability to perform organic CLP.
P - Pending (application submitted).
P/A - Pending, Air Toxics Lab
P/M - Pending Marblehead.

LABORATORY LOCATIONS

Quality Assurance Office

Enseco Incorporated
2200 Cottontail Lane
Somerset, NJ 08893
(201) 469-5800
Facsimile (201) 469-6257

Enseco-California Analytical Laboratory
2544 Industrial Boulevard
West Sacramento, CA 95691
(916) 372-1393
Facsimile (916) 372-1059

Enseco-CRL
7440 Lincoln Way
Garden Grove, CA 92641
(714) 898-6370
Facsimile (714) 891-5917

Enseco-East
2200 Cottontail Lane
Somerset, NJ 08873
(201) 469-5800
Facsimile (201) 469-7516

Enseco-Erco Laboratory
205 Alewife Brook Parkway
Cambridge, MA 02138
(617) 661-3111
Facsimile (617) 354-5258

Enseco-Houston
1420 East North Belt, Suite 120
Houston, TX 77032
(713) 987-9767
Facsimile (713) 987-9769

Enseco-Air Toxics
9537 Telstar Avenue #118
El Monte, CA 91731
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Facsimile (818) 442-3758

Enseco-Marblehead
Doaks Lane at Little Harbor
Marblehead, Massachusetts 01945
(617) 639-2695
Facsimile (617) 639-2637

Enseco-Mobile Laboratories
7440 Lincoln Way
Garden Grove, CA 92641
(714) 898-6370
Facsimile (714) 891-5917

Enseco-Rocky Mountain Analytical Laboratory
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611
Facsimile (303) 431-7171

Enseco-Santa Maria
2325 Skyway Drive, Suite K
Santa Maria, CA 93455
(805) 922-2776
Facsimile (805) 922-5897

Enseco-Ventura
2810 Bunsen Avenue, Unit A
Ventura, CA 93003
(805) 650-0546
Facsimile (805) 650-0756

RMAL CERTIFICATIONS AND GOVERNMENT CONTRACTS
JANUARY 1991

Agency	Certification	Lab ID	Exp. Date	Term	Site Audit	PEs
FEDERAL						
US Air Force	Environmental Analyses		NA	Ongoing	9/7/88	
USATHAMA	Rocky Mountain Arsenal		NA	Ongoing by method		
US DOE	Hazwrap NEESA			Ongoing Ongoing	8/89	Yes
USEPA-CLP	Organics, Inorganics	NA	NA	Participate in PE Program	3/10/86, 5/22/86, 1/21/87, 6/1/87, 9/7/88, 6/29/89, 7/24/90	Quarterly
USEPA-NPDES	Organics, Metals, Inorganics	NA	NA	Participate in annual PE program if submitted by client		
STATE						
California	Analysis of Hazardous Waste	1227	8/92	2 years	1/7/88, 6/29/90	
Colorado	Analysis of Drinking Water	C0026	NA	Ongoing	3/22/84, 1/21/88 3/22/88	WS/WP
Florida-HRS	Analysis of Drinking Water	87278	6/91	1 year	10/16/86	WS
Florida-DER	Analysis of Non-Drinking Water	890328G	NA	Ongoing		

RMAL CERTIFICATIONS AND GOVERNMENT CONTRACTS
JANUARY 1991
(Continued)

Agency	Certification	Lab ID	Exp. Date	Term	Site Audit	PEs
STATE (Continued)						
Kansas	Analysis of Drinking Water	E-166	1/91	1 year		WS
	Analysis of Environmental Samples (CWA,RCRA)	E-1142	1/91	1 year		WP
New Jersey - NJDEP - ECRA	Water and Wastewater Environmental Analyses for Submission to NJDEP ECRA	45556	6/91	1 year	11/21/86, 7/21/88	WS/WP
New York - DOH	Potable/Nonpotable Water and Solid and Hazardous Waste	10809	4/91	1 year	2/2/87, 3/23/88 1/12/90	Semi-annually
- DEC	NYDEC Contract (via ERCO)			By Contract	8/28/90	
North Dakota	Analysis of Drinking Water	R-034	1/93	3 years		WS
	Analysis of Environmental Samples (CWA, RCRA)	R-034	2/92	2 years		WP
Oklahoma	General Water Analyses	8614	6/91	6 months		Annually

RMAL CERTIFICATIONS AND GOVERNMENT CONTRACTS
JANUARY 1991
(Continued)

Agency	Certification	Lab ID	Exp. Date	Term	Site Audit	PEs
STATE (Continued)						
South Carolina	Analysis of Environmental Samples (CWA,RCRA) Analysis of Drinking Water (SDWA)	72002		1 year		WS/WP
Tennessee	Analysis of Drinking Water (SDWA)	02944	10/93	3 years		WS/WP
Utah	Analysis of Environmental Samples (CWA,RCRA) Analysis of Drinking Water (SDWA)	E-83 #-83	9/92 8/92	2 years	6/12/86, 8/24/88, 9/27/90	WS/WP
Virginia	Analysis of Drinking Water	00297	6/91	1 year		WS/WP
Wisconsin	Environmental Analyses	999615430	6/91	1 year	3/22/90	Annually

NEW YORK STATE DEPARTMENT OF HEALTH CERTIFICATION AND PERFORMANCE EVALUATION SAMPLE RESULTS

Golder Associates

NEW YORK STATE DEPARTMENT OF HEALTH

DAVID AXELROD, M. D. COMMISSIONER

Expires 12:01 AM April 1, 199
ISSUED April 1, 1991
REVISED July 1, 1991

INTERIM CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

Lab ID No.: 10809

Director: DR. MARK BOLLINGER
Lab Name: ROCKY MOUNTAIN ANALYTICAL LAB
Address : 4955 YARROW ST
ARVADA CO 80002

is hereby APPROVED as an Environmental Laboratory for the category

ENVIRONMENTAL ANALYSES NON POTABLE WATER

All approved subcategories and/or analytes are listed below:

Chlor. Hydrocarbon Pesticides :
- 4,4'-DDD
- 4,4'-DDE
- 4,4'-DDT
- alpha-BHC
- Aldrin
- beta-BHC
- Chlordane Total
- ta-BHC
- eldrin
- Endrin aldehyde
- Endrin
- Endosulfan I
- Endosulfan II
- Endosulfan sulfate
- Heptachlor
- Heptachlor epoxide
- Isodrin
- Lindane
- Mirex
- Methoxychlor
- Trifluralin
- Toxaphene

Wastewater Miscellaneous :
- Bromide
- Boron, Total
- Cyanide, Total
- Color
- Corrosivity
- Phenols
- Oil & Grease Total Recoverable
- Hydrogen Ion (pH)
- Specific Conductance
- Silica, Dissolved
- Sulfide (as S)
- Surfactant (MBAS)
- Temperature
- Organic Carbon, Total

Purgeable Aromatics (ALL)

Priority Pollutant Phenols :
- 2,4,6-Trichlorophenol
- 2,4-Dichlorophenol
- 2,4-Dimethylphenol
- 2,4-Dinitrophenol
- 2-Chlorophenol
- 2-Methyl-4,6-dinitrophenol
- 2-Nitrophenol
- 4-Chloro-3-methylphenol
- 4-Nitrophenol
- Phenol
- Pentachlorophenol

Wastewater Metals III (ALL)
Wastewater Metals II (ALL)
Polynuclear Aromatics (ALL)
Purgeable Halocarbons (ALL)

Mineral :
- Acidity
- Alkalinity
- Calcium Hardness
- Chloride
- Fluoride, Total
- Sulfate (as SO4)

Residue :
- Solids, Total Suspended
- Solids, Total

Chlorophenoxy Acid Pesticides (ALL)
Demand (ALL)
Wastewater Metals I (ALL)
Nutrient (ALL)
Polychlorinated Biphenyls (ALL)

Herbert W. Dicke

Serial No.: 09205

Herbert W. Dickerman, M.D., Ph.D., Director
Wadsworth Center for Laboratories and Research

Property of the New York State Department of Health. Valid only at the address shown.
Must be conspicuously posted. Valid certificate has a red serial number.

DOH-3317 (11/90)

Rocky Mountain
Analytical Laboratory

Enseco
A CORNING Company

June 6, 1991

Margaret M. Prevost
Environmental Laboratory Approval Program
New York State Department of Health
Wadsworth Center for Laboratories and Research
P.O. Box 509, Rm. E299B
Albany, New York 12201-0509

Lab ID #10809

Dear Ms. Prevost:

The laboratory investigation of marginal and unsatisfactory analyte results for the ELAP January 1991 Non-Potable Proficiency Tests is enclosed.

Organic/Inorganic Nutrients

Sample 3588 for TKN was reported as 11.8 mg/L exceeding the marginal limits of 7.130 - 10.300. The data were reviewed and all calibrations and laboratory quality control samples were within the laboratory control limits. No definitive reason could be found for the unsatisfactory performance. The laboratory coordinator and analysts have been advised to watch for trends in this analysis.

Sample 3587 for Total Phosphorus was reported as 3.43 mg/L exceeding the marginal limits of 2.22 - 2.88. Sample 3588 for Total Phosphorus was reported as 10.6 mg/L exceeding the satisfactory limits of 8.71 - 10.5. Sample 3528 for Orthophosphate was reported as 1.27 mg/L exceeding the marginal limits of 0.837 - 1.00. The data were reviewed and all calibrations and laboratory quality control samples were within the laboratory control limits. These samples were run with an analytical batch that included a high concentration sample which could have contributed contamination. Glassware cleaning procedures will be reiterated with the analysts for all phosphorus analyses to limit any possible contamination problems.

Enseco Incorporated
4955 Yarrow Street
Arvada, Colorado 80002
303/421-6611 Fax: 303/431-7171

Wastewater Metals

The final result reported from the ICP analysis is the average of two exposures. After review of the data it was determined that the first exposure was run too soon; the instrument was not ready. The second exposure was closer to the satisfactory limits.

Sample 3547:	Element	#1 Exposure	#2 Exposure	Marginal Limits	Sat. Limits
	Cd	7.3	11.8	11.7 - 17.5	12.4 - 16.8
	Zn	637	650.7	626 -794	646 - 774
Sample 3548:					
	Cd	50.9	60.7	61.5 - 82.1	64.0 - 79.7
	Mn	87.7	89.5	87.8 - 113	90.9 - 110
	Zn	2509	2592	2480 - 3200	2560 - 3110

Sample 3547 for Mn was rounded incorrectly, 264.6 was rounded to 264 instead of 265; satisfactory limits: 265 - 309.

For sample 3547, Iron, no definitive error could be found. Instrument calibration was within laboratory control limits and there was no blank contamination.

Selenium for sample 3548 was run at a 20X dilution due to poor analytical spike recovery. The result outside of the satisfactory limits: 174 - 242, but within the marginal limits: 163 - 253 could be attributed to the dilution.

Beryllium for sample 3547 was reported as 741 ug/L, marginal limits: 73.1 - 97.7. This sample was incorrect by a factor of 10 due to a transcription error. This has been brought to the attention of the laboratory.

Purgeable Aromatics

For the 602/8020 analysis there were 2 ampules analyzed for 4 analytes each. The values for Chlorobenzene and Toluene were within the marginal limits and within 6% of the satisfactory limits, each being lower than the satisfactory limits. The other analytes were 1,4-Dichlorobenzene and Total Xylenes. The results were within the satisfactory limits, but each were in the lower end of the limits. Since aliquoting is a critical step that can affect all analytes, this could be a probable cause for such a trend. This will be reviewed with the analysts.

If you have any questions or need additional information, please call me at (303) 421-6611.

Sincerely,

Jan Redenbarger

Jan Redenbarger
QA Scientist

Enclosures

STATE OF NEW YORK
DEPARTMENT OF HEALTH

The Governor Nelson A. Rockefeller Empire State Plaza P.O. Box 509 Albany, New York 12201-0509

Axelrod M D
Commissioner

OFFICE OF PUBLIC HEALTH
ioa A Randolph M D M P H
Director

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH
Herbert W. Dickerman, M.D., Ph.D.
Director

May 8, 1991

LAB ID #10809

DR. MARK BOLLINGER
ROCKY MOUNTAIN ANALYTICAL LAB
4955 YARROW ST
ARVADA CO 80002

Dear DR. BOLLINGER:

Your laboratory's scores for the ELAP January 1991 Non-Potable Water/Solid & Hazardous Waste/Air & Emissions Chemistry Proficiency Test are enclosed. Scores should be interpreted as follows: 4-Satisfactory, 3=Marginal and 0=Unsatisfactory.

No scores are rendered for Non-Potable Water Mercury or Solid and Hazardous Waste Heptachlor Epoxide.

Our statistical analysis of the Mercury data displayed an unacceptably high standard deviation and low recoveries. Those laboratories dependent on demonstrating satisfactory performance in Non-Potable Water Mercury to regain approval should contact the Program for special proficiency test samples.

The Solid and Hazardous Waste sample contained the alpha isomer of Heptachlor Epoxide. Depending on the column and standards used, the alpha isomer is not always distinguishable from the beta isomer. Both isomers have the same CAS number and the EPA has yet to indicate which isomer is covered by the regulations.

Please note that if you submitted results for this test to be handscored, they are not included in this report. You will receive these scores as a separate report in the near future.

You are required to submit to the Program Office, within 30 days of the above date, May 8, 1991, a written statement of the reasons why your laboratory's interim approval should not be terminated for the analyte(s) which did not meet the required score of 75%, including any analytes failed for non-reporting. Your statement should include your ELAP ID Number, the reasons for the unsatisfactory performance and the corrective actions taken.

If there can be a reasonable presumption that the condition causing the unsatisfactory performance no longer exists, the Commissioner may determine not to terminate the laboratory's interim approval in the areas of unsatisfactory performance.

If you fail to respond within 30 days or your statement does not indicate that the problem has been corrected, your interim approval for the analytes may be revoked.

If you have any questions, please do not hesitate to call the ELAP Office at (518) 474-8519.

Sincerely,

Margaret M. Prevost

Margaret M. Prevost
Administrator
Environmental Laboratory
Approval Program

MMP:jj
Enc.

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 59

LABID : 10809 LAB NAME : ROCKY MOUNTAIN ANALYTICAL LAB

TEST DATE: 28-Jan-1991

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
Demand						
Biochemical Oxygen Demand	3257	29.500	25.3000	19.300 - 39.700	16.100 - 42.900	4
Biochemical Oxygen Demand	3307	67.700	57.2000	47.000 - 88.500	40.500 - 95.000	4
Chemical Oxygen Demand	3257	44.500	44.6000	32.900 - 56.000	29.300 - 59.700	4
Chemical Oxygen Demand	3307	102.000	100.0000	85.400 - 119.000	80.100 - 125.000	4
Organic Carbon, Total	3257	18.000	17.8000	15.600 - 20.500	14.800 - 21.300	4
Organic Carbon, Total	3307	41.800	41.6000	36.500 - 47.100	34.900 - 48.800	4
esidue						
lids, Total	3387	254.000	250.0000	227.000 - 282.000	218.000 - 290.000	4
olids, Total	3407	276.000	264.0000	251.000 - 301.000	243.000 - 309.000	4
Solids, Total Suspended	3387	87.000	85.2000	80.800 - 93.100	78.900 - 95.600	4
Solids, Total Suspended	3407	28.400	26.4000	24.800 - 32.000	23.700 - 33.200	4
H Hydrogen Ion (pH)						
Hydrogen Ion (pH)	3177	2.530	2.5600	2.410 - 2.640	2.370 - 2.680	4
Hydrogen Ion (pH)	3187	7.000	7.0600	6.930 - 7.060	6.920 - 7.080	4
rganic Nutrients						
Kjeldahl Nitrogen, Total	3587	4.400	4.4700	3.630 - 5.170	3.390 - 5.420	4
Kjeldahl Nitrogen, Total	3588	8.730	11.8000	7.510 - 9.960	7.130 - 10.300	0
Phosphorus, Total	3587	2.550	3.4300	2.300 - 2.810	2.220 - 2.880	0
Phosphorus, Total	3588	9.630	10.6000	8.710 - 10.500	8.430 - 10.800	3
ota' ''kalinity						
kalinity	3127	86.900	88.8000	81.900 - 92.000	80.300 - 93.500	4
Alkalinity	3128	70.400	73.4000	66.100 - 74.600	64.800 - 76.000	4

NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 59
TEST DATE: 28-Jan-1991

LABID : 10809   LAB NAME : ROCKY MOUNTAIN ANALYTICAL LAB

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
rganic Nutrients						
Ammonia (as N)	3527	1.490	1.5100	1.230 - 1.760	1.150 - 1.840	4
Ammonia (as N)	3528	2.570	2.6600	2.210 - 2.930	2.100 - 3.040	4
Nitrate (as N)	3527	2.000	1.8900	1.760 - 2.230	1.680 - 2.310	4
Nitrate (as N)	3528	9.220	8.5900	8.130 - 10.380	7.790 - 10.600	4
Orthophosphate (as P)	3527	2.350	2.3100	2.140 - 2.550	2.080 - 2.620	4
Orthophosphate (as P)	3528	0.919	1.2700	0.856 - 0.982	0.837 - 1.000	0
Minerals						
[illegible]loride	3467	96.500	94.3000	90.700 - 102.000	88.800 - 104.000	4
Chloride	3477	35.600	33.0000	32.300 - 38.900	31.300 - 40.000	4
Fluoride, Total	3467	2.580	2.5700	2.330 - 2.840	2.250 - 2.920	4
Fluoride, Total	3477	5.790	5.9300	5.210 - 6.370	5.030 - 6.550	4
Potassium, Total	3467	41.400	35.9000	36.100 - 46.600	34.500 - 48.200	3
Potassium, Total	3477	159.000	141.0000	141.000 - 178.000	135.000 - 183.000	4
Sodium, Total	3467	66.400	60.9000	59.400 - 73.300	57.200 - 75.500	4
Sodium, Total	3477	103.000	93.8000	92.300 - 113.000	89.100 - 116.000	4
Sulfate (as SO4)	3467	49.800	45.0000	44.100 - 55.600	42.400 - 57.300	4
Sulfate (as SO4)	3477	345.000	356.0000	302.000 - 389.000	289.000 - 402.000	4
ewater Metals						
Cadmium, Total	3547	14.600	9.6000	12.400 - 16.800	11.700 - 17.500	0
Cadmium, Total	3548	71.800	59.7000	64.000 - 79.700	61.500 - 82.100	0
Copper, Total	3547	101.000	100.0000	90.600 - 112.000	87.200 - 115.000	4
Copper, Total	3548	430.000	396.0000	395.000 - 465.000	384.000 - 476.000	4

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 59
TEST DATE: 28-Jan-1991

LABID : 10809 LAB NAME : ROCKY MOUNTAIN ANALYTICAL LAB

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
Lead, Total	3547	215.000	202.0000	190.000 - 240.000	183.000 - 247.000	4
Lead, Total	3548	358.000	330.0000	314.000 - 401.000	300.000 - 415.000	4
Manganese, Total	3547	287.000	264.0000	265.000 - 309.000	257.000 - 317.000	3
Manganese, Total	3548	101.000	88.6000	90.900 - 110.000	87.800 - 113.000	3
Nickel, Total	3547	146.000	136.0000	130.000 - 162.000	125.000 - 167.000	4
Nickel, Total	3548	435.000	412.0000	395.000 - 475.000	383.000 - 488.000	4
Silver, Total	3547	99.300	93.0000	88.700 - 110.000	85.400 - 113.000	4
Silver, Total	3548	288.000	263.0000	262.000 - 313.000	254.000 - 321.000	4
nc, Total	3547	710.000	644.0000	646.000 - 774.000	626.000 - 794.000	3
Zinc, Total	3548	2840.000	2550.0000	2560.000 - 3110.000	2480.000 - 3200.000	3
Aluminum, Total	3547	138.000	152.0000	101.000 - 176.000	89.100 - 188.000	4
Aluminum, Total	3548	366.000	363.0000	312.000 - 420.000	295.000 - 437.000	4
Arsenic, Total	3547	71.300	72.0000	57.600 - 84.900	53.300 - 89.200	4
Arsenic, Total	3548	143.000	130.0000	117.000 - 169.000	108.000 - 177.000	4
Chromium, Total	3547	69.600	69.5000	54.500 - 84.700	49.700 - 89.400	4
Chromium, Total	3548	283.000	278.0000	246.000 - 321.000	234.000 - 333.000	4
Iron, Total	3547	86.900	123.0000	71.100 - 103.000	66.100 - 108.000	0
Iron, Total	3548	359.000	340.0000	322.000 - 397.000	310.000 - 409.000	4
Selenium, Total	3547	82.800	74.0000	68.900 - 96.800	64.500 - 101.000	4
Selenium, Total	3548	208.000	250.0000	174.000 - 242.000	163.000 - 253.000	3
Antimony, Total	3547	705.000	617.0000	598.000 - 812.000	565.000 - 846.000	4
ntimony, Total	3548	219.000	192.0000	178.000 - 261.000	165.000 - 274.000	4

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH.
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 59
TEST DATE: 28-Jan-1991

LABID : 10809 LAB NAME : ROCKY MOUNTAIN ANALYTICAL LAB

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
Beryllium, Total	3547	85.400	741.0000	76.800 - 94.800	73.100 - 97.700	0
Beryllium, Total	3548	28.300	24.6000	24.200 - 32.400	22.900 - 33.600	4
Cobalt, Total	3547	581.000	536.0000	529.000 - 633.000	512.000 - 650.000	4
Cobalt, Total	3548	290.000	272.0000	259.000 - 321.000	249.000 - 330.000	4
Molybdenum, Total	3547	842.000	810.0000	760.000 - 924.000	734.000 - 950.000	4
Molybdenum, Total	3548	353.000	338.0000	310.000 - 395.000	297.000 - 408.000	4
Titanium, Total	3547	429.000	428.0000	374.000 - 484.000	357.000 - 502.000	4
Titanium, Total	3548	284.000	296.0000	254.000 - 314.000	245.000 - 324.000	4
anadium, Total	3547	569.000	541.0000	520.000 - 618.000	505.000 - 633.000	4
Vanadium, Total	3548	356.000	336.0000	319.000 - 393.000	307.000 - 405.000	4
tal Cyanide						
Cyanide, Total	3607	1.510	1.6500	1.130 - 1.890	1.020 - 2.000	4
Cyanide, Total	3608	2.790	2.7800	2.060 - 3.520	1.830 - 3.750	4
ols						
Phenols	3317	0.349	0.3210	0.288 - 0.410	0.269 - 0.429	4
Phenols	3318	0.101	0.0915	0.081 - 0.121	0.075 - 0.127	4
and Grease						
Oil & Grease Total Recove	3057	48.200	48.9000	39.800 - 56.500	37.200 - 59.200	4
Oil & Grease Total Recove	3058	133.000	121.0000	115.000 - 151.000	110.000 - 156.000	4
eable Aromatics						
1,4-Dichlorobenzene	2897	14.200	11.5000	9.210 - 19.100	7.650 - 20.600	4
1,4-Dichlorobenzene	2898	28.400	22.2000	21.000 - 35.800	18.700 - 38.100	4

NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 59

LABID : 10809 LAB NAME : ROCKY MOUNTAIN ANALYTICAL LAB

TEST DATE: 28-Jan-1991

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
Chlorobenzene	2897	27.800	21.5000	22.800 - 32.900	21.200 - 34.500	3
Chlorobenzene	2898	50.200	39.4000	41.600 - 58.800	38.900 - 61.500	3
Total Xylenes	2897	19.700	15.5000	15.100 - 24.400	13.600 - 25.800	4
Total Xylenes	2898	42.700	34.4000	33.600 - 51.800	30.700 - 54.700	4
Toluene	2897	17.200	13.0000	13.300 - 21.100	12.100 - 22.300	3
Toluene	2898	51.100	40.3000	40.700 - 61.600	37.400 - 64.900	3
Purgeable Halocarbons						
Bromodichloromethane	3107	29.600	23.4000	21.900 - 37.300	19.500 - 39.700	4
Bromodichloromethane	3108	89.900	76.8000	70.600 - 109.000	64.600 - 115.000	4
2-Chloroethylvinyl ether	3107	29.600	25.8000	18.500 - 40.600	15.100 - 44.100	4
2-Chloroethylvinyl ether	3108	61.000	57.7000	35.200 - 86.700	27.100 - 94.800	4
1,2-Dichloroethane	3107	25.600	25.0000	20.300 - 30.900	18.700 - 32.500	4
1,2-Dichloroethane	3108	64.300	60.0000	50.100 - 78.600	45.600 - 83.000	4
1,2-Dichloropropane	3107	16.700	13.5000	13.400 - 20.100	12.400 - 21.100	4
1,2-Dichloropropane	3108	67.300	58.1000	53.600 - 80.900	49.300 - 85.200	4
1,1,1-Trichloroethane	3107	26.300	26.5000	20.000 - 32.700	18.000 - 34.700	4
1,1,1-Trichloroethane	3108	59.500	62.6000	46.100 - 72.900	41.900 - 77.100	4
Vinyl chloride	3107	23.300	13.9000	11.400 - 35.200	7.710 - 38.900	4
Vinyl chloride	3108	33.800	24.6000	16.400 - 51.200	10.900 - 56.700	4
Polynuclear Aromatic Hydrocarbons						
Dibenzo(a,h)anthracene	2977	48.200	55.3000	16.100 - 92.000	6.020 - 106.000	4
Dibenzo(a,h)anthracene	2978	22.800	23.5000	7.610 - 39.200	2.850 - 44.400	4

NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 59
LABID : 10809 LAB NAME : ROCKY MOUNTAIN ANALYTICAL LAB
TEST DATE: 28-Jan-1991

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
Fluoranthene	2977	74.000	67.0000	41.300 - 107.000	31.000 - 117.000	4
Fluoranthene	2978	41.300	35.4000	24.700 - 57.900	19.500 - 63.100	4
Phenanthrene	2977	96.600	94.4000	52.200 - 141.000	38.200 - 155.000	4
Phenanthrene	2978	39.400	36.3000	25.300 - 53.500	20.900 - 57.900	4
Pyrene	2977	64.800	57.7000	31.400 - 98.200	20.900 - 109.000	4
Pyrene	2978	32.600	27.3000	17.200 - 47.900	12.400 - 52.700	4
Priority Pollutant Phenols						
2-Chlorophenol	3047	143.000	141.0000	73.500 - 212.000	51.800 - 234.000	4
2-Chlorophenol	3048	75.500	76.2000	42.800 - 108.000	32.600 - 118.000	4
2,4-Dinitrophenol	3047	23.900	28.4000	7.980 - 54.200	2.990 - 63.700	4
2,4-Dinitrophenol	3048	69.900	82.2000	23.400 - 139.000	8.740 - 161.000	4
2-Nitrophenol	3047	54.600	54.3000	25.800 - 83.400	16.800 - 92.400	4
2-Nitrophenol	3048	111.000	111.0000	57.300 - 165.000	40.400 - 182.000	4
Phenol	3047	59.400	90.1000	19.800 - 117.000	7.430 - 135.000	4
Phenol	3048	31.200	49.0000	10.400 - 59.900	3.900 - 68.900	4
Polychlorinated Biphenyls						
PCB-1232	2537	2.820	1.6900	1.400 - 4.240	0.954 - 4.680	4
PCB-1232	2538	5.600	3.0500	2.970 - 8.220	2.150 - 9.040	4
PCB-1254	2537	2.410	2.4200	1.490 - 3.330	1.200 - 3.620	4
PCB-1254	2538	5.740	6.0300	3.590 - 7.880	2.910 - 8.560	4
Ch[illegible]ated Hydrocarbon Pesticides						
Aldrin	2917	46.300	44.5000	28.400 - 64.300	22.700 - 69.900	4
Aldrin	2918	107.000	103.0000	62.400 - 151.000	48.400 - 165.000	4

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 59
TEST DATE: 28-Jan-1991

LABID : 10889 LAB NAME : ROCKY MOUNTAIN ANALYTICAL LAB

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
4,4'-DDD	2917	28.600	27.9000	15.800 - 41.300	11.800 - 45.300	4
4,4'-DDD	2918	74.700	73.7000	38.300 - 111.000	26.900 - 122.000	4
Endosulfan I	2917	54.400	56.5000	28.000 - 80.800	19.700 - 89.000	4
Endosulfan I	2918	31.400	34.1000	15.800 - 46.900	10.900 - 51.800	4
Heptachlor	2917	101.800	103.0000	59.300 - 142.000	46.400 - 155.000	4
Heptachlor	2918	27.800	31.5000	16.300 - 39.400	12.600 - 43.000	4
Boron, Total	3627	235.000	244.0000	191.000 - 279.000	177.000 - 293.000	4
Boron, Total	3628	632.000	627.0000	556.000 - 708.000	532.000 - 732.000	4

STATE OF NEW YORK
DEPARTMENT OF HEALTH

The Governor Nelson A. Rockefeller Empire State Plaza P.O. Box 509 Albany, New York 12201-0509

David Axelrod, M.D.
Commissioner

OFFICE OF PUBLIC HEALTH
Linda A. Randolph, M.D., M.P.H.
Director

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH
Herbert W. Dickerman, M.D., Ph.D.
Director

November 16, 1990

Dear Laboratory Director:

Your laboratory's handscores for the ELAP July 1990 Non-Potable Water Chemistry Proficiency Test are enclosed.

We apologize for including Mirex as an analyte in the Solid Waste sample 5500. Accreditation for Mirex is not offered in the Solid Waste category. Therefore, those results could not be included on the enclosed report. We regret any inconvenience this may have caused. For your information, the mean of the data submitted for Mirex was 2.55 ug/g. The marginal limits were 0.318 to 7.127.

If you have any questions, please do not hesitate to call the Program Office at (518) 474-8519.

Sincerely,

Linda L. Madlin

Linda L. Madlin
Administrative Assistant
Environmental Laboratory
Approval Program

LLM:mes
Enc.

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER 51
TEST DATE 4-Jul-1991

LABID : 10809 LAB NAME : Rocky Mountain Analytical Lab

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
and						
Biochemical Oxygen Demand	5151	24.600	29.30	15.800 - 33.400	13.000 - 36.200	4
Biochemical Oxygen Demand	7190	72.700	83.70	50.200 - 95.100	43.200 - 102.000	4
Chemical Oxygen Demand	5151	37.200	36.80	27.000 - 47.400	23.700 - 50.600	4
Chemical Oxygen Demand	7190	112.000	111.00	96.900 - 127.000	92.100 - 132.000	4
Organic Carbon, Total	5151	15.200	15.20	13.200 - 17.100	12.600 - 17.700	4
Organic Carbon, Total	7190	44.800	45.70	39.800 - 49.800	38.200 - 51.400	4
Solids, Total	5130	172.000	176.00	148.000 - 196.000	140.000 - 203.000	4
Solids, Total	6131	345.000	351.00	321.000 - 370.000	313.000 - 377.000	4
Solids, Total Suspended	5130	18.800	22.00	15.400 - 22.200	14.400 - 23.200	4
Solids, Total Suspended	6131	47.600	51.20	43.100 - 52.200	41.700 - 53.500	4
Hydrogen Ion (pH)						
Hydrogen Ion (pH)	5117	5.460	5.45	5.390 - 5.520	5.370 - 5.540	4
Hydrogen Ion (pH)	5121	7.900	7.92	7.820 - 7.980	7.790 - 8.010	4
janic Nutrients						
Kjeldahl Nitrogen, Total	5138	2.250	2.20	1.600 - 2.910	1.390 - 3.110	4
Kjeldahl Nitrogen, Total	6138	4.970	4.98	4.250 - 5.690	4.020 - 5.920	4
Phosphorus, Total	5138	3.200	3.04	2.850 - 3.560	2.740 - 3.670	4
Phosphorus, Total	6138	5.360	5.15	4.740 - 5.980	4.550 - 6.180	4
Alkalinity						
Alkalinity	5116	49.500	48.00	45.400 - 53.600	44.100 - 54.900	4
Alkalinity	6116	197.000	199.00	187.000 - 207.000	184.000 - 210.000	4

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 52
TEST DATE: 9-Jul-1990

LABID : 10809 LAB NAME : Rocky Mountain Analytical Lab

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
ganic Nutrients						
Ammonia (as N)	5145	1.970	1.94	1.630 - 2.320	1.530 - 2.420	4
Ammonia (as N)	6145	3.920	3.61	3.440 - 4.410	3.280 - 4.570	4
Nitrate (as N)	5145	3.730	3.68	3.260 - 4.190	3.120 - 4.340	4
Nitrate (as N)	6145	5.890	5.84	5.260 - 6.510	5.070 - 6.710	4
Orthophosphate (as P)	5145	1.520	1.54	1.320 - 1.720	1.260 - 1.780	4
Orthophosphate (as P)	6145	4.520	7.11	4.010 - 5.030	3.850 - 5.190	0
rals						
Chloride	6141	242.000	246.00	227.000 - 257.000	222.000 - 262.000	4
Chloride	8175	302.000	308.00	286.000 - 318.000	281.000 - 323.000	4
Fluoride, Total	6141	5.260	5.79	4.740 - 5.770	4.550 - [illegible]	2
Fluoride, Total	8175	9.060	9.86	8.220 - 9.910	7.960 - 10.200	4
Sulfate (as SO4)	6141	498.000	498.00	456.000 - 541.000	442.000 - 554.000	4
Sulfate (as SO4)	8175	409.000	432.00	364.000 - 454.000	350.000 - 468.000	4
al Cyanide						
Cyanide, Total	5123	1.490	1.47	1.090 - 1.890	0.961 - 2.020	4
Cyanide, Total	6123	2.690	2.70	1.960 - 3.400	1.760 - 3.630	4
nols						
Phenols	5110	0.423	0.40	0.354 - 0.492	0.333 - 0.513	4
Phenols	6110	0.075	0.07	0.057 - 0.093	0.052 - 0.098	4
l Grease						
Oil & Grease Total Recove	5114	29.100	29.70	23.600 - 34.700	21.800 - 36.400	4
Oil & Grease Total Recove	6114	94.900	94.40	80.700 - 109.000	76.300 - 114.000	4

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NEW YORK STATE DEPARTMENT OF HEALTH
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NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 52
TEST DATE: 9-Jul-1990

LABID : 10809   LAB NAME : Rocky Mountain Analytical Lab

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
Purgeable Aromatics						
1,2-Dichlorobenzene	5157	34.100	32.90	23.800 - 44.500	20.500 - 47.700	4
1,2-Dichlorobenzene	6157	68.500	69.30	45.600 - 91.500	38.400 - 98.700	4
Benzene	5157	19.000	13.40	14.400 - 23.500	13.000 - 24.900	3
Benzene	6157	37.400	36.20	29.400 - 45.400	26.900 - 47.900	4
Ethyl benzene	5157	12.100	9.96	9.460 - 14.700	8.640 - 15.600	4
Ethyl benzene	6157	20.300	17.70	15.600 - 25.000	14.100 - 26.500	4
Toluene	5157	26.500	23.60	20.200 - 32.700	18.300 - 34.700	4
Toluene	6157	35.200	32.30	27.000 - 43.400	24.400 - 45.900	4
Purgeable Halocarbons						
Bromomethane	5158	31.600	26.10	17.300 - 45.300	12.800 - 50.300	4
Bromomethane	6158	63.800	56.90	35.500 - 92.000	26.600 - 101.300	4
Carbon tetrachloride	5158	15.900	14.90	10.600 - 21.200	8.880 - 22.900	4
Carbon tetrachloride	6158	63.400	56.50	43.000 - 83.700	36.600 - 90.100	4
Chloroform	5158	45.100	38.70	34.900 - 55.400	31.700 - 58.600	4
Chloroform	6158	22.500	18.90	17.000 - 28.000	15.200 - 29.600	4
Methylene chloride	5158	53.000	52.30	34.900 - 71.000	29.300 - 76.600	4
Methylene chloride	6158	27.000	26.90	16.700 - 37.300	13.500 - 40.500	4
1,1,2,2-Tetrachloroethane	5158	32.000	32.60	23.100 - 40.900	20.300 - 43.700	4
1,1,2,2-Tetrachloroethane	6158	62.500	63.20	44.400 - 80.600	38.700 - 86.300	4
trans-1,3-Dichloropropene	5158	32.800	12.10	14.900 - 50.700	9.340 - 56.300	3
trans-1,3-Dichloropropene	6158	25.500	9.08	12.600 - 38.300	8.530 - 42.400	3

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NEW YORK STATE DEPARTMENT OF HEALTH
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NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 52
TEST DATE: 9-Jul-1990

LABID : 10809 LAB NAME : Rocky Mountain Analytical Lab

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
Polynuclear Aromatic Hydrocarbons						
Anthracene	5162	47.800	38.00	26.800 - 85.100	22.300 - 102.000	4
Anthracene	6162	75.000	72.30	45.900 - 104.000	36.700 - 113.900	4
Benzo(b)fluoranthene	5162	38.000	37.20	19.400 - 74.300	15.800 - 91.700	4
Benzo(b)fluoranthene	6162	96.500	91.70	46.700 - 146.000	31.000 - 162.000	4
Chrysene	5162	59.100	54.80	29.800 - 117.000	24.100 - 145.000	4
Chrysene	6162	23.700	25.00	14.400 - 33.000	11.500 - 35.900	4
Naphthalene	5162	24.200	20.60	13.700 - 34.800	10.400 - 38.100	4
Naphthalene	6162	47.200	28.20	24.900 - 69.400	17.900 - 76.400	4
Priority Pollutant Phenols						
2,4-Dimethylphenol	5136	57.600	56.80	22.300 - 92.900	11.300 - 104.000	4
2,4-Dimethylphenol	6136	90.600	86.40	44.200 - 137.000	29.700 - 151.000	4
4-Nitrophenol	5136	54.600	43.80	18.200 - 114.000	6.820 - 132.000	4
4-Nitrophenol	6136	25.200	13.80	8.410 - 54.200	3.150 - 63.300	4
Pentachlorophenol	5136	41.000	18.70	13.700 - 72.000	5.120 - 81.900	4
Pentachlorophenol	6136	90.500	73.80	32.700 - 148.000	14.600 - 166.000	4
2,4,6-Trichlorophenol	5136	114.000	118.00	60.800 - 168.000	44.000 - 185.000	4
2,4,6-Trichlorophenol	6136	70.300	52.90	39.700 - 101.000	30.200 - 110.900	4
Polychlorinated Biphenyls						
PCB-1221	5131	2.680	2.33	1.270 - 4.100	0.830 - 4.540	4
PCB-1221	6134	5.140	4.14	2.220 - 8.060	1.300 - 8.980	4
PCB-1260	5131	1.990	1.79	1.110 - 2.860	0.839 - 3.130	4
PCB-1260	6134	4.860	4.28	3.010 - 6.700	2.430 - 7.280	4

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

NON-POTABLE WATER CHEMISTRY PROFICIENCY TEST REPORT

TEST NUMBER: 52
TEST DATE: 9-Jul-1990

LABID : 10809 LAB NAME : Rocky Mountain Analytical Lab

Analyte	Sample	Mean	Result	Satisfactory Limits	Marginal Limits	Score
rinated Hydrocarbon Pesticides						
delta-BHC	5122	22.100	17.80	12.800 - 31.400	9.930 - 34.300	4
delta-BHC	6122	53.900	39.40	30.500 - 77.200	23.200 - 84.500	4
4,4'-DDE	5122	44.100	31.60	24.400 - 63.800	18.200 - 69.900	4
4,4'-DDE	6122	85.200	40.80	35.400 - 135.000	19.800 - 151.000	4
Endosulfan sulfate	5122	35.700	33.50	21.100 - 50.300	16.500 - 54.900	4
Endosulfan sulfate	6122	107.000	91.70	58.100 - 155.000	42.800 - 170.000	4
Endrin	5122	26.000	21.40	15.200 - 36.800	11.800 - 40.200	4
Endrin	6122	70.700	50.70	42.200 - 99.200	33.300 - 106.000	4
Heptachlor epoxide	5122	55.000	51.10	31.300 - 78.700	23.900 - 86.100	4
Heptachlor epoxide	6122	108.000	91.70	58.300 - 158.000	42.600 - 174.000	4
ific Conductance						
Specific Conductance	5142	689.000	676.00	631.000 - 746.000	613.000 - 764.000	4
Specific Conductance	6142	1950.000	1870.00	1780.000 - 2110.000	1720.000 - 2170.000	4

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

HAND-SCORED PROFICIENCY TEST REPORT

TEST NUMBER: 50
TEST DATE: 9-Jul-1990

LABID : 10009 LAB NAME : Rocky Mountain Analytical Lab

Analyte	Ampul	Mean	Result	Satisfactory Limits			Marginal Limits			Score
NW Cadmium, Total	5127	43.000	38.000	37.600	-	48.900	35.800	-	50.600	4
NW Cadmium, Total	6127	100.000	98.000	89.600	-	111.000	86.200	-	114.000	4
NW Copper, Total	5127	87.800	86.900	79.800	-	95.700	77.000	-	98.200	4
NW Copper, Total	6127	424.000	420.000	392.000	-	456.000	382.000	-	467.000	4
NW Lead, Total	5127	189.000	200.000	163.000	-	214.000	155.000	-	222.000	4
NW Lead, Total	6127	[illegible]	[illegible]	451.000	-	551.000	435.000	-	566.000	4
nganese, Total	5127	130.000	116.000	115.000	-	140.000	110.000	-	145.000	4
ganese, Total	6127	416.000	405.000	374.000	-	458.000	360.000	-	[illegible]	4
NW Nickel, Total	5127	115.000	111.000	102.000	-	128.000	97.400	-	130.000	4
NW Nickel, Total	6127	505.000	477.000	457.000	-	552.000	453.000	-	565.000	4
NW Silver, Total	5127	71.800	600.000	63.200	-	80.400	60.500	-	83.000	0
NW Silver, Total	6127	336.000	305.000	305.000	-	364.000	296.000		370.000	4
NW Iron, Total	5127	2520.000	2060.000	2300.000	-	2750.000	2230.000	-	2820.000	3
NW Zinc, Total	6127	[illegible]	770.000	770.000		907.000	749.000	-	920.000	4
NW Aluminum, Total	5127	370.000	353.000	307.000	-	430.000	288.000	-	450.000	4
NW Aluminum, Total	6127	524.000	517.000	[illegible]	-	535.000	445.000	-	564.000	4
senic, Total	5127	71.000	51.000	[illegible]		81.500	57.200	-	[illegible]	0
senic, Total	6127	415.000	389.000	352.000		471.000	334.000	-	[illegible]	4

WADSWORTH CENTER FOR LABORATORIES AND RESEARCH
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

HAND-SCORED PROFICIENCY TEST REPORT

TEST NUMBER: 52
TEST DATE: 9-Jul-1990

LABID : 10009 LAB NAME : Rocky Mountain Analytical Lab

Analyte	Ampul	mean	Result	Satisfactory Limits	Marginal Limits	Score
NW Chromium, Total	5127	57.100	65.600	43.700 - 70.500	38.400 - 74.700	4
NW Chromium, Total	6127	505.000	477.000	420.000 - 590.000	397.000 - 612.000	4
NW Iron, Total	5127	147.000	1820.000	127.000 - 167.000	121.000 - 173.000	0
NW Iron, Total	6127	509.000	550.000	461.000 - 555.000	445.000 - 573.000	4
NW Mercury, Total	5127	2.550	2.190	1.190 - 3.910	.757 - 4.340	4
NW Mercury, Total	6127	1.750	.050	.583 - 3.520	.218 - 4.090	4
NW Selenium, Total	5127	115.000	123.000	95.000 - 134.000	88.900 - 141.000	4
NW Selenium, Total	6127	167.000	157.000	138.000 - 196.000	129.000 - 205.000	4
[illegible]timony, Total	5127	299.000	251.000	247.000 - 352.000	230.000 - 369.000	4
NW Antimony, Total	6127	1030.000	928.000	887.000 - 1180.000	841.000 - 1230.000	4
NW Beryllium, Total	5127	21.300	19.700	17.800 - 24.900	16.700 - 26.000	4
NW Beryllium, Total	6127	165.000	155.000	151.000 - 179.000	147.000 - 183.000	4
NW Cobalt, Total	5127	584.000	552.000	525.000 - 640.000	506.000 - 661.000	4
NW Cobalt, Total	6127	856.000	80.400	778.000 - 933.000	754.000 - 957.000	0
NW Molybdenum, Total	5127	355.000	336.000	318.000 - 390.000	304.000 - 405.000	4
NW Molybdenum, Total	6127	657.000	625.000	605.000 - 710.000	588.000 - 730.000	4
NW Titanium, Total	5127	289.000	275.000	262.000 - 316.000	254.000 - 324.000	4
NW Titanium, Total	6127	849.000	770.000	768.000 - 931.000	743.000 - 956.000	4
[illegible]adium, Total	5127	719.000	691.000	668.000 - 771.000	651.000 - 787.000	4
NW Vanadium, Total	6127	418.000	398.000	383.000 - 453.000	373.000 - 463.000	4

DRAFT 373 PERMIT
DATA PACKAGE COMPONENT REQUIREMENTS

3/19/91

373 Appendix III-A

COMPONENTS REQUIRED FOR RCRA ANALYTICAL DATA SUBMITTED TO NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION*

Bell Aerospace Textron

A Report Narrative should accompany each submission, summarizing the contents, data and QA/QC results and all relevant circumstances of the work.

A. Parameter requested.

B. Sample Number or Numbers, Matrix, and:

1. Date and time collected;
2. Date extracted and/or digested;
3. Date and time analyzed; and
4. Chain of custody report and/or form, including confirmation of unbroken chain of custody, intact sample packaging and container seals and adequate temperature and/or other preservation.

C. Results [b,e,f,]

1. Sample Results;
2. Duplicate;
3. Blanks[a];
4. Matrix Spike; matrix spike duplicate; blank spike; and
5. Surrogate recoveries, if applicable.

D. Supporting QA/QC[b]

1. Methodology;
2. Method detection limits, instrument detection limits[c];
3. Linear curves[d];
4. Percent solids for soils, sludges, sediments, and where otherwise applicable;
5. Calculations[d];
6. Cleanup procedures;
7. Data validation procedures, results, and completed data validation checklists; and
8. Documentation which illustrates how blank water is determined to be analyte-free.

In addition to submitting the above, all sample data and its QA/QC data as specified in SW-846, 3rd edition, Chapter 1, must be maintained accessible to NYSDEC either in hard copy or on magnetic tape or disk (computer data files). The data, if requested by NYSDEC, should be formatted as described in SW-846, 3rd edition, Chapter 1. This requirement may be changed in the future to mandate computer data files, accessible to NYSDEC on request.

This does not obviate the requirement to do the QA/QC specified in each individual EPA-approved method.

* Components for RCRA submissions for non-contract Lab Protocols.
If CLP, then CLP deliverables are required, unless otherwise stated in the approved plan.

a The data should include all blanks (trip, equipment rinse, method and instrument blanks) as specified in the sampling and analysis plan, guidance and regulation.

b Supporting QA/QC should be specific to the RCRA samples analyzed.

c Every effort practicable must be made to achieve detection limits below regulatory limits and comparable to or better than the Practical Quantification Limits specified in the EPA-approved methods. In no case, will reporting limits above the specified PQL's be accepted without extensive and complete documentation to the Department.

d These may not need to be submitted if adequate QA/QC summaries validating the data, including calibration control charts, correlation coefficients, etc., are submitted. The Report Narrative should describe the data validation and explain discrepancies. The supporting data should be provided to NYSDEC upon request, without restriction. Calibration data must include date and time of analysis.

e Frequencies of blanks, duplicates, spikes, surrogates, calibrations, standard reference materials, etc., should be as stated in the approved sampling and analysis plan, the approved analytical methods and the SW-846 3rd edition, Chapter 1, requirements. If there are any perceived conflicts, these should be resolved with NYSDEC in advance of sampling.

f Spiking for metals, organics or other parameters must be done before sample preparation (i.e. before digestions, extractions etc.) unless otherwise stated in the approved plan. Furnace analysis for metals will still require post-digestion spikes on all samples analyzed by this technique.

APPENDIX D

Health and Safety Plan

Golder Associates Inc.
CONSULTING ENGINEERS

FINAL
HEALTH AND SAFETY PLAN FOR THE CORRECTIVE MEASURES IMPLEMENTATION PLAN
BELL AEROSPACE WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

Submitted to:

Bell Aerospace Textron Inc.
Niagara Falls, New York

Approvals:

GAI SAFETY OFFICER Anthony L. Grasso/for William E. Harris Date 12/5/91

GAI PROJECT MANAGER Anthony L. Grasso Anthony L. Grasso, P.G. Date 12/5/91

GAI PROJECT COORDINATOR For/ Richard C.F. King, P. Eng. Date 12/5/91

December 1991

913-6384

GOLDER ASSOCIATES INC. • 210 JOHN GLENN DRIVE, SUITE ONE, AMHERST, NEW YORK, U.S.A. 14228 • TELEPHONE (716) 691-1156 • FAX (716) 691-5109

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Golder Associates Inc.
CONSULTING ENGINEERS

December 9, 1991

914-1014

Mr. Brian Smith
Bell Aerospace Textron
Post Office Box One
Buffalo, New York 14240

RE: HEALTH AND SAFETY PLAN
BELL AEROSPACE TEXTRON
WHEATFIELD, NEW YORK

Dear Mr. Smith:

Golder Associates Inc. (Golder Associates) is pleased to present the final Health and Safety Plan for Bell Aerospace Textron (BAT), Wheatfield, New York facility. This Health and Safety Plan will supplement the pending Corrective Measures Implementation (CMI) Plan. The Health and Safety Plan has been modified to incorporate comments from the New York State Department of Environmental Conservation (NYSDEC) and the New York State Department of Health (NYSDOH), as presented in a letter dated October 17, 1991, on the revised Draft Health and Safety Plan.

As always, Golder Associates appreciates the opportunity to provide continuing services to BAT. Please call if you have any questions.

Very truly yours,

GOLDER ASSOCIATES INC.

Anthony L. Grasso

Anthony L. Grasso, P.G.
Senior Hydrogeologist

for/ Richard C. F. King, P.Eng.
Principal

ALG/RCFK:dml/cr

F/N: COVER.FIN

GOLDER ASSOCIATES INC. • 210 JOHN GLENN DRIVE, SUITE ONE, AMHERST, NEW YORK, U.S.A. 14228 • TELEPHONE (716) 691-1156 • FAX (716) 691-5109

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APPENDIX B - Daily Air Monitoring Sheet

1.0 GENERAL REQUIREMENTS

This document describes the general Health and Safety Program to be utilized during the activities outlined in the Corrective Measures Implementation Plan (CMI) at the Bell Aerospace Textron (BAT), Wheatfield Plant, Niagara Falls, New York. Specific amendments to this document may be issued for particular tasks if activities or conditions requiring specialized protocols are encountered. The plan includes a description of BAT site security, general precautionary procedures to be followed during implementation activities, decontamination and waste disposal practices and emergency safety equipment required. Adherence to this plan will minimize the potential that personnel or the surrounding community will be injured or exposed to contaminants during remedial activities. This plan is intended to govern the activities and be for the sole use of Golder Associates Inc. (Golder) employees and provide guidance for Golder subcontractors, along with BAT subcontractors operating under the guidance of the Safety Officer or their designated representative. Golder employees, Golder subcontractors, and BAT subcontractors will also adhere to local, State, and Federal regulations, such as 29 CFR 1910 and 1926, during the activities outlined in the CMI Plan.

A Safety Officer or their designated representative shall be available whenever CMI tasks requiring active air monitoring are performed. Golder's on-site Health and Safety Coordinator will be the assigned Safety Officer or their designated representative and liaise directly to the BAT's Health and Safety Manager, Golder's Project Manager and Golder's Health and Safety Officer. All Golder employees and subcontracted personnel, who are directly involved with the remediation activities as defined in the CMI, will have received a minimum of forty (40) hours of training as prescribed by OSHA (29 CFR 1910.120) and have received annual eight (8) hour updates, or be denied access to active working areas. Copies of documentation noting an individual's attendance to appropriate training courses shall be maintained in the registry of records.

All involved Golder personnel, subcontractors and their employees are required to be familiar with, and follow the guidelines presented in, this plan and sign the attached acknowledgement form to ensure that the necessary health and safety requirements are complied with. Additionally, Golder and subcontractor personnel should be familiar with the location and use of all on-site safety equipment. (see section 6.0)

1.1 Safety Officer

Golder Associates utilizes a multilayered hierarchy of health and safety professionals, with the Safety Officer or their designated representative being ultimately responsible for daily implementation, adherence to guidelines, safety briefings, and recommendations for modification of this document. Particularly, this individual shall verify that each party or firm engaged in construction of CMI components is made aware of the health and safety provisions contained herein through the receipt of the Acknowledgement Form contained in Appendix (A) of this document and regularly update the BAT Health and Safety Manager of any discrepancies. Additionally, the identified Safety Officer or their designated representative will discuss with individuals engaged in observed CMI tasks, the risks associated with exposure to the identified contaminants, verify proper use of monitoring equipment, review the use of protective safety equipment and identify the action levels listed within this plan to protect the worker from exposure. Lastly, the Safety Officer or their designated representative shall retain the authority to suspend activities if conditions arise that pose an imminent threat to either the worker's safety, the surrounding community, or the environment.

1.2 Emergency Response

All health, fire or utility emergencies involving on-site BAT or off-site municipal emergency organizations (fire, police, ambulance) during the course of CMI activities will be handled in accordance with BAT's Contingency Plan and Emergency Procedures Manual (Reference 1). In addition, prior to the commencement of work activities, notification to local police, fire department, and potential rescue personnel (i.e. paramedics) will be made advising them of the remedial activities and the proposed schedule of events. In the case of such emergencies, the Golder Safety Officer, the drilling contractor, or groundwater treatment contractor will immediately contact the BAT Safety Department, who will then contact the appropriate emergency agency, unless an event of life threatening magnitude has occurred wherein immediate medical attention is required.

Contacts at the BAT Safety Department are:

Primary Emergency Coordinator:	Robert Sherwood	Ext 6764
First Emergency Coordinator:	Joseph Winarski	Ext 6960
Second Emergency Coordinator:	Brian Smith	Ext 6754
BAT Emergency Telephone:	(716) 298-Extension Listed	

These phone numbers, along with those of local police, fire and paramedics, and a map showing routes to the nearest hospital or medical emergency facility should be posted at the work site and in all vehicles operated by Golder or CMI Contractors. A listing of these numbers is contained in Table 1 and a proposed route to the nearest hospital is shown in Figure 1.

1.3 Medical Examination

Personnel specifically involved in CMI activities shall have received a medical examination in compliance with CFR 1910.120 (f) within one year of commencement of this work and have been updated at least annually. A registry of medical examination dates shall be established and maintained on site, as part of the Registry of Records. Information included in the medical registry shall be: name of the person, address, age, social security number, and name and address of the examining physician. Copies of this registry shall be made available to NYSDEC.

1.4 Description of Site Tasks

Refer to CMI plan and the anticipated activities. On- and Off-site activities include surveying of locations, drilling of extraction wells, setting of pumping equipment, excavation for trenches and manholes, laying of double containment piping, etc.

1.5 Registry of Records

A Registry of Records containing acknowledgement forms, medical exam history, required training and air monitoring results will be maintained in the project office. At a minimum, each Golder employee and subcontractor employee shall provide copies of their most recent medical surveillance records, OSHA training certificate or update and a signed copy of their Health and Safety Acknowledgement/Acceptance Form.

2.0 SITE SECURITY

The BAT plant is a secure facility surrounded by a chain-link fence topped with barbed wire. Thus, the drilling equipment and tools used on-site should be reasonably secure; provisions for any additional security measures should be determined by the Contractor in consultation with BAT. However, no security exists presently in the off-site location, between Jagow Road and Cayuga Drive, within the Niagara Mohawk Power Corp. alignment. Therefore, all activities must be concluded at the end of the day, and left in a manner as to not create either a nuisance or hazard to the community or environment. At a minimum, warning signs and temporary fencing will be installed within the Niagara Mohawk Power Corp. alignment to delineate the work zone and to inhibit unauthorized access. Use of additional temporary security measures shall be reviewed on a case by case basis, and subject to approval by BAT, Golder and local health departments.

3.0 STANDARD PRECAUTIONARY PROCEDURES

In addition to the personal protective equipment described in the following sections, safe operations require responsibility and common sense on the part of everyone. Safe working practices, as detailed by OSHA, shall be adhered to, along with the following additional special safety procedures:

a. An exclusion zone, or work areas/zones, will be defined by a construction flagging barrier which shall surround the exclusion zone. An entrance way into the exclusion zone and an exit way from the exclusion zone shall also be defined;

b. Personnel working within the exclusion zone, handling drilling or sampling equipment, or handling samples or cuttings, shall wear a hard hat, safety glasses, disposable blue tyveks, rubber gloves, steel-toe rubber boots and have received 40 hours of health and safety training as a minimum;

c. No smoking, eating, drinking, chewing gum or tobacco is permitted during drilling or sampling;

d. No gloves or boots worn in the exclusion zone shall be removed without being cleaned, unless they are disposed of in a drum of discarded clothing which will then be stored on-site and become the responsibility of BAT;

e. Upon leaving the exclusion zone, personal protective equipment will be appropriately cleaned or disposed of, be removed and personnel will thoroughly wash their face and hands;

f. Do not unnecessarily walk through puddles, pools or mud. Do not lean, sit or place equipment on drums of unknown or hazardous substances. Avoid contact with suspected contaminated materials;

g. Beards or mustaches which interfere with satisfactory fitting of respiratory protection equipment are prohibited;

h. Visitors are not allowed within the exclusion zone unless they have completed a 24 hour Health and Safety training course (CFR 1910.120) and are authorized representatives of BAT, Golder Associates, the drilling contractor, or the regulatory agencies, and the air monitoring equipment is reading background levels. Any such visitors are responsible for their own personal protective equipment and shall be informed that such equipment is required. Visitor's names and company or agency affiliation shall be noted in the daily records; and,

i. During active drilling operations, at least two people, meeting all specified requirements, shall be present at the drill rig, groundwater discharge area or soil excavation (i.e. instrument technician and operator or professional).

4.0 PROTECTIVE EQUIPMENT

All contractor personal protective equipment required by this plan shall be supplied by the Contractor. Specific safety equipment required by OSHA, for a particular trade or subcontractor, shall be that entity's responsibility. Use of personal protective equipment, against specific known chemical constituents, is described below and is based on action levels detailed herein.

4.1 Site Background

Previous groundwater monitoring programs have shown that volatile organics constitute the major source of groundwater contamination at the BAT site. Low levels of PCBs and polycyclicaromatic compounds have also been detected. Based on the results of recent groundwater sampling (January 1991) for quarterly monitoring, the major contaminants (and maximum concentrations) detected in the groundwater below the site were trichloroethylene (7300 ppb), methylene chloride (4500 ppb), trans 1,2-dichloroethene (640 ppb), acetone (870 ppb), carbon disulfide (350 ppb), and vinyl chloride (80 ppb). Dense non-aqueous phase liquids (DNAPLs) are known to be present in the subsurface and are composed of up to 95% trichloroethylene, methylene chloride, PCBs (300 ppm), and small quantities of semivolatile organic compounds.

The available groundwater and soil chemistry analytical data suggest that personal protective equipment is necessary. Previous experience during drilling and well development indicates that Level D or Level C respiratory protection with dermal protection should provide adequate protection.

4.2 Off-Site Conditions

Previous groundwater sampling and evaluation programs, along with prior drilling experience, indicate that probable airborne concentrations in planned off-site work areas will not typically exceed a 5 ppm above background action value during activities which expose subsurface soils or groundwater. During planned activities that may create possible exposure (which shall include subsurface drilling, trenching, and ditching), continuous air monitoring is considered essential to protect the health of workers, and the surrounding community, and minimize environmental effects. However, indications show that some areas of greater hazard may exist and use of full-face air-purifying respirators and chemically resistant clothing may be reasonably anticipated. Level C requirements will be determined from air monitoring, and in the event such conditions are encountered (see Table 2), the appropriate protective measures will be enacted.

4.3 On-Site Conditions

Historically, groundwater and soils beneath the BAT site proper have shown higher concentrations of the chemical compounds outlined above. Therefore, a heightened sense of awareness will be required on the BAT site proper due to the increased risk of exposure. It is anticipated that dermal protection will be required for drilling and excavating activities on-site and that ambient air monitoring will be used to evaluate the need for air-purifying respirators.

4.4 Air Monitoring Program

Since the presence of volatile organic compounds is known to exist in the subsurface soils and groundwater, work occurring in conjunction with the execution of approved remedial activities, which will expose workers to either the subsurface soils or groundwater, will be performed in the presence of appropriate air monitoring equipment, operated by a qualified individual. The air monitoring program defined herein will be implemented to assess potential worker and the surrounding community exposures. Both Flame Ionization Detectors (FIDs) and Photoionization Detectors (PIDs) are acceptable for monitoring ambient air conditions for organic vapors. A FID, with portable chromatographic capabilities is preferable to a PID, as PIDs are susceptible to humidity. However, if there are large quantities of methane present, the PID will react more favorably than the FID. Use of a portable particulate meter, with settable alarms, at the downwind perimeter of the exclusion zone is also required. Therefore, the preferred suite of air monitoring instruments would be;

PREFERRED

For organic vapors-Foxboro 128 GC FID
For toxic/explosive conditions-MSA 361 Multimeter
For Particulate Matter-Continuous Reading Meter

BACK-UP

For organic vapors-OVM, Microtip or Hnu 10.2 eV PID

For toxic/explosive conditions-since confined space entry and flammability are not considered likely, no back up is specified

For Particulate Matter no back up is specified

In the event that air monitoring of organic vapors indicates an increase of 5 ppm or greater over background in the ambient air (breathing zone) within the exclusion zone, or if air monitoring of organic vapors indicates an increase of 5 ppm or greater over background in the ambient air downwind and outside of the exclusion zone (which will provide a measure of protection for the surrounding community), the following steps will be enacted:

1. Work activities will be temporarily suspended;
2. Air monitoring will continue up and downwind (outside of the exclusion zone) from a safe distance. If the condition abates, continue activities; if levels remain 5 ppm above background within the exclusion zone and are below 5 ppm above background outside of the exclusion zone, proceed to step 3;
3. Establish the exclusion zone as a Level C respiratory protection zone;
4. Workers will don full-face air purifying respirators, secure equipment, and move upwind;
5. If the readings remain below 25 ppm above background in the breathing zone and air monitoring of the areas downwind from the exclusion zone are not 5 ppm above background levels, work may resume, using Level C respiratory protection within the exclusion zone;
6. If readings persist above 25 ppm in the breathing zone within the exclusion zone or 5 ppm above background levels outside (downwind) of the exclusion zone, activities within the exclusion zone will be suspended and the air will be monitored at the downwind perimeter of the exclusion zone;

Additionally, the Safety Officer or their designated representative will notify their project manager and the BAT manager of this condition. According to New

York State this may indicate the case of a major vapor emission, as such the protocol specified in section 4.6 would govern.

7. Continuous air monitoring, with no work activities occurring in the exclusion zone, will continue until the airborne concentration returns to less than 25 ppm above background within the exclusion zone and less than 5 ppm above background levels outside of the exclusion zone. Work may resume, with level C dermal and respiratory protection once the ambient air conditions stabilize below 25 ppm above background within the exclusion zone and less than 5 ppm above background levels outside the exclusion zone; and,

8. If ambient air conditions fall to within 5 ppm of background levels within the exclusion zone and outside of the exclusion zone and stabilize, the work area may be downgraded to Level D respiratory protection, at the discretion of the Safety Officer or their designated representative.

In the event that continuous monitoring of particulate matter indicates levels greater than 150 ug/m^3, over a 15 minute time interval at the perimeter of the exclusion zone, the following steps shall be enacted:

1. Temporarily suspend operations;
2. Move to the upwind perimeter of the exclusion zone and monitor particulate levels;
3. If the upwind and downwind levels are within 100 ug/m3 of each other, re-commence activities;
4. If the upwind and downwind levels are over 100 ug/m3 of each other, suspend operations and report to Project Manager and BAT contact; and,
5. Begin appropriate correct actions based on guidance of Project Manager and BAT contact.

Additionally, flammability will be regularly monitored at the work site during drilling and at the well head by use of a combustible vapor analyzer. Drilling activity will be stopped when combustible vapor concentrations exceed 25 percent of the lower explosive limit (LEL) one foot above the top of casing and conditions will be monitored from a safe distance. If the condition does not subside, contact the Project Manager and Health and Safety Officer for further instructions.

Records of all daily air monitoring readings will be maintained by the technician operating the air monitoring equipment and the on-site Safety Officer shall collect and maintain these records. The daily log will be reviewed regularly by the both the BAT and Golder Safety Officers who may recommend changes in the air monitoring program and level of protection required. Air monitoring records will be kept on file and will be available for State personnel to review. An example "Air Monitoring Data Sheet", which will be used to record the daily air monitoring readings is presented as Appendix B.

4.5 Levels of Protection

The standard level of protection for CMI activities which disturb the subsurface or involve extraction of groundwater shall be termed Level D Personal Protection and includes the following at a minimum:

- Continuous Air Monitoring with a FID or PID;
- Continuous Air Monitoring with a CGI, if deemed necessary;
- Continuous Air Monitoring with Particulate Matter meter;
- Disposable Coveralls -Blue Tyvek off-site
  -Blue or White Tyvek on-site
  (Note; Grey PE coated also acceptable when raining)
    - Boots-Chemical-resistant steel-toed and shanked;
    - Safety glasses or safety goggles;
    - Hard hat-face shield, if splash hazard exists;
- Gloves-inner latex or vinyl surgeons glove;
- Gloves-outer, chemically resistant (<u>nitrile</u> for groundwater and short-term DNAPL exposure); and,
- Gloves-cotton, if necessary.

In addition to the above, when air monitoring indicates the need to upgrade, Level

C personal protection will include and be available on-site:

- Full-face, air-purifying respirator (MSHA/NIOSH approved) with acid gas/organic vapor cartridges;
- Gloves - outer, chemically resistant (NBR, Viton, etc); and,
- Disposable Booties - disposable, outer, chemically resistant.

As previously discussed, it is contemplated that work will continue with only Level D personal protection, although at times Level C personal protection may be required. The total atmospheric concentrations of unidentified vapors or gases will determine the level of required respiratory and dermal protection. Personnel will upgrade to Level C respiratory protection when monitoring with an organic vapor detector reveals that airborne contamination levels in the breathing zone exceed the established upwind background by 5 ppm for more than a short duration.

4.6 Major Emissions Response

In the event that vapor emissions exceed 5 ppm above background at the perimeter of the established exclusion zone, drilling, pumping or excavation operations must be suspended. If monitoring indicates a reduction of volatile vapor concentrations in ambient air, operations may resume, but more frequent observations of perimeter air quality must be performed. If, however, the levels measured at the perimeter remain 5 ppm above background, but less than 25 ppm, operations may resume provided:

a. Workers shall don appropriate protective equipment;

b. Downwind vapor concentrations measured either 200 feet downwind or half the distance to the nearest structure, which ever is less, indicate an ambient air concentration less than 5 ppm above background; and,

c. Air monitoring intervals are decreased, thereby increasing the frequency of downwind monitoring.

In the event that levels remain 25 ppm or more above background, at the perimeter of the exclusion zone, work must be suspended and monitoring continued downwind. If levels of volatilized organics are 5 ppm above background 200 feet downwind or halfway to the nearest structure, a 20 foot buffer zone shall be established around that structure. If levels within the 20 foot buffer zone remain elevated 5 ppm above background for more than 30 minutes, then the Major Vapor Emission Response Plan shall automatically be placed in effect which is described below.

The Major Vapor Emission Response Plan shall consist of the following steps:

1. Notify the BAT Health and Safety Officer, who will in turn notify the local police of the situation;
2. Air monitoring within the 20 foot zone shall be conducted at 30 minute intervals. If two successive readings fall below the 5 ppm action level, the event shall be considered over and emergency services may be demobilized; and,
3. All emergency contacts or BAT actions shall go into effect.

5.0 DECONTAMINATION AND WASTE DISPOSAL

A decontamination facility has been established for equipment used during the investigation. This is situated near building 70, on the BAT site. Adequate water supply is available for the decontamination of equipment, tools, personnel footwear, etc exposed to contaminated groundwater. The wash water and the rinse water shall be collected and stored in a water storage tank for subsequent treatment. Methods for off-site decontamination of personnel protective equipment and collection of waste will be implemented. The personal protective gear and clothing that is worn during activities which expose the worker to contaminated groundwater will be disposed of in closed waste containers for future disposal by BAT, or decontaminated and re-used, if appropriate. Additionally, any groundwater or drill cuttings retrieved from contaminated areas shall be containerized and retained by BAT for future disposal. As no off-site soil contamination has been identified, this requirement is not applicable to excavated off-site soils unless conditions indicate otherwise.

6.0 EMERGENCY SAFETY EQUIPMENT

Emergency safety equipment will be available at all times when CMI activities are occurring which may expose workers to subsurface conditions. The Contractor shall ensure that the following items are available either within the exclusion zone or immediately adjacent as a minimum;

1. A first aid kit (Johnson and Johnson Standard Industrial First Aid Kit) or equivalent;
2. Emergency Eyewash Station;
3. Washing facilities for routine decontamination; and,
4. Fully charged Halon fire extinguisher (30 lbs minimum).

Each item shall be stored at the border of the exclusion zone and be immediately available. Additionally, emergency showers are standard emergency safety equipment at the plant site and the Contractor should determine where the stations are in relation to the work locations and ensure that the equipment is functioning properly. All safety equipment will be readily accessible and must be maintained in a clean and workable condition.

7.0 CALIBRATION

The calibration must be checked in the field daily to establish a frame of reference and to verify that the instrument is working properly. Also, each direct reading air-monitoring instrument must have the calibration verified at a maintenance facility at least once every three months and have a manufacturers approved calibration yearly, if required. Golder owned and maintained equipment shall meet the above guidelines, but will have calibration verified in Golder's equipment laboratory. Unless otherwise specified in the Task-Specific Health and Safety Addendum, each instrument shall be field calibrated weekly, at a minimum, according to the manufacturers instructions (see Table 3).

REFERENCE

1. Bell Aerospace Textron, "Contingency Plan and Emergency Procedures", February 1990.

TABLE #1

EMERGENCY TELEPHONE NUMBERS

SHERIFF	911	(716) 434-6611
FIRE, AIRPORT	911	(716) 236-2000
PARAMEDICS	911	
HOSPITALS	Niagara Falls Memorial	(716) 278-4000
	DeGraff Hospital	(716) 694-4500
	St. Mary's Hospital	(716) 297-4800
BAT Contacts	Robert Sherwood*	(716) 298-6764
	Joseph Winarski*	(716) 298-6960
	Brian Smith*	(716) 298-6754
NYSDEC	Mark Hans	(716) 851-7220
NYSDOH	Cameron O'Connor	(716) 847-4502
NCHD	Paul Dicky	(716) 284-3128
GOLDER Contacts	Anthony Grasso	(716) 691-1156 (O) (716) 875-4767 (H)
	William Harris	(609) 273-1110 (O) (609) 268-2591 (H)

** Home numbers for these personnel are listed in the BAT Contingency Plan.*

TABLE #2
AIR MONITORING ACTION LEVELS

READING ABOVE BACKGROUND (ppm)	LEVEL OF PROTECTION (see table below)	RESPONSE
0-5	Level D-1	None required
5-25	Level C-2	Don air purifying respirator, suspend activities temporarily, continue monitoring
+25	Level C-2	Suspend activities, continue monitoring notify BAT Institute M. V. E. Protocol

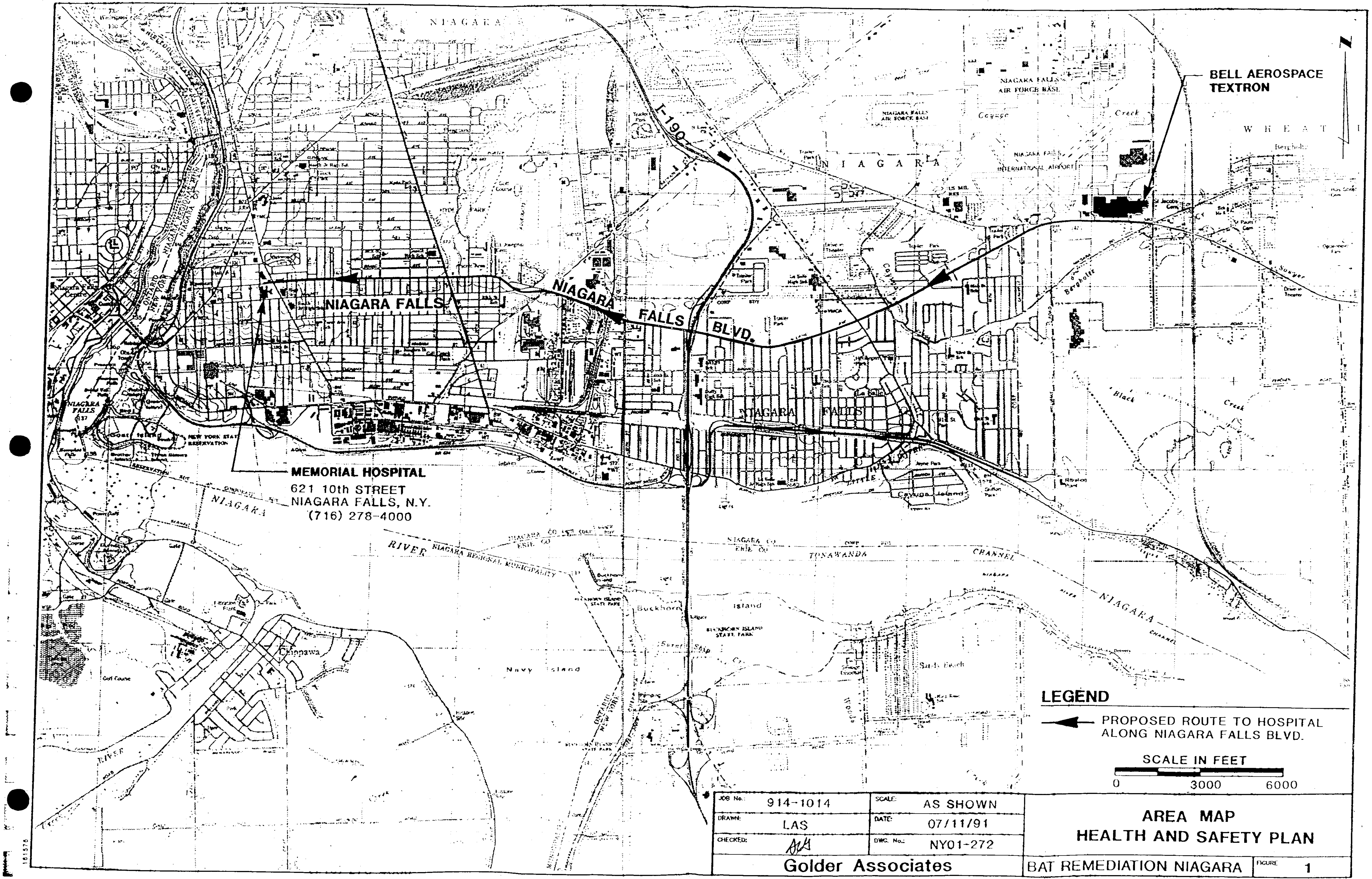
M. V. E. = Major Vapor Emmission

PERSONAL PROTECTION LEVEL

LEVEL	DESCRIPTION
D-1	Hard hat, safety glasses, disposable tyvek suit, liner gloves, work or nitrile glove, steel toed chemically resistant boot
C-1	above with air purifying respirator, use full face if splash hazard exists
C-2	if splash hazard exists, use full-face respirator and P.E. coated tyveks

TABLE #3
AIR MONITORING EQUIPMENT
CALIBRATION SUMMARY

DEVICE	FREQUENCY	DESCRIPTION
FOXBORO OVA Model 128 GC	DAILY	Verify calibration/operation with Methane (9 ppm), before and after work day
	WEEKLY	Recalibrate using 9 ppm, 90 ppm and 900 ppm Methane to insure linear response
	QUARTERLY	Return to Golder's lab for calibration verification
MSA 361 MULTI-METER	DAILY	Verify operation using ambient air, 15% O2 mixture, 10 ppm H2S for Toxic Gas and 2.5% Methane for Lower Explosive Limit
	WEEKLY	As above, with the addition of 40 ppm H2S, and 1.25% Pentane to verify response
	QUARTERLY	Return to Golder's lab for calibration verification
PID OVM/HNU/TIP	DAILY	Verify operation using 100 ppm isobutylene with the appropriate span setting. Span setting based on lamp type
	WEEKLY	As above, allow gas to flow and device to stablize, adjust per manufacturer's instructions
	QUARTERLY	Return to Golder's lab for calibration verification



BELL AEROSPACE TEXTRON

MEMORIAL HOSPITAL
621 10th STREET
NIAGARA FALLS, N.Y.
(716) 278-4000

LEGEND

⟵ PROPOSED ROUTE TO HOSPITAL ALONG NIAGARA FALLS BLVD.

SCALE IN FEET
0 3000 6000

JOB No.: 914-1014	SCALE: AS SHOWN	AREA MAP HEALTH AND SAFETY PLAN		
DRAWN: LAS	DATE: 07/11/91			
CHECKED: AW	DWG. No.: NY01-272			
Golder Associates		BAT REMEDIATION NIAGARA	FIGURE	1

APPENDIX A

Acknowledgement of Safety Briefing

Job No. ____________ Short Title: ________________

ACKNOWLEDGEMENT OF SAFETY BRIEFING

I hereby acknowledge that I have been given a safety briefing on the work I am to do at the above-referenced site. I understand that the site may contain materials classified by EPA or others as potentially hazardous. I have read and understand the safety plans for this project and will adhere to the procedures contained therein. I have been instructed in and understand the use of the safety equipment for this project. I understand that failure to follow the safety plan may result in dismissal from employment.

Employee

DATE ______________________________

PRINT NAME __________________________

SIGNED ____________________________

Project Manager or Representative

DATE ______________________________

PRINT NAME __________________________

SIGNED ____________________________

Original - Job File
1 Copy - Personnel File
1 Copy - Safety File

APPENDIX B

Daily Air Monitoring Sheet

Golder Associates Inc.

AIR MONITORING DATA SHEET

Date ____________ Sheet ______ of ______

Job Name ______________________________ Job Number ______________

Location ____

Time In ________ Time Out ________ Weather ____________ Temp. ______ Wind D. ______ V ______

Instrument Type ______________________________ Serial No. ______________

Calibration Gas and Concentration ______________ Instrument Reading ____________ Span/Gain/RF Setting ____________

** If more than one instrument is used, document calibration procedures and results for each additional instrument in recommendations section below and indicate the instrument used (eg. OVA, 361, OVM, etc.) for each observation.*

Time	Station	Instr. *	Reading	Procedure/Observations/Comments

Recommendations

____

____

____

____

____

______________________________ ______________________________

Printed Name Signature

APPENDIX E

Solute and Transport Model

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1.0 INTRODUCTION

Ground water flow and solute transport modeling studies were carried out for the Bell Aerospace Textron (BAT) Wheatfield Plant site located in Niagara Falls, New York. The modeling studies were based upon the results of previous field investigations at the site (Golder Associates Inc. (Golder Associates) February 1991) and pertinent literature. The investigations were carried out for the RCRA Facility Investigation (RFI) of the Neutralization Pond Solid Waste Management Unit (SWMU) in compliance with Consent Order #RCRA 85-010-91, Index No. 051485 between BAT and the New York State Department of Environmental Conservation (NYSDEC). The report included the site history; regional and site specific geologic and hydrogeologic characteristics; analytical results from soil, surface water, and ground water sampling; and the interpreted nature and extent of ground water contamination at the site. The RFI Report was submitted in draft form on February 12, 1991.

A Corrective Measures Study (CMS) has been completed to develop corrective measures for the ground water degradation related to the Neutralization Pond SWMU. This CMS study, which was submitted in draft form on April 17, 1991 and was accepted as final by NYSDEC on June 7, 1991 indicated that ground water control and extraction and treatment would form the major components of the corrective action for the site.

The numerical ground water flow modeling portion of this project was completed and reported in the CMS report (Golder Associates, April 1991). Solute transport modeling and other associated modeling studies are included in this report which is provided as an addendum to the Corrective Measures Implementation Plans (CMI Plan). These studies include numerical and analytical solute transport modeling, and analytical ground water flow modeling. The modeling objective, modeling approach, database, and results of each modeling study are presented in detail in the following sections. To show the basis and background for the modeling studies, the geologic and hydrogeologic characteristics, nature and extent of ground water contamination, and rate of contaminant migration have been summarized from previous reports and presented herein in sections preceding the modeling studies.

2.0 PURPOSE AND OBJECTIVE OF MODELING

The primary objectives of the solute transport modeling study of the BAT site include the following:

- Determination of the potential rate of cleanup of the dissolved phase plume in Zone 1 due to the effects of the corrective measures (ground water control and extraction from Zone 1);
- Estimate the quantities of volatile organic compounds (VOCs) which will be discharged from the extraction systems;
- Assessment of molecular diffusion against flowing ground water on the off-site dissolved phase plume in Zone 1;
- Determination of the hydraulic interaction between Zone 1 and the Overburden soils under pumping conditions in Zone 1;
- Determination of the hydraulic interaction between Zone 1 and Zone 3 under pumping conditions in Zone 1;
- Determination of the hydraulic interaction between Zone 1 and surface water bodies under pumping conditions in Zone 1; and
- Analysis of matrix diffusion for a system of parallel fractures to determine if the matrix diffusion will significantly influence cleanup rates.

Both numerical and analytical solute transport modeling were conducted in an attempt to satisfy these objectives.

3.0 SITE GEOLOGY AND HYDROGEOLOGY

3.1 Data Sources

Initial hydrogeologic investigations of the BAT site were performed by Goldberg-Zoino Associates Inc. (GZA) between 1982 and 1985 (G. P. Kruseman and N. A. DeRidder (Kruseman, et al.), 1983). Interim monitoring of the wells installed by GZA was continued by Frontier Technical Associates, Inc. between 1986 and 1987. The RFI was completed in five phases of investigation by Golder Associates between 1987 and 1990. Various aquifer testing programs were performed during these investigations. These programs included:

- Pump-in tests;
- A large scale pump-out test;
- Step-drawdown testing;
- Rising/falling head tests; and
- Packer testing.

The final draft report, "Results of the Pump-In and Pump-Out Testing, Bell Aerospace Textron, Wheatfield Plant, New York," was completed in early 1990 and submitted to NYSDEC on February 23, 1990 (Golder Associates, February 1990; Golder Associates, October 1990). The draft final RFI was completed by Golder Associates in early 1991 (Golder Associates, February 1991) and accepted as final by NYSDEC on April 17, 1991. The RFI report summarized the results of the geologic, hydrogeologic and plume definition investigations. The above referenced documents were used as data sources for the previous ground water modeling effort (reported in the CMS report) and for the solute transport modeling reported in this document.

3.2 Site Geology

The subsurface material at the site is Overburden soil composed of glacio-lacustrine silts and clays with occasional sand lenses, and glacial till underlain by Middle Silurian dolomitic bedrock. Based upon geologic and hydrogeologic characteristics, the bedrock strata have been subdivided into four hydrostratigraphic zones as follows (Golder Associates, April 1991, Figure 4):

3.2.1 Zone 1 (Ten Feet to 20 Feet Thick)

Consists of fine grained, thinly bedded, light brownish-gray dolomite with numerous open bedding partings (bedding fractures) that have been formed by the weathering of gypsum from the bedding planes due to the dissolving action of moving ground water. The influence of weathering is most pronounced in the upper one foot to five feet of rock beneath the bedrock surface, and in the lower one foot to two feet of the zone. This lower zone stratum has been termed the A Marker Bed and is recognized as a bed of dolomite with abundant intergranular gypsum. The A Marker Bed frequently contains open bedding planes and is usually the most permeable section of the bedrock encountered at site.

3.2.2 Zone 2 (Six Feet to Seven Feet Thick)

Consists of fresh (unweathered) medium to thickly bedded, massive dolomite with a light brown to medium gray coloration and fine to medium granularity. Well developed, serrated stylolites form subhorizontal features between rare bedding planes. Some beds within Zone 2 have a distinct white speckled appearance due to intergranular gypsum. The rock has a generally non-porous appearance; however, some beds do have the appearance of a faint porosity associated with fine pitting.

3.2.3 Zone 3 (18 Feet to 29 Feet Thick)

Consists of a medium brownish-gray, medium grain with saccharoidal textured sections, moderately porous, medium to thickly bedded dolomite. Occasional stylolites and argillaceous laminations form subhorizontal features and bedding partings. The upper one foot to 1½ feet of Zone 3 is a distinct light to medium brownish-gray thinly bedded laminar textured dolomite with soft sediment slump structures. This bed is referred to as the B Marker Bed.

3.2.4 Zone 4

Is the lowest unit explored by the deepest boreholes completed in the study area. It is a fresh, light to medium brownish-gray, fine to medium grained dolomite with medium to very thick bedding. The beds exhibit massive texture.

3.3 Site Hydrogeology

The Overburden soils exhibit low hydraulic conductivity (10^{-5} to 10^{-6} cm/s) and yield very little water. The Overburden ground water is unconfined. The interpreted phreatic surface is presented in Figure B-2 of the CMS report (Golder Associates, April 1991). Bergholtz Creek is a discharge zone for the Overburden ground water. The sanitary sewers in the area also act as discharge zones for Overburden ground water.

The Zone 1 aquifer is under confined conditions and has a hydraulic conductivity ranging between $1\text{x}10^{-4}$ cm/s and $2\text{x}10^{-2}$ cm/s. Well yields during development ranged from 2 gpm to 20 gpm. The confining units of Zone 1 are the Overburden soils above and the Zone 2 aquitard below. These confining units allow leakage from the Overburden soils to Zone 1, and between Zone 1 and Zone 3. The vertical gradients between the Overburden and Zone 1 are generally downward (0.01 ft/ft to 0.02 ft/ft) with some exceptions where upward gradients were recorded (0.02 ft/ft to 0.2 ft/ft). The vertical gradients between Zone 1 and Zone 3 are also generally downward (0.0008 ft/ft to 0.09 ft/ft), although some upward gradients have been measured in limited areas (0.01 to 0.05 ft/ft.). The interpreted potentiometric contours for the Zone 1 aquifer are presented in Figure B-3 of the CMS report (Golder Associates, April 1991). As noted in the RFI report (Golder Associates, February 1991), the potentiometric pressure in Zone 1 in the vicinity of the Neutralization Pond is influenced by discharge of cooling water from the Rocket Test Facility.

The effective porosity of the Zone 1 aquifer is estimated to range between 1-percent and 3-percent. The 1-percent effective porosity has been considered to be characteristic of the upper part of the aquifer and the 3-percent characteristic of the lower part of the aquifer. The A Marker Bed, located at the base of Zone 1, is considered to be the dominant flowpath of this unit.

The average horizontal gradient in Zone 1 between the Rocket Test Cell area and Bergholtz Creek is about 0.01 ft/ft. The ground water seepage velocity across this area is estimated to be approximately 1.9 ft/day to 2.8 ft/day for the lower part of the aquifer (3-percent effective porosity for the A Marker Bed) and 5.7 ft/day to 8.4 ft/day for the upper part of the aquifer (1-percent effective porosity). The horizontal hydraulic gradient from Bergholtz Creek to Jagow Road has been estimated to be between 0.002 ft/ft to 0.0008 ft/ft. This corresponds to a seepage velocity in the area south of the creek of about 0.3 ft/day to 0.4 ft/day for the lower part of the aquifer (3-percent effective porosity for A Marker Bed) and 0.9 ft/day to 1.2 ft/day for the upper part of the aquifer (1-percent effective porosity). Ground water discharge from the Zone 1 aquifer to Bergholtz Creek is considered to be limited due to the fine grained nature of the Overburden, the presence of stream sediments in the creek bed, and the predominance of horizontal bedding planes in Zone 1 which likely restricts vertical movement of ground water.

The Zone 2 aquitard separates the Zone 1 aquifer and the Zone 3 aquifer. The hydraulic conductivity measurements taken in Zone 2 ranged from $1\text{x}10^{-5}$ cm/s to $1\text{x}10^{-6}$ cm/s.

The Zone 3 aquifer is believed to be under confined conditions. The hydraulic conductivity of this unit has been measured in the range of $9\text{x}10^{-6}$ cm/s to $2\text{x}10^{-4}$ cm/s. Well yields, determined during well development, range from 1 gpm to 10 gpm. The interpreted potentiometric contours for Zone 3 are presented in Figure B-4 of the CMS report (Golder Associates, April 1991).

The Zone 4 aquifer has a low hydraulic conductivity (measured between $3\text{x}10^{-6}$ cm/s to $5\text{x}10^{-4}$ cm/s) and low yield.

Ground water flow directions in the various units are predominantly southwards, which reflects the regional flow direction towards the Niagara River. Local ground water flow directions in the Overburden soils and Zone 1, however, may vary as a result of the influence of manmade structures, the variability of hydraulic conductivity and/or surficial streams. Downward hydraulic gradients generally exist between the Overburden soils and the Zone 1 aquifer. This may also vary locally due to the influence of sewer lines and as discussed above. Within Zone 1, gradients are generally downwards towards the A Marker Bed.

Both downward and upward gradients have been measured between the Zone 1 and Zone 3 aquifers. Water measurements taken on August 28, 1990 (which included all monitoring wells in the study area) indicated downward gradients over most of the area. Any variation in the magnitude and direction of the vertical gradients is likely due to the pressure pulse phenomenon caused by the infiltration of rocket test discharge water and/or surface water runoff to the Walmore Road Sanitary Sewer trench. During such events, downward vertical gradients between Zone 1 and Zone 3 likely increase.

The dominant flow path in the Zone 1 aquifer is within the A Marker Bed at the base of this unit. It is considered that the flow of water in this stratum beneath Bergholtz Creek has been the prime factor in the development of the dissolved phase plume south of the creek. Ground water discharge from Zone 1 to Bergholtz Creek is considered to be limited, and potentially only from the upper part of the aquifer.

4.0 GROUND WATER CHEMISTRY

4.1 Nature and Extent of Contamination

Release of predominantly chlorinated solvents occurred during operation of the now-closed Neutralization Pond between 1948 and 1984. This release resulted in the development of a dense non-aqueous phase liquid (DNAPL) plume and three associated dissolved phase plumes. Although these plumes likely are all interconnected, they have been differentiated based on the results of the May 1990 and June 1990 Contract Laboratory Program (CLP) sampling event into the following four plumes:

- A plume containing organic solvents within the Overburden around the Neutralization Pond and Blade Bonding Building (Golder Associates, April 1991, Figure 5);
- A DNAPL plume in the Zone 1 aquifer stretching about 750 feet to the southeast of the Neutralization Pond (Golder Associates, April 1991, Figure 6);
- A plume containing dissolved solvents in the Zone 1 bedrock extending about 4,000 feet to the southeast of the Pond, roughly pear shaped, spreading to about 3,000 feet to 4,000 feet wide, (Golder Associates, April 1991, Figure 6); and
- A dissolved phase plume of limited extent in the Zone 3 bedrock stratum, beneath the DNAPL plume (Golder Associates, April 1991, Figure 7).

Details regarding the nature, extent and rate of contaminant migration were previously presented in the final RFI report (Golder Associates, February 1991). A summary of these data is presented below.

The Overburden plume located near the east side of the Helicopter Blade Bonding Building is relatively limited, and appears to have migrated downgradient towards the Walmore Road Sanitary Sewer trench. A plume containing organic solvents exists in the Overburden surrounding the Neutralization Pond. This plume appears to have migrated in the basal till to the eastern boundary of the BAT property at the Walmore Road Sanitary Sewer trench. The migration rate of this plume is considered to be relatively slow.

A DNAPL plume has been defined in the Zone 1 aquifer. The DNAPL is believed to be located in two slight depressions in the base of the A Marker Bed of the Zone 1 aquifer. The DNAPL plume has migrated approximately 750 feet to the southeast of the Neutralization Pond and eastwards from the Pond to Walmore Road. This plume may extend partway under Walmore Road. The solvents which collected in the base of the Neutralization Pond are believed to have been the driving force for the DNAPL plume. Since this driving force was removed when the Pond was closed and the plume is surrounded by small topographic ridges in the top of the Zone 2 aquitard, the DNAPL plume is considered to have effectively stopped moving.

The Zone 1 dissolved phase plume, which is roughly elliptical in shape and located primarily in the base of this aquifer, has migrated a distance of approximately 4,000 feet southwards from the Neutralization Pond. During this migration, the plume apparently passed beneath Bergholtz Creek. The plume is relatively wide in relation to its length, which may be due to the interaction between the surface drainage system along Walmore Road and the adjacent Walmore Road Sanitary Sewer trench which was excavated almost to the bedrock surface. Water infiltrating this trench may have caused an east-west flow component that spread the plume laterally. The main components of the Zone 1 dissolved phase plume are trichloroethene (TCE), methylene chloride, 1,2-dichloroethene (DCE), and vinyl chloride (VC). The disposition of these components in the plume and the ratios between them, indicate that the TCE is undergoing a transformation to DCE, which, in turn, appears to be transforming to VC. These transformations may well be the result of anaerobic bacterial activity.

A relatively small plume of VOCs has been detected in the Zone 3 aquifer. This plume is located predominantly below the DNAPL plume. The present rate of migration of this plume has been estimated at 30 feet per year.

4.2 Rate of Migration

The Neutralization Pond was in operation for a period of about 35 years from 1948 to 1984. Given this, the time for plume development and migration to its present location in 1991 is approximately 40 years.

The nature, extent, and rate of migration of the plumes in the Overburden, Zone 1, and Zone 3 aquifers have been, and will continue to be, influenced by the following processes:

- Ground water flow (advection) and flow velocity;
- Continued dissolution of the DNAPL into the dissolved phase plumes in the Overburden, Zone 1 aquifer, and to a lesser extent the Zone 3 aquifer;
- Dilution of the dissolved phase plumes by percolating ground water either by infiltration of precipitation (in the case of the Overburden plume) or by percolation of ground water from the Overburden to the Zone 1 dissolved phase plume;
- Dispersion of the plumes due to the tortuous movement of ground water through the surrounding medium and intermingling of the plume fronts with water adjacent to the plume;
- Sorption of the compounds in the plumes to particles of the medium through which it is moving;
- Diffusion of the compounds in the plumes into the matrix of the surrounding material; and
- Reaction with the natural ground water or by biologic bacterial activity changing the parent compounds to daughter compounds.

In addition to these natural processes, it is considered that the pressure pulse phenomenon in the Zone 1 aquifer discussed in Section 6.3 of the RFI report (Golder Associates, February 1991) may well have had a considerable influence on the lateral (east-west) migration of the Zone 1 plume. It has also become apparent that ground water leakage into the sanitary sewer lift pump station near borehole B-09 has occurred (Golder Associates, February 1991; Section 7.1.2). This seepage may have locally modified the shape of the plume in Zone 1.

The DNAPL plume is the only plume at the site which is influenced by dissolution; all other plumes are composed of compounds which have already dissolved. As previously mentioned, the DNAPL plume is considered to be trapped within depressions in the base of the A Marker Bed. Since the Neutralization Pond has been closed, the original driving force (the DNAPL in the base of the Pond) has been removed. Therefore it is considered that the DNAPL plume has likely stopped migrating and will maintain its current position unless the present equilibrium is disturbed.

The amount of DNAPL in the plume is difficult to determine. Calculations based on observations in the boreholes during monitoring well installations, yield of DNAPL to the wells (which is relatively low), and the secondary porosity of the Zone 1 dolomite are considered to result in essentially speculative numbers. It is considered that the DNAPL may be viewed as a plume which has the potential to maintain the dissolved phase plumes (by the process of dissolution and advection) for a considerable period of time unless the dissolution rate and direction of advection is controlled.

The migration rates of the dissolved phase plumes have been, and will continue to be, influenced by all the processes listed above except for dissolution. These processes cause movement, retardation and transformation effects on the plumes.

Rather than attempt to determine the magnitude of the various components of the overall effect and thereby determine the eventual fate of the plumes, the extent of the plumes coupled with the known hydrogeologic data and chemistry data have been assessed to provide a mechanism for the assessment of migration rates. The following assumptions form the basis of these assessments:

- Current hydrogeologic conditions will be maintained; and
- The DNAPL will maintain a steady state supply of dissolved phase components to the dissolved phase plumes.

The Overburden plume has moved roughly southeastwards from the Neutralization Pond to the edge of the BAT property along Walmore Road. No contamination has been detected in the Overburden on the east side of Walmore Road. This suggests that the Walmore Road Sanitary Sewer trench is intercepting the plume. Since the edge of the plume cannot be defined, the average rate of movement cannot be calculated using a simple time-distance formula. A more appropriate approach in this case is to assume that the plume moved with the ground water. GZA calculated the range of flow velocities in the Overburden at $1.4x10^{-3}$ to $5.5x10^{-2}$ feet per day in the coarser soil units to $2.7x10^{-6}$ to $2.7x10^{-4}$ feet per day in the silty clays (Kruseman, et al., 1983). Given a 40-year time frame for migration and a retardation factor of 2 (which is probably low (see Section 5.4.4), it would appear that, except for flow in the coarser soil units, there has been insufficient time for the volatile organics to migrate to the sewer trench through the finer grain soils. This suggests that the main area of Overburden contamination is in the lower basal till unit or the sandy lens.

The ground water flow rates in the Zone 1 aquifer vary due to changes in hydraulic gradient. Based upon the average hydraulic conductivity of $2x10^{-3}$ cm/s, a 3-percent porosity in the Zone 1 bedrock and the average hydraulic gradient north of the creek, the flow rates between the Neutralization Pond and Bergholtz Creek are estimated to be about 1.9 feet per day. In the southern section of the plume these velocities have been assessed at 0.4 feet per day. This lower velocity is due to the much lower gradient in this southern area of the site. Using the appropriate velocities for those areas north and south of the creek and an overall retardation factor of 2, the current length of the plume (approximately 4,000 feet) is commensurate with a calculated plume length for a 40-year migration period of 3,750 feet.

An estimate of the contaminant migration rate within the Zone 3 plume was completed using the following:

- An average Zone 3 hydraulic conductivity equals $1x10^{-4}$ cm/s, (as indicated by packer test results);
- An average hydraulic gradient of $6x10^{-3}$, (as indicated by the potentiometric surface map for the Zone 3 aquifer; Golder Associates, April 1991, Figure B-4);

- An average effective porosity of 1-percent (based on examination of rock core recovered from Zone 3); and
- A retardation factor of 2, (as discussed in Section 5.4.4).

The results of these calculations indicated a ground water velocity of 61 feet/year, with a corresponding contaminant migration rate of 30.5 feet per year. The travel time of contaminants is estimated at about 40 years which, coupled with the above velocity, predicts a plume length of 1,200 feet. Figure 7 in the CMS report (Golder Associates, April 1991) shows the interpreted concentration contours for total volatile organic constituents in the Zone 3 aquifer. As shown, the length of the plume is approximately 1,100 feet, which is in good agreement with the predicted plume length.

5.0 SOLUTE TRANSPORT MODELING FOR ZONE 1

5.1 Introduction

As outlined in Section 2.0, one of the primary purposes of solute transport modeling was to estimate the rate of cleanup of the dissolved contaminant plumes in Zone 1 under various remedial actions and estimate the rate of contaminant removal. The ground water flow modeling portion of Zone 1 was previously presented in the CMS report (Golder Associates, April 1991). Therefore, this report deals primarily with subsequent solute transport modeling.

In the following sections, a summary of the previously calibrated ground water flow model, methodologies for the solute transport modeling, and modeling results are presented.

5.2 Ground Water Flow Modeling

A 2-dimensional numerical ground water flow modeling study was carried out for Zone 1, which is located between the Overburden and Zone 2 (Figure E5-1). Zone 1 is considered to be a confined aquifer. Ground water flow simulations in this unit were previously carried out using the finite-difference computer code FLOWPATH developed by T. Franz and N. Guiguer (Franz, et al.) (1990). The FLOWPATH model grid for the BAT site study is approximately 10,000 feet by 11,000 feet (Figure E5-2).

The primary objective of the ground water flow modeling study was to evaluate corrective measures to hydraulically control ground water flow to restrict contaminant migration and remove the dissolved phase contaminants in the study area. Two ground water extraction systems were evaluated with this modeling study:

- One to remediate the off-site portion of the dissolved phase plume; and
- The other to remediate the on-site portion of the dissolved phase plume and contain the DNAPL phase contamination.

The modeling study was focused to:

- Establish an optimum configuration of ground water extraction wells to provide for remediation of the dissolved phase plume in the study area; and
- Evaluate several configurations of extraction wells for hydraulic control of the DNAPL plume so DNAPL contaminants will not contribute further to the dissolved phase plume, and to reduce the potential for the vertical migration of the DNAPL plume into the Zone 3 aquifer.

Details and results of the ground water flow modeling study can be found in the CMS report (Golder Associates, April 1991).

5.3 Solute Transport Modeling Methodology

Both analytical and numerical solute transport modeling studies were conducted to calibrate and determine the cleanup levels of the dissolved phase plume in Zone 1 under various remedial actions. Calibration was carried out using ATF2, a 2-dimensional analytical solute transport model developed by V. Batu (Batu, 1989). The numerical analysis of the solute transport was performed using FTWORK, a finite-difference 3-dimensional ground water flow and solute transport code developed by C. R. Faust, P. N. Sims, C. P. Spalding, and P. F. Andersen (Faust, et al.) (1990). A telescopic mesh refinement approach (TMR) similar to that developed by D. S. Ward, D. R. Buss, J. W. Mercer, and S. S. Hughes (Ward, et al.) (1987) was used for the numerical solute transport modeling. The modeling approaches, assumptions, and definition of the computer codes are presented in detail in the following sections.

5.3.1 Telescopic Mesh Refinement (TMR)

The ground water flow modeling previously undertaken for the site covered a much larger area than the solute transport modeling. As shown in Figure E5-2, the ground water flow model (Model 1) using FLOWPATH encompassed an area of 10,000 feet by 11,000 feet, whereas the solute transport model (Model 2) using FTWORK covered an area of only 4,000 feet by 5,200 feet. TMR provides the means of accurately incorporating regional controlling factors into smaller model domains, and also increases grid resolution in areas of critical importance. The application of TMR at the BAT site integrates the regional and site flow system characteristics to analyze the effectiveness of the proposed corrective measures at the site scale. TMR has been shown to be an effective, appropriate approach to simulate ground water flow and solute transport (Ward, et al., 1987).

Using the TMR approach, the regional system (Model 1) was modeled to provide an overall understanding of the ground water flow system under natural conditions and also under the influence of the corrective measures. The regional model was also used to determine boundary conditions for the site model (Model 2). All extraction well simulations were performed using the regional model. The boundary values for piezometric head calculated with this model were then used for the site model.

The site system (Model 2) was used for both ground water flow and solute transport simulations, and to assess proposed corrective measures. The areal extent of the site model was chosen to encompass the known extent of the dissolved contaminant plumes, the DNAPL area, and the proposed extraction wells. The grid was also designed to allow sufficient discretization of the dissolved plumes, and to obey the numerical criteria required to maintain model accuracy. By direct interpolation from the regional model (Model 1) to the site model (Model 2), the boundary effects on the simulated site scale flow were minimized.

5.3.2 Assumptions for the Numerical Solute Transport Model

In addition to those geologic and hydrogeologic data summarized in Section 3.0, the numerical ground water flow and solute transport modeling of the hydrogeologic regime is based upon the following assumptions:

- Ground water flow in Zone 1 is horizontal;
- The aquifer (Zone 2) is predominantly a confined aquifer;
- Darcy's law applies throughout the aquifer, and nonlaminar flow near wells may be neglected;
- The confined aquifer receives recharge from the Overburden and from Bergholtz Creek;

- Horizontal hydraulic conductivity does not change with depth;
- Within each hydraulic conductivity zone, the aquifer is homogeneous and isotropic;
- Within each defined recharge zone, the recharge rate is uniform;
- The piezometric water levels in the overlying and underlying aquifers (Overburden and Zone 2, respectively) are constant with respect to time;
- Ground water flow in the aquifer is steady;
- Dissolved phase concentration of a contaminant at any point in the transport domain is constant along the thickness of Zone 1;
- The density of water containing dissolved phase contaminants is the same as the density of water;
- Longitudinal and transverse dispersivities are constant throughout the solute transport domain;
- Adsorption may be approximated by a linear equilibrium isotherm;
- The retardation factor is constant throughout the solute transport domain;
- Molecular diffusion is insignificant compared to mechanical dispersion; and
- The transport mechanism of the solutes is based on advection and hydrodynamic dispersion.

5.3.3 Assumptions for the Analytical Solute Transport Model

As mentioned above, calibration for the numerical solute transport model was carried out using a 2-dimensional analytical solute transport code. Calibration of the analytical solute transport model is based upon the following assumptions:

- Ground water flow in Zone 1 is 1-dimensional;
- Solute transport in Zone 1 is 2-dimensional, and the concentration of a contaminant at any point in the transport domain does not change along the thickness of Zone 1;
- The contaminants have a finite length which is perpendicular to the ground water flow direction;

- The solute transport domain is semi-infinite;
- Hydrogeological parameters are constant throughout the transport domain;
- Adsorption may be approximated by a linear equilibrium isotherm;
- Molecular diffusion is insignificant compared with the mechanical dispersion;
- The transport mechanism of the solutes is based upon advection and hydrodynamic dispersion; and
- Longitudinal and transverse dispersivities and the retardation factor are constant throughout the transport domain.

5.3.4 Definition of Computer Codes

As described above, three different computer codes were used for ground water flow and solute transport modeling of the site:

- FLOWPATH;
- FTWORK; and
- ATF2.

Each of these codes are defined in the following sections.

Definition of FLOWPATH

FLOWPATH is a 2-dimensional finite-difference code for simulating steady state saturated ground water flow developed by Franz, et al. (1990). FLOWPATH can be used to calculate:

- Steady state piezometric head distributions;
- Ground water velocities;
- Pathlines;
- Travel times; and
- Capture zones.

Features and processes which can be modeled with this computer code include:

- Heterogeneous and anisotropic media;
- Multiple pumping or injection wells;

- Interaction with surface water bodies;
- Irregular domain boundaries;
- Specified head or flux boundary conditions;
- Areal recharge or evapotranspiration; and
- Unconfined and confined aquifers.

Data input and output are facilitated by interactive on-screen graphics, built-in windows, and CAD system features. The program also provides extensive internal data checking and on-line help screens. The FLOWPATH code has been validated against other numerical (MODFLOW) and analytical codes for hydraulic head distribution, pathlines, and travel times (Franz, et al., 1990).

Definition of FTWORK

FTWORK is a 3-dimensional finite-difference code developed by Faust, et al. (1990) for simulating saturated ground water flow and the transport of dissolved components under both confined and unconfined aquifer conditions. Solute transport mechanisms which are taken into account by the model include:

- Advection; hydrodynamic dispersion;
- Linear equilibrium adsorption; and
- First order decay.

The model uses a block-centered grid that allows variable spacing and the approximation of irregular geometry. FTWORK also allows approximation of layers that have irregular thickness and/or that are not horizontal. Features and processes which can be modeled include:

- 3-dimensional solution of ground water flow and solute transport;

- Deformed coordinate approximation for variable thickness layers;

- Prescribed head, prescribed flux, and head-dependent flux boundary conditions;

- Steady or unsteady ground water flow with unsteady solute transport;

- Parameter-estimation module for semi-automated calibration of steady state flow;

- First-order decay (hazardous, biological, or radioactive);
- Linear equilibrium adsorption isotherm;
- Cumulative mass balance report;
- Restart capability; and
- Auxiliary plot files.

The ground water flow portion of the model is similar in many respects to the United States Geological Survey modular ground water flow code (MODFLOW) developed by M. G. McDonald, and A. W. Harbaugh (McDonald, et al., 1984).

Several test problems involving 1-, 2-, and 3-dimensional ground water flow and solute transport are presented in the FTWORK documentation (Faust, et al., 1990) to demonstrate the utility and verify the numerical accuracy of the model. One series of problems tests FTWORK against analytical solutions for ground water flow and solute transport. Another series illustrates FTWORK's capabilities for 3-dimensional flow and solute transport under complex boundary conditions and field scale applications. The test problems also offer a comparison between FTWORK and MODFLOW for ground water flow. Additional verification studies for FTWORK were carried out by Golder Associates' staff (Golder Associates, 1991a, and Golder Associates, 1991b). In those reports, the results of FTWORK were compared to the results of ATT2, an analytical model developed by Golder Associates' staff. The ATT2 model is a 2-dimensional analytical solute transport code with flux-type boundary condition at the source. The mathematical theory of ATT2 was developed by V. Batu (Batu, 1986). It should be noted that in all of the comparisons mentioned above, the results of FTWORK and other models were very close, verifying both the utility and numerical accuracy of the FTWORK model.

Definition of ATF2

ATF2 is 2-dimensional analytical solute transport code that was developed by Golder Associates (Golder Associates, 1991a). The mathematical theory of ATF2 was previously developed by Batu (Batu, 1989). The ATF2 model was developed for hydrodynamic dispersion in a unidirectional ground water flow field from time and space-dependent finite sources with a first-type (fixed concentration) boundary condition at the source. Longitudinal and transverse dispersion, radioactive decay, and linear equilibrium adsorption can all be taken into account by the model. Several analytical solutions existing in the literature have been shown to be special solutions of the ATF2 model. The results of the model were compared to several different numerical solute transport codes with good agreement. The mathematical developments and comparisons are presented in detail (Batu, 1989).

5.4 Model Calibration

5.4.1 Purpose

Calibration of the solute transport model for the BAT site was performed using the analytical code ATF2 described above. Prior to calibration, quantitative and qualitative information for different contaminant constituents were analyzed in order to estimate the retardation factor (R_d). In addition, hydraulic gradients in Zone 1 were analyzed in order to estimate an average value for the model area. Model calibration was then performed to determine values for longitudinal and transverse dispersivities, and the effective width of the origins of the contaminants perpendicular to the average ground water flow direction. In the following sections, the site specific information for contaminant constituents, hydraulic gradients of the ground water flow, estimation of the retardation factor, calibration procedure, and calibration results are presented.

5.4.2 Contaminant Constituents and Extent

As discussed in Section 4.0, the primary dissolved phase contaminants in Zone 1 are TCE, DCE, VC and methylene chloride. The extent of individual plumes are shown in Figures 6, 8, 9, 10, and 11 of the CMS report (Golder Associates, April 1991). As can be seen from these figures, the dissolved phases plume component compounds (TCE, DCE, VC) have migrated a distance of approximately 4,000 feet southwards (downgradient) from the Neutralization Pond. This is consistent with the qualitative evaluation of the sorption characteristics of DCE and TCE described by the United States Environmental Protection Agency (USEPA) (USEPA, 1985). Calibration was carried out for only one constituent, TCE. The concentration (Co) of TCE in the vicinity of the DNAPL plume was assumed to be 1,100,000 ug/l, the highest reported value of this compound in the 1990 CLP sampling event (well 87-13(1)). Based upon this value, normalized concentration (C/Co) values were calculated.

As mentioned in Section 4.0, the plume is relatively wide compared to its length (approximately 3,600 feet wide versus 4,000 feet long). This plume widening is believed to be due to an interaction between the surface drainage system along Walmore Road and the adjacent Walmore Road Sanitary Sewer trench.

5.4.3 Average Hydrogeologic Parameters

Information regarding site hydrogeologic parameters are summarized in Section 4.0. Based upon assessment of these values, average hydrogeologic parameters were determined for use with the analytical solute transport model (Table E5-1). With these values, an average ground water velocity of 0.51 ft/day was calculated using Darcy's law.

5.4.4 Estimation of the Retardation Factor

The interpreted isoconcentration contours for TCE are shown in Figure 9 of the CMS report (Golder Associates, April 1991). At downgradient monitoring wells 89-05(1A) and 89-05(1B) the reported concentration is approximately 1 ug/l, which is assumed to be the plume front of TCE. The distance between the DNAPL at the Neutralization Pond and the monitoring wells is approximately 3,400 feet. The elapsed time for the TCE to migrate from the DNAPL to this front is estimated to be 40 years. Using this value along with the estimated average ground water velocity, the retardation factor for TCE were estimated to be 2.2.

Based upon the analysis presented above, a retardation factor of 2 was chosen as an average value for TCE and the other contaminant constituents. Sorption effects are relatively unimportant for a retardation factor of 2. This is consistent with published qualitative evaluation of the sorption characteristics for the site contaminant constituents for DCE and TCE (USEPA, 1985, Table II-9).

5.4.5 Estimation of Dispersion Coefficients and Effective Source Width

As mentioned in Section 5.4.1, the primary goal of model calibration was to determine the longitudinal and transverse dispersivities and the effective width of the DNAPL (the origin of the dissolved phase plume components) perpendicular to the average ground water flow direction. Calibration runs were carried out for a 20-year time period. The hydrogeologic parameters listed in Table E5-1 along with a retardation factor of 2 were used for the calibration runs. By varying the values for longitudinal and transverse dispersivity and source width, an iterative procedure was developed to match the longitudinal extent of the observed contaminant plume with the simulated plume. The transverse extent of the observed contaminant plume was not targeted because of the reasons mentioned in Section 5.4.2. The extent of the simulated plume from each computer run was compared to the observed plume and the differences were noted. Successive runs were revised in an attempt to minimize these differences. This process was repeated until the extent of the simulated plume closely matched that of the observed plume.

The solute transport parameters used in generating the closest match are listed in Table E5-2. A comparison of this simulation with the observed plume is shown in Figure E5-3. Some important aspects with regard to this comparison are as follows:

- The longitudinal extent of the measured and simulated plumes are approximately the same. For example, the measured normalized concentration of monitoring wells 89-5 (1A) and 89-5 (1B) is $0.91\text{x}10^{-6}$. The simulated isoconcentration contour approximately 300 feet away from this location is $0.5\text{x}10^{-6}$ value;
- Almost all sampling locations that show detected concentrations fall within the outermost isoconcentration contour ($0.5\text{x}10^{-6}$); and
- The measured normalized concentration values around the symmetry axis of the simulated plume are reasonably close to those of the observed plume. One exception is the 87-20(1) sampling location, which has a relatively low measured value compared to the simulated values.

As can be seen from Table E5-2, the longitudinal and transverse dispersivity values that established the closest match have the values 20 feet and two feet, respectively. In general, transverse dispersivity values are normally lower than longitudinal dispersivity values by a factor of 5 to 20 (R. A. Freeze, and J. A. Cherry (Freeze, et al.) (1979)). The ratio between the calibrated longitudinal and transverse dispersivities is 10, which is well within the above range. The corresponding effective DNAPL width is 25 feet.

5.5 Solute Transport Model Results

5.5.1 General

The numerical solute transport simulations were developed taking into account the following:

- Extraction well configuration;
- The estimated range of effective porosity; and
- The elapsed time between the start up of the off-site extraction system and the on-site extraction system.

The classification of the solute transport runs, with respect to the above mentioned categories, are described below.

Extraction Well Configuration

The extraction well configurations and corresponding FLOWPATH runs used for the solute transport simulations are as follows:

- Configuration 1A (Hydraulic containment of DNAPL):

  Six off-site wells (total pumping rate 42 gpm):

  a. FLOWPATH RUNS: 5005 and 6005 (Golder Associates, April 1991, Figure B-15, and Figure B-17);

  b. FTWORK RUNS: B10, and B20

- Configuration 1B (Hydraulic containment of DNAPL):

  Six off-site wells, two on-site wells and four DNAPL wells (total pumping rate 66 gpm):

  a. FLOWPATH RUNS: 5041 and 6041 (Golder Associates Inc., April 1991; Figure B-23 and Figure B-25);

  b. FTWORK RUNS: B12, B13, B22, and B23

- Configuration 2 (Physical Containment)

  Grout curtain and extraction wells (total pumping rate 60 gpm):

  a. FLOWPATH RUNS: 5041 and 6041 (Golder Associates, April 1991, Figure B-31, and Figure B-33);

  b. FTWORK RUNS: B1, and B26.

Estimated Range of Effective Porosity

Simulation runs with the same effective porosity can be grouped as follows:

- 1-Percent Effective Porosity

  a. FTWORK RUNS: B10, B12, B13, and B16; and

- 3-Percent Effective Porosity

  a. FTWORK RUNS: B20, B22, B23, and B26.

The structure of the solute transport computer runs is indicated in Figure E5-4. This structure was selected in such a manner to account for start up of the off-site extraction system approximately 300 days prior to the on-site extraction system. Because of the difficulty in assessing the changes in concentrations in the on-site area during the 300 days of pumping, the following two sets of simulations were developed:

- In the first set of simulations (B10, and B20), the initial concentrations for the total VOCs (Figure E5-5), as indicated by the RFI report (Golder Associates, February 1991), were used in addition to three constant concentration sources in the DNAPL area to account for plume development during the initial 300 days. Six off-site extraction wells were used for these simulations (runs B10 and B20).

The concentrations predicted after 300 days were subsequently used as input data for the next set of runs (B12 and B22) with all the wells (both on-site and off-site) pumping; and

- The present concentrations were assumed to be quasi-stable, and both systems (on-site and off-site) were considered to start simultaneously (Runs B13, B23, B16, and B26).

The changes in concentrations in the on-site area (during 300 days; runs B10, and B20) were found to be extremely high (due to the constant concentration developed by the DNAPL), compared with annual changes observed for various phases of monitoring. By considering that all the wells start to pump simultaneously, it was assumed that the present concentrations are relatively stable (supported by observation data).

Figure E5-4 presents a diagram showing the grouping of the solute transport runs. As shown, there are six cases:

Case 1	Pumping using extraction well configuration 1A for 300 days (run B10) followed by the extraction well configuration 1B (run B12), assuming an effective porosity of 1-percent (hydraulic containment of DNAPL);
Case 2	Pumping using extraction well configuration 1B (run B13), assuming an effective porosity of 1-percent (hydraulic containment of DNAPL);
Case 3	Pumping using extraction well configuration 1A for 300 days (run B20) followed by the extraction well configuration 1B (run B22), assuming an effective porosity of 3-percent (hydraulic containment of DNAPL);
Case 4	Pumping using extraction well configuration 1B (run B23), assuming an effective porosity of 3-percent (hydraulic containment of DNAPL);
Case 5	Using a grout curtain and pumping using extraction well configuration 2 (run B16), assuming an effective porosity of 1-percent (physical containment of DNAPL);
Case 6	Using a grout curtain and pumping using extraction well configuration 2 (run B26), assuming an effective porosity of 3-percent (physical containment of DNAPL).

The figures that illustrate the results of the numerical solute transport modeling include simulated potentiometric head contours, followed by the simulated concentration contours for one year (or 300 days), two years, five years, ten years and the year prior to clean-up of the site for each extraction well configuration.

The parameters which were calculated using the simulated concentrations for each time step (time between successive computer iterations) for grid cells corresponding to the extraction wells are listed below. [NOTE: A 5-day time step was used for all the computer runs].

- Average contaminant mass flux rate for discrete time step intervals (f_{EWi}) - calculated for each extraction well by multiplying the simulated concentration for a time step (c_{Ewi}) by the corresponding pumping rate of the extraction well (q_{EW})

$$f_{Ewi} = c_{Ewi} \times q_{EW}$$

- Contaminant mass per time step (m_{Ewi}) calculated for each extraction well as the product of contaminant flux rate (f_{Ewi}) and time (t = five days)

$$m_{Ewi} = f_{Ewi} \times t$$

- Total contaminant mass removed by a well (M_{EW}) - calculated by adding the contaminant mass per time step for all the simulation period

$$M_{EW} = m_{Ewi}$$

- Contaminant mass per time step removed by an extraction system (m_{ESi}) for a time step period (t = five days) - calculated as the sum of the individual mass per time step for all wells in the extraction system (m_{Ewi})

$$m_{Esi} = m_{EW1i} + m_{EW2i} + m_{EW3i} + \ldots$$

- Total contaminant mass removed by an extraction system M_{ES} - calculated by adding the contaminant mass per time step (m_{ES}) for the entire simulation period

$$M_{ES} = m_{Esi}$$

- Average concentrations in the extracted water from a given system (c_{Esi}) for a time step period - calculated by dividing the mass per time step removed by the extraction system (m_{Esi}) by the total flow rate of the extraction system (Q_{ES}), and dividing that quotient by the time step period (t = five days)

$$c_{Esi} = m_{Esi} / Q_{ES} / t$$

The summary of these calculations are included in Tables E5-3 to E5-14.

The estimation of concentrations and mass fluxes in the DNAPL wells is a special case. The numerical solute transport model cannot quantify the flux of contaminant being transferred from the DNAPL to the dissolved phase plume. These calculations have been performed with the following assumptions:

- Initially the concentrations and mass fluxes for the DNAPL wells were calculated using the simulated concentrations generated by the model. In this situation, the calculated mass fluxes represent that part of the dissolved phase plume removed by the DNAPL wells, but does not take into account the influence of the DNAPL plume (Table E5-5, and Table E5-11);

- In order to assess the mass of contaminants removed by the DNAPL wells, it was assumed that the maximum simulated concentration would remain constant for the duration of pumping (Table E5-6, and E5-12); and

- An estimate of contaminant flume from the DNAPL was calculated assuming that the present known concentrations of the dissolved phase in the DNAPL area will remain constant while the area around but outside of the DNAPL will be cleaned up. It was further assumed that for configurations 1A and 1B (DNAPL control wells) the DNAPL wells will pump ¼ of the water from the DNAPL area with concentrations similar to the present ones and 3/4 of the water from the adjacent area with no contaminants (Table E5-8). For configuration 2 (grout curtain) it was assumed that the DNAPL wells will pump ½ of the water from the DNAPL area with concentrations similar to the present values and ½ of the water from the adjacent areas with no contaminants (Table E5-14).

5.5.2 Extraction Well Configurations 1A and 1B

These extraction well configurations include:

- Six off-site extraction wells (EW1 to EW6), pumping at a rate of 7 gpm each;
- Two on-site extraction wells, EW7 pumping at 7 gpm and EW8 pumping at 5 gpm; and
- Four DNAPL wells (DW9 to DW12) pumping at 4 gpm each.

Case No. 1

The first group of assumptions considered pumping the off-site extraction wells (configuration 1A) for 300 days (run B10), followed by pumping the on-site extraction wells and DNAPL wells (configuration 1B; run B12). The effective porosity of the aquifer was assumed to be 1-percent. Three constant concentration sources were defined within the DNAPL area (Figure E5-5).

The simulated potentiometric head contours using the extraction well configuration 1A are presented in Figure E5-6. The simulated concentration contours after 300 days of pumping are presented in Figure E5-7. These concentrations were used as initial concentrations for run B12, which includes the on-site extraction system. The three constant concentration sources were removed from the initial concentration input data, for it is not currently possible to quantify the dissolution of the DNAPL with time. The simulated potentiometric head contours for the extraction well configuration 1B are included in Figure E5-8, and the simulated concentration contours for two years, five years, ten years and 14 years after the start up of the off-site extraction system are presented in Figures E5-9 to E5-12.

Using the assumptions mentioned above, the model indicated that for the off-site extraction system, the initial VOC concentration in the water removed by the six extraction wells is about 300 ug/l with the corresponding flux rate of 0.15 pounds per day (lbs/day) (Table E5-3). A maximum flux rate and concentration may develop about 1.3 years after initiating pumping because upgradient of the off-site extraction wells, the concentrations are higher than that found than in the immediate vicinity of these extraction wells. The maximum concentration in this case is 1,500 ug/l with a corresponding flux rate of 0.7 lbs/day. The estimated total mass of VOC to be removed by the system is 550 pounds (lbs). The estimated time for removal of the entire dissolved phase plume is about 14 years.

As can be seen from the figures, the areal extent of the volatile organic plume diminishes with time. Extraction wells located in those areas which have been remediated will not be required. A tentative time table for switching off the extraction wells is included in Table E5-4. By switching off some of the extraction wells that are pumping clean water, the corresponding concentration of the ground water constituents extracted by all the wells will increase, because the dilution will be reduced. The estimated schedule for switching off the off-site extraction wells (Table E5-4) indicates that the system will operate with six wells for one year, with five wells for two years, with three wells for five years, and with two wells until the clean-up of the area is complete (14 years).

Case No. 2

The second group of assumptions considered pumping with all the wells simultaneously (configuration 1B; run B13). The effective porosity of the aquifer is assumed to be 1-percent. No constant concentration sources were defined within the DNAPL area (Figure E5-5). The simulated potentiometric contours are presented in Figure E5-8. Figures E5-13 to E5-16 present the simulated concentration contours for one year, five years, ten years and 13 years, respectively.

Using this group of assumptions, the model indicated that for the off-site extraction system the initial VOC concentration in the water removed by the six extraction wells is about 350 ug/l with a corresponding contaminant flux rate of 0.18 lbs/day (Table E5-3). The maximum flux rate and concentration is developed at the beginning of pumping. The estimated total mass of VOC to be removed by this system is 75 lbs. The estimated time for removal of the dissolved phase plume is about 12 years.

The relatively large ranges of the calculated parameters between these two groups of simulations is the result of the presence of the three constant concentration sources which were used in computer run B10 which also generated artificially high concentrations for the on-site area. For this reason only run B13 was used to estimate the concentrations and mass loading of the on-site extraction system. The results are presented in Tables E5-5 and E5-6.
Table E5-5 presents the concentrations and mass fluxes for the on-site extraction wells by taking into account only the dissolved phase plume and neglecting the future mass transfer from DNAPL to the dissolved phase plume. Using this assumption, it is estimated that the maximum concentration of the total VOCs is 94,300 ug/l, with a corresponding mass flux rate of 27.2 lbs/day. The clean-up time is estimated at about 12 years, and the total mass of VOC removed is about 1,410 lbs. The total mass removed by both systems (on-site and off-site) is 1,485 lbs (75 lbs removed by the off-site extraction system and 1,410 lbs removed by the on-site extraction system). This amount represents the total mass of the dissolved phase plume as defined by concentrations reported in the 1990 CLP sampling event.

A verification of this was performed by measuring the area covered by two consecutive isoconcentration contours for total VOCs, as defined in the RFI report (Golder Associates, February 1991, Figure 7-7). This area was multiplied by the corresponding average concentration, the average thickness of Zone 1 (estimated at 18 feet), and the porosity (considered in this case to be 1-percent). This calculation indicated a total mass of the dissolved phase plume of about 1,500 lbs, which is in good agreement with the total mass indicated by computer run B13 (1,485 lbs).

In order to estimate the total mass of volatile organics, (including the mass transfer from DNAPL to the dissolved phase plume), it was assumed that the maximum simulated concentration for the DNAPL wells is likely to remain constant for the duration of pumping. Table E5-6 summarizes these results. As shown, the maximum concentration for the on-site extraction wells is 118,000 ug/l, with a corresponding mass flux rate of 33.9 lbs/day. The maximum concentrations in the DNAPL control wells do not occur simultaneously. This explains the difference between the estimated concentrations and flux rates shown on Table E5-5 and Table E5-6 for the run B13 results. Approximately two years after the start of the on-site extraction system, the concentrations tend to stabilize at 114,000 ug/l, with a mass flux rate of 32.8 lbs/day. The tentative schedule for switching off the extraction wells is included in Table E5-7. After switching off extraction wells EW7, and EW8, the concentration of the ground water contaminants extracted by the DNAPL wells is estimated to be 228,000 ug/l, with a corresponding flux rate of 32.8 lbs/day (Table E5-7).

Case No. 3

This group of assumptions considered pumping using the off-site extraction wells (configuration 1A) for 300 days (run B20), followed by pumping of the on-site extraction wells and DNAPL wells (configuration 1B; run B22), assuming an effective aquifer porosity of 3-percent and no influence by Bergholtz Creek.

The simulated potentiometric contours using extraction well configuration 1A (run B20) are presented in Figure E5-17. The simulated concentration contours after 300 days of pumping are presented in Figure E5-18. These concentrations were used as initial concentrations for run B22, which includes the on-site extraction system. The three constant concentration sources were removed from the initial concentration input data. The simulated potentiometric contours for configuration 1B (run B22) are presented in Figure E5-19, and the simulated concentration contours for two years, five years, ten years and 21 years after the start up of the off-site extraction system are presented in Figures E5-20 through E5-23.

Using this group of assumptions, the model indicated that for the off-site extraction system, the initial VOC concentrations in the water removed by the six extraction wells is about 320 ug/l, with a corresponding contaminant flux rate of 0.16 lbs/day (Table E5-3). The maximum flux rate and concentration is achieved about two years after the initiation of pumping. The maximum concentration in this case is 470 ug/l, with a corresponding mass flux rate of 0.24 lbs /day. The estimated total mass of VOC to be removed by the system is 406 lbs. The estimated time for removal of the dissolved phase plume is about 21 years. The tentative schedule to switch off the extraction wells is included in Table E5-4.

Case No. 4

This group of assumptions considered the simultaneous pumping of all wells (configuration 1B; run B23). The effective porosity of the aquifer is assumed to be 3-percent. No constant concentration sources were defined within the DNAPL area. The simulated potentiometric contours are shown in Figure E5-19. Figures E5-24 to E5-27 present the simulated concentration contours for one year, five years, ten years and 20 years, respectively.

Using this group of assumptions, the model indicated that for the off-site extraction system, the initial concentrations of the water removed by the six extraction wells is about 330 ug/l with a corresponding contaminant flux rate of 0.17 lbs/day (Table E5-3). The maximum flux rate and concentration is achieved two years after pumping is begun. The maximum concentration is 360 ug/l and the corresponding mass flux rate is 0.18 lbs/day. The estimated total mass of VOC to be removed by the system is 291 lbs. The estimated time for the removal of the dissolved phase plume is 21 years.

Computer run B23 was designed to estimate the concentrations and mass loading of the on-site extraction system. The results are presented in Tables E5-5 and E5-6. Table E5-5 presents the concentrations and mass fluxes for the on-site extraction wells taking into account only the dissolved phase plume and neglecting the future mass transfer from DNAPL to the dissolved phase plume. Using this assumption, it is estimated that the maximum concentration of the total VOCs is 91,000 ug/l, with a corresponding mass flux rate of 26.20 lbs/day. The clean-up time is estimated at 20 years, and the total mass of VOC removed is 4,294 lbs. The total mass removed by both systems is 4,585 lbs (291 lbs removed by the off-site extraction system and 4,294 lbs removed by the on-site extraction system). This amount represents the total mass of the dissolved phase plume as defined by the concentrations reported in the 1990 CLP sampling event.

A verification of this was performed by measuring the area covered by two consecutive isoconcentration contours for total VOCs, as defined in the RFI report (Golder Associates, February 1991, Figure 7-7). This area was multiplied by the corresponding average concentration, the average thickness of Zone 1 (estimated at 18 feet), and the porosity (considered in this case to be 3-percent). This calculation indicated a total mass of the dissolved phase plume of about 4,500 lbs, which is in good agreement with the total mass indicated by computer run B23 (4,585 lbs).

To estimate the total mass of volatile organics (including the mass transfer from DNAPL to the dissolved phase plume), it was assumed that the maximum simulated concentration for the DNAPL wells is likely to remain constant for the duration of pumping. Table E5-6 summarizes these results. As shown, the maximum concentration for the on-site extraction wells is 117,000 ug/l with a corresponding mass flux rate of 33.6 lbs/day. The concentrations tend to stabilize at 113,000 ug/l, with a mass flux rate of 32.6 lbs/day after approximately 2.5 years following start up of the extraction system. The tentative schedule for switching off extraction wells (Table E5-7) shows that extraction wells WE7 and WE8 may be turned off after 16 years. The corresponding concentration of the ground water extracted by the DNAPL control wells will be 226,000 ug/l (32.6 lbs/day) at that time.

Summary

In conclusion, if hydraulic containment of the DNAPL area is implemented the off-site extraction system will remove ground water with maximum VOC concentrations between 350 ug/l to 1,500 ug/l at a maximum mass flux rate of 0.2 lbs/day to 0.7 lbs/day. The total mass of VOC to be removed by the off-site extraction system is estimated to be between 75 lbs and 550 lbs. The upper range of values may represent an over estimation due to the three constant concentration sources included in computer runs B10 and B20.

Taking into consideration the estimative calculations for the DNAPL wells, maximum concentrations ranging between 117,000 ug/l and 466,000 ug/l with a corresponding maximum mass flux rate ranging between 33.6 lbs/day and 134.4 lbs/day are expected for the on-site extraction system.

Following clean-up of the dissolved phase plume, the DNAPL control wells will extract ground water with concentrations in total VOC between 226,000 ug/l and 231,000 ug/l with a flux rate of 32.6 lbs/day to 33.34 lbs/day.

The estimated clean-up time of the dissolved phase plume ranges between 12 years and 21 years.

5.5.3 Extraction Well Configuration 2

These extraction well configurations include:

- Grout curtain and extraction wells (total pumping rate 60 gpm);
- FLOWPATH runs:

  5041 and 6041 (Golder Associates, April 1991; Figure B-31, and Figure B-33); and
- FTWORK runs:

  B16, and B26.

Case No. 5

This group of assumptions considered simultaneous pumping of all wells (configuration 2; run B16). The effective porosity of the aquifer is assumed to be 1-percent. No constant concentration sources were defined within the DNAPL area. The simulated potentiometric contours are presented in Figure E5-28. Figures E5-29 through E5-32 present the simulated concentration contours for one year, five years, ten years and 11 years respectively.

Using this group of assumptions, the solute transport model indicated that for the off-site extraction system, the initial VOC concentrations in the water removed by the six extraction wells is about 350 ug/l, with a corresponding contaminant flux rate of 0.18 lbs/day (Table E5-9). The maximum flux rate and concentration is achieved at the initiation of pumping. The estimated total mass of VOC to be removed by the system is 80 lbs. The estimated time to the removal of the dissolved phase plume is 12 years. Table E5-10 presents an estimated schedule for switching off the off-site extraction wells. As shown, the extraction system will operate with six wells for one year, five wells for two years, three wells for four years, and two wells for 12 years.

Table E5-11 presents the concentrations and mass fluxes for the on-site extraction wells taking into account only the dissolved phase plume, and neglecting the future mass transfer from DNAPL to the dissolved phase plume. Using this assumption, it is estimated that the maximum concentration of the total VOCs is 158,000 ug/l, with a corresponding mass flux rate of 34.1 lbs/day. The clean-up time is estimated to be 12 years, and the total mass of VOC removed is about 1,405 lbs. The total mass removed by both systems (on-site and off-site) is 1,485 lbs (80 lbs removed by the off-site extraction system and 1,405 lbs removed by the on-site extraction system). This amount represents the total mass of the dissolved phase plume as defined by concentrations reported as a result of the 1990 CLP sampling event.

To estimate the total mass of volatile organics, (including the mass transfer from DNAPL to the dissolved phase plume), it was assumed that the maximum simulated concentration for the DNAPL wells is likely to remain constant for the duration of pumping. Table E5-11 summarizes these results. As shown, the maximum concentration for the on-site extraction wells is 158,000 ug/l, with a corresponding mass flux rate of 34.2 lbs/day. After approximately two years following the start-up of the on-site extraction system, the concentrations tend to stabilize at 153,000 ug/l, with a mass flux rate of 33.1 lbs/day. The tentative schedule for switching off the extraction wells is included in Table E5-12. After switching off extraction wells EW7 and EW8, the concentration of the ground water extracted by the DNAPL wells is estimated at 459,000 ug/l, with a corresponding flux rate of 33.1 lbs/day (Table E5-12).

Case No. 6

This group of assumptions also considered simultaneous pumping of all wells (configuration 2; run B26). The effective porosity of the aquifer is assumed to be 3-percent. No constant concentration sources were defined within the DNAPL area. The simulated potentiometric contours are shown in Figure E5-33. Figures E5-34 to E5-37 present the simulated concentration contours for one year, five years, ten years and 20 years, respectively.

Using this group of assumptions, the model indicated that the initial VOC concentrations of the water removed by the six extraction wells is about 320 ug/l with a corresponding contaminant flux rate of 0.16 lbs/day for the off-site extraction system (Table E5-9). The maximum flux rate and concentration is achieved two years after pumping has begun. The maximum concentration is 380 ug/l, and the corresponding mass flux rate is 0.19 lbs/day. The estimated total mass of VOC to be removed by the system is 305 lbs. The estimated time for the removal of the entire dissolved phase plume is 20 years. Table E5-10 presents an estimated schedule for switching off the off-site extraction wells. The extraction system will operate with six wells for three years, five wells for six years, three wells for eight years and two wells for 20 years.

Table E5-11 presents the concentrations and mass fluxes for the on-site extraction wells taking into account only the dissolved phase plume, and neglecting the future mass transfer from DNAPL to the dissolved phase plume. Using this assumption, it is estimated that the maximum concentration of the total VOC is 136,500 ug/l, with a corresponding mass flux rate of 29.5 lbs/day. The clean-up time is estimated at 20 years, and the total mass of VOC removed is about 4,214 lbs. The total mass removed by both systems is 4,519 lbs (305 lbs removed by the off-site extraction system and 4,214 lbs removed by the on-site extraction system). This amount represents the total mass of the dissolved phase plume as defined by 1990 concentrations.

To estimate the total mass of volatile organics (including the mass transfer from DNAPL to the dissolved phase plume), it was assumed that the maximum simulated concentration for the DNAPL wells is likely to remain constant for the duration of pumping. Table E5-12 summarizes these results. As shown, the maximum concentration of VOCs for the on-site extraction wells is 136,000 ug/l, with a corresponding mass flux rate of 29.5 lbs/day. About three years after start-up of the on-site extraction system, the concentrations tend to stabilize at 132,000 ug/l, with a mass flux rate of 28.5 lbs/day. The tentative schedule for switching off the extraction wells (Table E5-13) shows that extraction wells EW7 and EW8 may be turned off after 16 years. The corresponding concentration of the ground water extracted by the DNAPL wells is 395,500 ug/l, and the mass flux rate 28.5 lbs/day.

Summary

In conclusion, if physical containment of the DNAPL area is implemented the modeling indicates the off-site extraction system will extract ground water with maximum VOC concentrations between 350 ug/l to 380 ug/l, and with maximum mass flux rates of 0.18 lbs/day to 0.19 lbs/day. The total mass of VOC to be removed by the off-site extraction system is calculated to be between 80 lbs and 305 lbs.

Including estimates for the DNAPL wells, it is expected that the maximum concentrations for the on-site extraction system range between 136,000 ug/l, and 505,000 ug/l, with a corresponding maximum mass flux rate between 29.5 lbs/day and 109.18 lbs/day.

Following clean-up of the dissolved phase plume, the modeling indicates that the DNAPL wells will extract ground water with concentrations in total VOC between 395,000 ug/l and 750,000 ug/l, with a flux rate of 28.5 lbs/day to 54.06 lbs/day.

The estimated clean-up time of the dissolved phase plume ranges between 12 years and 20 years.

6.0 ASSESSMENT OF THE OFF-SITE DISSOLVED PHASE PLUME MIGRATION BY MOLECULAR DIFFUSION AGAINST FLOWING GROUND WATER

6.1 Introduction

Control of the dissolved phase DNAPL plume has been proposed by the use of containment wells. These wells have been designed to prevent the migration of contaminants in the product plume by reversing the direction of ground water flow. However, the dissolved phase concentrations at the DNAPL area are reported to be high (1.1x10^6≤g/*l*), and the concentration gradients may also be relatively high. Although the DNAPL containment wells will create a cone of depression in Zone 1, the dissolved phase contaminants may migrate by the process of molecular diffusion, which is proportional to the concentration gradients against flowing ground water. A schematic representation of this process is shown in Figure E6-1. If the hydraulic head difference between $x=0$ and $x=L$ in Figure E6-1 is sufficiently high, the dissolved plume cannot migrate against the flow towards the outside of the containment system. Therefore, the objective of the analysis presented in this section is to assess the performance of the containment system in preventing off-site migration of the dissolved contaminant plume due to molecular diffusion by taking into account the anticipated hydraulic head differences around the boundaries of the containment system.

6.2 Methodology

An analytical solution for hydrodynamic dispersion in a finite system in which the bulk flow of ground water is opposite to the direction of the concentration gradient is provided in A. N. S. Al-Niami and K. R. Rushton (Al-Niami, et al.) (1977). Their solution is based on the classic advection-dispersion equation. The initial and boundary conditions used in the solution to Equation A1-1 are:

- Initial Condition:

$$C(x,0)=0 \quad \text{for } 0 \leq x \leq L \qquad (1)$$

- Boundary Conditions:

$$\frac{C}{x}(0,t)=\frac{u}{2D}C(0,t) \text{ for all } t \qquad (2)$$

$$C(L,t)=C_o \text{ for } t>0 \qquad (3)$$

If time approaches infinity (steady-state), and if the above conditions are imposed, the solution to Equation A1-1 becomes:

$$\frac{C}{C_o}=\frac{\exp(\frac{ux}{D})+1}{\exp(\frac{uL}{D})+1} \qquad (4)$$

Assumptions used by Al-Niami and Rushton in deriving their analytical solution include the following:

- The system is 1-dimensional and of finite length;
- The aquifer is an isotropic, homogeneous, porous medium;
- The ground water velocity is constant and is in a direction opposite to that of hydrodynamic dispersion;
- Ground water flow is 1-dimensional; and
- The solutes are non-reactive.

Based upon site-specific parameters, the exponential terms in Equation A1-1 are extremely large numbers. Therefore, the solution to Equation A1-1 can be approximated as:

$$\frac{C}{C_o} \sim \exp\left[\frac{u}{D}(x-L)\right] \qquad (5)$$

or

$$-\ln\left(\frac{C}{C_o}\right) = \beta\ h\ \left(1-\frac{x}{L}\right) \qquad (6)$$

where

$$\beta = \frac{K_h}{n_e D} \qquad (7)$$

Using this approximation to the Al-Niami and Rushton solution, the potential molecular diffusion out of a DNAPL containment well cone of depression was calculated as described in the following paragraphs.

6.3 Analysis

A schematic of the conceptual model for which the analytical solution as employed is presented in Figure E6-1. Potential diffusion of DNAPL from a containment well cone of depression was calculated for wells DW-10, DW-11, and DW-12. As molecular diffusion is anticipated to be greatest where hydraulic gradients are smallest, potential diffusion was calculated in the downgradient direction (relative to regional ground water flow) from each containment well.

Site-specific variables used in the analytical model are largely those used in the numerical model presented in Section 5.0. Hydraulic head profiles generated during numerical model run B23 were used to obtain the average hydraulic gradient within each system (see Figures E6-2 and E6-3). The system length was assumed to extend from the well (x=L) to the edge of its cone of depression (x=0). The hydraulic heads generated when x=0 and x=L were used to determine a total head change across the system (h). An average hydraulic gradient acting on the system was then calculated (h/L) using a horizontal hydraulic conductivity of 11.6 ft/d for Zone 1, as previously determined for the numerical model. The initial concentration of the DNAPL (C_o) at x=L was assumed to be $1.1\text{x}10^6$ ≤*g/l*, as described in Section 5.4.2. The coefficient of diffusion was assumed to be $1.0\text{x}10^{-6}$ cm^2/s (USEPA, 1985; Freeze, et al., 1979). A conservative estimate of effective porosity (n_e) was assumed to be 3-percent, though an additional value of 20-percent was used for comparative purposes.

To determine the propensity for contaminant migration out of the well cone of depression, Equation 6 was used to determine the normalized concentration distribution between $x=0$ and $x=L$. The results, which are based upon Equation 6, are presented in Figure E6-4. The sensitivity of the argument $\beta \ h$ due to the estimated parameter n_e was tested by increasing the parameter to the maximum value considered reasonable (20-percent). However, increasing this parameter did not significantly change the overall trend of extremely low concentrations predicted by the equation. For example, for 20-percent porosity and 0.1 ft head difference, the relative concentration $C/C_o=\exp(-60000)$ at $x/L=0$ (see Figure E6-4). With the assumed value of C_o ($1.1\text{x}10^{6}\leq g/l$), this gives an extremely low concentration at the edge of the depression zone ($10^{-25000}\ \leq g/l$ or less).

Therefore, this analysis indicates that the high hydraulic conductivity, combined with the hydraulic gradients generated; likely would overwhelm the diffusion process at the DNAPL containment wells. As a result, migration of contaminants out of the cones of depression of containment wells due to molecular diffusion appears negligible to non-existent, as suggested by the Al-Niami and Rushton model.

6.4 Conclusions

Migration of non-reactive contaminants out of the cone of depression of the proposed DNAPL containment wells due to molecular diffusion was examined using the analytical model of Al-Niami, et al. (1977). Hydraulic parameters either previously determined during field investigations, or generated during the numerical modeling phase of the investigation were used to calculate potential contaminant migration due to diffusion processes. Given these parameters, calculated concentrations of contaminants leaving the cone of depression of a containment well were extremely small (on the order of $10^{-25000}\ \leq g/l$ or less) and likely near zero. The diffusion process appears to be restrained by the high seepage velocity in the direction opposite to that of diffusion.

7.0 PREDICTION OF DRAWDOWN IN OVERBURDEN UNDER PUMPING CONDITIONS IN ZONE 1

7.1 Introduction

Following the development of the ground water flow model for the remedial extraction system in the Zone 1 aquifer, it was necessary to determine the potential effects of this system on the water table in the overlying Overburden system. There were several reasons for the necessity of this analysis, these included:

- To determine if pumping of the Zone 1 aquifer alone would be sufficient to remediate the dissolved phase plume in the Overburden;
- The assessment of potential dewatering impacts of the Overburden on-site structures; and
- To assess the potential impacts of the Zone 1 pumping system on surface water bodies such as Bergholtz Creek.

This problem could be assessed in one of two ways; either by a 3-dimensional numerical ground water flow model, or by a simplified analytical technique. Golder Associates decided that the volume of additional data required, coupled with time constraints, would not only make 3-dimensional modeling of the area flow system impractical, but it probably would not render a significantly improved definition of the problem relative to the needs of the study. That is, if dewatering effects in the Overburden were indicated to be relatively small by an analytical approach, a slightly more accurate solution determined by a complex numerical model would not probably provide a significant amount of additional, pertinent information.

Presented in the following sections is a discussion of the methodology and form of analysis used to determine potential drawdown in the Overburden system, and the results and conclusions of that study.

7.2 Methodology

The Zone 1 aquifer is believed to be representative of a leaky, semi-confined aquifer system. Above the Zone 1 unit, the system is believed to be confined by a leaky, semipervious layer roughly corresponding to the basal units of the Overburden. The lower ten feet of the Overburden, immediately overlying the Zone 1 aquifer, is comprised principally of very dense silty sand (Basal Till), compact to dense sandy silt (Lacustrine Till), and very stiff to hard silty clay to clay (Lacustrine Clay) (Golder Associates, May 1987). A single recovery test performed in the Overburden indicated a hydraulic conductivity of 7.1 x 10^{-6} cm/sec (Golder Associates, February 1991). It should also be noted that no response was observed in Overburden well 87-14(0) during the Zone 1 pumping test conducted on well 87-14(1) (immediately adjacent to 87-14(0)). However, the limited duration of the pumping test may have been insufficient to reveal any vertical hydraulic interconnection which may exist between the two systems.

To use the analytical model, it was necessary to define several different hydraulic parameters. These included: the hydraulic conductivity of Zone 1 and the Overburden, the vertical leakage of the basal units within the Overburden, the specific yield of the Overburden aquifer, the storativity of Zone 1, and the location and pumping rates of the wells to be used in the Zone 1 aquifer. Results from actual field tests, and/or hydraulic parameters developed during the numerical modeling exercise were used whenever possible. Parameters such as the vertical leakage of the basal portions of the Overburden system were not precisely known from field tests. However, this parameter was varied over a range of anticipated values during the calibration exercise affiliated with the 2-dimensional numerical modeling of the Zone 1 extraction system (Golder Associates, April 1991). The leakage derived from the previous modeling exercise was used to assess the problem of drawdown in the Overburden water table system. Hydraulic conductivities and transmissivities used in the numerical modeling of the Zone 1 system were derived from actual field test results (Golder Associates, February 1990), and these data were subsequently used in the analytical solution. Estimates of specific yield for the Overburden were determined from C. W. Fetter (Fetter) (1980) based upon material type, and the storativity of the Zone 1 aquifer was determined from results of the pumping test conducted in that unit (Golder Associates, February 1990). The pumping rates for the proposed extraction wells used in the numerical modeling of Zone 1, were applied in the analytical simulations to determine potential drawdown at each location. Once drawdown and a radius of influence within the Overburden had been established for each well point, this information could be plotted on a map, superposition was used to determine the composite drawdown in areas where overlap occurred between respective cones of depression.

Once the results of the analytical modeling were complete, a qualitative analysis could then be made to determine the likelihood of extraction of dissolved phase contaminants from the Overburden by the Zone 1 extraction system. If drawdowns in the Overburden proved to be significant, further analysis of dewatering effects could be performed to assess what impact, if any, such dewatering would have on the structural integrity of existing site buildings. Further, head drops within the Overburden in the vicinity of local streams, such as Bergholtz Creek, could be used in subsequent analyses of potential loss from these streams due to reduced flow within the Overburden, as the result of pumping within the Zone 1 system.

After careful consideration of the problem, and a review of the available literature, the analytical solution developed by Hantush (1967) entitled "Flow to Wells in Aquifers Separated by a Semipervious Layer" was selected to assess potential dewatering effects in the Overburden system. Presented in the following section is a discussion of this analytical method.

7.3 Theory of Hantush Analytical Solution

Many analytical solutions consider the problem of pumping of leaky aquifers. However, most of these solutions assume that the distribution of hydraulic head in the unpumped aquifer remains constant with time. The solution developed by Hantush (1967) is a transient form of analysis which allows for the determination of drawdowns within both the pumped and unpumped aquifers over time. Presented in Figure E7-1 is a diagrammatic representation of a leaky aquifer system upon which Hantush (1967) has based his solution. Figure E7-1 depicts an artesian aquifer which is overlain by an unconfined aquifer, and separated from the unconfined aquifer by a semipervious bed. In this example, the semi-confined artesian aquifer is the one subjected to pumping. The example shown in Figure E7-1 corresponds well to the situation being studied between the Zone 1 and Overburden aquifers at the BAT facility.

The following assumptions were made by Hantush (1967) regarding the solution of this problem:

- The aquifers are individually elastic, homogeneous, isotropic, uniform in thickness, and the tangent of the angle of tilt is less than 1-percent;
- The induced drawdown in the water-table aquifer is small relative to its depth of saturation;
- The hydraulic conductivity, storativity, and the leakage coefficient remain constant with time and in the space of the layer they characterize;
- The hydraulic conductivities of the two aquifers are so large relative to that of the semipervious layer (greater than 100) that the flow is essentially vertical in this layer and horizontal in the two aquifers;
- The storage in the semipervious layer is negligible; and
- The well is perforated throughout one of the aquifers.

Hantush (1967) developed several variations of the solution of this problem. Hantush's (1967) solution for pseudo steady-state conditions was used to simulate conditions at the BAT site, as these equations possessed a moderate degree of complexity, and the Zone 1 extraction system is anticipated to reach pseudo steady-state after a relatively short period of time once pumping begins. Hantush (1967) developed the following equations to describe drawdown in both the pumped (s_2) and unpumped (s_1) aquifers:

$$s_1 = \frac{Q_2}{2(T_1 + T_2)} [\ln(r_e/r) - K_o(\beta)] \qquad (1)$$

Q_2

$$s_2 = \underline{\qquad} \quad \frac{[ln(r_e/r) + {}_1K_o(\beta)]}{2(T_1 + T_2)} \qquad (2)$$

where: $$r_e = 1.5\ (V_v\ t)^{1/2} \qquad (3)$$

$$V_v = \frac{2V_1V_2}{V_1+V_2} \qquad (4)$$

$$V_1 = T_1/S_1 \qquad (5)$$

$$V_2 = T_2/S_2 \qquad (6)$$

$$\beta = [(r^2/B_1^2)+(r^2/B_2^2)]^{1/2} \qquad (7)$$

$$B_1 = (T_1b'/K')^{1/2} \qquad (8)$$

$$B_2 = (T_2b'/K')^{1/2} \qquad (9)$$

K_o = zero-order modified Bessel function

r = radius from pumping well to observation point

Q_2 = pumping rate of well in pumped aquifer

T_1 = transmissivity of unpumped aquifer

T_2 = transmissivity of pumped aquifer

t = duration of pumping

S_1 = specific yield of unpumped aquifer

S_2 = storativity of pumped aquifer

b' = thickness of semipervious layer .

K' = hydraulic conductivity of semipervious layer

To facilitate computations, a Fortran 77 program called "HANTAQ2" was developed by Golder Associates, the results of which were verified by hand calculations. Values of r (range), Q_2, T_1, T_2, t, S_1, S_2, b', and K' were entered for each simulation of each extraction well. The program calculated the results of equations (3) through (9), and returned a value of β. The zero-order modified Bessel function was determined from either Kruseman, et al. (1983) or Korn (1968), depending upon the magnitude of β returned. The corresponding value of K_o was then entered and the program calculated the value of s_1 (Equation (1)) for a given value of r. The program was then rerun to perform the recalculation of equations (3) through (9) for the next value of r, β was again returned, a new value of K_o entered, and the next value of s_1 was determined. In this way, a table of s_1 versus r values (distance-drawdown) was generated for each proposed Zone 1 extraction well. Distance-drawdown plots were then created for the Overburden corresponding to each modeled extraction well.

A discussion of the input parameters and the results of the analytical modeling are presented in the following section.

7.4 Conclusions

A value of 0.15 ft^2/day was used for the transmissivity of the Overburden (T_1), based upon the slug test result mentioned previously. The values of T_2 (Zone 1) were varied depending upon the location of the proposed extraction well. The value of T_2 was based upon a hydraulic conductivity of 11.6 ft/day, and varied in accordance with the thickness used at a given location in the numerical ground water flow model (based on boring data). The vertical hydraulic conductivity of the semipervious layer (K′) and the thickness of this layer (b′) were derived from the previously calibrated numerical ground water flow modeling effort. The value of b′ was held constant at ten feet, but K′ was varied by location. The value of specific yield used for the Overburden was 0.2, as determined by material type from Fetter (1980). The value of storativity used for Zone 1 was 2.8×10^{-4}, which was derived from the previous pumping test investigation. The values for all parameters used for each proposed Zone 1 extraction well simulation appear in Table E7-1.

Simulations were performed for each of the proposed extraction wells as shown in Figure E7-2. Notice that well notations beginning with the prefix "EW" correspond to dissolved phase plume extraction wells, and well notations beginning with "DW" correspond to those wells which are to vertically contain the DNAPL plume. The function of these wells and the rationale for their placement is discussed in greater detail in the CMS report (Golder Associates, April 1991). Table E7-2 presents the results of the Zone 1 extraction well simulations of drawdown in the Overburden system. It also depicts the resulting drawdowns in the Overburden at various distances (r) from the Zone 1 pumping well, for different pumping durations (t), for each extraction well simulation. For a reference to the parameters used in each simulation, refer to Table E7-1. Note that sensitivity analyses were run for some of the extraction wells with regard to vertical hydraulic conductivity in the semipervious layer. For example, for extraction well EW1, simulations (a) and (b) were completed, in which K′ values of 0.17 ft/day and 0.003 ft/day were used, respectively. These variations were performed for proposed wells EW1, EW7, and EW8, due to their proximity to Bergholtz Creek, as a slightly higher leakance (0.17 ft/day) was used in the numerical modeling exercise for areas underlying and immediately adjacent to the creek. Thus, a maximum and minimum value of s_1 could be calculated in the vicinity of Bergholtz Creek to determine potential maximum impacts which could result in reduced creek flows.

Simulation times for each of the proposed extraction wells were varied in steps of one year, five years, and ten years. The maximum radius of influence where at least some drawdown in the Overburden could be seen for all of the extraction wells after ten years of pumping was about 110 feet. As anticipated, Overburden drawdowns were greatest around wells with the highest K′ value (of the semipervious layer) and for wells with higher rates of withdrawal (Q_2). The highest drawdown observed was for extraction wells EW1 and EW7 (the (a) simulation of each) where a K′ value for the semipervious layer of 0.17 ft/day and a Q_2 value of 7 gpm were used. The drawdown in the Overburden in these two cases at a distance of two feet after ten years was estimated at about 4.1 feet (Table E7-2).

Since all of the wells shown in Figure E7-2 were located at distances greater than 110 feet away from each other, superposition of drawdown cones was not necessary. In a strictly qualitative sense, the effect on the dissolved phase plume in the Overburden by the proposed Zone 1 extraction wells is expected to be limited to those areas immediately adjacent to the pumping wells. This analysis would indicate that drawdown within the Overburden will not be sufficient, nor are the radii of influence expected to be large enough, to result in damage to existing site buildings due to dewatering. It is strongly recommended, however, that periodic monitoring of Overburden water levels be continued once pumping begins, to ensure that dewatering does not become a significant problem in areas underlying and adjacent to the site buildings. Should decreases in water level in the Overburden become evident, the potential for settlement of the structure in the influenced areas should be re-evaluated. Ground water quality in the Overburden should also continue to be monitored to ascertain whether the Zone 1 pumping system is having any effect in reducing concentrations of any of the observed constituents in the Overburden. Furthermore, it is not anticipated that the dewatering of the Overburden in areas adjacent to Bergholtz Creek will result in significant reductions of stream flows. Further analysis of the effects on Bergholtz Creek as the result of pumping in Zone 1 are discussed in greater detail in Section 9.0.

8.0 PREDICTION OF DRAWDOWN IN ZONE 3 UNDER PUMPING CONDITIONS-IN ZONE 1

8.1 Introduction

Following the development of the numerical ground water flow model for the Zone 1 dissolved phase extraction system and DNAPL control wells, it was necessary to assess the potential impact of this pumping on the Zone 3 aquifer. The reason for this particular analysis is to determine whether the pumping of Zone 1 would cause a reduction in heads within Zone 3.

As was the case in the assessment of potential drawdown effects in the Overburden flow system, this problem can be assessed by using either a 3-dimensional numerical ground water model, or by a simplified analytical solution. A simplified analytical solution was selected for this problem for the same reasons given in Section 7.1.

A description of the method selected, and the results of the study are presented in the following sections.

8.2 Methodology

As previously noted, the Zone 1 aquifer is believed to be representative of a leaky artesian system. Zone 1 is separated from the Zone 3 aquifer by Zone 2, which is believed to act as a confining layer or aquitard between the two units. Vertical fractures are known to exist within similar units in the region (Richard M. Yager, and William M. Kappel (Yager, et al.) (1987), therefore it is suspected that Zone 2 does permit some leakage between the two units. There is some minor separation in hydraulic heads between Zone 1 and Zone 3, and no response was noted in any of the Zone 3 monitoring wells during the Zone 1 pumping test conducted in well 87-14(1). This includes well 87-14(3), completed in Zone 3, and located adjacent to pumping well 87-14(1), which showed no response to pumping. However, it is possible that the duration of pumping was insufficient to establish a hydraulic connection between the two aquifers, and does not necessarily mean that some leakage is not possible with sustained pumping. The horizontal hydraulic conductivity of the Zone 2 aquifer is estimated to be 10^{-6} cm/sec (2.8×10^{-3} ft/day), based upon packer test results conducted across the contacts between Zone 2 and Zone 1, and between Zone 2 and Zone 3 (Golder Associates, May 1987). Zone 2 is comprised principally of slightly fractured and poorly weathered dolostone. Thus, the lithology, lack of fracturing and weathering, low permeability estimates, and lack of response during the pumping test, suggest that Zone 2 may be considered to serve as a confining layer, although some leakage through this zone may be possible.

To produce analytical solutions of drawdown in Zone 3 as a response to pumping within Zone 1, several hydraulic parameters required definition. These parameters included the hydraulic conductivity of Zone 1 and Zone 3, the vertical hydraulic conductivity of Zone 2, the specific storage of Zones 1, 2, and 3, and the thickness of each unit. The hydraulic parameters for the three zones are given in Figure E8-1. Pumping was assumed to take place within the Zone 1 aquifer, and the pumping rates used were obtained from final simulations conducted during the numerical ground water flow modeling of the Zone 1 extraction system. The intent was to determine drawdown in Zone 3 in areas immediately adjacent to Zone 1 pumping wells. Furthermore, a qualitative analysis of the effectiveness of Zone 1 pumping on the Zone 3 dissolved phase plume was made.

Values used for the hydraulic parameters mentioned above, were obtained primarily from actual field test data. Pumping rates in the Zone 1 wells were taken from those used in the 2-dimensional numerical ground water flow modeling analysis of the Zone 1 extraction system (Golder Associates, April 1991). After careful consideration of the problem, and a review of the available literature, the only analytical solution that could be identified as being applicable to this problem was the solution developed by S. P. Neuman, and P. A. Witherspoon (Neuman, et al.) (1969b) entitled: "Theory of Flow in a Confined Two Aquifer System," which is described below.

8.3 Theory of Neuman and Witherspoon Analytical Method

Neuman, et al. (1969a, and 1969b) developed a complete analytical solution for the problem of flow to a well in a confined infinite radial system composed of two aquifers that are separated by an aquitard. The schematic diagram of a 2-aquifer system is shown in Figure

E8-1. The well, which is represented by a line sink, completely penetrates only one of the aquifers and discharges at a constant rate. In this example, Zone 1 or Aquifer 1 is subjected to pumping. The example shown in Figure E8-1 corresponds well to the situation being studied between the Zone 1 and Zone 3 aquifers at the BAT facility.

The following assumptions were made by Neuman and Witherspoon (1969a, 1969b) for the solution of the problem mentioned above:

- Each layer is homogeneous, isotropic, horizontal, and of infinite radial extent;
- The diameter of the well is infinitesimally small and is completed in the upper aquifer;
- Each layer is homogeneous, isotropic, horizontal, and of infinite radial extent;
- The system remains saturated at all times, and Darcy's law applies;
- The direction of flow is vertical on the aquitard; and
- The upper and lower limits of the complete system are no-flow boundaries.

Neuman, et al. (1969a, 1969b) presented a complete solution that includes consideration of both release of water from storage in the aquitard and hydraulic head drawdowns in the unpumped aquifer. Their solutions require the calculation of four dimensionless parameters, with reference to Figure 8-1, they are defined as follows:

$$\beta_{11} = \frac{r}{4b_1}\left(\frac{K_1' S_{s1}'}{K_1 S_{s1}}\right)^{1/2} \qquad (1)$$

$$\beta 21 = \frac{r}{4b_2}\left(\frac{K_1' S_{s1}'}{K_2 S_2}\right)^{1/2} \qquad (2)$$

$$\frac{r}{B_{11}} = r\left(\frac{K_1'}{K_1 b_1 b_1'}\right)^{1/2} \qquad (3)$$

$$\frac{r}{B_{21}} = r\left(\frac{K_1'}{K_2 b_2 b_1'}\right)^{1/2} \qquad (4)$$

Neuman and Witherspoon's solutions provide the drawdown in both aquifers as a function of radial distance from the well, and in the aquitard as a function of both radial distance and elevation above the base of the aquitard. The solutions are in complex forms, and can only be evaluated with numerical integration. The authors verified independently the validity of their solutions using the finite element method of analysis and generated a series of dimensionless drawdown (s) versus dimensionless time (t) for various values of β_{11}, β_{21}, r/B_{11}, and r/B_{21}. The values given by Eqs. 1, 2, 3, and 4 need to be calculated for a specific problem to use these curves. The number of curves presented by Neuman and Witherspoon have limited usage with regard to the site specific values of parameters calculated from Equations 1, 2, 3 and 4. The curves presented by the authors for two sets are shown in Figures E8-2 and E8-3 and the corresponding parameter values are given in Table E8-1.

8.4 Results

Using the site specific average hydrogeological parameters given in Figure E8-1, the parameters given by Eqs. 1, 2, 3, and 4 were calculated and listed in Table E8-2 for different radial distances. The extraction wells are located along a line with approximately 330 feet spacing (see Figure E7-2). Of the four sets of Neuman and Witherspoon parameters in Table E8-2, the values for 100 feet radial distance are the closest ones to those in Figure E8-2. The dimensionless quantities taken from Figure E8-2, as well as the dimensional values calculated using the corresponding equations, are given in Table E8-3. The results based upon Figure E8-3 are also presented although the Neuman and Witherspoon parameters (see Table E8-1) are somewhat different compared with the site specific parameters given in Table E8-2. The results in Table E8-3 correspond to 160 days, which is based upon the maximum dimensionless time in Figure E8-2 and Figure E8-3. These values correspond to 100 feet radial distance from a single well. As can be seen from Table E8-3, based upon Figure E8-2, the drawdowns in the unpumped aquifer (Zone 3) and pumped aquifer (Zone 1) are 1.5 feet and 3.7 feet, respectively. The drawdowns produced from Figure E8-2 are approximately the same (2.1 feet) in both aquifers (Zone 1 and Zone 3).

8.5 Conclusions

Based upon the analysis presented above the main conclusions may be summarized as follows:

- Zone 3 will be affected under pumping conditions in Zone 1. This is not unexpected because the aquitard separating Zone 1 from Zone 3 is relatively thin (approximately seven feet); and
- After approximately five months pumping from Zone 1, the drawdowns at 100 feet radial distance in Zone 1 and Zone 3 will be approximately 3.7 feet and 1.5-feet, respectively.

9.0 PREDICTION OF DRAWDOWN IN SURFACE WATER BODIES UNDER PUMPING CONDITIONS IN ZONE 1

9.1 Introduction

The proposed ground water remediation system for the BAT site involves pumping ground water from the Zone 1 aquifer. Since this could potentially result in the loss of water from nearby surface water bodies, it is necessary to analyze this situation to determine whether the anticipated loss is acceptable. Two surface water bodies exist in the BAT study area: Bergholtz Creek and Sawyer Creek. The most prominent is Bergholtz Creek. This small stream often lies close to the top of the Zone 1 bedrock. In some areas, one or two feet of sediment may be present between the base of Bergholtz Creek and the top of Zone 1. The composition of this sediment is rather variable, and may consist of either sand and gravel, or thick organic clays, mud, and silt. Conversely, though, Sawyer Creek often exhibits very low flows (especially in the summer and fall), and several feet of Overburden lacustrine clays and silts does separate the base of this creek from the Zone 1 aquifer. Consequently, it was determined that only the Bergholtz Creek surface water body required further investigation.

The following sections present a discussion of the forms of analysis used to assess the potential impact on Bergholtz Creek from the proposed Zone 1 extraction well systems.

9.2 Method of Analysis

The basic premise of this study was to analytically determine the potential flow from Bergholtz Creek into Zone 1 based upon the configuration and pumping rates of the Zone 1 extraction system. To assess the overall impact on the creek, it was necessary to obtain some estimate of ordinary flows within Bergholtz Creek as it passes along the southern margin of the BAT facility. By noting the difference between the flow of water out of the creek and the total flow of water in the creek (at any given time), an assessment of the relative impact due to pumping could be made. Flow within Bergholtz Creek may be attributed to the following sources:

- Flow entering the study area from upgradient locations;
- Baseflow from the Overburden; and
- Baseflow from Zone 1.

Results of the analytical study of drawdown in the Overburden due to pumping in Zone 1 (previously discussed in Section 7.0) indicate that any alteration of water levels within the Overburden would probably not significantly impact creek flows. Therefore, only the effect emanating from Zone 1 to the creek was examined.

Two independent sources were used to estimate overall flow in Bergholtz Creek under non-pumping conditions. The first estimate came from B. Eissler (1979), who reported a low flow rate of Bergholtz Creek in June 1955 of 0.23 ft^3 /sec (approximately 103 gpm). A second estimate of flow was obtained by the Manning Equation, (Fetter, 1980). The Manning Equation computes flow velocity 'v' as follows:

$$v = (1.49 R^{2/3} S^{1/2})/n \qquad (1)$$

where:

v = Average velocity in ft/sec

R = Hydraulic radius or ratio of cross-sectional flow area

_ = To the wetted perimeter = A/P

S = Energy gradient or slope of water surface dh/dl

n = Manning Roughness Coefficient

A = Area (ft) from designated cross-section of creek

P = Wetted perimeter (ft) = a+c

a,c = Wetted sides of cross-section of stream (ft)

Manning's Equation assumes that water elevations represent current conditions, that flow is homogeneous, and that the stream channel is 'V'-shaped. The flow rate past any given point (Q) may be then be estimated by:

$$Q = AV \qquad (2)$$

For this assessment, the April 1990 surface water elevations determined at three survey points along Bergholtz Creek (Golder Associates, February 1991, Figure 6-1) were used. The parameters in Equation 1 were estimated from these surface water survey points by determining the energy gradient 'S' from the slope of the water surface between the points, determining the hydraulic radius 'R' and subsequently the velocity 'v.' A Manning Roughness Coefficient of 0.04 to 0.05 was used (Chow, 1988). The flow rate 'Q' was calculated using the cross-sectional area of the flow 'A' and the calculated velocities 'v' (Table E9-1). The flow in Bergholtz Creek was estimated at approximately 3.8 ft^3/sec to 5/5 ft^3/sec, or about 1,700 gpm to 2,450 gpm (Table E9-1). A second calculation was performed assuming low water levels in the stream. These water levels were assumed to be 0.5 feet lower than the April 1990 levels. The second calculation yielded a flow rate of 1.3 ft^3/sec to 2.1 ft^3/sec, or about 588 gpm to 946 gpm (Table E9-2).

The potential loss or discharge from Bergholtz Creek into Zone 1 upon pumping, was estimated from the Darcy's equation:

$$Q = (K'A)\,(h/l) \quad (3)$$

where:

Q = discharge from creek to Zone 1

K' = vertical hydraulic conductivity of stream sediment

h = difference in head between modeled head distribution in Zone 1 with pumping and the estimated head in Bergholtz Creek

l = thickness of stream sediment

A = area of the creek bottom over the length indicated as being affected by pumping according to the numerical flow model.

The vertical hydraulic conductivity of the sediment used was derived from the numerical modeling effort (Golder Associates, April 1991) and estimated at 2.8×10^{-1} ft/day. The modeled distribution of hydraulic head with pumping of the proposed extraction system and the length of the stream over which '*Q*' was calculated are shown in Figure E9-1. Because the difference in head changes at different points in the stream bottom, potential discharges were calculated along various lengths of the streams. The largest discharge calculated was 0.0325 ft^3/sec, or about 14.6 gpm. The total discharge from all of the individual lengths of the stream over which discharge occurs, was estimated at about 0.041 ft^3/sec, or about 18.4 gpm.

9.3 Conclusions

The results of the calculations of discharge from Bergholtz Creek into Zone 1, as compared to the estimates of discharge within the creek under no-pumping conditions, indicate that the pumping of the Zone 1 aquifer should not have any significant impact on the flow of Bergholtz Creek. The total pumping rate of the entire extraction system is proposed to be approximately 66 gpm. Even if the entire 66 gpm discharge of this system was derived solely from the creek (which is considered unlikely), it would result in a reduction in flow of only 11-percent, if the estimated low flow rate from Manning Equation (1.3 ft^3/sec) is assumed for comparison.

10.0 ASSESSMENT OF MATRIX DIFFUSION IN ZONE 1

10.1 Introduction

The primary objective of this analysis was to determine the anticipated extent and concentration of contaminants along bedrock fractures and within bedrock matrices. Diffusion of contaminants into the rock material from water in the fractures can serve as a reservoir of contaminants. During remediation this reservoir has the potential to supply low levels of contaminants to "clean" ground water down into a fracture by the action of the ground water extraction wells. The concentration of TCE as a function of time and distance has been determined for both the fracture system and the rock matrix under uniform flow assumption. The choice of the compound TCE for this analysis was explained in Section 5.4.2. The analysis is based upon an analytical model for a system of parallel fractures originally developed by E. A. Sudicky and E. O. Frind (Sudicky, et al.) (1982). Site specific data, model assumptions, definition of the computer code, analysis, and model results are presented in the following sections.

10.2 Site Specific Data

As previously described Zone 1 includes the bedrock surface, and is stratigraphically equivalent to lower units within the Guelph Formation dolomite. This hydrostratigraphic unit is composed of fine grained, thinly bedded, light brownish-gray dolostone with numerous open bedding partings (bedding fractures) that have formed by the weathering of gypsum due to ground water flow. The bedding-parallel fractures are believed to be the principal water bearing features within this aquifer. Based on the field investigations, the Zone 1 unit exhibits significantly more fractures per foot than the underlying units.

The Zone 1 unit has relatively high measured hydraulic conductivity values. The overall mean value is about 2 x 10^{-3} cm/sec. Estimated effective porosities for the Zone 1 bedrock (based on visual examination of rock core) are in the range of 1-percent to 3-percent.

10.3 Methodology and Assumptions

The matrix diffusion analysis is based upon an analytical model for a system of parallel fractures originally developed by Sudicky, et al. (1982) which incorporated a set of identical fractures whose axes were parallel and equally spaced (Figure E10-1). The analytical solution is based upon the following assumptions:

- The ground water velocity in each fracture is constant;
- A contaminant source of constant strength exists at the origin of each fracture;
- The width of each fracture is much smaller than its length;
- Transverse diffusion and dispersion within each fracture assures complete mixing across its width at all times;
- The hydraulic conductivity of the intervening porous matrix is low and transport within the matrix will be mainly by molecular diffusion; and
- Transport along each fracture is much faster than transport within the matrix.

The second and third assumptions form the basis for a 1-dimensional analysis of transport along the fractures. The last two assumptions permit the mass flux in the porous matrix to be taken in a direction perpendicular to the fracture axes. Thus, a basically 2-dimensional system is reduced to two 1-dimensional problems that are much more amenable to solution by analytical techniques. The model developed by Sudicky and Frind takes into account the following processes:

- Advective transport along each fracture;
- Molecular diffusion and mechanical dispersion along the fracture axis;
- Molecular diffusion from the fracture to the porous matrix; and
- Adsorption onto the surface of the matrix.

The computer code CRAFLUSH (E. A. Sudicky (Sudicky) (1988)) based upon the model described above was used for the matrix diffusion analysis at the site.

10.4 Definition and Determination of Model Parameters

A number of site specific parameters are required for input into the CRAFLUSH model. These model parameters include the following:

- Source concentration at fracture origin (Co);
- Initial concentration in matrix (Cim);
- Ground water velocity in fracture (V);
- Longitudinal dispersivity in fracture (alpha);
- Fracture aperture (B);
- Fracture spacing (sep);
- Matrix porosity (theta);
- Matrix tortuosity (tau);
- Diffusion coefficient in water (Do);
- Fracture retardation factor (R); and
- Matrix retardation factor (Rp).

As indicated below, many of these hydraulic parameters were previously established and were used in the ground water flow/solute transport models. In addition, several of the values used for the geologic parameters are based upon direct observation. Since the parameter units had to be kept consistent for use in the model, the parameters are described below with their commonly used units, followed by model consistent units in parenthesis, if a conversion was necessary.

The source concentration at the fracture origin (Co) is assigned the value 1.1×10^{6} ug/l (6.9×10^{-2} lb/ft^3), which is the maximum reported concentration for TCE in the Zone 1 aquifer for the 1990 CLP sampling event. The initial concentration in the matrix (Cim) is assumed to be 0 ug/l (0 lb/ft^3).

The ground water velocity in the fracture (V) is a very site-specific parameter which cannot easily be measured. However, if some reasonable assumptions are made, this value can be estimated. The measured length of the dissolved phase plume in Zone 1 is approximately 4,400 feet long. The plume is assumed to have migrated for 40 years, therefore the average rate of contaminant movement has been approximately 110 ft/yr or 0.30 ft/day. If a conservative retardation factor of two is used for the contaminant, then the ground water velocity is 0.60 ft/day. The longitudinal dispersivity in the fracture (alpha) was chosen as 20 feet, as previously determined from the solute transport modeling calibration (see Section 5.4.5).

Values used for fracture geometry in the CRAFLUSH model were either estimated or based upon available field data. The fracture aperture (B) was estimated to be approximately 4 x 10^{-3} ft. This value was determined by multiplying the aquifer thickness (18 feet) by its porosity (2-percent, estimated average). Assuming that all of the porosity is due to horizontal fractures, then there is a total of 0.36 feet of fracture (void) space in the aquifer. Based upon the observation of Zone 1 cores, there are approximately five fractures per foot of aquifer thickness. Therefore, the average aperture of each fracture is 4 x 10^{-3} ft (0.36 ft/90 fractures). Although the observed fracture frequency was approximately five per foot, it appears from available data that effective (interconnected) fractures occur, on average, only every two feet.

The effective matrix porosity (theta) for the Zone 1 aquifer was estimated to be 2-percent. This is within the range of zero to 20-percent noted by both Freeze, et al. (1979), and F. G. Driscoll (Driscoll) (1986) for dolomite. The matrix tortuosity (tau), is the ratio of the distance between two points by way of connected pores and the straightline distance. Since the fractures are believed to be predominantly horizontal bedding planes, a value of one (unitless) was assigned to this parameter.

A value of 1 X 10^{-6} cm^2/sec (9.33 X 10^{-5} ft^2/day) was used for the diffusion coefficient in water (Do), as per USEPA Guidelines (USEPA, 1985).

As previously described, a value of two was assigned to the fracture retardation factor (R). The matrix retardation factor (RP) was assumed to be one.

10.5 Results

Using the parameters detailed in Section 10.4, the CRAFLUSH model was used to determine the anticipated extent and concentration of TCE contamination along fracture and within the rock matrix in the vicinity of the DNAPL plume in Zone 1. The model calculated the concentration along a parallel fracture for a distance of 4,000 feet from a given source at distances of 500 feet, 1,000 feet, 1,500 feet, 2,000 feet, 3,000 feet and 4,000 feet. The model also calculated the concentration of contaminants in the matrix every 0.1 foot from zero feet to one foot. Since the fracture spacing is given to be two feet, the calculated concentration should be a maximum at the fracture/matrix interface (distance = zero feet) and a minimum at halfway between two parallel fractures (distance = one foot), with the concentration distribution being a mirror image between adjacent fractures. Concentrations were calculated for both the fracture and matrix locations every five years for a total of 40 years.

Table E10-1 shows both the absolute and relative concentration calculated for TCE at 500 foot intervals along the fracture at 5-year time intervals. As shown, the model predicts that contaminant concentration diminishes very rapidly (by several orders of magnitude) from the source (distance = zero) for the first five years. The contaminant continues to migrate away from the source and increase in concentration up to the end of the model run. This is also shown graphically in Figure E10-2. At that time, 40 years after introduction of the source, the CRAFLUSH model predicts that the contaminant front has moved between 3,000 and 3,500 feet from the source along the fractures. This is very close to what is actually believed to have happened, as shown by the extent of the present day TCE plume (Golder Associates, April 1991; Figure 9). This provides a rough calibration of the CRAFLUSH analytical model.

Table E10-2 shows the absolute and relative concentration of TCE calculated every tenth of a foot into the rock matrix at 500 foot intervals from the source after one and 40 years elapsed time. Similar to those calculations described above for the fracture, the CRAFLUSH model predicts that contaminant concentration in the rock matrix diminish rapidly from the source for the first several years, then gradually migrates downgradient from the source and deeper into the rock matrix, and increases in concentration over time. At the end of the model run, (40 years), significant concentrations in the rock matrix are predicted by the model out to approximately 2,500 feet from the source. This is indicated by Figure E10-3 which shows relative concentration as a function of matrix depth after

40 years. The model therefore suggests that matrix diffusion could be a possible source of contamination during remediation efforts at the BAT site. However, since the Zone 1 plume is believed to have originated approximately 40 years ago, this should only be an issue for a distance of approximately 2,500 feet from the Neutralization Pond. The possible impact of this process would be primarily within the on-site remediation capture area, which extends approximately 1,500 feet from the Neutralization Pond. Further downgradient from that point (in the off-site remediation capture area), the model predicts relatively low concentrations in the matrix which could potentially be diffused out during remediation.

To summarize, using the parameters previously defined in Section 10.4, the CRAFLUSH analytical model predicts that the concentration of the contaminant TCE in a fracture decreases away from a source, and its migration is limited to between 3,000 and 3,500 feet from the source after 40 years at the site. This approximates the known field conditions. The predicted contaminant concentration in the rock matrix also decreases away from a source, however, concentrations do increase further downgradient and deeper into the rock matrix over time. Results suggest that matrix diffusion may be a source of contamination in the on-site remediation area, but of much lower impact in the off-site remediation area.

10.6 Sensitivity Analysis

The CRAFLUSH analytical model required input of 11 different site specific parameters as described in Section 10.4. The results of modeling are obviously dependent upon the model parameters which are used. The choice of the values used for the model parameters were based upon previously established parameters, direct observation, literature recommendations or estimates which Golder Associates believes are reasonable. However, many of these parameters either cannot be precisely determined, may range in value across the site area, or may change during remediation. Therefore, the results presented in Section 10.6 should be regarded as estimates only.

To determine the likely range of model results, Golder Associates varied the input to test how sensitive the model is to changes in model parameters. Given the number of parameters involved, it was determined that it was not reasonable to vary all parameters. However, several parameters, such as fracture velocity, fracture aperture, fracture retardation, matrix porosity and the coefficient of diffusion were varied independently to see their effect upon model results. The sensitivity runs show that an increase in either fracture velocity or fracture aperture results in an increase in matrix diffusion (i.e., model predicts higher contaminant concentrations at a given location either along a fracture or into the rock matrix). Conversely, an increase in fracture retardation, or the coefficient of diffusion results in a decrease in matrix diffusion. The sensitivity analysis also indicates a decrease in matrix diffusion if the matrix porosity is increased. This is because that for a given contaminant mass, the higher matrix porosity equates with more pore water, resulting in the dilution of the contaminant mass and an apparent decrease in matrix diffusion concentrations. These results show that the model is indeed sensitive to a change in input parameters.

It was noted during the sensitivity analysis that if the values were varied within a range considered to be reasonable, then the results generally agreed with those described above in Section 10.6. However, it was possible to generate results indicating either extremely high or extremely low concentrations in the fracture or rock matrix depending upon the values used for input. As neither of these cases describe what is currently observed at the site (a dissolved phase plume approximately 4,000 feet long which originated about 40 years ago), Golder Associates does not consider these "extreme" sensitivity runs to predict the likely impact of matrix diffusion on ground water remediation at the site. The sensitivity analysis does, however, indicate a need for caution in the interpretation of model results.

10.7 Conclusions

Results of the CRAFLUSH analytical model suggest that matrix diffusion may provide a reservoir of contamination during ground water remediation in the on-site remediation area. Based upon the model results, this mechanism may not significantly affect remediation within the off-site capture area.

Sensitivity analyses generally agree with this conclusion, however the model indicates that contaminant concentrations along a fracture and within the matrix can be significant, depending on the model input. Since many of the model parameters cannot be precisely determined, may range in value across the site area, or may change during remediation, it should be noted that matrix diffusion could possibly be a source of contamination, and therefore may be a factor in the ground water cleanup schedule.

11.0 OVERALL CONCLUSIONS

The off-site ground water extraction system comprised of six wells, located along the Nymo right of way, has been designed to extract ground water from the Zone 1 bedrock beneath the off-site portion of the site. The wells will be cased through the Overburden and back through Zone 1 to the top of Zone 2. Pumps, will discharge water to a common pipe line which will discharge to a manhole on the Walmore road Sanitary Sewer.

Solute transport modeling indicates that if hydraulic containment of the on-site DNAPL area is concluded the off-site extraction system will remove ground water with maximum VOC concentrations between 350 ug/l to 1,500 ug/l at a maximum mass flux rate of 0.2 lbs/day to 0.7 lbs/day. The total mass of VOC to be removed by the off-site extraction system is estimated to be between 75 lbs and 550 lbs. The upper range of values may represent an over estimation due to the three constant concentration sources included in computer runs B10 and B20. These were included to allow assessment of the impact of not starting on-site corrective measures until after (300 days) the off-site system is started.

Taking into consideration the estimated calculations for the DNAPL wells, maximum concentrations ranging between 117,000 ug/l and 466,000 ug/l with a corresponding maximum mass flux rate ranging between 33.6 lbs/day and 134.4 lbs/day are expected for the on-site extraction system.

Following clean-up of the dissolved phase plume, the DNAPL control wells will extract ground water with concentrations in total VOC between 226,000 ug/l and 231,000 ug/l with a flux rate of 32.6 lbs/day to 33.34 lbs/day.

The estimated clean-up time of the off-site dissolved phase plume ranges between 12 years and 21 years.

In conclusion, if physical containment of the DNAPL area is implemented the modeling indicates the off-site extraction system will extract ground water with maximum VOC concentrations between 350 ug/l to 380 ug/l, and with maximum mass flux rates of 0.18

lbs/day to 0.19 lbs/day. The total mass of VOC to be removed by the off-site extraction system is calculated to be between 80 lbs and 305 lbs.

Including estimates for the DNAPL wells, it is expected that the maximum concentrations for the on-site extraction system range between 136,000 ug/l, and 505,000 ug/l, with a corresponding maximum mass flux rate between 29.5 lbs/day and 109.18 lbs/day.

Following clean-up of the dissolved phase plume, the modeling indicates that the DNAPL wells will extract ground water with concentrations in total VOC between 395,000 ug/l and 750,000 ug/l, with a flux rate of 28.5 lbs/day to 54.06 lbs/day.

The estimated clean-up time of the dissolved phase plume ranges between 12 years and 20 years.

Migration of contaminants out of the cone of depression of the proposed DNAPL containment wells due to molecular diffusion was examined using the analytical model of Al-Niami and Rushton (1977). Hydraulic parameters either previously determined during field investigations, or generated during the numerical modeling phase of the investigation were used to calculate potential contaminant migration due to diffusion processes. Given these parameters, calculated concentrations of contaminants leaving the cone of depression of a containment well were extremely small (on the order of 10^{-25000} ≤*g/l* or less) and likely near zero. The diffusion process appears to be restrained by the high seepage velocity in the direction opposite to that of diffusion.

In a strictly qualitative sense the effect on the dissolved phase plume in the Overburden by the proposed wells in the Zone 1 bedrock is expected to be limited to those areas immediately adjacent to the pumping wells. The on-site CMI Plan will propose a monitoring program to determine actual effects. This analysis would indicate that drawdown within the Overburden will not be sufficient, nor are the radii of influence expected to be large enough, to result in damage to existing site buildings due to dewatering. It is strongly recommended, however, that periodic monitoring of

Overburden water levels be continued once pumping begins, to ensure that dewatering does not become a significant problem in areas underlying and adjacent to the site buildings. Should decreases in water level in the Overburden become evident, the potential for settlement of the structure in the influenced areas should be re-evaluated. Ground water quality in the Overburden should also continue to be monitored to ascertain whether the Zone 1 pumping system is having any effect in reducing concentrations of any of the observed constituents in the Overburden. Furthermore, it is not anticipated that the dewatering of the Overburden in areas adjacent to Bergholtz Creek will result in significant reductions of stream flows.

Based upon the analysis presented above the it is considered that:

- Zone 3 will be affected under pumping conditions in Zone 1. This is not unexpected because the aquitard separating Zone 1 from Zone 3 is relatively thin (approximately seven feet); and
- After approximately five months pumping from Zone 1, the drawdowns at 100 feet radial distance in Zone 1 and Zone 3 will be approximately 3.7 feet and 1.5-feet, respectively.

The results of the calculations of discharge from Bergholtz Creek into Zone 1, as compared to the estimates of discharge within the creek under no-pumping conditions, indicate that the pumping of the Zone 1 aquifer should not have any significant impact on the flow of Bergholtz Creek. The total pumping rate of the entire extraction system is estimated to be approximately 66 gpm. Even if the entire 66 gpm discharge of this system was derived solely from the creek (which is considered unlikely), it would result in a reduction in flow of only 11-percent, if the estimated low flow rate from Manning Equation (1.3 ft^3/sec) is assumed for comparison.

Results of the CRAFLUSH analytical model suggest that matrix diffusion may provide a reservoir of contamination during ground water remediation in the on-site remediation area. Based upon the model results, this mechanism may not significantly affect remediation within the off-site capture area.

Sensitivity analyses generally agree with this conclusion, however the model indicates that contaminant concentrations along a fracture and within the matrix can be significant, depending on the model input. Since many of the model parameters cannot be precisely determined, may range in value across the site area, or may change during remediation, it should be noted that matrix diffusion could possibly be a source of contamination, and therefore may be a factor in the ground water cleanup schedule.

REFERENCES

1. Al-Niami, A.N.S. and K.R. Rushton, 1977, "Analysis of Flow Against Dispersion in Porous Media," Journal of Hydrology, Vol. 33, pp. 87-97

2. Batu, V., 1986, "A Generalized Two-Dimensional Analytical Solution for Hydrodynamic Dispersion in Bounded Media With the Flux-Type (Third-Type) Boundary Condition at the Source," Unpublished manuscript

3. Batu, V., 1989, "A Generalized Two-Dimensional Analytical Solution for Hydrodynamic Dispersion in Bounded Media With the First-Type Boundary Condition at the Source, Water Resources Research," Vol. 25, No. 6, pp 1125-1132

4. Driscoll, F.G., 1986, "Ground Water and Wells," Johnson Filtration Systems Inc., St. Paul, Minnesota, 1089 pp

5. Eissler, B., 1979, "Low Flow Frequency Analysis of Streams in New York," Department of Interior, U.S. Geological Survey, and New York Department of Environmental Conservation Bulletin #74

6. Faust, C. R., P. N. Sims, C. P. Spalding, and P. F. Andersen, 1990, "FTWORK: Ground Water Flow and Solute Transport In Three Dimensions," Version 2.4, GeoTrans Inc., Sterling, Virginia

7. Fetter, C.W., 1980, "Applied Hydrogeology," Merrill Publishing Company, Columbus, Ohio 592 pp

8. Franz, T., and N. Guiguer, 1990, "FLOWPATH, Two-Dimensional horizontal Aquifer Simulation Model, Version 2.0," Waterloo Hydrogeologic Software, Waterloo, Ontario, Canada

9. Freeze, R.A., and Cherry J.A., 1979, "Ground Water," Prentice-Hall, Inc. Englewood Cliffs, NJ 604 pp

10. Golder Associates Inc., May 1987, "Results of Phase I and II Investigation, Plume Definition Plan, Bell Aerospace Textron, Wheatfield, New York"

11. Golder Associates Inc., February 1990, "Draft Report Results of the Pump-In and Pump-Out Testing, Bell Aerospace Textron, Wheatfield, New York"

12. Golder Associates Inc., October 1990, "RCRA Facility Investigation, Neutralization Pond, Bell Aerospace Textron, Wheatfield Plant, Niagara, New York"

13. Golder Associates Inc., February 1991, "Draft Final Report RCRA Facility Investigation, Neutralization Pond, Bell Aerospace Textron, Wheatfield, New York"

14. Golder Associates Inc., April 1991, "Draft Final Report Corrective Measures Study, Bell Aerospace Textron, Wheatfield, New York"

15. Golder Associates Inc., 1991a, "Analytical Solute Transport Models, Theory and User's Manuals, Version 1.0," Mount Laurel, New Jersey

16. Golder Associates Inc., 1991b, "Statement of Qualifications, Ground Water Flow and Solute Transport Services," Mount Laurel, New Jersey

17. Hantush, 1967, "Flow to Wells in Aquifers Separated by a Semipervious Layer"

18. Kruseman, G.P. and N.A. DeRidder, 1983, "Analysis and Evaluation of Pumping Test Data," International Institute for Land Reclamation and Improvement/ILRI, Wageningen, The Netherlands

19. McDonald, M. G., and A. W. Harbaugh, 1984, "A Modular Three-Dimensional Finite-Difference Ground Water Flow Model," U. S. Geological Survey Open File Report 83-875

20. Neuman, S.P., and P.A. Witherspoon, 1969a, "Transient Flow of Ground Water to Wells in Multiple-Aquifer Systems," Department of Civil Engineer, Institute of Transportation and Traffic Engineering, University of California, Publication No. 69-1, Berkeley, California

21. Neuman, S.P., and P.A. Witherspoon, 1969b, "Theory of Flow in a Confined Two Aquifer System," Water Resources Research, Vol. 5, No. 4, pp. 803-816

22. Sudicky, E.A., 1988, "CRAFLUSH, Parallel Crack Model D>0," Waterloo Centre for Ground Water Research, University of Waterloo, Waterloo, Ontario, Canada

23. Sudicky, E.A., and Frind, E.O., 1982, "Contaminant Transport in Fractured Porous Media: Analytical Solutions for a System of Parallel Fractures," Water Resources Research, V.18, No. 6, pp. 1634-1642

24. United States Environmental Protection Agency, 1985, "Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water, Part I and Part II," Environmental Research Laboratory, Office of Research and Development, Athens, Georgia

25. Ward, D. S., D. R. Buss, J. W. Mercer, and S. S. Hughes, 1987, "Evaluation of a Ground Water Corrective Action at the Chem-Dyne Hazardous Waste Site Using a Telescopic Mesh Refinement Modeling Approach," Water Resources Research, Vol. 23, No. 4, pp 603-617

26. Yager, Richard M., and William M. Kappel, September 1987, "Detection and Characterization of Fractures and Their Relation to Ground-Water Movement in the Lockport Dolomite, Niagara County, New York," Proceedings of the 3rd Annual Ground Water Technology Conference, City of New York, New York

TABLE E5-1
AVERAGE HYDROGEOLOGIC PARAMETERS FOR ZONE 1
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

PARAMETER	VALUE
Hydraulic Conductivity	0.003/sec/(8.5 ft/day)
Hydraulic Gradient	0.0018 ft/ft
Effective Porosity	0.03

F/N: TABE5-1.WK1

TABLE E5-2
CALIBRATED SOLUTE TRANSPORT PARAMENTS FOR TRICHLOROETHENE
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

PARAMETER	VALUE
Longitudinal Dispersivity	20 Feet
Transverse Dispersivity	2 Feet
Effective Source Width	25 Feet

F/N: TABE5-2.WK1

T[illegible] E5-3
SUMMARY OF ESTIMATED MASS LOADINGS AND CONCENTRATIONS FROM THE ZONE 1 DISSOLVED PHASE PLUME TO THE OFF SITE EXTRACTION SYSTEM
COMPUTER RUNS B10, B12, B13, B20, B22 AND B23.
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPUTER RUN	PUMPING RATE	INITIAL CONDITIONS		MAXIMUM FLUX RATE AND CONCENTRATION			ESTIMATED TOTAL MASS OF VOC TO BE REMOVED				
		CONTAMINANT FLUX RATE (lbs/day)	CONCENTRATION (ug/l)	CONTAMINANT FLUX RATE (lbs/day)	CONCENTRATION (ug/l)	TIME FROM THE START OF THE EXTRACTION SYSTEM (YEARS)	MASS OF TOTAL VOC (lbs)	ESTIMATED MASS OF MAJOR CONSTITUENTS (%)		(lbs)	TIME FROM THE START OF THE EXTRACTION SYSTEM (YEARS)
B10 AND B12	8086	0.15	300	0.76	1500	1.30	550	15	TCE	83	14.0
1% POROSITY	(cuFt/day)							40	DCE	220	
STARTED 300 DAYS	42							40	VC	220	
BEFORE THE ON SITE	(gpm)							5	MC	28	
SYSTEM USED 3 CONSTANT											
CONCENTRATION SOURCES											
B13	8086	0.18	350	0.18	350	0	75	15	TCE	11	12.0
1% POROSITY	(cuFt/day)							40	DCE	30	
STARTED AT THE	42							40	VC	30	
SAME TIME WITH THE	(gpm)							5	MC	4	
ON SITE SYSTEM											
B20 AND B22	8086	0.16	320	0.24	470	2.00	406	15	TCE	61	21.0
3% POROSITY	(cuFt/day)							40	DCE	162	
STARTED 300 DAYS	42							40	VC	162	
BEFORE THE ON SITE	(gpm)							5	MC	20	
SYSTEM USED 3 CONSTANT											
CONCENTRATION SOURCES											
B23	8086	0.17	330	0.18	360	2.00	291	15	TCE	44	20.0
3% POROSITY	(cuFt/day)							40	DCE	116	
STARTED AT THE	42							40	VC	116	
SAME TIME WITH THE	(gpm)							5	MC	15	
ON SITE SYSTEM											
SUMMARY											
MINIMUM	8086	0.16	320	0.20	350	1.00	75	15	TCE	11	12
	(cuFt/day)							40	DCE	30	
	42							40	VC	30	
	(gpm)							5	MC	4	
MAXIMUM	8086	0.18	350	0.76	1500	2.00	550	15	TCE	83	21
	(cuFt/day)							40	DCE	220	
	42							40	VC	220	
	(gpm)							5	MC	28	

F/N TABE5-3.WK1

TABLE E5-4
ESTIMATED SCHEDULE FOR SWITCHING OFF THE OFF SITE EXTRACTION WELLS
COMPUTER RUNS B10, B12, B13, B20, B22 AND B23.
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPUTER RUN	OPERATING TIME OF THE EXTRACTION WELLS						TOTAL PUMPING RATE (cuFt/day)	TOTAL VOLUME OF WATER (cuFt)	MAXIMUM CONTAMINANT FLUX RATE (lbs/day)	MAXIMUM CONCENTRATION (ug/l)
	EW1 (years)	EW2 (years)	EW3 (years)	EW4 (years)	EW5 (years)	EW6 (years)				
B10 AND B12						1	8086.2	2951463	1.50E-01	297
1% POROSITY				2	2		6738.5	2459553	7.54E-01	1,795
STARTED 300 DAYS			5				4043.1	4427195	5.52E-01	2,189
BEFORE THE ON SITE	14	14					2695.4	8854389	3.28E-02	195
SYSTEM. USED 3 CONSTANT								18692599		
CONCENTRATION SOURCES										
B13						1	8086.2	2951463	1.80E-01	357
1% POROSITY				2	2		6738.5	2459553	1.23E-01	293
STARTED AT THE			4				4043.1	2951463	1.56E-02	62
SAME TIME WITH THE	12	12					2695.4	7870568	3.09E-03	18
ON SITE SYSTEM								16233047		
B20 AND B22						3	8086.2	8854389	2.40E-01	476
3% POROSITY				6	6		6738.5	7378658	1.86E-01	442
STARTED 300 DAYS			8.5				4043.1	3689329	5.67E-02	225
BEFORE THE ON SITE	21	21					2695.4	12297763	2.94E-02	175
SYSTEM. USED 3 CONSTANT								32220138		
CONCENTRATION SOURCES										
B23						3	8086.2	8854389	1.80E-01	357
3% POROSITY				6	6		6738.5	7378658	1.46E-01	347
STARTED AT THE			8				4043.1	2951463	2.63E-02	104
SAME TIME WITH THE	20	20					2695.4	11805852	1.47E-02	87
ON SITE SYSTEM								30990362		

F/N: TABE5-4 WK1

TABLE E5-5
ESTIMATED MASS LOADINGS AND CONCENTRATIONS FROM THE ZONE 1 DISSOLVED PHASE PLUME TO THE ON SITE EXTRACTION SYSTEM AND DNAPL WELLS
COMPUTER RUNS B13 AND B23
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPUTER RUN	PUMPING RATE	INITIAL (MAXIMUM) CONDITION		ESTIMATED TOTAL MASS OF VOC TO BE REMOVED				
		CONTAMINANT FLUX RATE (lbs/day)	CONCENTRATION (ug/l)	MASS OF TOTAL VOC (lbs)	ESTIMATED MASS OF MAJOR CONSTITUENTS (%)		(lbs)	TIME FROM THE START OF THE EXTRACTION SYSTEM (YEARS)
EXTRACTION WELLS EW7 AND EW8								
B13	2310	1.07	7,430	119	50	TCE	705	12.0
1% POROSITY	(cuFt/day)				10	DCE	141	
STARTED AT THE	12				10	VC	141	
SAME TIME WITH THE	(gpm)				30	MC	423	
OFF SITE SYSTEM								
B23	2310	1.04	7,200	345	50	TCE	173	20.0
3% POROSITY	(cuFt/day)				10	DCE	35	
STARTED AT THE	12				10	VC	35	
SAME TIME WITH THE	(gpm)				30	MC	104	
OFF SITE SYSTEM								
DNAPL WELLS								
B13	2310	26.50	185,000	1291	50	TCE	646	12.0
1% POROSITY	(cuFt/day)				10	DCE	129	
STARTED AT THE	12				10	VC	129	
SAME TIME WITH THE	(gpm)				30	MC	387	
OFF SITE SYSTEM								
B23	2310	25.30	176,000	3949	50	TCE	1975	20.0
3% POROSITY	(cuFt/day)				10	DCE	395	
STARTED AT THE	12				10	VC	395	
SAME TIME WITH THE	(gpm)				30	MC	1185	
OFF SITE SYSTEM								
TOTAL EXTRACTION WELLS EW7, EW8 AND DNAPL WELLS								
B13	4621	27.20	94,300	1410	50	TCE	705	12.0
1% POROSITY	(cuFt/day)				10	DCE	141	
STARTED AT THE	24				10	VC	141	
SAME TIME WITH THE	(gpm)				30	MC	423	
OFF SITE SYSTEM								
B23	4621	26.20	91,000	4294	50	TCE	2147	20.0
3% POROSITY	(cuFt/day)				10	DCE	429	
STARTED AT THE	24				10	VC	429	
SAME TIME WITH THE	(gpm)				30	MC	1288	
OFF SITE SYSTEM								

TABLE E5-6
ESTIMATED MASS LOADINGS AND CONCENTRATIONS FROM THE ZONE 1 DISSOLVED PHASE PLUME AND DNAPL PLUME TO THE ON SITE EXTRACTION SYSTEM AND DNAPL WELLS ASSUMING A CONSTANT CONTAMINANT FLUX RATE FOR THE DNAPL WELLS; COMPUTER RUNS B13 AND B23
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPUTER RUN	PUMPING RATE	INITIAL (MAXIMUM) CONDITIONS		STABILIZED FLUX RATE AND CONCENTRATION			ESTIMATED FLUX RATE AND CONCENTRATIONS FOR MAJOR CONSTITUENTS IN STABILIZED CONDITIONS			
		CONTAMINANT FLUX RATE (lbs/day)	CONCENTRATION (ug/l)	CONTAMINANT FLUX RATE (lbs/day)	CONCENTRATION (ug/l)	TIME FROM THE START OF THE EXTRACTION SYSTEM (YEARS)	(%)		CONTAMINANT FLUX RATE (lbs)	CONCENTRATION (ug/l)
B13	4621	33.90	118,000	32.80	114,000	1.75	50	TCE	16.40	57,000
1% POROSITY	(cuFt/day)						10	DCE	3.28	11,400
STARTED AT THE	24						10	VC	3.28	11,400
SAME TIME WITH THE	(gpm)						30	MC	9.84	34,200
OFF SITE SYSTEM										
B23	4621	33.60	117,000	32.60	113,000	2.50	50	TCE	16.30	56,500
3% POROSITY	(cuFt/day)						10	DCE	3.26	11,300
STARTED AT THE	24						10	VC	3.26	11,300
SAME TIME WITH THE	(gpm)						30	MC	9.78	33,900
OFF SITE SYSTEM										
ESTIMATIVE CALCULATIONS										
ALL THE	4621	134.41	466,000	33.34	116,000	NA	50	TCE	16.67	58,000
WELLS	(cuFt/day)						10	DCE	3.33	11,600
PUMPING	24						10	VC	3.33	11,600
	(gpm)						30	MC	10.00	34,800
SUMMARY										
MINIMUM	4621	33.60	117,000	32.60	113,000	2	50	TCE	16.30	56,500
	(cuFt/day)						10	DCE	3.26	11,300
	24						10	VC	3.26	11,300
	(gpm)						30	MC	9.78	33,900
MAXIMUM	4621	134.41	466,000	33.34	116,000	3	50	TCE	16.67	58,000
	(cuFt/day)						10	DCE	3.33	11,600
	24						10	VC	3.33	11,600
	(gpm)						30	MC	10.00	34,800

F/N: TABE5-6.WK1

TABLE E5-7
ESTIMATED SCHEDULE FOR SWITCHING OFF
THE ON SITE EXTRACTION WELLS (20 YEAR ESTIMATION)
ASSUMING CONSTANT CONTAMINANT FLUX FOR THE DNAPL WELLS
COMPUTER RUNS B13 AND B23
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPUTER RUN	OPPERATING TIME OF THE EXTRACTION WELLS						TOTAL PUMPING RATE (cuFt/day)	TOTAL VOLUME OF WATER (cuFt)	MAXIMUM CONTAMINANT FLUX RATE (lbs/day)	MAXIMUM CONCENTRATION (ug/l)
	EW7 (years)	EW8 (years)	DW9 (years)	DW10 (years)	DW11 (years)	DW12 (years)				
B13										
1% POROSITY	10	10					4621	16866285	33.9	117,600
STARTED AT THE			20	20	20	20	2311	8433544	32.8	227,557
SAME TIME WITH THE										
ON SITE SYSTEM								25299829		
B23	16	16					4621	26986056	33.6	116,559
3% POROSITY			20	20	20	20	2311	3373418	32.6	226,169
STARTED AT THE										
SAME TIME WITH THE										
ON SITE SYSTEM								30359474		
ESTIMATIVE CALCULATIONS										
	13	13					4621	21926171	134.41	466,294
			20	20	20	20	2311	5903481	33.34	231,313
								27829651		

TABLE E5-8
ESTIMATED CONCENTRATIONS FOR THE DNAPL CONTROL WELLS
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

WELL	PUMPING RATE (cuFt/day)	ESTIMATED CONCENTRATION (ug/l)	CONTAMINANT FLUX RATE (lbs/day)
<u>DNAPL CONTROL WELLS</u>			
ASSUMING CONSTANT CONCENTRATIONS EQUAL WITH THE 1990 CONCENTRATIONS			
DW9	578	350,000	12.61
DW10	578	2,500,000	90.10
DW11	578	500,000	18.02
DW12	578	350,000	12.61
TOTAL/AVERAGE	2310	925,252	133.35
<u>ON SITE EXTRACTION WELLS (EW7 AND EW8)</u>			
AVERAGE VALUES FROM COMPUTER RUNS B13 AND B23			
EW7 AND EW8	2310	7,320	1.06
TOTAL/AVERAGE	4621	466,294	134.41
<u>DNAPL CONTROL WELLS</u>			
ASSUMING CONSTANT CONCENTRATIONS EQUAL WITH 1/4 OF THE 1990 CONCENTRATIONS			
DW9	578	87,500	3.15
DW10	578	625,000	22.53
DW11	578	125,000	4.51
DW12	578	87,500	3.15
TOTAL/AVERAGE	2310	231,313	33.34
<u>ON SITE EXTRACTION WELLS (EW7 AND EW8)</u>			
AVERAGE VALUES FROM COMPUTER RUNS B13 AND B23			
EW7 AND EW8	2310	7,320	1.06
TOTAL/AVERAGE	4621	119,319	34.39

TABLE E5-9
SUMMARY OF ESTIMATED MASS LOADINGS AND CONCENTRATIONS FROM THE ZONE 1 DISSOLVED PHASE PLUME TO THE OFF SITE EXTRACTION SYSTEM
COMPUTER RUNS B16 AND B26
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPUTER RUN	PUMPING RATE	INITIAL CONDITIONS		MAXIMUM FLUX RATE AND CONCENTRATION			ESTIMATED TOTAL MASS OF VOC TO BE REMOVED				
		CONTAMINANT FLUX RATE (lbs/day)	CONCENTRATION (ug/l)	CONTAMINANT FLUX RATE (lbs/day)	CONCENTRATION (ug/l)	TIME FROM THE START OF THE EXTRACTION SYSTEM (YEARS)	MASS OF TOTAL VOC (lbs)	ESTIMATED MASS OF MAJOR CONSTITUENTS (%)		(lbs)	TIME FROM THE START OF THE EXTRACTION SYSTEM (YEARS)
B16	8086	0.18	350	0.18	350	0	80	15	TCE	12	12.0
1% POROSITY	(cuFt/day)							40	DCE	32	
STARTED AT THE	42							40	VC	32	
SAME TIME WITH THE	(gpm)							5	MC	4	
ON SITE SYSTEM											
B26	8086	0.16	320	0.19	380	2	305	15	TCE	46	20.0
3% POROSITY	(cuFt/day)							40	DCE	122	
STARTED AT THE	42							40	VC	122	
SAME TIME WITH THE	(gpm)							5	MC	15	
ON SITE SYSTEM											

TABLE E5-10
ESTIMATED SCHEDULE FOR SWITCHING OFF THE OFF SITE EXTRACTION WELLS
COMPUTER RUNS B16 AND B26.
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPUTER RUN	OPERATING TIME OF THE EXTRACTION WELLS						TOTAL PUMPING RATE (cuFt/day)	TOTAL VOLUME OF WATER (cuFt)	MAXIMUM CONTAMINANT FLUX RATE (lbs/day)	MAXIMUM CONCENTRATION (ug/l)	
	EW1 (years)	EW2 (years)	EW3 (years)	EW4 (years)	EW5 (years)	EW6 (years)					
B16						1	8086.2	2951463	1.80E-01	357	0 - 1 YEAR
1% POROSITY				2	2		6738.5	2459553	1.23E-01	293	1 - 2 YEARS
STARTED AT THE			4				4043.1	2951463	1.62E-02	64	2 - 4 YEARS
SAME TIME WITH THE	12	12					2695.4	7870568	6.75E-03	40	4 - 12 YEARS
ON SITE SYSTEM								16233047			
B26						3	8086.2	8854389	1.90E-01	380	0 - 3 YEAR
3% POROSITY				6	6		6738.5	7378658	1.48E-01	352	3 - 6 YEARS
STARTED AT THE			8				4043.1	2951463	2.92E-02	116	6 - 8 YEARS
SAME TIME WITH THE	20	20					2695.4	11805852	1.99E-02	118	8 - 20 YEARS
ON SITE SYSTEM								30990362			

TABLE E5-11
ESTIMATED MASS LOADINGS AND CONCENTRATIONS FROM THE ZONE 1 DISSOLVED PHASE PLUME TO THE ON SITE EXTRACTION SYSTEM AND DNAPL WELLS
COMPUTER RUNS B16 AND B26
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPUTER RUN	PUMPING RATE	INITIAL (MAXIMUM) CONDITION		ESTIMATED TOTAL MASS OF VOC TO BE REMOVED				
		CONTAMINANT FLUX RATE (lbs/day)	CONCENTRATION (ug/l)	MASS OF TOTAL VOC (lbs)	ESTIMATED MASS OF MAJOR CONSTITUENTS (%)		(lbs)	TIME FROM THE START OF THE EXTRACTION SYSTEM (YEARS)
EXTRACTION WELLS EW7 AND EW8								
B16	2310	1.07	7,430	114	50	TCE	703	12.0
1% POROSITY	(cuFt/day)				10	DCE	141	
STARTED AT THE	12				10	VC	141	
SAME TIME WITH THE	(gpm)				30	MC	422	
OFF SITE SYSTEM								
B26	2310	1.04	7,200	340	50	TCE	170	20.0
3% POROSITY	(cuFt/day)				10	DCE	34	
STARTED AT THE	12				10	VC	34	
SAME TIME WITH THE	(gpm)				30	MC	102	
OFF SITE SYSTEM								
DNAPL WELLS								
B16	1155	33.04	458,000	1291	50	TCE	646	12.0
1% POROSITY	(cuFt/day)				10	DCE	129	
STARTED AT THE	6				10	VC	129	
SAME TIME WITH THE	(gpm)				30	MC	387	
OFF SITE SYSTEM								
B26	1155	28.46	395,000	3874	50	TCE	1937	20.0
3% POROSITY	(cuFt/day)				10	DCE	387	
STARTED AT THE	6				10	VC	387	
SAME TIME WITH THE	(gpm)				30	MC	1162	
OFF SITE SYSTEM								
TOTAL EXTRACTION WELLS EW7, EW8 AND DNAPL WELLS								
B16	3466	34.11	158,000	1405	50	TCE	703	12.0
1% POROSITY	(cuFt/day)				10	DCE	141	
STARTED AT THE	18				10	VC	141	
SAME TIME WITH THE	(gpm)				30	MC	422	
OFF SITE SYSTEM								
B26	3466	29.50	136,455	4214	50	TCE	2107	20.0
3% POROSITY	(cuFt/day)				10	DCE	421	
STARTED AT THE	18				10	VC	421	
SAME TIME WITH THE	(gpm)				30	MC	1264	
OFF SITE SYSTEM								

TABLE E5-12
ESTIMATED MASS LOADINGS AND CONCENTRATIONS FROM THE ZONE 1 DISSOLVED PHASE PLUME AND DNAPL PLUME TO THE ON SITE EXTRACTION SYSTEM AND DNAPL WELLS ASSUMING A CONSTANT CONTAMINANT FLUX RATE FOR THE DNAPL WELLS; COMPUTER RUNS B16 AND B26
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPUTER RUN	PUMPING RATE	INITIAL (MAXIMUM) CONDITIONS		STABILIZED FLUX RATE AND CONCENTRATION			ESTIMATED FLUX RATE AND CONCENTRATIONS FOR MAJOR CONSTITUENTS IN STABILIZED CONDITIONS			
		CONTAMINANT FLUX RATE (lbs/day)	CONCENTRATION (ug/l)	CONTAMINANT FLUX RATE (lbs/day)	CONCENTRATION (ug/l)	TIME FROM THE START OF THE EXTRACTION SYSTEM (YEARS)	(%)		CONTAMINANT FLUX RATE (lbs)	CONCENTRATION (ug/l)
B16	3466	34.20	158,000	33.10	153,000	1.75	50	TCE	16.55	76,500
1% POROSITY	(cuFt/day)						10	DCE	3.31	15,300
STARTED AT THE	18						10	VC	3.31	15,300
SAME TIME WITH THE	(gpm)						30	MC	9.93	45,900
OFF SITE SYSTEM										
B26	3466	29.50	136,000	28.50	132,000	3.00	50	TCE	14.25	66,000
3% POROSITY	(cuFt/day)						10	DCE	2.85	13,200
STARTED AT THE	18						10	VC	2.85	13,200
SAME TIME WITH THE	(gpm)						30	MC	8.55	39,600
OFF SITE SYSTEM										
ESTIMATIVE CALCULATIONS										
ALL THE	3466	109.18	505,000	54.06	253,000	NA	50	TCE	27.03	126,500
WELLS	(cuFt/day)						10	DCE	5.41	25,300
PUMPING	18						10	VC	5.41	25,300
	(gpm)						30	MC	16.22	75,900
SUMMARY										
MINIMUM	3466	29.50	136,000	28.50	132,000	2	50	TCE	14.25	66,000
	(cuFt/day)						10	DCE	2.85	13,200
	18						10	VC	2.85	13,200
	(gpm)						30	MC	8.55	39,600
MAXIMUM	3466	109.18	505,000	54.06	253,000	3	50	TCE	27.03	126,500
	(cuFt/day)						10	DCE	5.41	25,300
	18						10	VC	5.41	25,300
	(gpm)						30	MC	16.22	75,900

F/N TABE5-12.WK1

TABLE E5-13
ESTIMATED SCHEDULE FOR SWITCHING OFF THE ON SITE EXTRACTION WELLS (20 YEAR ESTIMATION) ASSUMING CONSTANT CONTAMINANT FLUX FOR THE DNAPL WELLS
COMPUTER RUNS B16 AND B26
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

COMPUTER RUN	OPPERATING TIME OF THE EXTRACTION WELLS				TOTAL PUMPING RATE (cuFt/day)	TOTAL VOLUME OF WATER (cuFt)	MAXIMUM CONTAMINANT FLUX RATE (lbs/day)	MAXIMUM CONCENTRATION (ug/l)
	EW7 (years)	EW8 (years)	DW9 (years)	DW10 (years)				
B16								
1% POROSITY	10	10			3466	12649513	34.2	158,190
STARTED AT THE			20	20	1155	4216772	33.1	459,277
SAME TIME WITH THE								
ON SITE SYSTEM						16866285		
B26	16	16			3466	20239221	29.5	136,450
3% POROSITY			20	20	1155	1686709	28.5	395,450
STARTED AT THE								
SAME TIME WITH THE						21925930		
ON SITE SYSTEM								
ESTIMATIVE CALCULATIONS								
	13	13			3466	16444367	109.18	505,028
			20	20	1155	2951740	54.06	750,204
						19396107		

TABLE E5-14
ESTIMATED CONCENTRATIONS FOR THE DNAPL CONTROL WELLS
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

WELL	PUMPING RATE (cuFt/day)	ESTIMATED CONCENTRATION (ug/l)	CONTAMINANT FLUX RATE (lbs/day)
DNAPL CONTROL WELLS			
ASSUMING CONSTANT CONCENTRATIONS EQUAL WITH THE 1990 CONCENTRATIONS			
DW9	578	2,500,000	90.10
DW10	578	500,000	18.02
TOTAL/AVERAGE	1155	1,500,408	108.12
ON SITE EXTRACTION WELLS (EW7 AND EW8)			
AVERAGE VALUES FROM COMPUTER RUNS B13 AND B23			
EW7 AND EW8	2310	7,320	1.06
TOTAL/AVERAGE	3465	505,028	109.18
DNAPL CONTROL WELLS			
ASSUMING CONSTANT CONCENTRATIONS EQUAL WITH 1/2 OF THE 1990 CONCENTRATIONS			
DW9	578	1,250,000	45.05
DW10	578	250,000	9.01
TOTAL/AVERAGE	1155	750,204	54.06
ON SITE EXTRACTION WELLS (EW7 AND EW8)			
AVERAGE VALUES FROM COMPUTER RUNS B13 AND B23			
EW7 AND EW8	2310	7,320	1.06
TOTAL/AVERAGE	3465	254,954	55.12

F/N: TABE5-14.WK1

TABLE E7-1
OVERBURDEN ANALYSIS
EXTRACTION WELL SIMULATION VALUES
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

WELL POINT	Q (ft /d)	T1 (ft /d)	T2 (ft /d)	K' (ft/d)	b' (ft)	Sy	S
EW1(a) & EW7(a)	1347.7	0.15	174	0.17	10	0.2	2.8e-04
EW1(b) & EW7(b)	1347.7	0.15	174	0.003	10	0.2	2.8e-04
EW2	1347.7	0.15	174	0.003	10	0.2	2.8e-04
EW3,EW4 EW5,EW6	1347.7	0.15	208.8	0.003	10	0.2	2.8e-04
EW8(a)	962.64	0.15	174	0.17	10	0.2	2.8e-04
EW8(b)	962.64	0.15	174	0.003	10	0.2	2.8e-04
DW9, DW10 DW11, DW12	577.58	0.15	139.2	0.003	10	0.2	2.8e-04

F/N TABE7-1 WK1

TABLE E7-2
SUMMARY OF RESULTS OF OVERBURDEN ANALYTICAL MODELING
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

EW1(a) & EW7(a)					
t = 365 days		t = 1825 days		t = 3650 days	
r(ft)	s(ft)	r(ft)	s(ft)	r(ft)	s(ft)
2	2.68008	2	3.66999	2	4.09685
5	2.19211	5	3.18325	3	3.93604
8	1.76019	10	2.50951	5	3.61011
10	1.51838	20	1.68321	10	2.93637
20	0.69201	30	1.18442	25	1.83575
30	0.19329	40	0.83012	50	0.98214
31	0.15291	50	0.55528	100	0.12842
32	0.11372	60	0.33072	105	0.06833
34	0.03914	70	0.14086	110	0.01103
35	0.00344	80	0	115	0

EW1(b) & EW7(b)					
t = 365 days		t = 1825 days		t = 3650 days	
r(ft)	s(ft)	r(ft)	s(ft)	r(ft)	s(ft)
1	0.41032	1	1.40885	2	1.82321
2	0.40521	3	1.39701	5	1.7859
3	0.39356	5	1.34426	10	1.70813
5	0.36791	10	1.28989	25	1.39788
10	0.29259	25	0.97102	50	0.87708
15	0.19349	50	0.45052	100	0.12027
20	0.08919	60	0.26862	105	0.06201
25	0	75	0.02758	110	0.00607
28	0	76	0.01253	115	0
30	0	77	0	120	0

TABLE E7-2
SUMMARY OF RESULTS OF
OVERBURDEN ANALYTICAL MODELING
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

EW2					
t = 365 days		t = 1825 days		t = 3650 days	
r(ft)	s(ft)	r(ft)	s(ft)	r(ft)	s(ft)
2	0.40521	2	1.39635	2	1.82321
3	0.39479	5	1.36397	5	1.79083
5	0.37283	10	1.28373	10	1.71059
10	0.29259	20	1.07909	20	1.50595
15	0.19472	40	0.64808	50	0.86347
20	0.08796	60	0.26894	80	0.3812
21	0.06678	70	0.10411	100	0.12031
22	0.04496	75	0.02744	105	0.06199
23	0.02297	78	0	110	0.00608
24	0.00098	80	0	115	0

EW3, EW4, EW5, EW6					
t = 365 days		t = 1825 days		t = 3650 days	
r(ft)	s(ft)	r(ft)	s(ft)	r(ft)	s(ft)
2	0.33773	2	1.16379	2	1.51956
3	0.32904	3	1.15510	5	1.49257
5	0.31074	5	1.13680	10	1.42570
10	0.24386	10	1.06993	25	1.16435
15	0.16229	25	0.80858	50	0.71966
20	0.07331	50	0.36390	75	0.37864
21	0.05566	70	0.08677	100	0.10027
23	0.01915	72	0.06083	110	0.00506
24	0.00081	75	0.02287	112	0
25	0	80	0	115	0

TABLE E7-2
SUMMARY OF RESULTS OF OVERBURDEN ANALYTICAL MODELING
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

EW8 (a)					
t = 365 days		t = 1825 days		t = 3650 days	
r(ft)	s(ft)	r(ft)	s(ft)	r(ft)	s(ft)
2	1.91434	2	2.62311	2	3.19112
3	1.79877	5	2.27445	5	2.57864
5	1.56579	10	1.79306	10	2.09740
10	1.08455	25	1.00666	25	1.31124
20	0.49429	50	0.39675	50	0.70153
30	0.13806	60	0.23630	75	0.34482
33	0.05422	65	0.16587	100	0.09173
35	0.00246	70	0.10065	110	0.00788
37	0	75	0.03993	115	0
40	0	80	0	120	0

EW8 (b)					
t = 365 days		t = 1825 days		t = 3650 days	
r(ft)	s(ft)	r(ft)	s(ft)	r(ft)	s(ft)
2	0.28944	2	0.99770	2	1.30229
3	0.28199	5	0.97457	5	1.27916
5	0.26631	10	0.91723	10	1.22185
10	0.20899	25	0.69319	25	0.99787
15	0.13908	50	0.31196	50	0.61676
20	0.06283	70	0.07439	75	0.32450
22	0.03211	72	0.05215	100	0.08594
25	0	75	0.01960	105	0.04428
28	0	77	0	110	0.00434
30	0	80	0	112	0
				114	0
				115	0

TABLE E7-2
SUMMARY OF RESULTS OF OVERBURDEN ANALYTICAL MODELING
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

DW9, DW10, DW11, DW12					
t = 365 days		t = 1825 days		t = 3650 days	
r(ft)	s(ft)	r(ft)	s(ft)	r(ft)	s(ft)
2	0.21703	2	0.74788	2	0.97650
3	0.21145	5	0.73053	5	0.95916
5	0.19969	10	0.68756	10	0.91618
10	0.15671	25	0.51961	25	0.74824
15	0.10429	40	0.34711	50	0.46247
20	0.04711	60	0.14405	75	0.24332
21	0.03577	75	0.01470	100	0.06444
22	0.02408	76	0.00671	105	0.03321
24	0.00052	78	0	110	0.00326
25	0	80	0	112	0
				115	0
				120	0

F/N: TABE7-2.WK1

TABLE E8-1
SITE SPECIFIC PARAMETER VALUES AND PARAMETERS FOR THE NEUMAN-WITHERSPOON CURVES
BELL AEROSPACE TEXTRON WHEATFIELD PLANT NIAGARA FALLS, NEW YORK

PARAMETER	SITE SPECIFIC VALUES FOR r=100 FT.	VALUES FOR FIGURE 2	VALUES FOR FIGURE 3
ß11	0.007	0.01	1.0
ß21	0.068	0.01	1.0
r/ß11	0.15	0.1	1.0
r/ß11	1.43	0.1	1.0

F/N: TABE8-1.WK1

TABLE E8-2
SITE SPECIFIC PARAMETER VALUES OF THE NEUMAN-WITHERSPOON EQUATION FOR DIFFERENT RADIAL DISTANCES
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

PARAMETER	RADIAL DISTANCE (R) (FT)			
	10	50	100	150
β11	0.0007	0.0035	0.007	0.0105
β21	0.0068	0.034	0.068	0.102
r/β11	0.015	0.075	0.150	0.225
r/β21	0.143	0.715	1.430	2.145

F/N: TABE8-2.WK1

TABLE E8-3
VALUES OF DRAWDOWNS AT 100 FEET RADIAL LOCATIONS IN THE UNPUMPED (ZONE 3) AND PUMPED AQUIFERS (ZONE 1) AFTER 160 DAYS
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

PARAMETER	FROM FIGURE 2	FROM FIGURE 3
td1	10,000	10,000
t (days)	160	160
sd (unpumped aquifer)	2.4	3.4
s (pumped aquifer) (ft)	1.5	2.1
sd (pumped aquifer)	6.0	3.4
s (pumped aquifer) (ft)	3.7	2.1

F/N: TABE8-3.WK1

TABLE E10-1
SUMMARY OF MATRIX DIFFUSION ANALYSIS
FRACTURE DATA
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

TIME (YEARS)	FRACTURE DISTANCE (FT)	PREDICTED CONCENTRATION (LB/CU.FT)	PREDICTED CONCENTRATION (UG/L)	SOURCE CONCENTRATION (LB/CU.FT)	RELATIVE CONCENTRATION (PERCENT)
1	0	6.90E-02	1,104,000	6.90E-02	100.00
1	500	0.00E+00	0	6.90E-02	0.00
1	1000	0.00E+00	0	6.90E-02	0.00
1	1500	0.00E+00	0	6.90E-02	0.00
1	2000	0.00E+00	0	6.90E-02	0.00
1	2500	0.00E+00	0	6.90E-02	0.00
1	3000	0.00E+00	0	6.90E-02	0.00
1	3500	0.00E+00	0	6.90E-02	0.00
1	4000	0.00E+00	0	6.90E-02	0.00
5	0	6.90E-02	1,104,000	6.90E-02	100.00
5	500	2.63E-03	42,080	6.90E-02	3.81
5	1000	0.00E+00	0	6.90E-02	0.00
5	1500	0.00E+00	0	6.90E-02	0.00
5	2000	0.00E+00	0	6.90E-02	0.00
5	2500	0.00E+00	0	6.90E-02	0.00
5	3000	0.00E+00	0	6.90E-02	0.00
5	3500	0.00E+00	0	6.90E-02	0.00
5	4000	0.00E+00	0	6.90E-02	0.00
10	0	6.90E-02	1,104,000	6.90E-02	100.00
10	500	1.59E-02	255,200	6.90E-02	23.12
10	1000	2.60E-04	4,160	6.90E-02	0.38
10	1500	0.00E+00	0	6.90E-02	0.00
10	2000	0.00E+00	0	6.90E-02	0.00
10	2500	0.00E+00	0	6.90E-02	0.00
10	3000	0.00E+00	0	6.90E-02	0.00
10	3500	0.00E+00	0	6.90E-02	0.00
10	4000	0.00E+00	0	6.90E-02	0.00
15	0	6.90E-02	1,104,000	6.90E-02	100.00
15	500	2.63E-02	421,120	6.90E-02	38.14
15	1000	2.74E-03	43,840	6.90E-02	3.97
15	1500	3.00E-05	480	6.90E-02	0.04
15	2000	0.00E+00	0	6.90E-02	0.00
15	2500	0.00E+00	0	6.90E-02	0.00
15	3000	0.00E+00	0	6.90E-02	0.00
15	3500	0.00E+00	0	6.90E-02	0.00
15	4000	0.00E+00	0	6.90E-02	0.00
20	0	6.90E-02	1,104,000	6.90E-02	100.00
20	500	3.37E-02	539,200	6.90E-02	48.84
20	1000	6.82E-03	109,120	6.90E-02	9.88
20	1500	3.90E-04	6,240	6.90E-02	0.57
20	2000	0.00E+00	0	6.90E-02	0.00
20	2500	0.00E+00	0	6.90E-02	0.00
20	3000	0.00E+00	0	6.90E-02	0.00
20	3500	0.00E+00	0	6.90E-02	0.00
20	4000	0.00E+00	0	6.90E-02	0.00

TABLE E10-1
SUMMARY OF MATRIX DIFFUSION ANALYSIS
FRACTURE DATA
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

TIME (YEARS)	FRACTURE DISTANCE (FT)	PREDICTED CONCENTRATION (LB/CU.FT)	PREDICTED CONCENTRATION (UG/L)	SOURCE CONCENTRATION (LB/CU.FT)	RELATIVE CONCENTRATION (PERCENT)
25	0	6.90E–02	1,104,000	6.90E–02	100.00
25	500	3.99E–02	638,400	6.90E–02	57.83
25	1000	1.15E–02	183,680	6.90E–02	16.64
25	1500	1.41E–03	22,560	6.90E–02	2.04
25	2000	5.00E–05	800	6.90E–02	0.07
25	2500	0.00E+00	0	6.90E–02	0.00
25	3000	0.00E+00	0	6.90E–02	0.00
25	3500	0.00E+00	0	6.90E–02	0.00
25	4000	0.00E+00	0	6.90E–02	0.00
30	0	6.90E–02	1,104,000	6.90E–02	100.00
30	500	4.54E–02	727,040	6.90E–02	65.86
30	1000	1.67E–02	266,560	6.90E–02	24.14
30	1500	3.19E–03	51,040	6.90E–02	4.62
30	2000	2.70E–04	4,320	6.90E–02	0.39
30	2500	1.00E–05	160	6.90E–02	0.01
30	3000	0.00E+00	0	6.90E–02	0.00
30	3500	0.00E+00	0	6.90E–02	0.00
30	4000	0.00E+00	0	6.90E–02	0.00
35	0	6.90E–02	1,104,000	6.90E–02	100.00
35	500	5.03E–02	804,320	6.90E–02	72.86
35	1000	2.22E–02	355,520	6.90E–02	32.20
35	1500	5.74E–03	91,840	6.90E–02	8.32
35	2000	8.00E–04	12,800	6.90E–02	1.16
35	2500	5.00E–05	800	6.90E–02	0.07
35	3000	0.00E+00	0	6.90E–02	0.00
35	3500	0.00E+00	0	6.90E–02	0.00
35	4000	0.00E+00	0	6.90E–02	0.00
40	0	6.90E–02	1,104,000	6.90E–02	100.00
40	500	5.42E–02	867,680	6.90E–02	78.59
40	1000	2.77E–02	443,200	6.90E–02	40.14
40	1500	8.88E–03	142,080	6.90E–02	12.87
40	2000	1.72E–03	27,520	6.90E–02	2.49
40	2500	1.90E–04	3,040	6.90E–02	0.28
40	3000	1.00E–05	160	6.90E–02	0.01
40	3500	0.00E+00	0	6.90E–02	0.00
40	4000	0.00E+00	0	6.90E–02	0.00

F/N: TABE10–1.WK1

TABLE E10-2
SUMMARY OF MATRIX DIFFUSION ANALYSIS
MATRIX DATA
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

TIME (YEARS)	DISTANCE FRACTURE (FT)	MATRIX DEPTH (FT)	PREDICTED CONCENTRATION (LB/CU.FT)	PREDICTED CONCENTRATION (UG/L)	SOURCE CONCENTRATION (LB/CU.FT)	RELATIVE CONCENTRATION (PERCENT)
1	0	0.0	6.90E-02	1,104,000	6.90E-02	100.00
1	0	0.1	6.90E-02	1,104,000	6.90E-02	100.00
1	0	0.2	6.90E-02	1,104,000	6.90E-02	100.00
1	0	0.3	6.90E-02	1,104,000	6.90E-02	100.00
1	0	0.4	6.90E-02	1,104,000	6.90E-02	100.00
1	0	0.5	6.90E-02	1,104,000	6.90E-02	100.00
1	0	0.6	6.90E-02	1,104,000	6.90E-02	100.00
1	0	0.7	6.90E-02	1,104,000	6.90E-02	100.00
1	0	0.8	6.90E-02	1,104,000	6.90E-02	100.00
1	0	0.9	6.90E-02	1,104,000	6.90E-02	100.00
1	0	1.0	6.90E-02	1,104,000	6.90E-02	100.00
1	500	0.0	0.00E+00	0	6.90E-02	0.00
1	500	0.1	0.00E+00	0	6.90E-02	0.00
1	500	0.2	0.00E+00	0	6.90E-02	0.00
1	500	0.3	0.00E+00	0	6.90E-02	0.00
1	500	0.4	0.00E+00	0	6.90E-02	0.00
1	500	0.5	0.00E+00	0	6.90E-02	0.00
1	500	0.6	0.00E+00	0	6.90E-02	0.00
1	500	0.7	0.00E+00	0	6.90E-02	0.00
1	500	0.8	0.00E+00	0	6.90E-02	0.00
1	500	0.9	0.00E+00	0	6.90E-02	0.00
1	500	1.0	0.00E+00	0	6.90E-02	0.00
1	1000	0.0	0.00E+00	0	6.90E-02	0.00
1	1000	0.1	0.00E+00	0	6.90E-02	0.00
1	1000	0.2	0.00E+00	0	6.90E-02	0.00
1	1000	0.3	0.00E+00	0	6.90E-02	0.00
1	1000	0.4	0.00E+00	0	6.90E-02	0.00
1	1000	0.5	0.00E+00	0	6.90E-02	0.00
1	1000	0.6	0.00E+00	0	6.90E-02	0.00
1	1000	0.7	0.00E+00	0	6.90E-02	0.00
1	1000	0.8	0.00E+00	0	6.90E-02	0.00
1	1000	0.9	0.00E+00	0	6.90E-02	0.00
1	1000	1.0	0.00E+00	0	6.90E-02	0.00
1	1500	0.0	0.00E+00	0	6.90E-02	0.00
1	1500	0.1	0.00E+00	0	6.90E-02	0.00
1	1500	0.2	0.00E+00	0	6.90E-02	0.00
1	1500	0.3	0.00E+00	0	6.90E-02	0.00
1	1500	0.4	0.00E+00	0	6.90E-02	0.00
1	1500	0.5	0.00E+00	0	6.90E-02	0.00
1	1500	0.6	0.00E+00	0	6.90E-02	0.00
1	1500	0.7	0.00E+00	0	6.90E-02	0.00
1	1500	0.8	0.00E+00	0	6.90E-02	0.00
1	1500	0.9	0.00E+00	0	6.90E-02	0.00
1	1500	1.0	0.00E+00	0	6.90E-02	0.00

TABLE E10-2
SUMMARY OF MATRIX DIFFUSION ANALYSIS
MATRIX DATA
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

TIME (YEARS)	DISTANCE FRACTURE (FT)	MATRIX DEPTH (FT)	PREDICTED CONCENTRATION (LB/CU.FT)	PREDICTED CONCENTRATION (UG/L)	SOURCE CONCENTRATION (LB/CU.FT)	RELATIVE CONCENTRATION (PERCENT)
1	2000	0.0	0.00E+00	0	6.90E-02	0.00
1	2000	0.1	0.00E+00	0	6.90E-02	0.00
1	2000	0.2	0.00E+00	0	6.90E-02	0.00
1	2000	0.3	0.00E+00	0	6.90E-02	0.00
1	2000	0.4	0.00E+00	0	6.90E-02	0.00
1	2000	0.5	0.00E+00	0	6.90E-02	0.00
1	2000	0.6	0.00E+00	0	6.90E-02	0.00
1	2000	0.7	0.00E+00	0	6.90E-02	0.00
1	2000	0.8	0.00E+00	0	6.90E-02	0.00
1	2000	0.9	0.00E+00	0	6.90E-02	0.00
1	2000	1.0	0.00E+00	0	6.90E-02	0.00
1	2500	0.0	0.00E+00	0	6.90E-02	0.00
1	2500	0.1	0.00E+00	0	6.90E-02	0.00
1	2500	0.2	0.00E+00	0	6.90E-02	0.00
1	2500	0.3	0.00E+00	0	6.90E-02	0.00
1	2500	0.4	0.00E+00	0	6.90E-02	0.00
1	2500	0.5	0.00E+00	0	6.90E-02	0.00
1	2500	0.6	0.00E+00	0	6.90E-02	0.00
1	2500	0.7	0.00E+00	0	6.90E-02	0.00
1	2500	0.8	0.00E+00	0	6.90E-02	0.00
1	2500	0.9	0.00E+00	0	6.90E-02	0.00
1	2500	1.0	0.00E+00	0	6.90E-02	0.00
1	3000	0.0	0.00E+00	0	6.90E-02	0.00
1	3000	0.1	0.00E+00	0	6.90E-02	0.00
1	3000	0.2	0.00E+00	0	6.90E-02	0.00
1	3000	0.3	0.00E+00	0	6.90E-02	0.00
1	3000	0.4	0.00E+00	0	6.90E-02	0.00
1	3000	0.5	0.00E+00	0	6.90E-02	0.00
1	3000	0.6	0.00E+00	0	6.90E-02	0.00
1	3000	0.7	0.00E+00	0	6.90E-02	0.00
1	3000	0.8	0.00E+00	0	6.90E-02	0.00
1	3000	0.9	0.00E+00	0	6.90E-02	0.00
1	3000	1.0	0.00E+00	0	6.90E-02	0.00
1	3500	0.0	0.00E+00	0	6.90E-02	0.00
1	3500	0.1	0.00E+00	0	6.90E-02	0.00
1	3500	0.2	0.00E+00	0	6.90E-02	0.00
1	3500	0.3	0.00E+00	0	6.90E-02	0.00
1	3500	0.4	0.00E+00	0	6.90E-02	0.00
1	3500	0.5	0.00E+00	0	6.90E-02	0.00
1	3500	0.6	0.00E+00	0	6.90E-02	0.00
1	3500	0.7	0.00E+00	0	6.90E-02	0.00
1	3500	0.8	0.00E+00	0	6.90E-02	0.00
1	3500	0.9	0.00E+00	0	6.90E-02	0.00
1	3500	1.0	0.00E+00	0	6.90E-02	0.00

TABLE E10-2
SUMMARY OF MATRIX DIFFUSION ANALYSIS
MATRIX DATA
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

TIME (YEARS)	DISTANCE FRACTURE (FT)	MATRIX DEPTH (FT)	PREDICTED CONCENTRATION (LB/CU.FT)	PREDICTED CONCENTRATION (UG/L)	SOURCE CONCENTRATION (LB/CU.FT)	RELATIVE CONCENTRATION (PERCENT)
1	4000	0.0	0.00E+00	0	6.90E-02	0.00
1	4000	0.1	0.00E+00	0	6.90E-02	0.00
1	4000	0.2	0.00E+00	0	6.90E-02	0.00
1	4000	0.3	0.00E+00	0	6.90E-02	0.00
1	4000	0.4	0.00E+00	0	6.90E-02	0.00
1	4000	0.5	0.00E+00	0	6.90E-02	0.00
1	4000	0.6	0.00E+00	0	6.90E-02	0.00
1	4000	0.7	0.00E+00	0	6.90E-02	0.00
1	4000	0.8	0.00E+00	0	6.90E-02	0.00
1	4000	0.9	0.00E+00	0	6.90E-02	0.00
1	4000	1.0	0.00E+00	0	6.90E-02	0.00
40	0	0.0	6.90E-02	1,104,000	6.90E-02	100.00
40	0	0.1	6.90E-02	1,104,000	6.90E-02	100.00
40	0	0.2	6.90E-02	1,104,000	6.90E-02	100.00
40	0	0.3	6.90E-02	1,104,000	6.90E-02	100.00
40	0	0.4	6.90E-02	1,104,000	6.90E-02	100.00
40	0	0.5	6.90E-02	1,104,000	6.90E-02	100.00
40	0	0.6	6.90E-02	1,104,000	6.90E-02	100.00
40	0	0.7	6.90E-02	1,104,000	6.90E-02	100.00
40	0	0.8	6.90E-02	1,104,000	6.90E-02	100.00
40	0	0.9	6.90E-02	1,104,000	6.90E-02	100.00
40	0	1.0	6.90E-02	1,104,000	6.90E-02	100.00
40	500	0.0	5.42E-02	867,680	6.90E-02	78.59
40	500	0.1	5.17E-02	827,360	6.90E-02	74.94
40	500	0.2	4.93E-02	789,600	6.90E-02	71.52
40	500	0.3	4.72E-02	755,680	6.90E-02	68.45
40	500	0.4	4.54E-02	725,600	6.90E-02	65.72
40	500	0.5	4.37E-02	699,680	6.90E-02	63.38
40	500	0.6	4.24E-02	678,240	6.90E-02	61.43
40	500	0.7	4.13E-02	661,440	6.90E-02	59.91
40	500	0.8	4.06E-02	649,440	6.90E-02	58.83
40	500	0.9	4.01E-02	642,080	6.90E-02	58.16
40	500	1.0	4.00E-02	639,680	6.90E-02	57.94
40	1000	0.0	2.77E-02	443,200	6.90E-02	40.14
40	1000	0.1	2.52E-02	403,360	6.90E-02	36.54
40	1000	0.2	2.30E-02	367,200	6.90E-02	33.26
40	1000	0.3	2.10E-02	335,520	6.90E-02	30.39
40	1000	0.4	1.93E-02	308,320	6.90E-02	27.93
40	1000	0.5	1.78E-02	285,440	6.90E-02	25.86
40	1000	0.6	1.67E-02	266,720	6.90E-02	24.16
40	1000	0.7	1.58E-02	252,320	6.90E-02	22.86
40	1000	0.8	1.51E-02	241,920	6.90E-02	21.91
40	1000	0.9	1.47E-02	235,840	6.90E-02	21.36
40	1000	1.0	1.46E-02	233,760	6.90E-02	21.17

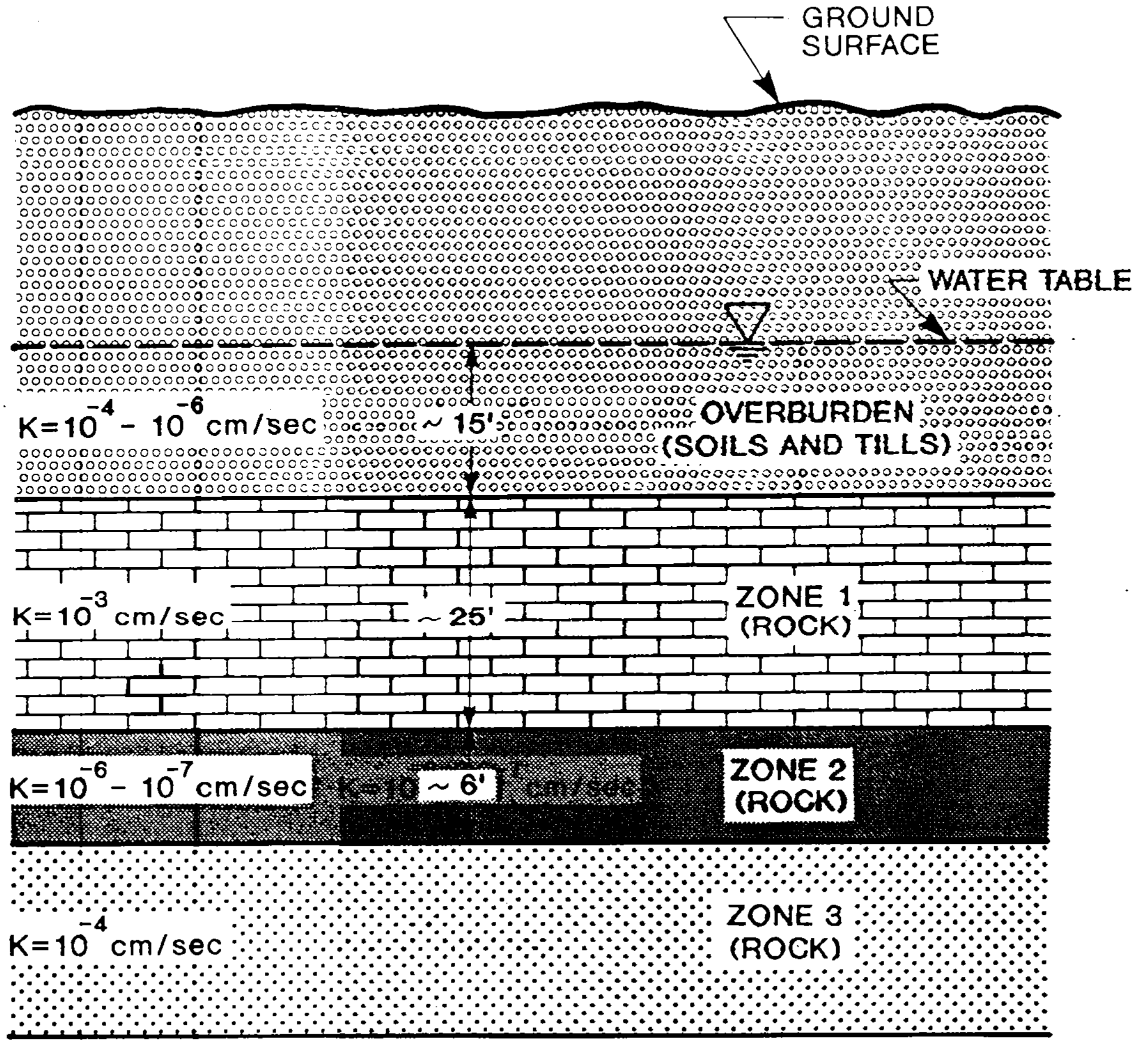
TABLE E10-2
SUMMARY OF MATRIX DIFFUSION ANALYSIS
MATRIX DATA
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

TIME (YEARS)	DISTANCE FRACTURE (FT)	MATRIX DEPTH (FT)	PREDICTED CONCENTRATION (LB/CU.FT)	PREDICTED CONCENTRATION (UG/L)	SOURCE CONCENTRATION (LB/CU.FT)	RELATIVE CONCENTRATION (PERCENT)
40	1500	0.0	8.88E-03	142,080	6.90E-02	12.87
40	1500	0.1	7.72E-03	123,520	6.90E-02	11.19
40	1500	0.2	6.69E-03	107,040	6.90E-02	9.70
40	1500	0.3	5.82E-03	93,120	6.90E-02	8.43
40	1500	0.4	5.09E-03	81,440	6.90E-02	7.38
40	1500	0.5	4.50E-03	72,000	6.90E-02	6.52
40	1500	0.6	4.02E-03	64,320	6.90E-02	5.83
40	1500	0.7	3.65E-03	58,400	6.90E-02	5.29
40	1500	0.8	3.40E-03	54,400	6.90E-02	4.93
40	1500	0.9	3.25E-03	52,000	6.90E-02	4.71
40	1500	1.0	3.20E-03	51,200	6.90E-02	4.64
40	2000	0.0	1.72E-03	27,520	6.90E-02	2.49
40	2000	0.1	1.42E-03	22,720	6.90E-02	2.06
40	2000	0.2	1.17E-03	18,720	6.90E-02	1.70
40	2000	0.3	9.70E-04	15,520	6.90E-02	1.41
40	2000	0.4	8.00E-04	12,800	6.90E-02	1.16
40	2000	0.5	6.70E-04	10,720	6.90E-02	0.97
40	2000	0.6	5.70E-04	9,120	6.90E-02	0.83
40	2000	0.7	4.90E-04	7,840	6.90E-02	0.71
40	2000	0.8	4.40E-04	7,040	6.90E-02	0.64
40	2000	0.9	4.10E-04	6,560	6.90E-02	0.59
40	2000	1.0	4.00E-04	6,400	6.90E-02	0.58
40	2500	0.0	1.90E-04	3,040	6.90E-02	0.28
40	2500	0.1	1.50E-04	2,400	6.90E-02	0.22
40	2500	0.2	1.10E-04	1,760	6.90E-02	0.16
40	2500	0.3	9.00E-05	1,440	6.90E-02	0.13
40	2500	0.4	7.00E-05	1,120	6.90E-02	0.10
40	2500	0.5	5.00E-05	800	6.90E-02	0.07
40	2500	0.6	4.00E-05	640	6.90E-02	0.06
40	2500	0.7	3.00E-05	480	6.90E-02	0.04
40	2500	0.8	3.00E-05	480	6.90E-02	0.04
40	2500	0.9	3.00E-05	480	6.90E-02	0.04
40	2500	1.0	3.00E-05	480	6.90E-02	0.04
40	3000	0.0	1.00E-05	160	6.90E-02	0.01
40	3000	0.1	1.00E-05	160	6.90E-02	0.01
40	3000	0.2	1.00E-05	160	6.90E-02	0.01
40	3000	0.3	0.00E+00	0	6.90E-02	0.00
40	3000	0.4	0.00E+00	0	6.90E-02	0.00
40	3000	0.5	0.00E+00	0	6.90E-02	0.00
40	3000	0.6	0.00E+00	0	6.90E-02	0.00
40	3000	0.7	0.00E+00	0	6.90E-02	0.00
40	3000	0.8	0.00E+00	0	6.90E-02	0.00
40	3000	0.9	0.00E+00	0	6.90E-02	0.00
40	3000	1.0	0.00E+00	0	6.90E-02	0.00

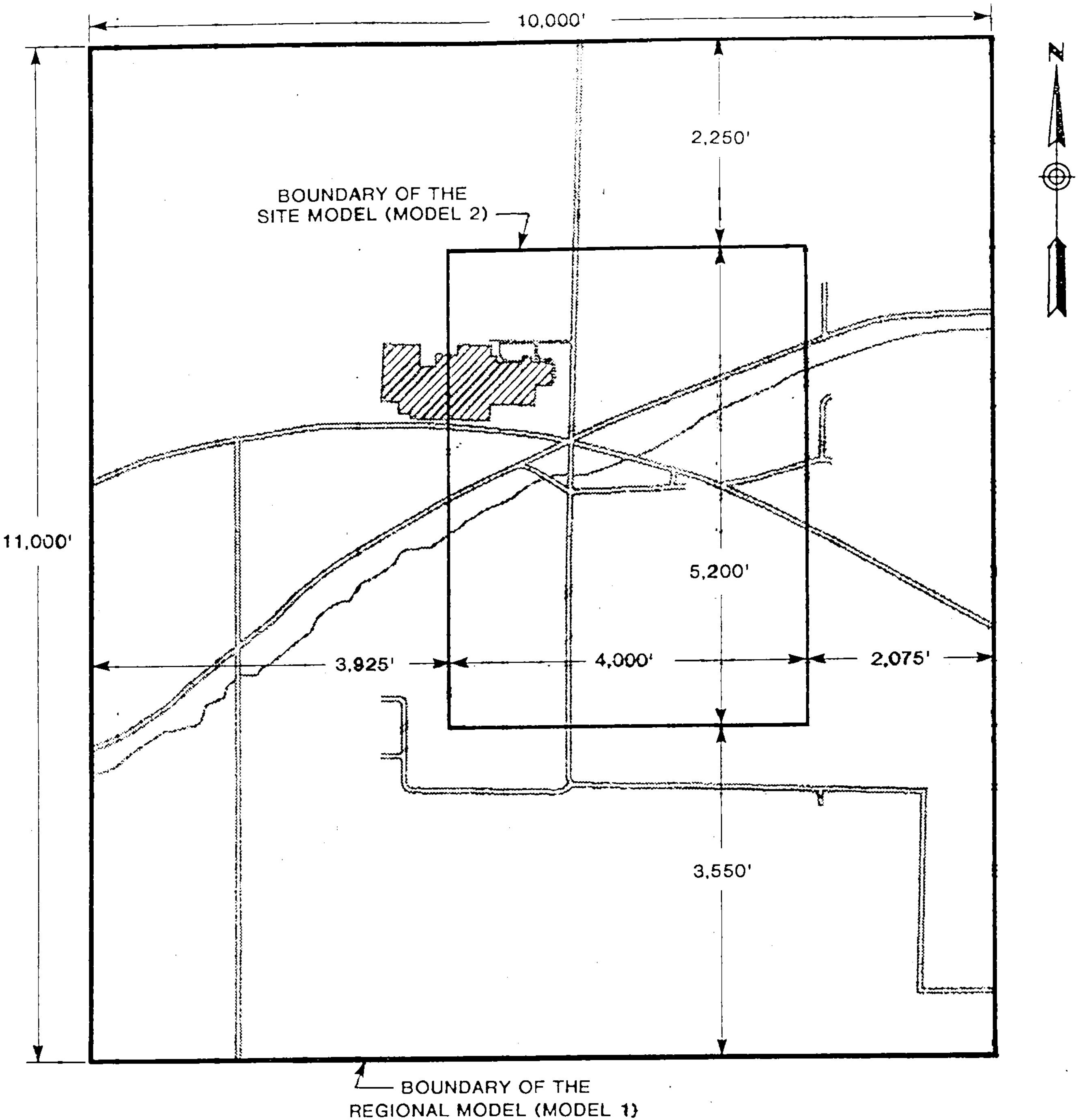
TABLE E10-2
SUMMARY OF MATRIX DIFFUSION ANALYSIS
MATRIX DATA
BELL AEROSPACE TEXTRON
WHEATFIELD PLANT
NIAGARA FALLS, NEW YORK

TIME (YEARS)	DISTANCE FRACTURE (FT)	MATRIX DEPTH (FT)	PREDICTED CONCENTRATION (LB/CU.FT)	PREDICTED CONCENTRATION (UG/L)	SOURCE CONCENTRATION (LB/CU.FT)	RELATIVE CONCENTRATION (PERCENT)
40	3500	0.0	0.00E+00	0	6.90E-02	0.00
40	3500	0.1	0.00E+00	0	6.90E-02	0.00
40	3500	0.2	0.00E+00	0	6.90E-02	0.00
40	3500	0.3	0.00E+00	0	6.90E-02	0.00
40	3500	0.4	0.00E+00	0	6.90E-02	0.00
40	3500	0.5	0.00E+00	0	6.90E-02	0.00
40	3500	0.6	0.00E+00	0	6.90E-02	0.00
40	3500	0.7	0.00E+00	0	6.90E-02	0.00
40	3500	0.8	0.00E+00	0	6.90E-02	0.00
40	3500	0.9	0.00E+00	0	6.90E-02	0.00
40	3500	1.0	0.00E+00	0	6.90E-02	0.00
40	4000	0.0	0.00E+00	0	6.90E-02	0.00
40	4000	0.1	0.00E+00	0	6.90E-02	0.00
40	4000	0.2	0.00E+00	0	6.90E-02	0.00
40	4000	0.3	0.00E+00	0	6.90E-02	0.00
40	4000	0.4	0.00E+00	0	6.90E-02	0.00
40	4000	0.5	0.00E+00	0	6.90E-02	0.00
40	4000	0.6	0.00E+00	0	6.90E-02	0.00
40	4000	0.7	0.00E+00	0	6.90E-02	0.00
40	4000	0.8	0.00E+00	0	6.90E-02	0.00
40	4000	0.9	0.00E+00	0	6.90E-02	0.00
40	4000	1.0	0.00E+00	0	6.90E-02	0.00

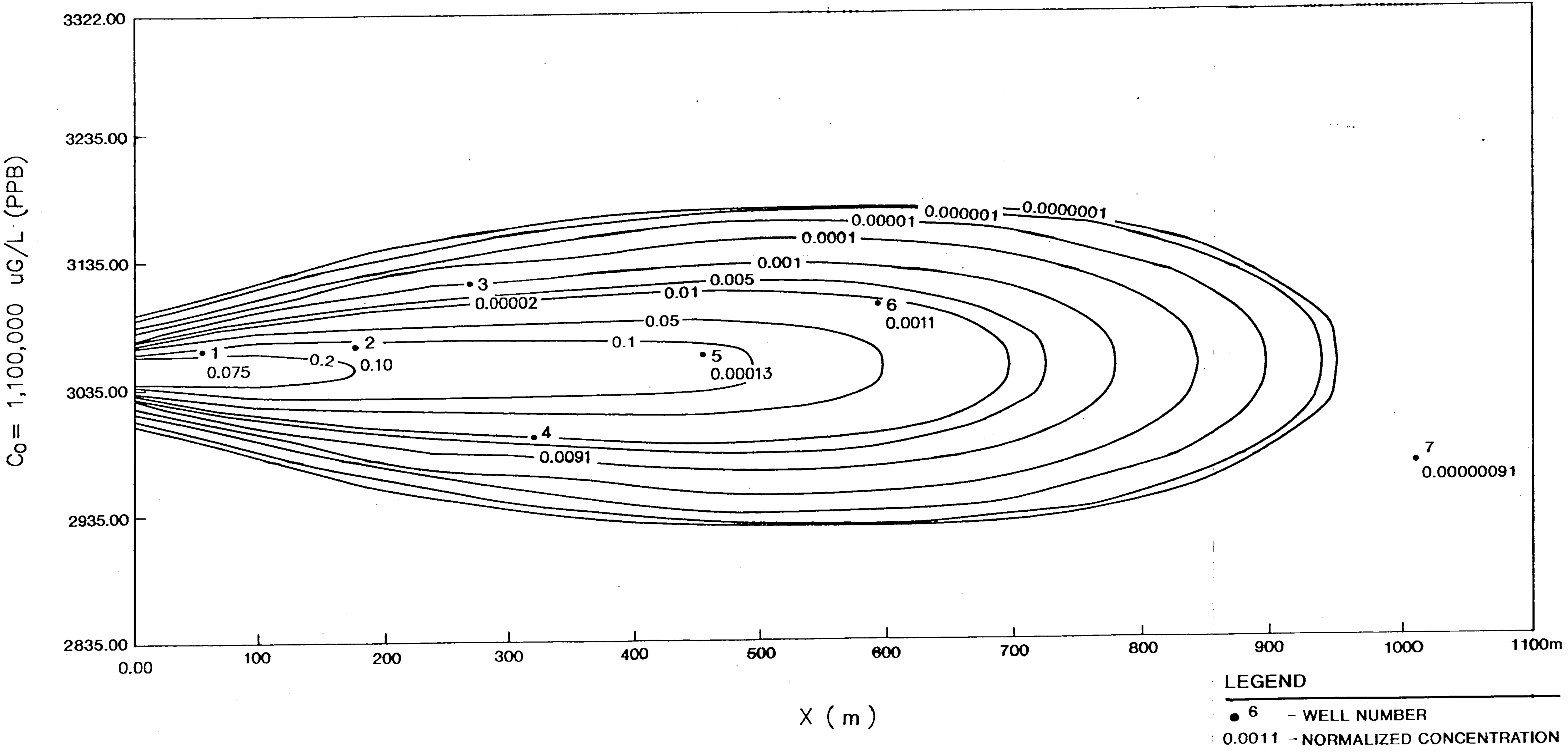
F/N: TABE10-2.WK1



JOB No.: 913-6384	SCALE: N.T.S.	**CONCEPTUAL HYDROGEOLOGIC CROSS SECTION**
DRAWN: LAS	DATE: 04/23/91	
CHECKED:	DWG. No.: NY01-197	
Golder Associates		**BELL AEROSPACE TEXTRON** FIGURE **E5-1**



JOB No.:	913-6384	SCALE:	AS SHOWN	**GRID BOUNDARIES OF MODEL 1 AND MODEL 2**	
DRAWN:	FG	DATE:	03/20/91		
CHECKED:	RCFK	DWG. No.:	NY01-196		
Golder Associates				BELL AEROSPACE TEXTRON	FIGURE **E5-2**



• 87-06 (1) MONITORING WELL
0.075 RELATIVE CONCENTRATION C/Co

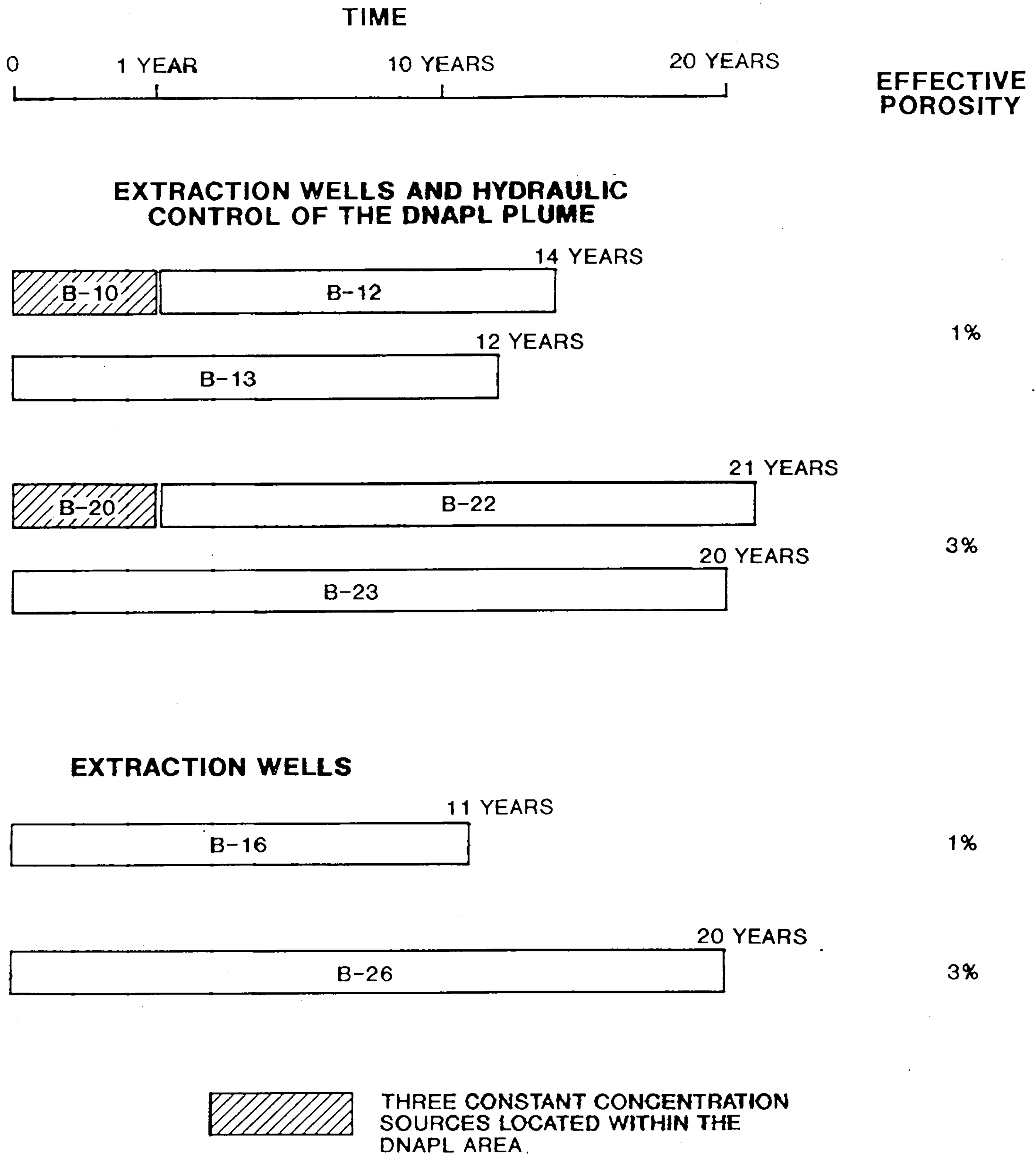
JOB No.:	913-6384	SCALE:	N/A
DRAWN:	WME	DATE:	05/02/91
CHECKED:		DWG. No.:	NY01-191

Golder Associates

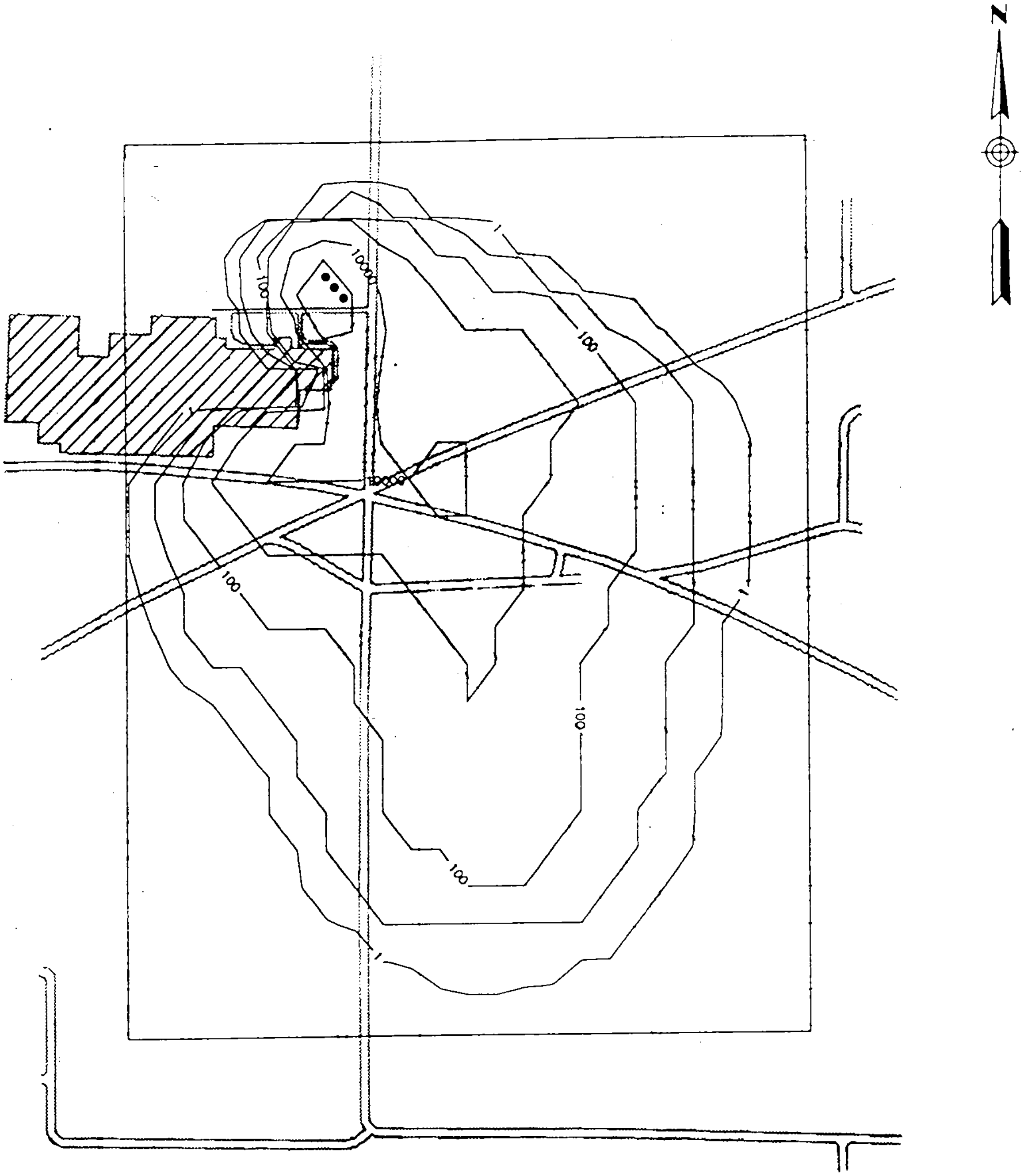
NORMALIZED CONCENTRATION CONTOURS, TIME - 20 YEARS

BELL AEROSPACE TEXTRON

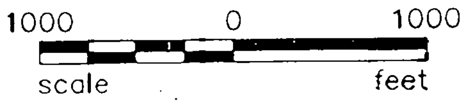
FIGURE **E5-3**



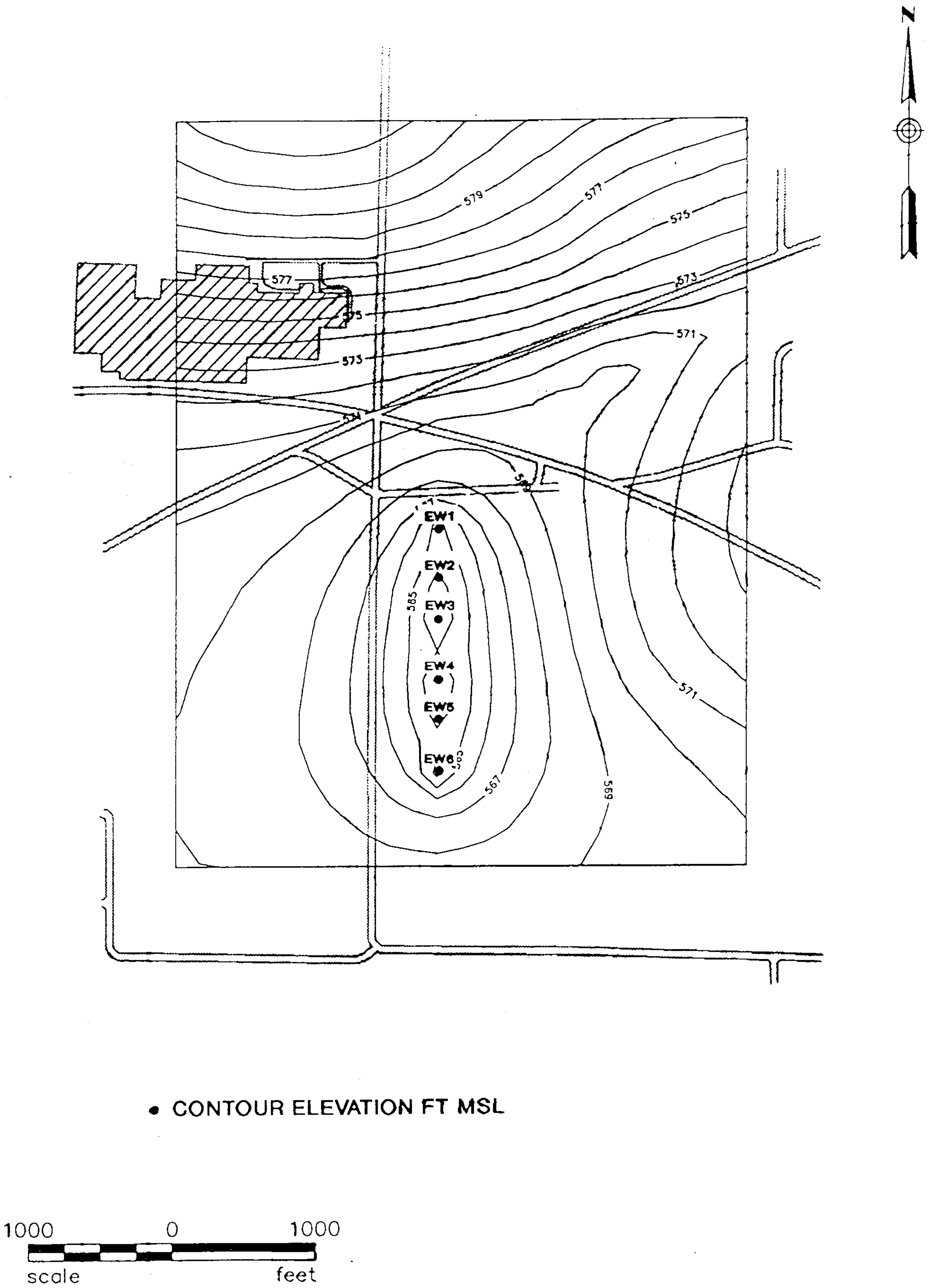
JOB No.: 913-6384	SCALE: N.T.S.	**CHART OF THE SOLUTE TRANSPORT SIMULATIONS**
DRAWN: LAS	DATE: 04/29/91	
CHECKED:	DWG. No.: NY01-229	
Golder Associates		BELL AEROSPACE TEXTRON — FIGURE **E5-4**



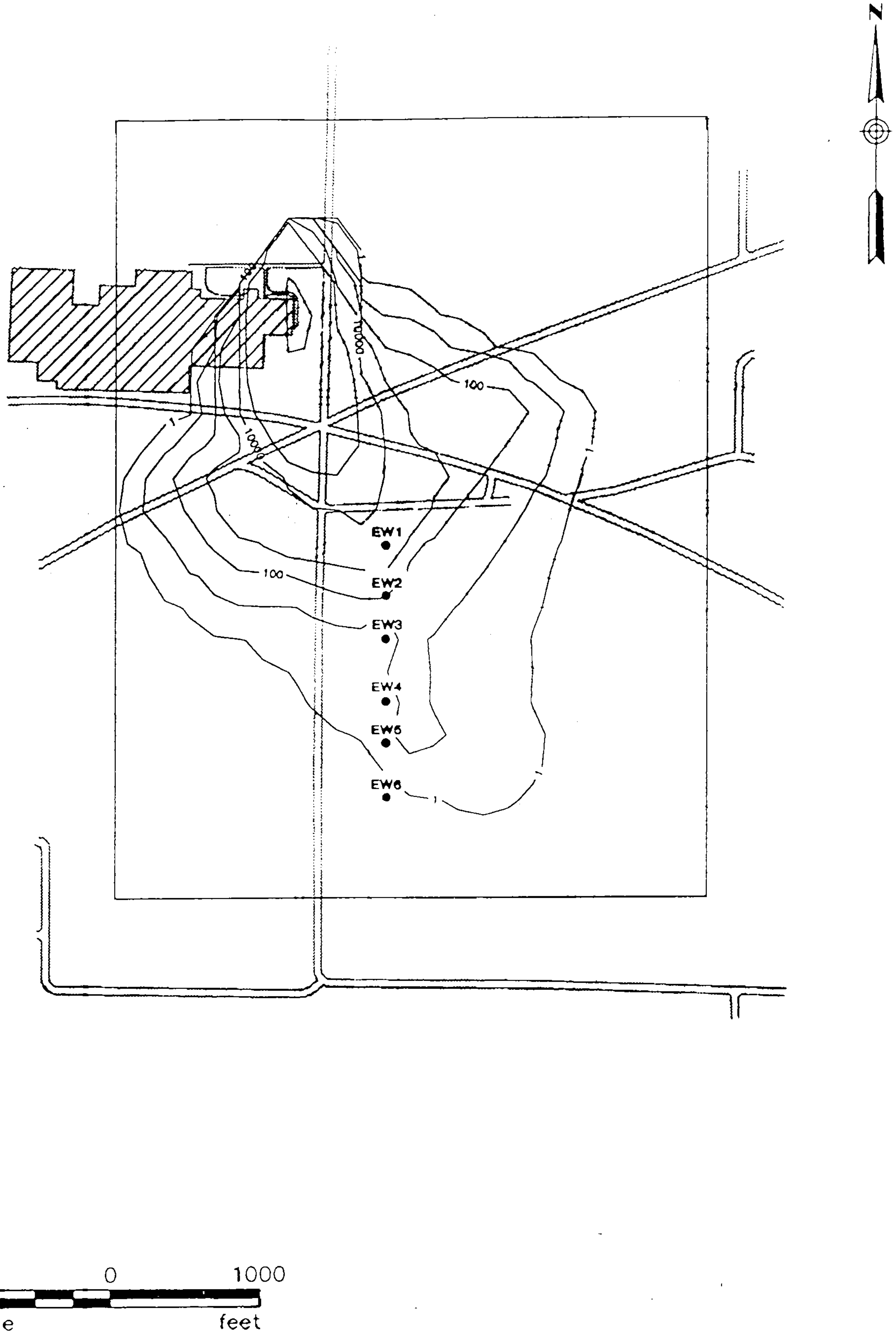
- CONSTANT CONCENTRATION SOURCE DEFINED FOR THE COMPUTER RUNS B-10 AND B-12 ONLY



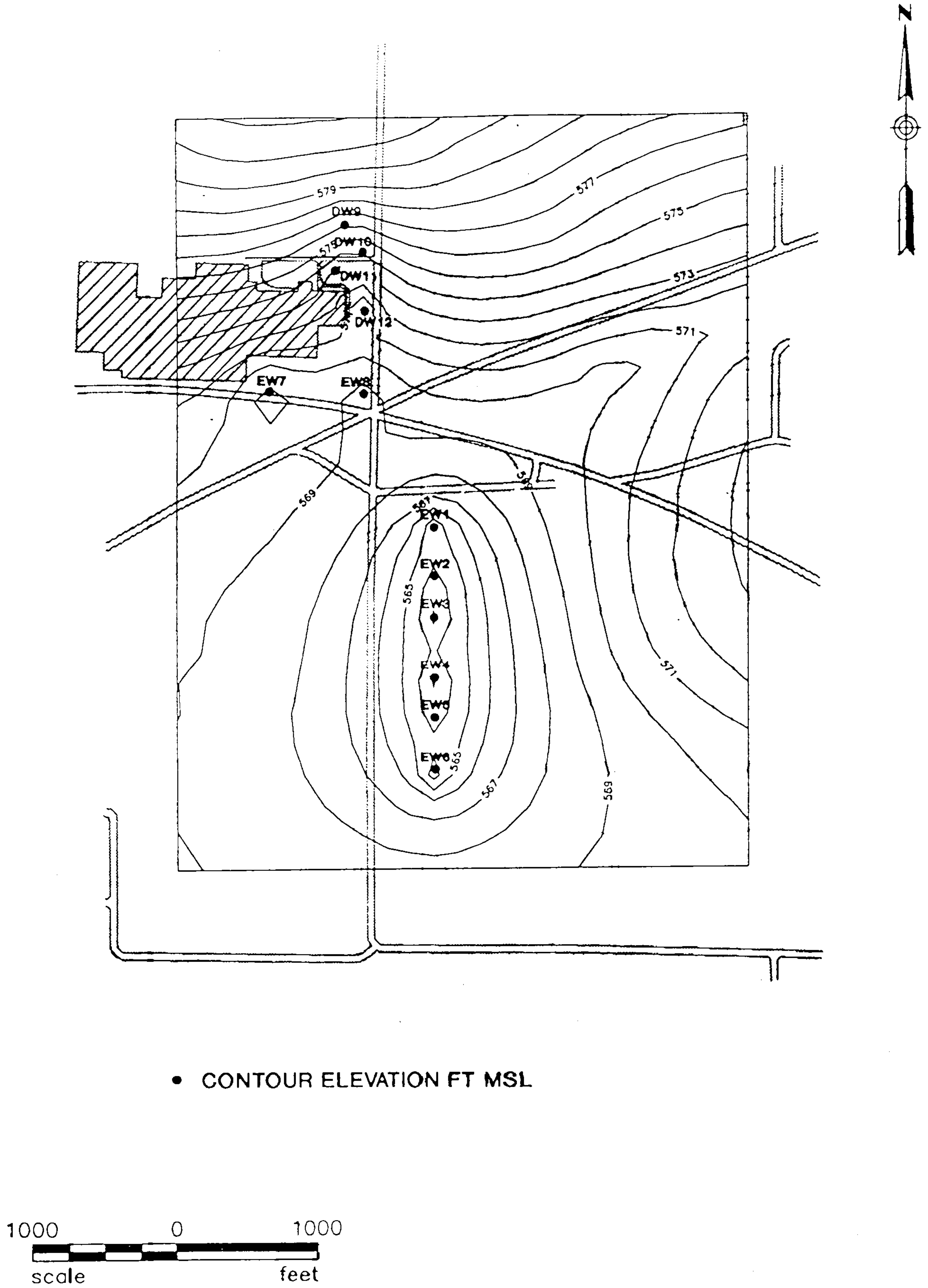
JOB No.: 913-6384	SCALE: AS SHOWN	**INITIAL CONCENTRATION CONTOURS** **(TOTAL VOLATILE ORGANICS, ppb)** **2-D ANALYTICAL SOLUTE TRANSPORT MODEL**
DRAWN: LAS	DATE: 04/24/91	
CHECKED: RCFK.	DWG. No.: NY01-218	
Golder Associates		BELL AEROSPACE TEXTRON — FIGURE **E5-5**



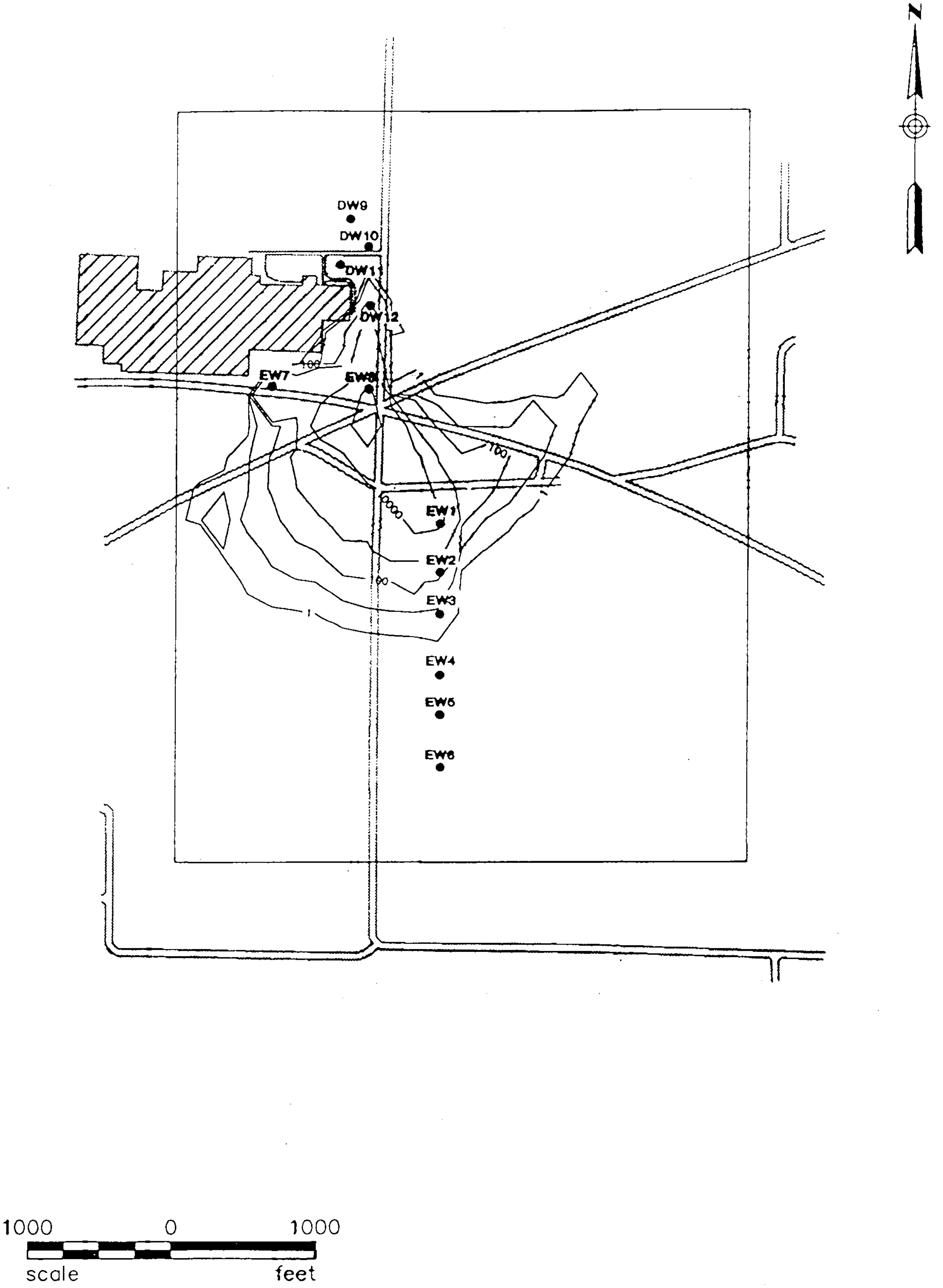
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-10 SIMULATED POTENTIOMETRIC CONTOURS
DRAWN: LAS	DATE: 04/24/91	
CHECKED: RLFK.	DWG. No.: NY01-210	
Golder Associates		BELL AEROSPACE TEXTRON FIGURE **E5-6**



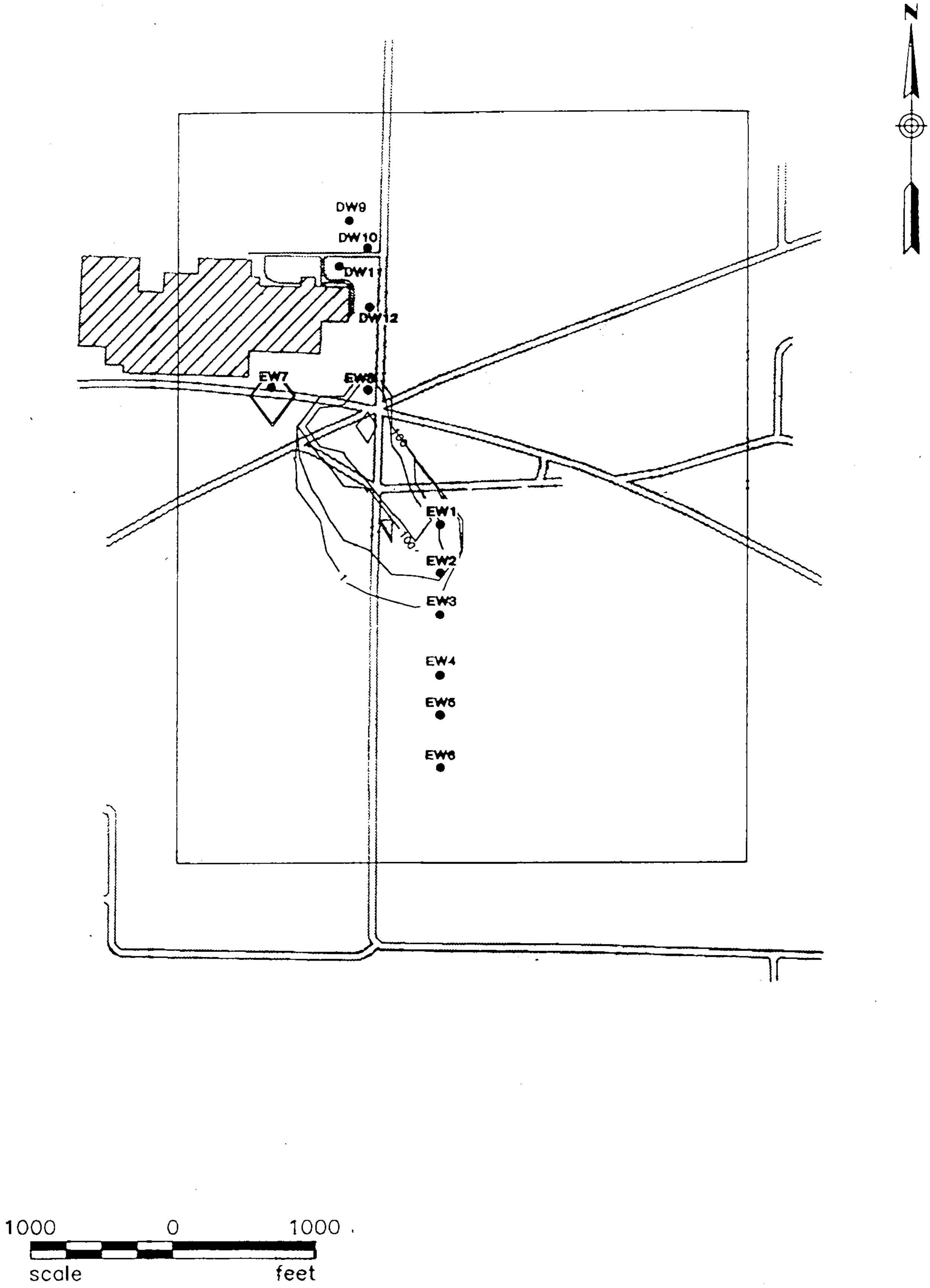
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-10 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 300 DAYS AFTER INITIATION OF PUMPING
DRAWN: LAS	DATE: 04/24/91	
CHECKED: RUFR.	DWG. No.: NY01-206	
Golder Associates		BELL AEROSPACE TEXTRON FIGURE **E5-7**



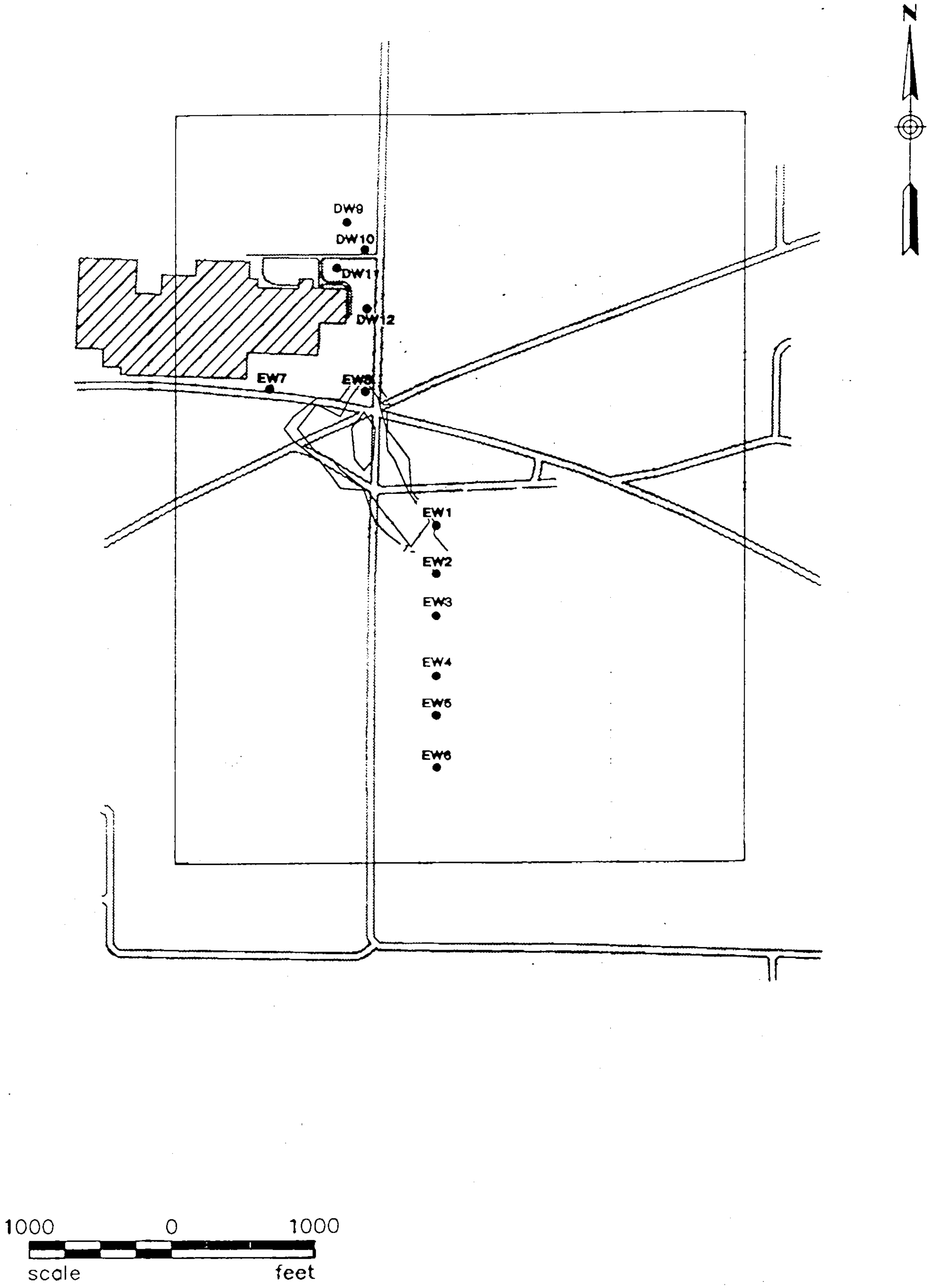
JOB No.:	913-6384	SCALE:	AS SHOWN	**RUNS B-12 AND B-13** **SIMULATED POTENTIOMETRIC CONTOURS**
DRAWN:	LAS	DATE:	05/29/91	
CHECKED:	RCFK	DWG. No.:	NY01-269	
Golder Associates				BELL AEROSPACE TEXTRON FIGURE **E5-8**



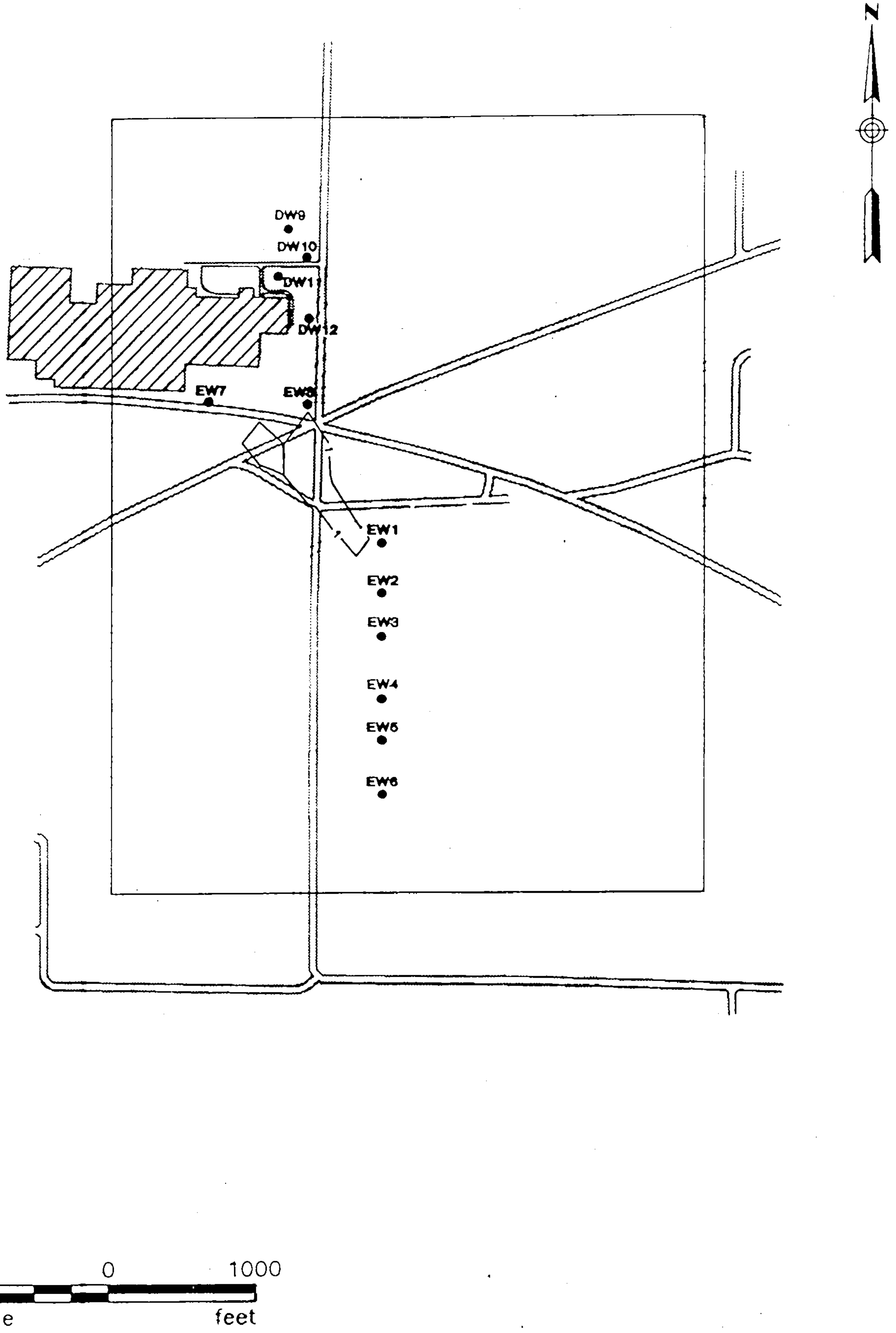
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-12 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 2 YEARS AFTER INITIATION OF PUMPING	
DRAWN: LAS	DATE: 04/24/91		
CHECKED: DLFK	DWG. No.: NY01-188		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE: E5-9



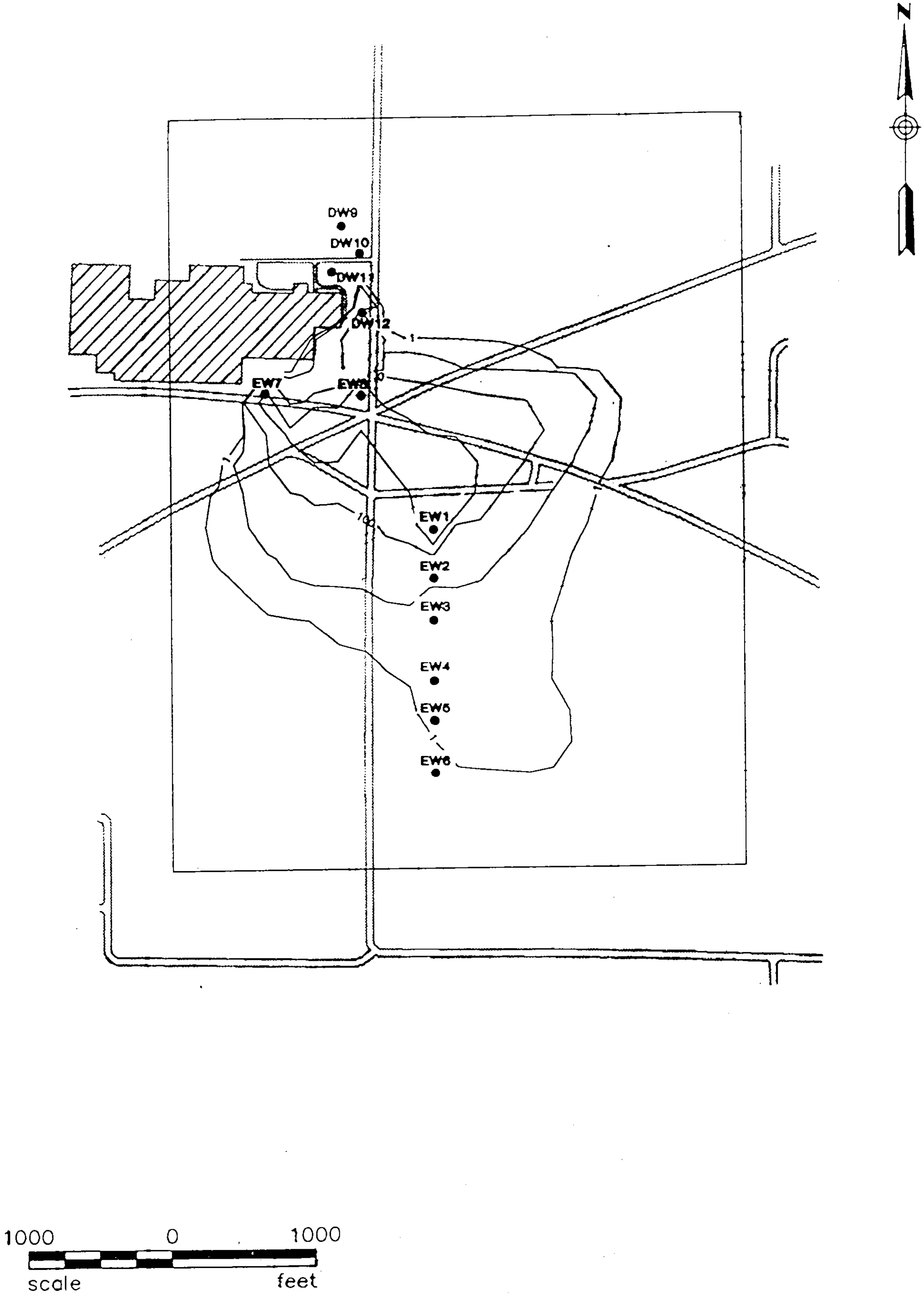
JOB No.:	913-6384	SCALE:	AS SHOWN	RUN B-12 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 5 YEARS AFTER INITIATION OF PUMPING
DRAWN:	LAS	DATE:	04/24/91	
CHECKED:	RFK	DWG. No.:	NY01-187	
Golder Associates				BELL AEROSPACE TEXTRON — FIGURE E5-10



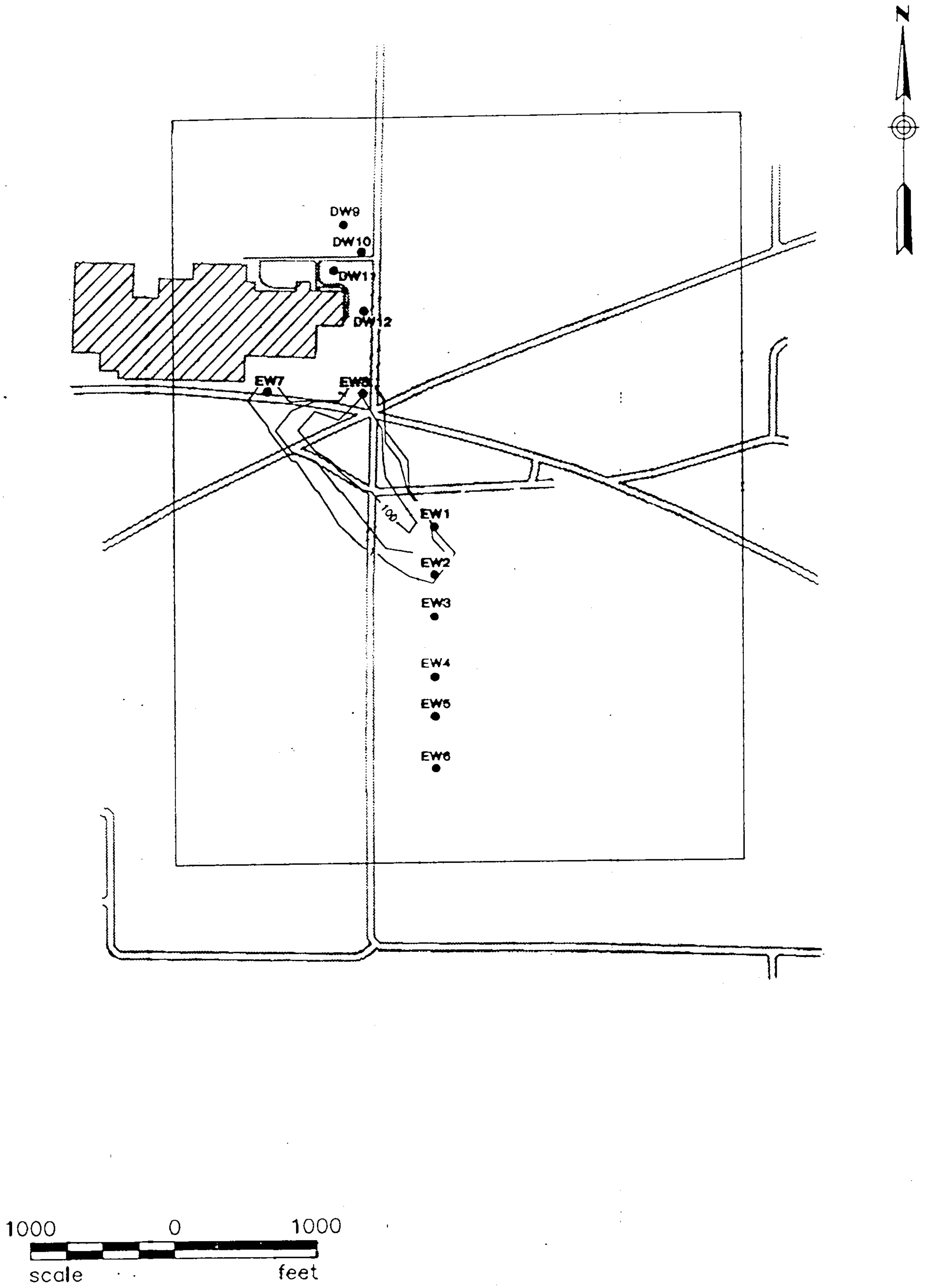
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-12 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 10 YEARS AFTER INITIATION OF PUMPING	
DRAWN: LAS	DATE: 04/24/91		
CHECKED:	DWG. No.: NY01-186		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE **E5-11**



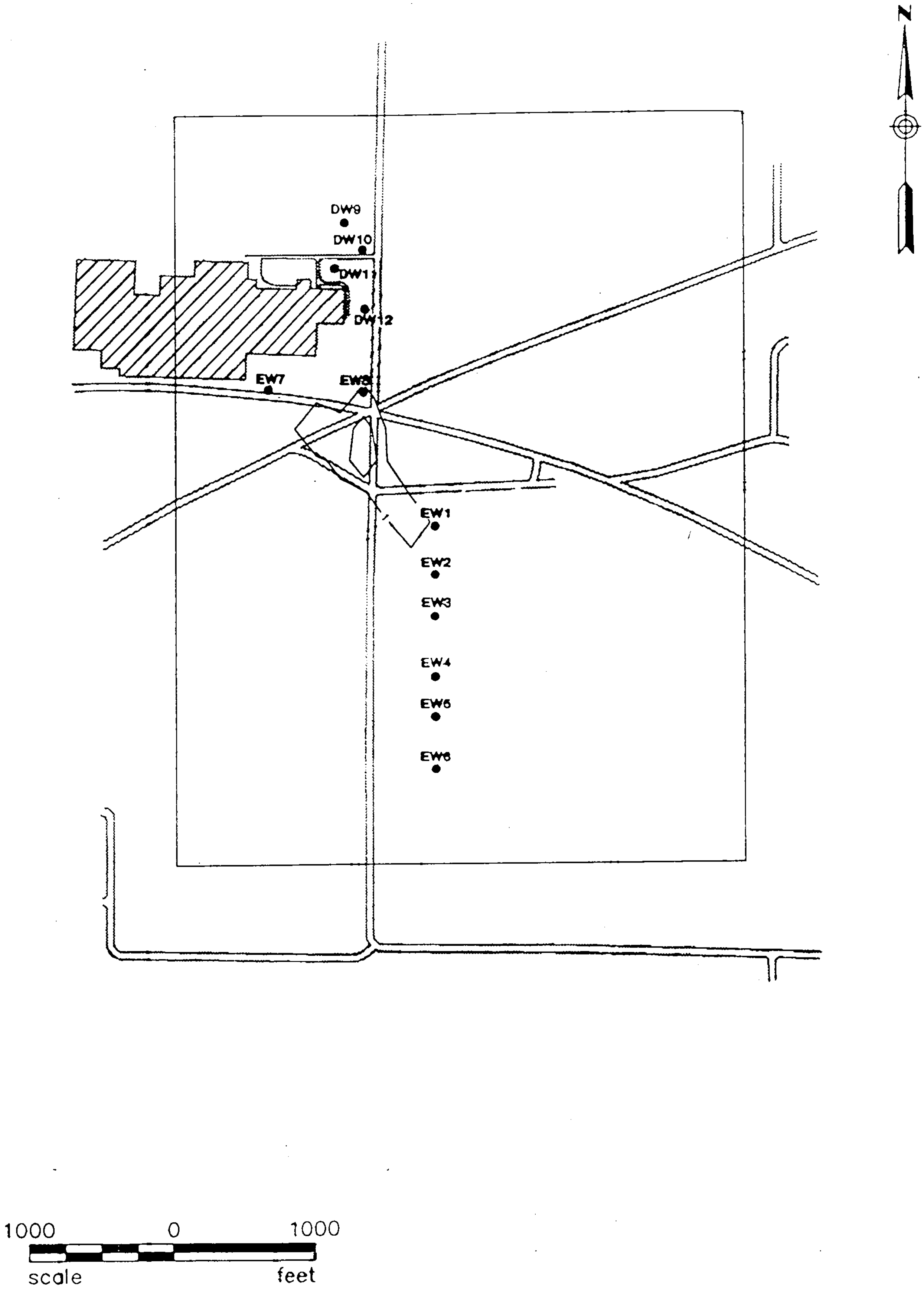
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-12 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 14 YEARS AFTER INITIATION OF PUMPING
DRAWN: LAS	DATE: 04/24/91	
CHECKED: DFR	DWG. No.: NY01-185	
Golder Associates		BELL AEROSPACE TEXTRON — FIGURE E5-12



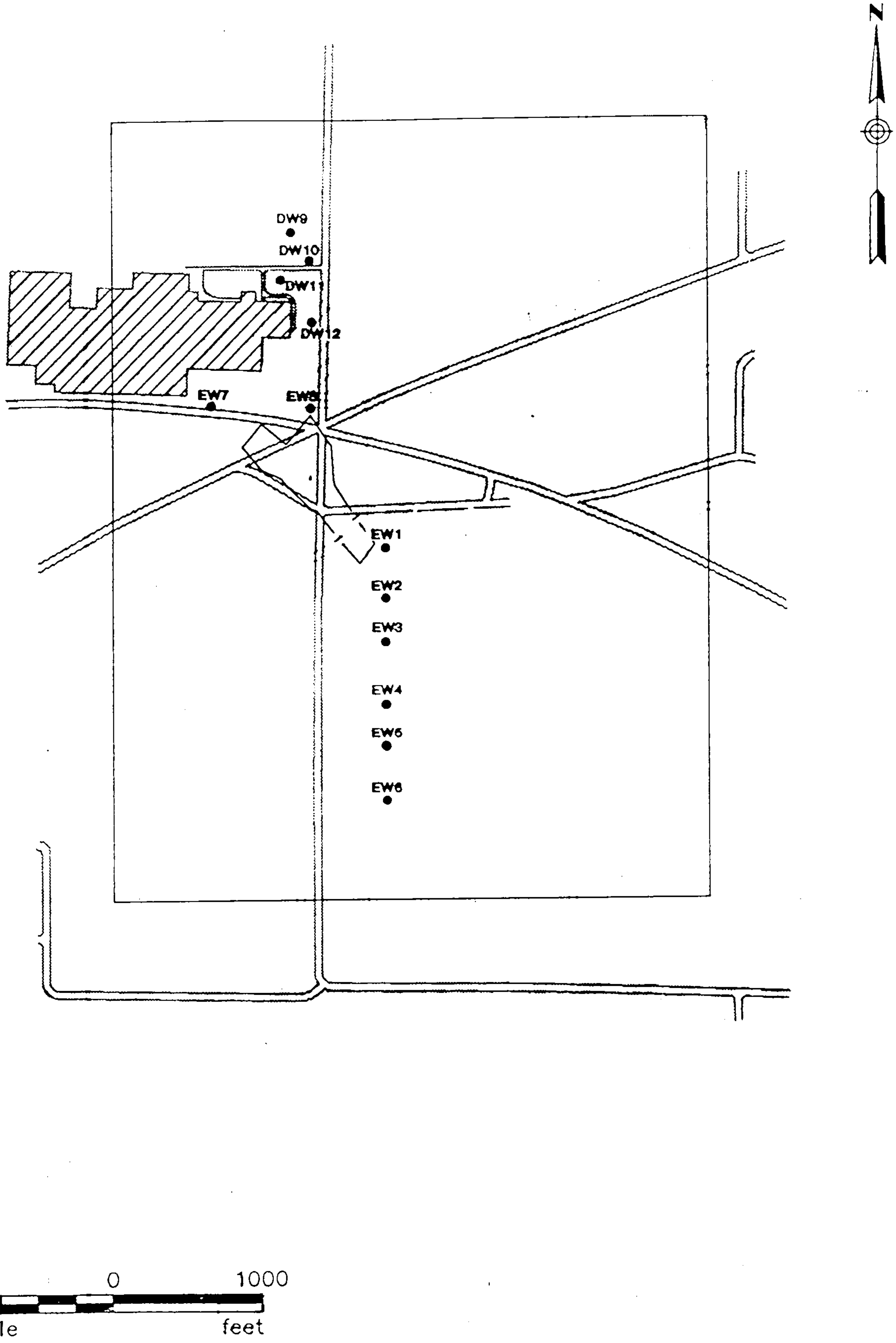
JOB No.: 913-6384	SCALE: AS SHOWN	**RUN B-13 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 1 YEAR AFTER INITIATION OF PUMPING**	
DRAWN: LAS	DATE: 04/24/91		
CHECKED: DCPK	DWG. No.: NY01-184		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE **E5-13**



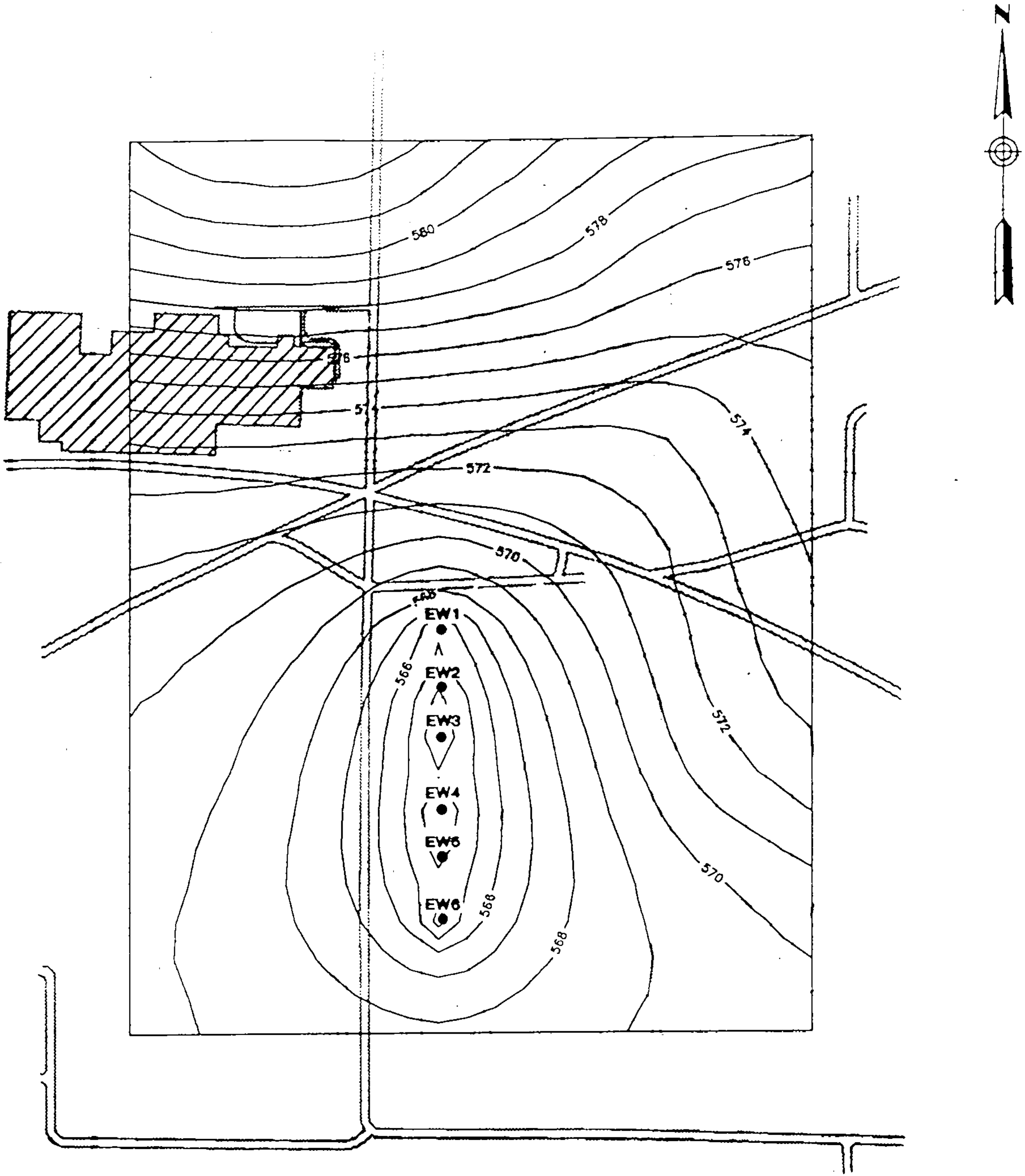
JOB No.: 913-6384	SCALE: AS SHOWN	**RUN B-13 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 5 YEARS AFTER INITIATION OF PUMPING**
DRAWN: LAS	DATE: 04/24/91	
CHECKED:	DWG. No.: NY01-183	
Golder Associates		BELL AEROSPACE TEXTRON
		FIGURE **E5-14**



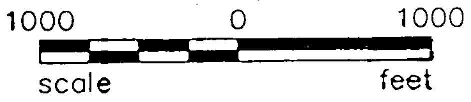
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-13 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 10 YEARS AFTER INITIATION OF PUMPING	
DRAWN: LAS	DATE: 04/24/91		
CHECKED:	DWG. No.: NY01-182		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE E5-15



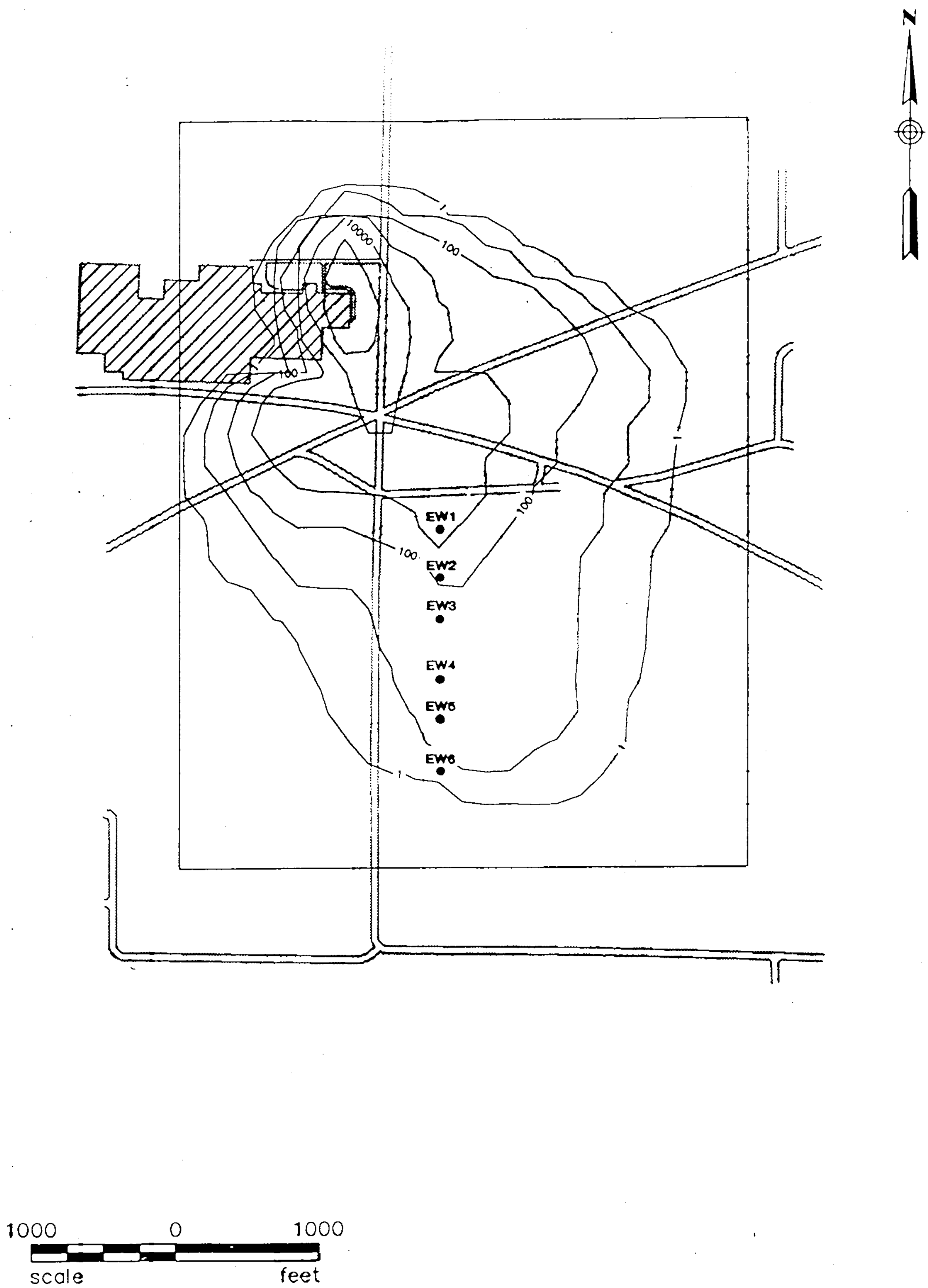
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-13 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 13 YEARS AFTER INITIATION OF PUMPING	
DRAWN: LAS	DATE: 04/24/91		
CHECKED: RCFK	DWG. No.: NY01-181		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE: **E5-16**



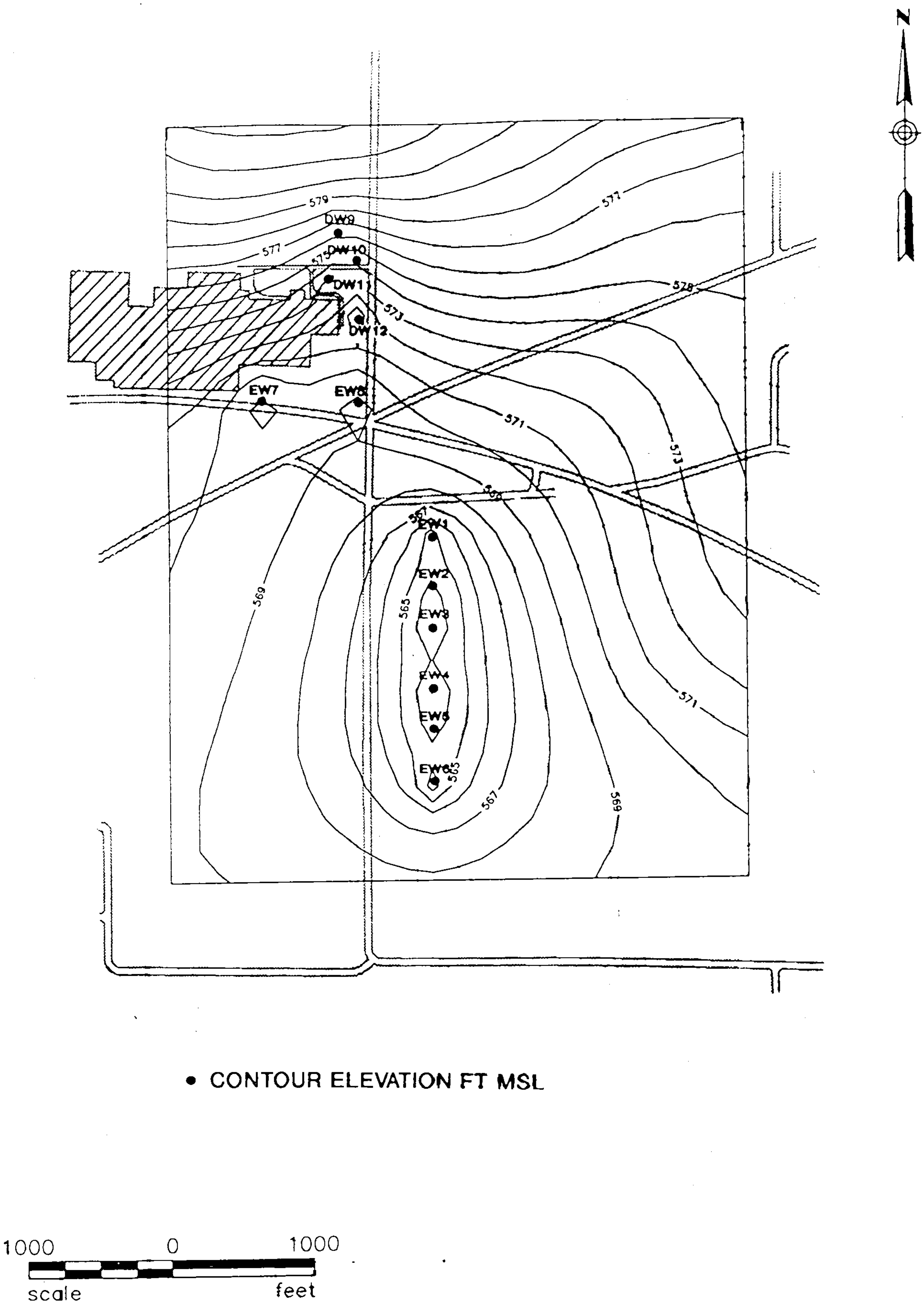
• CONTOUR ELEVATION FT MSL



JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-20 SIMULATED POTENTIOMETRIC CONTOURS
DRAWN: LAS	DATE: 04/24/91	
CHECKED: RFK	DWG. No.: NY01-205	
Golder Associates		BELL AEROSPACE TEXTRON
		FIGURE E5-17

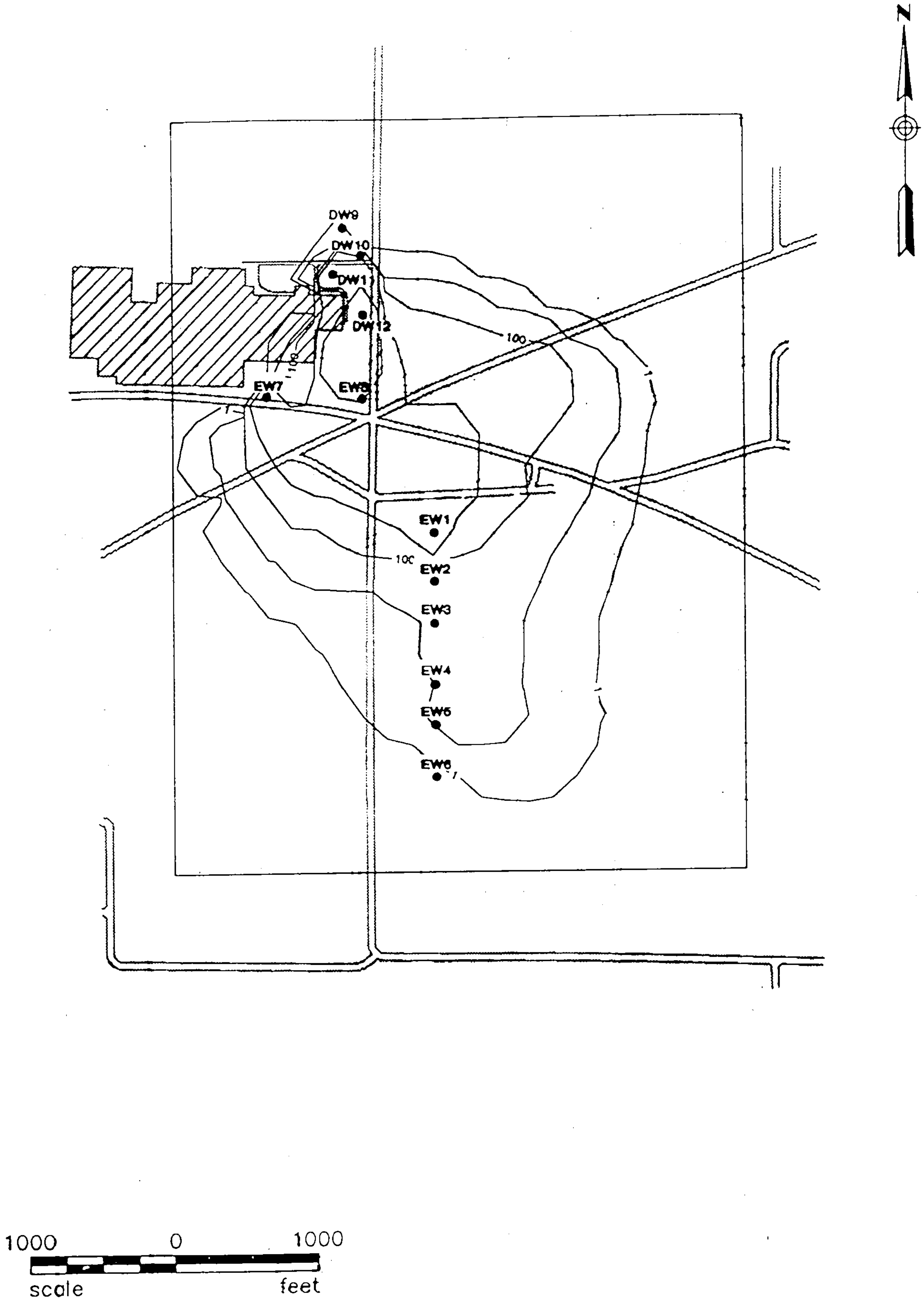


JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-20 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 300 DAYS AFTER INITIATION OF PUMPING
DRAWN: LAS	DATE: 04/24/91	
CHECKED: RWK	DWG. No.: NY01-201	
Golder Associates		BELL AEROSPACE TEXTRON FIGURE E5-18

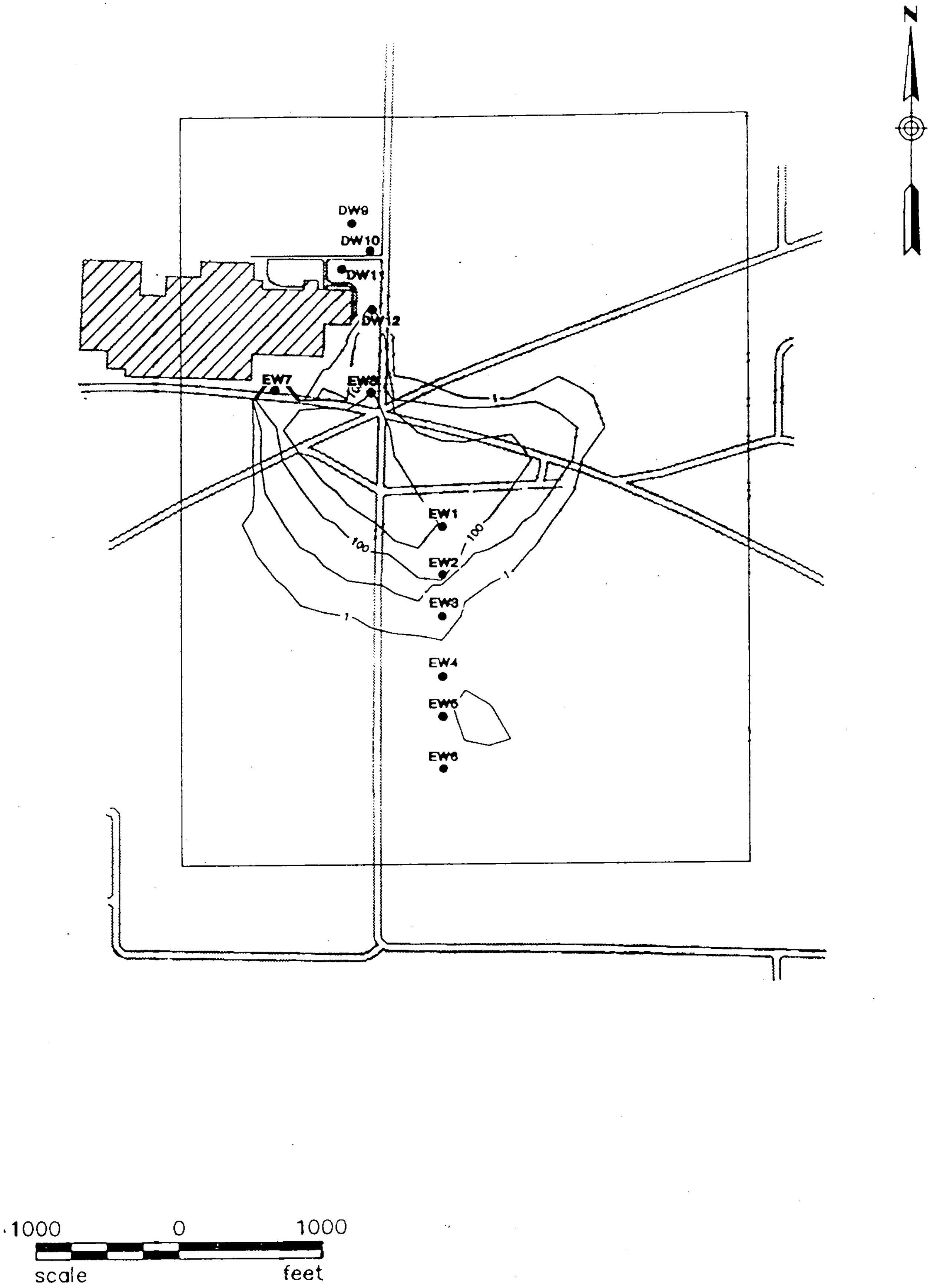


• CONTOUR ELEVATION FT MSL

JOB No.: 913-6384	SCALE: AS SHOWN	**RUNS B-22 AND B-23** **SIMULATED POTENTIOMETRIC CONTOURS**		
DRAWN: LAS	DATE: 05/29/91			
CHECKED:	DWG. No.: NY01-270			
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE **E5-19**	



JOB No.:	913-6384	SCALE:	AS SHOWN	RUN B-22 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 2 YEARS AFTER INITIATION OF PUMPING
DRAWN:	LAS	DATE:	04/24/91	
CHECKED:		DWG. No.:	NY01-180	
Golder Associates				BELL AEROSPACE TEXTRON FIGURE E5-20



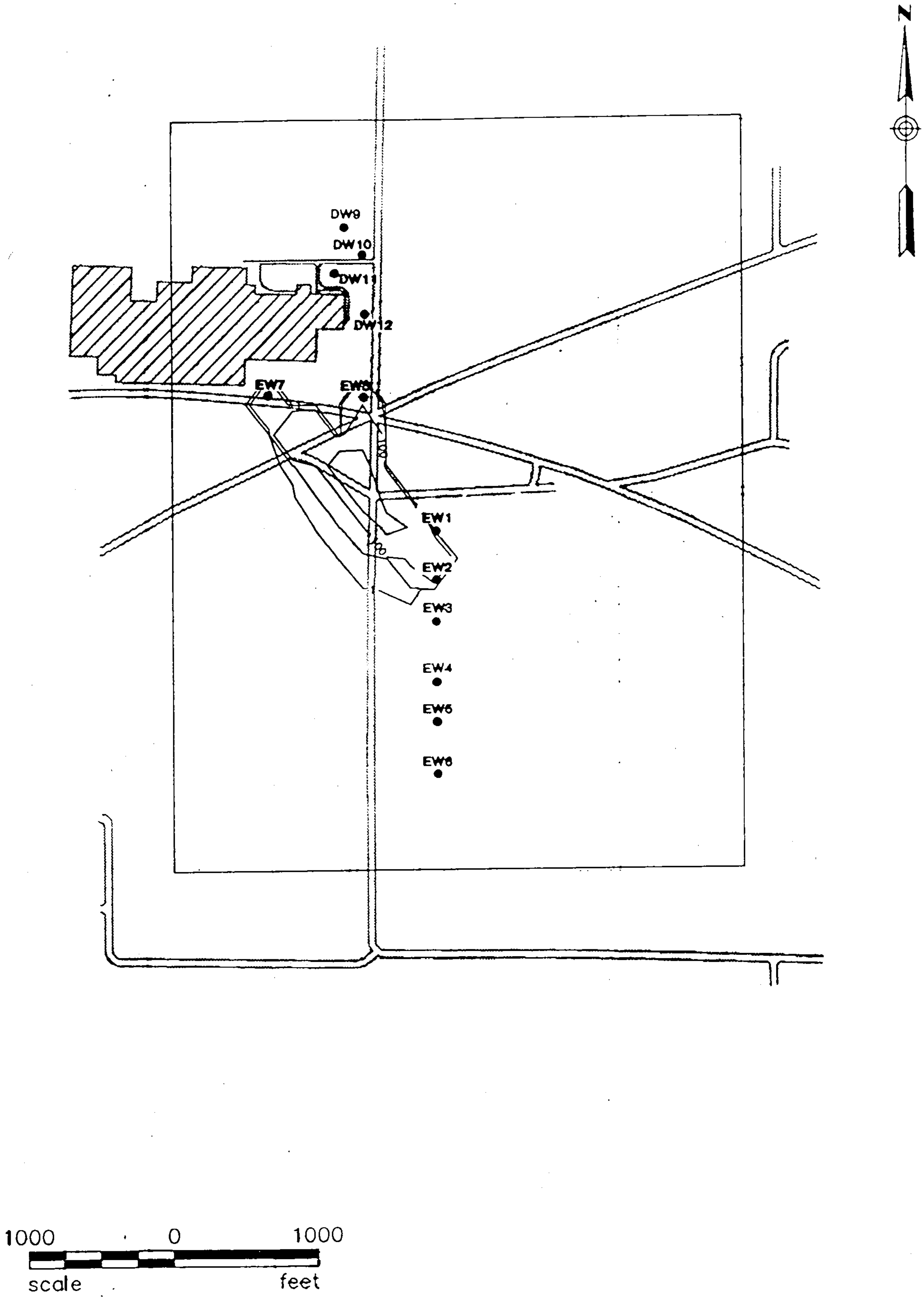
JOB No.: 913-6384
SCALE: AS SHOWN
DRAWN: LAS
DATE: 04/24/91
CHECKED: RFK
DWG. No.: NY01-179

RUN B-22
SIMULATED CONCENTRATION CONTOURS
(TOTAL VOLATILE ORGANICS, ppb)
5 YEARS AFTER INITIATION OF PUMPING

Golder Associates

BELL AEROSPACE TEXTRON

FIGURE **E5-21**



JOB No.: 913-6384	SCALE: AS SHOWN		
DRAWN: LAS	DATE: 04/24/91		
CHECKED:	DWG. No.: NY01-178		

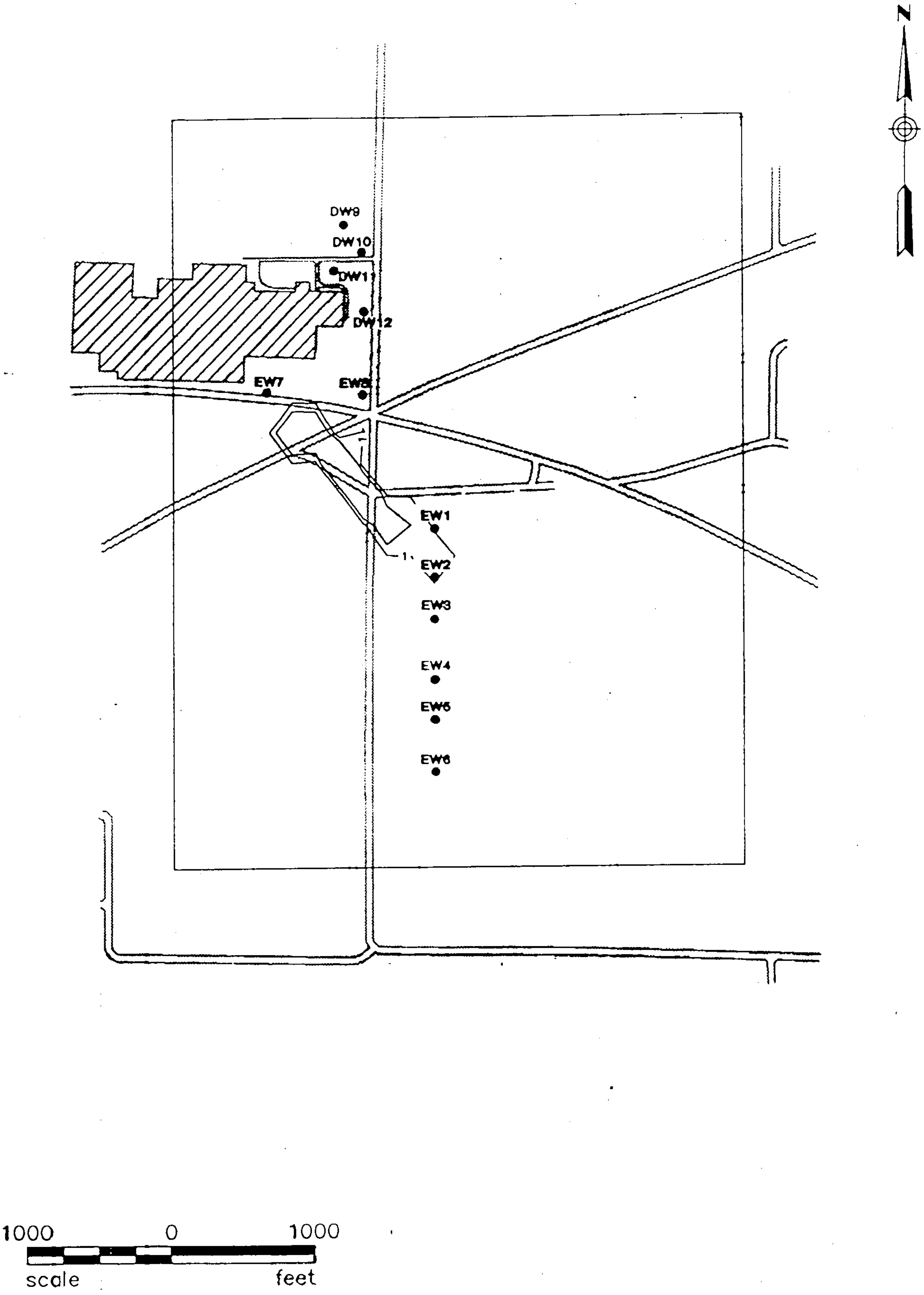
RUN B-22

SIMULATED CONCENTRATION CONTOURS
(TOTAL VOLATILE ORGANICS, ppb)
10 YEARS AFTER INITIATION OF PUMPING

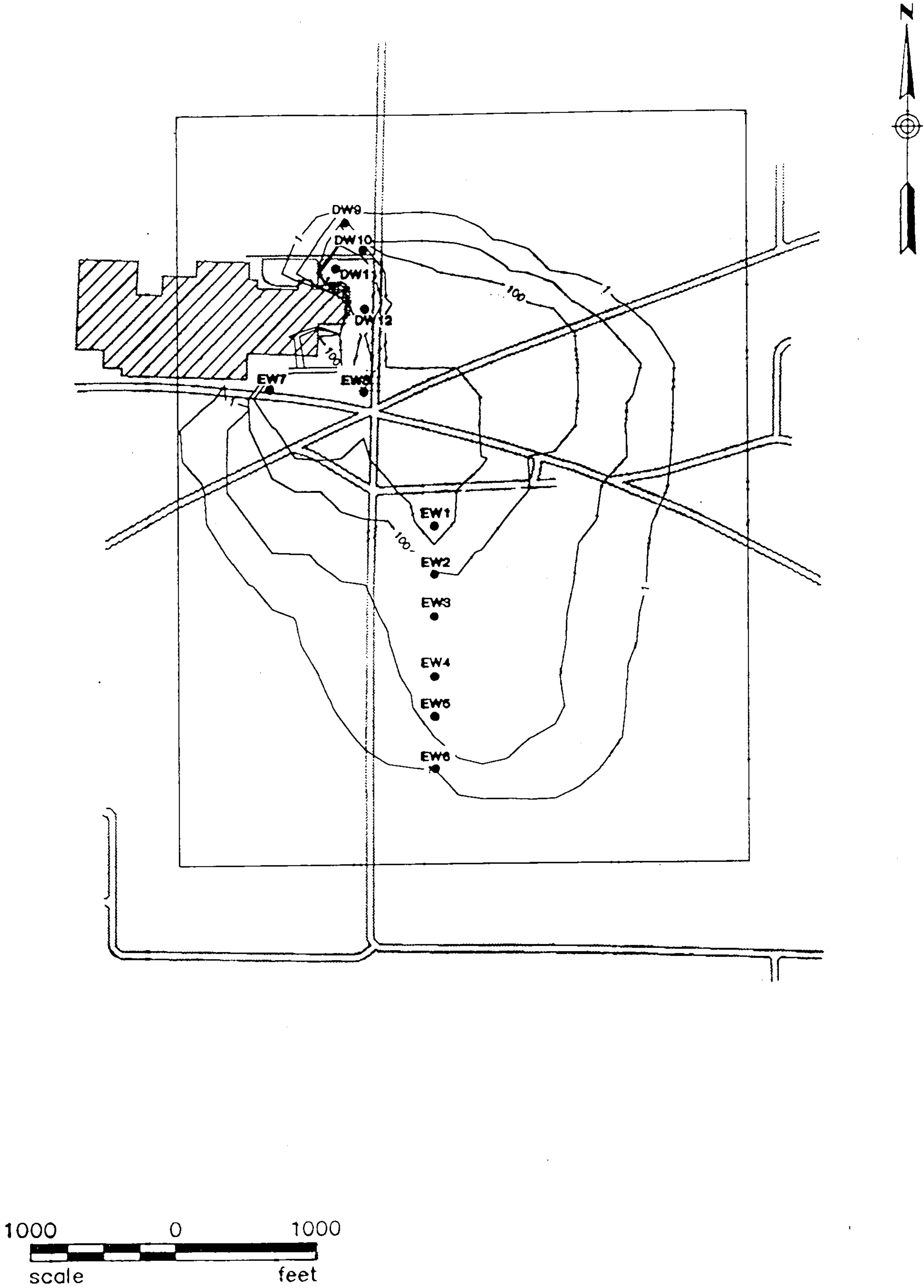
Golder Associates

BELL AEROSPACE TEXTRON

FIGURE **E5-22**



JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-22 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 21 YEARS AFTER INITIATION OF PUMPING	
DRAWN: LAS	DATE: 04/24/91		
CHECKED:	DWG. No.: NY01-176		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE **E5-23**



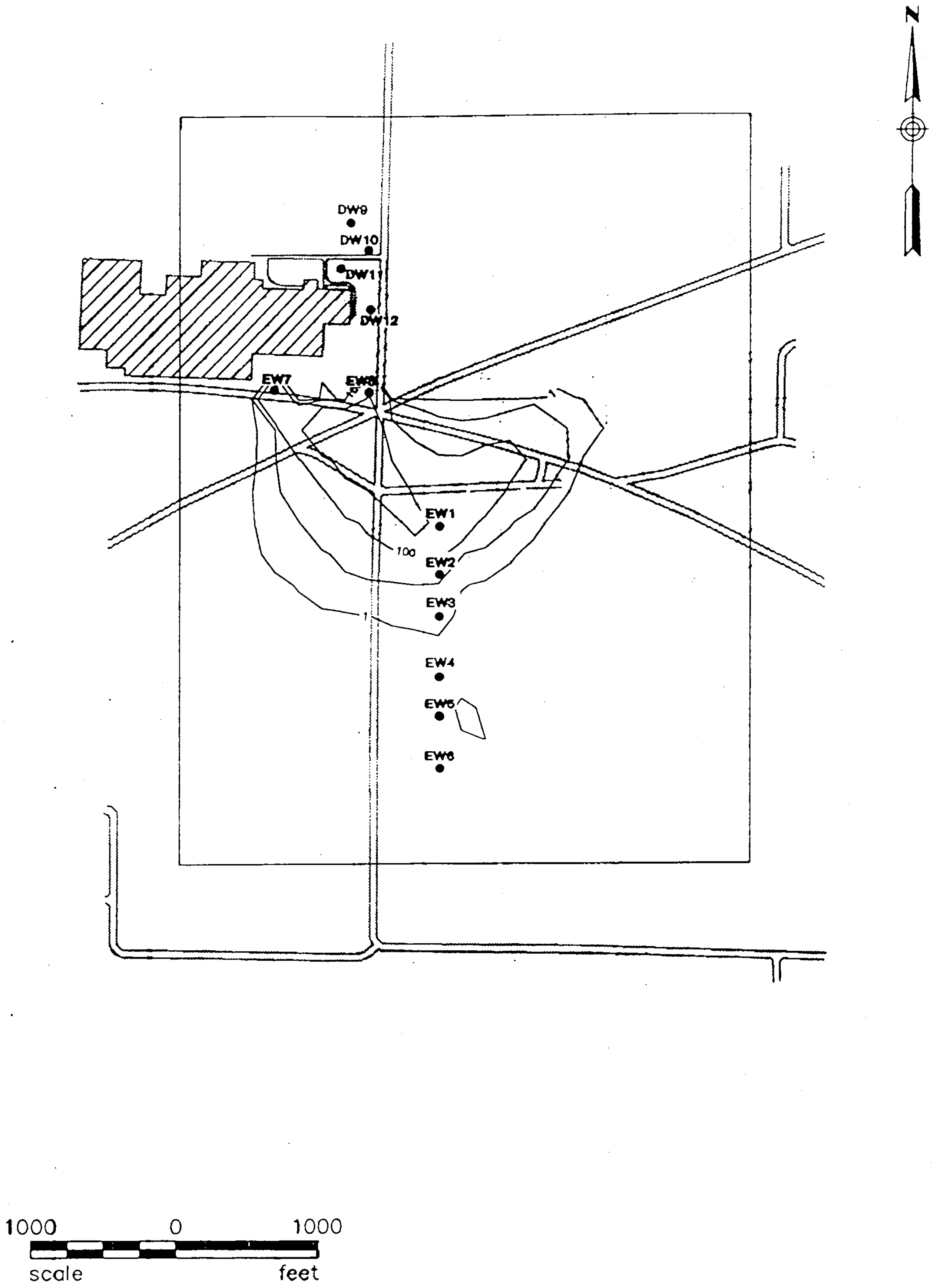
JOB No.:	913-6384	SCALE:	AS SHOWN
DRAWN:	LAS	DATE:	04/24/91
CHECKED:		DWG. No.:	NY01-175

RUN B-23 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 1 YEAR AFTER INITIATION OF PUMPING

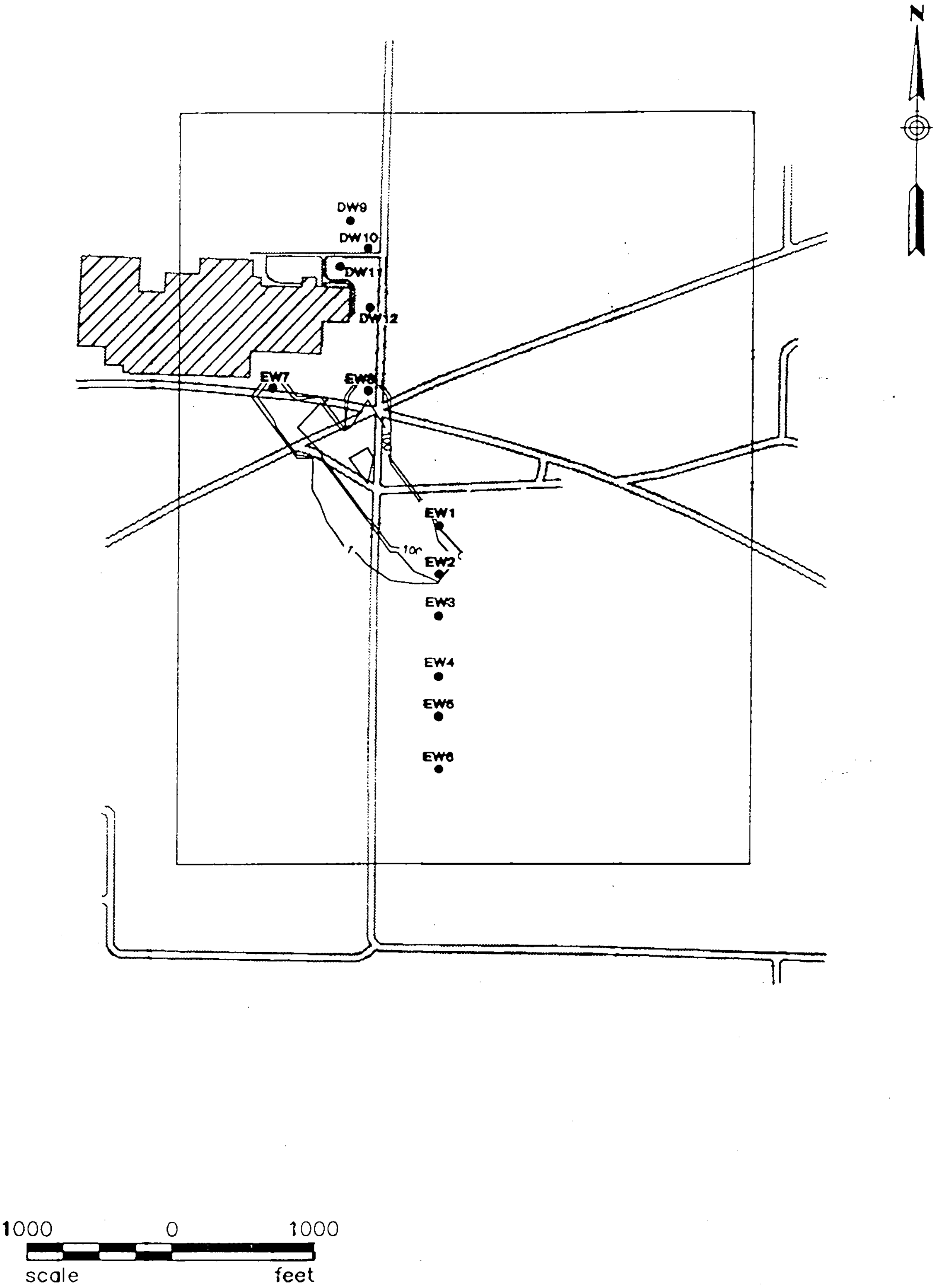
Golder Associates

BELL AEROSPACE TEXTRON

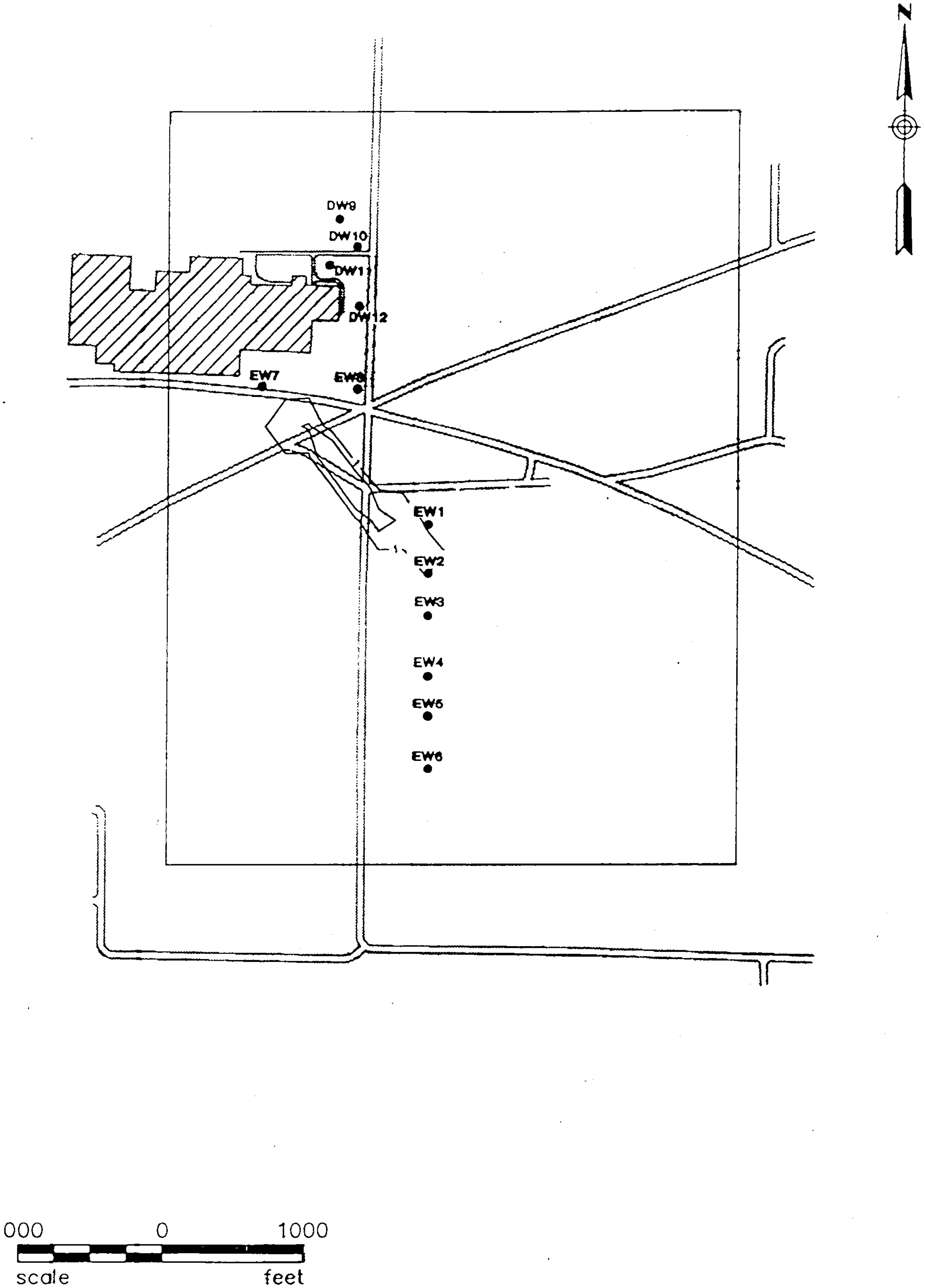
FIGURE E5-24



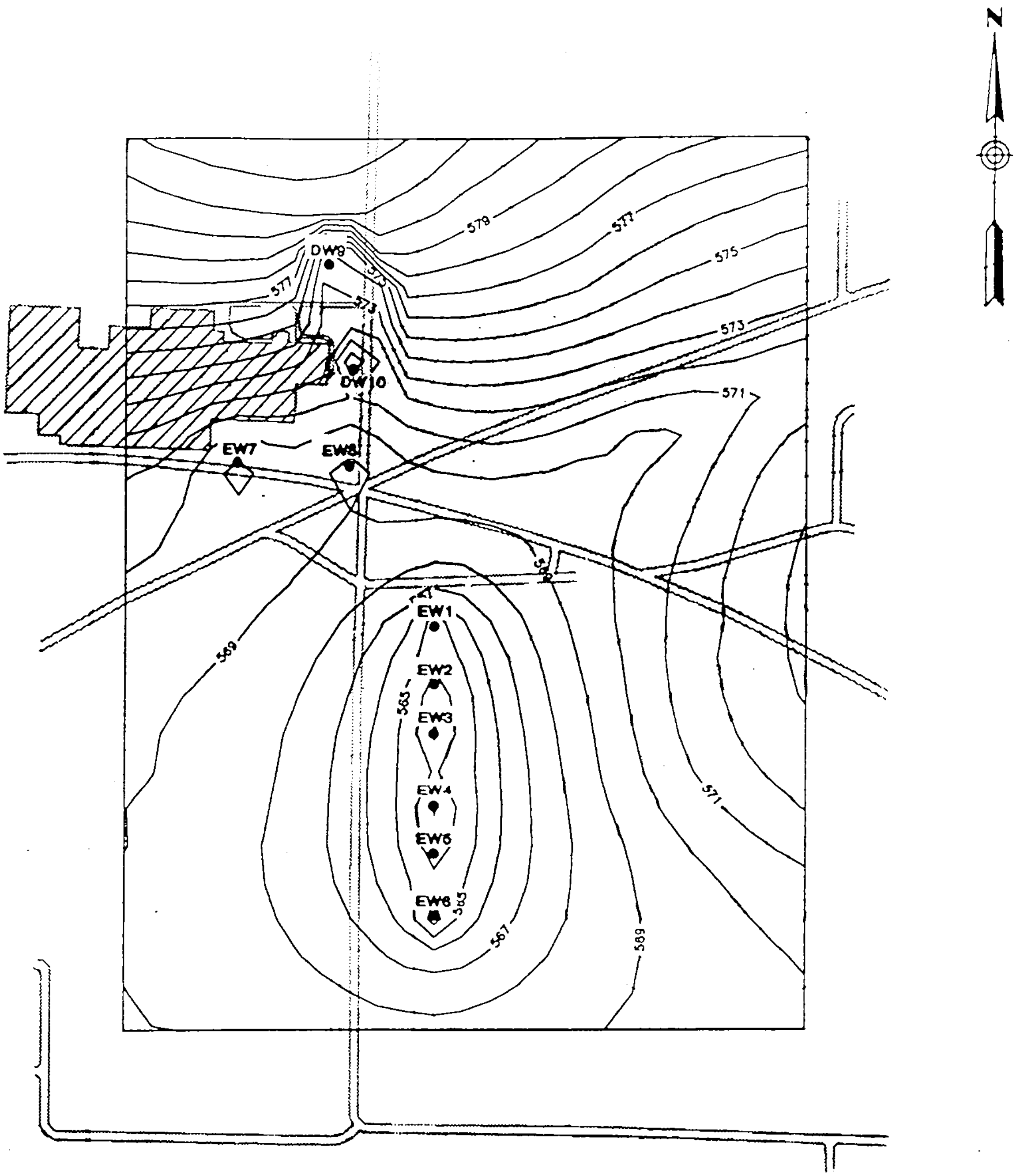
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-23 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 5 YEARS AFTER INITIATION OF PUMPING	
DRAWN: LAS	DATE: 04/24/91		
CHECKED:	DWG. No.: NY01-174		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE **E5-25**



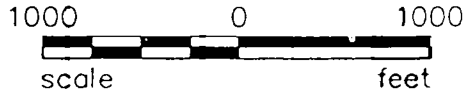
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-23 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 10 YEARS AFTER INITIATION OF PUMPING	
DRAWN: LAS	DATE: 04/24/91		
CHECKED: RKR	DWG. No.: NY01-173		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE E5-26



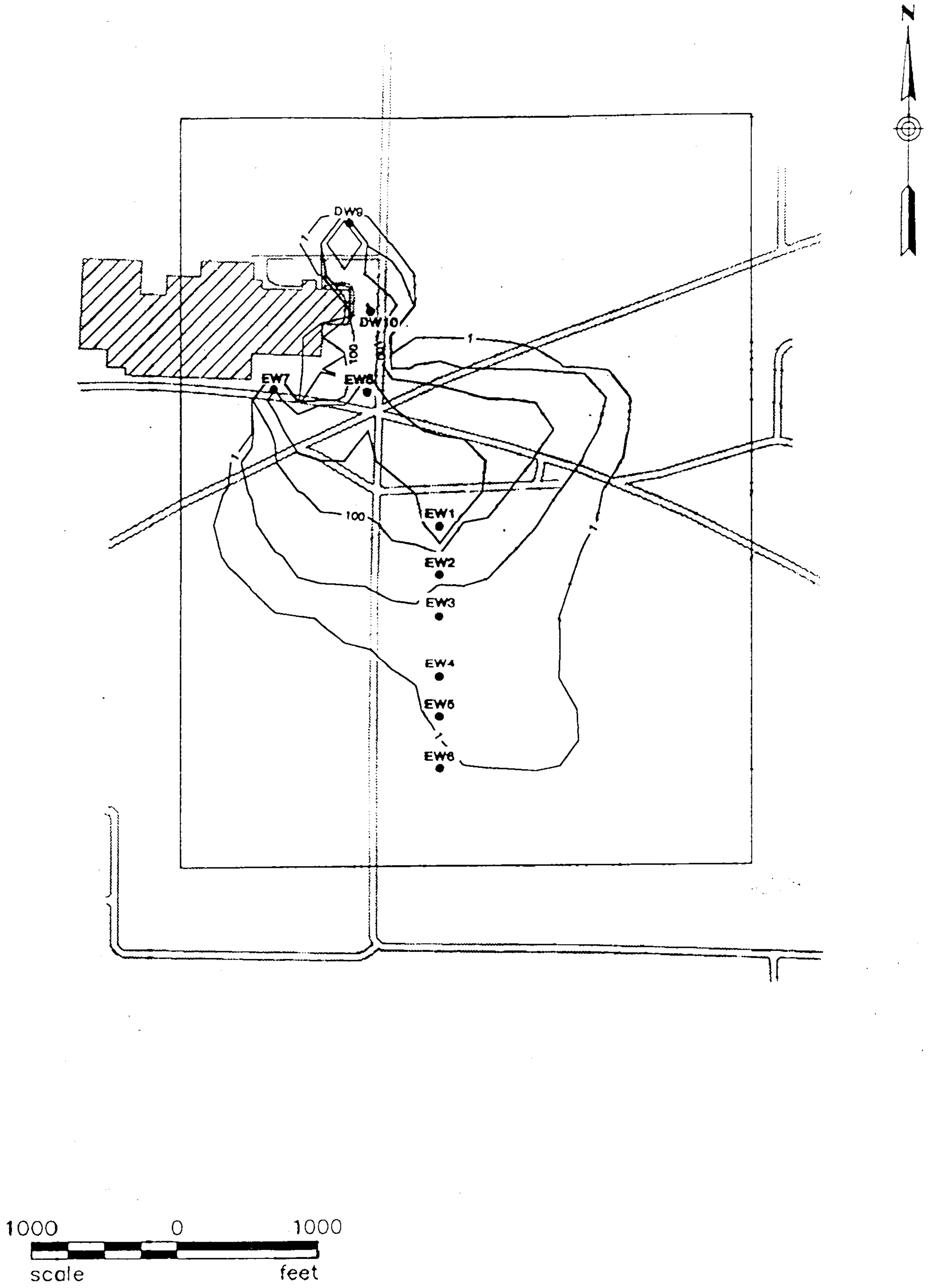
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-23 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 20 YEARS AFTER INITIATION OF PUMPING
DRAWN: LAS	DATE: 04/24/91	
CHECKED: RFR	DWG. No.: NY01-172	
Golder Associates		BELL AEROSPACE TEXTRON / FIGURE E5-27



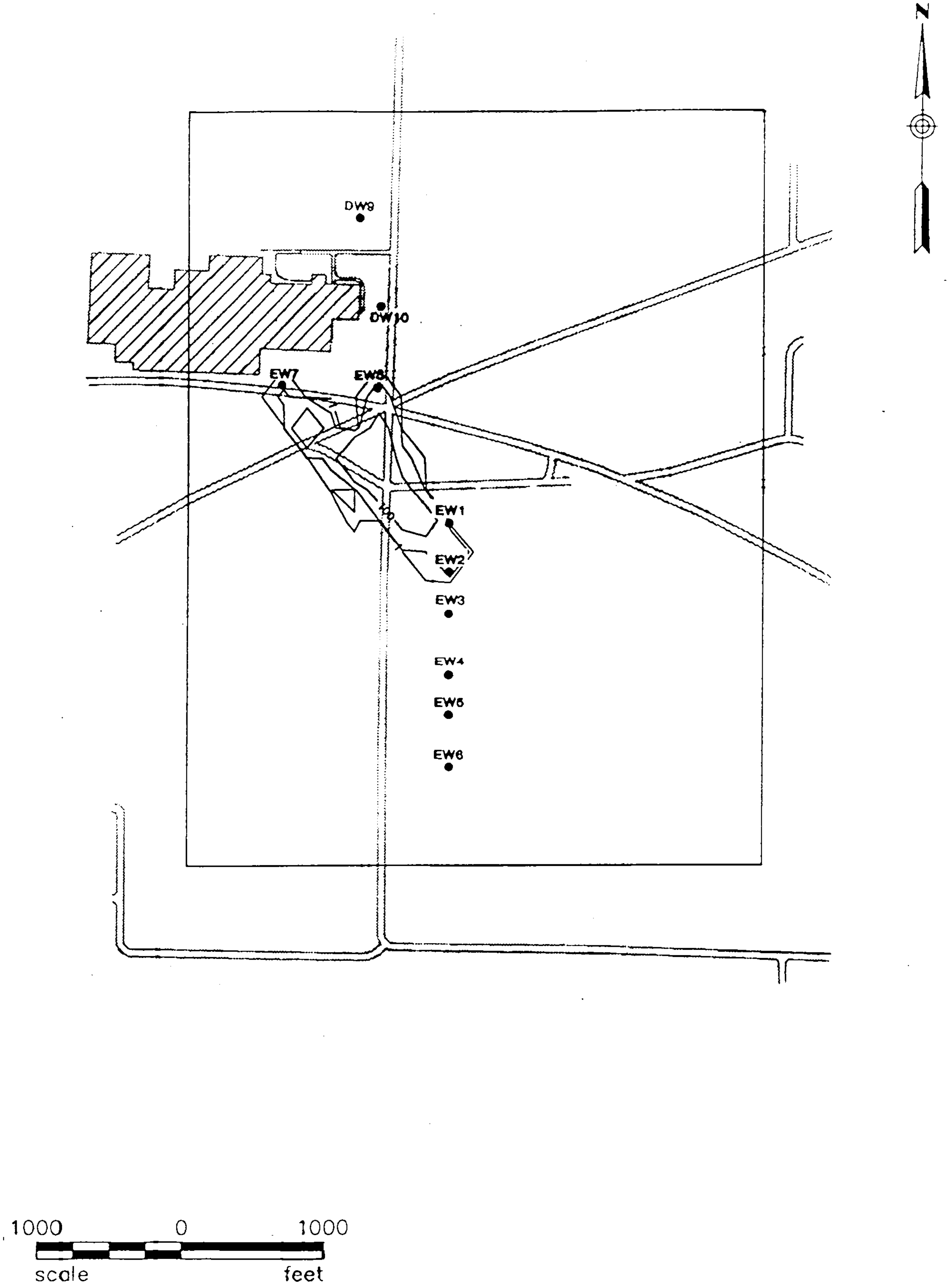
• CONTOUR ELEVATION FT MSL



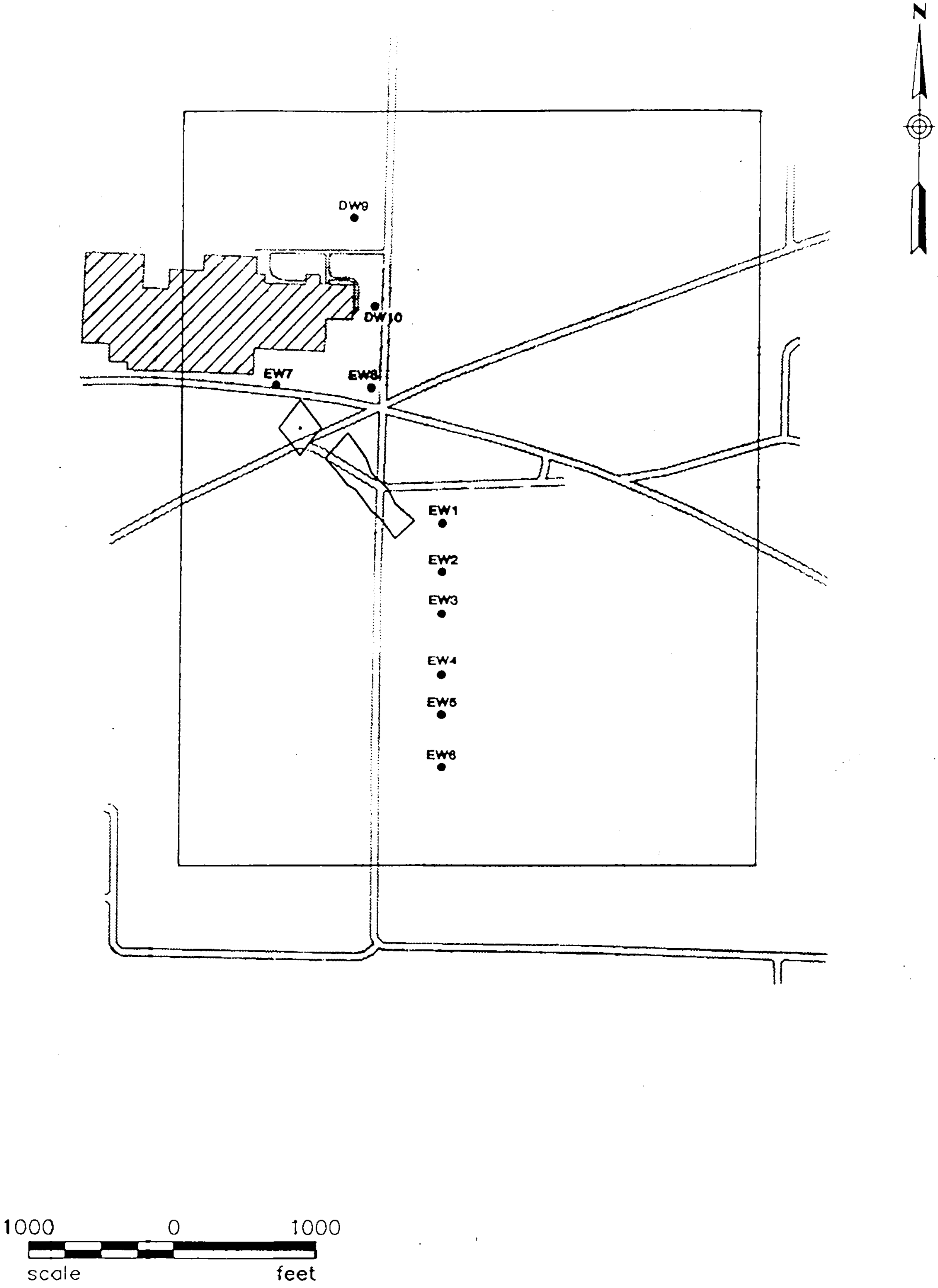
JOB No.: 913-6384	SCALE: AS SHOWN	**RUN B-16 SIMULATED POTENTIOMETRIC CONTOURS**	
DRAWN: LAS	DATE: 04/24/91		
CHECKED:	DWG. No.: NY01-228		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE **E5-28**



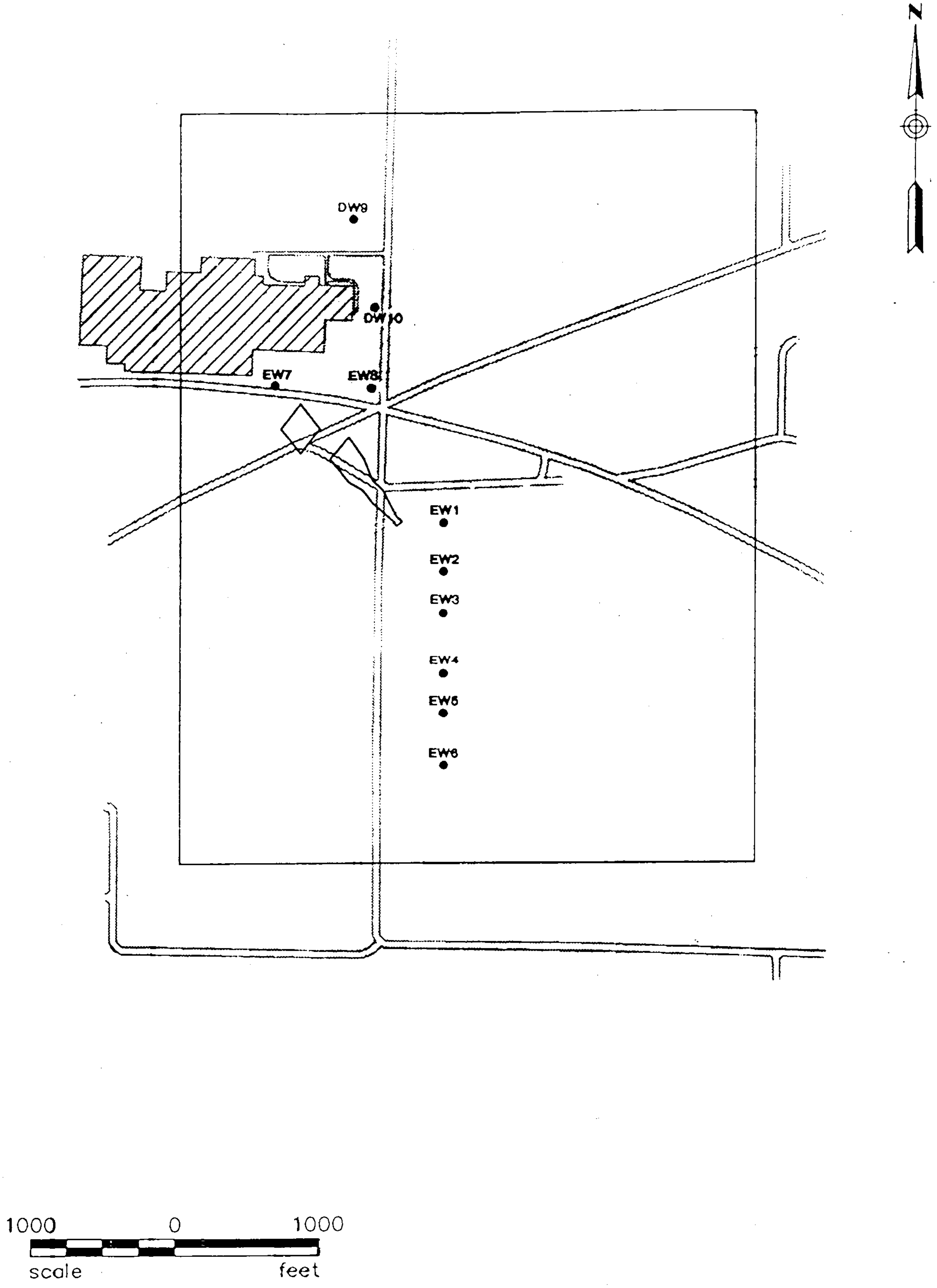
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-16 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 1 YEAR AFTER INITIATION OF PUMPING		
DRAWN: LAS	DATE: 04/24/91			
CHECKED:	DWG. No.: NY01-227			
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE E5-29	



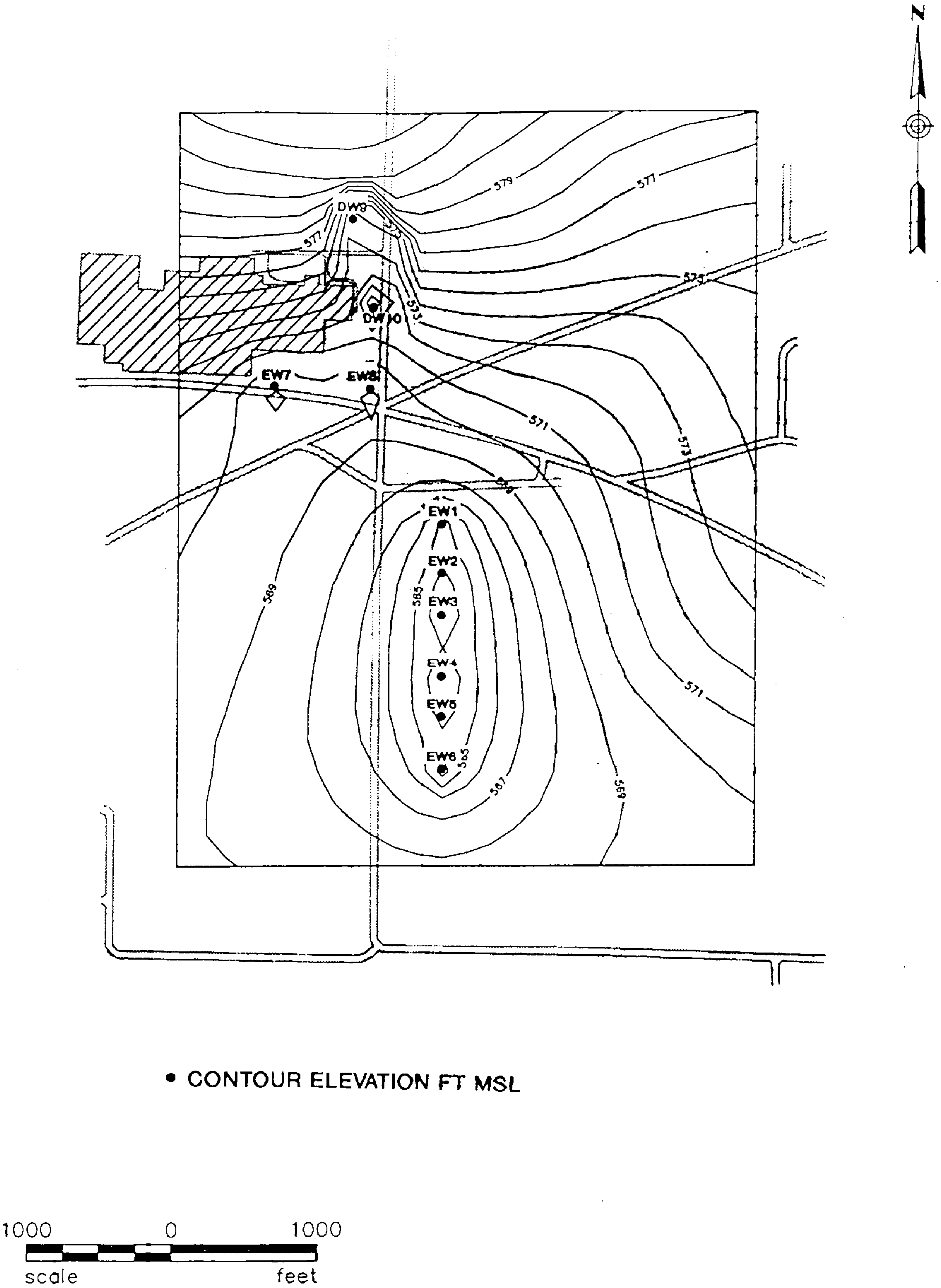
JOB No.:	913-6384	SCALE:	AS SHOWN	**RUN B-16 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 5 YEARS AFTER INITIATION OF PUMPING**
DRAWN:	LAS	DATE:	04/24/91	
CHECKED:	DRK	DWG. No.:	NY01-226	
Golder Associates				BELL AEROSPACE TEXTRON FIGURE **E5-30**



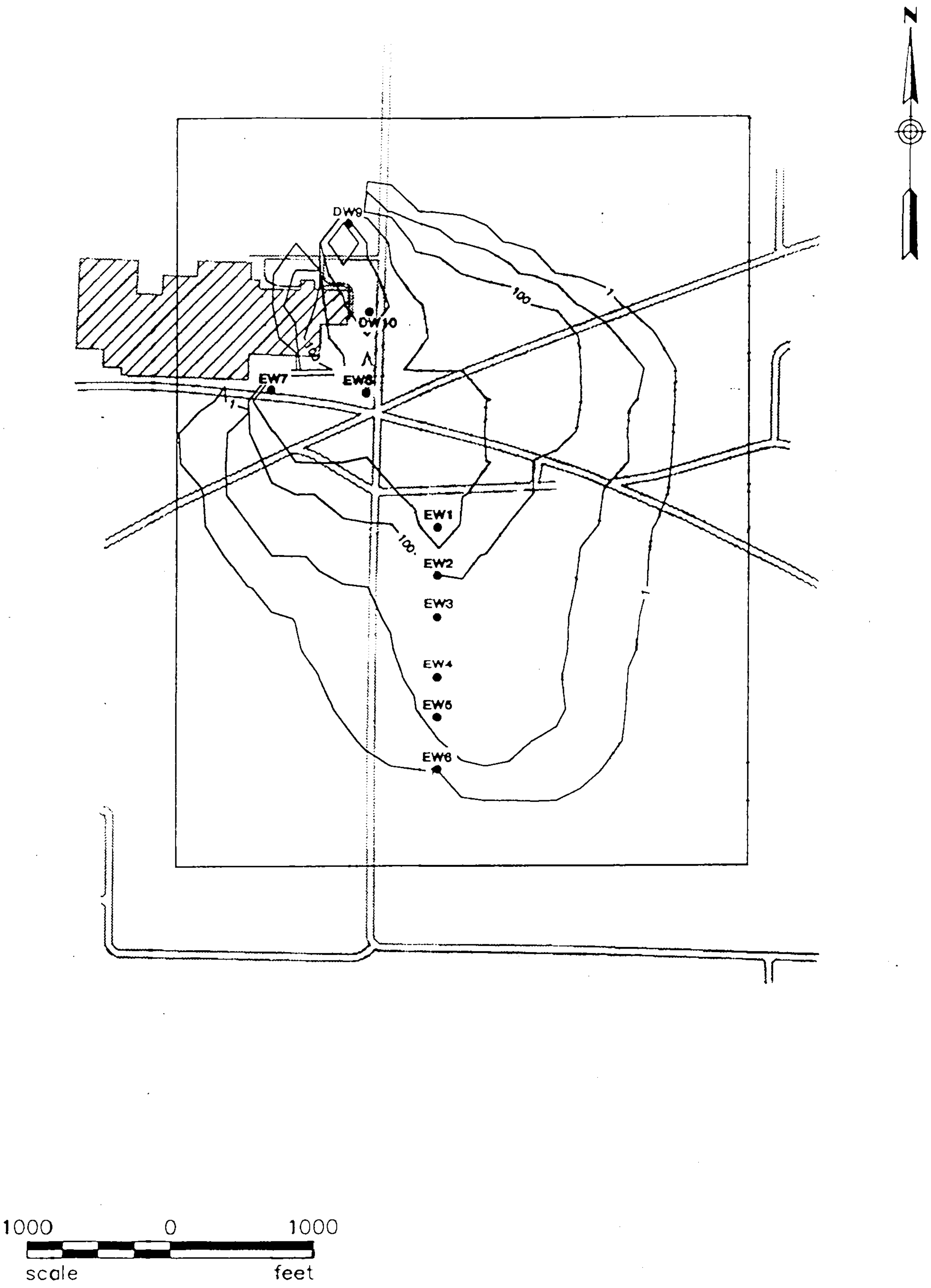
JOB No.:	913-6384	SCALE:	AS SHOWN	RUN B-16 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 10 YEARS AFTER INITIATION OF PUMPING
DRAWN:	LAS	DATE:	04/24/91	
CHECKED:		DWG. No.:	NY01-225	
Golder Associates				BELL AEROSPACE TEXTRON — FIGURE E5-31



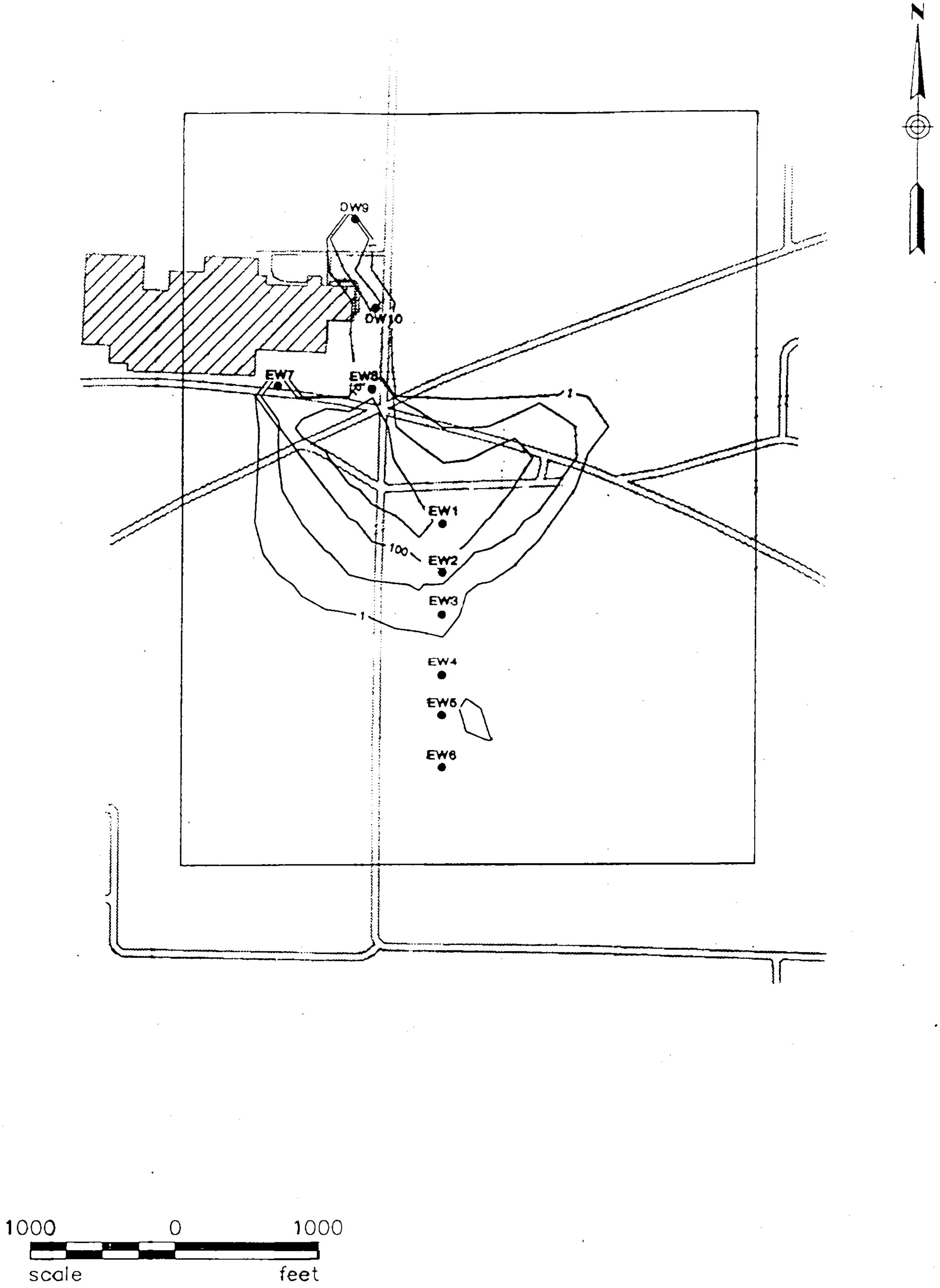
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-16 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 11 YEARS AFTER INITIATION OF PUMPING	
DRAWN: LAS	DATE: 04/24/91		
CHECKED:	DWG. No.: NY01-224		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE E5-32



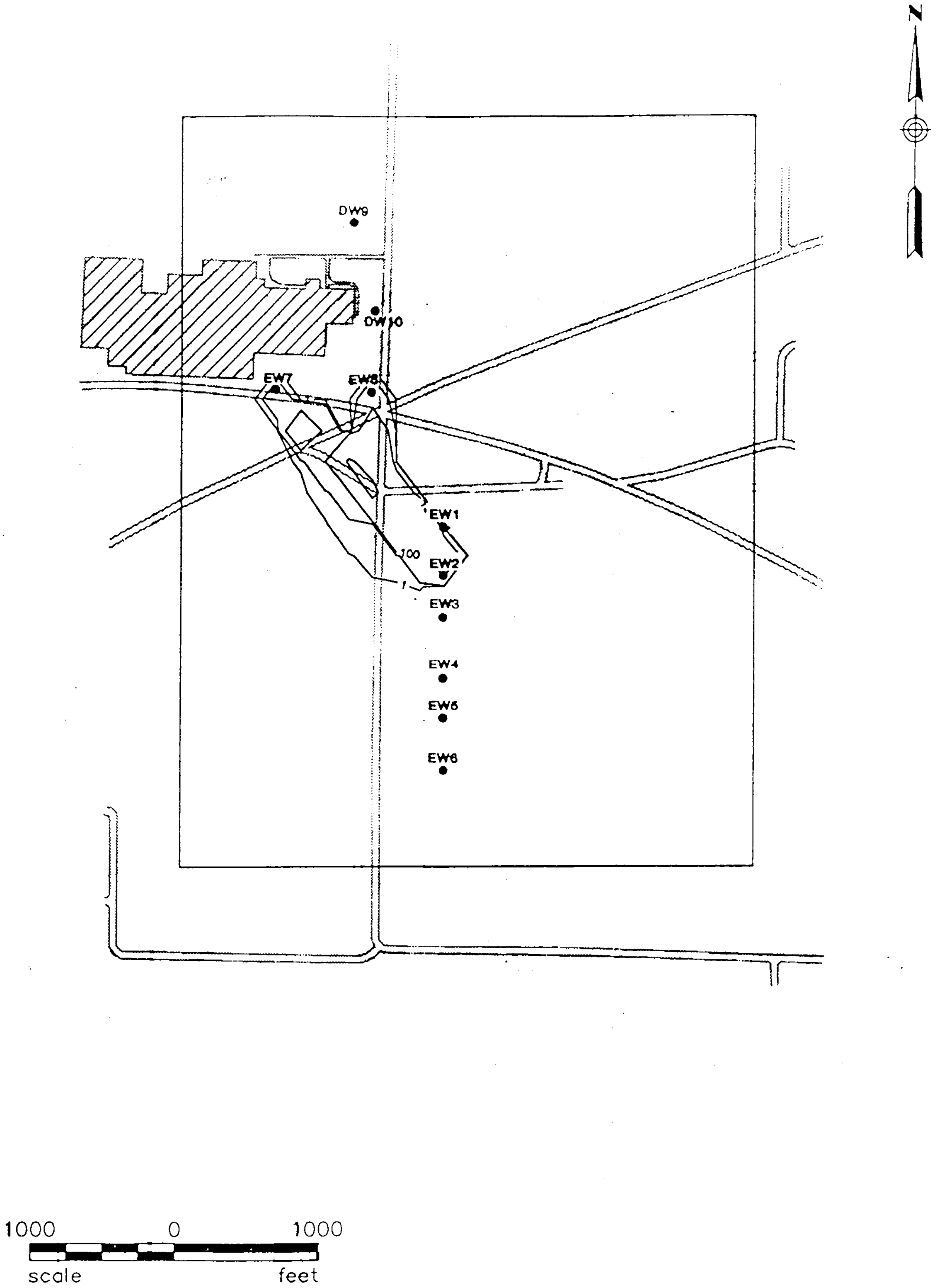
JOB No.: 913-6384	SCALE: AS SHOWN	**RUN B-26 SIMULATED POTENTIOMETRIC CONTOURS**	
DRAWN: LAS	DATE: 04/24/91		
CHECKED: RAK	DWG. No.: NY01-223		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE **E5-33**



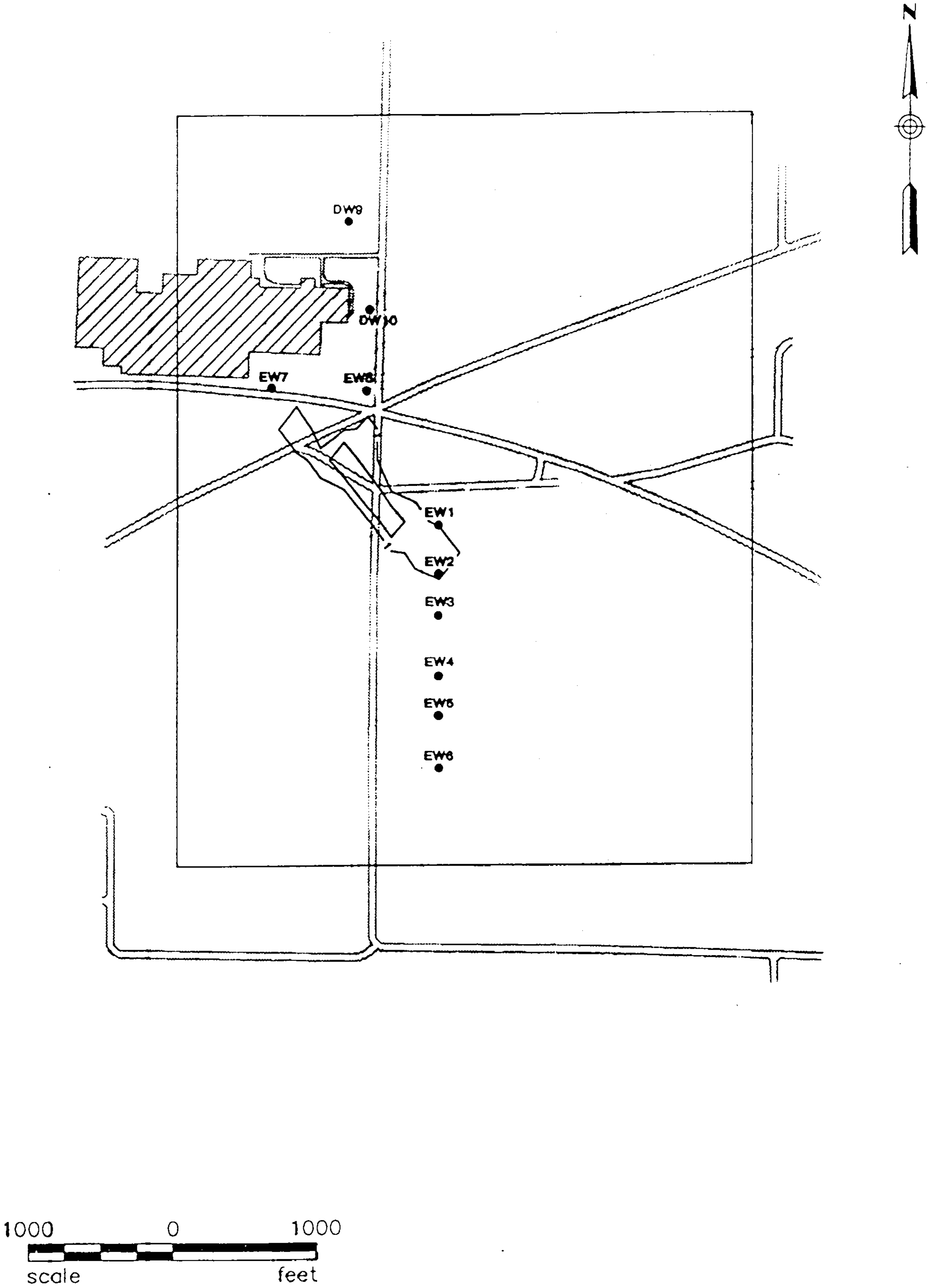
JOB No.:	913-6384	SCALE:	AS SHOWN	**RUN B-26 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 1 YEAR AFTER INITIATION OF PUMPING**
DRAWN:	LAS	DATE:	04/24/91	
CHECKED:		DWG. No.:	NY01-222	
Golder Associates				BELL AEROSPACE TEXTRON FIGURE **E5-34**



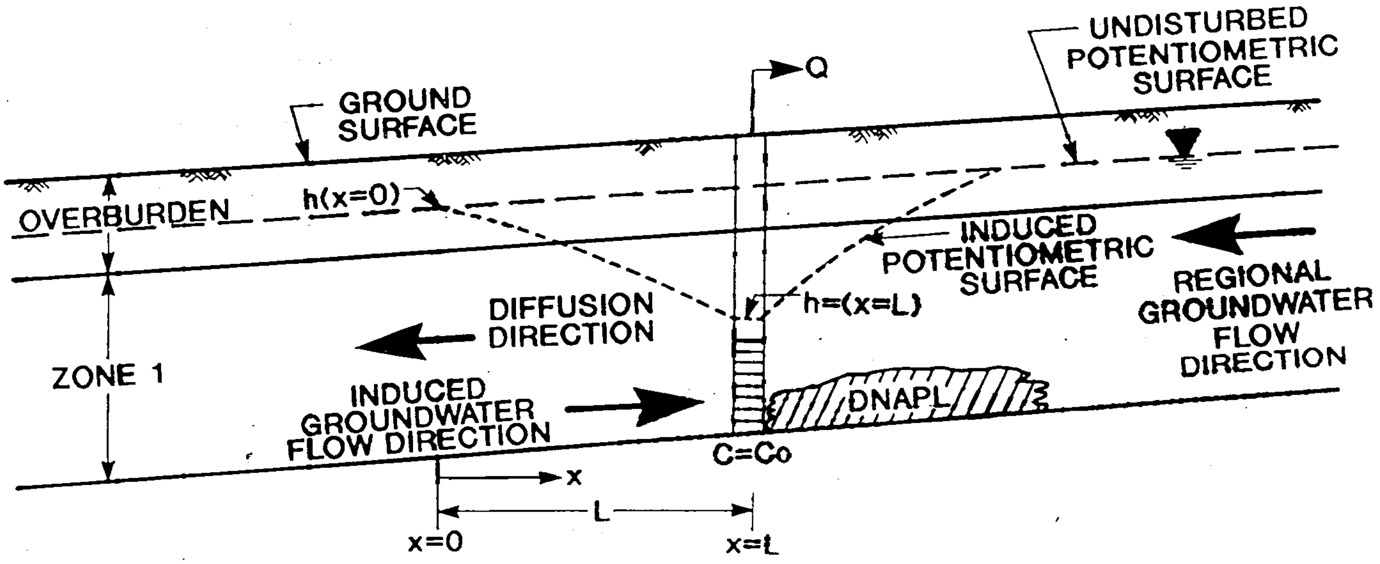
JOB No.: 913-6384	SCALE: AS SHOWN	RUN B-26 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 5 YEARS AFTER INITIATION OF PUMPING	
DRAWN: LAS	DATE: 04/24/91		
CHECKED:	DWG. No.: NY01-221		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE E5-35



JOB No.:	913-6384	SCALE:	AS SHOWN	RUN B-26 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 10YEARS AFTER INITIATION OF PUMPING
DRAWN:	LAS	DATE:	04/24/91	
CHECKED:		DWG. No.:	NY01-220	
Golder Associates				BELL AEROSPACE TEXTRON FIGURE E5-36



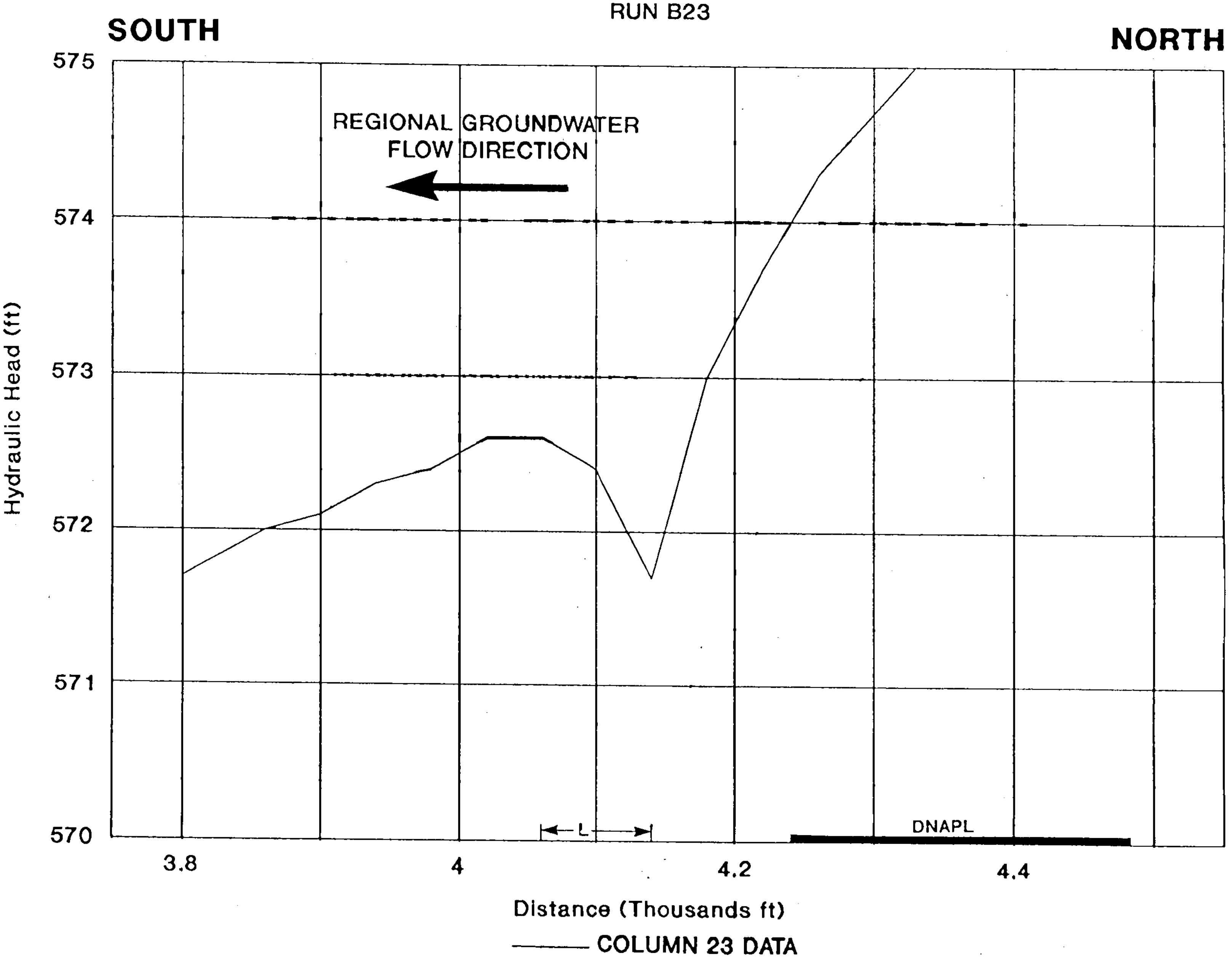
JOB No.:	913-6384	SCALE:	AS SHOWN	RUN B-26 SIMULATED CONCENTRATION CONTOURS (TOTAL VOLATILE ORGANICS, ppb) 20 YEARS AFTER INITIATION OF PUMPING
DRAWN:	LAS	DATE:	04/24/91	
CHECKED:		DWG. No.:	NY01-219	
Golder Associates				BELL AEROSPACE TEXTRON — FIGURE E5-37



JOB No.: 913-6384	SCALE: AS SHOWN	**SCHEMATIC REPRESENTATION OF THE DISSOLVED PHASE PLUME MIGRATION BY MOLECULAR DIFFUSION AGAINST FLOWING GROUNDWATER**
DRAWN: LAS	DATE: 04/24/91	
CHECKED:	DWG. No.: NY01-189	
Golder Associates		BELL AEROSPACE TEXTRON FIGURE **E6-1**

HYDRAULIC HEAD ALONG TRANSECT

RUN B23



JOB No.:	913-6384
DRAWN:	LAS
CHECKED:	
SCALE:	AS SHOWN
DATE:	04/24/91
DWG. No.:	NY01-190

Golder Associates

HYDRAULIC HEAD PROFILE GENERATED FROM THE NUMERICAL MODEL ALONG COLUMN 23

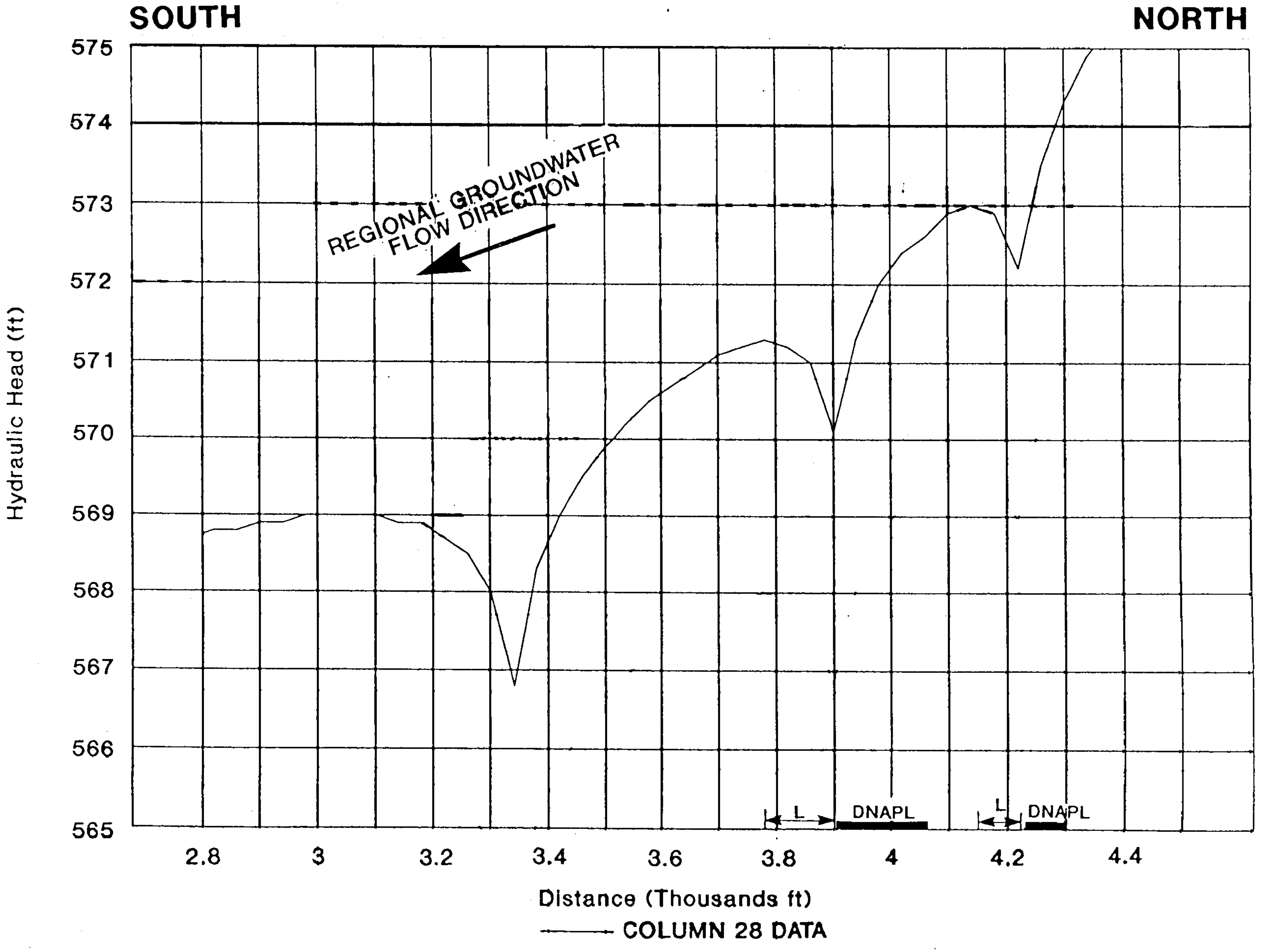
BELL AEROSPACE TEXTRON

FIGURE **E6-2**

158696

HYDRAULIC HEAD ALONG TRANSECT

RUN B23



Golder Associates

JOB No.: 913-6384
DRAWN: LAS
CHECKED:
SCALE: AS SHOWN
DATE: 04/24/91
DWG. No.: NY01-192

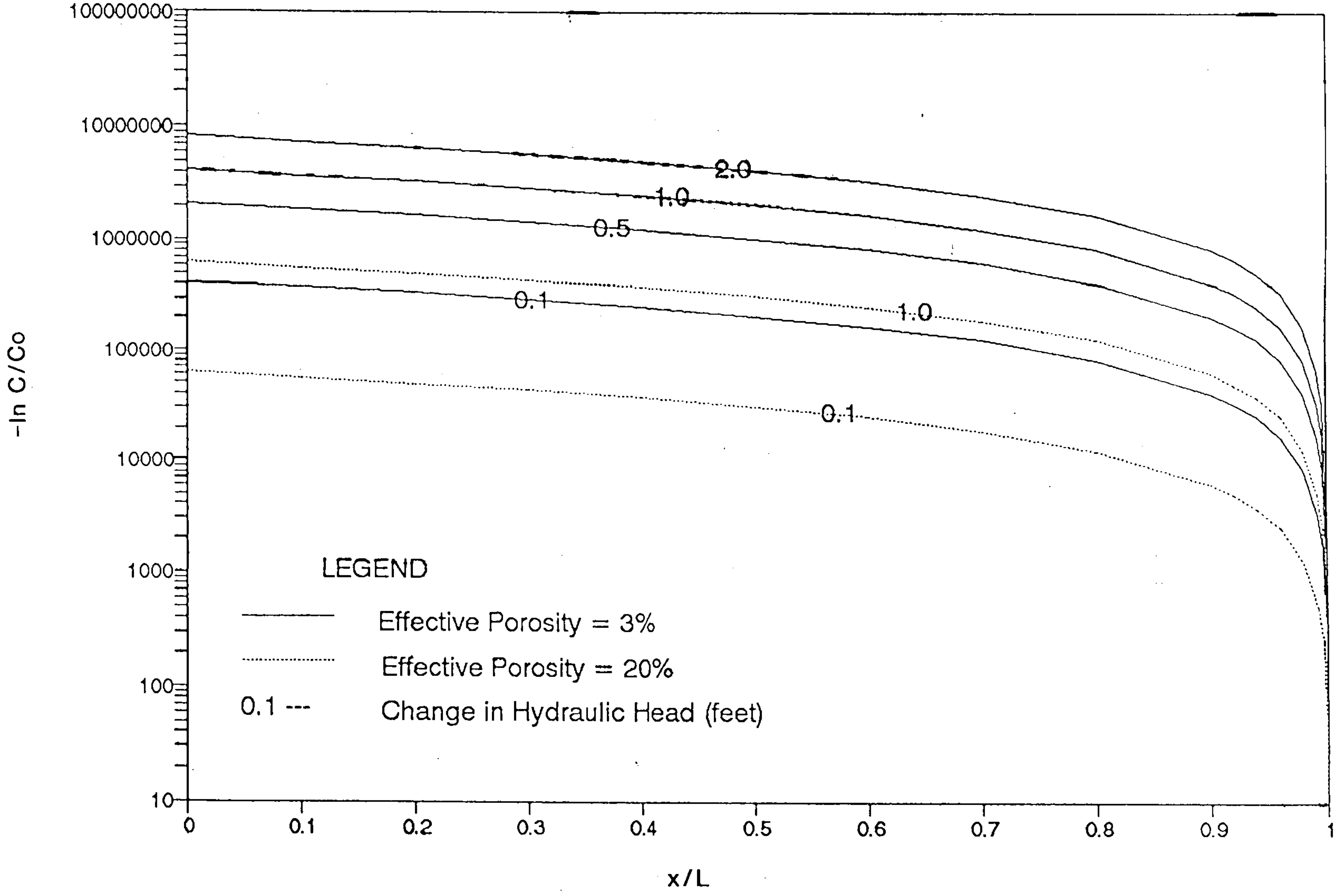
HYDRAULIC HEAD PROFILE GENERATED FROM THE NUMERICAL MODEL ALONG COLUMN 28

BELL AEROSPACE TEXTRON

FIGURE **E6-3**

x/L vs. –Log Normalized Concentration

Al-Niami and Rushton Model



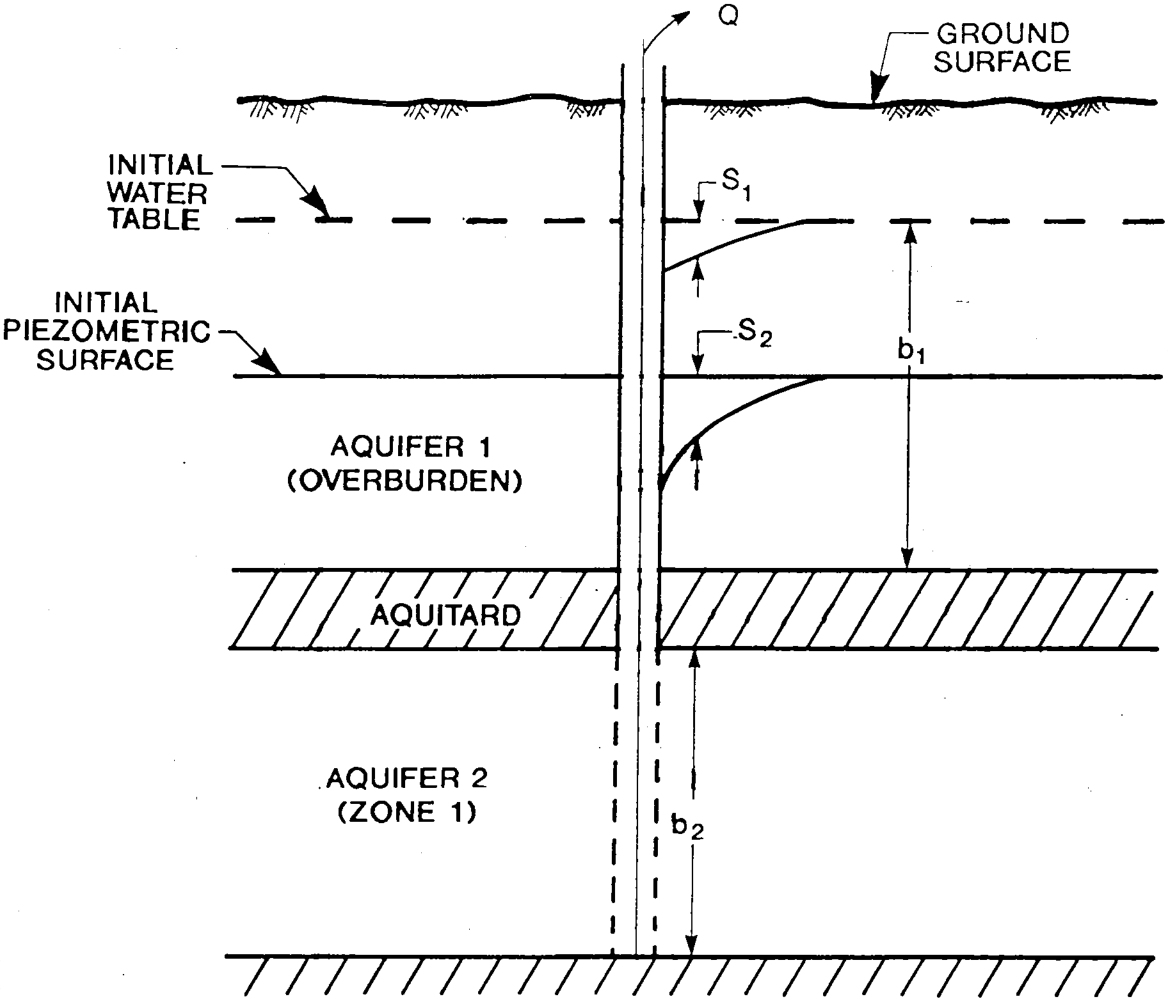
Golder Associates

JOB No.: 913-6384
DRAWN: LAS
CHECKED:
SCALE: AS SHOWN
DATE: 04/24/91
DWG. No.: NY01-264

LOGARITHMIC NORMALIZED CONCENTRATION (–ln C/Co) VERSUS DIMENSIONLESS DISTANCE (x/L)

BELL AEROSPACE TEXTRON

FIGURE **E6-4**



JOB No.:	913-6384	SCALE:	N.T.S.
DRAWN:	LAS	DATE:	04/23/91
CHECKED:	DEK	DWG. No.:	NY01-195

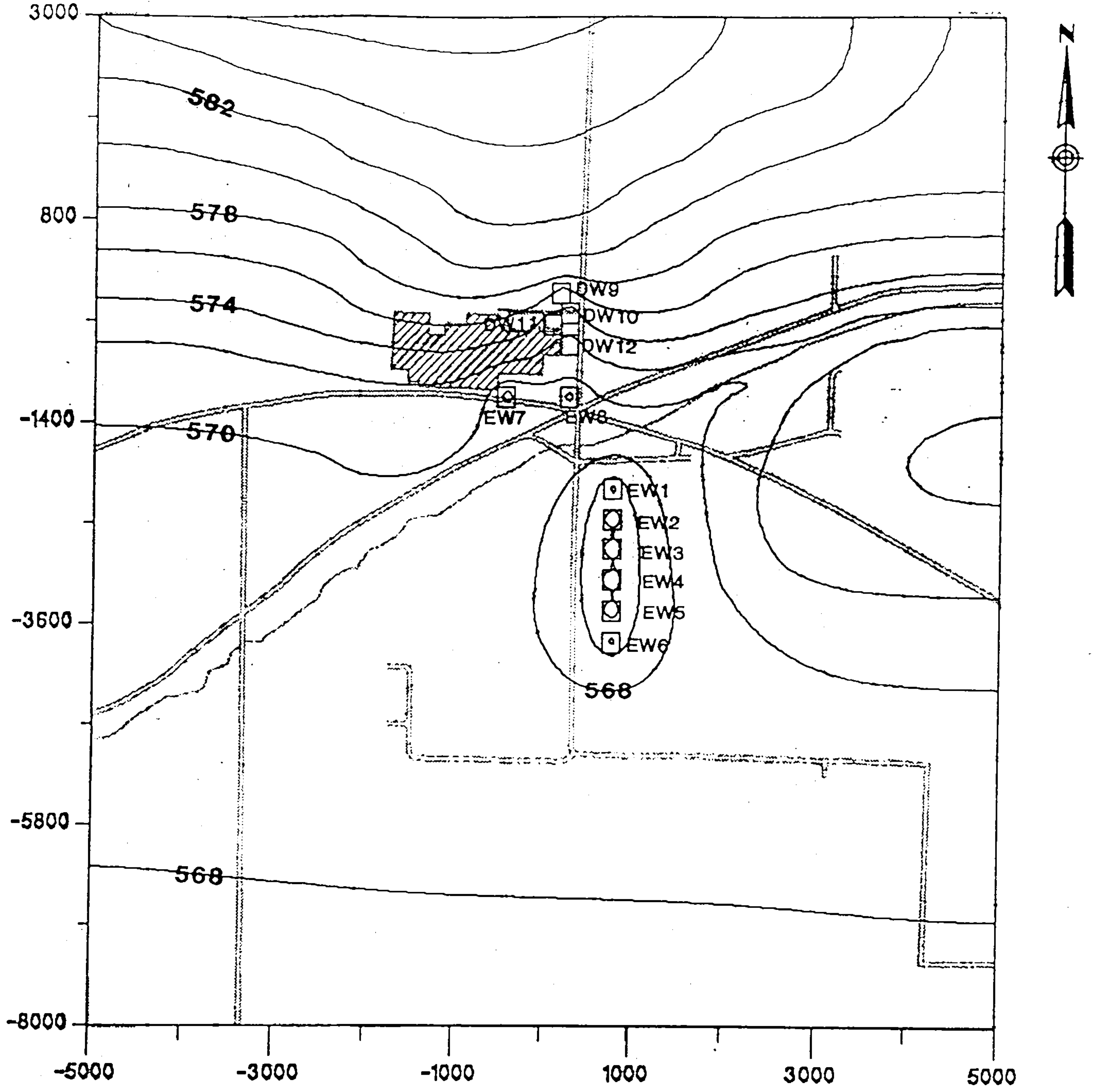
Golder Associates

SCHEMATIC REPRESENTATION OF THE AQUIFER SYSTEM

BELL AEROSPACE TEXTRON

FIGURE E7-1

158696



NOTES

PUMPING RATE FOR EW1 THROUGH EW7
7 gpm FOR EACH WELL.

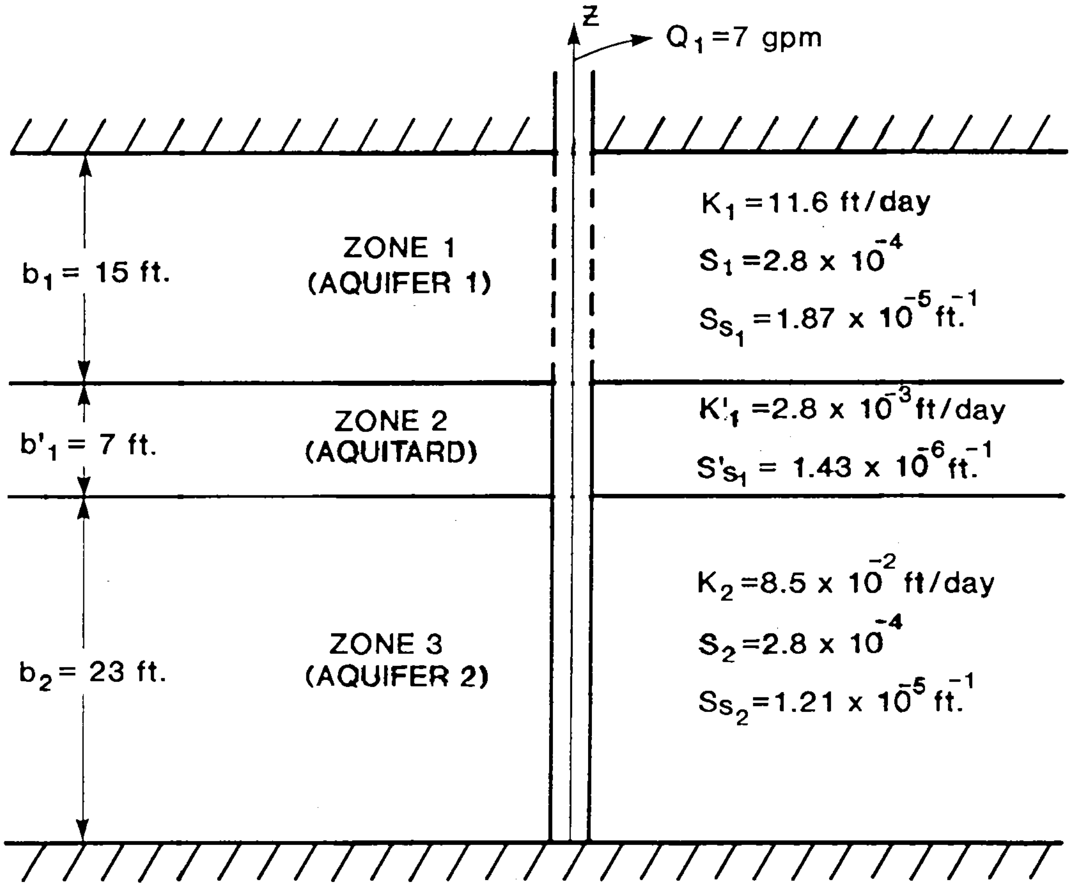
PUMPING RATE FOR EW8 5 gpm.

PUMPING RATE FOR DW9 THROUGH DW12
3 gpm FOR EACH WELL.

TOTAL PUMPING RATE 66 gpm.

CONTOUR ELEVATION FT MSL

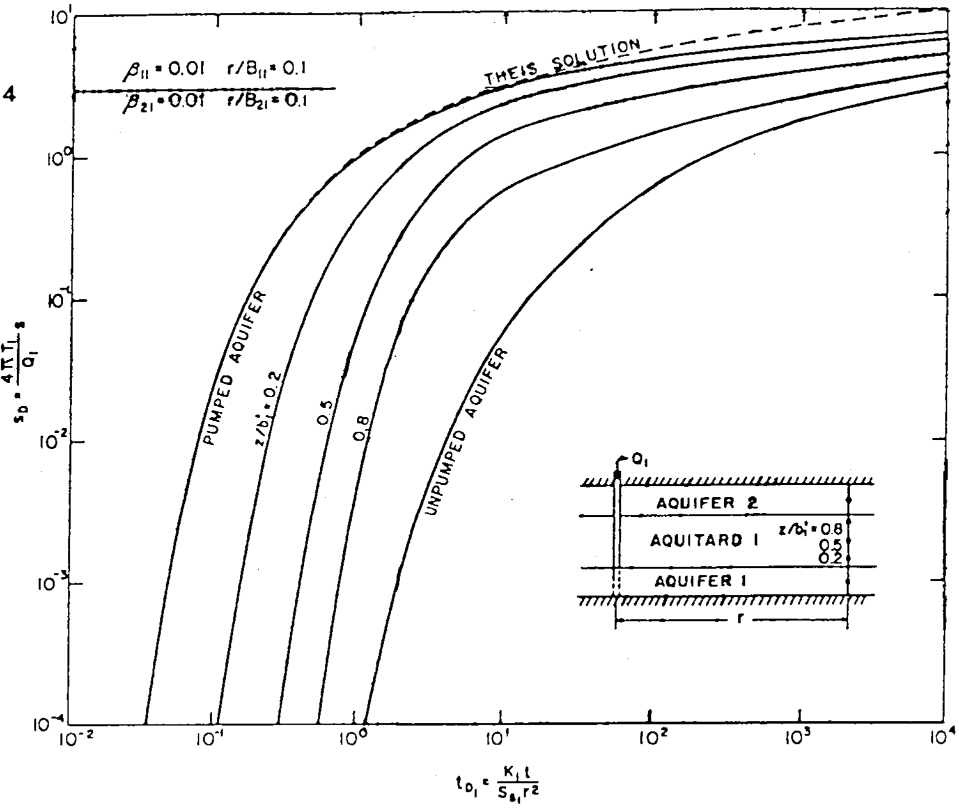
No.:	913-6384	SCALE:	AS SHOWN	**LOCATION OF PROPOSED EXTRACTION WELLS**
DRAWN:	FG	DATE:	03/20/91	
CHECKED:		DWG. No.:	NY01-199	
Golder Associates				**BELL AEROSPACE TEXTRON** FIGURE **E7-2**



JOB No.: 913-6384	SCALE: N.T.S.	**SCHEMATIC DIAGRAM OF TWO AQUIFER SYSTEM FOR NEUMAN-WITHERSPOON ANALYSIS**		
DRAWN: LAS	DATE: 04/23/91			
CHECKED:	DWG. No.: NY01-198			
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE **E8-1**	

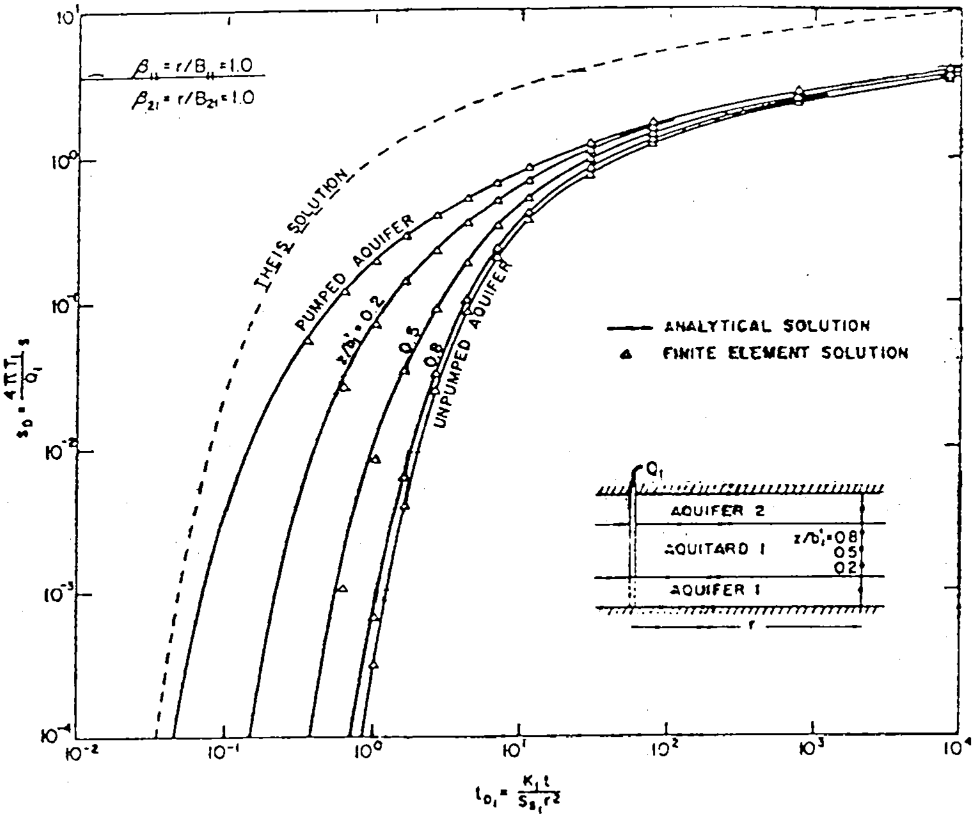
PUMPED AQUIFER 6.0

UNPUMPED AQUIFER 2.4



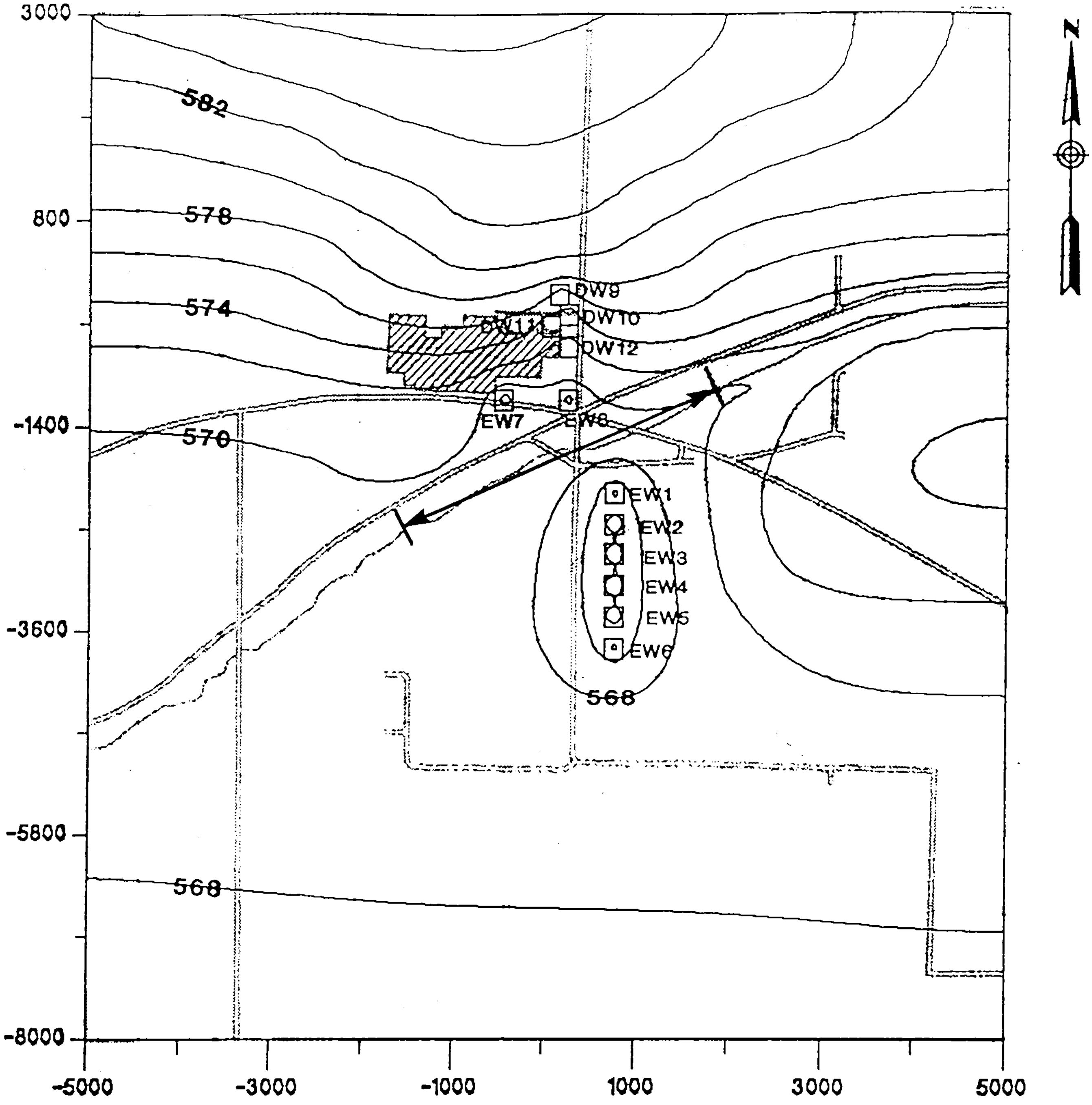
JOB No.: 913-6384	SCALE: AS SHOWN	**DIMENSIONLESS DRAWDOWN VERSUS DIMENSIONLESS TIME IN A TWO AQUIFER SYSTEM FOR $B_{11} = B_{21} = r/B_{11} = r/B_{21} = 0.1$ (NEUMAN AND WITHERSPOON, 1969b)**
DRAWN: LAS	DATE: 04/23/91	
CHECKED:	DWG. No.: NY01-194	
Golder Associates		BELL AEROSPACE TEXTRON
		FIGURE **E8-2**

158696



JOB No.: 913-6384	SCALE: AS SHOWN	**DIMENSIONLESS DRAWDOWN VERSUS DIMENSIONLESS TIME IN A TWO AQUIFER SYSTEM FOR $B_{11}= B_{21}= r/B_{11}= r/B_{21}= 1.0$ (NEUMAN AND WITHERSPOON, 1969b)**
DRAWN: LAS	DATE: 04/23/91	
CHECKED: RCFK	DWG. No.: NY01-193	
Golder Associates		BELL AEROSPACE TEXTRON — FIGURE: **E8-3**

158606



NOTES

PUMPING RATE FOR EW1 THROUGH EW7
7 gpm FOR EACH WELL.

PUMPING RATE FOR EW8 5 gpm.

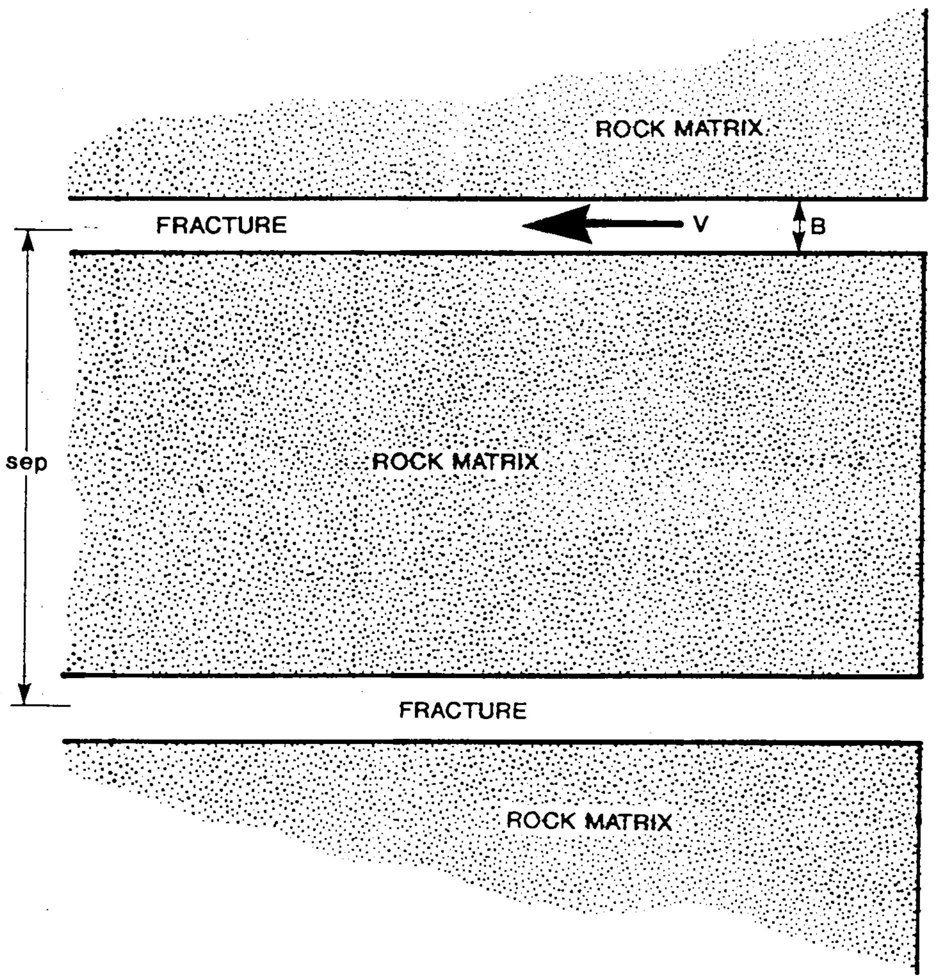
PUMPING RATE FOR DW9 THROUGH DW12
3 gpm FOR EACH WELL.

TOTAL PUMPING RATE 66 gpm.

CONTOUR ELEVATION FT MSL

⟷ STREAM LENGTH STUDIED

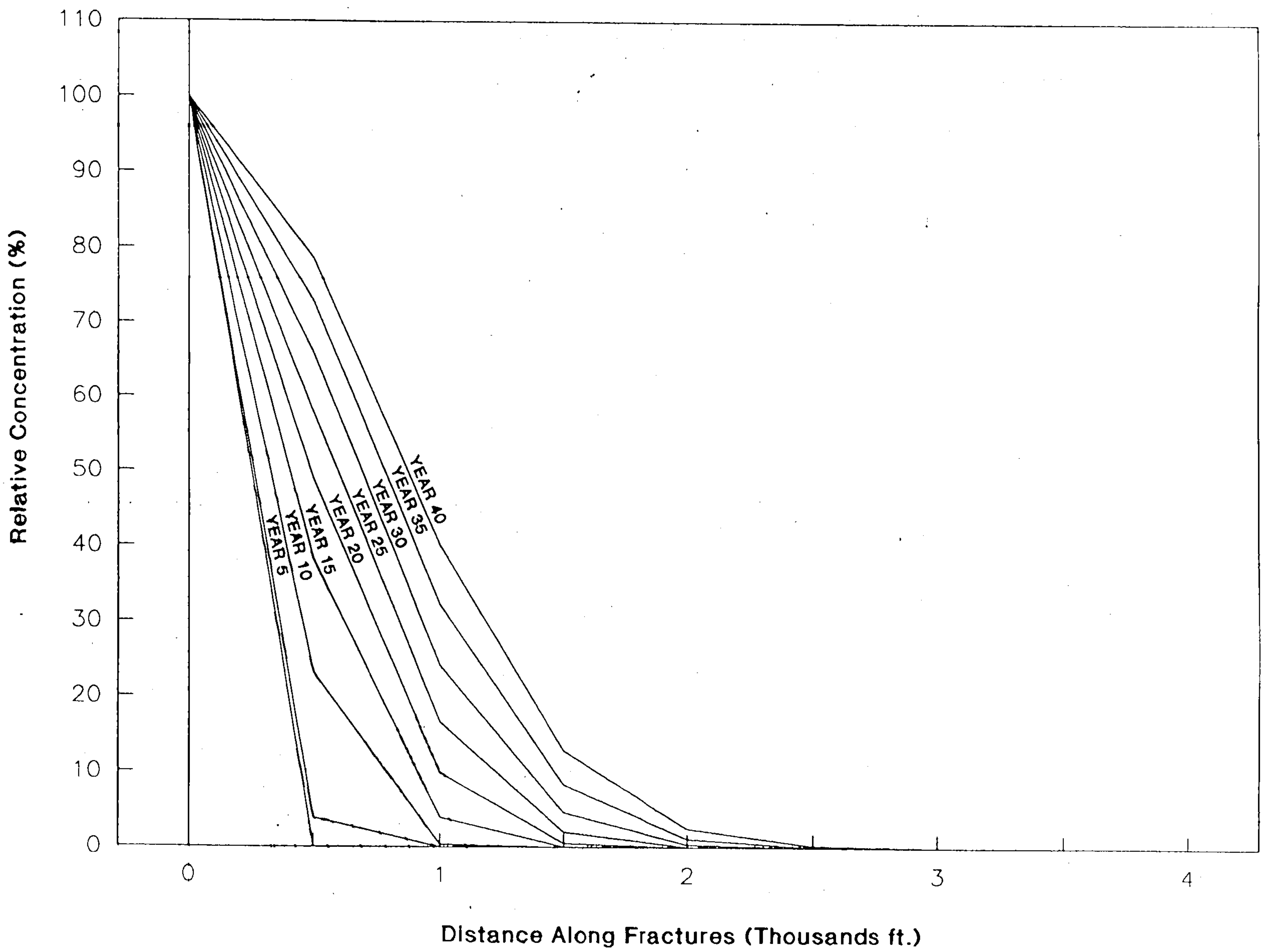
JOB No.:	913-6384	SCALE:	AS SHOWN	**MODELED HEAD DISTRIBUTION WITH STREAM LENGTH STUDIED**
DRAWN:	FG	DATE:	03/20/91	
CHECKED:	DuFK	DWG. No.:	NY01-200	
Golder Associates				BELL AEROSPACE TEXTRON — FIGURE **E9-1**



JOB No.: 913-6384	SCALE: N.T.S.	**FRACTURE–MATRIX SYSTEM MATRIX DIFFUSION MODEL**	
DRAWN: LAS	DATE: 04/29/91		
CHECKED:	DWG. No.: NY01-265		
Golder Associates		BELL AEROSPACE TEXTRON	FIGURE **E10-1**

158696

MATRIX DIFFUSION ANALYSIS



JOB No.: 913-6384
DRAWN: LAS
CHECKED:
SCALE: AS SHOWN
DATE: 04/29/91
DWG. No.: NY01-266

Golder Associates

PREDICTED CONCENTRATION PROFILES ALONG FRACTURE AT 5 YEAR TIME INTERVALS

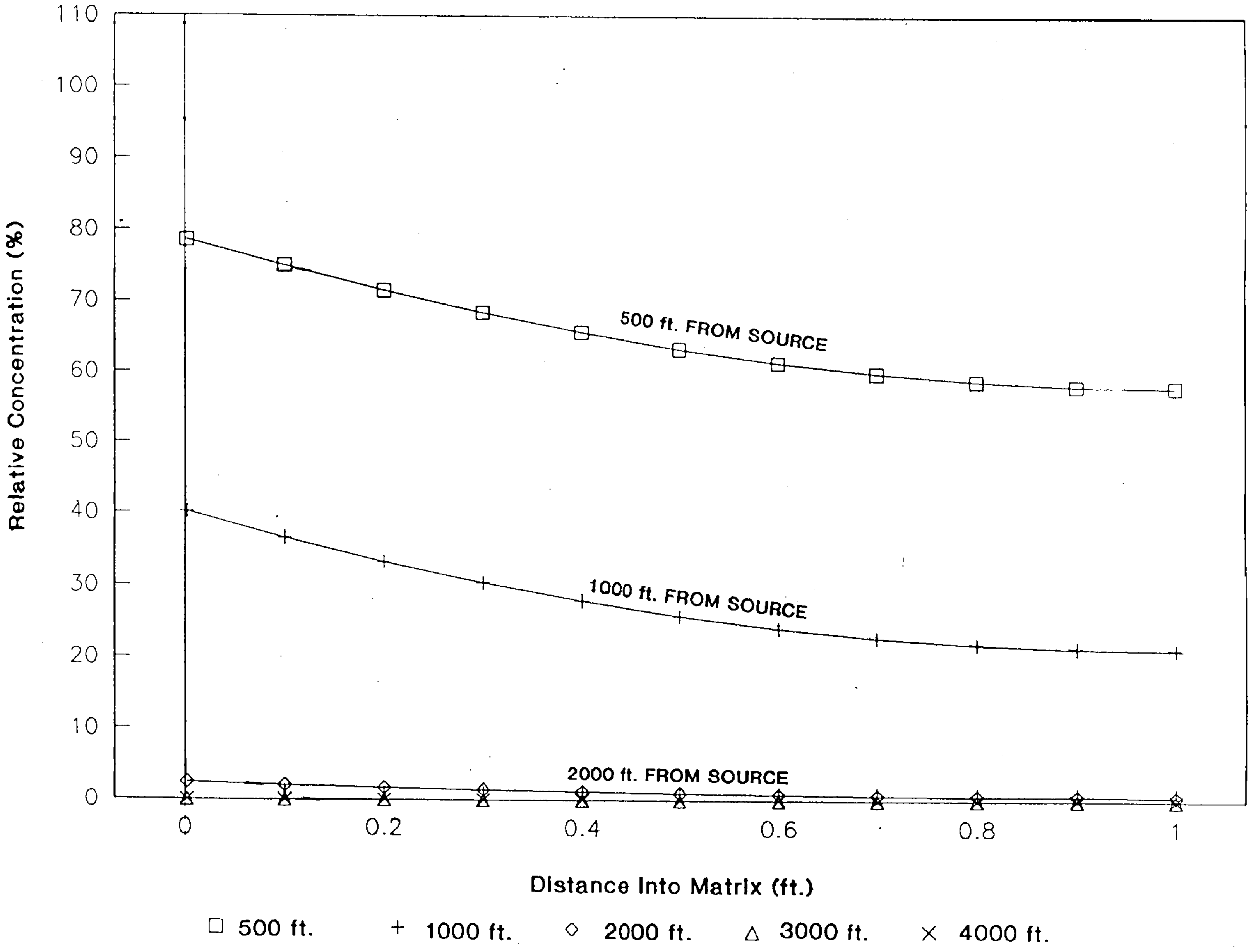
BELL AEROSPACE TEXTRON

FIGURE **E10-2**

158696

MATRIX DIFFUSION ANALYSIS

YEAR 40



JOB No.: 913-6384	SCALE: AS SHOWN
DRAWN: LAS	DATE: 04/29/91
CHECKED:	DWG. No.: NY01-267

Golder Associates

PREDICTED CONCENTRATION PROFILES INTO THE ROCK MATRIX AFTER 40 YEARS

BELL AEROSPACE TEXTRON

FIGURE **E10-3**

APPENDIX F

Off-Site Extraction System Design and Specifications

(Revision 7)

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4.0 INSTALLATION STANDARDS F-10

REFERENCES F-16

Drawing Package In Order Following Page F-16

1.0 GENERAL

These specifications and accompanying drawings are intended to cover the provisions of all labor, material and equipment necessary for construction of the Off-Site Ground Water Extraction System for Bell Aerospace Textron (Owner). Any reference to a specific manufacturer is to establish a standard of quality. Substitution of equipment of equal or better quality is acceptable, following Owner or Owner's representative approval. It becomes the Contractor's responsibility to coordinate, adjust, and install the new equipment in accordance with the manufactures recommendations and workman like practices which includes notification of and coordination with the other trades on the project.

It is the intent and purpose of these specifications and accompanying drawings to cover and include all materials, machinery, apparatus and labor necessary to properly install, equip, adjust and place into operation the respective portions of the installation and to so interconnect **the** various items or sections of the work as to form a complete and properly operating system. Any equipment, apparatus, machinery, material and small items not mentioned in detail, and labor not specifically mentioned, which may be found necessary to complete any portion of the installation in a substantial manner, and in compliance with these requirements, implied or intended in these specifications shall be the responsibility of the Contractor. This shall include all materials, devices or methods peculiar to the machinery, equipment, apparatus or systems furnished and installed by the selected Contractor(s).

The Contractor shall obtain all necessary permits or licenses, arrange for and perform all tests on any or all parts of his work, as may be required by State and/or local authorities. Each trade shall perform their work in strict compliance with applicable laws, regulations and codes, including those of the Federal, State or Municipal; National Fire Protection Agency; BOCA, Occupational Safety and Health Administration (OSHA), and any other authority having jurisdiction. Four copies of all certificates and permits shall be submitted to the Owner or Owner's Representative. All the associated fees for the above shall be paid by the Contractor and shall not be the responsibility of the Owner.

2.0 STANDARD CLAUSES

- All Contractors shall work in conjunction with each of the other trades to facilitate proper and intelligent execution of work and with minimum of interference. Each Contractor shall carefully examine all drawings and shall be responsible for the proper fitting of all material and equipment as planned and without interference with other piping or equipment. Proper judgment shall be exercised to secure reasonable space conditions throughout; to provide adequate arrangements for piping and conduit; and to overcome all local difficulties and interference to best advantage. Approval of any and all changes to plans and specifications shall be obtained from the Owner or Owner's Representative before proceeding. Each Contractor should carefully examine the specifications and drawings, visit the site and fully inform themselves as to all existing conditions and limitations to be met;

- Should any discrepancies occur between the existing conditions and the drawings and specifications, they shall be reported immediately to the Owner or Owner's Representative for clarification;

- Each Contractor shall be responsible for delivery of their equipment and shall unload and store same in a manner not to interfere with operations of other trades;

- All work shall be completed in an approved first class workmanlike manner and shall conform to the standard construction practices;

- Before ordering any material or doing any work each trade shall verify all measurements at the site, and shall be responsible for correctness of same. Any difference which may be found shall be submitted to Owner or Owner's Representative for consideration before proceeding any further with the work; and

- All trades shall layout work and establish heights and grades for all lines, and equipment in strict accordance with the intent expressed by the drawings, and all the physical conditions and shall be responsible for the accuracy of the same.

3.0 PRODUCT STANDARDS

3.1 Materials and Equipment

All materials and equipment installed by the employed trades shall be new and shall conform to the grade, quality and standards specified herein. All material and equipment offered under these specifications shall be limited to products regularly produced and recommended by the manufacturer for the service intended. This material and equipment shall have capacities and ratings sufficient to amply meet the requirements of the project. The capacities and ratings shall be in accordance with those published by the manufacturer and be in accordance with engineering data or other comprehensive literature made available to the public by the manufacturer and in effect at the time of ordering. Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. The effected trade shall obtain instructions from the manufacturer, and these instructions shall be considered part of these specifications. Outlined below are the primary items considered crucial to the construction of the system. Miscellaneous items not specifically specified shall be of a type suitable to operate satisfactorily for the purpose for which it is intended within the system. No experimental material or equipment shall be permitted.

3.2 Primary Components

- Containment Pipe

  All sizes 100-pound (lb) Class vinyl ester resin filament wound fiberglass pipe in accordance with ASTM D 2992-A and ASTM D 2996-71.

  Fittings

  Compression molded vinyl ester resin base with minimum 39-percent chopped glass fiber reinforcement.

NOTE: *Before commencing work check invert elevations required for proper connection and to insure proper slope for piping installation.*

- Carrier Pipe

  Carrier pipe and fittings shall meet the requirements for a type-II copolymer polypropylene material according to ASTM D 4101-86. Carrier guides shall be as per manufacturers recommendation.

  Fittings

  Polypropylene thermal weld type.

- Butterfly Valves

  Wafer style ANSI full face flat flanges, body - PVDF, disc - PVDF, seats and seals- viton, gear operated.

- Flow Sensor

  PVDF body with six blade impeller square wave signal generator transmitted via Beldon type 9320 two conductor shielded cable . Flow range - one to 30 feet per second (ft/sec), accuracy - ±1%. Housing, impeller and bearing - PVDF, impeller shaft - ceramic, O-rings - Viton, Transmitter - Inputs - 120vac and 8vdc square wave signal, output - 4-20ma, 24vdc. Each flow sensor shall be calibrated and checked for accuracy prior to installation.

- Flow Limiting Valve

  Threaded nipple type, Grade 316 Stainless Steel Nipple, 300 series Stainless Steel cartridge as manufactured by Griswold or equal, rated at 14 gpm.

- Y-Check Valve

  Body - PVDF, stem - PVDF, seats - Teflon

- Flexible Pump Connector

  Flanges - stainless steel plate ANSI 150, bellows - spherical Viton, Movement - 7/8"+, 1/2" lateral, 15 deg. As manufactured by MetraFlex.

- Hinged Expansion Joints

  Adsco corruflex packless expansion joints hinged, Grade 316 stainless steel flanged, 316 stainless steel bellows or equal. Installed to rotate in the horizontal plane.

- Pipe Insulation

  Insulate all exposed piping in vaults or access areas with Cellular Glass Thermal Insulation, ASTM C 552. Seal joints with silicon sealer. For direct bury piping requiring insulation, apply pit-coat to exterior of insulation.

- Heat Trace Tape

  Install heat trace cable to all carrier piping within the vaults and to piping sections as indicated. Raychem XL-Trace, 5W/FT, 208V with AMC-1B sensor.

- Leak Detection

  Install leak detection to bottom of exposed carrier pipe within the vaults, and along the bottom of all containment piping. Cable to be Raychem type TT3000 or approved equal. Logic panel to be Raychem Type TTB Alarm and locator module.

- Data Acquisition System

  Omega OM-270-T32 series, 32 Channel. Provide an auxiliary modem.

- On-Site Computer Control

  IBM compatible 386 or better, VGA graphics, color screen, two disk drives, two RS232 serial ports, 4 Meg RAM minimum, 120 Meg Hard Drive, 9600 BAUD Modem.

- On-Site Alarm Panels

  Supply as configured, one for guard shack.

- Polymerized Concrete Vaults

  Underground enclosure shall be Composolite as manufactured by Quartite Corp. or equal. Enclosures and covers shall be gray color and rated for no less than 5,000 lbs. over a space 10-inch x 10-inch area and be designed and tested to temperatures of -50 deg F. Material compressive strength shall be no less than 9,000 psi. Provide locking cover and neoprene gasketing for watertight service. Provide a breather anti-flood valve mounted in one cover section for each vault, as detailed on drawing A-3.

- <u>Breather Valve</u>

  Shall be an inverted foot valve with the screen on the opposite end. Material shall be PVC, Schedule 80 as manufactured by Hayward True Check type or approved equal.

- <u>Control Panel Housing</u>

  Electromate E-30H240SS Nema 4X or equal.

- <u>Vault Heater</u>

  Chromolox, Type H, Model #H-1801, 208V, single phase, or equal.

- <u>Heater Thermostat</u>

  Match to selected heater type.

- <u>Overburden Casing</u>

  Ten inch diameter, Polypropylene Schedule 40, flush threaded.

- <u>Cement/Bentonite Grout</u>

  One 94-lb bag Type I Portland Cement, mixed with 4- to 6-percent powdered bentonite, hydrated with five gallons of potable water.

- <u>Submersible Pump</u>

  Pump shall be Grundfos, Redi-Flow, Environmental Submersible Pump, Model Number 10E5, powered by 1/3 horsepower (hp), 208V, single phase Grundfos Environmental Submersible Motor. Pumps shall be of stainless steel and Teflon construction.

- Pump Riser

1¼-inch diameter Grade 316 stainless steel, Schedule 10, flush threaded NPT, 5-foot maximum lengths.

- Level Control Switches

Conductance actuated type, constructed of stainless steel and Teflon.

- Stilling Well

2-inch diameter, Schedule 10, flush threaded NPT, 5-foot maximum lengths.

- Electrical Wiring

All wiring installed shall be type THWN or RHWN. All wiring for branch circuits for lighting or receptacles shall be type THWN. All wiring shall be copper, aluminum wire will not be allowed, and have 600 volt insulation. Identify all main feeder and branch circuits by color coded wire as required by code. Wire from Phelps-Dodge, General Cable or approved equal.

- Terminal Connections

All terminal connection of feeder and branch circuits shall be of an approved solderless, high pressure clamping type equal to "Lock-Tite" by Thomas and Betts, Co.

- Connection and Splices

Make all splices, etc. using only 3M Scotchlok electrical spring connectors and insulate with approved plastic electrical tape. Wire nuts or porcelain connectors are not acceptable.

- Uninsulated Conductors

Shall be bare type ACSR.

- Raceways

All conduit shall be non-metallic and Class 1, Schedule 40 Vinyl ester resin fiberglass.

- Conduit Fittings

All fittings shall be copper-free die cast aluminum and be water proof NEMA 4 type. All fittings and conduits are to be watertight. All insulated bushings shall be plastic or bakelight insulating rings molded into hot dip galvanized malleable iron threaded bushings.

- Junction and Pull Boxes

Minimum of #12 gauge, NEMA 4 enclosure of type and style suitable for number of cables or wire present, located as required and for convenience, in compliance with applicable codes. Manufactured of copper-free die cast aluminum.

- Motor Controllers and Starters

Controllers shall be full voltage magnetic having thermal overload protection and neon pilot lights. Equip all starters with at least two auxiliary contacts (one normally open, one normally closed) in addition to holding circuit contacted. Coil shall be 120 volts with overload contact side of control transformer, grounded in compliance with paragraph 430-73 of NEC. Acceptable manufacturers are Square D Company, Westinghouse and General Electric.

- Piping Support

All supports and rollers shall be Teflon coated, minimum 5 mil. The use of pipe hooks, chains or perforated metal straps for pipe support will not be permitted.

- Cast in Place Concrete

Materials and work shall conform to the American Concrete Institute. Cement to be Portland Cement, type I, conforming to ASTM C150. Aggregates shall conform to ASTM C-33 and be suitable for 3,000-pound test concrete. Concrete reinforcement shall be deformed bars in accordance with ASTM A615 and tied with 16 gauge black annealed wire. Space #5 bars 3-inches from the edges with 12-inch spacing throughout.

- Butt and Wrap Joint

Wrap with saturated glass mat, wrapped circumventally around butted area and let cure. Wrap should be wound at 35¼-degree helix angle.

4.0 INSTALLATION STANDARDS

All products and materials shall be installed by the employed trades in strict accordance with the originating manufacturer's installation manual, in accordance with these specifications. Installation guidelines shall be submitted, along with product approval sheets, prior to ordering and installation for the owner's approval and the supplied guidelines are considered to be a part of these specifications. All installation activities shall be performed in accordance with a written and approved Contractor specific Health and Safety Plan. Each Contractor shall be responsible for the development, implementation of and adherence to their Health and Safety Plan. Refer to the attached Health and Safety Plan for site specific information.

- All materials and equipment installed by each trade shall be new and shall conform to the grade, quality and standards specified herein;
- Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. Each trade shall obtain these instructions from the manufacturer, and these instructions shall be considered part of these specifications. Type suitable to operate satisfactorily for the purpose for which intended in the systems. No experimental material or equipment shall be permitted;
- All work, equipment and materials shall be protected at all times;
- Contractors of the various trades shall coordinate the installation of materials and equipment to assure a smooth and uninterrupted flow of the project;
- Each Contractor shall carefully examine all mechanical drawings and shall be responsible for the proper fitting of all material and equipment as planned and without interference with other piping or equipment. Proper judgment shall be exercised to secure reasonable space conditions throughout; to secure neat arrangements for piping, and conduit; and to overcome all local difficulties and interference to best advantage;
- Each Contractor shall work in conjunction with each of the other trades to facilitate proper and intelligent execution of work and with minimum of interference;

- Check drawings of the various mechanical and electrical trades so that piping will not interfere with equipment installation or other piping systems so that equipment can be serviced or replaced without excessive pipe removal;

- Approval of any and all changes to plans and specifications shall be obtained from the Owner or Owner's Representative, in writing, before proceeding;

- All work and methods of executing same under these specifications shall be completed in an approved first class workmanlike manner and shall conform to the best mechanical practice;

- All rotary boring equipment and accessories shall be decontaminated, using steam and non-phosphate detergents, prior to drilling of each extraction well. All waste and rinse water shall be collected for proper disposal by BAT, if deemed contaminated;

- Overburden drilling shall be performed using flight auger drilling techniques, and then completed one foot into bedrock, using appropriate rotary methods;

- Overburden casing shall be cemented and grouted in-place prior to core drilling. Cement grout shall be allowed to cure for a minimum of 24 hours or until the grout has set which ever is the greater;

- Bedrock drilling shall be a combination of N-sized rock coring, followed by wash rotary reaming with an 8-inch roller cone bit;

- Following reaming the boring shall be flushed with potable water until clear of cuttings and debris;

- All drill cuttings and circulated fluids shall be contained and collected into 55-gallon drums for appropriate disposal by BAT, if deemed contaminated;

- Each monitoring well shall be constructed in strict accordance with approved protocols, see attached Golder Associates Inc. (Golder Associates), "Phase V Investigation, Monitoring Well Installation Specification" (September 1989);

- Installation of flush threaded stainless steel risers and stilling wells shall be performed without the use of any petroleum based lubricants;

- No adhesives of any type shall be used in extraction well construction;

- The pump sleeve shall be constructed of grade 316 stainless steel, Schedule 10, and be five inches in diameter by 30 inches long, and threaded or welded onto the first riser pipe;

- All piping shall be installed in a workmanlike manner and in accordance with standard practices of the trade as shown on the drawings and required for the complete installation of the systems;

- Piping shown on drawings show the general run and connections. The Contractor shall be responsible for erecting the piping suitable in every respect for the work. Piping shall be installed so that access, clearance, headroom, and pitch are maintained;

- After piping is installed between vaults, let the ground temperature at the piping stabilize to surrounding earth temperature at the same depth before cutting and connecting piping to vault piping. The null pipe/ground temperature is 63.5-degrees Fahrenheit. Any variation from the null temperature requires flexing the expansion joints to accommodate 0.15-inches per degree for expansion and contraction.

- The piping Contractor shall furnish and install all supports, including angles, channels and beams for the support of all equipment and piping installed under this contract. All piping shall be arranged to maintain the required pitch and provide for proper expansion and contraction;

- All lines shall be rigidly and firmly installed to prevent swaying, vibrating and sagging. For piping running near floor, use brackets or pedestals. Provide additional supports for heavy valves and specialties;

- Piping shall be properly supported and provisions shall be made for expansion, contraction, guiding, anchoring;

- All supports and rollers shall be Teflon coated, minimum 5 mil;

- All supports and rollers shall have a five to one safety factor and to be as manufactured by Grinnell Company, Fee and Mason, or approved equal;

- All connections to equipment on piping two inches and larger shall be flanged, standard weight pattern, with face and gasket to match the equipment flange;

- All piping connecting to pumps and all other equipment shall be installed without strain at the connection to this equipment. All piping shall be clean before connecting to pump and equipment;

- All piping openings shall be closed, with caps or plugs during installation. All equipment shall be tightly covered and protected against dirt, water, chemicals or mechanical injury during entire progress of installation. The Contractor shall make good all damage caused either directly or indirectly by his workmen;

- Keep all openings in pipes or fittings plugged or capped during installation;

- All valves shall be selected for not less than 150 psi or 150-percent of normal working pressure, whichever is greater;

- All valves for this project shall be the product of one manufacturer when possible;

- Install all valves shown on the diagrams and specified herein without strain on the piping system;

- Valves and specialties shall be so placed to permit easy operation and access. All valves shall be regulated, packed and adjusted before acceptance;

- Anchors shall be situated midway between vaults and constructed as shown on drawings;

- All pipe connections shall be made so as to allow for perfect freedom of movement for piping during expansion and contraction, without springing or creating air pockets;

- Carrier piping shall be rigidly fixed to the containment pipe at the midpoint of each run in accordance with the manufacturers specifications. Provision shall be made for bypass and inspection of the leak detection cable;

- Maintenance Ports shall be spaced at intervals along the pipeline not to exceed 100-foot intervals;

- Piping shall be spaced so that it will be possible to install insulation around pipes and fittings without cutting part of the insulation;

- All piping installed underground (direct bury) shall be installed without insulation except as otherwise noted;

- Cut and taper piping to be joined to vaults. Pipe and vaults shall be joined with vinyl ester adhesive using matching tapered cuts in accordance with ASTM D 2310-71 and D 2517-73;

- Polypropylene pipe fittings, valves etc. shall be prepared using butt-fusion techniques as outlined in ASTM D 2657, Section 9;

- All fittings used on the piping system shall be of an approved manufactured type, and tees and elbows shall be with wall thickness not less than the pipe;

- Should leaks develop in the various systems after they have been placed in operation for a period of one year, it shall be the responsibility of the Contractor to repair them;

- All joints of the assembled vaults shall be joined with vinyl ester epoxy resin adhesive. Vaults shall be made water tight.

- The Contractor will excavate the trench in accordance with the dimensions shown in the design drawings. At certain locations, the trench excavation may need to be modified to facilitate installation. At all times, the Contractor will provide a safe working area;

- The final bedding of the trench must be uniform and continuous. Remove all sharp rocks and other abrasive material from the trench bottom. If the trench is excavated through rock or shale ledges, the trench must be slightly deeper and a layer of AASATO #57 stone (see detail A-4) used in the bottom of the trench and over the pipe to assure protection of the pipe from the rocks;

- The installation shall be backfilled with sufficient fill to hold it in place with all of the fittings and joints left open for inspection during the testing period. Once the testing period is complete, then the backfilling may be finished. Only clean backfill will be approved for use;

- The Contractor shall adjust each and every part of the new system and submit the necessary reports as required by the Owner or Owner's Representative. All equipment must be adjusted so that no vibration or sound is transmitted to adjacent areas.

- All piping will be tested to a pressure of 150 psi or 1½ times the operating pressure, whichever is greater, for a period of 24 hours. Should leaks develop in any part of the piping systems, these defective sections, fittings, etc., must be removed and replaced as caulking with metal or compound will not be permitted. The actual testing procedure shall be specified by the contractor and approved by the Owner or Owner's Representative;

- The contractor will be responsible for locating and protecting all underground and overhead utilities; and

- The contractor will be responsible for repair of any utility damaged during construction, due to the contractors activities.

REFERENCES

1. Golder Associates Inc., September 1989, "Phase V Investigation, Monitoring Well Installation Specifications."