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Technical Memorandum

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Date: June 25, 2004

To: Frank Battaglia—United States Environmental Protection Agency (USEPA)

cc: Ed Waddles—MTD Products Inc. (MTD)
David Herrington—Wegman, Hessler & Vanderburg
Barry Culp, Steve Schroeder, Chris Kline—RMT.

From: Britney Barnes, Greg Mitchell, Dr. Steve Webb, P.E.—RMT

Project No.: 00-71360.01

Subject: MTD – Columbia Manufacturing Facility (site), Westfield, Massachusetts
Final Design – *In situ* Oxidation of Chlorinated Volatile Organic Compounds (CVOCs) in Groundwater

Introduction

This final design technical memorandum has been developed by RMT Consulting Engineers, P.C. (RMT) to present the results of technical evaluations and design information associated with the implementation of planned interim measures at the site located in Westfield, Massachusetts. The interim measures consist of the reduction of elevated concentrations of CVOCs through *in situ* oxidation, combined with monitored natural attenuation (MNA) for any remaining CVOCs and site-specific metals.

The overall plan for implementing these measures was previously outlined in the *Workplan for Accelerated Site Closure* (RMT, March 12, 2004). This workplan also included a MNA sampling and analysis program. USEPA has reviewed this document and provided initial approval of the proposed technologies and approach.

The following information is provided in this document:

- Summary tables and maps depicting the extent and magnitude of CVOC impacts in groundwater beneath the northern and southern portions of the site, including the results of the supplemental direct-push investigation conducted in the southern portion of the site (see Subsection 2.1 of the March 12, 2004 Workplan). This information is presented in Attachment A.
- Results of groundwater fate and transport modeling conducted to establish target CVOC treatment areas and provide estimates of post-treatment CVOC levels in groundwater over time. This information is presented in Attachment B.
- Additional information regarding the application of *in situ* oxidation at the site (potential influencing factors, effects, and limitations), as specifically requested by USEPA.

- Design plans and specifications for the proposed *in situ* oxidation program are presented in Attachment C. The *in situ* oxidation program addresses oxidation of CVOC plumes identified in both the northern and southern areas of the site.
- A performance monitoring program proposed to monitor and evaluate the progress of the *in situ* oxidation treatment program.

Design Basis

Summary of Northern CVOC Distribution and Groundwater Flow Conditions

Groundwater in the northern portion of the site generally flows in a north to northeasterly direction, under non-pumping conditions. Since startup of the groundwater migration control system during the first quarter of 2003, groundwater flow has been considerably influenced by the operation of the recovery wells. Water level data shows that a cone of depression now extends across the affected groundwater effectively controlling its migration off the site. The December 2003 water table configuration is presented in the March 2004 Workplan.

The area and magnitude of affected groundwater within the northern portion of the site were established from data collected during the following events:

- **October 2001, June 2002, and September 2003:** Discrete-interval groundwater samples were collected at 46 locations in the northern portion of the site using direct push sampling technology. Groundwater samples were collected in order to assess groundwater quality conditions within the surficial aquifer. Groundwater samples were submitted to Spectrum Analytical, Inc., under chain-of-custody, for analysis of volatile organic compounds (VOCs) via USEPA Method SW8260B. Compounds detected during these sampling events are summarized on Tables A-1 through A-3 presented in Attachment A.
- **December 2003 and February 2004:** Groundwater samples were collected from 13 monitoring wells (December 2003) and seven recovery wells (February 2004) as a part of the performance monitoring for the groundwater migration control system. Groundwater samples were submitted to Spectrum Analytical, Inc., under chain-of-custody, for analysis of VOCs via USEPA Method SW8260B. Compounds detected during these sampling events are summarized on Tables A-4 and A-5 presented in Attachment A.

Based on the analytical data obtained during the aforementioned groundwater sampling events, four CVOCs have been identified as the site-specific constituents of concern (COCs); tetrachloroethene (PCE), trichloroethene (TCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), and vinyl chloride. TCE is the most prevalent and widespread CVOC and, thus, provides the basis for establishing the remedial target area for CVOCs in groundwater. The maximum concentration of TCE observed during the above sampling events conducted in the northern portion of the site was 11.0 milligram per liter (mg/L) at DP-37 and 6.1 mg/L in MW-24S. The distribution of TCE in groundwater for the north is shown on Figure A-1 in Attachment A.

Summary of Southern CVOC Distribution and Groundwater Flow Conditions

Groundwater in the southern portion of the site generally flows in a south to southeasterly direction, off the site toward the Little River (see March 2004 Workplan). A groundwater divide, potentially influenced by a topographic high in the top of the underlying lacustrine surface, appears to be present in the vicinity of the former plating room. The operation of the recovery wells in the northern portion of the site does not appear to influence groundwater flow south of this groundwater divide.

The area of affected groundwater within the southern portion of the site was established from data collected during the following events:

- **September 2001:** Groundwater samples were collected from 32 monitoring wells to evaluate groundwater quality conditions. Groundwater samples were submitted to Spectrum Analytical, Inc., under chain-of-custody, for analysis of VOCs via USEPA Method SW8260B. Analytical data for VOCs detected during this sampling event is summarized on Table A-6 presented in Attachment A.
- **March 2004:** Twenty discrete-interval groundwater samples were collected using direct push sampling technology in order to confirm groundwater quality conditions and the depth to the top of the lacustrine unit. Groundwater samples were collected from top of the lacustrine unit. Additionally, groundwater samples were collected from 25 monitoring wells as a part of the MNA program discussed in the March 2004 Workplan. Groundwater samples were submitted to Spectrum Analytical, Inc., under chain-of-custody, for analysis of site-specific CVOCs via USEPA Method SW8260B. CVOCs detected during this sampling event are summarized on Tables A-7 and A-8 presented in Attachment A.

Based on the analytical data obtained from the aforementioned groundwater sampling events, four CVOCs have been identified as the site-specific COCs; PCE, TCE, *cis*-1,2-DCE, and vinyl chloride. High concentrations of PCE (3,480 mg/L in DP-60 and 61.5 mg/L in MW–52S) and TCE (194 mg/L in DP-60) have been observed, to the extent that potential for dense nonaqueous-phase liquid (DNAPL) may exist in the southern portion of the site. PCE is the most prevalent CVOC and, thus, provides the basis for establishing the remedial target area for CVOCs in groundwater. The distribution of PCE in groundwater beneath the southern portion of the site is shown on Figure A-2 in Attachment A.

Summary of Groundwater Fate and Transport Modeling

As described in the workplan, groundwater modeling was used to assist in the evaluation of groundwater flow within the surficial aquifer and the fate and transport of CVOCs in groundwater. The groundwater flow model was calibrated to site-specific water levels; the fate and transport model was developed based on transport information derived from the distribution of CVOCs at the site combined with data from technical literature.

The specific purpose of the groundwater modeling was to estimate the extent of future migration potential of the CVOCs and the time frame in which the CVOCs will achieve maximum contaminant levels (MCLs). Alternative scenarios were evaluated to simulate future conditions with, and without, the addition of the *in situ* oxidation program.

Under all of the scenarios run, MNA provides the final polishing step for ultimately achieving MCLs in both the northern and southern portions of the site. It should be noted that the treatment areas and cleanup concentrations proposed have been developed as estimated "targets", from which modeling could be used to predict the fate of the CVOCs from the combined treatment/MNA approach. It is likely that final, treated CVOC concentrations at individual monitoring points will vary to some degree from those modeled. Thus, it is appropriate that the overall mass reduction of CVOCs, areal averaging of treated concentrations, and updated modeling of MNA (using the actual, post-treatment CVOC levels as input parameters) be used to assess when a sufficient level of CVOC reduction has been achieved by active treatment.

The modeling results are summarized below, with a detailed presentation provided in Attachment B.

Northern CVOC Plume

Two modeling scenarios were evaluated in order to compare and contrast the effectiveness of alternative treatment approaches for CVOCs in the northern portion of the site. The following summarizes the scenarios that were evaluated:

— ***Scenario 1:*** no active treatment implemented for observed CVOC source areas or high CVOC concentration groundwater. The groundwater recovery and migration control system would remain active for a period of 20 years, after which MNA would be relied upon to complete the remediation of CVOCs in groundwater.

  The results of this modeling scenario indicate that the CVOCs would achieve MCLs over a period ranging from approximately 20 to 32 years, with no further horizontal migration of CVOCs from the current edge of the plume.

— ***Scenario 2:*** *in situ* oxidation used to treat observed CVOC source area soils and reduce high concentrations of TCE observed in groundwater to a concentration of approximately 1 mg/L. The groundwater recovery and migration control system would remain active for a short time period, after which MNA would be used to complete the remediation of CVOCs in groundwater.

  Note: *A target treatment concentration of 1 mg/L was selected for TCE, which represents the highest concentrations of CVOCs in groundwater, by an order of magnitude or greater, compared to the other CVOCs present. While not specifically proposed as "target" levels for active treatment, it is anticipated that the remaining CVOCs, namely cis-1,2-DCE and vinyl chloride will be reduced to levels below their respective MCLs of 0.070 mg/L and 0.002 mg/L within the prescribed treatment area. Thus, the MCL values for these compounds (along with the 1.0 mg/L level for TCE) were used as model inputs to simulate post-treatment conditions.*

  The results of this modeling scenario indicate that the CVOCs will achieve MCLs over a period ranging from 5 to 25 years, with no further horizontal migration of CVOCs from the current edge of the plume. These values show a significant improvement compared to Scenario 1, where no source area controls or high CVOC concentration zone treatment were applied. In addition to the improved timeframes, the value of the treatment program can be

seen by comparing the residual concentrations in groundwater for the two scenarios during the period of MNA. After 10 years, without treatment, residual TCE concentrations of 0.5 mg/L and above are predicted to be present over a widespread area (see Figures B-5 in Attachment B). With treatment as proposed, however, residual TCE concentrations after 10 years are predicted to be no greater than 0.050 mg/L (See Figure B-8).

Southern CVOC Plumes

Two modeling scenarios were also evaluated to compare the effectiveness of treatment of CVOCs in the southern portion of the site. The primary criteria evaluated for the southern CVOC plume is the estimated distance of CVOC migration, relative to the potential discharge of CVOCs into the Little River. The following summarizes these scenarios and their results:

— ***Scenario 1:*** no active treatment implemented for CVOC source areas or high CVOC concentration groundwater. As there is no active groundwater remediation underway in the south, MNA would be relied on to complete the remediation of CVOCs in groundwater.

  Scenario 1 presents a worst-case scenario in which the observed source of the CVOCs continues to leach over time into the surficial aquifer. This scenario was developed to evaluate whether a continuing source, without any active remediation applied, would adversely impact the Little River. The results of this modeling scenario indicate that TCE and vinyl chloride would reach the Little River at concentrations above their respective MCLs. The model predicts that MCL exceedences of these compounds in the Little River would occur approximately 60 to 75 years in the future. The higher degradation rates for the PCE and DCE result in these compounds reaching a "steady state," in which neither is likely to reach the Little River at concentrations above their respective MCLs. Because the observed source of the CVOCs will continue to be present for an unknown period of time under this scenario, the time frame necessary for CVOCs in groundwater to ultimately achieve their MCLs would be extremely long, and is beyond the predictive capabilities of the model.

  It should be noted that CVOC concentrations in groundwater, discharging to the Little River, would be substantially diluted by the surface water. The discharge of the river is reported to be 68 million cubic feet per day. The discharge of groundwater containing CVOCs above MCLs is estimated to be on the order of 480 cubic feet per day (assuming discharge along a 1000 foot stretch of the river). This mixing would provide a dilution factor of greater than 100,000 to 1 for the affected groundwater discharging into the river.

— ***Scenario 2:*** *In situ* oxidation used to treat high concentrations of PCE observed in groundwater to a concentration of approximately 1 mg/L, after which MNA would be used to complete the remediation of CVOCs in groundwater.

  Note: *A target treatment concentration of 1 mg/L was selected for PCE, which retains the highest concentrations and greatest distribution in groundwater. TCE is also present at elevated concentrations and while not proposed as a "target" level for active treatment, it is anticipated that TCE will be reduced to approximately 1 mg/L within the target treatment area. RMT predicts that*

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low levels of cis-1,2-DCE and vinyl chloride will be present, and it is anticipated that these compounds will be reduced to their respective MCLs of 0.070 mg/L and 0.002 mg/L within the target treatment area. These values were used as model inputs to simulate post-treatment conditions for CVOCs in the southern portion of the site.

The results of this modeling scenario predicts that the maximum extent of CVOC migration (above MCLs) is approximately 1,200 feet from the Little River. This suggests that, with treatment, CVOCs above MCLs will not discharge into the Little River. Two variations of Scenario 2 were evaluated. Scenario 2a is based on degradation rates for the CVOCs that are calculated from the limited amount of south CVOC data available. Scenario 2b is based on the assumption that degradation rates in the south will be comparable to those observed over time in the north CVOC plume, which reflects a higher degradation rate of the CVOCs in the groundwater. Based on this range of potential future degradation rates of the CVOCs, the modeling results indicate a time frame of between approximately 30 and 150 years after treatment may be required for the CVOCs to ultimately achieve MCLs in all locations in the southern portion of the site.

In situ Oxidation Systems Design

Overview of Proposed Technologies

General

In situ oxidation has been chosen to treat high levels of CVOCs at the site. Target treatment areas were selected based on the mass of CVOCs to be removed in order to achieve MCLs on the site by natural attenuation, as shown by the modeling results. Another factor contributing to the selection of the target areas is the reasonable spatial area in which ozone treatment will be applied. Factors that can influence or limit the effectiveness of oxidation are summarized as follows:

— The selected oxidizing agent needs to be of sufficient strength and concentration so as to treat the target constituents in a reasonable timeframe. Standard oxidants such as ozone, hydrogen peroxide, and various permanganate salts have been successful in remediating a wide range of chlorinated ethenes and ethanes, as well as various aromatic VOCs (*i.e.*, benzene, toluene, xylenes). Permanganate salts can generate oxidized inorganic precipitates, which can reduce the permeability of the aquifer. More complex organics, such as pesticides and polychlorinated biphenyls (PCBs), have proven difficult to treat, and partial oxidation of these compounds can generate undesirable bi-products.

— Natural organic (*i.e.*, humic acids) and inorganic (*i.e.*, iron) compounds can compete for and use a portion of the supplied oxidant. Where high natural levels of these compounds occur, effective treatment may be delayed or occur at a slower rate than anticipated, until these naturally occurring substances are themselves chemically oxidized.

— Like most *in situ* technologies, the site-specific hydrogeology will determine the effectiveness in delivering the oxidant to the target constituents in the subsurface. Moderate to highly permeable aquifers (10^{-4} cm/sec or greater) are generally amenable to effective distribution. Lower permeability materials can be effectively treated, but require more closely spaced injection wells and higher operating pressures. The presence of low permeability layers and other subsurface heterogeneities can also complicate the distribution of the oxidant.

Westfield Site Application

The Westfield site is an ideal candidate for the use of *in situ* oxidation, specifically ozone, due to the moderate to highly permeable aquifer, which allows better distribution and has demonstrated treatment effectiveness on CVOCs, such as those present at the site. Oxidation technologies have been selected to address the challenges of the area-specific conditions present in each of the North and South Target Areas. Because of the large distance separating the two target areas and the difference in the concentrations of CVOCs that require treatment, two separate chemical supply units will be used to conduct *in situ* oxidation treatment at the site.

For the North Target Area, an ozone supply unit has been designed to reduce TCE groundwater concentrations from current levels to an average of 1 mg/L across the treatment area. The North Ozone System is sized to provide ozone treatment to 22 ozone sparge wells. Each sparge well consists of a 2-inch porous sparge point and ¾-inch riser pipe, to distribute ozone from the supply unit into the aquifer.

The March 2004 Workplan identified removal of the former degreasing units and soil excavation as a possible means of source reduction in the North Target Area. While removal of the degreasing units remains feasible, it has been determined that soil removal would require extensive and costly shoring of the building. An alternative to excavation of these affected soils is to conduct *in situ* oxidation in the vadose zone. Currently, only limited data is available regarding the effectiveness of CVOC treatment in the vadose zone using ozone. Therefore, ozone sparging in the area of the former degreasing operation is proposed as a pilot test, to determine the effectiveness of ozone oxidation technology on vadose zone soils at the site. If shown to be effective, *in situ* oxidation of affected vadose zone soils will be expanded in lieu of soil excavation.

For the South Target Area, a separate ozone supply system has been designed to reduce PCE concentrations to an average groundwater concentration of 1 mg/L across the treatment area. The South Ozone System has been sized to provide ozone treatment to 11 sparge wells. The south supply system will include the capability to mix the ozone gas with dilute hydrogen peroxide (tradenamed Perozone™). This will facilitate the ability to readily enhance treatment of the higher concentrations of CVOCs, if deemed necessary in the future, upon assessing the progress of the treatment program. To accommodate this capability, "laminar" sparge wells will be installed for the south system. Laminar wells are very similar in design to the standard sparge wells; however, the laminar wells include a ¼-inch liquid supply line, which is secured to the ¾-inch riser to deliver the peroxide to the laminar sparge point.

The capability to be able to use the Perozone™ technology was chosen for the South Target Area, due to the high levels of PCE and TCE measured in this area. Conventional wisdom suggests that CVOC concentrations at such levels can be indicative of the potential presence of DNAPL. If necessary, the increased oxidizing potential of the combined ozone and peroxide may prove beneficial in achieving the target CVOC concentrations in a reasonable timeframe.

In both target areas, sparge wells will be operated in a sequential fashion, with a given set of wells operating together, for a continuous period of 20 to 40 minutes. After which time, the supply system program will switch the oxidant supply to the next set of wells. The North Ozone System will be capable operating of four sparge wells simultaneously, while the South Ozone System will be capable of operating two sparge wells simultaneously. Although the operation of the wells will be sequenced, treatment will be continuously cycled, such that each sparge well will receive several treatment cycles within the course of a 24-hour day.

Sparge Well Design

The layout and spacing of sparge wells has been determined based on the estimated area of treatment exhibited by each sparge well. This area is referred to as a sparge well's radius of influence (ROI). RMT and the technology provider, Kerfoot Technologies, Inc. (KTI), have experience with injecting ozone in a variety of geological conditions. An expected, ROI for an ozone sparge well in geological conditions such as that present at the site typically range from 40 to 60 feet. To establish the design spacing of sparge wells at the site, RMT used a conservatively low ROI value of 40 feet for each sparge well. To ensure full coverage over the target area, an overlap of 30 percent (*i.e.,* the degree to which each well's ROI overlaps the adjacent well's ROI) was applied. Figures C-1 and C-2 in Attachment C show the design sparge well layout and depict the estimated 40-foot ROI associated with each sparge well.

All sparge points located in the saturated zone will be installed directly on top of the lacustrine unit, in order to maximize treatment of the surficial aquifer. The location of the sparge wells provided in Figures C-1 and C-2 is based on current data concerning the location of the top of lacustrine. Final locations of the sparge wells may shift slightly based on further refining the top of lacustrine surface, through direct push work conducted as part of the sparge well installation. Final sparge well locations may also be modified slightly to avoid conflicts with underground utilities. Using current top of lacustrine data, sparge well depths will vary from 13 to 30 feet from ground surface.

A total of 22 sparge wells will be installed in the North Target Area. The majority of these (16 total – identified as wells SP-1 through SP-16) will be standard sparge wells, designed solely for ozone injection. Four laminar sparge wells (LSP-1 through LSP-4) that are capable of handling either ozone alone or Perozone™, will be installed in the North Target Area. The laminar wells are located in the area between recovery wells RW-2 and RW-3 where the highest concentrations of TCE have been observed and where a deeper lacustrine surface, or trough, is present. RMT anticipates that these four laminar sparge wells will be used for the injection of ozone only, however, Perozone™ injection may be applied, if TCE concentrations in this area do not decrease as rapidly as expected.

Three additional standard sparge wells (VSP-1, VSP-2, and VSP-3) will be installed directly beneath the floor of the former vapor degreasing room in the North Target Area, to treat vadose zone soil. These sparge points will be located on top of the water table and be designed to distribute ozone directly into TCE-impacted soils. Upon completion of the remediation, soil samples will be collected from beneath the former degreasing room to verify the effectiveness of the vadose zone of treatment.

A total of 11 laminar sparge wells will be implemented in the South Target Area. RMT anticipates that these sparge wells will be used for the injection of ozone, however, Perozone™ injection may be applied if CVOC concentrations in this area do not decrease as rapidly as expected.

Supply and Distribution System Design

The North Ozone System will consist of the following main components: an air compressor, an oxygen generator, an ozone controller, five ozone generators, and two booster pumps. This equipment is sized to generate an ozone concentration of 600 parts per million (ppm), using 20 actual cubic feet per minute (acfm) of air supply at 40 pounds per square inch-gauge (psig). The unit will be capable of supplying 4 sparge wells operating simultaneously with up to 5 acfm each, at the design ozone concentration. Design details, including site features, proposed well locations and process and instrumentation diagrams for the North Ozone System, are provided in Attachment C.

The South Ozone System will have components similar to that of the North Ozone System with the addition of a peroxide metering system. The South Ozone System will be capable of generating an ozone concentration of approximately 500 ppm and 10 acfm at 40 psig. In addition, the system will be capable of supplying 5 to 8 percent, by weight, of hydrogen peroxide solution to each sparge point, if necessary to effect successful treatment. Additional details for the South Ozone System are provided in Attachment C.

Teflon® tubing connecting the sparge wells located outside the building in the North Target Area to the ozone system will be placed in conduit and trenched to a depth of 1 foot below grade. Teflon® tubing to supply sparge wells located inside the building, for both the North Ozone System and the South Perozone™ System, will be placed in conduit and routed overhead or beneath flooring. Given the nature of the site (multiple buried utilities, used and unused portions of the building interior, etc.) the connecting tubing from the supply units to the wells will be field located, and is not detailed in this design.

Performance Monitoring Plan

Monitoring Objectives

The primary objectives for performance monitoring of the oxidation systems are as follows:

- Verify concentration reduction of CVOCs within the target treatment zones.
- Verify that unexpected migration of CVOCs is not occurring.
- Verify the radius of influence from the ozone and Perozone™ injection points.

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Performance Monitoring

New performance monitoring points (PMPs) and selected existing monitoring wells will be monitored throughout the duration of the remediation. In and around the North Target Area, five existing on-site monitoring wells, four existing monitoring points and observation wells, and four new PMPs have been located and designed to evaluate the performance of the system. In the South Target Area, three existing on-site monitoring wells and three new PMPs will be monitored. To satisfy the monitoring objectives, the following information will be collected and evaluated:

- A total of 13 monitoring points will be monitored in the northern portion of the site, and a total of six monitoring points will be monitored in the southern portion of the site.
  - Seven new performance monitoring points will be installed, four in the northern portion of the site and three in the southern portion of the site. Performance monitoring points will be installed using hollow stem auger drilling methodologies. These points will be screened throughout the entire length of the saturated portion of the surficial aquifer in order to obtain an average groundwater concentration within the target treatment area. In areas of the site where the saturated thickness of the aquifer exceeds 20 feet, a nested performance monitoring well pair may be installed.
- Field parameters such as dissolved oxygen (DO) and oxidation-reduction potential (ORP) provide "indicators" that oxidation of the aquifer is occurring. DO and ORP will be measured in the performance monitoring wells located within the treatment area to assess overall changes in the aquifer due to treatment.
- Samples will be collected from the performance monitoring wells located within the treatment area to verify the reduction of CVOC concentrations observed in groundwater.
- Samples will be collected from the performance monitoring wells downgradient of the each of the target treatment areas to verify that undesirable migration of CVOCs is not occurring.

Table 1 provides a detailed schedule for monitoring well sampling and analysis. System monitoring will continue until treatment goals have been achieved. PMP locations and construction details are shown on the design drawings provided in Attachment C.

Groundwater samples collected from the performance monitoring well network will be submitted to Spectrum Analytical, Inc., under chain-of-custody, for analysis of site-specific CVOCs via USEPA Method SW8260B.

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Table 1
Groundwater Performance Monitoring Plan

MONITORING PARAMETER	FREQUENCY/SAMPLING TIME AFTER STARTUP	COMMENTS
Field Measurements DO Redox Potential	Baseline—prior to startup 1 week 2 weeks 1 month 2 months 3 months 6 months 12 months	— Field parameters will be monitored at the following wells: **North End** ▪ MP-04 ▪ MP-05 ▪ MP-06 ▪ PMP-01 ▪ PMP-02 ▪ PMP-03 ▪ PMP-04 ▪ MW-20C ▪ MW-20B ▪ MW-24S **South End** ▪ PMP-05 ▪ PMP-06 ▪ PMP-07 ▪ MW-27S ▪ MW-36S ▪ MW-52S — If steady state conditions develop, monitoring frequency may be modified.
Laboratory Analyses CVOCs (PCE, TCE, *cis*-1,2-DCE, and vinyl chloride)	Baseline – prior to startup 3 months 6 months 12 months 18 months	— Sampling and analysis will be conducted for the following sampling locations at the baseline, 3-month, 6-month, 12-month, and 18-month sampling events to evaluate reduction in concentrations within the treatment area: (1) **North End** ▪ PMP-01 ▪ PMP-02 ▪ PMP-03 ▪ PMP-04 ▪ MW-24S ▪ MW-20B ▪ MW-20C **South End** ▪ PMP-05 ▪ PMP-06 ▪ PMP-07 ▪ MW-27S ▪ MW-36S ▪ MW-52S — Sampling and analysis will be conducted for the following sampling locations at the 1-month, 3-month, and 6-month sampling events to evaluate the radius of influence of the ozone sparge points: **North End** ▪ MP-04 ▪ MP-05 ▪ MP-06

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Table 1
Groundwater Performance Monitoring Plan

MONITORING PARAMETER	FREQUENCY/SAMPLING TIME AFTER STARTUP	COMMENTS
Laboratory Analyses (continued)	Baseline – prior to startup 6 months 12 months 18 months	— Sampling and analysis will be conducted for the following sampling locations directly downgradient of the treatment area at the baseline, 6-month, 12-month, and 18-month sampling events to evaluate general improvement in groundwater quality and verify migration is not occurring:[2] **North End** ▪ MW-32S ▪ MW-51S ▪ OW-03 **South End** Monitoring wells downgradient of the treatment area will be evaluated during the scheduled MNA sampling events, per the March 2004 Workplan. — If steady state conditions develop, monitoring frequency may be modified.

(1) After six months, the sampling program will be re-evaluated to determine if the sampling frequency and number of wells should be modified.

(2) Sampling and analysis of the listed monitoring wells may be conducted in tandem with the MNA sampling events, thus frequency of sampling may be altered

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Attachment A
Summary of Constituents Detected in Groundwater and Soil

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Figure A-1 North End Distribution of Trichloroethene in Groundwater
Figure A-2 South End Distribution of Tetrachloroethene in Groundwater

List of Tables for Attachment A

Table A-1 Summary of VOCs Detected in Groundwater Screening Samples, October 2001
Table A-2a Summary of VOCs Detected in Groundwater Screening Samples, June 2002
Table A-2b Summary of VOCs Detected in Soil Screening Samples, June 2002
Table A-3 Summary of VOCs Detected in Groundwater Screening Samples, September 2003
Table A-4 Summary of VOCs Detected in Groundwater Screening Samples, December 2003
Table A-5 Summary of Detections in Recovery Wells, Interim Groundwater System, February 2004
Table A-6 Summary of VOCs Detected in Groundwater, October 2001
Table A-7 Summary of CVOCs Detected in Groundwater, March 2004
Table A-8 Summary of Detections in Groundwater, March 2004

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LEGEND

- DIRECT PUSH LOCATIONS
- MONITORING WELL LOCATIONS
- RECOVERY WELL LOCATIONS
- FORMER VAPOR DEGREASING AREA
- TCE CONTOURS SHOWN IN mg/L, DASHED WHERE INFERRED
- PROPERTY BOUNDARY / FENCE LINE

N

0 150 300 Feet

NO.	BY	DATE	REVISION	APP'D.
3.				
2.				
1.				

PROJECT : MTD PRODUCTS INC. COLUMBIA MANUFACTURING FACILITY

SHEET TITLE: NORTH END DISTRIBUTION OF TRICHLOROETHENE IN GROUNDWATER

DRAWN BY: ARR	SCALE AS NOTED	PROJECT NO.: 71360.01
CHECKED BY: BCB		FILE NO.: LNorthendTCE
APPROVED BY: BEC	DATE PRINTED: JUNE 2004	FIGURE: A-I
DATE: JUNE 2004		

RMT

100 Verdae Boulevard
P.O. Box 16778
Greenville, SC 29606
(864) 281-0030

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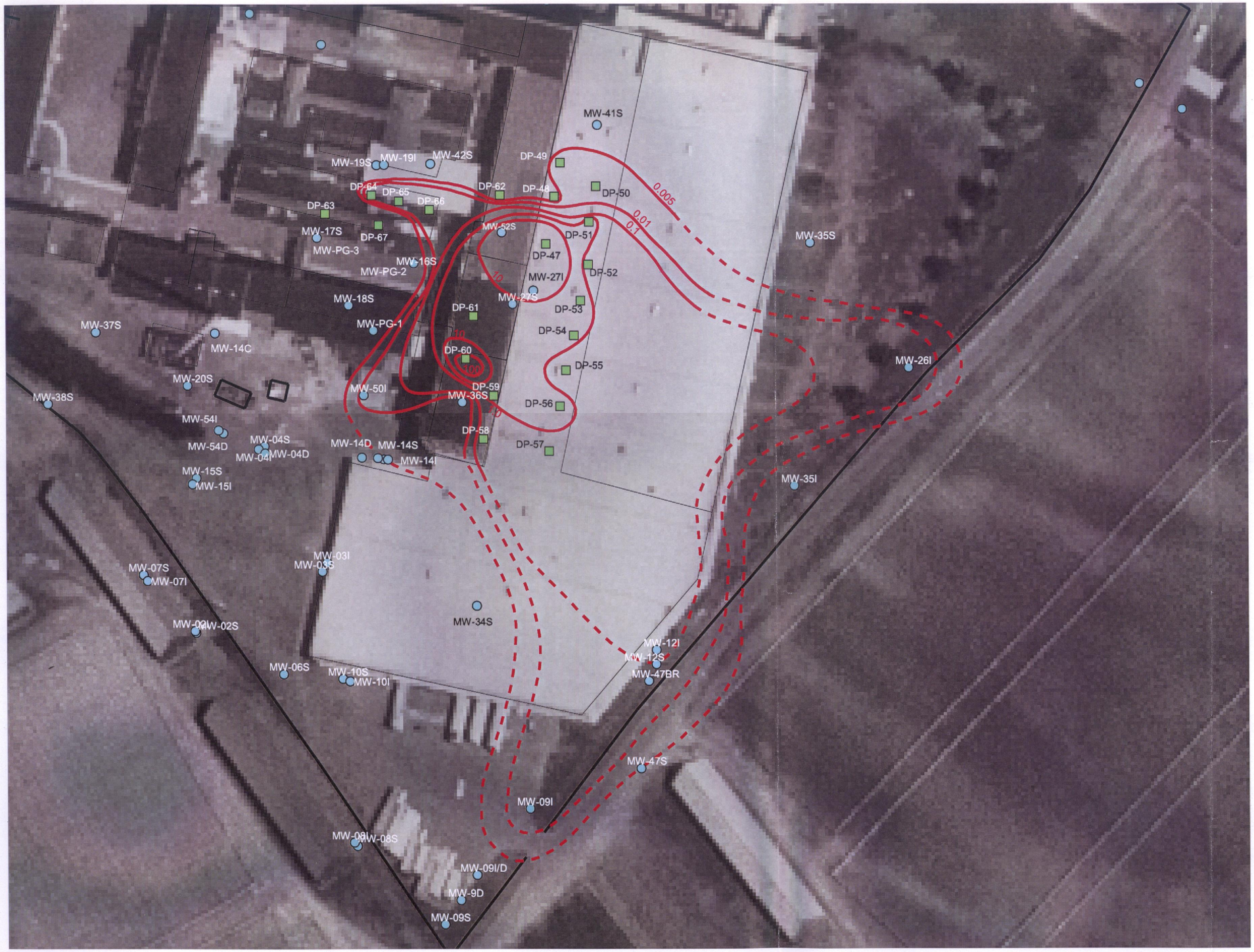

LEGEND

- DIRECT PUSH LOCATIONS
- MONITORING WELL LOCATIONS
- PCE CONTOURS SHOWN IN mg/L, DASHED WHERE INFERRED
- PROPERTY BOUNDARY / FENCE LINE

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PROJECT : MTD PRODUCTS INC. COLUMBIA MANUFACTURING FACILITY

SHEET TITLE: SOUTH END DISTRIBUTION OF TETRACHLOROETHENE IN GROUNDWATER

DRAWN BY: ARR	SCALE AS NOTED	PROJECT NO.: 71360.01	
CHECKED BY: BCB		FILE NO.: LSouthendPCE	
APPROVED BY: BEC	DATE PRINTED: JUNE 2004	FIGURE: A-2	
DATE: JUNE 2004			

RMT

100 Verdae Boulevard
P.O. Box 16778
Greenville, SC 29606
(864) 281-0030

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Table A-1
Summary of VOCs Detected in Groundwater Screening Samples
Columbia Manufacturing Facility, Westfield, MA
October 2001

PARAMETER [1]	MCL [2]	LOCATION/SAMPLE DATE									
		DP-01 10/01/01	DP-02 10/01/01	DP-03 10/01/01	DP-04 10/01/01	DP-04I 10/01/01	DP-05 10/02/01	DP-06 10/02/01	DP-07 10/02/01	DP-08 10/02/01	DP-09 10/02/01
Volatile Organics											
1,1,1-Trichloroethane	0.2	<0.005	<0.005	<0.005	<0.01	**0.054**	<0.005	<0.005	<0.005	<0.005	<0.005
1,1-Dichloroethane		<0.005	<0.005	**0.018**	<0.005	<0.025	<0.005	<0.005	<0.005	<0.005	<0.005
1,1-Dichloroethene	0.007	<0.005	<0.005	<0.005	**0.012**	<0.025	<0.005	<0.005	<0.005	<0.005	<0.005
Chloroform	0.1	<0.005	<0.005	<0.005	<0.005	<0.025	<0.005	<0.005	<0.005	<0.005	<0.005
cis -1,2-Dichloroethene	0.07	**0.12**	**0.22**	**0.21**	**0.47**	**0.65**	**0.14**	**0.23**	**0.081**	**0.22**	**0.21**
Methyl tert-butyl ether		<0.005	<0.005	<0.005	<0.005	<0.025	<0.005	<0.005	<0.005	<0.005	<0.005
Tetrachloroethene	0.005	<0.005	**0.072**	**0.072**	**0.052**	**0.41**	<0.005	<0.005	<0.005	**0.47**	**0.26**
trans -1,2-Dichloroethene	0.1	<0.005	<0.005	<0.005	<0.01	<0.025	<0.005	<0.005	<0.005	<0.005	<0.005
Trichloroethene	0.005	**DP-58**	**0.7**	**0.47**	**0.91**	**7.6**	**0.66**	**1.3**	**0.41**	**1.3**	**0.64**
Vinyl chloride	0.002	**(14-16)**	**0.1**	**0.37**	**0.37 j**	**0.36**	**0.023 j**	**0.038 j**	<0.01	**0.052 j**	**0.13 j**

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted

[2] Maximum Contaminant Level (National Primary Drinking Water Standards)

j - Concentration considered an estimate based on data validation.

< - Concentration less than the Quantitation Limit.

Bolded text indicates detection.

Shaded text indicates sample exceeds MCL.

Close File

Table A-1
Summary of VOCs Detected in Groundwater Screening Samples
Columbia Manufacturing Facility, Westfield, MA
October 2001

PARAMETER [1]	MCL [2]	LOCATION/SAMPLE DATE									
		DP-10 10/02/01	DP-11 10/02/01	DP-12 10/02/01	DP-13 10/03/01	DP-14 10/03/01	DP-15 10/03/01	DP-16 10/03/01	DP-17 10/03/01	DP-18 10/03/01	DP-19 10/03/01
Volatile Organics											
1,1,1-Trichloroethane	0.2	<0.025	<0.025	<0.05	**0.04**	**0.018**	**0.033**	<0.005	**0.0029**	<0.001	<0.001
1,1-Dichloroethane		<0.025	<0.025	**0.07**	**0.053**	**0.02**	<0.01	**0.022**	**0.0068**	**0.0035**	**0.0018**
1,1-Dichloroethene	0.007	<0.025	<0.025	<0.025	**0.025**	**0.018**	<0.01	**0.017**	**0.0084**	**0.0015**	<0.001
Chloroform	0.1	<0.025	<0.025	<0.025	<0.01	<0.01	<0.01	<0.005	<0.001	<0.001	<0.001
cis -1,2-Dichloroethene	0.07	**0.16**	**0.51**	**0.42**	**0.76**	**0.44**	**0.31**	**0.42**	**0.45**	**0.11**	**0.065**
Methyl tert-butyl ether		<0.025	<0.025	<0.025	<0.01	<0.01	<0.01	<0.005	<0.001	<0.001	<0.001
Tetrachloroethene	0.005	**0.071**	**0.24**	**0.21**	**0.46**	**0.15**	**0.25**	**0.041**	**0.016**	**0.005**	**0.0078**
trans -1,2-Dichloroethene	0.1	<0.025	<0.025	<0.025	**0.011**	<0.01	<0.01	**0.0052**	**0.0049**	**0.0013**	<0.001
Trichloroethene	0.005	**2.6**	**10.5**	**3.3**	**8**	**4.3**	**4.1**	**0.67**	**0.36**	**0.032**	**0.097**
Vinyl chloride	0.002	**0.13 j**	**0.31 j**	**1.8 j**	**1.1 j**	**0.34 j**	**0.18 j**	**0.36 j**	**0.31 j**	**0.049 j**	**0.018 j**

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted

[2] Maximum Contaminant Level (National Primary Drinking Water Standards)

j - Concentration considered an estimate based on data validation.

< - Concentration less than the Quantitation Limit.

Bolded text indicates detection.

Shaded text indicates sample exceeds MCL.

Close File

Table A-1
Summary of VOCs Detected in Groundwater Screening Samples
Columbia Manufacturing Facility, Westfield, MA
October 2001

PARAMETER [1]	MCL [2]	LOCATION/SAMPLE DATE									
		DP-19I 10/03/01	DP-20 10/03/01	DP-21 10/03/01	DP-22 10/03/01	DP-23 10/03/01	DP-24 10/03/01	DP-25 10/03/01	DP-26 10/03/01	DP-26I 10/04/01	DP-27 10/04/01
Volatile Organics											
1,1,1-Trichloroethane	0.2	**0.0076**	**0.0031**	**0.0038**	<0.001	**0.0024**	**0.0014**	<0.001	<0.001	<0.001	**0.0015**
1,1-Dichloroethane		<0.005	**0.0043**	**0.0062**	**0.0023**	**0.0042**	**0.0022**	**0.0015**	**0.0018**	**0.0022**	**0.0024**
1,1-Dichloroethene	0.007	<0.005	**0.002**	**0.0021**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**
Chloroform	0.1	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
cis -1,2-Dichloroethene	0.07	**0.17**	**0.094**	**0.096**	**0.047**	**0.098**	**0.049**	**0.029**	**0.035**	**0.052**	**0.06**
Methyl tert-butyl ether		<0.005	<0.001	**0.0021**	<0.001	<0.001	<0.001	<0.001	**0.0013**	**0.0017**	**0.0025**
Tetrachloroethene	0.005	**0.071**	**0.023**	**0.043**	**0.0097**	**0.027**	**0.013**	**0.0093**	**0.005**	**0.011**	**0.017**
trans -1,2-Dichloroethene	0.1	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Trichloroethene	0.005	**1.3**	**0.46**	**0.61**	**0.19**	**0.46**	**0.23**	**0.13**	**0.1**	**0.15**	**0.21**
Vinyl chloride	0.002	**0.086 j**	**0.037 j**	**0.04 j**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted

[2] Maximum Contaminant Level (National Primary Drinking Water Standards)

j - Concentration considered an estimate based on data validation.

< - Concentration less than the Quantitation Limit.

Bolded text indicates detection.

Shaded text indicates sample exceeds MCL.

Close File

Table A-1
Summary of VOCs Detected in Groundwater Screening Samples
Columbia Manufacturing Facility, Westfield, MA
October 2001

PARAMETER [1]	MCL [2]	LOCATION/SAMPLE DATE		
		DP-29 10/04/01	DP-30 10/04/01	DP-31 10/04/01
Volatile Organics				
1,1,1-Trichloroethane	0.2	<0.001	<0.001	<0.001
1,1-Dichloroethane		<0.001	<0.001	**0.0015**
1,1-Dichloroethene	0.007	<0.001	<0.001	**0.0016**
Chloroform	0.1	**0.0014**	<0.001	**0.0028**
cis-1,2-Dichloroethene	0.07	<0.001	**0.02**	**0.28**
Methyl tert-butyl ether		<0.001	<0.001	<0.001
Tetrachloroethene	0.005	<0.001	**0.0019**	<0.001
trans-1,2-Dichloroethene	0.1	<0.001	<0.001	**0.0014**
Trichloroethene	0.005	**0.004**	**0.026**	**0.11**
Vinyl chloride	0.002	<0.001	**0.0021**	**0.022**

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted

[2] Maximum Contaminant Level (National Primary Drinking Water Standards)

j - Concentration considered an estimate based on data validation.

< - Concentration less than the Quantitation Limit.

Bolded text indicates detection.

Shaded text indicates sample exceeds MCL.

Close File

Table A-2a
Summary of VOCs Detected in Groundwater Screening Samples
Columbia Manufacturing Facility, Westfield, MA
June 2002

PARAMETER[1]	MCL	LOCATION/SAMPLE DATE								
		DP-32 (8-12) 06/13/02	DP-32 (16-20) 06/12/02	DP-33 (14-18) 06/12/02	DP-34 (6-10) 06/13/02	DP-34 (14-18) 06/13/02	DP-35 (14-18) 06/13/02	(DUP-1) DP-35 (14-18) 06/13/02	DP-36 (8-12) 06/13/02	DP-37 (8-12) 06/13/02
Volatile Organics										
Vinyl chloride	0.002	**1.3**	**0.064**	**0.094**	**0.067**	**0.084**	**0.13**	**0.11**	**0.018**	**0.2**
Methylene chloride	0.005	<0.02	<0.004	**0.023**	<0.06	<0.003	<0.15	<0.1	<0.001	<0.1
1,1-Dichloroethene	0.007	<0.02	**0.0026**	**0.011**	<0.01	**0.012**	<0.05	<0.05	<0.001	<0.05
1,1-Dichloroethane		**0.28**	**0.0035**	**0.01**	**0.012**	<0.001	<0.05	<0.05	<0.001	<0.05
cis -1,2-Dichloroethene	0.07	**5**	**0.37**	**0.77**	**0.22**	**0.49**	**0.9**	**0.88**	**0.025**	**0.37**
trans -1,2-Dichloroethene	0.1	**0.099**	**0.0027**	**0.0054**	<0.01	**0.0019**	<0.05	<0.05	<0.001	<0.05
Chloroform	0.1	**DP-58**	**0.0047**	**0.0014**	<0.01	<0.001	<0.05	<0.05	<0.001	<0.05
1,1,1-Trichloroethane	0.2	**(14-16)**	**0.0021**	**0.0055**	<0.01	<0.001	<0.05	<0.05	<0.001	<0.05
Trichloroethene	0.005	**0.97 j**	**3.9**	**1.4**	**0.54**	**1.1**	**3**	**3.2**	**0.0096**	**3.2**
Tetrachloroethene	0.005	**0.026**	**0.61**	**0.54**	<0.01	<0.001	**1.5**	**1.4**	**0.0028**	**0.11**
Toluene	1	<0.02	**0.0013**	**0.0024**	<0.01	**0.0015**	<0.05	<0.05	**0.0016**	<0.05
Ethylbenzene	0.7	<0.02	<0.001	**0.0017**	<0.01	<0.001	<0.05	<0.05	**0.0014**	<0.05
o-Xylene	10	<0.02	<0.001	**0.0017**	<0.01	<0.001	<0.05	<0.05	<0.001	<0.05
m,p-Xylenes	10	<0.04	<0.002	**0.0025**	<0.02	<0.002	<0.1	<0.1	<0.002	<0.1
1,2,4-Trimethylbenzene		**0.032**	**0.0023**	**0.01**	<0.01	<0.001	<0.05	**0.05**	**0.0018**	<0.05
1,3,5-Trimethylbenzene		<0.02	<0.001	**0.0028**	<0.01	<0.001	<0.05	<0.05	<0.001	<0.05
Isopropylbenzene		<0.1	**0.0012**	**0.002**	**0.014**	**0.0019**	<0.05	<0.05	**0.0015**	<0.05
4-Isopropyltoluene		<0.02	<0.001	<0.001	<0.01	<0.001	<0.05	<0.05	**0.001**	<0.05
n-Butylbenzene		<0.02	<0.001	<0.001	<0.01	<0.001	<0.05	<0.05	**0.013**	<0.05
n-Propylbenzene		<0.02	<0.001	**0.0013**	**0.011**	**0.0012**	<0.05	<0.05	**0.007**	<0.05
sec-Butylbenzene		<0.02	<0.001	**0.0011**	**0.024**	**0.0023**	<0.05	<0.05	**0.023**	<0.05
tert-Butylbenzene		<0.02	<0.001	<0.001	<0.01	<0.001	<0.05	<0.05	**0.0089**	<0.05
Naphthalene		<0.02	<0.001	**0.0019**	<0.01	<0.001	<0.05	<0.05	<0.001	<0.05

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted.

< - Concentration less than the Quantitation Limit.

Shaded cells indicate compound detected above Federal MCL

j - Concentration considered an estimate based on data validation.

Close File

Table A-2a
Summary of VOCs Detected in Groundwater Screening Samples
Columbia Manufacturing Facility, Westfield, MA
June 2002

PARAMETER[1]	MCL	LOCATION/SAMPLE DATE						
		DP-37 (16-20) 06/13/02	DP-38 (8-12) 06/13/02	DP-38 (16-20) 06/13/02	DP-39 (8-12) 06/14/02	DP-39 (16-20) 06/14/02	DP-40 (8-12) 06/14/02	DP-40 (16-20) 06/14/02
Volatile Organics								
Vinyl chloride	0.002	**0.13**	**0.38**	**0.066**	**0.18**	**0.096**	<0.001	<0.01
Methylene chloride	0.005	<0.06	<0.04	<0.02	<0.02	<0.04	<0.001	<0.02
1,1-Dichloroethene	0.007	<0.02	<0.02	<0.01	<0.01	<0.02	<0.001	<0.01
1,1-Dichloroethane		<0.02	<0.02	<0.01	<0.01	<0.02	<0.001	<0.01
cis -1,2-Dichloroethene	0.07	**0.49**	**0.52**	**0.2**	**0.21**	**0.33**	<0.001	**0.066**
trans -1,2-Dichloroethene	0.1	<0.02	<0.02	<0.01	<0.01	<0.02	<0.001	<0.01
Chloroform	0.1	<0.02	<0.02	<0.01	<0.01	<0.02	<0.001	<0.01
1,1,1-Trichloroethane	0.2	**0.079**	<0.02	<0.01	<0.01	<0.02	<0.001	<0.01
Trichloroethene	0.005	**11**	**0.29**	**1.6**	**0.68**	**3.8**	**0.0055**	**0.81**
Tetrachloroethene	0.005	**0.8**	**0.071**	**0.055**	**0.034**	**0.19**	<0.001	<0.01
Toluene	1	<0.02	<0.02	<0.01	<0.01	<0.02	<0.001	<0.01
Ethylbenzene	0.7	<0.02	**0.047**	<0.01	<0.01	<0.02	<0.001	<0.01
o-Xylene	10	<0.02	<0.02	<0.01	<0.01	<0.02	<0.001	<0.01
m,p-Xylenes	10	<0.04	<0.04	<0.02	<0.02	<0.04	<0.002	<0.02
1,2,4-Trimethylbenzene		<0.02	**0.22**	**0.022**	<0.01	<0.02	<0.001	<0.01
1,3,5-Trimethylbenzene		<0.02	**0.045**	<0.01	<0.01	<0.02	<0.001	<0.01
Isopropylbenzene		<0.02	**0.037**	<0.01	<0.01	<0.02	<0.001	<0.01
4-Isopropyltoluene		<0.02	**0.02**	<0.01	<0.01	<0.02	<0.001	<0.01
n-Butylbenzene		<0.02	**0.12**	<0.01	<0.01	<0.02	<0.001	<0.01
n-Propylbenzene		<0.02	**0.072**	<0.01	<0.01	<0.02	<0.001	<0.01
sec-Butylbenzene		<0.02	**0.062**	<0.01	<0.01	<0.02	<0.001	<0.01
tert-Butylbenzene		<0.02	<0.02	<0.01	<0.01	<0.02	<0.001	<0.01
Naphthalene		<0.02	**0.33**	**0.06**	<0.01	<0.02	<0.001	<0.01

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted.

< - Concentration less than the Quantitation Limit.

Shaded cells indicate compound detected above Federal MCL

j - Concentration considered an estimate based on data validation.

Close File

Table A-2b
Summary of VOCs Detected in Soil Screening Samples
Columbia Manufacturing Facility, Westfield, MA
June 2002

PARAMETER[1]	LOCATION/SAMPLE DATE									
	DP-32 (1.5-2.5) 06/12/02	DP-32 (6.5-7.5) 06/12/02	DP-33 (0.5-1.5) 06/12/02	DP-34 (2-3) 06/13/02	DP-34 (6-7) 06/13/02	DP-35 (1-2) 06/13/02	DP-35 (5-6) 06/13/02	DP-36 (4.5-5.5) 06/13/02	DP-37 (7-8) 06/13/02	DP-38 (6-7) 06/13/02
Volatile Organics										
Methylene chloride	**11.4**	<0.235	**259**	<0.488	<1.043	<0.296	<0.739	<0.364	<0.016	<0.522
1,1-Dichloroethane	**0.82**	**0.45**	**3.3**	<0.163	<0.348	**0.46**	**1.3**	<0.182	<0.004	<0.13
cis -1,2-Dichloroethene	**64.5**	**11.8**	**268**	**0.91**	<0.348	**39.1**	**122.2**	<0.182	<0.004	<0.13
trans -1,2-Dichloroethene	**0.9**	**0.15**	**8.9**	<0.163	<0.348	**0.65**	**1.3**	<0.182	<0.004	<0.13
Chloroform	**0.42**	<0.117	**0.57**	<0.163	<0.348	<0.296	<0.37	<0.182	<0.004	<0.13
1,1,1-Trichloroethane	**3**	**0.47**	**17**	**0.87**	<0.348	**0.42**	**3.4**	<0.182	<0.004	<0.13
Trichloroethene	**878.4**	**0.18**	**902.7**	**66.1**	<0.348	**575.2**	**48.7**	<0.3	<0.004	**0.14**
Tetrachloroethene	**5.2**	**DP-58**	**3.1**	**6.3**	<0.348	**12.8**	**11.6**	<0.182	<0.004	<0.13
Toluene	<0.173	**(14-16)**	**0.6**	<0.163	<0.348	**0.95**	**1.5**	<0.182	<0.004	<0.13
Ethylbenzene	<0.173	**0.25**	**0.45**	<0.163	<0.348	<0.296	<0.37	<0.182	<0.004	**0.18**
o-Xylene	<0.173	<0.15	<0.386	<0.163	<0.348	<0.296	**0.46**	<0.182	<0.004	<0.13
1,2,4-Trimethylbenzene	<0.173	**0.98**	**1.8**	<0.163	<0.348	<0.296	**6.9**	<0.182	<0.004	**1.1**
1,3,5-Trimethylbenzene	<0.173	**0.2**	**1.2**	<0.163	<0.348	<0.296	**1.4**	<0.182	<0.004	<0.13
Isopropylbenzene	<0.173	**0.28**	<0.386	<0.163	**1**	<0.296	**0.94**	**0.64**	<0.004	**0.25**
4-Isopropyltoluene	<0.173	**0.43**	**0.42**	<0.163	<0.348	<0.296	**1.4**	<0.182	<0.004	<0.13
n-Butylbenzene	<0.173	**0.34**	<0.386	<0.163	**1.3**	<0.296	**1.7**	**0.63**	<0.004	**1.3**
n-Propylbenzene	<0.173	**0.35**	<0.386	<0.163	**1.6**	<0.296	**1.2**	**0.52**	<0.004	**0.54**
sec-Butylbenzene	<0.173	**0.35**	<0.386	<0.163	**1.4**	<0.296	**1.8**	**0.6**	<0.004	**0.6**
tert-Butylbenzene	<0.173	<0.117	<0.386	<0.163	<0.348	<0.296	<0.37	**0.25**	<0.004	<0.13
Naphthalene	<0.173	**0.12**	**1.7**	<0.163	**1.3**	<0.296	**0.64**	<0.182	<0.004	**1.3**

[1] Analytical results are reported in milligrams per kilogram (mg/kg) unless otherwise noted.

< - Concentration less than the Quantitation Limit.

Close File

Table A-3
Summary of VOCs Detectioned in Groundwater Screening Samples
Columbia Manufacturing Facility, Westfield, MA
September 2003

PARAMETER[1]	MCL[2]	LOCATION/SAMPLE DATE					
		DP-41 (16-20) 09/10/03	DP-42 (20-24) 09/10/03	DP-43 (13-17) 09/11/03	DP-44 (20-24) 09/11/03	DP-45 (12-16) 09/11/03	DP-46 (12-16) 09/11/03
Volatile Organics							
cis -1,2-Dichloroethene	0.07	<0.001	<0.001	<0.001	<0.001	<0.001	**0.00315**
Methyl tert-butyl ether (MTBE)		0.00649	<0.001	<0.001	<0.001	<0.001	<0.001
Trichloroethene	0.005	**0.00261**	**0.00215**	<0.001	<0.001	**0.00332**	**0.0537**

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted.

[2] Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

< - Concentration less than the Laboratory Reporting Limit.

Bolded text indicates detection

Shaded text in **DP-58**
(14-16)

Close File

Table A-4
Summary of VOC Detections in Groundwater
Columbia Manufacturing Facility, Westfield, MA
December 2003

PARAMETER [1]	MCL [2]	LOCATION/SAMPLE DATE							
		MW-11I 12/19/03	MW-20B 12/19/03	MW-20C 12/19/03	MW-24S 12/19/03	MW-27S 12/07/03	MW-32I 12/19/03	MW-32S 12/19/03	MW-40I 12/19/03
Volatile Organics									
Acetone	--	<0.02	<0.02	<0.02	<1.0	**0.0376**	<0.1	<0.02	<0.02
Benzene	0.005	<0.001	<0.001	<0.001	<0.05	<0.001	**0.00675**	<0.001	<0.001
cis -1,2-Dichloroethene	0.07	**0.0208**	**0.00559**	<0.001	**0.296**	**0.00335**	**0.22**	<0.001	<0.001
Chloroform	0.08	<0.001	<0.001	<0.001	<0.05	**0.002**	<0.005	<0.001	<0.001
Ethylbenzene	0.7	<0.001	<0.001	<0.001	<0.05	**0.00233**	<0.005	<0.001	<0.001
Isospropylbenzene	--	<0.001	<0.001	<0.001	<0.05	**0.00306**	<0.005	<0.001	<0.001
n-Butylbenzene	--	<0.001	<0.001	<0.001	<0.05	**0.00231**	<0.005	<0.001	<0.001
n-Propylbenzene	--	**DP-58**	<0.001	<0.001	<0.05	**0.00489**	<0.005	<0.001	<0.001
Naphthalene	--	(14-16)	<0.001	<0.001	<0.05	**0.00876**	<0.005	<0.001	<0.001
sec-Butylbenzene	--	<0.001	<0.001	<0.001	<0.05	**0.00134**	<0.005	<0.001	<0.001
tert-Butylbenzene	--	<0.001	<0.001	<0.001	<0.05	<0.001	<0.005	<0.001	<0.001
Tetrachloroethene	0.005	**0.00574**	<0.001	<0.001	**0.402**	**0.307**	**0.0129**	<0.001	<0.001
Trichloroethene	0.005	**0.0396**	<0.001	<0.001	**3.38**	**0.00407**	**0.171**	<0.001	<0.001
1,2,4-Trimethylbenzene	--	<0.001	<0.001	<0.001	<0.05	**0.00927**	<0.005	<0.001	<0.001
1,3,5-Trimethylbenzene	--	<0.001	<0.001	<0.001	<0.05	**0.00246**	<0.005	<0.001	<0.001
Vinyl chloride	0.002	<0.001	**0.00118**	<0.001	**0.113**	<0.001	**0.0222**	<0.001	<0.001

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted.

[2] Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

< - Concentration less than the Laboratory Reporting Limit.

Bolded text indicates detection

Shaded text indicates concentration exceeds MCL.

NA - Not analyzed

Close File

Table A-4
Summary of VOC Detections in Groundwater
Columbia Manufacturing Facility, Westfield, MA
December 2003

PARAMETER [1]	MCL[2]	LOCATION/SAMPLE DATE					
		MW-40S 12/19/03	MW-43S 12/19/03	MW-45S 12/19/03	MW-46S 12/19/03	MW-51S 12/19/03	MW-53I 12/19/03
Volatile Organics							
Acetone	--	<0.02	<0.02	<0.02	<0.02	<0.02	<0.2
Benzene	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0124**
cis -1,2-Dichloroethene	0.07	<0.001	<0.001	<0.001	**0.00387**	**0.0806**	**0.198**
Chloroform	0.08	<0.001	<0.001	<0.001	**0.00165**	<0.001	<0.01
Ethylbenzene	0.7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
Isospropylbenzene	--	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
n-Butylbenzene	--	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
n-Propylbenzene	--	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
Naphthalene	--	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
sec-Butylbenzene	--	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
tert-Butylbenzene	--	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
Tetrachloroethene	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	**1**
Trichloroethene	0.005	**0.00277**	<0.001	<0.001	**0.00958**	**0.0698**	**0.498**
1,2,4-Trimethylbenzene	--	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
1,3,5-Trimethylbenzene	--	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
Vinyl chloride	0.002	<0.001	<0.001	<0.001	<0.001	**0.00687**	<0.01

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted.

[2] Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

< - Concentration less than the Laboratory Reporting Limit.

Bolded text indicates detection

Shaded text indicates concentration exceeds MCL.

NA - Not analyzed

Close File

Table A-5
Summary of Detections in Recovery Wells, Interim Groundwater System
Columbia Manufacturing Facility, Westfield, MA
February 2004

PARAMETER[1]	MCL[2]	LOCATION/SAMPLE DATE						
		RW-01 02/10/04	RW-02 02/10/04	RW-03 02/10/04	RW-04 02/10/04	RW-05 02/10/04	RW-06 02/10/04	RW-07 02/10/04
Volatile Organics								
1,1-Dichloroethane	--	<0.001	**0.00611**	**0.00131**	**0.00139**	<0.001	<0.001	<0.001
1,1-Dichloroethene	0.007	<0.001	**0.00472**	<0.001	<0.001	<0.001	<0.001	<0.001
cis -1,2-Dichloroethene	0.07	**0.0753**	**0.216**	**0.0279**	**0.0355**	**0.00303**	**0.0138**	**0.0176**
trans -1,2-Dichloroethene	0.1	<0.001	**0.00196**	<0.001	<0.001	<0.001	<0.001	<0.001
Methyl tert-butyl ether	--	<0.001	<0.001	<0.001	**0.00131**	<0.001	<0.001	<0.001
Tetrachloroethene	0.005	**0.00707**	**0.133**	**0.0163**	**0.014**	**0.00135**	**0.00854**	**0.00827**
Trichloroethene	0.005	**DP-58**	**1.65**	**0.205**	**0.148**	**0.0132**	**0.073**	**0.0809**
1,1,1-Trichloroethane	0.2	(14-16)	**0.00709**	**0.00126**	<0.001	<0.001	<0.001	<0.001
Vinyl chloride	0.002	**0.00495**	**0.0677**	**0.00535**	<0.001	<0.001	<0.001	<0.001

(1) Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted.

(2) Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

Shading indicates sample exceeds MCL.

< - Concentration less than the Quantitation Limit.

Bold indicates detections

Close File

Table A-6
Summary of VOCs Detected in Groundwater
Columbia Manufacturing Facility, Westfield, MA
October 2001

PARAMETER [1]	MCL[2]	LOCATION/SAMPLE DATE										
		MW-02S 10/01/01	MW-03I 10/02/01	MW-03S 10/02/01	MW-04D 10/03/01	MW-04I 10/02/01	MW-04S 10/02/01	MW-07S 10/01/01	MW-08S 10/01/01	MW-10I 10/02/01	MW-10S 10/02/01	MW-12S 10/01/01
Volatile Organics												
1,1,1-Trichloroethane	0.2	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
1,1-Dichloroethane		**0.0084**	<0.001	<0.001	<0.001	**0.0084**	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
1,1-Dichloroethene	0.007	<0.001	**0.0078**	**0.0052**	<0.001	**0.019**	**0.035**	**0.0033**	<0.001	<0.001	**0.0039**	<0.001
1,2,4-Trimethylbenzene		<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Acetone		<0.02	<0.02	<0.02	**0.095**	<0.1	<0.1	<0.02	<0.02	<0.02	<0.02	<0.02
Benzene	0.005	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Chloroform	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Chloromethane		**DP-58**	<0.002	<0.002	<0.002	<0.01	<0.01	<0.002	<0.002	<0.002	<0.002	<0.002
cis -1,2-Dichloroethene	0.07	**(14-16)**	**0.077**	**0.071**	<0.001	**0.055**	**0.37**	**0.019**	**0.0035**	**0.0094**	**0.046**	<0.001
Ethylbenzene	0.7	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Isopropylbenzene		<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Methyl tert-butyl ether		<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Naphthalene		<0.001	<0.005	<0.001	<0.001	<0.005	<0.005	<0.001	<0.005	<0.001	<0.001	<0.005
n-Butylbenzene		<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
n-Propylbenzene		<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
sec-Butylbenzene		<0.001	**0.0012**	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
tert-Butylbenzene		<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Tetrachloroethene	0.005	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Toluene	1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
trans -1,2-Dichloroethene	0.1	**0.0022**	**0.0013**	<0.001	<0.001	<0.005	**0.0068**	<0.001	<0.001	<0.001	<0.001	<0.001
Trichloroethene	0.005	**0.02**	**0.28**	**0.16**	<0.001	**4.6**	**1.1**	**0.0074**	**0.013**	**0.026**	**0.13**	<0.001
Vinyl chloride	0.002	**0.0011 j**	**0.034**	**0.0097**	<0.002	**0.021**	**0.077**	<0.001	<0.001	**0.0013**	**0.0061**	<0.001

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted

[2] Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

< - Concentration less than the Laboratory Reporting Limit.

j - Concentration considered an estimate based on data validation.

Shaded text indicates concentration exceeds MCL.

NA - Not analyzed

Close File

Table A-6
Summary of VOCs Detected in Groundwater
Columbia Manufacturing Facility, Westfield, MA
October 2001

PARAMETER [1]	MCL [2]	LOCATION/SAMPLE DATE									
		MW-14S 10/02/01	MW-16S 10/04/01	MW-17S 10/04/01	MW-18A 09/25/01	MW-19S 10/04/01	MW-21S 10/01/01	MW-22S 10/03/01	MW-26I 10/03/01	(DUP-03) MW-26I 10/03/01	MW-27S 09/25/01
Volatile Organics											
1,1,1-Trichloroethane	0.2	<0.005	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.0025	<0.0025	<0.001
1,1-Dichloroethane		<0.005	<0.001	<0.001	**0.056**	<0.001	<0.001	<0.001	<0.0025	<0.0025	<0.001
1,1-Dichloroethene	0.007	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.0025	<0.0025	<0.001
1,2,4-Trimethylbenzene		<0.005	<0.001	<0.001	<0.01	**0.0018**	<0.001	<0.001	<0.0025	<0.0025	**0.0043**
Acetone		<0.1	<0.02	<0.02	<0.2	<0.02	<0.02	<0.02	<0.05	<0.05	<0.02
Benzene	0.005	<0.005	<0.001	<0.001	<0.005	**0.0016**	<0.001	<0.001	<0.0025	<0.0025	<0.001
Chloroform	0.1	<0.005	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.0025	<0.0025	**0.0048**
Chloromethane		<0.01	<0.002	<0.002	<0.02	<0.002	<0.002	<0.002	<0.005	<0.005	**0.0023**
cis -1,2-Dichloroethene	0.07	**0.087**	<0.001	**0.003**	**0.8**	**0.0031**	<0.001	**0.027**	**0.081**	**0.075**	<0.001
Ethylbenzene	0.7	<0.005	<0.001	<0.001	<0.01	**0.018**	<0.001	<0.001	<0.0025	<0.0025	<0.001
Isopropylbenzene		<0.005	**0.0015**	<0.001	<0.01	**0.027**	<0.001	<0.001	<0.0025	<0.0025	**0.0019**
Methyl tert-butyl ether		<0.005	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.0025	<0.0025	<0.001
Naphthalene		<0.005	<0.005	<0.005	<0.01	**0.066**	<0.001	<0.001	<0.0025	<0.0025	<0.005
n-Butylbenzene		<0.005	**0.0034**	<0.001	<0.01	**0.012**	<0.001	<0.001	<0.0025	<0.0025	**0.0028**
n-Propylbenzene		<0.005	**0.0019**	<0.001	<0.01	**0.052**	<0.001	<0.001	<0.0025	<0.0025	**0.0036**
sec-Butylbenzene		<0.005	**0.0036**	<0.001	<0.01	**0.0087**	<0.001	<0.001	<0.0025	<0.0025	**0.0014**
tert-Butylbenzene		<0.005	<0.001	<0.001	<0.01	**0.0025**	<0.001	<0.001	<0.0025	<0.0025	<0.001
Tetrachloroethene	0.005	**0.009**	<0.001	<0.001	<0.005	<0.001	<0.002	**0.018**	**0.023**	**0.021**	**0.025**
Toluene	1	<0.005	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.0025	<0.0025	<0.001
trans -1,2-Dichloroethene	0.1	<0.005	<0.001	<0.001	**0.055**	<0.001	<0.001	<0.001	<0.0025	<0.0025	<0.001
Trichloroethene	0.005	**0.57**	<0.001	**0.0067**	<0.005	<0.001	**0.0043**	**0.049**	**0.18**	**0.17**	**0.0026**
Vinyl chloride	0.002	**0.041**	<0.001	<0.001	**0.29**	**0.0038**	<0.001	<0.001	<0.0025	<0.0025	<0.001

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted

[2] Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

< - Concentration less than the Laboratory Reporting Limit.

j - Concentration considered an estimate based on data validation.

Shaded text indicates concentration exceeds MCL.

NA - Not analyzed

Close File

Table A-6
Summary of VOCs Detected in Groundwater
Columbia Manufacturing Facility, Westfield, MA
October 2001

PARAMETER [1]	MCL[2]	LOCATION/SAMPLE DATE										
		MW-29S 10/01/01	MW-30I 10/01/01	(DUP-02) MW-30I 10/01/01	MW-35I 10/03/01	MW-35S 10/03/01	MW-38S 10/03/01	MW-39S 10/03/01	MW-41S 09/25/01	MW-47S 10/01/01	MW-48S 10/03/01	MW-50I 10/04/01
Volatile Organics												
1,1,1-Trichloroethane	0.2	<0.001	**0.0033**	**0.0033**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0025**	<0.005
1,1-Dichloroethane		<0.001	**0.0052**	**0.0066**	<0.001	<0.001	<0.001	**0.0023**	**0.0032**	<0.001	**0.0052**	<0.005
1,1-Dichloroethene	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0047**	<0.001	<0.001	<0.001	<0.001	**0.0067**
1,2,4-Trimethylbenzene		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005
Acetone		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1
Benzene	0.005	<0.001	<0.001	<0.001	**0.0021**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0071**
Chloroform	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005
Chloromethane		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.01
cis -1,2-Dichloroethene	0.07	<0.001	**0.004**	**0.0033**	**0.037**	<0.001	**0.092**	**0.0011**	**0.01**	**0.024**	**0.0032**	**0.25**
Ethylbenzene	0.7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0034**	<0.001	<0.001	<0.005
Isopropylbenzene		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0029**	<0.001	<0.001	<0.005
Methyl tert-butyl ether		<0.001	**0.016**	**0.019**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005
Naphthalene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.001	<0.005	**0.0034**	<0.001	<0.005	<0.005
n-Butylbenzene		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0028**	<0.001	<0.001	<0.005
n-Propylbenzene		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0031**	<0.001	<0.001	<0.005
sec-Butylbenzene		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0023**	<0.001	<0.001	<0.005
tert-Butylbenzene		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005
Tetrachloroethene	0.005	<0.001	<0.001	<0.001	**0.0041**	<0.001	<0.001	<0.001	**0.0057**	**0.027**	<0.001	<0.005
Toluene	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005
trans -1,2-Dichloroethene	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0026**	<0.001	<0.001	<0.001	<0.001	<0.005
Trichloroethene	0.005	**0.0053**	**0.0038**	**0.0034**	**0.069**	<0.001	**0.011**	**0.0014**	**0.0078**	<0.001	**0.0015**	**0.59**
Vinyl chloride	0.002	<0.001	<0.001	<0.001	<0.002	<0.001	**0.028**	<0.001	**0.0016**	<0.001	<0.001	**0.054**

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted

[2] Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

< - Concentration less than the Laboratory Reporting Limit.

j - Concentration considered an estimate based on data validation.

Shaded text indicates concentration exceeds MCL.

NA - Not analyzed

Close File

Table A-7
Summary of CVOCs Detected in Groundwater
Columbia Manufacturing Facility, Westfield, MA
March 2004

PARAMETER[1]	MCL[2]	LOCATION/SAMPLE DATE										
		DP-47 (13-15) 3/9/04	DP-48 (14-16) 03/09/04	DP-49 (22-24) 03/09/04	DP-50 (18-20) 03/09/04	DP-51 (15-17) 03/09/04	DP-52 (14-16) 03/10/04	DP-53 (13-15) 03/10/04	DP-54 (14-16) 03/10/04	DP-55 (15-17) 03/10/04	DP-56 (14-16) 03/10/04	DP-57 (21-23) 03/10/04
Volatile Organics												
cis -1,2-Dichloroethene	0.07	**0.252**	**0.174**	**0.114**	**0.0862**	**0.115**	**0.125**	**0.231**	**0.0882**	**0.226**	**0.265**	**0.964**
Tetrachloroethene	0.005	**24.7**	<0.01	**0.00665**	**0.00935**	**1.57**	**0.888**	**3.25**	**1.57**	**0.812**	**2.52**	**0.4**
Trichloroethene	0.005	**0.848**	**0.279**	**0.245**	**0.216**	**0.237**	**0.168**	**0.267**	**0.0608**	**0.0364**	**0.0934**	**0.576**
Vinyl chloride	0.002	**0.228**	**0.188**	**0.114**	**0.078**	**0.136**	**0.0783**	**0.0698**	**0.0112**	**0.0268**	**0.109**	**0.148**

PARAMETER[1]	MCL[2]	LOCATION/SAMPLE DATE										
		DP-58 (14-16) 3/10/04	DP-59 (14-16) 03/10/04	DP-60 (16-18) 03/10/04	DP-61 (16-18) 03/11/04	DP-62 (14-16) 03/11/04	DP-63 (13-15) 03/11/04	DP-64 (21-23) 03/11/04	DP-65 (22-24) 03/11/04	DP-66 (10-12) 03/11/04	DP-66 (20-22) 03/11/04	DP-68 (13-15) 03/12/04
Volatile Organics												
cis -1,2-Dichloroethene	0.07	**1.35**	**3.49**	**4.5**	**0.357**	**0.18 j**	**0.00979**	**0.343**	**0.126**	**0.00445**	**0.211**	**0.336**
Tetrachloroethene	0.005	**0.508**	**1.47**	**3480**	**0.271**	**0.00465 j**	<0.001	**0.0119**	**0.0148**	**0.00255**	**0.013**	**0.044**
Trichloroethene	0.005	**0.568**	**1.42**	**194**	**0.499**	**0.139 j**	**0.00431**	**0.176**	**0.117**	<0.0025	**0.374**	**2.22**
Vinyl chloride	0.002	**0.31**	**0.248**	< 2.5	**0.0782**	**0.0748 j**	**0.00524**	**0.268**	**0.104**	<0.0025	**0.0926**	**0.373**

(1) Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted.

(2) Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

( ) - Direct push sample collection depth

j - Concentration considered an estimate based on data validation.

< - Concentration less than the Quantitation Limit.

Bolded text indicates detections

Shaded text indicates concentration exceeds MCL.

Close File

Table A-8
Summary of Detections in Groundwater
Columbia Manufacturing Facility, Westfield, MA
March 2004

PARAMETER[1]	MCL[2]	LOCATION/SAMPLE DATE									
		MW-04S 03/10/04	(DU-04103) MW-04S 03/10/04	MW-09I 03/04/04	MW-09S 03/04/04	MW-10I 03/05/04	MW-10S 03/05/04	(DU-04102) MW-10S 03/05/04	MW-12I 03/04/04	MW-12S 03/04/04	MW-16SR 03/06/04
Volatile Organics											
Benzene	0.005	<0.005	<0.005	NA	NA	NA	NA	NA	NA	NA	NA
1,1-Dichloroethene	0.007	**0.0208**	**0.0198**	NA	NA	NA	NA	NA	NA	NA	NA
cis -1,2-Dichloroethene	0.07	**0.256**	**0.254**	**0.0429**	**0.00524**	**0.07**	**0.0643**	**0.0661**	**0.293**	<0.001	**0.00492**
trans -1,2-Dichloroethene	0.1	<0.005	<0.005	<0.001	<0.001	**0.00106**	**0.00104**	**0.00112**	<0.005	<0.001	<0.001
Tetrachloroethene	0.005	<0.005	<0.005	**0.0363**	**0.00133**	<0.001	<0.001	<0.001	**0.168**	<0.001	<0.001
Trichloroethene	0.005	**0.951**	**0.958**	**0.102**	**0.0138**	**0.226**	**0.198**	**0.214**	**0.49**	<0.001	**0.0362**
Vinyl chloride	0.002	**DP-58**	**0.0758**	**0.00209**	<0.001	**0.0107**	**0.0106**	**0.0229**	**0.0251**	<0.001	**0.00256**
Field Parameters		(14-16)									
Conductance, specific (us/cm)	--	399	NA	715	322	334	330	NA	412	70	906
Dissolved Oxygen	--	0.06	NA	0	1.24	0.33	0.22	NA	0.16	7.17	0
Iron, ferrous	--	4	NA	NA	0	NA	NA	NA	NA	0	NA
ORP (mV)	--	30	NA	185	181	176	166	NA	120	194	-14
pH (su)	--	6.1	NA	5.7	5.8	5.7	5.9	NA	7.8	5.2	6.6
Temperature (^{o}C)	--	8.3	NA	13.3	10.6	13.4	12.6	NA	14.4	12.6	11.3
Turbidity (ntu)	--	3.02	NA	67.9	0.31	35.7	1	NA	1.79	0.93	5.06

(1) Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted.

(2) Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

j - Concentration considered an estimate based on data validation.

< - Concentration less than the Quantitation Limit.

Bolded text indicates detections

Shaded text indicates concentration exceeds MCL.

NA- Not analyzed

Close File

Table A-8
Summary of Detections in Groundwater
Columbia Manufacturing Facility, Westfield, MA
March 2004

PARAMETER[1]	MCL[2]	LOCATION/SAMPLE DATE									
		MW-17S 03/06/04	MW-21S 03/07/04	MW-23I 03/07/04	MW-26I 03/04/04	MW-27I 03/10/04	MW-27S 03/06/04	MW-29S 03/07/04	MW-30I 03/11/04	MW-34S 03/29/04	MW-35I 03/04/04
Volatile Organics											
Benzene	0.005	NA	NA	NA	NA	<0.5	NA	NA	<0.001	NA	NA
1,1-Dichloroethene	0.007	NA	NA	NA	NA	<0.5	NA	NA	<0.001	NA	NA
cis -1,2-Dichloroethene	0.07	**0.0332**	<0.001	<0.001	**0.0641**	<0.5	**0.0014**	<0.001	**0.001**	**0.0582**	**0.049**
trans -1,2-Dichloroethene	0.1	<0.001	<0.001	<0.001	<0.0005	<0.5	<0.001	<0.001	<0.001	NA	<0.001
Tetrachloroethene	0.005	<0.001	<0.001	<0.001	**0.0926**	**79.1**	**0.32**	<0.001	<0.001	**0.0058**	**0.00493**
Trichloroethene	0.005	**0.00753**	<0.001	<0.001	**0.179 j**	**3.63**	**0.00344**	**0.00121**	**0.0013**	**0.128**	**0.094**
Vinyl chloride	0.002	**0.0105**	<0.001	<0.001	**0.00056**	<0.5	<0.001	<0.001	<0.001	**0.0105**	**0.00299**
Field Parameters											
Conductance, specific (us/cm)	--	755	129	276	139	1732	1138	121	852	1022	470
Dissolved Oxygen	--	0	4.95	1.68	3.37	999.99	0	5.53	0	NA	0.02
Iron, ferrous	--	NA	NA	0	0	0	1	0	0	NA	NA
ORP (mV)	--	-70	249	262	171	-75	366	237	140	NA	107
pH (su)	--	6.5	5.3	6.0	5.8	7.6	3.9	5.8	5.8	6	7.9
Temperature (^{o}C)	--	12.7	8.5	9.4	9.2	17.9	18	8.8	10.8	19.1	12.8
Turbidity (ntu)	--	253	1.48	0.36	0	OFF SCALE	3.81	1.42	0.79	NA	1.05

(1) Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted.

(2) Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

j - Concentration considered an estimate based on data validation.

< - Concentration less than the Quantitation Limit.

Bolded text indicates detections

Shaded text indicates concentration exceeds MCL.

NA- Not analyzed

Close File

Table A-8
Summary of Detections in Groundwater
Columbia Manufacturing Facility, Westfield, MA
March 2004

PARAMETER[1]	MCL[2]	LOCATION/SAMPLE DATE						
		MW-35S 03/05/04	MW-36S 03/13/04	MW-39S 03/06/04	MW-41S 03/06/04	MW-48S 03/07/04	MW-50I 03/10/04	MW-52S 03/06/04
Volatile Organics								
Benzene	0.005	NA	NA	NA	NA	NA	**0.0062**	NA
1,1-Dichloroethene	0.007	NA	NA	NA	<0.001	NA	**0.0101**	<1
cis -1,2-Dichloroethene	0.07	<0.0005	**0.0168**	<0.001	**0.0792**	<0.001	**0.314**	<1
trans -1,2-Dichloroethene	0.1	<0.0005	NA	<0.001	<0.001	<0.001	<0.005	<1
Tetrachloroethene	0.005	<0.0005	**0.009**	<0.001	**0.00307**	<0.001	**0.019**	**61.5**
Trichloroethene	0.005	**0.00052**	**0.0116**	<0.001	**0.00194**	<0.001	**1.05**	**1.19**
Vinyl chloride	0.002	<0.0005	**0.0228**	<0.001	**0.0132**	<0.001	**0.093**	<1
Field Parameters								
Conductance, specific (us/cm)	--	98	NA	132	432	374	1487	900
Dissolved Oxygen	--	3.96	NA	3.96	0.11	2.55	0	0
Iron, ferrous	--	NA	NA	NA	10	NA	NA	0
ORP (mV)	--	132	NA	97	-40	263	-118	18
pH (su)	--	6.3	NA	6.1	5.4	6.0	7.9	6.6
Temperature (^{o}C)	--	6.4	NA	6.4	17.2	8.5	13.1	18.7
Turbidity (ntu)	--	6.74	NA	21.2	49.5	0.68	787	27.7

[1] Analytical results are reported in milligrams per liter (mg/L) unless otherwise noted.

[2] Maximum Contaminant Level (*Drinking Water Standards and Health Advisories* ; USEPA, Summer 2000).

j - Concentration considered an estimate based on data validation.

< - Concentration less than the Quantitation Limit.

Bolded text indicates detections

Shaded text indicates concentration exceeds MCL.

NA- Not analyzed

Close File

Attachment B
Modeling Results

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Groundwater Flow and Transport Model Documentation

This attachment summarizes flow and transport modeling of CVOC-affected groundwater at the site, located in Westfield, Massachusetts. A groundwater flow model previously completed for the site was updated to include information obtained in 2003 and 2004. Groundwater transport modeling was conducted to estimate the remediation time frames for various possible remediation scenarios at the site. This attachment describes the modeling approach and data inputs, and summarizes the groundwater modeling results.

Background

CVOCs have been identified in two areas of the site; the north CVOC plume occurs in the northern portion of the site, and the south CVOC plume occurs in the southern portion of the site. During 2002, a migration control system was installed along the northern property boundary of the site to address the north CVOC plume. The system has operated since March 2003, and continues to recover groundwater from the northern portion of the site. Water levels have been measured at the site during operation of the system, and pumping rates of the wells have also been recorded. Periodic groundwater sampling has been conducted to determine CVOC concentrations in groundwater.

Subsequent to installation of the migration control system, the decision was made to implement interim remedial measures at the site for both the north CVOC plume and the south CVOC plume. The planned interim measures consist of source reduction combined with MNA and, for the north CVOC plume, continued operation of the migration control system for five years.

A groundwater flow model of the site was developed in 2002 to support the design of the migration control system. This flow model has been recently updated to reflect information collected during field investigations conducted subsequent to installation of the migration control system. Groundwater transport simulations of the north and south CVOC plumes have been completed based on the revised groundwater flow model.

Conceptual Model

The conceptual model upon which the numerical groundwater flow model is based was described in a July 26, 2002, technical memorandum submitted as Appendix B to *Interim Corrective Measures Workplan and Design Report, Light Nonaqueous-Phase Liquid (LNAPL) Extraction and Property Line Migration Control System* document (RMT, 2002). The basic conceptual model of the site remains unchanged in 2004.

Modeling Approach

MODFLOW and RT3D were selected for use in these simulations since they are well-documented public-domain codes, which are generally familiar to and accepted by regulatory agencies. The following summarizes the computer software used in the groundwater flow and transport modeling:

- Groundwater flow modeling was completed using the MODFLOW-2000 computer software (Harbaugh and McDonald, 1988; Harbaugh et. al, 2000). MODFLOW is a finite-difference model that

can be used to simulate three-dimensional groundwater flow in a heterogeneous and anisotropic system.

- Transport modeling to evaluate the migration of CVOCs at the site was completed using the RT3D computer software (Clement, 1997). RT3D is s three-dimensional, multi-species, reactive transport model based on MT3D (Zheng and Wang, 1999), and is used in conjunction with the groundwater flow model MODFLOW. RT3D incorporates the processes of advection, dispersion, diffusion, sorption, and degradation, and is readily applied to modeling natural attenuation processes such as biotic or abiotic chemical reactions. The groundwater flow field from the calibrated MODFLOW model is used in conjunction with an input/output data structure similar to the MT3D code. Nine "modules" of the RT3D software are available, with the user selecting the module representing the appropriate kinetic model for a particular application. For simulation of the transformation of PCE, TCE, and DCE, the RT3D code module simulates sequential degradation of these compounds via first-order decay kinetics.

Groundwater Flow Model Construction

The structure and basis for the groundwater flow model was originally described in the July 26, 2002, technical memorandum. The model domain extends from the site to the Little River on the south and east, and approximately 1,000 feet to the north and 1,200 feet to the west of the site (Figure B-1). This model domain is unchanged from that of the 2002 groundwater flow model. The model grid has been refined to provide a smaller cell size, particularly in the vicinity of the migration control system pumping wells. The minimum cell size in the revised model grid is approximately 8 by 10 feet, while the maximum cell size is approximately 50 feet by 50 feet. The model is structured with 123 rows, 170 columns, and four layers; layer 1 represents the alluvium/glacial drift, layer 2 represents the lacustrine unit, layer 3 represents the glacial till unit, and layer 4 represents the bedrock.

Elevations defining the top and bottom of each layer are assigned based on contoured surfaces generated using unit contacts identified from borehole data at the site. Elevations for the bottom of layer 1/top of layer 2 (the bottom of the alluvium/top of the lacustrine unit) have been updated in the 2004 flow model based on data collected during field investigations conducted in 2003 and 2004 (see Figure B-2 for the revised layer elevation configuration). Other model domain and boundary conditions remain the same as those defined in the model developed in 2002.

The model was recalibrated in 2004 to pumping water levels observed in December 2003 during operation of the migration control system. Pumping rates for the wells were assigned based on operational information collected during 2003. Recalibration involved modification of the hydraulic conductivity distribution in Layer 1 and adjustment of the recharge values across the model domain. Table B-1 lists the range of hydraulic conductivity values used in each layer of the model.

Table B-1
Groundwater Flow Model Hydraulic Conductivity Values

GEOLOGIC MATERIAL (Model Layer)	HYDRAULIC CONDUCTIVITY RANGE (Feet per day)
Alluvium/Glacial Drift (Layer 1)	0.2 to 20
Lacustrine (Layer 2)	1.96 to 3.0
Glacial Till (Layer 3)	0.5
Bedrock (Layer 4)	2.8

Calibration statistics were used to compare the measured hydraulic head values to the model-calculated hydraulic heads. Calibration statistics were calculated based on all wells for which water level measurements were available from December 2003. The resulting calibration statistics, summarized in Table B-2, are considered acceptable for the purpose of this modeling effort. The low mean error for the wells screened in the alluvium is important since most of the CVOC transport occurs through this unit. Figure B-3 presents the calculated versus observed water levels in graph form for site wells.

Table B-2
Groundwater Flow Model Calibration Statistics

CALIBRATION STATISTIC	ALL WELLS (feet)	SHALLOW WELLS (ALLUVIUM) ONLY (feet)
Mean Error	1.40	-0.09
Mean Absolute Error	2.68	1.79
Root Mean Square Error	3.53	2.39

Transport Model Construction

The conceptual model for the site includes the assumption that PCE and TCE were used for the manufacturing process, and the presence of *cis*-1,2-DCE and vinyl chloride in the aquifer is a result of reductive dechlorination of PCE and TCE. Groundwater transport modeling was conducted to simulate the migration and distribution of PCE, TCE, *cis*-1,2-DCE, and vinyl chloride under various potential remediation scenarios at the site. Transport simulations take into account the transformation of PCE to TCE to *cis*-1,2-DCE to vinyl chloride, as well as physical processes such as advection, dispersion and sorption.

The north CVOC plume and the south CVOC plume have been modeled independently (each based on the flow model described above) in order to predict the fate of the chlorinated compounds in groundwater for the north and for the south portion of the site. In order to conserve computer memory and to improve transport model run times, model layers 1 and 2 were specified to be active for transport simulations.

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Aquifer porosity and dispersivity were defined in the transport model based on information about geologic materials present at the site and the general distribution of the CVOC plumes observed at the site. Table B-3 summarizes porosity and dispersivity values assigned to the transport model domain (the same dispersivity and porosity values were assigned to both the north CVOC and south CVOC plume areas in the transport model).

Table B-3
Groundwater Transport Model Porosity and Dispersivity Values

GEOLOGIC MATERIAL (Model Layer)	POROSITY	LONGITUDINAL DISPERSIVITY (feet)	TRANSVERSE DISPERSIVITY (feet)	VERTICAL DISPERSIVITY (feet)
Alluvium/Glacial Drift (Layer 1)	0.25	100	30	5.6
Lacustrine (Layer 2)	0.20	75	22.5	4.2

A bulk density of 1.5 g/cc was assigned to both the alluvium/glacial drift and the lacustrine materials throughout the transport model domain.

RT3D allows for the retardation of compounds due to sorption onto aquifer materials, resulting in a constituent migration rate slower than the rate of groundwater flow. Retardation is represented by use of a distribution coefficient (sorption constant) for each compound; for purposes of this model, a linear sorption function is considered appropriate. The distribution coefficient (Kd) is the product of the organic carbon content of the aquifer (f_{oc}) and the organic-carbon partition coefficient (K_{oc}) of the specific compound. The distribution coefficient is used in the program along with the bulk density and the porosity to calculate a retardation factor for each CVOC. The distribution coefficient for each CVOC was determined based on literature values (USEPA, 1990; USEPA, 1996) for the Koc of each compound in the north and south plumes, and estimated values of f_{oc} in the aquifer. A value of 0.4 percent organic carbon (0.004) was considered representative for the north CVOC plume, based on fraction organic carbon measurements made on subsurface soil samples collected at the site. For the south CVOC plume, a slightly higher fraction organic carbon of 0.5 percent (0.005) was assigned to more closely match plume dimensions. Kd values used in the model for the north area CVOC plume and the south area CVOC plume are presented in Table B-4.

Table B-4
Groundwater Transport Model Sorption Parameters

NORTH PLUME CVOC	K_{oc} (ml/g) (USEPA, 1990)	Kd (ml/g) f_{oc} = 0.004
PCE	155	0.62
TCE	166	0.664
DCE	35.5	0.142
Vinyl Chloride	57	0.228

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Table B-4
Groundwater Transport Model Sorption Parameters

SOUTH PLUME CVOC	K_{oc} (ml/g) (USEPA, 1996)	Kd (ml/g) f_{oc} = 0.005
PCE	155	0.775
TCE	166	0.830
DCE	35	0.175
Vinyl Chloride	19	0.095

The RT3D model input includes a first-order degradation rate constant assigned for each CVOC. This degradation rate constant specifies the decay rate of the compound in the decay sequence. Site-specific degradation rates for each constituent in the north plume and in the south plume were calculated separately using the Buscheck and Alcantar (1995) method. This method couples a regression of constituent concentration versus distance with an analytical solution for one-dimensional steady-state transport in groundwater. For the north CVOC plume, the calculations were based on the plume configuration mapped in June 2002, prior to startup of the property line migration control system. For the south CVOC plume, the calculations were based on data collected in 2001 and 2004. Degradation rates for each constituent are presented in Table B-5.

Table B-5
Groundwater Transport Model Degradation (Decay) Rates

NORTH PLUME CVOC	DEGRADATION RATE (day^{-1})	HALF-LIFE (Days)
PCE	0.002700	257
TCE	0.003767	184
DCE	0.002	347
Vinyl Chloride	0.0075	92
SOUTH PLUME CVOC	**DEGRADATION RATE (day^{-1})**	**HALF-LIFE (Days)**
PCE	0.0021	330
TCE	0.00038	1,824
DCE	0.0043	161
Vinyl Chloride	0.00058	1,194

Simulation of Remediation Scenarios

The groundwater transport models were used to assist in the evaluation of the fate and transport of CVOCs for the north and south plumes under potential alternative remediation scenarios. Two potential scenarios were modeled for each plume. Scenario 1 for each plume consists of no additional remedial action, with no specific treatment of potential or suspected CVOC sources identified at each plume.

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Initial concentrations for CVOCs in Scenario 1 simulations were defined based on existing concentrations observed at the site in October 2002, December 2003, and March 2004. The isoconcentration contours for the recent CVOC data were digitized and interpolated to the model grid using a linear interpolation method.

Simulation of North CVOC Plume Scenarios

Scenario 1 for the north CVOC plume consists of continued operation of the migration control system for a period of 20 years, followed by MNA of the CVOCs remaining in groundwater. No active treatment would be implemented for source areas or high-concentration CVOC areas of the aquifer, though operation of the migration control system would continue. The primary mechanisms for aquifer remediation under this scenario are flushing of the subsurface materials (induced by groundwater recovery) and degradation of the CVOCs in groundwater and soils over time. This scenario was simulated by starting with the initial concentrations defined for the north area CVOC plume, running the model for a period of 20 years with the migration control system in operation, then continuing to simulate the migration of CVOCs with the pumping wells turned off. Under this scenario, groundwater concentrations of the CVOCs would reach MCLs at periods ranging from approximately 20 years for PCE to approximately 32 years for vinyl chloride. Figure B-4 illustrates the initial groundwater concentrations for PCE, and subsequent simulated PCE concentrations at 10 years and 20 years into the future. Figure B-5 illustrates initial and future projected concentrations of TCE, and Figure B-6 illustrates the information for vinyl chloride.

Scenario 2 for the north CVOC plume consists of oxidation treatment of the source area soils that remain in place and oxidation treatment of groundwater, supplemented with continued operation of the migration control system for a limited period of time following oxidation treatment. The primary mechanisms for aquifer remediation under this scenario are the reduction of CVOC concentrations in soil and groundwater via treatment of the high-concentration CVOC areas, flushing of the subsurface materials (induced by groundwater recovery), and degradation of the CVOCs in groundwater over time. For the simulation of this scenario, it was assumed that, within the treatment area, concentrations of TCE in groundwater currently above 1 mg/L will be reduced to a maximum of 1 mg/L following oxidation treatment, and concentrations of PCE, DCE, and vinyl chloride will be reduced to values equal to their respective MCLs. Thus, post-treatment concentrations assigned in the model for the treatment area are 1 mg/L for TCE, 0.005 mg/L for PCE, 0.07 mg/L for *cis*-1,2-DCE, and 0.002 mg/L for vinyl chloride. Under this scenario, CVOCs in groundwater reach concentrations below MCLs in a minimum of 5 years for PCE to a maximum of 25 years for vinyl chloride. Figure B-7 illustrates the initial groundwater concentrations for PCE assigned in the transport model for simulating this scenario, with the resulting concentrations at 10 years and 20 years following the oxidation treatment. Figures B-8 and B-9 illustrates the initial concentrations and projected future concentrations of TCE and vinyl chloride under this scenario. Table B-6 summarizes the estimated time required for the CVOC plumes to reach MCLs for Scenarios 1 and 2.

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Table B-6
Groundwater Transport Model Estimated Transport Model Results

NORTH PLUME SCENARIO	DESCRIPTION	TIME UNTIL ENTIRE PLUME <MCL (YEARS)			
		PCE	TCE	DCE	VINYL CHLORIDE
1	Operate migration control system for 20 years followed by MNA	20	28	20	32
2	Source area treatment, operate migration control system for 5 more years	5	23	14	25

SOUTH PLUME SCENARIO	DESCRIPTION	TIME UNTIL PLUME (>MCL) REACHES RIVER (YEARS)				TIME UNTIL ENTIRE PLUME <MCL (YEARS)			
		PCE	TCE	DCE	VINYL CHLORIDE	PCE	TCE	DCE	VINYL CHLORIDE
1	PCE and TCE constant source areas	Unlikely to happen	~ 75	Unlikely to happen	~ 60	10s to 100s	10s to 100s	10s to 100s	10s to 100s
2a	Source area treatment, low degradation rates	Unlikely to happen	Unlikely to happen	Unlikely to happen	Unlikely to happen	38	154	2	144
2b	Source area treatment, high degradation rates	Unlikely to happen	Unlikely to happen	Unlikely to happen	Unlikely to happen	30	34	20	34

Simulation of South CVOC Plume Scenarios

Scenario 1 for the south area CVOC plume consists of no active remediation of the high-concentration CVOC areas. The primary mechanism for aquifer remediation under this scenario is degradation of the CVOCs in groundwater and soils over time. In simulating this scenario, areas where PCE and TCE were detected at concentrations >1 percent of their solubility were defined as PCE and TCE source areas in the transport model. It is not unreasonable to expect that depletion of CVOCs from these source areas would require several decades to hundreds of years; thus, these source areas were defined as constant sources in the transport model. This representation of plume conditions in the model means that the simulated CVOC plume in the aquifer will persist until the CVOC source is depleted – potentially hundreds of years.

Under this simulated condition of continuous PCE and TCE sources, TCE and vinyl chloride would reach the Little River at concentrations greater than MCLs, and at periods ranging from approximately 60 years in the future (for vinyl chloride) to 75 years in the future (for TCE). The higher degradation rates for the PCE and DCE results in both of these plumes reaching a "steady state," in which neither plume is likely to reach the Little River at concentrations above their respective MCLs. Table B-6 summarizes the estimated time required for the CVOC plumes to reach the Little River and for the entire plume to reach MCLs for Scenario 1. Figures B-10 to B-12 illustrates the initial PCE, TCE, and vinyl chloride concentrations, respectively under Scenario 1 with the modeled concentrations at 25 and 50 years in the future.

Scenario 2 for the south area CVOC plume consists of oxidation treatment of the high-concentration CVOC areas, followed by MNA of the remaining CVOCs in groundwater. The oxidation treatment area is defined by the area of the plume having PCE concentrations greater than 1 mg/L. For the simulation of this scenario, it was assumed that, within the treatment area, concentrations of PCE and TCE in groundwater currently above 1 mg/L will be reduced to a maximum of 1 mg/L following oxidation treatment, and concentrations of DCE and vinyl chloride will be reduced to values equal to their respective MCLs.

Thus, post-treatment concentrations assigned in the model for the treatment area are 1 mg/L for PCE and TCE, 0.07 mg/L for DCE, and 0.002 mg/L for vinyl chloride.

Two variations of this scenario were developed for this modeling evaluation. The first variation (identified as Scenario 2a) is based on degradation rates for the CVOCs calculated from the south CVOC plume data using the Buscheck and Alcantar(1995) regression method (described in the discussion about the transport model construction). The second variation (identified as Scenario 2b) is based on the use of degradation rates comparable to the north CVOC plume, reflecting a faster degradation of the CVOCs in the groundwater.

Under both of these treatment scenarios, none of the CVOCs are expected to reach the Little River at concentrations greater than the MCL. The estimated amount of time required to fall below MCLs was determined by the model for each of the CVOCs. The estimated times to fall below MCLs for Scenario 2a range from 2 years for DCE to 154 years for TCE. The estimated times to

fall below MCLs for Scenario 2b range from 20 years for DCE to 34 years for TCE and vinyl chloride. Table B-6 presents the estimated time for the CVOC plumes to reach the river at concentrations above the MCLs and the time for each CVOC to fall below the MCL for Scenarios 2a and 2b.

Figure B-13 illustrates the initial groundwater concentrations for PCE assigned in the transport model for simulating Scenario 2a, with the resulting PCE concentrations at 20 and 36 years following the oxidation treatment. Figures B-14 to B-15 illustrates the initial TCE and vinyl chloride concentrations, respectively, under Scenario 2a with the modeled concentrations at 50 and 100 years in the future. Figure B-16 illustrates the initial groundwater concentrations for PCE assigned in the transport model for simulating Scenario 2b, with the resulting PCE concentrations at 14 and 28 years following the oxidation treatment. Figures B-17 to B-18 illustrates the initial TCE and vinyl chloride concentrations, respectively, under Scenario 2b with the modeled concentrations at 16 and 32 years in the future.

Discussion of Results

The evaluation of potential remediation scenarios for the north and south area CVOC plumes indicates that active treatment of the high-concentration CVOC areas will decrease the time required for the CVOC plume areas to ultimately achieve MCLs. It is important to recognize that the modeled output assumes that the treatment effectively removed the CVOC sources, which may be present at the site. Under this assumption, active treatment in the north CVOC plume area will allow for the property line migration control system to be shut down earlier than would be otherwise possible, while achieving MCLs in groundwater in a shorter time period. For the south CVOC plume area, active treatment of the high-concentration CVOC areas will reduce constituent concentrations such that CVOCs will not reach the Little River, or such that CVOC concentrations in groundwater discharging to the Little River will be below MCLs. Thus, the advantages of active treatment of the high-concentration CVOC areas in groundwater are illustrated from the modeling results.

The transport modeling results are strongly influenced by the presence of source areas, and the distribution coefficient and degradation rate coefficients assigned to each constituent simulated in the transport calculations. Values for these parameters have been assigned in the transport models based on our understanding of site conditions, information gathered from technical literature, and professional judgment. However, actual field values of these parameters may differ from what has been assigned in the model; actual field values may also vary spatially or temporally at the site. Thus, the model results should be considered indicative of what may be expected under the different remediation scenarios simulated, and the time frames developed from the model simulations should be considered relative estimates of the times within which the desired results (attainment of MCLs) will be achieved.

Close File

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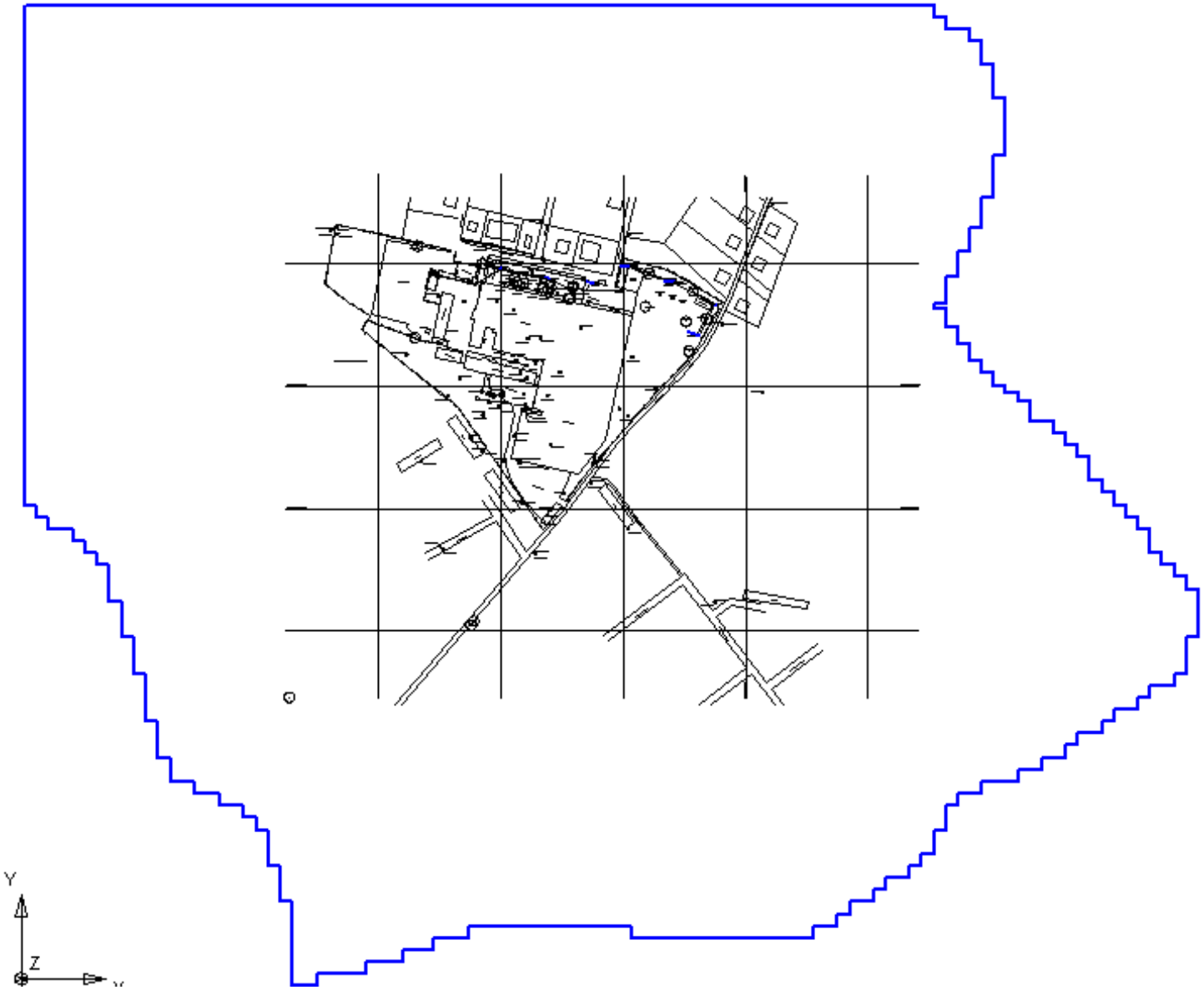

Figure B-1 Model Domain

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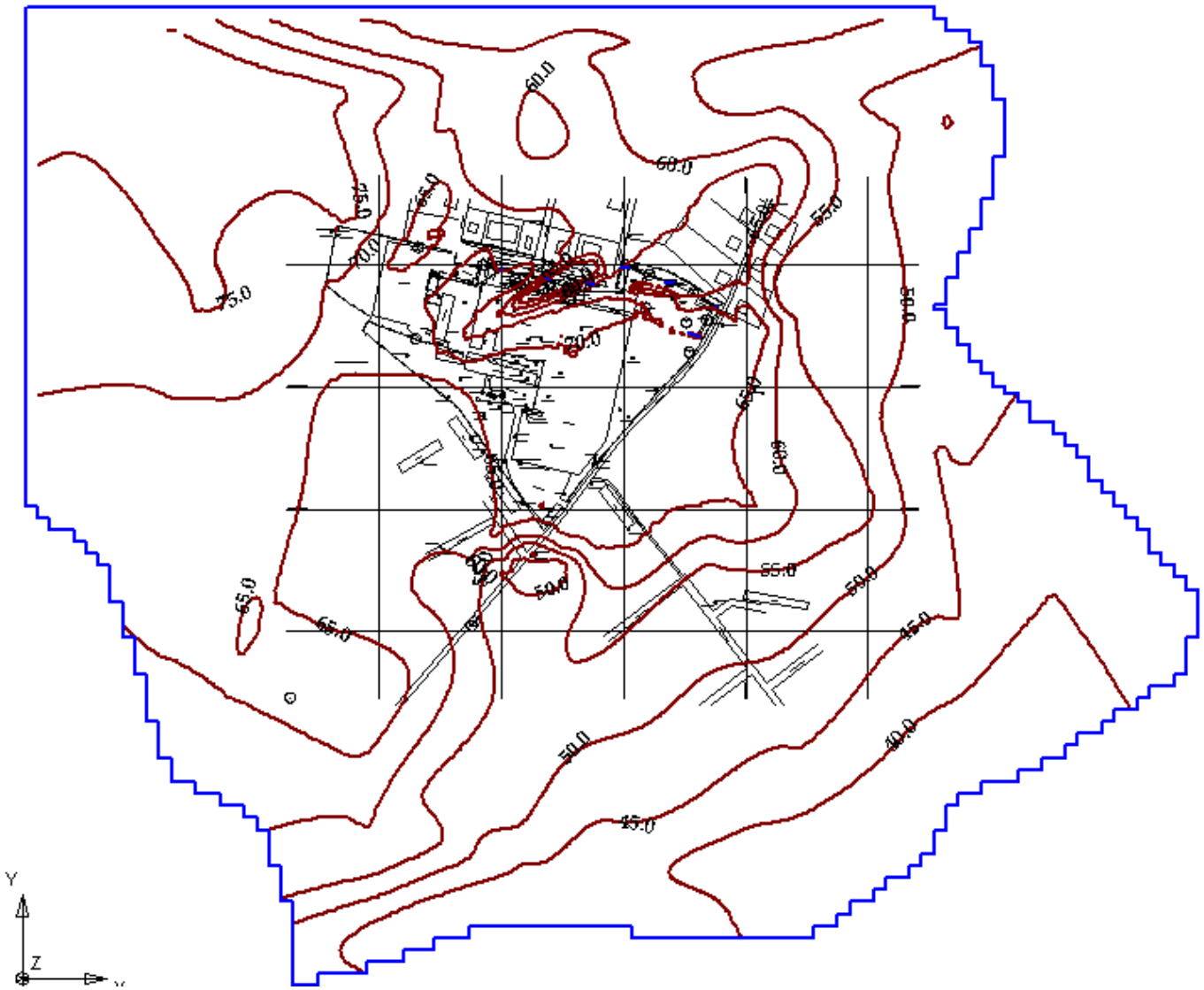

Figure B-2 Elevations of Bottom of Layer 1/Top of Layer 2

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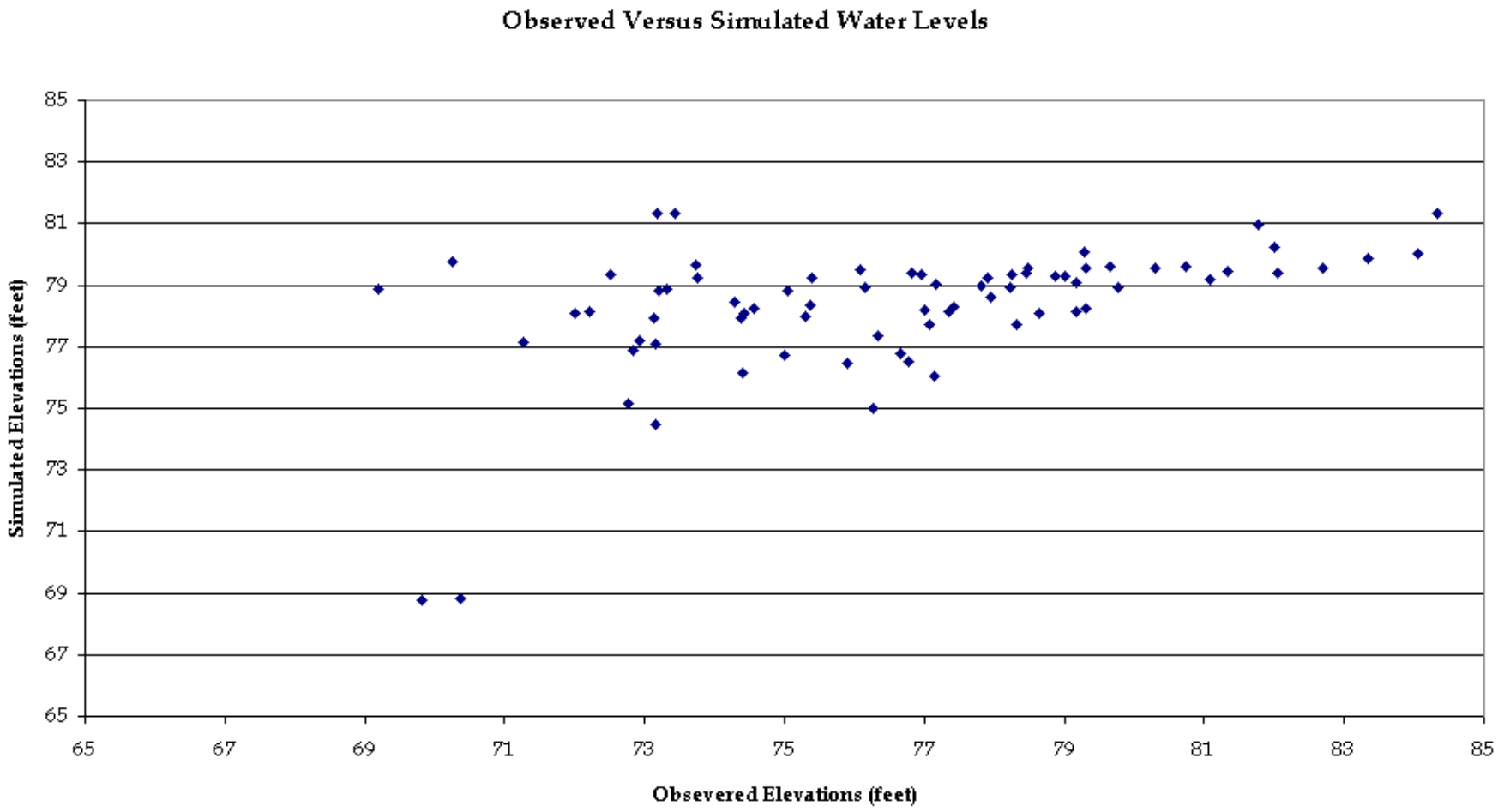


Figure B-3 Graph of Observed versus Modeled (Simulated) Water Levels

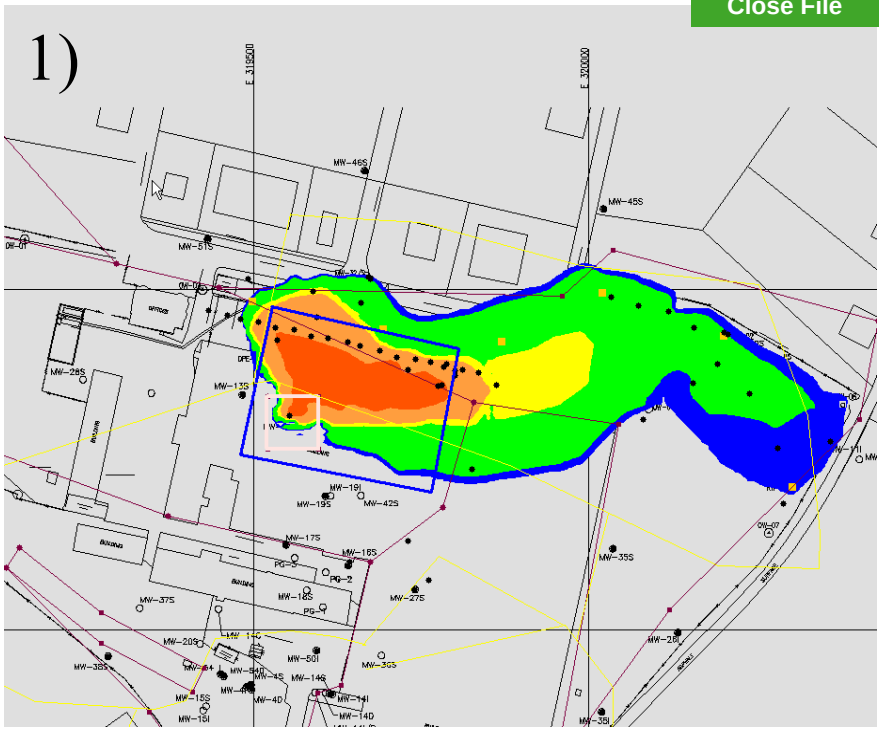
FIGURE B-4

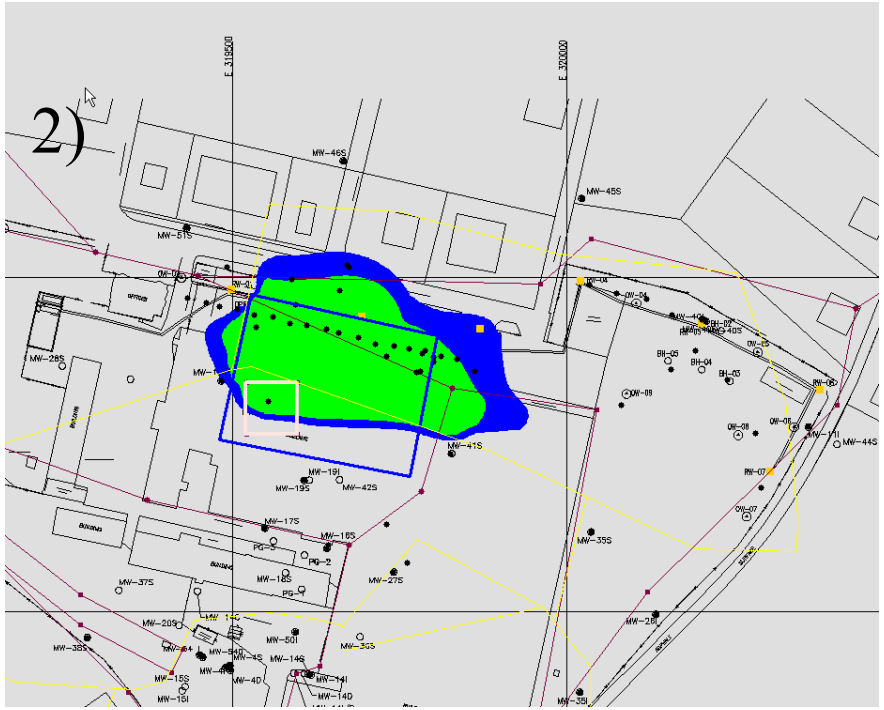
Scenario 1: PCE

1) Existing groundwater
2) 10 years
3) 20 years

Legend:

Blue = 0.005 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 0.5 mg/L
Red Orange = 0.5 to 1 mg/L
Red = 1 to 10.5 mg/L





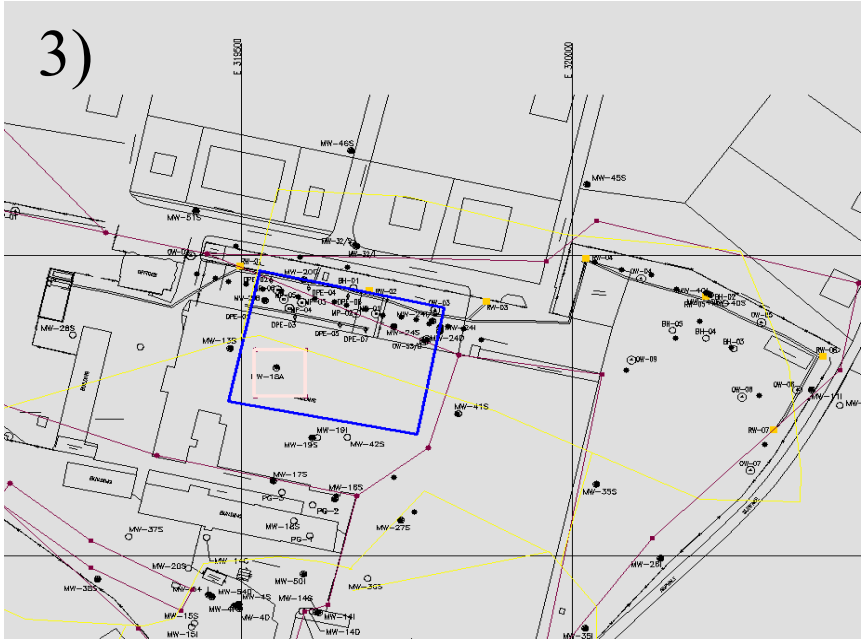


FIGURE B-5

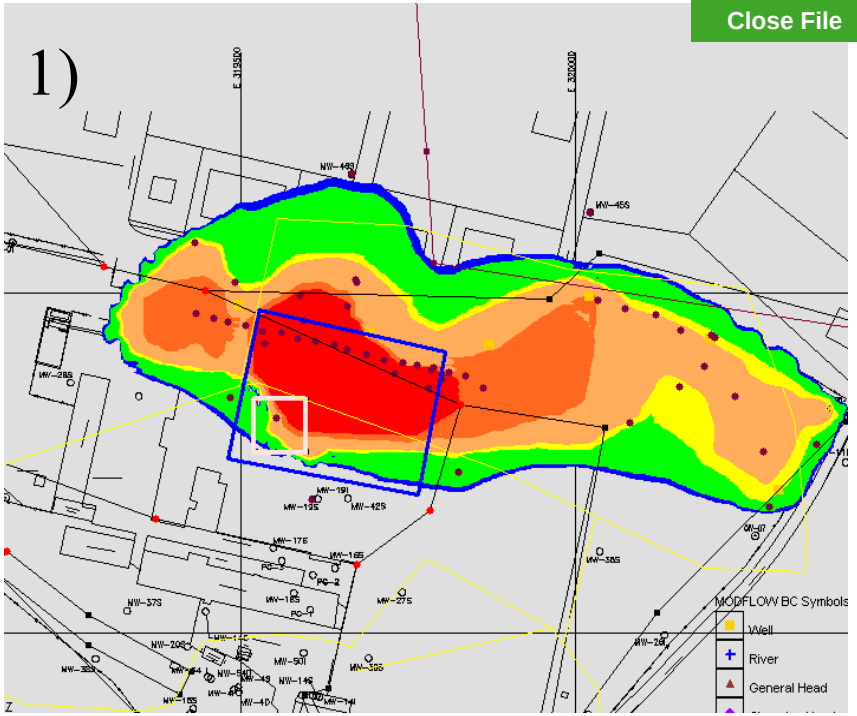
Scenario 1: TCE

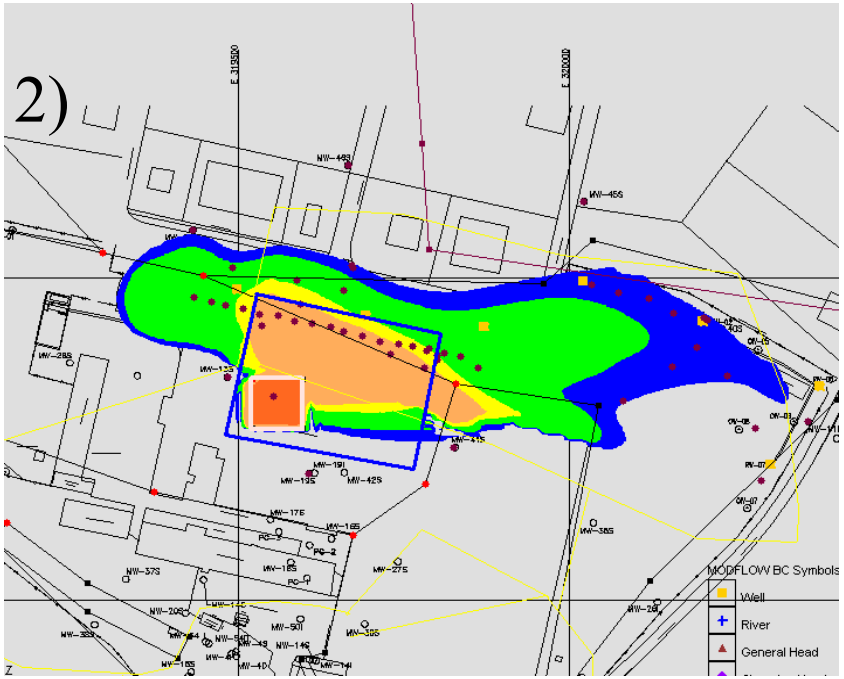
1) Existing groundwater
2) 10 years
3) 20 years

Concentrations below MCLs after 28-29 years.

Legend:

Blue = 0.005 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 0.5 mg/L
Red Orange = 0.5 to 1 mg/L
Red = 1 to 10.5 mg/L





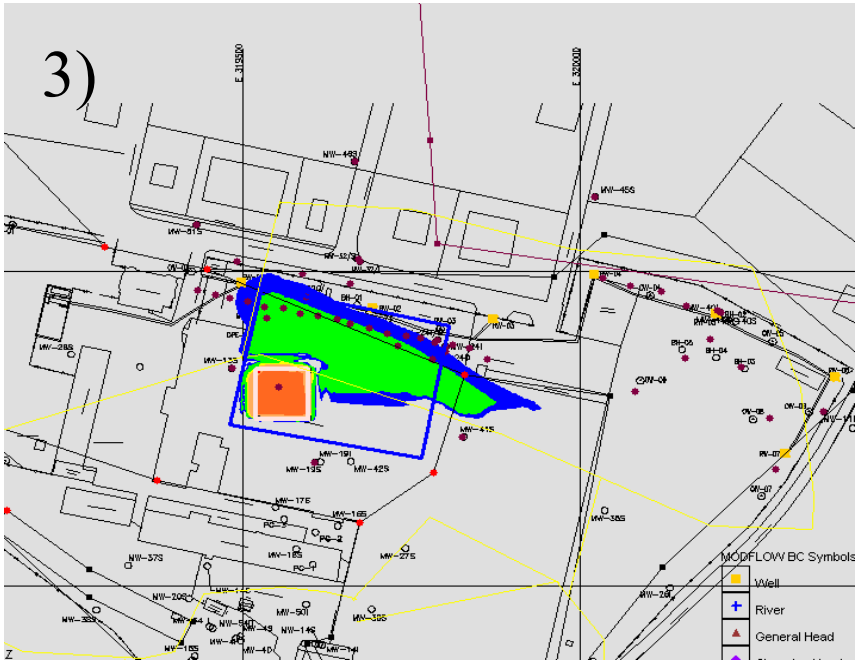


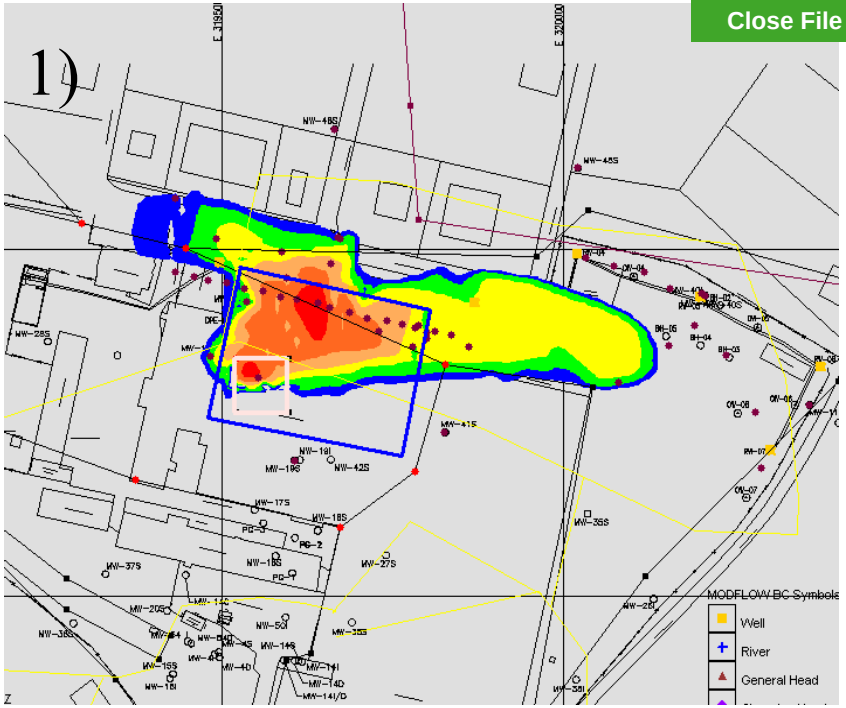
FIGURE B-6

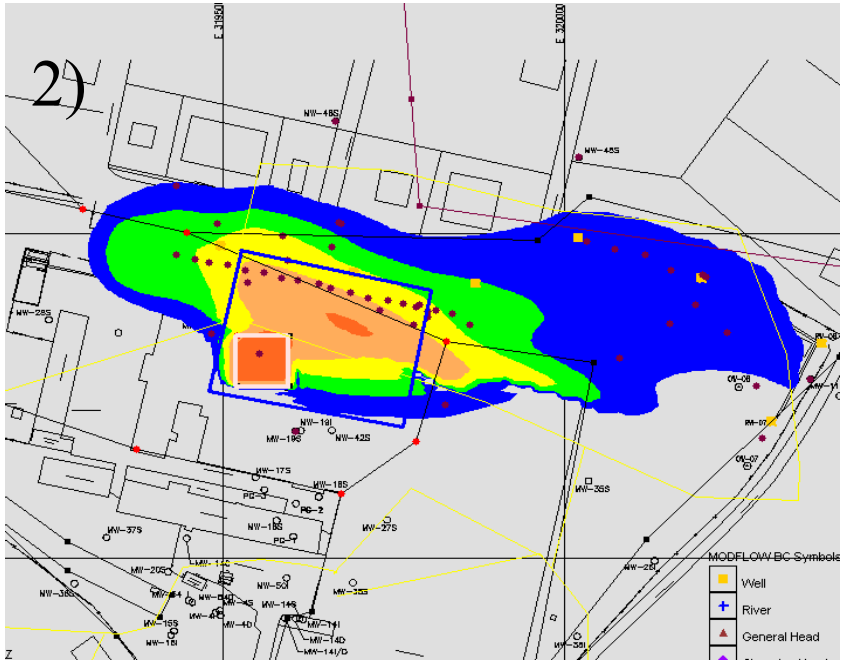
Scenario 1: Vinyl Chloride

1) Existing groundwater
2) 10 years
3) 20 years

Legend:

Blue = 0.002 to 0.007 mg/L
Green = 0.007 to 0.02 mg/L
Yellow = 0.02 to 0.07 mg/L
Light Orange = 0.07 to 0.2 mg/L
Red Orange = 0.2 to 0.7 mg/L
Red = 0.7 to 7 mg/L





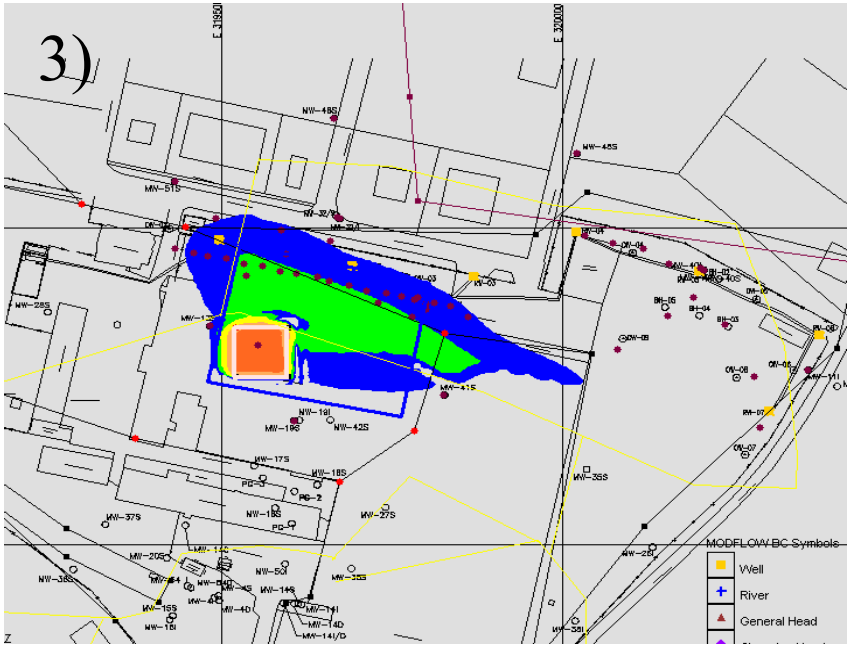


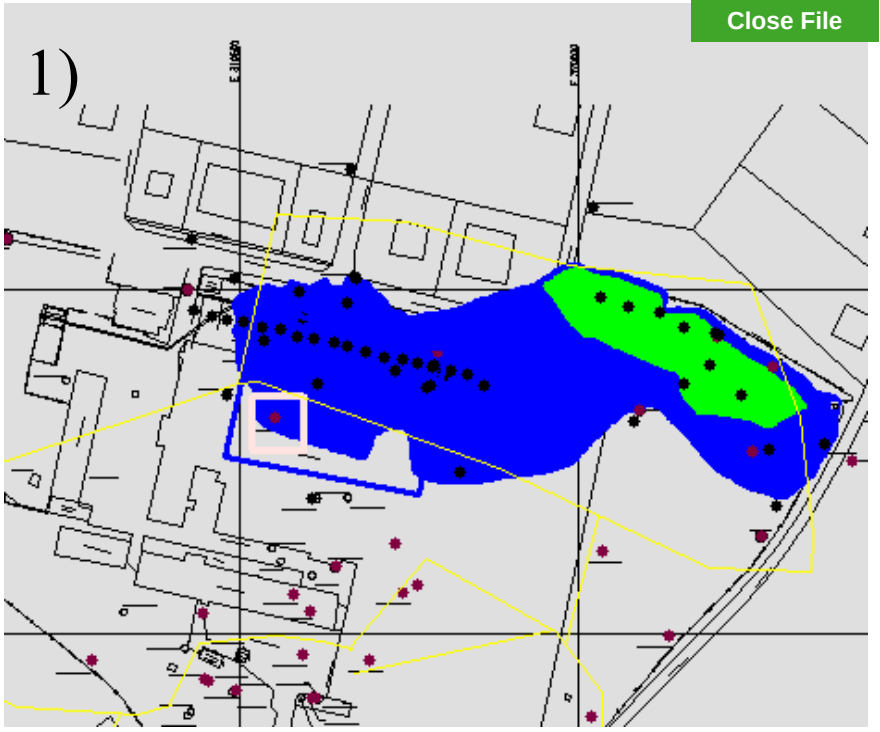
FIGURE B-7

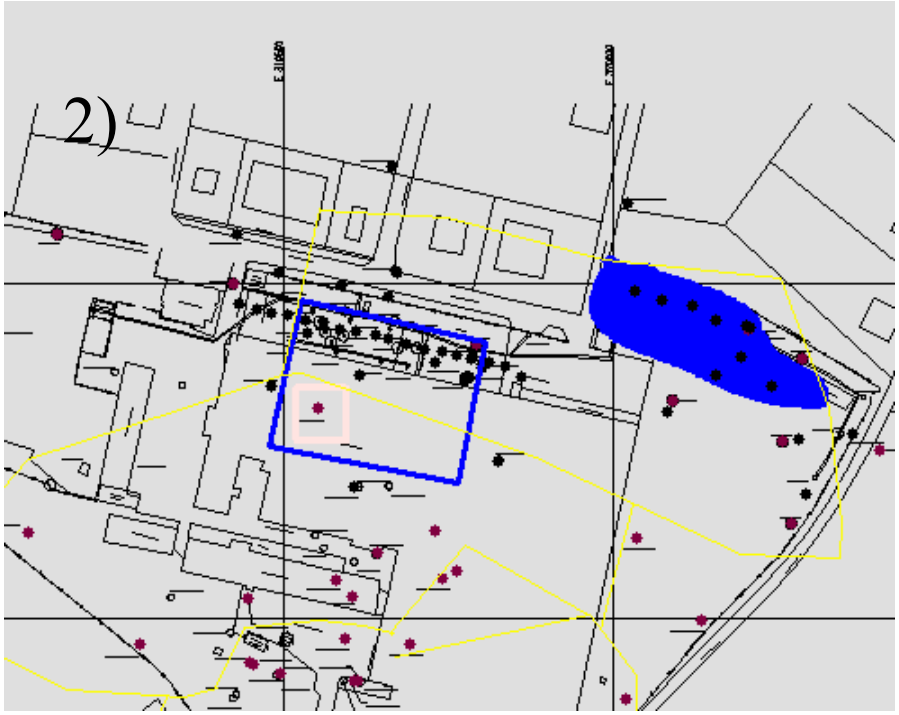
Scenario 2: PCE

1) Concentrations After Ozone Treatment
2) 2 years
3) 5 years

Legend:

Blue = 0.005 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 0.5 mg/L
Red Orange = 0.5 to 1 mg/L
Red = 1 to 10.5 mg/L





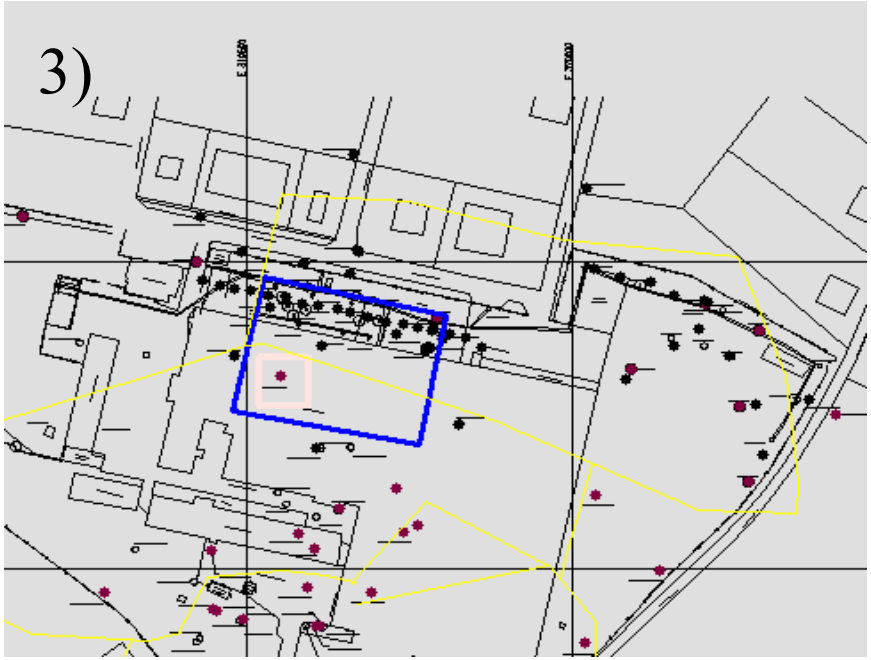


FIGURE B-8

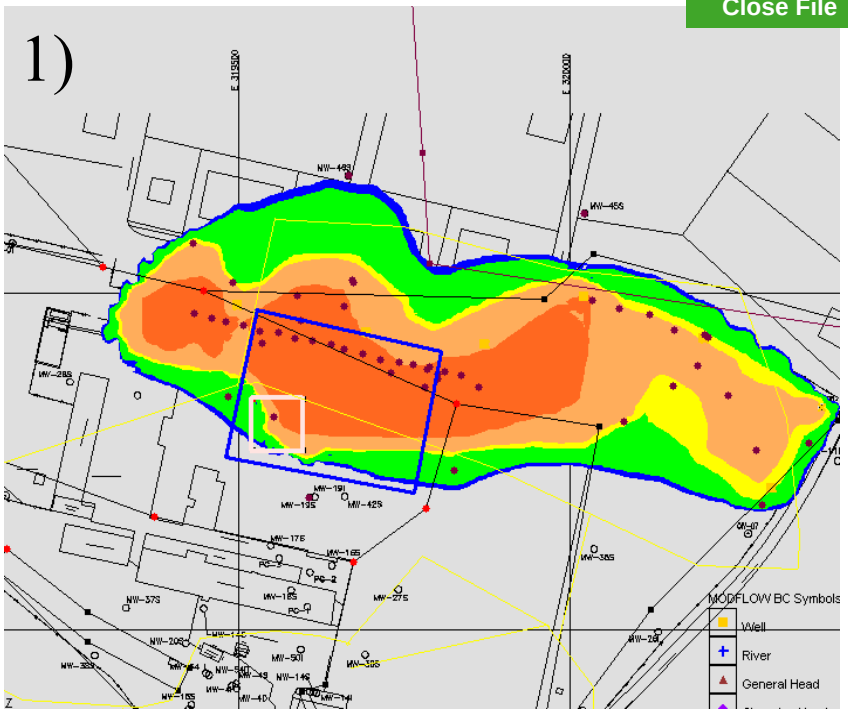
Scenario 2: TCE

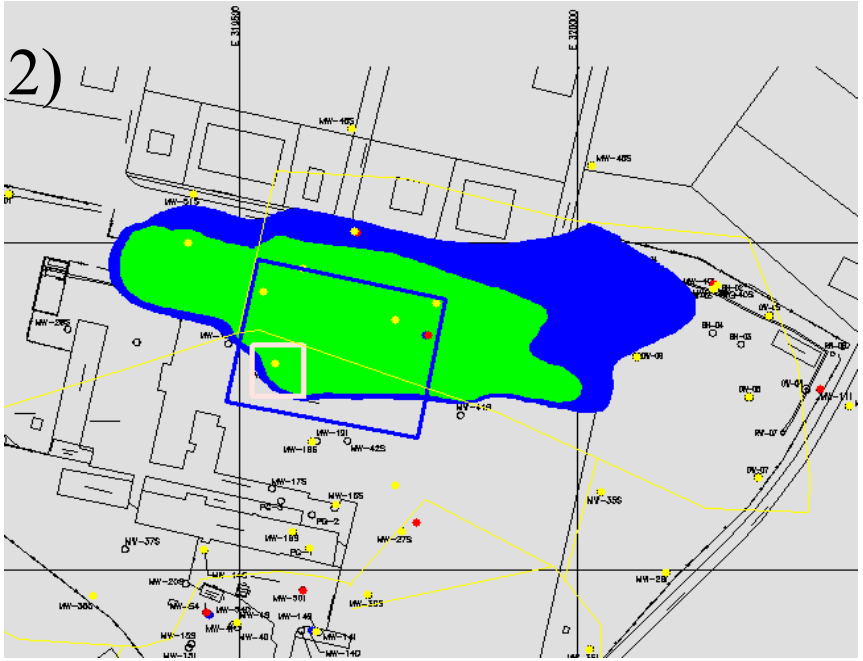
1) Concentrations after Ozone Treatment
2) 10 years
3) 20 years

Concentrations below MCLs at 23 years.

Legend:

Blue = 0.005 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 0.5 mg/L
Red Orange = 0.5 to 1 mg/L
Red = 1 to 10.5 mg/L





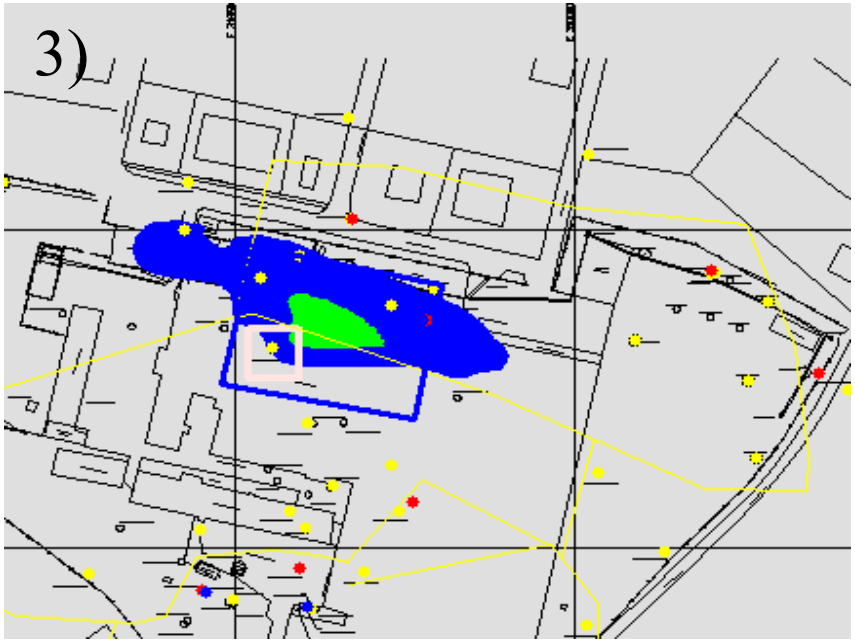


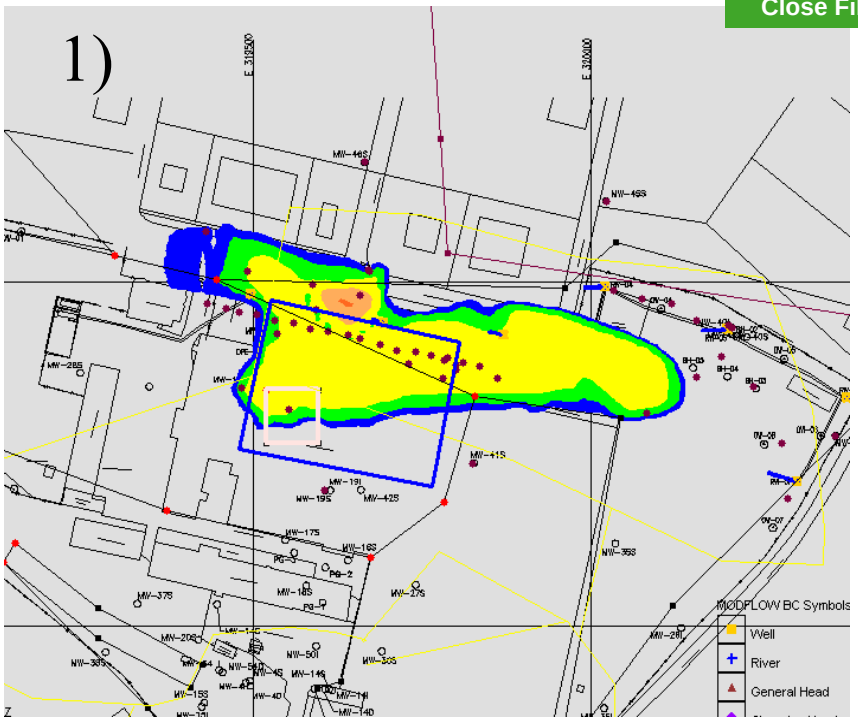
FIGURE B-9

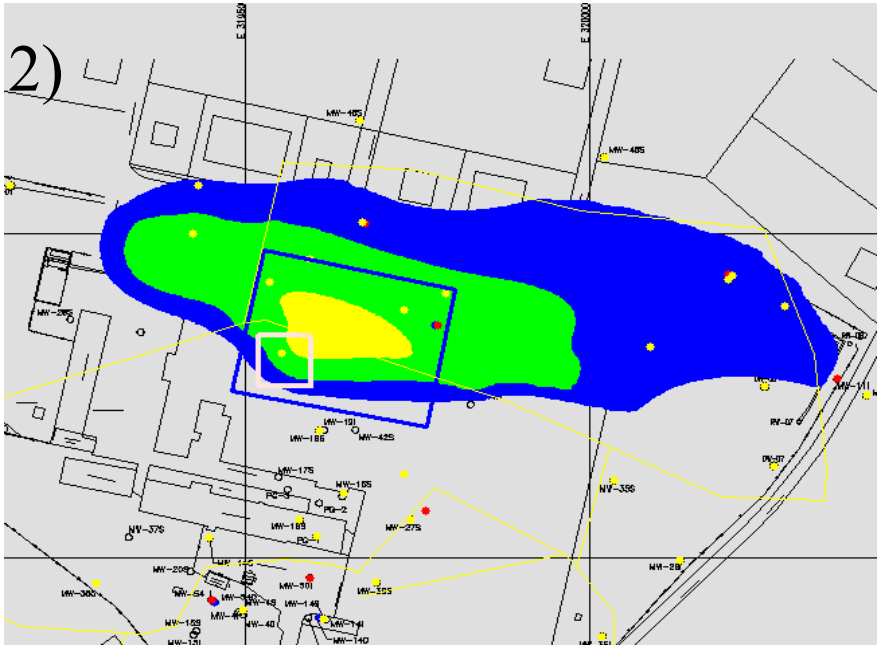
Scenario 2: Vinyl Chloride

1) Concentrations after Ozone Treatment
2) 10 years
3) 20 years

Legend:

Blue = 0.002 to 0.007 mg/L
Green = 0.007 to 0.02 mg/L
Yellow = 0.02 to 0.07 mg/L
Light Orange = 0.07 to 0.2 mg/L
Red Orange = 0.2 to 0.7 mg/L
Red = 0.7 to 7 mg/L





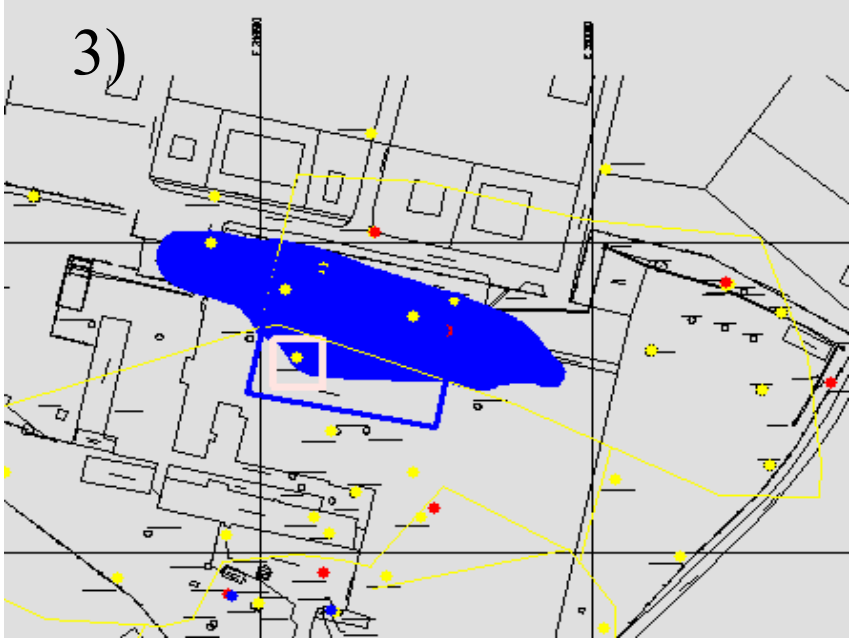


FIGURE B-10

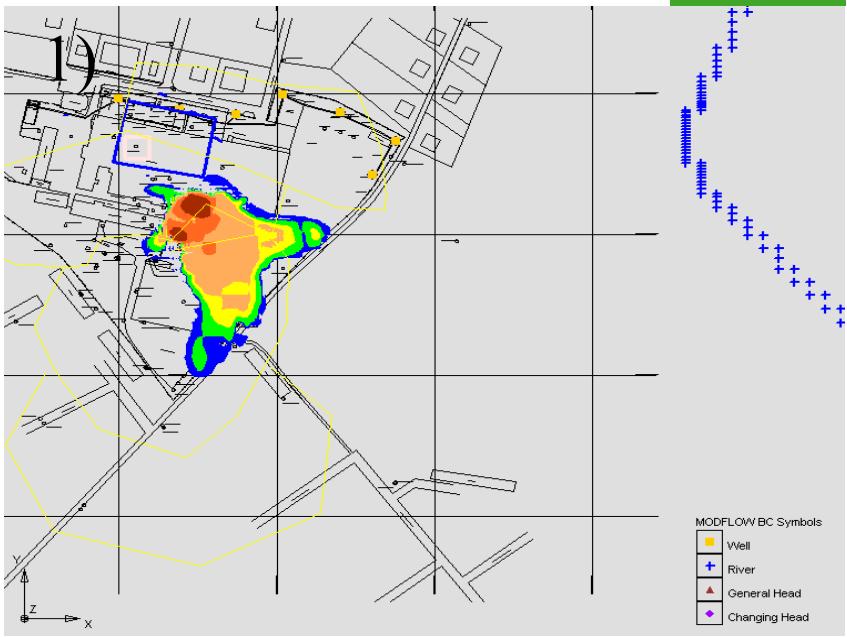
Scenario 1: PCE

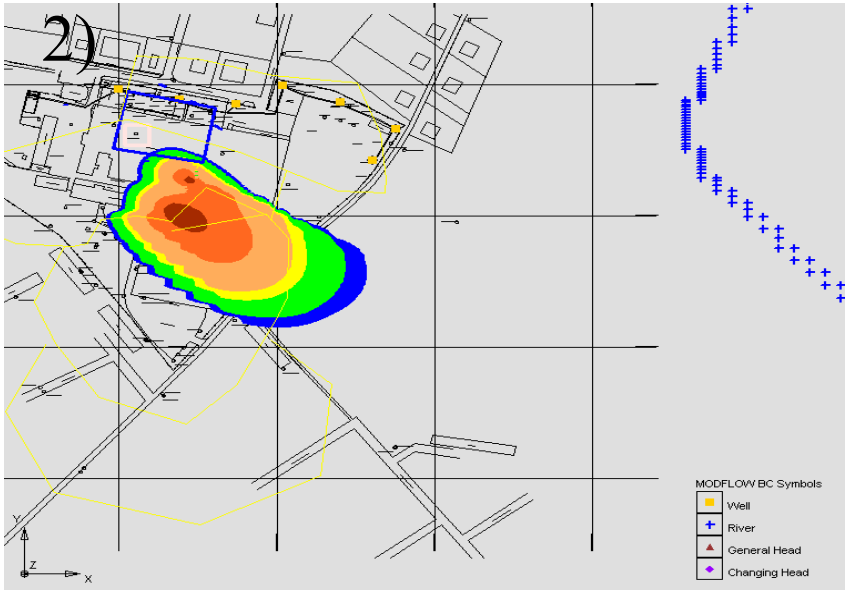
1) Existing concentrations
2) 25 years
3) 50 years

PCE not likely to reach river.

Legend:

Blue = 0.005 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 1.0 mg/L
Red Orange = 1 to 10 mg/L
Rust = 10 to 100 mg/L





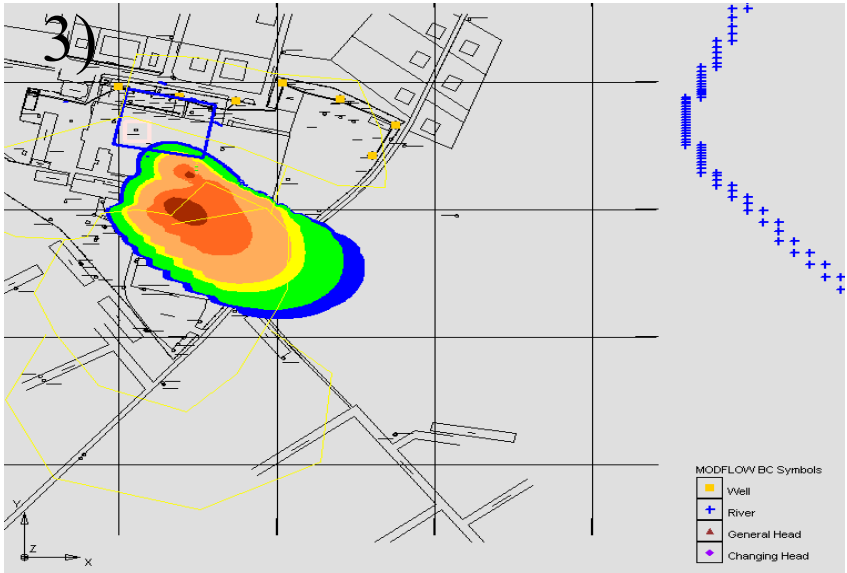


FIGURE B-11

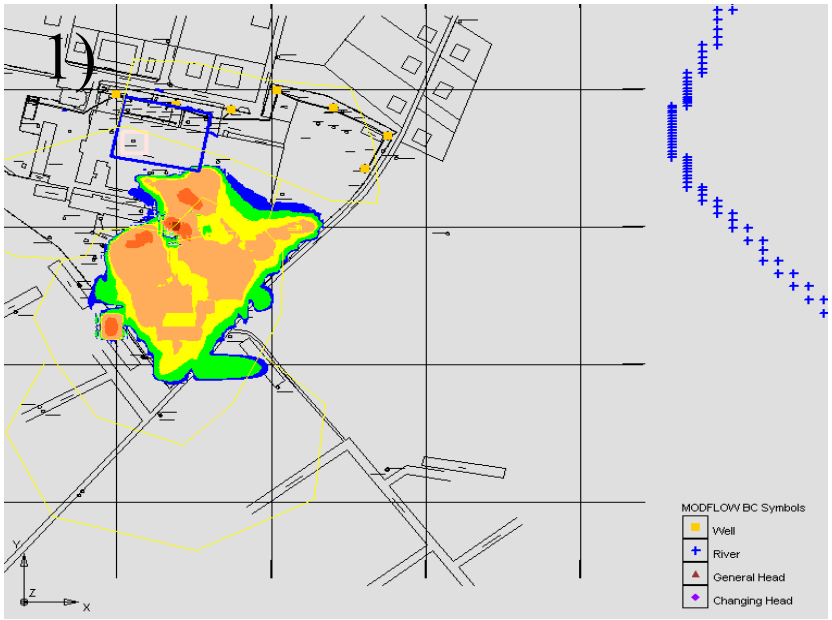
Scenario 1: TCE

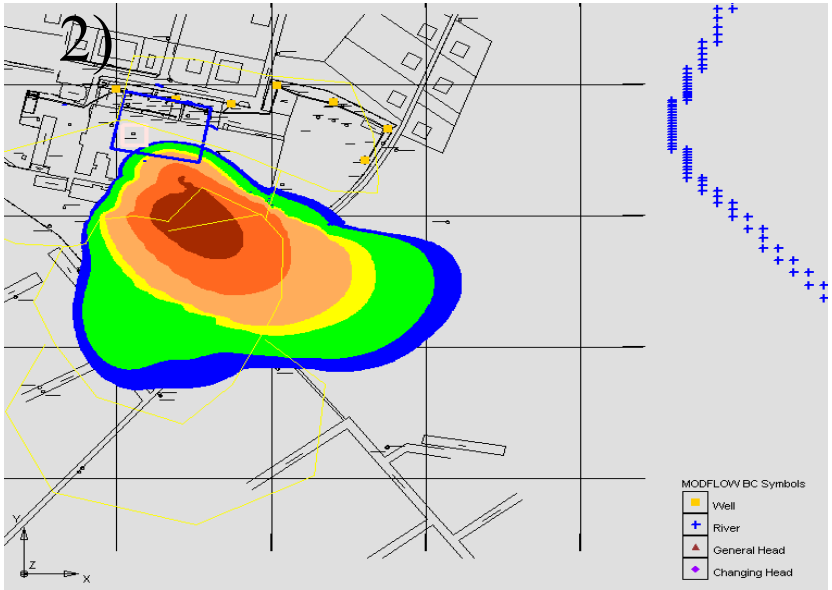
1) Existing concentrations
2) 25 years
3) 50 years

>75 yrs before TCE (>0.005mg/L) reaches river.

Legend:

Blue = 0.005 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 1.0 mg/L
Red Orange = 1 to 10 mg/L
Rust = 10 to 200 mg/L





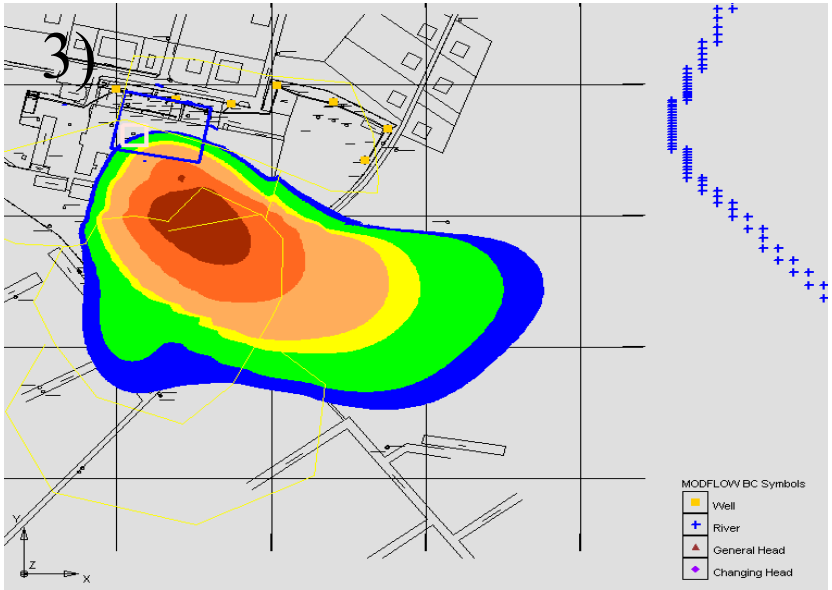


FIGURE B-12

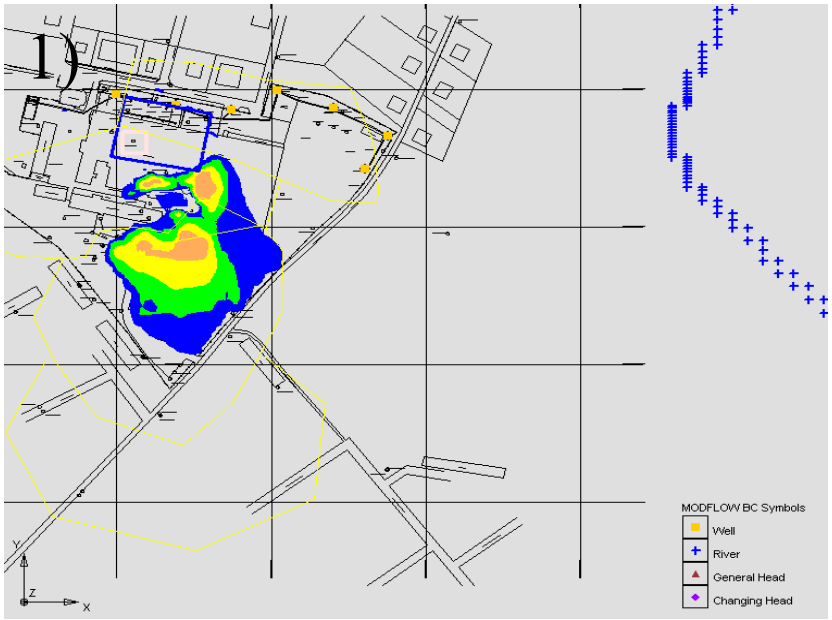
Scenario 1: Vinyl Chloride

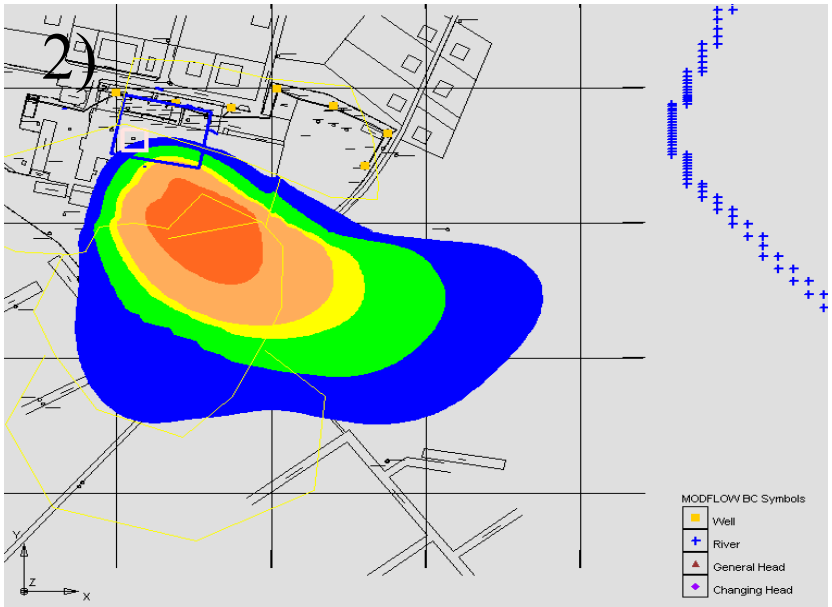
1) Existing concentrations
2) 25 years
3) 50 years

>60 yrs before VC (>0.002mg/L) reaches river.

Legend:

Blue = 0.002 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 1.0 mg/L
Red Orange = 1 to 10 mg/L
Rust = 10 to 100 mg/L





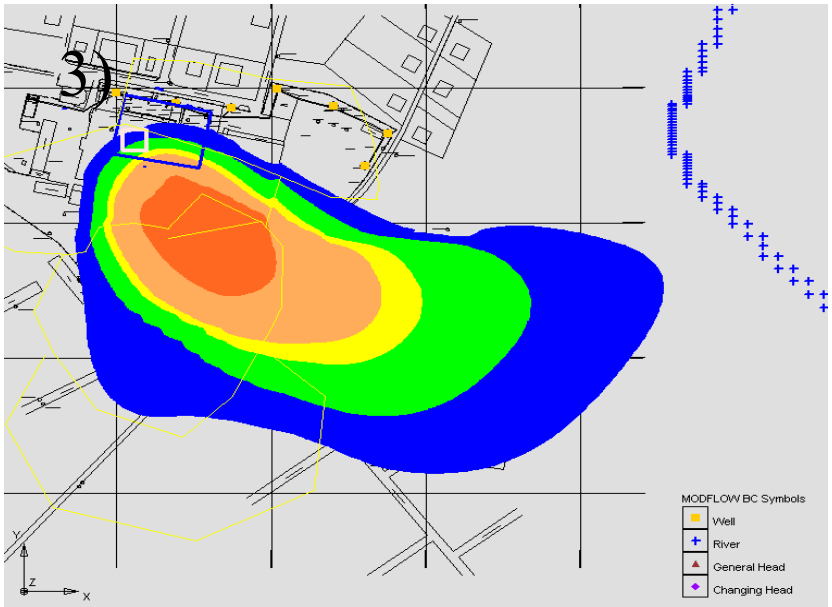


FIGURE B-13

Scenario 2a: PCE

1) Treatment concentrations
2) 20 years
3) 36 years

PCE below MCLs after 38 yrs

Legend:

Blue = 0.005 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 1.0 mg/L
Red Orange = 1 to 10 mg/L
Rust = 10 to 100 mg/L

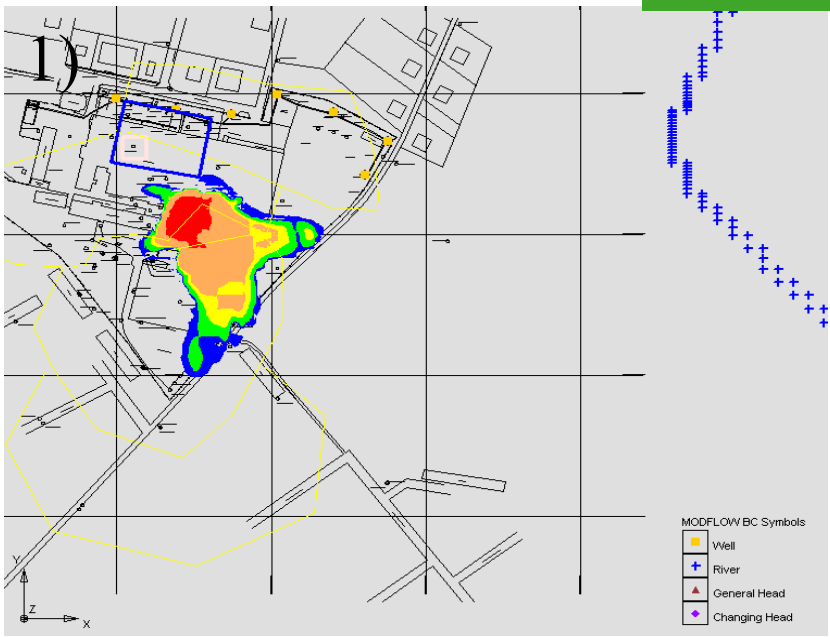


FIGURE B-14

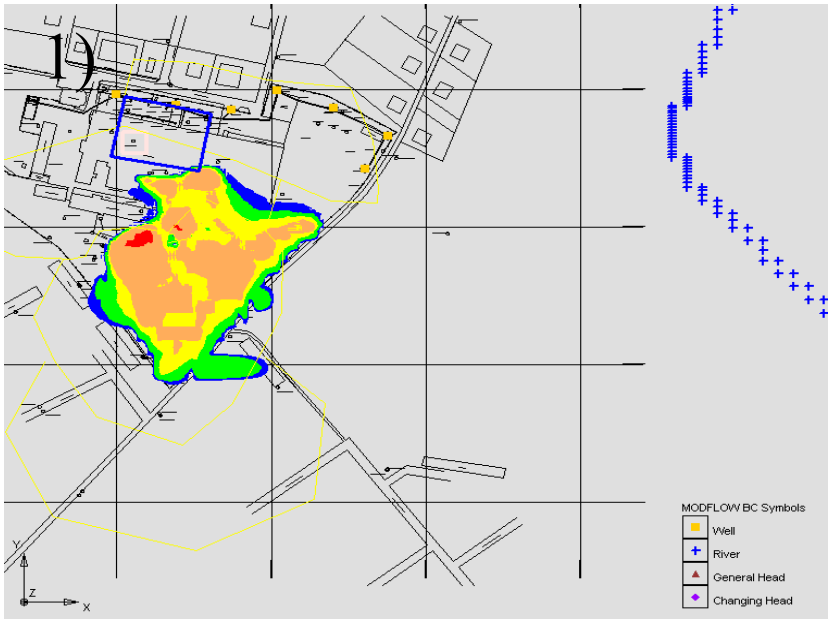
Scenario 2a: TCE

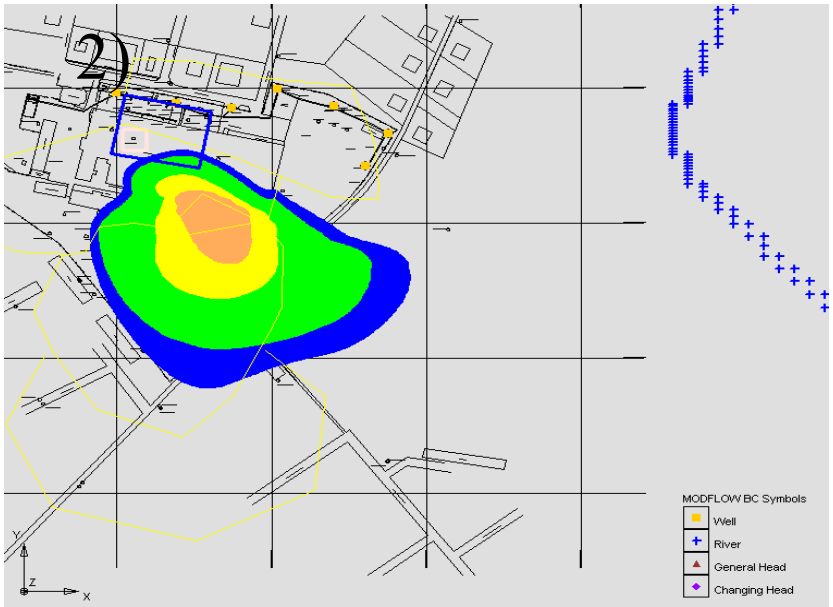
1) Treatment concentrations
2) 50 years
3) 100 years

TCE (>0.005mg/L) not likely to reach river. TCE below MCLs after 154 yrs

Legend:

Blue = 0.005 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 1.0 mg/L
Red Orange = 1 to 10 mg/L
Rust = 10 to 200 mg/L





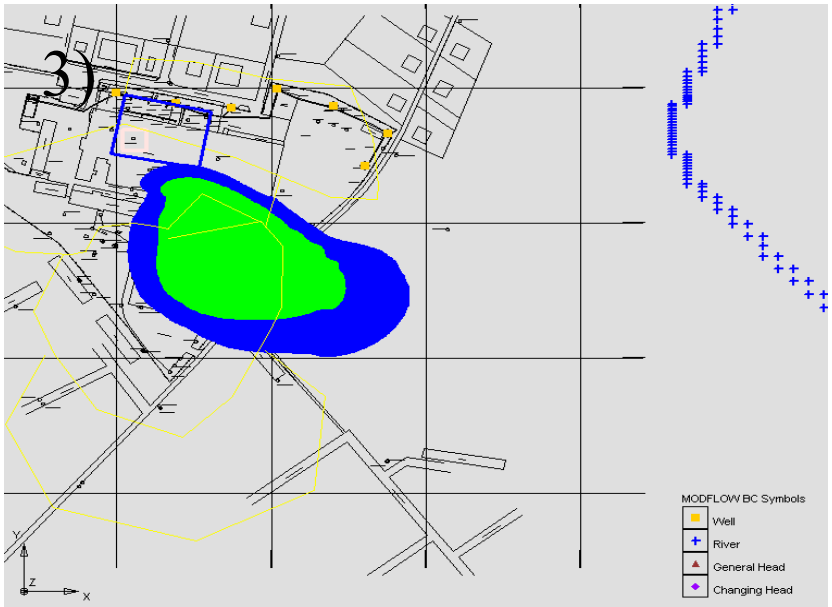


FIGURE B-15

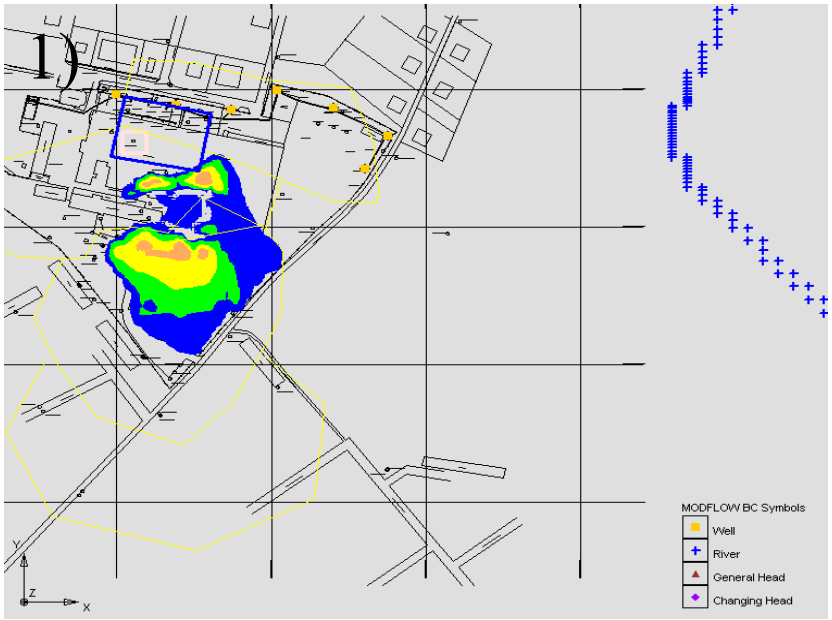
Scenario 2a: Vinyl Chloride

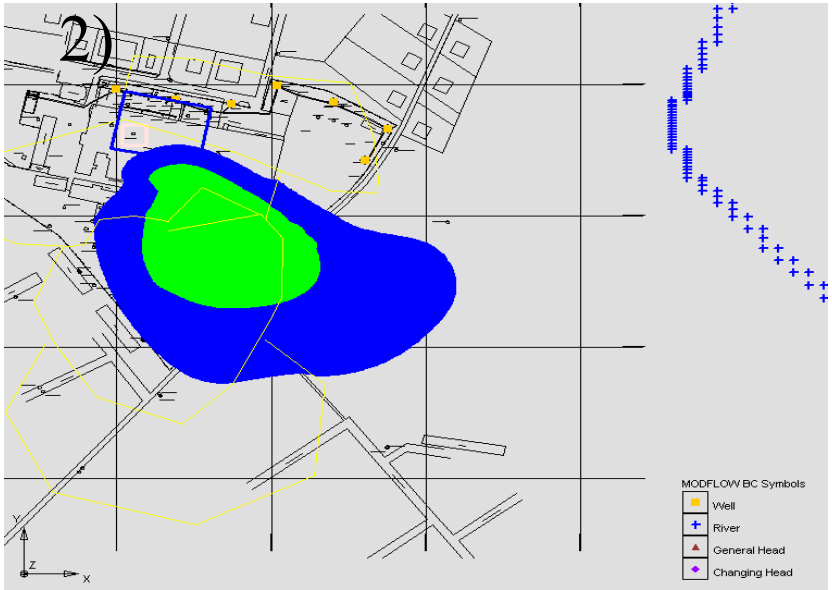
1) Treatment concentrations
2) 50 years
3) 100 years

VC (>0.002mg/L) not likely to reach river. VC below MCLs after 144 yrs

Legend:

Blue = 0.002 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 1.0 mg/L
Red Orange = 1 to 10 mg/L
Rust = 10 to 100 mg/L





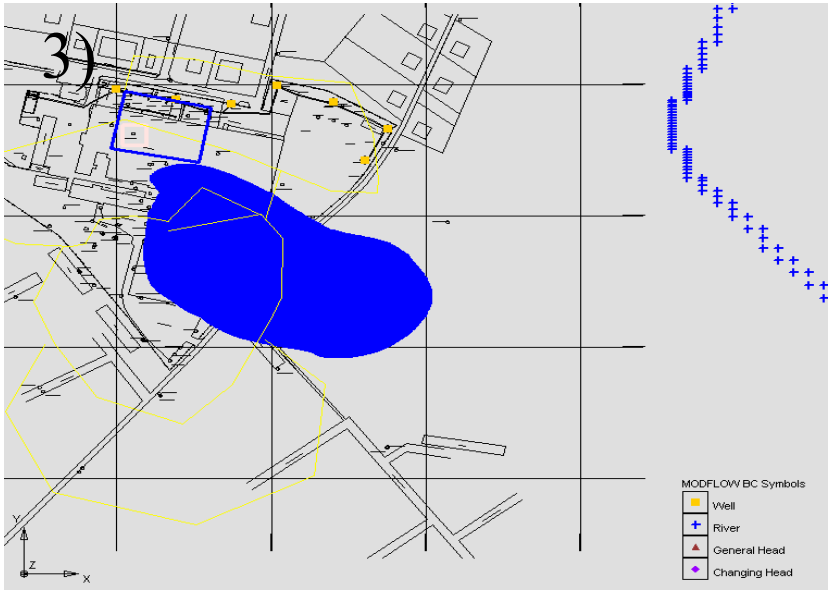


FIGURE B-16

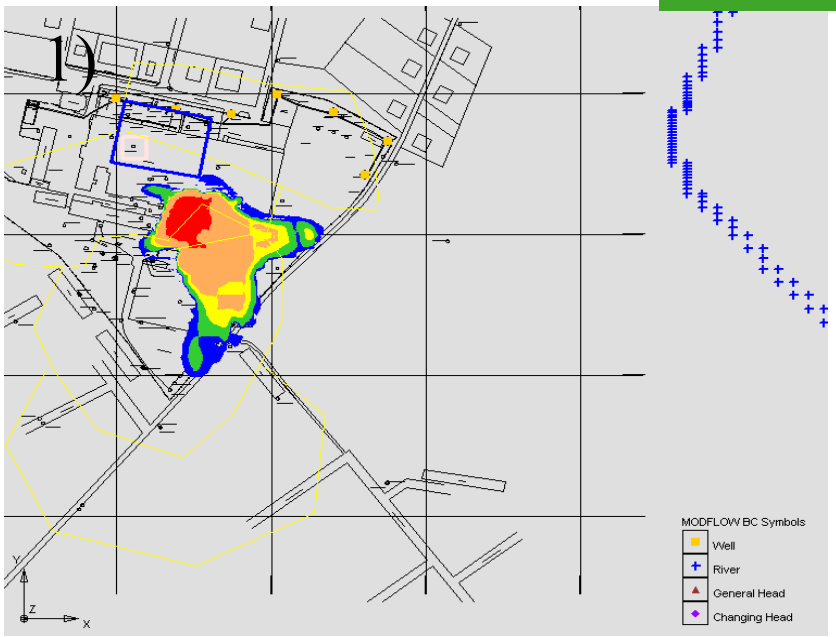
Scenario 2b: PCE

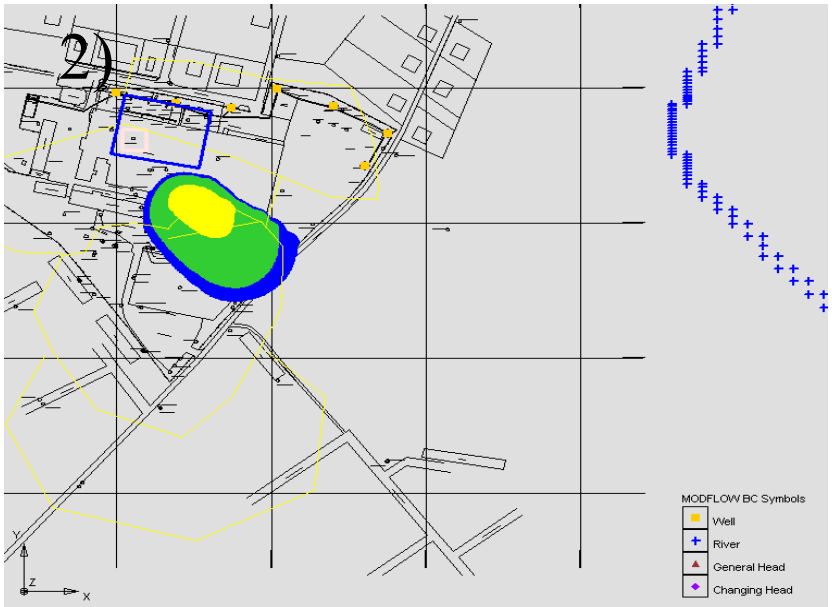
1) Treatment concentrations
2) 14 years
3) 28 years

PCE below MCLs after 30 yrs

Legend:

Blue = 0.005 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 1.0 mg/L
Red Orange = 1 to 10 mg/L
Rust = 10 to 100 mg/L





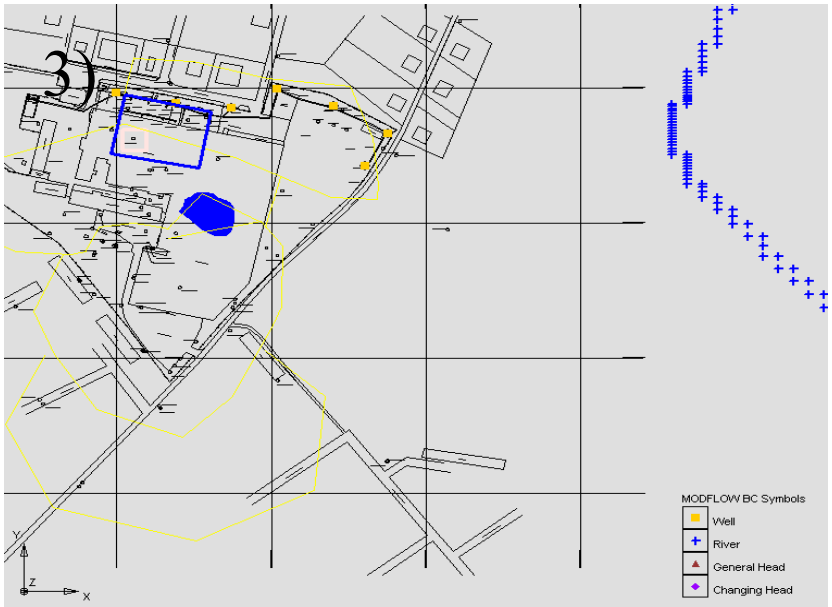


FIGURE B-17

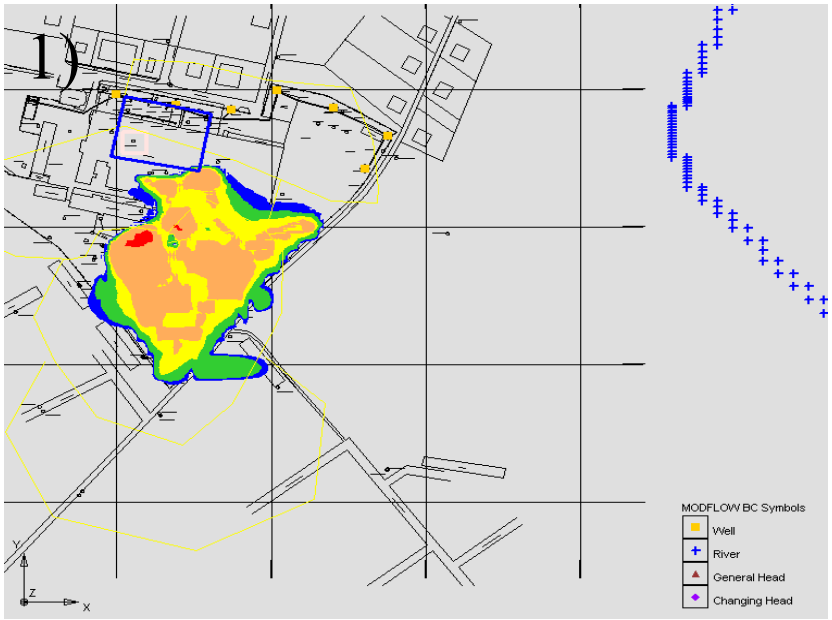
Scenario 2b: TCE

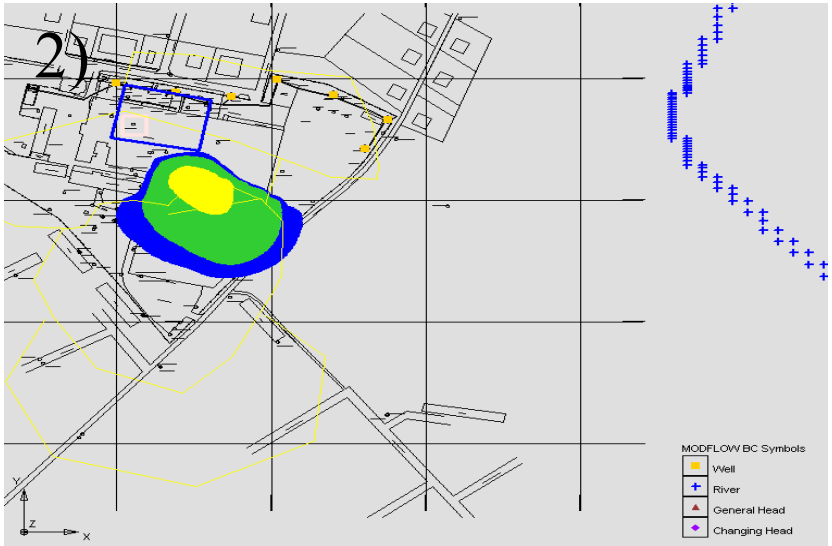
1) Treatment concentrations
2) 16 years
3) 32 years

TCE (>0.005mg/L) not likely to reach river. TCE below MCLs after 34 yrs

Legend:

Blue = 0.005 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 1.0 mg/L
Red Orange = 1 to 10 mg/L
Rust = 10 to 200 mg/L





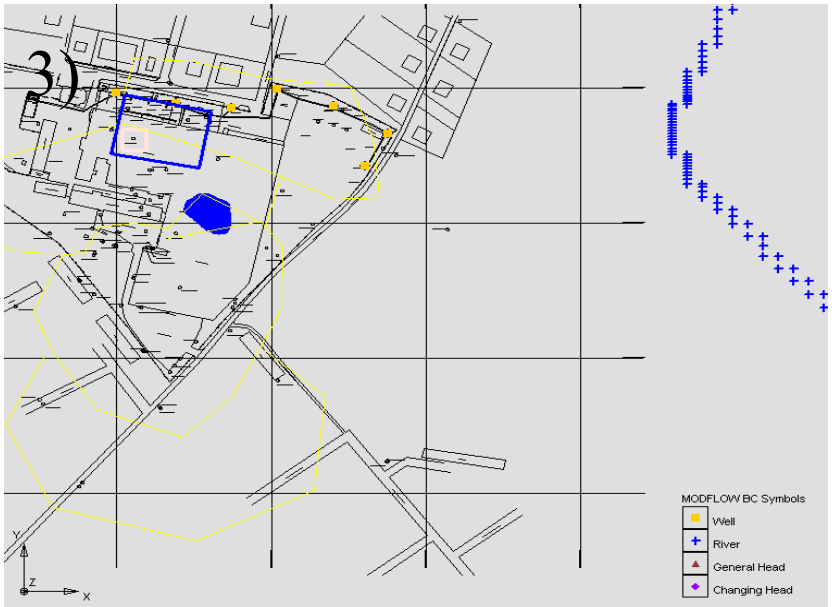


FIGURE B-18

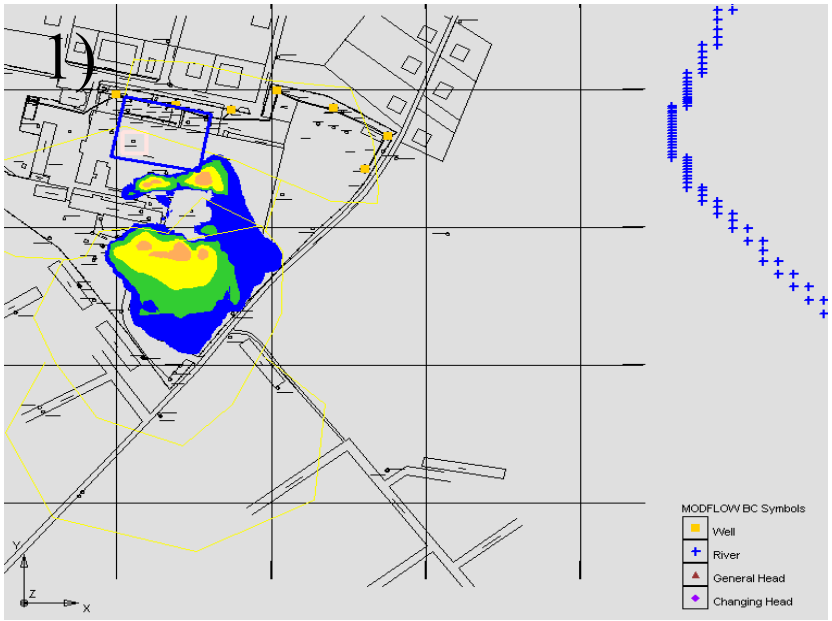
Scenario 2b: Vinyl Chloride

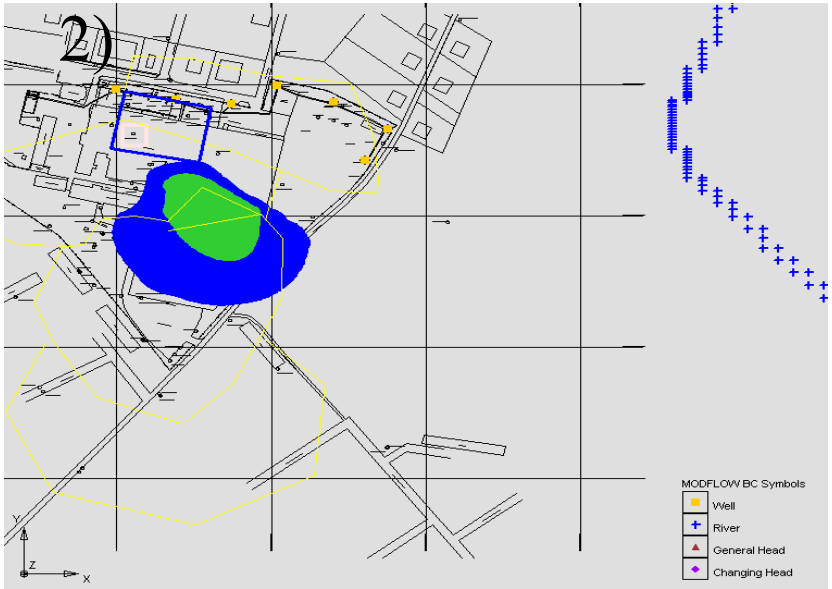
1) Treatment concentrations
2) 16 years
3) 32 years

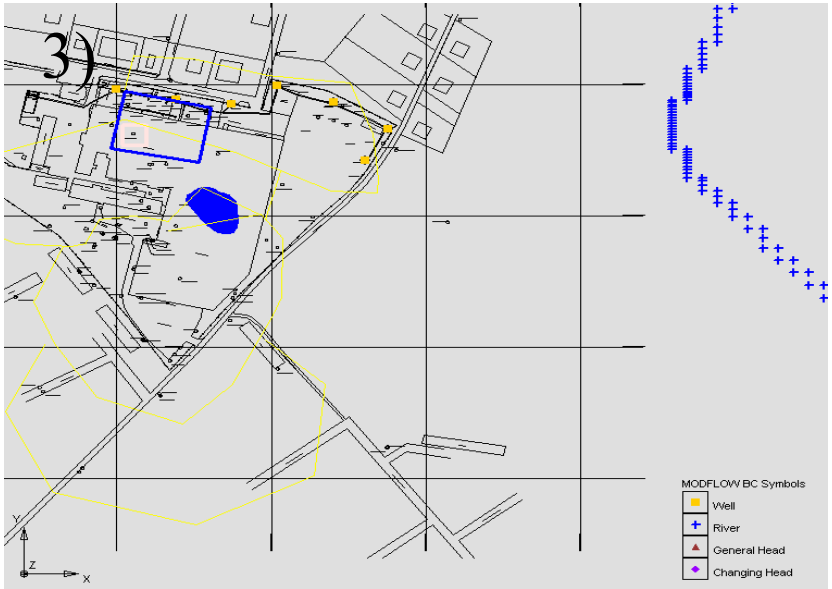
VC (>0.002mg/L) not likely to reach river. VC below MCLs after 34 yrs

Legend:

Blue = 0.002 to 0.01 mg/L
Green = 0.01 to 0.05 mg/L
Yellow = 0.05 to 0.1 mg/L
Light Orange = 0.1 to 1.0 mg/L
Red Orange = 1 to 10 mg/L
Rust = 10 to 100 mg/L







Close File

Attachment C
Design Details

List of Figures for Attachment C

Figure C-1 North Area Proposed Ozone System Well Layout
Figure C-2 South Area Proposed Ozone System Well Layout

List of Drawings for Attachment C

Drawing 1 of 3 North Area Proposed Sparge Well and Performance Monitoring Point Locations
Drawing 2 of 3 South Area Proposed Sparge Well and Performance Monitoring Point Locations
Drawing 3 of 3 Miscellaneous Details

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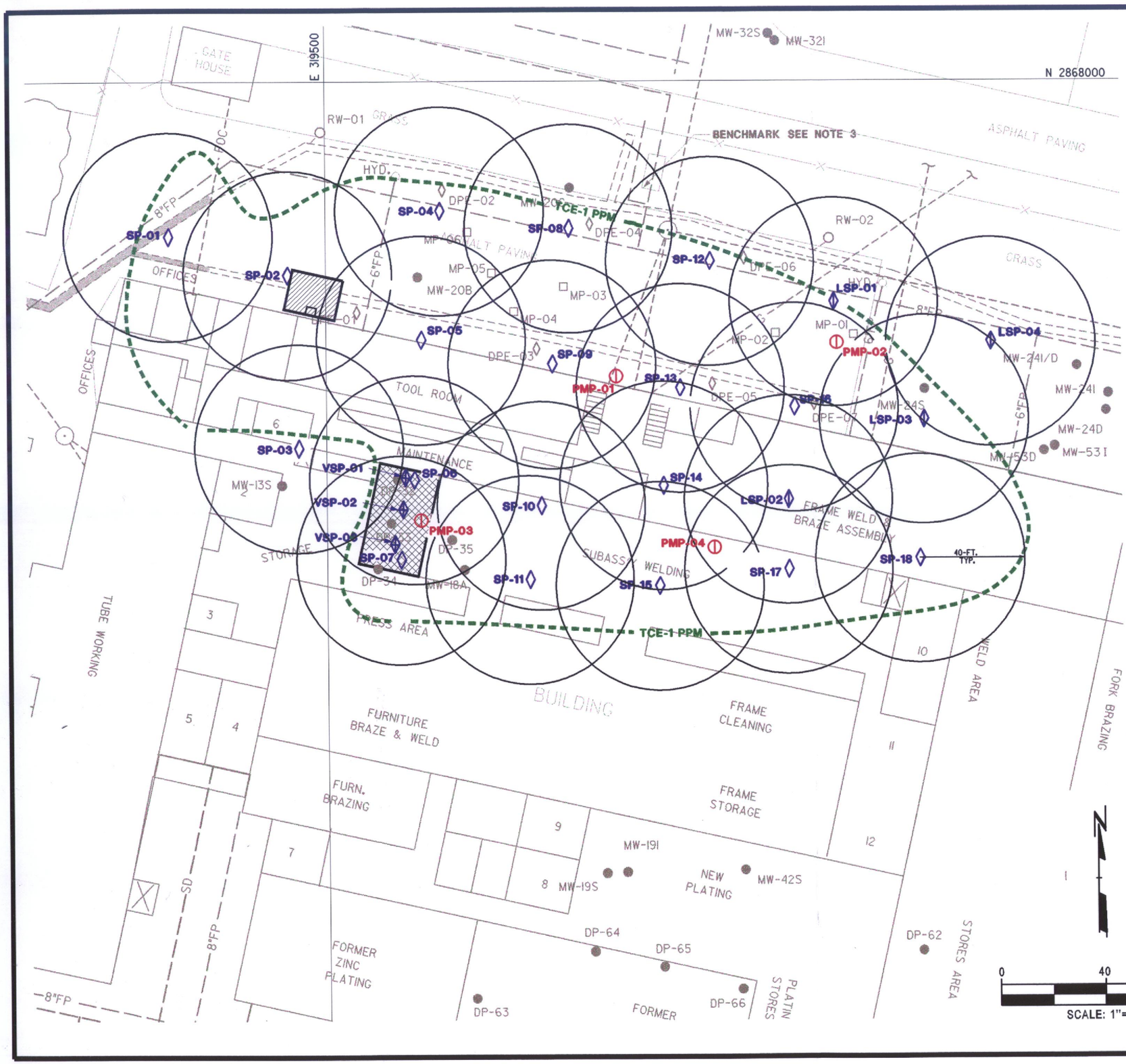

LEGEND

	EXISTING	NEW
BUILDING		
POWER POLE (LIGHT POLE)	PP	
FIBER-OPTIC CABLE	FOC	
STORM DRAIN LINE	SD	
SANITARY SEWER LINE	SS	
FIRE PROTECTION LINE	FP	
GAS LINE	G	
GROUNDWATER RECOVERY WELL	RW-2	
DUAL-PHASE VACUUM EXTRACTION WELL	DPE-01	
MONITORING WELL	MW-44S	
MONITORING POINT	MP-06	
DIRECT PUSH	DP-32	
GRATE INLET		
ASPHALT		
CHAIN LINK FENCE		
MANHOLE		
TCE ISOCONCENTRATION LINE		TCE-1 PPM
INTERNAL WALLS		
PROPOSED PERFORMANCE MONITORING POINT		PMP-01
PROPOSED SPARGE POINT LOCATIONS		SP-01
PROPOSED LAMINAR SPARGE POINT LOCATIONS		LSP-01
PROPOSED VADOSE ZONE SPARGE POINT LOCATIONS		VSP-01
ANTICIPATED RADIUS OF INFLUENCE		
FORMER VAPOR DEGREASING ROOM		
OZONE SPARGING SYSTEM EQUIPMENT ENCLOSURE		

NOTES

1. EXISTING SITE FEATURES AND UNDERGROUND UTILITY LOCATIONS WERE TAKEN FROM DRAWINGS MADE BY LANCY LABORATORIES INC. DATED MAY 5, 1970, FACTORY MUTUAL ENGINEERING DIVISION, NORWOOD, MASSACHUSETTS DATED JUNE 6, 1974 AND RECORD DRAWINGS PREPARED BY RMT ENGINEERS, P.C., GREENVILLE, SOUTH CAROLINA DATED APRIL 2003 PROJECT NUMBER 998.73.
2. COORDINATES ARE IN FEET AND ARE BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, NAD83.
3. ELEVATIONS ARE IN FEET AND ARE BASED ON THE CITY OF WESTFIELD DPW DATUM. BENCHMARK IS SOUTHWEST CORNER OF CONCRETE PAD FOR SEWER MANHOLE ON SOUTH SIDE OF CYCLE STREET OPPOSITE THE INTERSECTION WITH LOZIER AVENUE. ELEVATION = 89.48 FEET.
4. LOCATIONS OF ALL EXISTING UTILITIES SHOWN ARE APPROXIMATE. CONTRACTOR SHALL LOCATE ALL ABOVE AND BELOW GRADE UTILITIES PRIOR TO ANY NEW CONSTRUCTION ACTIVITIES AND PROTECT FROM DAMAGE DURING CONSTRUCTION.
5. INTERNAL WALL LOCATIONS ARE APPROXIMATE AND NOT TO SCALE.
6. OZONE TREATMENT AREA BASED ON THE RESULTS OF THE FATE AND TRANSPORT GROUNDWATER MODEL.

PROJECT: **MTD PRODUCTS**
COLUMBIA MANUFACTURING FACILITY
WESTFIELD, MASSACHUSETTS

SHEET TITLE:
NORTH AREA
PROPOSED OZONE SYSTEM WELL LAYOUT

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CHECKED BY: SDS		FILE NO. NOG-00.71360.01-002 1.DGN	
APPROVED BY: SWW	DATED PRINTED: JUNE 2004	FIGURE C-1	
DATE: JUNE 2004			

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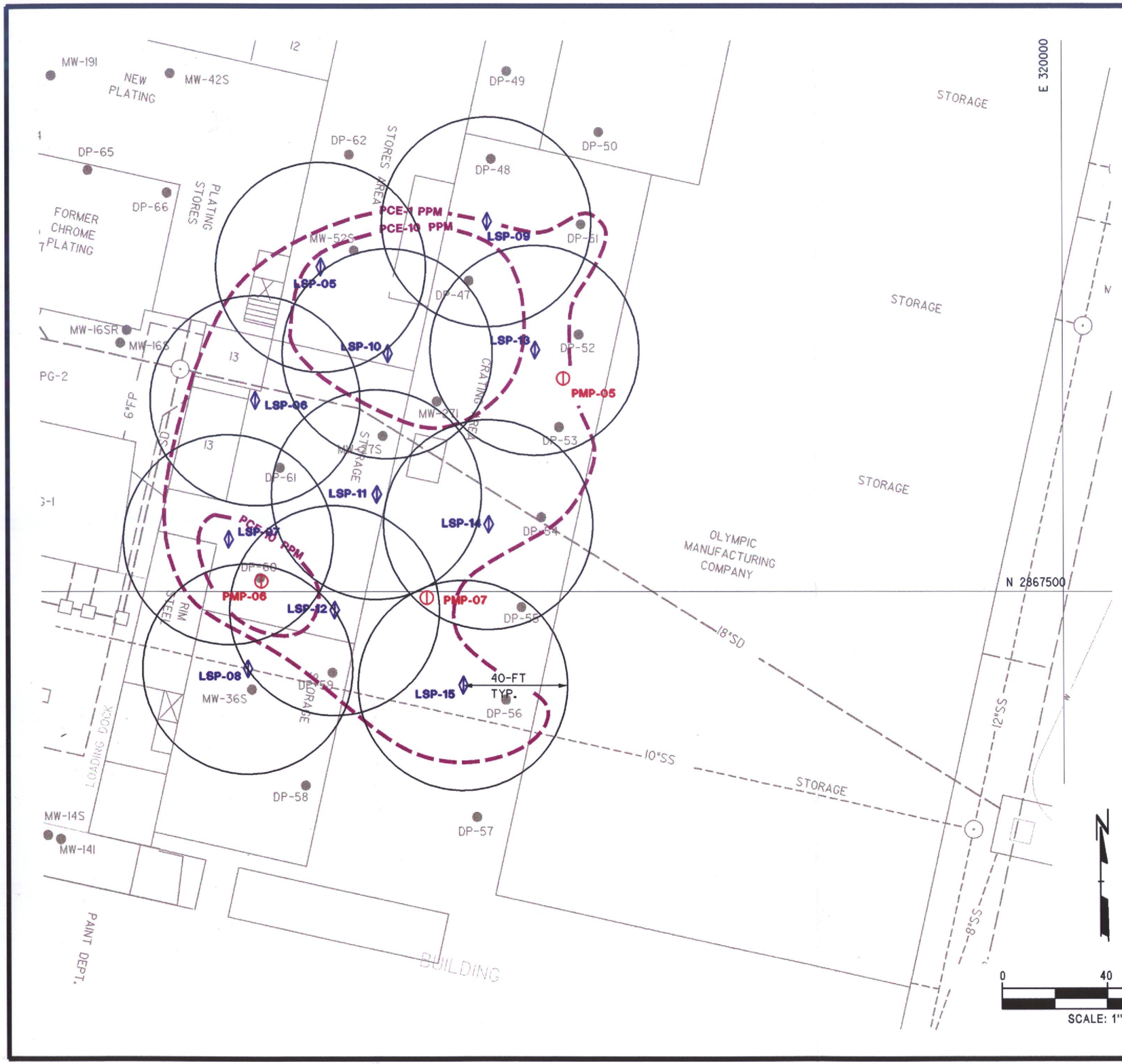

LEGEND

	EXISTING	NEW
BUILDING		
STORM DRAIN LINE	—SD—	
SANITARY SEWER LINE	----SS----	
FIRE PROTECTION LINE	—FP—	
GAS LINE	----G----	
MONITORING WELL	MW-44S	
DIRECT PUSH	DP-32	
GRATE INLET		
MANHOLE		
PCE ISOCONCENTRATION LINE		PCE-1 PPM
INTERNAL WALLS		
PROPOSED PERFORMANCE MONITORING POINT		PMP-01
PROPOSED LAMINAR SPARGE POINT LOCATIONS		LSP-01
ANTICIPATED RADIUS OF INFLUENCE		

NOTES

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3. ELEVATIONS ARE IN FEET AND ARE BASED ON THE CITY OF WESTFIELD DPW DATUM. BENCHMARK IS SOUTHWEST CORNER OF CONCRETE PAD FOR SEWER MANHOLE ON SOUTH SIDE OF CYCLE STREET OPPOSITE THE INTERSECTION WITH LOZIER AVENUE. ELEVATION = 89.48 FEET.
4. LOCATIONS OF ALL EXISTING UTILITIES SHOWN ARE APPROXIMATE. CONTRACTOR SHALL LOCATE ALL ABOVE AND BELOW GRADE UTILITIES PRIOR TO ANY NEW CONSTRUCTION ACTIVITIES AND PROTECT FROM DAMAGE DURING CONSTRUCTION.
5. INTERNAL WALL LOCATIONS ARE APPROXIMATE AND NOT TO SCALE.
6. OZONE TREATMENT AREA BASED ON THE RESULTS OF THE FATE AND TRANSPORT GROUNDWATER MODEL.

PROJECT:

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SHEET TITLE:

SOUTH AREA
PROPOSED OZONE SYSTEM WELL LAYOUT

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DATE: JUNE 2004			

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WESTFIELD, MASSACHUSETTS

SHEET TITLE: **MISCELLANEOUS DETAILS**

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8. LOCATION OF PEROZONE SUPPLY SYSTEM TO BE FIELD DETERMINED PRIOR TO INSTALLATION OF PIPING/TUBING RUNS.

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SHEET TITLE: **SOUTH AREA PROPOSED SPARGE WELL AND PERFORMANCE MONITORING POINT LOCATIONS**

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60 90 120
SCALE: 1"=30'

EXTERNAL RUNS TO BE INSTALLED IN BELOW-GRADE TRENCHES. INTERNAL RUNS TO BE ROUTED AND ANCHORED TO OVER HEAD BEAMS AND THEN ROUTED VERTICALLY TO WELLS USING NEW RIGID SUPPORTS.
(SEE SHEET 3 FOR PIPING AND CONNECTION DETAILS).

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SHEET TITLE: **NORTH AREA PROPOSED SPARGE WELL AND PERFORMANCE MONITORING POINT LOCATIONS**

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