ENVIRONMENTAL CONSTRUCTION OPERATIONS & REMEDIATION

Enhanced Reductive Dechlorination In-Situ Bioremediation
Interim Remedial Measures Workplan
Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York

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ECOR Solutions, Inc.
3191 Copper Oaks Pl.
Woodbury, MN 55125

ECOR
Solutions, Inc.

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1.0 INTRODUCTION

1.1 Background

ECOR Solutions, Inc. (ECOR), on behalf of the HB Fuller Company (HB Fuller) has developed this *Enhanced Reductive Dechlorination In-Situ Bioremediation Interim Measures Workplan* (Workplan) to implement a Interim Remedial Measure (IRM) for an in-situ enhanced reductive dechlorination (ERD) bioremediation program at the Former Monarch Chemicals Facility (Site) located at 61 Gates Avenue in the city of Geneva, Ontario County, New York (Figure 1). The purpose of this Workplan is to provide the New York State Department of Environmental Conservation (NYSDEC) with a summary of the data supporting the proposed IRM, a chronological description of the anticipated IRM activities to be completed at the Site, and a schedule for performance of the IRM activities, including the submission of a draft *IRM Performance Report*.

1.2 Site Location

The Site is located on a parcel of property approximately 1.75-acres in size, located at 61 Gates Avenue in the city of Geneva, Ontario County, New York (Latitude 042° 52’ 54” N, Longitude 076° 58’ 52” W (Figure 1). The Site is industrially developed with a manufacturing plant occupying approximately 33,700 ft^2, with accompanying loading and unloading areas, parking lots, and an above ground storage tank (AST) containment area. The Site is typical of the gently rolling glacial topography of the Finger Lakes region, the result of repeated glaciations, most recently during the Wisconsinan glacial period in the late Pleistocene epoch.

Access to the Site is via Gates Avenue, which is contiguous along the southern property boundary (Figure 2). The Site is located in an industrial area of Geneva, north of Seneca Lake. Properties bordering the Site include a furniture manufacturer (CCN International) to the north, and railroad tracks (Finger Lakes Railroad), an intermittent stream and adjacent vacant lots and residences to the east, and vacant manufacturing facilities and residential developments located to the south and west. Located south and southwest of the Site is the Market Basket brownfields property (B-00018-8) at the intersection of Gates Avenue and Lehigh Street.

1.3 Site History and Regulatory Summary

The property was developed around 1910 with the construction of part of the existing manufacturing plant, with further additions and improvements completed in the 1930s and 1950s. A boiler and circuit board manufacturer operated on the property until it was purchased in 1979 by Monarch Chemical Company (Monarch), a former operating division of the H.B. Fuller Company (HB Fuller). Monarch utilized the Site to manufacture food grade cleaners and sanitizers used in the dairy and related industries. In 1996, HB Fuller sold the property and business to HoltraChem Distribution Inc. HoltraChem continued to engage in similar production activities that were employed by Monarch. In the late 1990s, HoltraChem was acquired by Basic Chemical Solutions (BCS), and now occupies the Site.

Information and aerial maps coupled with a Sanborn map from 1967 indicated the site was occupied by Magnetic Components, Inc., and in the northern portion of the manufacturing plant Magnetic Components manufactured circuit boards and impregnated capacitors and associated board components for an undisclosed period of time.

The Site currently consists of the 33,700 ft^2 manufacturing plant, exterior bulk liquid powder loading and unloading areas, parking and truck turnaround areas, and a railroad spur. Currently, BCS stores, mixes, and packages powdered and liquid cleaners and sanitizers on-site. The components of this operation include acids, caustics, sodium hypochloride and surfactants. Bulk liquids are delivered by tanker truck, connected to piping located outside the east portion of the plant within a concrete secondary containment area. Additional raw materials are delivered via truck in drums and totes and unloaded at a dock along the southeast corner of the manufacturing building. The mixing tanks are connected via piping to the bulk loading area along the northeast portion of the manufacturing plant.

A series of phased investigations began in May 1996, with a *Phase I Assessment*, and continued into March 2006, with the submittal of the *Supplemental Remedial Investigation* (SRI), continuing with the *Baseline Soil Vapor Intrusion Report* (Delta, June 12, 2007), and the *Heating Season Soil Vapor Intrusion Sampling Event* (ERM, May 2008). The January 2008, SVI sampling detected concentrations of TCE and PCE in all indoor air samples, however these did not exceed the NYSDOH Indoor Air Guidelines of 5 and 100 micrograms per cubic meter (ug/m^3), respectively. Carbon tetrachloride was detected in ambient air, indoor air and sub-slab samples. Similar to the March 2007 Baseline Sampling Event (Delta, June 12, 2007), indoor air concentrations of carbon tetrachloride were higher than sub-slab concentrations. Although carbon tetrachloride is not a Site-related compound of concern in soil and groundwater, an evaluation indicates that mitigation is not necessary and source identification/exposure reduction would be protective of human health.

Within these series of investigations, on March 4, 2002, a Voluntary Cleanup Agreement (VCA) between HB Fuller and NYSDEC, VCP No. V00119-8, was executed concerning remediation of VOCs detected in soil, groundwater, and air at the Site. These investigations determined the presence of petroleum hydrocarbons and chlorinated volatile organics compounds (VOCs), including primary chemicals tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane (111TCA), and the degradation products 1,1-dichloroethene (11DCE), 1,1-dichloroethane (11DCA), cis-1,2-dichloroethene (cDCE), trans-1,2-dichloroethene (tDCE), vinyl chloride (VC), chloroform, and non-chlorinated VOCs including methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), benzene, toluene, ethyl benzene, and xylene (BTEX) compounds. VOCs, the primary compounds of concern, are not used to manufacture food-grade cleaners and sanitizers used in the dairy and related industries. The VOC detected in soil and groundwater are remnant of previous manufacturing practices conducted on-site unrelated to H.B. Fuller operations.

1.4 Workplan Objectives

The objective of this Workplan is to provide a working document which describes an injection program to implement an anaerobic enhanced reductive dechlorination in-situ bioremediation program. Included in this Workplan is a groundwater monitoring schedule designed to evaluate the progress of the IRM and to document the in-situ destruction of the chlorinated solvents and other biodegradable contaminants. This Workplan summarizes planned schedules and other aspects of the IRM which will be performed with oversight from NYSDEC. To complete this Scope of Work, a continuation of the current groundwater sampling will be required, along with additional ERD performance sampling parameters. Based on a review of hydrogeologic and analytical data, the IRM is planned over roughly a 27-month period, followed by a continued assessment of the data to demonstrate the effectiveness of the program. This ERD IRM Workplan seeks to address the VOCs in the shallow soil and groundwater environment, with the added benefit of reducing or eliminating the VOC mass contributing to soil vapor concentrations detected below the northern portion of the manufacturing plant.

2.0 SUMMARY OF PREVIOUS SITE INVESTIGATIONS

Multiple previous reports provide for the site history and procession of site investigations. The following sections summarize this information and is referenced as applicable.

In May 1996, ESC conducted a Phase I of the Site, concluding that in 1984 an underground storage tank (UST) containing fuel oil was removed near the northwest corner of the manufacturing building. Impacted soils were encountered and an excavation removed approximately 25 yds^3. No confirmation soil samples were collected, and the soil was land farmed on the parking lot northwest of the plant. ESC also determined that in 1982 an acid spill occurred outside the plant, which was neutralized and containerized and disposed of off-site. Additionally, in 1992 a wastewater sump inside the building was found to be leaking, releasing an unknown quantity of untreated wasted consisting of dilute solutions of acids, bases, and surfactants into the underlying soils. This material is summarized in the *Phase I Environmental Assessment of Monarch Facility, Geneva, New York* (Environmental Strategies Corp., May 1996).

In May 1996, LBG began a Phase II site assessment to determine potential on-site source areas for impacted soil and groundwater. Soil borings and groundwater samples were collected and analyzed for VOCs, semi-VOCs (SVOCs), pesticides, metals, polychlorinated biphenyls (PCBs), and petroleum hydrocarbons. This investigation determined the shallow subsurface consisted of glacial deposits of fine to very fine sand, silt and clay, with groundwater encountered between 4 and 7 feet below ground surface (bgs). Through soil boring data this investigation determined that VOCs, PCBs, and pesticides were detected below NYSDEC cleanup standards, however, metals and SVOCs were detected exceeding the NYSDEC standards for soil. Additionally, groundwater sampling revealed surfactants, VOCs, and metals exceeding the NYSDEC Class GA water quality standards. This information is summarized from the *Phase II Site Assessment, HB Fuller Company, Monarch Chemicals Division, Geneva, New York* (Leggette, Brashears & Graham, Inc., July 1996).

In October 1996, Delta continued the Remedial Investigation (RI), in an attempt to determine the nature and extent of soil and groundwater impacts from Site operations, evaluate the risk to human health and the environment, as well as determine the potential for natural attenuation to remediate the VOC impacted groundwater. As part of this investigation, soil borings were conducted inside the manufacturing plant, and additional groundwater samples were collected. Between July 1997, and July 1998, additional monitoring wells were installed and surface water samples were collected from the adjacent drainage ditch to the east of the site. The primary outcome of this investigation is that no light non-aqueous phase liquids (LNAPL), or dense non-aqueous phase liquids (DNAPL), have been detected in soil or in the saturated zone. Additionally, biodegradation of chlorinated VOCs was occurring through reductive dechlorination. This information is summarized from the *Remedial Investigation Report, Former Monarch Chemicals Division, 61 Gates Avenue, Geneva, New York* (Delta Environmental Consultants, December 1998).

Delta continued site investigation activities in 1999 and 2000, with the addition of two additional groundwater monitoring wells in April 1999, and confirmation groundwater and surface water sampling which continued through early 2000. The primary conclusions of this work were that the drainage ditch to the east of the site acted as a surface water discharge point and that groundwater impacted by VOCs did not extend downgradient of this area, and that evidence strongly suggested the active bioattenuation of on-site groundwater. In February 2000, a decision was made to cease groundwater monitoring and abandon all on- and off-site groundwater monitoring wells (Figure 3), however, NYSDEC indicated that continued groundwater sampling would be required as part of any monitored natural attenuation (MNA) corrective action strategy. This information is summarized from the Compilation of Site Data/Recommendations for No Further Action, Former Monarch Chemicals Division, 61 Gates Avenue, Geneva, New York (Delta Environmental Consultants, August 2000).

In June 2003, Delta conducted a passive soil gas survey in an attempt to determine the lateral impacts of VOCs in the subsurface and further refine the remedial investigation activities. This investigation indicated the highest chlorinated VOCs (CVOC) were detected along the northeast and northern fence lines. Recommendations of this investigation included further soil and groundwater investigations. This information is summarized from the Passive Soil Gas Survey Findings and Recommendations, Former Monarch Chemicals Division, 61 Gates Avenue, Geneva, New York (Delta Environmental Consultants, August 2003).

Continued subsurface investigations were carried on by Delta in 2005 to further advance soil borings and install groundwater wells to further refine the horizontal and vertical impacts of petroleum hydrocarbons and VOCs in the soil and groundwater environment. This investigative work generated evidence for a petroleum spill in the northwest corner of the building, and NYSDEC assigned Spill No.0504324 to the case. This investigation determined petroleum impacted soils were detected adjacent to a 3,000 gallon UST, and that these impacted soils were below the applicable NYSDEC TAGM 4046 soil cleanup objectives. The NYSDEC issued a closure letter for this spill on June 13, 2006, requiring no further action. This information is summarized from the Limited Site Investigation Report, 61 Gates Avenue, Geneva, New York (Delta Environmental Consultants, November 2005).

Delta continued investigative activities in July 2005, with the addition of thirteen (13) soil borings via direct-push methods, and monitoring wells installed with hollow stem auger (HSA) drilling techniques. Borings were advanced to 16 feet bgs, and wells were installed approximately 14 feet bgs. The investigation generally revealed a fill layer is underlain by glacial silt and clay ranging in depth from 0 to 8 feet bgs. This is underlain by a sand and mixed sand\silt unit ranging in thickness from 2 to 10 feet. This sandy and silt unit is underlain by clay and mixed silty clay unit found at depths ranging from 9 to 14 feet bgs, however, this unit was not contiguous on the eastern side of the site near monitoring well MW-116 and MW-120, or off-site (Figure 2). Groundwater was generally found in the unconfined sand and mixed silt and sand unit beneath the site. The highest levels of total VOCS (TVOCs), including PCE, TCE, and 111TCA were detected in monitoring well MW-118 along the northern side of the manufacturing plant (Figure 2). The monitoring well construction details are summarized on Table 1. This information is summarized from the Supplemental Remedial Investigation, Former Monarch Chemicals Facility, 61 Gates Avenue, Geneva, New York, VCP No. V00119-8 (Delta Environmental Consultants, March 17, 2006).

In March 2007, in accordance with NYSDEC criteria, a soil vapor intrusion (SVI) monitoring program was initiated with sampling of indoor air (IA), soil vapor sub-floor (SS), and outdoor air (OA) upwind of the plant (Figure 4). The results of the SVI indicated that of the VOCs detected in the indoor air samples between 7 and 15 compounds were not detected below the manufacturing plant floor (SS), up to 23 separate VOCs were detected in the indoor air samples at concentrations ranging from 0.21 ug/m^3 to 750 ug/m^3. Carbon tetrachloride (CCl_4) was the only VOC detected in indoor air at concentrations at or near the NYSDOH Indoor Air Guidelines, while TCE and PCE were detected in both the sub-floor soil vapor samples and in indoor air, but below the NYSDOH Indoor Air Guidelines of 5 ug/m^3 and 100 ug/m^3, respectively. The detection of carbon tetrachloride was attributed to current plant operations as it was not associated with past operations, and has not been detected in soil or groundwater. Up to 16 separate VOCs were detected in the sub-floor soil vapor at concentrations ranging from 0.83 ug/m^3 to 1,000 ug/m^3. This information is summarized from the *Baseline Soil Vapor Intrusion Report* (Delta Environmental Consultants, June 12, 2007).

Due to the inconsistency of these results, NYSDEC and NYSDOH requested re-sampling these points. This was conducted in January 2008, where sampling detected concentrations of TCE and PCE in all indoor air samples, however these did not exceed the NYSDOH Indoor Air Guidelines of 5 and 100 micrograms per cubic meter (ug/m^3), respectively. Carbon tetrachloride was detected in ambient air, indoor air and sub-slab samples. Similar to the March 2007 Baseline Sampling Event (Delta, June 12, 2007), indoor air concentrations of carbon tetrachloride were higher than sub-slab concentrations. Although carbon tetrachloride is not a Site-related compound of concern in soil and groundwater, an evaluation indicates that mitigation is not necessary and source identification/exposure reduction would be protective of human health. For this reason, SVI issues will not be addressed further in this ERD IRM Workplan.

2.1 Site Conceptual Model

An accurate site conceptual model is important to properly plan site responses and to navigate the appropriate regulatory programs. This process requires careful considerations are made concerning source areas, chemical compounds, and identifying fate and transport scenarios and completed exposure pathways for potential receptors. A well defined site conceptual model identifies:

(1) the chemicals of concern;
(2) the sources areas & impacted media;
(3) the nature and extent of impacted media;
(4) the dominant fate and transport characteristics of the site;
(5) potential exposure pathways; and,
(6) potentially receptors.

A review of the data and information regarding the Site indicates several items critical in developing the conceptual model, including:

1. There has been no DNAPL or LNAPL detected at this site. Concentrations in soil and groundwater show evidence of VOCs adsorbed to soil, in the soil vapor, and in groundwater. The extent of impacts in soil and groundwater indicate there is a small area of residual VOCs in soil, primarily centered north of the manufacturing plant in the vicinity of MW-118. There is likely a preferential N-S oriented pathways (natural or man-made) which may have led to the observed soil vapor contaminant pattern detected.

2. The site has been adequately investigated and no further investigative activities are necessary to implement this fully functional IRM. This was verbally agreed to with NYSDEC in a February 2, 2007, meeting.

3. The VOC source area in soil is restricted, and shallow, less than 14 feet bgs.

4. VOC impacted groundwater extends downgradient from the source area and is largely confined between the MW-117 location and an adjacent drainage ditch. Impacted groundwater is shallow, less than 15 feet bgs.
5. Surface water impacts to the drainage ditch appear to be unrelated to the Former Monarch Chemicals property. Surface water impacts from the Site by groundwater seepage is seasonal, and minor.
6. Potential receptors to VOC impacted soil, other than through planned future subsurface construction activities, is extremely remote.
7. Beyond the existing manufacturing plant, there are no known potential receptors to soil vapor concentrations emanating from the impacted soil or groundwater on-site. Continued monitoring at BCS suggests this may not appear to present a significant pathway or risk at this site, and the carbon tetrachloride may be unrelated to Monarch operations.
8. The primary exposure pathway is advective groundwater transport, potentially discharging a limited volume of VOCs to the adjacent drainage ditch. Exposure to VOC impacted groundwater, other than through planned subsurface construction activities, is extremely remote.
9. Natural attenuation is a functioning, albeit slow process, already active on-site.
10. There are no known potential receptors to VOCs in soil or groundwater related to Monarch Chemicals operations.

Regulatory Concerns	**Completed**
Identifying chemicals of concern	Yes
Identifying sources areas & impacted media	Yes
Determining the nature and extent of impacted media	Yes
Determining dominant fate and transport characteristics	Yes
Identifying potential exposure pathways	Yes
Identifying potentially receptors	Yes

Based on this model, it is appropriate to propose an IRM to address the existing impacted on-site soil and groundwater. To accomplish this task, no further investigation is necessary, and as the RI\FS process has not been formally completed, it is fitting to propose and ERD IRM Workplan to achieve reductions in VOCs in the soil and groundwater environment. We believe the outlined IRM will achieve this goal.

2.1.1 Soil Conditions

The Site is underlain by several unconsolidated units of varying composition and thickness. The subsurface sediments are typical of the gently undulating glacial topography in the Finger Lakes Region of upstate New York. The near surface sediments between 0 and 4 feet bgs consist of a mixed fill (gravel to silt) which extends across the Site. This fill layer is underlain by native silt and clays ranging in thickness from 0 to 8 feet thick. A sand and sandy loam underlies this unit and ranges from 2 to 10 feet thick. Each of these units is variable in composition, and interbedded laterally with other discontinuous layers, common of a deltaic or fluvial depositional environment. Beneath these granular sediments is a clay and silty clay unit encountered between 9 and 14 feet bgs. This lower confining unit was not encountered in the upper 16 feet at MW-116 and MW-120, or at off-site locations.

VOC Impacts

This summary includes a review of all past soil data generated at the Site, and includes maps and data generated during the SRI, which is generally representative of the subsurface soil conditions. Concentrations of all VOCs and petroleum hydrocarbons were detected below NYSDEC Technical and Administrative Guidance Memorandum (TAGM) #4046 soil cleanup objectives. Low level VOCs (less than TAGM #4046 soil cleanup values) were detected in all soil samples except the near surface soils (between 0 and 4 feet bgs) at MW-115, as depicted on Figure 5. Concentration profiles were evaluated in roughly 5-foot intervals, and contoured to demonstrate relative VOC impacts in the soil from data collected above and below the water table. The highest VOCs were detected just west of the railroad tracks, and north of the manufacturing plant. As noted from soils collected deeper, Figure 6, TVOC Concentrations in Soil (ug/kg); 456 - 451' AMSL Interval, provides only a few data points, but similar to Figure 5 depicts a soil source area extending from MW-117 eastward to MW-118. VOC concentrations decrease further with depth as demonstrated on Figure 7, TVOC Concentrations in Soil (ug/kg); 451 - 446' AMSL Interval, which generally reflect submerged soils.

The primary chlorinated VOCs detected were each separately evaluated, which as expected delineated the mass center of VOCs occurred in the shallow surface soils as demonstrated on Figure 8, 111TCA Concentrations in Soil (ug/kg); 460 - 456' AMSL Interval. As shown on this figure the primary source is located near and adjacent to MW-118. The source area for TCE is depicted on Figure 9, TCE Concentrations in Soil (ug/kg); 460 - 456' AMSL Interval, which shows the shallow subsurface area is centered just south and east in the MW-119 area, and the concentrations decrease rapidly with depth as shown on Figure 10, TCE Concentrations in Soil (ug/kg); 451 - 446' AMSL Interval. Similar to the 111TCA profile, Figure 11, PCE Concentrations in Soil (ug/kg); 460 - 456' AMSL Interval depicts the soil source area is located near MW-118.

To evaluate the subsurface area of petroleum hydrocarbon impacts previously delineated in the western areas of the site, Figure 12, Total BTEX Concentrations in Soil (ug/kg), provides a sum of all the BTEX compounds detected at each boring, which shows the primary area centered near MW-117, decreasing rapidly radially from this area. As noted in the June 13, 2006 NYSDEC closure letter, the concentrations of all VOCs and petroleum hydrocarbons were detected below NYSDEC TAGM 4046 soil cleanup objectives. No further action was required by NYSDEC.

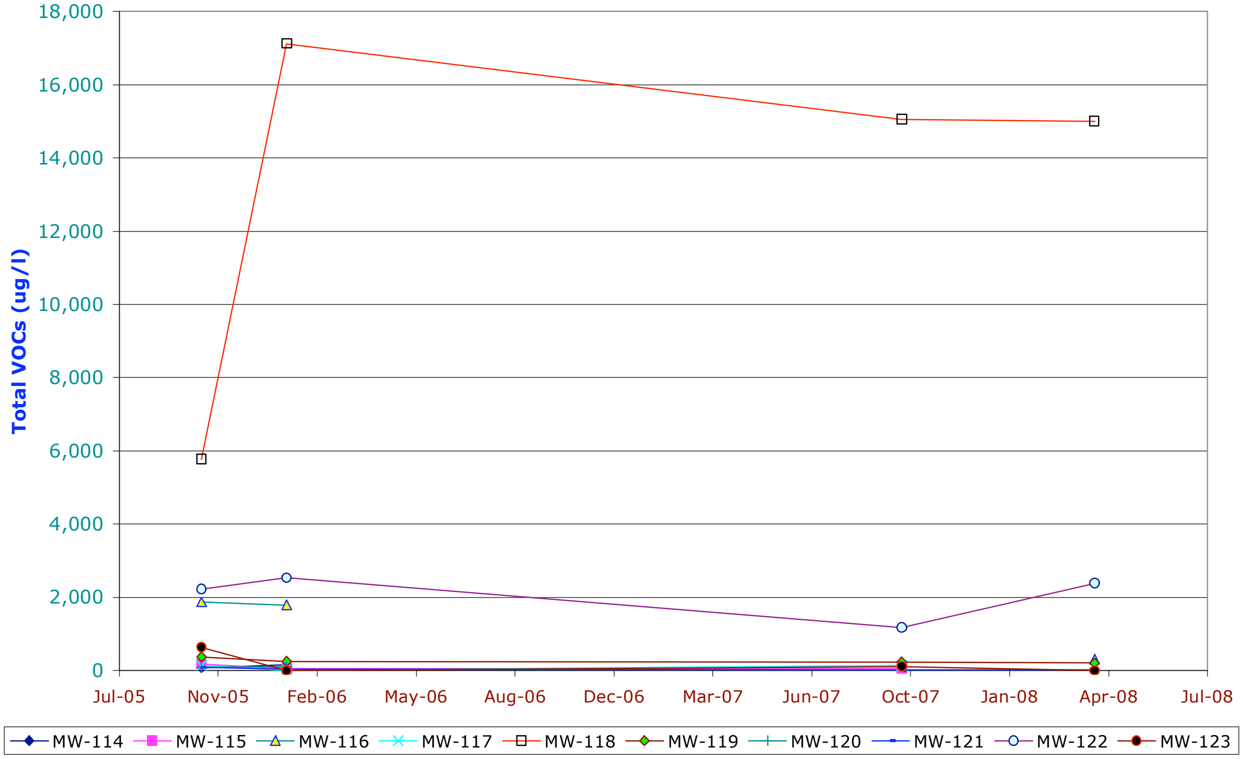
To evaluate the vertical distribution of VOCs from the source areas to downgradient locations a cross section, Figure 13, Cross Section Location Map A - A', was developed. The subsurface geologic environment is portrayed on Figure 14, Geologic Cross Section A - A', which shows the glacial sediments are typical of Finger Lakes region, in a deltaic or alternating fluvial depositional environment. The VOC profiles were also plotted along this cross section which shows the highest levels of VOCs were detected at MW-116, MW-117, and MW-118 during the SRI, largely conducted during the summer-2005 and into early 2006. Figure 15, TVOC Detected in Soil (ug/kg); Cross Section A - A', July 2005, depicts the primary area of impacted soil is relatively shallow, with an likely off-site source area near MW-123. Again, Figure 16, 111TCA Detected in Soil (ug/kg); Cross Section A - A', July 2005, shows the primary source area is located near and downgradient of MW-118. The extent of 111TCA in soil does not extend to the drainage ditch. The extent of TCE in soil along this profile is extremely limited, as depicted on Figure 17, TCE Detected in Soil (ug/kg); Cross Section A - A', July 2005, indicating a separate source area near MW-119. If the primary source for TCE was the degradation of PCE, the profile of TCE would be more similar to that depicted on Figure 18, PCE Detected in Soil (ug/kg); Cross Section A - A', July 2005. The profile for PCE is similar to that of 111TCA.

Based on the relatively low levels of VOCs in unsaturated subsurface soils, the soil does not contain a large mass of chlorinated VOCs sorbed onto the soil matrix, and there does not appear to be LNAPL or DNAPL source present on-site.

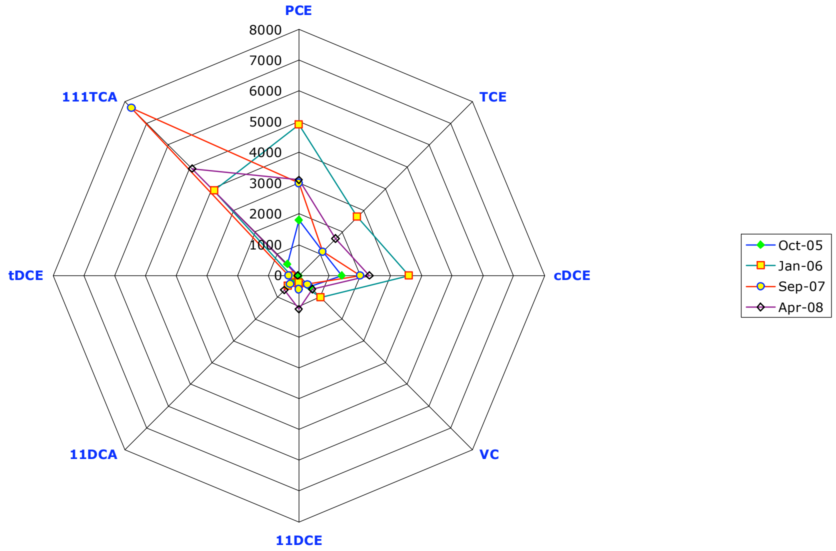
2.1.2 Groundwater Monitoring

Groundwater is found in the shallow unconfined sands and sandy clay units below the Site. The depth to groundwater generally follows the surface topography, typical of a shallow unconfined glacial sediments in this region. The area of greatest depth to groundwater is on the eastern portion of the property near the drainage ditch where the hydraulic gradient steepens near the channel. Groundwater flow is somewhat radially outward from the manufacturing plant, with a general easterly flow direction across the Site, as shown on Figure 19, Groundwater Potentiometric Contour Map; January 2006.

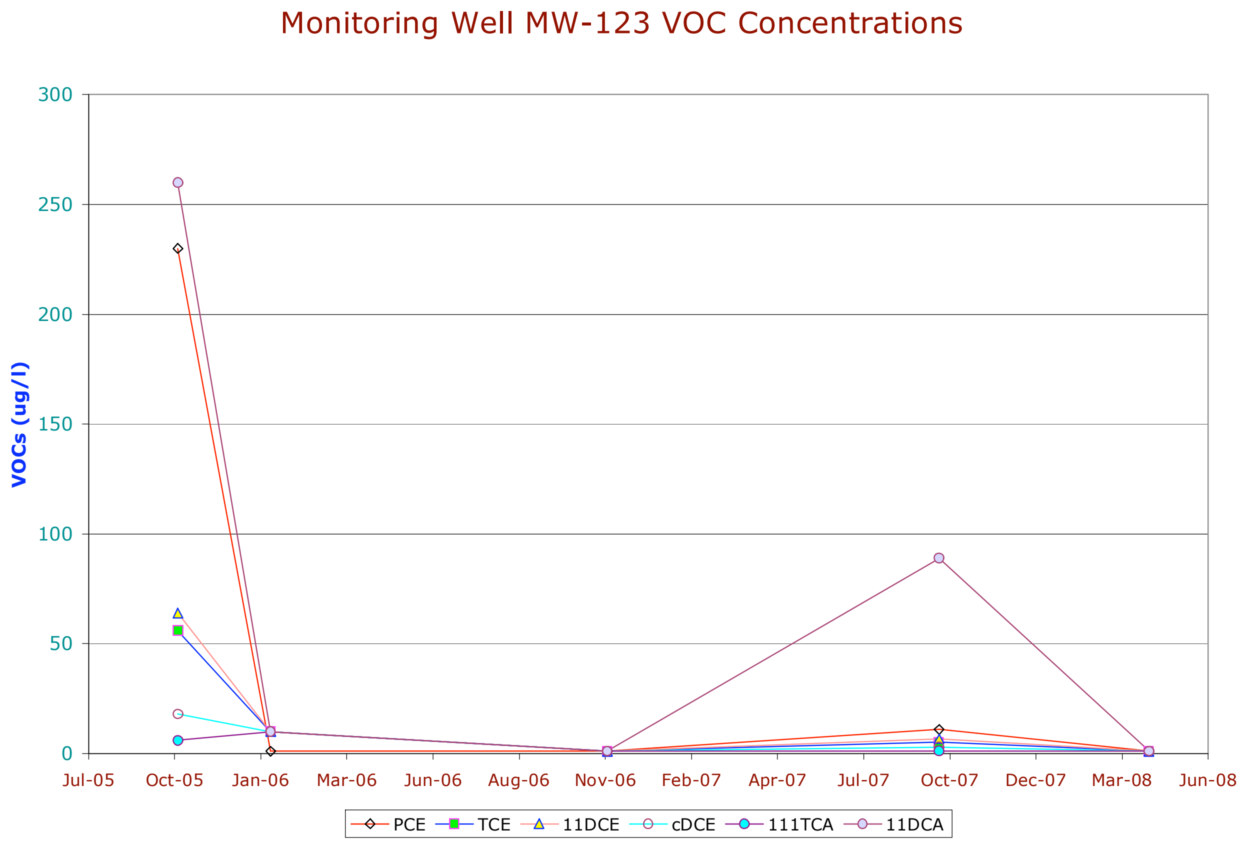
The TVOC concentrations are highest at MW-118 for virtually all constituents of concern.


Total VOC Concentrations in Groundwater

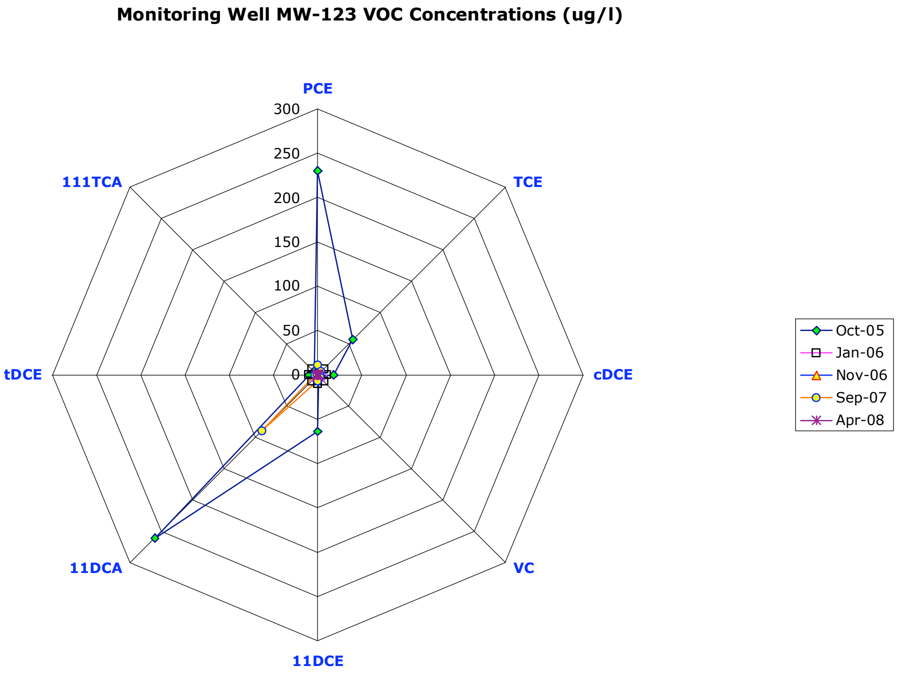
The principle VOC suite at MW-118 is 111TCA, PCE, cDCE and TCE. Well MW-116, downgradient of MW-118 has remained relatively consistent, while MW-122 also downgradient of MW-118 has exhibited steady to decreasing VOC concentrations over time.


Monitoring Well MW-118 VOC Concentrations (ug/l)

In general, VOC concentrations in most wells have remained relatively stable or decreased, with the principle exception MW-123 (east of the drainage ditch), exhibiting wide fluctuations in VOCs.



The principle VOC suite at MW-123 is 11DCA, followed by PCE, TCE and 11DCE.



The following figures depict the area of impacted groundwater based on the data collected in January 2006. A sum of all the VOCs are contoured on Figure 20, TVOC Concentrations in Groundwater (ug/l); January 2006, which shows the mass center of impacted groundwater centered just north of the manufacturing building at MW-118, extending downgradient to MW-116 and MW-122. As noted in the unsaturated soils, the groundwater impacts for 111TCA is also centered at MW-118 is depicted on Figure 21, 111TCA Concentrations in Groundwater (ug/l); January 2006.

The source area for TCE in soil was centered at MW-119, however, the TCE in groundwater is centered at MW-118 as depicted on Figure 22, TCE Concentrations in Groundwater (ug/l); January 2006. The likely source area for TCE is located between these two points. The profile of the groundwater impacted with PCE is different than that of TCE, as shown on Figure 23, PCE Concentrations in Groundwater (ug/l); January 2006, which indicates the area downgradient of well MW-116 is impacted primarily due to advective groundwater flow rather than a source area located here. The concentrations decrease rapidly downgradient of MW-116, a strong indication of natural attenuation in this area.

To evaluate the downgradient transport of VOCs in groundwater, the January 2006 groundwater data was plotted and contoured on cross section A-A’, which is roughly downgradient from the VOC source areas. Figure 24, TVOC Concentrations in Groundwater (ug/l); Cross Section A - A', January 2006, depicts the mass of VOCs centered at MW-118, decreasing rapidly downgradient to the drainage ditch on the eastern portion of the Site. Figure 25, 111TCA Concentrations in Groundwater (ug/l); Cross Section A - A', January 2006, depicts the characteristic single source area located near monitoring well MW-118. This profile is similar for both TCE and PCE, respectively, provided in Figure 26, TCE Concentrations in Groundwater (ug/l); Cross Section A - A', January 2006, and Figure 27, PCE Concentrations in Groundwater (ug/l); January 2006.

Based on the levels of VOCs in the saturated subsurface soils, the surficial groundwater does not contain a large mass of chlorinated VOCs sorbed onto the glacial sediments, and there does not appear to be LNAPL or DNAPL present on-site.

2.1.3 Surface Water Monitoring

The SRI collected surface water samples at three locations (SW-1, SW-2, SW-3) along the eastern drainage ditch. VOCs were detected in all surface water samples at concentrations below the NYSDEC Class D surface water standards or guidance values, except at SW-1 the upstream sample, which detected PCE at a concentration of 4 µg/l, above the established guidance criteria of 1 µg/l. The concentrations of TVOCs, and individual constituents generally decrease downstream. As such, the monitoring of surface waters related to this Workplan will consist of annual monitoring of VOCs, as well as visual observations made daily during the injection program and subsequent groundwater sampling programs.

3.0 INTERIM REMEDIAL MEASURES IMPLEMENTATION

Several potential in-situ treatment options were evaluated for the Site, including chemical oxidation (ISCO), monitored natural attenuation (MNA), and enhanced in-situ bioremediation to address the direct treatment of soil and groundwater impacted by VOCs. The VOCs detected on-site are potentially amenable to several in-situ remediation methods, including aerobic biodegradation (via cometabolism for some VOCs), anaerobic biodegradation (reductive dechlorination), chemical oxidation, and chemical reduction. Because of the different properties exhibited by chloroethanes and chloroethenes, a given treatment technology may not work equally well with each class of contaminant. In some cases, it may be possible to modify the subsurface environment to actively encourage aerobic or anaerobic natural attenuation, providing that suitable microorganisms are present to catalyze the desired biochemical reactions. More aggressive in-situ treatment processes, such as direct chemical oxidation or chemical reduction, can also be implemented, however, these also have drawbacks due to limited contact with the oxidizing agent for sufficient time to complete chemical destruction. ECOR conducted an evaluation of each of these options and determined the most feasible option, given the Site conditions, is an in-situ enhanced bioremediation program via injection of a carbon substrate coupled with the source area injection of zero-valent iron (ZVI). Elemental iron (Fe^o) is a strong reducing agent that is capable of abiotically dehalogenating chlorinated solvents. A summary of this analysis is provided in the table below.

	aerobic biodegradation	anaerobic biodegradation	chemical oxidation	chemical reduction
Applicability to Contaminant Type	2	3	4	1
Ease of Application	3	4	2	1
Health and Safety Issues	3	4	1	2
Infrastructure Compatibility	3	4	1	2
Permanence	3	4	2	1
O&M, Remediation Effectiveness	3	4	1	2
Cost	3	4	2	1
Score	**20**	**27**	**13**	**10**

1= least applicable, 4 = most applicable

Based on site conditions, anaerobic biodegradation is the most applicable technology for IRM implementation.

3.1 In-Situ Enhanced Bioremediation Applicability to Site

A relatively thorough evaluation of MNA conditions was provided in the RI (Delta, 1998). The US Air Force Center for Environmental Excellence (AFCEE) and EPA developed technical standards to evaluate MNA of chlorinated VOCs in groundwater (Wiedemeier, 1996). NA in groundwater results from the integration of several subsurface attenuation processes that are classified as either destructive or non-destructive, with biodegradation the most important destructive attenuation mechanism. Non-destructive attenuation mechanisms include sorption, dispersion, dilution, and volatilization (Wiedemeier, 1996).

Based on the AFCEE system, a site-specific score of 22 was determined for the source area groundwater, a strong indication of reductive dechlorination in groundwater (Delta, 1998), and the reader is directed to this report for a more in-depth description of this study. Routine monitoring has shown that the three primarily chlorinated aliphatics (PCE, TCE, 111TCA) and the mono-chlorinated aliphatics (VC, chloroethane) have been effectively attenuated upgradient of the drainage ditch east of the Site. Other chlorinated aliphatics (11DCA, cDCE) appear to be recalcitrant but natural attenuation is a functioning, albeit slow process already active at the Site. This evaluation leads to the determination that a program to enhance the reductive dechlorination process will have a positive effect on the soil and groundwater conditions.

While both aerobic oxidation and anaerobic reductive dechlorination can occur naturally under proper conditions, augmentation by the addition of electron donors, electron acceptors, or nutrients enhances proper conditions for aerobic oxidation or anaerobic reductive dechlorination to occur. In general, chlorinated VOCs degrade primarily through reductive reactions, while less chlorinated compounds degrade primarily through oxidation (Vogel, 1987). Highly chlorinated VOCs are reduced relatively easily because their carbon atoms are highly oxidized. During direct reactions, the microorganism causing the reaction gains energy or grows as the VOC is degraded or oxidized. During cometabolic reactions, the VOC degradation or oxidation is caused by an enzyme or co-factor produced during microbial metabolism. VOC degradation or oxidation does not yield any energy or growth benefit for the microorganism mediating the cometabolic reaction (US EPA, 2000).

In Situ Biodegradation Mechanisms

	Aerobic Oxidation		**Anaerobic Reductive Dechlorination**	
	Direct	**Cometabolic**	**Direct**	**Cometabolic**
Chlorinated Ethenes				
tetrachloroethene	X	X	◇	◇
trichloroethene	X	◇	◇	◇
cDCE	X	◇	◇	◇
tDCE	X	◇	◇	◇
11DCE	X	◇	◇	◇
vinyl chloride	◇	◇	◇	◇
Chlorinated Ethanes				
111TCA	X	◇	X	◇
12DCA	◇	X	X	◇
11DCA	◇	X	X	◇
Chloroethane	X	X	X	X
Chlorinated Methanes				
carbon tetrachloride	X	X	X	◇
chloroform	X	◇	X	◇
methylene chloride	◇	◇	◇	◇
chloromethane	◇	◇	X	X

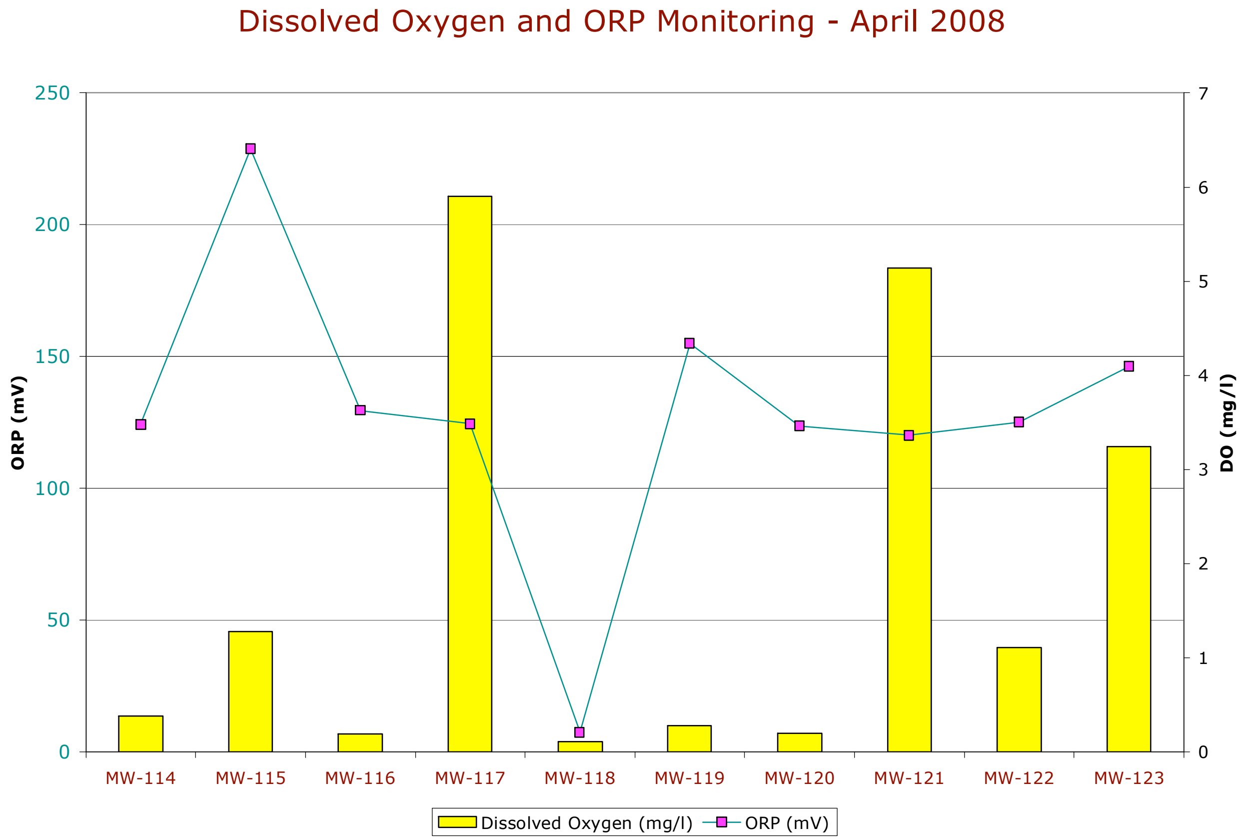
Adapted from RTDF 1997; ITRC 1998; EPA 1998

◇ = Typically occurring
X = Not typically occurring

3.2 In-Situ Reductive Dechlorination

As stated previously, the overall Site trend in groundwater quality indicates stable to decreasing concentrations of VOCs in the source areas and most downgradient locations. The detection of VOC degradation products and their ratios indicate that NA of the CVOCs is occurring, however, solely relying on natural attenuation processes will be slow. The ratio of 11DCA to 111TCA (2005 – 2006 average ~1:1) is indicative of a moderate activity for reductive dechlorination occurring naturally in the surficial groundwater. Reductive dechlorination is the mechanism by which VOCs are biodegraded into less harmful constituents such as water, carbon dioxide, ethene and ethane. The rate of dechlorination at the Site appears to be limited by zones with reducing conditions and low availability of organic carbon. Additionally, oxygen appears to be the predominant electron acceptor in the shallow groundwater. Under these conditions, the addition of sufficient carbon substrate would stimulate the aerobic microorganisms, drive the groundwater anaerobic, and accelerate the enhanced reductive dechlorination of VOCs in the groundwater. Although an extended history of groundwater monitoring at any specific well is not available, several key indicators provide evidence for reductive dechlorination, as summarized below.

- Monitoring for oxidation-reduction potential (ORP), measured in millivolts, is the tendency of a chemical substance to oxidize or reduce one another. This oxidation is the loss of electrons by an atom, molecule, or ion. When a substance has been oxidized, its oxidation state increases. The typical purpose of monitoring ORP is to evaluate the ERD process has gone to completion (i.e., the substance of interest has been completely reduced or completely oxidized). Highly negative environments ([typically in the range of -200 millivolts (mV) to -400 mV] indicate a strongly anaerobic environment, conducive to reductive dechlorination. Reductive dechlorination involves the sequential removal of chlorine atoms from the chlorinated VOC molecule and subsequent replacement with hydrogen atoms. The reductive dechlorination processes occur primarily in anaerobic (or oxygen-deficient) groundwater, where the indigenous microbes utilize an organic carbon source as the primary substrate for obtaining energy. The organic carbon serves as an electron donor and is oxidized during this process. A snap-shot, representative of the site conditions is provided in the chart below.



These results show only marginal reductive zones occur within the shallow glacial sediments.

- Daughter products of the CVOCs. The detection of DCE is common across the site. As a general rule if 80 % of the DCE is cDCE, it is probably a TCE reduction product. The site-wide DCE average in 2006 was 94.3 % cDCE, another indicator of reductive dechlorination. Additionally, the generation of vinyl chloride in the source area at MW-118, and downgradient at MW-122 is another strong indicator of reductive dechlorination.
- The detection of volatile fatty acids for past sampling at MW-3 is an indicator of intermediates detected from the biodegradation of aromatic compounds.
- Other conditions are limiting factors for ERD, including the level of dissolved oxygen. In site-wide groundwater monitoring the average DO was measured at:

1997 - 4.7 mg/l
1998 - 4.9 mg/l
1999 - 3.3 mg/l
2007 - 1.9 mg/l
2008 - 1.8 mg/l

- At this time, total organic carbon (TOC) levels are largely unknown, but past sampling averaged 54.5 mg/l (range 3 – 1,600 mg/l). By providing a long-term carbon source it will assist in reducing the subsurface environment and drive the system anaerobic, consuming the DO, and creating favorable conditions for reductive dechlorination.

3.3 Amendment Options

The data evaluation and feasibility analysis indicates the in-situ amendment of a carbon substrate will be effective in enhanced reductive dechlorination of the Site VOCs. There are several viable, low cost options for a carbon substrate including food-grade carbohydrates such as edible oils, molasses, lactic acid, dairy whey, as well as, manufactured products such as hydrogen release compounds (HRC®, HRC-X™, HRC Advanced™, HRC Primer®), Newman Zone™, and others. There are particular benefits of each of these amendments such as cost, implementability, effectiveness, monitoring requirements and unique site conditions, all of which need to be taken under consideration prior to choosing the proper amendment.·

- Simple oils and whey have been proven effective in reductive dechlorination. Whey is a lactose rich by-product of the dairy industry which generates lactate compounds, as well as, acetates, butyrates, and other substances that can strip chlorine atoms from 111TCA and the breakdown products 11DCA and 11DCE. Cost is a beneficial consideration for these amendments.
- Molasses has a proven track record as a carbohydrate substrate amendment in the subsurface to serve as a supplemental energy source for indigenous microbes and enhance the existing microbial processes occurring within the subsurface. Cost is also a beneficial consideration, however, a history of repeated injections tend to increase the cost of this option.
- HRC is a food grade product which is viscous (similar to honey-like material) and composed of glycerol tripolylactate or glycerol polylactate. The viscosity of this amendment is often a detrimental consideration as uniform application can be difficult.
- Newman Zone provides a rapid electron donor in a food grade sodium lactate, and a slow release electron donor as emulsified oil, which is designed to enhance in-situ bioremediation of VOCs. This amendment is comprised of a food grade sodium lactate to stimulate microbial growth within hours of application and rapidly produces anaerobic conditions in the subsurface, while an emulsified, soluble vegetable oil is retained on soil surfaces and in pore spaces where it slowly ferments. The residual vegetable oil fermentation provides a carbon source for anaerobic biodegradation for extended periods of time, often several years.

Summary of Amendment Application & Methods

Substrate	Bulk Price\lb ($)	Application Techniques	Frequency of Application	Applicability to Site Conditions
Soluble Substrate				
Lactate	1.00 to 2.00	Injection well or circulatory system	Continuous to monthly	**3**
Methanol	0.10 to 0.25	Injection well or circulatory system	Continuous to monthly	**3**
Ethanol	0.10 to 0.26	Injection well or circulatory system	Continuous to monthly	**3**
Molasses	0.25 to 0.35	injection wells	Continuous to monthly	**2**
corn syrup	0.25 to 0.30	injection wells	Continuous to monthly	**3**
Viscous Fluid Substrates				
HRC	5.00 to 7.00	direct injection	Annual to bi-annual	**2**
HRC-X	5.00 to 7.00	direct injection	Every 3-4 yrs	**2**
Vegetable Oils	0.20 to 0.40	direct injection or injection well	One-time application	**2**
Low-Viscosity Fluid Substrates				
Vegetable Oil Emulsions	1.50 to 4.00	direct injection or injection well	Every 2-3 yrs	**1**
Experimental Applications				
Whey (soluble)	1.00 to 1.50	direct injection or injection well	Monthly to annually	**4**

1= most applicable, 4 = least applicable
(Adapted from AFCEE, 2004)

Based on site conditions, the recommended amendment would be Newman Zone (NZ). Newman Zone (Patent 6,806,078) provides both a rapidly utilized electron donor as well as a slow-release long- term electron donor designed to enhance ERD of chlorinated solvents. The NZ electron donor formulation has the advantage of both fast and slow release electron donors, with sodium lactate in the formulation to stimulate microbial growth within hours of injection and to rapidly drive the groundwater environment toward anaerobic conditions. As the lactate is being consumed the soluble vegetable oil portion is retained on soil surfaces and in pore spaces where it slowly ferments. This fermentation further supports anaerobic biodegradation for extended periods of time, often years. The vegetable oil slowly ferments to release volatile fatty acids, and molecular hydrogen which support the anaerobic microbial community. The NZ amendment is a concentrated source of electron donors, with an electron equivalent dose for the lactate, soybean oil, and food grade additives over 175 electron equivalents per kilogram. The Material Safety Data Sheet (MSDS) for NZ is provided in Appendix C.

In the source area near MW-118 an additional reductive dechlorination compound will be utilized, consisting of Z-Loy^{TM}, a sub-micrometer, zero valent metal powder suspension engineered for in-situ applications. The ZVI contains discrete, irregular sub-micrometer particles with a median particle size of about 200 nm and a typical surface area of 15 m^2/g. Key features include:

- Small Particle Size - mean particle size below 250 nm
- Limited Aggregation - Provides optimum sub-surface mobility
- High Surface Areas - Tailorable from 1 to 30 m^2/g. High surface area particles provide enhanced reaction kinetics.
- Biocompatible - often used with other ERD amendments
- Range of Compositions & Reactivity - Most metals and metal alloys can be produced including compositions more reactive than iron
- Hydrogenation Catalysts - All Z-Loy^{TM} materials can be amended with Pd, Cu, and other hydrogenation catalysts

Z-Loy^{TM} is packaged as a concentrated non-aqueous suspension. The fully water miscible propylene glycol and glycol ether solvent is inert and helps maintain the zero valent metal interface. The NZ, coupled in the source area soil and groundwater by ZVI, will create a reducing environment (target ORP < −400 mV), lasting long enough for an extended anaerobic environment after the injection.

4.0 PROPOSED INJECTION AND MONITORING PLAN

The intended zone for treatment is north of the manufacturing plant, and downgradient to the east. It is recommended that the amendment delivery be conducted in consideration of the weather (spring-summer-fall) given the shallow zone for treatment. Given periodic drought conditions experienced at the site, for optimal treatment in the intended source areas the groundwater conditions should need several feet of saturated glacial sediments to be most effective. To evaluate and monitor the effectiveness of the IRM, the current groundwater sampling program to have to be modified to include additional ERD parameters in the following locations:

Inside source area: These areas (MW-117, MW-118) provide data on geochemical conditions and contaminant trends induced by the injected amendment.

Downgradient of source area: These wells (MW-114, MW-116, MW-119, MW-120, MW-121, and MW-122) provide data on the residence time effects, and the contact time that the electron donor has in the target treatment area.

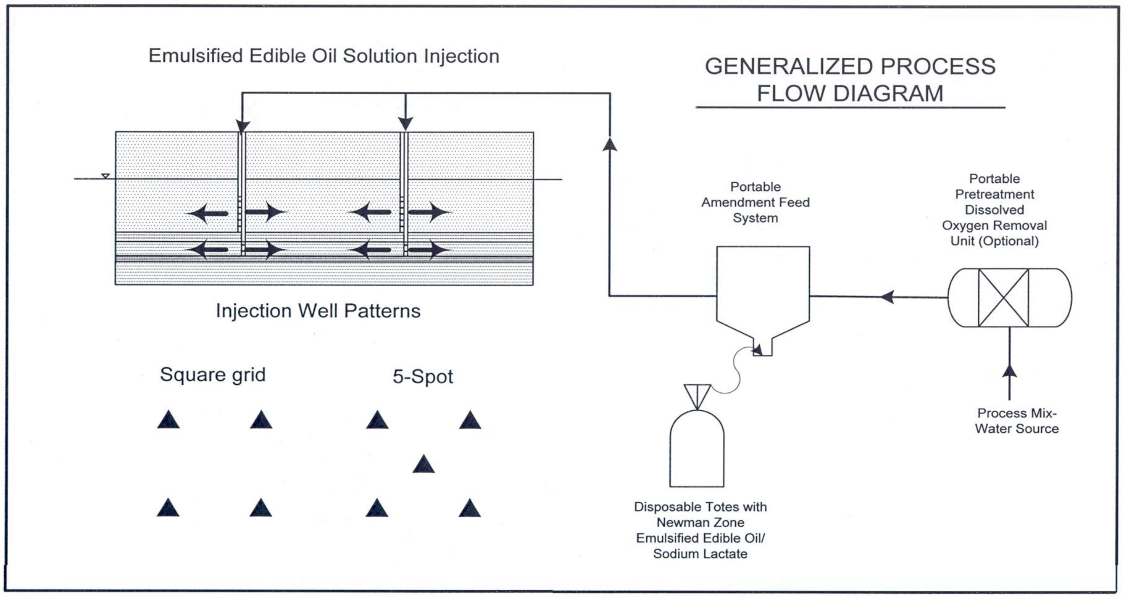
Cross Gradient or Significantly Downgradient of the treatment area: Provides a measure of general trends outside the direct influence of the ERD IRM (MW-115, MW-123).

4.1 Amendment Delivery

The proposed amendment delivery through direct-push drilling technology (i.e., Geoprobe), will occur over a contiguous area north of the manufacturing plant in two adjacent areas:

1. NZ injected through temporary points from approximately 4 to 14 feet bgs.
2. ZVI injected through temporary points from approximately 3 to 14 feet, followed by NZ through the same interval.

The injection plan will be conducted from the “outside, inward” toward the center of the source area (i.e., radially toward MW-118), and conducted on a square grid pattern based on ~10-foot centers. To maximize the injection activities, a 10-channel proportional feed system will inject at multiple points during probe extraction (i.e., injection from bottom, up).



Based on the hydraulic testing and groundwater sampling, the shallow glacial sediments will accept the amendment delivery through the Geoprobe rods as they are extracted from the borehole. Historic hydraulic gradient measurements from nested wells (MW-101\201, MW-102\202, MW-108\203) conducted during the RI indicated a consistent downward vertical gradient (Delta, 1998). This fact will ensure the amendment is not prematurely discharged and will follow groundwater flowpaths to ensure necessary treatment. While other gradient measurements were taken, the data table below is representative of the groundwater flow conditions.

Well Nest	Average Gradient
MW-101\201	0.385
MW-102\202	0.458
MW-108\203	0.673
Site-wide Average	**0.505333**

These characteristics are typical of a shallow recharge-to-discharge groundwater flow system in glacial sediments. Hydraulic conductivity tests conducted during the RI indicated the geometric mean hydraulic conductivity of the soils at or near the water table was 1.35 feet/day (Delta, 1998). Deeper within the saturated section (20 to 26 feet bgs interval), the geometric mean hydraulic conductivity was measured at 0.34 feet/day. This establishes a more permeable target zone for the injected amendment, with a downward gradient to carry the amendment toward the base of the permeable glacial sediments, which is in turn underlain by an effective aquitard. At some locations however, the injection will extend into the upper section of the aquitard.

With an site-measured horizontal hydraulic gradient of 0.056 (Delta, 1998), a mean hydraulic conductivity value of 1.35 ft/day based on aquifer testing in the surficial glacial sediments, and an estimated effective porosity of 22 percent, the average linear flow velocity ranges would be in the range of 0.34 feet/day:

$$\mathbf{V} = \mathbf{K}\iota\backslash\eta$$

where,

$\mathbf{K}$= Hydraulic Conductivity (1.35 ft/day)
ι= Hydraulic Gradient (0.056)
η= Effective Porosity 0.22 (estimated from field data)

The vertical flux determined in the RI (Delta, 1998) was approximately 0.00067 feet/day. The horizontal flow rates greatly exceeds the vertical flux, and with a characteristic recharge-to-discharge flow regime the downward migration of dissolved phase VOCs is restricted spatially. To ensure adequate distribute the amendment, the injection program will be completed on a square-grid pattern with 10-foot centers. This spacing is based on providing overlap of the injected amendment from each injection point and providing a 5% Newman's Zone solution, or 2.5% oil.

The ZVI would be employed only in the MW-118 area, and would consist of injection of Z-Loy with a water carrier, followed by NZ alone injected through the same interval (roughly from 3 to 14' bgs). Each injection point will treat a volume of glacial sediments equal to approximately 785

ft^3. Figure 28, ERD Injection Area, depicts an overlay of the soil detecting greater than 100 µg/kg TVOCs and the groundwater area detecting greater than 1,000 µg/l TVOCs, and the proposed treatment area from an areal perspective. The injection program proposes to employ the amendment on a rough grid spacing on 10-foot squares, extending from just west of MW-117 in the west, extending south into the manufacturing plant near SS-3, and eastward to the railroad tracks. Angled injection points, directed to the area below the AST containment area will be advanced near MW-118, as noted on Figure 29. Also adjacent to MW-118, an injection point will be added to the center point of the grid and the combination NZ and Z-Loy will be injected. A separate line of injection points will be placed upgradient of MW-122, as shown on Figure 29, Proposed Injection Point Locations. Due to the slope of the bank leading to the drainage ditch, these points may be installed via roto-hammer drill or other means. It is noted that underground utilities and above ground structures will move some injection locations, but it is proposed that this grid location is surveyed onto the Site, then flagging placed at each injection location. All of the injection points shown on Figure 29 are approximate, and subject to relocation or elimination due to field conditions.

Figure 30, ERD Treatment Zone; Cross Section A - A', depicts the area treated with both Newman's Zone and the ZVI near MW-118. As shown on Figure 30, the downgradient injection area near MW-122 will extend just above and below the water table as unsaturated soils are not impacted in this area.

4.1.1 Soil Sampling Program

During the advancement of Geoprobe rods in the area of MW-118, up to 10 soil samples will be collected and quantitatively evaluated for the presence of NAPLs. The GeoProbe rods will be advanced from the ground surface to 14 feet bgs, and screened with Sudan IV® field test kits. To analyze the potential for NAPLs, soil from this interval is added to the sample bottle, potable water is added, then the contents shaken vigorously. A rapidly dissolving cube is attached to the jar cap, which contains the Sudan IV based red oil soluble dye and a fluorescing yellow/green water soluble dye. After agitation, the sample is allowed to settle and if present, a dye will stain petroleum products (including DNAPLs) red; while the green dye colors the water to provide a visual contrast between the two colors. This sampling method is quantitative because of individual soil affinity to oil and NAPLs vary. Since DNAPL is heavier than water it is typically seen near the bottom of the sample container, and often DNAPL can also be seen as red "beading" on the sides of the jar.

During the course of the injection program, the lithology at some injection locations may be cataloged by either electrical conductivity or other methods to show changes in sediment grain size, thickness, or elevation of lithologic units of interest. Soil conductivity logging continues to increase in usage because conductivity logging can be efficiently performed with the Geoprobe equipment. This lithologic evaluation will be used to optimize the injection program, and establish the lithologic sequence along the eastern boundary near MW-122.

4.2 IRM Sampling and Analysis Plan

The current sampling program consists of a tri-annual sampling program, as identified on Table 2. A baseline VOC sampling was conducted in September 2007, for all the groundwater monitoring wells, however, due to drought conditions in the region, several monitoring wells were dry, and others did not contain enough water to get a sample to the surface. In September 2007, wells MW-

114, MW-121 and MW-122 were completely dry, and wells MW-116, MW-120, MW-121, and MW-122 did not have enough water to sample. Groundwater samples were collected for VOCs from wells MW-115, MW-117, MW-118, MW-119, and MW-123. This condition has implications on both the ERD IRM Workplan, as well as the IRM monitoring plan for groundwater. Functionally, the IRM will be treating non-potable, geographically limited groundwater in glacial sediments subject to complete evapotranspiration dewatering.

Prior to the amendment injection a baseline groundwater sampling event will be conducted for performance monitoring. Based on contamination profiles, it is proposed that wells MW-114, MW-116, MW-117, MW-118, MW-119, MW-120, MW-121, MW-122, and MW-123 be sampled for VOCs, ERD performance monitoring parameters, and field parameters, as outlined on Table 3. Additionally, to determine the indigenous microorganisms present further sampling at MW-118 will be conducted (Table 3). The groundwater monitoring program will extend post-injection, to include the sample parameters from the baseline sampling, as well as, the additional analyses for degradation byproducts (Table 3). Water levels will be measured in each monitoring well to determine flow characteristics. A summary of the information to be gathered is provided below.

Field Parameters - Field parameters will be measured at each well in the performance groundwater monitoring well network. Parameters include DO, oxidation reduction potential (ORP), pH, temperature, and specific conductance. These data will be used to assess conditions in the groundwater system supporting anaerobic biodegradation of the target VOCs.

Electron Acceptors - Analyses for electron acceptors provide data regarding the relative levels of natural inorganic compounds, which act as electron acceptors for various respiration processes. These compounds include sulfate, nitrate, and ferric iron. Evaluation of electron-acceptor concentrations in site groundwater before and after reagent injection can facilitate a determination regarding which degradation mechanisms are active and/or dominant.

Degradation Byproducts and End Products - Analyses for VOC degradation byproducts and end products provide data regarding the relative levels of compounds formed. Combined with other observations, these data can indicate the amount of relative reductive dechlorination. The degradation byproducts and end products for reductive dechlorination include ferrous iron, sulfide, nitrite, nitrogen, CO_2, methane, chloride, ethene, and ethane.

Volatile Organic Compounds (VOCs) - Analyses for target VOCs and their degradation products include TCE, 111TCA, cDCE, 11DCE, 11DCA and VC, which provides information directly demonstrating the effectiveness of pilot test enhanced bioremediation program. Following initiation of the injection program pilot testing, groundwater samples will be collected to assess the performance of the reductive dechlorination process. Groundwater samples will be collected from the monitoring well network and analyzed for the same parameters evaluated during baseline monitoring (Table 3).

4.2.1 Groundwater Sampling Procedures

Groundwater monitoring wells are divided into two categories; wells with dedicated downhole sampling systems, and those wells where downhole sampling systems have not been installed. As of September 2007, no site wells (Figure 3) have dedicated downhole equipment and this sampling outline includes the procedures for sampling wells and locations without dedicated downhole equipment. Numerous studies have been completed on groundwater sampling methods involving low-flow rate purging. Studies by Barcelona, et. al., (1994) and Puls and Barcelona, (1996) discuss and compare conventional versus low-flow purging methods and show that low-flow rate sampling meets high data quality objectives. Low flow sampling techniques will be employed in the groundwater monitoring program for the Site. All of the groundwater monitoring wells will be sampled with low-flow bladder pumps, at an initial purge rate ~ 50 – 300 ml/min. Purge rates will be adjusted with the goal of inducing less than 0.3' drawdown in the well during purging. Field parameters will be collected during purging.

Wells sampled without downhole equipment

1. Wells will be sampled in sequence from least contaminated to most contaminated which reduces the potential for cross contamination.
2. Weather conditions such as temperature and general atmospheric conditions will be observed and noted on the *Water Sampling Log* Form.
3. The well and immediate area will be inspected and the integrity of the well noted. Any maintenance requirements and problems will be noted on the *Water Sampling Log* Form.
4. The well will be unlocked and the well cap removed. The top and inside of the casing will be wiped off, if needed.
5. A photoionization detector may be used to check for any organic vapors emanating from the well. The readings will be recorded on the well *Water Sampling Log* Form.
6. The depth to all fluid phases (groundwater, LNAPL, and DNAPL) detected in the wells will be measured to the nearest 0.01 foot using either a steel tape with indicator paste, an acrylic bailer, or an electric or optical probe. All groundwater monitoring wells (Table 7), on-site and off-site, associated with the Facility have permanent datum etched into the top of casing (TOC), identified by a notch and permanent markings on the casing, or the north side of the well casing. All measurements of total depth, water elevation and immiscible phases will be measured and referenced from this point and recorded on the *Water Sampling Log* Form.
7. The total depth of the well to be sampled will be measured to the nearest 0.01-foot and the measurement recorded on the *Water Sampling Log* Form. The depth will be compared to the total depth recorded from initial construction. Wells will be redeveloped if the comparison of total depth (less well bottom sump) shows that 10 % of the well screen is occluded by sediment.
8. The required volume of water to be purged from each well just prior to sampling will be calculated and noted on the *Water Sampling Log*. The calculated purged volume necessary for representative groundwater samples will be determined just prior to sample collection. Purge volumes are calculated specifically for each well by multiplying the well casing volume determined in each well in gallons per foot of water by the feet of water in the well.
9. The wells without dedicated downhole pumps will be purged with a non-dedicated submersible pump such as a 2-inch Grundfos Redi-Flo^2, a low-flow bladder pump, or a peristaltic pump until at least three well volumes have been removed and the field parameters of pH, conductivity, and temperature of the water have stabilized within 10 percent of the last two measurements or the well is pumped dry in which case only one group of readings will be taken. Instances where the saturated thickness is insufficient to

purge with a pump a dedicated bailer will be used to collect the sample. Field measurements will be measured according to equipment manufacturer's instructions and referenced EPA methods. Three readings will be taken unless the well goes dry in which case only one reading will be recorded. The readings will be recorded on the *Water Sampling Log* Form. All instruments will be calibrated before each days use according to manufacturer's instructions and referenced EPA methods. The manufacturer and model number of the instruments used at each sample location will be logged in the *Calibration Log Book* for that instrument.

10. The final measurements collected are the most representative of the water sampled and will be recorded on the *Water Sampling Log* Form. All purge volumes and calculations will be recorded on the *Water Sampling Log* Form.
11. The non-dedicated submersible or bladder pump will be fitted with polyethylene tubing for discharge. The pump and tubing will be lowered by hand to 5-feet below the water level or to bottom of the well minus 5 feet. The pump will be powered with a portable generator, situated down-wind and away from the well to avoid contamination from exhaust fumes. Purge rates will be kept low (50 – 300 ml/min), with the intent of limiting drawdown to less than 0.3' during purging. If recharge can not keep pace with the pump rate and the pump breaks suction, the pump will be shut off immediately and the well will be considered dry. The pump will then be lowered by hand to the bottom of the well screen and all sampling containers placed nearby. The pump will then be turned on and the pumping rate reduced to 100 ml/min or less. When the sampling is complete, the pump and tubing will be withdrawn from the well. The pump and tubing will either be decontaminated or disposable equipment will be containerized. Water pumped from the wells will be contained and profiled prior to proper disposal.
12. Samples will be collected directly from the sampling port located at the discharge manifold or tubing. Samples will be preserved as appropriate in sample containers provided by the laboratory and submitted and analyzed before the required holding time has expired. Water samples for dissolved metals analyses will be filtered through a 0.45 micron filter to remove suspended particulate matter prior to filling sample bottles, or shipped next day for filtration at the appropriate analytical laboratory. Information on the sample location, analysis to be performed, date and time of sample collection, name of sampler, and preservatives used will be recorded on the sample container label.
13. The individual sample containers will be identified with the unique well ID, identical to the information recorded on the *Water Sampling Log* Form. Samples requiring refrigeration will be placed in a cooler immediately after sampling and cooled to 4^{o} Celsius. Prior to shipment to the laboratory, the samples will remain chilled using ice packs or an on-site refrigerator and kept under constant chain-of-custody surveillance. When shipped to the laboratory, the shipping containers will include the completed Chain-of-Custody Records and laboratory instructions, and sealed with a custody seal. The shipping containers will be shipped to the appropriate laboratory via overnight or same-day courier service.

Groundwater samples will be collected from monitoring wells using low-flow sampling procedures, in accordance with the *Sampling and Analysis Plan* (SAP), included as Appendix A. The purging and sampling procedures utilized during collection of the performance monitoring samples will comply with the procedures outlined in the SAP. The preserved groundwater samples will be placed on ice in a cooler and shipped to STL\TestAmerica, Buffalo, New York.

Quality assurance/quality control (QA/QC) sampling will include the collection of one field blank, and one trip blank during each groundwater monitoring event. Each sample blank will be analyzed for VOCs (Table 5). All the data generated from the groundwater sampling (Table 4) will be used to determine the progress of the ERD program (Table 6). The length of time and relative concentrations observed will depend upon the effectiveness of the ERD and distance from the injection points to the monitor wells. Post-injection concentration increases can be expected for some parameters as the VOC constituent mass is liberated and transported by groundwater flow and/or chemical dispersion. An important concept in the reductive dechlorination process is that the resultant production of degradation and/or byproducts (cDCE, VC, ethene, and ethane) in the injection and downgradient groundwater monitoring wells are expected to rise, even in some wells with no history of detection of these compounds. Often, the rise in concentrations could bring the degradation byproduct above the NYSDEC water quality standard, which would provide evidence of biologically mediated degradation of the target VOCs, which would be considered a positive effect of the pilot test program. Even if the acceptance criteria are not met (groundwater concentrations below NYSDEC criteria) during the IRM test period, the program may be extended if there is sufficient evidence that the criteria could be met through extended and/or modified testing or further injections.

4.2.1.1 BioTrap Installation

The objective of the Bio-Trap investigation is to determine the bacteria present and changes in the bacteria community structure during the IRM. The significance and effectiveness of the ERD will be assessed following the initial injection for Denaturing Gradient Gel Electrophoresis (DGGE), CENSUS, and Phospholipids Fatty Acid (PLFA) analyses. These analytical parameters were selected to provide a snapshot of the current biological community active in the source area at MW-118. The first Bio-Trap installation was completed in September 2007, and should be re-scheduled approximately 9-months after the initial injection.

The laboratory Microbial Insights, Inc. (MI) located in Rockford, Tennessee provides the Bio-Trap samplers. The sampler was installed approximately in the middle of the water column, and will be kept in the wells for approximately 60-days to give bacteria time to grow on the cell beads.

4.2.2 Groundwater Monitoring and Data Evaluation

Groundwater level data generated from monitoring will be tabulated and used to generate groundwater potentiometric contour maps. Contouring and evaluation of the data will be performed by or under the direction of an experienced hydrogeologist. Groundwater quality data will be tabulated for each sampling event. Isoconcentration contour maps will be prepared for selected constituents and reported in the *IRM Performance Report*. The data tables will be used to summarize the constituents analyzed, concentrations detected, units of the concentrations, detection limits, sample location and data of sampling. A separate table may be prepared for the QA/QC samples and will include similar information. The quality assurance information for the groundwater program will be presented as required and will include the following:

- Field and laboratory quality assurance activities;
- Laboratory data validation results;
- Precision and accuracy of data;
- Completeness of data;
- Usability of data.

Groundwater monitoring reports will contain analytical results, field parameter measurements, copies of field sampling and well inspection log sheets, well repair documentation, QA/QC data, statistical analyses of groundwater data, field investigation results, and other relevant groundwater related information collected during the reporting period. A summary of the information for each report will include the following:

Description of field activities

- status and integrity of the monitoring well network;
- surface and subsurface well integrity problems noted, or repaired;
- discussion of any variations in sampling protocol.

Summary of groundwater quality data

- contaminant transport rate and direction;
- horizontal and vertical extent of contamination;
- analytical data summary tables;
- discussion of data validation results;
- evaluation of variations in upgradient and/or downgradient groundwater quality.

Summary of water level data

- water level data summary tables;
- various hydrographs to depict groundwater conditions during reporting period

4.2.3 Surface Water Monitoring

The drainage ditch located along the eastern portion of the site is classified as a Class D surface water body. Previous monitoring has detected the highest VOC levels at the upstream sampling point, indicating an off-site source. The implementation of this IRM will necessitate daily visual observation of the stream, particularly in the area of MW-122 during the injection program. Surface water sampling will be conducted annually, as noted on Table 2, generally occurring during the spring triannual sampling event.

Prior to the injection program commencing, further work will be proposed to NYSDEC to evaluate the surface water\groundwater interactions across the area of impacted groundwater to hydraulically determine the timing of groundwater seepage into the drainage ditch. This will likely consist of multi-level mini-piezometers and elevation stations along the drainage ditch between MW-114 and MW-121.

4.3 Summary of Site Health & Safety Plan

A copy of the *Site Health and Safety Plan* (SHSP), included in Appendix B, will be made available to all employees prior to their Site work. They will be required to review this plan before the start of any site activities. All other personnel involved with remediation activities will have received a pre-entry briefing.

Chemical Hazards

A summary of the exposure limits and physical properties of the organic chemicals of concern are outlined in the SHSP, consisting primarily of chlorinated solvents and petroleum hydrocarbons in soil, vapor, groundwater and surface water. The potential pathways of chemical exposure may be through inhalation, ingestion, injection, and skin contact. This information was used to develop action levels for on-site activities. Although the chemicals identified are a potential health concern, measures will be taken to minimize potential for exposure. Because these contaminants were identified as potential constituents in groundwater, employees performing intrusive activities, such as drilling, subsurface injections involving soil and groundwater, and miscellaneous maintenance work, excavations, and equipment installations, should follow the specific health and safety procedures provided in the SHSP. The potential acute and chronic affects of chlorinated solvents and VOC exposures are described in the SHSP, as well as action levels to mitigate these risks.

Physical Hazards

The SHSP contains a summary of potential work hazards that may be encountered during remediation activities. Potential hazards are described according to each specific job task. The two main physical tasks performed at this Site include drilling and injection activities into the shallow subsurface, groundwater monitoring and soil sampling, and risks associated with large construction equipment related to conducting site investigation and sampling (drilling rigs, forklifts, trucking, maintenance equipment, vehicle traffic). Other physical activities performed at this Site, such as regular maintenance work and equipment installations, exposure of employees to potential hazards, and standard operating safety procedures are described in detail in the SHSP.

Health and Safety Program Manager

ECOR has designated an employee as its Health and Safety Program Manager (HSPM). This person has the authority to command sufficient resources to safely perform the Work. Mike Wisnewski, P.E., has been designated as the HSPM.

Project Manager

ECOR has designated an employee as its Project Manager (PM), who oversees all aspects of the implementation of this work. This person has the authority to command sufficient resources to perform all work associated with this IRM Workplan. Keith Rapp has been designated as the PM.

Health and Safety Coordinator

ECOR has designated a Site Health and Safety Coordinator (SHSC) for this project. Day-to-day industrial hygiene support, including air monitoring, training, site safety inspections, shall be provided by the SHSC. The SHSC has the authority to stop on-site operations whenever conditions threaten the health or safety of employees. The SHSC or his\her designee will remain on-site during all project operations.

ECOR has designated Jennifer Good as the SHSC. Ms. Good has a sound working knowledge of occupational safety and health regulations; experience on the type of project described in this SHSP; and training in air monitoring practices and techniques.

Subcontractors

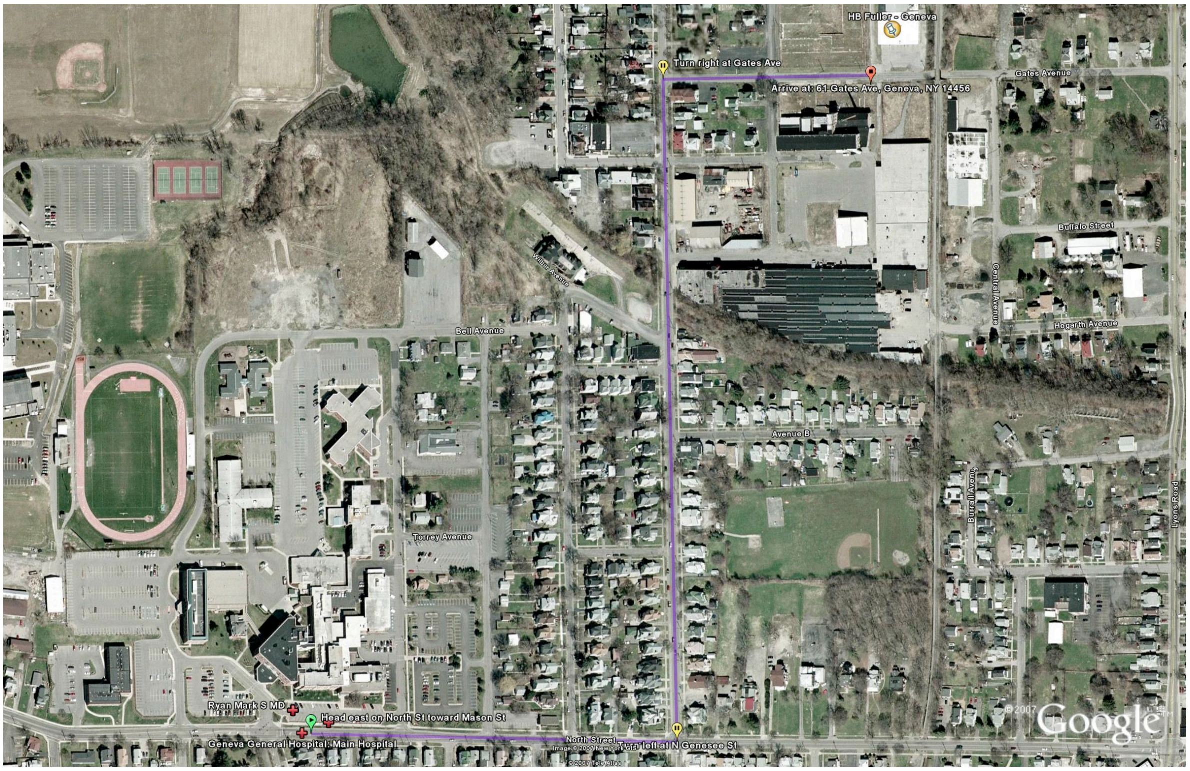
ECOR may be supported in the remediation activities by subcontractors. All subcontractors involved with on-site operations will be provided a copy of the SHSP. Subcontractors involved with intrusive remediation activities will be informed of the health and safety concerns and will be responsible, at a minimum, for maintaining the health and safety requirements presented in the SHSP. Information, such as air monitoring and analytical results, will be shared with subcontractors to assist them in addressing the health and safety recommendations. ECOR will ensure that subcontractors have met the training, respirator certification and medical examination requirements of the OSHA Hazardous Waste Operations and Emergency Response Standard (29 CFR 1910.120). Subcontractors involved with intrusive activities will be required to provide to ECOR completed certification forms for this purpose.

The nearest emergency room to the Site is the Geneva General Hospital. The directions are:

From: Former Monarch Chemical Facility
61 Gates Ave, Geneva, NY 14456
Arrive: Geneva General Hospital
196 North St, Geneva, NY

Drive time: 0.7 mi – about 2 mins

1. Head west on Gates Ave toward Lehigh Ave
2. Turn left at N Genesee St
3. Turn right at North St



4.4 Summary of Citizen Participation Plan

HB Fuller will conduct such public participation activities as NYSDEC deems necessary and appropriate for the implementation of this *ERD IRM Workplan*.

4.5 Contingency Plan

As common in many in-situ bioremediation programs, based on performance monitoring, adjustments may be necessary and a re-application of the amendment is sometimes required. The contingency plan for this IRM Workplan would be re-application of the amendment, to be implemented based on the results of the performance monitoring program.

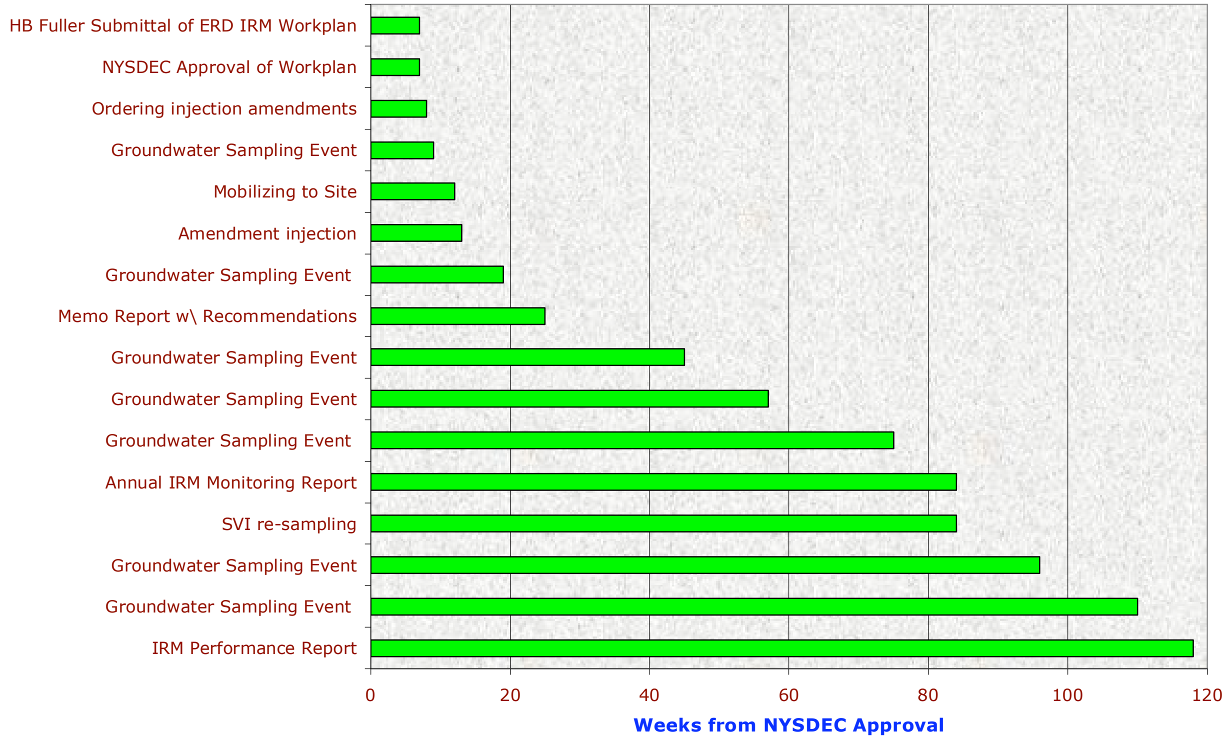
4.6 Schedule for Draft IRM Workplan Report

Based on experience implementing this technology at similar sites and our understanding of conditions at the Site, ECOR proposes the IRM Workplan continue for approximately 116-weeks (~27-months). It is expected that this period will permit adequate time to demonstrate the effectiveness of the in-situ enhanced bioremediation. The proposed schedule for implementing the

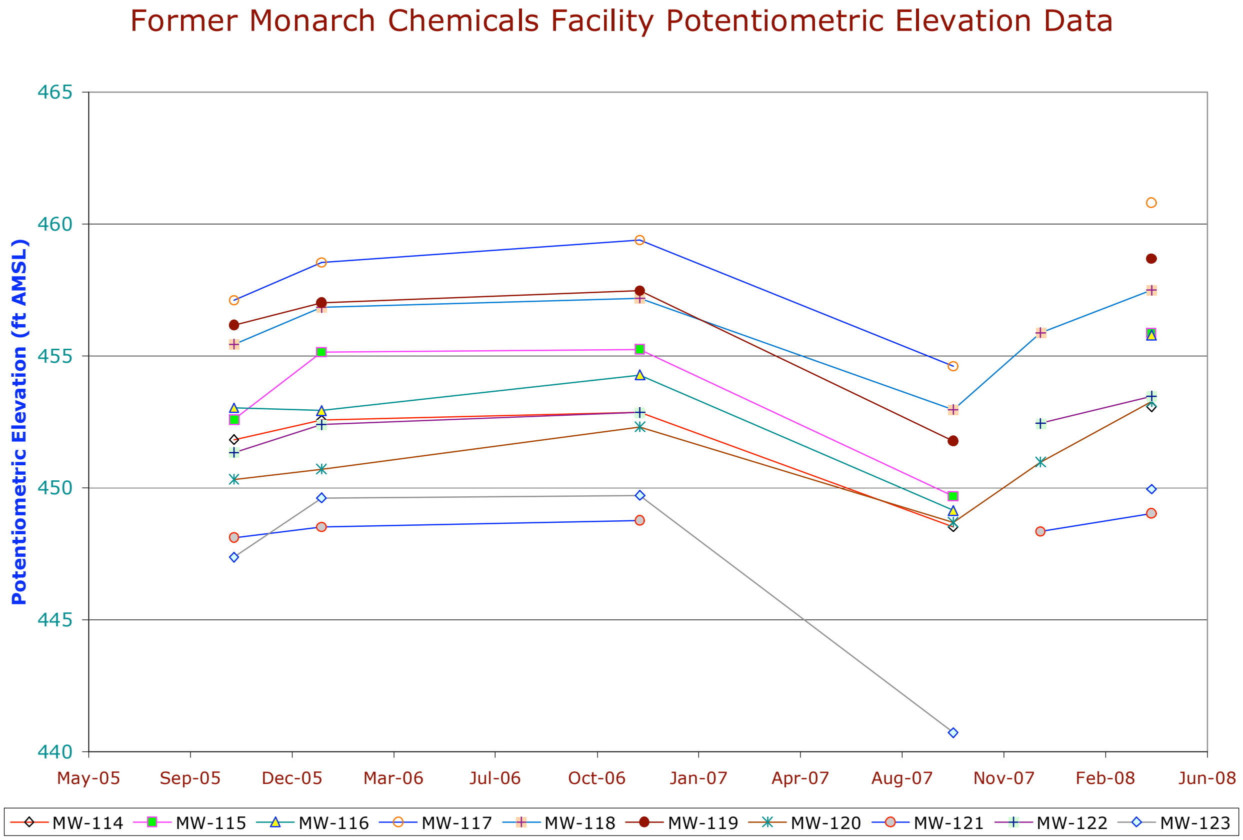
Workplan is presented below, indicating when monitoring and reporting activities would likely occur from an anticipated date of regulatory approval of this Workplan.

Weeks from Workplan Submittal	Task	Projected Date
1	HB Fuller Submittal of ERD IRM Workplan	20-May-08
7	NYSDEC Approval of Workplan	8-Jul-08
9	Ordering injection amendments	15-Jul-08
15	Groundwater Sampling Event	22-Jul-08
20	Mobilizing to Site	12-Aug-08
21	Amendment injection	19-Aug-08
27	Groundwater Sampling Event	30-Sep-08
31	Memo Report w\ Recommendations	11-Nov-08
38	Groundwater Sampling Event	31-Mar-09
49	Groundwater Sampling Event	23-Jun-09
68	Groundwater Sampling Event	27-Oct-09
84	Annual IRM Monitoring Report	29-Dec-09
85	SVI re-sampling	29-Dec-09
90	Groundwater Sampling Event	23-Mar-10
103	Groundwater Sampling Event	29-Jun-10
116	*IRM Performance Report*	24-Aug-10

Proposed ERM IRM Work Schedule



As noted in the chart above, an outline of the IRM Workplan consists of pre-injection SVI and groundwater sampling, a roughly week-long on-site injection program, followed by six (6) groundwater sampling events with associated interim reporting. Due to the fall in water levels and reduced saturated zone in the surficial glacial sediments by occasional drought conditions in the Geneva area, the injection program would be contingent on satisfactory groundwater conditions, including several saturated feet of glacial sediments in the injection zone. The April 2008 groundwater sampling event indicates groundwater rebounded in most wells, sufficient to commence with the IRM program.



At this time, it is recommended to modify the reporting schedule for all Site activities. Due to the extended period of time to implement the Workplan, it is recommended that the structure and requirements of the monthly Project Status Reports (PSR) be incorporated into a task-related reporting format. As outlined in the schedule above, it is recommended that within one-month following each task outlined in the table and chart above, a detailed PSR is prepared and submitted to NYSDEC which outlines the task completed and upcoming tasks and schedule. This would culminate in a draft *IRM Performance Report* prepared at the end of the proposed schedule outlined above.

5.0 REFERENCES

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Table 1
Monitoring Well Completion Details
Former Monarch Chemicals Division Facility
61 Gates Avenue
Geneva, New York

	Top of Casing Elevation (ft AMSL)	Depth of Borehole (ft below TOC)	Well Diameter (in)	Casing Material	Screen Material	Screen Slot Size (in)	Screen Length (ft)	Total Well Depth (ft below TOC)	Height of TOC (ft. above surface)	Bottom Sump Depth (ft)	Depth to Top of Screen (ft below TOC)	Top of Screen Elevation (ft AMSL)	Depth to Bottom of Screen (ft below TOC)	Bottom of Screen Elevation (ft AMSL)	Date Installed
MW-114	462.03	16	2	PVC	unk	0.01	10	14.0	0	0	4.0	458.03	14.0	448.03	7/14/05
MW-115	462.25	16	2	PVC	unk	0.01	10	14.0	0	0	4.0	458.25	14.0	448.25	7/12/05
MW-116	462.44	16	2	PVC	unk	0.01	10	13.9	0	0	3.9	458.54	13.9	448.54	7/12/05
MW-117	463.44	16	2	PVC	unk	0.01	10	13.7	unk	0	3.7	459.74	13.7	449.74	7/12/05
MW-118	462.40	16	2	PVC	unk	0.01	10	14.0	0	0	4.0	458.40	14.0	448.40	7/12/05
MW-119	462.68	16	2	PVC	unk	0.01	10	14.0	0	0	4.0	458.68	14.0	448.68	7/11/05
MW-120	462.12	16	2	PVC	unk	0.01	10	14.0	0	0	4.0	458.12	14.0	448.12	7/11/05
MW-121	461.77	16	2	PVC	unk	0.01	10	14.0	0	0	4.0	457.77	14.0	447.77	7/13/05
MW-122	461.65	16	2	PVC	unk	0.01	10	14.0	0	0	4.0	457.65	14.0	447.65	7/13/05
MW-123	456.42	16	2	PVC	unk	0.01	10	16.5	0.5	0	6.5	449.92	16.5	439.92	7/14/05

Table 2
Groundwater Monitoring Schedule
Former Monarch Chemicals Division Facility
61 Gates Avenue
Geneva, New York

Sample Location	Annual Sampling Event [1]	Tri-Annual Sampling Events [2]
MW-114	X	X
MW-115	X	X
MW-116	X	X
MW-117	X	X
MW-118	X	X
MW-119	X	X
MW-120	X	X
MW-121	X	X
MW-122	X	X
MW-123	X	X
SW-1	X	
SW-2	X	
SW-3	X	

[1] Annual Perimeter Groundwater Sampling Events for all wells for VOCs, performance monitoring parameters and field parameters for all wells and surface water sampled (see Table 3)

[2] Tri-Annual Sampling Events consists of VOCs + field parameters. All wells will be sampled 3 times\year, as field conditions permit.

Annual sampling event will be conducted Mar-Apr yearly.
Triannual sampling will be conducted in July and October.

Table 3
Annual Groundwater Performance Sampling Program
Former Monarch Chemicals Division Facility
61 Gates Avenue
Geneva, New York

Annual Performance Well Geochemical Monitoring Parameters

Geochemical Parameter	Test Method (or equivalent)	MW-114	MW-116	MW-117	MW-118	MW-122	MW-123
Iron, Total [mg/L]	6010	X	X	X	X	X	
Iron, Dissolved [mg/L]	6010	X	X	X	X	X	
Manganese, Total [mg/L]	6010	X	X	X	X	X	
Manganese, Dissolved [mg/L]	6010	X	X	X	X	X	
Biochemical Oxygen Demand [mg/L]	405.1	X	X	X	X	X	
Chemical Oxygen Demand [mg/L]	410.4	X	X	X	X	X	
Chloride [mg/L]	9056	X	X	X	X	X	
Nitrate-Nitrite [mg/L]	300	X	X	X	X	X	
Sulfate [mg/L]	9056	X	X	X	X	X	
Sulfide [mg/L]	9056	X	X	X	X	X	
Total Kjeldahl Nitrogen [mg/L]	300	X	X	X	X	X	
Total Organic Carbon [mg/L]	9060	X	X	X	X	X	X
Total Phosphorous [mg/L]	365.2	X	X	X	X	X	
VOCs [ug/l]	8260	X	X	X	X	X	X
Ethane, Ethene, Methane [ug/l]	AM18 or AM20GAX	X	X	X	X	X	
Carbon Dioxide [ug/l]	RSK114	X	X	X	X	X	

Amendment Response Monitoring Program

Phospholipid Fatty Acid Analysis (PLFA)					X	
Census					X	
Quantitative PCR (/Q-Expression)					X	
Denaturing Gradient Gel Electrophoresis (DGGE)					X	

Annual Sampling Parameters

Well	Water Level	Temp [°C]	ORP [mV]	pH [SU]	DO [mg/L]	Specific Cond. [umhos/cm]	VOCs (8260)	TOC (9060)
MW-114	X	X	X	X	X	X	X	X
MW-115	X	X	X	X	X	X	X	X
MW-116	X	X	X	X	X	X	X	X
MW-117	X	X	X	X	X	X	X	X
MW-118	X	X	X	X	X	X	X	X
MW-119	X	X	X	X	X	X	X	X
MW-120	X	X	X	X	X	X	X	X
MW-121	X	X	X	X	X	X	X	X
MW-122	X	X	X	X	X	X	X	X
MW-123	X	X	X	X	X	X	X	X
SW-1		X	X	X	X	X	X	
SW-2		X	X	X	X	X	X	
SW-3		X	X	X	X	X	X	

X = Annual performance monitoring location

annual sampling conducted in Mar-April

Table 4
Groundwater Monitoring Parameters
Former Monarch Chemicals Division Facility
61 Gates Avenue
Geneva, New York

Parameters	**Sampling Method**	**Frequency**
VOCs	EPA 8260	Annually all wells. Tri-Annual groundwater Locations listed in Table 3.
VOCs (air)	TO-14\TO-15	As necessary for SVI.
SVOCs	EPA 8270	As necessary for RFI.
Metals	EPA 6010	As necessary for RFI.
Cyanide	EPA 335.2	As necessary for RFI.
Inorganics	EPA 300 Series	As necessary for RFI.
Groundwater elevation	field measurement	Measured Tri-annually, at a minumum for all locations in Table 1.
NAPL Thickness	field measurement	NAPL not expected, ELM suitable for measurements.
Well Depths	field measurement	Measured at time of sampling or well repairs\maintenance.
pH	field measurement	Measured during purging.
Temperature	field measurement	Measured during purging.
Specific conductance	field measurement	Measured during purging.
Dissolved Oxygen	field measurement	Measured during purging.
ORP	field measurement	Measured during purging.

Surface Water and

Volatile Organic Compounds (EPA 8260)	**Metals (Dissolved - EPA Method 6010)**
(All Sampling Events)	**(As necessary for performance monitoring)**
1,1,1-Trichloroethane	Barium
1,1,2,2-Tetrachloroethane	Cadmium
1,1,2-Trichloroethane	Chromium
1,1-Dichloroethane	Lead
1,1-Dichloroethene	Zinc
1,2-Dichloroethane	
1,2-Dichloropropane	
2-Butanone	**Inorganics - Non-Metals (Total - EPA Method 335.2)**
2-Chloroethyl vinyl ether	**(As necessary for performance monitoring)**
2-Hexanone	Cyanide
4-Methyl 2-pentanone	
Acetone	**Pilot Testing Programs**
Benzene	**(As necessary for performance monitoring)**
Bromodichloromethane	Fluoride (EPA 300)
Bromoform	Sulfate (EPA 300)
Bromomethane	Chloride (EPA 300)
Carbon disulfide	Iron (EPA Method 6010)
Carbon tetrachloride	Bromide, Chloride Nitrogen, Sulfate (ion chromotograph EPA 300.0)
Chlorobenzene	Ethane, Ethene (Test Method AM18 or AM20GAX)
Chloroethane	Methane (Test Method AM18 or AM20GAX)
Chloroform	Carbon Dioxide (Method RSK114)
Chloromethane	Total Organic Carbon (EPA 415.1)
Dibromochloromethane	Alkalinity (as $CaCO_3$ [Method 310.1])
Ethyl benzene	
Methylene chloride	**Physical Parameters (Field)**
Styrene	Temperature
Tetrachloroethene	pH
Toluene	Conductivity
Trichloroethene	Dissolved Oxygen
Vinyl acetate	Oxidation Reduction Potential
Vinyl chloride	
Xylenes - Total	
cis-1,2-Dichloroethene	
cis-1,3-Dichloropropene	
trans-1,2-Dichloroethene	
trans-1,3-Dichloropropene	

Table 5
Collection and Preservation of Groundwater and Surface Water Samples
Former Monarch Chemicals Division Facility
61 Gates Avenue
Geneva, New York

Parameter	Volume Required	Container[1]	Preservative[2]	Holding Time[3]
VOCs				
VOCs	40 ml	G	4° C, HCL	14 Days
SVOCs				
SVOCs	1000 ml	G	4° C, HCL	7 Days
Inorganics – Metals				
All Metals	1000 ml	P	HNO_3	6 months
Inorganics -- Non-Metals				
Cyanide	500 ml	P, G	4° C, NaOH	14 Days
Physical				
pH	25 ml	flowcell	None	Immediately
Temperature	25 ml	flowcell	None	Immediately
Conductivity	25 ml	flowcell	None	Immediately
Diss. Oxygen	25 ml	flowcell	None	Immediately
ORP	25 ml	flowcell	None	Immediately

Notes:

[1] Plastic (P), or Glass (G). For metals, polyethylene with a polypropylene cap. Physical parameters measured in QED MicroPurge flowcell.

[2] When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the U.S. Department of Transportation Hazardous Material Regulations (49 CFR Part 172). The Person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of environmental samples, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials regulations do not apply to the following materials: Nitric Acid (HN03) in water solution at concentrations of 0.15% by weight or less (pH about 1.62 or greater).

[3] Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held for analysis and the results considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for a longer time, and has received a variance from the USEPA Regional Administrator. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the samples for a shorter period of time, if knowledge exists to show this is necessary to maintain sample stability.

Table 6
Sampling Parameters, Detection Limits, and QA/QC Summary for Water Samples
Former Monarch Chemicals Division Facility
61 Gates Avenue
Geneva, New York

Parameters	USEPA Method	Detection Limit	Precision	Accuracy	Completeness
Organics[1]					
VOCs	8260	2-10.0 ug/l	30 % RPD	55-145 %	100%
Semi-Volatile Organics[1]					
SVOCs	8270	3-5.0 ug/l	30 % RPD	55-145 %	100%
Inorganics -- Metals[2,3]					
Barium	6010	5.0 ug/l	20% RPD	75-125%	100%
Cadmium	6010	3.0 ug/l	20% RPD	75-125%	100%
Chromium	6010	5.0 ug/l	20% RPD	75-125%	100%
Lead	6010	3.0 ug/l	20% RPD	75-125%	100%
Zinc	6010	2.0 ug/l	20% RPD	75-125%	100%
Air					
VOCs	TO-14\TO-15	0.006-0.02 ug/l	20% RPD	75-125%	100%
ethene, ethane	AM20GAX	5.0 ng/l	20% RPD	75-125%	100%
methane	AM20GAX	0.015 ug/l	20% RPD	75-125%	100%
Inorganics -- Non-Metals [2,4]					
Chloride	300	1,000 ug/l	20% RPD	75-125%	100%
Cyanide	335.3	5.0 ug/l	20% RPD	75-125%	100%
Fluoride	300	100 ug/l	20% RPD	75-125%	100%
Sulfate	300	1,000 ug/l	20% RPD	75-125%	100%
Physical Parameters[5]					
pH	--	--	0.1 SU	0.2 SU	100%
Temperature	--	--	0.1° C	0.2° C	100%
Conductivity	--	--	50 umhos/cm	2 umhos/cm	100%
Diss. Oxygen	--	--	0.1 mg/l	0.2 mg/l	100%
ORP	--	--	1 eV	1 eV	100%

RPD = Relative Percent Difference

[1] Test Methods for Evaluating Solid Wastes, USEPA SW-846, December 1996; Methods for Organic Chemical Analysis of Municipal and Industrial Waste-Water, USEPA 600/4-82-057, July 1982; Guidelines Establishing Test Procedures for the Analysis or Organic Pollutants Under the Clean Water Act, Federal Register, V. 49, no. 209; and USEPA Contract Laboratory Program (CLP) Statement of Work for Organics Analysis, October 1986 (revised December 1996).

[2] Test Methods for Evaluating Solid Wastes, USEPA SW-846, November 1986; Methods for Chemical Analysis of Water and Wastes, USEPA-600/4-79-020 1979 (revised December 1996).

[3] Test Methods for Evaluating Solid Wastes, USEPA SW-846, November 1986; USEPA Contract Laboratory Program (CLP) Statement of Work for Inorganic Analysis, July 1987 (revised December 1996).

[4] Standard Methods for the Examination of Water and Wastewater, 17th Ed., 1989.

[5] Field parameters during purging measured with portable meter.

Basemap Source: USGS Digital Orthoimagery of Ontario County, New York, April 2005.

ECOR Solutions, Inc.

1075 Andrew Drive, Suite I
West Chester, PA 19380

Figure 1
Site Location Map

pointmap incorporated

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Date: 09/20/07

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York

ECOR Solutions, Inc.

1075 Andrew Drive, Suite I
West Chester, PA 19380

pointmap incorporated

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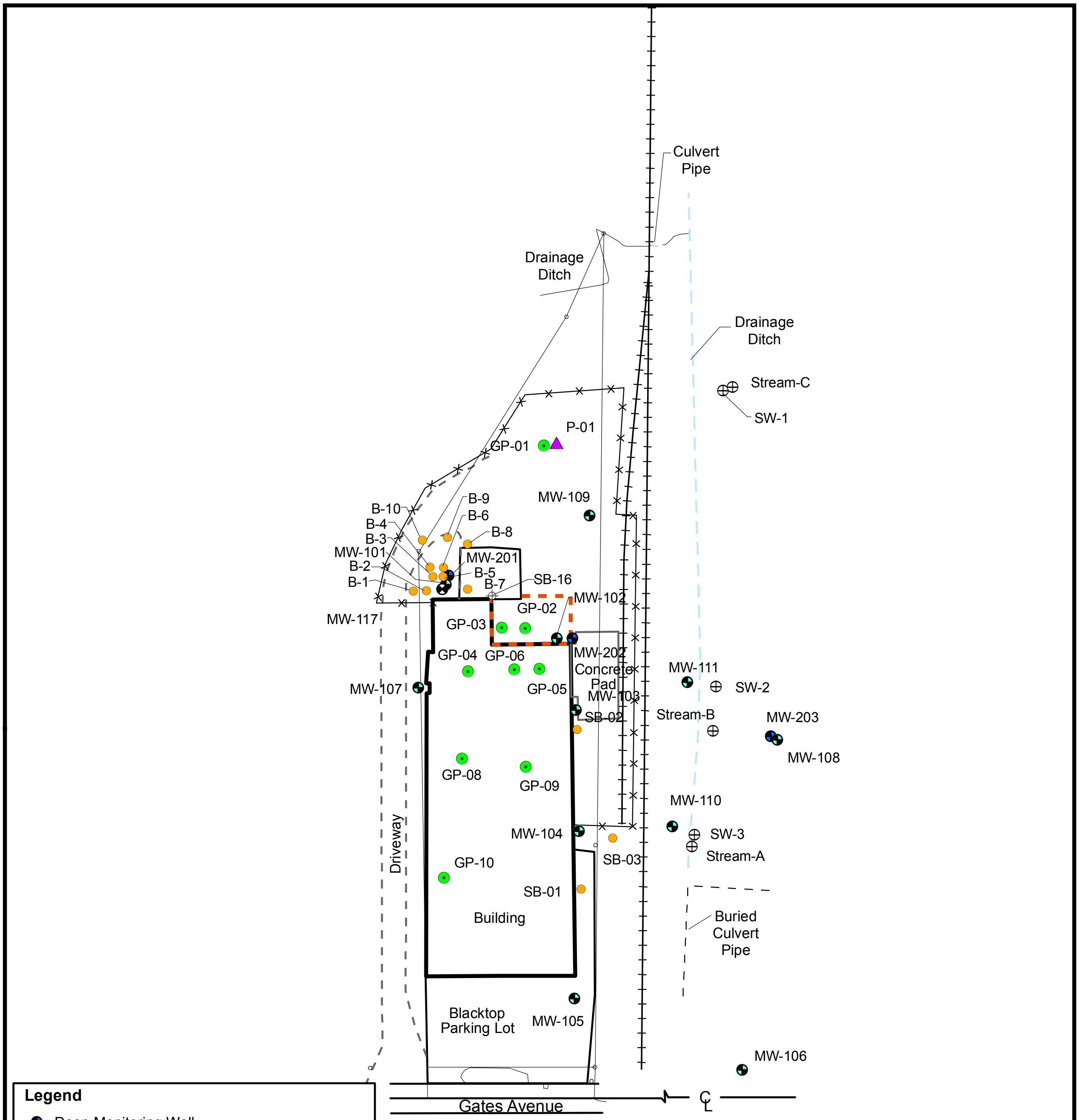
ECOR\Geneva\Fig-2.mxd

Date:
09/20/07

Figure 2
Site Map

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



Legend

- ● Deep Monitoring Well
- ● Shallow Monitoring Well
- ⊕ Surface Water Sample Point
  Note: SW's denote surface water sample points.
  Stream's denote surface water gauge points.
- 🟢 Geoprobe
- ▲ Piezometer
- ● Soil Boring
- ● VCP Monitoring Well Location
- ⊕ VCP Soil Boring Location
- ✕ Fence
- ┼ Railroad
- ▬ AST Containment Area

0 60 120
Feet

N E S W

ECOR Solutions, Inc.
1075 Andrew Drive, Suite I
West Chester, PA 19380

Figure 3
Abandoned Monitoring Locations

pointmap incorporated

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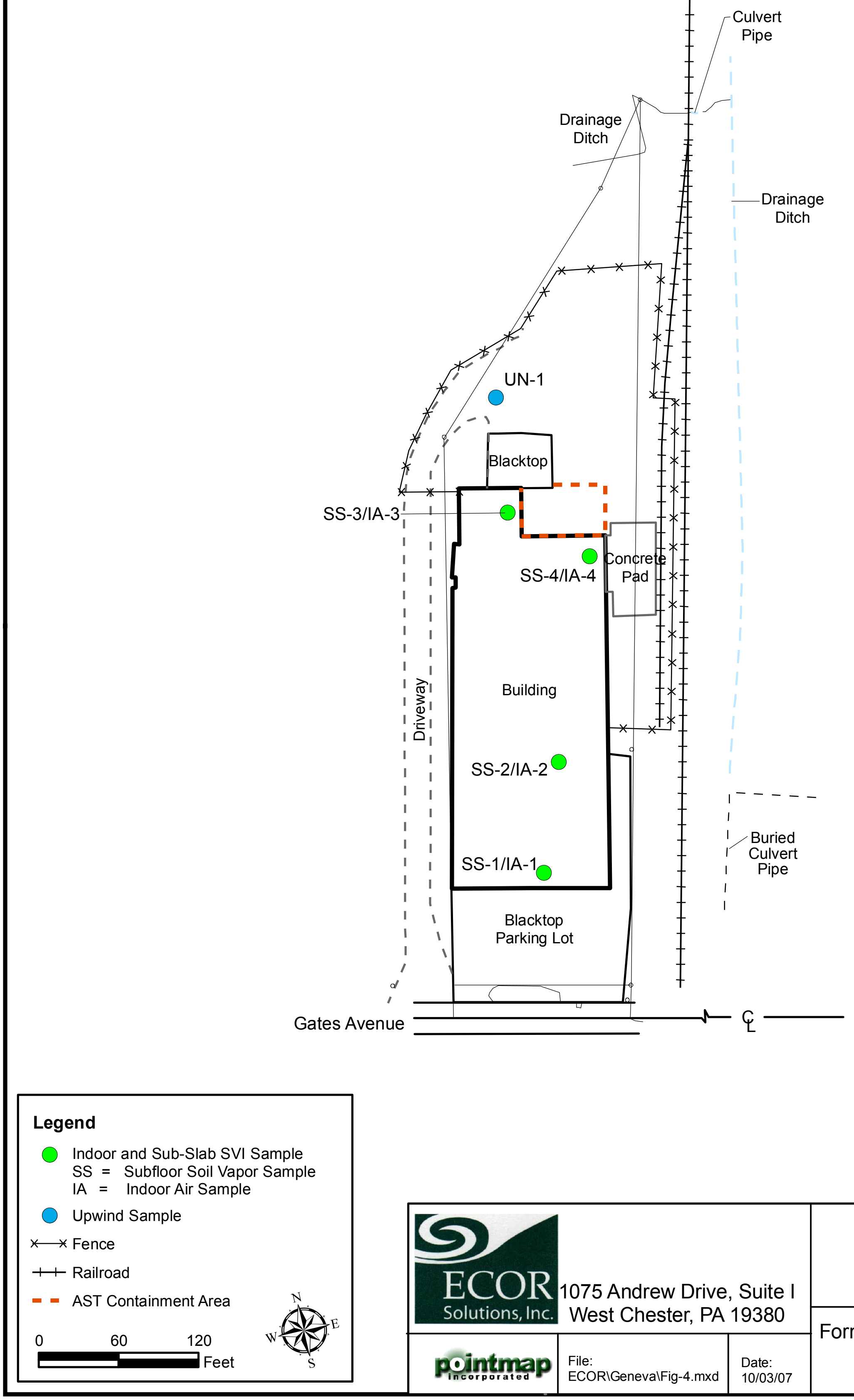
Date:
10/03/07

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



ECOR Solutions, Inc.

1075 Andrew Drive, Suite I
West Chester, PA 19380

pointmap incorporated

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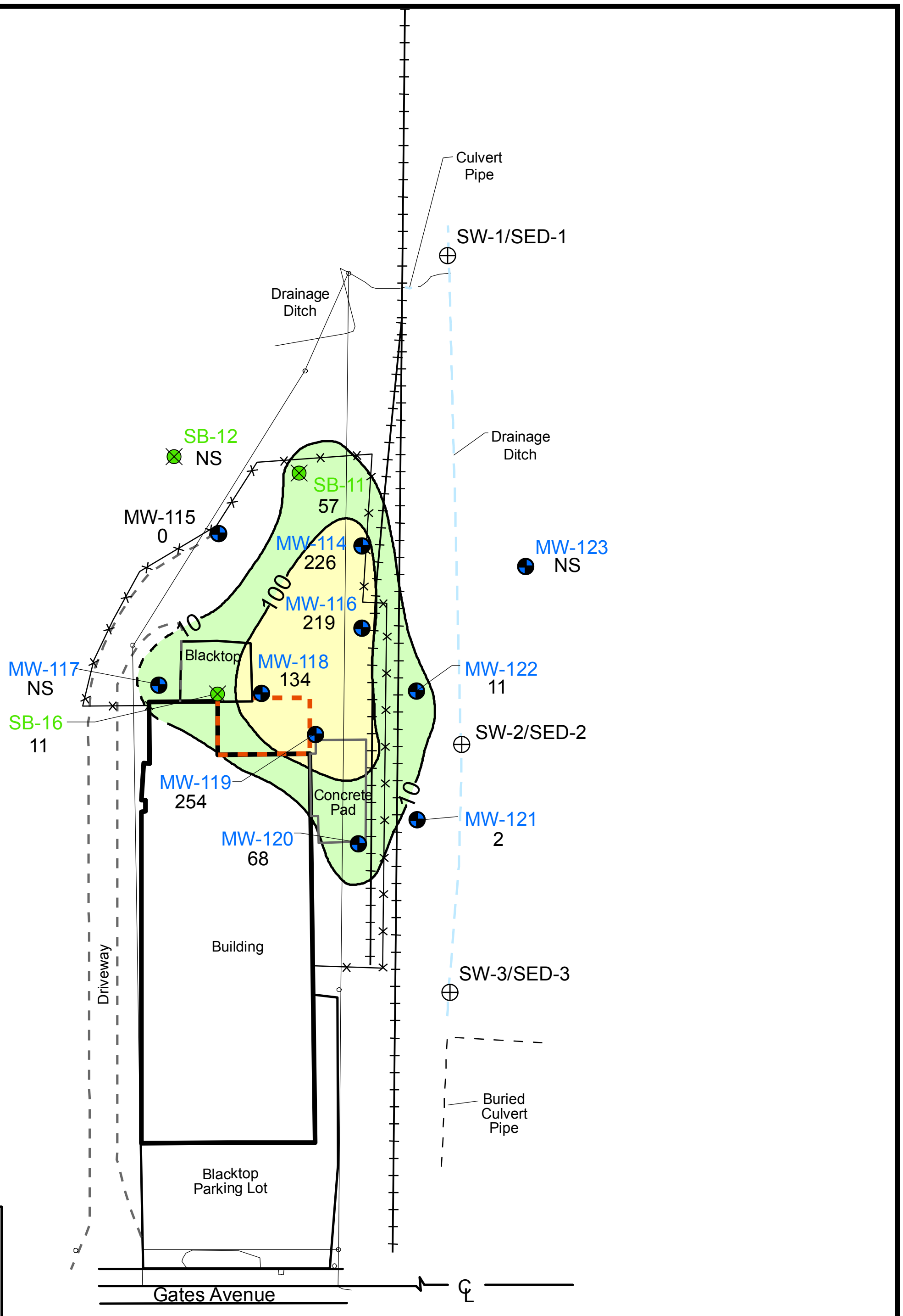
Date:
10/03/07

Figure 4
SVI Sampling Locations

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



Legend

● Monitoring Well Location
☒ Soil Boring Location
⊕ Surface Water and Sediment Sampling Location
×—× Fence
+++ Railroad
- - - AST Containment Area
10 TVOC Isoconcentration Contour
Dashed where inferred
🟩 10-100 ug/kg
🟨 100-1000 ug/kg

68	Total VOC Concentration Detected, July 2005
NS	Not Sampled

0 60 120
Feet

N E S W

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Figure 5
TVOC Concentrations in Soil (ug/kg)
460'-456' AMSL Interval

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York

pointmap incorporated

File:
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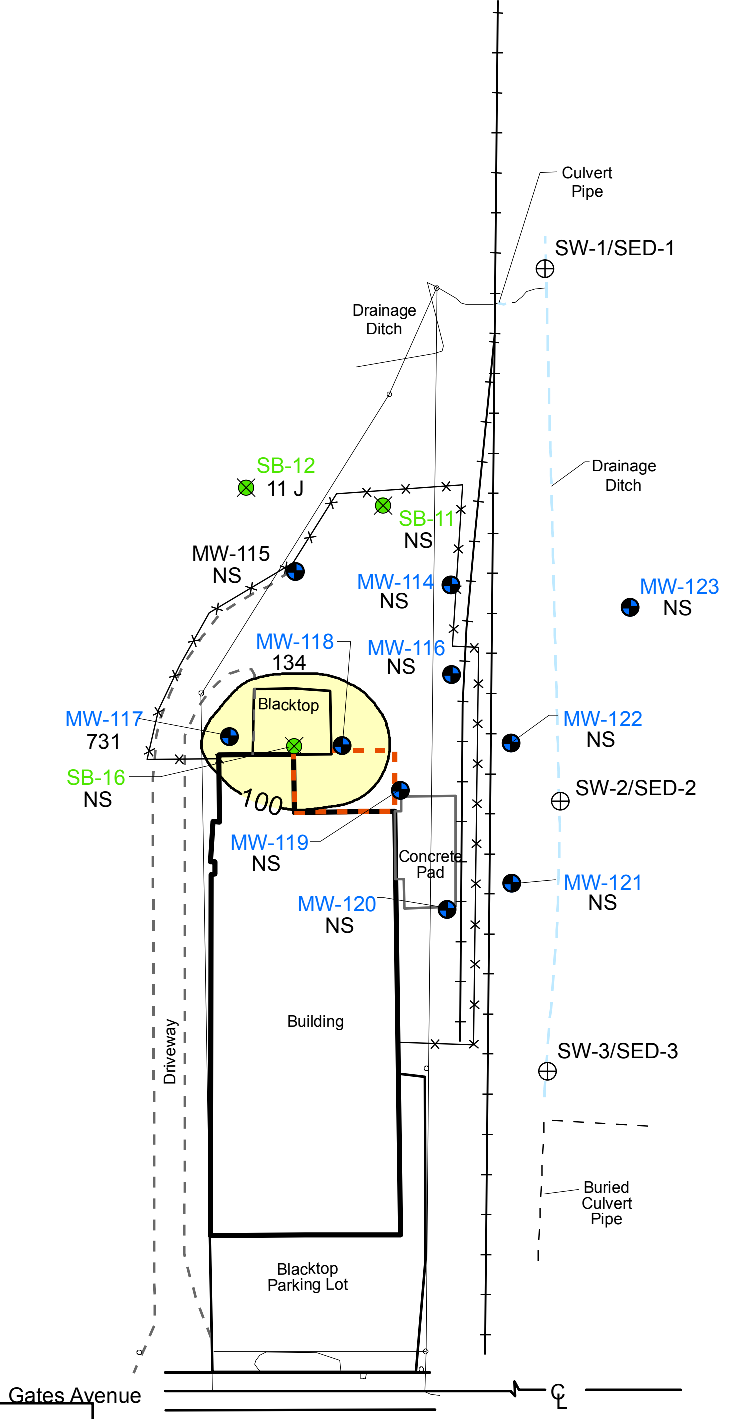
Date:
11/07/07



Legend

● Monitoring Well Location
⊗ Soil Boring Location
⊕ Surface Water and Sediment Sampling Location
×—× Fence
—+— Railroad
- - AST Containment Area
100 TVOC Isoconcentration Contour
🟨 100-1000 ug/kg
134 TVOCs Detected in Soil, July 2005
NS Not Sampled

0 60 120 Feet

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West Chester, PA 19380

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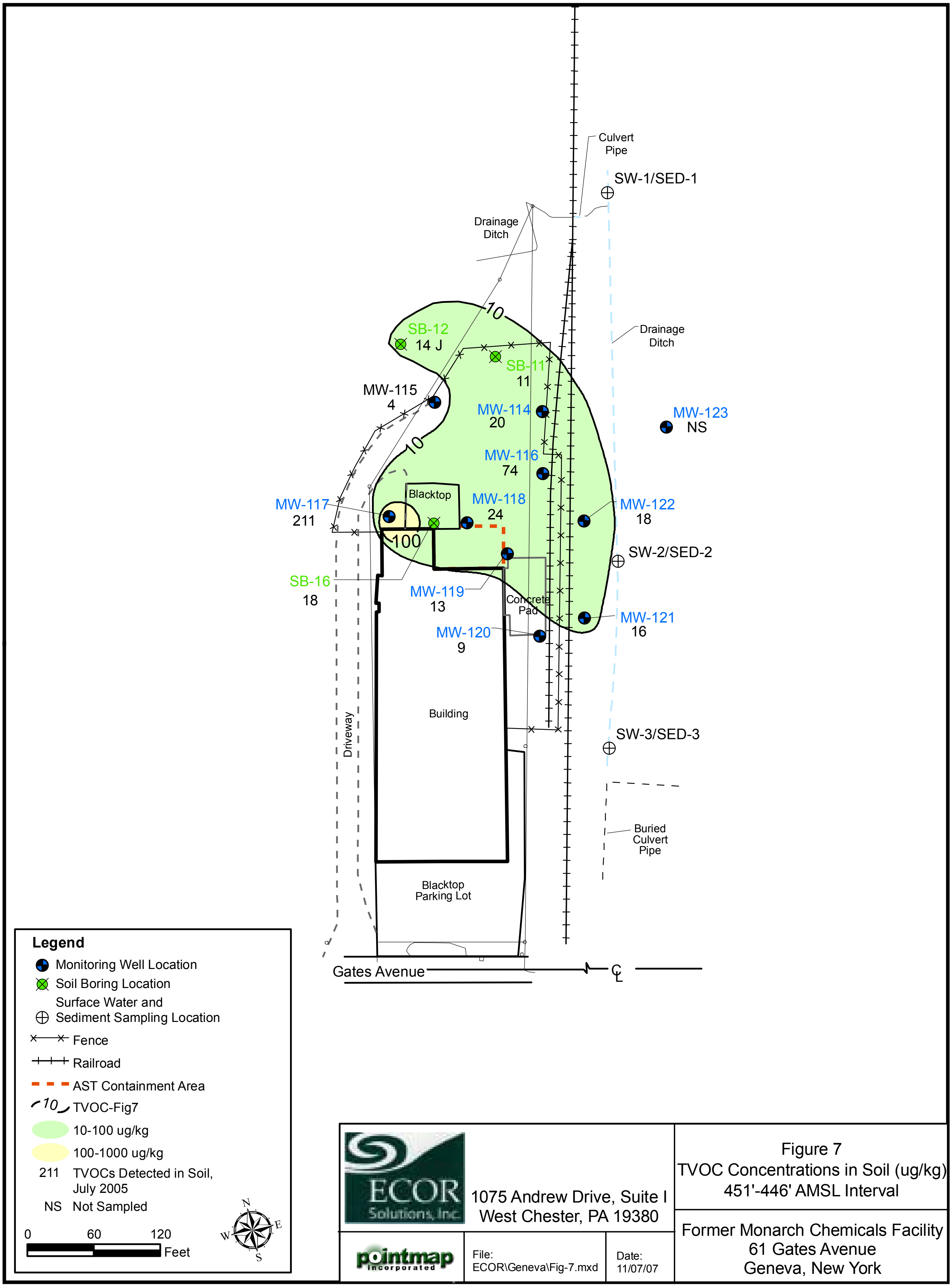
File: ECOR\Geneva\Fig-6.mxd

Date: 11/07/07

Figure 6
TVOC Concentrations in Soil (ug/kg)
456'-451' AMSL Interval

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



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pointmap incorporated

File:
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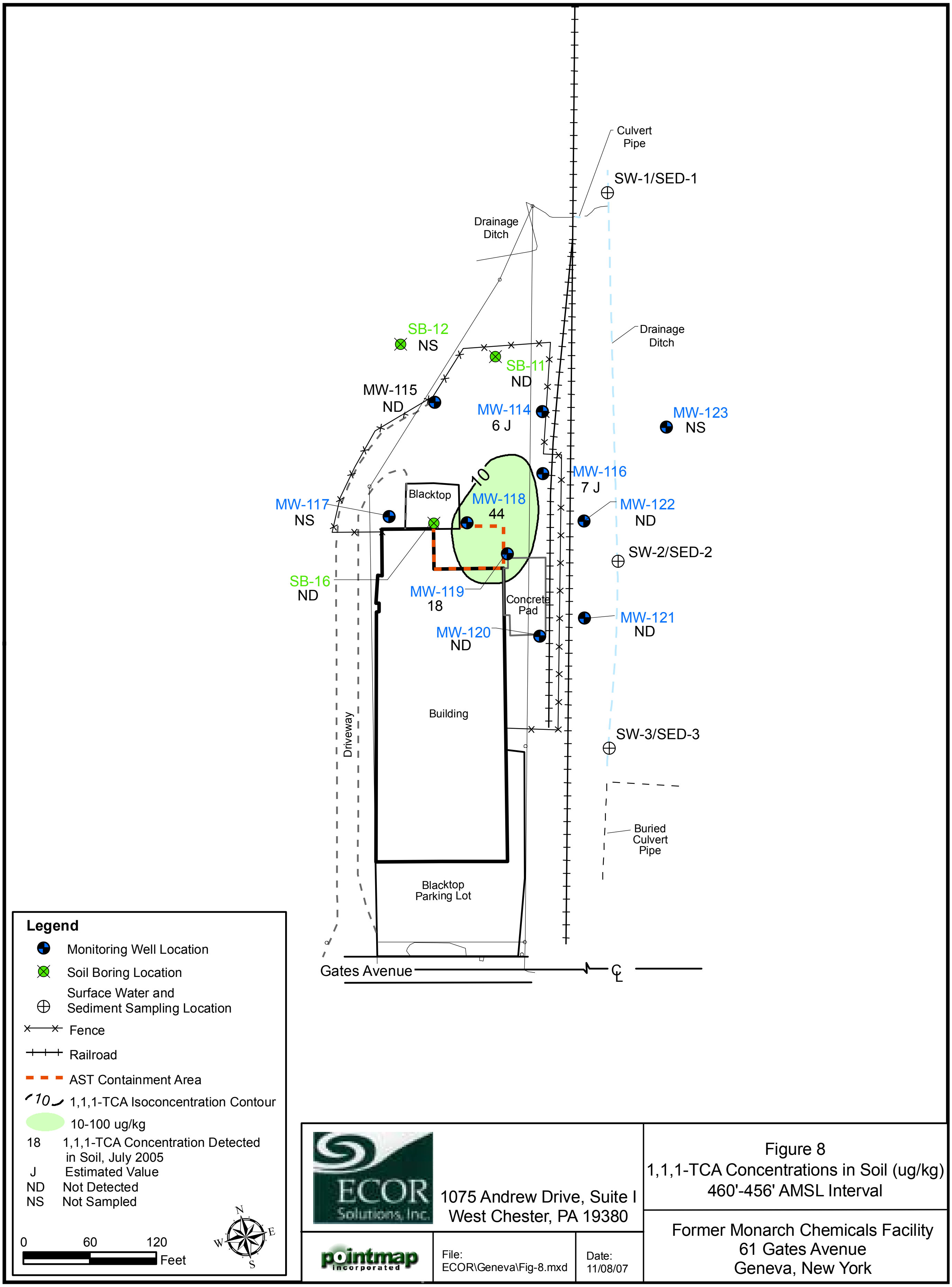
Date:
11/07/07

Figure 7
TVOC Concentrations in Soil (ug/kg)
451'-446' AMSL Interval

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



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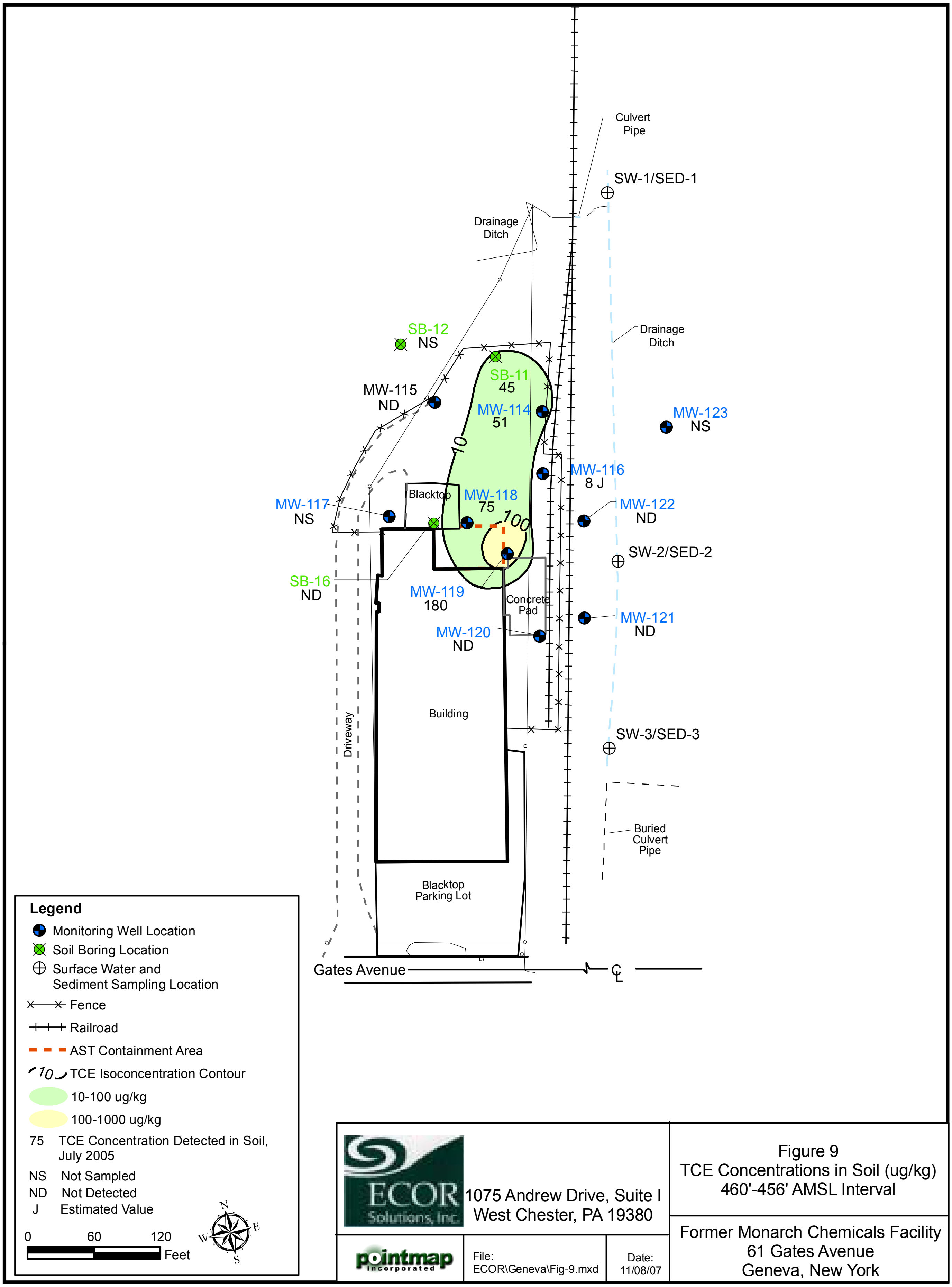
West Chester, PA 19380

File:
ECOR\Geneva\Fig-8.mxd

Date:
11/08/07

Figure 8
1,1,1-TCA Concentrations in Soil (ug/kg)
460'-456' AMSL Interval

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



Legend

- ● Monitoring Well Location
- ⊗ Soil Boring Location
- ⊕ Surface Water and Sediment Sampling Location
- Fence
- Railroad
- AST Containment Area
- 10 TCE Isoconcentration Contour
- 🟩 10-100 ug/kg
- 🟨 100-1000 ug/kg

75	TCE Concentration Detected in Soil, July 2005
NS	Not Sampled
ND	Not Detected
J	Estimated Value

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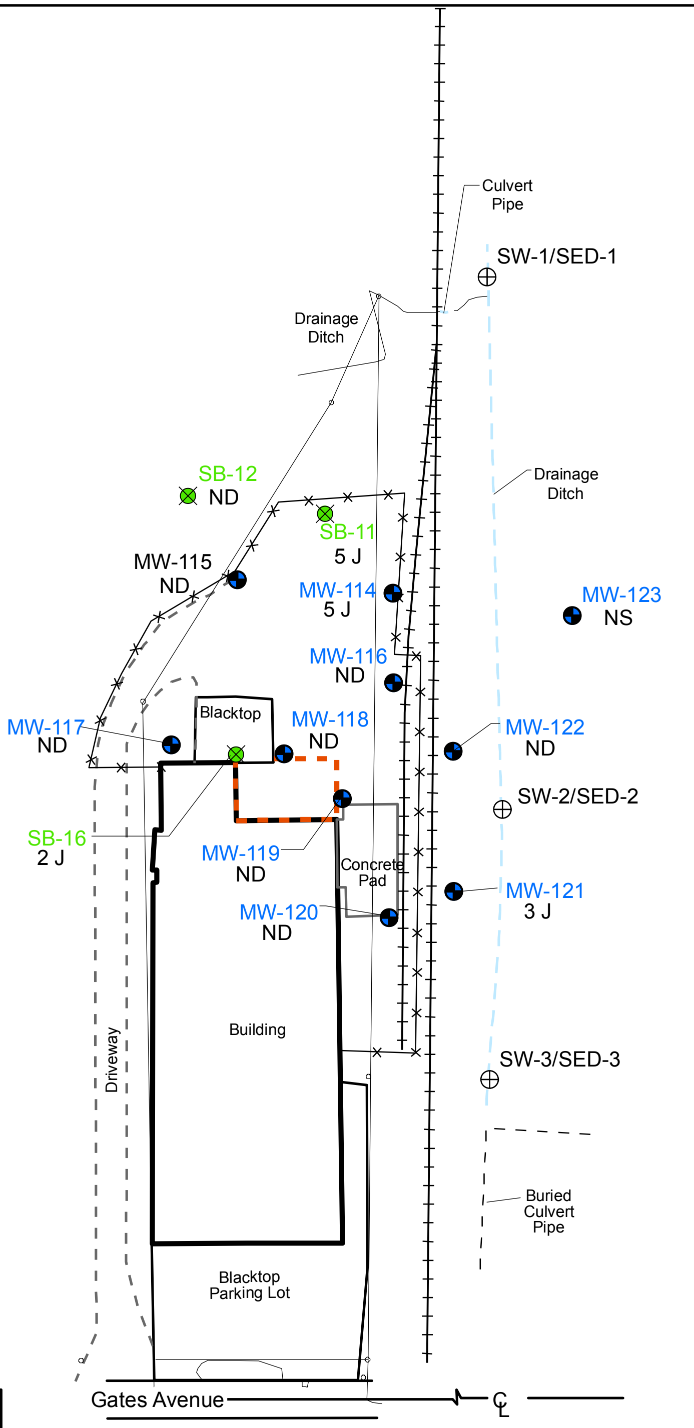
File: ECOR\Geneva\Fig-9.mxd

Date: 11/08/07

Figure 9
TCE Concentrations in Soil (ug/kg)
460'-456' AMSL Interval

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



Legend

- ● Monitoring Well Location
- ⊗ Soil Boring Location
- ⊕ Surface Water and Sediment Sampling Location
- ×—× Fence
- +++ Railroad
- - - - AST Containment Area

2 J	TCE Concentration Detected in Soil, July 2005
NS	Not Sampled
ND	Not Detected
J	Estimated Value

0 60 120 Feet

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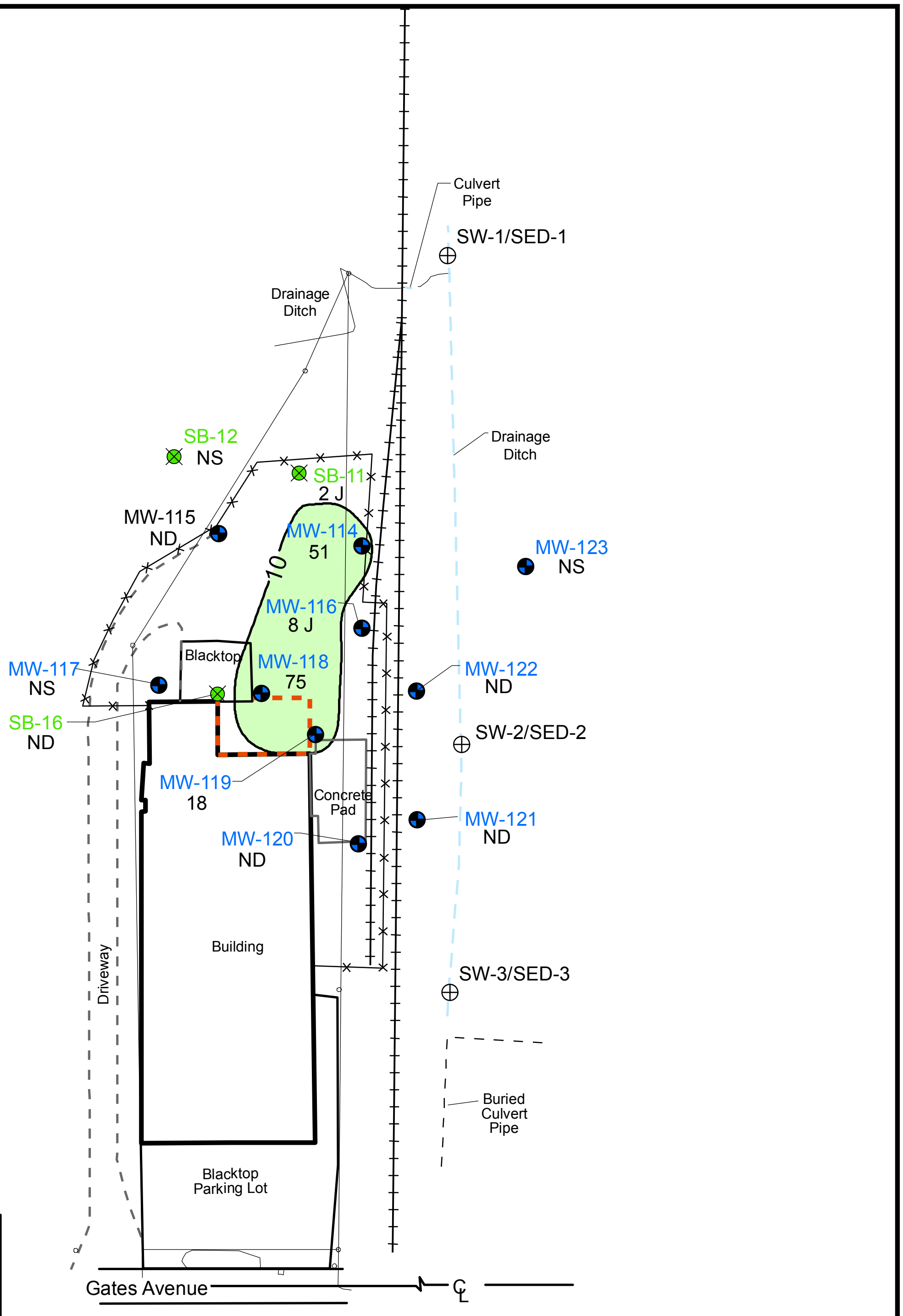
Figure 10
TCE Concentrations in Soil (ug/kg)
451'-446' AMSL Interval

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York

File: ECOR\Geneva\Fig-10.mxd

Date: 11/08/07



Legend

● Monitoring Well Location
⊗ Soil Boring Location
⊕ Surface Water and Sediment Sampling Location
-×-×- Fence
-+-+- Railroad
- - - AST Containment Area
10 PCE Isoconcentration Contour
🟩 10-100 ug/kg

18	PCE Concentration Detected in Soil, July 2005
NS	Not Sampled
ND	Not Detected
J	Estimated Value

0 60 120 Feet

N E S W

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File:
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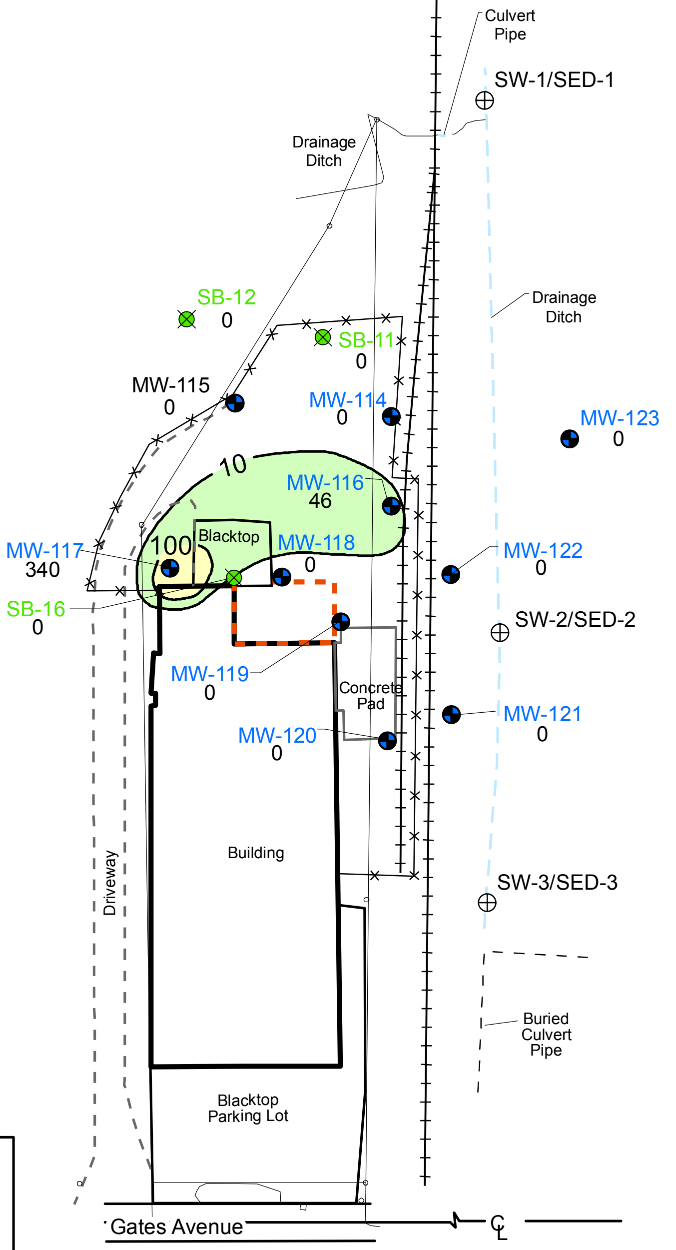
Date:
11/08/07

Figure 11
PCE Concentrations in Soil (ug/kg)
460'-456' AMSL Interval

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



Legend

- ● Monitoring Well Location
- ⊗ Soil Boring Location
- ⊕ Surface Water and Sediment Sampling Location
- ×—× Fence
- +++ Railroad
- - - AST Containment Area
- 10 BTEX Isoconcentration Contour
- 🟩 10-100 ug/kg
- 🟨 100-1000 ug/kg
- 340 Sum of Benzene, Toluene, Ethyl Benzene and Xylenes (Total) in Soil, July 2005

0 60 120
Feet

N
W E
S

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Figure 12
Total BTEX Concentrations in Soil (ug/kg)

pointmap incorporated

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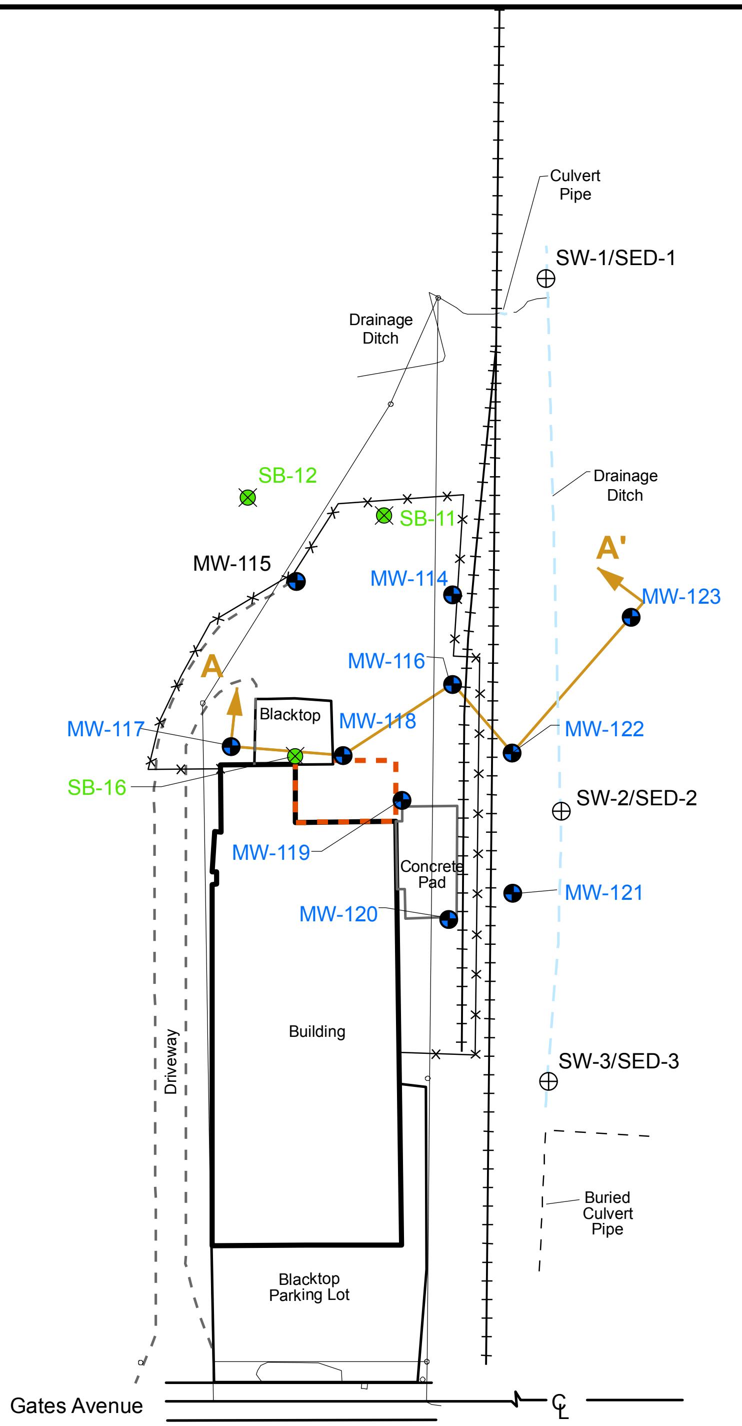
Date:
11/08/07

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



Legend

● Monitoring Well Location

☒ Soil Boring Location

⊕ Surface Water and Sediment Sampling Location

Fence

Railroad

AST Containment Area

A A' Cross Section Location

0 60 120 Feet

N E S W

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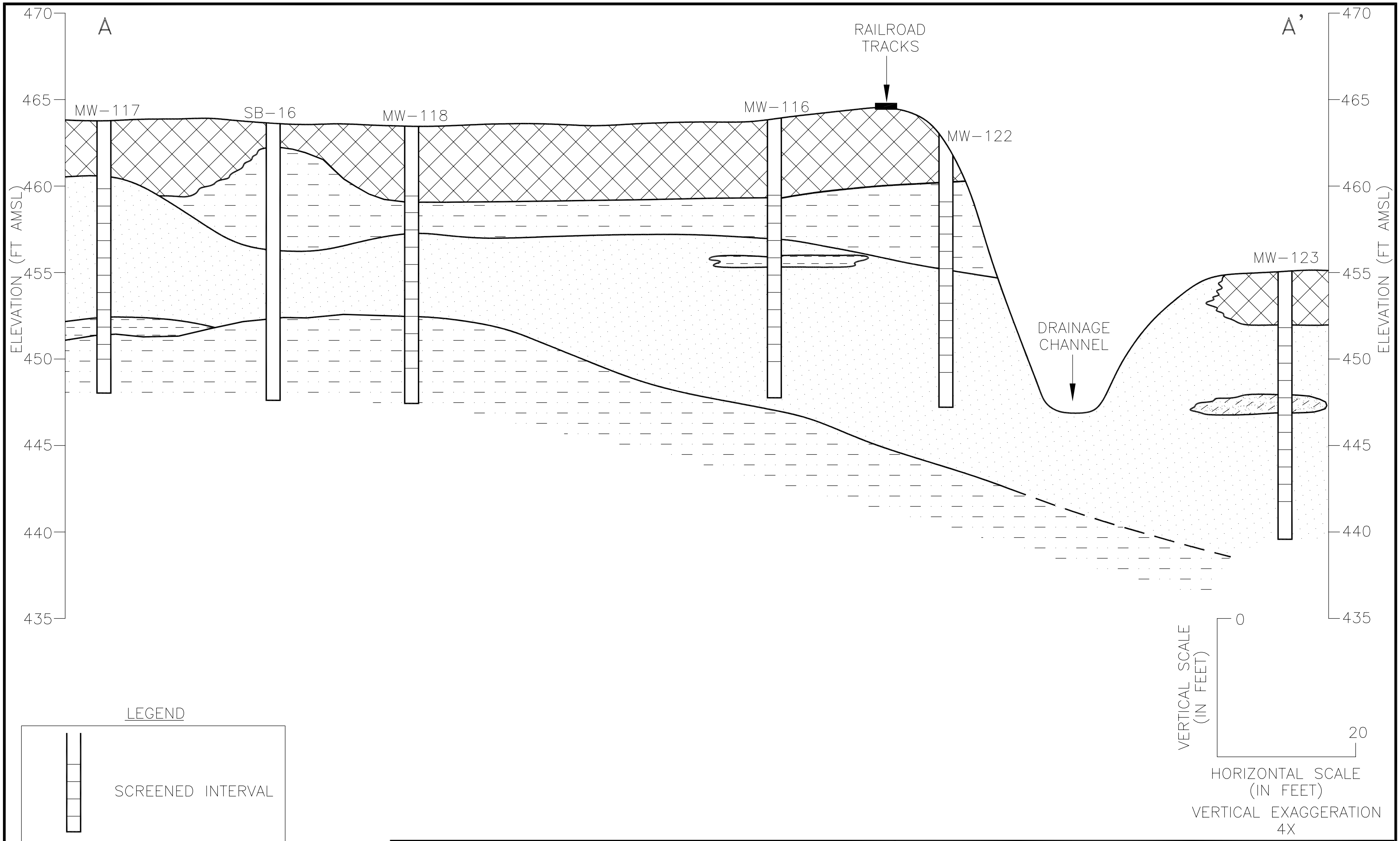
Date:
10/04/07

Figure 13
Cross Section Location Map A-A'

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



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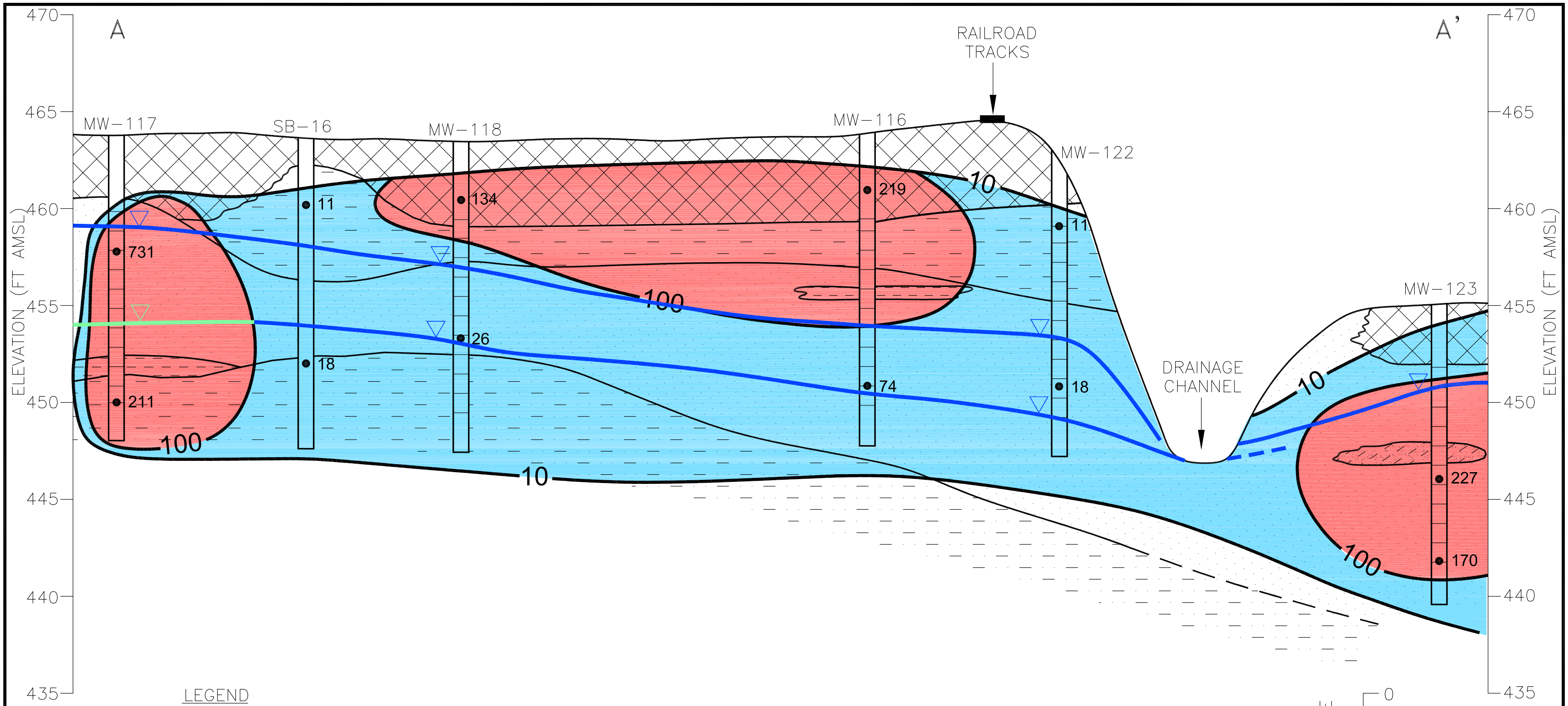
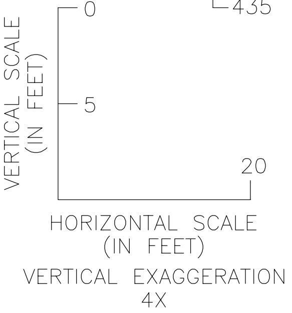
File: GENEVA-AA-F14.dwg Date: 10/1/07

Figure 14
Geologic Cross Section A-A'

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York





VERTICAL EXAGGERATION
4X

LEGEND

▯	SCREENED INTERVAL
▽	WATER TABLE, JANUARY 2006
▽	WATER TABLE, SEPTEMBER 2007
▨	FILL
▭	SILT & CLAY
▭	SAND
▭	CLAY
▨	SILTY SAND
● 731	TVOCs DETECTED IN SOIL; JANUARY 2006
—10—	TVOC ISOCONCENTRATION

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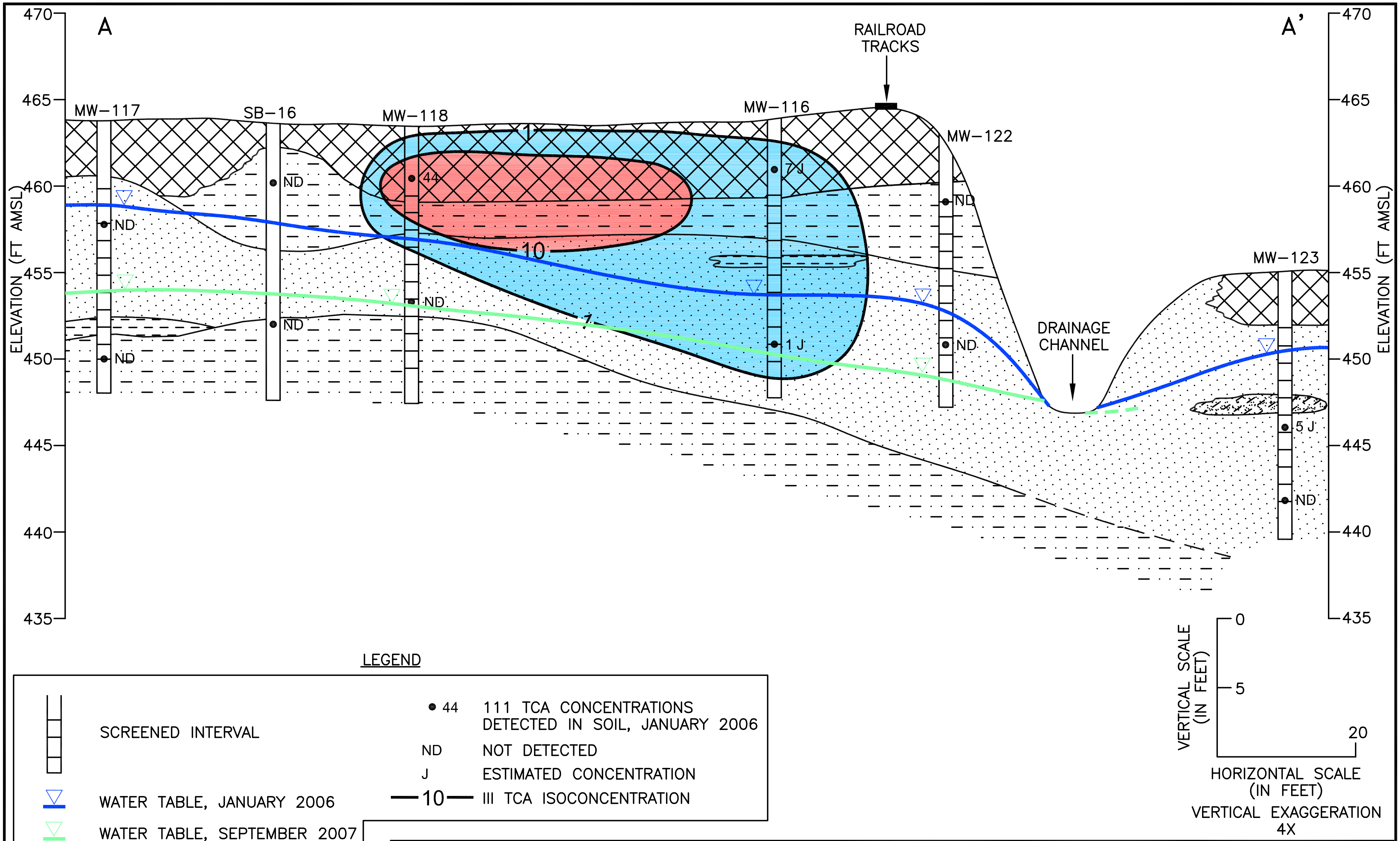
File: GENEVA-AA-F15.dwg Date: 11/8/07

Figure 15
TVOCs Detected in Soil (ug/kg); Cross Section A-A'; July 2005

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



LEGEND

▥	SCREENED INTERVAL
▽	WATER TABLE, JANUARY 2006
▽	WATER TABLE, SEPTEMBER 2007
☒	FILL
▤	SILT & CLAY
⬚	SAND
▤	CLAY
▨	SILTY SAND
● 44	111 TCA CONCENTRATIONS DETECTED IN SOIL, JANUARY 2006
ND	NOT DETECTED
J	ESTIMATED CONCENTRATION
—10—	III TCA ISOCONCENTRATION

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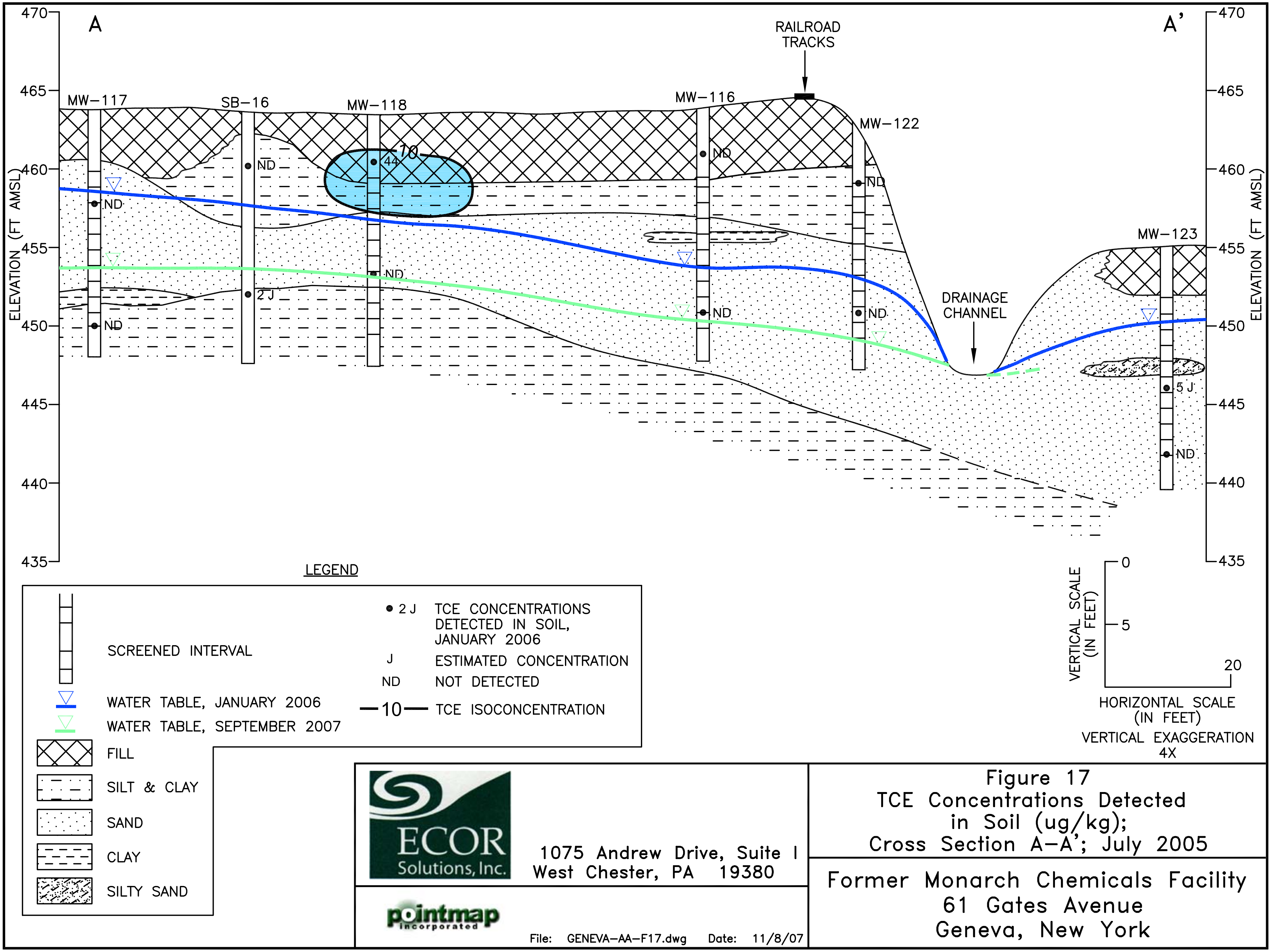
File: GENEVA–AA–F16.dwg Date: 11/8/07

Figure 16
111 TCA Concentrations in Soil (ug/kg); Cross Section A–A'; July 2005

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



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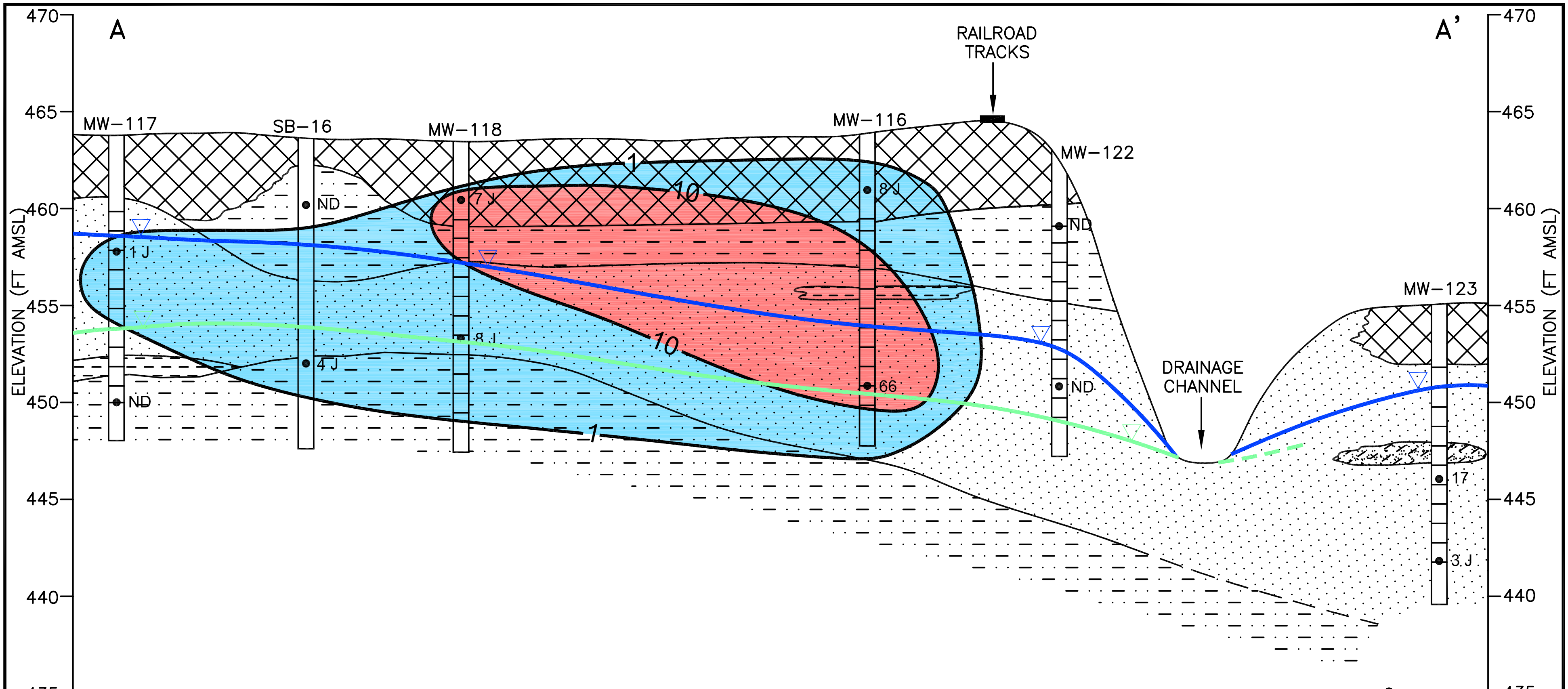
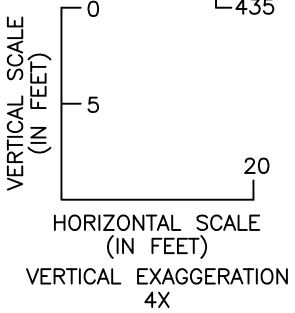
File: GENEVA-AA-F17.dwg Date: 11/8/07

Figure 17
TCE Concentrations Detected in Soil (ug/kg); Cross Section A-A'; July 2005

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York





LEGEND

▥	SCREENED INTERVAL
▽	WATER TABLE, JANUARY 2006
▽	WATER TABLE, SEPTEMBER 2007
⊠	FILL
▤	SILT & CLAY
░	SAND
▤	CLAY
▨	SILTY SAND
● 17	PCE CONCENTRATIONS DETECTED IN SOIL, JANUARY 2006
ND	NOT DETECTED
J	ESTIMATED CONCENTRATION
—10—	PCE ISOCONCENTRATION

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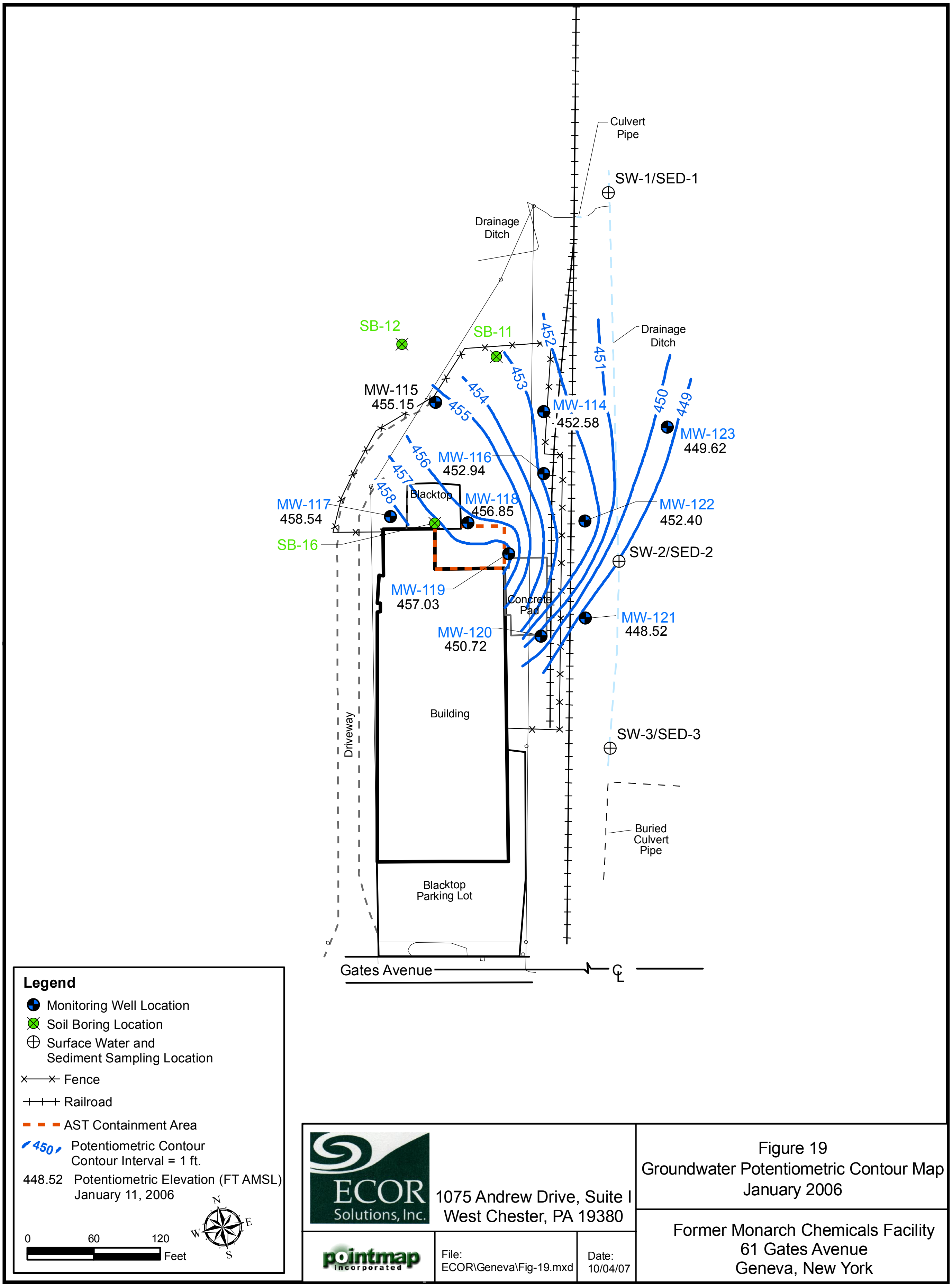
Figure 18
PCE Concentrations Detected in Soil (ug/kg); Cross Section A-A'; July 2005

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



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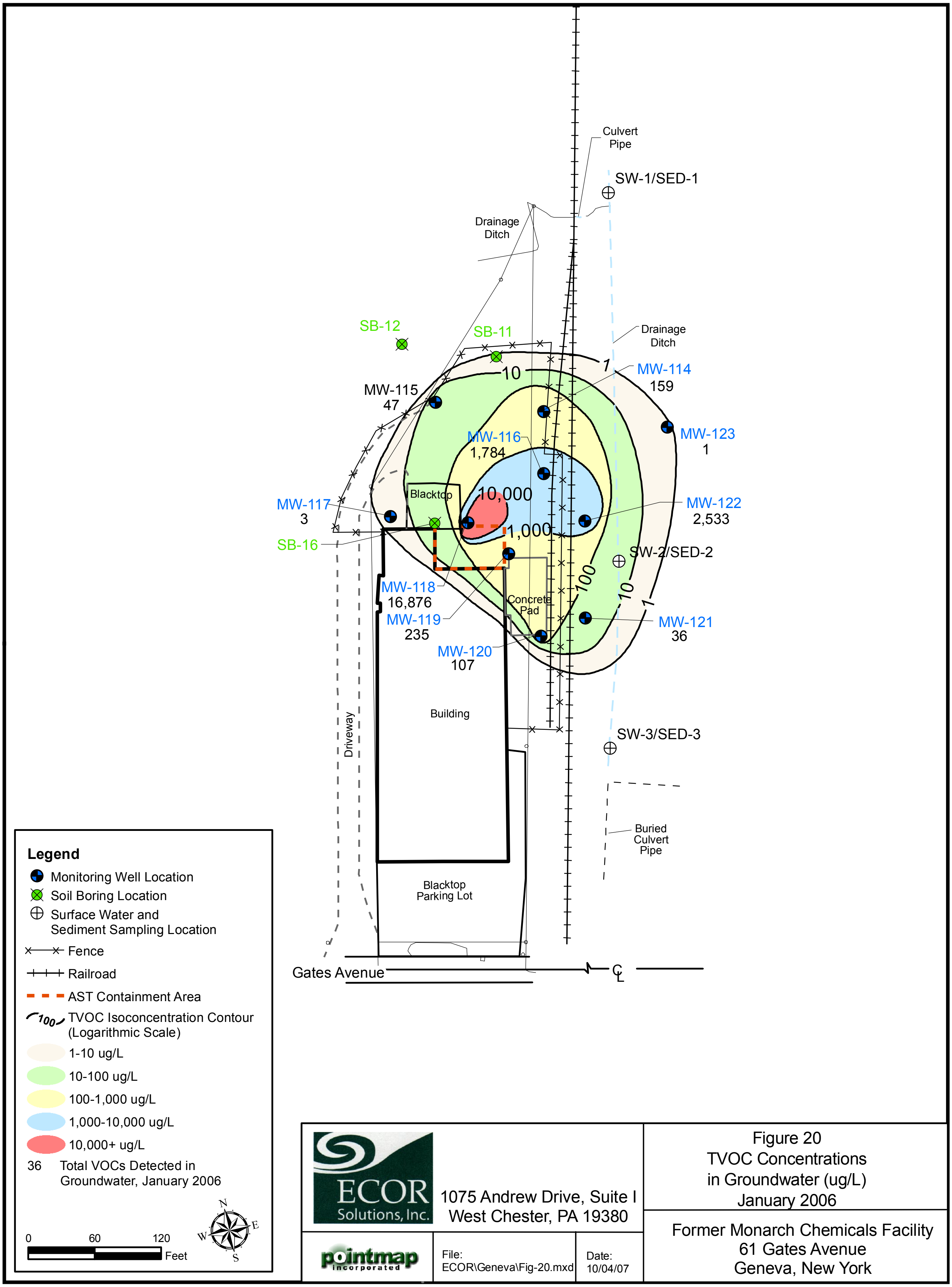
Date:
10/04/07

Figure 19
Groundwater Potentiometric Contour Map
January 2006

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



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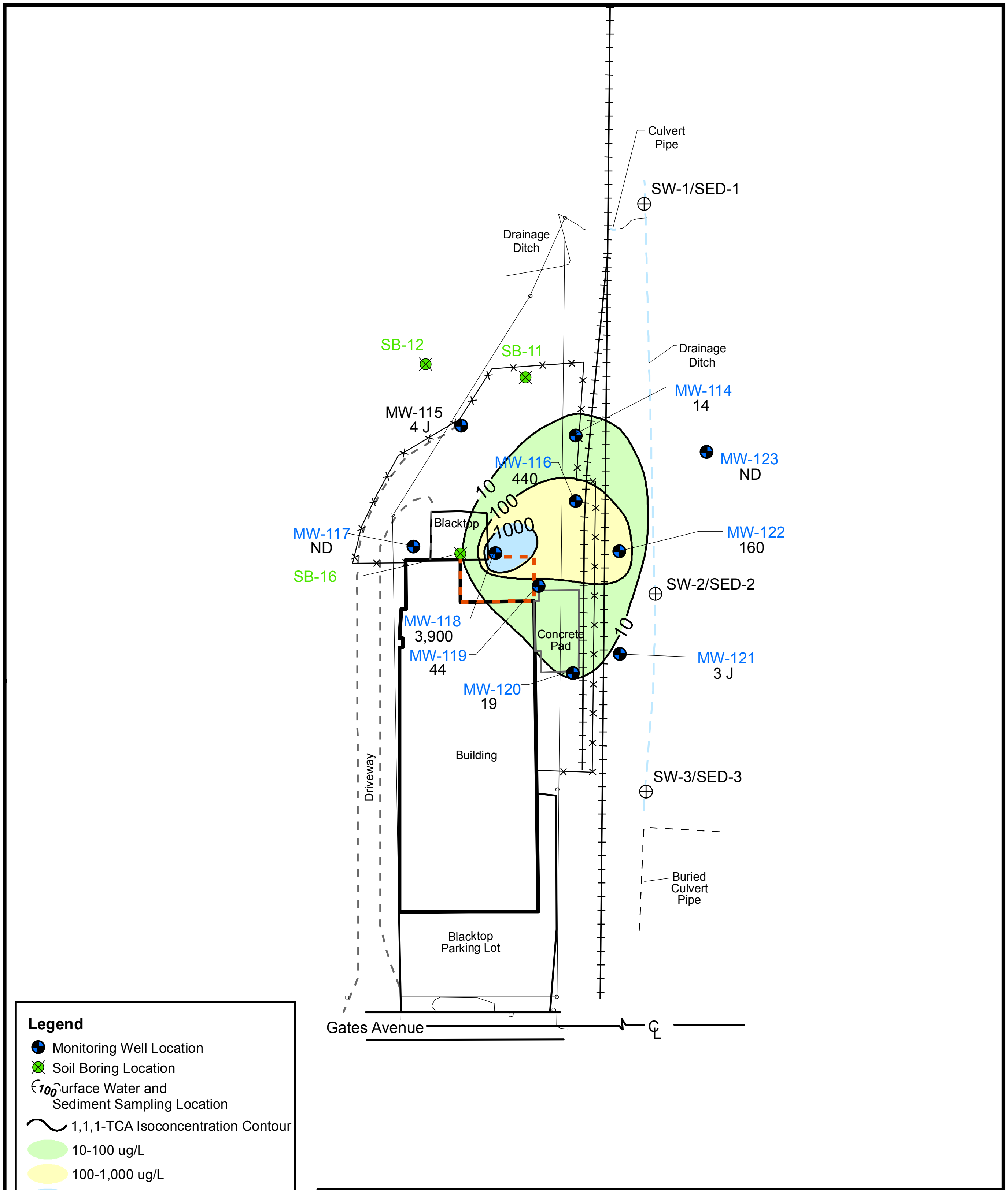
Date:
10/04/07

Figure 20
TVOC Concentrations
in Groundwater (ug/L)
January 2006

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



Legend

● Monitoring Well Location

☒ Soil Boring Location

⊕ Surface Water and Sediment Sampling Location

100 1,1,1-TCA Isoconcentration Contour

🟩 10-100 ug/L

🟨 100-1,000 ug/L

🟦 1,000-10,000 ug/L

14	1,1,1-TCA Detected in Groundwater, January 2006
ND	Not Detected
J	Estimated Value

0 60 120 Feet

N E S W

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Date: 10/04/07

Figure 21
1,1,1-TCA Concentrations in Groundwater (ug/L)
January 2006

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York

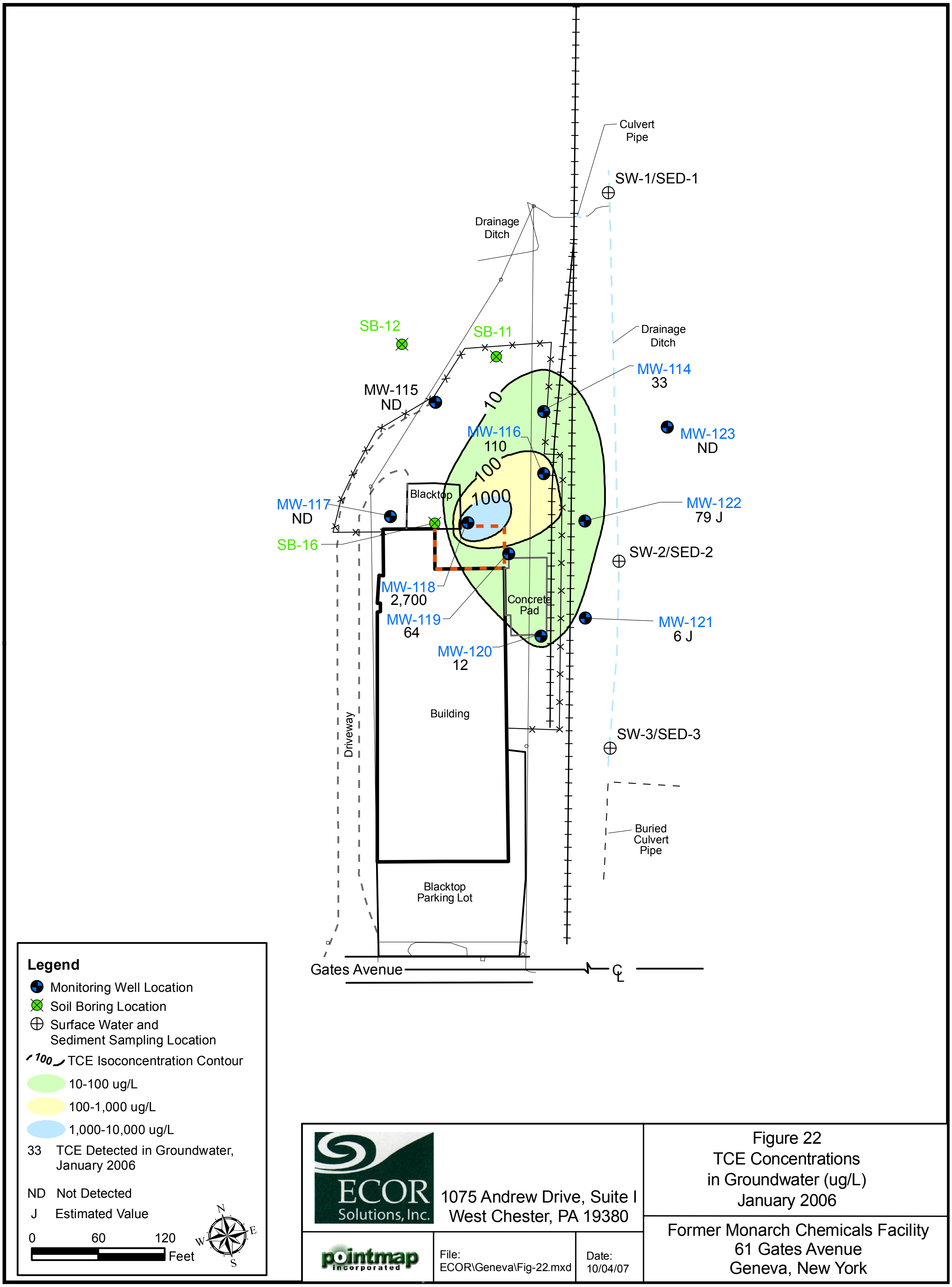

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Figure 22
TCE Concentrations in Groundwater (ug/L)
January 2006

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York

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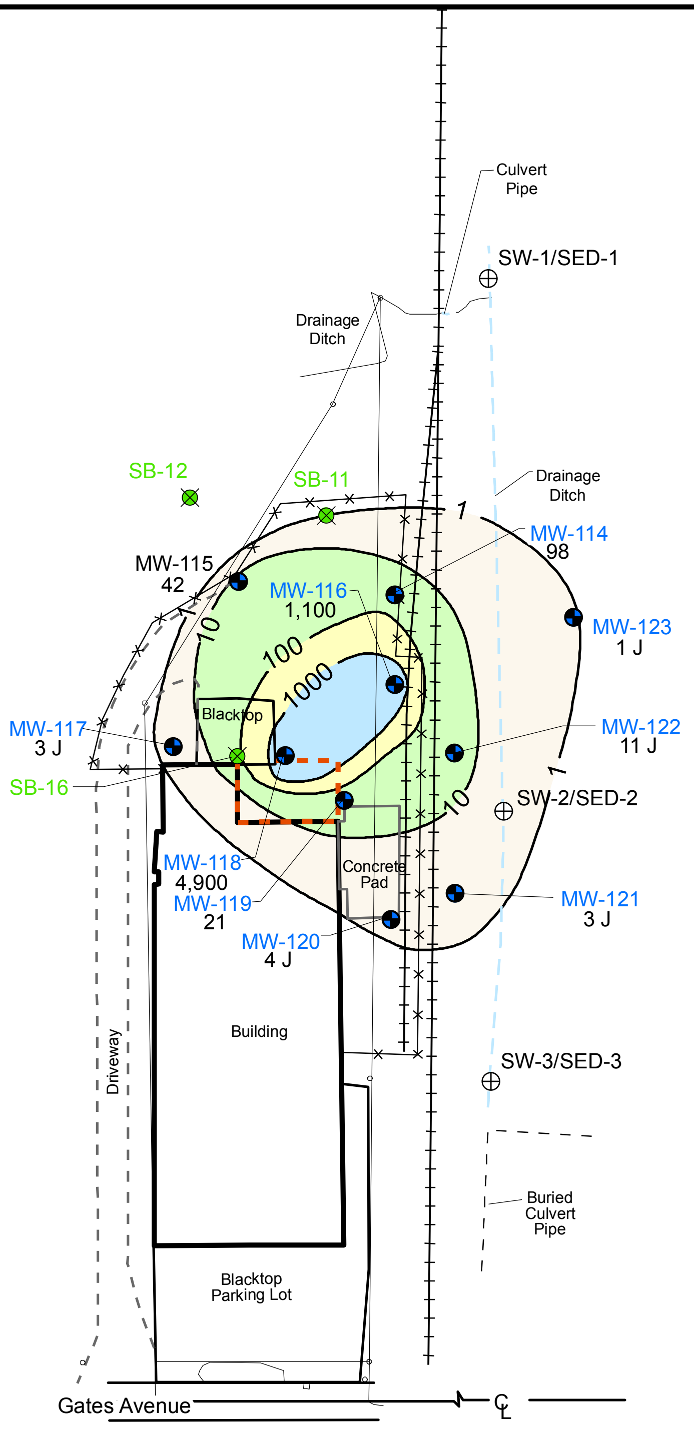
File:
ECOR\Geneva\Fig-22.mxd

Date:
10/04/07



Legend

- ● Monitoring Well Location
- ⊗ Soil Boring Location
- ⊕ Surface Water and Sediment Sampling Location
- ×—× Fence
- +++ Railroad
- - - AST Containment Area
- 100 PCE Isoconcentration Contour
- ▨ 1-10 ug/L
- 🟩 10-100 ug/L
- 🟨 100-1,000 ug/L
- 🟦 1,000-10,000 ug/L
- 33 PCE Detected in Groundwater, January 2006
- J Estimated Value

0 60 120 Feet

N E S W

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Figure 23
PCE Concentrations in Groundwater (ug/L)
January 2006

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York

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File: ECOR\Geneva\Fig-23.mxd

Date: 10/04/07

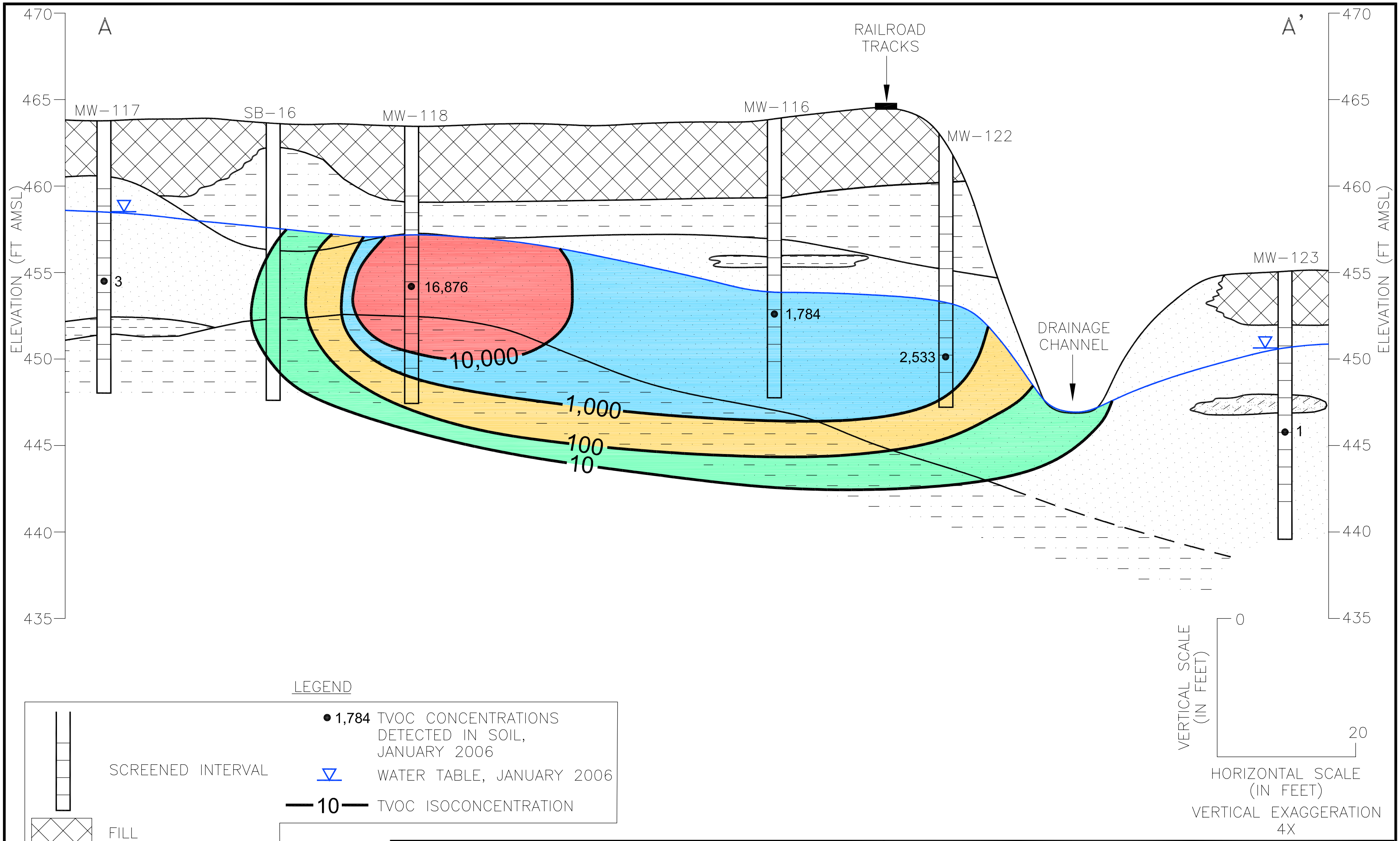

Figure 24
TVOC Concentrations in Groundwater (ug/l)
Cross Section A–A'; July 2005

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York

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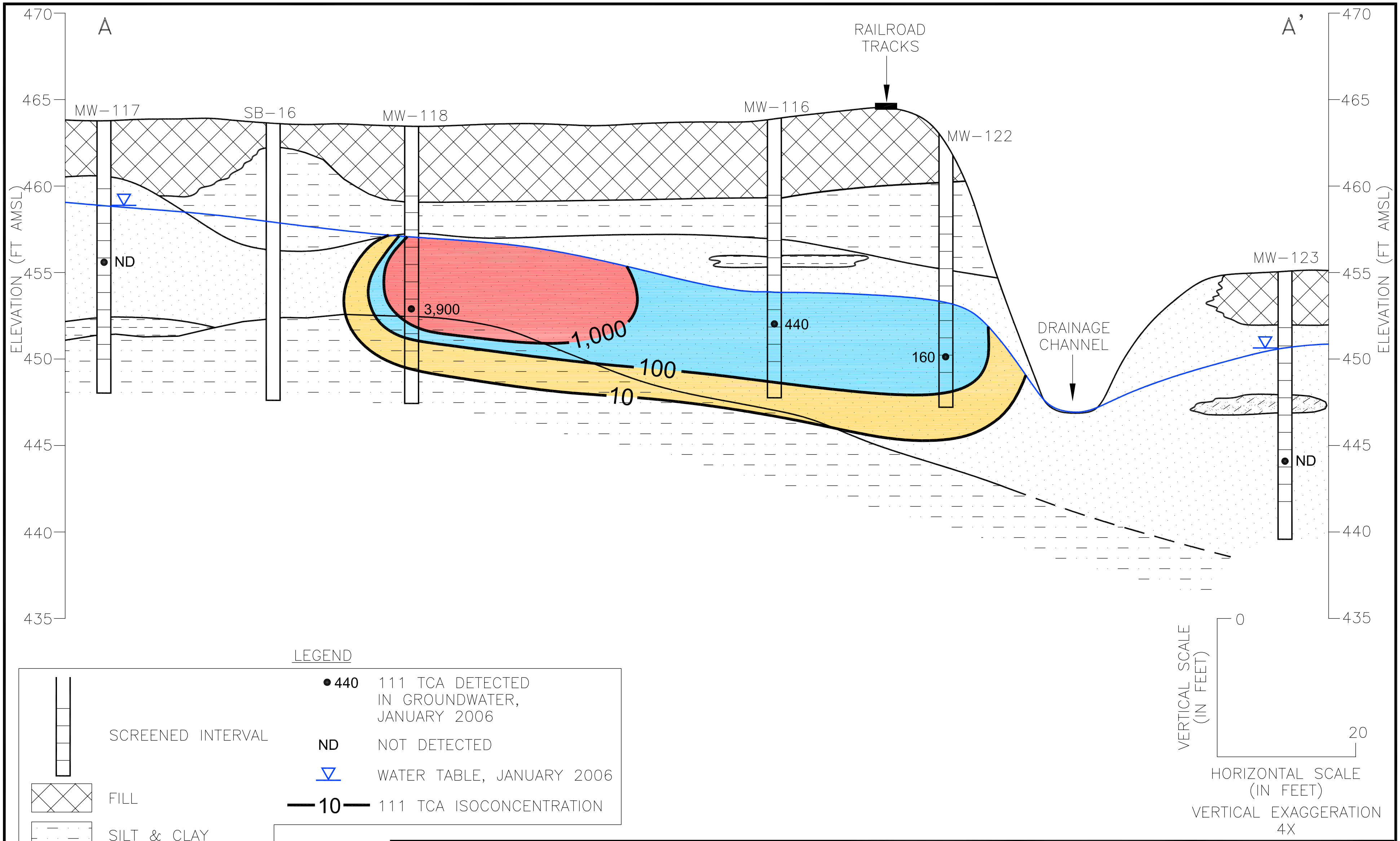
File: GENEVA–AA–F24.dwg Date: 10/2/07



LEGEND

▯	SCREENED INTERVAL
▨	FILL
┄	SILT & CLAY
⋯	SAND
╌	CLAY
▨	SILTY SAND
● 440	111 TCA DETECTED IN GROUNDWATER, JANUARY 2006
ND	NOT DETECTED
▽	WATER TABLE, JANUARY 2006
—10—	111 TCA ISOCONCENTRATION

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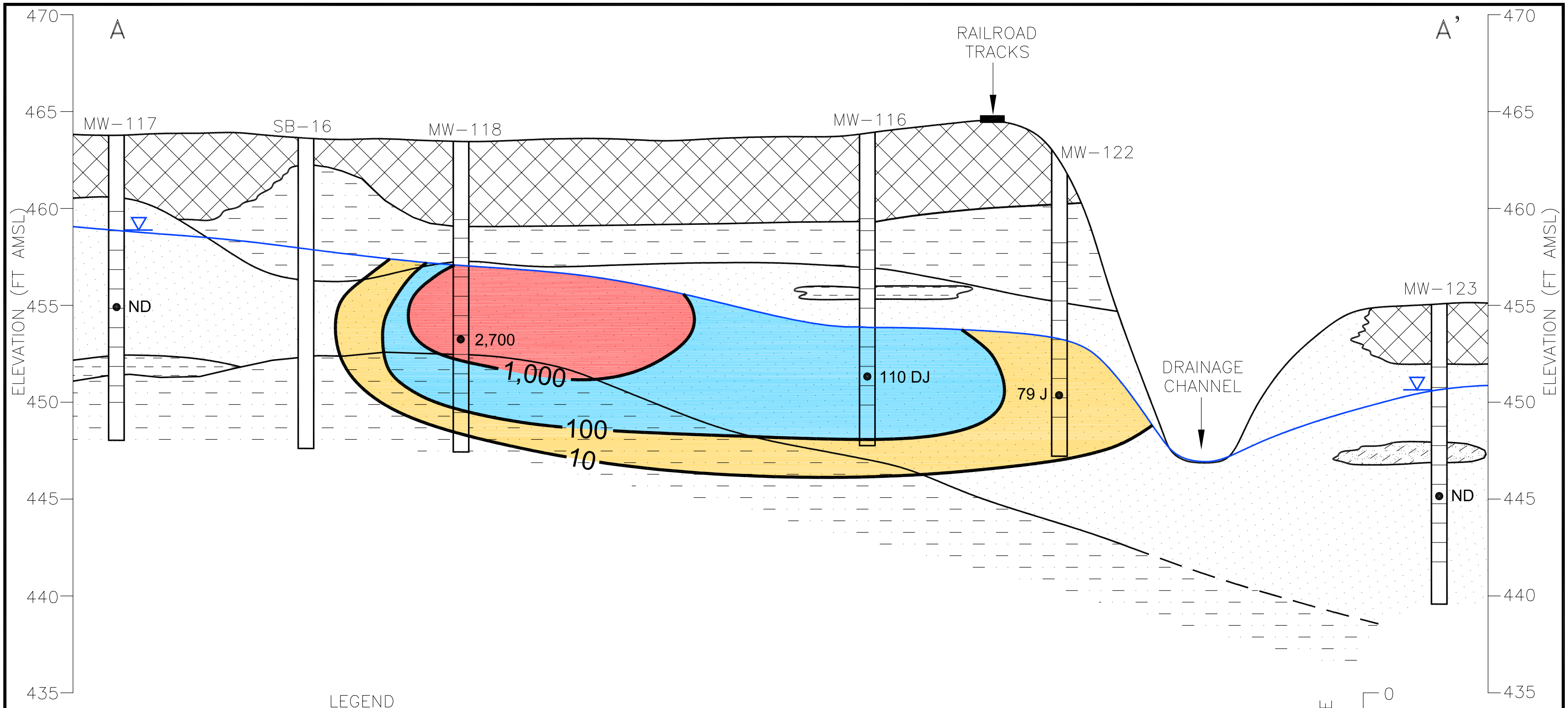
File: GENEVA-AA-F25.dwg Date: 10/2/07

Figure 25
111 TCA Detected in Groundwater (ug/l)
Cross Section A-A'; July 2005

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



LEGEND

SCREENED INTERVAL

▨ FILL

SILT & CLAY

SAND

CLAY

SILTY SAND

● 33 TCE CONCENTRATIONS DETECTED IN GROUNDWATER, JANUARY 2006

ND NOT DETECTED

D

J ESTIMATED CONCENTRATION

▽ WATER TABLE, JANUARY 2006

—10— TCE ISOCONCENTRATION

VERTICAL SCALE (IN FEET)
0
20
HORIZONTAL SCALE (IN FEET)
VERTICAL EXAGGERATION
4X

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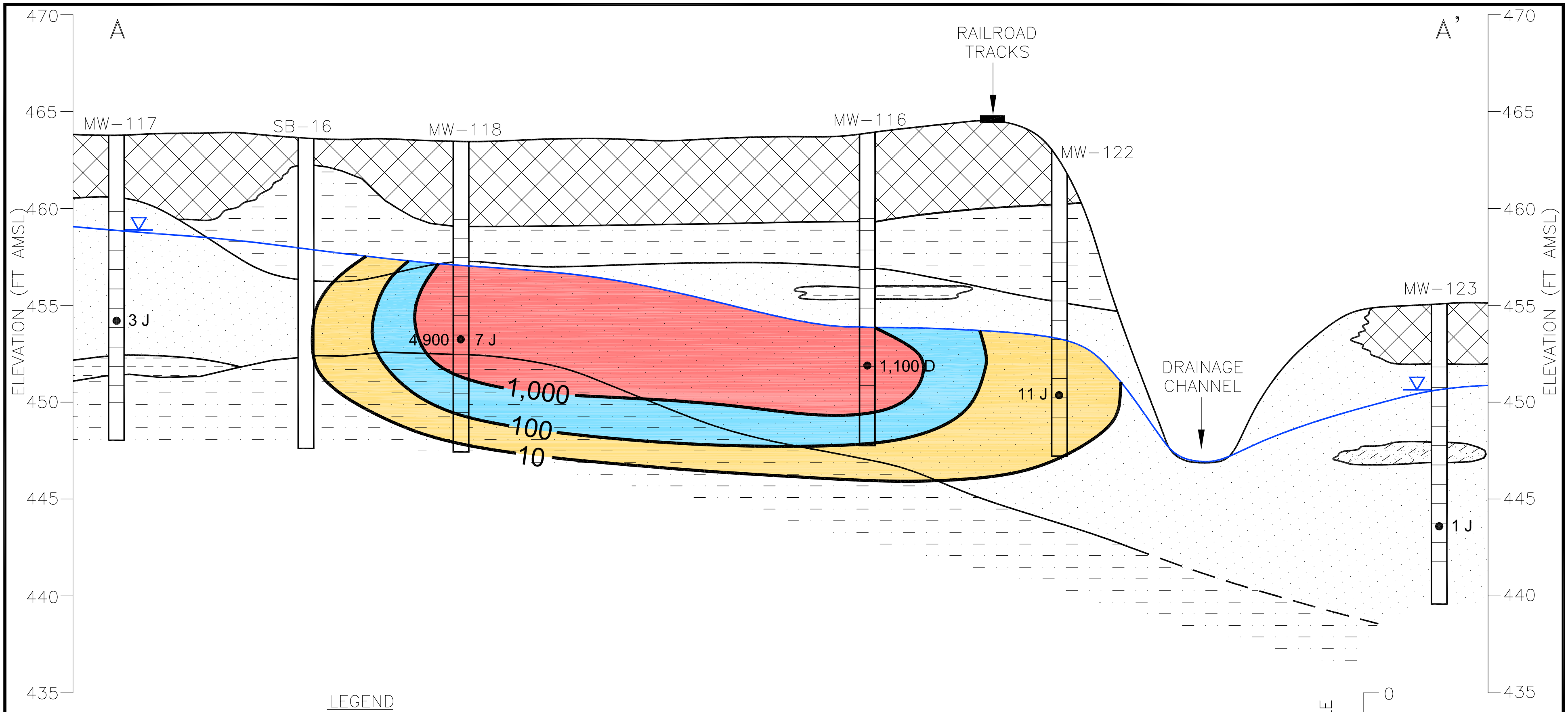
File: GENEVA-AA-F26.dwg Date: 10/2/07

Figure 26
TCE Concentrations Detected in Groundwater (ug/l); Cross Section A-A'; July 2005

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



LEGEND

SCREENED INTERVAL	
▨	FILL
☐	SILT & CLAY
☐	SAND
☐	CLAY
▨	SILTY SAND

● 4,900	PCE CONCENTRATIONS DETECTED IN GROUNDWATER, JANUARY 2006
ND	NOT DETECTED
D	
J	ESTIMATED CONCENTRATION
▽	WATER TABLE, JANUARY 2006
—10—	PCE ISOCONCENTRATION

VERTICAL SCALE (IN FEET) 0 20

HORIZONTAL SCALE (IN FEET)

VERTICAL EXAGGERATION 4X

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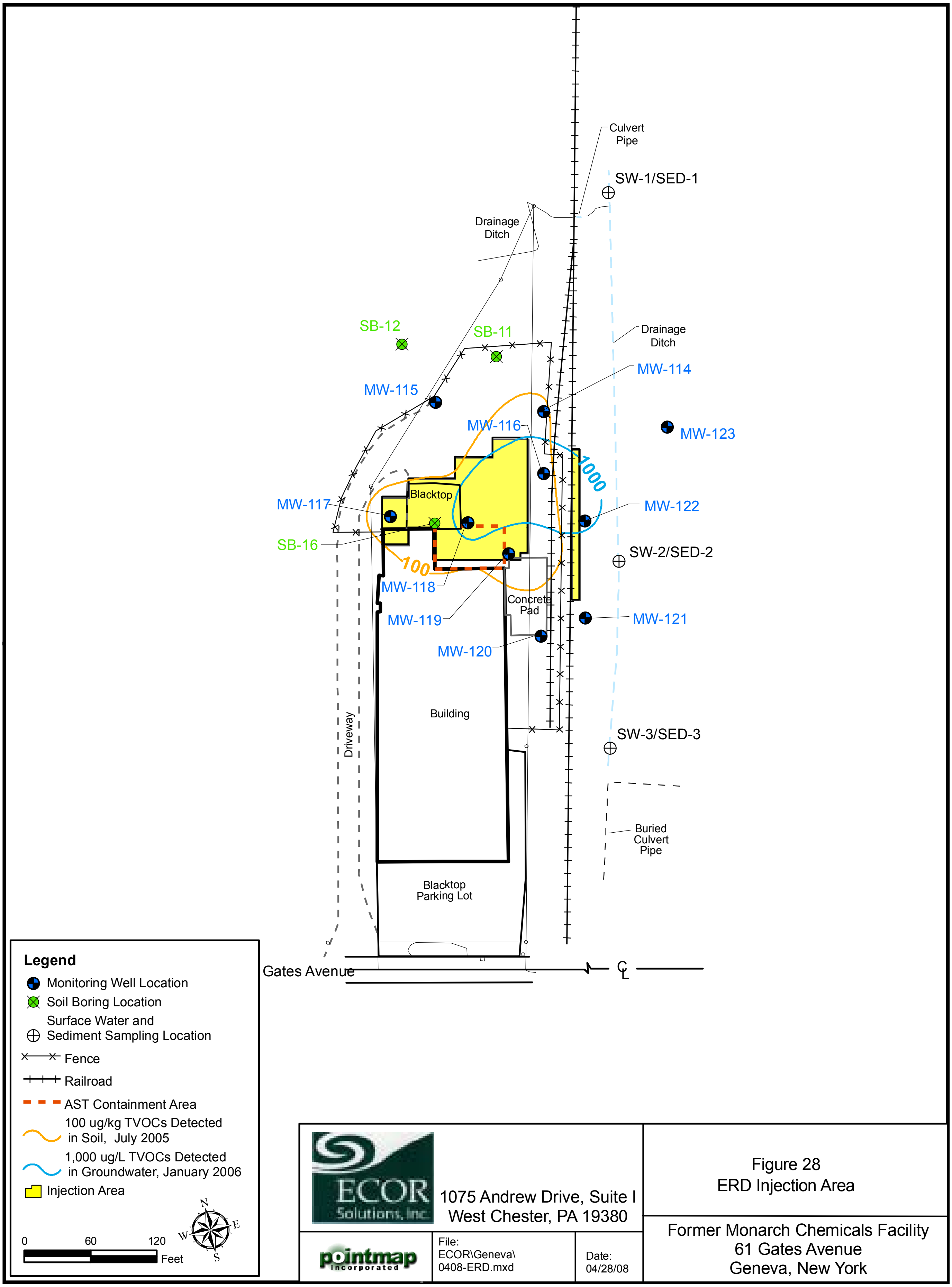
File: GENEVA–AA–F27.dwg Date: 10/2/07

Figure 27
PCE Concentrations Detected in Groundwater (ug/l); Cross Section A–A'; July 2005

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



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West Chester, PA 19380

pointmap incorporated

File:
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0408-ERD.mxd

Date:
04/28/08

Figure 28
ERD Injection Area

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York

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1075 Andrew Drive, Suite I
West Chester, PA 19380

pointmap incorporated

File:
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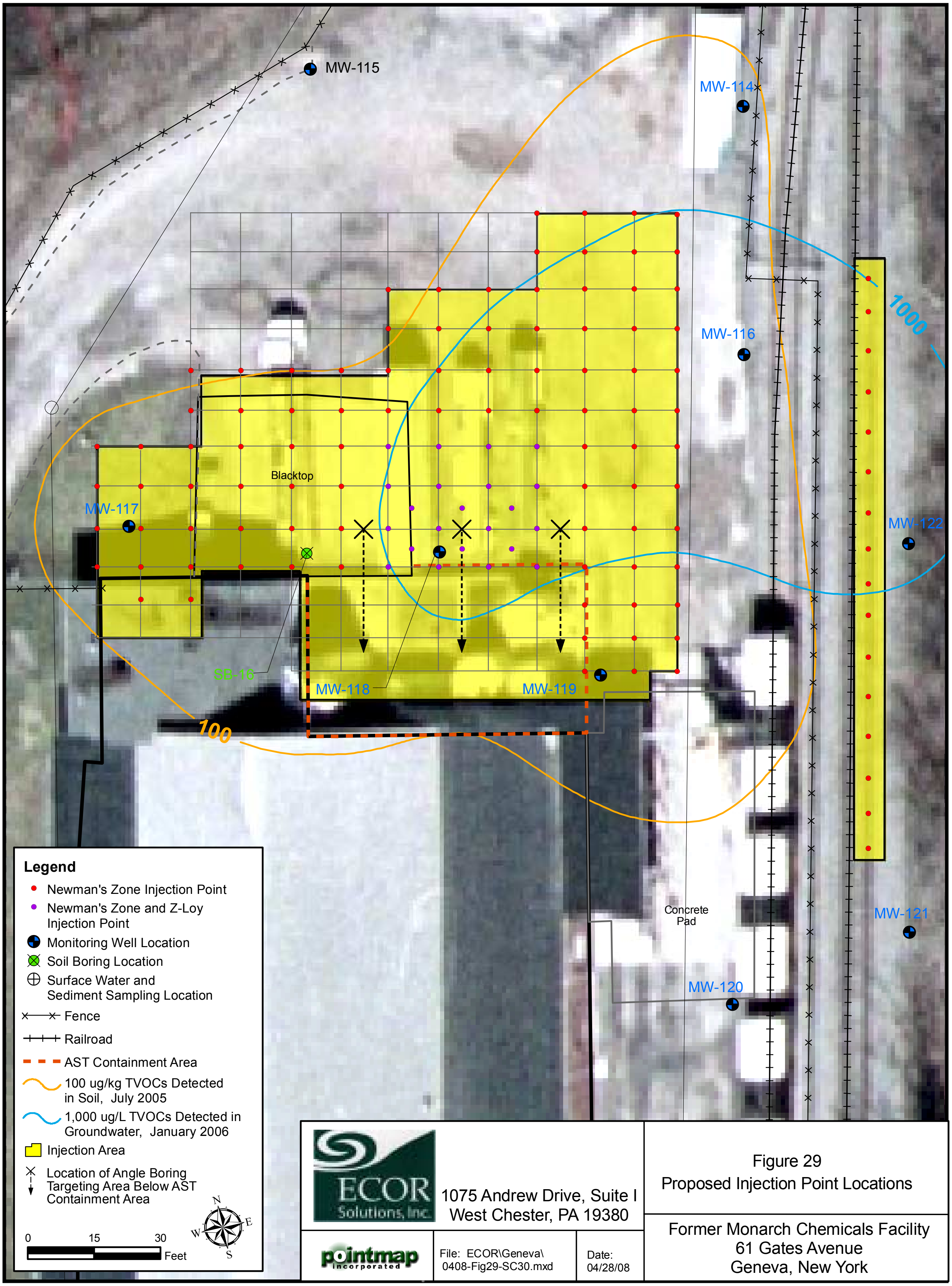
0408-ERD.mxd

Date:
04/28/08

Figure 28
ERD Injection Area

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



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West Chester, PA 19380

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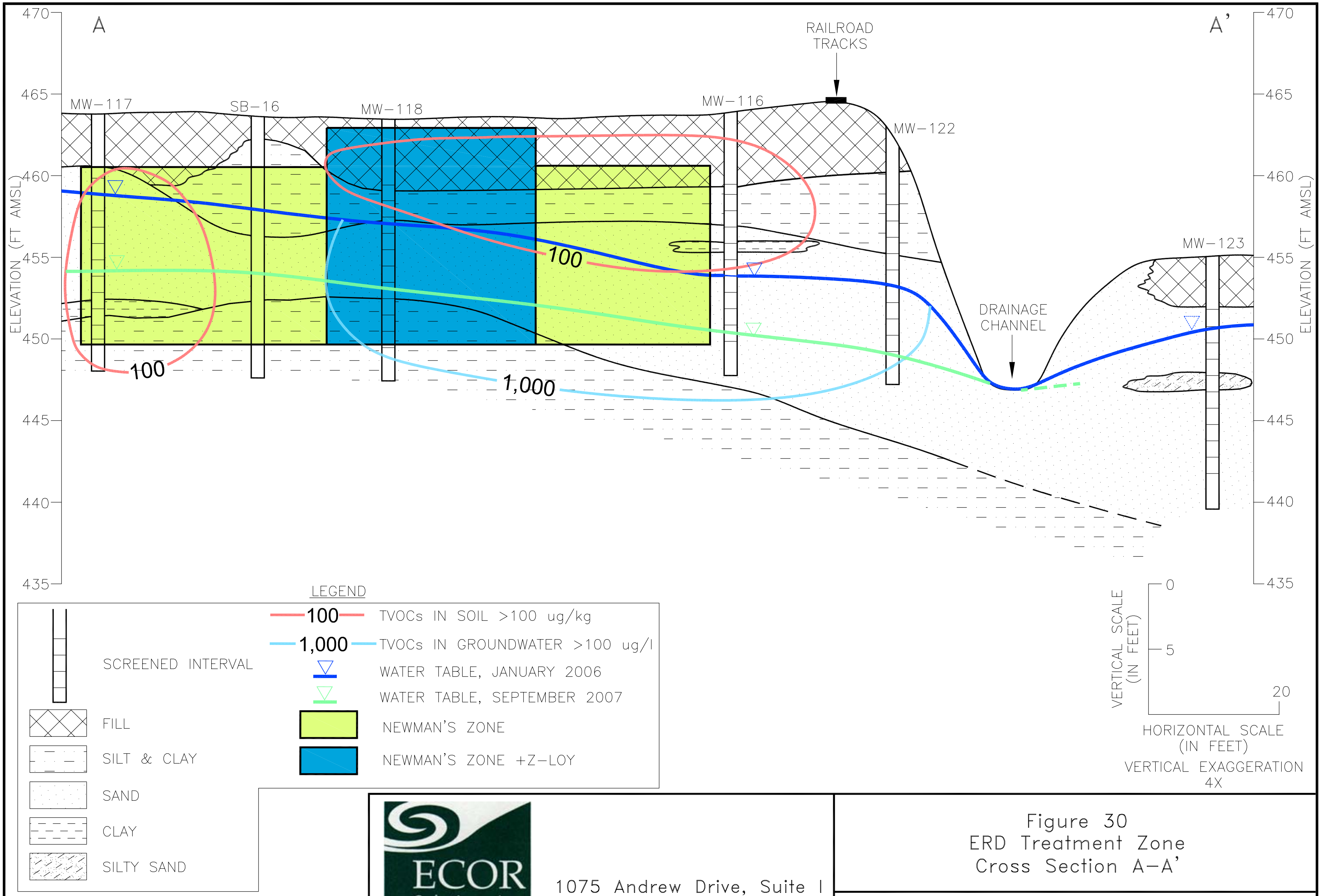
File: ECOR\Geneva\0408-Fig29-SC30.mxd

Date: 04/28/08

Figure 29
Proposed Injection Point Locations

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York



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pointmap incorporated

File: GENEVA–AA–F30.dwg Date: 11/8/07

Figure 30
ERD Treatment Zone
Cross Section A–A'

Former Monarch Chemicals Facility
61 Gates Avenue
Geneva, New York