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SRSNE Site Group

Groundwater Conceptual Site Model Update

Solvents Recovery Service of New England, Inc.
Superfund Site
Southington, Connecticut

April 2015

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SRSNE Site Group

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Executive Summary

This document presents an integrated and updated Groundwater Conceptual Site Model (CSM) for the Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site in Southington, Connecticut (the Site). The CSM includes an overview of site history and physical setting, remedial actions, hydrogeology, lateral and vertical groundwater plume extent, groundwater quality trends, mass removal, and progress toward groundwater remedial goals.

Between 1957 and 1991, SRSNE processed over 41 million gallons of waste solvents, fuels, paints, and similar liquid materials. A small fraction of these materials is believed to have entered the subsurface in the form of non-aqueous phase liquids (NAPLs). Partial dissolution of the NAPLs produced dissolved plumes of volatile organic compounds (VOCs) in overburden and bedrock groundwater, which extend southward within the Quinnipiac River Valley. Groundwater investigations between the 1960s and the present, including ongoing monitoring as part of the Remedial Action for the Site, provide a robust database in terms of groundwater hydraulics, plume extent, and groundwater quality trends.

The VOC plumes are hydraulically controlled by a containment and treatment system (HCTS). The capture zone for this system has been confirmed by a combination of groundwater elevation data mapping, modeling, and groundwater sampling at monitoring wells. Groundwater outside of the capture zone meets drinking water standards for VOCs. In addition, groundwater pumped by the downgradient extraction wells themselves shows declining concentrations and often meets drinking water standards for VOCs.

Considerable progress has been made toward the remedial goals for the Site. At least nine substantial removal or remedial actions have been performed at the Site. Most recently, and most significantly, between May 2014 and February 2015, in-situ thermal remediation (ISTR) was performed in the Overburden NAPL Area identified during the Feasibility Study (FS). The FS estimated that the Overburden NAPL Area contained approximately 84% of the total VOC mass at the Site in the form of NAPLs. The in-situ thermal remedy removed this NAPL mass, and reduced the dissolved VOC concentrations in this initially high-concentration source area by 97%; the total mass removed by the thermal remedy was approximately 220,000 kilograms (kg).

Even before the thermal remedy, VOCs were already undergoing substantial degradation within the subsurface, as documented by annual Monitored Natural Attenuation (MNA) reports. VOC concentrations have been steadily declining in overburden and bedrock groundwater since the completion of the Remedial Investigation (RI) in 1996, including the area immediately downgradient of the Overburden NAPL Area and the downgradient, dilute portion of the plume. It is estimated that nearly 300,000 kg of VOCs have been removed by degradation – including biotic and abiotic reactions - within overburden and bedrock groundwater since 1996.

In total, approximately 525,000 kg of VOC mass has been removed or degraded since the completion of the RI in 1996. It is estimated that the remaining mass is approximately 3% of the VOC mass that was present in 1996.

As stated in the Record of Decision (ROD), “Eventual restoration of the contaminated groundwater plume in both overburden and bedrock to cleanup levels is expected to take longer than 225 years, which is the estimated time frame for the entire plume at the Site to achieve safe drinking water standards.” Most monitoring locations included in the trend analyses demonstrate decreasing concentration trends, and locations with VOC concentrations above drinking water standards are estimated to reach these levels generally within the next few decades to 100 years.

The VOC plumes have been delineated, will continue to degrade, and will continue to be evaluated in MNA reports. Groundwater geochemistry and microbiology data support the interpretation that VOC degradation will continue, for the foreseeable future, at rates favorable for achieving groundwater restoration goals envisioned in the ROD. Future Five-Year Reviews will continue to track progress toward groundwater remedy completion.

1. Introduction

1.1 Purpose and Scope

This document presents an integrated and updated Groundwater Conceptual Site Model (CSM) for the Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site in Southington, Connecticut (the Site; Figures 1-1 and 1-2). The CSM focuses on the presence, distribution, transport, and fate of site-related constituents in groundwater, and updates prior CSM information presented in the Remedial Investigation (RI) and FS Reports (Blasland, Bouck, & Lee, Inc. [BBL] 1998, and BBL and United States Environmental Protection Agency [USEPA], 2005). In doing so, it summarizes:

- The distribution and mass of volatile organic compounds (VOCs) based on 2014 groundwater monitoring data (Section 2).
- The status of the Site's existing Hydraulic Containment and Treatment System (HCTS) (Section 3).
- Plume extents for VOCs and metals, as well as the ongoing Monitored Natural Attenuation (MNA) program (Section 4).
- An evaluation of progress made toward achieving remedial goals for the Site (Section 5).

This CSM has been prepared to support the second Five-Year Review of the remedial approach selected for the site and documented in the Record of Decision (ROD; USEPA 2005). Relevant to this CSM, in-situ thermal remediation (ISTR) of the overburden non-aqueous phase liquid (NAPL) zone has recently been completed. In addition, this CSM incorporates data collected as part of groundwater monitoring performed pursuant to Tasks E, F, and J (outlined below) of the Remedial Design/Remedial Action (RD/RA) Statement of Work (SOW) (USEPA 2008).

1.2 Historical Overview

Between 1957 and 1991, SRSNE processed over 41 million gallons of waste solvents, fuels, paints, and similar liquid materials. A small fraction of these materials is believed to have entered the subsurface due to placement of distillation sludge in two unlined lagoons on site, occasional overflow of materials from these lagoons to ditches adjacent to the Site, and incidental spills and leaks from drums, hoses, tanks, trucks, etc. (Figures 1-3 through 1-5). Resulting releases produced a complex, multi-component NAPL source zone in the glacial overburden and fractured bedrock, along with associated aqueous-phase plumes. Dense NAPL (DNAPL) and, to a lesser extent, light NAPL (LNAPL) have been encountered in borings and monitoring wells at the Site. DNAPL and LNAPL samples collected from monitoring wells have contained predominantly chlorinated and aromatic hydrocarbons, but also alcohols,

ketones, furans, and polychlorinated biphenyls (PCBs). The associated VOC plume in groundwater extends generally southward along the Quinnipiac River Valley, and is controlled by a hydraulic containment system that includes overburden and bedrock groundwater extraction wells.

Subsurface investigations in the region near the Site began in the 1960s and are ongoing. The RI was completed in 1998 and the Feasibility Study (FS) in 2005. USEPA Region 1 issued the ROD in 2005. The ROD describes the Remedial Action (RA) required for the Site. An RD/RA Consent Decree (CD) for the Site was entered on March 26, 2009, by the United States District Court for the District of Connecticut in connection with Civil Actions No. 3:08cv1509 (SRU) and No. 3:08cv1504 (WWE).

The RD/RA SOW is presented as Appendix B of the CD. The remedy required in the ROD, as detailed in the SOW, is as follows:

A. Design, construct and operate an in-situ thermal treatment system to treat contamination in the Overburden NAPL Area.

B. Excavate contaminated soil and wetland soil from the Cianci Property and culvert outfall. Consolidate excavated soils with contaminated soil in the Operations Area unless USEPA determines that contaminated soils should be excavated and disposed of off-site due to PCB contamination exceeding Toxic Substances Control Act (TSCA) levels, consistent with Section L of the ROD.

C. Remove existing concrete culvert; re-route drainage from the Site to the Quinnipiac River through a new, impermeable pipe.

D. Design and construct a low-permeability, multi-layer, composite Resource Conservation and Recovery Act (RCRA) Subtitle C cap that meets the requirements of the Connecticut Remediation Standard Regulations (RSRs) over the contaminated soil in the Operations Area and along the Railroad Right-of-Way (RR ROW).

E. Design, construct and/or operate and maintain, as necessary, a hydraulic containment, extraction and treatment system for groundwater in the overburden and bedrock aquifers. Modify the hydraulic containment and treatment system as necessary to meet changes in hydrogeologic or other site conditions including, but not limited to, the installation of additional containment wells in the event that the Southington Water Department (SWD) provides written notification, in accordance with the Memorandum of Agreement to be negotiated under Section V.B. 3 of the SOW, of its intent to activate municipal production wells located in the Curtiss Street Well Field.

F. Monitor natural attenuation of the groundwater in the Severed Plume that exceeds cleanup levels in Table L-1 of the ROD. Monitor natural attenuation of the NAPL in the overburden aquifer that lies outside the Overburden NAPL Area and in the bedrock aquifer underlying the Site. Note that Section L (the Selected Remedy) of the ROD (page 88) states that restoration of groundwater is expected to take longer than 225 years.

G. Implement any institutional controls determined by USEPA to be necessary to restrict future use of site property and groundwater. Monitor compliance and enforce and/or assist USEPA and the Connecticut Department of Energy and Environmental Protection (CT DEEP) in enforcing such institutional controls.

H. Restore the functions and values of any and all habitats affected by the remediation.

I. Assist USEPA in performing Five-Year Reviews to evaluate effectiveness and protectiveness of the remedy.

J. Design and implement a long-term monitoring program to evaluate the performance of the HCTS and the overall effectiveness and protectiveness of the remedy, including the MNA component.

K. Implement changes to the selected remedy to meet the ROD requirements that may be necessary as a result of remedial design and construction processes.

1.3 Summary of Pre-2010 Conceptual Site Model Information

The RI Report (BBL 1998) presented a detailed assessment of the history of SRSNE operations, the physical setting of the Site, and the nature and extent of chemicals of concern in soil, groundwater, surface water and sediment in the vicinity of the Site. Key sections of the RI that inform the CSM include:

- Section 2.5 - Previous Investigations of SRSNE and Town Well Field Areas
- Section 2.6 - Previous Remedial Actions
- Section 3.5 - Hydrogeologic Conceptual Model
- Section 4.4 - Migration and Exposure Conceptual Model

While these sections provide details that are not reiterated herein, a summary of the relevant information is provided below.

1.3.1 Summary of Historical Investigations

The SRSNE Site and surrounding areas of interest are situated within the Quinnipiac River Valley, approximately 15 miles southwest of the city of Hartford, Connecticut (Figures 1-1 and 1-2). Subsurface investigations in the region surrounding the Site originated during the development of the Town of Southington Well Field in the 1960s, including the installation and startup of two production wells (Figure 1-2). Production Well No. 4 was installed in August 1965 and provided drinking water to the Town of Southington from July 1966 to December 1977. Production Well No. 6 was installed in April 1976 and was pumped from May - October 1978, May - July 1979, and March 1980. Except for the brief period of pumping at Production Well No. 6 in March 1980, neither well has been used for water supply since approximately 1979 due to the detection of VOCs in the discharge water from the wells (Haliburton NUS [HNUS] May 1994).

Beginning in 1978, numerous investigations were conducted by various consultants and contractors to determine the sources of VOCs detected at Town Production Wells No. 4 and 6. At least twelve investigations were conducted between 1978 and 1990, and these focused on hydrogeology, potential VOC migration pathways, and potential sources of the VOCs detected at the production wells. These investigations identified at least 8 potential sources of VOCs in the study area, including the SRSNE Operations Area. A key focus of the RI completion, therefore, was to distinguish the off-site VOC plume associated with the SRSNE Site from VOC plumes associated with the other VOC sources. The USEPA performed the first three phases of the RI between 1990 and 1994. In 1994 and 1995, additional soil and groundwater studies were conducted at the former SRSNE Operations Area and immediately downgradient area to supplement the RI data and evaluate potential remedial options. Between 1996 and 1998, BBL completed the RI. Between 1997 and 1999, pumping wells and piezometers were installed in the northern portion of the Town Well Field Property and hydraulic tests were performed in support of a groundwater containment system. A NAPL delineation pilot study was conducted in 2003 to delineate the overburden NAPL zone using strictly visual assessment of NAPL and sheens, as well as hydrophobic dye tests. The results of this assessment, and supplemental data collected beyond the former Operations Area property line in 2009, were used to define the extent of the overburden thermal treatment zone (see below).

1.3.2 Summary of Remedial Actions

At least nine substantial removal or remedial actions have been performed at the SRSNE Site:

- Lagoon closure (1967)

- 1983 CD remedial measures (installation of spill control and fire prevention measures, and surface pavement) (1983 to 1991)

- On-site interceptor system installation and use for groundwater extraction and treatment (1985 through 1992)

- SRSNE Site post-shutdown cleanup of tanks and containment structures (1991)

- USEPA's Time-Critical Removal Action (TCRA) #1 to remove soil and sediments in a drainage ditch (1992)

- USEPA's TCRA #2 to remove and dispose of laboratory chemicals and equipment, and removal of building asbestos that SRSNE had abandoned at the Site (1994)

- Non-Time-Critical Removal Action No. 1 (NTCRA 1), including the design, installation, and operation of an overburden groundwater containment and treatment system immediately east of the former Operations Area (1994 through present)

- NTCRA 2, including the design, installation, and operation of a downgradient overburden and bedrock groundwater containment and treatment system (1997 through present)

- Work pursuant to the RD/RA CD, including operation of the HCTS, groundwater monitoring, and ISTR of the overburden NAPL Zone within and near the former Operations Area (2009 through present)

Additional site cleanup activities included the demolition of the former Operations Area buildings, aboveground tanks and distillation equipment in 1998 as part of NTCRA 2. The NTCRA 1 and NTCRA 2 groundwater extraction and treatment systems have controlled the plumes of VOCs in overburden and bedrock groundwater since 1995 and 1998, respectively. Following entry of the RD/RA CD, NTCRA 1 and NTCRA 2 continued to be operated and maintained (collectively, the HCTS).

1.3.3 Geology and Hydrogeology

The SRSNE Site is located within the Connecticut Valley Lowland section of the New England physiographic province. The Connecticut Valley Lowland occupies a regional, structural rift basin, which is characterized by block-faulted and tilted bedrock strata. The bedrock consists of the fractured, Triassic New Haven Arkose bedrock. Bedrock bedding plane fractures dip approximately 22 degrees to the east-southeast, and calculated fracture apertures decrease with depth below the top of rock (BBL 1998). The overburden geology of the area includes unconsolidated deposits composed of Pleistocene glacial outwash and a thin, discontinuous layer of till at the bedrock surface, with isolated deposits of fill and alluvium. The overburden thickness is approximately 15 feet at the Former SRSNE Operations Area, 50 feet at the Quinnipiac River east of the former Operations Area, 100 feet near Queen Street and Curtiss Street, and up to 200 feet east of Queen Street (Figure 1-2). The overburden thickness and

hydraulic conductivity increase southward within the river valley. The overburden materials between the Operations Area and the river have permeabilities in the range of 1 to 10 feet per day (ft/d). At the Connecticut Light & Power (CL&P) powerline easement that crosses the Town Well Field, the overburden has permeabilities in the range of 10 to 100 ft/d. Further south, in the vicinity of Curtiss Street, hydraulic conductivities of over 1,000 ft/d have been measured. The geometric mean bedrock hydraulic conductivity is approximately 0.4 ft/d.

A total of 166 groundwater monitoring wells, extraction wells and piezometers (collectively referred to as “wells”) comprise the current groundwater monitoring network: 131 are used to monitor groundwater quality, plume extent and concentration trends; the other 35 wells were previously sampled but are currently used for water-level gauging only (Figures 1-6 and 1-7). Since the completion of the RI (BBL 1998), the wells have been sorted into the following five hydrostratigraphic zones for ease in data interpretation:

- *Shallow, middle and deep overburden*, which represent the upper, middle, and lower thirds of the saturated overburden deposits, respectively

- *Shallow and deep bedrock*, which represent approximately the upper 30 feet of bedrock and the portion of bedrock that is more than 30 feet below the top of rock, respectively

The original deep bedrock monitoring wells installed during the RI were approximately 60 to 90 feet below the top of bedrock (700 series wells). Between 2010 and 2012, deeper bedrock wells were installed to depths of up to approximately 125 feet below the top of bedrock to further characterize and delineate the deep bedrock VOC plume (900 and 1000 series wells). Monitoring wells in all five zones have been installed at depths that exhibited one or both of the following:

- Evidence of VOCs based on photoionization detector (PID) readings or screening-level laboratory analysis of soil and/or groundwater

- Enhanced permeability as interpreted based on soil and bedrock samples or field measurements of hydraulic conductivity during drilling

Based on the available groundwater (potentiometric) elevation data, and the surface-water elevation and flow measurements for the Quinnipiac River, the river is the predominant discharge location for all groundwater within the monitored geologic section of the RI Study Area, which extends to a depth of approximately 270 feet below ground surface (bgs) (Figure 1-8). With the exception of the groundwater that is extracted by the HCTS or removed from the subsurface via evapotranspiration, all of the overburden and bedrock groundwater within the monitored subsurface in the study area ultimately reaches the Quinnipiac River. Surface water samples collected at multiple points along the river within the study area have indicated non-detectible or negligible VOC concentrations.

1.3.4 Distribution of VOC Mass

NAPL zone evaluation during the RI was performed in collaboration with Dr. Bernard H. Kueper, Ph.D., P.Eng., of Queen's University in Kingston, Ontario. NAPL zone delineation included ten different screening criteria to identify potential or known NAPL locations.

NAPLs in each unit were delineated at two levels of relative confidence:

- Probable NAPL zone – delineated based on direct observations of NAPL, Site history, anomalous VOC distributions or accepted technical principles based on effective solubility limits of NAPL constituents.

- Potential NAPL zone – serves as safety factor around the probable NAPL zone, but also is consistent with effective solubility principles recognized as indicating the potential nearby presence of NAPL (USEPA 1992).

The potential NAPL zones delineated in overburden and bedrock covered approximately 12.4 and 14.2 acres, respectively. The probable NAPL zones delineated in overburden and bedrock during the RI covered approximately 4.9 and 6.0 acres, respectively (Figures 1-9 and 1-10). The maximum depth of the potential NAPL zone in bedrock was interpreted to be on the order of 200 feet bgs based on the 3-D distribution of dissolved VOCs and groundwater flow directions (BBL 1998).

During the FS, the area within the overburden potential NAPL zone was further investigated to delineate the zone containing NAPLs based solely on direct visual indications of NAPL in soil samples. The results indicated that, while the existence of NAPL in the overburden downgradient of the former Operations Area cannot be absolutely ruled out, NAPL was found to be much more prevalent in the former Operations Area. The resulting Overburden NAPL Area presented in the FS covered an area of 1.7 acres at and near the former Operations Area. It was estimated that the soil in this zone contained 500,000 to 2,000,000 pounds [230,000 to 900,000 kilograms (kg)] of VOCs in the form of NAPLs (BBL and USEPA 2005); this zone was ultimately the subject ISTR (Figure 1-11).

The FS Report estimated the total VOC (TVOC) mass at the Site as 550,000 kg, which includes all physical phases of VOCs and assumes the midpoint of estimated range for the overburden NAPL mass (460,000 kg). Converted to an equivalent volume of NAPL, the total estimated VOC mass in all phases in overburden and bedrock corresponds to approximately 1 percent of the waste materials known to have been processed at the Site. An update regarding the distribution of VOC mass at the Site is presented in Section 2.

During the RI, the regulatory VOC plumes related to the SRSNE Site were delineated in the shallow, middle and deep overburden, the shallow bedrock and, on a preliminary basis, the deep bedrock. In the mid- to late-1990s, the VOC plumes in the middle overburden and shallow bedrock extended the furthest downgradient (south) of the Site, beyond the CL&P easement. Startup of the NTCRA 2 system in mid-1999 established a capture zone that extends to the vicinity of the CL&P easement, and consequently the VOCs in groundwater south of the CL&P easement attenuated to below drinking water standards by 2001, as predicted in the 1998 draft of the FS. Concentration trend statistics included in MNA Reports (e.g., ARCADIS 2014) demonstrate predominantly decreasing VOC concentrations in groundwater within all five hydrostratigraphic zones. Several other plumes, which are unrelated to the SRSNE Site, were also identified during the RI and post-ROD monitoring, based on groundwater quality and hydraulics data.

1.3.5 Risk Assessment Summary

Potential direct-contact and ecological risks associated with shallow soil and sediment will be addressed by targeted removal of affected materials as part of the site remedy. With respect to groundwater, no completed risk pathways are known to exist. Current and future risk and exposure are controlled, as (1) VOC concentrations in groundwater are stable or decreasing and do not exceed drinking water standards at wells beyond the capture zone of the hydraulic containment system; (2) the properties situated over the plume will be subject to Environmental Land Use Restrictions (ELURs); (3) no known water wells exist in the vicinity of the SRSNE-related VOC plume; and (4) an existing town ordinance prohibits drilling or use of potable water wells in the area (which is served by public water).

2. VOC Distribution and Mass – 2015 Update

2.1 NAPL Monitoring and Removal

Following the first detection of DNAPL at well MWD-601 during NTCRA 1, NAPLs have been periodically monitored and removed from wells when found. NAPL monitoring and removal has been performed on a monthly basis since September 2003 at wells that have had any indication of NAPL accumulation, except for wells that were installed or abandoned within this timeframe.

Well ID	Total DNAPL Removed (Gallons)	Last DNAPL Occurrence	Total LNAPL Removed (Gallons)	Last LNAPL Occurrence	Total NAPL Removed (Gallons)	Last NAPL Occurrence
Overburden Wells						
RW-5	3	1995	--	--	3	1995
P-2B	0.002	2004	2	2009*	2	2009
MWD-601	0.3	1995	0.002	2003	0.3	2003
P-4B	--	--	0.2	2009	0.2	2009**
CPZ-8	--	--	0.05	2006	0.05	2006
P-1B	0.002	1996	0.01	2004	0.01	2004
CPZ-2A	--	--	0.003	2004	0.003	2004
P-2A	--	--	0.002	2004	0.002	2004
Bedrock Wells						
PZ-906DR	14	2011	--	--	14	2011
CPZ-8R	3	2014	0.05	2011	3	2014
MW-705DR	0.8	2014	--	--	0.8	2014
CPZ-7R	--	--	0.003	2009	0.003	2009
CPZ-9R	0.002	1996	--	--	0.002	1996
Total	21		2.3		23	

Notes: * Last LNAPL at P-2B observed in November 2009; well abandoned in December 2009. ** Last LNAPL at P-4B observed in June 2009; well abandoned in December 2009.

NAPL recovery volumes vary widely, and have been dominated by a few wells. NTCRA 1 overburden extraction well RW-5, shallow bedrock well CPZ-8R and deep bedrock well PZ-906DR have recovered 95% of the DNAPL collected from wells. Overburden monitoring well P-2B recovered approximately 90% of the LNAPL collected from wells.

2.2 Deeper Bedrock Groundwater Investigations

The SOW required the installation of additional monitoring wells to monitor changes in VOC plume concentrations, plume size and shape, and the effectiveness of natural attenuation processes, in three dimensions, throughout the plume and within the overburden and bedrock aquifers. Monitoring clusters 903 and 906 were installed to better define the eastern edge of the plume (east of the Quinnipiac River), and cluster 907 was installed in the northern portion of the Town Well Field Property. Investigations at these locations between 2009 and 2010 included drilling and vertical profiling of VOC concentrations and hydraulic conductivity at three deep bedrock boreholes to approximate depths of 200 feet bgs, up to 125 feet below the top of rock.

Bedrock borehole PZ-906DR was drilled at the eastern edge of the potential NAPL zone in bedrock, as estimated during the RI (Figure 2-1). DNAPL was encountered approximately 170 to 177 feet bgs (100 to 107 feet below the top of rock). PZ-906DR produced 13.4 gallons of DNAPL in the first six months. The DNAPL was chemically and physically similar to DNAPL samples previously collected and characterized at updip bedrock wells west of the Quinnipiac River, and consisted primarily of trichloroethene (TCE) with minor components of other organic compounds. Physical property measurements included density (1.24 grams per milliliter [g/mL]); viscosity (0.92 centistokes); and interfacial tension (8.5 dynes/centimeter [dynes/cm]).

Figure 2-2 was produced using Mine Visualization Software (MVS; 3-D data depiction and analysis tool) and shows the relationship between the depth where DNAPL was encountered at PZ-906DR, and the depths of the other bedrock wells where DNAPL or sheens have been encountered. Figure 2-2 is a horizontal view looking north-northeast, along the “strike” of the average bedrock fracture. The colorful surface at the top of the figure is the top-of-bedrock. Specific depths with visible DNAPL and/or sheens in bedrock align with the average bedrock fracture orientation. It is interpreted that DNAPL migrated downdip from locations within the footprint of the Overburden NAPL Area, and near a former on-site interceptor system (OIS). The OIS extraction wells were screened in the overburden; some of them penetrated the upper 10 feet of bedrock. Seven of the 25 OIS wells contained visible evidence of NAPL during their abandonment as part of the NTCRA 1 construction activities, and two of these were screened to the top of bedrock. Therefore, the OIS system wells are considered among the likely historical entry points of DNAPL into the bedrock. From entry point locations at the top of rock, DNAPL migrated down into the bedrock toward the east-southeast following bedding plane fractures. Also, as discussed in the RI, some DNAPL evidently migrated along strike within the bedrock fracture network to the location of the former Cianci Trucking Company’s supply well, which provided water for truck washing purposes. During the RI, bedrock wells MW-709R and MW-709DR were installed in this former supply well (Figure 2-1).

The accumulation of nearly 14 gallons of DNAPL at PZ-906DR indicates that at a depth of 100 to 107 feet below the top of rock, the DNAPL encountered a structural trap or capillary barrier (such as pinching fractures; see below) that locally resisted further downdip migration of the DNAPL. In addition to the pinch out of bedrock fractures with depth, other factors that would resist further downdip DNAPL migration include: the westward and upward components of hydraulic gradient in bedrock east of the river; dissolution of DNAPL and diffusion of dissolved mass into the matrix; and potential DNAPL entry (assuming sufficient height of DNAPL) into the unfractured “matrix” of the rock.

DNAPL may extend further downdip than PZ-906DR, and dissolves and contributes to the plume of VOCs within the deep bedrock groundwater. Based on the extensive characterization of bedrock hydrogeology at the Site, the plume in bedrock migrates toward the south, and upward, as shown conceptually in Figure 2-3. Due to the complexity of DNAPL migration in fractured rock, delineation of mobile DNAPL by drilling cannot be considered definitive. Therefore, in lieu of direct delineation, modeling was performed to estimate the extent of the

TCE plume, assuming DNAPL may exist deeper downdip (Gefell et al. 2012). The modeling approach included generalized groundwater flow path assessment using MODFLOW and MODPATH, and solute-transport using CRAFLUSH. The fate of plumes in fractured bedrock depends strongly on the width, or "aperture" of bedrock fractures and the transfer of dissolved mass to the unfractured blocks of rock ("matrix") bounding the fractures (Lipson et al. 2005). The bedrock matrix has measured average porosity of 7.7%, and has a much higher storage capacity than the fracture system.

During the RI and RD/RA, bedrock fracture apertures were calculated for each depth interval where hydraulic conductivity was measured and the number of fractures was known based on core samples and/or downhole fracture logging. Figure 2-4 shows site-specific fracture aperture data versus depth below the top of rock. The small red dots indicate that the aperture of the specified intervals was below the indicated value, because the hydraulic conductivity value was below the measurement limit. The SRSNE data show decreasing fracture aperture with increasing depth. This finding is consistent with data reported for sandstone and shale (Snow 1968) (also shown on Figure 2-4). With increasing depth, fracture apertures, groundwater velocities and potential VOC plume length decrease.

Based on the modeling results, two additional well clusters (1002 and 1003) were installed to monitor VOC concentrations along simulated flow path downgradient (southward) from the potential locations of DNAPL within the deep bedrock. VOCs were detected at these wells, suggesting that some DNAPL may extend structurally further downdip than the elevation of well PZ-906DR. However, all of the wells with VOCs above drinking water standards, including deep bedrock wells MW-1002DR and MW-1003DR, are within the simulated capture zone of the HCTS (Figure 2-5). In addition, all of the monitoring wells downgradient of the capture zone boundary meet drinking water standards for VOCs. These factors indicate that the HCTS hydraulically controls the VOC plume above drinking water standards.

The primary risk pathway for the VOC plume associated with DNAPL in the deep bedrock east of the Quinnipiac River is bedrock groundwater ingestion. Completion of this potential risk pathway is extremely unlikely considering the following factors:

- Public water supply is available throughout the study area
- A local ordinance forbids the drilling of water wells for potable purposes where public water is available
- ELURs will be obtained for properties over the plume (Figure 2-6)
- If the plume extends east of Queen Street, that portion of the plume would be several hundred feet bgs, of very limited extent in the direction parallel to groundwater flow, and below a cemetery (Figure 2-6)

- Accessing the bedrock TCE plume would require drilling a water supply well through a thick sequence of highly productive sand and gravel, and extending the borehole deep into relatively impermeable bedrock

- Groundwater sampling results consistently show stable or decreasing VOC plume concentrations

- The plume is controlled by the HCTS

Based on these considerations, extent of down-dip DNAPL has been evaluated and the extent of VOCs in bedrock groundwater has been delineated. Further information regarding VOC plume boundaries is presented in Section 4.

2.3 Updated Bedrock NAPL Zone Boundaries

Based on the elevated concentrations of VOCs in deep bedrock well MW-907DR near the north edge of the Town Well Field Property, additional modeling was performed to estimate the distance of that well from the bedrock DNAPL zone. The results suggested that the bedrock DNAPL zone in the area directly north of that well may extend to the approximate northern property line of the Town Well Field Property. Using this information, the concentrations of VOCs at wells PZ-903DR and MW-1002DR, and the occurrence of DNAPL at PZ-906DR, the estimated bedrock DNAPL zone boundaries have been updated as shown on Figure 2-5.

2.4 Distribution of VOC Mass

Between 1957 and 1991, SRSNE processed over 41 million gallons of waste solvents, fuels, paints, and similar liquid materials. A small fraction of these materials is believed to have entered the subsurface in the form of NAPLs. However, the specific timing, locations, durations and volumes of such releases are unknown. NAPLs that entered the subsurface migrated within the overburden and bedrock, and underwent partial dissolution to produce the observed VOC plumes. After the last occurrence of NAPL entry into the subsurface, the total mass of VOCs has decreased because of continued NAPL dissolution and destruction of VOCs in the aqueous phase by biotic and abiotic degradation processes.

The initial VOC mass within the subsurface at the site would be difficult to estimate, because of the complexities noted above. The RI and FS reports presented estimates regarding the mass of VOCs at the site based on the data available at the time of each report. To support this CSM update, additional VOC mass calculations were performed, as summarized on Figures 2-7 and 2-8, and detailed in Attachment A. In addition, Figures 2-7 and 2-8 illustrate the primary mechanisms by which VOC mass has been depleted since the RI, and the estimated quantities of VOC mass removal. The VOC mass estimates presented herein

illustrate that the total mass of VOCs in the subsurface has decreased considerably since the time of the RI, particularly during thermal remediation in 2014 and 2014. The following subsections describe changes in TVOC mass, and current estimates of remaining VOC mass. In general, the mass numbers discussed below are rounded to two significant digits.

2.4.1 In-Situ Thermal Remediation Zone

Thermal Mass Removal

Thermal remediation removed approximately 220,000 kg of VOCs between May 2014 and February 2015. The majority of that VOC mass, 210,000 kg, is estimated to have originated from NAPL. The remainder, approximately 8,800 kg of VOCs, is from dissolved and sorbed phases within the saturated and unsaturated portions of the thermal treatment zone (Figure 2-7).

NAPL

Historical estimates of VOC mass distribution concluded that the majority of the VOC mass at the Site was in the form of NAPL in the overburden in the vicinity of the former Operations Area. Based on the changes in VOC mass measured and estimated since the RI, the original mass of NAPL in the overburden at the time of the RI (approximately 1996-1997) was back-calculated as approximately 490,000 kg (Figure 2-7). This estimate is within the range of estimates developed during the RI and FS. As indicated above, an estimated 210,000 kg of NAPL was removed during thermal treatment. In addition, as discussed below, a substantial fraction of the NAPL mass that was present at the time of the RI is interpreted as having dissolved and degraded within the capture zone of the NTCRA 1 system.

All of the locations with visible NAPL during the 2003 NAPL Delineation Pilot Test were within the zone that has been remediated using thermal treatment. Following thermal treatment, confirmatory soil samples had an average TVOC concentration approximately two orders of magnitude below the cleanup levels that the USEPA established to achieve complete NAPL removal. Thus, it is interpreted that ISTR has eliminated NAPL from the Overburden NAPL Zone.

Dissolved and Sorbed Mass Stored in Saturated Zone

The dissolved and sorbed mass of VOCs also declined within the thermal treatment zone. The pre-thermal, average dissolved TVOC concentration at the seven ISTR-series monitoring wells was 175 milligrams per liter (mg/L) (March 2014). Based on the initial saturated volume of the Overburden NAPL Area (32,000 cubic yards), and the average soil porosity of 27.5%, the dissolved TVOC mass in the Overburden NAPL Area before thermal treatment was approximately 1,176 kg. The RI estimated that the ratio of sorbed to dissolved TVOC mass in the overburden, assuming chemical equilibrium, is approximately 4.9. Therefore, the initial

sorbed TVOC mass in the Overburden NAPL Area was approximately 5,761 kg, producing a total dissolved and sorbed VOC mass of approximately 6,900 kg prior to thermal treatment.

Following thermal treatment, average dissolved TVOC concentration at the seven ISTR-series monitoring wells was 4.9 mg/L (February 2015). Based on the same principles, the combined dissolved and sorbed VOC mass Overburden NAPL Area after thermal treatment was approximately 190 kg. Therefore, the TVOC mass reduction in the dissolved and sorbed phases due to thermal treatment was approximately 6,700 kg.

Dissolved and Sorbed Mass Stored in Unsaturated Zone

It is assumed that the vadose zone VOC mass reduction was similar to that in the saturated zone above. To prepare these mass calculations, we estimate that the TVOC mass in the unsaturated zone within the thermal treatment area was reduced by approximately 95% as a result of thermal treatment, from 2,200 (estimated during the RI) to 110 kg.

NAPL Removal from Wells

As summarized in Section 2.1, approximately 11 kg of NAPL has historically been removed from overburden wells within the thermal treatment zone since 1996. This mass is based on a total of 2.5 gallons of NAPL removed from wells MWD-601, P-1B, P-2A, P-2B, and P-4B, with an estimated average NAPL density of 1.15 g/mL

2.4.2 NTCRA 1 Containment Area

Outside of the thermal treatment zone, the majority of the VOC mass in the Overburden Groundwater category is in the NTCRA 1 Containment Area, where the typical TVOC concentrations have been in the tens of mg/L. Reductions in TVOC mass in the NTCRA 1 Containment Area are attributable to the mass extracted by the NTCRA 1 recovery wells and VOC degradation.

NTCRA 1 Extraction Wells

Based on HCTS operating records, approximately 6,700 kg of dissolved VOCs were removed by the NTCRA 1 extraction wells between 1996 and 2014. After the startup of the NTCRA 2 wells in 1998, the NTCRA 2 wells also contributed a small fraction of the TVOC mass pumped to the HCTS. However, the TVOC concentration pumped by the NTCRA 2 wells is approximately 3 orders of magnitude lower than that from the NTRCA 1 wells. Thus, the cumulative mass removal for the HCTS continues to be dominated by the mass pumped by the NTCRA 1 wells.

Dissolved and Sorbed Mass Stored within Saturated Zone

Concentrations of VOCs in the combined, untreated water pumped by the NTCRA 1 wells are considered representative of the average dissolved TVOC concentration within the NTCRA 1 Containment Area, upgradient of the NTCRA 1 sheet pile wall (shown as "downgradient hydraulic barrier" on Figure 1-5). The average pumped TVOC concentrations have declined from an approximately 25 mg/L in 1996-1997 to 11 mg/L in 2014. Based on the approximate saturated volume of the NTCRA 1 Containment Area (46,000 cubic yards), and the average soil porosity of 27.5%, the dissolved TVOC mass in this area in 1996-1997 was approximately 240 kg. Using the same ratio of sorbed to dissolved mass discussed above (4.9), the sorbed TVOC mass in this area was approximately 1,200 kg, producing a total dissolved and sorbed VOC mass of approximately 1,400 kg in 1996. Based on the average TVOC concentration of approximately 11 mg/L pumped by the NTCRA 1 wells in 2014, the total combined VOC mass in the NTCRA 1 Containment Area is estimated as 650 kg, indicating a decrease of approximately 790 kg since 1996.

2.4.3 VOC Degradation in the Combined Thermal Treatment Zone and NTCRA 1 Containment Area

Degradation

The historical source materials for the VOCs within the capture zone of the NTCRA 1 extraction wells were NAPLs. As VOCs have dissolved from the NAPLs into the surrounding groundwater, they have undergone biodegradation and abiotic reactions that transformed them into innocuous by-products. The combination of chlorinated VOCs (CVOCs) and non-chlorinated VOCs (e.g., ketones and aromatic hydrocarbons) promotes robust degradation of both groups of VOCs. The overall degradation of VOCs within the capture zone of the NTCRA 1 wells is well demonstrated by the overall decline in VOC mass pumped by the NTCRA 1 system. In addition, the rate of VOC degradation was estimated to be considerably higher than the rate of VOC removal by the NTCRA 1 extraction wells, as discussed below.

CVOCs

During the FS, Geosyntec Consultants (Geosyntec) compared the chloride concentrations in untreated water pumped by the NTCRA 1 system to those at background monitoring wells. The higher concentrations of chloride detected in NTCRA 1 pumped water was attributed to degradation of CVOCs in the groundwater within the capture zone of the NTCRA 1 extraction wells. This area includes the portions of the Operations Area that are within the thermal treatment zone and also the NTCRA 1 Containment Area upgradient of the sheet pile wall. Based on mass-balance calculations, Geosyntec estimated that the rate of chlorinated ethene degradation, in TCE equivalents, was approximately 30 to 72 times faster than the rate of CVOC mass removal achieved by the NTCRA 1 extraction wells (BBL and USEPA 2005). Specifically, in the first 8 years of NTCRA 1 system operation (between July 1995 and June

2003), the NTCRA 1 mass removal rate for TCE, cis-1,2-dichloroethene (cDCE) and vinyl chloride (VC) was 260 kg/year. Based on the mass of chloride removed by the NTCRA 1 wells during that same period, it was estimated that the degradation of these compounds within the NTCRA 1 capture zone was 7,700 to 19,000 kg/yr. Thus, within the capture zone of the NTCRA 1 extraction wells, a much higher fraction of the dissolved CVOC mass has been degraded than the fraction that has reached the NTCRA 1 extraction wells.

Non-Chlorinated VOCs

The degradation rates of the non-chlorinated VOCs have not been explicitly measured. However, based on lab analysis of four overburden NAPL samples, the VOC mass in the overburden NAPL consisted of approximately 43% non-chlorinated VOCs and 57% chlorinated VOCs, on average. Based on these data and the molecular weights of the compounds, the initial effective solubility of the non-chlorinated VOCs detected in the NAPL was approximately one-half of that for the CVOCs. Over time, the effective solubility of the non-chlorinated compounds has increased as the CVOCs were preferentially dissolved. Nevertheless, the concentrations of the non-chlorinated VOCs in pumped NTCRA 1 water have continued to decline since 1996; therefore the non-chlorinated hydrocarbons also are undergoing robust degradation.

Total VOCs

For the purposes of these estimates, we assume that the total combined VOC mass degradation rate within the Operations Area and NTCRA 1 containment area – including CVOCs and non-chlorinated VOCs – is approximately 40 times faster than the TVOC mass removal by the NTCRA 1 wells. This estimate may be slightly conservative because it is within the lower half of the range calculated for CVOCs alone during the FS.

The TVOC mass removed by the NTCRA 1 wells between 1996 and 2014 was approximately 6,700 kg. Based on the rate discussed above, it is estimated that the TVOC mass removed by degradation within the combined thermal treatment zone and the NTCRA 1 Containment Area in the 18-year period from 1996 and 2014 was approximately 270,000 kg. Nearly all of this mass is interpreted as having come from the continuous dissolution (“mining”) of NAPL mass. Combined with the estimated 210,000 kg of NAPL VOCs removed by the thermal remedy, the estimated degraded mass accounts for most of the initial estimated VOC mass in the form of NAPL, 490,000 kg (Section 2.4.1). A similar calculation using the NTCRA 1 TVOC mass extracted between 2003 and the present suggests that the NAPL mass at the time of the NAPL Delineation Pilot Test was approximately 330,000 kg.

The estimated average degradation rate was 15,000 kilograms per year (kg/year) over the past 18 years. For comparison, the thermal remedy removed approximately 220,000 kg of VOCs in 9 months, equal to a VOC mass removal rate of 290,000 kg/year. Given that the NAPL has now been essentially eliminated from the overburden, future estimates of VOC

degradation will no longer have to consider the “mining” of VOCs from NAPL as a significant source of degraded VOC mass.

The calculation of the VOC mass degraded since 1996-1997 was performed to support the back-calculation of the total VOC mass that existed at the site during the time of the RI. The amount of VOC mass degraded discussed above is a rough approximation. In contrast, the current VOC mass at the site is considered better-constrained because it was calculated based on: measured VOC concentrations at monitoring wells; observed VOC concentration trends; measured site-specific partitioning parameters; and NAPL bulk retention in bedrock calculated based on measured, site-specific bedrock fracture characteristics and post-RI literature. Thus, although the backward-looking, historical mass estimate is less certain, the current mass estimates are considered better known and better constrained by measured data.

2.4.4 Overburden VOC Plume Downgradient of NTCRA 1 Sheet-Pile Wall

VOC attenuation in the dilute portion of the overburden VOC plume, downgradient of the NTCRA 1 sheet pile wall, has been well documented, with average bulk attenuation half-lives of between 2 and 8 years for TVOCs since the mid-1990s (Table 2-1). During the RI, it was estimated that the total dissolved and sorbed mass within all overburden zones was approximately 11,200 kg. This total included the mass within the former Operations Area and NTCRA 1 Containment Area, as well as the plume downgradient of the NTCRA 1 sheet pile wall. As discussed above, the estimated initial dissolved and sorbed VOC mass within the NTCRA 1 area in 1996 was approximately 1,400 kg. In addition, within the thermal treatment zone, the pre-thermal-treatment dissolved and sorbed VOC mass was approximately 6,900 kg. Given the close proximity between the groundwater and NAPL within the thermal treatment zone, it is inferred that the TVOC concentrations in this area remained approximately constant (near the effective solubility) between 1996 and the beginning of thermal treatment. Subtracting these numbers from 11,200 kg, we estimate that the total dissolved and sorbed VOC mass in the downgradient overburden plume in 1996 was approximately 2,800 kg.

As summarized on Table 2-1, TVOC attenuation half lives in the downgradient overburden plume range from approximately 2 to 8 years. The RI estimated that approximately 90% of the total dissolved and sorbed VOC mass in the overburden was in the middle and deep overburden. In addition, the extent of the shallow overburden regulatory plume is relatively limited compared to the middle and deep overburden plumes. Thus, it is inferred that the majority of the VOC degradation within the dilute VOC plume is occurring in the middle and deep overburden. The average VOC attenuation half-life in the middle and deep overburden is approximately 4.3 years. Given the 18-year period between 1996 and 2014, the 2,800 kg of total dissolved and sorbed VOC mass in 1996 is estimated to have decreased by 2,700 kg to a current total of 160 kg. This mass reduction is attributed to degradation. The TVOC mass pumped by the NTCRA 2 extraction wells during this period was approximately 20 kg.

2.4.5 Bedrock

Dissolved and Sorbed VOC Mass

VOC attenuation has also been observed within the bedrock groundwater, with an average bulk attenuation half-life of approximately 5.8 years in the shallow bedrock and 17 years in the deep bedrock (Table 2-1). During the RI, it was estimated that the total dissolved and sorbed VOC mass in the bedrock was approximately equally split between these two zones, with a total of 39,000 kg. Based on these half-lives and the 18-year period between 1996 and 2014, the total estimated mass remaining in the shallow and deep bedrock is estimated as 2,300 kg and 9,400 kg, respectively, for a total of approximately 12,000 kg. The decrease in total dissolved and sorbed VOC mass in the bedrock, 27,000 kg, is attributed to degradation.

NAPL Removal from Wells

As summarized in Section 2.1, approximately 78 kg of NAPL has historically been removed from bedrock wells. This mass is based on a total of 17.8 gallons of NAPL removed from bedrock wells since 1996, with an estimated average NAPL density of 1.15 g/mL.

NAPL

As shown on Figure 2-5, the plan-view area of the updated probable NAPL zone in bedrock is approximately 500,000 square feet (11.5 acres). Based on MVS modeling and the locations where NAPL has been observed in bedrock wells, the vertical extent of this zone is estimated as 60 feet, and oriented parallel to the average bedrock fracture dip (Figure 2-2). Thus, the total volume (Vtot) of the bedrock DNAPL zone is estimated as 30,000,000 cubic feet.

The DNAPL volume within the bedrock (V_{Db}) was estimated as:

$$V_{Db} = V_{tot}\ R_b$$

where: V_{tot} is the total volume of the bedrock DNAPL zone and R_b is the DNAPL bulk retention capacity within the bedrock DNAPL zone.

The bulk retention capacity, R_b, can be calculated as:

$$R_b = \Theta_{fx}\ R_{fx}\ F_{\%}$$

where: Θ_{fx} is the fracture porosity, R_{fx} is the retention capacity of a single fracture contacted by DNAPL, and $F_{\%}$ is the estimated percentage of the fracture porosity that has been contacted by DNAPL.

The fracture porosity is the proportion of the total bedrock volume occupied by fractures, and can be estimated as mean fracture aperture divided by mean fracture spacing. Based on the fracture data collected during the RI and from three (900-series) deep bedrock boreholes in 2010, the mean fracture aperture and spacing are 0.0097 centimeters (cm) and 155 cm, respectively, producing a fracture porosity of $6.3x10^{-5}$. Laboratory research indicates that the retention capacity of a single bedrock fracture with an approximately 20° dip following DNAPL entry and drainage is approximately 7% to 17% (Longino and Kueper 1999). A single-fracture retention capacity value of 12% was assumed in these calculations. The term $F_{\%}$ accounts for the fact that, at the field scale, not all of the fracture porosity within the probable DNAPL zone was invaded by DNAPL. Given the complex and variable nature of bedrock fracture network geometry, aperture, and surface roughness, it is estimated that DNAPL may have contacted only 10% to 30% of the total fracture porosity within the probable DNAPL zone in the bedrock. Assuming the DNAPL contacted 20% of the fracture volume, the resulting bulk retention capacity is approximately 1.5×10^{-6} (i.e., 1.5×10^{-4} %).

Based on the total volume of the probable DNAPL zone in bedrock and calculated bulk retention capacity, the DNAPL volume within the bedrock is estimated as 1,300 liters; assuming an average DNAPL density of approximately 1.2 kilograms per liter (kg/L), this equates to 1,500 kg. This estimate is lower than a preliminary estimate presented in the RI, which did not account for the fact that DNAPL only contacts a fraction of the total fracture porosity. In addition, the RI estimate did not account for subsequently published measurements regarding single-fracture NAPL retention as a function of fracture dip (Longino and Kueper 1999).

NAPL dissolution within the bedrock has produced the plumes of VOCs observed in the shallow and deep bedrock. The estimated total mass of VOCs in the form of NAPL in the bedrock is lower than the mass of dissolved and sorbed VOCs within the bedrock. In addition, NAPL is still observed at selected bedrock wells. These facts suggest that bedrock NAPL was replenished during the development of the bedrock VOC plume, presumably by downward NAPL migration from the Overburden NAPL Area. This inference seems reasonable based on the fact that the estimated NAPL mass in the overburden at the time of the RI was 490,000 kg (as calculated herein; see Section 2.4.1, above), and the Overburden NAPL Area was directly above the probable NAPL zone in bedrock. To be conservative, it is assumed that the mass of NAPL in the bedrock has remained approximately constant between the RI (1996) and the beginning of the thermal remedy. However, thermal treatment has now removed the “reservoir” of NAPL from the overburden. Therefore, it is expected that the VOC mass within the bedrock will deplete by ongoing NAPL dissolution, reverse diffusion and degradation in the dissolved phase.

2.4.6 Estimated Remaining VOC Mass

As detailed above, and summarized below, approximately 525,000 kg of TVOC mass has been removed and degraded in the subsurface between the RI (1996) and the present. The remaining TVOC mass in the overburden and bedrock are 1,100 kg and 14,000 kg, respectively. Thus, it is estimated that the remaining mass is approximately 3% of the VOC mass that was present in 1996. Approximately 70% of the remaining VOC mass is sequestered over 100 feet bgs in the deep bedrock, which has been characterized by relatively small fracture apertures and low permeability. As detailed in Section 4, VOCs in all five hydrostratigraphic zones are attenuating, as expected in accordance with the MNA remedy selected in the ROD.

Summary of VOC Mass Reduction Over Time		
Overburden VOC Mass (kg)	Initial	Current
Thermal Treatment Zone		
Unsaturated Zone	2,200	110
Dissolved and Sorbed in Saturated Zone	6,900	190
NAPL	490,000	-
NTCRA 1 Area		
Dissolved and Sorbed in Saturated Zone	1,400	650
Downgradient of NTCRA 1 Sheet Pile Wall		
	2,800	160
Overburden Total	**500,000**	**1,100**
	Mass decrease	99.8%
Bedrock VOC Mass (Kg)	Initial	Current
Dissolved and Sorbed	39,000	12,000
NAPL	1,500	1,500
Bedrock Total	**41,000**	**14,000**
	Mass decrease	66%
OVERALL TOTAL	**540,000**	**15,000**
	Mass decrease	97%

3. HCTS Status

3.1 Operating History

The HCTS includes 10 groundwater extraction wells within the NTCRA 1 Containment Area and three downgradient groundwater extraction wells that were installed, operated and monitored as part of NTCRA 2. In addition, a fourth extraction well (RW-15) has recently been installed adjacent to the NTCRA 2 wells (Figure 1-2). In combination, the NTCRA 1- and NTCRA 2-area extraction wells are all components of the HCTS. For clarity, they are still referred to as NTCRA 1 and NTCRA 2 extraction wells in this document to differentiate the extraction locations and operational histories.

The NTCRA 1 containment system was installed and began operating in 1995. The system includes an approximately 700-foot-long sheet pile wall that extends through the overburden to the top of bedrock, and overburden groundwater extraction wells just west of the sheet pile wall (Figure 1-5). The purpose for the NTCRA 1 system was to physically and hydraulically control the highest concentrations of dissolved VOCs in overburden groundwater migrating downgradient from the former SRSNE Operations Area. The original NTCRA 1 system had twelve overburden extraction wells. Two wells (RW-5 and RW-6) were abandoned in 2011 during preparation for thermal treatment system construction. Groundwater extraction rates from the NTCRA 1 wells since 1995 have typically been in the range of 5 to 15 gallons per minute (gpm), combined. Groundwater pumped from the wells is treated using metals pre-treatment, ultraviolet oxidation, and carbon polish, and then discharged to the Quinnipiac River. In addition to hydraulically controlling overburden groundwater, the NTCRA 1 overburden extraction wells produce a hydraulic response in the shallow bedrock, indicating that the overburden and shallow bedrock are hydraulically connected in this area. Concentrations of dissolved VOCs extracted by the NTCRA 1 system, and consequently its mass removal rate, have declined from 1995 to the present. The overall decrease indicates source zone attenuation due to continued dissolution of NAPL and degradation in the dissolved phase.

The NTCRA 2 system was installed to hydraulically control bedrock groundwater downgradient of the interpreted NAPL zones in overburden and bedrock. A pumping test of well RW-13 during the FS indicated that this overburden well – which is screened from the middle overburden to the top of bedrock – has a significant hydraulic influence in the shallow bedrock and even the deep bedrock. Because the overburden and bedrock are hydraulically connected in the Town Well Field Property, and the natural groundwater flow direction is upward from bedrock to overburden in that area, the NTCRA 2 system hydraulically controls overburden and bedrock groundwater.

A summary of the NTCRA 2 extraction wells, which are shown on Figure 1-2, is as follows.

- RW-13 began operation in July 1999 – it extracts groundwater from the middle and deep overburden with a screened interval from 35 to 75 feet bgs, and typically operates between 10 and 25 gpm.

- RW-14 began operation in October 2007 – it extracts groundwater from the middle and deep overburden with a screened interval from 31 to 71 feet bgs, and typically operates between 10 and 25 gpm.

- RW-1R began operation in September 2001 – it extracts groundwater from the shallow and deep bedrock with an open-bedrock interval from 82 to 271 feet bgs. In spite of its long open interval, well RW-1R has historically produced approximately 0.1 gpm or less.

- RW-15 was installed in October 2014 – it will also extract groundwater from the middle and deep overburden, between 30 and 72 feet bgs; initial yield tests suggest it can sustain at least 40 gpm.

The recent addition of well RW-15 provides additional pumping capacity and is expected to allow two of the three overburden NTCRA 2 extraction wells to operate continuously, even when the third well is undergoing maintenance. Concentrations of VOCs pumped by the NTCRA 2 wells have declined steadily in recent years, similar to TVOC concentration trends observed at surrounding monitoring wells (Section 4). As of July 2014, 48 of the previous 50 monthly influent samples met drinking water standards for VOCs. The only two exceptions were a detection of 6 micrograms per liter (µg/L) of TCE in 2010 and a detection of 7 µg/L of VC in 2014.

Groundwater pumped from the NTCRA 2 wells is also treated at the UV-OX treatment system that was constructed as part of NTCRA 1. With the exception of sporadic power outages and system maintenance, the HCTS operates nearly continuously. Weston Solutions, which operates the system, estimates that the HCTS operates over 99% of the time. The average combined pumping rates in 2013 and 2014 were approximately 5 gpm from the NTCRA 1 extraction wells, and 31 gpm from the NTCRA 2 extraction wells.

3.2 Groundwater Elevation Contours

The latest round of comprehensive groundwater elevation measurements was collected in June 2014. Groundwater elevation contours maps for the five hydrostratigraphic zones are presented on Figures 3-1 through 3-5. Figures 3-6 and 3-7 show cross sections with hydraulic head contours and the vertical and lateral extent of the regulatory VOC plume.

The overall pattern of hydraulic gradients indicates groundwater flow toward the Quinnipiac River from the east and the west, and southward flow within the Quinnipiac River Valley in all five hydrostratigraphic zones. In the NTCRA 1 Containment Area, potentiometric depressions

are observed in the shallow, middle, and deep overburden, and also within the shallow bedrock. In the Town Well Field Property, the NTCRA 2 extraction wells produce a potentiometric depression within the middle and deep overburden, and the middle and deep bedrock. Water level data in the area south of the off-site extraction wells indicate a "stagnation zone" near the southern CL&P easement boundary. This observation is consistent with previous data sets, and indicates that the HCTS capture zone is relatively consistent, and extends to the general area near the southern end of the CL&P easement in the overburden and bedrock.

3.3 Simulated Capture Zone

Based on simulations using a calibrated regional MODFLOW groundwater flow model and MODPATH (particle tracking code), the monitoring wells with SRSNE-related VOCs detected above drinking water standards are within the capture zone established by the HCTS (Figure 3-8). As shown on Figure 3-8, groundwater flow in the bedrock east of the Quinnipiac River migrates toward the south-southeast beneath the river, approximately parallel to the strike of bedrock fractures, and rises into the overburden where it is captured by the HCTS. Colors indicate the relative depth of modeled particle tracks. The simulated capture zone boundary is also shown; its southern extent compares closely with the hydraulic head data discussed above, which indicate a stagnation zone near the southern CL&P easement boundary.

3.4 Groundwater Quality Outside of HCTS Capture Zone

An extensive network of overburden and bedrock monitoring wells, including deep bedrock wells, has demonstrated that, when the NTCRA 2 wells maintain a combined pumping rate of at least 25 gpm, the VOC plume above drinking water standards does not extend south the CL&P power line easement shown on Figure 1-2. A rare exception occurred in 2012, during a period when combined pumping rates had dropped below 25 gpm due to fouling within the wells and piping.

In June and August 2012, low concentrations of benzene (1.1 µg/L), slightly above the Connecticut drinking water standard of 1 µg/L, were detected at deep bedrock groundwater monitoring well MW-707DR. MW-707DR is located south of the CL&P power-line easement approximately 425 feet downgradient (south) of recovery well RW-1R. Benzene had previously been detected sporadically at lower concentrations in MW-707DR since 2010, but the June and August 2012 data were the first detections of any VOC above drinking water standards south of the CL&P easement since 2001.

It was hypothesized that the slight increase in benzene concentrations at well MW-707DR in 2012 indicated a temporary reduction in the HCTS capture zone extent. The combined extraction rates of the former NTCRA 2 wells in spring and summer 2012 were below the 25 gpm rate that was used as a practical goal to maintain effective plume capture. In response to those observations, overburden extraction wells RW-13 and RW-14 were redeveloped in

October 2012, and a new extraction rate goal of 30 gpm was set for reliable plume capture. As noted above, the average total extraction rate from the former NTCRA 2 wells in 2013 and 2014 was 31 gpm. Also, in October and November 2012, the open bedrock borehole of extraction well RW-1R was drilled deeper – from 172 to 271 feet total depth – in an attempt to intersect deeper water bearing fractures and improve its yield and effectiveness. Its pumping equipment was then modified to increase the available drawdown. Subsequent hydraulic testing indicated that, in spite of its still low yield (approximately 0.12 gpm), the modified well RW-1R is hydraulically well-connected to deep bedrock monitoring wells MW-704DR, MW-1002DR and MW-1003DR. These deep bedrock wells have indicated VOCs above drinking water standards and they are within the interpreted capture zone of the HCTS.

Following the activities described above and a lag period of several months, the benzene concentration at well MW-707DR gradually declined again. All six samples collected between July 2013 and December 2014 have been at or below the drinking water standard.

4. VOC and Metals Plume Status and MNA Summary

Data collected during nearly 20 years of groundwater monitoring since the RI indicate declining concentrations of constituents of concern (COCs), validating the ROD selection of MNA as the remedial measure for COCs in groundwater at the Site. The COCs at the Site are primarily VOCs, but also 1,4-dioxane and metals. The efficiency of natural attenuation for remediation of COCs in site groundwater is monitored via the MNA program using techniques set forth in the MNA Plan, including:

- Defining changes in the VOC regulatory plume boundaries, including exceedance of USEPA's Maximum Contaminant Levels (MCLs) and Connecticut Class GA Groundwater Protection Criteria (GWPC), as well as exceedance of Interim Cleanup Levels (ICLs).
- Evaluating COC concentration trends with time.
- Assessing changes in the distribution of COCs that can serve as electron donors to support degradation of CVOCs, especially ketones and aromatic compounds.
- Monitoring of groundwater redox conditions continuously.

In addition, this report introduces results of a microbial population survey conducted to establish baseline conditions prior to completion of the thermal treatment remedy.

4.1 Current Extent of Regulatory Plumes

The 2014 comprehensive groundwater sampling event was conducted to satisfy the requirements of SOW Section IV.B.5.c (comprehensive sampling events across the entire plume for Five-Year Reviews). Groundwater samples were obtained from the following well groups and analyzed for the parameters specified below.

Well Group	Analytical Parameters
"C" Wells	VOCs 1,4-Dioxane TAL Metals
"R" Wells "N" Wells	VOCs 1,4-Dioxane TAL Metals MNA parameters
"M" Wells	TAL Metals (background) MNA parameters (background)
"B" Wells	TAL Metals (background)

The "C" wells are intended to be sampled during each of the comprehensive events (i.e., every five years). "R" wells are sampled routinely for VOCs (annually) and MNA parameters (every two years, or "biennially"). "N" wells are located between the RR ROW and the NTCRA 1 sheet pile wall (i.e., within the NTCRA 1 Containment Area) and are sampled for VOCs and MNA parameters at various frequencies throughout the remediation phase of the project. "M" wells are background wells that are sampled annually for Target Analyte List (TAL) Metals and biennially for MNA parameters, while the "B" wells are additional background wells that are sampled annually for TAL Metals only. Sampling frequencies for each well group were summarized in Table N-1 of the *Monitoring Well Network Evaluation and Groundwater Monitoring Program* (Work Plan; Attachment N to the Remedial Design Work Plan [RDWP]; ARCADIS 2010). In total, 129 monitoring wells were sampled as part of the 2014 monitoring event. The locations of these well groups are presented in annual MNA reports.

Groundwater VOC concentrations were compared against MCLs and GWPC, with the lower of the two criteria, which are the Applicable or Relevant and Appropriate Requirements (ARARs)-based "Action Levels" (ALs), used as the criterion for the comparison for each VOC; these generally represent drinking water standards.

4.1.1 VOC Plume Delineation and Concentration Trends with Time

Data from the 2014 comprehensive groundwater monitoring event were used to delineate the VOC plume in each of the five hydrostratigraphic units. Using the approach initially presented in the RI (BBL June 1998), groundwater VOC results were used to derive VOC regulatory exceedance ratios by dividing detected concentrations of VOCs by the ALs. An exceedance ratio value greater than 1.0 for a given COC indicates that the detected concentration exceeded the AL for that compound. Exceedance ratios less than 1.0 indicate that the detected VOC concentrations were less than the AL. The highest (and in some cases, the two highest) VOC exceedance ratio(s) for each well, and the specific compound associated with

each ratio, are summarized for each hydrostratigraphic unit on Figures 4-1 through 4-5. These regulatory exceedance ratios were used to delineate groundwater with VOCs above ALs in 2014, as shown by the light green contour lines on Figures 4-1 through 4-5. As demonstrated by Figures 4-1 through 4-5, concentrations of VOCs greater than ALs are contained within the capture zone of the HCTS.

Since the completion of the RI, VOC concentrations have generally declined throughout the plumes in all five hydrostratigraphic zones. VOCs detected in the water pumped by the NTCRA 2 extraction wells usually meet drinking water standards. Similarly, TVOC concentrations have declined with time at the adjacent MW-704 well cluster (Figure 4-6). TVOC concentrations at this well cluster (detailed below) have declined by more than an order of magnitude in all hydrostratigraphic units since monitoring began at this location in 1996, with the exception of MW-704S, where the TVOC concentration has been more variable but is currently less than 1 µg/L.

- MW-704S (shallow overburden) – TVOC concentrations decreased from a maximum of 91.48 µg/L in May 2010 to no VOCs detected in June 2014.

- MW-704M (middle overburden) – TVOC concentration decreased from 176 µg/L in December 1996 to 7.016 µg/L in June 2014. No constituent was reported above the AL in June 2014.

- MW-704D (deep overburden) – TVOC concentration decreased from 670 µg/L in December 1996 to 16.234 µg/L in June 2014. Tetrahydrofuran (THF) (4.88 J µg/L) was the only VOC detected at a concentration above AL (4.6 µg/L) in June 2014.

- MW-704R (shallow bedrock) – TVOC concentration decreased from 753 µg/L in December 1996 to 32.864 µg/L in June 2014. No constituent was reported above the AL in June 2014.

- MW-704DR (deep bedrock) – TVOC concentration decreased from 456 µg/L in December 1996 to 27.497 µg/L in June 2014. Benzene and chloroethane (CA) (2.59 and 17.3 µg/L, respectively) were the only constituents detected at concentrations above their respective ALs (1.0 and 12.1 µg/L, respectively).

The VOC concentration history at the MW-704 cluster, which is adjacent to the NTCRA 2 extraction wells, provides a synopsis of the general groundwater conditions within the downgradient plume, beyond the NTCRA 1 sheet pile wall. A more detailed assessment of VOC concentration trends and attenuation rates is provided below.

4.1.2 Total VOC Concentration Trends and Attenuation Rates

As described in detail in the 2014 MNA Report (ARCADIS 2014), groundwater TVOC concentrations trends at 21 monitoring locations have been periodically evaluated using trend analyses. Linear regression trend analysis results for TVOCs are summarized in Table 2-1.

The linear regression test estimates the slope and confidence level and quantifies how well the data correlate to the estimated trend line. Trend analyses were conducted with natural log (ln) normalized TVOC concentrations. A 90% confidence level, with a corresponding p-value less than or equal to 0.10, was used to determine statistical significance for the trend analyses. Linear regression trend results with p-values greater than 0.10 were not considered to be statistically significant; however, trend direction was noted in Table 2-1. The trend direction was defined as decreasing if TVOC concentrations decreased with time (negative slope), and increasing if TVOC concentrations increased with time (positive slope).

Results of the 2014 trend analyses indicate that most of the monitoring locations included in the trend analysis have statistically significant decreasing TVOC concentration trends (Table 2-1). Graphs of groundwater TVOC concentrations with time are provided in Figures 4-7 through 4-11. As shown on these figures, TVOC concentrations are generally declining or stable in all hydrostratigraphic zones.

Results from the linear regression analyses were used to estimate attenuation rates for TVOCs in groundwater at the Site (Table 2-1). Attenuation rates were calculated in accordance with the USEPA guidance document on determining first-order attenuation rate constants for MNA studies (USEPA 2002). Following this guidance, the ln of TVOC concentrations in groundwater versus time was plotted and a best-fit linear regression line was generated for TVOC concentrations over time. For monitoring locations where decreasing trends were observed, the slope of the best-fit line was used to estimate an attenuation rate. The slope of the linear regression lines provide estimates of the TVOC attenuation rate constant (k_{point}) in groundwater at the respective monitoring locations.

$$k_{point} = [slope\ of\ best\text{-}fit\ regression\ line]$$

The half-life ($t_{1/2}$) for TVOC concentrations in groundwater was estimated for each sampling location from the equation:

$$t_{1/2} = 0.693 / k_{point}$$

where: 0.693 is the negative of the ln of 0.5 (half of the starting TVOC concentration).

Estimated half-life values for TVOCs in groundwater range from 1.7 to 8.0 years (average 4.7 years) for overburden groundwater. In the bedrock, TVOC half-lives range from 2.4 to 27.7 years. However, using more recent TVOC concentrations for monitoring wells MW-706DR (since 2010) and MW-707DR (since 2004), the bedrock TVOC half-lives are less, ranging from 2.4 to 10.4 years, with an average of 7.0 years. These estimated half-life values for TVOC concentrations compare well with literature values of attenuation rates presented for individual compounds in Appendix H of the FS (BBL and USEPA 2005) and in USEPA (2011). These results demonstrate that overall, COC concentrations in groundwater are attenuating.

4.1.3 THF and 1,4-Dioxane

THF and 1,4-dioxane have been detected in site groundwater at concentrations above the ALs (4.6 µg/L and 20 µg/L, respectively). As shown on Figures 4-12 through 4-14, concentrations of THF and 1,4-dioxane in middle and deep overburden and shallow bedrock groundwater above ALs are within the capture zone of the HCTS. Similar figures for shallow overburden and deep bedrock groundwater were not developed due to the limited number of locations with detections above ALs – those are also within the HCTS capture zone.

Linear regression trend analyses were conducted for THF and 1,4-dioxane at select monitoring locations, as summarized in Table 4-1. The number of locations evaluated for 1,4-dioxane concentration trends was limited due to the limited number of monitoring events during which 1,4-dioxane concentrations have been measured.

Based on linear regression trend analysis results, concentrations of THF and 1,4-dioxane in groundwater are generally decreasing with time (Table 4-1). Half-life estimates for THF ranged from 1.5 to 19.6 years (average 4.4 years) and were similar for overburden and bedrock groundwater. Half-life estimates for 1,4-dioxane ranged from 6.0 to 41.6 years (average 16.1 years) for overburden groundwater. These results are generally consistent with estimated half-life values for TVOCs in site groundwater.

A qualitative assessment of THF and 1,4-dioxane concentrations was also conducted for locations with limited data sets, where concentrations were assigned a decreasing trend if the most recent sample was less than previous sample results (Figures 4-12 through 4-14). As shown, THF and 1,4-dioxane concentrations are generally declining in groundwater across the Site. THF and 1,4-dioxane concentration trends with time will be re-evaluated during the next Five-Year Review.

4.1.4 TAL Metals Plume Delineation

Groundwater concentrations of TAL metals during the June 2014 comprehensive groundwater monitoring event were compared against the ALs. ICLs have not yet been developed for metals in groundwater because they are a function of background concentrations, which are to

be established in the future based on background sampling performed through that time. TAL metals that were reported above ALs at one or more sampling locations include antimony (Sb), arsenic (As), barium (Ba), chromium (Cr), cobalt (Co), manganese (Mn) and vanadium (V).

Groundwater monitoring locations with TAL metals concentrations above ALs are shown for each of the five hydrostratigraphic units on Figures 17 through 21 of the 2014 MNA Report (ARCADIS 2014). Mn is the primary metal that exceeded MCLs or GWPC in groundwater. Total and dissolved Mn concentrations are generally similar, indicating that Mn is primarily present in the dissolved phase as divalent manganese [Mn(II)]. Exceedances for other metals are sporadic and are not indicative of a plume of elevated metals concentrations in groundwater.

As described in the 2014 MNA Report (ARCADIS 2014 in *de maximis, inc.* 2014), concentrations of metals in June 2014 were compared with historic groundwater metals concentrations. With the exception of Mn at locations within or in close proximity to the VOC Exceedance Plume in each of the five hydrostratigraphic units and Ba at well P-101B, elevated concentrations of metals detected historically in groundwater were generally not detected at concentrations above ALs in the 2014 groundwater samples (ARCADIS 2014). Historic groundwater samples were analyzed for total metals, and the elevated metals concentrations in those samples may have been caused by the inadvertent entrainment of aquifer solids in the groundwater sample during sample collection. As described in the *Field Sampling Plan* (FSP; Attachment B to the RD Project Operations Plan [POP]) (ARCADIS 2012), monitoring wells were inspected and redeveloped prior to the May–June 2010 comprehensive groundwater sampling event. Well redevelopment was conducted to remove sediments that may have accumulated in well casings. Therefore, concentrations of metals in groundwater samples collected since 2010 likely are more representative of true groundwater metals concentrations than historic (i.e., pre-2010) groundwater metals concentrations. As described in the 2014 MNA Report, concentrations of Mn above the AL are likely related to the reducing groundwater conditions present within the VOC Exceedance Plume.

4.2 Distribution of VOCs in NAPL and Groundwater

An assessment of the distribution of select VOCs in NAPL and groundwater samples was conducted as part of the 2010 comprehensive MNA report to gain insight into how VOC distributions in NAPL and site groundwater varied by location and with time. This assessment was repeated for the 2014 MNA Report based on VOC results from the 2014 comprehensive groundwater monitoring event. VOCs evaluated in the assessment included:

- Chlorinated ethenes (tetrachloroethene [PCE], TCE, cDCE, 1,1-dichloroethene [1,1-DCE], and VC)

- Chlorinated ethanes (1,1,1-trichloroethane [TCA], 1,1-dichloroethane [1,1-DCA], and CA)

- Ketones (2-butanone [MEK], 4-methyl-2-pentanone [MIBK], and acetone)
- Toluene, ethylbenzene, and xylenes (TEX)
- Methylene chloride, styrene, THF, and 1,4-dioxane

Data used to assess the distribution of VOCs in NAPL, and in groundwater in close proximity to NAPL, were presented in the comprehensive 2010 MNA Report (ARCADIS 2010) and are provided in Attachment B. NAPL samples consisted primarily of PCE, TCE, TCA, TEX, methylene chloride, and styrene, with lesser contributions from cDCE, 1,1-DCE, and 1,1-DCA. Ketones generally were not detected in NAPL samples and 1,4-dioxane was not analyzed. Detected groundwater constituents are generally consistent with NAPL constituents, with the exception of ketones. The general absence of detectable ketones in the NAPL samples may relate to the elevated detection levels associated with the NAPL samples (due to the dilutions required to quantify those COCs present at higher concentrations). Ketones may also be formed in situ during microbial degradation (fermentation) of COCs.

Molar groundwater VOC concentration plots are presented by approximate locations relative to the NTCRA 1 area and by depth interval for 2014 groundwater VOC results (Attachment C) and with time for select locations and monitoring periods (Attachment D). ALs for the individual compounds are also shown. In general, VOC concentrations in groundwater were greatest in the NTCRA 1 area for the three overburden depth intervals and shallow bedrock with consistently decreasing primary (parent) constituent (e.g., TCE, TCA, ketones, and TEX) concentrations and increasing concentrations of secondary (degradation product) compounds (e.g., c-DCE, 1,1-DCA, 1,1-DCE, VC, and CA) relative to parent compounds observed in directions downgradient from the NTCRA 1 area. For deep bedrock groundwater, higher VOC concentrations were observed in the northern portion of the HCTS capture zone area, where DNAPL has been historically observed. Similar to overburden and shallow bedrock groundwater, concentrations of parent constituents in the deep bedrock decrease in the downgradient direction (southward) while concentrations of secondary compounds increase relative to the parent compounds. With increasing distance downgradient, concentrations of primary and secondary compounds decrease or compounds are not detected. These results clearly demonstrate that degradation of the parent and secondary compounds is occurring in site groundwater.

Groundwater molar VOC concentration plots for select groundwater monitoring locations with samples collected during multiple sampling events illustrate that most locations have declining concentration trends for most or all constituents. Shifts in the relative distribution of CVOCs towards greater proportions of daughter product compounds to parent compounds demonstrate ongoing degradation of CVOCs in site groundwater with time (Attachment D).

In summary, molar concentration plots of select CVOCs provide a means for readily comparing the distribution of COC concentrations in site groundwater with distance from the source area, as well as with depth and with time at discrete locations. Molar concentration plots will be updated as part of the next five-year comprehensive groundwater monitoring event in 2019.

4.3 Electron Donor Supply

Changes in the composition and availability of electron donors with time may affect the efficiency and sustainability of natural attenuation. As electron donors (e.g., ketones, aromatic compounds, and alcohols) are consumed, the efficiency of natural attenuation may decline. As noted in the 2010 MNA Report (ARCADIS 2010), alcohols are currently only minimally detected in site groundwater. However, electron donors including ketones and aromatic compounds are still present in site groundwater. Figures 4-15 through 4-19 show the distribution of total halogenated VOCs (e.g., PCE, TCE, TCA) and total non-halogenated VOCs (including aromatics and ketones) concentrations in site groundwater. Concentrations of total halogenated VOCs tend to be higher than concentrations of total non-halogenated VOCs, especially towards the leading edge of the VOC plume. However, as demonstrated by decreasing TVOC concentration trends and shifts towards daughter products, natural attenuation of all VOCs is occurring throughout the VOC plume.

As concentrations of the readily available electron donors decline, other electron donor sources should be available to support continued natural attenuation of COCs in site groundwater. Other potential electron donor sources include natural organic matter in the aquifer matrix, natural organic matter in groundwater, as well as recycling of microbial biomass. As described in Sections 4.4 and 4.5 below, site groundwater geochemical conditions are conducive to COC degradation and robust microbial populations are present in site groundwater.

4.4 Groundwater Redox Geochemistry

Concentrations and distributions of electron acceptors, electron donors, and byproducts of microbially mediated reactions were evaluated to verify the types of geochemical and biodegradation processes active in site groundwater. MNA parameters (alkalinity, chloride, sulfate, dissolved iron and manganese, nitrate, total organic carbon [TOC], methane, ethane and ethane) measured during the June 2014 comprehensive groundwater monitoring event indicate predominant moderately to very strongly reducing conditions within the VOC plumes for each hydrostratigraphic unit (Figures 4-1 through 4-5). Ethene and ethane concentrations demonstrate complete reductive dechlorination of chlorinated ethenes and ethanes. These results support the interpretation of ongoing natural attenuation of COCs via microbial degradation.

4.5 Microbiological Study

A microbiological population survey was conducted during summer 2014 to provide data against which post-thermal treatment monitoring data can be compared. This section presents a summary of the microbiological population survey results presented in detail in Attachment E.

In support of ongoing evaluations of natural attenuation of organic constituents in groundwater, microbial population sampling was conducted at 12 groundwater monitoring locations. This included locations in the vicinity of the thermal treatment area, in downgradient areas with higher VOC concentrations, and in close proximity to DNAPL. This microbial population sampling served to enumerate populations of select microorganisms, and related functional genes, capable of degrading CVOCs and petroleum hydrocarbons. The results of this sampling event provided:

- An overview of the native microbial community in key areas of the Site.
- A dataset against which the potential effects of thermal treatment on the native microbiological community can be assessed.
- A supporting line of evidence for current and potential future evaluations regarding the efficacy of the selected MNA remedy for dissolved-phase COCs in site groundwater.

Bio-Trap® samplers were deployed at 12 monitoring wells (TW-08B, TW-08D, ISTR-1, ISTR-5, CPZ-6A, CPZ-7R, CPZ-8R, MW-502, MW-705DR, PZ-906DR, MW-907DR, MW-907M) over a period of approximately 30 days. Upon retrieval, Bio-Trap® samplers were submitted to Microbial Insights, deoxyribonucleic acid (DNA) was extracted from Bio-Sep® beads from each sampler, and QuantArray-Chlor qPCR analyses were performed. Additionally, DNA extracted from Bio-Trap® samplers deployed at monitoring wells TW-08B and ISTR-5 was analyzed with QuantArray-Petro.

Bio-Trap® samplers are a passive sampling tool used to survey subsurface microbial communities. These samplers consist of a plastic housing filled with Bio-Sep® beads. These beads are approximately 2 to 4 millimeters in diameter, and are a composite of an inert structural material (Nomex®) covered with powdered activated carbon. Together, these form a suitable surface for colonization by microbes.

QuantArray analysis is a method by which quantitative polymerase chain reaction (qPCR) is used to simultaneously enumerate gene copy numbers for a range of phylogenetic and functional gene targets that have been identified as characteristic of specific degradation processes. The QuantArray-Chlor analysis assesses the potential for anaerobic reductive dechlorination of CVOCs as well as aerobic cometabolism of CVOCs. The QuantArray-Petro analysis assesses the potential for aerobic and anaerobic degradation of benzene, toluene,

ethylbenzene, xylenes (BTEX), methyl *tert*-butyl ether (MTBE), polycyclic aromatic hydrocarbons (PAHs), and alkanes. In addition to quantifying gene copy numbers for microorganisms and enzymes relevant to the degradation of CVOCs and petroleum hydrocarbons, QuantArray analyses count methanogenic organisms, sulfate-reducing bacteria, and total bacteria to provide additional context for results. Phylogenetic and functional genes enumerated by the QuantArray-Chlor and QuantArray-Petro analyses are summarized in Tables 1 and 2 of Attachment E.

QuantArray-Chlor results indicate robust communities capable of full reductive dechlorination to innocuous end products, and also cometabolism of chlorinated compounds, at eleven of the twelve monitoring locations sampled (Attachment E). Based on the results of this study, conditions at monitoring well PZ-906DR may not be conducive to reductive dechlorination, potentially due to the presence of DNAPL at this location. QuantArray-Petro results indicate that microbial communities capable of both aerobic and anaerobic degradation of petroleum hydrocarbons are present at the two locations analyzed by QuantArray-Petro (ISTR-5 and TW-08B) (Attachment E). Together, these data provide a baseline for comparison for post-thermal treatment conditions and provide an additional line of evidence that site conditions are conducive to ongoing natural attenuation of VOCs in site groundwater.

4.6 Stable Carbon Isotopes in DNAPL and Water in Contact with DNAPL

Samples of DNAPL and groundwater collected from deep bedrock well PZ-906DR in March 2012 were submitted to the University of Oklahoma for analysis of stable carbon isotope composition of PCE, TCE, and 1,1,1-TCA. These samples were analyzed to establish the stable isotopic composition of parent CVOCs in source material for potential future assessments of ongoing natural attenuation.

Isotopes are atoms of the same element that have different masses due to differing numbers of neutrons in the nucleus. The two most common stable isotopes of carbon are carbon-12, (^{12}C), and carbon-13, (^{13}C). Microbial degradation of chlorinated solvents imparts a characteristic change in the isotopic composition of the carbon that composes organic compounds (e.g., Hunkeler, et al. 1999; Kirtland et al. 2003). This characteristic change, called fractionation, is due to the preferential microbial degradation of compounds that are comprised of isotopes of lighter mass. Non-degrading processes, such as sorption and volatilization, have a negligible effect on the isotopic composition of organic compounds (Dempster et al. 1997; Slater et al. 1999). Therefore, if in the future there is concern that CVOC attenuation is no longer occurring, analysis of site groundwater samples for delta (δ) ^{13}C isotopic composition of CVOCs may provide a qualitative, and potentially quantitative, means for confirming in-situ biodegradation of CVOCs (Hirschorn et al. 2003).

The isotopic composition of two stable isotopes is typically measured against a known standard and is expressed in δ notation in units of ‰ (per mil) as shown for carbon:

$$\delta^{13}C = [(^{13}C/^{12}C)_{sample}/(^{13}C/^{12}C)_{std}–1]*1000 \text{ (‰ or per mil)}.$$

The carbon isotope standard is Pee Dee Belemnite with a δ-value of 0‰ relative to itself (Clark and Fritz 1997). The margin of error for carbon isotope analyses is typically less than 0.5‰.

Stable carbon isotope results for the PZ-906DR DNAPL and groundwater samples are provided in the table below. The $\delta^{13}C$ values of CVOCs in groundwater were consistently less negative compared with DNAPL suggesting a slight fractionation of the stable carbon isotopes during dissolution of the DNAPL or degradation of parent CVOCs in the vicinity of DNAPL. However, these differences were within the margin of error of the analysis. These data provide a baseline for potential future comparison for groundwater samples. If the $\delta^{13}C$ values of PCE, TCE, or 1,1,1-TCA in future groundwater samples are substantially less negative than these baseline $\delta^{13}C$ values (greater than 1‰ or 2‰ difference), then ongoing microbial degradation can be inferred.

	PCE $\delta^{13}C$ (‰)	TCE $\delta^{13}C$ (‰)	1,1,1-TCA $\delta^{13}C$ (‰)
PZ-906DR DNAPL	-29.3	-26.5	-27.5
PZ-906DR Groundwater	-28.8	-26.2	-26.8

4.7 Summary of Progress for the MNA Remedy

Multiple lines of evidence indicate ongoing natural attenuation of COCs in site groundwater and overall effectiveness of the MNA remedy:

- The VOC plume with constituent concentrations above drinking water standards has decreased since the RI and is completely contained within the HCTS capture zone (Figures 4-1 through 4-5).
- VOC concentrations are decreasing throughout the dissolved-phase plume, including near the leading edge of the plume at the MW-704 well cluster (Figure 4-6). Estimated half-life values for TVOCs in groundwater range from 1.7 to 8.0 years (average 4.7 years) for overburden groundwater. Using current TVOC concentrations for monitoring wells MW-706DR (since 2010) and MW-707DR (since 2004), the bedrock TVOC half-lives range from and 2.4 to 10.4 years, with an average of 7.0 years.
- Since the RI, order of magnitude decreases in TVOC concentrations and concentrations of individual constituents have been observed at many locations (Figures 4-6 through 4-11 and Attachment D). Although VOC concentrations in groundwater at some monitoring locations within deep bedrock DNAPL zones have been relatively stable with time (e.g.,

MW-706DR, Figure 4-11), decreasing VOC concentrations downgradient of those locations (e.g., MW-704DR, Figure 4-6) indicate that the mass flux from the bedrock DNAPL zone is decreasing.

- Molar concentration plots for VOCs in groundwater demonstrate shifts from parent compounds to daughter products with time and with distance downgradient from source areas (Attachments C and D). With increasing distance downgradient, concentrations of primary and secondary compounds decrease or compounds are not detected. These results demonstrate that degradation of the parent and secondary compounds is occurring in site groundwater.
- Concentrations of THF and 1,4-dioxane above ALs are contained within the HCTS capture zone. The half live values for THF (1.5 to 19.6 years; Table 4-1) are similar to half-life values for TVOCs (Table 2-1). Half-life values for 1,4-dioxane (6.0 to 41.6 years; Table 4-1) are longer than for TVOCs and THF. However, the period of record for 1,4-dioxane, monitored since 2010, is considerably shorter compared with other COCs. These constituents will continue to be monitored and THF and 1,4-dioxane concentration trends will be re-evaluated during the next Five-Year Review.
- TAL metals concentrations above ALs are contained within the HCTS capture zone. Mn is the TAL metal most frequently detected at concentrations above the AL. Mn concentrations above the AL are associated with areas of more strongly reducing redox conditions within the VOC plume. Detections of other TAL metals at concentrations above ALs are sporadic and are not indicative of a plume.
- Groundwater redox conditions indicate moderately to strongly reducing conditions throughout the VOC plume (Figures 4-1 through 4-5) demonstrating geochemical conditions conducive to degradation of COCs.
- Microbial population survey results indicate robust communities capable of both full reductive dechlorination to innocuous end products, and also cometabolism of chlorinated compounds, at 11 of the 12 monitoring locations sampled (Attachment E). In addition, microbes capable of degrading aromatic compounds were detected at the two locations where the QuantArray-Petro analysis was conducted. The limited microbial population in the PZ-906DR sample suggests that immediate proximity to DNAPL may limit microbial growth. The 2014 microbial population data provide a baseline for comparison for post-thermal treatment conditions and provide an additional line of evidence that site conditions are conducive to ongoing natural attenuation of VOCs in site groundwater.

These results indicate the success and continuing value of MNA as a remedy for COCs in site groundwater.

5. Progress Toward Remedial Goals

Considerable progress has been made toward the remedial goals for the Site since the completion of the RI/FS. As presented in Section 2.4, approximately 525,000 kg of VOC mass has been removed or degraded since the completion of the RI in 1996. The initial VOC mass in the form of NAPL in the overburden during the RI (1996) was calculated to be approximately 490,000 kg. This mass has been completely or nearly completely removed via in-situ thermal treatment and NAPL dissolution/degradation. An additional 12,000 kg of VOCs formerly stored within the overburden in the dissolved and sorbed phases has also been depleted, primarily via degradation. The total remaining VOC mass in the overburden is approximately 1,100 kg, or 0.2% of the estimated overburden VOC mass in1996.

Bedrock VOC mass has also been significantly depleted since the completion of the RI. An estimated 27,000 kg of VOCs have been degraded within the shallow and deep bedrock since 1996. The remaining VOC mass in the bedrock is interpreted as approximately 12,000 kg of dissolved and sorbed VOCs, and 1,500 kg of NAPL. The combined dissolved, sorbed and NAPL mass is estimated as 34% of the mass that was present in the bedrock in 1996. The NAPL mass in the bedrock has been re-evaluated based on our current understanding of the probable NAPL zone within bedrock, the bedrock fracture characteristics, and information published after the RI regarding the NAPL retention capacity of natural bedrock fractures. The remaining NAPL will ultimately be depleted by dissolution and degradation. In addition, the dissolved and sorbed VOC mass stored in the bedrock will continue to attenuate.

The MNA remedy is proceeding as planned. The dissolved-phase plume of VOCs and TAL metals is fully contained within the HCTS capture zone. In addition, even before the implementation of the thermal remedy (May 2014 to February 2015), the extent of VOCs above ALs had receded considerably since the RI and FS, especially within overburden groundwater. Shifts in the composition of VOCs in groundwater from parent compounds to daughter products for chlorinated VOCs indicate ongoing VOC degradation. Detected concentrations of ethene and ethane in groundwater demonstrate that complete reductive dechlorination of chlorinated ethenes and ethanes is occurring.

As stated in the ROD, “Eventual restoration of the contaminated groundwater plume in both overburden and bedrock to cleanup levels is expected to take longer than 225 years, which is the estimated time frame for the entire plume at the Site to achieve safe drinking water standards.” Most monitoring locations included in the trend analyses demonstrate decreasing TVOC, THF, and 1,4-dioxane concentration trends with time. Demonstrating decreasing concentrations trends with time is a key component of evaluating the ongoing effectiveness of a MNA remedy (USEPA 2011). For locations with VOC concentrations above ALs, estimated times to reach drinking water levels are generally within the next few decades to 100 years.

Natural attenuation processes in the deep bedrock groundwater appear to be occurring more slowly than in other hydrostratigraphic units. However, even in the deep bedrock, declining concentration trends are observed at the leading edge of the VOC plume. Groundwater particle tracking modeling results indicate that deep bedrock groundwater with elevated VOC concentrations discharges upward to shallow bedrock within the capture zone of the HCTS. Nevertheless, VOC concentrations in the downgradient portion of shallow bedrock groundwater in the vicinity of the NTCRA 2 extraction wells are below drinking water standards. In addition, where VOC-affected groundwater discharges from shallow bedrock to deep overburden, it becomes diluted due to the higher permeability of the deep overburden geologic materials and in some areas encounters more strongly reducing conditions.

This Five-Year Review is based on data collected prior to completion of the thermal treatment remedy. The beneficial effects of the thermal remedy with respect to groundwater quality will be evaluated during the next Five-Year Review, consistent with USEPA (2011) guidance. It is expected that the MNA remedy will continue to be protective, and VOC concentrations will continue to decline in all monitored hydrostratigraphic zones.

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Tables

Table 2-1 - Statistical Summary of Groundwater Total VOC Concentration Trends
Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site
Southington, Connecticut

DRAFT

		Data Range						Linear Regression Analysis						
Well	Constituent	Minimum Concentration (µg/L)	Maximum Concentration (µg/L)	Most Recent Concentration (µg/L)	% of Data Below Laboratory Minimum Detection Limit	Start Date	End Date	Correlation Coefficient, R^2	p-value of Correlation	Estimated Attenuation Half-life (years)	Trend Direction (slope of trend line)	Trend Significant?	Year for Total VOCs to Reach 5 µg/L	Year for Total VOCs to Reach 1 µg/L
Shallow Overburden Wells														
P-13	Total VOCs	2.4	69	7.142	0	3/28/1995	6/11/2014	0.40	0.002	7.4	Decreasing	Yes	2017	2035
MWL-312	Total VOCs	<0.5	49	0.428	72	3/27/1995	6/10/2014	0.17	0.09	5.3	Decreasing	Yes	1989	2001
P-101C	Total VOCs	8.0	479	22.159	0	3/27/1995	6/12/2014	0.72	<0.001	5.0	Decreasing	Yes	2024	2035
Middle Overburden Wells														
MW-03	Total VOCs	0.5	120	0.48	0	12/5/1996	6/9/2014	0.25	0.023	4.6	Decreasing	Yes	2007	2017
MW-205B	Total VOCs	<0.5	24	0.364	11	3/23/1995	6/12/2014	0.44	0.003	4.0	Decreasing	Yes	2001	2010
P-101B	Total VOCs	12	187,400	17.916	0	3/27/1995	6/12/2014	0.74	<0.001	1.7	Decreasing	Yes	2016	2020
MW-127B	Total VOCs	<0.5	22	0.384	11	3/23/1995	6/11/2014	0.33	0.01	4.5	Decreasing	Yes	1997	2008
MW-501B	Total VOCs	1.8	65	4.618	0	3/24/1995	6/11/2014	0.50	<0.001	3.7	Decreasing	Yes	2008	2017
Deep Overburden Wells														
MW-204B	Total VOCs	<0.5	87	1.603	17	3/28/1995	6/9/2014	0.21	0.05	4.7	Decreasing	Yes	2001	2011
MW-502	Total VOCs	630	118,160	4613	0	3/21/1995	6/11/2014	0.71	<0.001	3.1	Decreasing	Yes	2042	2049
MW-704D	Total VOCs	7.0	665	16.23	0	12/18/1996	6/12/2014	0.15	0.09	8.0	Decreasing	Yes	2025	2043
MW-707D	Total VOCs	<0.5	21	0.224	53	12/6/1996	6/10/2014	<0.001	0.93	NA	No Trend	No	NA	NA
Shallow Bedrock Wells														
MW-127C	Total VOCs	10.14	147	10.143	0	3/23/1995	6/11/2014	0.59	<0.001	7.8	Decreasing	Yes	2024	2042
MW-128	Total VOCs	2.2	15	2.196	0	3/23/1995	6/11/2014	0.62	<0.001	8.1	Decreasing	Yes	2005	2024
MW-204A	Total VOCs	0.9	682	0.892	0	3/28/1995	6/9/2014	0.62	<0.001	2.4	Decreasing	Yes	2006	2012
MW-501A	Total VOCs	9	118	8.733	0	3/24/1995	6/11/2014	0.85	<0.001	4.9	Decreasing	Yes	2016	2027
P-11A	Total VOCs	223	26,400	9461.4	0	3/27/1995	6/11/2014	0.1	0.13	NA	No Trend	No	NA	NA
Deep Bedrock Wells														
MW-703DR	Total VOCs	<0.5	8.0	0.5	76	12/9/1996	6/10/2014	0.005	0.79	NA	No Trend	No	NA	NA
MW-704DR	Total VOCs	11	455	27.50	0	12/17/1996	6/13/2014	0.53	<0.001	6.9	Decreasing	Yes	2030	2046
MW-706DR	Total VOCs	2,835	11,240	5655	0	12/10/1996	6/12/2014	0.16	0.08	27.7	Decreasing	Yes	2295	2359
MW-706DR since 2010	Total VOCs	2,835	10,860	5655	0	5/18/2010	6/12/2014	0.06	0.69	8.5	Decreasing	No	2099	2188
MW-707DR	Total VOCs	<0.5	18	2.481	32	12/30/1996	6/11/2014	0.24	0.02	NA	Increasing	Yes	NA	NA
MW-707DR since 2004	Total VOCs	2.48	16.9	2.481	0	4/20/2004	6/11/2014	0.20	0.19	10.4	Decreasing	No	2014	2038

Notes and Assumptions:
µg/L = micrograms per liter
NS = no significant trend
NA = not applicable due to increasing trend or non-significant trend
VOCs = volatile organic compounds
Indicates total VOC concentrations below respective screening level

Table 4-1 - Statistical Summary of Groundwater Tetrahydrofuran and 1,4-Dioxane Concentration Trends
Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site
Southington, Connecticut

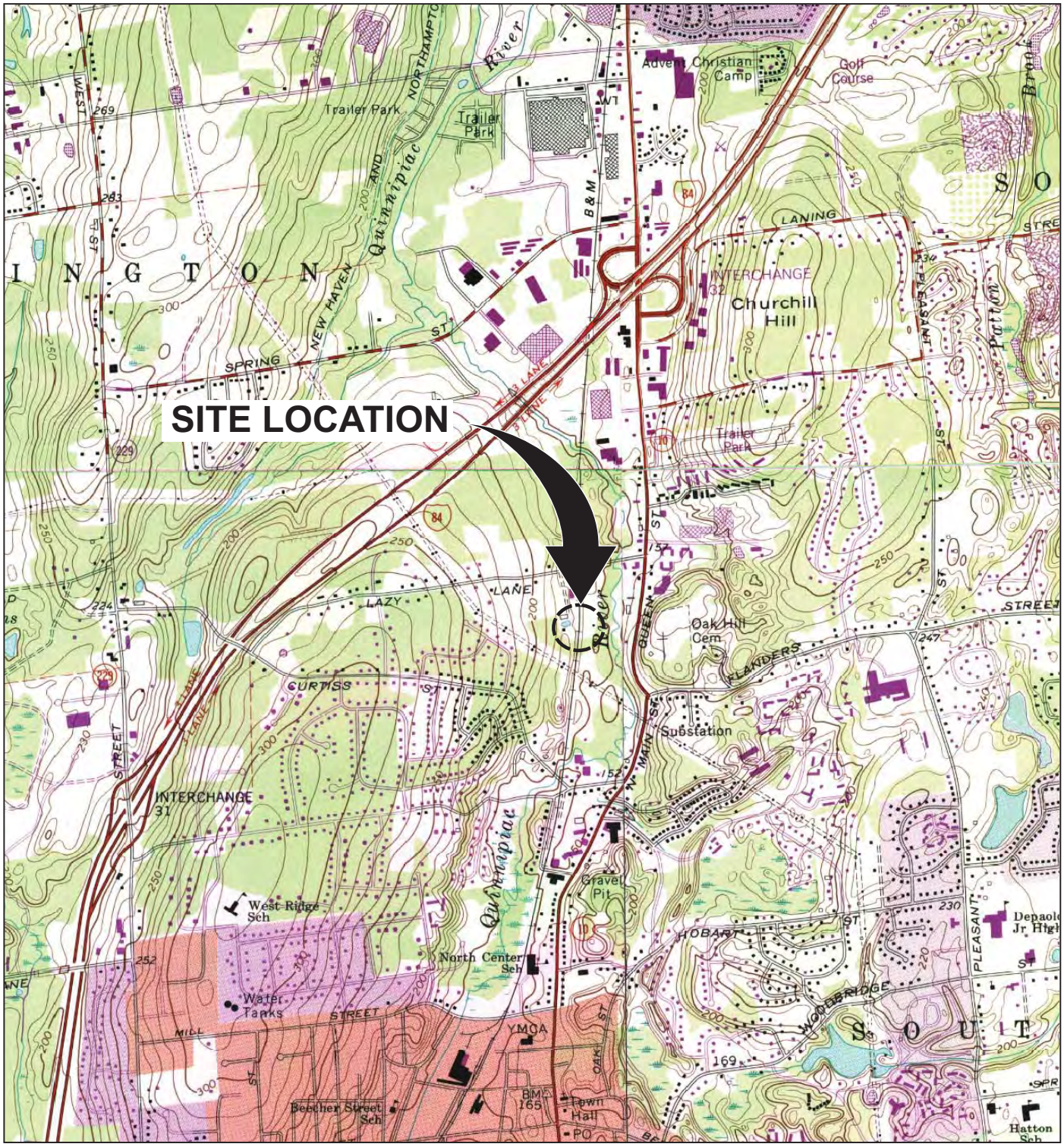
DRAFT

			Data Range					Linear Regression Analysis					
Well	**Constituent**	**Zone**	**Minimum Concentration (µg/L)**	**Maximum Concentration (µg/L)**	**% of Data Below Laboratory Minimum Detection Limit**	**Start Date**	**End Date**	**Correlation Coefficient, R^2**	**p-value of Correlation**	**Estimated Attenuation Half-life (years)**	**Trend Direction (slope of trend line)**	**Trend Significant?**	**Predicted Time to Meet Action Level**
P-11B	THF	SOB	1.6	990	0	12/1/1994	5/18/2010	0.99	0.001	2.0	Decreasing	Yes	2010
MWL-309	THF	SOB	5.0	1,800	25	12/1/1994	6/13/2014	0.76	0.005	3.0	Decreasing	Yes	2020
P-101C	THF	SOB	1.9	250	4	12/3/1994	6/12/2014	0.69	<0.001	4.2	Decreasing	Yes	2012
P-3B	THF	MOB	1.6	990	0	12/1/1994	6/13/2014	0.99	0.001	2.0	Decreasing	Yes	2010
CPZ-6	THF	MOB	1.8	2,200	0	12/20/1996	6/12/2014	0.86	0.07	1.8	Decreasing	Yes	2015
MW-907M	THF	MOB	3,170	3,900	0	5/19/2010	6/10/2014	0.50	0.18	19.6	Decreasing	No	2199
MW-704M	THF	MOB	2	37	13	12/17/1996	6/12/2014	0.76	0.005	4.9	Decreasing	Yes	2013
P-101B	THF	MOB	3.5	44,000	5	12/3/1994	6/12/2014	0.80	<0.001	1.5	Decreasing	Yes	2012
CPZ-6A	THF	MOB/DOB	1,000	52,000	25	12/26/1996	6/11/2014	0.41	0.36	4.8	Decreasing	No	2054
MW-502	THF	DOB	530	18,000	0	3/21/1995	6/11/2014	0.47	<0.001	6.0	Decreasing	Yes	2068
MW-121B	THF	DOB	98	5,500	0	11/30/1994	6/11/2014	0.97	<0.001	3.4	Decreasing	Yes	2030
MW-121C	THF	SBR	9	3,300	0	11/30/1994	6/11/2014	0.78	0.002	2.9	Decreasing	Yes	2020
MW-05	THF	SBR	90	11,000	0	11/30/1994	6/11/2014	0.97	0.002	3.0	Decreasing	Yes	2027
P-11A	THF	SBR	24	3,100	0	12/1/1994	5/24/2011	0.53	<0.001	3.0	Decreasing	Yes	2017
MW-704DR	THF	DBR	4	190	0	12/17/1996	6/13/2014	0.75	<0.001	4.1	Decreasing	Yes	2013
P-101C	1,4-Dioxane	SOB	60	180	0	4/22/2004	6/12/2014	0.03	0.79	41.6	Decreasing	No	2113
MW-03	1,4-Dioxane	MOB	3.5	21	0	4/20/2004	6/9/2014	0.52	0.17	6.0	Decreasing	No	2002
P-101B	1,4-Dioxane	MOB	145	440	0	4/22/2004	6/12/2014	0.76	0.05	7.5	Decreasing	Yes	2035
MW-502	1,4-Dioxane	DOB	570	3,000	0	4/23/2004	6/11/2014	0.26	0.38	9.5	Decreasing	No	2068

Notes and Assumptions:
µg/L = micrograms per liter
NS = no significant trend
NA = not applicable due to increasing trend or non-significant trend
THF = tetrahydrofuran
SOB = shallow overburden
MOB = middle overburden
DOB = deep overburden
SBR = shallow bedrock
DBR = deep bedrock

ARCADIS

Figures



REFERENCE: SOUTHINGTON, CONN. USGS QUAD. 1968 PR 1992, MERIDEN, CONN. USGS QUAD. 1966 PR 1984, NEW BRITAIN, CONN. USGS QUAD. 1966 PR 1984, & BRISTOL, CONN. USGS QUAD 1967 PR 1984

DRAFT

2000' 0 2000'

APPROX. SCALE: 1" = 2000'

QUADRANGLE LOCATION

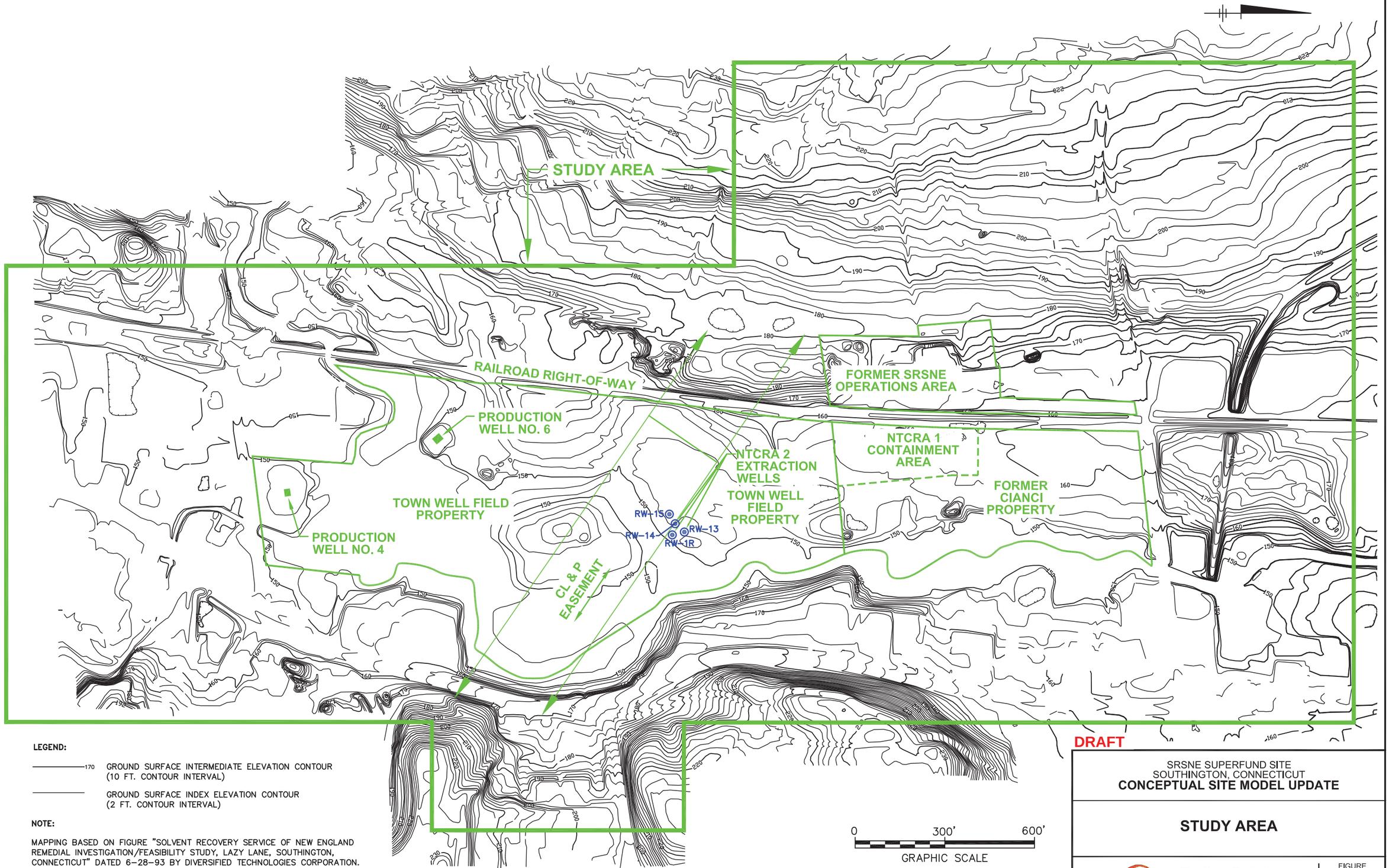
SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

SITE LOCATION MAP

ARCADIS

FIGURE
1-1

02/20/2015 SYRACUSE, NY-ENV/CAD DJHOWES
B0054634\0001\03700\CDR\54634N01.CDR



LEGEND:

170 GROUND SURFACE INTERMEDIATE ELEVATION CONTOUR (10 FT. CONTOUR INTERVAL)

GROUND SURFACE INDEX ELEVATION CONTOUR (2 FT. CONTOUR INTERVAL)

NOTE:

MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONNECTICUT" DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

STUDY AREA

ARCADIS

FIGURE
1-2

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJPOSENAUER LD:(Opt) PIC: G.CAMERON PM: J.HOLDEN TM: J.HOLDEN LYR:(Opt)ON=*;OFF=*REF*
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NOTES:

1. BASE MAP WAS SCANNED FROM AN AERIAL PHOTOGRAPH TAKEN APRIL 3, 1965.
2. ALL SITE LOCATION INFORMATION AND PROPERTY BOUNDARIES ARE APPROXIMATE.
3. OPERATIONS AREA PROPERTY LINE ESTIMATED: SPECIFIC TO AIR PHOTO DATE.

0 100' 200'
GRAPHIC SCALE

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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

AERIAL PHOTOGRAPH - 1965

ARCADIS

FIGURE
1-3

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJPOSENAUER LD:(Opt) PIC: G.CAMERON PM: J.HOLDEN TM: J.HOLDEN LYR:(Opt)ON=*;OFF=*REF*
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54634X00 54634X01.jpg

NOTES:

1. BASE MAP WAS SCANNED FROM AN AERIAL PHOTOGRAPH TAKEN APRIL 3, 1965.
2. ALL SITE LOCATION INFORMATION AND PROPERTY BOUNDARIES ARE APPROXIMATE.
3. OPERATIONS AREA PROPERTY LINE ESTIMATED: SPECIFIC TO AIR PHOTO DATE.

0 100' 200'

GRAPHIC SCALE

DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

AERIAL PHOTOGRAPH - 1980

ARCADIS

FIGURE
1-4

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJPOSENAUER LD:(Opt) PIC: G.CAMERON PM: J.HOLDEN TM: J.HOLDEN LYR:(Opt)ON=*;OFF=*REF*
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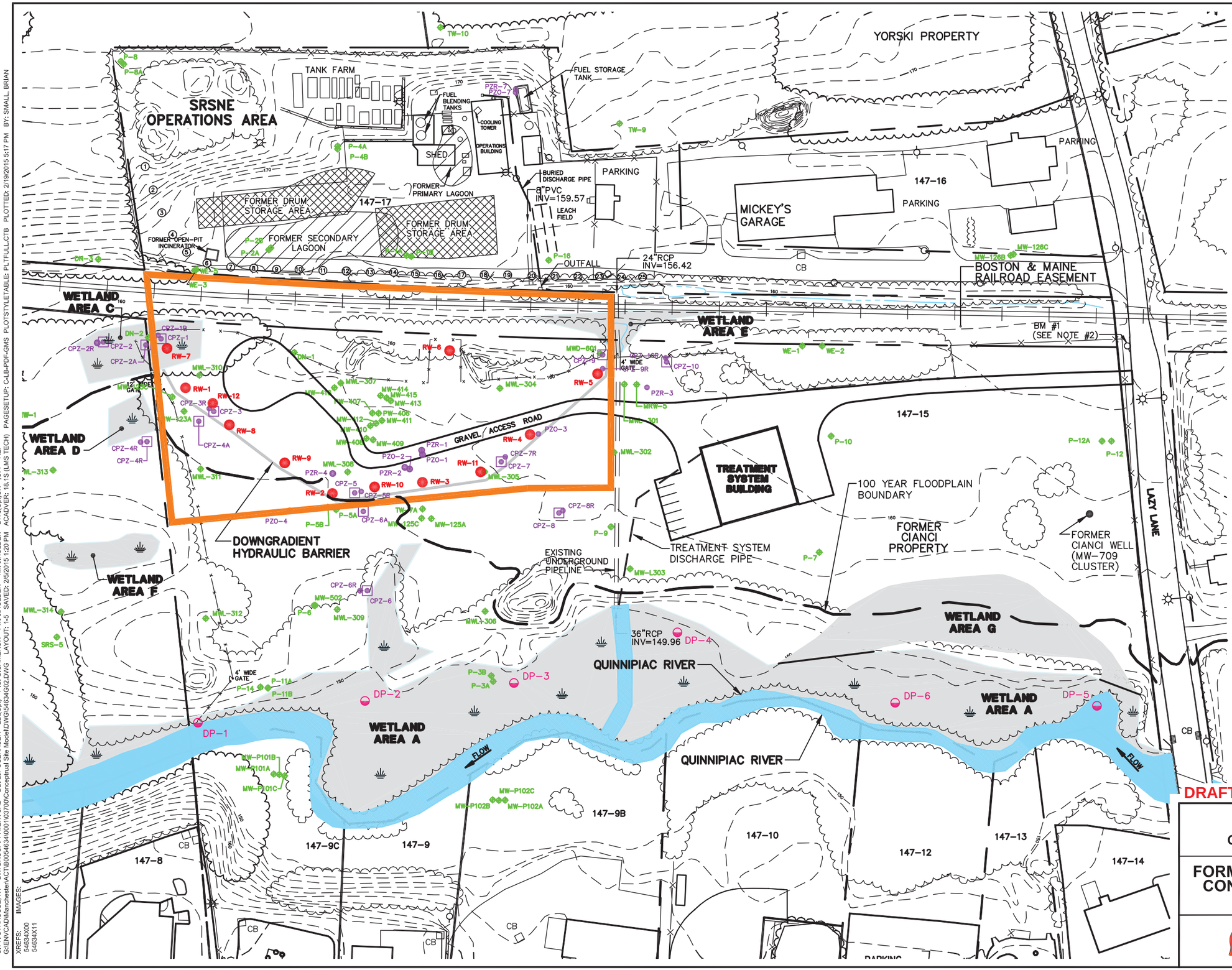

LEGEND

- PROPERTY LINE
- 100-YEAR FLOOD LIMIT
- WATER
- RIVER
- WETLAND
- NTCRA 1 CONTAINMENT AREA
- EXISTING STRUCTURE
- VEGETATION
- EXISTING CONTOUR
- FENCE
- P-10 — PREVIOUSLY INSTALLED MONITORING WELL
- PZR-3 — NTCRA 1 PIEZOMETER
- CPZ-10 — NTCRA 1 COMPLIANCE PIEZOMETER
- RW-1 — NTCRA 1 OVERBURDEN EXTRACTION WELL
- DP-5 — WETLAND DRIVE POINT
- 147-12 — LOT NUMBER
- ABOVE-GROUND TANK
- (12) — FORMER ON-SITE INTERCEPTOR SYSTEM EXTRACTION WELL

NOTES

1. SITE PLAN TAKEN FROM DIVERSIFIED TECHNOLOGIES CORP., 556 WASHINGTON AVE., NORTH HAVEN, CT, DATED 6/93. TOPOGRAPHY REPORTED TO HAVE BEEN DIGITIZED FROM TOWN OF SOUTHINGTON TOPOGRAPH MAPS G-7, G-8, G-9; PHOTOGRAPHY DATED NOV. 1978, SCALE: 1"=100'. PROPERTY LINES REPORTED TO HAVE BEEN DIGITIZED AND LOT NUMBERS TAKEN FROM "PROPERTY MAP, TOWN OF SOUTHINGTON" MAPS 134 & 147, SCALE: 1"=100' BY DIVERSIFIED TECHNOLOGIES CORPORATION.
2. BENCHMARK #1 IS AT ELEVATION 164.03. PK NAIL; S'LY SIDE; POLE #9049.
3. THE 100-YEAR FLOOD LIMIT AND WETLAND AREAS WERE TAKEN FROM THE FINAL REMEDIAL INVESTIGATION REPORT (HNUS, MAY 1994). THE 100-YEAR FLOOD LIMIT WAS REVISED TO FOLLOW THE ELEVATION 156 CONTOUR BASED ON INFORMATION PROVIDED BY THE SOUTHINGTON TOWN ENGINEER.

   THE LOCATIONS OF EXISTING DRIVE POINTS, WELLS AND PIEZOMETERS ARE APPROXIMATE ONLY.
4.

0 100' 200'

GRAPHIC SCALE

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

FORMER OPERATIONS AREA, NTCRA 1 CONTAINMENT AREA, AND FORMER CIANCI PROPERTY MAP

ARCADIS

FIGURE 1-5

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJPOSENAUER LD:(Opt) PIC: G.CAMERON PM: J.HOLDEN TM: J.HOLDEN LYR:(Opt)ON=*;OFF=*REF*
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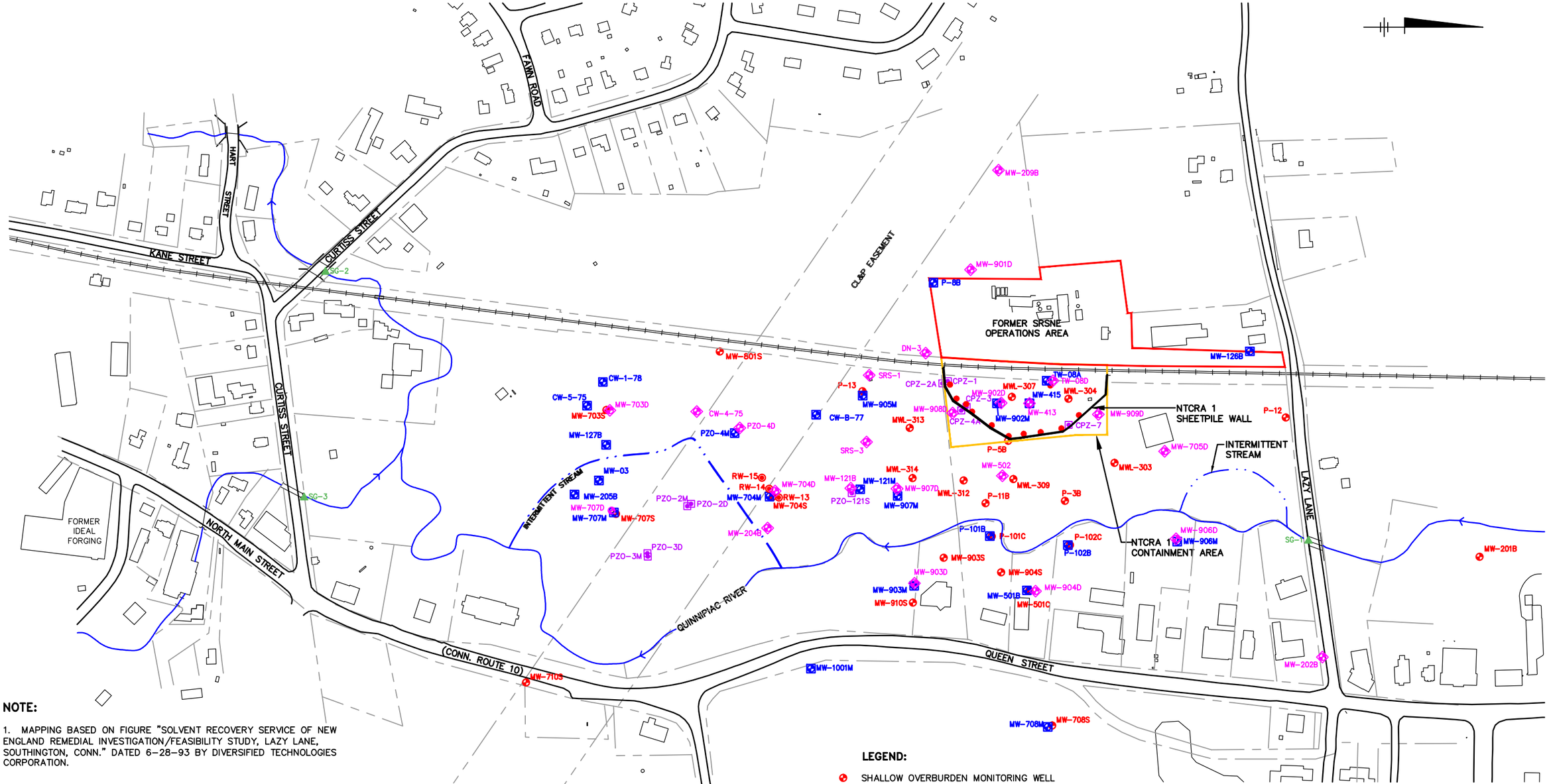


NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- SHALLOW OVERBURDEN MONITORING WELL
- MIDDLE OVERBURDEN MONITORING WELL
- DEEP OVERBURDEN MONITORING WELL
- NTCRA 1 EXTRACTION WELL
- NTCRA 2 EXTRACTION WELL
- PIEZOMETER
- STREAM/RIVER GAUGE POINT

0 300' 600'

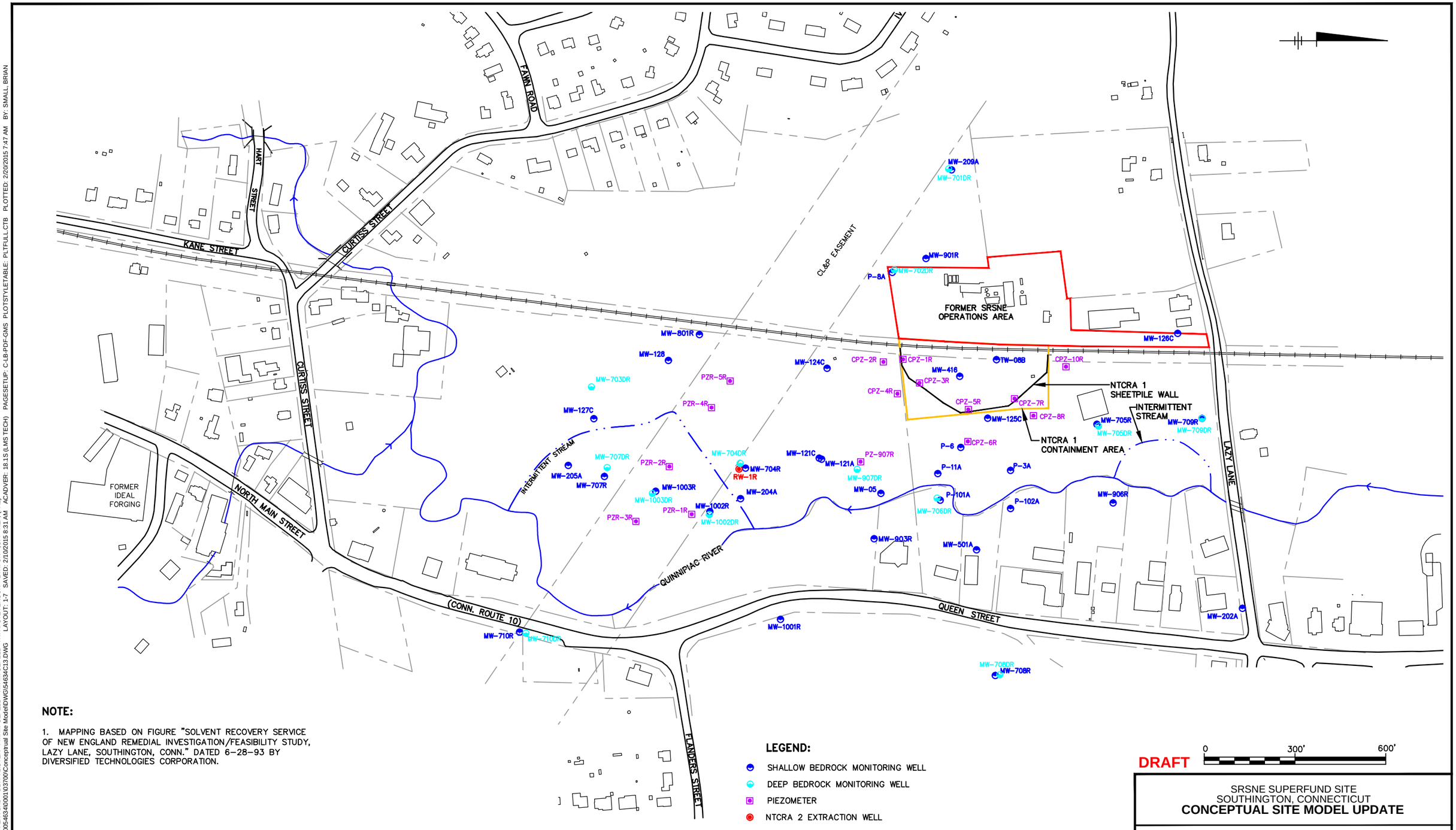
DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

GROUNDWATER MONITORING LOCATIONS OVERBURDEN

ARCADIS

FIGURE
1-6



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- SHALLOW BEDROCK MONITORING WELL
- DEEP BEDROCK MONITORING WELL
- PIEZOMETER
- NTCRA 2 EXTRACTION WELL

DRAFT

0 300' 600'

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

GROUNDWATER MONITORING LOCATIONS BEDROCK

ARCADIS

FIGURE
1-7

CITY: SYRACUSE, NY GROUP: ENVCAD DB: P. LISTER PM: M. GEFELL TM: M. GEFELL TR: R. STEVENSON LYR: ON=*;OFF=REF; (FR2)
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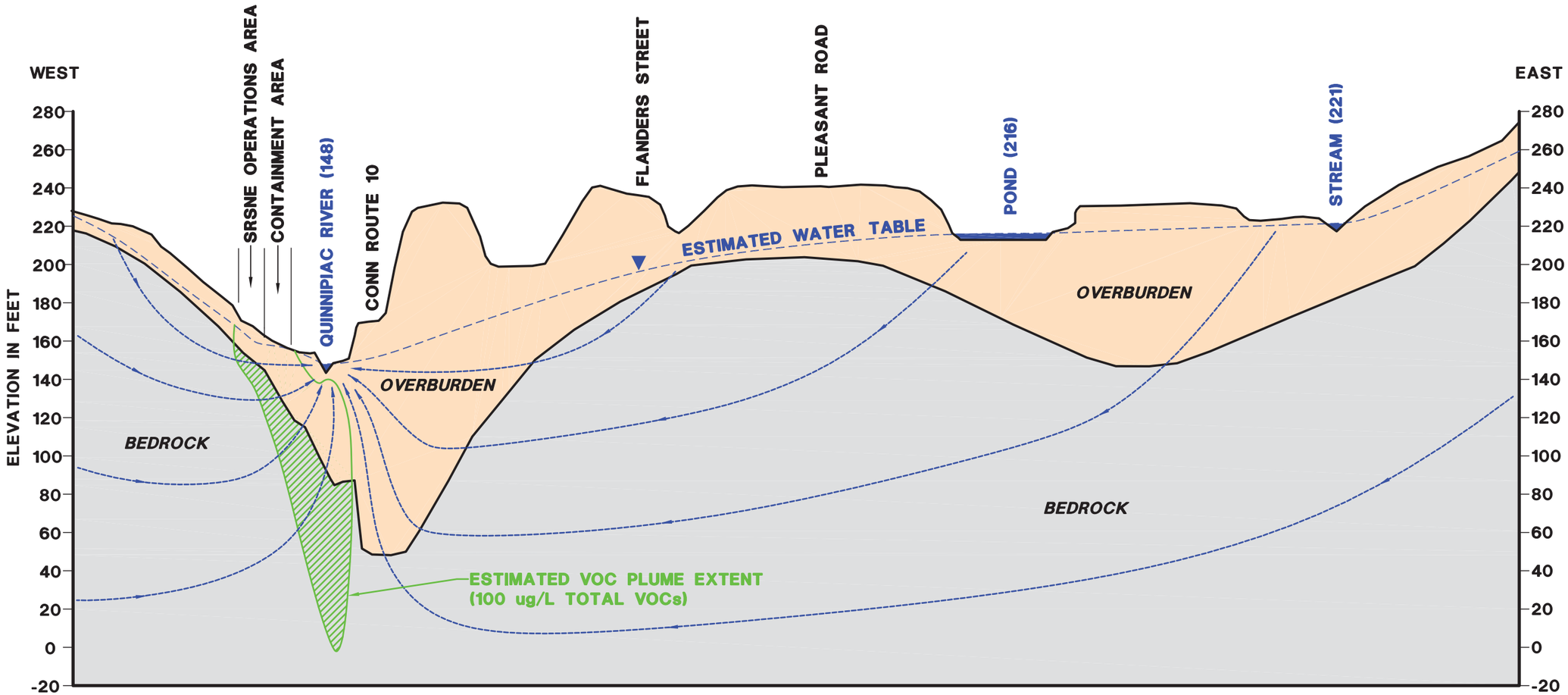

NOTES:

1. GROUND SURFACE AND WATER TABLE CONTINUE TO RISE TO THE EAST OF THIS CROSS SECTION.
2. APPROXIMATELY 17,000 FT TO THE EAST IS HATCHERY BROOK, WHICH IS AT THE SAME ELEVATION AS QUINNIPIAC RIVER.
3. WATER TABLE DIVIDE APPROXIMATELY 6,000 FT EAST OF THIS CROSS SECTION.
4. TOP OF BEDROCK AND GROUND SURFACE DATA FROM USGS MAPS MF-660A (1975) AND MF-661A (1976).

APPROXIMATE HORIZONTAL SCALE:

1000' 0 1000'

DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

GENERALIZED REGIONAL GEOLOGIC CROSS SECTION

ARCADIS

FIGURE
1-8

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=REF*
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IMAGES:
54634X00

NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONNECTICUT" DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- SATURATED SOIL AND/OR GROUND-WATER SAMPLING LOCATION WITH VOCs DETECTED >10% OF EFFECTIVE SOLUBILITY (MATHEMATICAL AND/OR EMPIRICAL EVALUATION)
- GROUND-WATER SAMPLING LOCATION WITH VOCs DETECTED >1% OF EFFECTIVE SOLUBILITY (MATHEMATICAL EVALUATION)
- GROUND-WATER SAMPLE WITH VOCs DETECTED >1% OF EMPIRICAL SOLUBILITY
- GROUND-WATER SAMPLING LOCATION WITH ALCOHOLS DETECTED
- OTHER LOCATIONS WHERE NAPL VISUALLY OBSERVED, OR IDENTIFIED BY SHEEN OR POSITIVE HYDROPHOBIC DYE TEST
- SOIL SAMPLE WITH VOCs DETECTED >10% OF EFFECTIVE SOLUBILITY CALCULATED IN PORE WATER (MATHEMATICAL EVALUATION)
- SOIL SAMPLE WITH VOCs DETECTED >100% OF EFFECTIVE SOLUBILITY CALCULATED IN PORE WATER (MATHEMATICAL EVALUATION)
- SOIL SAMPLE WITH VOCs DETECTED >10% OF EMPIRICAL SOLUBILITY CALCULATED IN PORE WATER
- SOIL SAMPLE WITH VOCs DETECTED >100% OF EMPIRICAL SOLUBILITY CALCULATED IN PORE WATER
- VADOSE SOIL SAMPLE WITH VOCs DETECTED >100% OF EMPIRICAL SOLUBILITY CALCULATED IN PORE WATER
- MW-704S: SHALLOW OVERBURDEN MONITORING WELL
- P-10: MIDDLE OVERBURDEN MONITORING WELL
- MW-121B: DEEP OVERBURDEN MONITORING WELL
- NTCRA 1 EXTRACTION WELL
- NTCRA 1 COMPLIANCE PIEZOMETER

0 200' 400'
GRAPHIC SCALE

DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

ESTIMATED NAPL-ZONE BOUNDARY IN OVERBURDEN

ARCADIS

FIGURE
1-9

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJPOSENAUER LD: (Opt) PIC: G.CAMERON PM: J.HOLDEN TM: J.HOLDEN LYR: (Opt)ON=*;OFF=*REF*
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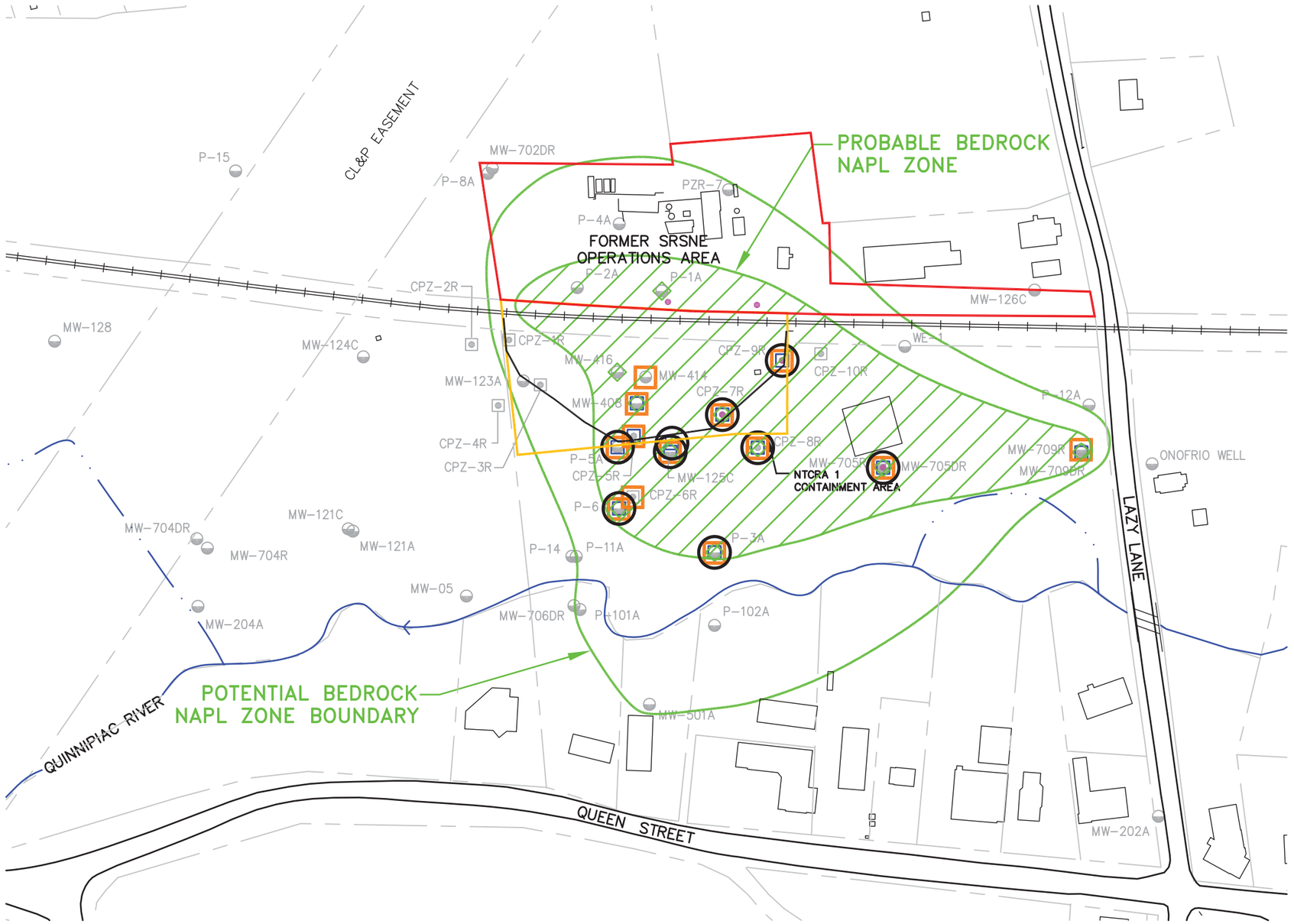

LEGEND:

- GROUND-WATER SAMPLE WITH VOCs DETECTED >10% OF EFFECTIVE SOLUBILITY (MATHEMATICAL AND/OR EMPIRICAL EVALUATION)
- GROUND-WATER SAMPLING LOCATION WITH VOCs DETECTED >1% OF EFFECTIVE SOLUBILITY (MATHEMATICAL EVALUATION)
- GROUND-WATER SAMPLE WITH COMPOUNDS DETECTED >1% OF EMPIRICAL SOLUBILITY
- GROUND-WATER SAMPLING LOCATION WITH ALCOHOLS DETECTED
- LOCATIONS WHERE NAPL VISUALLY DETECTED BY SHEEN OR POSITIVE HYDROPHOBIC DYE TEST
- MW-709R — BEDROCK MONITORING WELL
- CPZ-10R — BEDROCK PIEZOMETER

0 200' 400'

GRAPHIC SCALE

NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONNECTICUT" DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

ESTIMATED NAPL-ZONE BOUNDARY IN BEDROCK

ARCADIS

FIGURE
1-10

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJPOSENAUER LD:(Opt) PIC: G.CAMERON PM: J.HOLDEN TM: J.HOLDEN LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\Manchester\ACTIB\00546340\00\103700\Conceptual Site Model\DWG\54634B08.DWG LAYOUT: 1-10 SAVED: 2/19/2015 7:38 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: C-LB-PDF-GMS PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/19/2015 7:41 PM BY: SMALL, BRIAN
XREFS: 54634X00 54634X01
IMAGES:

NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONNECTICUT" DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- SATURATED SOIL AND/OR GROUNDWATER SAMPLING LOCATION WITH VOCs DETECTED >10% OF EFFECTIVE SOLUBILITY (MATHEMATICAL AND/OR EMPIRICAL EVALUATION)
- GROUNDWATER SAMPLING LOCATION WITH VOCs DETECTED >1% OF EFFECTIVE SOLUBILITY (MATHEMATICAL EVALUATION)
- GROUNDWATER SAMPLE WITH VOCs DETECTED >1% OF EMPIRICAL SOLUBILITY
- GROUNDWATER SAMPLING LOCATION WITH ALCOHOLS DETECTED
- OTHER LOCATIONS WHERE NAPL VISUALLY OBSERVED, OR IDENTIFIED BY SHEEN OR POSITIVE HYDROPHOBIC DYE TEST
- SOIL SAMPLE WITH VOCs DETECTED >10% OF EFFECTIVE SOLUBILITY CALCULATED IN PORE WATER (MATHEMATICAL EVALUATION)
- SOIL SAMPLE WITH VOCs DETECTED >100% OF EFFECTIVE SOLUBILITY CALCULATED IN PORE WATER (MATHEMATICAL EVALUATION)
- SOIL SAMPLE WITH VOCs DETECTED >10% OF EMPIRICAL SOLUBILITY CALCULATED IN PORE WATER
- SOIL SAMPLE WITH VOCs DETECTED >100% OF EMPIRICAL SOLUBILITY CALCULATED IN PORE WATER
- VADOSE SOIL SAMPLE WITH VOCs DETECTED >100% OF EMPIRICAL SOLUBILITY CALCULATED IN PORE WATER
- MW-704S SHALLOW OVERBURDEN MONITORING WELL
- P-10 MIDDLE OVERBURDEN MONITORING WELL
- MW-121B DEEP OVERBURDEN MONITORING WELL
- NTCRA 1 EXTRACTION WELL
- NTCRA 1 COMPLIANCE PIEZOMETER
- P-10

0 200' 400'
GRAPHIC SCALE

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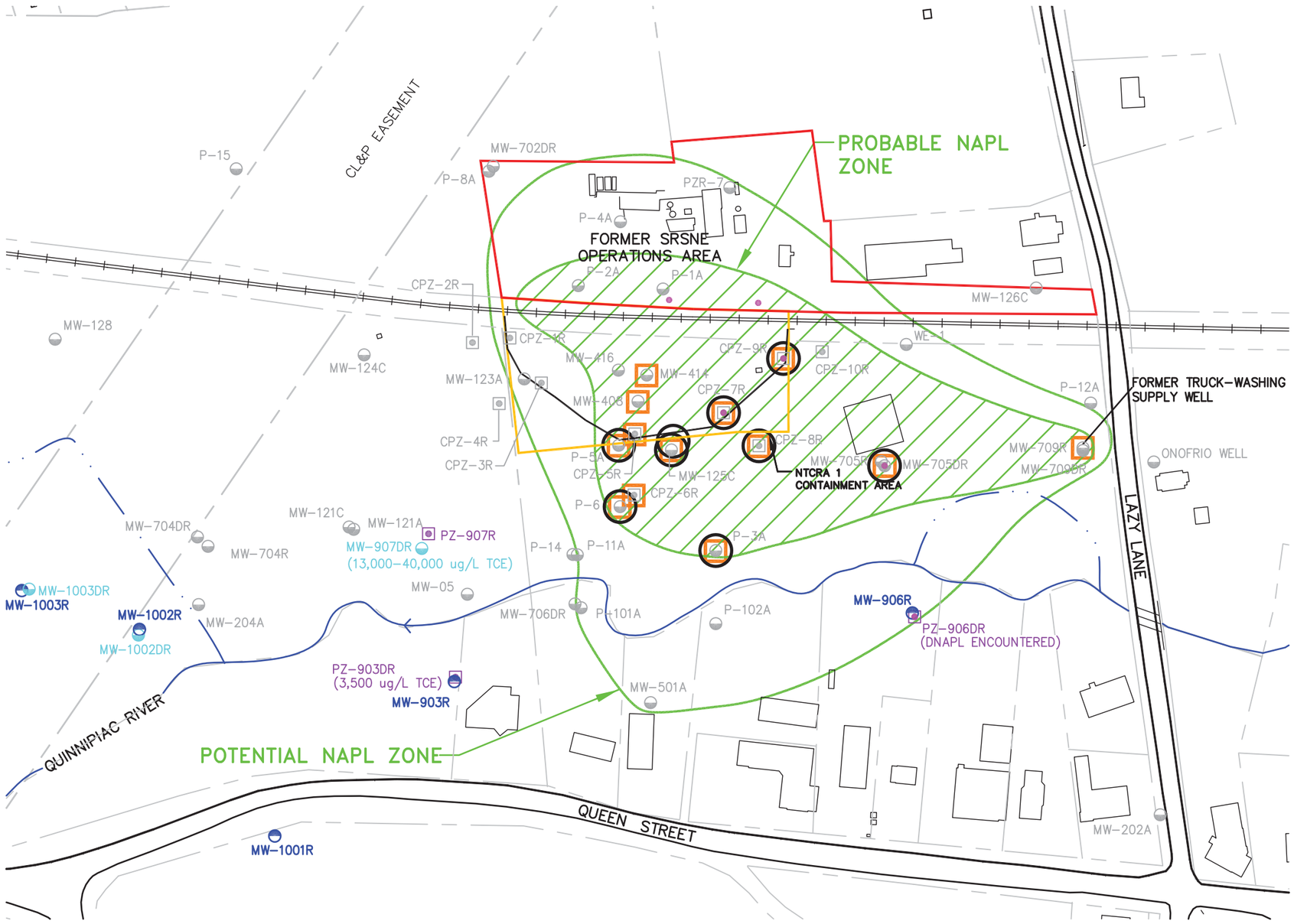
SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

ESTIMATED NAPL-ZONE BOUNDARY IN OVERBURDEN AND THERMAL TREATMENT ZONE

ARCADIS

FIGURE
1-11



LEGEND:

- GROUNDWATER SAMPLE WITH VOCs DETECTED >10% OF EFFECTIVE SOLUBILITY (MATHEMATICAL AND/OR EMPIRICAL EVALUATION)
- GROUNDWATER SAMPLING LOCATION WITH VOCs DETECTED >1% OF EFFECTIVE SOLUBILITY (MATHEMATICAL EVALUATION)
- GROUNDWATER SAMPLE WITH COMPOUNDS DETECTED >1% OF EMPIRICAL SOLUBILITY
- GROUNDWATER SAMPLING LOCATION WITH ALCOHOLS DETECTED
- LOCATIONS WHERE NAPL VISUALLY DETECTED BY SHEEN OR POSITIVE HYDROPHOBIC DYE TEST
- BEDROCK MONITORING WELL
- BEDROCK PIEZOMETER
- SHALLOW BEDROCK MONITORING WELL
- DEEP BEDROCK MONITORING WELL
- BEDROCK PIEZOMETER (R SUFFIX = SHALLOW BEDROCK; DR SUFFIX = DEEP BEDROCK)

0 200' 400'

GRAPHIC SCALE

AVERAGE BEDROCK FRACTURE ORIENTATION

NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONNECTICUT" DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

ORIGINAL BEDROCK NAPL ZONE AND LOCATIONS OF NEW RD/RA WELL CLUSTERS

ARCADIS

FIGURE
2-1

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJPOSENAUER LD:(Opt) PIC: G.CAMERON PM: J.HOLDEN TM: J.HOLDEN LYR:(Opt)ON=*;OFF=*REF*
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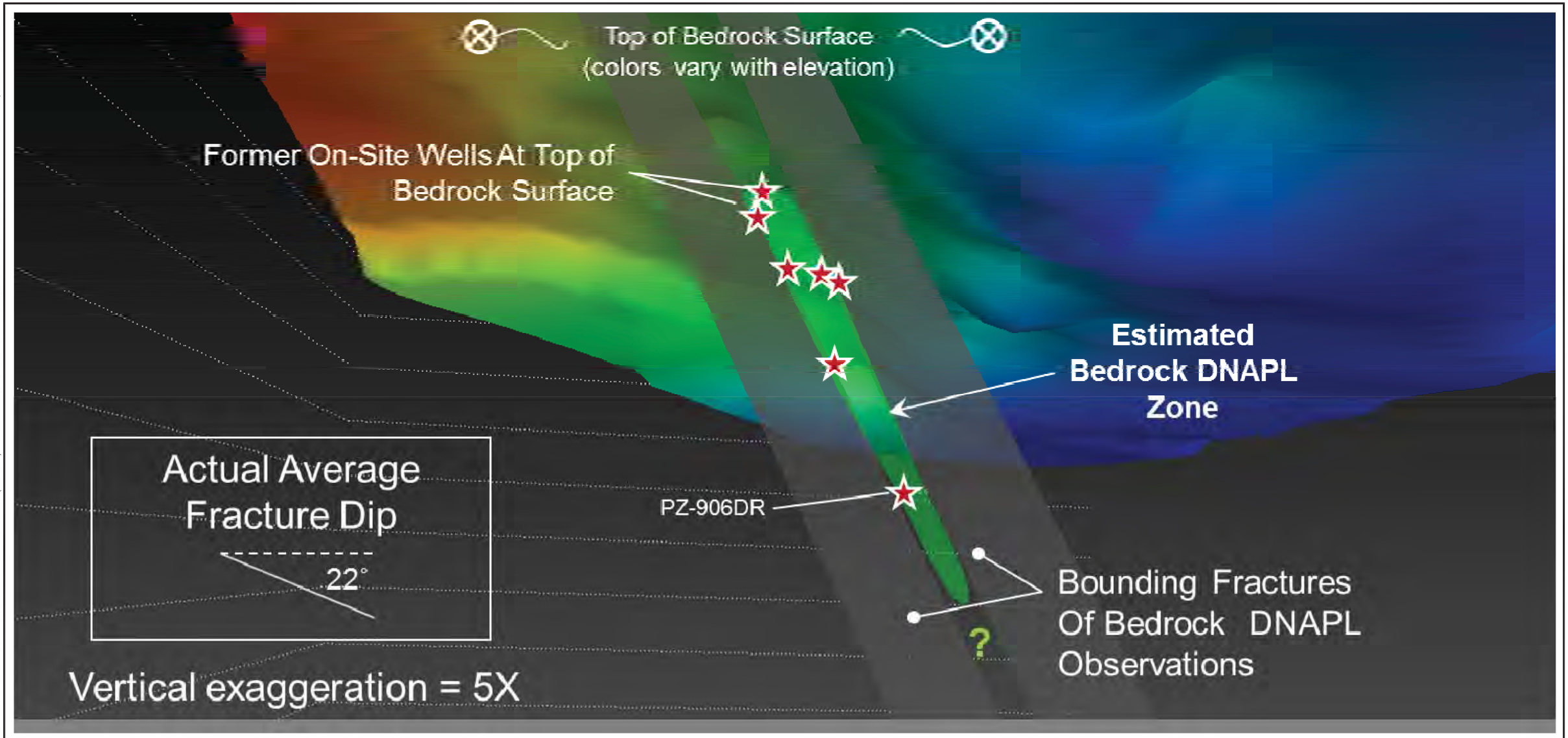

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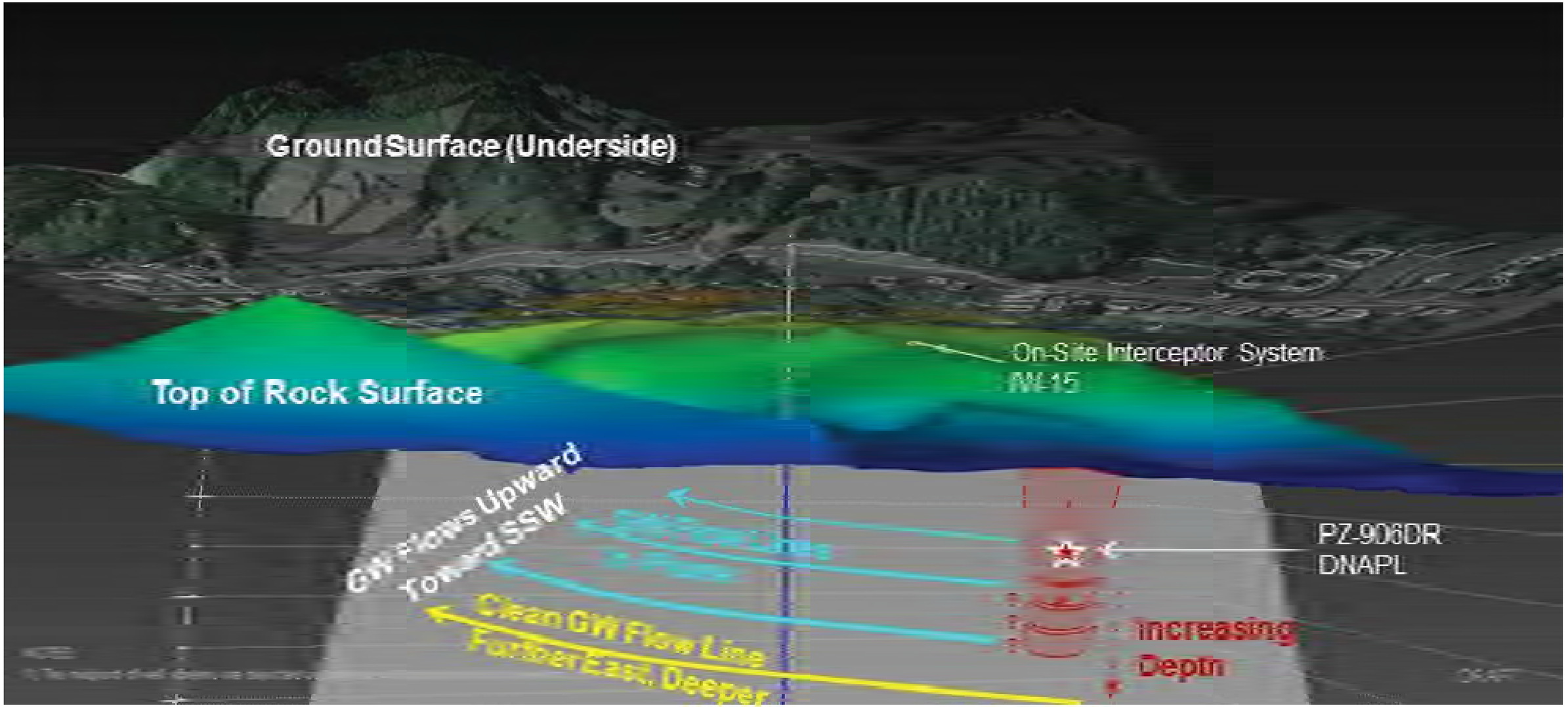
SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

DNAPL OBSERVATIONS IN BEDROCK AND AVERAGE FRACTURE DIP

ARCADIS

FIGURE
2-2



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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

DNAPL AND PLUME ASSESSMENT CHALLENGE EVS MODEL – LOOKING WEST, IN UPDIP DIRECTION

ARCADIS

FIGURE
2-3

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJPOSENAUER LD:(Opt) PIC: G.CAMERON PM: J.HOLDEN TM: J.HOLDEN LYR:(Opt)ON=*;OFF=*REF*
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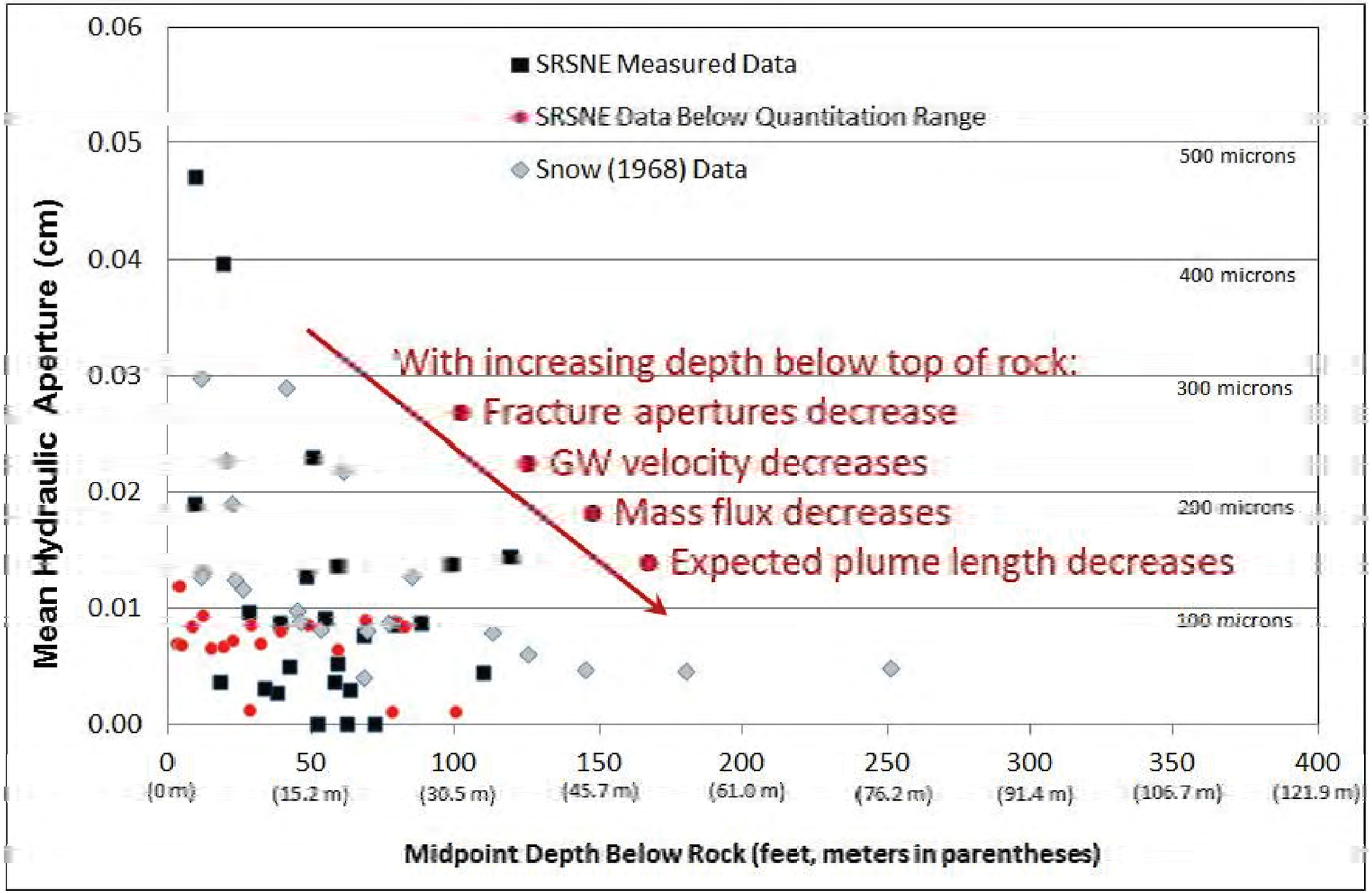

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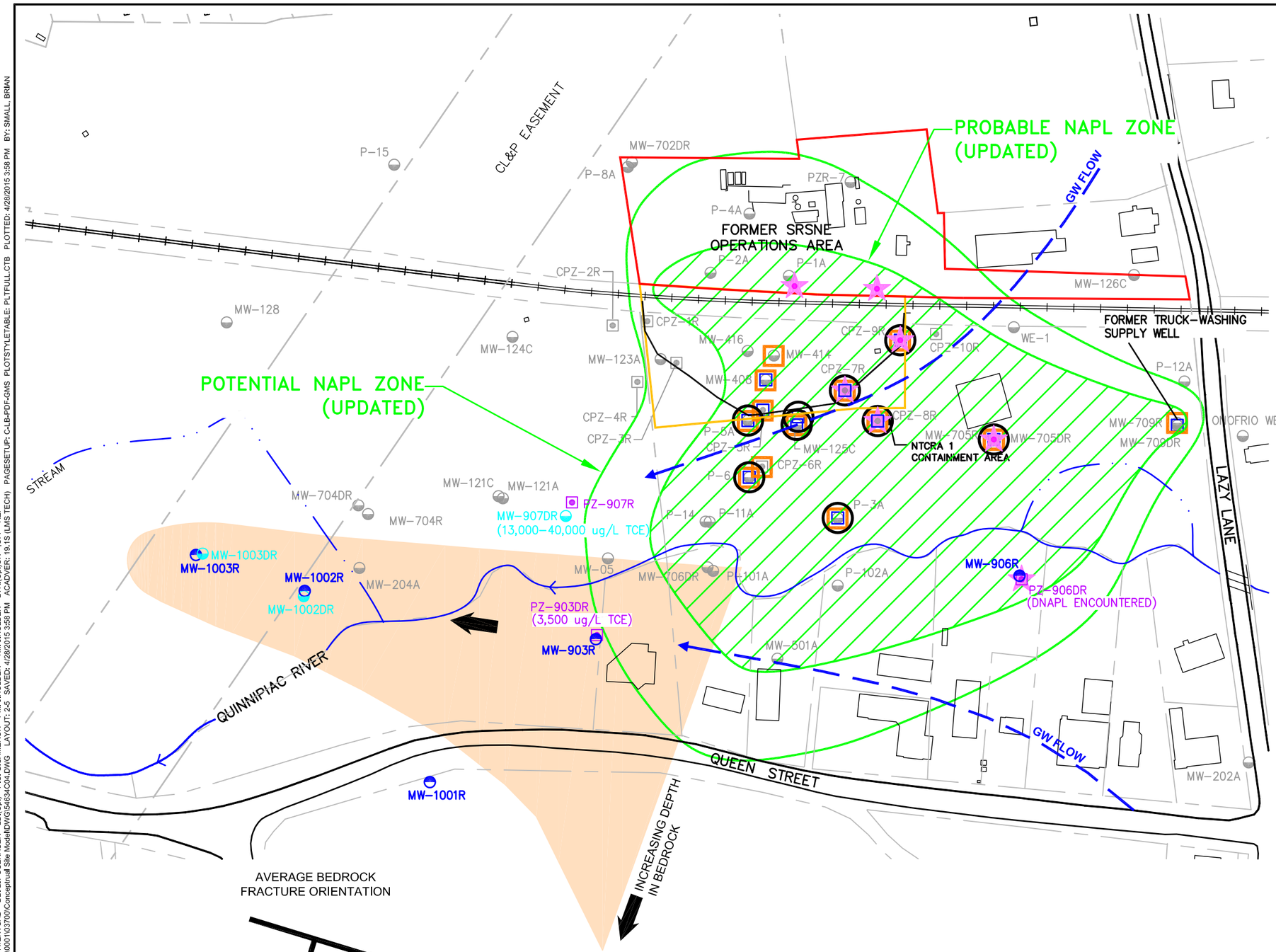
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

FRACTURE HYDRAULIC APERTURE VERSUS DEPTH

ARCADIS

FIGURE
2-4



LEGEND:

- GROUNDWATER SAMPLE WITH VOCs DETECTED >10% OF EFFECTIVE SOLUBILITY (MATHEMATICAL AND/OR EMPIRICAL EVALUATION)
- GROUNDWATER SAMPLING LOCATION WITH VOCs DETECTED >1% OF EFFECTIVE SOLUBILITY (MATHEMATICAL EVALUATION)
- GROUNDWATER SAMPLE WITH COMPOUNDS DETECTED >1% OF EMPIRICAL SOLUBILITY
- GROUNDWATER SAMPLING LOCATION WITH ALCOHOLS DETECTED
- OTHER LOCATIONS WHERE NAPL VISUALLY DETECTED BY SHEEN OR POSITIVE HYDROPHOBIC DYE TEST
- BEDROCK MONITORING WELL (PRE-RD/RA)
- BEDROCK PIEZOMETER (PRE-RD/RA)
- SHALLOW BEDROCK MONITORING WELL (RD/RA)
- SHALLOW BEDROCK PIEZOMETER (RD/RA)
- DEEP BEDROCK MONITORING WELL (RD/RA)
- DEEP BEDROCK PIEZOMETER (RD/RA)
- NAPL/SHEEN OBSERVED IN BEDROCK, OR AT TOP OF BEDROCK IN FORMER OPERATIONS AREA
- GENERALIZED GROUNDWATER FLOW DIRECTION
- CONCEPTUAL TCE PLUME PATHWAY IN DEEP BEDROCK

0 200' 400'

GRAPHIC SCALE

NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONNECTICUT" DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

BEDROCK PLUME DELINEATION WELLS AND UPDATED BEDROCK NAPL ZONE

ARCADIS

FIGURE
2-5

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJPOSENAUER LD:(Opt) PIC: G.CAMERON PM: J.HOLDEN TM: J.HOLDEN LYR:(Opt)ON=*;OFF=*REF*
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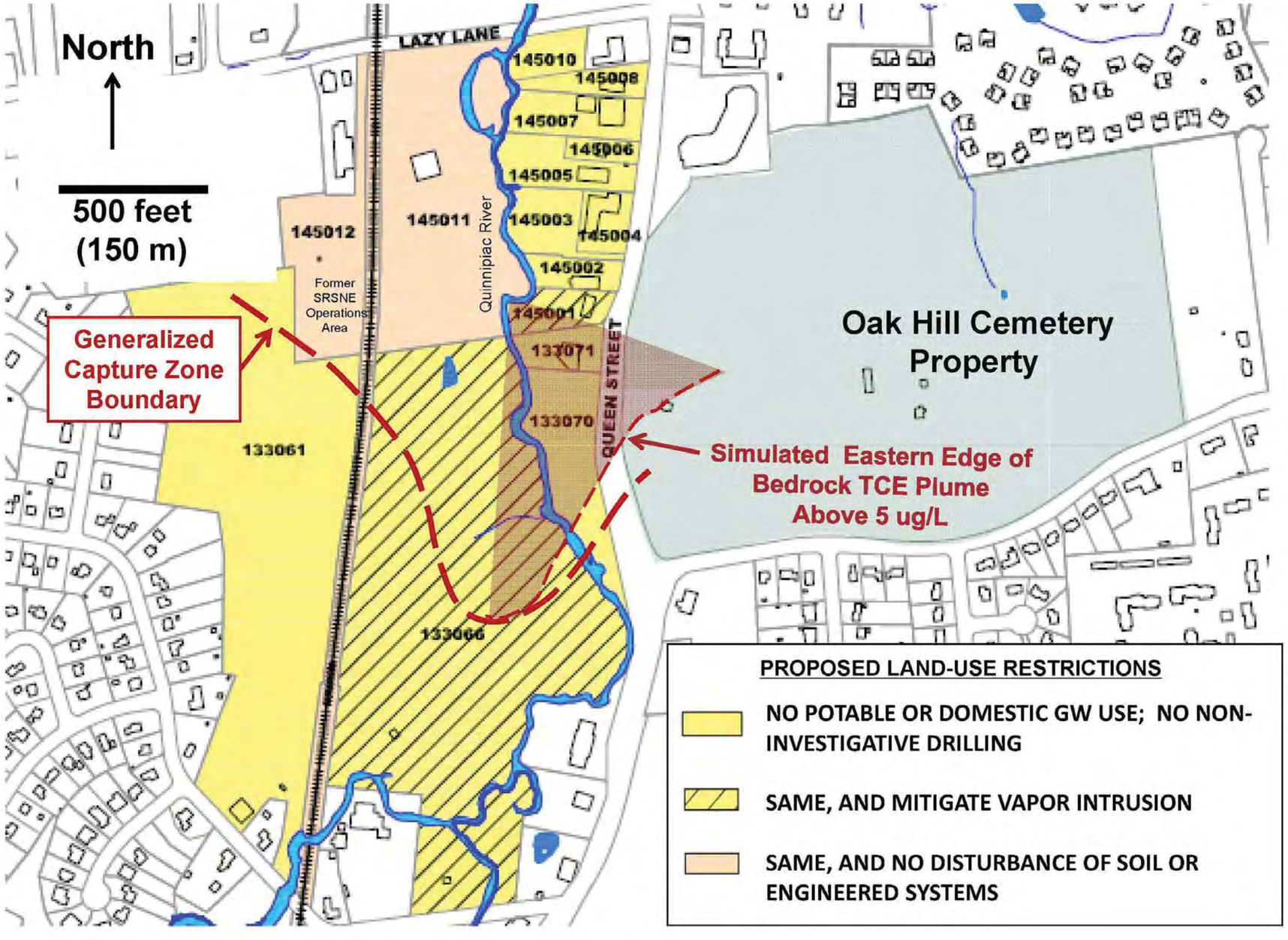
XREFS: 546634X00 546634X01 IMAGES:



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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

LAND USE AND PLANNED DEED RESTRICTIONS

ARCADIS

FIGURE
2-6

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJPOSENAUER LD:(Opt) PIC: G.CAMERON PM: J.HOLDEN TM: J.HOLDEN LYR:(Opt)ON=*;OFF=*REF*
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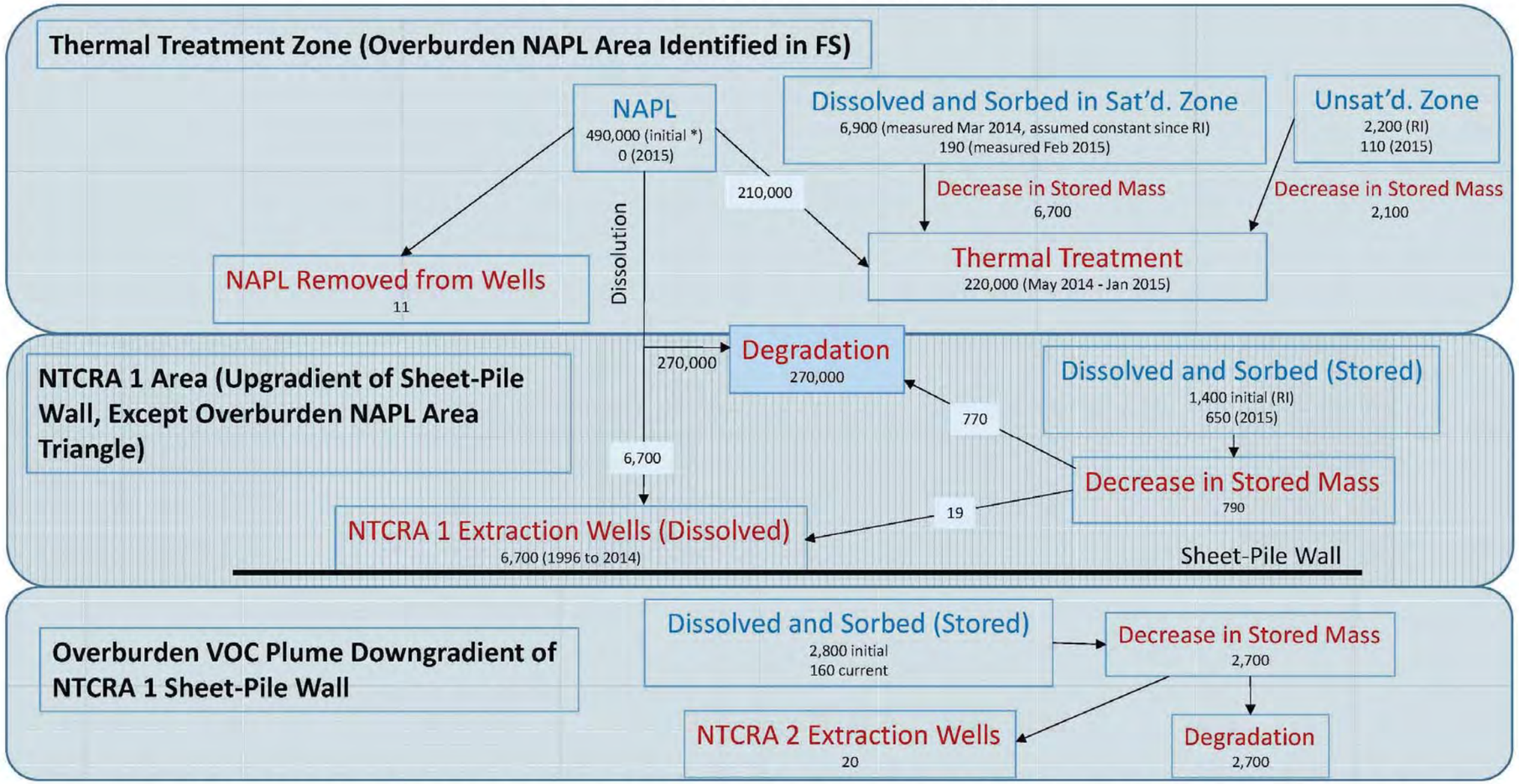
54634X00
IMAGES:
Figure 2-6.jpg

Figure 2-7: Total VOC Mass in Overburden (kg)



Notes: * Initial overburden NAPL mass was back-calculated to time of the RI data collection (1996/1997). Back-calculation is based on measured or estimated TVOC mass removed by thermal remediation, degradation and wells.

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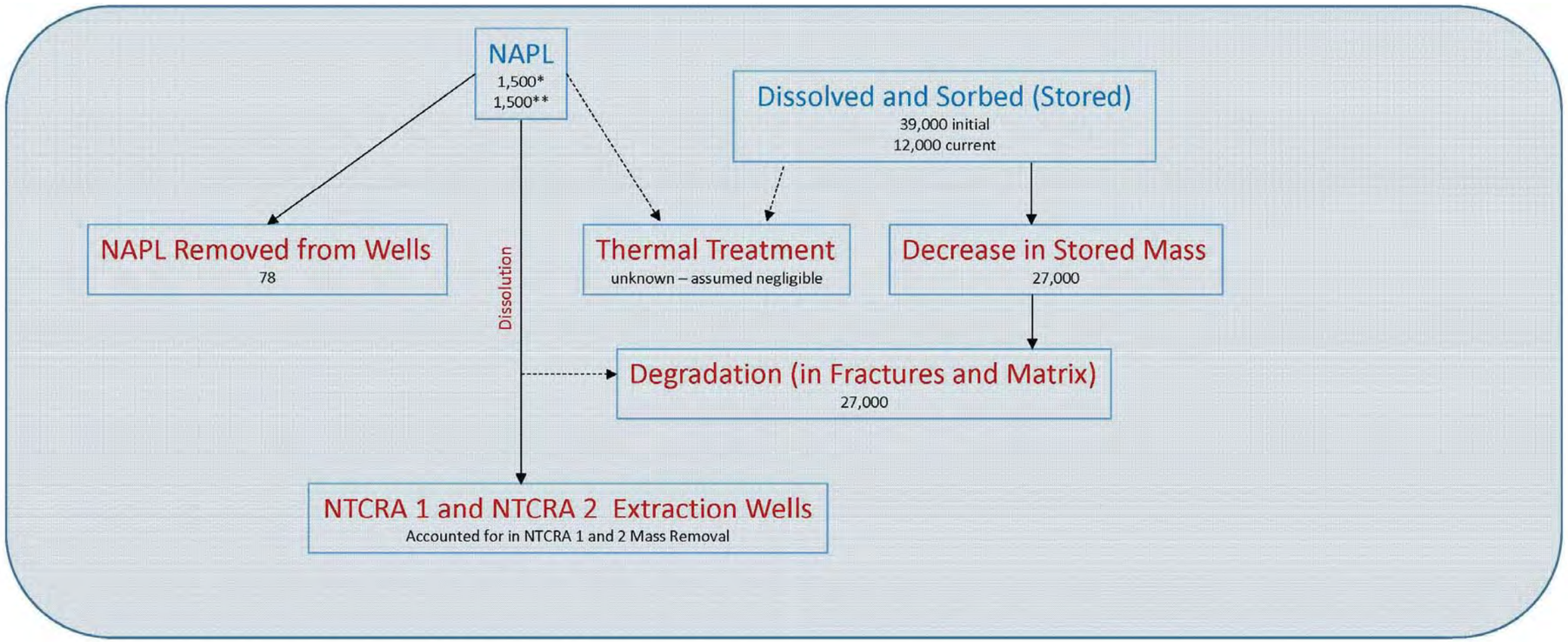
SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

TOTAL VOC MASS IN OVERBURDEN (kg)

ARCADIS

FIGURE
2-7



Notes: * - NAPL mass in bedrock estimated based on site-specific fracture porosity and Longino and Kueper (1999).
** - To be conservative, NAPL mass in bedrock assumed to be unchanged between completion of RI and 2015. NAPL dissolution in bedrock may have been balanced by additional NAPL drainage from overburden prior to thermal treatment of overburden NAPL source zone (completed in 2015).

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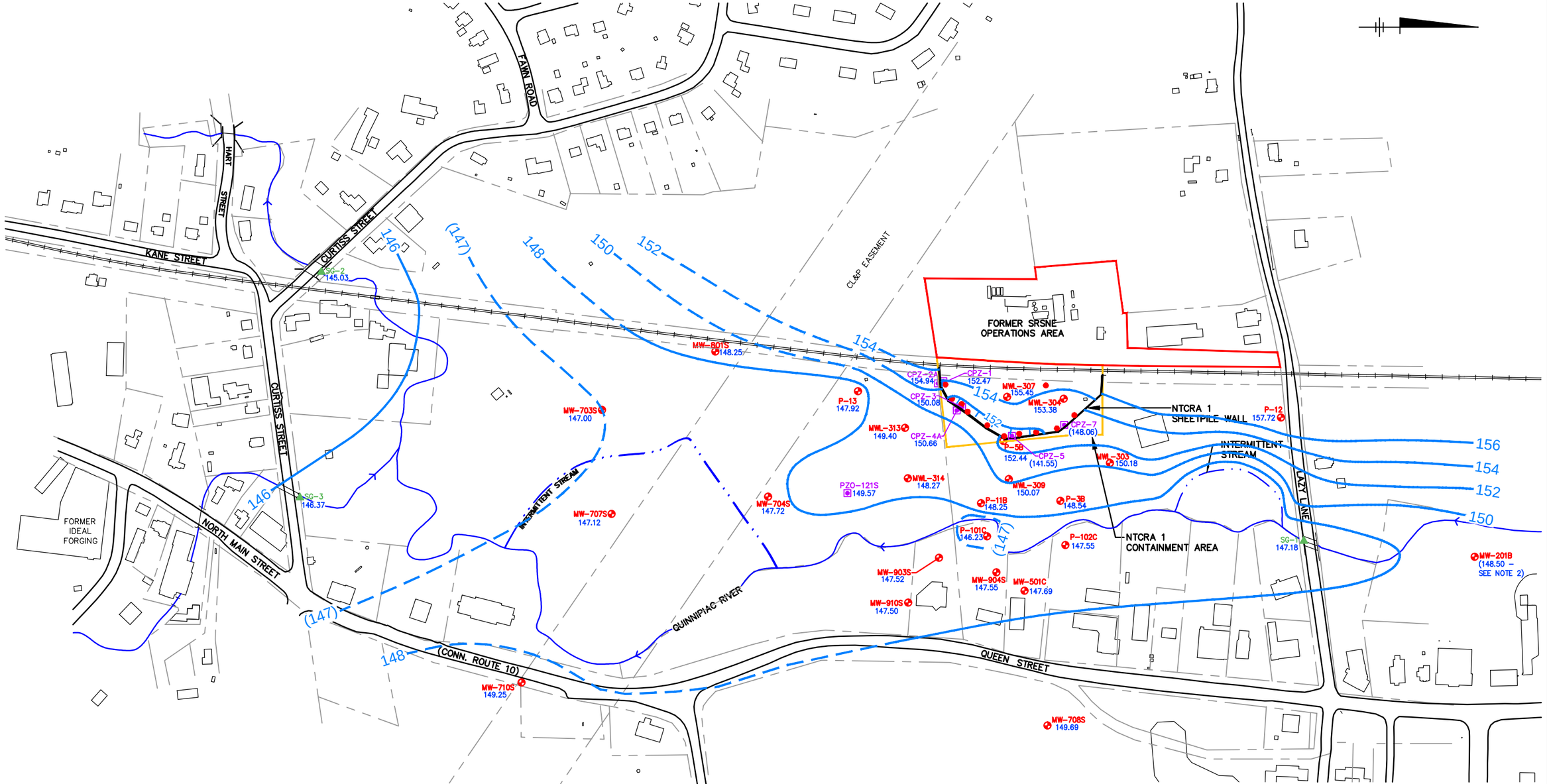
SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

TOTAL VOC MASS IN BEDROCK (kg)

ARCADIS

FIGURE
2-8



NOTES:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.
2. GROUNDWATER ELEVATION AT MW-201B ESTIMATED BASED ON HISTORICAL MEASUREMENTS.
3. HEAD VALUES IN PARENTHESES WERE NOT USED FOR CONTOURING.
4. NTCRA 1 EXTRACTION WELLS WERE NOT INCLUDED IN CONTOURING; GROUNDWATER ELEVATIONS ARE NOT REPRESENTATIVE OF REGIONAL GROUNDWATER CONDITIONS.

LEGEND:

- SHALLOW OVERBURDEN MONITORING WELL
- NTCRA 1 EXTRACTION WELL
- PIEZOMETER
- STREAM/RIVER GAUGE POINT
- 147.50 HYDRAULIC HEAD VALUE
- 154 GROUNDWATER ELEVATION CONTOUR (FT AMSL) (DASHED WHERE INFERRED)
- FT AMSL FEET ABOVE MEAN SEA LEVEL

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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

SHALLOW OVERBURDEN GROUNDWATER ELEVATION CONTOURS JUNE 9, 2014

ARCADIS

FIGURE **3-1**

CITY: SYRACUSE, NY DIV/GROUP: ENV/M-DV DB: P. LISTER PM: J. HOLDEN TM/TR: R. STEVENSON LYR: ON=*;OFF=REF; (FR2)
G:\ENVCAD\Manchester\ACTIB0054634\0001\03700\Conceptual Site Model\DWG\54634C3-1.DWG LAYOUT: 3-1 SAVED: 9/11/2014 11:58 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/20/2015 7:14 AM BY: SMALL, BRIAN
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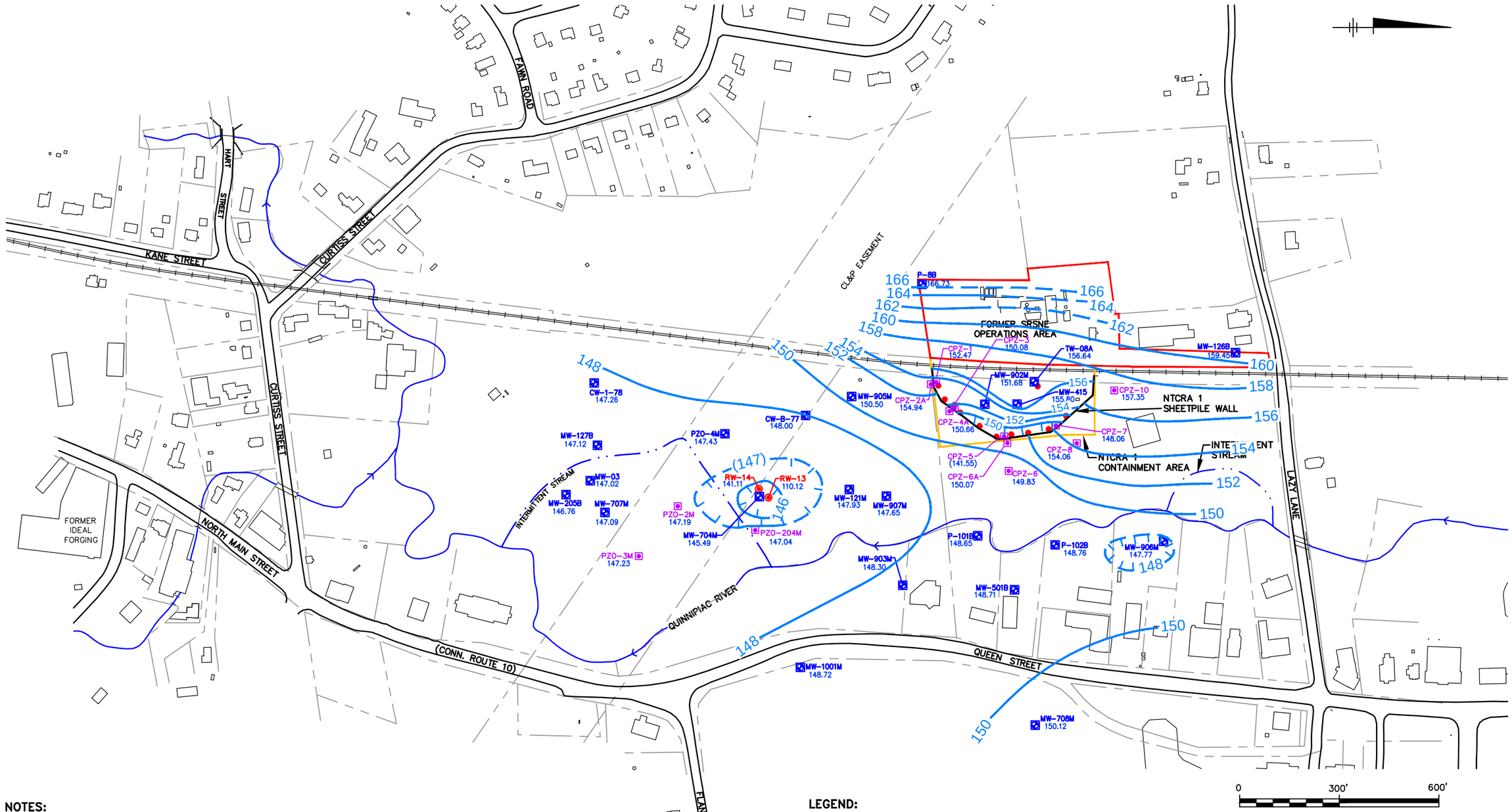

NOTES:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.
2. HEAD VALUES IN PARENTHESES WERE NOT USED FOR CONTOURING.
3. NTCRA 1 EXTRACTION WELLS WERE NOT INCLUDED IN CONTOURING; GROUNDWATER ELEVATIONS ARE NOT REPRESENTATIVE OF REGIONAL GROUNDWATER CONDITIONS.

LEGEND:

- MIDDLE OVERBURDEN MONITORING WELL
- PIEZOMETER
- NTCRA 1 EXTRACTION WELL
- NTCRA 2 EXTRACTION WELL
- 148.71 HYDRAULIC HEAD VALUE
- 154 GROUNDWATER ELEVATION CONTOUR (FT AMSL) (DASHED WHERE INFERRED)
- FT AMSL FEET ABOVE MEAN SEA LEVEL

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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

MIDDLE OVERBURDEN GROUNDWATER ELEVATION CONTOURS JUNE 9, 2014

ARCADIS

FIGURE
3-2

CITY: SYRACUSE, NY DIV/GROUP: ENV/IM-DV DB: P. LISTER PM: J. HOLDEN TM/TR: R. STEVENSON LYR: ON=*;OFF=REF,(FRZ)
G:\ENVCAD\Manchester\ACTIB0054634\0013700\Conceptual Site Model\DWG\54634C3-2.DWG LAYOUT: 3-2 SAVED: 2/20/2015 7:15 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/20/2015 7:15 AM BY: SMALL, BRIAN
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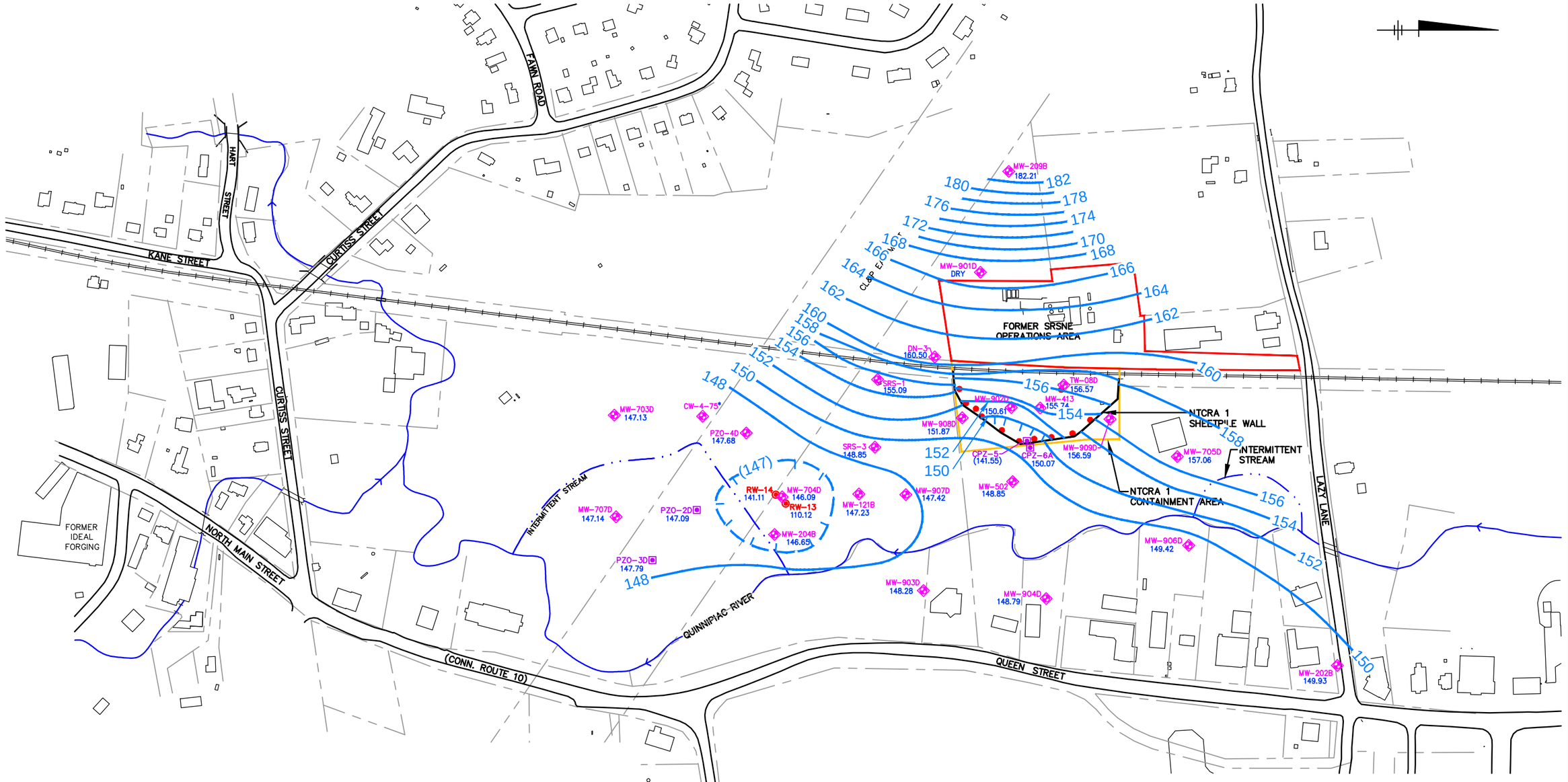

NOTES:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.
2. HEAD VALUES IN PARENTHESES WERE NOT USED FOR CONTOURING.
3. NTCRA 1 EXTRACTION WELLS WERE NOT INCLUDED IN CONTOURING; GROUNDWATER ELEVATIONS ARE NOT REPRESENTATIVE OF REGIONAL GROUNDWATER CONDITIONS.

LEGEND:

- DEEP OVERBURDEN MONITORING WELL
- NTCRA 1 EXTRACTION WELL
- PIEZOMETER
- NTCRA 2 EXTRACTION WELL
- 149.93 HYDRAULIC HEAD VALUE
- 154 GROUNDWATER ELEVATION CONTOUR (FT AMSL) (DASHED WHERE INFERRED)
- FT AMSL FEET ABOVE MEAN SEA LEVEL
- WELL DESTROYED (TO BE ABANDONED)

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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

DEEP OVERBURDEN GROUNDWATER ELEVATION CONTOURS JUNE 9, 2014

ARCADIS

FIGURE
3-3

CITY: SYRACUSE, NY GROUP: ENVCAD DB: P. LISTER PM: M. GEFELL TM: M. GEFELL TR: R. STEVENSON LYR: ON=*;OFF=REF; (FRZ)
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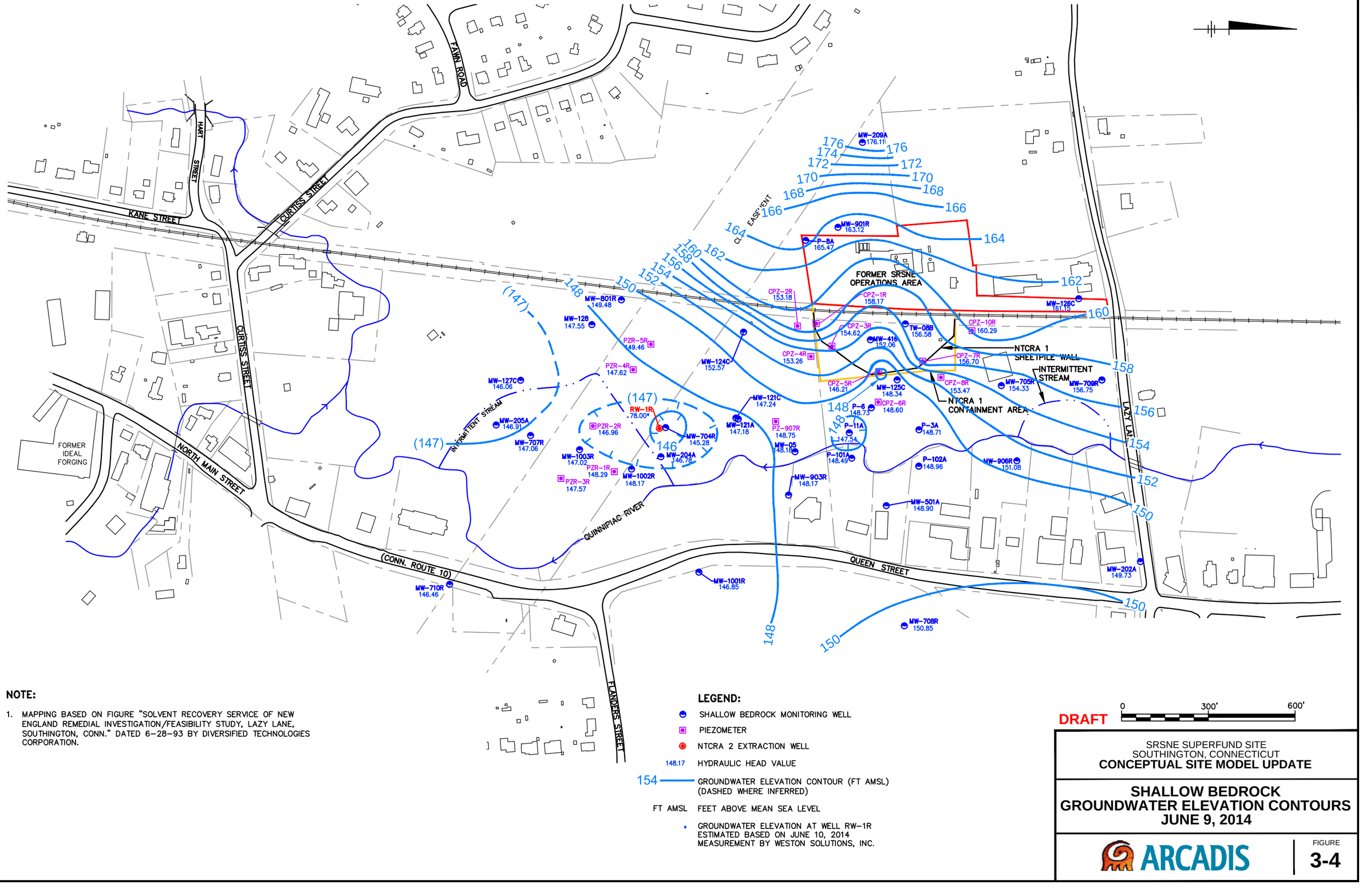

NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- SHALLOW BEDROCK MONITORING WELL
- PIEZOMETER
- NTCRA 2 EXTRACTION WELL
- 148.17 HYDRAULIC HEAD VALUE
- 154 GROUNDWATER ELEVATION CONTOUR (FT AMSL) (DASHED WHERE INFERRED)
- FT AMSL FEET ABOVE MEAN SEA LEVEL
- * GROUNDWATER ELEVATION AT WELL RW-1R ESTIMATED BASED ON JUNE 10, 2014 MEASUREMENT BY WESTON SOLUTIONS, INC.

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0 300' 600'

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

SHALLOW BEDROCK GROUNDWATER ELEVATION CONTOURS JUNE 9, 2014

ARCADIS

FIGURE
3-4

CITY: SYRACUSE, NY DIV/GROUP: ENV/IM-DV DB: P. LISTER PM: J. HOLDEN TM/TR: R. STEVENSON LYR: ON=*;OFF=REF; (FR2)
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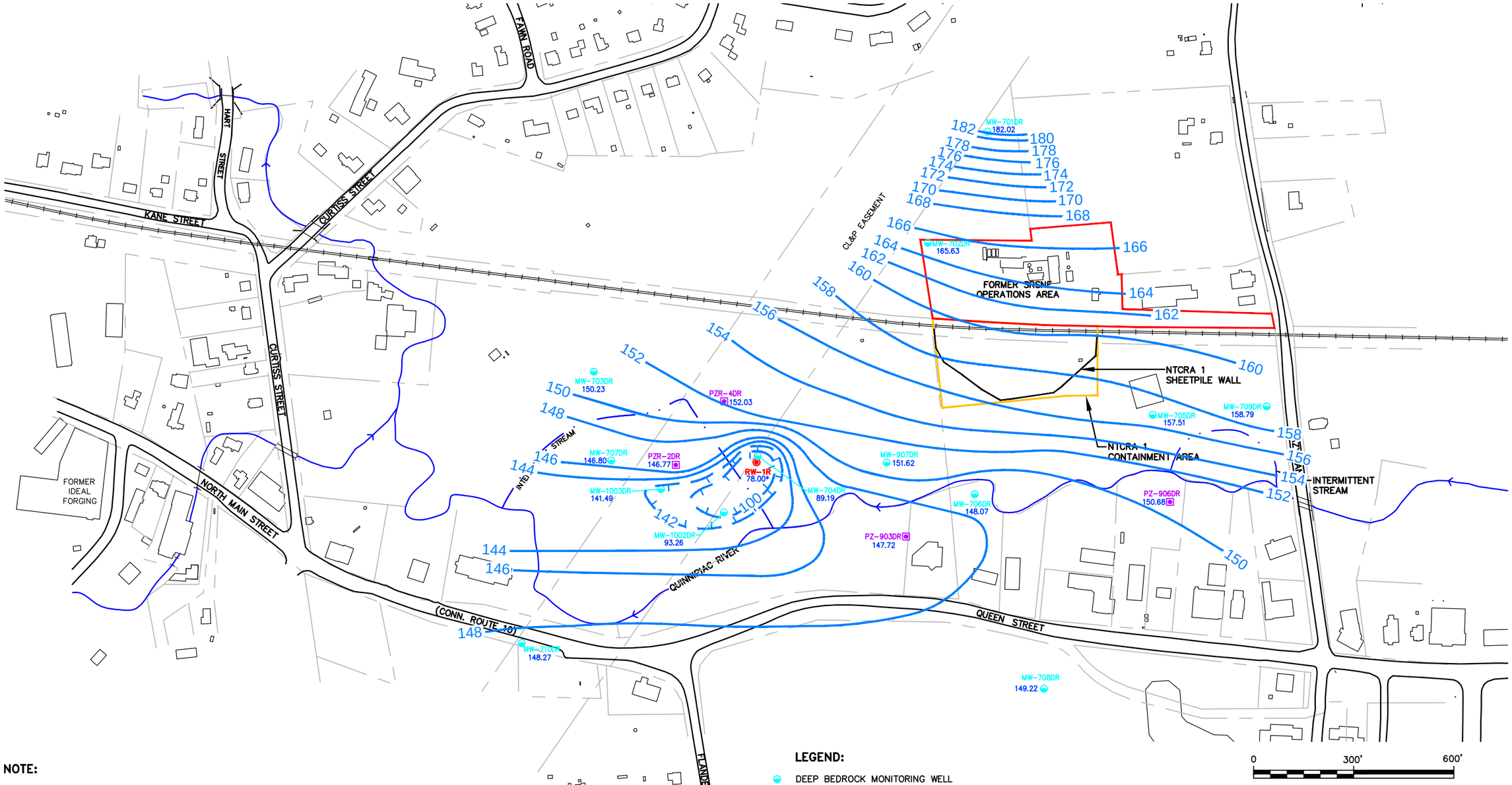


NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- DEEP BEDROCK MONITORING WELL
- NTCRA 2 EXTRACTION WELL
- PIEZOMETER
- 147.72 HYDRAULIC HEAD VALUE
- 154 GROUNDWATER ELEVATION CONTOUR (FT AMSL) (DASHED WHERE INFERRED)
- FT AMSL FEET ABOVE MEAN SEA LEVEL
- GROUNDWATER ELEVATION AT WELL RW-1R ESTIMATED BASED ON JUNE 10, 2014 MEASUREMENT BY WESTON SOLUTIONS, INC.

DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

DEEP BEDROCK GROUNDWATER ELEVATION CONTOURS JUNE 9, 2014

ARCADIS

FIGURE
3-5

CITY: SYRACUSE, NY DIV/GROUP: ENV/IM-DV DB: P. LISTER PM: J. HOLDEN TM/TR: R. STEVENSON LYR: ON=*;OFF=REF; (FRZ)
G:\ENVCAD\Manchester\ACTIB\00546340001\03700\Conceptual Site Model\DWG\54634C3-5.DWG LAYOUT: 3-5 SAVED: 9/11/2014 2:51 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/20/2015 7:17 AM BY: SMALL, BRIAN
XREFS: IMAGES: PROJECTNAME: ----
54634X01

CROSS SECTION A-A'

HORIZONTAL SCALE: 300' 0 300'

WEST A — EAST A'

ELEVATION IN FEET

240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50

PZO-6 PZR-6 — NS DRY — NS 206.2 — TILL — NS 182.21 — MW-209B MW-209A MW-701DR — NS 176.11 — NS 182.02 — BEDROCK

MW-901D MW-901R — NS DRY — NS 163.12 — SRSNE OPERATIONS AREA

TW-08A, TW-08D — MW-415 MW-413 — CONTAINMENT AREA

CPZ-5, CPZ-5R — P-5B, P-5A — NE 152.44 — MW-502, P-6 — SHEET PILE WALL

P-11B, P-14, P-11A — P-101C, P-101B, P-101A, MW-706DR — QUINNIPIAC RIVER

MW-904S — NE 147.55 — MW-501C MW-501B MW-904D MW-501A — NE* 147.69

KAME TERRACE? — MW-708S MW-708M MW-708R MW-708DR — NS 149.69 — OUTWASH

3,820V (214D) 156.64 — 9,700V (418D) 156.57 — 58,600T (7,000V) 156.58 — 6,100V (190D) 155.74

157V (24.0G) 153.80 — 213V (23.9D) 141.55 — 186T (66.5V) 146.21 — NS 148.6

NE 148.25 — 920F (0.01D) 148.85 — 4,087F (206B) 148.73 — NS 148.6

3.14V (2.48B) 146.23 — 4.28B (0.75F) 148.65 — 0.55T (0.09P) 148.71 — 0.36T (0.08P) 148.79 — 0.95T (0.09P) 148.90 — TILL

580V (177T) 147.54 — 4.55V (3.43B) 148.49 — 938T (38.6P) 148.07 — BEDROCK

NS 150.12 — NS 150.85 — NS 149.22

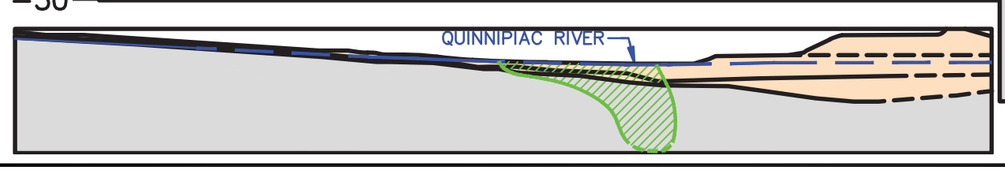
50 — 145 — 148 — 150 — 155 — 160 — 170 — 180 — 190 — 200

ESTIMATED EXTENT OF REGULATORY VOC PLUME IN GROUNDWATER

400' 0 400'

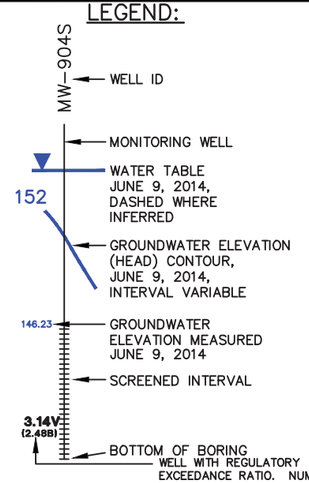
CROSS SECTION A-A'

WITH NO VERTICAL EXAGGERATION
HORIZONTAL SCALE:



XREF: 08331X01,08331X02.DWG
P:CSA2.PCP OR CXE.PCP
7/5/02 SYR-54-DMW,AK,PGL
08331004/08331CA2.DWG

LEGEND:

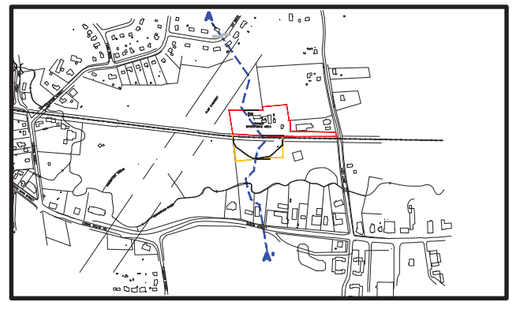


B BENZENE
D 1,2-DICHLOROETHENE
F TETRAHYDROFURAN
G CHLOROETHANE
P TETRACHLOROETHENE
T TRICHLOROETHENE
V VINYL CHLORIDE
NS NOT SAMPLED
NE EXCEEDANCE RATIO LESS THAN 0.10
* NO DETECTIONS ABOVE INTERIM CLEANUP LEVELS (ICLs) AT THIS LOCATION

WELL WITH REGULATORY EXCEEDANCE RATIO. NUMBERS >1.0 INDICATE GROUNDWATER REGULATORY LIMIT EXCEEDED. NUMBERS <1.0 INDICATE EXCEEDANCE RATIO FOR COMPOUNDS DETECTED BELOW REGULATORY LIMIT. FIRST NUMBER INDICATES MAXIMUM MULTIPLE OF A DETECTED VOC OVER REGULATORY LIMIT (e.g., 130 INDICATES 130 x LIMIT). LETTER INDICATES COMPOUND WITH INDICATED EXCEEDANCE RATIO (e.g., P = TETRACHLOROETHENE). NUMBERS IN PARENTHESES INDICATE OTHER EXCEEDANCE RATIOS FOR SELECT COMPOUNDS AND WELLS. COMPOUNDS DETECTED IN BLANK(S) ARE NOT INCLUDED IN THIS EVALUATION

NOTE:

1. POSTED DATA FOR WELLS IN THE CURRENT MONITORING WELL NETWORK ARE THE LATEST SAMPLING RESULTS AT EACH WELL, AS OF JUNE 2014.
2. ESTIMATED WATER LEVEL DATA SHOWN FOR PZR-6, P-5A, AND P-14 WERE MEASURED DURING THE REMEDIAL INVESTIGATION (RI, JULY 1997).



LOCATION MAP

1500' 0 1500'

DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

GEOLOGIC CROSS SECTION A-A' WITH HEAD CONTOURS AND REGULATORY PLUME

ARCADIS

FIGURE 3-6

SOUTH B

B' NORTH

ELEVATION IN FEET

FORMER IDEAL FORGING PROPERTY

TOWN WELL FIELD PROPERTY

FORMER CIANCI PROPERTY

DARLING STREET

NORTH MAIN STREET

CURTISS STREET

TRIBUTARY STREAM

QUINNIPIAC RIVER

INTERMITTENT STREAM

LAZY LANE

W-7 W-8 W-4 (PROJECTED) MW-208A MW-206B MW-206A MW-205B MW-205A MW-707S MW-707M MW-707D MW-707DR MW-1003R MW-1003DR PZO-2M PZO-2D PZO-2DR MW-704S MW-704M MW-704D MW-704R MW-704DR PZO-121S MW-121M MW-121B MW-121C MW-121A MW-907M MW-907D MW-907R MW-907DR MW-06 MW-05 P-101C P-101B P-101A MW-706DR P-102C P-102B P-102A DP-4 MW-906M MW-906R PZ-906DR P-7 MW-709R MW-709DR TW-12

OUTWASH

GRAVELLY DRIFT

SILTY TILL

BEDROCK

3,100P 5.4P (150T, 6.0R)

3.2P (2.0T)

0.11T 147.12

3.54T (1.73P) 147.19

0.37T (0.01D) 147.09

0.46B (0.12T) 147.02

0.28T (0.01D) 147.06

0.17B 146.80

10.8T (0.93P) 141.49

0.70F (0.15G) 145.49

4.13F (2.31G) 147.93

689F (51.2B) 147.65

1.06F 148.09

32.4F 147.23

0.38B 145.28

2.59B (1.43G) 89.19

2.16B (1.17F) 147.18

10.2B (8.83F) 147.24

120F (0.07T) 147.42

19.7F (7.85B) 148.18

ND 148.75

10,860T (990P) 151.62

3.14V (2.48B) 148.4

4.26B (0.75F) 148.65

4.55V (3.43B) 148.49

938T (38.6P) 148.07

5.10T (1.13D) 148.78

1.41V (0.99T) 148.96

3.18T (0.55P) 149.42

2.16T (1.25P) 147.77

34.4T (1.74P) 151.08

DNAPL

850T (62.0V) 158.79

24.4T (9.00V) 156.75

NS 147.4

NS 146.2

NS 146.91

NS 149.57

NS 149.14

NS 149.03

NS 110.12

NS 108.38

NE* 147.72

NE* 146.76

NE* 147.09

NE* 147.14

NE* 146.96

NE* 146.77

NE* 147.55

NS 148.3

NS 156.5

NS 156.6

NS 156.0

148

147

146

155

150

1981 SAMPLING RESULTS FROM FORMER IDEAL FORGING PROPERTY AFTER: CWA, JULY 31, 1981; AND CWA, OCTOBER 22, 1981

ESTIMATED HCTS CAPTURE ZONE BOUNDARY

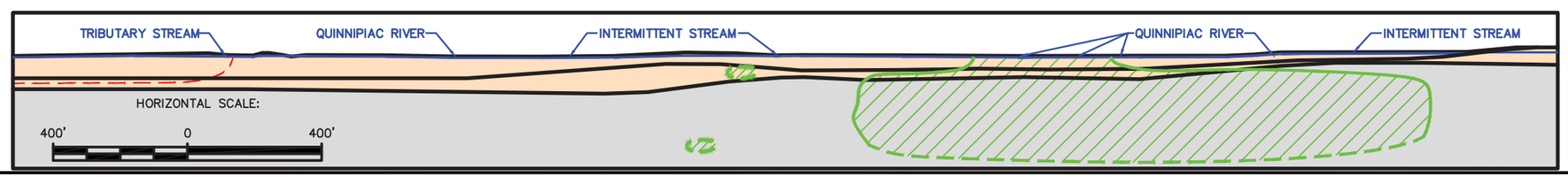
ESTIMATED EXTENT OF REGULATORY VOC PLUME IN GROUNDWATER

CROSS SECTION B-B'

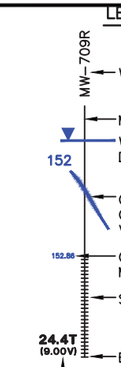
HORIZONTAL SCALE:

400' 0 400'

CROSS SECTION B-B' WITH NO VERTICAL EXAGGERATION



LEGEND

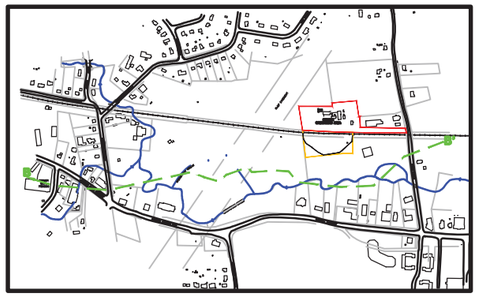


WELL WITH REGULATORY EXCEEDANCE RATIO. NUMBERS >1.0 INDICATE GROUNDWATER REGULATORY LIMIT EXCEEDED. NUMBERS <1.0 INDICATE EXCEEDANCE RATIO FOR COMPOUNDS DETECTED BELOW REGULATORY LIMIT. FIRST NUMBER INDICATES MAXIMUM MULTIPLE OF A DETECTED VOC OVER REGULATORY LIMIT (e.g., 130 INDICATES 130 x LIMIT). LETTER INDICATES COMPOUND WITH INDICATED EXCEEDANCE RATIO (e.g., P = TETRACHLOROETHENE). NUMBERS IN PARENTHESES INDICATE OTHER EXCEEDANCE RATIOS FOR SELECT COMPOUNDS AND WELLS. COMPOUNDS DETECTED IN BLANK(S) ARE NOT INCLUDED IN THIS EVALUATION

B	BENZENE
D	1,2-DICHLOROETHENE
F	TETRAHYDROFURAN
G	CHLOROETHANE
P	TETRACHLOROETHENE
T	TRICHLOROETHENE
V	VINYL CHLORIDE
NS	NOT SAMPLED
NE	EXCEEDANCE RATIO LESS THAN 0.10
*	NO DETECTIONS ABOVE INTERIM CLEANUP LEVELS (ICLs) AT THIS LOCATION

NOTE:

1. POSTED DATA FOR WELLS IN THE CURRENT MONITORING WELL NETWORK ARE THE LATEST SAMPLING RESULTS AT EACH WELL, AS OF JUNE 2014.
2. ESTIMATED WATER LEVEL DATA SHOWN FOR MW-208A, MW-206A, MW-206B, MW-06, DP-4, P-7, AND TW-12 WERE MEASURED DURING THE REMEDIAL INVESTIGATION (RI, JULY 1997). WATER LEVEL AT PZ-906DR IS SLOWLY RECOVERING – ESTIMATED STATIC LEVEL SHOWN.



LOCATION MAP

1500' 0 1500'

DRAFT

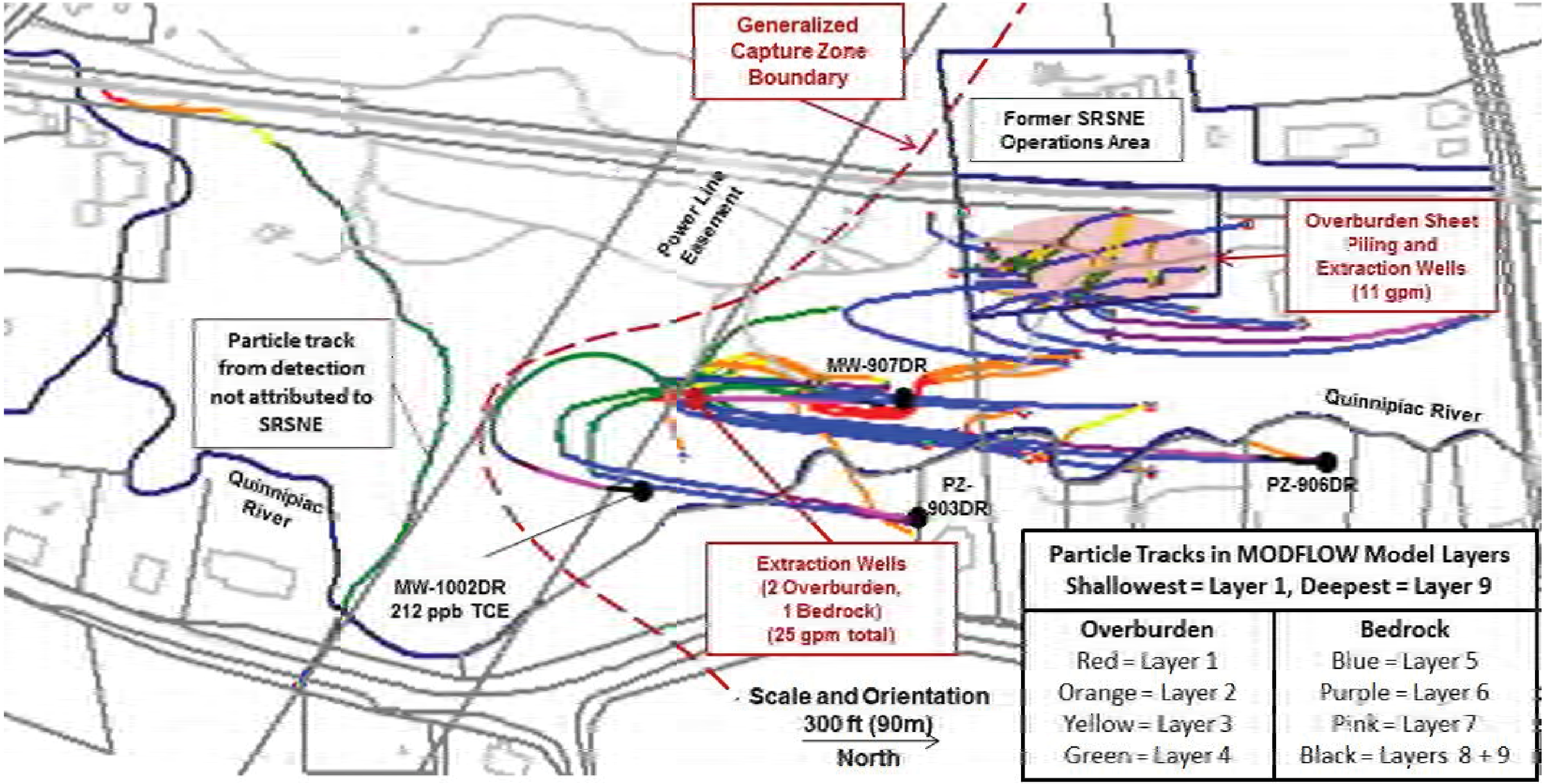
SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

GEOLOGIC CROSS SECTION B-B' WITH HEAD CONTOURS AND REGULATORY PLUME

ARCADIS

FIGURE 3-7

CITY: MANCHESTER DIV/GROUP: ENVCAD DB: B.SMALL PM: TM:
G:\ENVCAD\Manchester\ACT\B0054634\0001\03700\Conceptual Site Model\DWG\Cross Sections\54634V3-7.dwg LAYOUT: 3-7 SAVED: 2/20/2015 11:44 AM BY: SMALL, BRIAN
5 11:44 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/20/2015 11:50 AM BY: SMALL, BRIAN



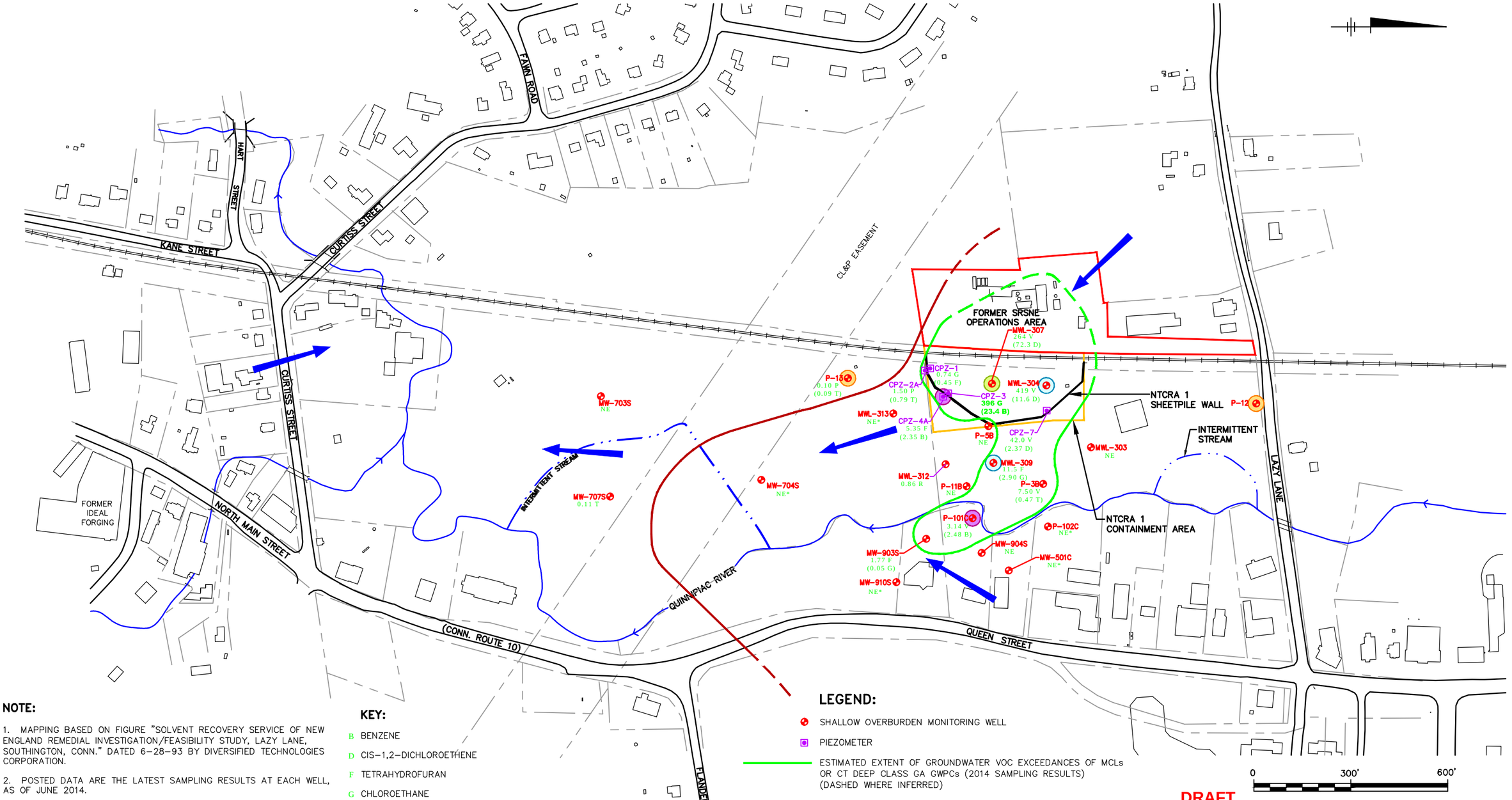
DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

MODPATH PARTICLE TRACKS FROM WELLS WITH VOCS ABOVE DRINKING WATER STANDARDS AND SIMULATED CAPTURE ZONE OF HYDRAULIC CONTAINMENT SYSTEM

ARCADIS

FIGURE
3-8



DRAFT

NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

2. POSTED DATA ARE THE LATEST SAMPLING RESULTS AT EACH WELL, AS OF JUNE 2014.

REDOX CONDITIONS:

- MILDLY REDUCING
- MODERATELY REDUCING
- STRONGLY REDUCING
- VERY STRONGLY REDUCING

KEY:

- B BENZENE
- D CIS-1,2-DICHLOROETHENE
- F TETRAHYDROFURAN
- G CHLOROETHANE
- N ACETONE
- P TETRACHLOROETHENE
- R TRANS-1,3-DICHLOROPROPENE
- T TRICHLOROETHENE
- V VINYL CHLORIDE
- NE EXCEEDANCE RATIO LESS THAN 0.10

LEGEND:

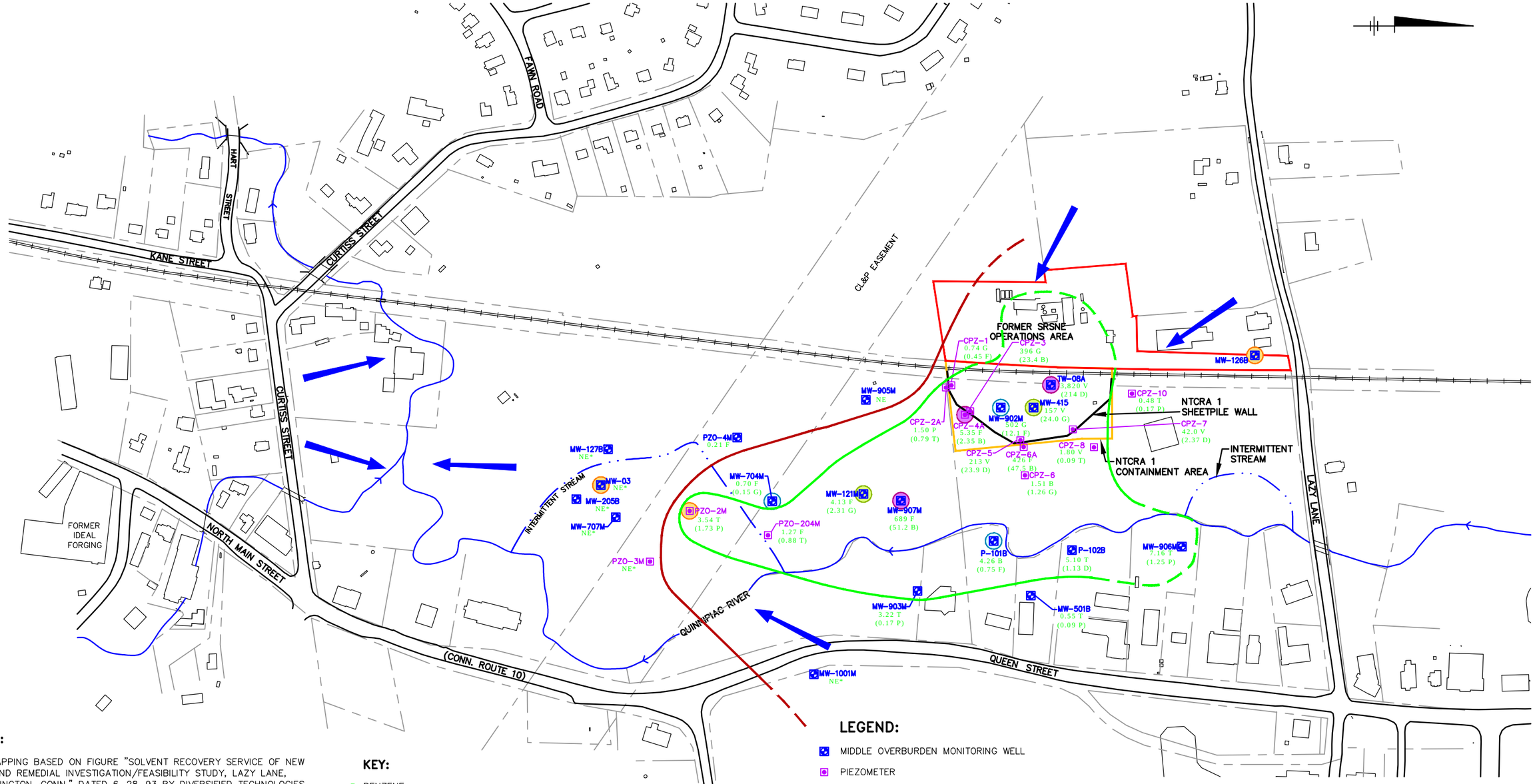
- SHALLOW OVERBURDEN MONITORING WELL
- PIEZOMETER
- ESTIMATED EXTENT OF GROUNDWATER VOC EXCEEDANCES OF MCLs OR CT DEEP CLASS GA GWPCs (2014 SAMPLING RESULTS) (DASHED WHERE INFERRED)
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- GENERALIZED GROUNDWATER FLOW DIRECTION
- P-101C 3.14 V (2.48 B) — WELL WITH REGULATORY EXCEEDANCE RATIO. NUMBERS >1.0 INDICATE GROUNDWATER REGULATORY LIMIT EXCEEDED. NUMBERS <1.0 INDICATE EXCEEDANCE RATIO FOR COMPOUNDS DETECTED BELOW REGULATORY LIMIT. FIRST NUMBER INDICATES MAXIMUM MULTIPLE OF A DETECTED VOC OVER REGULATORY LIMIT (e.g., 130 INDICATES 130 x LIMIT). LETTER INDICATES COMPOUND WITH INDICATED EXCEEDANCE RATIO (e.g., P = TETRACHLOROETHENE). NUMBERS IN PARENTHESES INDICATE OTHER EXCEEDANCE RATIOS FOR SELECT COMPOUNDS AND WELLS. COMPOUNDS DETECTED IN BLANK(S) ARE NOT INCLUDED IN THIS EVALUATION.
- * NO DETECTIONS ABOVE INTERIM CLEANUP LEVELS (ICLs) AT THIS LOCATION.

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

VOC EXCEEDANCE PLUME SHALLOW OVERBURDEN

ARCADIS

FIGURE
4-1



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

2. POSTED DATA ARE THE LATEST SAMPLING RESULTS AT EACH WELL, AS OF JUNE 2014.

REDOX CONDITIONS:

- MILDLY REDUCING
- MODERATELY REDUCING
- STRONGLY REDUCING
- VERY STRONGLY REDUCING

KEY:

- B BENZENE
- D CIS-1,2-DICHLOROETHENE
- F TETRAHYDROFURAN
- G CHLOROETHANE
- P TETRACHLOROETHENE
- T TRICHLOROETHENE
- V VINYL CHLORIDE
- NE EXCEEDANCE RATIO LESS THAN 0.10

LEGEND:

- MIDDLE OVERBURDEN MONITORING WELL
- PIEZOMETER
- ESTIMATED EXTENT OF GROUNDWATER VOC EXCEEDANCES OF MCLs OR CT DEEP CLASS GA GWPCs (2014 SAMPLING RESULTS) (DASHED WHERE INFERRED)
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- GENERALIZED GROUNDWATER FLOW DIRECTION
- MW-903M 3.22 T (0.17 P) WELL WITH REGULATORY EXCEEDANCE RATIO. NUMBERS >1.0 INDICATE GROUNDWATER REGULATORY LIMIT EXCEEDED. NUMBERS <1.0 INDICATE EXCEEDANCE RATIO FOR COMPOUNDS DETECTED BELOW REGULATORY LIMIT. FIRST NUMBER INDICATES MAXIMUM MULTIPLE OF A DETECTED VOC OVER REGULATORY LIMIT (e.g., 130 INDICATES 130 x LIMIT). LETTER INDICATES COMPOUND WITH INDICATED EXCEEDANCE RATIO (e.g., P = TETRACHLOROETHENE). NUMBERS IN PARENTHESES INDICATE OTHER EXCEEDANCE RATIOS FOR SELECT COMPOUNDS AND WELLS. COMPOUNDS DETECTED IN BLANK(S) ARE NOT INCLUDED IN THIS EVALUATION.
- * NO DETECTIONS ABOVE INTERIM CLEANUP LEVELS (ICLs) AT THIS LOCATION.

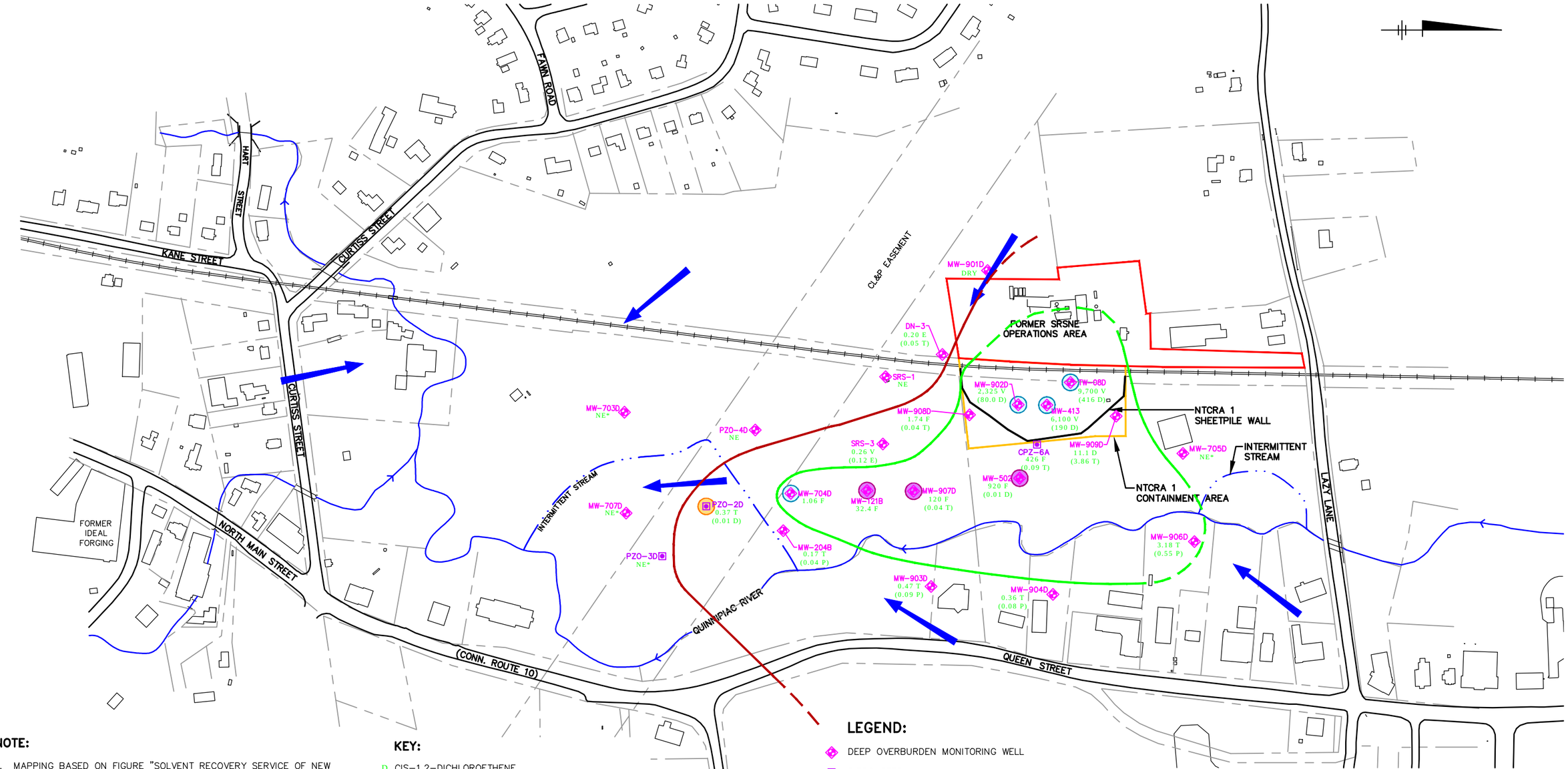
DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

VOC EXCEEDANCE PLUME MIDDLE OVERBURDEN

ARCADIS

FIGURE
4-2



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6–28–93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

2. POSTED DATA ARE THE LATEST SAMPLING RESULTS AT EACH WELL, AS OF JUNE 2014.

REDOX CONDITIONS:

- MILDLY REDUCING
- STRONGLY REDUCING
- VERY STRONGLY REDUCING

KEY:

- D CIS–1,2–DICHLOROETHENE
- E 1,1–DICHLOROETHANE
- F TETRAHYDROFURAN
- P TETRACHLOROETHENE
- T TRICHLOROETHENE
- V VINYL CHLORIDE
- NE EXCEEDANCE RATIO LESS THAN 0.10

LEGEND:

- DEEP OVERBURDEN MONITORING WELL
- PIEZOMETER
- ESTIMATED EXTENT OF GROUNDWATER VOC EXCEEDANCES OF MCLs OR CT DEEP CLASS GA GWPCs (2014 SAMPLING RESULTS) (DASHED WHERE INFERRED)
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- GENERALIZED GROUNDWATER FLOW DIRECTION
- MW-502 920 F (0.01 D) — WELL WITH REGULATORY EXCEEDANCE RATIO. NUMBERS >1.0 INDICATE GROUNDWATER REGULATORY LIMIT EXCEEDED. NUMBERS <1.0 INDICATE EXCEEDANCE RATIO FOR COMPOUNDS DETECTED BELOW REGULATORY LIMIT. FIRST NUMBER INDICATES MAXIMUM MULTIPLE OF A DETECTED VOC OVER REGULATORY LIMIT (e.g., 130 INDICATES 130 x LIMIT). LETTER INDICATES COMPOUND WITH INDICATED EXCEEDANCE RATIO (e.g., P = TETRACHLOROETHENE). NUMBERS IN PARENTHESES INDICATE OTHER EXCEEDANCE RATIOS FOR SELECT COMPOUNDS AND WELLS. COMPOUNDS DETECTED IN BLANK(S) ARE NOT INCLUDED IN THIS EVALUATION.
- * NO DETECTIONS ABOVE INTERIM CLEANUP LEVELS (ICLs) AT THIS LOCATION.

0 300' 600'

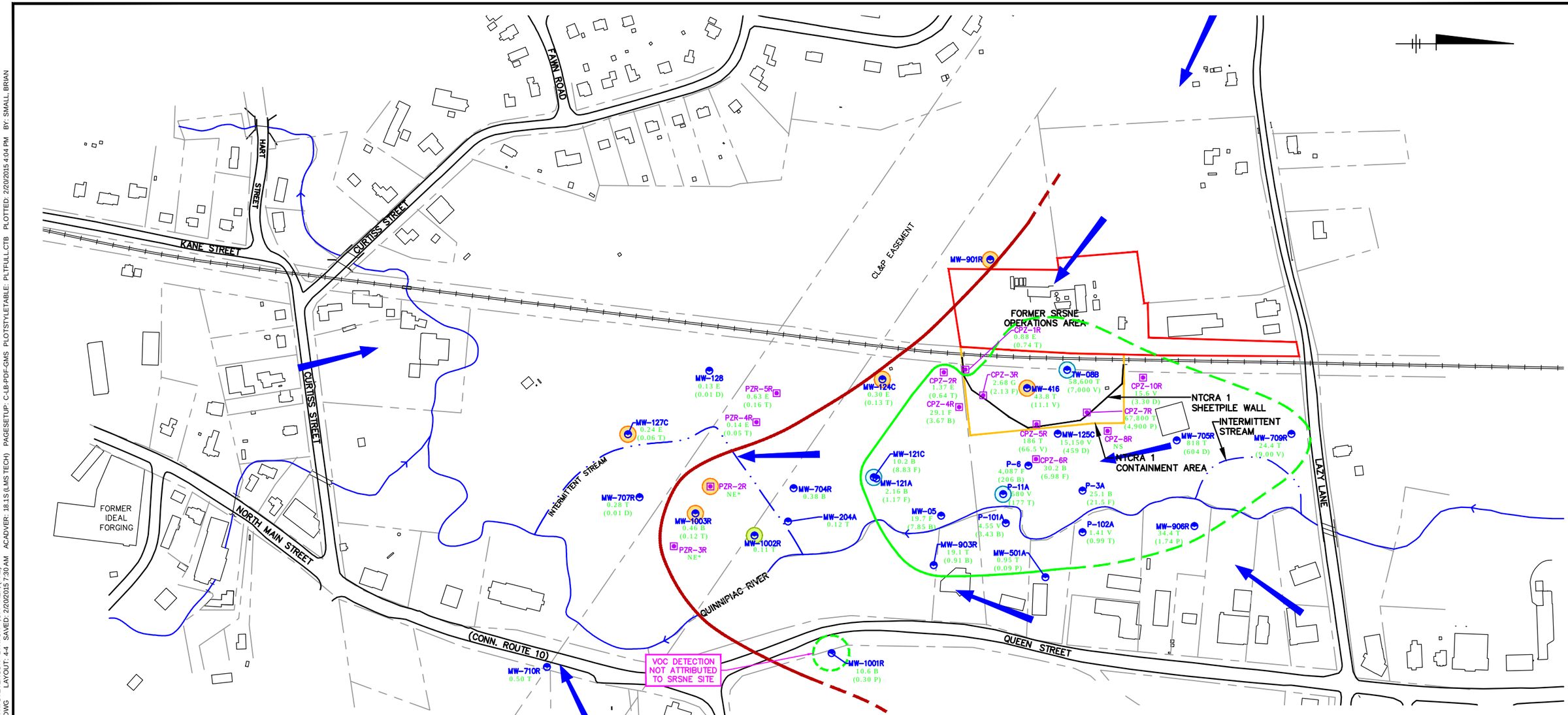
DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

VOC EXCEEDANCE PLUME DEEP OVERBURDEN

ARCADIS

FIGURE
4-3



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

2. POSTED DATA ARE THE LATEST SAMPLING RESULTS AT EACH WELL, AS OF JUNE 2014.

REDOX CONDITIONS:

- MILDLY REDUCING
- MODERATELY REDUCING
- STRONGLY REDUCING

KEY:

- B BENZENE
- D CIS-1,2-DICHLOROETHENE
- E 1,1-DICHLOROETHENE
- F TETRAHYDROFURAN
- G CHLOROETHANE
- P TETRACHLOROETHENE
- T TRICHLOROETHENE
- V VINYL CHLORIDE
- NE EXCEEDANCE RATIO LESS THAN 0.10
- NS NOT SAMPLED

LEGEND:

- SHALLOW BEDROCK MONITORING WELL
- PIEZOMETER
- ESTIMATED EXTENT OF GROUNDWATER VOC EXCEEDANCES OF MCLs OR CT DEEP CLASS GA GWPCs (2014 SAMPLING RESULTS) (DASHED WHERE INFERRED)
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- GENERALIZED GROUNDWATER FLOW DIRECTION
- P-11A 580 V (177 T) WELL WITH REGULATORY EXCEEDANCE RATIO. NUMBERS >1.0 INDICATE GROUNDWATER REGULATORY LIMIT EXCEEDED. NUMBERS <1.0 INDICATE EXCEEDANCE RATIO FOR COMPOUNDS DETECTED BELOW REGULATORY LIMIT. FIRST NUMBER INDICATES MAXIMUM MULTIPLE OF A DETECTED VOC OVER REGULATORY LIMIT (e.g., 130 INDICATES 130 x LIMIT). LETTER INDICATES COMPOUND WITH INDICATED EXCEEDANCE RATIO (e.g., P = TETRACHLOROETHENE). NUMBERS IN PARENTHESES INDICATE OTHER EXCEEDANCE RATIOS FOR SELECT COMPOUNDS AND WELLS. COMPOUNDS DETECTED IN BLANK(S) ARE NOT INCLUDED IN THIS EVALUATION.
- * NO DETECTIONS ABOVE INTERIM CLEANUP LEVELS (ICLs) AT THIS LOCATION.

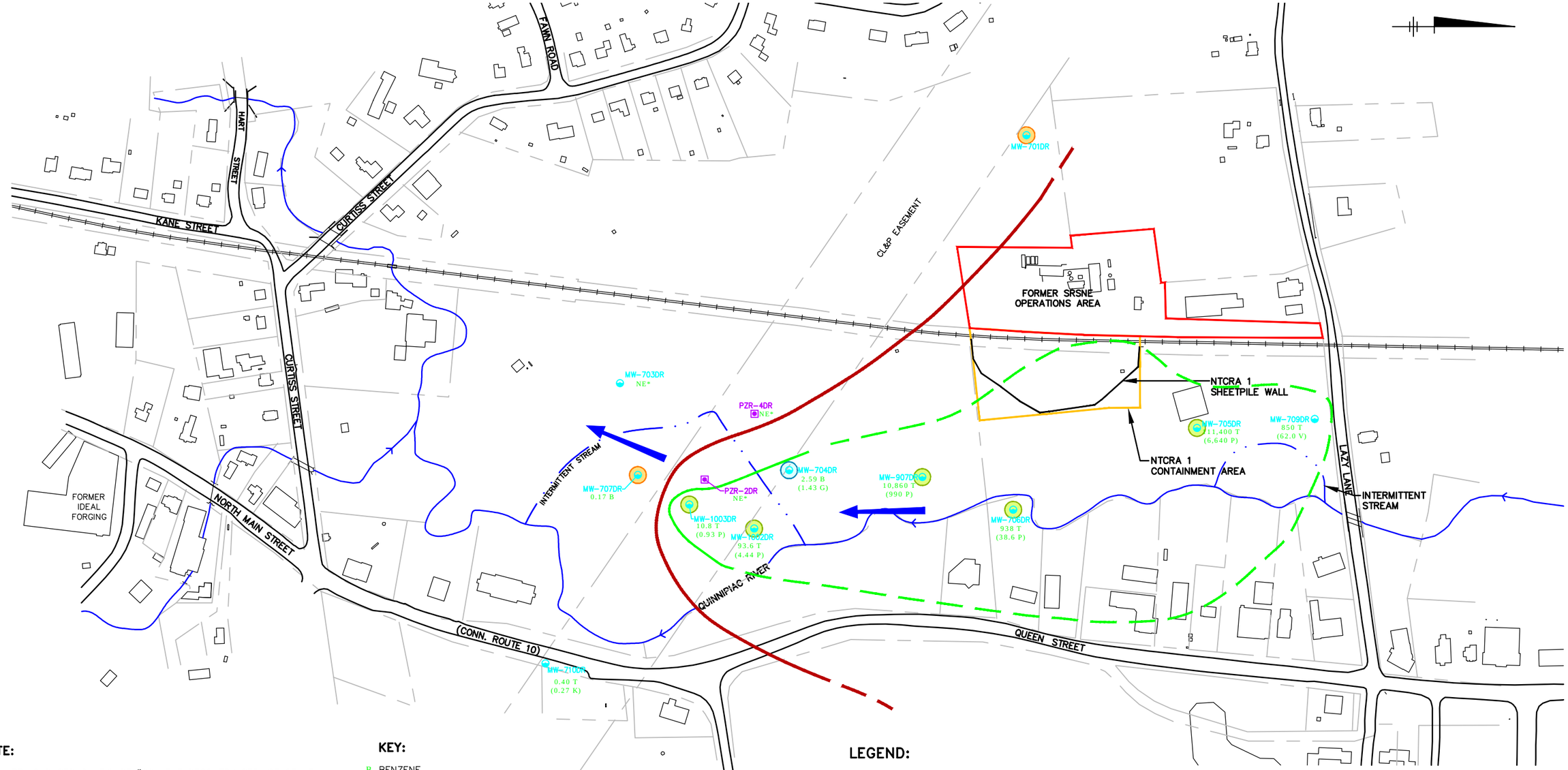
DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

VOC EXCEEDANCE PLUME SHALLOW BEDROCK

ARCADIS

FIGURE
4-4



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

2. POSTED DATA ARE THE LATEST SAMPLING RESULTS AT EACH WELL, AS OF JUNE 2014.

REDOX CONDITIONS:

- MILDLY REDUCING
- MODERATELY REDUCING
- STRONGLY REDUCING

KEY:

B	BENZENE
G	CHLOROETHANE
K	1,2-DICHLOROETHANE
P	TETRACHLOROETHENE
T	TRICHLOROETHENE
V	VINYL CHLORIDE
NE	EXCEEDANCE RATIO LESS THAN 0.10

LEGEND:

- DEEP BEDROCK MONITORING WELL
- PIEZOMETER
- ESTIMATED EXTENT OF GROUNDWATER VOC EXCEEDANCES OF MCLs OR CT DEEP CLASS GA GWPCs (2014 SAMPLING RESULTS) (DASHED WHERE INFERRED)
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- GENERALIZED GROUNDWATER FLOW DIRECTION
- MW-907DR 10,860 T (990 P) — WELL WITH REGULATORY EXCEEDANCE RATIO. NUMBERS >1.0 INDICATE GROUNDWATER REGULATORY LIMIT EXCEEDED. NUMBERS <1.0 INDICATE EXCEEDANCE RATIO FOR COMPOUNDS DETECTED BELOW REGULATORY LIMIT. FIRST NUMBER INDICATES MAXIMUM MULTIPLE OF A DETECTED VOC OVER REGULATORY LIMIT (e.g., 130 INDICATES 130 x LIMIT). LETTER INDICATES COMPOUND WITH INDICATED EXCEEDANCE RATIO (e.g., P = TETRACHLOROETHENE). NUMBERS IN PARENTHESES INDICATE OTHER EXCEEDANCE RATIOS FOR SELECT COMPOUNDS AND WELLS. COMPOUNDS DETECTED IN BLANK(S) ARE NOT INCLUDED IN THIS EVALUATION.
- * NO DETECTIONS ABOVE INTERIM CLEANUP LEVELS (ICLs) AT THIS LOCATION.

0 300' 600'

DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

VOC EXCEEDANCE PLUME DEEP BEDROCK

ARCADIS

FIGURE 4-5

CITY: SYRACUSE, NY DIV/GROUP: ENV/IM-DV DB: P. LISTER PM: J. HOLDEN TM/TR: R. STEVENSON LYR: ON=*;OFF=REF, (FRZ)
G:\ENVCAD\Manchester\ACTIVE\00546340001\03700\Conceptual Site Model\DWG\54634C11.DWG LAYOUT: 4-5 SAVED: 2/20/2015 4:05 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: C:\LB-PDF-GMS PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/20/2015 4:05 PM BY: SMALL, BRIAN
XREFS:
54634X01
54634X00
IMAGES:

CITY: SYRACUSE, NY GROUP: ENVCAD DB: P. LISTER PM: M. GEFELL TM: M. GEFELL TR: R. STEVENSON LYR: ON=*;OFF=REF, (FRZ)
G:\ENVCAD\Manchester\ACT\B0054634\0001\03700\Conceptrual Site Model\DWG\54634C4-6.dwg LAYOUT: 4-6 SAVED: 2/19/2015 6:56 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/19/2015 6:56 PM BY: SMALL, BRIAN
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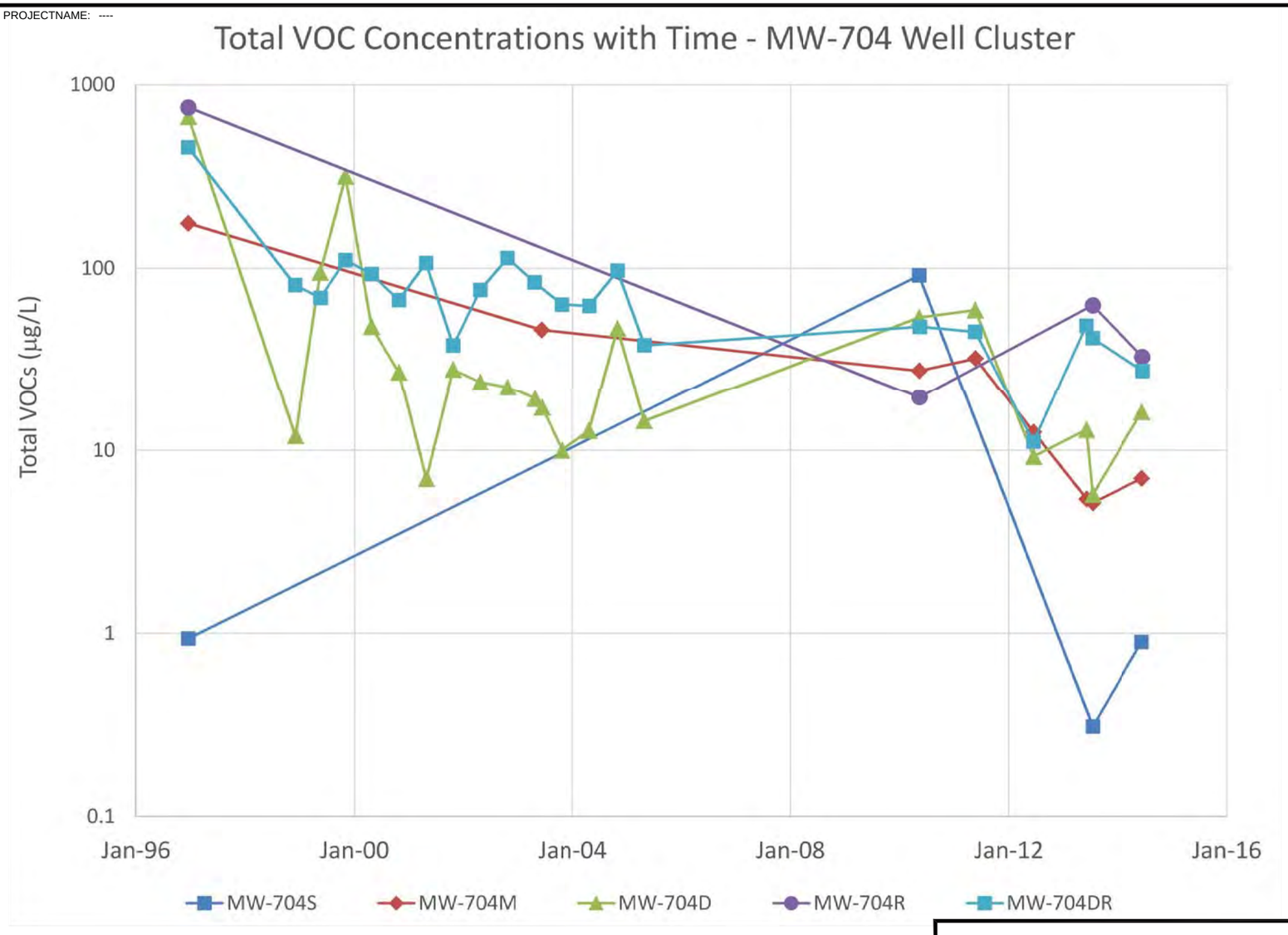


DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

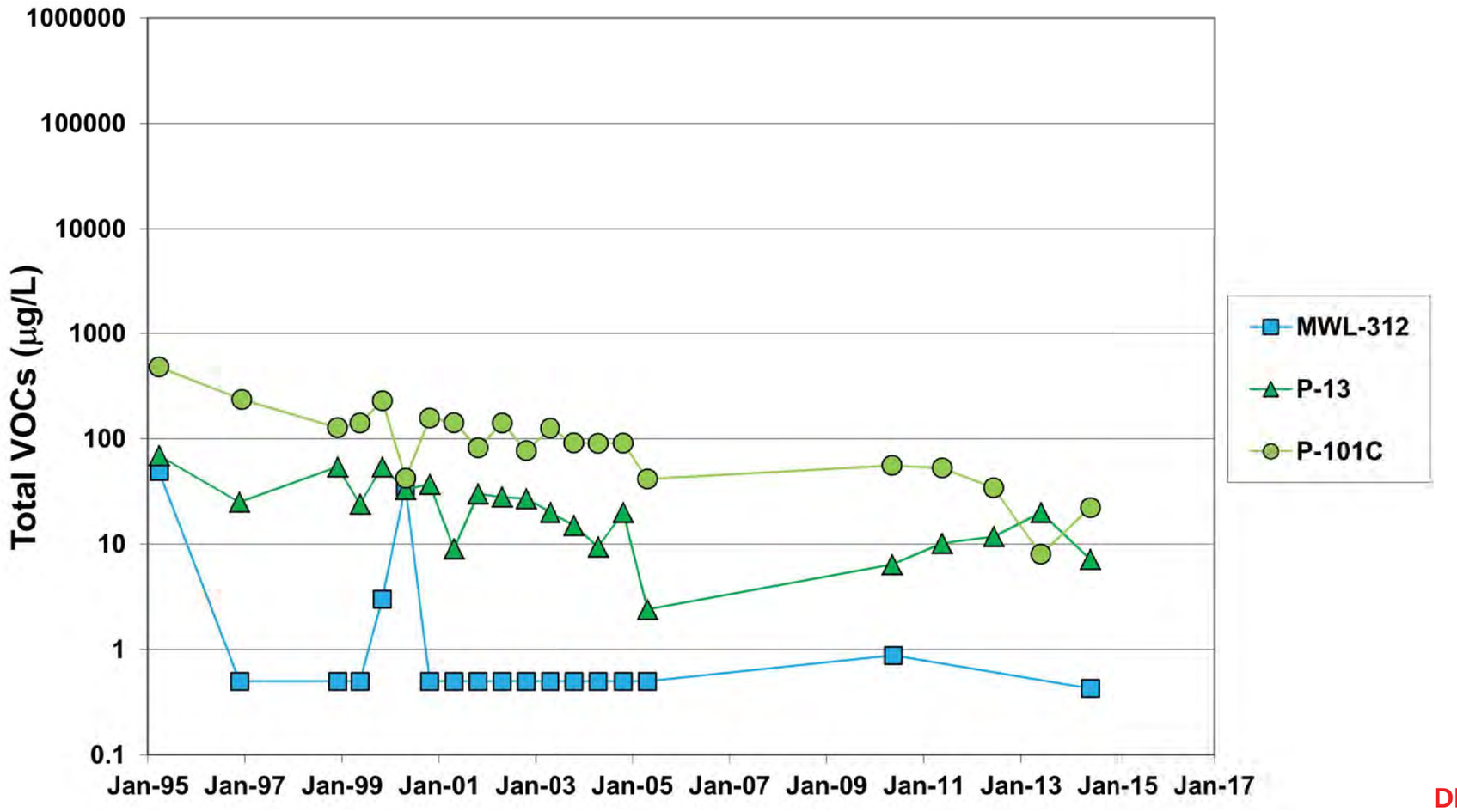
TOTAL VOC CONCENTRATIONS WITH TIME - MW-704 WELL CLUSTER

ARCADIS

FIGURE
4-6

CITY: SYRACUSE, NY GROUP: ENVCAD DB: P. LISTER PM: M. GEFELL TM: M. GEFELL TR: R. STEVENSON LYR: ON=*;OFF=REF, (FRZ)
G:\ENVCAD\Manchester\ACT\B0054634\0001\03700\Conceptrual Site Model\DWG\54634C4-7.dwg LAYOUT: 4-7 SAVED: 2/19/2015 6:48 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/19/2015 6:58 PM BY: SMALL, BRIAN
XREFS: IMAGES: PROJECTNAME: ----

Shallow Overburden Wells



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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

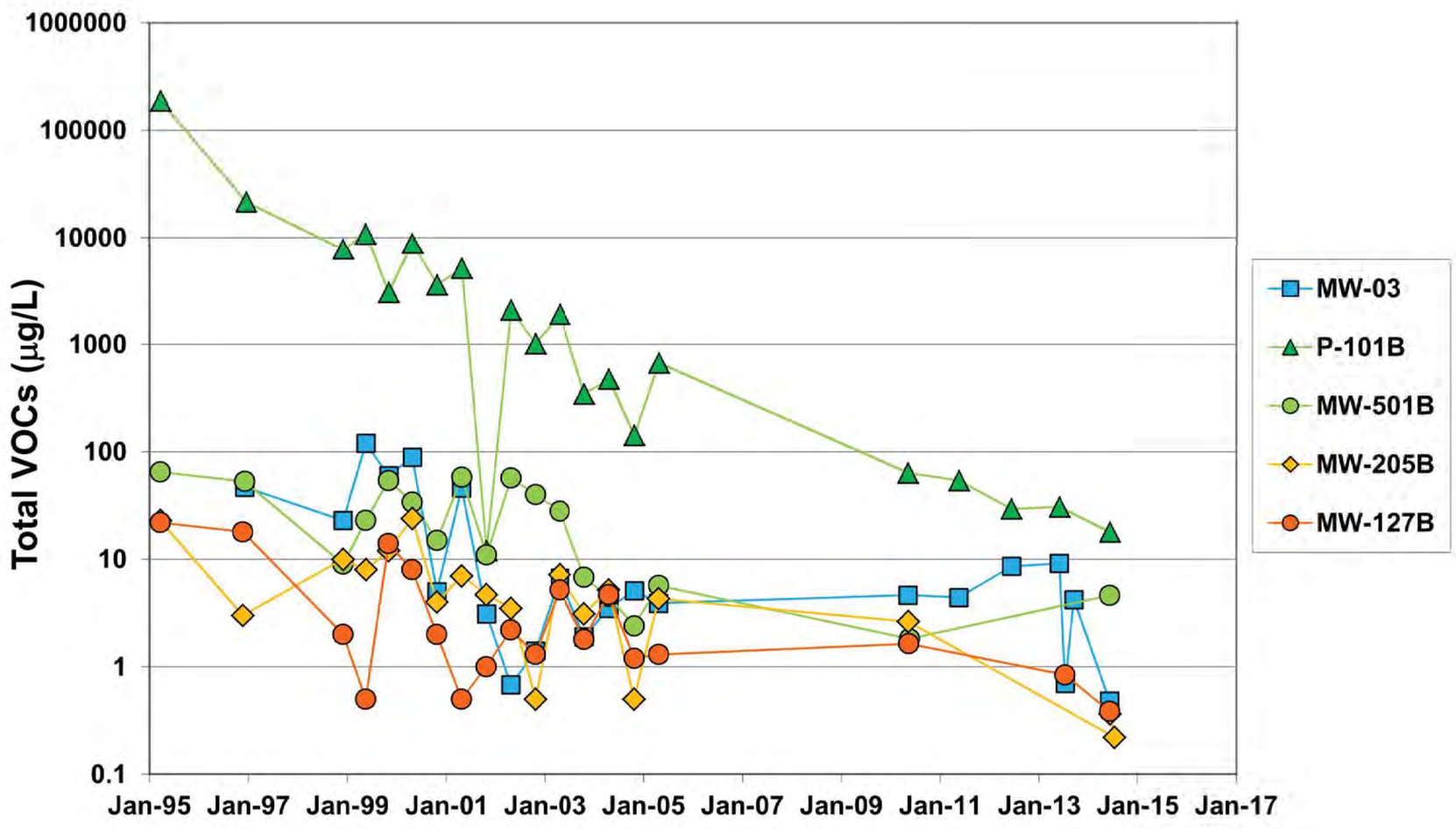
GROUNDWATER TOTAL VOC CONCENTRATIONS WITH TIME SHALLOW OVERBURDEN

ARCADIS

FIGURE
4-7

CITY: SYRACUSE, NY GROUP: ENVCAD DB: P. LISTER PM: M. GEFELL TM: M. GEFELL TR: R. STEVENSON LYR: ON=*;OFF=REF, (FRZ)
G:\ENVCAD\Manchester\ACT\B0054634\0001\03700\Conceptrual Site Model\DWG\54634C4-8.dwg LAYOUT: 4-8 SAVED: 9/11/2014 1:09 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/19/2015 7:01 PM BY: SMALL, BRIAN
XREFS: IMAGES: PROJECTNAME: ----

Middle Overburden Wells



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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

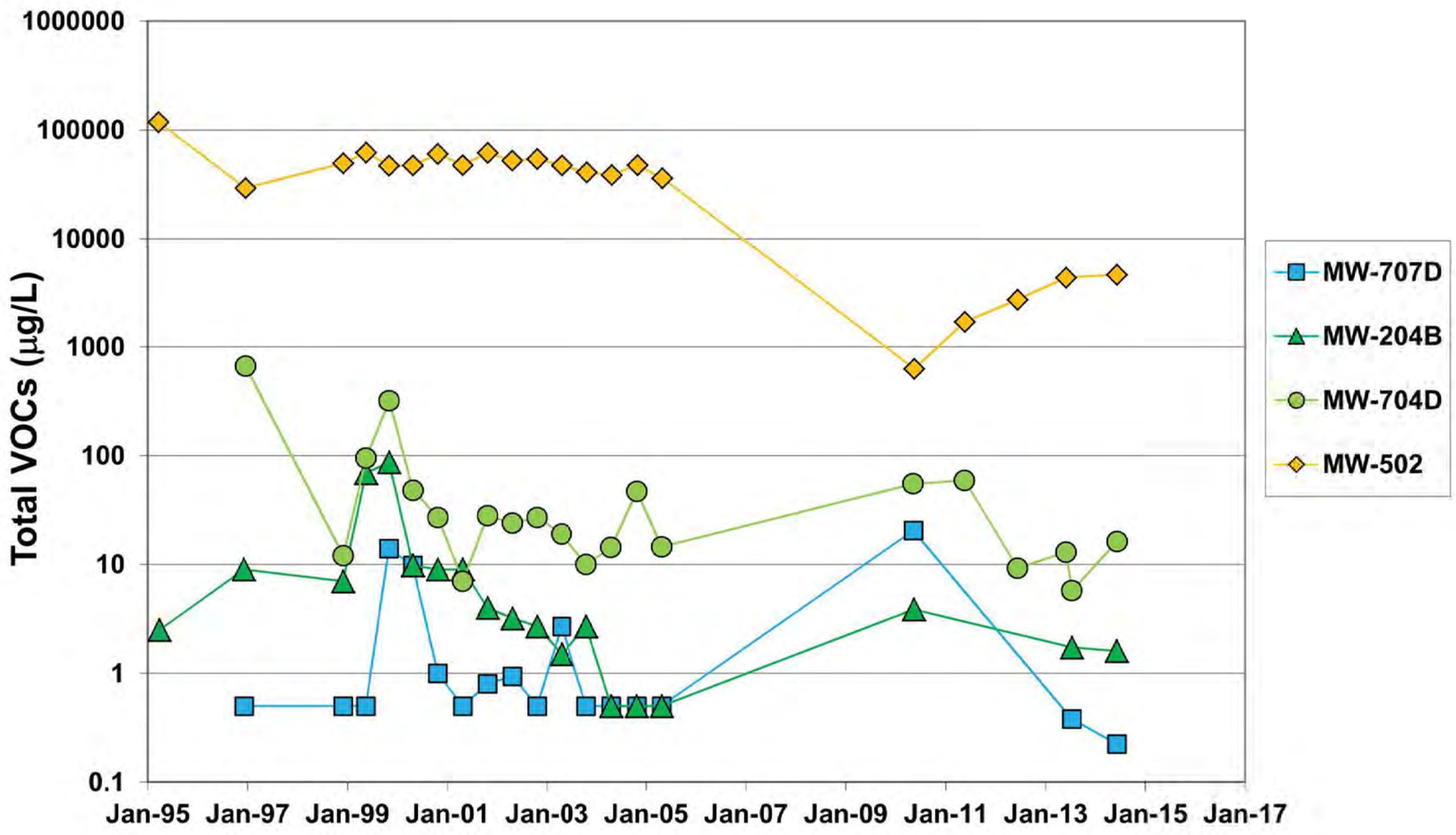
GROUNDWATER TOTAL VOC CONCENTRATIONS WITH TIME MIDDLE OVERBURDEN

ARCADIS

FIGURE
4-8

CITY: SYRACUSE, NY GROUP: ENVCAD DB: P. LISTER PM: M. GEFELL TM: M. GEFELL TR: R. STEVENSON LYR: ON=*;OFF=REF, (FRZ)
G:\ENVCAD\Manchester\ACT\B0054634\0001\03700\Conceptrual Site Model\DWG\54634C4-9.dwg LAYOUT: 4-9 SAVED: 9/11/2014 1:09 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/19/2015 7:02 PM BY: SMALL, BRIAN
XREFS: IMAGES: PROJECTNAME: ----

Deep Overburden Wells



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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

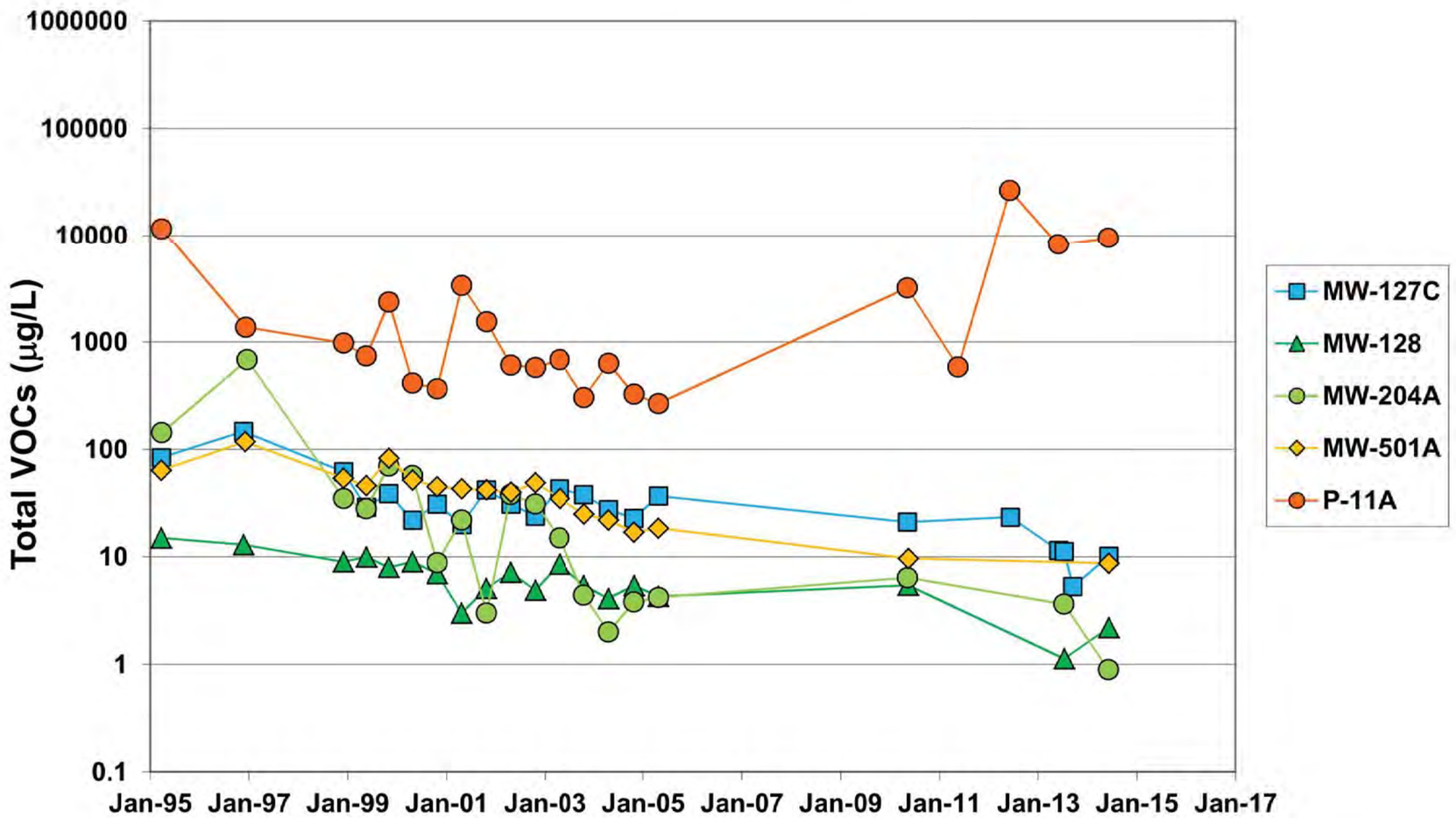
GROUNDWATER TOTAL VOC CONCENTRATIONS WITH TIME DEEP OVERBURDEN

ARCADIS

FIGURE
4-9

CITY: SYRACUSE, NY GROUP: ENVCAD DB: P. LISTER PM: M. GEFELL TM: M. GEFELL TR: R. STEVENSON LYR: ON=*;OFF=REF, (FRZ)
G:\ENVCAD\Manchester\ACT\B0054634\0001\03700\Conceptrual Site Model\DWG\54634C4-10.dwg LAYOUT: 4-10 SAVED: 9/11/2014 1:10 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/19/2015 7:03 PM BY: SMALL, BRIAN
XREFS: IMAGES: PROJECTNAME: ----

Shallow Bedrock Wells



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SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

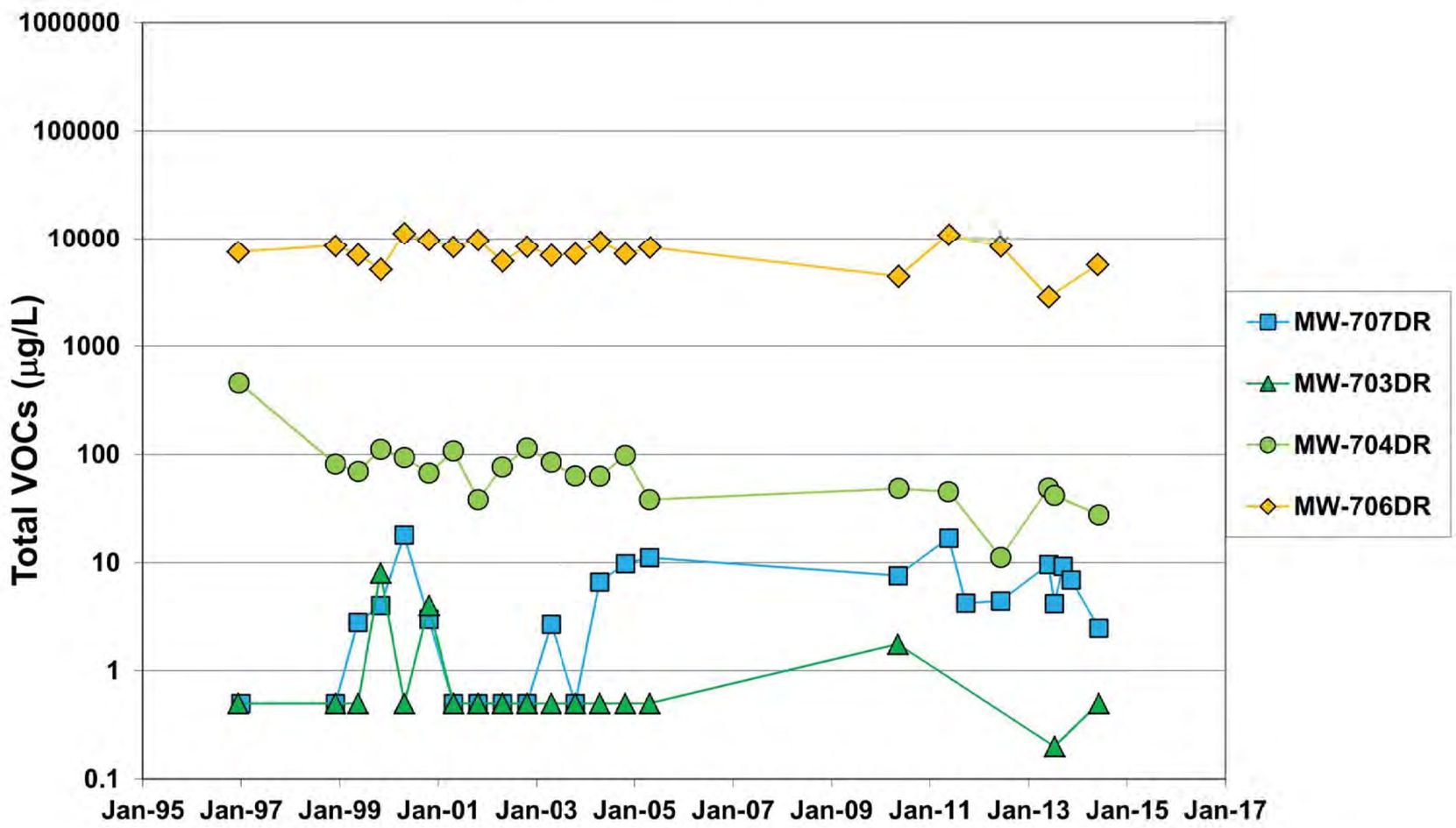
GROUNDWATER TOTAL VOC CONCENTRATIONS WITH TIME SHALLOW BEDROCK

ARCADIS

FIGURE
4-10

CITY: SYRACUSE, NY GROUP: ENVCAD DB: P. LISTER PM: M. GEFELL TM: M. GEFELL TR: R. STEVENSON LYR: ON=*;OFF=REF, (FRZ)
G:\ENVCAD\Manchester\ACT\B0054634\0001\03700\Conceptrual Site Model\DWG\54634C4-11.dwg LAYOUT: 4-11 SAVED: 2/19/2015 7:04 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/19/2015 7:04 PM BY: SMALL, BRIAN
XREFS: IMAGES: PROJECTNAME: ----

Deep Bedrock Wells



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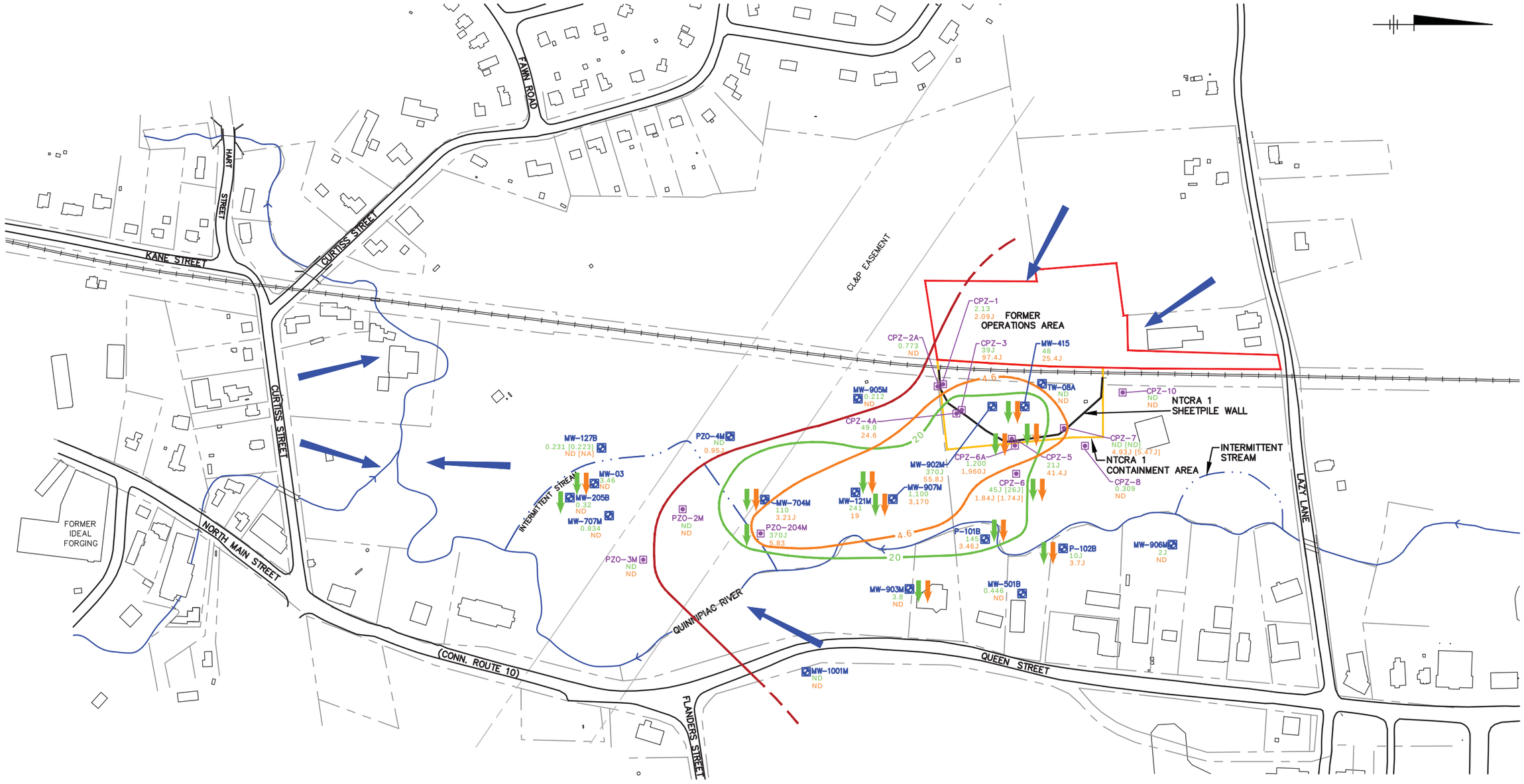
SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

GROUNDWATER TOTAL VOC CONCENTRATIONS WITH TIME DEEP BEDROCK

ARCADIS

FIGURE
4-11



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- MIDDLE OVERBURDEN MONITORING WELL
- PIEZOMETER
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- GENERALIZED GROUNDWATER FLOW DIRECTION
- 1,4-DIOXANE ISOCONCENTRATION CONTOUR (20 ug/L)
- TETRAHYDROFURAN ISOCONCENTRATION CONTOUR (4.6 ug/L)
- DECREASING 1,4-DIOXANE CONCENTRATION TREND INDICATED
- DECREASING TETRAHYDROFURAN CONCENTRATION TREND INDICATED

1,100	1,4-DIOXANE CONCENTRATION (ug/L)
3,170	TETRAHYDROFURAN CONCENTRATION (ug/L)
ug/L	MICROGRAMS PER LITER
[ ]	DUPLICATE SAMPLE RESULT
J	ANALYTE RESULT IS ESTIMATED
NA	NOT ANALYZED
ND	NOT DETECTED

DRAFT

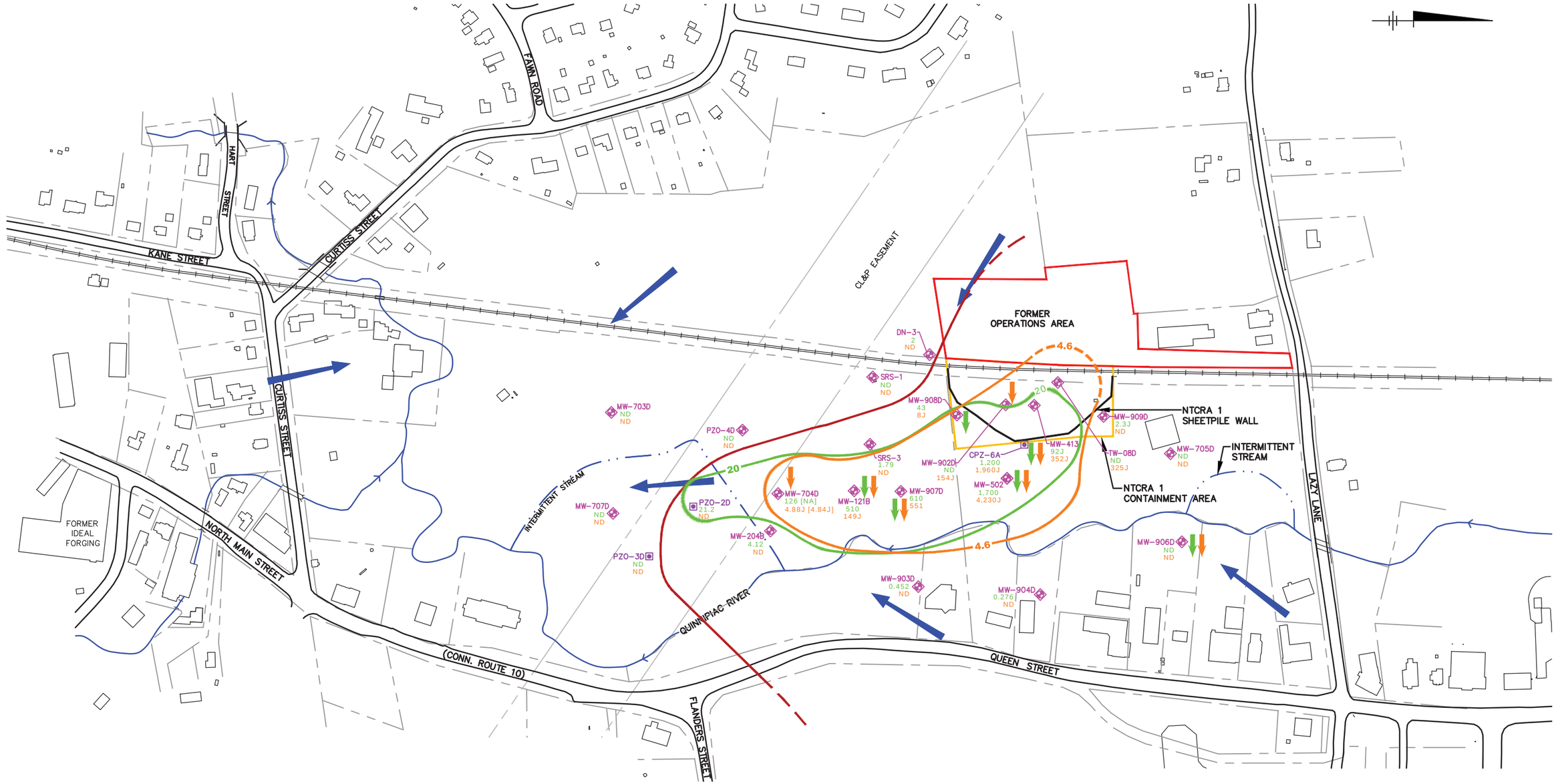
SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

TETRAHYDROFURAN AND 1,4-DIOXANE RESULTS MIDDLE OVERBURDEN

ARCADIS

FIGURE
4-12

CITY: SYRACUSE, NY DIV/GROUP: ENV/IM-DV DB: P. LISTER PM: J. HOLDEN TM/TR: R. STEVENSON LYR:ON;*-OFF=REF; (FRZ)
G:\ENVCAD\Manchester\ACTIB005463400010370O\Conceptrual Site Model\54634C01.DWG LAYOUT: 4-12 SAVED: 2/17/2015 2:25 PM ACADVER: 18.1S (LMS TECH)
XREFS: IMAGES: PROJECTNAME: ---
54634X01
PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/20/2015 7:32 AM BY: SMALL, BRIAN



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- DEEP OVERBURDEN MONITORING WELL
- PIEZOMETER
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- GENERALIZED GROUNDWATER FLOW DIRECTION
- 1,4-DIOXANE ISOCONCENTRATION CONTOUR (20 ug/L)
- TETRAHYDROFURAN ISOCONCENTRATION CONTOUR (4.6 ug/L) (DASHED WHERE INFERRED)
- DECREASING 1,4-DIOXANE CONCENTRATION TREND INDICATED
- DECREASING TETRAHYDROFURAN CONCENTRATION TREND INDICATED

1,700 1,4-DIOXANE CONCENTRATION (ug/L)
4,230 TETRAHYDROFURAN CONCENTRATION (ug/L)
ug/L MICROGRAMS PER LITER
[ ] DUPLICATE SAMPLE RESULT
J ANALYTE RESULT IS ESTIMATED
NA NOT ANALYZED
ND NOT DETECTED

DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

TETRAHYDROFURAN AND 1,4-DIOXANE RESULTS DEEP OVERBURDEN

ARCADIS

FIGURE
4-13

KANE STREET
HART STREET
CURTISS STREET
FAIRFIELD ROAD
CL&P EASEMENT
FORMER IDEAL FORGING
NORTH MAIN STREET
INTERMITTENT STREAM
QUINNIPIAC RIVER
(CONN. ROUTE 10)
FLANDERS STREET
QUEEN STREET
LAZY LANE
FORMER OPERATIONS AREA
NTCRA 1 SHEETPILE WALL
NTCRA 1 CONTAINMENT AREA

MW-128 0.136J [0.16J] ND [NA]
PZR-5R 0.998 ND
PZR-4R 0.413 [NA] ND [ND]
MW-127C 4.22 ND
PZR-2R 2.32 [2.49] ND [NA]
MW-704R 6.9 ND
MW-707R 2.28 ND
MW-1003R 0.29 ND
MW-204A 1.62 ND
MW-1002R ND ND
PZR-3R ND [ND] ND [ND]
MW-710R 0.872 ND
MW-1001R ND ND
MW-903R ND ND
MW-501A 0.946 ND
MW-906R ND ND
MW-705R ND ND
MW-709R ND ND
MW-124C 0.586 ND
CPZ-1R 2.79 1.11J
MW-416 ND 7.61J
CPZ-2R 2.49 1.13J
TW-08B 300J 436J
CPZ-3R 98J 9.81
CPZ-4R 140 [NA] 134J [66]
CPZ-5R ND [ND] ND [ND]
CPZ-10R ND ND
CPZ-7R ND ND
CPZ-8R NS NS
MW-125C 620J 1,090J
MW-121C 420 40.6J
MW-121A 120 5.36J
P-11A 770 ND
MW-05 350 90.4J
P-6 5,600 18,800J
CPZ-6R 940J 32.1
P-101A 63J 5.95
P-3A 350 98.7J
P-102A 11.1 2J
20
4.6

NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- SHALLOW BEDROCK MONITORING WELL
- PIEZOMETER
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- GENERALIZED GROUNDWATER FLOW DIRECTION
- 1,4-DIOXANE ISOCONCENTRATION CONTOUR (20 ug/L)
- TETRAHYDROFURAN ISOCONCENTRATION CONTOUR (4.6 ug/L)
- DECREASING 1,4-DIOXANE CONCENTRATION TREND INDICATED
- DECREASING TETRAHYDROFURAN CONCENTRATION TREND INDICATED

5,600 1,4-DIOXANE CONCENTRATION (ug/L)
32.1 TETRAHYDROFURAN CONCENTRATION (ug/L)
ug/L MICROGRAMS PER LITER
[ ] DUPLICATE SAMPLE RESULT
J ANALYTE RESULT IS ESTIMATED
NA NOT ANALYZED
ND NOT DETECTED
NS NOT SAMPLED

DRAFT

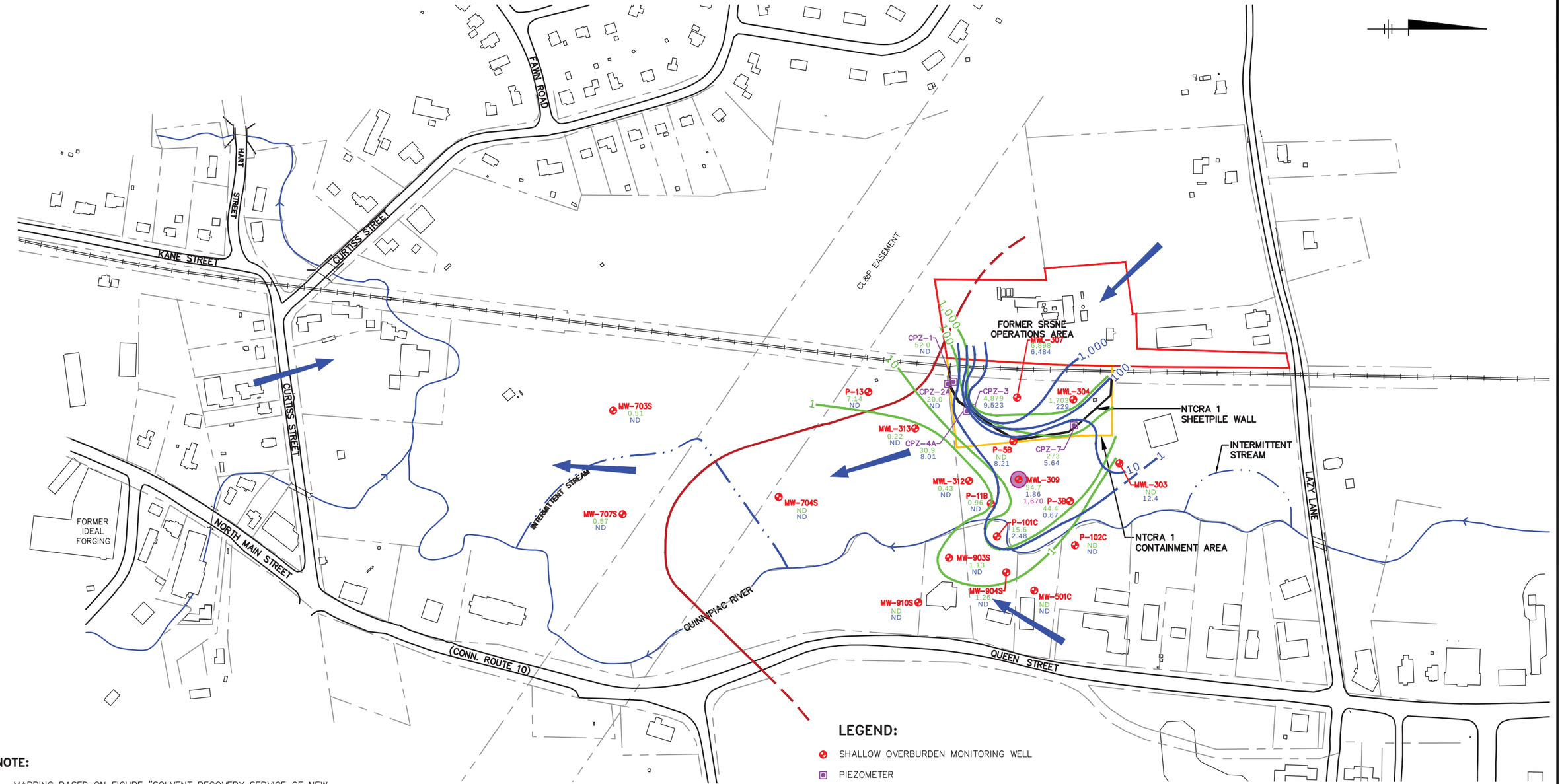
0 300' 600'

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

TETRAHYDROFURAN AND 1,4-DIOXANE RESULTS SHALLOW BEDROCK

ARCADIS

FIGURE
4-14



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- SHALLOW OVERBURDEN MONITORING WELL
- PIEZOMETER
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- HALOGENATED VOCs ISOCONCENTRATION CONTOUR
- NON-HALOGENATED VOCs ISOCONCENTRATION CONTOUR (DASHED WHERE INFERRED)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- 52.0 HALOGENATED VOC CONCENTRATION (ug/L)
- 8.01 NON-HALOGENATED VOC CONCENTRATION (ug/L)
- 1,670 1,4-DIOXANE CONCENTRATION (ug/L)
- 1,4-DIOXANE CONCENTRATION GREATER THAN 1,000 ug/L
- ug/L MICROGRAMS PER LITER
- ND NOT DETECTED

DRAFT

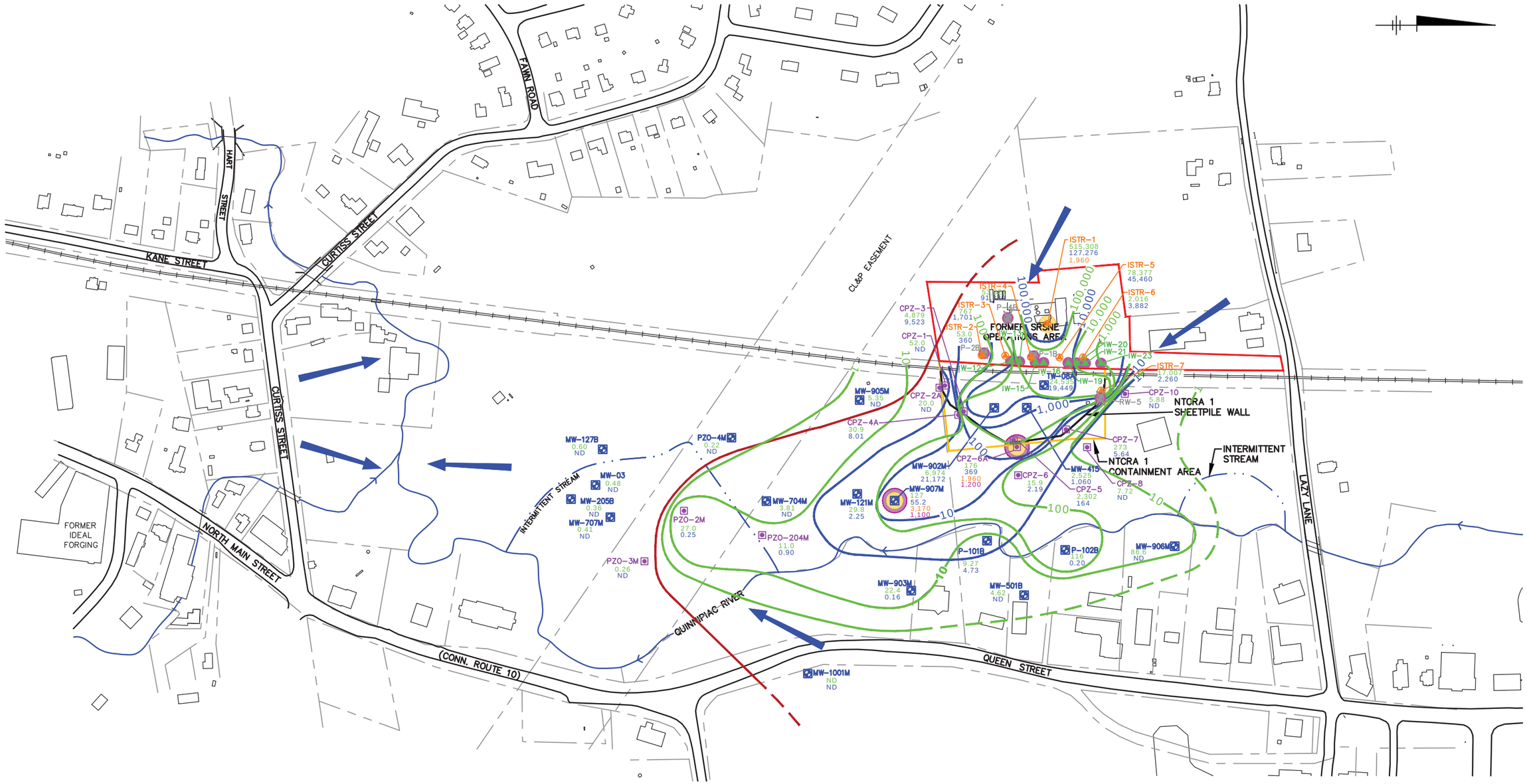
SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

ISOCONCENTRATION MAP SHALLOW OVERBURDEN

ARCADIS

FIGURE **4-15**

CITY: SYRACUSE, NY DIV/GROUP: ENV/IM-DV DB: P. LISTER PM: J. HOLDEN TM/TR: R. STEVENSON LYR: ON=*;OFF=REF; (FR2)
G:\ENVCAD\Manchester\ACTIB0054634000103700\Conceptual Site Model\DWG\54634C4-15.dwg LAYOUT: 4-15 SAVED: 2/20/2015 7:38 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/20/2015 7:38 AM BY: SMALL, BRIAN
XREFS: IMAGES: PROJECTNAME: ----
54634X01



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- MIDDLE OVERBURDEN MONITORING WELL
- ABANDONED OVERBURDEN MONITORING WELL
- PIEZOMETER
- FORMER ON-SITE INTERCEPTOR SYSTEM EXTRACTION WELL
- ISTR WELL
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- HALOGENATED VOCs ISOCONCENTRATION CONTOUR (DASHED WHERE INFERRED)
- NON-HALOGENATED VOCs ISOCONCENTRATION CONTOUR
- GENERALIZED GROUNDWATER FLOW DIRECTION

22.4	HALOGENATED VOC CONCENTRATION (ug/L)
0.16	NON-HALOGENATED VOC CONCENTRATION (ug/L)
3,170	TETRAHYDROFURAN CONCENTRATION (ug/L)
1,100	1,4-DIOXANE CONCENTRATION (ug/L)
	TETRAHYDROFURAN CONCENTRATION GREATER THAN 1,000 ug/L
	1,4-DIOXANE CONCENTRATION GREATER THAN 1,000 ug/L
	INDICATES LOCATION WHERE NAPL HAS BEEN OBSERVED HISTORICALLY. NAPL LOCATIONS WERE NOT INCLUDED IN CONTOURING OF DISSOLVED-PHASE GROUNDWATER VOC CONCENTRATIONS
ug/L	MICROGRAMS PER LITER
ND	NOT DETECTED

0 300' 600'

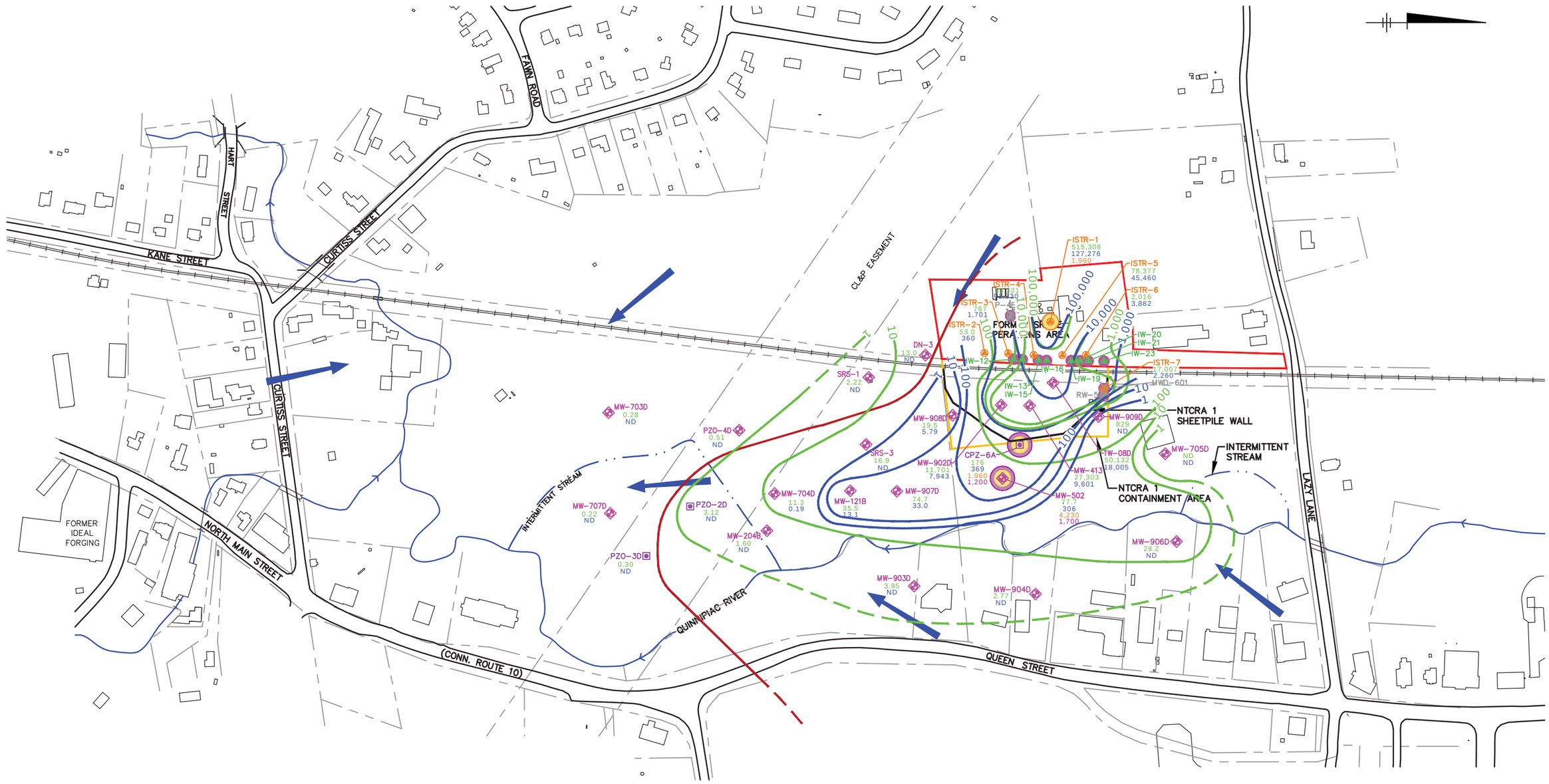
DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

ISOCONCENTRATION MAP MIDDLE OVERBURDEN

ARCADIS

FIGURE
4-16



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- DEEP OVERBURDEN MONITORING WELL
- ABANDONED OVERBURDEN MONITORING WELL
- PIEZOMETER
- FORMER ON-SITE INTERCEPTOR SYSTEM EXTRACTION WELL
- ISTR WELL
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- HALOGENATED VOCs ISOCONCENTRATION CONTOUR (DASHED WHERE INFERRED)
- NON-HALOGENATED VOCs ISOCONCENTRATION CONTOUR
- GENERALIZED GROUNDWATER FLOW DIRECTION

- 176 HALOGENATED VOC CONCENTRATION (ug/L)
- 369 NON-HALOGENATED VOC CONCENTRATION (ug/L)
- 4,230 TETRAHYDROFURAN CONCENTRATION (ug/L)
- 1,700 1,4-DIOXANE CONCENTRATION (ug/L)
- TETRAHYDROFURAN CONCENTRATION GREATER THAN 1,000 ug/L
- 1,4-DIOXANE CONCENTRATION GREATER THAN 1,000 ug/L
- INDICATES LOCATION WHERE NAPL HAS BEEN OBSERVED HISTORICALLY. NAPL LOCATIONS WERE NOT INCLUDED IN CONTOURING OF DISSOLVED-PHASE GROUNDWATER VOC CONCENTRATIONS
- ug/L MICROGRAMS PER LITER
- ND NOT DETECTED

0 300' 600'

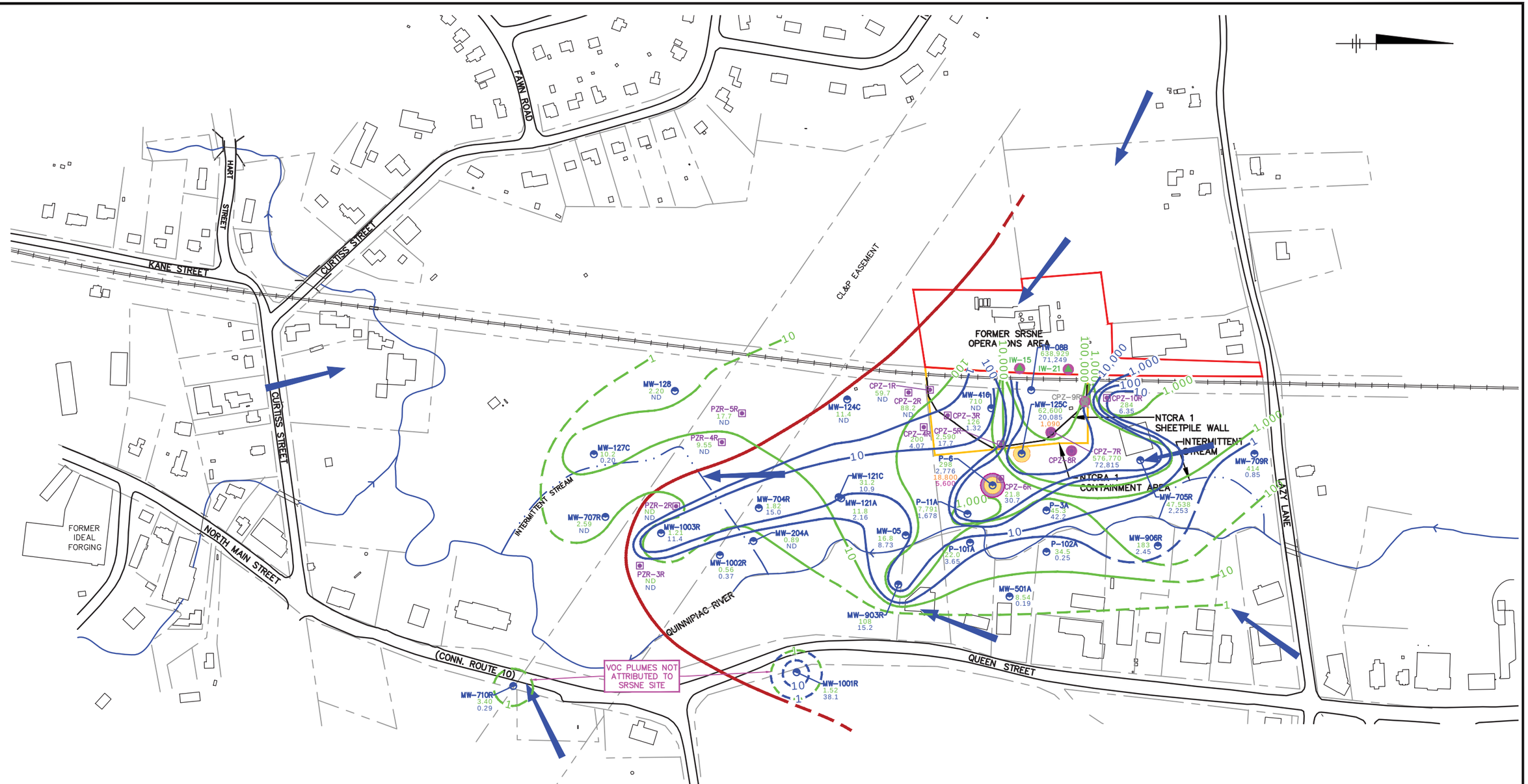
DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

ISOCONCENTRATION MAP DEEP OVERBURDEN

ARCADIS

FIGURE
4-17



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- SHALLOW BEDROCK MONITORING WELL
- ABANDONED OVERBURDEN MONITORING WELL
- PIEZOMETER
- FORMER ON-SITE INTERCEPTOR SYSTEM EXTRACTION WELL
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- HALOGENATED VOCs ISOCONCENTRATION CONTOUR (DASHED WHERE INFERRED)
- NON-HALOGENATED VOCs ISOCONCENTRATION CONTOUR (DASHED WHERE INFERRED)
- GENERALIZED GROUNDWATER FLOW DIRECTION

284	HALOGENATED VOC CONCENTRATION (ug/L)
6.35	NON-HALOGENATED VOC CONCENTRATION (ug/L)
18,800	TETRAHYDROFURAN CONCENTRATION (ug/L)
5,600	1,4-DIOXANE CONCENTRATION (ug/L)
	TETRAHYDROFURAN CONCENTRATION GREATER THAN 1,000 ug/L
	1,4-DIOXANE CONCENTRATION GREATER THAN 1,000 ug/L
	INDICATES LOCATION WHERE NAPL HAS BEEN OBSERVED HISTORICALLY. NAPL LOCATIONS WERE NOT INCLUDED IN CONTOURING OF DISSOLVED-PHASE GROUNDWATER VOC CONCENTRATIONS
ug/L	MICROGRAMS PER LITER
ND	NOT DETECTED

DRAFT

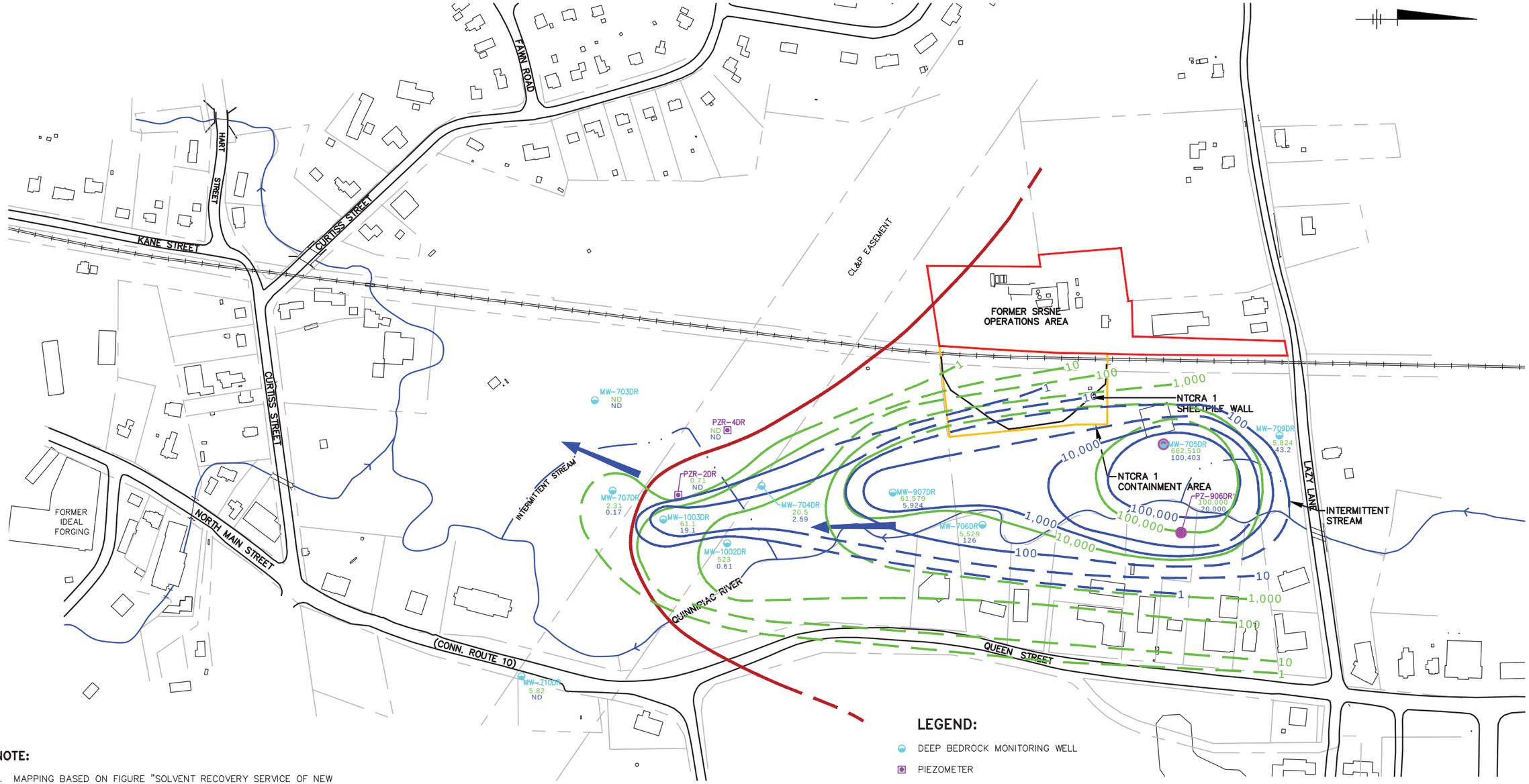
0 300' 600'

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

ISOCONCENTRATION MAP SHALLOW BEDROCK

ARCADIS

FIGURE
4-18



NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

LEGEND:

- DEEP BEDROCK MONITORING WELL
- PIEZOMETER
- ESTIMATED NTCRA 2 CAPTURE ZONE BOUNDARY
- HALOGENATED VOCs ISOCONCENTRATION CONTOUR (DASHED WHERE INFERRED)
- NON-HALOGENATED VOCs ISOCONCENTRATION CONTOUR (DASHED WHERE INFERRED)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- 523 HALOGENATED VOC CONCENTRATION (ug/L)
- 0.61 NON-HALOGENATED VOC CONCENTRATION (ug/L)
- WELLS WHERE HISTORICALLY NAPL HAS BEEN PRESENT
- * ASSUMED CONCENTRATION BASED ON PRESENCE OF NAPL
- ug/L MICROGRAMS PER LITER
- ND NOT DETECTED

DRAFT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
CONCEPTUAL SITE MODEL UPDATE

ISOCONCENTRATION MAP DEEP BEDROCK

ARCADIS

FIGURE
4-19

ARCADIS

Attachments

ARCADIS

Attachment A

Detailed VOC Mass Calculations

DETAILED CALCULATIONS OF TOTAL VOC MASS IN OVERBURDEN

OVERBURDEN NAPL ZONE | **input values** | **summary figure #s**

NAPL Mass (kg)	Initial	458,000
	2015	0

[Initial NAPL mass back-calculated to time of RI (1996)]

Total Mass Removed By Thermal Treatment (kg)		192,820
May 2014 - January 2015	**427,000** lb	
	From Saturated Zone (kg)	6744
	From Unsaturated Zone (kg)	2090
	From NAPL (kg)	183986

NAPL Removed From Overburden Wells (kg)	11

SATURATED ZONE

Dissolved and Sorbed TVOC Mass

Date	Diss Conc. Avg, mg/L	Diss. Mass, kg	Sorb. Mass, kg	Total Mass, kg
Mar-14	**174.786**	1,176	5,761	6,937
Feb-15	**4.856**	33	160	193
Decrease in Dissolved and Sorbed TVOC Mass				6744
				97%

UNSATURATED ZONE

Dissolved and Sorbed TVOC Mass (kg)

Date	Diss + Sorb Mass, kg	Estimated Reduction
Initial	2,200	**95%**
Final	110	
Decrease in TVOC Mass (kg)		2,090
		95%

Degradation In NTCRA 1 Capture Zone Prior To Thermal Remedy (Including Former Operations Area and NTCRA 1 Containment Area)

Dissolved Mass Removed by NTCRA 1 Wells (kg)	6,701		
Estimated Ratio of Mass Degraded:Mass Removed By NTCRA 1 Treatment System	**40**		
Total Degraded Based on Mass Removed By NTCRA 1 System (kg)	268,051	768	267,283
		from Diss, Sorbed	from NAPL dissolution

NTCRA 1 AREA (OVERBURDEN)

Diss. Mass Removed From NTCRA 1 Wells (kg)		6,701	19	6,682
	lb	kg	kg	kg
Total Mass Removed as of 1996/1997 (RI)	**2,500**	1129	from Diss,	from NAPL
Total Mass Removed through 2014	**17,340**	7830	Sorbed	dissolution

Dissolved and Sorbed TVOC Mass (Stored in NTCRA 1 Area) (kg)

Date	NTCRA 1 Influent Avg, mg/L	Diss. Mass, NTCRA 1 Area kg	Sorb. Mass, NTCRA 1 Area kg	Total Mass, kg	NTCRA 1 Wells kg	Remainder Degraded kg
RI (1996-1997 avg)	**25.2**	244	1,194	1,438		
2014 (avg)	**11.4**	110	540	650		
Decrease in Dissolved and Sorbed TVOC Mass (kg)				787	19	768
				55%		

DOWNGRADIENT OVERBURDEN VOC PLUME

SATURATED OVERBURDEN DOWNGRADIENT OF NTCRA 1 SHEET PILE WALL

Dissolved and Sorbed TVOC Mass (kg)

Date	Diss + Sorb Mass, kg	Average Half-Life (yrs)**	Elapsed Time (yrs)	
Initial (1996)*	2,825	4.3	18	
Final (2014)	155			
Decrease in Dissolved and Sorbed TVOC Mass (kg)				2,670
				95%

OVERBURDEN TOTAL MASS REMAINING, 2015 (kg)	1,108

Notes:

* -- Initial dissolved and sorbed TVOC mass in downgradient VOC plume estimated as total dissolved and sorbed VOC mass in entire overburden during RI, minus total combined dissolved and sorbed TVOC mass upgradient of NTCRA 1 sheet pile wall.

** - Half life based on data from middle and deep overburden wells. Shallow overburden excluded because it accounts for less than 10% of total overburden dissolved and sorbed VOC mass (BBL, June 1998).

Sorbed TVOC mass estimated as 4.9 times dissolved TVOC mass based on partitioning calculations presented in RI (BBL, June 1998).

DETAILED CALCULATIONS OF TOTAL VOC MASS IN BEDROCK

input values | summary figure #s

BEDROCK NAPL

Updated Probable NAPL Zone Dimensions

Area (sq ft)	**502,000**
Thickness (ft)	**60**
Volume (cf)	30,120,000
Volume (L)	852,751,416

NAPL Bulk Retention Capacity

Average Fracture Porosity	0.000063
Percentage of Total NAPL Zone Volume Contactedby NAPL	**20%**
Single-Fracture Retention Capacity*	**12%**
NAPL Bulk Retention Capacity	0.0000015

Updated Fracture System Characteristics

Average Fracture Aperture (cm)	**0.0097**
Average Fracture Spacing (cm)	**155**
Average Fracture Porosity	0.000063

Updated Bedrock NAPL Mass (kg)

NAPL Zone Volume (L)	852,751,416
NAPL Bulk Retention Capacity	0.0000015
NAPL Density (kg/L)	**1.2**
Total Bedrock NAPL Mass (kg)	**1,537**

SHALLOW BEDROCK VOC PLUME

Dissolved and Sorbed TVOC Mass (kg)

Date	Diss + Sorb Mass, kg	Average Half-Life (yrs)	Elapsed Time (yrs)
Initial (1996)	**19,500**	5.8	18
Final (2014)	**2,270**		

Decrease in Dissolved and Sorbed TVOC Mass **17,230**

88%

DEEP BEDROCK VOC PLUME

Dissolved and Sorbed TVOC Mass (kg)

Date	Diss + Sorb Mass, kg	Average Half-Life (yrs)	Elapsed Time (yrs)
Initial (1996)	**19,500**	17	18
Final (2014)	**9,362**		

Decrease in Dissolved and Sorbed TVOC Mass **10,138**

52%

TOTAL BEDROCK VOC PLUME

Dissolved and Sorbed TVOC Mass (kg)

Date	Diss + Sorb Mass, kg
Initial (1996)	**39,000**
Final (2014)	**11,632**

Decrease in Dissolved and Sorbed TVOC Mass **27,368**

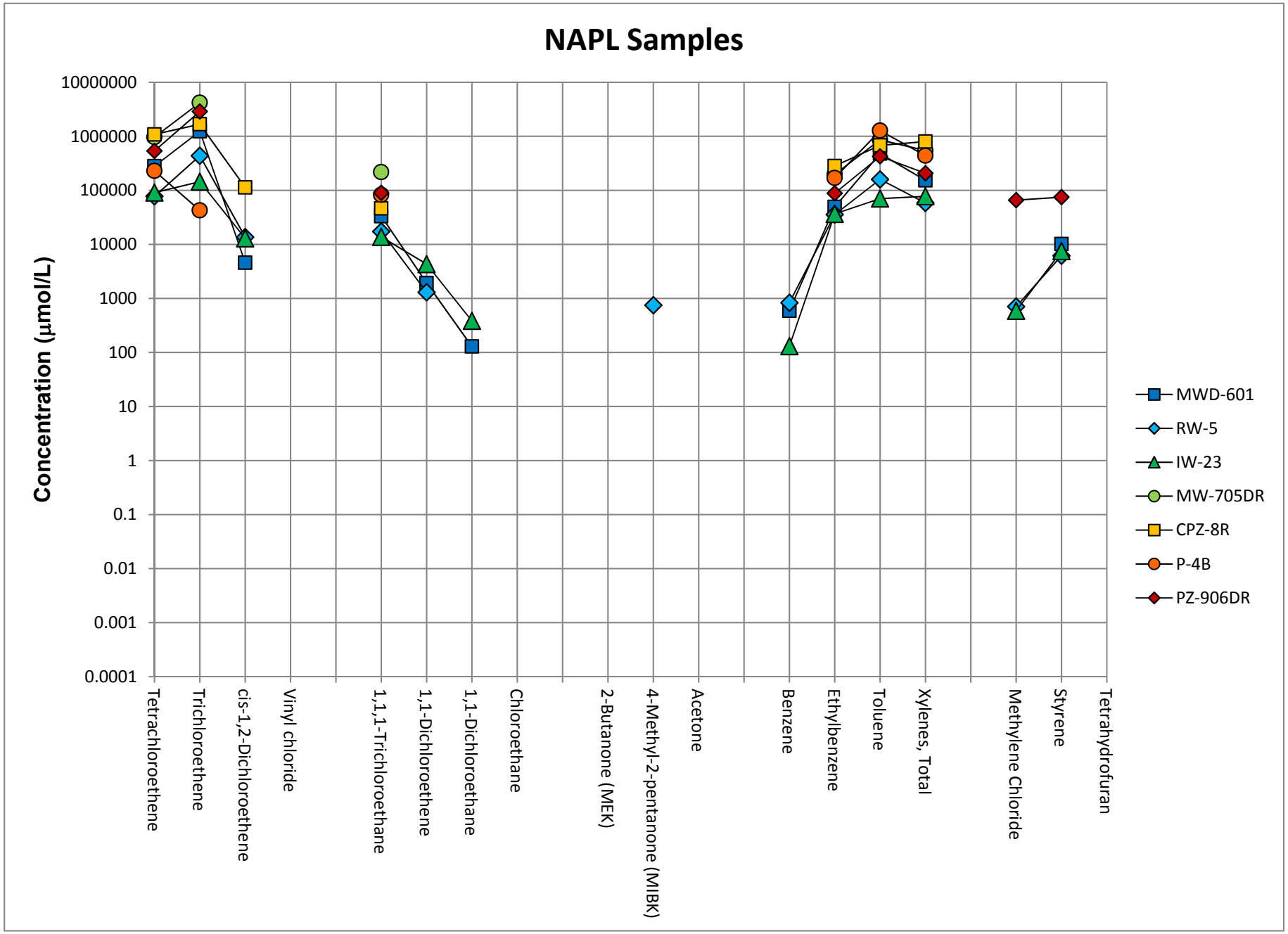
70%

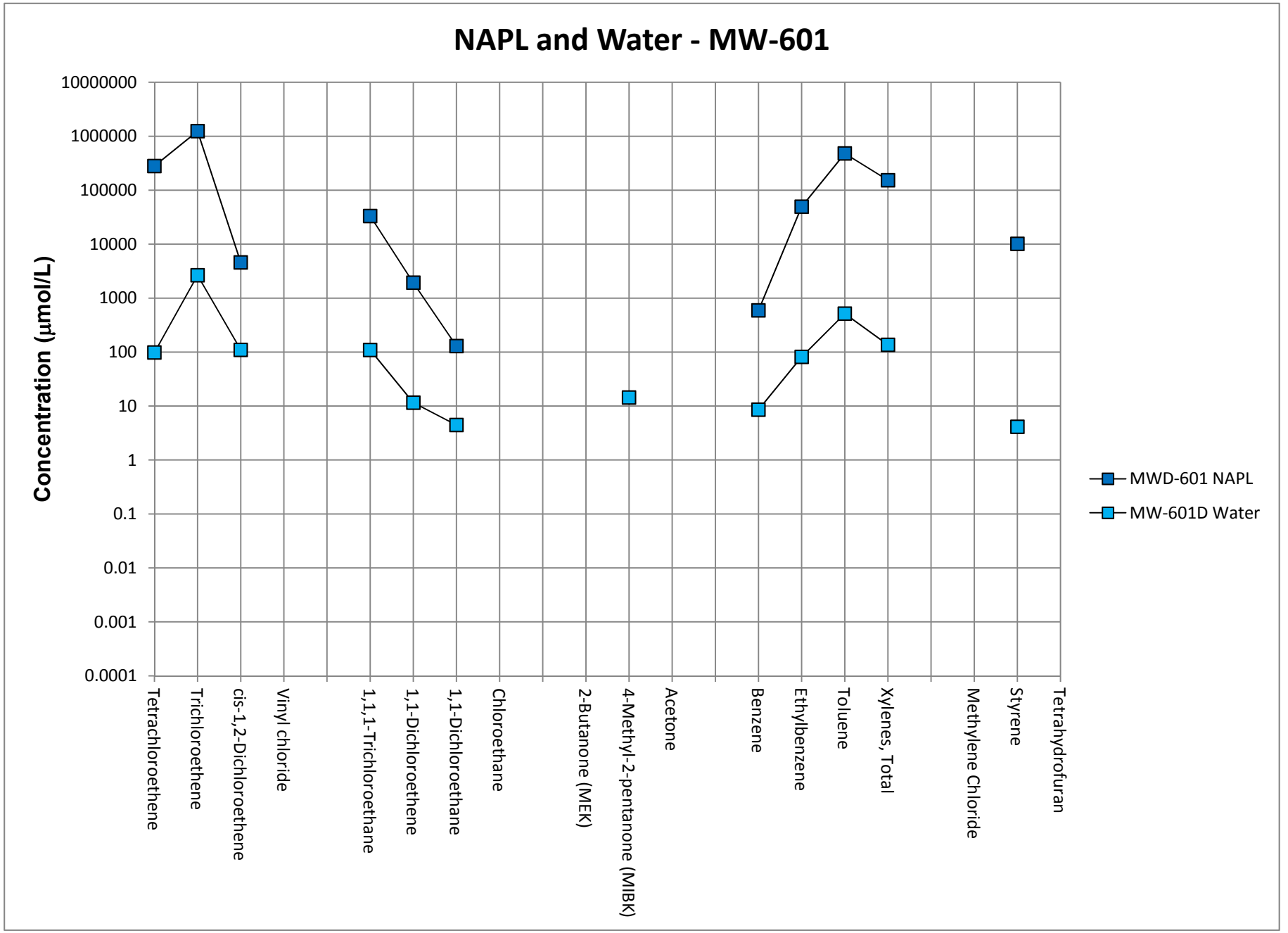
BEDROCK TOTAL MASS REMAINING, 2015 (kg) **13,169**

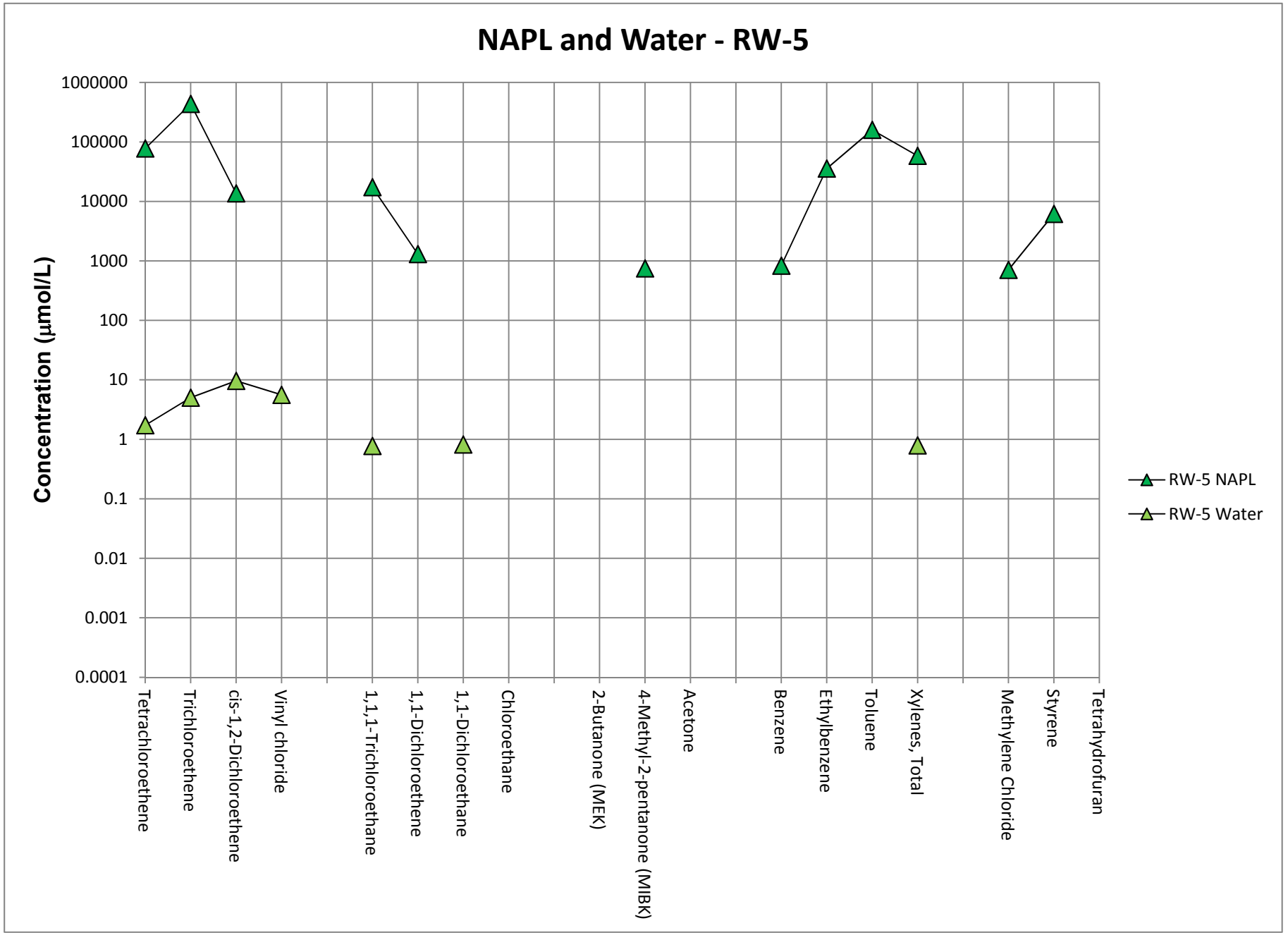
Notes: * Midpoint of range of single-fracture retention capacity reported for 20 degree fracture dip.
(Longino, B.L., and B.H. Kueper. 1999. Non-wetting phase retention and mobilizaiton in rock fractures. Water Resources Research, vol. 35, no. 7, pp. 2085-2093. July 1999.)

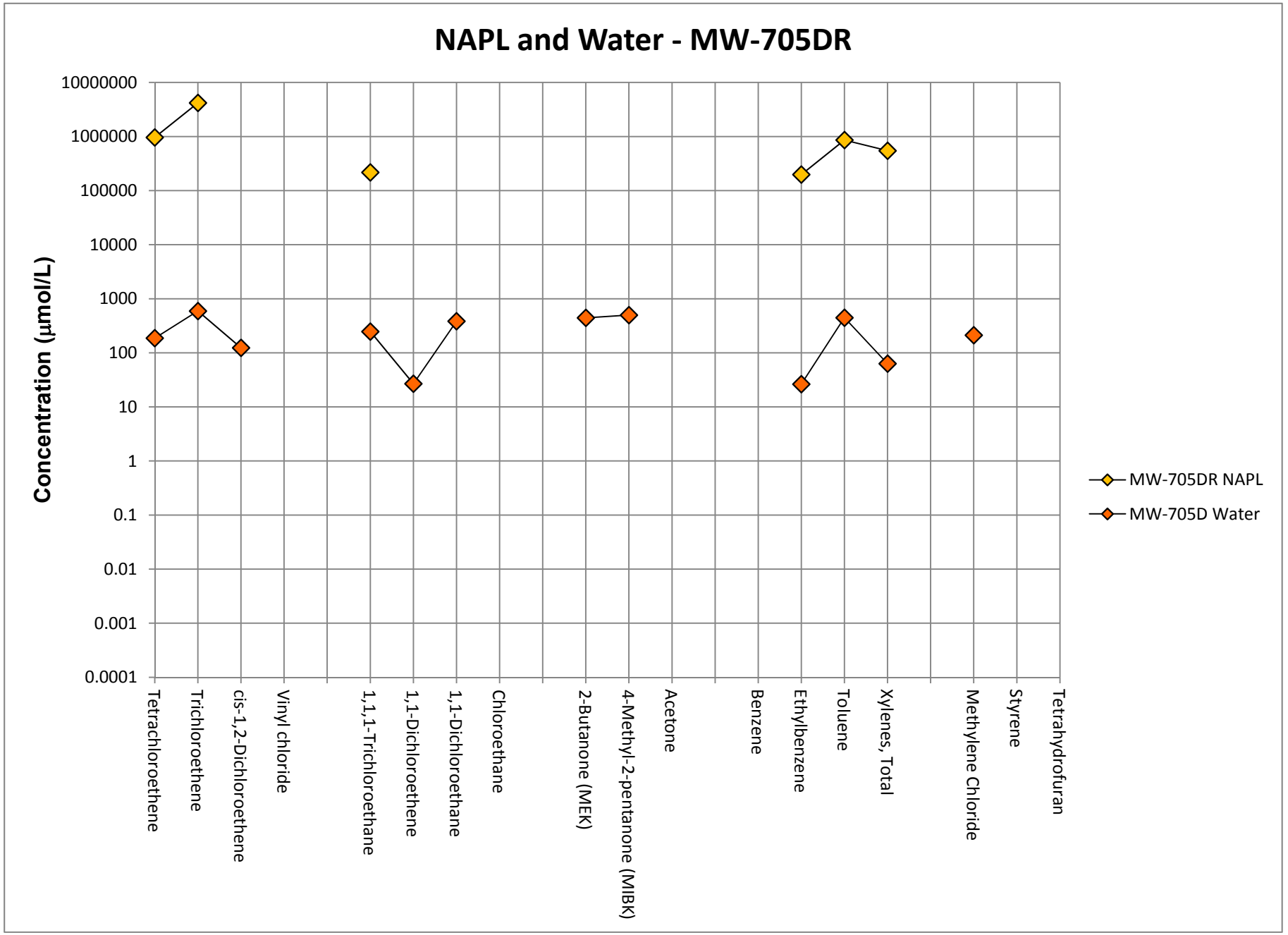
Attachment B

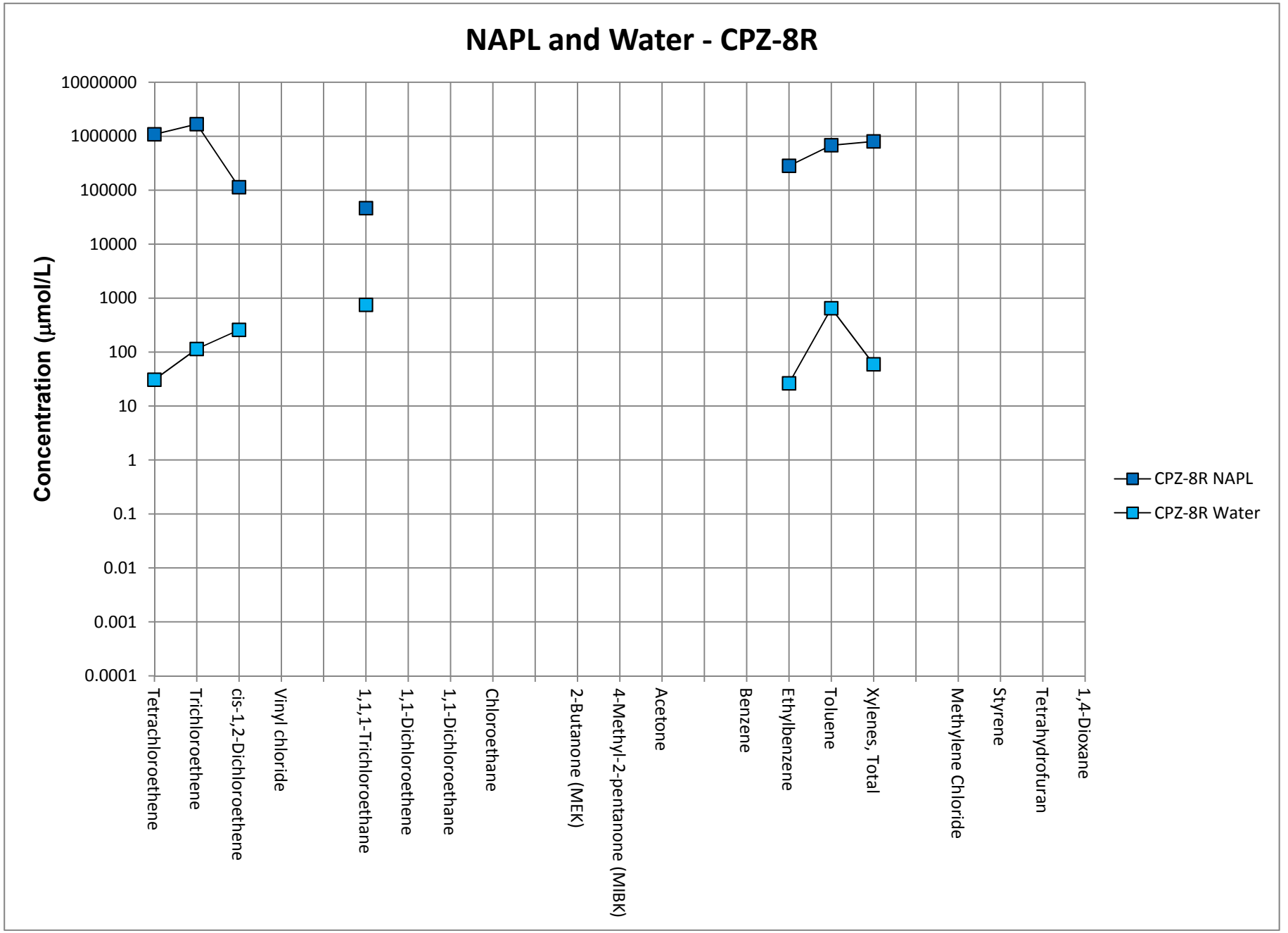
Distribution of Select VOCs in NAPL and Water in Contact with NAPL

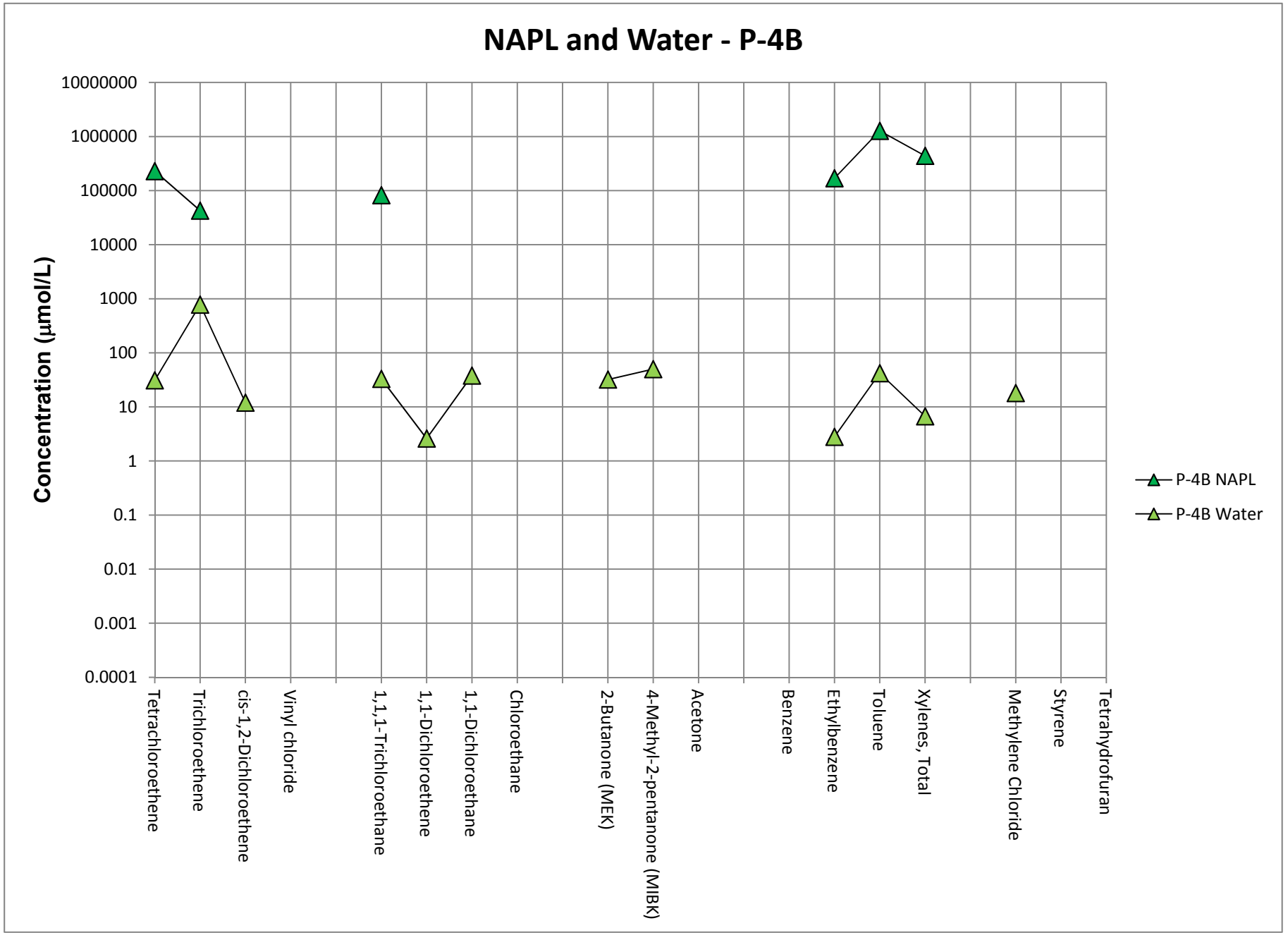

NAPL Samples
Concentration (µmol/L)
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
MWD-601
RW-5
IW-23
MW-705DR
CPZ-8R
P-4B
PZ-906DR


NAPL and Water - MW-601
Concentration (µmol/L)
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
MWD-601 NAPL
MW-601D Water


NAPL and Water - RW-5
Concentration (µmol/L)
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
RW-5 NAPL
RW-5 Water


NAPL and Water - MW-705DR
Concentration (µmol/L)
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
MW-705DR NAPL
MW-705D Water

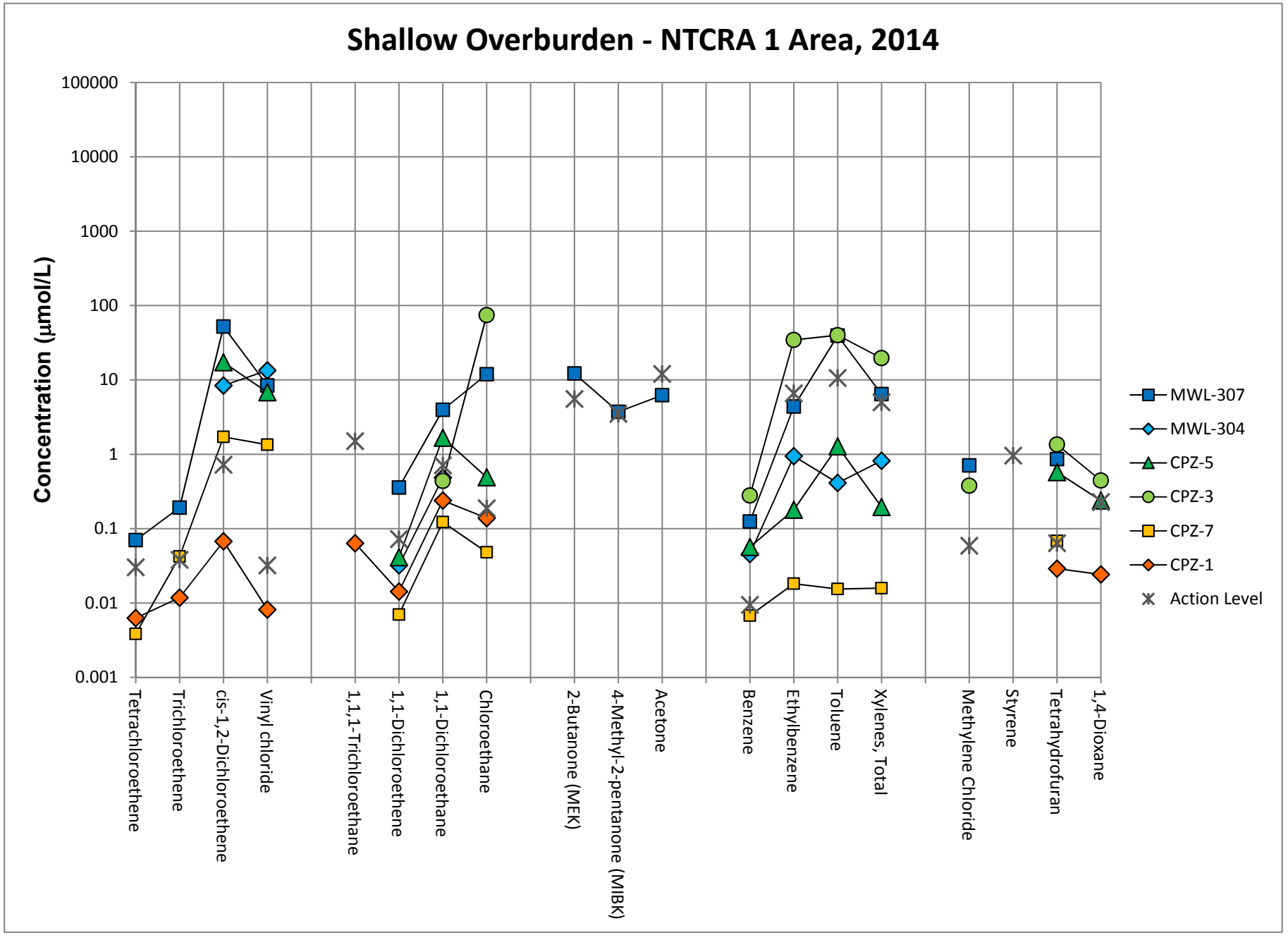

NAPL and Water - CPZ-8R
Concentration (µmol/L)
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
CPZ-8R NAPL
CPZ-8R Water

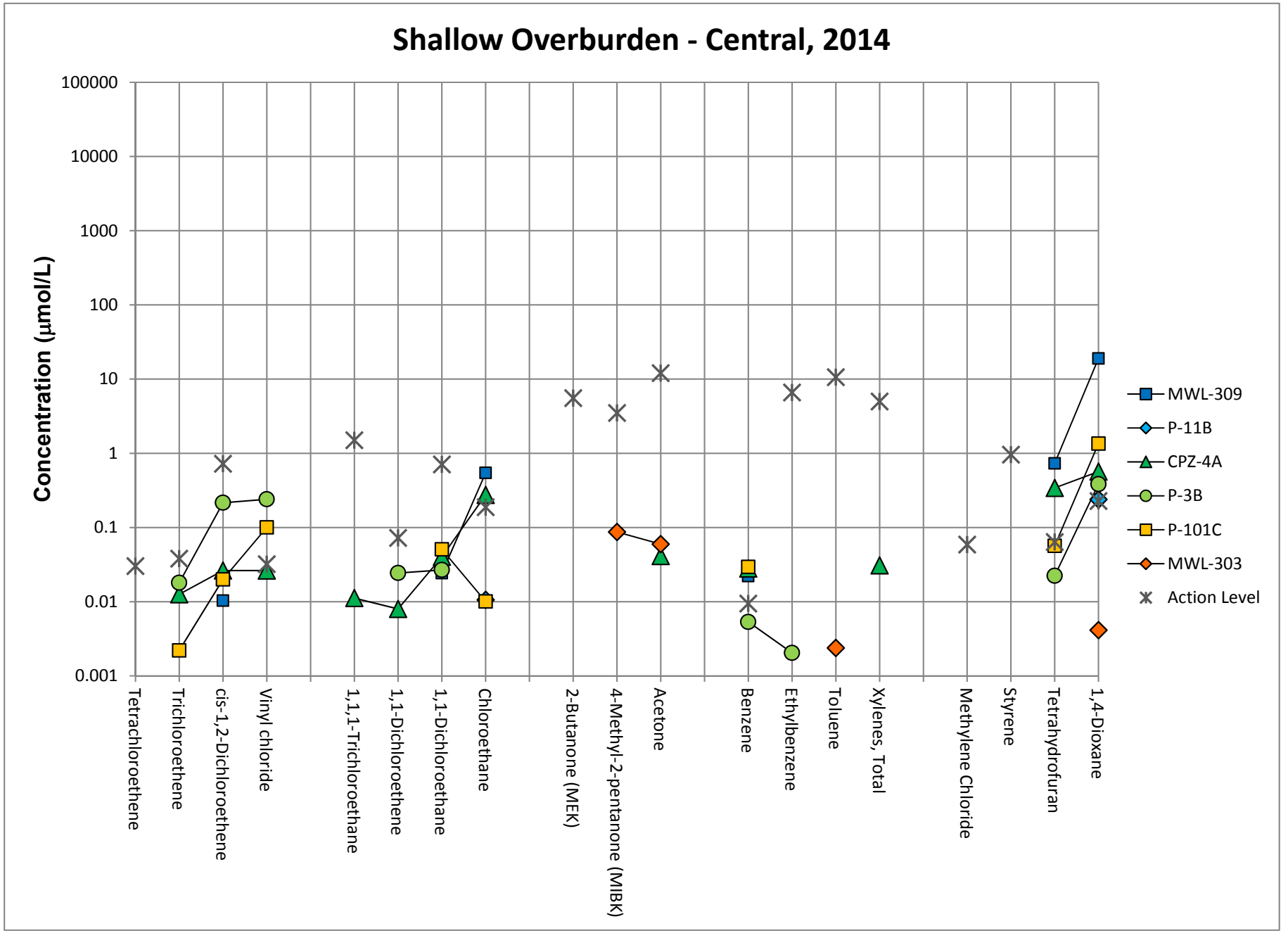

NAPL and Water - P-4B
Concentration (µmol/L)
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
P-4B NAPL
P-4B Water

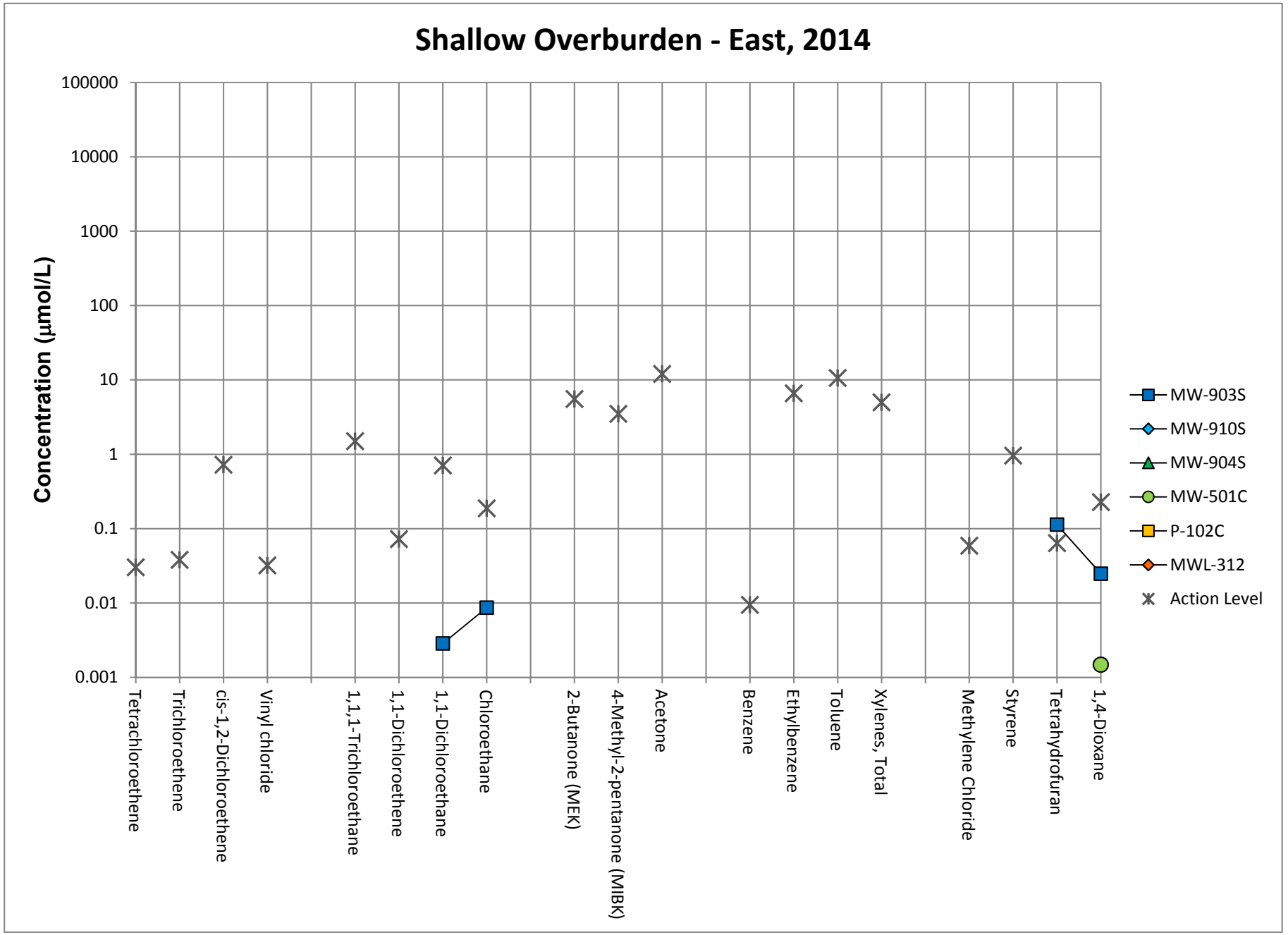
ARCADIS

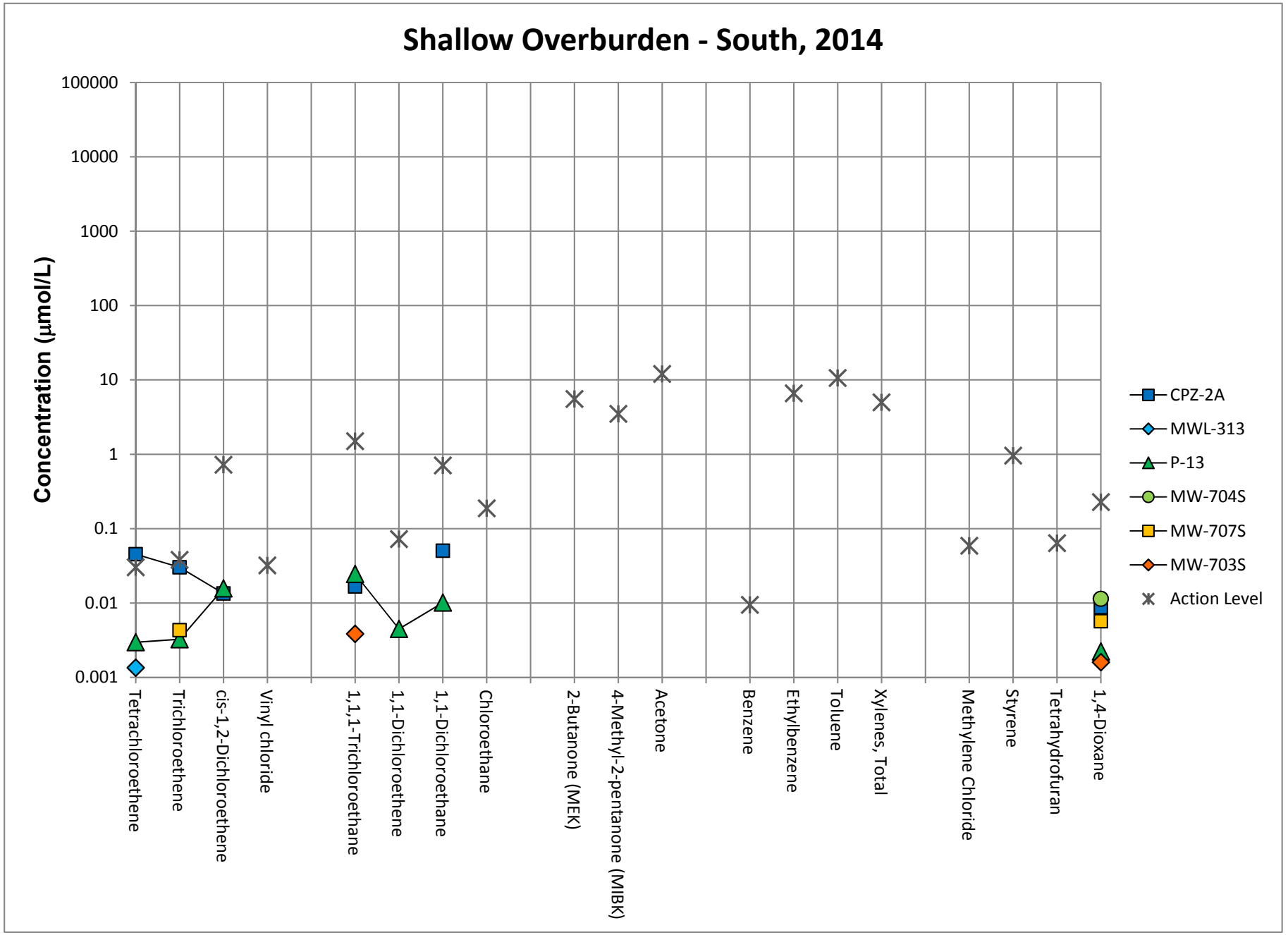
Attachment C

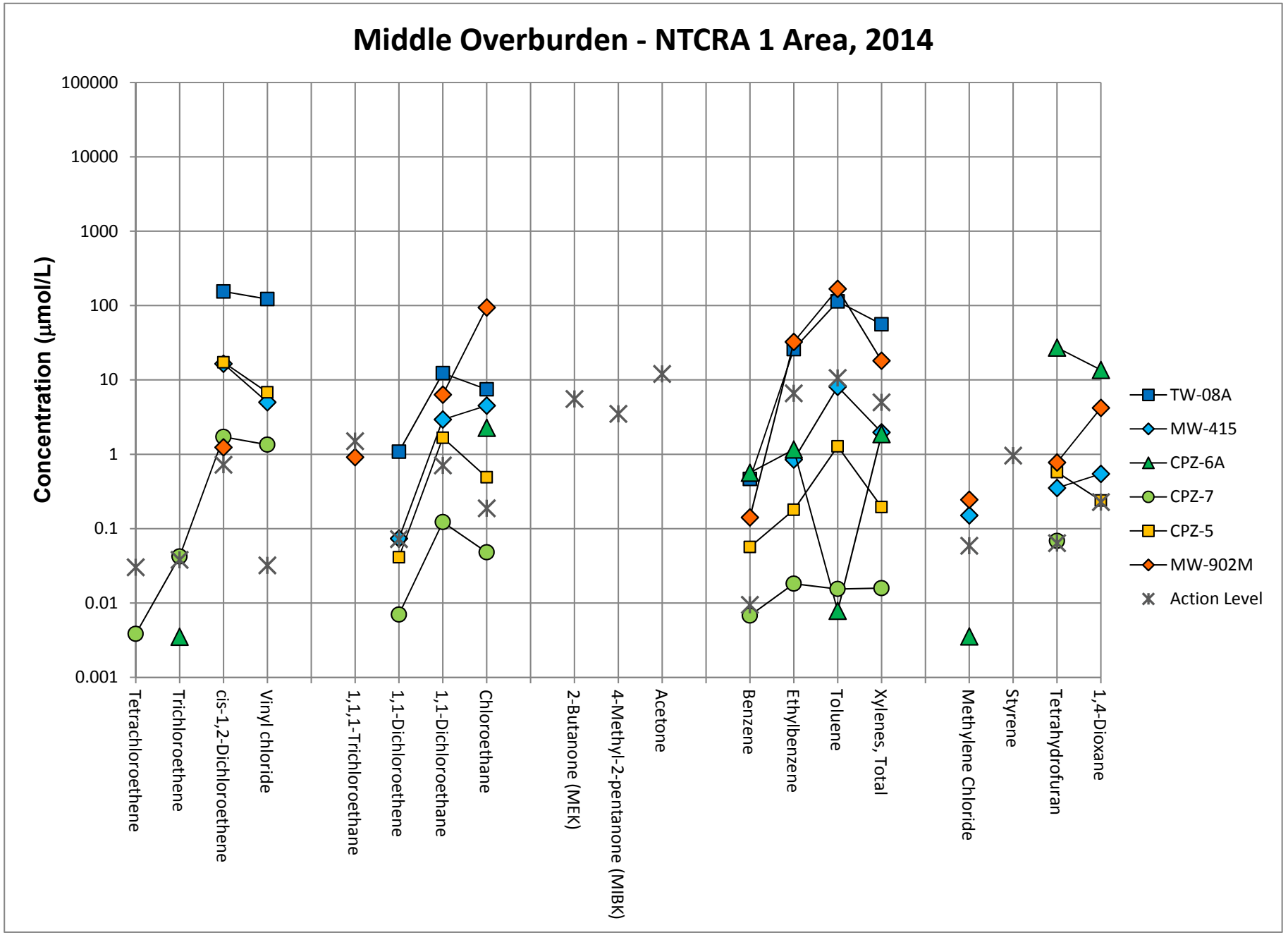
Distribution of Select VOCs in Groundwater by Hydrostratigraphic Units for all 2014 Comprehensive Groundwater Monitoring Locations

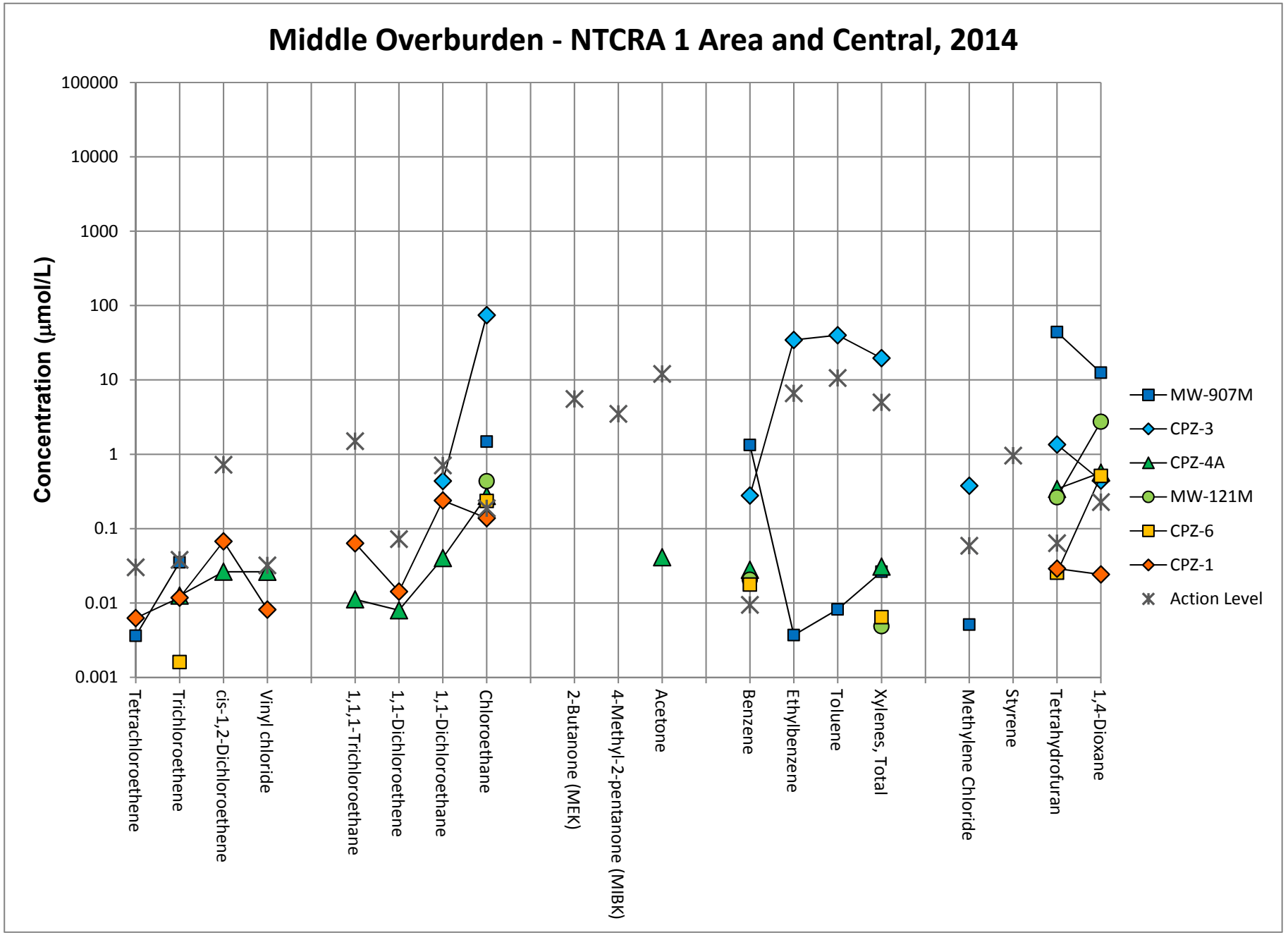

Shallow Overburden - NTCRA 1 Area, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
MWL-307
MWL-304
CPZ-5
CPZ-3
CPZ-7
CPZ-1
Action Level

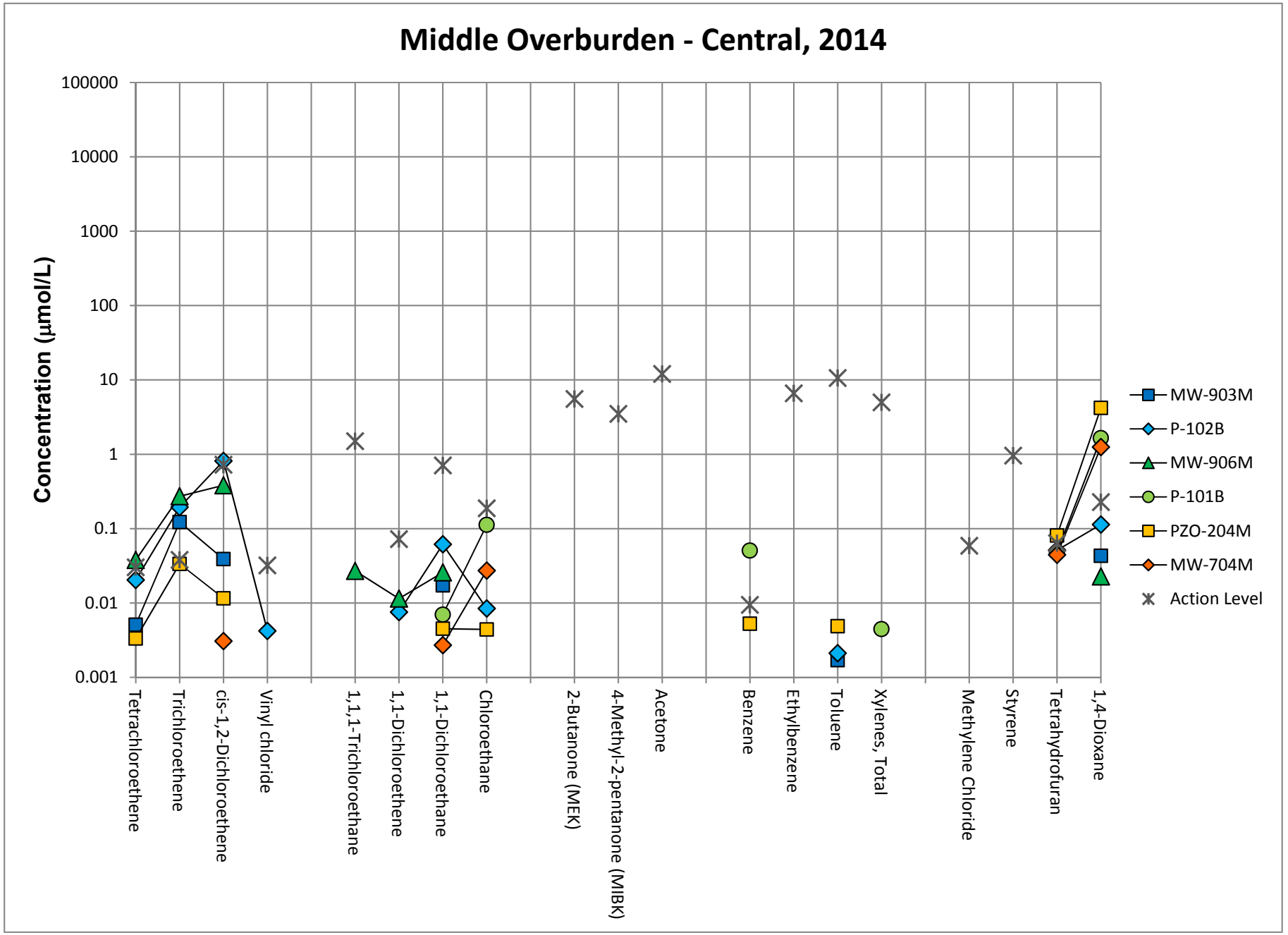

Shallow Overburden - Central, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
MWL-309
P-11B
CPZ-4A
P-3B
P-101C
MWL-303
Action Level

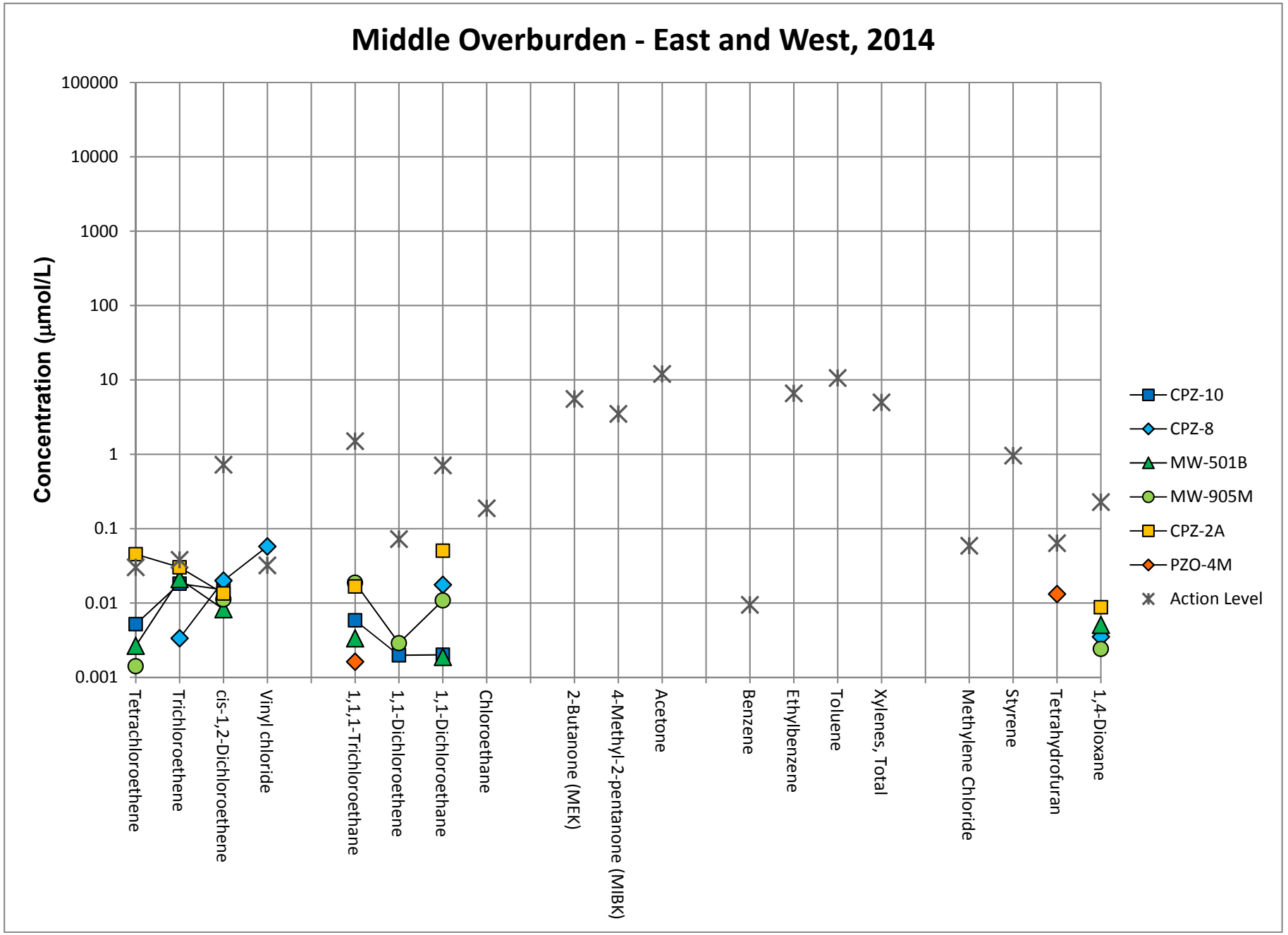

Shallow Overburden - East, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
MW-903S
MW-910S
MW-904S
MW-501C
P-102C
MWL-312
Action Level

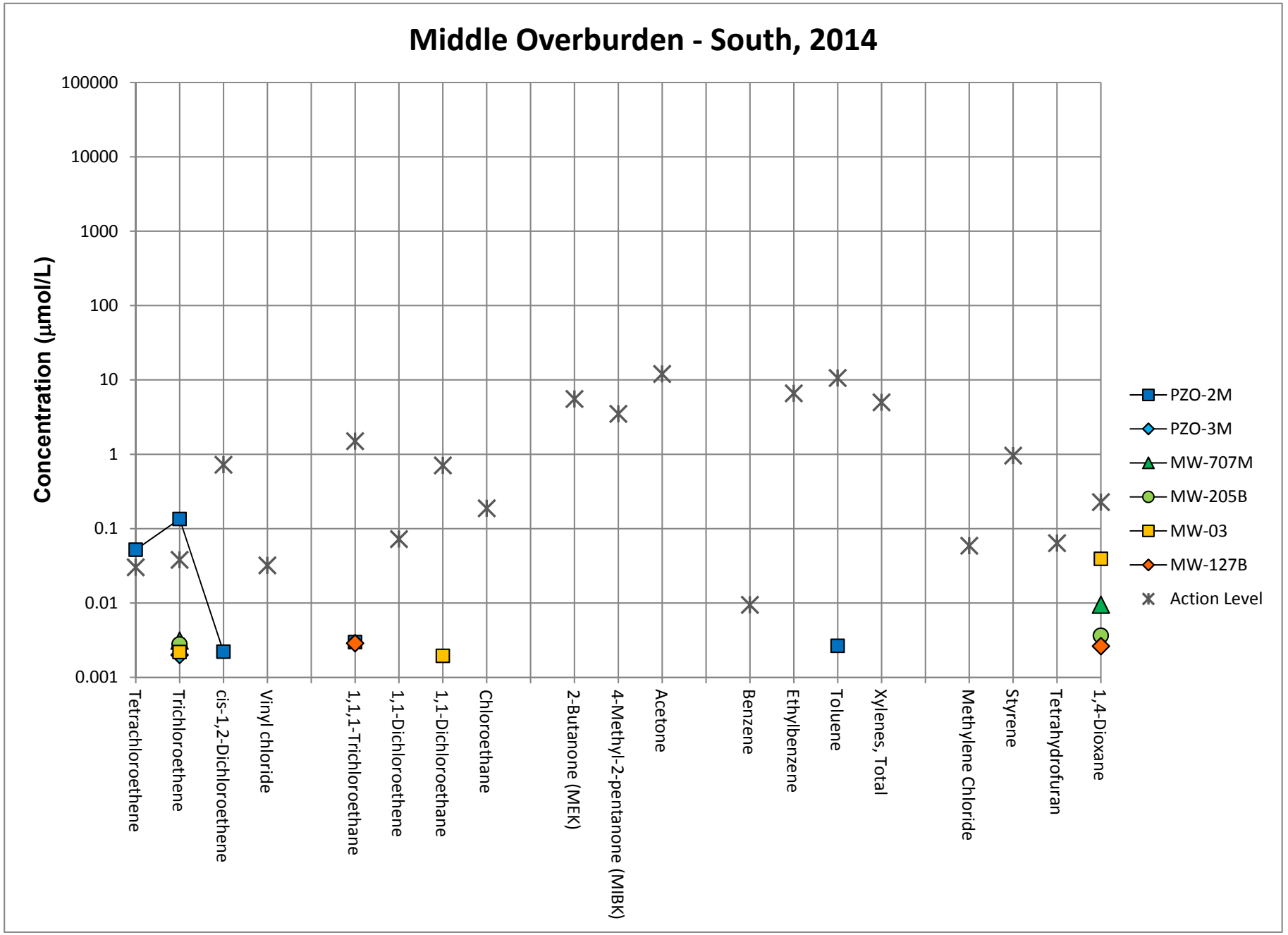

Shallow Overburden - South, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
CPZ-2A
MWL-313
P-13
MW-704S
MW-707S
MW-703S
Action Level

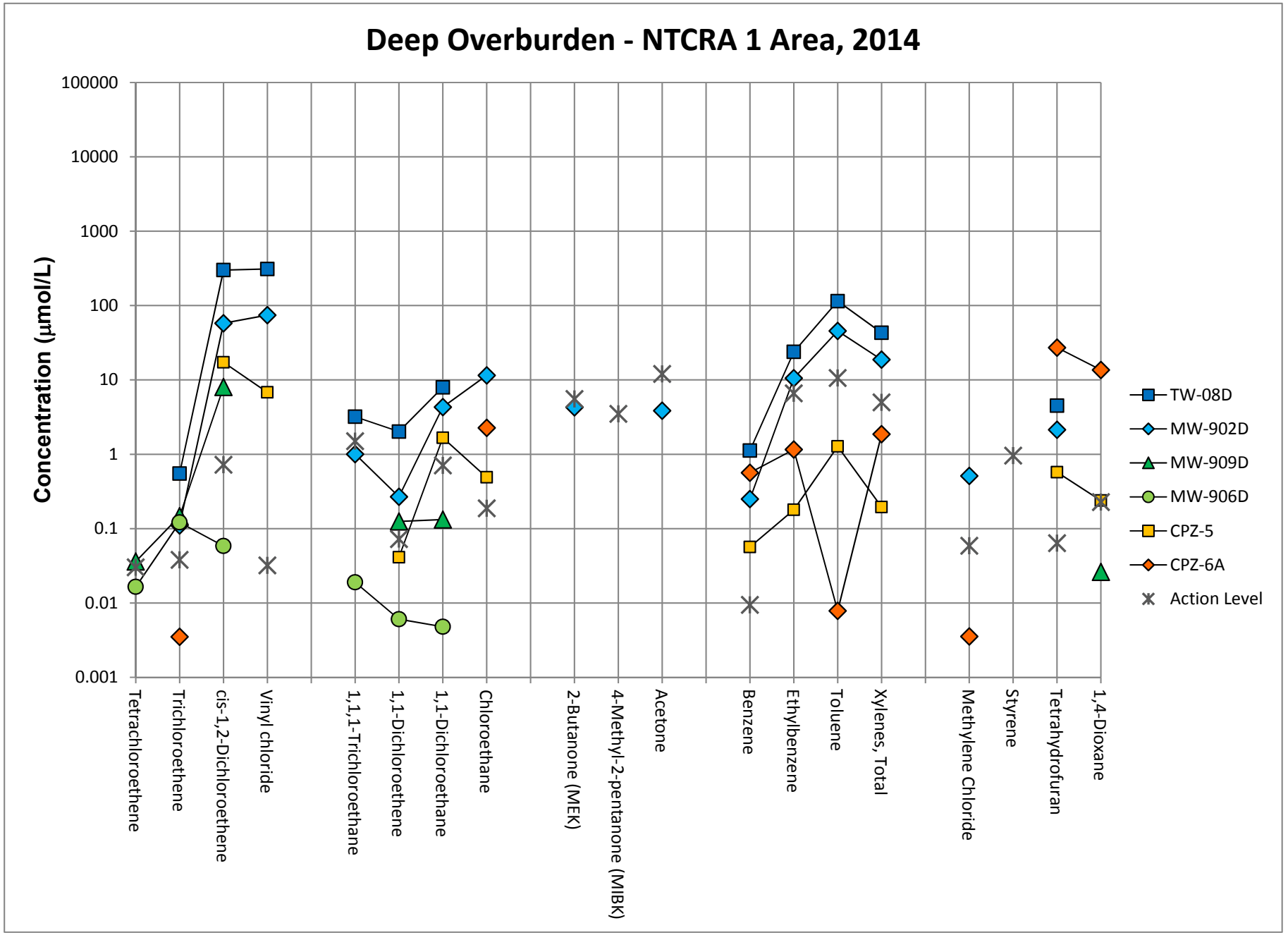

Middle Overburden - NTCRA 1 Area, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
TW-08A
MW-415
CPZ-6A
CPZ-7
CPZ-5
MW-902M
Action Level

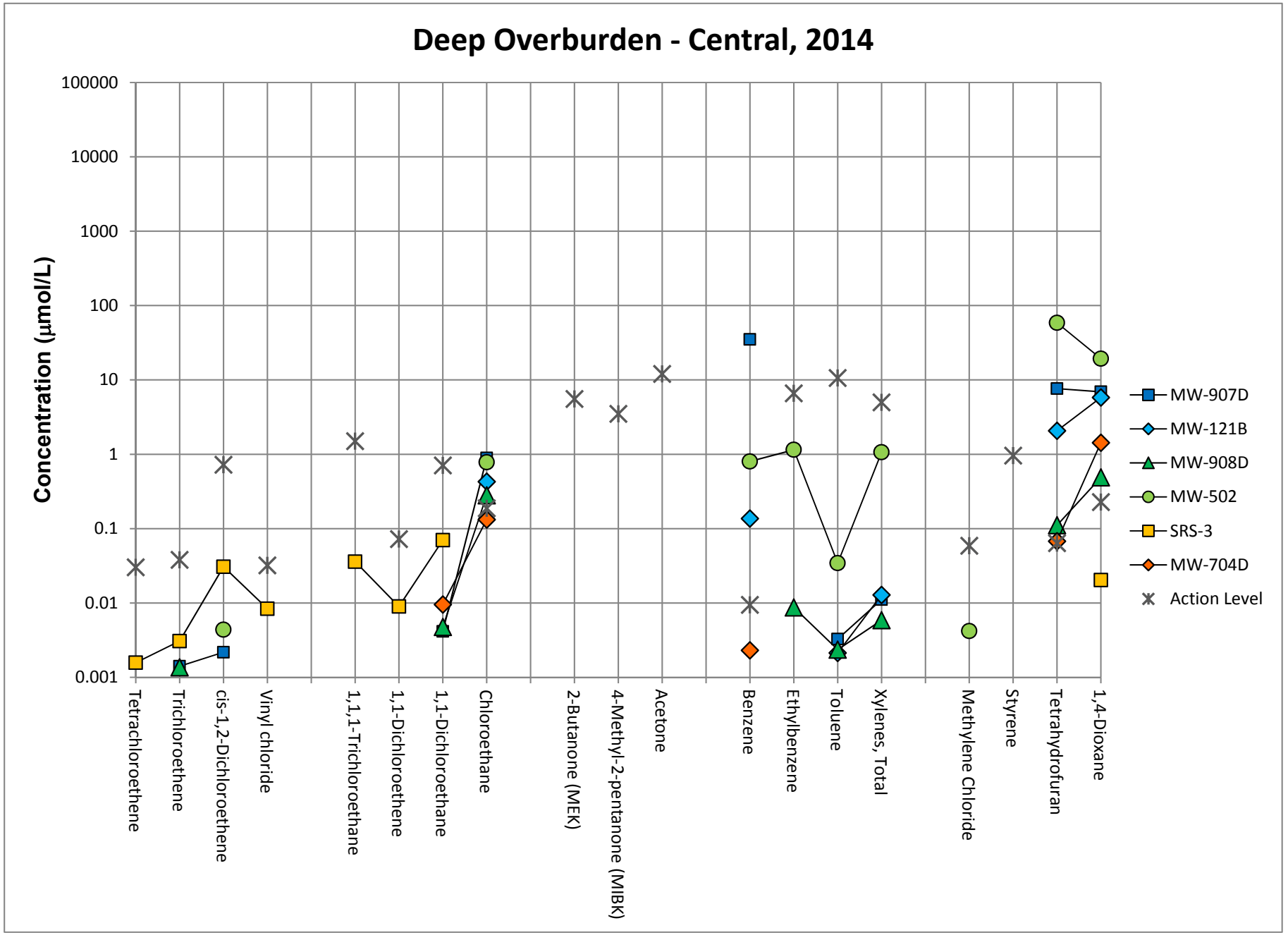

Middle Overburden - NTCRA 1 Area and Central, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
MW-907M
CPZ-3
CPZ-4A
MW-121M
CPZ-6
CPZ-1
Action Level

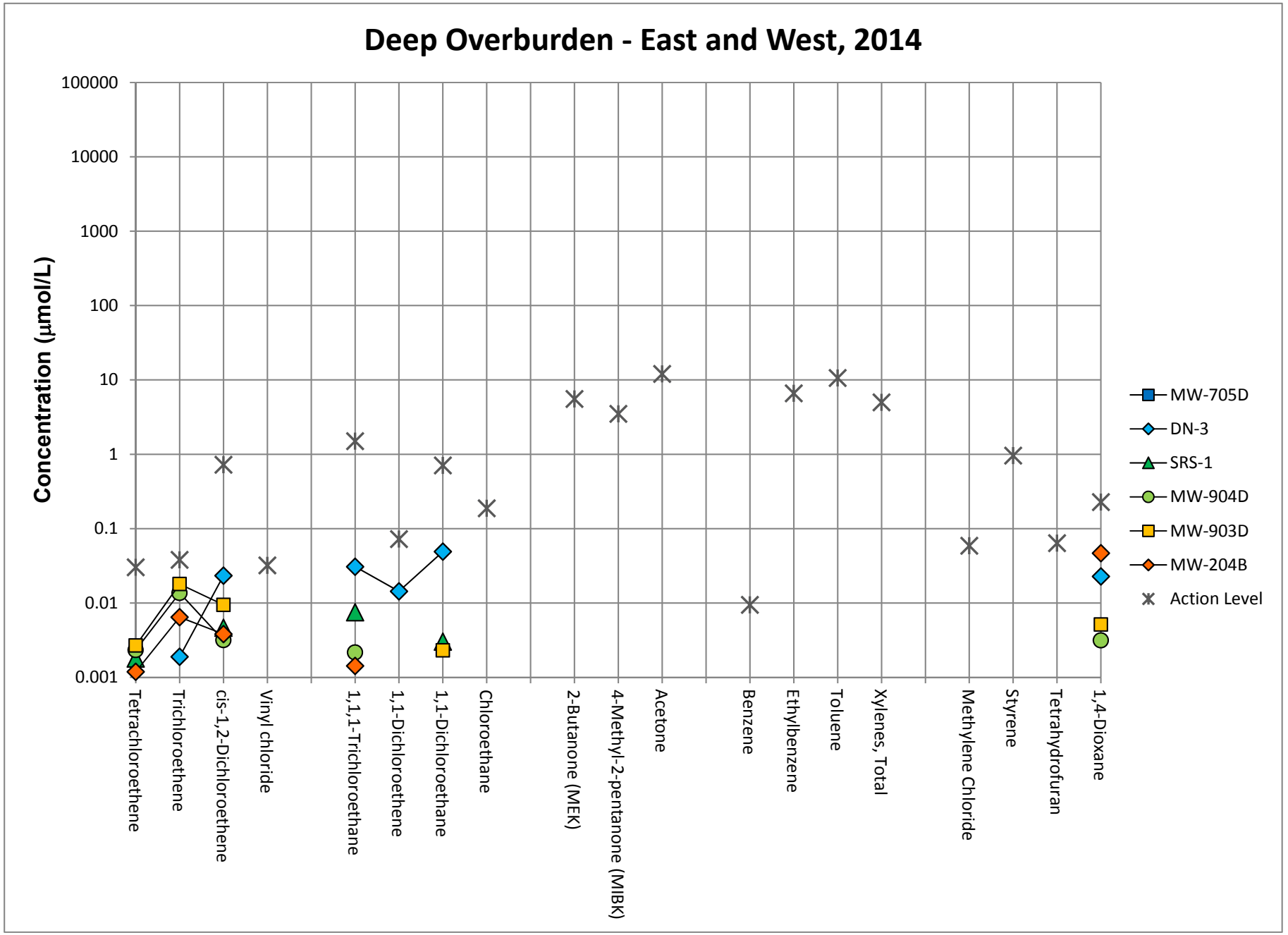

Middle Overburden - Central, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
MW-903M
P-102B
MW-906M
P-101B
PZO-204M
MW-704M
Action Level

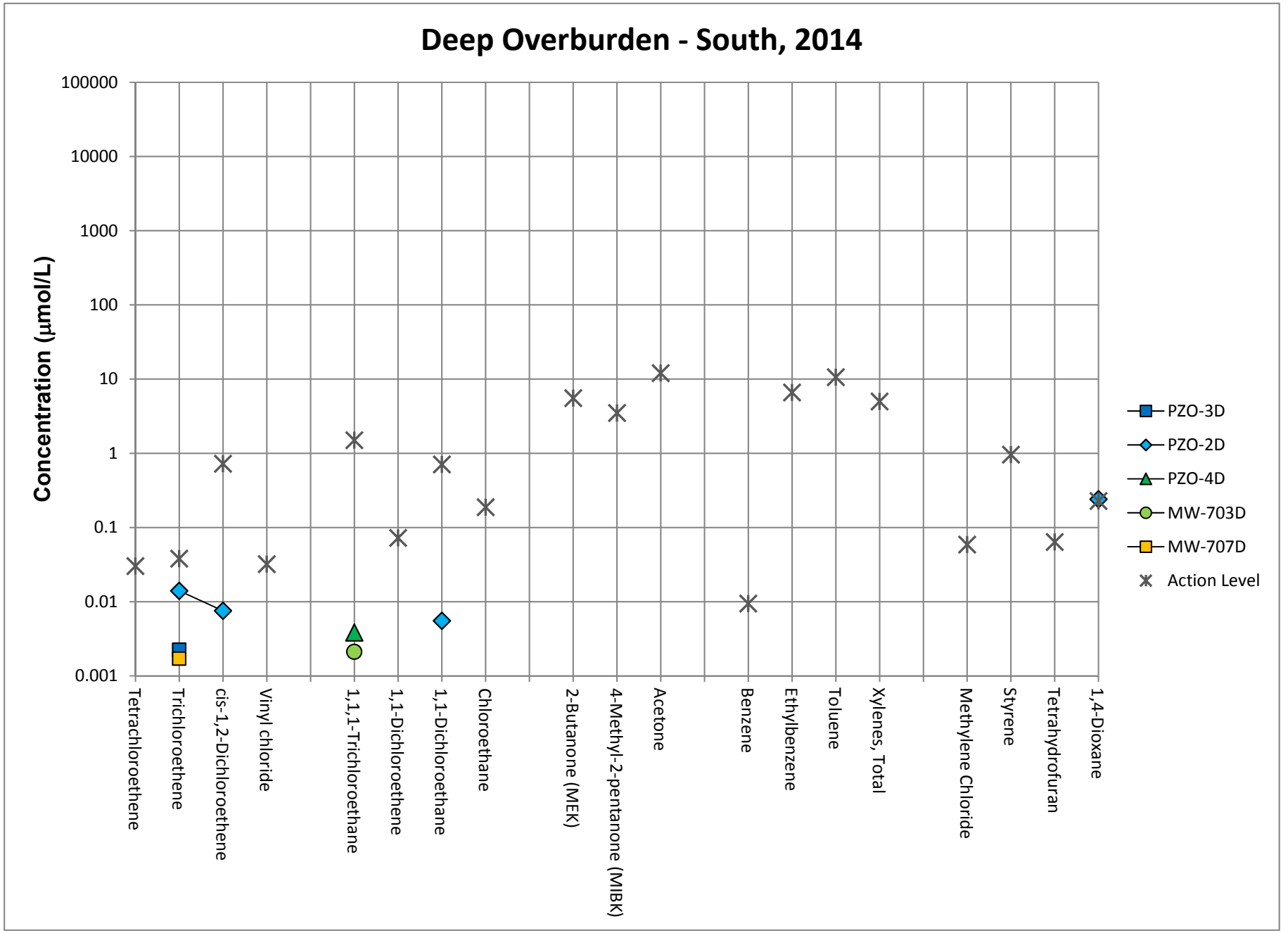

Middle Overburden - East and West, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
CPZ-10
CPZ-8
MW-501B
MW-905M
CPZ-2A
PZO-4M
Action Level

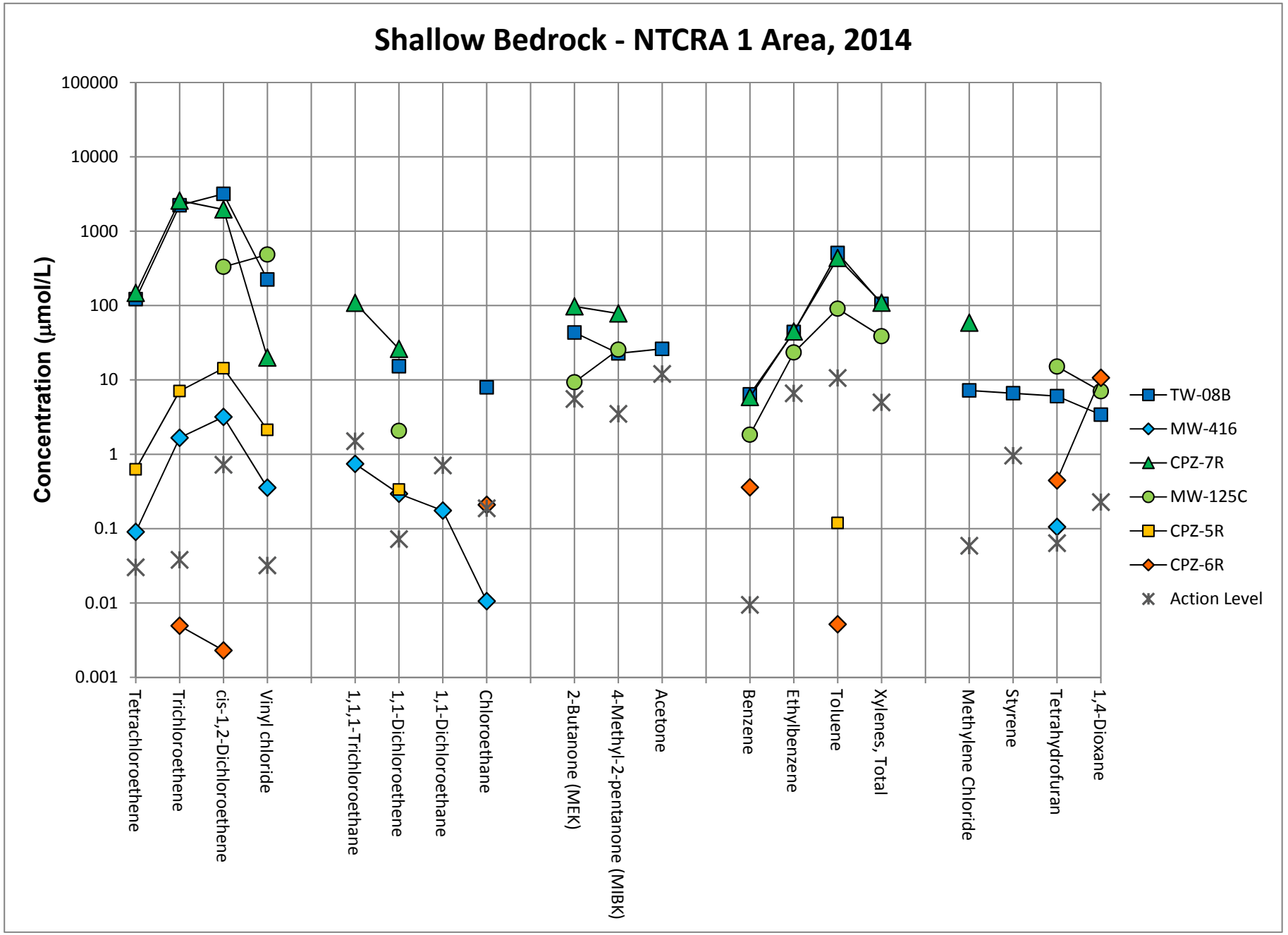

Middle Overburden - South, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
PZO-2M
PZO-3M
MW-707M
MW-205B
MW-03
MW-127B
Action Level

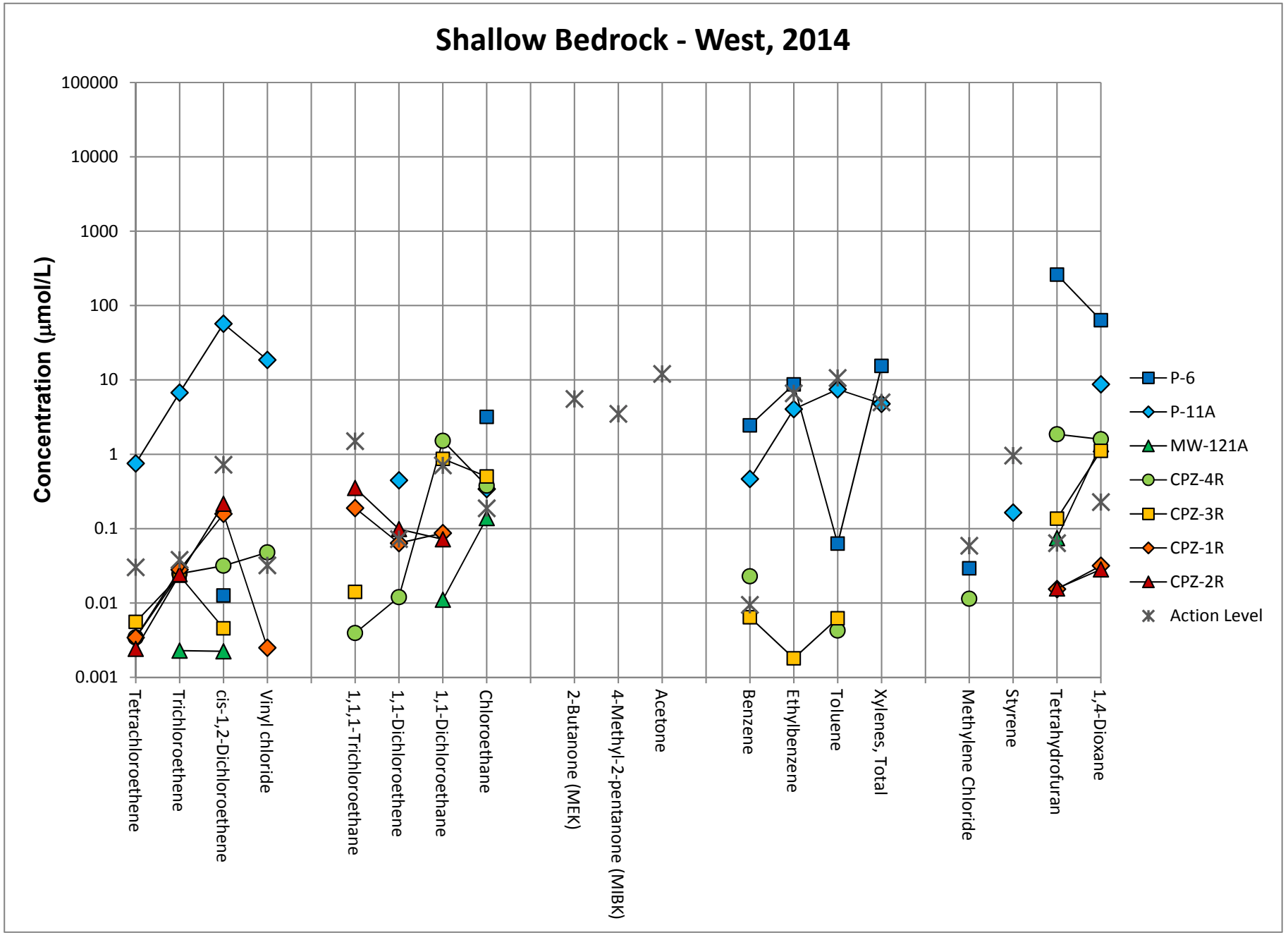

Deep Overburden - NTCRA 1 Area, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
TW-08D
MW-902D
MW-909D
MW-906D
CPZ-5
CPZ-6A
Action Level

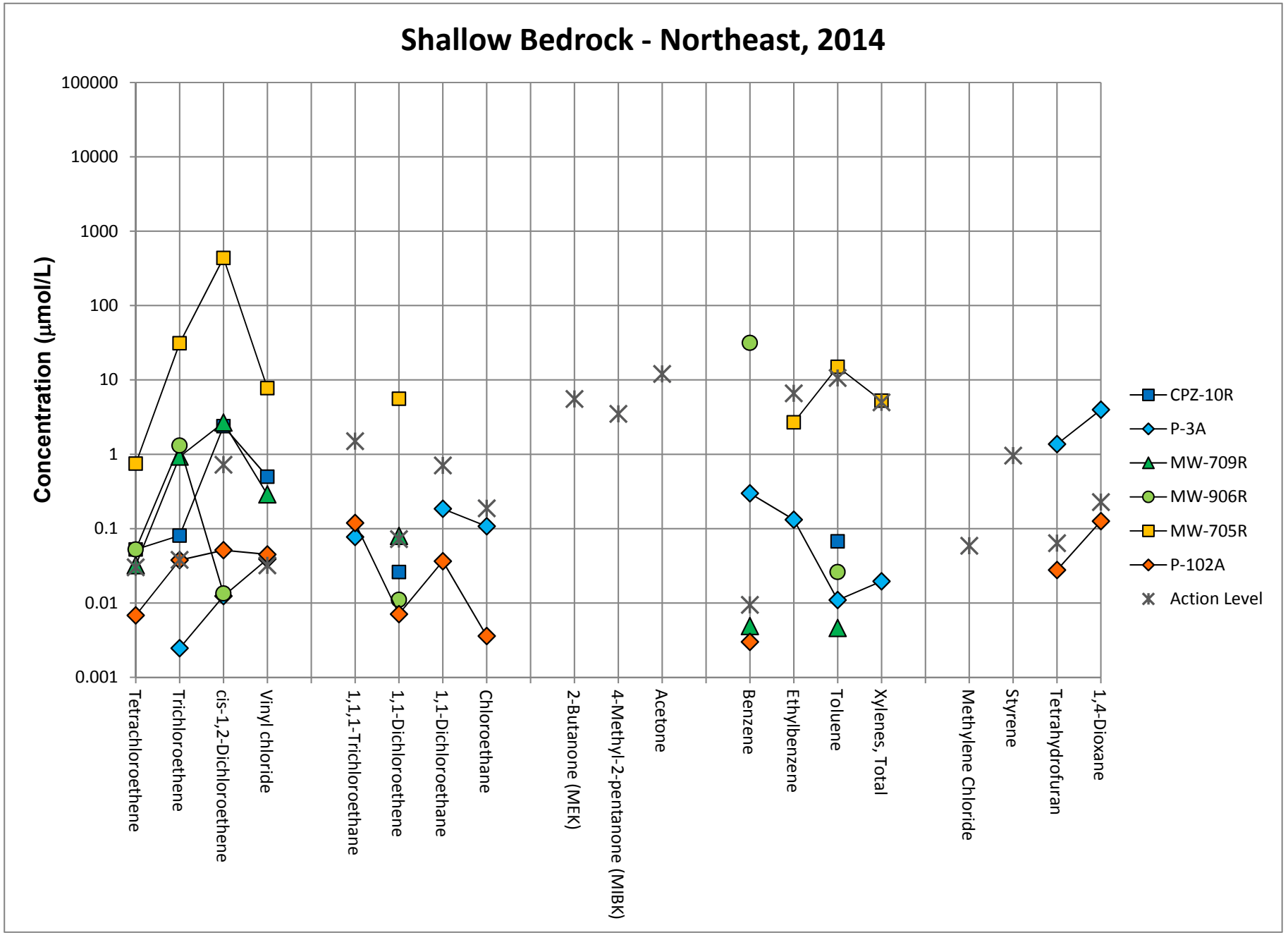

Deep Overburden - Central, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
MW-907D
MW-121B
MW-908D
MW-502
SRS-3
MW-704D
Action Level

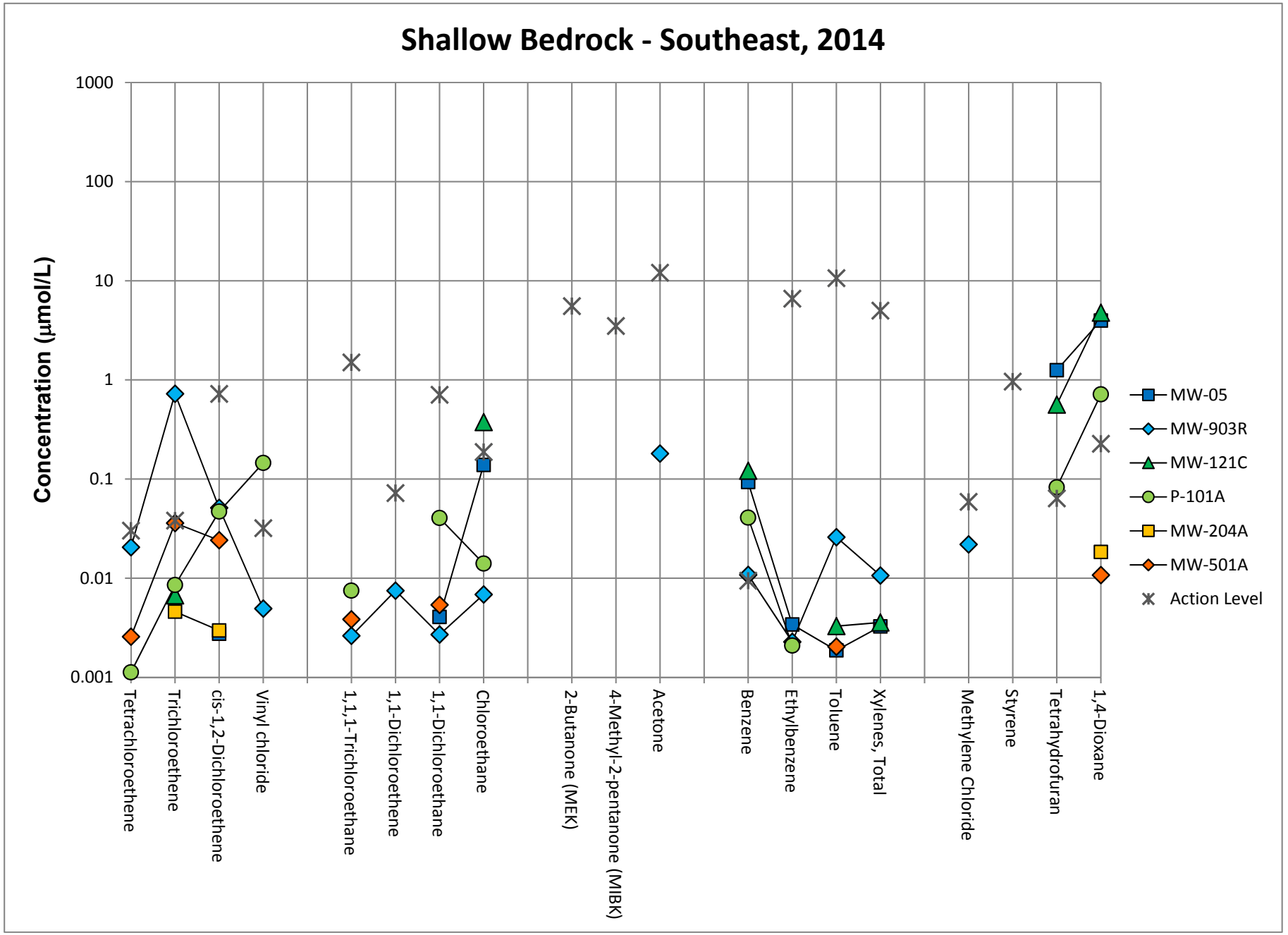

Deep Overburden - East and West, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
MW-705D
DN-3
SRS-1
MW-904D
MW-903D
MW-204B
Action Level

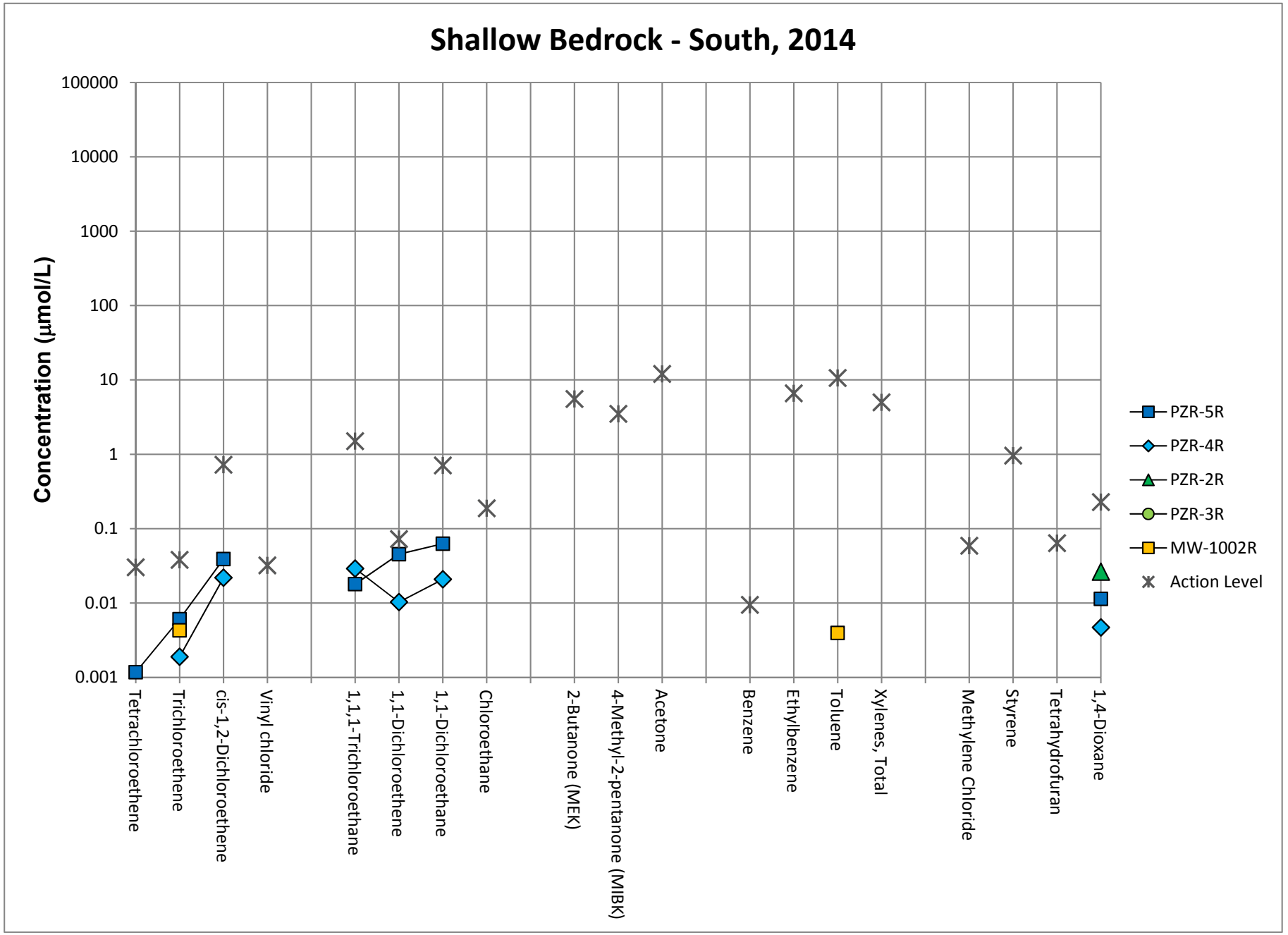

Deep Overburden - South, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
PZO-3D
PZO-2D
PZO-4D
MW-703D
MW-707D
Action Level

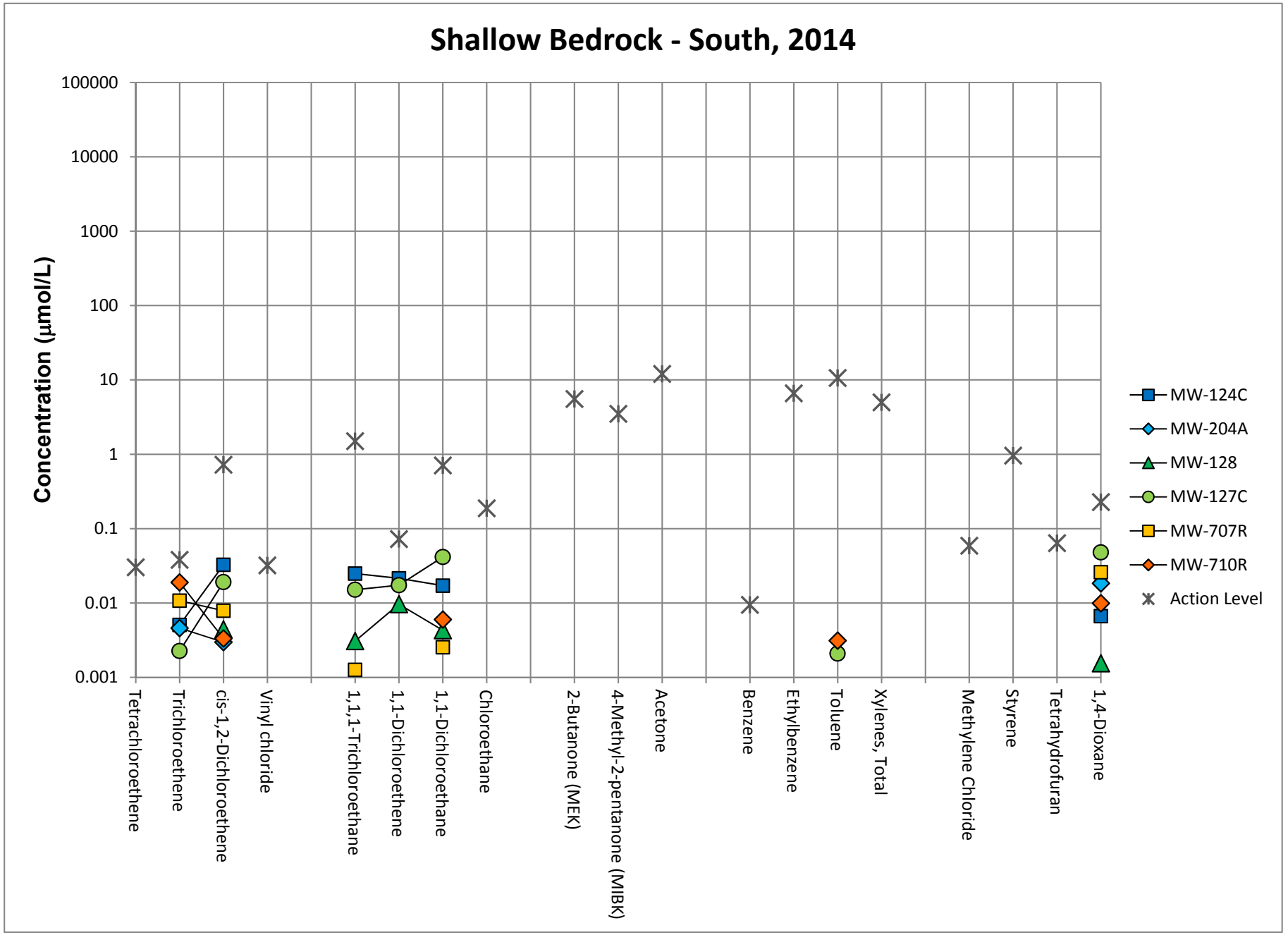

Shallow Bedrock - NTCRA 1 Area, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
TW-08B
MW-416
CPZ-7R
MW-125C
CPZ-5R
CPZ-6R
Action Level

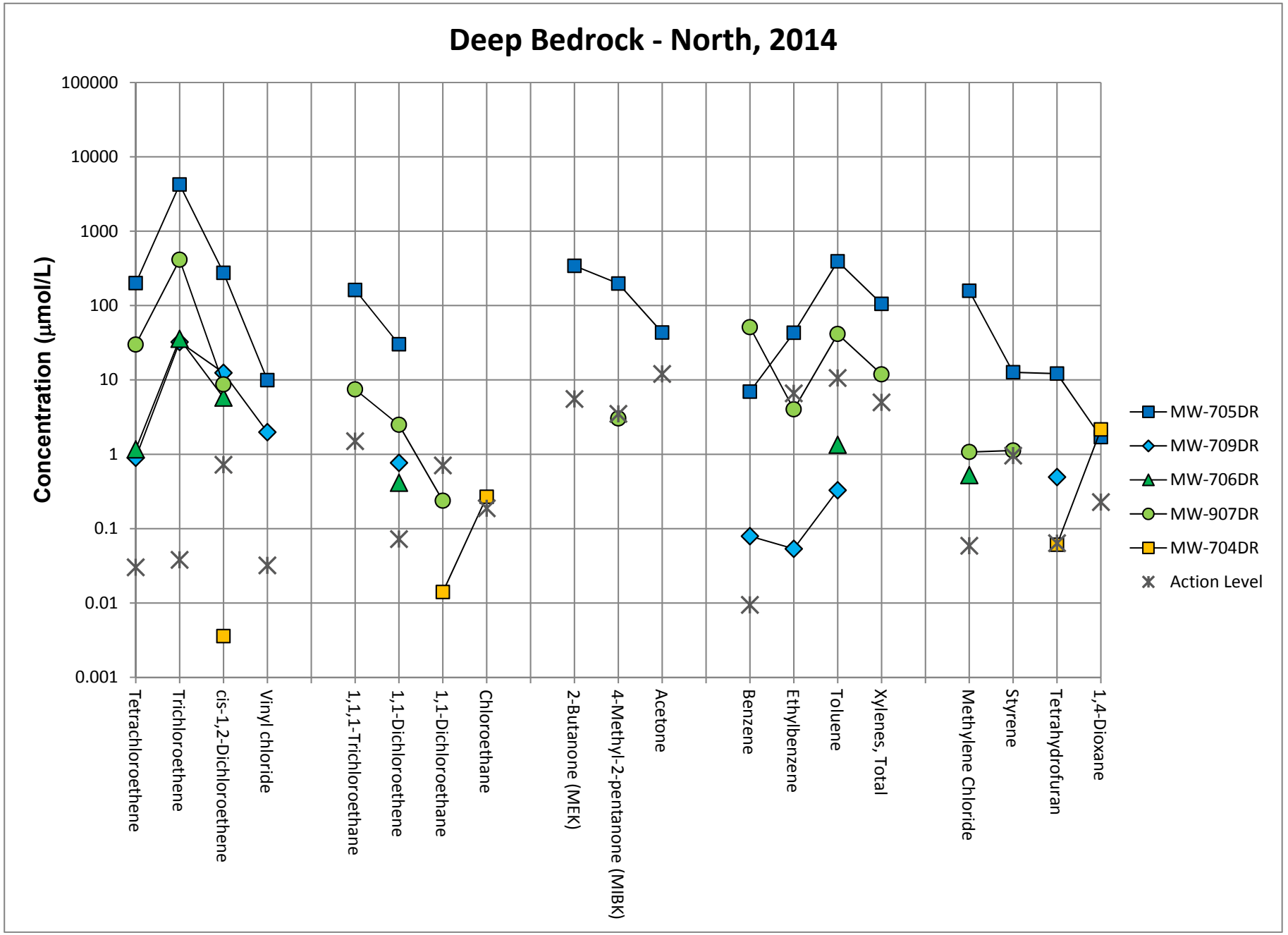

Shallow Bedrock - West, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
P-6
P-11A
MW-121A
CPZ-4R
CPZ-3R
CPZ-1R
CPZ-2R
Action Level

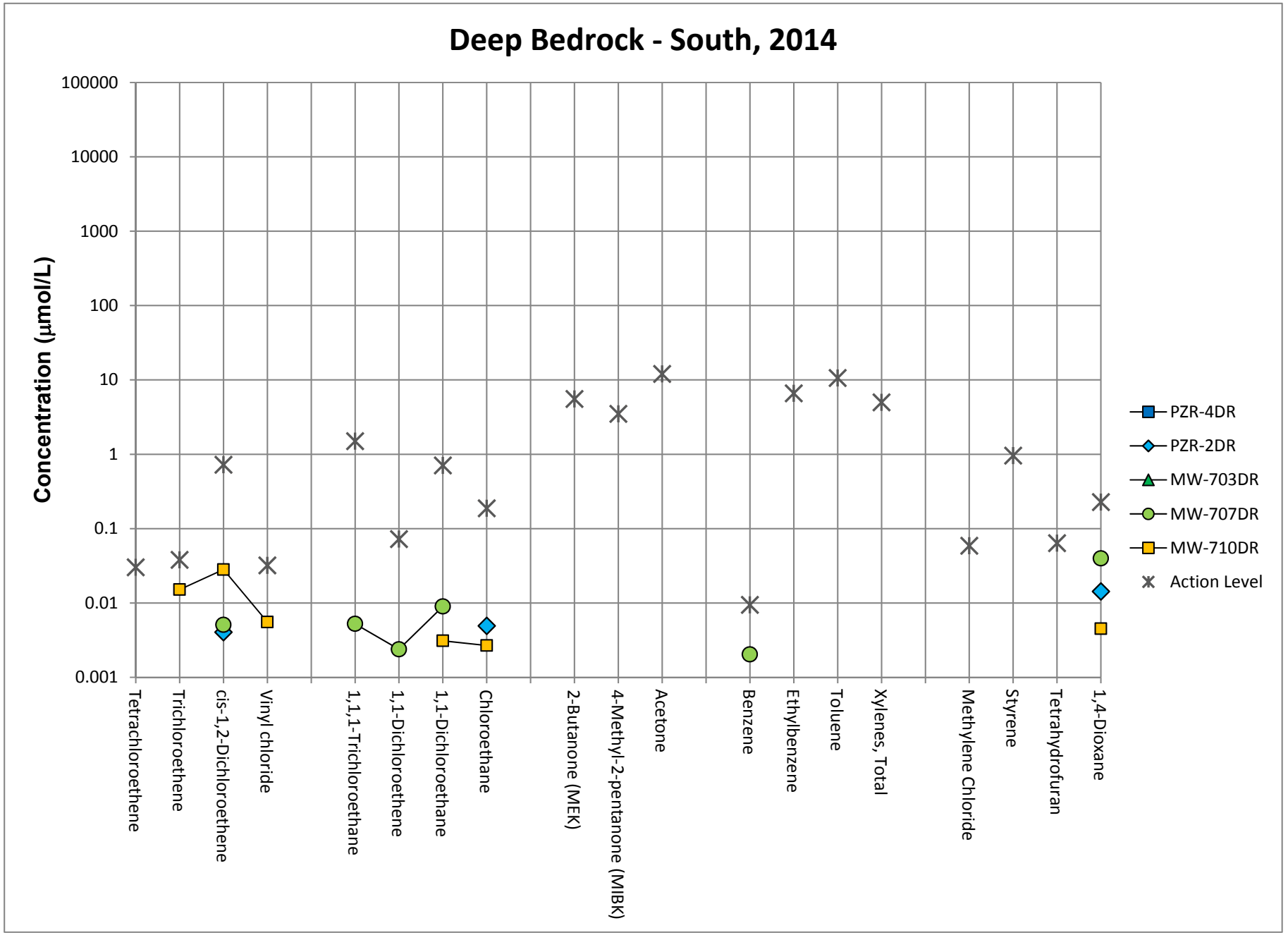

Shallow Bedrock - Northeast, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
CPZ-10R
P-3A
MW-709R
MW-906R
MW-705R
P-102A
Action Level


Shallow Bedrock - Southeast, 2014
Concentration (µmol/L)
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
MW-05
MW-903R
MW-121C
P-101A
MW-204A
MW-501A
Action Level


Shallow Bedrock - South, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
PZR-5R
PZR-4R
PZR-2R
PZR-3R
MW-1002R
Action Level


Shallow Bedrock - South, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
MW-124C
MW-204A
MW-128
MW-127C
MW-707R
MW-710R
Action Level

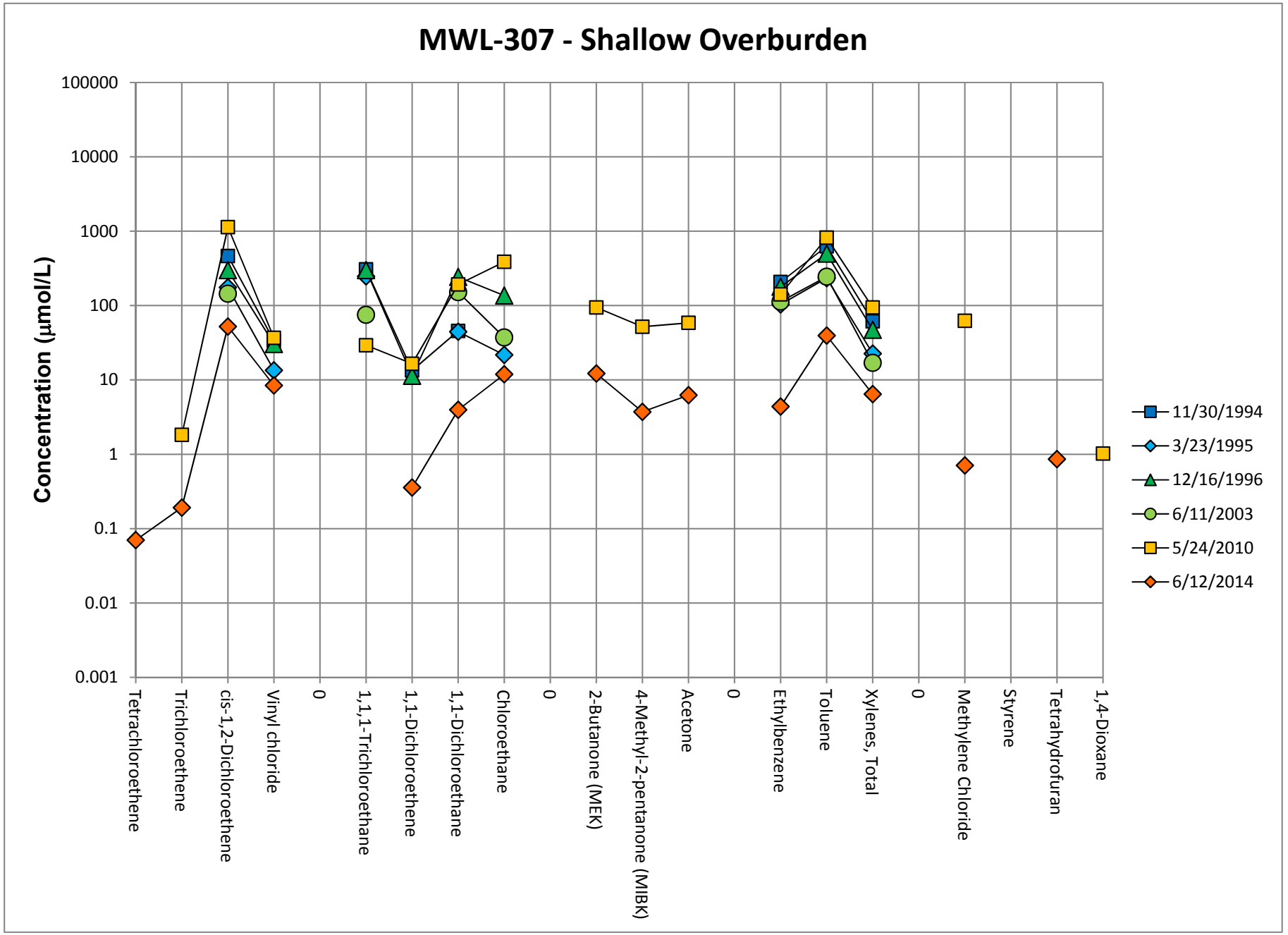

Deep Bedrock - North, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
MW-705DR
MW-709DR
MW-706DR
MW-907DR
MW-704DR
Action Level

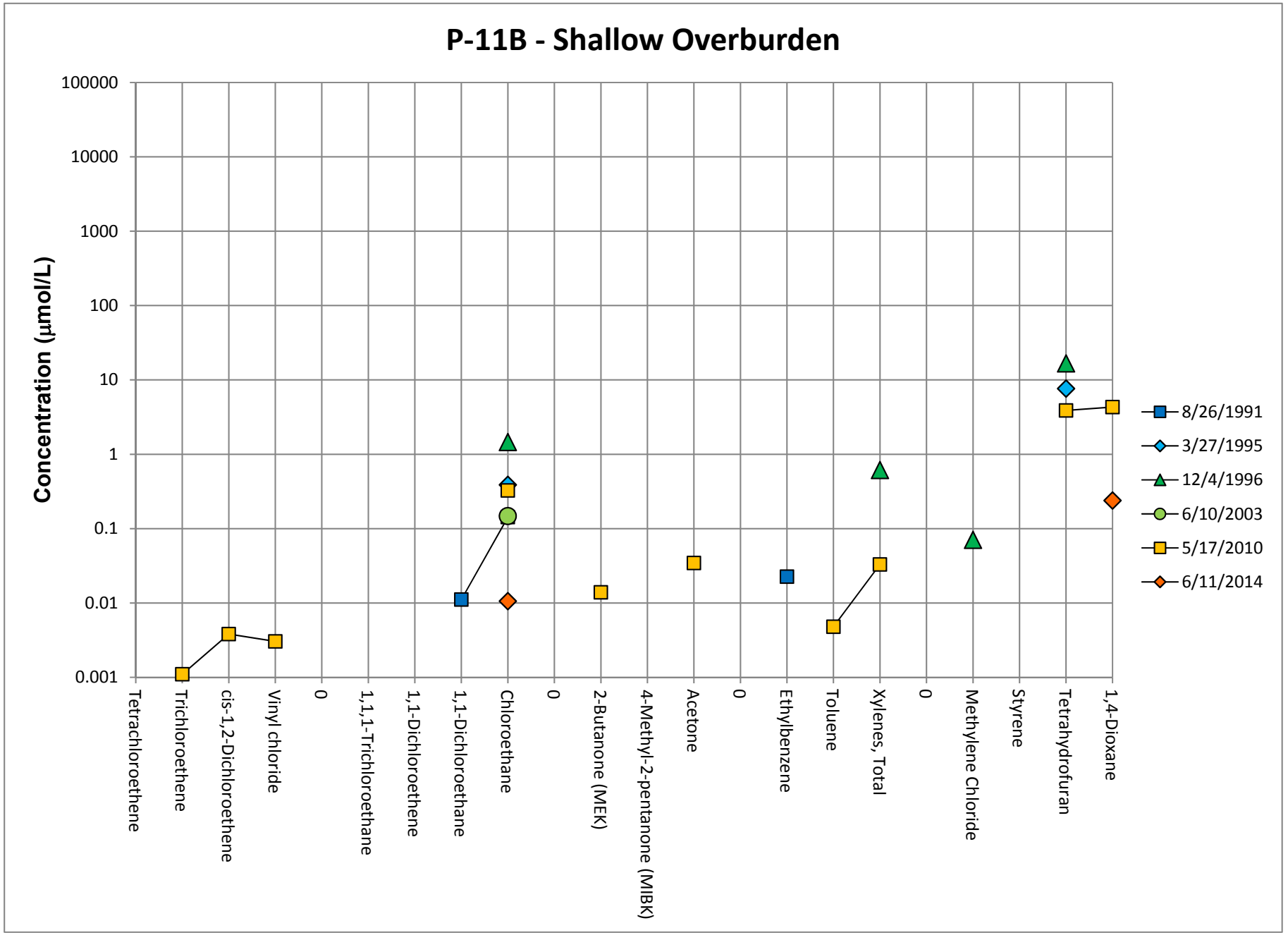

Deep Bedrock - South, 2014
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
Benzene
Ethylbenzene
Toluene
Xylenes, Total
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
PZR-4DR
PZR-2DR
MW-703DR
MW-707DR
MW-710DR
Action Level

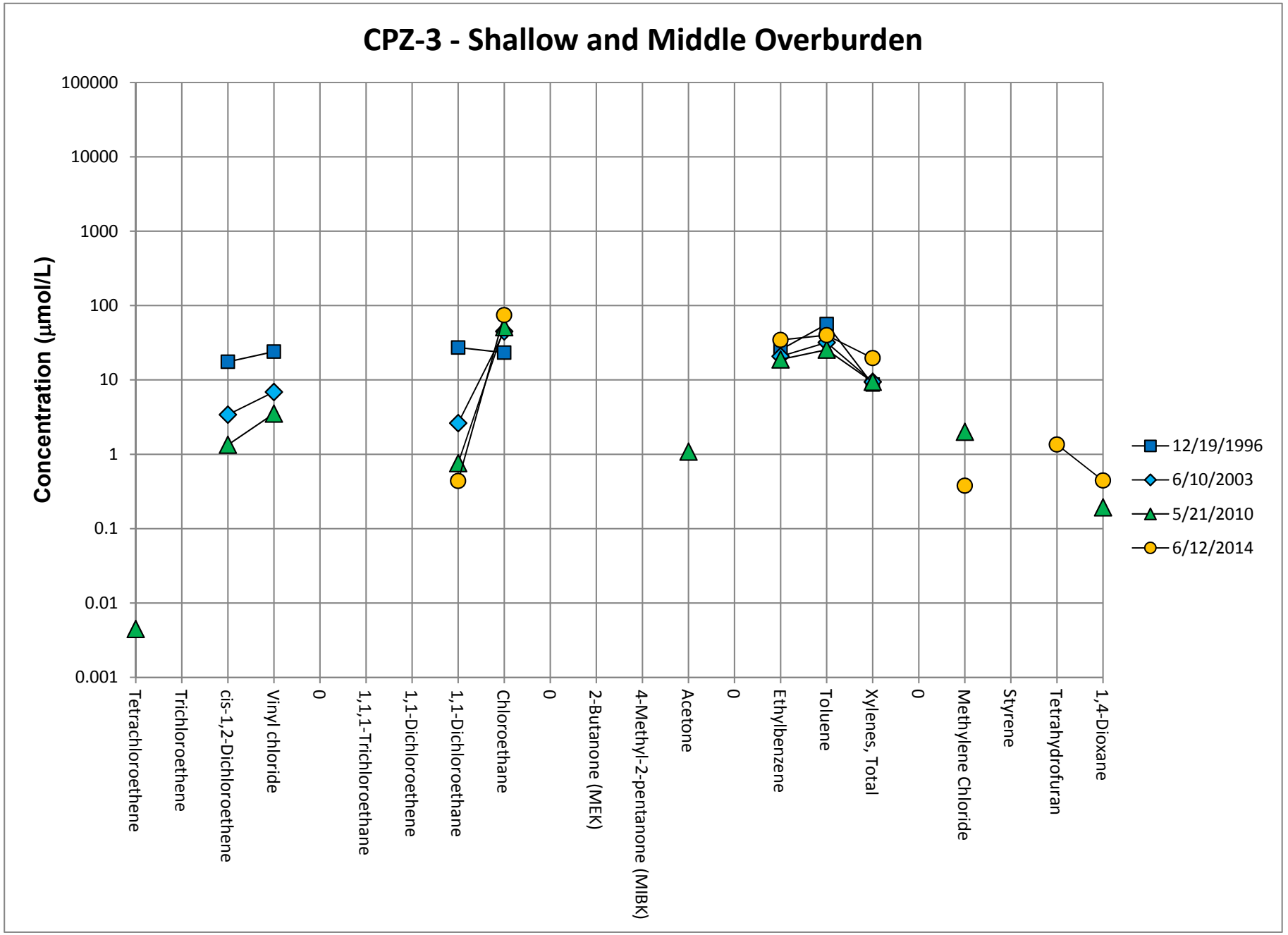
ARCADIS

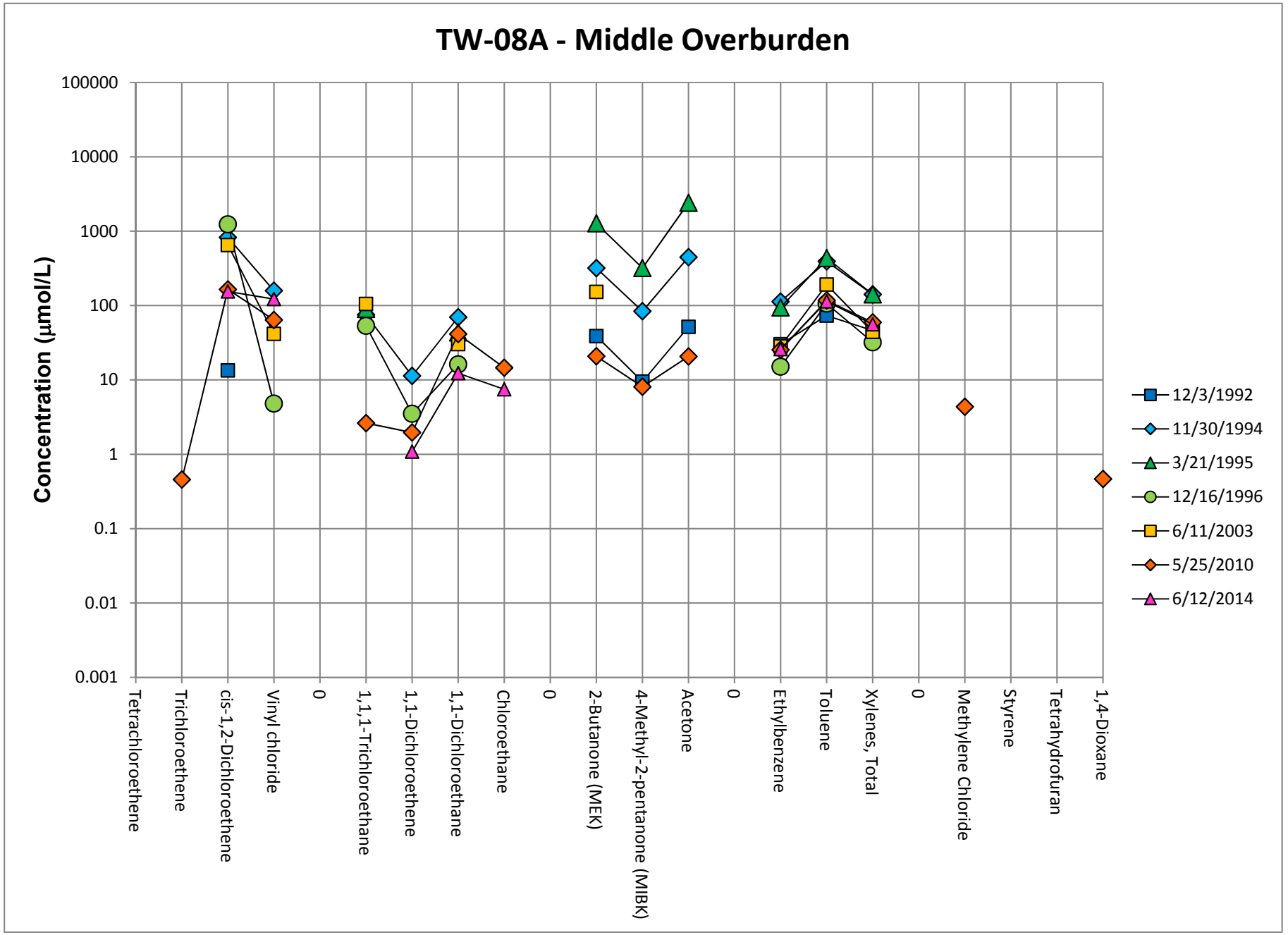
Attachment D

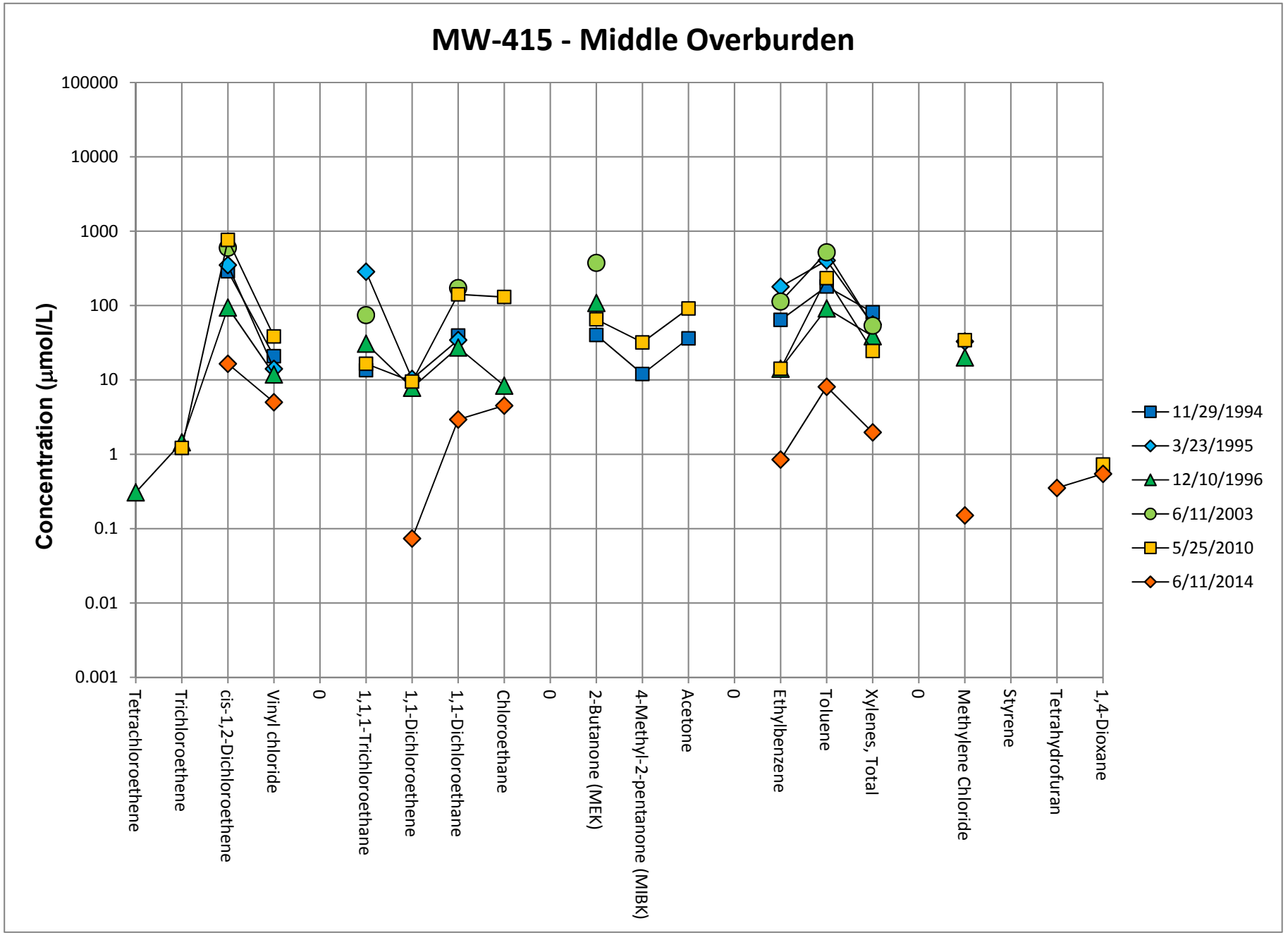
Distribution of Select VOCs in Groundwater with Time at Select Monitoring Well Locations

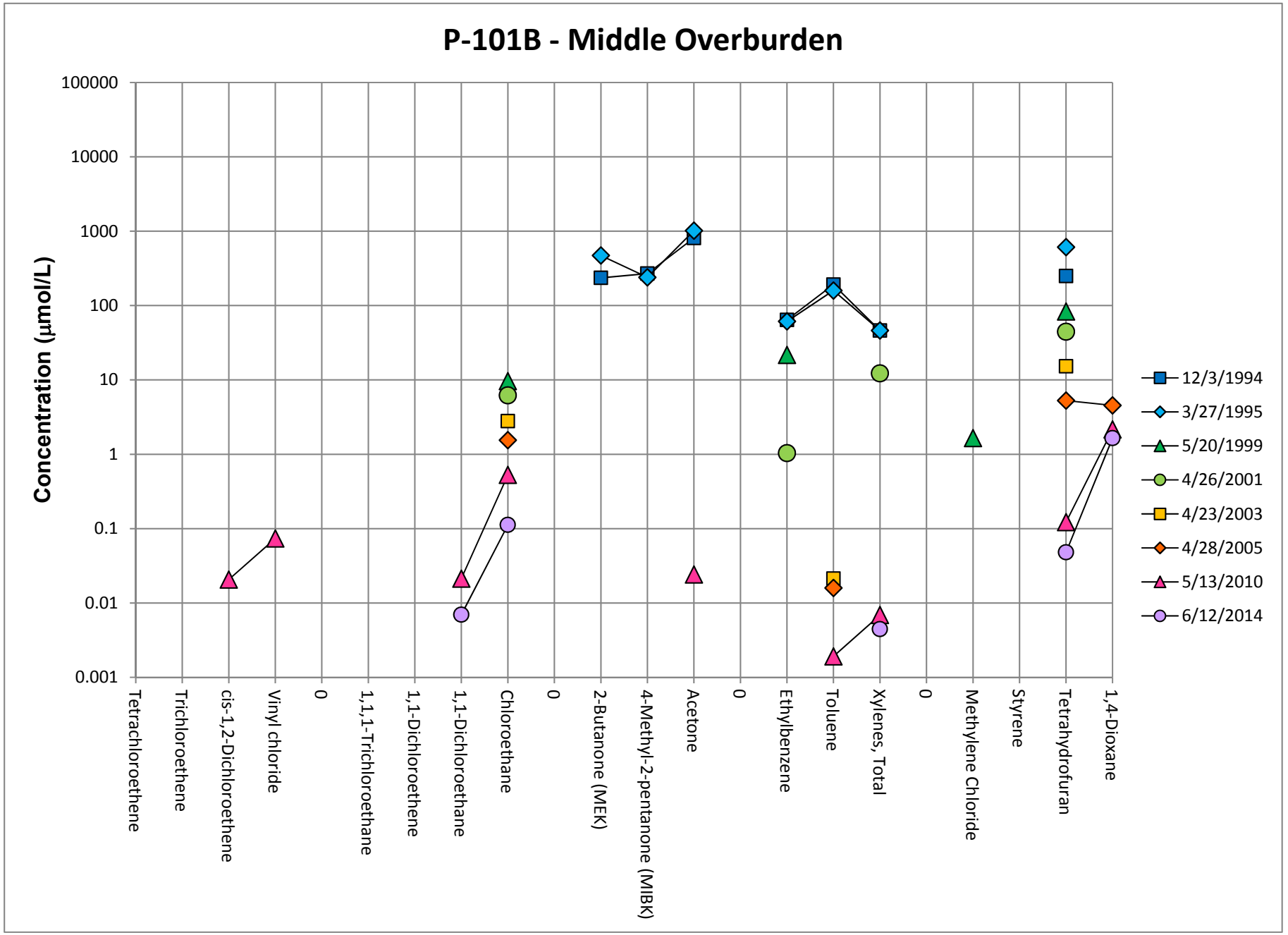

MWL-307 - Shallow Overburden
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
11/30/1994
3/23/1995
12/16/1996
6/11/2003
5/24/2010
6/12/2014

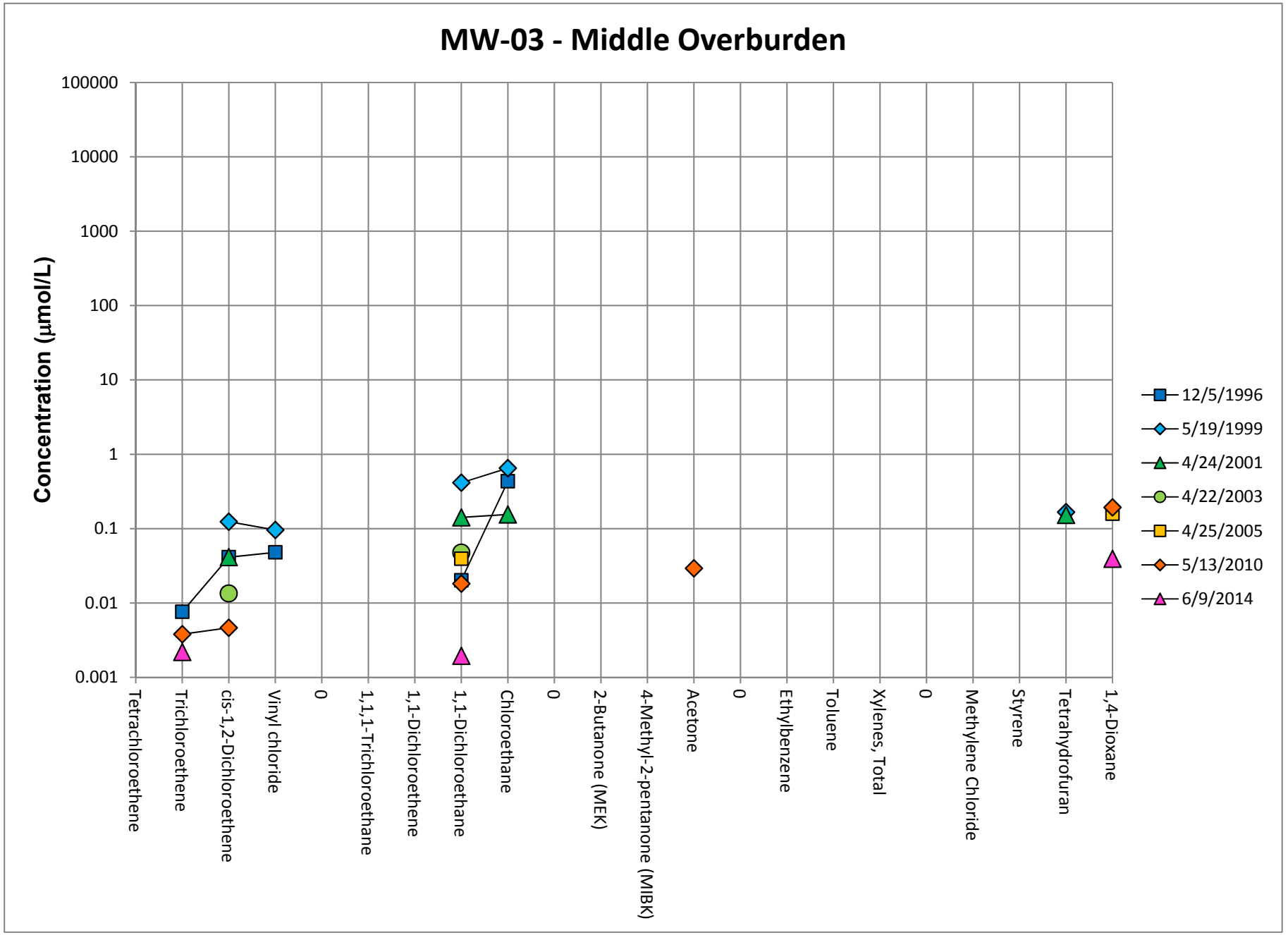

P-11B - Shallow Overburden
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
8/26/1991
3/27/1995
12/4/1996
6/10/2003
5/17/2010
6/11/2014


CPZ-3 - Shallow and Middle Overburden
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/19/1996
6/10/2003
5/21/2010
6/12/2014


TW-08A - Middle Overburden
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/3/1992
11/30/1994
3/21/1995
12/16/1996
6/11/2003
5/25/2010
6/12/2014


MW-415 - Middle Overburden
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
11/29/1994
3/23/1995
12/10/1996
6/11/2003
5/25/2010
6/11/2014


P-101B - Middle Overburden
Concentration (µmol/L)
100000
10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/3/1994
3/27/1995
5/20/1999
4/26/2001
4/23/2003
4/28/2005
5/13/2010
6/12/2014


MW-03 - Middle Overburden
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1000
100
10
1
0.1
0.01
0.001
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Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
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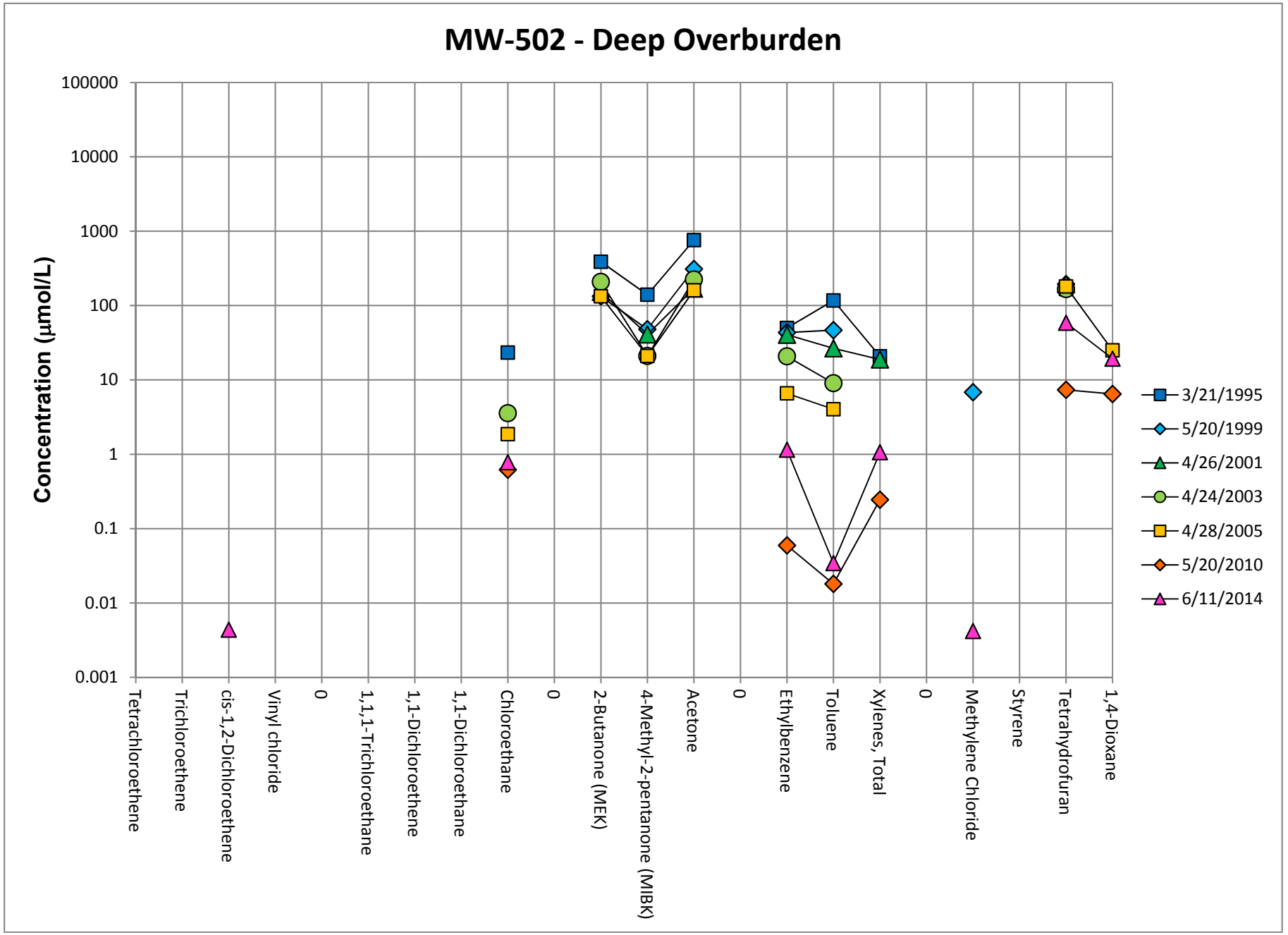
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/5/1996
5/19/1999
4/24/2001
4/22/2003
4/25/2005
5/13/2010
6/9/2014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Concentration (µmol/L)
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10000
1000
100
10
1
0.1
0.01
0.001
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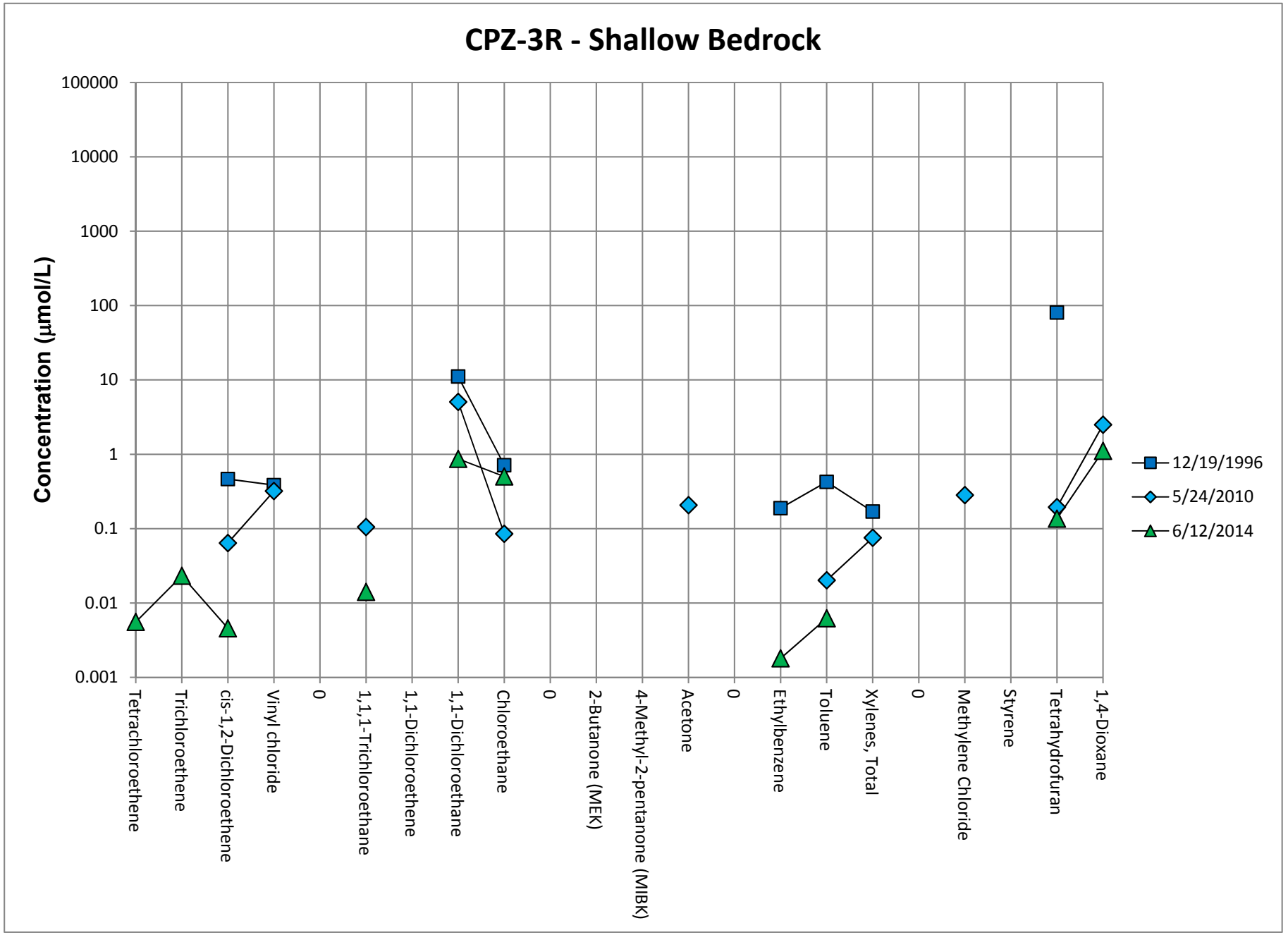
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
3/21/1995
5/20/1999
4/26/2001
4/24/2003
4/28/2005
5/20/2010
6/11/2014


CPZ-3R - Shallow Bedrock
Concentration (µmol/L)
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10000
1000
100
10
1
0.1
0.01
0.001
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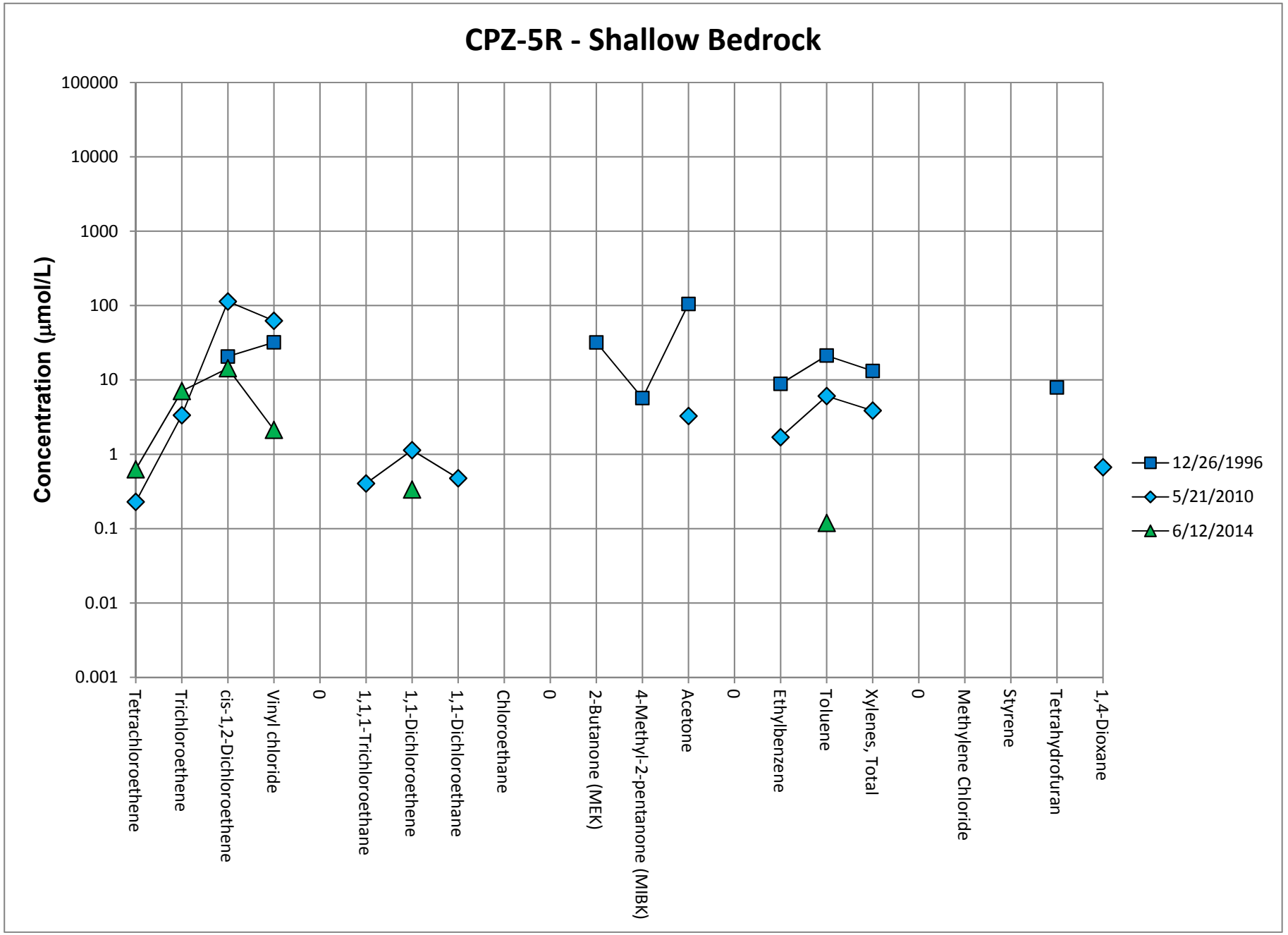
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/19/1996
5/24/2010
6/12/2014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Concentration (µmol/L)
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10000
1000
100
10
1
0.1
0.01
0.001
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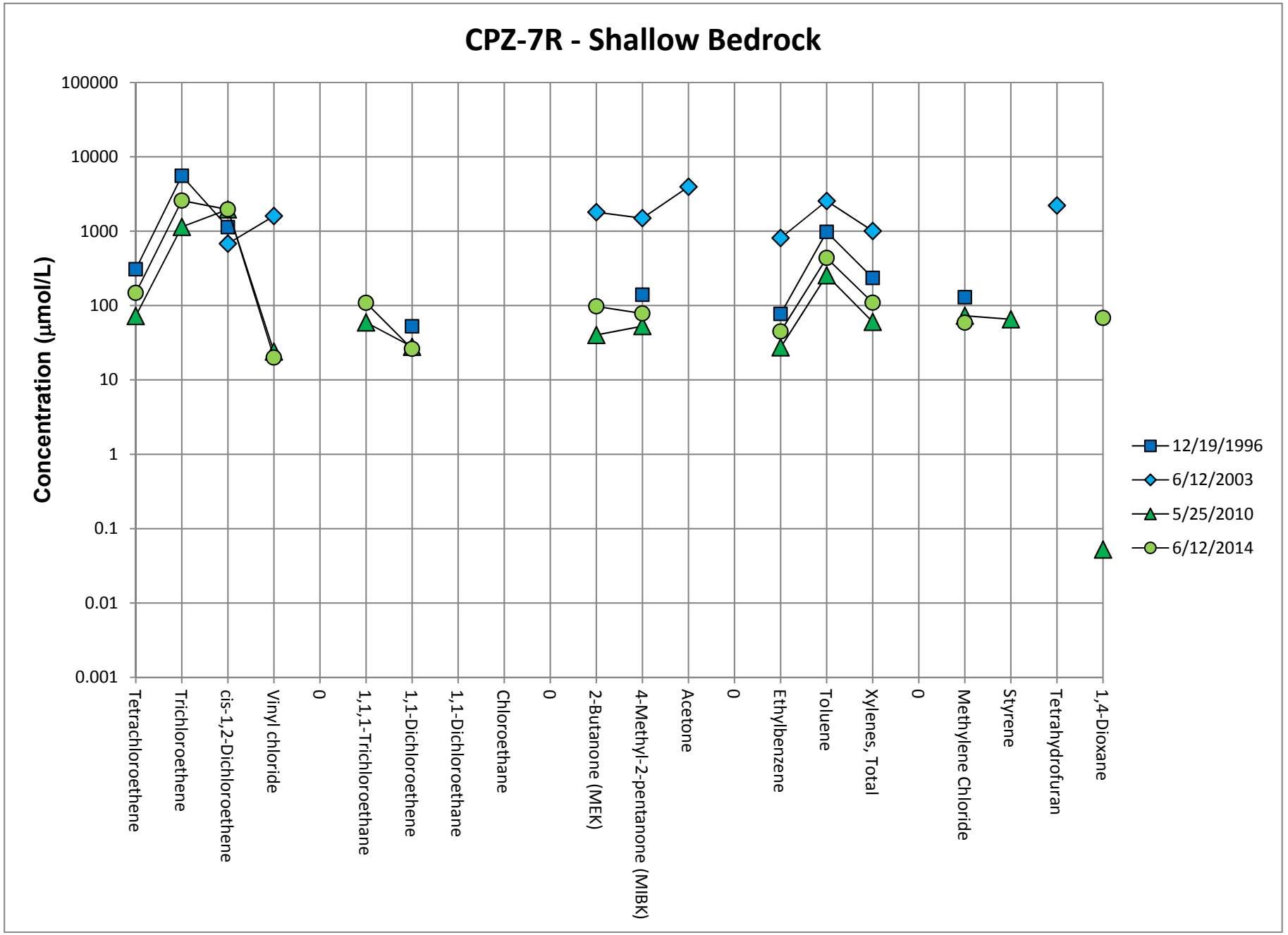
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/26/1996
5/21/2010
6/12/2014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Concentration (µmol/L)
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10000
1000
100
10
1
0.1
0.01
0.001
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Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
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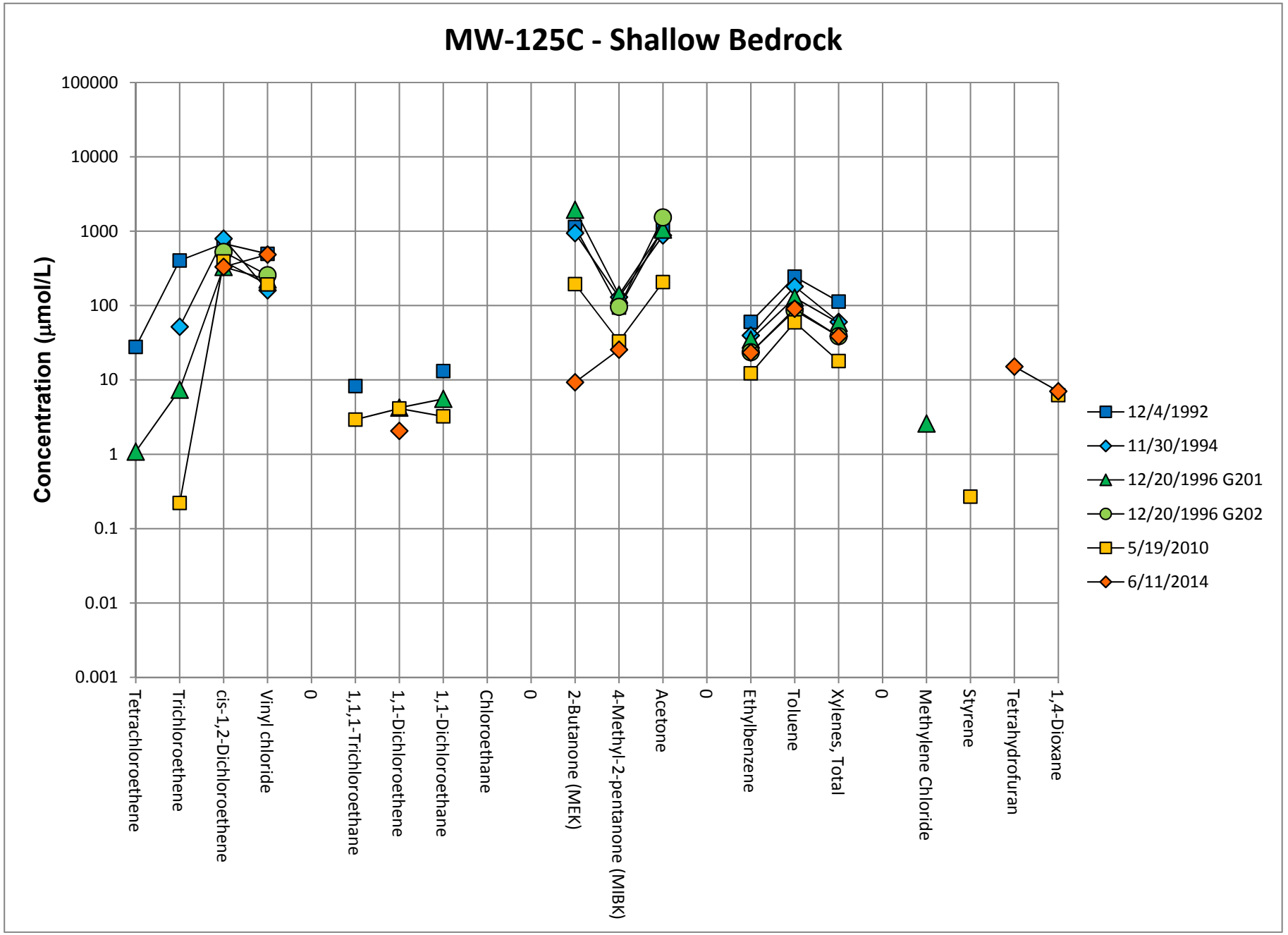
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/19/1996
6/12/2003
5/25/2010
6/12/2014


MW-125C - Shallow Bedrock
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100
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0.1
0.01
0.001
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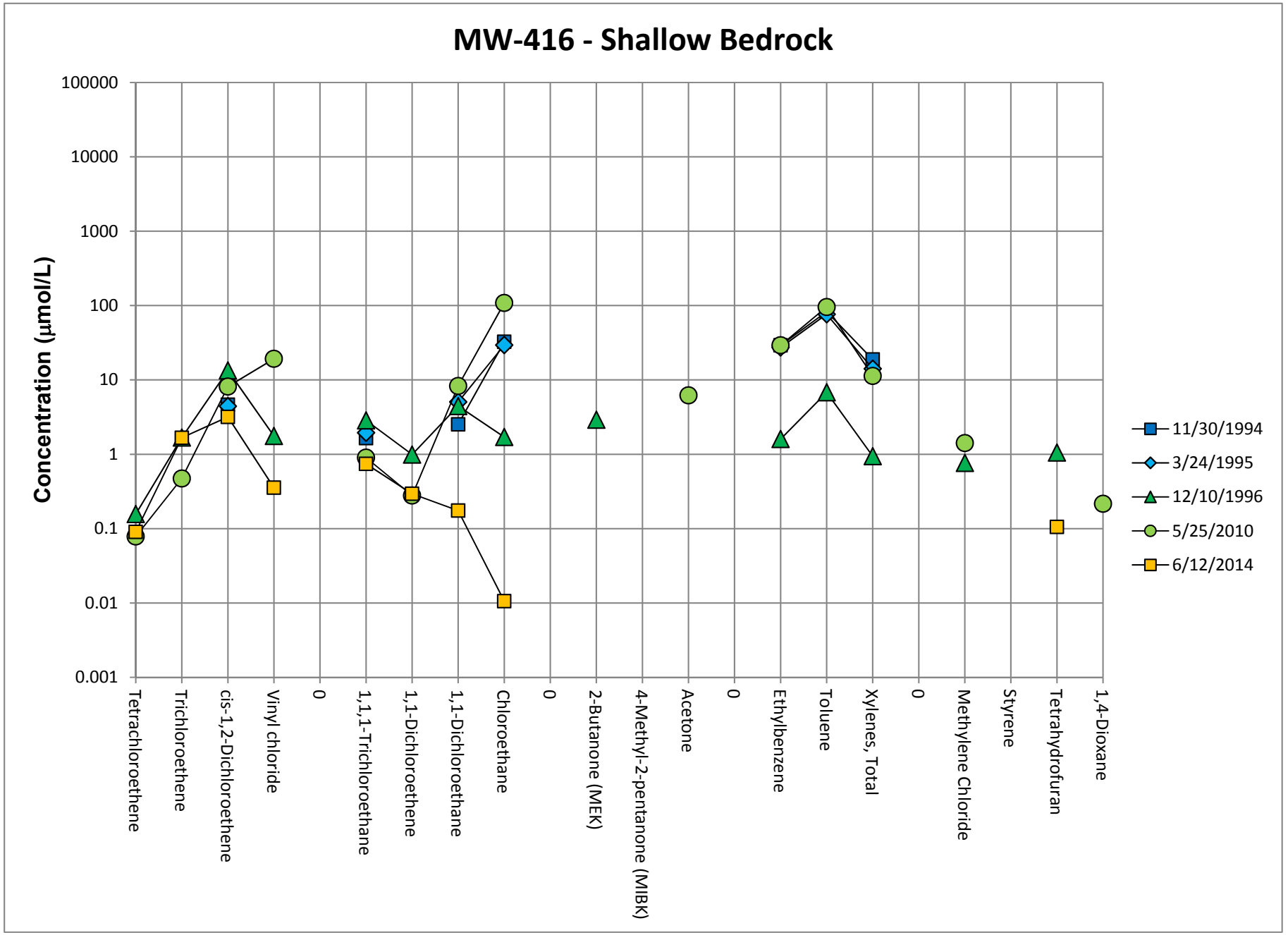
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/4/1992
11/30/1994
12/20/1996 G201
12/20/1996 G202
5/19/2010
6/11/2014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1000
100
10
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0.1
0.01
0.001
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Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
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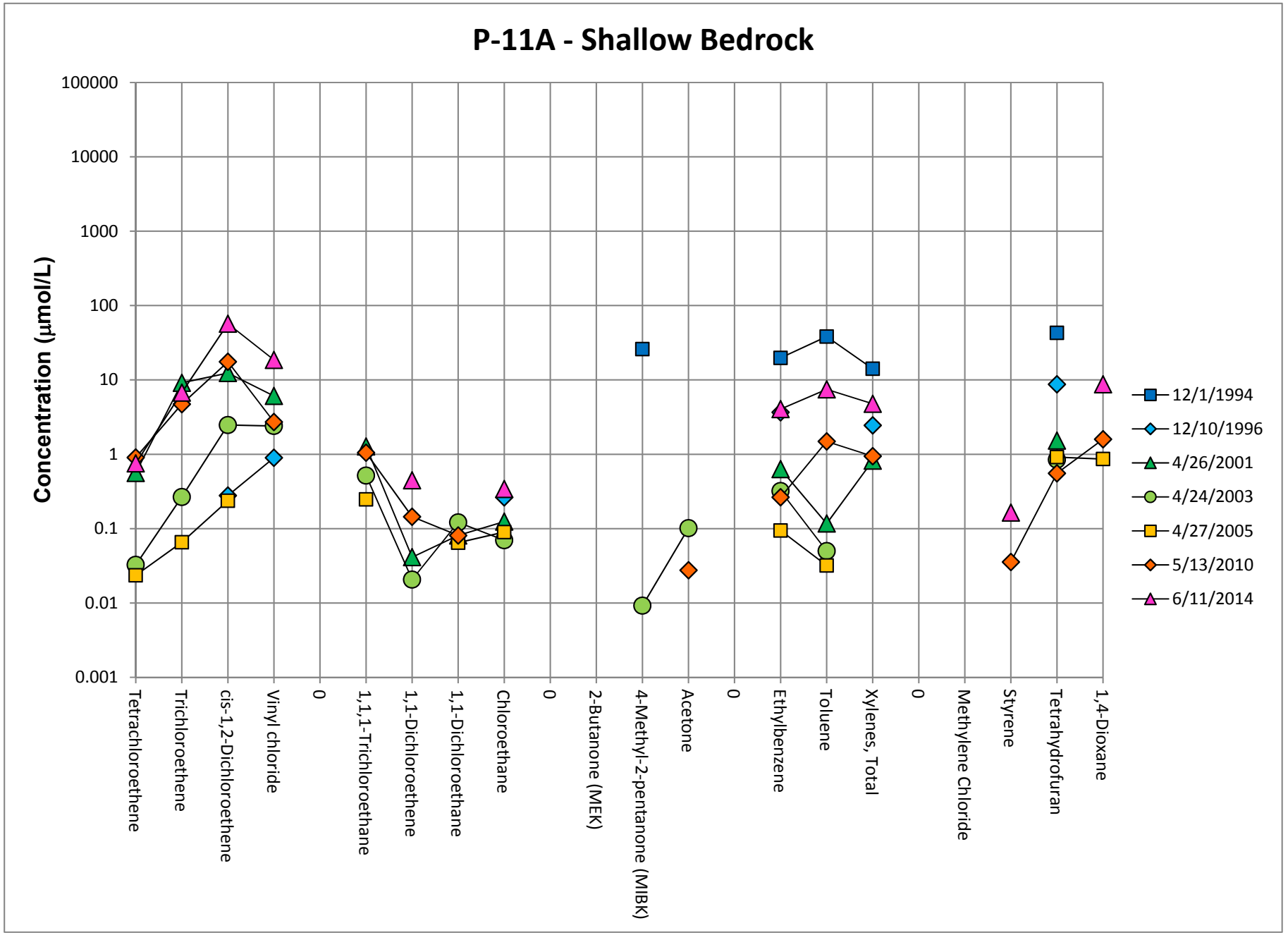
1,4-Dioxane
11/30/1994
3/24/1995
12/10/1996
5/25/2010
6/12/2014


P-11A - Shallow Bedrock
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1000
100
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0.1
0.01
0.001
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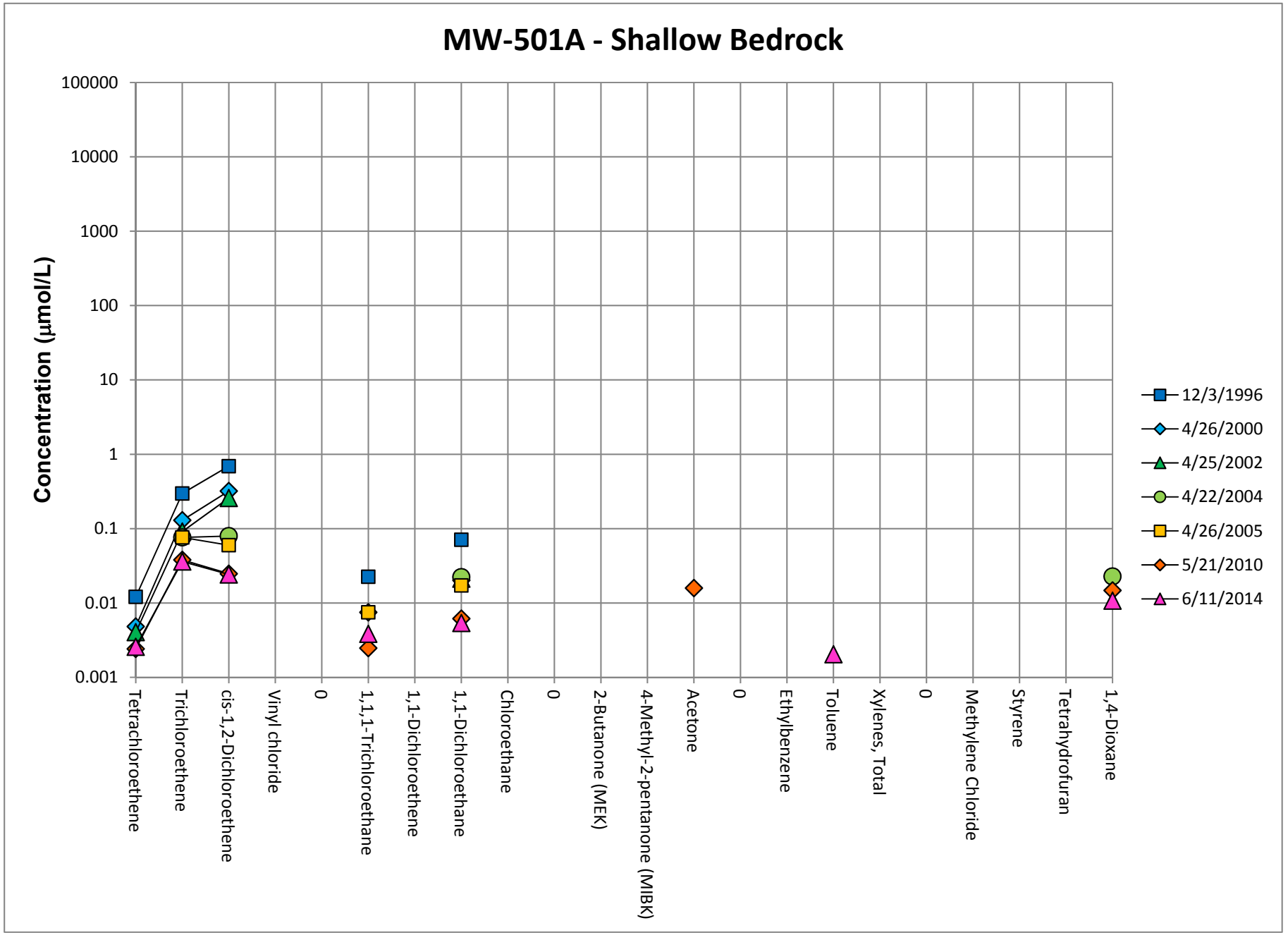
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/1/1994
12/10/1996
4/26/2001
4/24/2003
4/27/2005
5/13/2010
6/11/2014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Concentration (µmol/L)
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10000
1000
100
10
1
0.1
0.01
0.001
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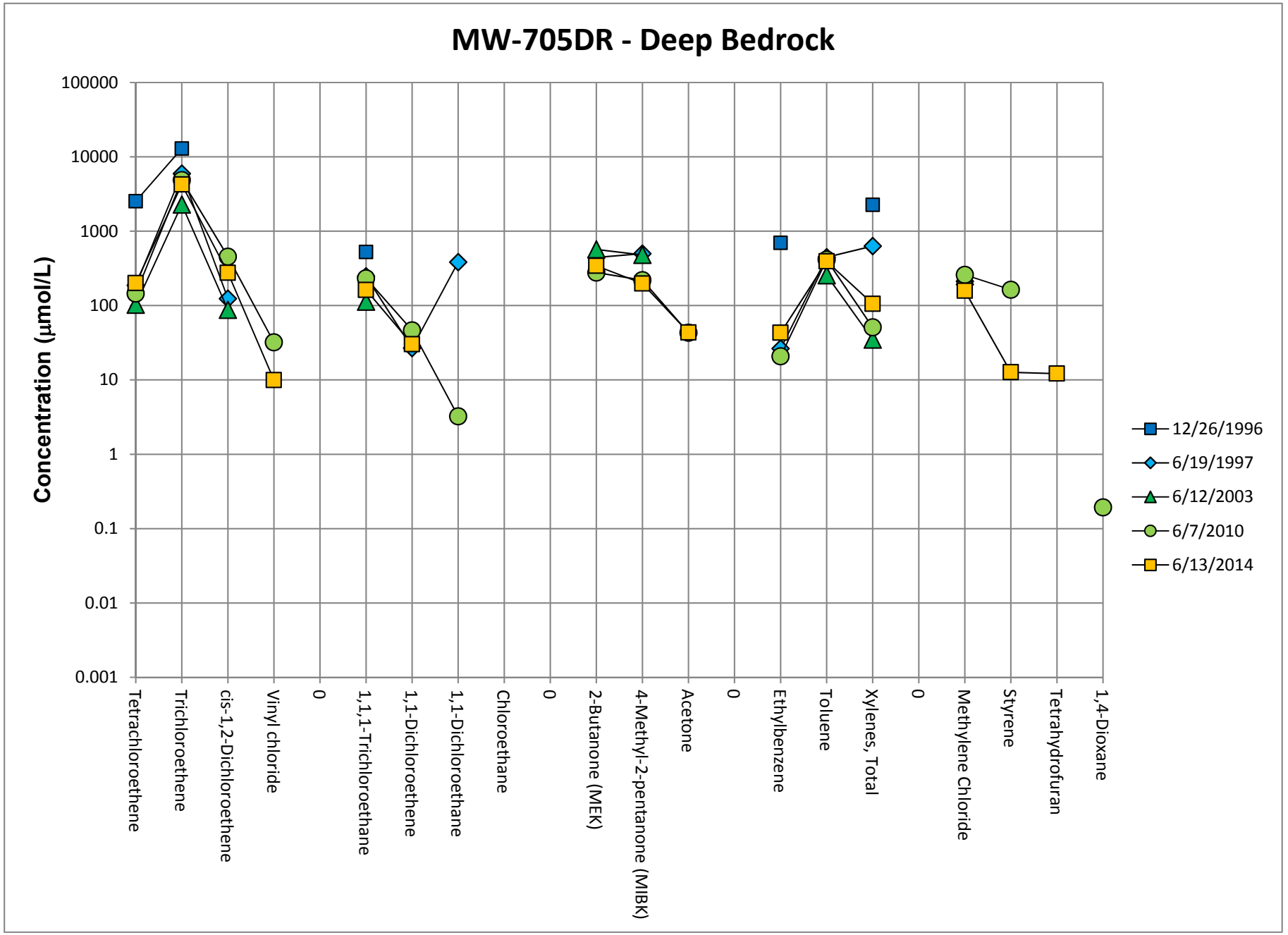
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/3/1996
4/26/2000
4/25/2002
4/22/2004
4/26/2005
5/21/2010
6/11/2014


MW-705DR - Deep Bedrock
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10000
1000
100
10
1
0.1
0.01
0.001
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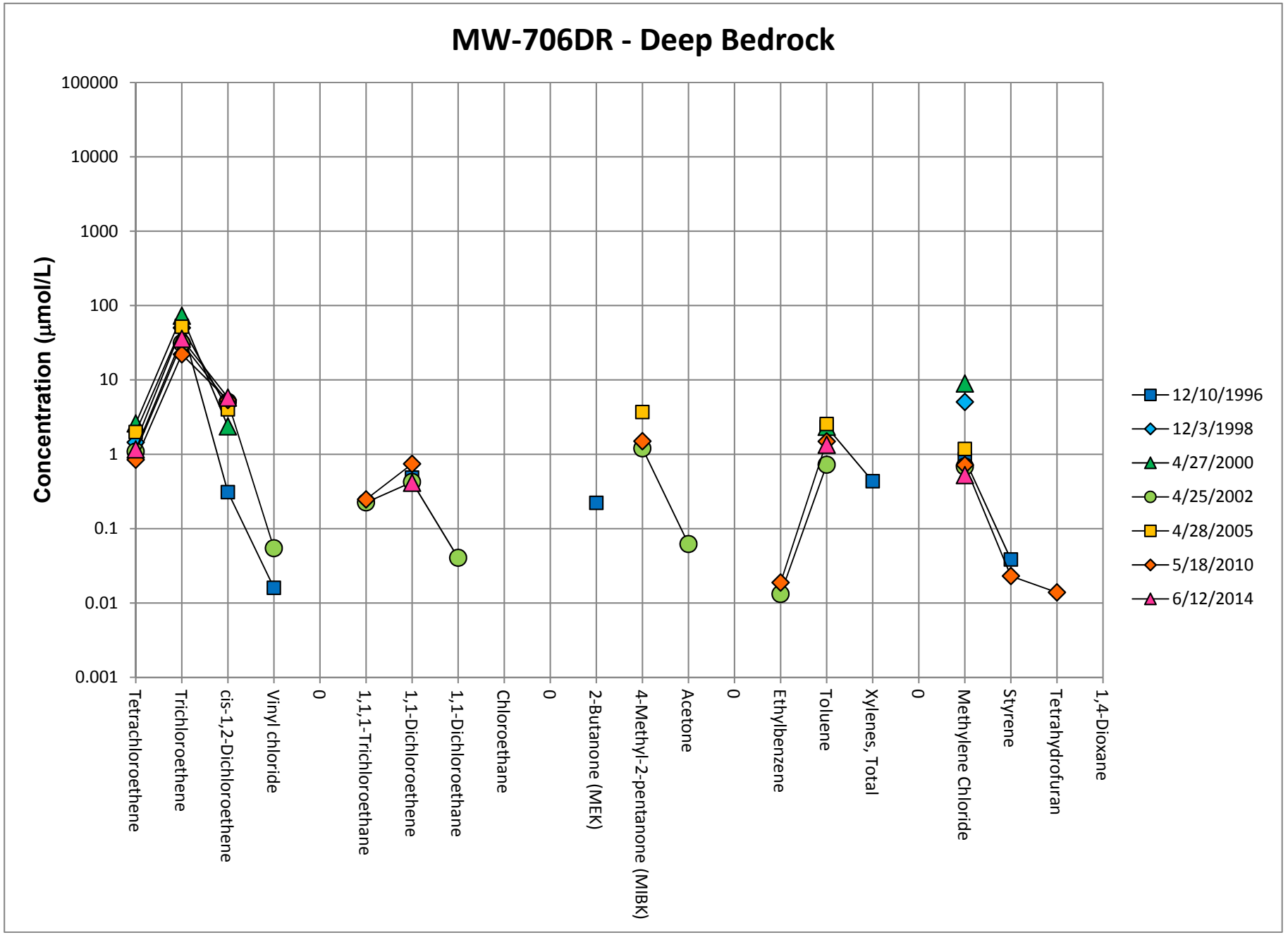
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/26/1996
6/19/1997
6/12/2003
6/7/2010
6/13/2014


MW-706DR - Deep Bedrock
Concentration (µmol/L)
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10000
1000
100
10
1
0.1
0.01
0.001
Tetrachloroethene
Trichloroethene
cis-1,2-Dichloroethene
Vinyl chloride
0
1,1,1-Trichloroethane
1,1-Dichloroethene
1,1-Dichloroethane
Chloroethane
0
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)
Acetone
0
Ethylbenzene
Toluene
Xylenes, Total
0
Methylene Chloride
Styrene
Tetrahydrofuran
1,4-Dioxane
12/10/1996
12/3/1998
4/27/2000
4/25/2002
4/28/2005
5/18/2010
6/12/2014

Attachment E

2014 Baseline Microbiological Survey
Technical Memorandum

DRAFT

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Lakewood
Colorado 80401
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MEMO

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de maximis, inc.
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Jessie McCusker, ***de maximis, inc.***
Mike Gefell, ARCADIS
Jeff Holden, ARCADIS

From:
Julie Sueker, Ph.D., P.H., P.E.

Date:
September 15, 2014

ARCADIS Project No.:
B0054634.0001.01900

Subject:
2014 Baseline Microbiological Survey Technical Memorandum
SRSNE Superfund Site, Southington, CT

I. Introduction

This memorandum summarizes the scope and results of a supplemental groundwater sampling and analysis activity performed by ARCADIS U.S., Inc. (ARCADIS) for the Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site in Southington, Connecticut (Site) (Figure 1). This activity included the collection of microbiological samples from 12 onsite monitoring wells, with analysis of the samples using Microbial Insights' QuantArray-Chlor and/or QuantArray-Petro analytical methods. The purpose of this sampling effort was to provide an enumeration of microbial populations capable of degrading chlorinated volatile organic compounds (CVOCs) and petroleum hydrocarbons. The associated data provide a baseline against which post-thermal treatment data and future monitored natural attenuation (MNA) data may be compared when assessing the progress of the site toward achieving cleanup goals. Data presented herein also allow for a single-time point evaluation of the microbial population.

In support of ongoing evaluations of natural attenuation (NA) of organic constituents in groundwater, the 12 groundwater monitoring wells sampled during this study included: four locations in the vicinity of the thermal treatment area (ISTR-1, ISTR-5, TW-08B, and TW-08D), five wells in downgradient areas with elevated concentrations of constituents of concern (COCs) (CPZ-6A, CPZ-7R, MW-502, MW-907DR, and MW-907M), and three wells in close proximity to dense non-aqueous phase liquid (DNAPL) (CPZ-8R, MW-705DR, and MW-906DR).

The results of this sampling event provide:

- An overview of the native microbial community in key areas of the Site.
- A baseline dataset against which the potential effects of thermal treatment on the native microbiological community can be assessed.
- A supporting line of evidence for potential future evaluations regarding the efficacy of the selected MNA remedy for dissolved-phase COCs in Site groundwater.

The remainder of this memo is organized into the following sections:

- **Section II – Sample Collection and Analysis:** describes when and where samples were collected and the laboratory analyses performed on each sample.
- **Section III – Microbiological Sampling and Analysis Background Information:** provides background information regarding the microbiological sampling methods and laboratory analytical methods used in this investigation.
- **Section IV – Results and Baseline Data Evaluation:** presents analytical results and a preliminary evaluation of the data collected during this baseline microbiological survey.
- **Section V – Summary and Conclusions:** presents a summary and conclusions from the baseline microbiological survey.

Supporting tables, figures, and attachments are provided and referenced where appropriate.

II. Sample Collection and Analysis

Bio-Trap® samplers were deployed at 12 monitoring wells with a target incubation period of approximately 30 days. Table 1 presents the rationale for the selection of each monitoring well for sampling, the date range over which a sampler was deployed, and the analyses performed upon retrieval.

Upon retrieval, Bio-Trap® samplers were submitted to Microbial Insights, Deoxyribonucleic acid (DNA) was extracted from Bio-Sep® beads from each sampler, and quantitative polymerase chain reaction (qPCR) analyses were performed with QuantArray-Chlor and QuantArray-Petro. Laboratory reports are included as Attachment 1.

Samples for analysis of concentrations of NA geochemical parameters were collected at six of the 12 monitoring wells between June 10 and 13, 2014, in association with the 2014 comprehensive groundwater sampling event. Samples for analysis of concentrations of geochemical parameters were collected at ISTR-1 and ISTR-5 on June 16 and 17, 2014, in association with treatment evaluation sampling. Samples for analysis of concentrations of geochemical parameters were collected from the remaining four monitoring wells (CPZ-8R, PZ-906DR, CPZ-6A, and CPZ-7R) on June 24, 2014 and submitted to Alpha Analytical and Microseeps. Laboratory reports including geochemical parameter data from these four monitoring wells are presented in Attachments 2 (Alpha Analytical) and 3 (Microseeps). Samples for analysis of concentrations of volatile organic compounds (VOCs) (i.e., both CVOCs and petroleum-related VOCs) were also recently collected from 10 of the 12 wells as part of the 2014 comprehensive event or the thermal treatment evaluation sampling (ISTR-1 and ISTR-5). Recent VOC data are not available for the two remaining wells (CPZ-8R and PZ-906DR) because NAPL has been observed within or in the vicinity of these wells such that analyses have not been performed.

III. Microbiological Sampling and Analysis Background Information

Bio-Trap® samplers are passive sampling tools used to survey subsurface microbial communities. These samplers consist of a plastic housing filled with Bio-Sep® beads. These beads are approximately 2 to 4 millimeters in diameter, and are a composite of an inert structural material (Nomex®) covered with powdered activated carbon. Together, these form a substrate for colonization by microbes. Bio-Trap® samplers are typically deployed for approximately 30 days and are preferred over the collection of microbial cells by groundwater filtration because:

- Microbial communities tend to colonize and develop on surfaces in areas where conditions are conducive to their growth, rather than floating through groundwater where conditions may not remain favorable. Therefore, by providing a surface for colonization under conditions of interest, more representative microbial communities are sampled with Bio-Trap® samplers.

- Microbial communities tend to develop over time following colonization. The 30-day deployment results in a time-integrated sample that is more representative of the microbial community than samples obtained from groundwater sampling over a shorter timeframe (e.g., less than an hour).

Following retrieval, the Bio-Trap® samplers are submitted to Microbial Insights of Knoxville, Tennessee. DNA is extracted from the Bio-Sep® beads, and qPCR analysis is applied to enumerate copy numbers of phylogenetic and functional genes of interest. Phylogenetic genes are genes that identify specific species of interest, while functional genes code for enzymes used in particular metabolic pathways. Phylogenetic genes are used to enumerate specific

microorganisms that are known to be involved in particular degradation pathways, while functional genes provide confirmation that the microbial community has the capacity to produce the enzymes necessary to complete specific reactions in known degradation pathways.[1]

QuantArray analysis is a method by which qPCR is used to simultaneously enumerate gene copy numbers for a range of phylogenetic and functional gene targets that have been identified as characteristic of specific degradation processes. The QuantArray-Chlor analysis provides a tool for simultaneously assessing the potential for anaerobic reductive dechlorination of CVOCs as well as aerobic cometabolism of CVOCs. The QuantArray-Petro analysis provides a tool for simultaneously assessing the potential for aerobic and anaerobic degradation of benzene, toluene, ethylbenzene, xylenes (BTEX), methyl *tert*-butyl ether (MTBE), polycyclic aromatic hydrocarbons (PAHs), and alkanes. In addition to providing enumeration of gene copy numbers for microorganisms and enzymes relevant to the degradation of CVOCs and petroleum hydrocarbons, QuantArray analyses enumerate methanogenic organisms, sulfate-reducing bacteria, and total bacteria in order to provide additional context for results. Phylogenetic and functional genes enumerated by the QuantArray-Chlor and QuantArray-Petro analyses are summarized in Tables 2 and 3.

For some gene targets, Microbial Insights presents a ranking of the abundance of these genes (from low to high) relative to numbers observed across a wide range of samples analyzed from different sites. These rankings are presented with QuantArray data in Figures 2 and 3.

IV. Results and Baseline Data Evaluation

Summary results from QuantArray-Chlor and QuantArray-Petro analyses are presented in Tables 2 and 3. Results are presented spatially and graphically in Figures 2 and 3. Concentrations of geochemical parameters from wells where Bio-Trap® samplers were deployed are presented in Table 4, and concentrations of VOCs at these wells are presented in Table 5.

[1] Interstate Technology & Regulatory Council. 2011. Technology Overview Environmental Molecular Diagnostics Fact Sheets. November 2011.

Overview of Microbial Populations

Estimated numbers of total bacteria range from $1.92x10^4$ cells per bead at monitoring well PZ-906DR to $1.04x10^7$ cells per bead at well ISTR-5. While these numbers cannot be interpreted as total number of microorganisms per bead (because Archaea [including methanogens] are excluded), they provide a broad baseline for comparisons of the bacterial community between monitoring locations and over time.

Population estimates of sulfate reducers (quantified by the APS gene) and methanogens (quantified by the MGN gene) along with characterization of site geochemistry may provide lines of evidence that environmental conditions are favorable for the degradation of CVOCs and petroleum hydrocarbons. As shown in Figures 2 and 3, QuantArray data indicate:

- At monitoring wells ISTR-5 and TW-08D, sulfate reducers are present, but methanogens were not detected above the reporting limit. However, depleted sulfate (<1 milligram per liter [mg/L]) and high methane (1,500 micrograms per liter [μg/L]) groundwater concentrations were measured at monitoring well TW-08D in June 2014, suggesting that methanogenic conditions exist in the vicinity of this monitoring location.

- At monitoring wells TW-08B, CPZ-7R, MW-705DR, methanogens are present, but sulfate reducers were not detected above the reporting limit. Moderate groundwater sulfate and methane concentrations were recently measured at monitoring wells CPZ-7R (98.4 mg/L sulfate and 260 μg/L methane) and MW-705DR (147 mg/L sulfate and 130 μg/L methane), and both of these monitoring wells are in the vicinity of DNAPL. At monitoring well TW-08B, sulfate is depleted (7.5 mg/L) and methane is elevated (2,100 μg/L).

- At monitoring wells CPZ-8R, MW-502, MW-907DR, MW-907M, and CPZ-6A, both sulfate reducers and methanogens are present. Sulfate and methane concentrations are variable between these monitoring wells, with sulfate concentrations between 0.343 mg/L at monitoring well MW-907M and 1,440 mg/L at monitoring well MW-907DR, and methane concentrations between non-detect above 1.7 μg/L at monitoring well MW-907DR and 28,000 μg/L at monitoring well MW-502.

At monitoring well MW-906DR, neither sulfate reducers nor methanogens were detected above the reporting limit. Recent geochemical results from this monitoring location indicate a relatively high sulfate concentration (625 mg/L) and a low methane concentration (39 μg/L).

CVOC degradation potential (QuantArray-Chlor)

QuantArray-Chlor analyses quantify phylogenetic and functional genes known to be characteristic of two separate degradation mechanisms for CVOCs: anaerobic reductive dechlorination and aerobic cometabolism. When CVOCs are degraded via reductive dechlorination, chlorine atoms are sequentially removed and daughter products are formed. Microorganisms performing reductive dechlorination reactions gain energy from this process. CVOC degradation via aerobic cometabolism occurs when microbes (including methanotrophs) utilize oxygenase enzymes with relaxed specificity. In most cases the oxygenase enzymes are used to degrade a primary substrate that the microorganism gains energy from (e.g., methane), but also tend to oxidize select CVOCs with no known benefit to the microorganism that created the enzyme.

The Bio-Trap® sampler deployed at well ISTR-1 was retrieved after approximately one week, while other Bio-Trap® samplers incubated for 33 to 36 days. As a result of the shortened incubation period at ISTR-1, fewer cell numbers per bead were generally observed at this location. While cell numbers cannot be readily compared between this sampler and others, the data indicate that both microorganisms able to degrade chlorinated compounds via reductive dechlorination and those capable of cometabolic degradation colonized this Bio-Trap® sampler during its short deployment period. These data will be useful for a comparison with the microbial community post-thermal treatment.

Anaerobic Reductive Dechlorination

Multiple groups of microorganisms are capable of performing reductive dechlorination reactions: *Dehalococcoides* (DHC), *Dehalobacter* (DHBt), Dehalobacter DCM (DHBt DCM), *Desulfitobacterium* (DSB), *Desulfuromonas* (DSM), and *Dehalogenimonas* (DHG) (orange columns, Figure 2). However, DHC are often considered the most important genus because they (1) are the only genus that includes species capable of the full dechlorination of parent ethenes including tetrachloroethene (PCE) and trichloroethene (TCE) to the innocuous end product ethene, and (2) are also able to catalyze the reductive dechlorination of chlorinated ethanes and chlorinated benzenes. Although DHC are known to be able to perform the final step of the reductive dechlorination reaction (from vinyl chloride [VC] to ethene), the absence of detectable copy numbers of genes that encode VC reductase enzymes (BAV1 VC reductase [BVC] and VC reductase [VCR]) may indicate that VC may be relatively more recalcitrant.

DHC were detected in samples collected at 10 of the 12 monitoring locations. Relatively high numbers of DHC were observed at monitoring wells ISTR-5, TW-08B, TW-08D, and CPZ-8R, and medium to high copy numbers of genes encoding VC reductase enzymes (BVC and VCR) were also observed. These wells are located near the primary source in the thermal treatment area (ISTR-5, TW-08B, and TW-08D), and in the vicinity of DNAPL (CPZ-8R). Results indicate

that a community capable of the full reduction of chlorinated ethenes is robust at these locations. Relatively low numbers of DHC and BVC were detected at monitoring well MW-705DR, located in the vicinity of DNAPL.

DHC were not detected at monitoring wells MW-906DR and MW-907DR, although DNAPL is present at MW-906DR and CVOC concentrations are fairly high at MW-907DR. No groups capable of reductive dechlorination were detected at monitoring well MW-906DR, and only a low copy number of a gene encoding for particulate methane monooxygenase (PMMO) enzymes and a small number of total bacteria were detected at this location. Recently measured geochemical parameter concentrations indicate that iron and manganese concentrations are low, sulfate is high, and methane is relatively low. As discussed above, sulfate-reducing bacteria were not detected above the reporting limit. Taken together, these results suggest that the geochemical conditions may be suitable for reductive dechlorination to occur, but that the relevant organisms were not detected above reporting limits. Therefore, this process may not occur efficiently at this monitoring location, which is in the vicinity of DNAPL. Although DHC were not detected at monitoring well MW-907DR, other groups capable of reductive dechlorination (DSM and DHG) were detected at this location. A low number of DHC were present at the shallower well in the vicinity (MW-907M).

With the exception of monitoring wells MW-705DR and ISTR-5 (where DHC are present), multiple microbial groups capable of reductive dechlorination of chlorinated ethanes are present at all wells where these COCs were recently measured above action levels.

The gene used to identify DHBt DCM (a group known to mediate the degradation of chloroform), and the functional gene chloroform reductase (CFR) were not detected above reporting limits at monitoring wells MW-705DR and TW-08B, where chloroform concentrations exceed the action level.

Aerobic Cometabolism

The presence and abundance of genes encoding for enzymes responsible for the aerobic cometabolic degradation of chlorinated compounds across samples (purple columns, Figure 2) indicate that while Site groundwater geochemical conditions are generally reducing and conducive to reductive dechlorination, the microbial community also may have the ability to degrade CVOCs in more oxic microenvironments and at a larger scale if there are shifts toward more oxidizing groundwater conditions in the future, or on the fringes of the plume.

Petroleum Hydrocarbon Degradation Potential (QuantArray-Petro)

Petroleum hydrocarbons can be biodegraded by both aerobic and anaerobic processes. QuantArray-Petro results indicate that genes encoding for enzymes that catalyze the anaerobic degradation of BTEX and MTBE (orange columns, Figure 3) and the aerobic degradation of BTEX, MTBE, PAHs, and alkanes (purple columns, Figure 3) are present in moderate to high numbers at the two monitoring wells selected for this analysis (ISTR-5 and TW-08B). Results indicate that a broader set of degradation pathways is likely utilized at TW-08B, where a higher diversity of gene targets was detected.

V. Conclusions

QuantArray-Chlor results indicate robust communities capable of both full reductive dechlorination to innocuous end products, and also aerobic cometabolism of chlorinated compounds, at 11 of the 12 monitoring locations sampled. Based on the results of this study, conditions at monitoring well MW-906DR may not be conducive to biodegradation, potentially due to the presence of DNAPL at this location. QuantArray-Petro results indicate that microbial communities capable of both aerobic and anaerobic degradation of petroleum hydrocarbons are present in Site groundwater. Together, these data provide a baseline for comparison for post-treatment conditions and provide an additional line of evidence that Site conditions are conducive to MNA.

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Tables

Table 1 – Microbiological Sampling Details
Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site
Southington, Connecticut

Monitoring Well	Sampling Rationale	Deployment Date	Retrieval Date	Incubation Period (days)	Analyses
CPZ-6A	High THF and benzene concentrations	6/24/2014	7/30/2014	36	QuantArray-Chlor
CPZ-7R	High TCE concentrations	6/24/2014	7/30/2014	36	QuantArray-Chlor
CPZ-8R	DNAPL well	6/24/2014	7/30/2014	36	QuantArray-Chlor
ISTR-1	Highest CVOC concentrations of ISTR wells	6/19/2004	6/26/2014	7*	QuantArray-Chlor
ISTR-5	Second highest CVOC concentrations of ISTR wells and high BTEX concentrations; limited heating to date providing source area baseline	6/18/2014	7/21/2014	33	QuantArray-Chlor and QuantArray-Petro
MW-502	High THF and benzene concentrations	6/24/2014	7/30/2014	36	QuantArray-Chlor
MW-705DR	DNAPL well	6/24/2014	7/30/2014	36	QuantArray-Chlor
MW-907DR	High TCE concentrations	6/25/2014	7/30/2014	36	QuantArray-Chlor
MW-907M	High THF and benzene concentrations	6/25/2014	7/30/2014	36	QuantArray-Chlor
PZ-906DR	DNAPL well	6/24/2014	7/30/2014	36	QuantArray-Chlor
TW-8D	Highest CVOC concentrations of overburden N wells	6/18/2014	7/21/2014	33	QuantArray-Chlor
TW-8B	Highest CVOC concentrations of bedrock N wells with high BTEX concentrations	6/18/2014	7/21/2014	33	QuantArray-Chlor and QuantArray-Petro

Notes:

THF = Tetrahydrofuran

TCE = Trichloroethene

DNAPL = Dense Non-Aqueous Phase Liquid

CVOC = Chlorinated volatile organic compounds

ISTR = In Situ Thermal Remediation

BTEX = Benzene, toluene, ethylbenzene, xylenes

N wells = wells which are located between the railroad right-of-way and the Non-Time-Critical Removal Action (NTCRA) 1 sheet pile wall (i.e., within the NTCRA 1 Containment Area), and are sampled for VOCs and MNA parameters at various frequencies throughout the remediation phase of the project

* = The Bio-Trap® sampler deployed at monitoring well ISTR-1 was retrieved after approximately one week because this well is located in an area of active in-situ thermal remediation, and excessive heating would not have lead to representative baseline results

Table 2 - QuantArray-Chlor Data Summary
Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site
Southington, Connecticut

			Sample Location	CPZ-6A		CPZ-7R		CPZ-8R		ISTR-1		ISTR-5		MW-502		MW-705DR		MW-907DR		MW-907M		PZ-906DR		TW-08D		TW-08B	
			Sample Date	7/30/2014		7/30/2014		7/30/2014		6/26/2014		7/21/2014		7/30/2014		7/30/2014		7/30/2014		7/30/2014		7/30/2014		7/21/2014		7/21/2014	
			MI Report Number	095LG		095LG		095LG		100LF		055LG_Chlor		095LG		095LG		095LG		095LG		095LG		055LG_Chlor		055LG_Chlor	
			Well Group	C		C		R		NA		NA		R		R		R		R		W		N		N	
			Hydrostratigraphic Zone(s)	MOB		SBR		SBR		MOB/DOB		MOB/DOB		DOB		DBR		DBR		MOB		DBR		DOB		SBR	
Gene Target		**Unit**	**Gene Type**																								
Dehalococcoides spp.	DHC	cells/bead	P	**2.50E+03**	--	**2.48E+03**	--	1.31E+05	--	**4.15E+02**	--	4.04E+05	--	**1.20E+03**	--	**2.81E+02**	--	2.50E+01	U	**3.72E+02**	--	2.50E+01	U	1.18E+06	--	3.86E+04	--
Dehalobacter spp.	DHBt	cells/bead	P	2.50E+02	U	2.50E+02	U	**1.76E+02**	J	**5.64E+02**	--	2.50E+02	U	**7.50E+01**	J	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U
Desulfitobacterium spp.	DSB	cells/bead	P	3.18E+05	--	**3.41E+04**	--	2.50E+02	U	2.50E+02	U	2.50E+02	U	6.26E+05	--	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U
Desulfuromonas spp.	DSM	cells/bead	P	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	**4.62E+03**	--	2.50E+02	U	**1.74E+03**	--	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U
BAV1 Vinyl Chloride Reductase	BVC	cells/bead	F	**1.33E+02**	--	**6.29E+02**	--	5.88E+04	--	**2.75E+02**	--	1.07E+05	--	2.50E+01	U	**7.38E+01**	--	2.50E+01	U	2.50E+01	U	2.50E+01	U	3.87E+05	--	1.02E+04	--
Vinyl Chloride Reductase	VCR	cells/bead	F	**5.40E+00**	J	**8.50E+00**	J	**4.34E+01**	--	**1.15E+01**	J	9.19E+04	--	2.50E+01	U	2.50E+01	U	2.50E+01	U	2.50E+01	U	2.50E+01	U	2.02E+05	--	**4.21E+03**	--
Dehalogenimonas spp.	DHG	cells/bead	P	2.50E+02	U	**2.43E+03**	--	**3.68E+04**	--	2.50E+02	U	2.50E+02	U	**4.52E+03**	--	2.50E+02	U	**4.90E+02**	--	2.50E+02	U	2.50E+02	U	**7.13E+04**	--	2.50E+02	U
Dehalobacter DCM	DCM	cells/bead	P	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U
Chloroform reductase	CFR	cells/bead	F	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	**5.06E+03**	--	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U
Dehalobium chlorocoercia	DECO	cells/bead	P	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U
Trichloroethene Reductase	TCE	cells/bead	F	**3.80E+01**	--	2.50E+01	U	2.50E+01	U	**4.39E+01**	--	**5.86E+01**	--	2.50E+01	U	2.50E+01	U	2.50E+01	U	2.50E+01	U	2.50E+01	U	**3.65E+01**	--	**2.59E+01**	--
Aerobic Cometabolism																											
Soluble Methane Monooxygenase	SMMO	cells/bead	F	**2.28E+04**	--	**6.11E+03**	--	**1.22E+04**	--	**7.15E+02**	--	**4.64E+03**	--	**4.53E+04**	--	**2.31E+03**	--	**2.67E+03**	--	**5.49E+04**	--	2.50E+02	U	**1.80E+03**	--	**1.93E+02**	--
Particulate Methane Monooxygenase	PMMO	cells/bead	F	**1.58E+04**	--	**2.07E+03**	--	**1.12E+02**	J	2.50E+02	U	2.50E+02	U	**5.22E+03**	--	**1.40E+01**	J	**4.82E+01**	J	**5.29E+02**	--	**3.98E+02**	--	**4.80E+01**	J	2.50E+02	U
Toluene Dioxygenase	TOD	cells/bead	F	**2.47E+05**	--	**5.23E+02**	--	**1.29E+04**	--	2.50E+02	U	**3.67E+02**	--	**9.09E+03**	--	**2.04E+02**	J	**3.43E+01**	J	**2.75E+03**	--	2.50E+02	U	**3.71E+02**	--	**8.67E+01**	J
Phenol Hydroxylase	PHE	cells/bead	F	**2.22E+04**	--	**1.79E+02**	J	**9.58E+03**	--	2.50E+02	U	**9.32E+03**	--	**4.53E+04**	--	**1.54E+03**	--	**3.49E+03**	--	**7.45E+03**	--	2.50E+02	U	**2.55E+04**	--	**7.21E+03**	--
Toluene Monooxygenase 2	RDEG	cells/bead	F	**7.18E+03**	--	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	**3.11E+04**	--	**8.04E+02**	--	**5.39E+02**	--	2.50E+02	U	2.50E+02	U	**8.45E+03**	--	**1.16E+03**	--
Toluene Monooxygenase	RMO	cells/bead	F	**4.09E+04**	--	**1.34E+03**	--	2.50E+02	U	2.50E+02	U	2.50E+02	U	**1.68E+01**	J	2.50E+02	U	2.50E+02	U	**1.18E+04**	--	2.50E+02	U	**2.82E+04**	--	**4.63E+03**	--
Epoxyalkane transferase	EtnE	cells/bead	F	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	**6.46E+02**	--	2.50E+02	U
Ethene Monooxygenase	EtnC	cells/bead	F	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	**1.80E+02**	J	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	**5.97E+02**	--	2.50E+02	U
Trichlorobenzene Dioxygenase	TCBO	cells/bead	F	2.50E+02	U	**3.34E+02**	--	2.50E+02	U	2.50E+02	U	2.50E+02	U	**3.37E+03**	--	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U	2.50E+02	U
Other																											
Methanogens	MGN	cells/bead	F	**2.00E+03**	--	**2.79E+01**	J	**2.93E+03**	--	2.50E+02	U	2.50E+02	U	**3.05E+02**	--	**3.99E+01**	J	**6.62E+01**	J	**5.87E+02**	--	2.50E+02	U	2.50E+02	U	**4.27E+02**	--
Sulfate Reducing Bacteria	APS	cells/bead	F	**8.71E+05**	--	2.50E+02	U	**9.44E+03**	--	2.50E+02	U	**4.13E+03**	--	**5.10E+05**	--	2.50E+02	U	**7.00E+02**	--	**3.89E+02**	--	2.50E+02	U	**1.77E+02**	--	2.50E+02	U
Total Eubacteria	EBAC	cells/bead	P	**2.67E+06**	--	**8.00E+05**	--	**5.71E+06**	--	**3.79E+05**	--	**1.04E+07**	--	**1.54E+06**	--	**4.14E+05**	--	**6.14E+05**	--	**1.58E+06**	--	**1.92E+04**	--	**4.22E+06**	--	**1.33E+06**	--

Notes:
U = Gene not detected at a copy number above the value indicated
J = Estimated gene copy number below practical quantitation limit, but above lower quantitation limit.
F= Functional gene
P = Phylogenetic gene
NA=Not applicable
Bold = Analyte detected above the laboratory reporting limit
MI = Microbial Insights
MOB = Middle Overburden
DOB = Deep Overburden
SBR = Shallow Bedrock
DBR = Deep Bedrock

Relative abundance indicated by MI in comparison with other sites

Low
Medium-Low
Medium
Medium-High
High

Table 3 - QuantArray-Petro Summary Table
Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site
Southington, Connecticut

			Sample Location	ISTR-5		TW-08B	
			Sample Date	7/21/2014		7/21/2014	
			Microbial Insights Report Number	055LG_Petro		055LG_Petro	
			Well Group	NA		N	
			Layer	MOB/DOB		SBR	
Gene Target		**Unit**	**Gene Type**				
Anaerobic BTEX							
Benzoyl Coenzyme A Reductase	BCR	cells/bead	F	**3.06E+06**	--	2.50E+02	U
Benzylsuccinate synthase	bssA	cells/bead	F	**5.07E+04**	--	**8.22E+04**	--
Benzene Carboxylase	abcA	cells/bead	F	2.50E+02	U	2.50E+02	U
Anaerobic PAHs and Alkanes							
Naphthalene Carboxylase	ANC	cells/bead	F	2.50E+02	U	2.50E+02	U
Naphthylmethylsuccinate Synthase	mnssA	cells/bead	F	2.50E+02	U	2.50E+02	U
Alklysuccinate Synthase	assA	cells/bead	F	2.50E+02	U	2.50E+02	U
Aerobic BTEX and MTBE							
Toluene/Benzene Dioxygenase	TOD	cells/bead	F	**3.67E+02**	--	**8.67E+01**	J
Phenol Hydroxylase	PHE	cells/bead	F	**9.32E+03**	--	**7.21E+03**	--
Toluene 2 Monooxygenase/Phenol Hydroxylase	RDEG	cells/bead	F	2.50E+02	U	**1.16E+03**	--
Toluene Ring Hydroxylating Monooxygenases	RMO	cells/bead	F	2.50E+02	U	**4.63E+03**	--
Xylene/Toluene Monooxygenase	TOL	cells/bead	F	2.50E+02	U	**5.73E+03**	--
Ethylbenzene/Isopropylbenzene Dioxygenase	EDO	cells/bead	F	2.50E+02	U	2.50E+02	U
Biphenyl/Isopropylbenzene Dioxygenase	BPH4	cells/bead	F	2.50E+02	U	**6.16E+02**	--
Methylibium petroliphilum	PM1	cells/bead	P	2.50E+02	U	**1.12E+05**	--
TBA Monooxygenase	TBA	cells/bead	F	2.50E+02	U	2.50E+02	U
Aerobic PAHs and Alkanes							
Naphthalene Dioxygenase	NAH	cells/bead	F	**2.29E+03**	--	**3.08E+04**	--
Phenanthrene Dioxygenase	PHNA	cells/bead	F	2.50E+02	U	2.50E+02	U
Alkane Monooxygenase	ALKB	cells/bead	F	2.50E+02	U	**4.29E+03**	--
Alkane Monooxygenase	ALMA	cells/bead	F	2.50E+02	U	2.50E+02	U
Other							
Sulfate Reducing Bacteria	APS	cells/bead	F	**4.13E+03**	--	2.50E+02	U
Total Eubacteria	EBAC	cells/bead	P	**1.04E+07**	--	**1.33E+06**	--

Notes:

U = Gene not detected at a copy number above the value indicated

J = Estimated gene copy number below practical quantitation limit, but above lower quantitation limit.

F = Functional gene

P = Phylogenetic gene

Bold = Analyte detected above the laboratory reporting limit

MI = Microbial Insights

BTEX = Benzene, toluene, ethylbenzene, xylenes

PAHs = Polycyclic aromatic hydrocarbons

MTBE = Methyl tertiary butyl ether

TBA = Tertiary butyl alcohol

Bold = Analyte detected above the laboratory reporting limit

MOB = Middle Overburden

DOB = Deep Overburden

SBR = Shallow Bedrock

Relative abundance indicated by MI in comparison with other sites

Low
Medium-Low
Medium
Medium-High
High

Table 4 – MNA Parameters – Groundwater Sample Results – June 2014
Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site
Southington, Connecticut

Sample Location			CPZ-6A		CPZ-7R		CPZ-8R		ISTR-1		ISTR-5		MW-502		MW-705DR		MW-907DR		MW-907M		PZ-906DR		TW-08D		TW-08B	
Sample Date			6/24/2014 13:20		6/24/2014 13:00		6/24/2014 13:40		6/17/2014 0:00		6/16/2014 0:00		6/11/2014 9:15		6/13/2014 9:45		6/10/2014 13:15		6/10/2014 14:30		6/24/2014 14:30		6/12/2014 15:10		6/12/2014 15:00	
Field Sample ID			CPZ-6A-HS-06242014		CPZ-7R-HS-06242014		CPZ-8R-HS-06242014		ISTR-1-06172014		ISTR-5-06162014		MW-502-HS-06112014		MW-705DR-HS-06132014		MW-907DR-HS-06102014		MW-907M-HS-06102014		PZ-906DR-HS-06242014		TW-08D-HS-06122014		TW-08B-HS-06122014	
Well Group			C		C		R		--		--		R		R		R		R		W		N		N	
HydroStratZone(s)			MOB		SBR		SBR		MOB, DOB		MOB, DOB		DOB		DBR		DBR		MOB		DBR		DOB		SBR	
Oxidation-Reduction Classification			Very Strongly Reducing		Moderately Reducing		Moderately Reducing		Strongly Reducing		Strongly Reducing		Very Strongly Reducing		Moderately Reducing		Moderately Reducing		Very Strongly Reducing		Moderately Reducing		Strongly Reducing		Strongly Reducing	
Analyte	**CAS No.**	**Unit**																								
MNA (Water)																										
Alkalinity	ALK	mg/L	**430**	--	**130**	--	**140**	--	**232**	--	**265**	--	**372**	--	**97**	--	**15.6**	--	**342**	--	**546**	--	**232**	--	**237**	--
Chloride	16887-00-6	mg/L	**88.4**	--	**94.2**	--	**69.9**	--	**145**	--	**128**	--	**146**	--	**39.8**	--	**72.4**	--	**138**	--	**153**	--	**76**	--	**198**	--
Sulfate	14808-79-8	mg/L	**3.5**	--	**98.4**	--	**33.7**	--	**15.5**	--	10	U	1	U	**147**	--	**1440**	--	**0.343**	J	**625**	--	1	U	**7.45**	--
Iron (Dissolved)	7439-89-6	ug/L	**15000**	--	**61**	--	**130**	--	**8200**	--	**46000**	--	**11500**	--	**72.1**	--	**45.3**	J	**9720**	--	**28**	--	**28900**	--	**3500**	--
Manganese (Dissolved)	7439-96-5	ug/L	**1350**	--	**144**	--	**458**	--	**10200**	--	**12400**	--	**2085**	--	**8.175**	--	**36.61**	--	**3649**	--	10	U	**9152**	--	**5280**	--
Nitrate as N	14797-55-8	mg/L	**0.049**	J	**0.053**	J	**0.11**	--	**0.041**	J	0.1	U	**0.024**	J	0.289	U	0.1	U	0.1	U	**0.09**	J	**0.148**	--	**2.06**	--
Nitrite as N	14797-65-0	mg/L	**0.03**	J	**0.02**	J	**0.018**	J	**0.038**	J	**0.13**	--	0.05	U	0.083	U	0.05	U	0.05	U	**0.042**	J	0.073	U	0.05	U
Total Organic Carbon	TOC	mg/L	**14**	--	**26**	--	**9.8**	--	**160**	--	**44**	--	**17**	J	**69**	J	**2.6**	J	**16**	J	**17**	--	**23**	J	**21**	J
Ethane	74-84-0	ug/L	**460**	--	**3.2**	--	**0.66**	--	**110**	--	**77**	--	**190**	--	**5.1**	--	**0.16**	--	**350**	--	**3.6**	--	**51**	--	**44**	--
Ethene	74-85-1	ug/L	**2.8**	--	**30**	--	**90**	--	**420**	--	**360**	--	**0.66**	--	**17**	--	**0.69**	--	**0.31**	--	**3.8**	--	**3600**	--	**2400**	--
Methane	74-82-8	ug/L	**24000**	--	**260**	--	**240**	--	**3300**	--	**2400**	--	**28000**	--	**130**	--	1.7	U	**22000**	--	**39**	--	**1500**	--	**2100**	--

Notes:
U = Analyte not detected above the laboratory reporting limit
J = Analyte result is estimated
ug/L = micrograms per liter
mg/L = milligrams per liter
MNA = Monitored Natural Attenuation
Bold = Analyte detected above the laboratory reporting limit
MOB = Middle Overburden
DOB = Deep Overburden
SBR = Shallow Bedrock
DBR = Deep Bedrock

Table 5 – VOCs – Groundwater Sample Results – June 2014
Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site
Southington, Connecticut

					Sample Location	CPZ-6A		CPZ-7R		ISTR-1		ISTR-5		MW-502		MW-705DR		MW-907DR		MW-907M		TW-08D		TW-08B	
					Sample Date	6/11/2014 15:00		6/12/2014 13:50		6/17/2014 0:00		6/16/2014 0:00		6/11/2014 9:15		6/13/2014 9:45		6/10/2014 13:15		6/10/2014 14:30		6/12/2014 15:10		6/12/2014 15:00	
					Field Sample ID	CPZ-6A-HS-06112014		CPZ-7R-HS-06122014		ISTR-1-06172014		ISTR-5-06162014		MW-502-HS-06112014		MW-705DR-HS-06132014		MW-907DR-HS-06102014		MW-907M-HS-06102014		TW-08D-HS-06122014		TW-08B-HS-06122014	
					Well Group	C		C		--		--		R		R		R		R		N		N	
					HydroStratZone(s)	MOB, DOB		SBR		MOB, DOB		MOB, DOB		DOB		DBR		DBR		MOB		DOB		SBR	
Analyte	**CAS No.**	**Unit**	**Action Level**	**ICL**																					
VOCs (8260C)																									
1,1,1,2-Tetrachloroethane	630-20-6	ug/L	1	0.5	0.5	U	1000	U	1000	U	500	U	0.5	U	**18.2**	J	25	U	0.5	U	100	U	200	U
1,1,1-Trichloroethane	71-55-6	ug/L	200	0.5	0.5	UJ	**14500**	--	**63700**	--	500	U	0.5	UJ	**21600**	--	**994**	--	0.5	U	**427**	--	200	U
1,1,2-Trichloroethane	79-00-5	ug/L	5	0.5	0.75	UJ	1500	U	1500	U	750	U	0.75	UJ	37.5	U	**18**	J	0.75	U	150	U	**138**	J
1,1-Dichloroethane	75-34-3	ug/L	70	0.5	0.75	UJ	1500	U	**5040**	--	**4450**	--	0.75	UJ	37.5	U	**23.5**	J	0.75	U	**787**	--	300	U
1,1-Dichloroethene	75-35-4	ug/L	7	0.5	0.5	U	**2530**	--	**2400**	--	**396**	J	0.5	U	**2920**	--	**241**	--	0.5	U	**196**	--	**1480**	--
1,2,4-Trichlorobenzene	120-82-1	ug/L	70	2	2.5	U	5000	U	5000	U	2500	U	2.5	U	125	U	125	U	2.5	U	500	U	1000	U
1,2-Dichlorobenzene	95-50-1	ug/L	600	0.5	**0.497**	J	5000	U	5000	U	2500	U	**0.297**	J	125	U	125	U	**0.444**	J	500	U	1000	U
1,2-Dichloroethane	107-06-2	ug/L	1	0.5	0.5	UJ	1000	U	1000	U	500	U	0.5	UJ	**728**	--	25	U	0.5	U	**106**	--	200	U
1,4-Dichlorobenzene	106-46-7	ug/L	75	0.5	2.5	U	5000	U	5000	U	2500	U	2.5	U	125	U	125	U	**0.57**	J	500	U	1000	U
2-Butanone (MEK)	78-93-3	ug/L	400	5	5	U	**7030**	J	**19900**	--	**5610**	--	5	U	**24700**	J	250	U	5	U	1000	U	**3130**	--
2-Hexanone	591-78-6	ug/L	140	5	5	U	10000	U	10000	U	5000	U	5	U	**28.1**	J	250	U	5	U	1000	U	2000	U
4-Methyl-2-pentanone (MIBK)	108-10-1	ug/L	350	5	5	U	**7830**	J	**11600**	--	5000	U	5	U	**19800**	J	**303**	--	5	U	1000	U	**2280**	--
Acetone	67-64-1	ug/L	700	5	5	U	10000	U	**7720**	J	**1630**	J	5	U	**2520**	--	250	U	5	U	1000	U	**1520**	J
Benzene	71-43-2	ug/L	1	0.5	**47.5**	J	**495**	J	**506**	J	500	U	**67.4**	J	**585**	--	**35.1**	--	**51.2**	--	**94.5**	J	**539**	--
Bromomethane	74-83-9	ug/L	9.8	0.5	1	U	2000	UJ	2000	U	1000	U	1	U	50	UJ	50	U	1	U	200	UJ	400	UJ
Carbon disulfide	75-15-0	ug/L	700	0.5	5	U	10000	U	10000	U	5000	U	5	U	250	U	250	U	5	U	1000	U	2000	U
Carbon tetrachloride	56-23-5	ug/L	5	0.5	0.5	U	1000	U	1000	U	500	U	0.5	U	**4500**	--	25	U	0.5	U	100	U	200	U
Chlorobenzene	108-90-7	ug/L	100	0.5	**24.5**	--	1000	U	1000	U	500	U	**25.5**	--	25	U	25	U	**23.6**	--	100	U	200	U
Chloroethane	75-00-3	ug/L	12.1	0.5	**146**	J	2000	U	**1460**	J	**2460**	--	**50.3**	J	50	U	50	U	**95.3**	--	200	U	**513**	--
Chloroform	67-66-3	ug/L	6	0.5	0.75	U	1500	U	1500	U	750	U	0.75	U	**486**	--	37.5	U	0.75	U	150	U	**162**	J
Chloromethane	74-87-3	ug/L	2.7	0.5	2.5	U	5000	UJ	5000	U	2500	U	2.5	U	125	U	125	U	2.5	U	500	U	1000	U
cis-1,2-Dichloroethene	156-59-2	ug/L	70	0.5	0.5	UJ	**190000**	--	**150000**	--	**67000**	--	**0.424**	J	**26700**	--	**844**	--	0.5	U	**29100**	--	**308000**	--
Ethylbenzene	100-41-4	ug/L	700	0.5	**123**	--	**4760**	--	**5750**	--	**4820**	--	**122**	--	**4570**	--	**426**	--	**0.392**	J	**2530**	--	**4680**	--
Hexachlorobutadiene	87-68-3	ug/L	0.45	0.45	0.6	U	1200	U	1200	U	600	U	0.6	U	30	U	30	U	0.6	U	120	U	240	U
Methylene chloride	75-09-2	ug/L	5	0.5	**0.301**	J	**4990**	J	**4810**	J	**471**	J	**0.356**	J	**13400**	J	**91**	J	**0.434**	J	1000	U	**613**	J
Naphthalene	91-20-3	ug/L	280	0.5	**4.04**	--	5000	U	5000	U	2500	U	**0.864**	J	**16.4**	J	125	U	**1.25**	J	500	UJ	1000	UJ
Styrene	100-42-5	ug/L	100	0.5	1	U	2000	U	**888**	J	1000	U	1	U	**1320**	--	**117**	--	1	U	200	U	**689**	--
Tetrachloroethene	127-18-4	ug/L	5	0.5	0.5	U	**24500**	--	**13800**	--	500	U	0.5	U	**33200**	--	**4950**	--	**0.601**	--	100	U	**20200**	--
Tetrahydrofuran	109-99-9	ug/L	4.6	0.5	**1960**	J	10000	U	**1960**	J	5000	U	**4230**	J	**876**	--	250	U	**3170**	--	**325**	J	**436**	J
Toluene	108-88-3	ug/L	1000	0.5	**0.738**	J	**41100**	--	**66500**	--	**20700**	--	**3.23**	--	**37000**	--	**3900**	--	**0.772**	--	**10800**	--	**47900**	--
trans-1,2-Dichloroethene	156-60-5	ug/L	100	0.5	**0.6**	J	1500	U	1500	U	750	U	0.75	U	37.5	U	37.5	U	0.75	U	**43.6**	J	**134**	J
trans-1,3-Dichloropropene	10061-02-6	ug/L	0.5	0.5	0.5	U	1000	U	1000	U	500	U	0.5	U	25	U	25	U	0.5	U	100	U	200	U
Trichloroethene	79-01-6	ug/L	5	0.5	**0.46**	J	**339000**	--	**272000**	--	500	U	0.5	UJ	**557000**	--	**54300**	--	**4.63**	--	**72.3**	J	**293000**	--
Vinyl chloride	75-01-4	ug/L	2	0.5	1	U	**1250**	J	**1210**	J	**3600**	--	1	U	**621**	--	50	U	1	U	**19400**	--	**14000**	--
Xylenes, Total	1330-20-7	ug/L	530	0.5	**198**	--	**11600**	--	**15300**	--	**12700**	--	**113**	--	**11200**	--	**1260**	--	**2.8**	--	**4580**	--	**11200**	--

Notes:

U = Analyte not detected above the laboratory reporting limit
J = Analyte result is estimated
ug/L = micrograms per liter
VOCs = volatile organic compounds
Action Level = the lower of the USEPA Maximum Contaminant Level (MCL)
ICL = Interim Cleanup Level based on Table L-1 from Record of Decision
Bold = Analyte detected above the laboratory reporting limit
Shaded Cell = Analyte detected above the Action Level
MOB = Middle Overburden
DOB = Deep Overburden
SBR = Shallow Bedrock
DBR = Deep Bedrock

ARCADIS

Figures

REFERENCE: SOUTHINGTON, CONN. USGS QUAD. 1968 PR 1992, MERIDEN, CONN. USGS QUAD. 1966 PR 1984, NEW BRITAIN, CONN. USGS QUAD. 1966 PR 1984, & BRISTOL, CONN. USGS QUAD 1967 PR 1984

2000' 0 2000'

APPROX. SCALE: 1" = 2000'

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
BASELINE MICROBIOLOGICAL SURVEY
TECHNICAL MEMORANDUM

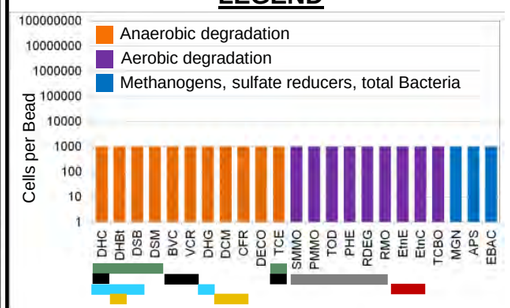
SITE LOCATION MAP

ARCADIS

FIGURE
1

09/11/2014 SYRACUSE, NY-ENV/CAD DJHOWES, LJPOSENAUER
B005463410000\01900\CDR\54634N01.CDR

LEGEND



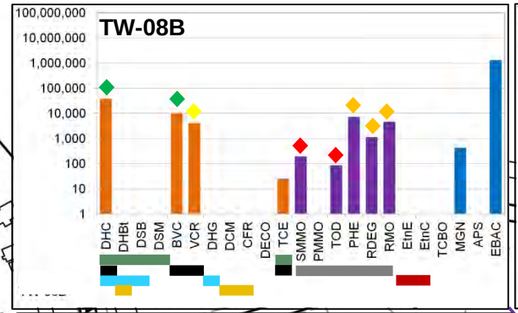
Abundance
- Low
- Medium-Low
- Medium
- Medium-High
- High

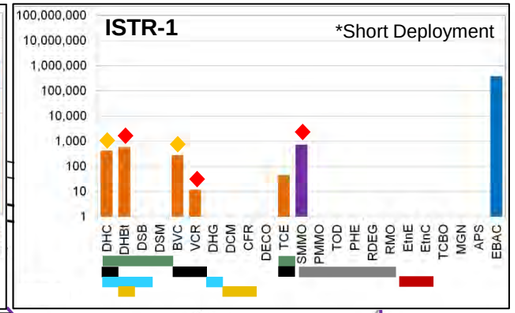
Anaerobic Degradation
- Parent Chlorinated Ethenes
- Daughter Chlorinated Ethenes
- Chlorinated Ethanes
- Chlorinated Methanes

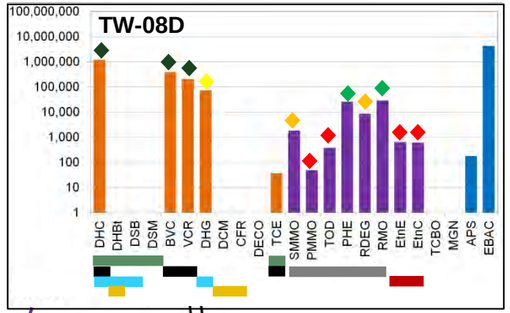
Aerobic Degradation
- Chlorinated Ethenes
- Vinyl Chloride

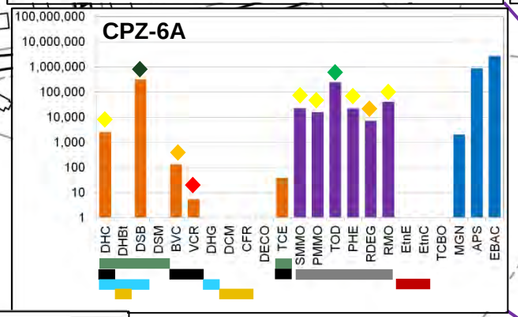
NAPL Well

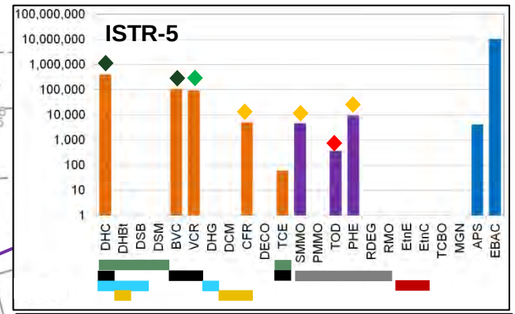
Redox Classification
- Moderately reducing
- Strongly reducing
- Very strongly reducing

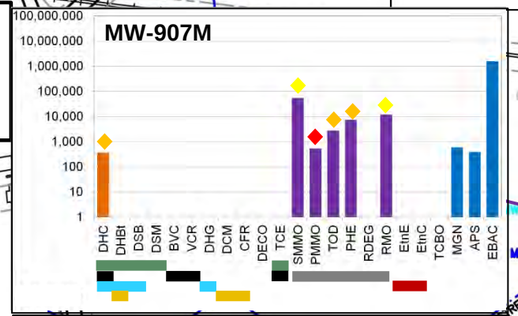


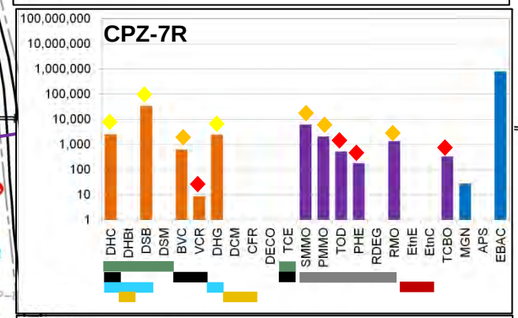


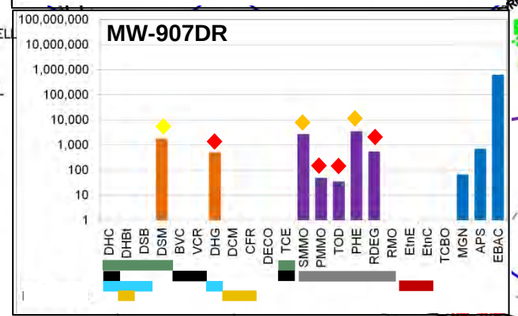


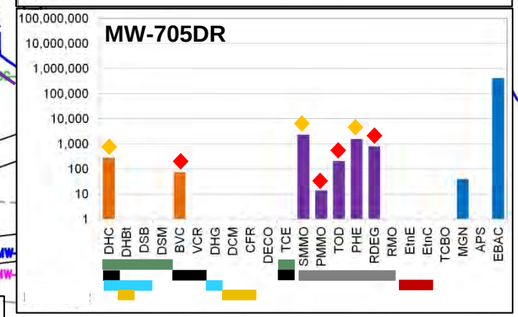


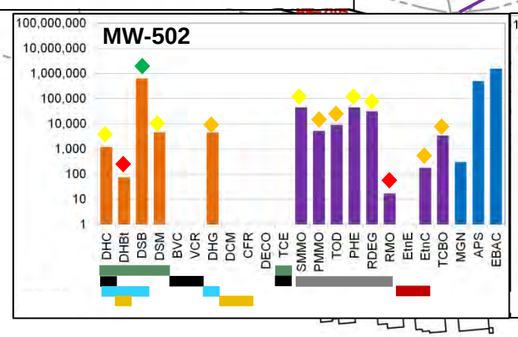


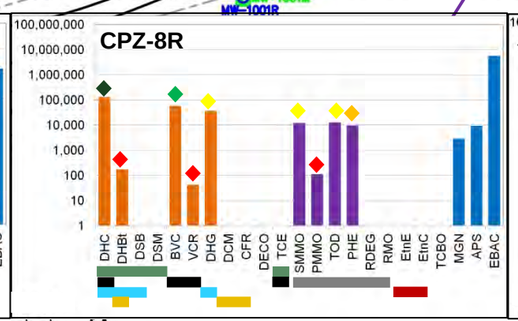


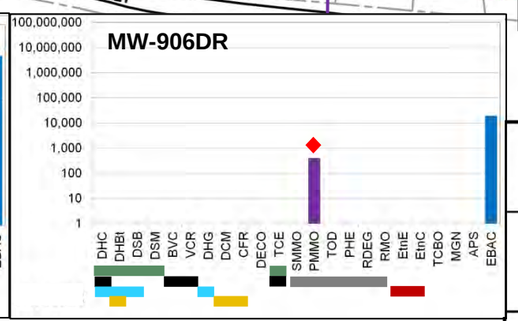












0 300' 600'

GRAPHIC SCALE

LEGEND:
- SHALLOW OVERBURDEN MONITORING WELL
- SHALLOW OVERBURDEN PIEZOMETER
- MIDDLE OVERBURDEN MONITORING WELL
- MIDDLE OVERBURDEN PIEZOMETER
- DEEP OVERBURDEN MONITORING WELL
- DEEP OVERBURDEN PIEZOMETER
- SHALLOW BEDROCK MONITORING WELL
- SHALLOW BEDROCK PIEZOMETER
- DEEP BEDROCK MONITORING WELL
- DEEP BEDROCK PIEZOMETER
- NTCRA 1 EXTRACTION WELL
- MIDDLE/DEEP OVERBURDEN NTCRA 2 EXTRACTION WELL
- SHALLOW/DEEP BEDROCK NTCRA 2 EXTRACTION WELL
- STREAM/RIVER GAUGE POINT

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
BASELINE MICROBIOLOGICAL SURVEY TECHNICAL MEMORANDUM

QUANTARRAY-CHLOR RESULTS SUMMARY

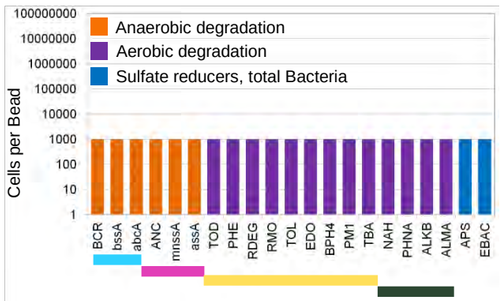
DRAFT

ARCADIS

FIGURE 2

CITY: SYRACUSE, NY DIV/GROUP: ENV/IM-DV DB: P. LISTER, B. SMALL P. LISTER PIC: G. CAMERON PM: J. HOLDEN TM: R.STEVENSON LYR: ON=*;OFF=*REF
G:\ENV\CAD\SYRACUSE\ACTIVE\605463\400\001700\DWG\605463-ALL WELLS.dwg LAYOUT: 1 SAVED: 11/13/2012 3:05 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: -----
PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 11/15/2012 11:50 AM BY: LISTER, PAUL

LEGEND



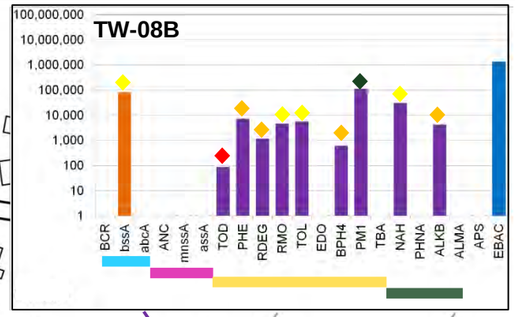
Abundance
- Low
- Medium-Low
- Medium
- Medium-High
- High

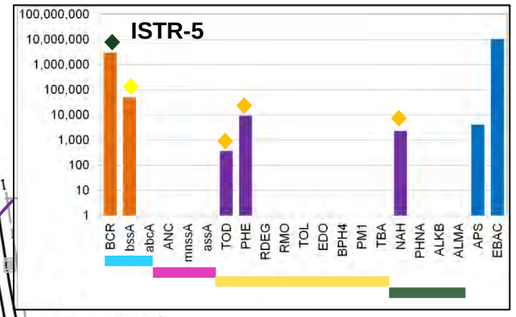
Anaerobic Degradation
- BTEX and MTBE
- PAH and Alkanes

Aerobic Degradation
- BTEX
- PAH and Alkanes

NAPL Well

Redox Classification
- Moderately reducing
- Strongly reducing
- Very strongly reducing





LEGEND:
- SHALLOW OVERBURDEN MONITORING WELL
- SHALLOW OVERBURDEN PIEZOMETER
- MIDDLE OVERBURDEN MONITORING WELL
- MIDDLE OVERBURDEN PIEZOMETER
- DEEP OVERBURDEN MONITORING WELL
- DEEP OVERBURDEN PIEZOMETER
- SHALLOW BEDROCK MONITORING WELL
- SHALLOW BEDROCK PIEZOMETER
- DEEP BEDROCK MONITORING WELL
- DEEP BEDROCK PIEZOMETER
- NTCRA 1 EXTRACTION WELL
- MIDDLE/DEEP OVERBURDEN NTCRA 2 EXTRACTION WELL
- SHALLOW/DEEP BEDROCK NTCRA 2 EXTRACTION WELL
- STREAM/RIVER GAUGE POINT

NOTE:

1. MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONN." DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.
2. ALL GRAY WELLS AND PIEZOMETERS ARE DORMANT STATUS.
3. THE LOCATIONS OF WELLS MW-1002R AND MW-1002DR ARE APPROXIMATE.
4. * = PIEZOMETERS THAT SPAN OVER TWO HYDROSTRATIGRAPHIC ZONES.

FAWN ROAD
CURTISS STREET
CL&P EASEMENT
INTERMITTENT STREAM
QUINNIPIAC RIVER
(CONN. ROUTE 10)
QUEEN STREET
FLANDERS STREET
LAZY LANE
NTCRA 1 SHEETPILE WALL
NTCRA 1 CONTAINMENT AREA
INTERMITTENT STREAM
FORMER OPERATION AREA

0 300' 600'
GRAPHIC SCALE

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
BASELINE MICROBIOLOGICAL SURVEY TECHNICAL MEMORANDUM

QUANTARRAY-PETRO RESULTS SUMMARY

ARCADIS

FIGURE 3

DRAFT

ARCADIS

Attachment 1

Microbial Insights Laboratory Report

10515 Research Drive
Knoxville, TN 37932
Phone: 865.573.8188
Fax: 865.573.8133
Web: www.microbe.com

SITE LOGIC Report

QuantArray® Petroleum Study

Contact: Jeff Holden
Phone: (860) 533-9906
Address: Arcadis
160 Chapel Road, Suite 201
Manchester, CT 06042
Email: Jeff.Holden@arcadis-us.com

MI Identifier: 055LG **Report Date:** 7/25/2014

Project: SRSNE; B0054634.0001
Comments:

The QuantArray® Approach

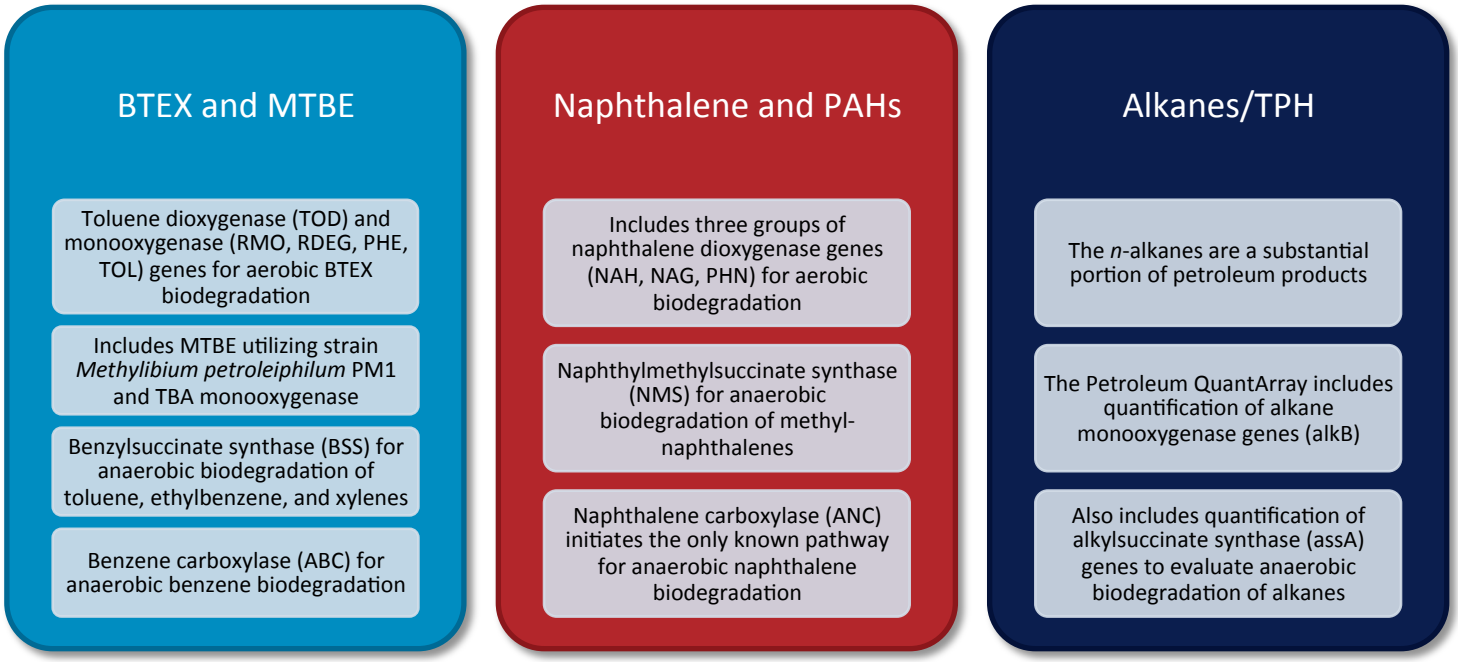
Comprehensive evaluation of biodegradation potential at petroleum impacted sites is inherently problematic due to two factors:

(1) Petroleum products are complex mixtures of hundreds of aliphatic, aromatic, cyclic and heterocyclic compounds
(2) Even for common classes of contaminants like benzene, toluene, ethylbenzene, and xylenes (BTEX), biodegradation can proceed by a multitude of pathways.

The Petroleum QuantArray has been designed to address both of these issues by providing the simultaneous quantification of the specific functional genes responsible for both aerobic and anaerobic biodegradation of BTEX, PAHs, and a variety of short and long chain alkanes.

Thus, when combined with chemical and geochemical groundwater monitoring programs, the QuantArray allows site managers to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of petroleum hydrocarbons through a multitude of aerobic and anaerobic pathways to give a much more clear and comprehensive view of contaminant biodegradation.

The Petroleum QuantArray is used to quantify specific microorganisms and functional genes to evaluate aerobic and anaerobic biodegradation of the following classes of compounds present in petroleum products:



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How do QuantArrays® work?

The QuantArray in many respects is a hybrid technology combining the highly parallel detection of microarrays with the accurate and precise quantification provided by qPCR into a single platform. The key to highly parallel qPCR reactions is the nanoliter fluidics platform for low volume, solution phase qPCR reactions.

How are QuantArray® results reported?

One of the primary advantages of the Petroleum QuantArray is the simultaneous quantification of a broad spectrum of different microorganisms and key functional genes involved in a variety of pathways for chlorinated hydrocarbon biodegradation. However, highly parallel quantification combined with the various metabolic and cometabolic capabilities of different target organisms can complicate data presentation. Therefore, in addition to Summary Tables, QuantArray results will be presented as Microbial Population Summary and Comparison Figures to aid in data interpretation and subsequent evaluation of site management activities.

Types of Tables and Figures:

Microbial Population Summary	•Figure presenting the concentrations of QuantArray target gene concentrations (e.g. toluene dioxygenase) relative to typically observed values.
Summary Tables	• Tables of target population concentrations grouped by biodegradation pathway and contaminant type.
Comparison Figures	•Depending on the project, sample results can be presented to compare changes over time or examine differences in microbial populations for along a transect of the dissolved plume.

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Results

Table 1. Summary of the QuantArray® results.

Sample Information	TW-08B	ISTR-5
Aerobic BTEX and MTBE	(cells/bead)	(cells/bead)
Toluene/Benzene Dioxygenase (TOD)	**8.67E+01 (J)**	**3.67E+02**
Phenol Hydroxylase (PHE)	**7.21E+03**	**9.32E+03**
Toluene 2 Monooxygenase/Phenol Hydroxylase (RDEG)	**1.16E+03**	<2.50E+02
Toluene Ring Hydroxylating Monooxygenases (RMO)	**4.63E+03**	<2.50E+02
Xylene/Toluene Monooxygenase (TOL)	**5.73E+03**	<2.50E+02
Ethylbenzene/Isopropylbenzene Dioxygenase (EDO)	<2.50E+02	<2.50E+02
Biphenyl/Isopropylbenzene Dioxygenase (BPH4)	**6.16E+02**	<2.50E+02
Methylibium petroliphilum PM1 (PM1)	**1.12E+05**	<2.50E+02
TBA Monooxygenase (TBA)	<2.50E+02	<2.50E+02
Aerobic PAHs and Alkanes		
Naphthalene Dioxygenase (NAH)	**3.08E+04**	**2.29E+03**
Phenanthrene Dioxygenase (PHN)	<2.50E+02	<2.50E+02
Alkane Monooxygenase (ALK)	**4.29E+03**	<2.50E+02
Alkane Monooxygenase (ALMA)	<2.50E+02	<2.50E+02
Anaerobic BTEX		
Benzoyl Coenzyme A Reductase (BCR)	<2.50E+02	**3.06E+06**
Benzylsuccinate synthase (BSS)	**8.22E+04**	**5.07E+04**
Benzene Carboxylase (ABC)	<2.50E+02	<2.50E+02
Anaerobic PAHs and Alkanes		
Naphthylmethylsuccinate Synthase (MNSSA)	<2.50E+02	<2.50E+02
Naphthalene Carboxylase (ANC)	<2.50E+02	<2.50E+02
Alklysuccinate Synthase (ASSA)	<2.50E+02	<2.50E+02
Other		
Total Eubacteria (EBAC)	**1.33E+06**	**1.04E+07**
Sulfate Reducing Bacteria (APS)	<2.50E+02	**4.13E+03**

Legend:
NA = Not Analyzed NS = Not Sampled J = Estimated gene copies below PQL but above LQL I = Inhibited
< = Result not detected

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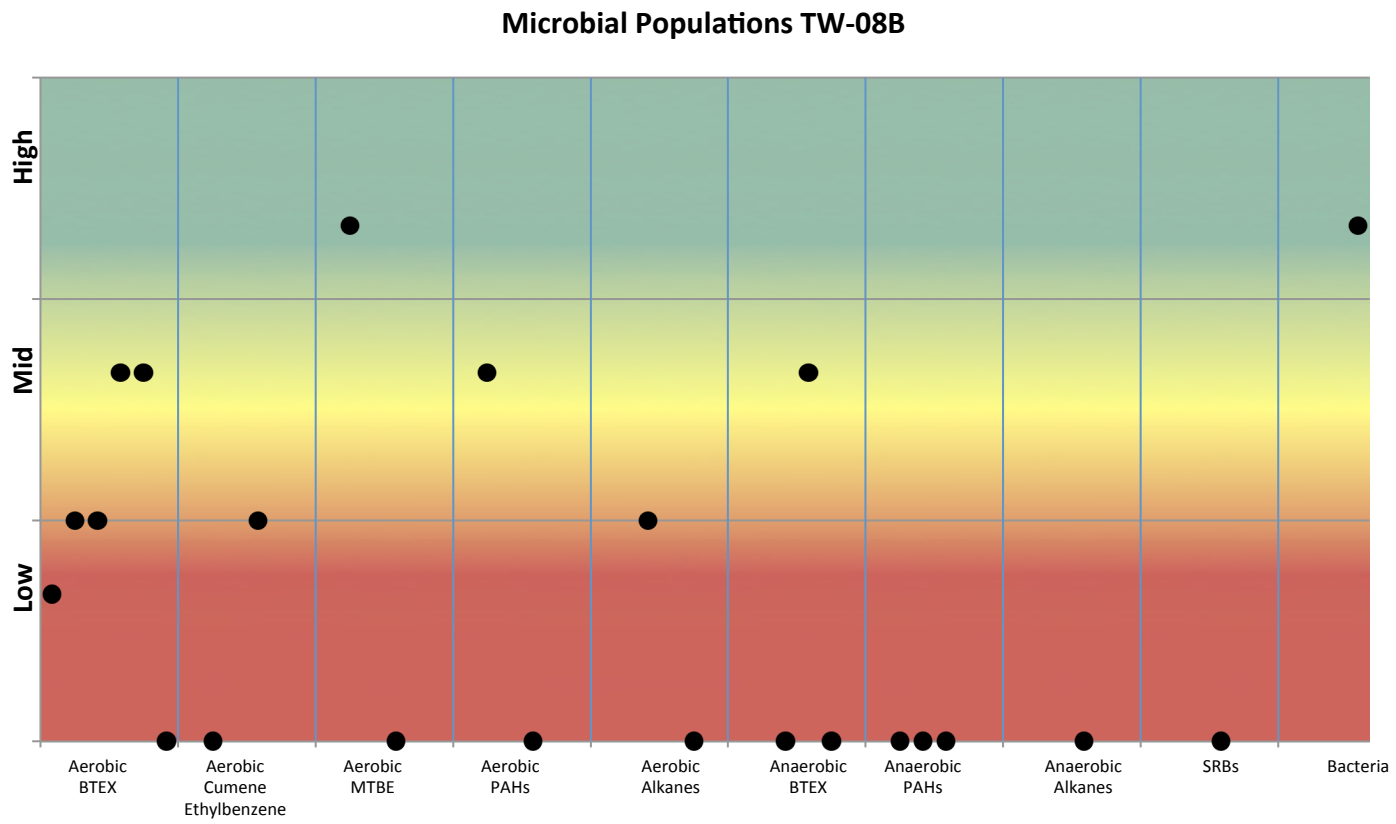
Figure 1. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Aerobic		Anaerobic	
BTEX	TOD, PHE , RDEG, RMO, TOL, EDO	BTEX	BCR, BSS, ABC
Cumene, Ethylbenzene	EDO, BPH4	Naphthalene/ Methylnaphthalene	BCR, MNSSA, ANC
MTBE/TBA	PM1, TBA	Alkanes	assA
Naphthalene	NAH		
Phenanthrene	PHN		
Alkanes	ALK, ALMA		

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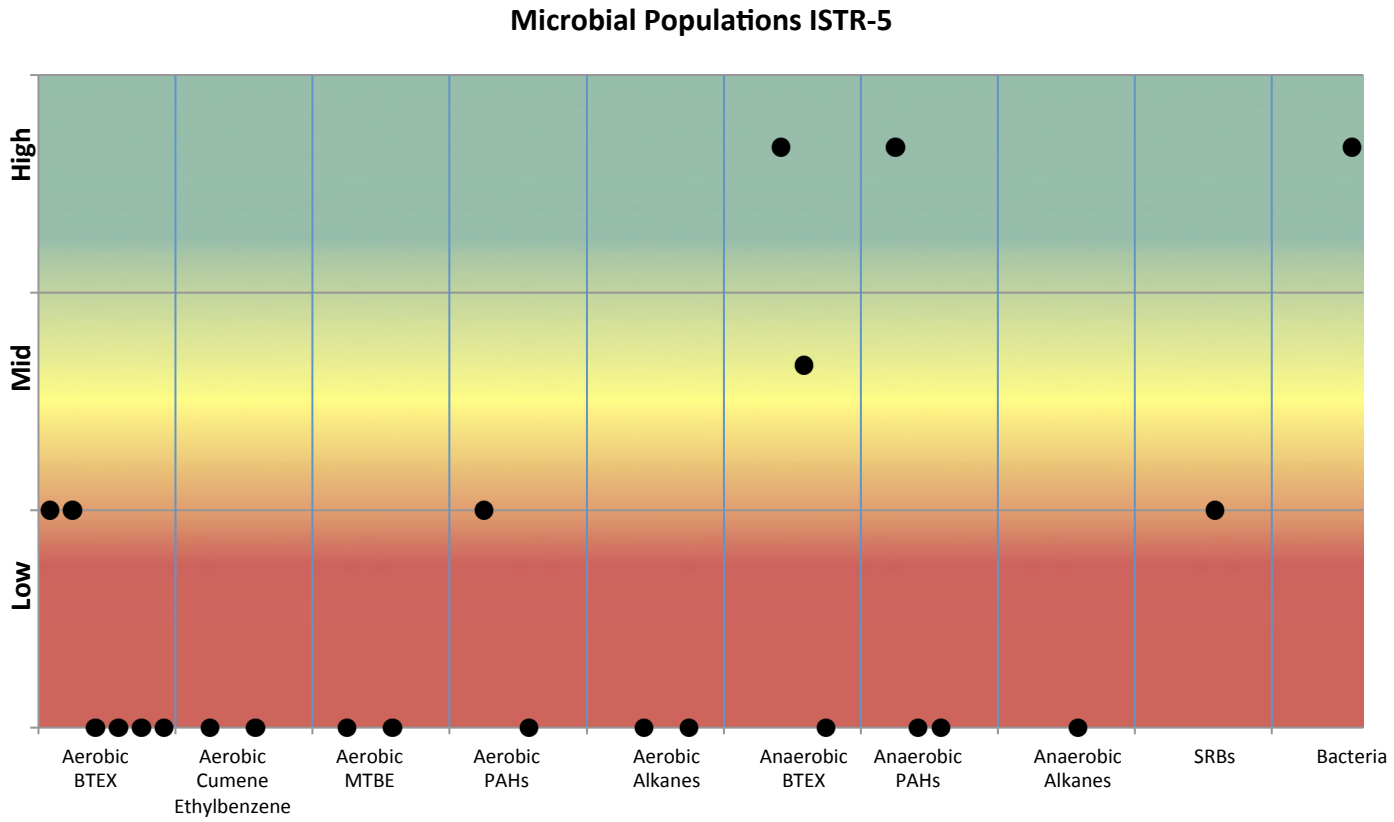
Figure 2. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Aerobic		Anaerobic	
BTEX	TOD, PHE , RDEG, RMO, TOL, EDO	BTEX	BCR, BSS, ABC
Cumene, Ethylbenzene	EDO, BPH4	Naphthalene/ Methylnaphthalene	BCR, MNSSA, ANC
MTBE/TBA	PM1, TBA	Alkanes	assA
Naphthalene	NAH		
Phenanthrene	PHN		
Alkanes	ALK, ALMA		

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Table 2. Summary of the QuantArray® results for microorganisms responsible for aerobic BTEX and MTBE biodegradation.

Sample Information	TW-08B	ISTR-5
Aerobic BTEX and MTBE	**(cells/bead)**	**(cells/bead)**
Toluene/Benzene Dioxygenase (TOD)	**8.67E+01 (J)**	**3.67E+02**
Phenol Hydroxylase (PHE)	**7.21E+03**	**9.32E+03**
Toluene 2 Monooxygenase/Phenol Hydroxylase	**1.16E+03**	<2.50E+02
Toluene Ring Hydroxylating Monooxygenases (RMO)	**4.63E+03**	<2.50E+02
Xylene/Toluene Monooxygenase (TOL)	**5.73E+03**	<2.50E+02
Ethylbenzene/Isopropylbenzene Dioxygenase (EDO)	<2.50E+02	<2.50E+02
Biphenyl/Isopropylbenzene Dioxygenase (BPH4)	**6.16E+02**	<2.50E+02
Methylibium petroliphilum PM1 (PM1)	**1.12E+05**	<2.50E+02
TBA Monooxygenase (TBA)	<2.50E+02	<2.50E+02

Figure 3. Comparison - Microbial populations involved in aerobic biodegradation of BTEX and MTBE.

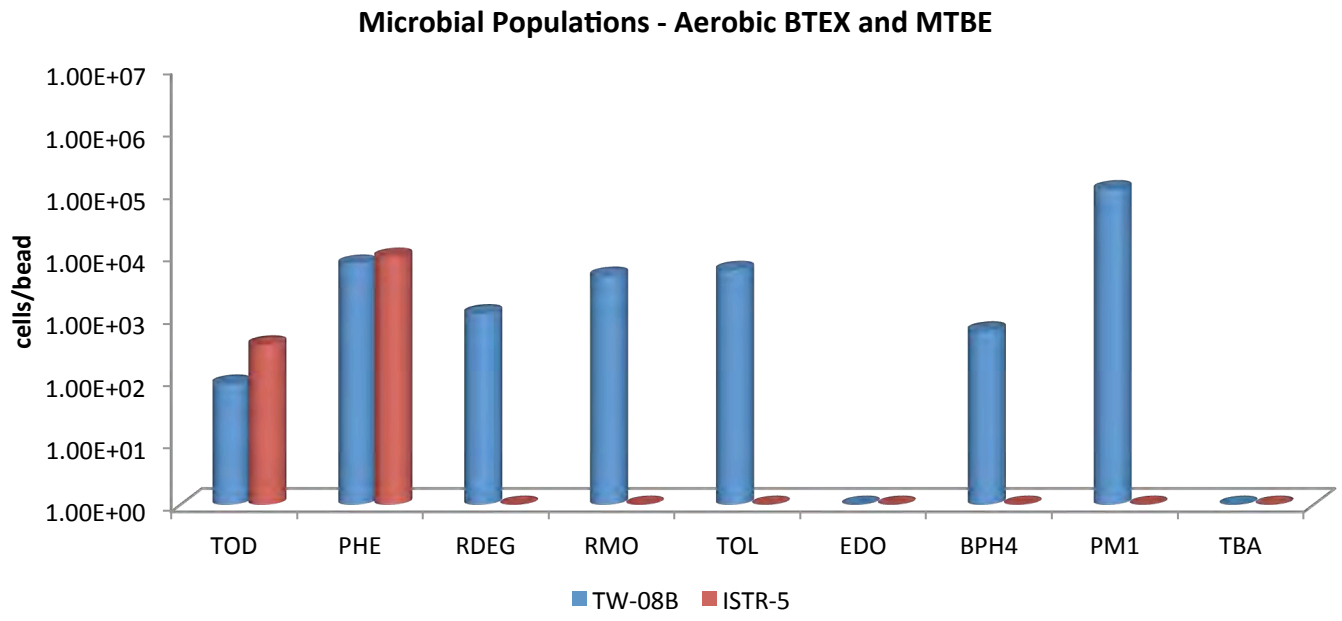

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Table 3. Summary of the QuantArray® results for microorganisms responsible for aerobic biodegradation of PAHs and alkanes.

Sample Information	TW-08B	ISTR-5
Aerobic PAHs and Alkanes	**(cells/bead)**	**(cells/bead)**
Naphthalene Dioxygenase (NAH)	**3.08E+04**	**2.29E+03**
Phenanthrene Dioxygenase (PHN)	<2.50E+02	<2.50E+02
Alkane Monooxygenase (ALK)	**4.29E+03**	<2.50E+02
Alkane Monooxygenase (ALMA)	<2.50E+02	<2.50E+02

Figure 4. Comparison - Microbial populations involved in aerobic biodegradation of PAHs and alkanes.

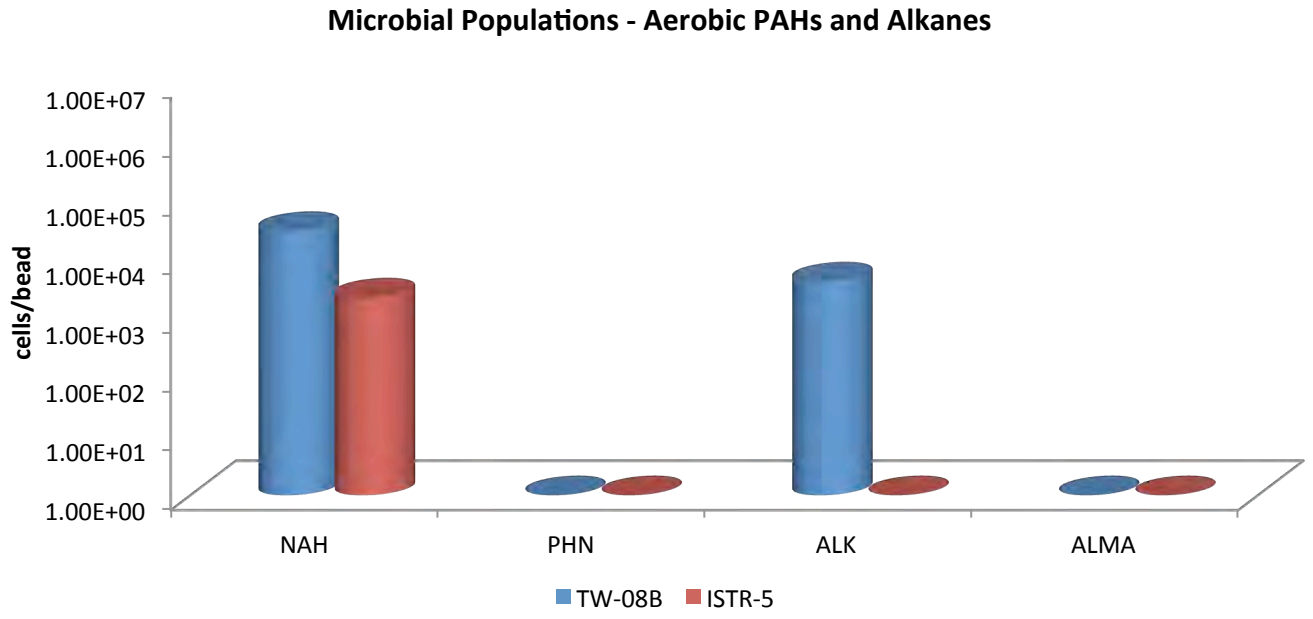

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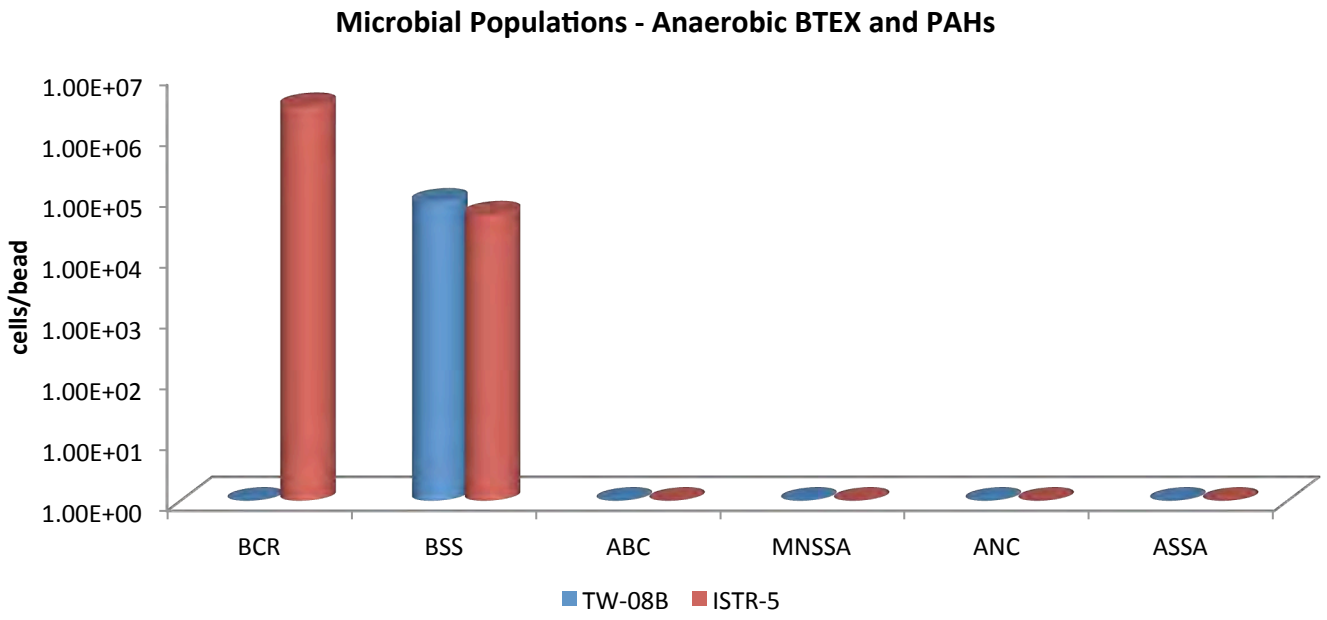
Table 4. Summary of the QuantArray® results for microorganisms responsible for anaerobic biodegradation of BTEX, PAHs, and alkanes.

Sample Information	TW-08B	ISTR-5
Anaerobic BTEX	**(cells/bead)**	**(cells/bead)**
Benzoyl Coenzyme A Reductase (BCR)	<2.50E+02	**3.06E+06**
Benzylsuccinate synthase (BSS)	**8.22E+04**	**5.07E+04**
Benzene Carboxylase (ABC)	<2.50E+02	<2.50E+02
Anaerobic PAHs and Alkanes		
Naphthylmethylsuccinate Synthase (MNSSA)	<2.50E+02	<2.50E+02
Naphthalene Carboxylase (ANC)	<2.50E+02	<2.50E+02
Alklysuccinate Synthase (ASSA)	<2.50E+02	<2.50E+02

Figure 5. Comparison - Microbial populations involved in anaerobic biodegradation of BTEX and PAHs.



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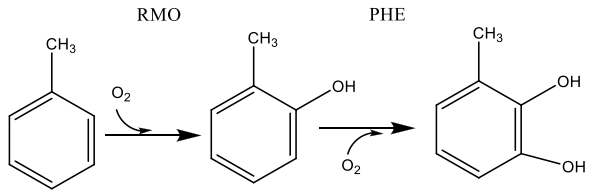
Interpretation

The overall purpose of the Petroleum QuantArray® is to give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of contaminants found in petroleum products through a multitude of aerobic and anaerobic pathways to give a much more clear and comprehensive view of contaminant biodegradation. The following discussion describes interpretation of results in general terms and is meant to serve as a guide.

Aerobic Biodegradation – Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX): At sites impacted by petroleum products, aromatic hydrocarbons including BTEX are often contaminants of concern. Aerobic biodegradation of aromatic hydrocarbons has been intensively studied and multiple catabolic pathways have been well characterized. The substrate specificity of each pathway (range of compounds biodegraded via each pathway) is largely determined by the specificity of the initial oxygenase enzyme. The Petro QuantArray® includes a suite of assays targeting the initial oxygenase genes of the known pathways for aerobic BTEX biodegradation.

Toluene/Benzene Dioxygenase (TOD): Toluene/benzene dioxygenase (TOD) incorporates both atoms of molecular oxygen directly into the aromatic ring. Although commonly called toluene dioxygenase, the substrate specificity of this enzyme is relaxed allowing growth on toluene and benzene along with co-oxidation of a variety of compounds including ethylbenzene, *o*-xylene, *m*-xylene and trichloroethene (TCE) when expressed.

Toluene/Benzene Monooxygenases (RMO/RDEG) and Phenol Hydroxylases (PHE): The next three known pathways for aerobic biodegradation of toluene (as well as benzene and xylenes) involve two steps: (1) an initial oxidation mediated by a toluene monooxygenase and (2) a second oxidation step catalyzed by a phenol hydroxylase. In these pathways, the toluene monooxygenases have been referred to as "ring hydroxylating monoxygenases" because they initiate biodegradation of toluene by incorporating oxygen directly into the aromatic ring rather than at the methyl group. The ring hydroxylating monoxygenases (RMOs) can be further described as toluene-2-monooxygenases, toluene-3-monooxygenases, or toluene-4-monooxygenases based upon where they attack the aromatic ring.



In general, phenol hydroxylases (PHE) catalyze the continued oxidation of phenols produced by RMOs. However, the difference between toluene monooxygenases (RMOs) and phenol hydroxylases (PHEs) is not absolute in terms of substrate specificity and catabolic function. For example, the TbmD toluene/benzene-2-monooxygenase (Johnson and Olsen 1995) may be responsible for both the initial and second oxidation step (Kahng et al. 2001).

The RMO, RDEG, and PHE assays target groups of genes encoding enzymes which perform the critical first and/or second steps in the aerobic biodegradation of BTX compounds. In general terms, the RMO assay quantifies families of toluene-3-monooxygenase and toluene-4-monooxygenase genes. The RDEG assay is used to quantify groups of toluene-2-monooxygenase and phenol hydroxylase genes. Similarly, the PHE assay targets phenol hydroxylase genes and several benzene monooxygenase genes which catalyze both oxidation steps.

Toluene/Xylene Monooxygenase (TOL): The final known pathway for aerobic toluene biodegradation involves initial monooxygenase attack at the methyl group by a toluene/xylene monooxygenase.

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Ethylbenzene Dioxygenase (EDO): Similar to TOD, this group of aromatic oxygenases exhibit relatively broad specificity and are responsible for aerobic biodegradation of alkylbenzenes including ethylbenzene and isopropylbenzene or cumene (Pflugmacher et al. 1996).

Biphenyl Dioxygenase (BPH4): In environmental restoration, biphenyl dioxygenases are best known for cometabolism of polychlorinated biphenyls (PCBs). However, this subfamily includes benzene (Na et al. 2005) and isopropylbenzene (Dabrock et al. 1994) dioxygenases from *Rhodococcus* spp.

Aerobic Biodegradation – MTBE and TBA: With increased use in the 1990's, the fuel oxygenate methyl *tert*-butyl ether (MTBE) has become one of the most commonly detected groundwater contaminants at gasoline contaminated sites. Pure cultures capable of utilizing MTBE as a growth supporting substrate have been isolated (Hanson et al. 1999) and aerobic biodegradation of MTBE and the intermediate *tert*-butyl alcohol (TBA) has been reasonably well characterized. The Petro QuantArray® includes quantification of two gene targets to assess the potential for aerobic biodegradation of MTBE and TBA.

Methylibium petroleiphilum PM1 (PM1): One of the few organisms isolated to date which is capable of utilizing MTBE and TBA as growth supporting substrates (Hanson et al. 1999).

TBA Monooxygenase (BPH4): Targets the TBA monooxygenase gene responsible for oxidation of TBA by *Methylibium petroleiphilum* PM1 (Hristova et al. 2007).

Aerobic Biodegradation – Naphthalene and other PAHs:

Naphthalene Dioxygenase (NAH): Naphthalene dioxygenase incorporates both atoms of molecular oxygen into naphthalene to initiate aerobic metabolism of the compound. However, the broad substrate specificity of naphthalene dioxygenase has been widely noted. When expressed, naphthalene dioxygenase is capable of catalyzing the oxidation of larger PAHs like anthracene, phenanthrene, acenaphthylene, fluorene, and acenaphthene. For a more comprehensive list of reactions mediated by naphthalene dioxygenases, see the University of Minnesota Biocatalysis/Biodegradation Database (http://umbbd.ethz.ch/).

Dinitrotoluene/Naphthalene Dioxygenase (DNT/NAG): The DNT/NAG assay quantifies a distinct subfamily of naphthalene dioxygenase genes that includes the *nagA*-like naphthalene dioxygenases from *Ralstonia* and *Burkholderia* spp. and *dntA*-like dinitrotoluene dioxygenases from *Burkholderia* spp. In addition to the NAH subfamily described above, the *nagA*-like (DNT/NAG) subfamily of naphthalene dioxygenase genes are commonly detected at PAH contaminated sites and have been correlated to naphthalene concentrations (Dionisi et al. 2004) and ^{14}C naphthalene mineralization (Tuomi et al. 2004).

Phenanthrene Dioxygenases (PHN): The PHN assays quantify phenanthrene/naphthalene dioxygenase genes from a diverse collection of microorganisms including *Pseudomonas*, *Burkholderia*, *Sphingomonas*, and *Acidovorax* spp. As with other naphthalene dioxygenases, substrate specificity is relatively broad and phenanthrene dioxygenases have been implicated in the biodegradation of naphthalene, phenanthrene, and anthracene and the co-oxidation of larger PAHs. Moreover, at least one research group has suggested that the PHN group of phenanthrene/naphthalene dioxygenases may be more environmentally relevant than the classical nah-like naphthalene dioxygenase (Laurie and Lloyd-Jones 2000).

Aerobic Biodegradation – *n*-alkanes: The *n*-alkanes are a substantial portion of petroleum products and are a component of TPH concentrations. The Petroleum QuantArray® includes quantification of alkane monooxygenase genes (AlkB) which allow a wide range of *Proteobacteria* and *Actinomycetals* to grow on n-alkanes with carbon lengths from C_5 to C_{16} (Wentzel et al. 2007). The QuantArray also includes a second type of alkane hydroxylase (almA) which catalyzes the aerobic biodegradation of longer chain alkanes (C_{20} – C_{32}) by some *Alcanivorax* spp. considered dominant in marine systems (Liu et al. 2011).

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Anaerobic Biodegradation – Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX): BTEX compounds are also susceptible to biodegradation under anoxic and anaerobic conditions although biodegradation pathways for each compound are not as well characterized as aerobic pathways. The Petro QuantArray® includes sets of assays targeting a number of upper and lower pathway functional genes involved in the anaerobic catabolism of BTEX compounds for better evaluation of anaerobic biodegradation at petroleum contaminated sites.

Benzylsuccinate Synthase (BSS): Of the BTEX compounds, toluene biodegradation under anaerobic conditions is the most extensively studied and best characterized. The first step in this pathway, mediated by benzylsuccinate synthase (*bss*A) is the addition of fumarate onto the toluene methyl group to form benzylsuccinate. While additional pathways are possible, some bacterial isolates capable of anaerobic biodegradation of ethylbenzene and xylenes follow the same metabolic approach where the first step is the addition of fumarate.

Anaerobic Benzene Carboxylase (ABC): Although additional pathways are possible, the only pathway for anaerobic biodegradation of benzene elucidated to date is initiated by a benzene carboxylase enzyme.

Benzoyl Coenzyme A reductase (BCR): Benzyl-CoA is the central intermediate in the anaerobic biodegradation of many aromatic hydrocarbons. Benzoyl-CoA Reductase (BCR) is the essential enzyme for reducing the benzene ring structure.

Anaerobic Biodegradation – PAHs: The anaerobic biodegradation of PAHs involves analogous mechanisms to those described for anaerobic biodegradation of BTEX compounds. For example, the anaerobic biodegradation of methyl-substituted PAHs like 2-methylnaphthalene is initiated by fumarate addition to the methyl group while the only characterized pathway for anaerobic naphthalene biodegradation is initiated by a carboxylase.

Naphthylmethylsuccinate Synthase (NMS): NMS is analogous to the benzylsuccinate synthase described above for anaerobic biodegradation of toluene. Naphthylmethylsuccinate synthase catalyzes the addition of fumarate onto the methyl group of 2-methylnaphthalene (Selesi et al. 2010).

Anaerobic Naphthalene Carboxylase (ANC): To date, the only pathway that has been characterized for anaerobic biodegradation of naphthalene is initiated by a naphthalene carboxylase enzyme (Mouttaki et al. 2012).

Anaerobic Biodegradation – *n*-alkanes: As mentioned previously, the *n*-alkanes are a substantial portion of petroleum products and should be considered particularly when site cleanup goals include TPH reduction. The addition of fumarate is a common mechanism for activating and initiating biodegradation a variety of petroleum hydrocarbons under anaerobic conditions including n-alkanes. The Petroleum QuantArray® includes quantification of alkane succinate synthase genes (assA) which have been characterized in nitrate reducing and sulfate reducing isolates utilizing n-alkanes from C_6 to at least C_{18} (Callaghan et al. 2010).

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SITE LOGIC Report

QuantArray® (Chlor) Study

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MI Identifier: 055LG **Report Date:** 7/25/2014

Project: SRSNE, B0054634.0001
Comments:

The QuantArray® Approach

Quantification of *Dehalococcoides* spp., the only known bacterial group capable of complete reductive dechlorination of PCE and TCE to ethene, has become an indispensable component of assessment, remedy selection, and performance monitoring a sites impacted by chlorinated solvents. While undeniably a key group of halorespiring bacteria, *Dehalococcoides* spp. are not the only bacteria of interest in the subsurface, reductive dechlorination is not the only potential biodegradation pathway, and chlorinated ethenes are not always the primary contaminants of concern. The Chlorinated QuantArray® not only includes a variety of halorespiring bacteria (*Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, etc.) to assess the potential for reductive dechlorination of chloroethenes, chloroethanes, chlorobenzenes, chlorophenols, and chloroform but also provides quantification of functional genes involved in aerobic (co)metabolic pathways for biodegradation of chlorinated solvents and even competing biological processes. Thus, the QuantArray® will give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co)metabolic pathways to give a much more clear and comprehensive view of contaminant biodegradation.

The Chlorinated QuantArray® is used to quantify specific microorganisms and functional genes to evaluate the following:

Anaerobic Reductive Dechlorination	•Quantification of important halorespiring bacteria (e.g. *Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, *Desulfitobacterium* spp.) and key functional genes (e.g vinyl chloride reductases, TCE reductase, 1,2-DCP reductase) responsible for reductive dechlorination of a broad spectrum of chlorinated solvents.
Aerobic Cometabolism	•Several different types of bacteria including methanotrophs and some toluene/phenol utilizing bacteria can co-oxidize TCE, DCE, and vinyl chloride. The Chlorinated QuantArray® quantifies functional genes like soluble methane monooxygenase encoding enzymes capable of co-oxidation of chlorinated ethenes.
Aerobic (Co)metabolism of Vinyl chloride	•Ethene oxidizing bacteria are capable of cometabolism of vinyl chloride. In some cases, ethenotrophs can also utilize vinyl chloride as a growth supporting substrate. The QuantArray® targets key functional genes in ethene metabolism.

How do QuantArrays® work?

The QuantArray® in many respects is a hybrid technology combining the highly parallel detection of microarrays with the accurate and precise quantification provided by qPCR into a single platform. The key to highly parallel qPCR reactions is the nanoliter fluidics platform for low volume, solution phase qPCR reactions.

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How are QuantArray® results reported?

One of the primary advantages of the Chlorinated QuantArray® is the simultaneous quantification of a broad spectrum of different microorganisms and key functional genes involved in a variety of pathways for chlorinated hydrocarbon biodegradation. However, highly parallel quantification combined with the various metabolic and cometabolic capabilities of different target organisms can complicate data presentation. Therefore, in addition to Summary Tables, QuantArray® results will be presented as Microbial Population Summary and Comparison Figures to aid in data interpretation and subsequent evaluation of site management activities.

Types of Tables and Figures:

Microbial Population Summary	•Figure presenting the concentrations of QuantArray® target populations (e.g. *Dehalococcoides* spp.) and functional genes (e.g. vinyl chloride reductase) relative to typically observed values.
Summary Tables	• Tables of target population concentrations grouped by biodegradation pathway and contaminant type.
Comparison Figures	•Depending on the project, sample results can be presented to compare changes over time or examine differences in microbial populations for along a transect of the dissolved plume.

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Results

Table 1. Summary of the QuantArray® results obtained for monitoring wells.

Sample Information	TW-08B	TW-08D	ISTR-5
Reductive Dechlorination	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**
Dehalococcoides spp. (DHC)	**3.86E+04**	**1.18E+06**	**4.04E+05**
tceA Reductase (TCE)	**2.59E+01**	**3.65E+01**	**5.86E+01**
BAV1 Vinyl Chloride Reductase (BVC)	**1.02E+04**	**3.87E+05**	**1.07E+05**
Vinyl Chloride Reductase (VCR)	**4.21E+03**	**2.02E+05**	**9.19E+04**
Dehalobacter spp. (DHBt)	<2.50E+02	<2.50E+02	<2.50E+02
Dehalobacter DCM (DCM)	<2.50E+02	<2.50E+02	<2.50E+02
Dehalogenimonas spp. (DHG)	<2.50E+02	**7.13E+04**	<2.50E+02
Desulfitobacterium spp. (DSB)	<2.50E+02	<2.50E+02	<2.50E+02
Dehalobium chlorocoercia (DECO)	<2.50E+02	<2.50E+02	<2.50E+02
Desulfuromonas spp. (DSM)	<2.50E+02	<2.50E+02	<2.50E+02
Chloroform reductase (CFR)	<2.50E+02	<2.50E+02	**5.06E+03**
Aerobic (Co)Metabolic			
Soluble Methane Monooxygenase (SMMO)	**1.93E+02**	**1.80E+03**	**4.64E+03**
Particulate Methane Monooxygenase	<2.50E+02	**4.80E+01 (J)**	<2.50E+02
Toluene Dioxygenase (TOD)	**8.67E+01 (J)**	**3.71E+02**	**3.67E+02**
Phenol Hydroxylase (PHE)	**7.21E+03**	**2.55E+04**	**9.32E+03**
Trichlorobenzene Dioxygenase (TCBO)	<2.50E+02	<2.50E+02	<2.50E+02
Toluene Monooxygenase 2 (RDEG)	**1.16E+03**	**8.45E+03**	<2.50E+02
Toluene Monooyxgenase (RMO)	**4.63E+03**	**2.82E+04**	<2.50E+02
Ethene Monooxygenase (EtnC)	<2.50E+02	**5.97E+02**	<2.50E+02
Epoxyalkane transferase (EtnE)	<2.50E+02	**6.46E+02**	<2.50E+02
Other			
Total Eubacteria (EBAC)	**1.33E+06**	**4.22E+06**	**1.04E+07**
Sulfate Reducing Bacteria (APS)	<2.50E+02	**1.77E+02**	**4.13E+03**
Methanogens (MGN)	**4.27E+02**	<2.50E+02	<2.50E+02

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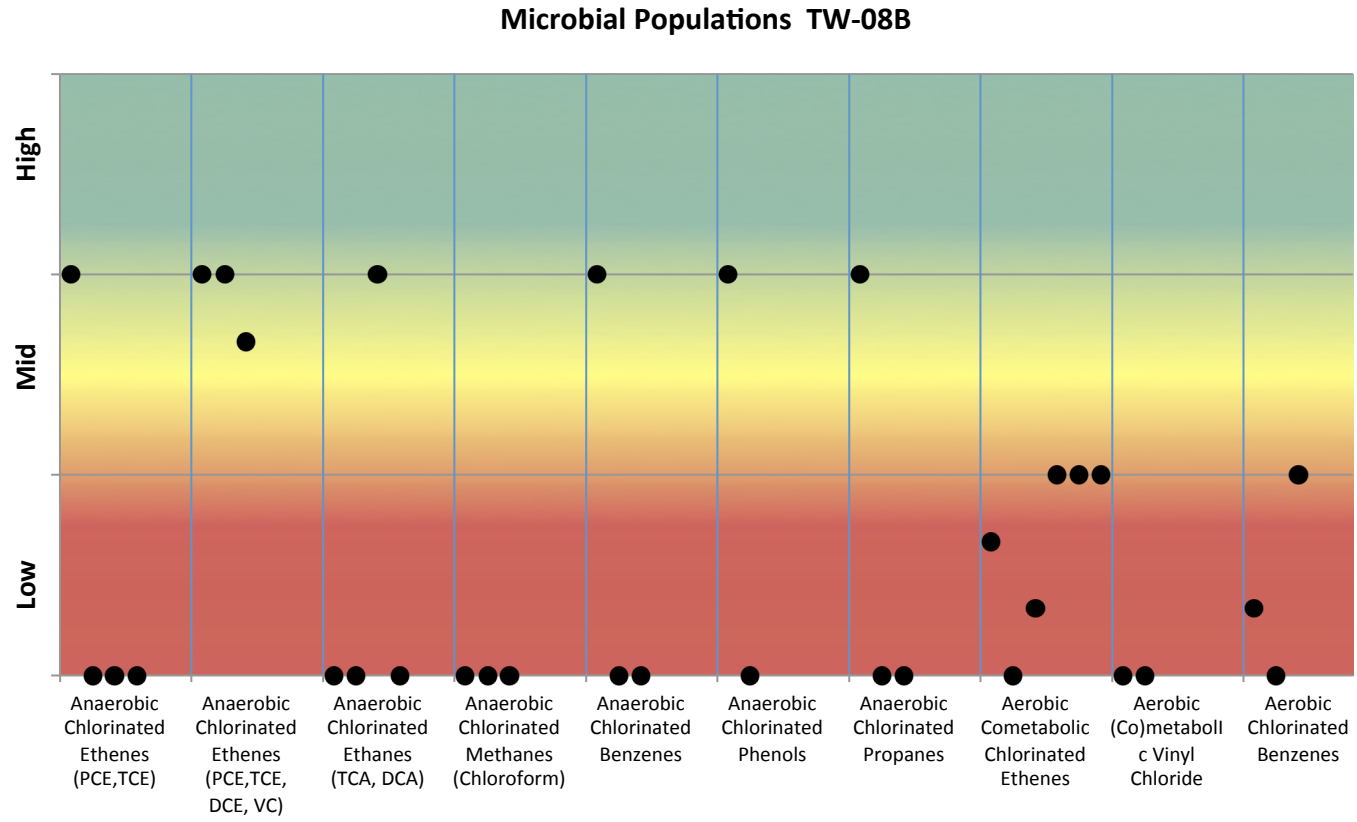
Figure 1. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DHB[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1] *Desulfitobacterium dichloroeliminans* DCA1. [2] Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene

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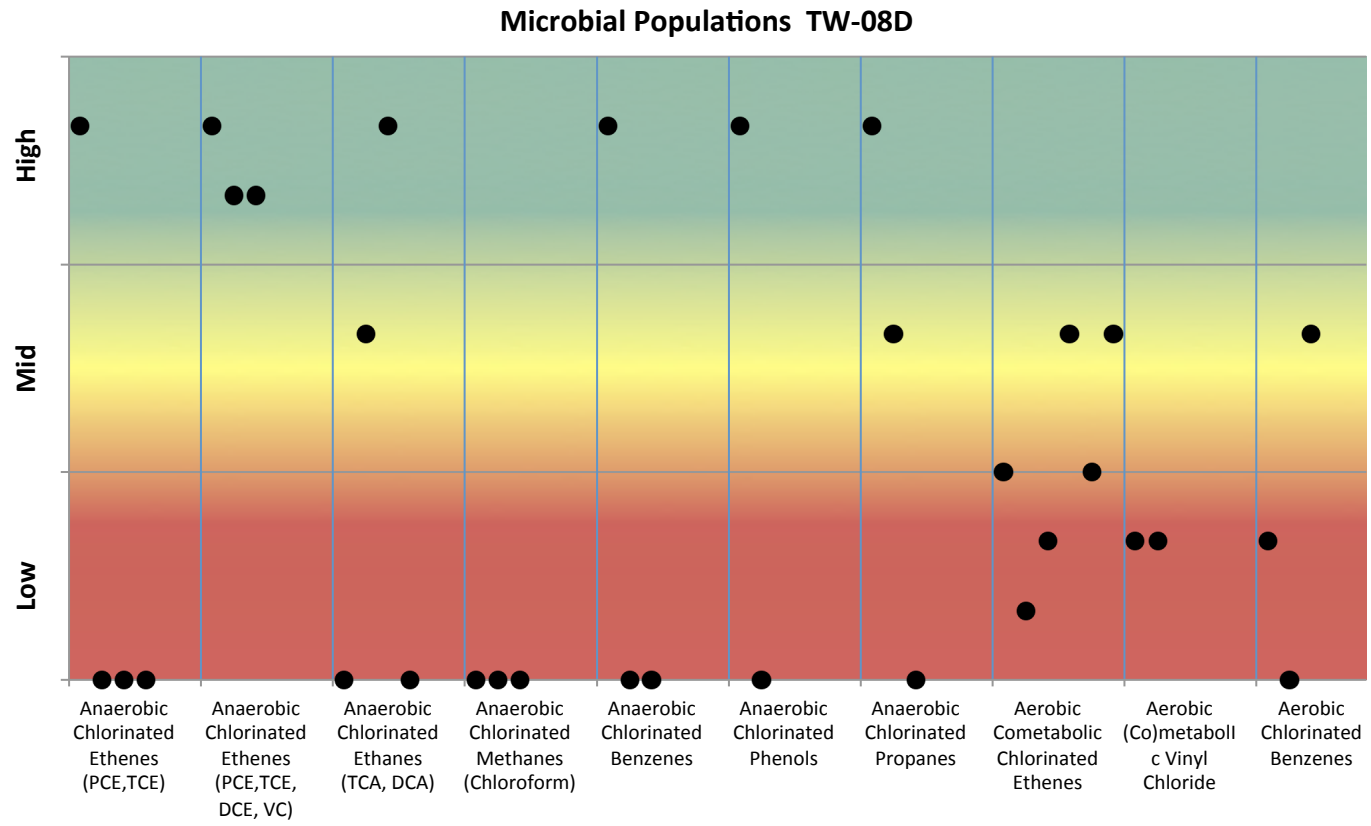
Figure 2. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DHB[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1] *Desulfitobacterium dichloroeliminans* DCA1. [2] Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene

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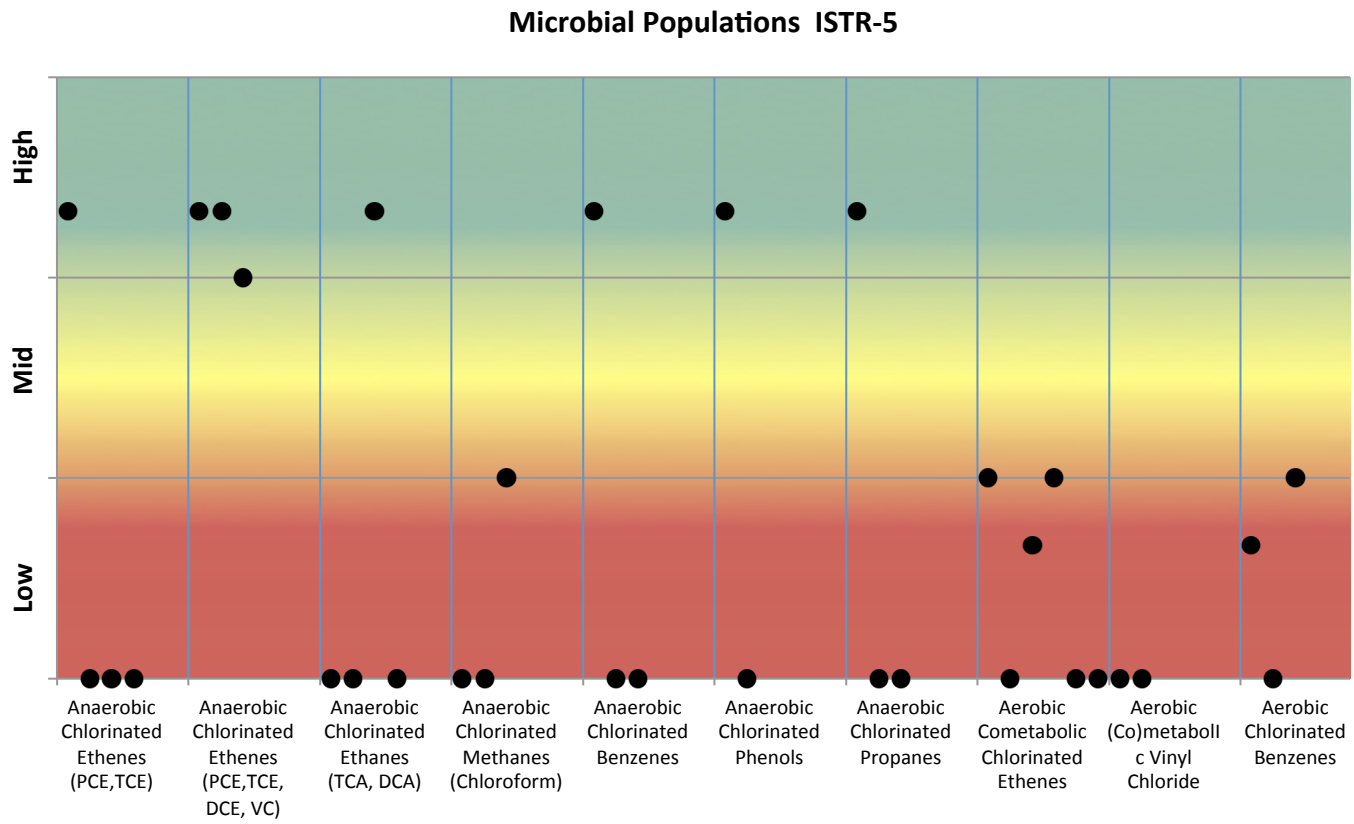
Figure 3. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DHB[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1] *Desulfitobacterium dichloroeliminans* DCA1. [2] Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene

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Table 2. Summary of the QuantArray® results for microorganisms responsible for reductive dechlorination.

Sample Information	TW-08B	TW-08D	ISTR-5
Reductive Dechlorination	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**
Dehalococcoides spp. (DHC)	**3.86E+04**	**1.18E+06**	**4.04E+05**
tceA Reductase (TCE)	**2.59E+01**	**3.65E+01**	**5.86E+01**
BAV1 Vinyl Chloride Reductase (BVC)	**1.02E+04**	**3.87E+05**	**1.07E+05**
Vinyl Chloride Reductase (VCR)	**4.21E+03**	**2.02E+05**	**9.19E+04**
Dehalobacter spp. (DHBt)	<2.50E+02	<2.50E+02	<2.50E+02
Dehalobacter DCM (DCM)	<2.50E+02	<2.50E+02	<2.50E+02
Dehalogenimonas spp. (DHG)	<2.50E+02	**7.13E+04**	<2.50E+02
Desulfitobacterium spp. (DSB)	<2.50E+02	<2.50E+02	<2.50E+02
Dehalobium chlorocoercia (DECO)	<2.50E+02	<2.50E+02	<2.50E+02
Desulfuromonas spp. (DSM)	<2.50E+02	<2.50E+02	<2.50E+02
Chloroform reductase (CFR)	<2.50E+02	<2.50E+02	**5.06E+03**

Figure 4. Comparison - Microbial populations involved in reductive dechlorination

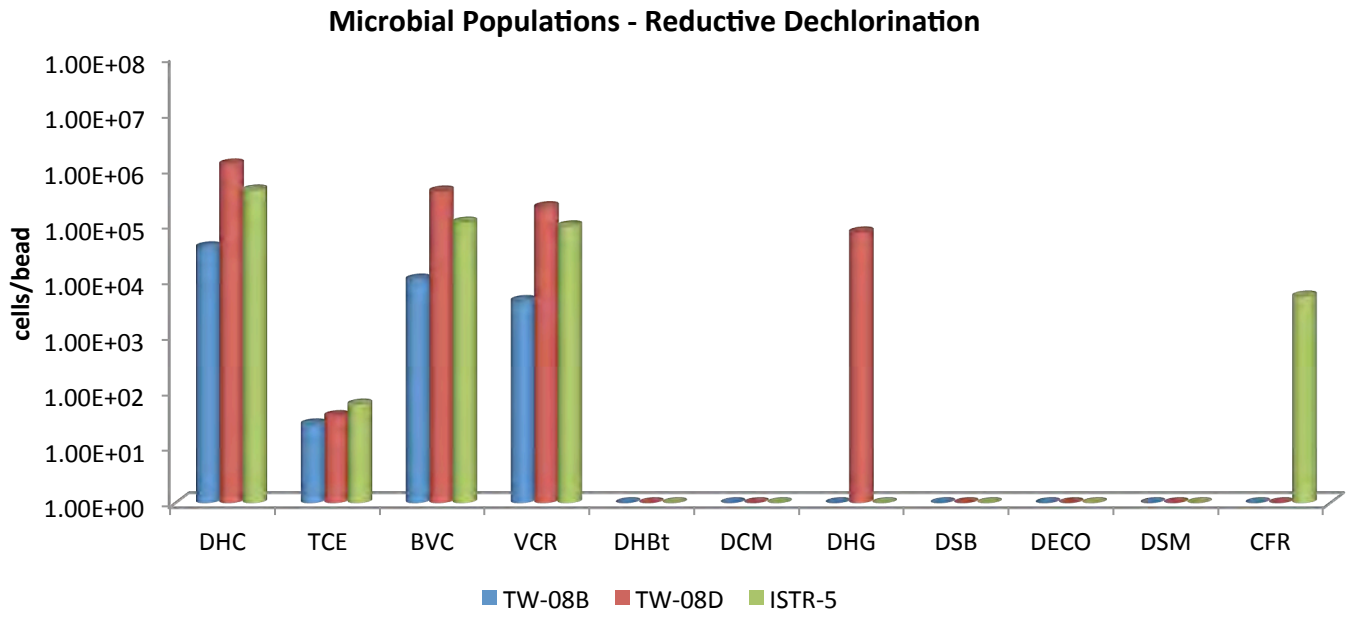

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Table 3. Summary of the QuantArray® results for microorganisms responsible for aerobic (Co)metabolism.

Sample Information	TW-08B	TW-08D	ISTR-5
Aerobic (Co)Metabolic	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**
Soluble Methane Monooxygenase (SMMO)	**1.93E+02**	**1.80E+03**	**4.64E+03**
Particulate Methane Monooxygenase	<2.50E+02	**4.80E+01 (J)**	<2.50E+02
Toluene Dioxygenase (TOD)	**8.67E+01 (J)**	**3.71E+02**	**3.67E+02**
Phenol Hydroxylase (PHE)	**7.21E+03**	**2.55E+04**	**9.32E+03**
Trichlorobenzene Dioxygenase (TCBO)	<2.50E+02	<2.50E+02	<2.50E+02
Toluene Monooxygenase 2 (RDEG)	**1.16E+03**	**8.45E+03**	<2.50E+02
Toluene Monooyxgenase (RMO)	**4.63E+03**	**2.82E+04**	<2.50E+02
Ethene Monooxygenase (EtnC)	<2.50E+02	**5.97E+02**	<2.50E+02
Epoxyalkane transferase (EtnE)	<2.50E+02	**6.46E+02**	<2.50E+02

Figure 5. Comparison - Microbial populations involved in aerobic (Co)metabolism.

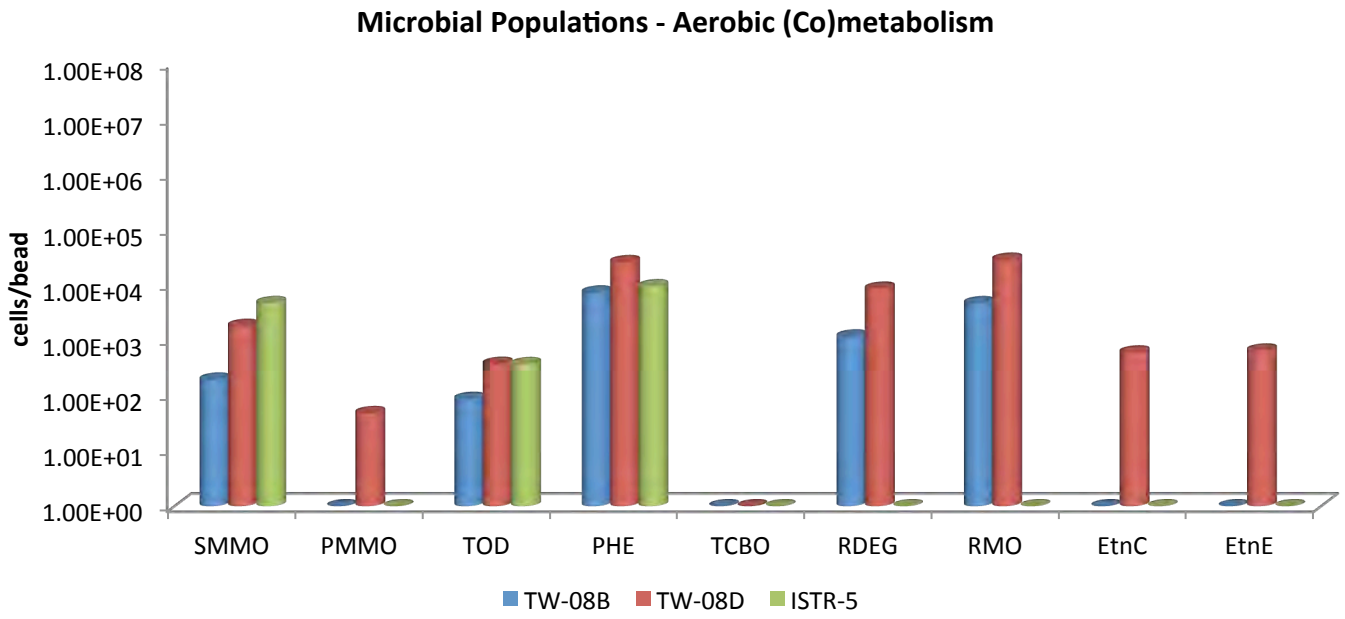

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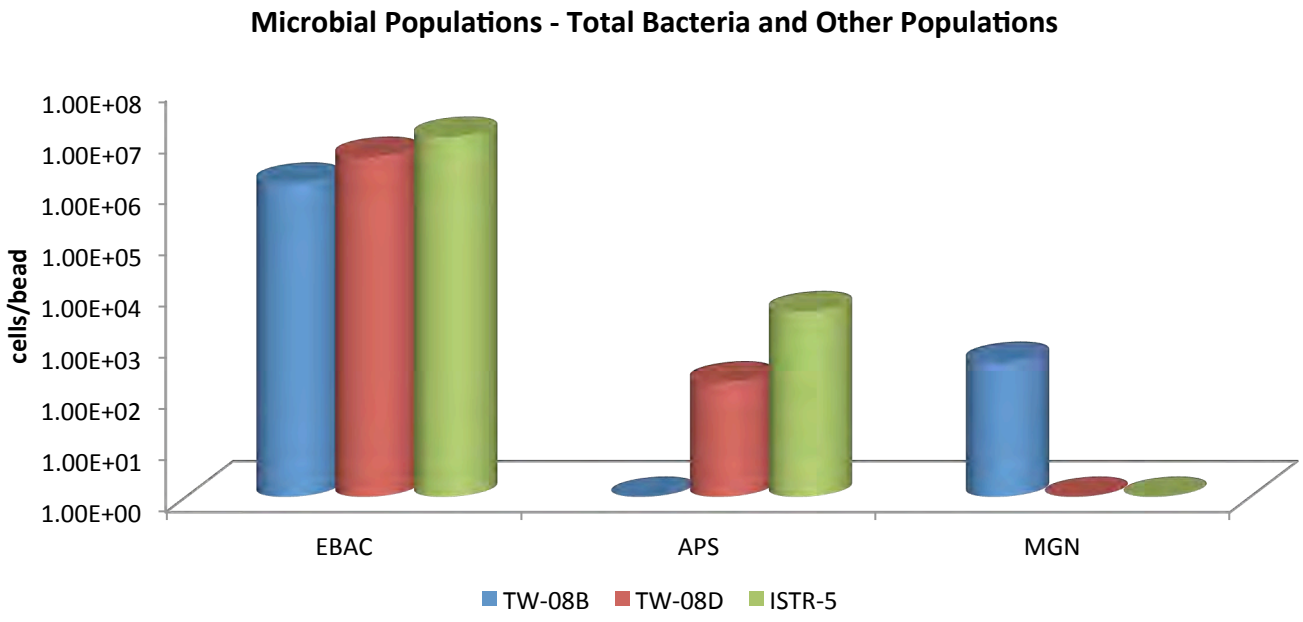
Table 4. Summary of the QuantArray® results for total bacteria and other populations.

Sample Information	TW-08B	TW-08D	ISTR-5
Other	(cells/bead)	(cells/bead)	(cells/bead)
Total Eubacteria (EBAC)	**1.33E+06**	**4.22E+06**	**1.04E+07**
Sulfate Reducing Bacteria (APS)	<2.50E+02	**1.77E+02**	**4.13E+03**
Methanogens (MGN)	**4.27E+02**	<2.50E+02	<2.50E+02

Figure 6. Comparison - Microbial populations



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Interpretation

The overall purpose of the Chlorinated QuantArray® is to give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co)metabolic pathways to give a much more clear and comprehensive view of contaminant biodegradation. The following discussion describes interpretation of results in general terms and is meant to serve as a guide.

Reductive Dechlorination – Chlorinated Ethenes: While a number of bacterial cultures including *Dehalococcoides*, *Dehalobacter*, *Desulfitobacterium*, and *Desulfuromonas* spp. capable of utilizing PCE and TCE as growth supporting electron acceptors have been isolated [1-5], *Dehalococcoides* spp. may be the most important because they are the only bacterial group that has been isolated to date which is capable of complete reductive dechlorination of PCE to ethene [6]. In fact, the presence of *Dehalococcoides* spp. has been associated with complete reductive dechlorination to ethene at sites across North America and Europe [7]. More recently, Lu et al. [8] have proposed using a *Dehalococcoides* concentration of 1×10^4 cells/mL as a screening criterion to identify sites where biological reductive dechlorination will proceed at "generally useful" rates.

A "stall" where daughter products *cis*-DCE and vinyl chloride accumulate can occur at PCE- and TCE-impacted sites especially under MNA conditions. The accumulation of vinyl chloride, generally considered more carcinogenic than the parent compounds, is particularly problematic. Although elevated *Dehalococcoides* concentrations correspond to ethene production in numerous studies, the range of chlorinated ethenes metabolized and cometabolized varies by species and strains within the *Dehalococcoides* genus. For example, *Dehalococcoides ethenogenes* str. 195 metabolizes PCE, TCE, and *cis*-DCE and cometabolizes vinyl chloride [6] to produce ethene. Conversely, *Dehalococcoides* sp. CBDB1 utilizes PCE and TCE but does not cometabolize additional chloroethenes [9]. Quantification of reductive dehalogenase genes is used to more definitively confirm the potential for reductive dechlorination of TCE, cis-DCE, and vinyl chloride [10-13].

Reductive Dechlorination – Chlorinated Ethanes: Under anaerobic conditions, chlorinated ethanes are susceptible to reductive dechlorination by several groups of halorespiring bacteria including *Dehalobacter*, *Dehalogenimonas*, and *Dehalococcoides* spp. While the reported range of chlorinated ethanes utilized varies by genus, species, and sometimes at the strain level, several general observations can be made regarding biodegradation pathways and daughter product formation. *Dehalobacter* spp. have been isolated that are capable of sequential reductive dechlorination of 1,1,1-TCA through 1,1-DCA to chloroethane. Biodegradation of 1,1,2-TCA by several halorespiring bacteria including *Dehalobacter* and *Dehalogenimonas* spp. proceeds via dichloroelimination producing vinyl chloride. Similarly, 1,2-DCA biodegradation by *Dehalobacter*, *Dehalogenimonas*, and *Dehalococcoides* spp occurs via dichloroelimination producing ethene. While not utilized by many *Desulfitobacterium* isolates, at least one strain, *Desulfitobacterium dichloroeliminans* strain DCA1, is also capable of dichloroelimination of 1,2-DCA [14].

Reductive Dechlorination – Chlorinated Methanes: Chloroform is a common co-contaminant at chlorinated solvent sites and can inhibit reductive dechlorination of chlorinated ethenes. Grostern et al demonstrated that a *Dehalobacter* population was capable of reductive dechlorination of chloroform to produce dichloromethane [15]. The *cfrA* gene encodes the reductase which catalyzes this initial step in chloroform biodegradation [16]. Justicia-Leon et al have since shown that dichloromethane can support growth of a distinct group of *Dehalobacter* strains via fermentation [17]. The *Dehalobacter* DCM assays targets the 16S rRNA gene of these strains.

Reductive Dechlorination – Chlorinated Benzenes: Chlorinated benzenes are an important class of industrial solvents and chemical intermediates in the productions of drugs, dyes, herbicides, and insecticides. The physical-chemical properties of chlorinated benzenes as well as susceptibility to biodegradation are functions of their degree of chlorination and the positions of

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chlorine substituents. Under anaerobic conditions, reductive dechlorination of higher chlorinated benzenes including hexachlorobenzene (HCB), pentachlorobenzene (PeCB), tetrachlorobenzene (TeCB) isomers, and trichlorobenzene (TCB) isomers by halorespiring bacteria has been well documented [18]. For example, although biodegradation of individual compounds and specific isomers does vary somewhat between isolates, *Dehalococcoides* spp. such as strain CBDB1 have been identified which reductively dechlorinate HCB, PeCB, all three TeCB isomers, 1,2,3-TCB, and 1,2,4-TCB [9, 19]. *Dehalobium chlorocoercia* DF-1 has been shown to be capable of reductive dechlorination of HCB, PeCB, and 1,2,3,5-TeCB [20]. The dichlorobenzene (DCB) isomers and chlorobenzene (CB) were considered relatively recalcitrant under anaerobic conditions. However, new evidence has demonstrated reductive dechlorination of DCBs to CB and CB to benzene [21] with corresponding increases in concentrations of *Dehalobacter* spp. [22].

Reductive Dechlorination – Chlorinated Phenols: Pentachlorophenol (PCP) was one of the most widely used biocides in the US and despite residential use restrictions is still extensively used industrially as a wood preservative. Along with PCP, the tetrachloropenol and trichlorophenol isomers were also used as fungicides in wood preserving formulations. 2,4-dichlorophenol and 2,4,5-TCP were used as chemical intermediates in herbicide production (e.g. 2,4-D) and chlorophenols are known byproducts of chlorine bleaching in the pulp and paper industry. While the range of compounds utilized varies by strain, some *Dehalococcoides* isolates are capable of reductive dechlorination of PCP and other chlorinated phenols. For example, *Dehalococcoides* strain CBDB1 is capable of utilizing pentachlorophenol (PCP), all three tetrachlorphenol (TeCP) congeners, all six trichlorophenol (TCP) congeners, and 2,3-dichlorophenol (2,3-DCP). PCP dechlorination by strain CBDB1 produces a mixture of 3,5-DCP, 3,4-DCP, 2,4-DCP, 3-CP, and 4-CP [23]. In the same study however, *Dehalococcoides ethenogenes* strain 195 dechlorinated a more narrow spectrum of chlorophenols which included 2,3-DCP, 2,3,4-TCP, and 2,3,6-TCP but no other TCPs or PCP. Similar to *Dehalococcoccoides*, some species and strains of *Desulfitobacterium* are capable of utilizing PCP and other chlorinated phenols. *Desulfitobacterium hagniense* PCP-1 is capable of reductive dechlorination of PCP to 3-CP [24]. However, the ability to biodegrade PCP is not universal among *Desulfitobacterium* isolates. *Desulfitobacterium* sp. strain PCE1 and *D. chlororespirans* strain Co23 for example can utilize some TCP and DCP isomers but not PCP for growth [2, 25].

Reductive Dechlorination – Chlorinated Propanes: *Dehalogenimonas* is a recently described bacterial genus of the phylum *Chloroflexi* which also includes the well-known chloroethene-respiring *Dehalococcoides* spp [26]. The *Dehalogenimonas* isolates characterized to date are also halorespiring bacteria but utilize a rather unique range of chlorinated compounds as electron acceptors including chlorinated propanes (1,2,3-TCP and 1,2-DCP) and a variety of other vicinally chlorinated alkanes including 1,1,2,2-tetrachlorethane, 1,1,2-trichloroethane, and 1,2-dichloroethane [26].

Aerobic – Chlorinated Ethene Cometabolism: Under aerobic conditions, several different types of bacteria including methane-oxidizing bacteria (methanotrophs), ammonia-oxidizing bacteria, and some toluene/phenol-utilizing bacteria can cometabolize or co-oxidize trichloroethene (TCE), dichlorethene (DCE), and vinyl chloride (VC). In general, cometabolism of chlorinated ethenes is mediated by monooxygenase enzymes with "relaxed" specificity that oxidize a primary (growth supporting) substrate and co-oxidize the chlorinated compound. Most methanotrophs are only capable of producing particulate methane monooxygenase (pMMO) which is capable of aerobic cometabolism but often at lower rates. Other methanotrophs are capable of producing both pMMO and soluble methane monooxygenase (sMMO) enzymes, which in general are believed to capable of greater rates of aerobic cometabolism.

Aerobic – Vinyl Chloride Cometabolism: Beginning in the early 1990s, numerous microcosm studies demonstrated aerobic oxidation of vinyl chloride under MNA conditions without the addition of exogenous primary substrates. Since then, strains of *Mycobacterium*, *Nocardioides*, *Pseudomonas*, *Ochrobactrum*, and *Ralstonia* species have been isolated which are capable of aerobic growth on both ethene and vinyl chloride (see Mattes et al., [27] for review). The initials steps in the pathway are the monooxygenase (*etn*ABCD) catalyzed conversion of ethene and vinyl chloride to their respective epoxyalkanes (epoxyethane and chlorooxirane) followed by epoxyalkane:CoM transferase (*etn*E) mediated conjugation and breaking of the epoxide [28].

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Aerobic – Chlorinated Benzenes: In general, chlorobenzenes with four or less chlorine groups are susceptible to aerobic biodegradation even serving as growth supporting substrates. Toluene dioxygenase (TOD) has relatively relaxed substrate specificity and mediates the incorporation of both atoms of oxygen into the aromatic ring of benzene and substituted benzenes (toluene and chlorobenzene). Comparison of TOD levels in background and source zone samples from a CB impacted site suggested that CBs promoted growth of TOD containing bacteria [29]. In addition, aerobic biodegradation of some trichlorobenzene and even tetrachlorobenzene isomers is initiated by a group of related trichlorobenzene dioxygenase genes (TCBO). Finally, phenol hydroxylases catalyze the continued oxidation and in some cases the initial oxidation of a variety of monoaromatic compounds. In an independent study, significant increases in numbers of bacteria containing PHE genes corresponded to increases in biodegradation of DCB isomers [29].

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SITE LOGIC Report

QuantArray® (Chlor) Study

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MI Identifier: 095LG **Report Date:** 8/11/2014

Project: SRSNE, B0054634.0001
Comments:

The QuantArray® Approach

Quantification of *Dehalococcoides* spp., the only known bacterial group capable of complete reductive dechlorination of PCE and TCE to ethene, has become an indispensable component of assessment, remedy selection, and performance monitoring a sites impacted by chlorinated solvents. While undeniably a key group of halorespiring bacteria, *Dehalococcoides* spp. are not the only bacteria of interest in the subsurface, reductive dechlorination is not the only potential biodegradation pathway, and chlorinated ethenes are not always the primary contaminants of concern. The Chlorinated QuantArray® not only includes a variety of halorespiring bacteria (*Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, etc.) to assess the potential for reductive dechlorination of chloroethenes, chloroethanes, chlorobenzenes, chlorophenols, and chloroform but also provides quantification of functional genes involved in aerobic (co)metabolic pathways for biodegradation of chlorinated solvents and even competing biological processes. Thus, the QuantArray® will give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co)metabolic pathways to give a much more clear and comprehensive view of contaminant biodegradation.

The Chlorinated QuantArray® is used to quantify specific microorganisms and functional genes to evaluate the following:

Anaerobic Reductive Dechlorination	•Quantification of important halorespiring bacteria (e.g. *Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, *Desulfitobacterium* spp.) and key functional genes (e.g vinyl chloride reductases, TCE reductase, 1,2-DCP reductase) responsible for reductive dechlorination of a broad spectrum of chlorinated solvents.
Aerobic Cometabolism	•Several different types of bacteria including methanotrophs and some toluene/phenol utilizing bacteria can co-oxidize TCE, DCE, and vinyl chloride. The Chlorinated QuantArray® quantifies functional genes like soluble methane monooxygenase encoding enzymes capable of co-oxidation of chlorinated ethenes.
Aerobic (Co)metabolism of Vinyl chloride	•Ethene oxidizing bacteria are capable of cometabolism of vinyl chloride. In some cases, ethenotrophs can also utilize vinyl chloride as a growth supporting substrate. The QuantArray® targets key functional genes in ethene metabolism.

How do QuantArrays® work?

The QuantArray® in many respects is a hybrid technology combining the highly parallel detection of microarrays with the accurate and precise quantification provided by qPCR into a single platform. The key to highly parallel qPCR reactions is the nanoliter fluidics platform for low volume, solution phase qPCR reactions.

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How are QuantArray® results reported?

One of the primary advantages of the Chlorinated QuantArray® is the simultaneous quantification of a broad spectrum of different microorganisms and key functional genes involved in a variety of pathways for chlorinated hydrocarbon biodegradation. However, highly parallel quantification combined with the various metabolic and cometabolic capabilities of different target organisms can complicate data presentation. Therefore, in addition to Summary Tables, QuantArray® results will be presented as Microbial Population Summary and Comparison Figures to aid in data interpretation and subsequent evaluation of site management activities.

Types of Tables and Figures:

Microbial Population Summary	•Figure presenting the concentrations of QuantArray® target populations (e.g. *Dehalococcoides* spp.) and functional genes (e.g. vinyl chloride reductase) relative to typically observed values.
Summary Tables	• Tables of target population concentrations grouped by biodegradation pathway and contaminant type.
Comparison Figures	•Depending on the project, sample results can be presented to compare changes over time or examine differences in microbial populations for along a transect of the dissolved plume.

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Results

Table 1. Summary of the QuantArray® results obtained for monitoring wells.

Sample Information	CPZ-6A	MW-502	MW-907M	MW-907DR
Reductive Dechlorination	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**
Dehalococcoides spp. (DHC)	**2.50E+03**	**1.20E+03**	**3.72E+02**	<2.50E+01
tceA Reductase (TCE)	**3.80E+01**	<2.50E+01	<2.50E+01	<2.50E+01
BAV1 Vinyl Chloride Reductase (BVC)	**1.33E+02**	<2.50E+01	<2.50E+01	<2.50E+01
Vinyl Chloride Reductase (VCR)	**5.40E+00 (J)**	<2.50E+01	<2.50E+01	<2.50E+01
Dehalobacter spp. (DHBt)	<2.50E+02	**7.50E+01 (J)**	<2.50E+02	<2.50E+02
Dehalobacter DCM (DCM)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Dehalogenimonas spp. (DHG)	<2.50E+02	**4.52E+03**	<2.50E+02	**4.90E+02**
Desulfitobacterium spp. (DSB)	**3.18E+05**	**6.26E+05**	<2.50E+02	<2.50E+02
Dehalobium chlorocoercia (DECO)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Desulfuromonas spp. (DSM)	<2.50E+02	**4.62E+03**	<2.50E+02	**1.74E+03**
Chloroform reductase (CFR)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Aerobic (Co)Metabolic				
Soluble Methane Monooxygenase (SMMO)	**2.28E+04**	**4.53E+04**	**5.49E+04**	**2.67E+03**
Particulate Methane Monooxygenase	**1.58E+04**	**5.22E+03**	**5.29E+02**	**4.82E+01 (J)**
Toluene Dioxygenase (TOD)	**2.47E+05**	**9.09E+03**	**2.75E+03**	**3.43E+01 (J)**
Phenol Hydroxylase (PHE)	**2.22E+04**	**4.53E+04**	**7.45E+03**	**3.49E+03**
Trichlorobenzene Dioxygenase (TCBO)	<2.50E+02	**3.37E+03**	<2.50E+02	<2.50E+02
Toluene Monooxygenase 2 (RDEG)	**7.18E+03**	**3.11E+04**	<2.50E+02	**5.39E+02**
Toluene Monooyxgenase (RMO)	**4.09E+04**	**1.68E+01 (J)**	**1.18E+04**	<2.50E+02
Ethene Monooxygenase (EtnC)	<2.50E+02	**1.80E+02 (J)**	<2.50E+02	<2.50E+02
Epoxyalkane transferase (EtnE)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Other				
Total Eubacteria (EBAC)	**2.67E+06**	**1.54E+06**	**1.58E+06**	**6.14E+05**
Sulfate Reducing Bacteria (APS)	**8.71E+05**	**5.10E+05**	**3.89E+02**	**7.00E+02**
Methanogens (MGN)	**2.00E+03**	**3.05E+02**	**5.87E+02**	**6.62E+01 (J)**

Legend:
NA = Not Analyzed NS = Not Sampled J = Estimated gene copies below PQL but above LQL I = Inhibited
< = Result not detected

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Table 2. Summary of the QuantArray® results obtained for monitoring wells.

Sample Information	PZ-906DR	CPZ-7R	CPZ-8R	MW-705DR
Reductive Dechlorination	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**
Dehalococcoides spp. (DHC)	<2.50E+01	**2.48E+03**	**1.31E+05**	**2.81E+02**
tceA Reductase (TCE)	<2.50E+01	<2.50E+01	<2.50E+01	<2.50E+01
BAV1 Vinyl Chloride Reductase (BVC)	<2.50E+01	**6.29E+02**	**5.88E+04**	**7.38E+01**
Vinyl Chloride Reductase (VCR)	<2.50E+01	**8.50E+00 (J)**	**4.34E+01**	<2.50E+01
Dehalobacter spp. (DHBt)	<2.50E+02	<2.50E+02	**1.76E+02 (J)**	<2.50E+02
Dehalobacter DCM (DCM)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Dehalogenimonas spp. (DHG)	<2.50E+02	**2.43E+03**	**3.68E+04**	<2.50E+02
Desulfitobacterium spp. (DSB)	<2.50E+02	**3.41E+04**	<2.50E+02	<2.50E+02
Dehalobium chlorocoercia (DECO)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Desulfuromonas spp. (DSM)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Chloroform reductase (CFR)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Aerobic (Co)Metabolic				
Soluble Methane Monooxygenase (SMMO)	<2.50E+02	**6.11E+03**	**1.22E+04**	**2.31E+03**
Particulate Methane Monooxygenase	**3.98E+02**	**2.07E+03**	**1.12E+02 (J)**	**1.40E+01 (J)**
Toluene Dioxygenase (TOD)	<2.50E+02	**5.23E+02**	**1.29E+04**	**2.04E+02 (J)**
Phenol Hydroxylase (PHE)	<2.50E+02	**1.79E+02 (J)**	**9.58E+03**	**1.54E+03**
Trichlorobenzene Dioxygenase (TCBO)	<2.50E+02	**3.34E+02**	<2.50E+02	<2.50E+02
Toluene Monooxygenase 2 (RDEG)	<2.50E+02	<2.50E+02	<2.50E+02	**8.04E+02**
Toluene Monooyxgenase (RMO)	<2.50E+02	**1.34E+03**	<2.50E+02	<2.50E+02
Ethene Monooxygenase (EtnC)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Epoxyalkane transferase (EtnE)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Other				
Total Eubacteria (EBAC)	**1.92E+04**	**8.00E+05**	**5.71E+06**	**4.14E+05**
Sulfate Reducing Bacteria (APS)	<2.50E+02	<2.50E+02	**9.44E+03**	<2.50E+02
Methanogens (MGN)	<2.50E+02	**2.79E+01 (J)**	**2.93E+03**	**3.99E+01 (J)**

Legend:
NA = Not Analyzed NS = Not Sampled J = Estimated gene copies below PQL but above LQL I = Inhibited
< = Result not detected

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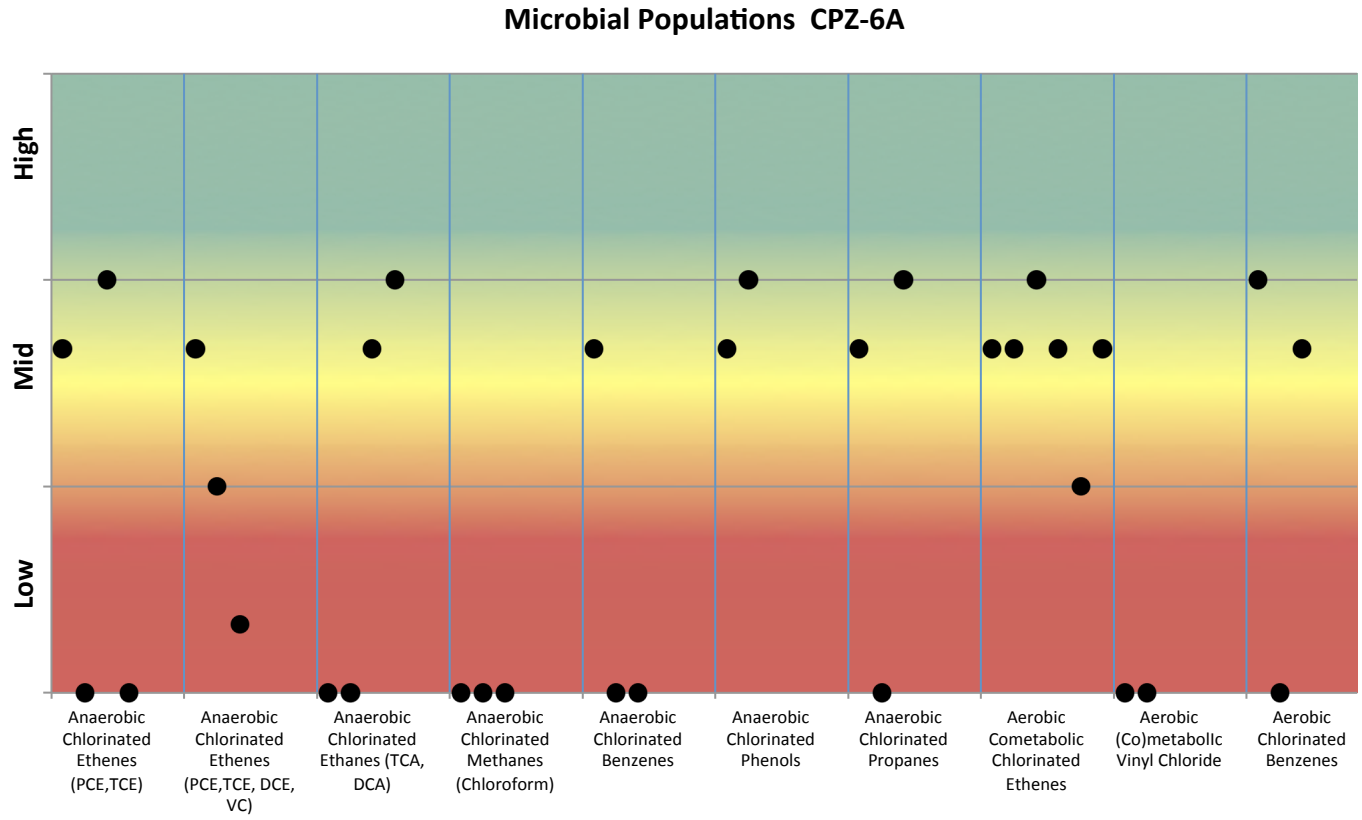
Figure 1. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DECO, DHB[2]		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1] *Desulfitobacterium dichloroeliminans* DCA1. [2] Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene

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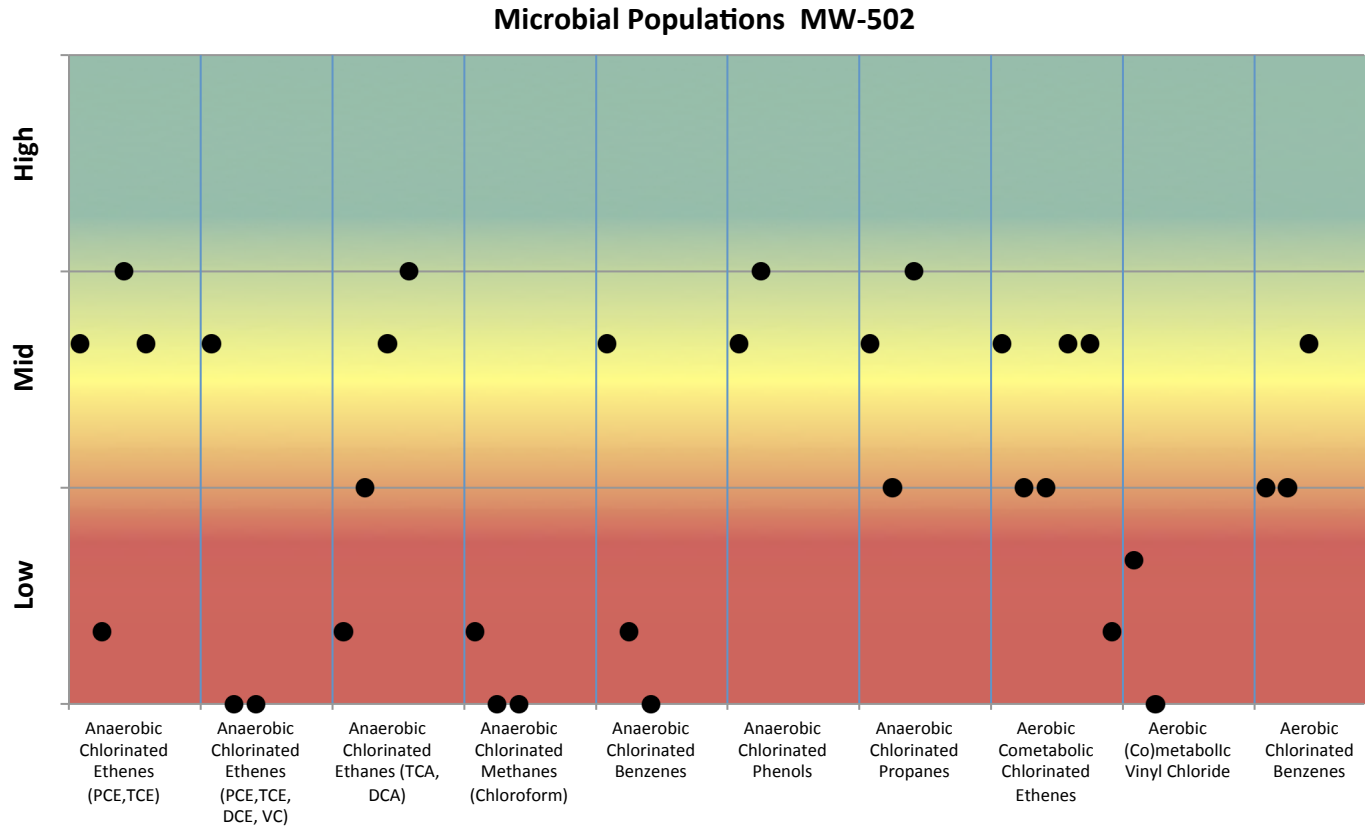
Figure 2. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DECO, DHB[2]		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1] *Desulfitobacterium dichloroeliminans* DCA1. [2] Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene

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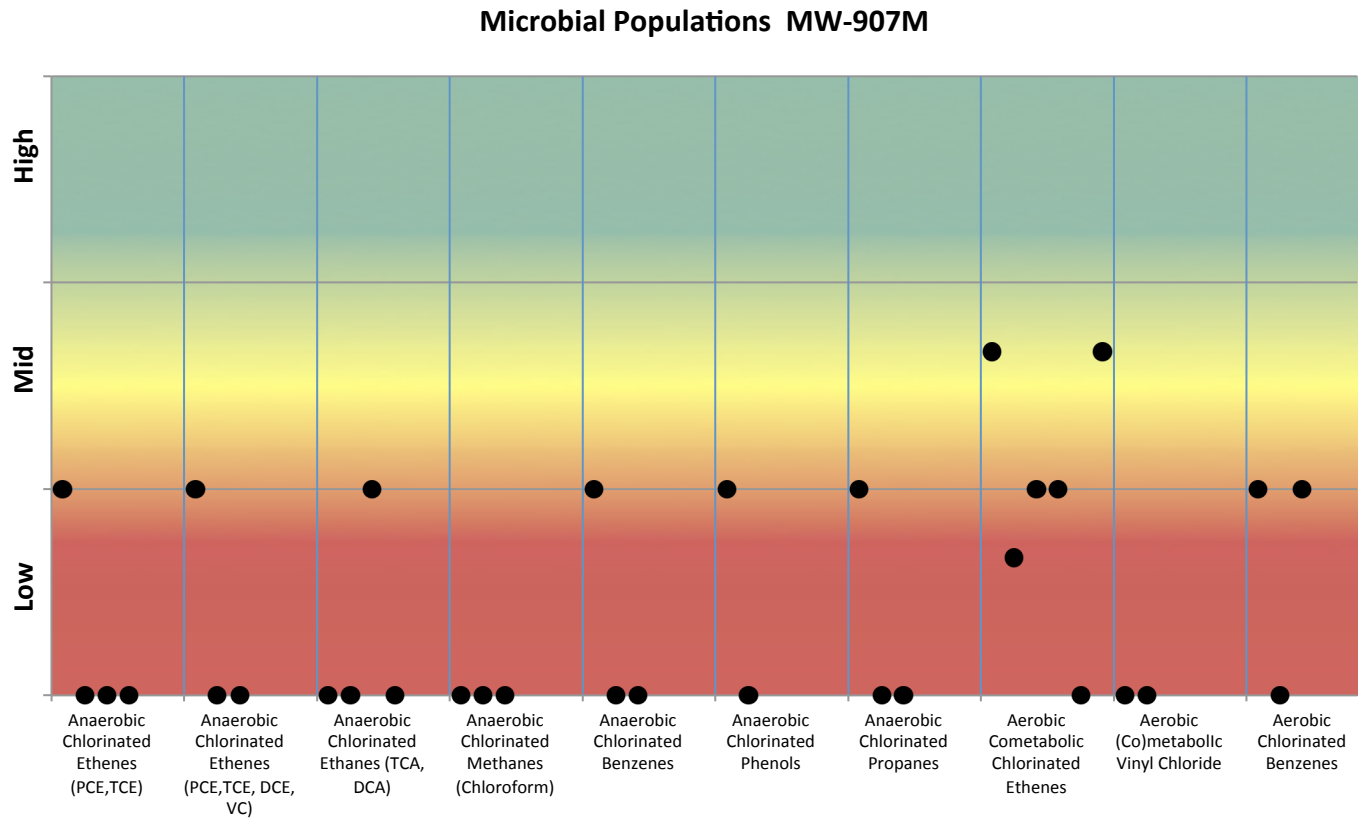
Figure 3. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DECO, DHB[2]		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1] *Desulfitobacterium dichloroeliminans* DCA1. [2] Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene

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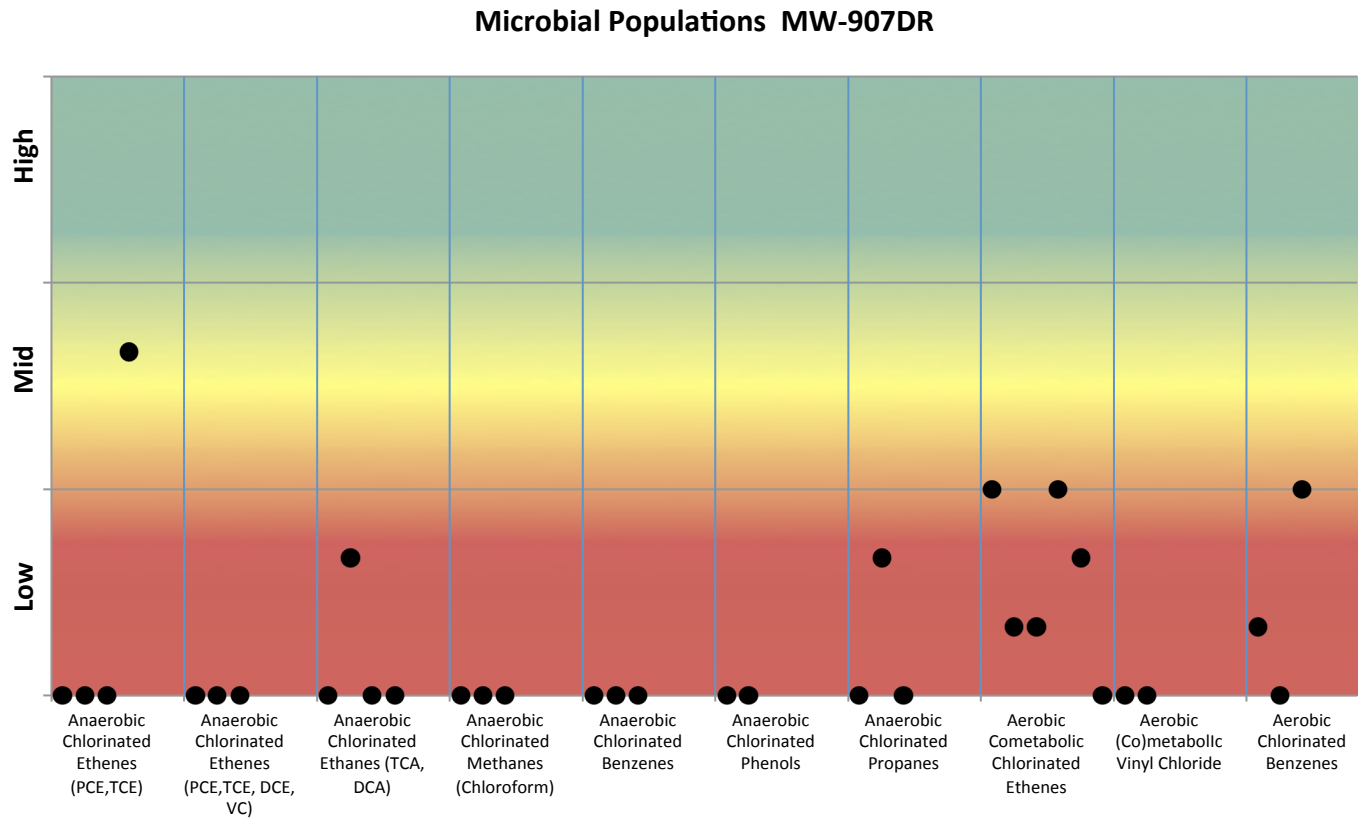
Figure 4. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DECO, DHB[2]		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1] *Desulfitobacterium dichloroeliminans* DCA1. [2] Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene

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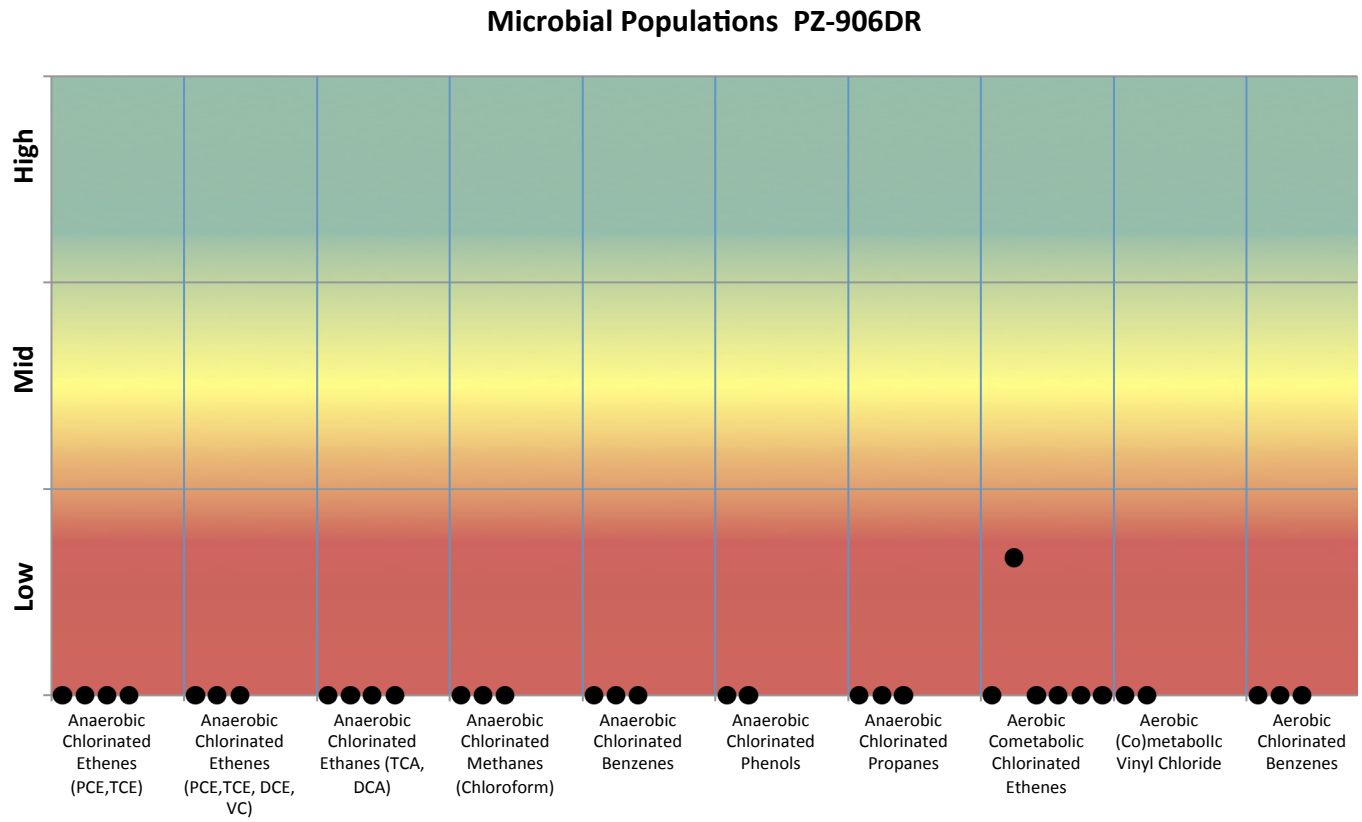
Figure 5. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DECO, DHB[2]		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

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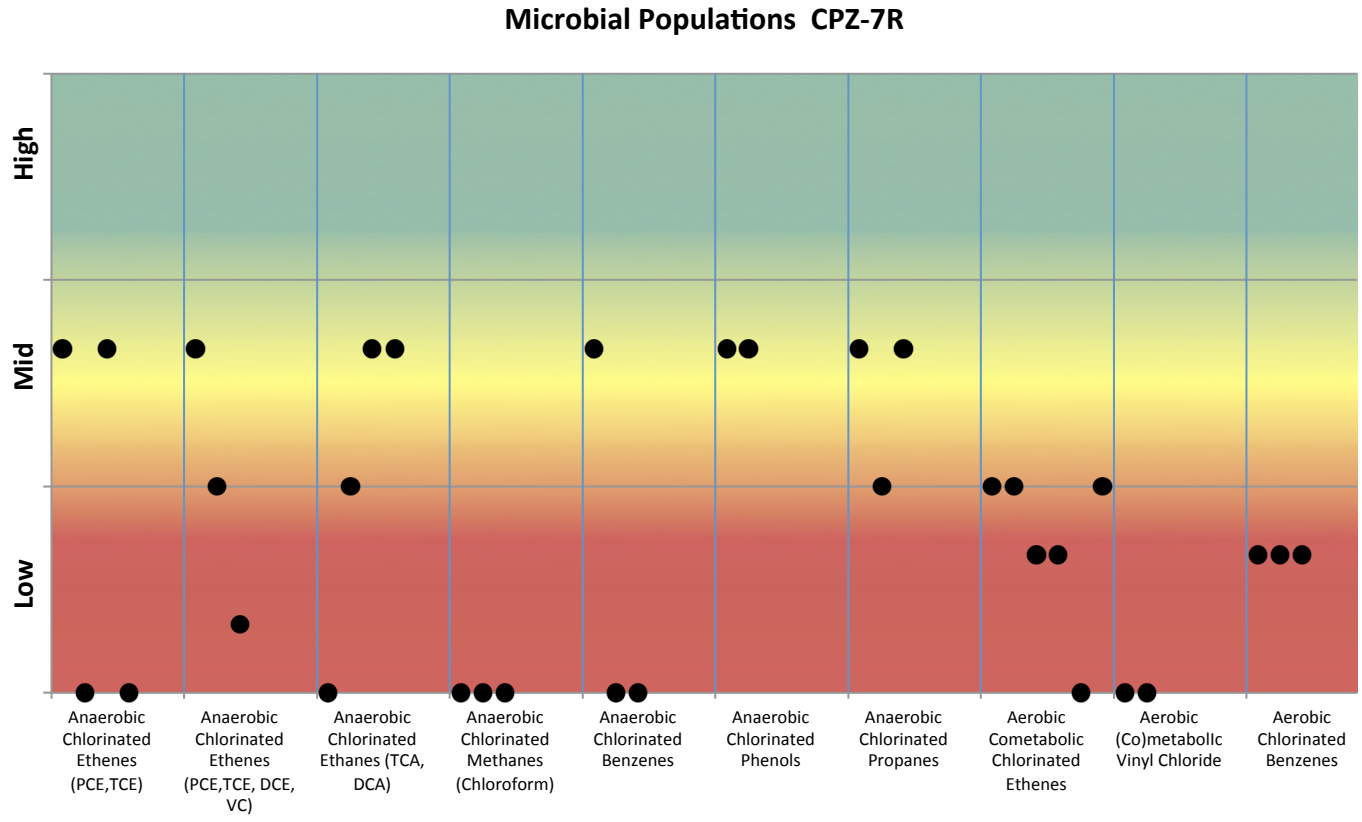

Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DECO, DHB[2]		
Chlorinated Phenols	DHC, DSB		
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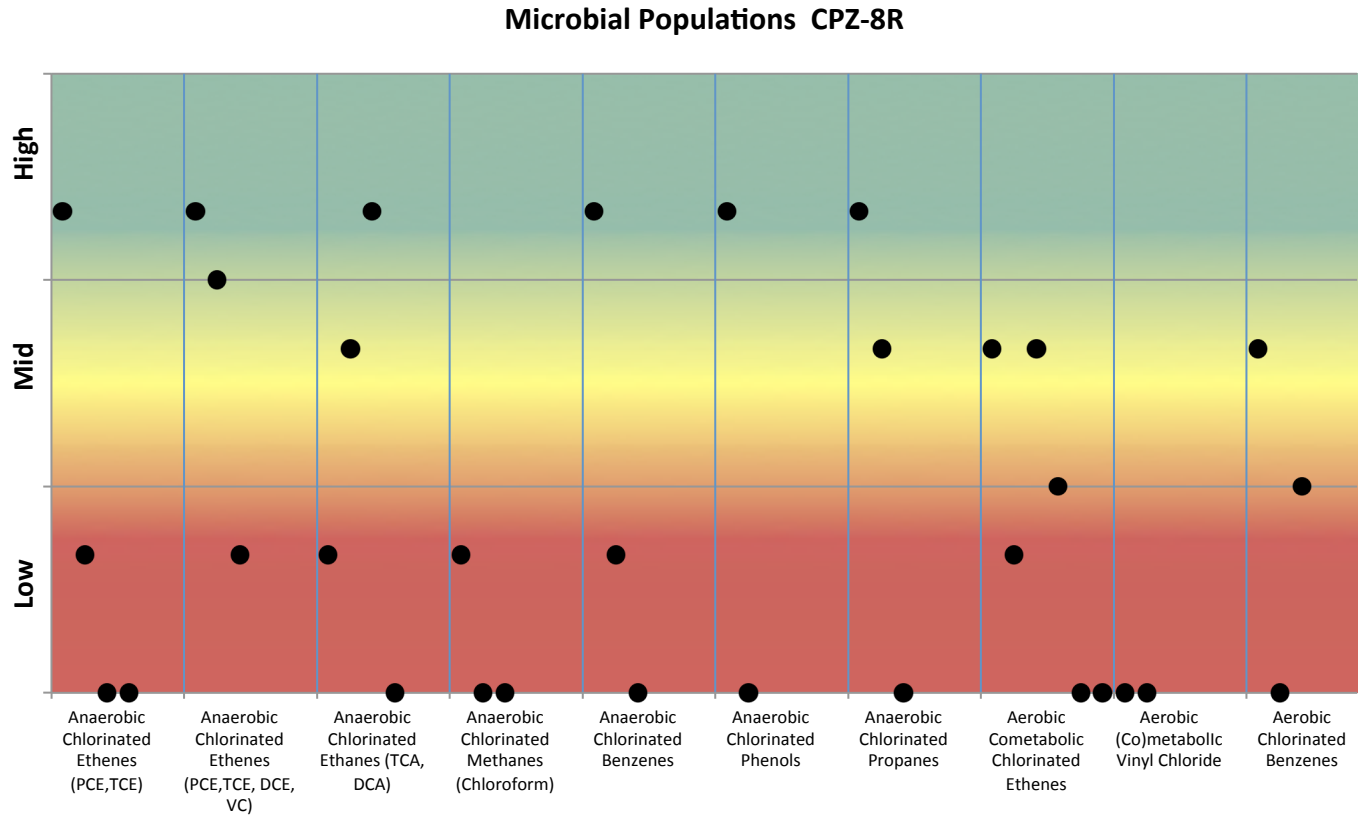

Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DECO, DHB[2]		
Chlorinated Phenols	DHC, DSB		
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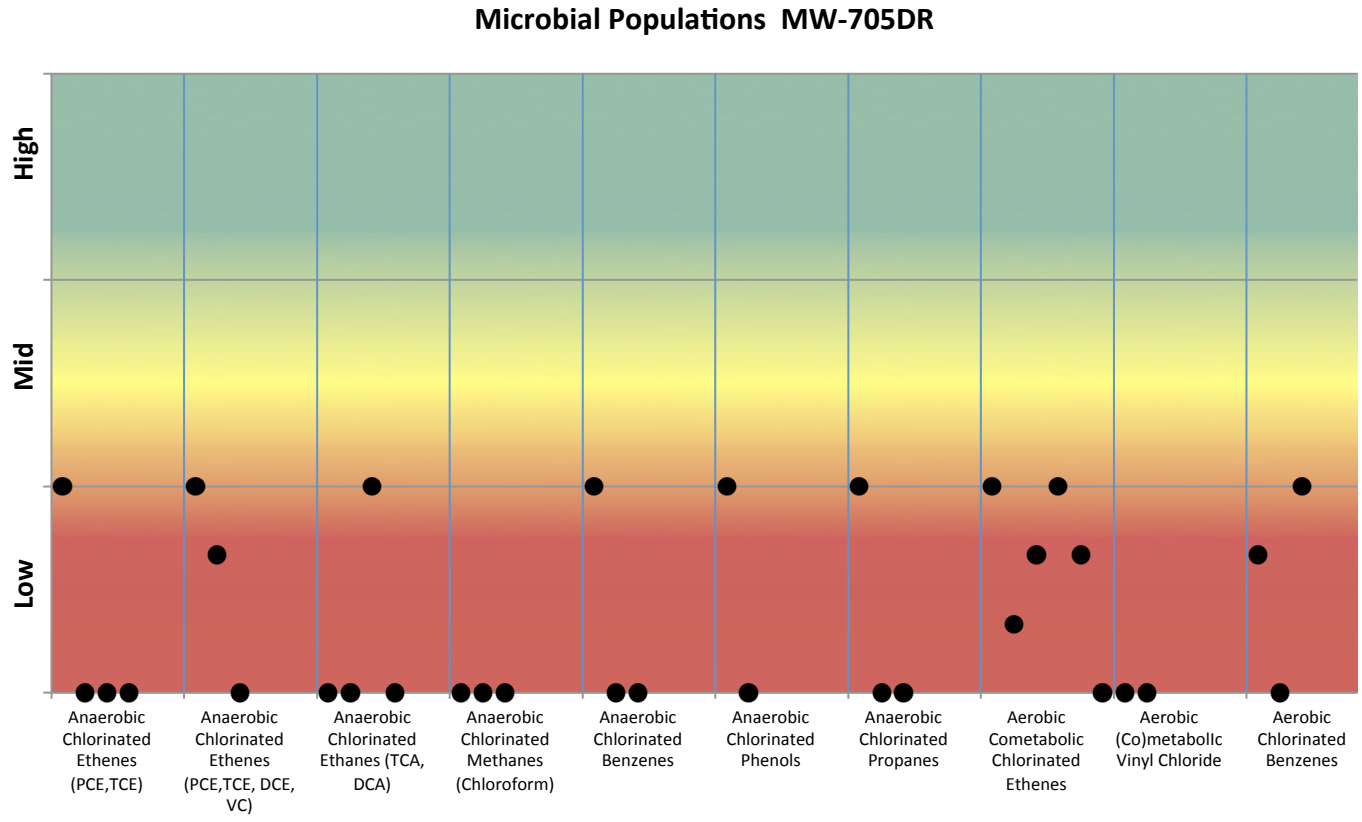
Figure 8. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DECO, DHB[2]		
Chlorinated Phenols	DHC, DSB		
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Table 3. Summary of the QuantArray® results for microorganisms responsible for reductive dechlorination.

Sample Information	CPZ-6A	MW-502	MW-907M	MW-907DR
Reductive Dechlorination	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**
Dehalococcoides spp. (DHC)	**2.50E+03**	**1.20E+03**	**3.72E+02**	<2.50E+01
tceA Reductase (TCE)	**3.80E+01**	<2.50E+01	<2.50E+01	<2.50E+01
BAV1 Vinyl Chloride Reductase (BVC)	**1.33E+02**	<2.50E+01	<2.50E+01	<2.50E+01
Vinyl Chloride Reductase (VCR)	**5.40E+00 (J)**	<2.50E+01	<2.50E+01	<2.50E+01
Dehalobacter spp. (DHBt)	<2.50E+02	**7.50E+01 (J)**	<2.50E+02	<2.50E+02
Dehalobacter DCM (DCM)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Dehalogenimonas spp. (DHG)	<2.50E+02	**4.52E+03**	<2.50E+02	**4.90E+02**
Desulfitobacterium spp. (DSB)	**3.18E+05**	**6.26E+05**	<2.50E+02	<2.50E+02
Dehalobium chlorocoercia (DECO)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Desulfuromonas spp. (DSM)	<2.50E+02	**4.62E+03**	<2.50E+02	**1.74E+03**
Chloroform reductase (CFR)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02

Figure 9. Comparison - Microbial populations involved in reductive dechlorination

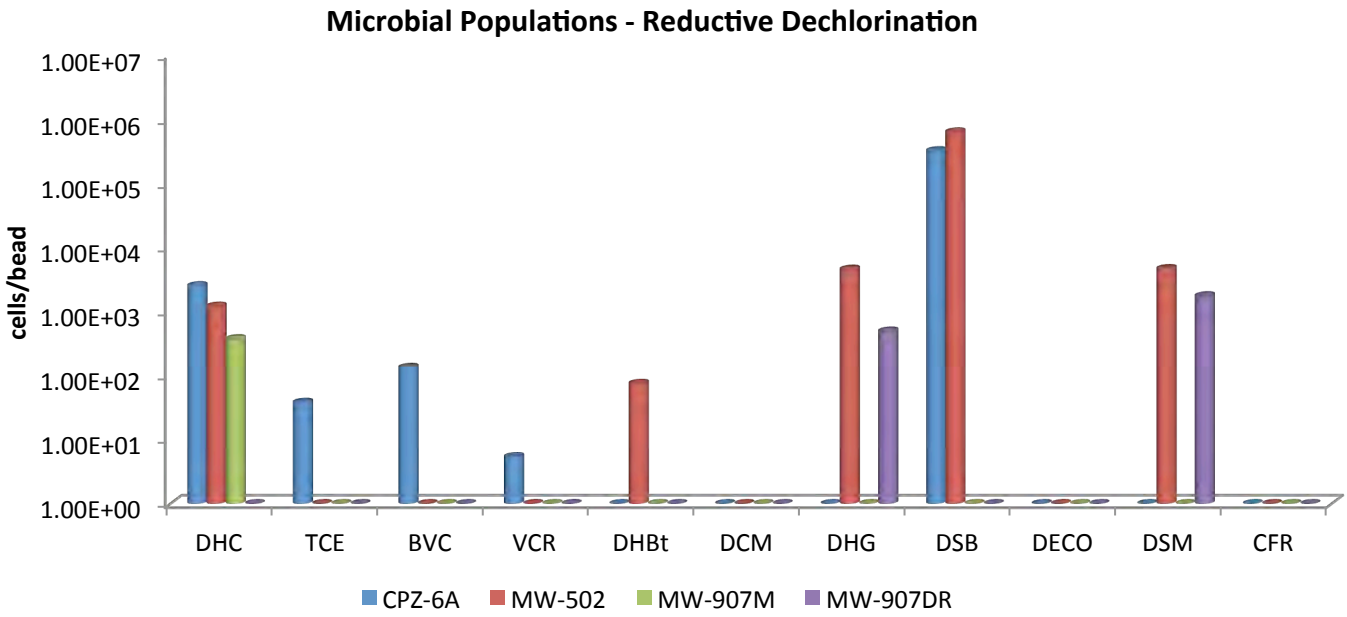

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Table 4. Summary of the QuantArray® results for microorganisms responsible for reductive dechlorination.

Sample Information	PZ-906DR	CPZ-7R	CPZ-8R	MW-705DR
Reductive Dechlorination	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**	**(cells/bead)**
Dehalococcoides spp. (DHC)	<2.50E+01	**2.48E+03**	**1.31E+05**	**2.81E+02**
tceA Reductase (TCE)	<2.50E+01	<2.50E+01	<2.50E+01	<2.50E+01
BAV1 Vinyl Chloride Reductase (BVC)	<2.50E+01	**6.29E+02**	**5.88E+04**	**7.38E+01**
Vinyl Chloride Reductase (VCR)	<2.50E+01	**8.50E+00 (J)**	**4.34E+01**	<2.50E+01
Dehalobacter spp. (DHBt)	<2.50E+02	<2.50E+02	**1.76E+02 (J)**	<2.50E+02
Dehalobacter DCM (DCM)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Dehalogenimonas spp. (DHG)	<2.50E+02	**2.43E+03**	**3.68E+04**	<2.50E+02
Desulfitobacterium spp. (DSB)	<2.50E+02	**3.41E+04**	<2.50E+02	<2.50E+02
Dehalobium chlorocoercia (DECO)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Desulfuromonas spp. (DSM)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Chloroform reductase (CFR)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02

Figure 10. Comparison - Microbial populations involved in reductive dechlorination

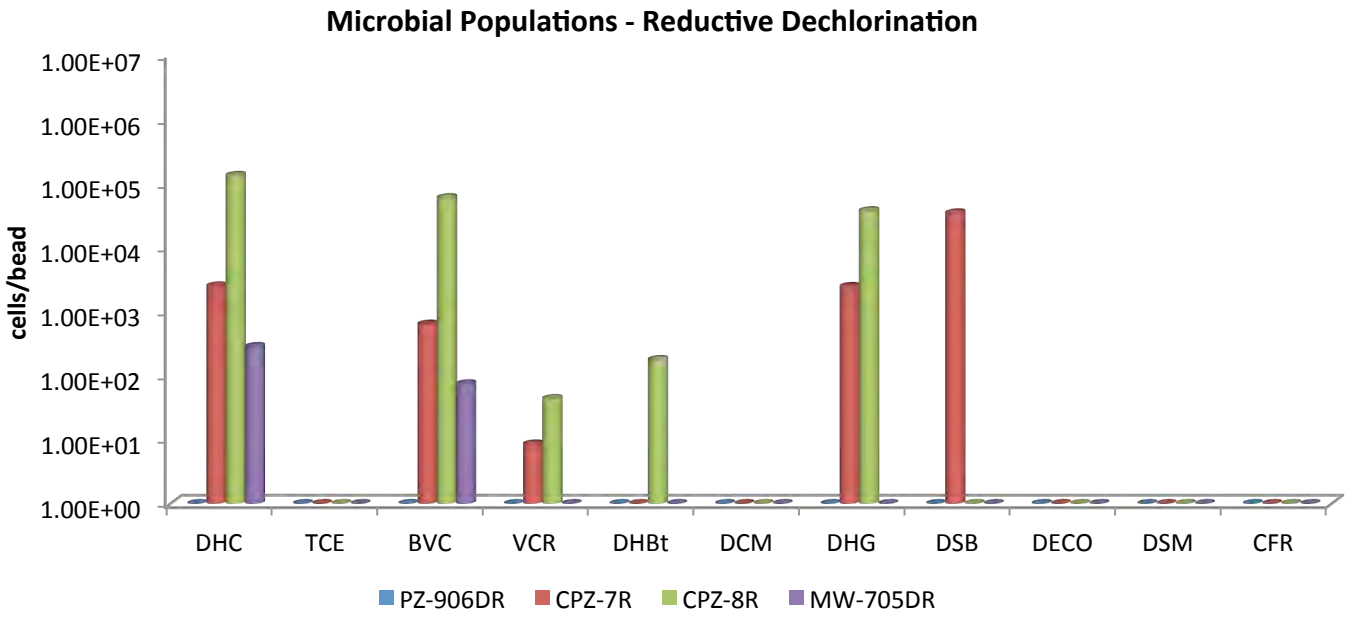

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Table 5. Summary of the QuantArray® results for microorganisms responsible for aerobic (Co)metabolism.

Sample Information	CPZ-6A	MW-502	MW-907M	MW-907DR
Aerobic (Co)Metabolic	(cells/bead)	(cells/bead)	(cells/bead)	(cells/bead)
Soluble Methane Monooxygenase (SMMO)	**2.28E+04**	**4.53E+04**	**5.49E+04**	**2.67E+03**
Particulate Methane Monooxygenase	**1.58E+04**	**5.22E+03**	**5.29E+02**	**4.82E+01 (J)**
Toluene Dioxygenase (TOD)	**2.47E+05**	**9.09E+03**	**2.75E+03**	**3.43E+01 (J)**
Phenol Hydroxylase (PHE)	**2.22E+04**	**4.53E+04**	**7.45E+03**	**3.49E+03**
Trichlorobenzene Dioxygenase (TCBO)	<2.50E+02	**3.37E+03**	<2.50E+02	<2.50E+02
Toluene Monooxygenase 2 (RDEG)	**7.18E+03**	**3.11E+04**	<2.50E+02	**5.39E+02**
Toluene Monooyxgenase (RMO)	**4.09E+04**	**1.68E+01 (J)**	**1.18E+04**	<2.50E+02
Ethene Monooxygenase (EtnC)	<2.50E+02	**1.80E+02 (J)**	<2.50E+02	<2.50E+02
Epoxyalkane transferase (EtnE)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02

Figure 11. Comparison - Microbial populations involved in aerobic (Co)metabolism.

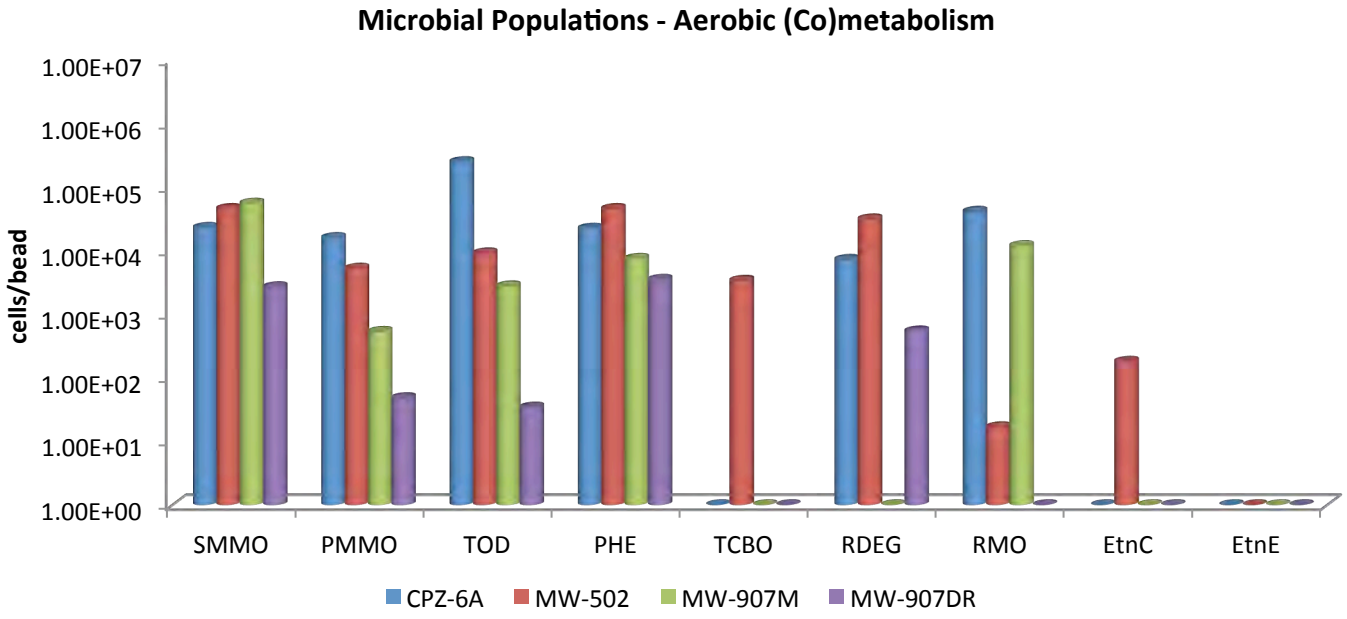

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Table 6. Summary of the QuantArray® results for microorganisms responsible for aerobic (Co)metabolism.

Sample Information	PZ-906DR	CPZ-7R	CPZ-8R	MW-705DR
Aerobic (Co)Metabolic	(cells/bead)	(cells/bead)	(cells/bead)	(cells/bead)
Soluble Methane Monooxygenase (SMMO)	<2.50E+02	**6.11E+03**	**1.22E+04**	**2.31E+03**
Particulate Methane Monooxygenase	**3.98E+02**	**2.07E+03**	**1.12E+02 (J)**	**1.40E+01 (J)**
Toluene Dioxygenase (TOD)	<2.50E+02	**5.23E+02**	**1.29E+04**	**2.04E+02 (J)**
Phenol Hydroxylase (PHE)	<2.50E+02	**1.79E+02 (J)**	**9.58E+03**	**1.54E+03**
Trichlorobenzene Dioxygenase (TCBO)	<2.50E+02	**3.34E+02**	<2.50E+02	<2.50E+02
Toluene Monooxygenase 2 (RDEG)	<2.50E+02	<2.50E+02	<2.50E+02	**8.04E+02**
Toluene Monooyxgenase (RMO)	<2.50E+02	**1.34E+03**	<2.50E+02	<2.50E+02
Ethene Monooxygenase (EtnC)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02
Epoxyalkane transferase (EtnE)	<2.50E+02	<2.50E+02	<2.50E+02	<2.50E+02

Figure 12. Comparison - Microbial populations involved in aerobic (Co)metabolism.

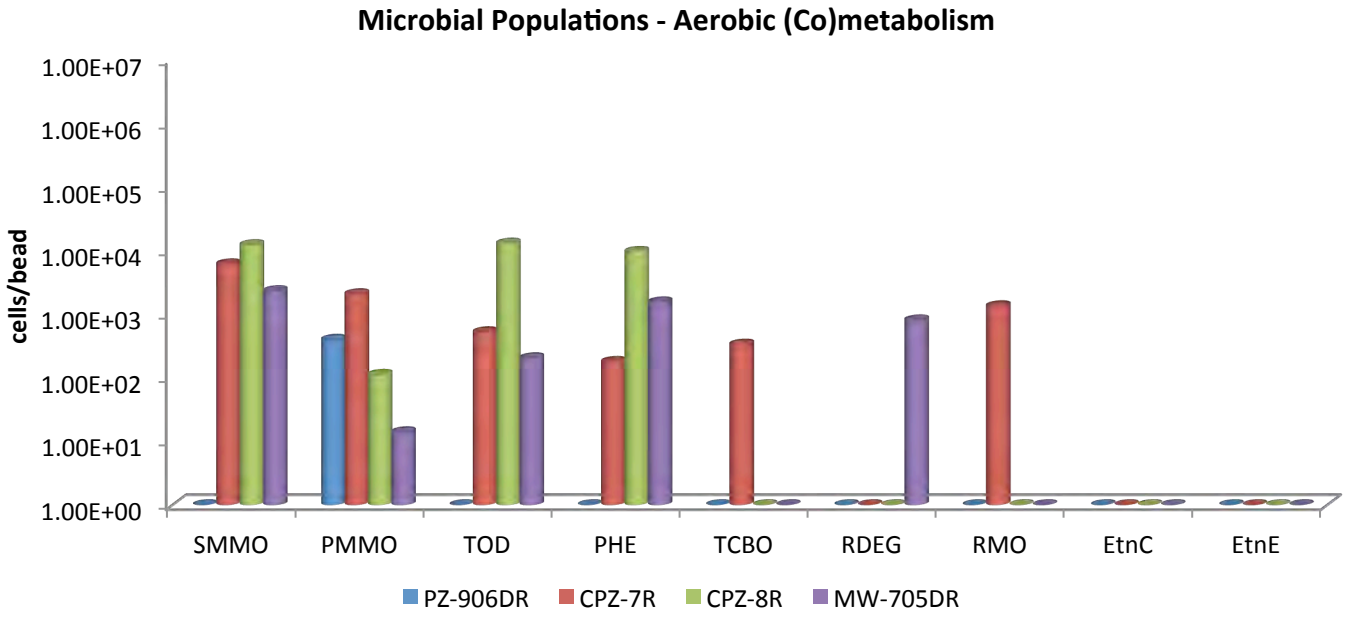

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Table 7. Summary of the QuantArray® results for total bacteria and other populations.

Sample Information	CPZ-6A	MW-502	MW-907M	MW-907DR
Other	(cells/bead)	(cells/bead)	(cells/bead)	(cells/bead)
Total Eubacteria (EBAC)	**2.67E+06**	**1.54E+06**	**1.58E+06**	**6.14E+05**
Sulfate Reducing Bacteria (APS)	**8.71E+05**	**5.10E+05**	**3.89E+02**	**7.00E+02**
Methanogens (MGN)	**2.00E+03**	**3.05E+02**	**5.87E+02**	**6.62E+01 (J)**

Figure 13. Comparison - Microbial populations

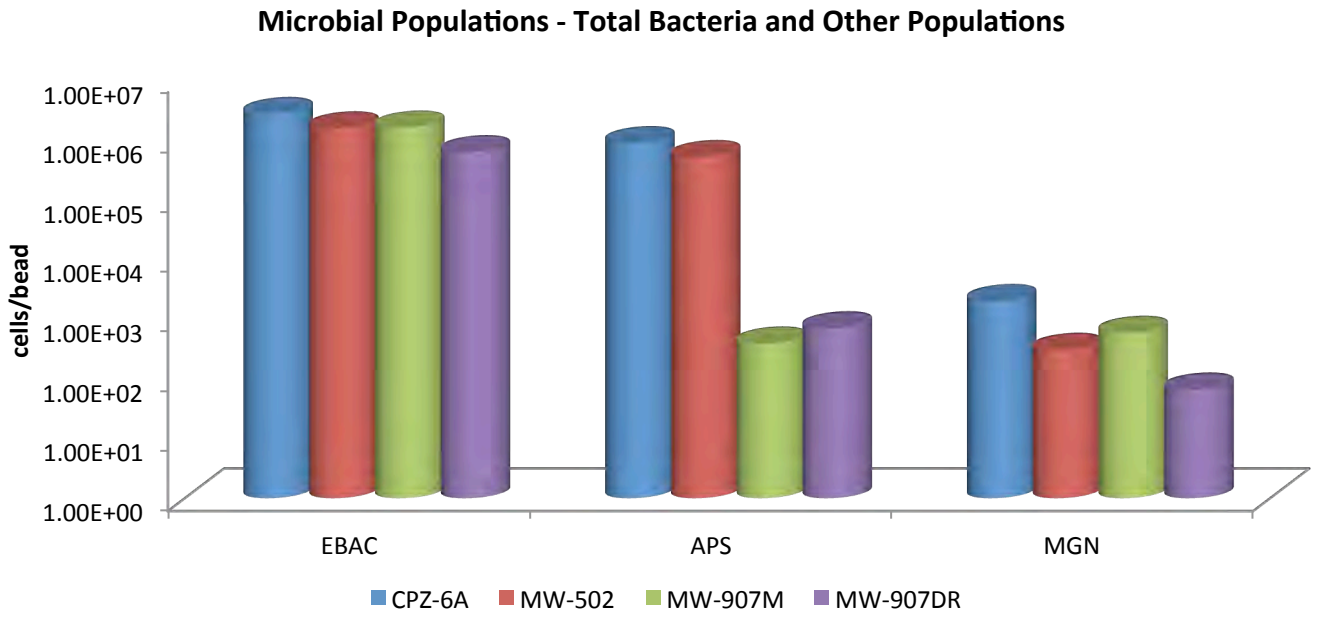

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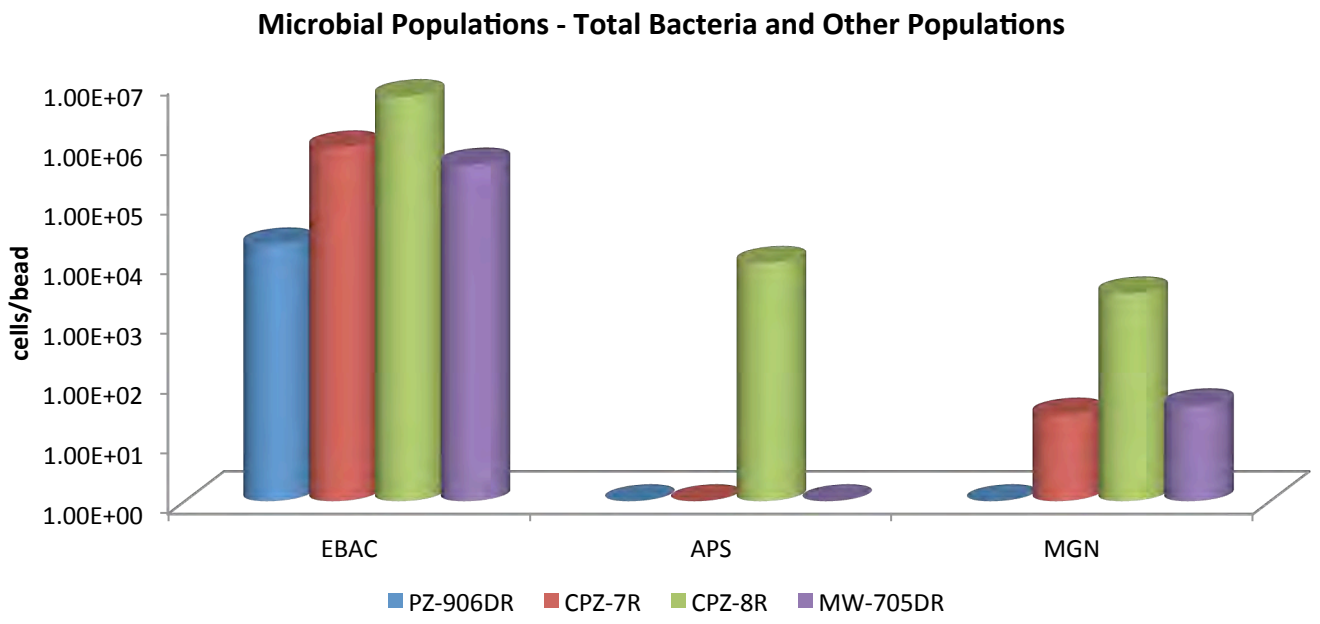
Table 8. Summary of the QuantArray® results for total bacteria and other populations.

Sample Information	PZ-906DR	CPZ-7R	CPZ-8R	MW-705DR
Other	(cells/bead)	(cells/bead)	(cells/bead)	(cells/bead)
Total Eubacteria (EBAC)	**1.92E+04**	**8.00E+05**	**5.71E+06**	**4.14E+05**
Sulfate Reducing Bacteria (APS)	<2.50E+02	<2.50E+02	**9.44E+03**	<2.50E+02
Methanogens (MGN)	<2.50E+02	**2.79E+01 (J)**	**2.93E+03**	**3.99E+01 (J)**

Figure 14. Comparison - Microbial populations



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Interpretation

The overall purpose of the Chlorinated QuantArray® is to give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co)metabolic pathways to give a much more clear and comprehensive view of contaminant biodegradation. The following discussion describes interpretation of results in general terms and is meant to serve as a guide.

Reductive Dechlorination – Chlorinated Ethenes: While a number of bacterial cultures including *Dehalococcoides*, *Dehalobacter*, *Desulfitobacterium*, and *Desulfuromonas* spp. capable of utilizing PCE and TCE as growth supporting electron acceptors have been isolated [1-5], *Dehalococcoides* spp. may be the most important because they are the only bacterial group that has been isolated to date which is capable of complete reductive dechlorination of PCE to ethene [6]. In fact, the presence of *Dehalococcoides* spp. has been associated with complete reductive dechlorination to ethene at sites across North America and Europe [7]. More recently, Lu et al. [8] have proposed using a *Dehalococcoides* concentration of 1×10^4 cells/mL as a screening criterion to identify sites where biological reductive dechlorination will proceed at "generally useful" rates.

A "stall" where daughter products *cis*-DCE and vinyl chloride accumulate can occur at PCE- and TCE-impacted sites especially under MNA conditions. The accumulation of vinyl chloride, generally considered more carcinogenic than the parent compounds, is particularly problematic. Although elevated *Dehalococcoides* concentrations correspond to ethene production in numerous studies, the range of chlorinated ethenes metabolized and cometabolized varies by species and strains within the *Dehalococcoides* genus. For example, *Dehalococcoides ethenogenes* str. 195 metabolizes PCE, TCE, and *cis*-DCE and cometabolizes vinyl chloride [6] to produce ethene. Conversely, *Dehalococcoides* sp. CBDB1 utilizes PCE and TCE but does not cometabolize additional chloroethenes [9]. Quantification of reductive dehalogenase genes is used to more definitively confirm the potential for reductive dechlorination of TCE, cis-DCE, and vinyl chloride [10-13].

Reductive Dechlorination – Chlorinated Ethanes: Under anaerobic conditions, chlorinated ethanes are susceptible to reductive dechlorination by several groups of halorespiring bacteria including *Dehalobacter*, *Dehalogenimonas*, and *Dehalococcoides* spp. While the reported range of chlorinated ethanes utilized varies by genus, species, and sometimes at the strain level, several general observations can be made regarding biodegradation pathways and daughter product formation. *Dehalobacter* spp. have been isolated that are capable of sequential reductive dechlorination of 1,1,1-TCA through 1,1-DCA to chloroethane. Biodegradation of 1,1,2-TCA by several halorespiring bacteria including *Dehalobacter* and *Dehalogenimonas* spp. proceeds via dichloroelimination producing vinyl chloride. Similarly, 1,2-DCA biodegradation by *Dehalobacter*, *Dehalogenimonas*, and *Dehalococcoides* spp occurs via dichloroelimination producing ethene. While not utilized by many *Desulfitobacterium* isolates, at least one strain, *Desulfitobacterium dichloroeliminans* strain DCA1, is also capable of dichloroelimination of 1,2-DCA [14].

Reductive Dechlorination – Chlorinated Methanes: Chloroform is a common co-contaminant at chlorinated solvent sites and can inhibit reductive dechlorination of chlorinated ethenes. Grostern et al demonstrated that a *Dehalobacter* population was capable of reductive dechlorination of chloroform to produce dichloromethane [15]. The *cfrA* gene encodes the reductase which catalyzes this initial step in chloroform biodegradation [16]. Justicia-Leon et al have since shown that dichloromethane can support growth of a distinct group of *Dehalobacter* strains via fermentation [17]. The *Dehalobacter* DCM assays targets the 16S rRNA gene of these strains.

Reductive Dechlorination – Chlorinated Benzenes: Chlorinated benzenes are an important class of industrial solvents and chemical intermediates in the productions of drugs, dyes, herbicides, and insecticides. The physical-chemical properties of chlorinated benzenes as well as susceptibility to biodegradation are functions of their degree of chlorination and the positions of

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chlorine substituents. Under anaerobic conditions, reductive dechlorination of higher chlorinated benzenes including hexachlorobenzene (HCB), pentachlorobenzene (PeCB), tetrachlorobenzene (TeCB) isomers, and trichlorobenzene (TCB) isomers by halorespiring bacteria has been well documented [18]. For example, although biodegradation of individual compounds and specific isomers does vary somewhat between isolates, *Dehalococcoides* spp. such as strain CBDB1 have been identified which reductively dechlorinate HCB, PeCB, all three TeCB isomers, 1,2,3-TCB, and 1,2,4-TCB [9, 19]. *Dehalobium chlorocoercia* DF-1 has been shown to be capable of reductive dechlorination of HCB, PeCB, and 1,2,3,5-TeCB [20]. The dichlorobenzene (DCB) isomers and chlorobenzene (CB) were considered relatively recalcitrant under anaerobic conditions. However, new evidence has demonstrated reductive dechlorination of DCBs to CB and CB to benzene [21] with corresponding increases in concentrations of *Dehalobacter* spp. [22].

Reductive Dechlorination – Chlorinated Phenols: Pentachlorophenol (PCP) was one of the most widely used biocides in the US and despite residential use restrictions is still extensively used industrially as a wood preservative. Along with PCP, the tetrachloropenol and trichlorophenol isomers were also used as fungicides in wood preserving formulations. 2,4-dichlorophenol and 2,4,5-TCP were used as chemical intermediates in herbicide production (e.g. 2,4-D) and chlorophenols are known byproducts of chlorine bleaching in the pulp and paper industry. While the range of compounds utilized varies by strain, some *Dehalococcoides* isolates are capable of reductive dechlorination of PCP and other chlorinated phenols. For example, *Dehalococcoides* strain CBDB1 is capable of utilizing pentachlorophenol (PCP), all three tetrachlorphenol (TeCP) congeners, all six trichlorophenol (TCP) congeners, and 2,3-dichlorophenol (2,3-DCP). PCP dechlorination by strain CBDB1 produces a mixture of 3,5-DCP, 3,4-DCP, 2,4-DCP, 3-CP, and 4-CP [23]. In the same study however, *Dehalococcoides ethenogenes* strain 195 dechlorinated a more narrow spectrum of chlorophenols which included 2,3-DCP, 2,3,4-TCP, and 2,3,6-TCP but no other TCPs or PCP. Similar to *Dehalococcoccoides*, some species and strains of *Desulfitobacterium* are capable of utilizing PCP and other chlorinated phenols. *Desulfitobacterium hagniense* PCP-1 is capable of reductive dechlorination of PCP to 3-CP [24]. However, the ability to biodegrade PCP is not universal among *Desulfitobacterium* isolates. *Desulfitobacterium* sp. strain PCE1 and *D. chlororespirans* strain Co23 for example can utilize some TCP and DCP isomers but not PCP for growth [2, 25].

Reductive Dechlorination – Chlorinated Propanes: *Dehalogenimonas* is a recently described bacterial genus of the phylum *Chloroflexi* which also includes the well-known chloroethene-respiring *Dehalococcoides* spp [26]. The *Dehalogenimonas* isolates characterized to date are also halorespiring bacteria but utilize a rather unique range of chlorinated compounds as electron acceptors including chlorinated propanes (1,2,3-TCP and 1,2-DCP) and a variety of other vicinally chlorinated alkanes including 1,1,2,2-tetrachlorethane, 1,1,2-trichloroethane, and 1,2-dichloroethane [26].

Aerobic – Chlorinated Ethene Cometabolism: Under aerobic conditions, several different types of bacteria including methane-oxidizing bacteria (methanotrophs), ammonia-oxidizing bacteria, and some toluene/phenol-utilizing bacteria can cometabolize or co-oxidize trichloroethene (TCE), dichlorethene (DCE), and vinyl chloride (VC). In general, cometabolism of chlorinated ethenes is mediated by monooxygenase enzymes with "relaxed" specificity that oxidize a primary (growth supporting) substrate and co-oxidize the chlorinated compound. Most methanotrophs are only capable of producing particulate methane monooxygenase (pMMO) which is capable of aerobic cometabolism but often at lower rates. Other methanotrophs are capable of producing both pMMO and soluble methane monooxygenase (sMMO) enzymes, which in general are believed to capable of greater rates of aerobic cometabolism.

Aerobic – Vinyl Chloride Cometabolism: Beginning in the early 1990s, numerous microcosm studies demonstrated aerobic oxidation of vinyl chloride under MNA conditions without the addition of exogenous primary substrates. Since then, strains of *Mycobacterium*, *Nocardioides*, *Pseudomonas*, *Ochrobactrum*, and *Ralstonia* species have been isolated which are capable of aerobic growth on both ethene and vinyl chloride (see Mattes et al., [27] for review). The initials steps in the pathway are the monooxygenase (*etn*ABCD) catalyzed conversion of ethene and vinyl chloride to their respective epoxyalkanes (epoxyethane and chlorooxirane) followed by epoxyalkane:CoM transferase (*etn*E) mediated conjugation and breaking of the epoxide [28].

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Aerobic – Chlorinated Benzenes: In general, chlorobenzenes with four or less chlorine groups are susceptible to aerobic biodegradation even serving as growth supporting substrates. Toluene dioxygenase (TOD) has relatively relaxed substrate specificity and mediates the incorporation of both atoms of oxygen into the aromatic ring of benzene and substituted benzenes (toluene and chlorobenzene). Comparison of TOD levels in background and source zone samples from a CB impacted site suggested that CBs promoted growth of TOD containing bacteria [29]. In addition, aerobic biodegradation of some trichlorobenzene and even tetrachlorobenzene isomers is initiated by a group of related trichlorobenzene dioxygenase genes (TCBO). Finally, phenol hydroxylases catalyze the continued oxidation and in some cases the initial oxidation of a variety of monoaromatic compounds. In an independent study, significant increases in numbers of bacteria containing PHE genes corresponded to increases in biodegradation of DCB isomers [29].

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SITE LOGIC Report

QuantArray® (Chlor) Study

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MI Identifier: 100LF
Report Date: 7/3/2014

Project: SRSNE, B0054634.0000
Comments:

The QuantArray® Approach

Quantification of *Dehalococcoides* spp., the only known bacterial group capable of complete reductive dechlorination of PCE and TCE to ethene, has become an indispensable component of assessment, remedy selection, and performance monitoring a sites impacted by chlorinated solvents. While undeniably a key group of halorespiring bacteria, *Dehalococcoides* spp. are not the only bacteria of interest in the subsurface, reductive dechlorination is not the only potential biodegradation pathway, and chlorinated ethenes are not always the primary contaminants of concern. The Chlorinated QuantArray® not only includes a variety of halorespiring bacteria (*Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, etc.) to assess the potential for reductive dechlorination of chloroethenes, chloroethanes, chlorobenzenes, chlorophenols, and chloroform but also provides quantification of functional genes involved in aerobic (co)metabolic pathways for biodegradation of chlorinated solvents and even competing biological processes. Thus, the QuantArray® will give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co)metabolic pathways to give a much more clear and comprehensive view of contaminant biodegradation.

The Chlorinated QuantArray® is used to quantify specific microorganisms and functional genes to evaluate the following:

Anaerobic Reductive Dechlorination	•Quantification of important halorespiring bacteria (e.g. *Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, *Desulfitobacterium* spp.) and key functional genes (e.g vinyl chloride reductases, TCE reductase, 1,2-DCP reductase) responsible for reductive dechlorination of a broad spectrum of chlorinated solvents.
Aerobic Cometabolism	•Several different types of bacteria including methanotrophs and some toluene/phenol utilizing bacteria can co-oxidize TCE, DCE, and vinyl chloride. The Chlorinated QuantArray® quantifies functional genes like soluble methane monooxygenase encoding enzymes capable of co-oxidation of chlorinated ethenes.
Aerobic (Co)metabolism of Vinyl chloride	•Ethene oxidizing bacteria are capable of cometabolism of vinyl chloride. In some cases, ethenotrophs can also utilize vinyl chloride as a growth supporting substrate. The QuantArray® targets key functional genes in ethene metabolism.

How do QuantArrays® work?

The QuantArray® in many respects is a hybrid technology combining the highly parallel detection of microarrays with the accurate and precise quantification provided by qPCR into a single platform. The key to highly parallel qPCR reactions is the nanoliter fluidics platform for low volume, solution phase qPCR reactions.

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How are QuantArray® results reported?

One of the primary advantages of the Chlorinated QuantArray® is the simultaneous quantification of a broad spectrum of different microorganisms and key functional genes involved in a variety of pathways for chlorinated hydrocarbon biodegradation. However, highly parallel quantification combined with the various metabolic and cometabolic capabilities of different target organisms can complicate data presentation. Therefore, in addition to Summary Tables, QuantArray® results will be presented as Microbial Population Summary and Comparison Figures to aid in data interpretation and subsequent evaluation of site management activities.

Types of Tables and Figures:

Microbial Population Summary	•Figure presenting the concentrations of QuantArray® target populations (e.g. *Dehalococcoides* spp.) and functional genes (e.g. vinyl chloride reductase) relative to typically observed values.
Summary Tables	• Tables of target population concentrations grouped by biodegradation pathway and contaminant type.
Comparison Figures	•Depending on the project, sample results can be presented to compare changes over time or examine differences in microbial populations for along a transect of the dissolved plume.

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Results

Table 1. Summary of the QuantArray® results obtained for monitoring wells.

Sample Information	ISTR-1
Reductive Dechlorination	**(cells/bead)**
Dehalococcoides spp. (DHC)	**4.15E+02**
tceA Reductase (TCE)	**4.39E+01**
BAV1 Vinyl Chloride Reductase (BVC)	**2.75E+02**
Vinyl Chloride Reductase (VCR)	**1.15E+01 (J)**
Dehalobacter spp. (DHBt)	**5.64E+02**
Dehalobacter DCM (DCM)	<2.50E+02
Dehalogenimonas spp. (DHG)	<2.50E+02
Desulfitobacterium spp. (DSB)	<2.50E+02
Dehalobium chlorocoercia (DECO)	<2.50E+02
Desulfuromonas spp. (DSM)	<2.50E+02
Chloroform reductase (CFR)	<2.50E+02
Aerobic (Co)Metabolic	
Soluble Methane Monooxygenase (SMMO)	**7.15E+02**
Particulate Methane Monooxygenase	<2.50E+02
Toluene Dioxygenase (TOD)	<2.50E+02
Phenol Hydroxylase (PHE)	<2.50E+02
Trichlorobenzene Dioxygenase (TCBO)	<2.50E+02
Toluene Monooxygenase 2 (RDEG)	<2.50E+02
Toluene Monooyxgenase (RMO)	<2.50E+02
Ethene Monooxygenase (EtnC)	<2.50E+02
Epoxyalkane transferase (EtnE)	<2.50E+02
Other	
Total Eubacteria (EBAC)	**3.79E+05**
Sulfate Reducing Bacteria (APS)	<2.50E+02
Methanogens (MGN)	<2.50E+02

Legend:
NA = Not Analyzed NS = Not Sampled J = Estimated gene copies below PQL but above LQL I = Inhibited
< = Result not detected

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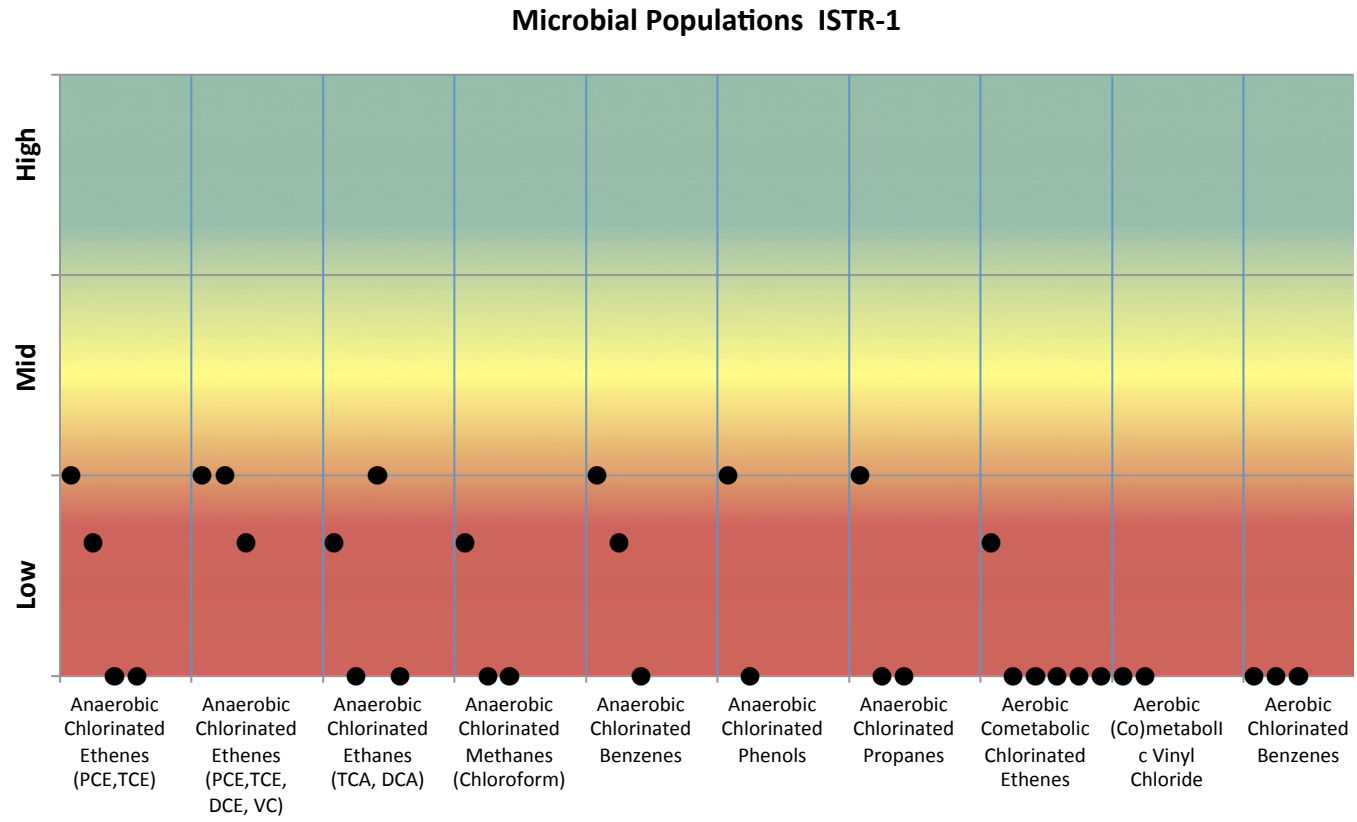
Figure 1. Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.



Anaerobic – Reductive Dechlorination or Dichloroelimination		Aerobic – (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHB, DSB, DSM	Chlorinated ethenes (TCE, DCE, VC)	sMMO, pMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic vinyl chloride	etnC, etnE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHB, DHG, DHC, DSB[1]	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Methanes (Chloroform)	DHB, DCM, CFR		
Chlorinated Benzenes	DHC, DHB[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1] *Desulfitobacterium dichloroeliminans* DCA1. [2] Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene

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Table 2. Summary of the QuantArray® results for microorganisms responsible for reductive dechlorination.

Sample Information	ISTR-1
Reductive Dechlorination	**(cells/bead)**
Dehalococcoides spp. (DHC)	**4.15E+02**
tceA Reductase (TCE)	**4.39E+01**
BAV1 Vinyl Chloride Reductase (BVC)	**2.75E+02**
Vinyl Chloride Reductase (VCR)	**1.15E+01 (J)**
Dehalobacter spp. (DHBt)	**5.64E+02**
Dehalobacter DCM (DCM)	<2.50E+02
Dehalogenimonas spp. (DHG)	<2.50E+02
Desulfitobacterium spp. (DSB)	<2.50E+02
Dehalobium chlorocoercia (DECO)	<2.50E+02
Desulfuromonas spp. (DSM)	<2.50E+02
Chloroform reductase (CFR)	<2.50E+02

Figure 2. Comparison - Microbial populations involved in reductive dechlorination

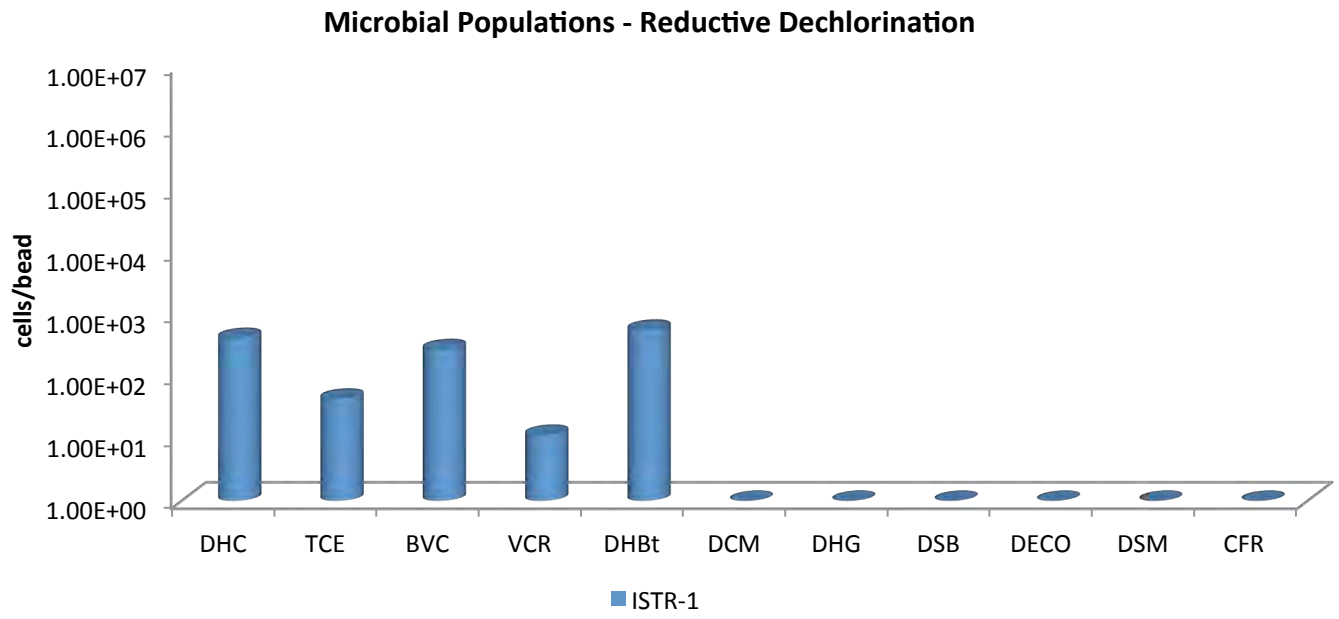

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Table 3. Summary of the QuantArray® results for microorganisms responsible for aerobic (Co)metabolism.

Sample Information	ISTR-1
Aerobic (Co)Metabolic	**(cells/bead)**
Soluble Methane Monooxygenase (SMMO)	**7.15E+02**
Particulate Methane Monooxygenase	<2.50E+02
Toluene Dioxygenase (TOD)	<2.50E+02
Phenol Hydroxylase (PHE)	<2.50E+02
Trichlorobenzene Dioxygenase (TCBO)	<2.50E+02
Toluene Monooxygenase 2 (RDEG)	<2.50E+02
Toluene Monooyxgenase (RMO)	<2.50E+02
Ethene Monooxygenase (EtnC)	<2.50E+02
Epoxyalkane transferase (EtnE)	<2.50E+02

Figure 3. Comparison - Microbial populations involved in aerobic (Co)metabolism.

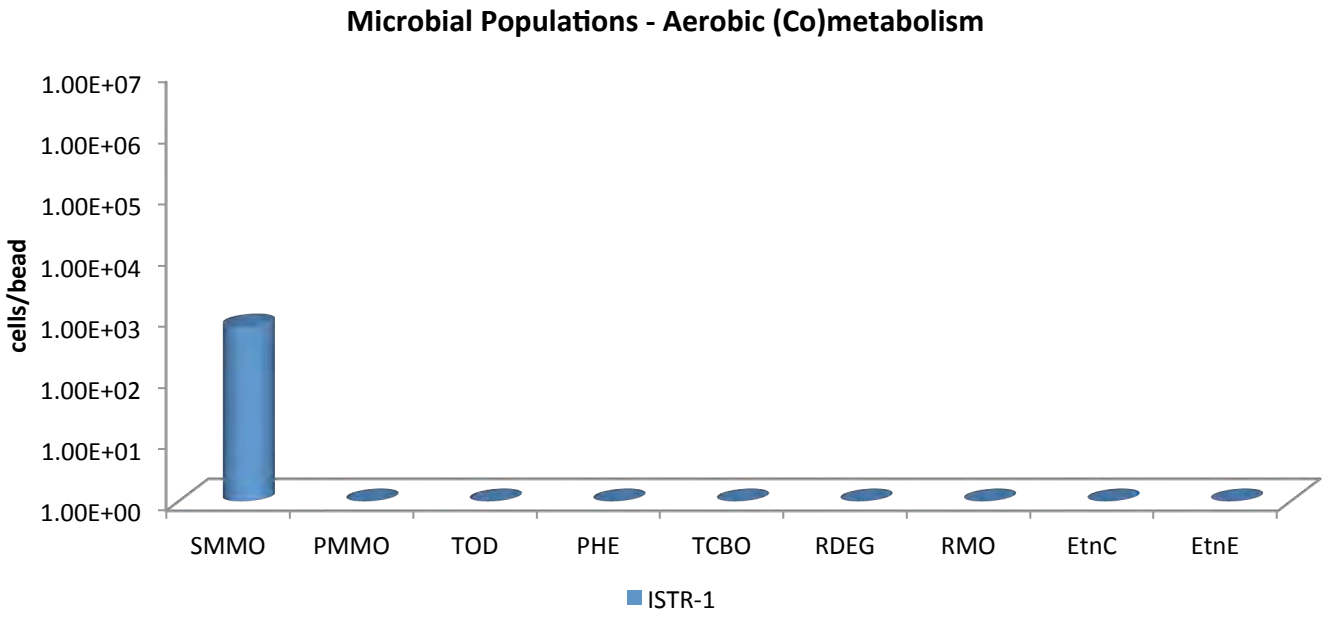

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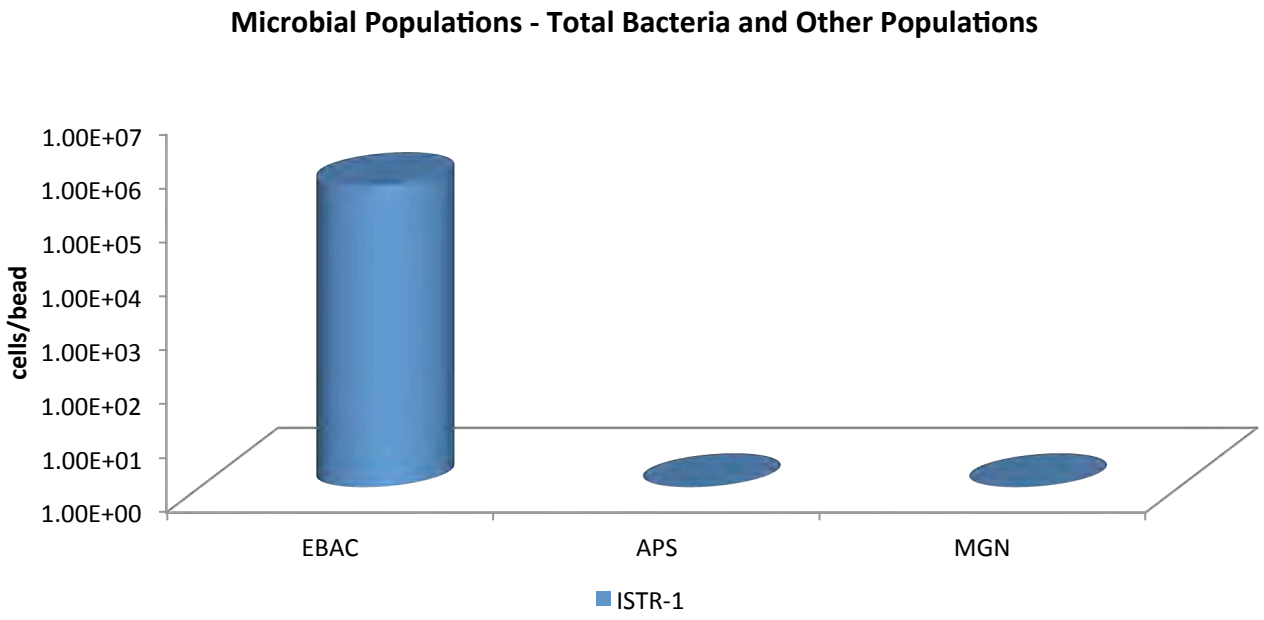
Table 4. Summary of the QuantArray® results for total bacteria and other populations.

Sample Information	ISTR-1
Other	**(cells/bead)**
Total Eubacteria (EBAC)	**3.79E+05**
Sulfate Reducing Bacteria (APS)	<2.50E+02
Methanogens (MGN)	<2.50E+02

Figure 4. Comparison - Microbial populations



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Interpretation

The overall purpose of the Chlorinated QuantArray® is to give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co)metabolic pathways to give a much more clear and comprehensive view of contaminant biodegradation. The following discussion describes interpretation of results in general terms and is meant to serve as a guide.

Reductive Dechlorination – Chlorinated Ethenes: While a number of bacterial cultures including *Dehalococcoides*, *Dehalobacter*, *Desulfitobacterium*, and *Desulfuromonas* spp. capable of utilizing PCE and TCE as growth supporting electron acceptors have been isolated [1-5], *Dehalococcoides* spp. may be the most important because they are the only bacterial group that has been isolated to date which is capable of complete reductive dechlorination of PCE to ethene [6]. In fact, the presence of *Dehalococcoides* spp. has been associated with complete reductive dechlorination to ethene at sites across North America and Europe [7]. More recently, Lu et al. [8] have proposed using a *Dehalococcoides* concentration of 1×10^4 cells/mL as a screening criterion to identify sites where biological reductive dechlorination will proceed at "generally useful" rates.

A "stall" where daughter products *cis*-DCE and vinyl chloride accumulate can occur at PCE- and TCE-impacted sites especially under MNA conditions. The accumulation of vinyl chloride, generally considered more carcinogenic than the parent compounds, is particularly problematic. Although elevated *Dehalococcoides* concentrations correspond to ethene production in numerous studies, the range of chlorinated ethenes metabolized and cometabolized varies by species and strains within the *Dehalococcoides* genus. For example, *Dehalococcoides ethenogenes* str. 195 metabolizes PCE, TCE, and *cis*-DCE and cometabolizes vinyl chloride [6] to produce ethene. Conversely, *Dehalococcoides* sp. CBDB1 utilizes PCE and TCE but does not cometabolize additional chloroethenes [9]. Quantification of reductive dehalogenase genes is used to more definitively confirm the potential for reductive dechlorination of TCE, cis-DCE, and vinyl chloride [10-13].

Reductive Dechlorination – Chlorinated Ethanes: Under anaerobic conditions, chlorinated ethanes are susceptible to reductive dechlorination by several groups of halorespiring bacteria including *Dehalobacter*, *Dehalogenimonas*, and *Dehalococcoides* spp. While the reported range of chlorinated ethanes utilized varies by genus, species, and sometimes at the strain level, several general observations can be made regarding biodegradation pathways and daughter product formation. *Dehalobacter* spp. have been isolated that are capable of sequential reductive dechlorination of 1,1,1-TCA through 1,1-DCA to chloroethane. Biodegradation of 1,1,2-TCA by several halorespiring bacteria including *Dehalobacter* and *Dehalogenimonas* spp. proceeds via dichloroelimination producing vinyl chloride. Similarly, 1,2-DCA biodegradation by *Dehalobacter*, *Dehalogenimonas*, and *Dehalococcoides* spp occurs via dichloroelimination producing ethene. While not utilized by many *Desulfitobacterium* isolates, at least one strain, *Desulfitobacterium dichloroeliminans* strain DCA1, is also capable of dichloroelimination of 1,2-DCA [14].

Reductive Dechlorination – Chlorinated Methanes: Chloroform is a common co-contaminant at chlorinated solvent sites and can inhibit reductive dechlorination of chlorinated ethenes. Grostern et al demonstrated that a *Dehalobacter* population was capable of reductive dechlorination of chloroform to produce dichloromethane [15]. The *cfrA* gene encodes the reductase which catalyzes this initial step in chloroform biodegradation [16]. Justicia-Leon et al have since shown that dichloromethane can support growth of a distinct group of *Dehalobacter* strains via fermentation [17]. The *Dehalobacter* DCM assays targets the 16S rRNA gene of these strains.

Reductive Dechlorination – Chlorinated Benzenes: Chlorinated benzenes are an important class of industrial solvents and chemical intermediates in the productions of drugs, dyes, herbicides, and insecticides. The physical-chemical properties of chlorinated benzenes as well as susceptibility to biodegradation are functions of their degree of chlorination and the positions of

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chlorine substituents. Under anaerobic conditions, reductive dechlorination of higher chlorinated benzenes including hexachlorobenzene (HCB), pentachlorobenzene (PeCB), tetrachlorobenzene (TeCB) isomers, and trichlorobenzene (TCB) isomers by halorespiring bacteria has been well documented [18]. For example, although biodegradation of individual compounds and specific isomers does vary somewhat between isolates, *Dehalococcoides* spp. such as strain CBDB1 have been identified which reductively dechlorinate HCB, PeCB, all three TeCB isomers, 1,2,3-TCB, and 1,2,4-TCB [9, 19]. *Dehalobium chlorocoercia* DF-1 has been shown to be capable of reductive dechlorination of HCB, PeCB, and 1,2,3,5-TeCB [20]. The dichlorobenzene (DCB) isomers and chlorobenzene (CB) were considered relatively recalcitrant under anaerobic conditions. However, new evidence has demonstrated reductive dechlorination of DCBs to CB and CB to benzene [21] with corresponding increases in concentrations of *Dehalobacter* spp. [22].

Reductive Dechlorination – Chlorinated Phenols: Pentachlorophenol (PCP) was one of the most widely used biocides in the US and despite residential use restrictions is still extensively used industrially as a wood preservative. Along with PCP, the tetrachloropenol and trichlorophenol isomers were also used as fungicides in wood preserving formulations. 2,4-dichlorophenol and 2,4,5-TCP were used as chemical intermediates in herbicide production (e.g. 2,4-D) and chlorophenols are known byproducts of chlorine bleaching in the pulp and paper industry. While the range of compounds utilized varies by strain, some *Dehalococcoides* isolates are capable of reductive dechlorination of PCP and other chlorinated phenols. For example, *Dehalococcoides* strain CBDB1 is capable of utilizing pentachlorophenol (PCP), all three tetrachlorphenol (TeCP) congeners, all six trichlorophenol (TCP) congeners, and 2,3-dichlorophenol (2,3-DCP). PCP dechlorination by strain CBDB1 produces a mixture of 3,5-DCP, 3,4-DCP, 2,4-DCP, 3-CP, and 4-CP [23]. In the same study however, *Dehalococcoides ethenogenes* strain 195 dechlorinated a more narrow spectrum of chlorophenols which included 2,3-DCP, 2,3,4-TCP, and 2,3,6-TCP but no other TCPs or PCP. Similar to *Dehalococcoccoides*, some species and strains of *Desulfitobacterium* are capable of utilizing PCP and other chlorinated phenols. *Desulfitobacterium hagniense* PCP-1 is capable of reductive dechlorination of PCP to 3-CP [24]. However, the ability to biodegrade PCP is not universal among *Desulfitobacterium* isolates. *Desulfitobacterium* sp. strain PCE1 and *D. chlororespirans* strain Co23 for example can utilize some TCP and DCP isomers but not PCP for growth [2, 25].

Reductive Dechlorination – Chlorinated Propanes: *Dehalogenimonas* is a recently described bacterial genus of the phylum *Chloroflexi* which also includes the well-known chloroethene-respiring *Dehalococcoides* spp [26]. The *Dehalogenimonas* isolates characterized to date are also halorespiring bacteria but utilize a rather unique range of chlorinated compounds as electron acceptors including chlorinated propanes (1,2,3-TCP and 1,2-DCP) and a variety of other vicinally chlorinated alkanes including 1,1,2,2-tetrachlorethane, 1,1,2-trichloroethane, and 1,2-dichloroethane [26].

Aerobic – Chlorinated Ethene Cometabolism: Under aerobic conditions, several different types of bacteria including methane-oxidizing bacteria (methanotrophs), ammonia-oxidizing bacteria, and some toluene/phenol-utilizing bacteria can cometabolize or co-oxidize trichloroethene (TCE), dichlorethene (DCE), and vinyl chloride (VC). In general, cometabolism of chlorinated ethenes is mediated by monooxygenase enzymes with "relaxed" specificity that oxidize a primary (growth supporting) substrate and co-oxidize the chlorinated compound. Most methanotrophs are only capable of producing particulate methane monooxygenase (pMMO) which is capable of aerobic cometabolism but often at lower rates. Other methanotrophs are capable of producing both pMMO and soluble methane monooxygenase (sMMO) enzymes, which in general are believed to capable of greater rates of aerobic cometabolism.

Aerobic – Vinyl Chloride Cometabolism: Beginning in the early 1990s, numerous microcosm studies demonstrated aerobic oxidation of vinyl chloride under MNA conditions without the addition of exogenous primary substrates. Since then, strains of *Mycobacterium*, *Nocardioides*, *Pseudomonas*, *Ochrobactrum*, and *Ralstonia* species have been isolated which are capable of aerobic growth on both ethene and vinyl chloride (see Mattes et al., [27] for review). The initials steps in the pathway are the monooxygenase (*etn*ABCD) catalyzed conversion of ethene and vinyl chloride to their respective epoxyalkanes (epoxyethane and chlorooxirane) followed by epoxyalkane:CoM transferase (*etn*E) mediated conjugation and breaking of the epoxide [28].

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Aerobic – Chlorinated Benzenes: In general, chlorobenzenes with four or less chlorine groups are susceptible to aerobic biodegradation even serving as growth supporting substrates. Toluene dioxygenase (TOD) has relatively relaxed substrate specificity and mediates the incorporation of both atoms of oxygen into the aromatic ring of benzene and substituted benzenes (toluene and chlorobenzene). Comparison of TOD levels in background and source zone samples from a CB impacted site suggested that CBs promoted growth of TOD containing bacteria [29]. In addition, aerobic biodegradation of some trichlorobenzene and even tetrachlorobenzene isomers is initiated by a group of related trichlorobenzene dioxygenase genes (TCBO). Finally, phenol hydroxylases catalyze the continued oxidation and in some cases the initial oxidation of a variety of monoaromatic compounds. In an independent study, significant increases in numbers of bacteria containing PHE genes corresponded to increases in biodegradation of DCB isomers [29].

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MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	PLFA	DGGE+3ID	DGGE+5ID	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tce, vcr)	DHBt (Dehalobacter)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Dentrifiers-nirS and nirK)	AOB (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add. qPCR:	add. qPCR:	RNA (Expression Option)*	Other:	Other:	Other:
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095LG1	CPZ-6A	7/30/14	1133	BioTrap				X																							
2	MW-502	"	1139	"				X																							
3	MW-907M	"	1144	"				X																							
4	MW-907DR	"	1146	"				X																							
5	PZ-906DR	"	1204	"				X																							
6	CPZ-7R	"	1325	"				X																							
7	CPZ-8R	"	1335	"				X																							
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Project Name:	SRSNE
Project Number:	B0054634.0000.01900
Report Date:	07/01/14

Certifications & Approvals: MA (M-MA086), NY (11148), CT (PH-0574), NH (2003), NJ NELAP (MA935), RI (LAO00065), ME (MA00086), PA (68-03671), USDA (Permit #P-330-11-00240), NC (666), TX (T104704476), DOD (L2217), US Army Corps of Engineers.

Eight Walkup Drive, Westborough, MA 01581-1019
508-898-9220 (Fax) 508-898-9193 800-624-9220 - www.alphalab.com

Project Name: SRSNE
Project Number: B0054634.0000.01900

Lab Number: L1413864
Report Date: 07/01/14

Alpha Sample ID	Client ID	Sample Location	Collection Date/Time
L1413864-01	CPZ-7R-HS-06242014	SOUTHINGTON, CT	06/24/14 13:00
L1413864-02	CPZ-6A-HS-06242014	SOUTHINGTON, CT	06/24/14 13:20
L1413864-03	CPZ-8R-HS-06242014	SOUTHINGTON, CT	06/24/14 13:40
L1413864-04	PZ-906DR-HS-06242014	SOUTHINGTON, CT	06/24/14 14:30

Project Name:	SRSNE	**Lab Number:**	L1413864
Project Number:	B0054634.0000.01900	**Report Date:**	07/01/14

CT DEP Reasonable Confidence Protocols
Laboratory Analysis
QA/QC Certification Form

1	For each analytical method referenced in this laboratory report package, were all specified QA/QC performance criteria followed (including the requirement to explain any criteria falling outside of acceptable guidelines, as specified in the CT DEP method-specific Reasonable Confidence Protocol documents)?	YES
1a	Were the method specified preservation and holding time requirements met?	YES
1b	VPH & EPH Methods Only: Was the VPH or EPH Method conducted without significant modifications (see Section 11.3 of respective Methods)?	N/A
2	Were all samples received by the laboratory in a condition consistent with that described on the associated chain-of-custody document(s)?	YES
3	Were all samples received at an appropriate temperature (<6°C)?	YES
4	Were all QA/QC performance criteria specified in the CT DEP Reasonable Confidence Protocol documents achieved?	YES
5a	Were reporting limits specified or referenced on the chain-of-custody?	YES
5b	Were these reporting limits met?	YES
6	For each analytical method referenced in this laboratory report package, were results reported for all constituents identified in the method-specific analyte lists presented in the Reasonable Confidence Protocol documents?	NO
7	Are project-specific matrix spikes and laboratory duplicates included in this data set?	NO

Note: For all questions to which the response was "No" (with the exception of question #7), additional information must be provided in an attached narrative. If the answer to question #1, #1A or question B is "No", the data package does not meet the requirements for "Reasonable Confidence".

Project Name: SRSNE **Lab Number:** L1413864
Project Number: B0054634.0000.01900 **Report Date:** 07/01/14

Case Narrative

The samples were received in accordance with the Chain of Custody and no significant deviations were encountered during the preparation or analysis unless otherwise noted. Sample Receipt, Container Information, and the Chain of Custody are located at the back of the report.

Results contained within this report relate only to the samples submitted under this Alpha Lab Number and meet all of the requirements of NELAC, for all NELAC accredited parameters. The data presented in this report is organized by parameter (i.e. VOC, SVOC, etc.). Sample specific Quality Control data (i.e. Surrogate Spike Recovery) is reported at the end of the target analyte list for each individual sample, followed by the Laboratory Batch Quality Control at the end of each parameter. If a sample was re-analyzed or re-extracted due to a required quality control corrective action and if both sets of data are reported, the Laboratory ID of the re-analysis or re-extraction is designated with an "R" or "RE", respectively. When multiple Batch Quality Control elements are reported (e.g. more than one LCS), the associated samples for each element are noted in the grey shaded header line of each data table. Any Laboratory Batch, Sample Specific % recovery or RPD value that is outside the listed Acceptance Criteria is bolded in the report. Performance criteria for CAM and RCP methods allow for some LCS compound failures to occur and still be within method compliance. In these instances, the specific failures are not narrated but are noted in the associated QC table. This information is also incorporated in the Data Usability format for our Data Merger tool where it can be reviewed along with any associated usability implications. Soil/sediments, solids and tissues are reported on a dry weight basis unless otherwise noted. Definitions of all data qualifiers and acronyms used in this report are provided in the Glossary located at the back of the report.

In reference to questions H (CAM) or 4 (RCP) when "NO" is checked, the performance criteria for CAM and RCP methods allow for some quality control failures to occur and still be within method compliance. In these instances the specific failure is not narrated but noted in the associated QC table. The information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications.

Please see the associated ADEx data file for a comparison of laboratory reporting limits that were achieved with the regulatory Numerical Standards requested on the Chain of Custody.

HOLD POLICY
For samples submitted on hold, Alpha's policy is to hold samples (with the exception of Air canisters) free of charge for 21 calendar days from the date the project is completed. After 21 calendar days, we will dispose of all samples submitted including those put on hold unless you have contacted your Client Service Representative and made arrangements for Alpha to continue to hold the samples. Air canisters will be disposed after 3 business days from the date the project is completed.

Please contact Client Services at 800-624-9220 with any questions.

Project Name: SRSNE **Lab Number:** L1413864
Project Number: B0054634.0000.01900 **Report Date:** 07/01/14

Case Narrative (continued)

Report Submission

All non-detect (ND) or estimated concentrations (J-qualified) have been quantitated to the limit noted in the MDL column.

The project number was supplied by the client.

RCP Related Narratives

Sample Receipt

The samples were field filtered for Dissolved Metals.

The sample L1413864-04 was received above the appropriate pH for the Total and Dissolved Metals analysis. The laboratory added additional HNO3 to a pH <2.

Metals

In reference to question 6:

At the client's request, all submitted samples were not analyzed for the full RCP list of constituents identified in the method specific analyte list presented in the RCP documents.

Non-RCP Related Narratives

Alkalinity, Total

The WG700728-4 MS recovery (73%), performed on L1413864-01, is outside the acceptance criteria; however, the associated LCS recovery was within criteria. No further action was taken.

I, the undersigned, attest under the pains and penalties of perjury that, to the best of my knowledge and belief and based upon my personal inquiry of those responsible for providing the information contained in this analytical report, such information is accurate and complete. This certificate of analysis is not complete unless this page accompanies any and all pages of this report.

Authorized Signature: Michelle M. Morris

Title: Technical Director/Representative Date: 07/01/14

METALS

Project Name: SRSNE
Project Number: B0054634.0000.01900
Lab Number: L1413864
Report Date: 07/01/14

SAMPLE RESULTS

Lab ID: L1413864-01
Client ID: CPZ-7R-HS-06242014
Sample Location: SOUTHINGTON, CT
Matrix: Water
Date Collected: 06/24/14 13:00
Date Received: 06/24/14
Field Prep: See Narrative

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
CT RCP Total Metals - Westborough Lab											
Iron, Total	320		ug/l	50	20.	1	06/26/14 08:17	06/26/14 13:21	EPA 3005A	77,6010C	JH
Manganese, Total	142		ug/l	10.0	2.00	1	06/26/14 08:17	06/26/14 13:21	EPA 3005A	77,6010C	JH
CT RCP Dissolved Metals - Westborough Lab											
Iron, Dissolved	61		ug/l	50	20.	1	06/26/14 12:07	06/27/14 11:34	NA	77,6010C	JH
Manganese, Dissolved	144		ug/l	10.0	2.00	1	06/26/14 12:07	06/27/14 11:34	NA	77,6010C	JH

Project Name: SRSNE
Project Number: B0054634.0000.01900
Lab Number: L1413864
Report Date: 07/01/14

SAMPLE RESULTS

Lab ID: L1413864-02
Client ID: CPZ-6A-HS-06242014
Sample Location: SOUTHINGTON, CT
Matrix: Water
Date Collected: 06/24/14 13:20
Date Received: 06/24/14
Field Prep: See Narrative

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
CT RCP Total Metals - Westborough Lab											
Iron, Total	18000		ug/l	50	20.	1	06/26/14 08:17	06/26/14 13:29	EPA 3005A	77,6010C	JH
Manganese, Total	1270		ug/l	10.0	2.00	1	06/26/14 08:17	06/26/14 13:29	EPA 3005A	77,6010C	JH
CT RCP Dissolved Metals - Westborough Lab											
Iron, Dissolved	15000		ug/l	50	20.	1	06/26/14 12:07	06/27/14 11:41	NA	77,6010C	JH
Manganese, Dissolved	1350		ug/l	10.0	2.00	1	06/26/14 12:07	06/27/14 11:41	NA	77,6010C	JH

Project Name: SRSNE
Project Number: B0054634.0000.01900
Lab Number: L1413864
Report Date: 07/01/14

SAMPLE RESULTS

Lab ID: L1413864-03
Client ID: CPZ-8R-HS-06242014
Sample Location: SOUTHINGTON, CT
Matrix: Water
Date Collected: 06/24/14 13:40
Date Received: 06/24/14
Field Prep: See Narrative

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
CT RCP Total Metals - Westborough Lab											
Iron, Total	680		ug/l	50	20.	1	06/26/14 08:17	06/26/14 13:33	EPA 3005A	77,6010C	JH
Manganese, Total	657		ug/l	10.0	2.00	1	06/26/14 08:17	06/26/14 13:33	EPA 3005A	77,6010C	JH
CT RCP Dissolved Metals - Westborough Lab											
Iron, Dissolved	130		ug/l	50	20.	1	06/26/14 12:07	06/27/14 11:45	NA	77,6010C	JH
Manganese, Dissolved	458		ug/l	10.0	2.00	1	06/26/14 12:07	06/27/14 11:45	NA	77,6010C	JH

Project Name: SRSNE
Lab Number: L1413864
Project Number: B0054634.0000.01900
Report Date: 07/01/14

SAMPLE RESULTS

Lab ID: L1413864-04
Client ID: PZ-906DR-HS-06242014
Sample Location: SOUTHINGTON, CT
Matrix: Water
Date Collected: 06/24/14 14:30
Date Received: 06/24/14
Field Prep: See Narrative

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
CT RCP Total Metals - Westborough Lab											
Iron, Total	200		ug/l	50	20.	1	06/26/14 08:17	06/26/14 13:40	EPA 3005A	77,6010C	JH
Manganese, Total	6.20	J	ug/l	10.0	2.00	1	06/26/14 08:17	06/26/14 13:40	EPA 3005A	77,6010C	JH
CT RCP Dissolved Metals - Westborough Lab											
Iron, Dissolved	28	J	ug/l	50	20.	1	06/26/14 12:07	06/27/14 11:49	NA	77,6010C	JH
Manganese, Dissolved	ND		ug/l	10.0	2.00	1	06/26/14 12:07	06/27/14 11:49	NA	77,6010C	JH

Project Name: SRSNE **Lab Number:** L1413864

Project Number: B0054634.0000.01900 **Report Date:** 07/01/14

Method Blank Analysis
Batch Quality Control

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
CT RCP Total Metals - Westborough Lab for sample(s): 01-04 Batch: WG701009-1										
Iron, Total	ND		ug/l	50	20.	1	06/26/14 08:17	06/26/14 13:02	77,6010C	JH
Manganese, Total	ND		ug/l	10.0	2.00	1	06/26/14 08:17	06/26/14 13:02	77,6010C	JH

Prep Information

Digestion Method: EPA 3005A

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
CT RCP Dissolved Metals - Westborough Lab for sample(s): 01-04 Batch: WG701095-1										
Iron, Dissolved	ND		ug/l	50	20.	1	06/26/14 12:07	06/27/14 11:26	77,6010C	JH
Manganese, Dissolved	ND		ug/l	10.0	2.00	1	06/26/14 12:07	06/27/14 11:26	77,6010C	JH

Prep Information

Digestion Method: NA

Lab Control Sample Analysis

Batch Quality Control

Project Name: SRSNE

Project Number: B0054634.0000.01900

Lab Number: L1413864

Report Date: 07/01/14

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
CT RCP Total Metals - Westborough Lab Associated sample(s): 01-04 Batch: WG701009-2								
Iron, Total	100		-		80-120	-		20
Manganese, Total	105		-		80-120	-		20
CT RCP Dissolved Metals - Westborough Lab Associated sample(s): 01-04 Batch: WG701095-2								
Iron, Dissolved	100		-		80-120	-		20
Manganese, Dissolved	112		-		80-120	-		20

INORGANICS
&
MISCELLANEOUS

Project Name: SRSNE
Project Number: B0054634.0000.01900

Lab Number: L1413864
Report Date: 07/01/14

SAMPLE RESULTS

Lab ID: L1413864-01
Client ID: CPZ-7R-HS-06242014
Sample Location: SOUTHINGTON, CT
Matrix: Water

Date Collected: 06/24/14 13:00
Date Received: 06/24/14
Field Prep: See Narrative

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Alkalinity, Total	130.		mg CaCO3/L	2.00	NA	1	-	06/25/14 10:17	30,2320B	AN
Nitrogen, Nitrite	0.020	J	mg/l	0.050	0.012	1	-	06/25/14 03:21	30,4500NO3-F	DB
Nitrogen, Nitrate	0.053	J	mg/l	0.100	0.015	1	-	06/25/14 03:21	30,4500NO3-F	DB
Total Organic Carbon	26.		mg/l	2.5	0.59	5	-	06/27/14 08:59	1,9060	DW
Anions by Ion Chromatography - Westborough Lab										
Chloride	94.2		mg/l	25.0	8.40	50	-	07/01/14 12:16	44,300.0	JT
Sulfate	98.4		mg/l	50.0	11.4	50	-	07/01/14 12:16	44,300.0	JT

Project Name: SRSNE
Project Number: B0054634.0000.01900

Lab Number: L1413864
Report Date: 07/01/14

SAMPLE RESULTS

Lab ID: L1413864-02
Client ID: CPZ-6A-HS-06242014
Sample Location: SOUTHINGTON, CT
Matrix: Water

Date Collected: 06/24/14 13:20
Date Received: 06/24/14
Field Prep: See Narrative

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Alkalinity, Total	430.		mg CaCO3/L	2.00	NA	1	-	06/25/14 10:17	30,2320B	AN
Nitrogen, Nitrite	0.030	J	mg/l	0.050	0.012	1	-	06/25/14 03:31	30,4500NO3-F	DB
Nitrogen, Nitrate	0.049	J	mg/l	0.100	0.015	1	-	06/25/14 03:31	30,4500NO3-F	DB
Total Organic Carbon	14.		mg/l	2.5	0.59	5	-	06/27/14 08:59	1,9060	DW
Anions by Ion Chromatography - Westborough Lab										
Chloride	88.4		mg/l	1.00	0.336	2	-	07/01/14 12:28	44,300.0	JT
Sulfate	3.50		mg/l	2.00	0.458	2	-	07/01/14 12:28	44,300.0	JT

Project Name: SRSNE
Project Number: B0054634.0000.01900

Lab Number: L1413864
Report Date: 07/01/14

SAMPLE RESULTS

Lab ID: L1413864-03
Client ID: CPZ-8R-HS-06242014
Sample Location: SOUTHINGTON, CT
Matrix: Water

Date Collected: 06/24/14 13:40
Date Received: 06/24/14
Field Prep: See Narrative

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Alkalinity, Total	140.		mg CaCO3/L	2.00	NA	1	-	06/25/14 10:17	30,2320B	AN
Nitrogen, Nitrite	0.018	J	mg/l	0.050	0.012	1	-	06/25/14 03:31	30,4500NO3-F	DB
Nitrogen, Nitrate	0.110		mg/l	0.100	0.015	1	-	06/25/14 03:31	30,4500NO3-F	DB
Total Organic Carbon	9.8		mg/l	2.5	0.59	5	-	06/27/14 08:59	1,9060	DW
Anions by Ion Chromatography - Westborough Lab										
Chloride	69.9		mg/l	12.5	4.20	25	-	07/01/14 13:40	44,300.0	JT
Sulfate	33.7		mg/l	25.0	5.72	25	-	07/01/14 13:40	44,300.0	JT

Project Name: SRSNE
Project Number: B0054634.0000.01900

Lab Number: L1413864
Report Date: 07/01/14

SAMPLE RESULTS

Lab ID: L1413864-04
Client ID: PZ-906DR-HS-06242014
Sample Location: SOUTHINGTON, CT
Matrix: Water

Date Collected: 06/24/14 14:30
Date Received: 06/24/14
Field Prep: See Narrative

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Alkalinity, Total	546.		mg CaCO3/L	2.00	NA	1	-	06/25/14 10:17	30,2320B	AN
Nitrogen, Nitrite	0.042	J	mg/l	0.050	0.012	1	-	06/25/14 03:32	30,4500NO3-F	DB
Nitrogen, Nitrate	0.090	J	mg/l	0.100	0.015	1	-	06/25/14 03:32	30,4500NO3-F	DB
Total Organic Carbon	17.		mg/l	2.5	0.59	5	-	06/27/14 08:59	1,9060	DW
Anions by Ion Chromatography - Westborough Lab										
Chloride	153.		mg/l	50.0	16.8	100	-	07/01/14 13:16	44,300.0	JT
Sulfate	625.		mg/l	100	22.9	100	-	07/01/14 13:16	44,300.0	JT

Project Name: SRSNE
Project Number: B0054634.0000.01900
Lab Number: L1413864
Report Date: 07/01/14

Method Blank Analysis
Batch Quality Control

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab for sample(s): 01-04 Batch: WG700565-1										
Nitrogen, Nitrate	ND		mg/l	0.100	0.015	1	-	06/25/14 01:21	30,4500NO3-F	DB
General Chemistry - Westborough Lab for sample(s): 01-04 Batch: WG700566-1										
Nitrogen, Nitrite	0.018	J	mg/l	0.050	0.012	1	-	06/25/14 01:23	30,4500NO3-F	DB
General Chemistry - Westborough Lab for sample(s): 01-04 Batch: WG700728-1										
Alkalinity, Total	ND		mg CaCO3/L	2.00	NA	1	-	06/25/14 10:17	30,2320B	AN
General Chemistry - Westborough Lab for sample(s): 01-04 Batch: WG701519-1										
Total Organic Carbon	ND		mg/l	0.50	0.12	1	-	06/27/14 08:59	1,9060	DW
Anions by Ion Chromatography - Westborough Lab for sample(s): 01-04 Batch: WG702501-1										
Chloride	ND		mg/l	0.500	0.168	1	-	07/01/14 11:52	44,300.0	JT
Sulfate	ND		mg/l	1.00	0.229	1	-	07/01/14 11:52	44,300.0	JT

Lab Control Sample Analysis

Batch Quality Control

Project Name: SRSNE

Project Number: B0054634.0000.01900

Lab Number: L1413864

Report Date: 07/01/14

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-04 Batch: WG700565-2								
Nitrogen, Nitrate	99		-		90-110	-		
General Chemistry - Westborough Lab Associated sample(s): 01-04 Batch: WG700566-2								
Nitrogen, Nitrite	101		-		90-110	-		
General Chemistry - Westborough Lab Associated sample(s): 01-04 Batch: WG700728-2								
Alkalinity, Total	102		-		90-110	-		10
General Chemistry - Westborough Lab Associated sample(s): 01-04 Batch: WG701519-2								
Total Organic Carbon	106		-		90-110	-		
Anions by Ion Chromatography - Westborough Lab Associated sample(s): 01-04 Batch: WG702501-2								
Chloride	102		-		90-110	-		
Sulfate	105		-		90-110	-		

Matrix Spike Analysis
Batch Quality Control

Project Name: SRSNE
Project Number: B0054634.0000.01900

Lab Number: L1413864
Report Date: 07/01/14

Parameter	Native Sample	MS Added	MS Found	MS %Recovery	Qual	MSD Found	MSD %Recovery	Qual	Recovery Limits	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG700565-4 QC Sample: L1413864-01 Client ID: CPZ-7R-HS-06242014												
Nitrogen, Nitrate	0.053J	4	3.99	100		-	-		83-113	-		17
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG700566-4 QC Sample: L1413864-01 Client ID: CPZ-7R-HS-06242014												
Nitrogen, Nitrite	0.020J	4	3.9	97		-	-		80-120	-		20
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG700728-4 QC Sample: L1413864-01 Client ID: CPZ-7R-HS-06242014												
Alkalinity, Total	130.	100	203	**73**	Q	-	-		86-116	-		10
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG701519-4 QC Sample: L1413865-05 Client ID: MS Sample												
Total Organic Carbon	1.2	4	5.4	106		-	-		80-120	-		20
Anions by Ion Chromatography - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG702501-4 QC Sample: L1413864-02 Client ID: CPZ-6A-HS-06242014												
Chloride	88.4	20	107	94		-	-		40-151	-		18
Sulfate	3.50	40	43.0	99		-	-		60-140	-		20

Lab Duplicate Analysis
Batch Quality Control

Project Name: SRSNE
Project Number: B0054634.0000.019

Lab Number: L1413864
Report Date: 07/01/14

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG700565-3 QC Sample: L1413864-01 Client ID: CPZ-7R-HS-06242014						
Nitrogen, Nitrate	0.053J	0.048J	mg/l	NC		17
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG700566-3 QC Sample: L1413864-01 Client ID: CPZ-7R-HS-06242014						
Nitrogen, Nitrite	0.020J	0.019J	mg/l	NC		20
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG700728-3 QC Sample: L1413864-02 Client ID: CPZ-6A-HS-06242014						
Alkalinity, Total	430.	431	mg CaCO3/L	0		10
General Chemistry - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG701519-3 QC Sample: L1413865-03 Client ID: DUP Sample						
Total Organic Carbon	2.2	2.7	mg/l	20		20
Anions by Ion Chromatography - Westborough Lab Associated sample(s): 01-04 QC Batch ID: WG702501-3 QC Sample: L1413864-02 Client ID: CPZ-6A-HS-06242014						
Chloride	88.4	86.9	mg/l	2		18
Sulfate	3.50	3.24	mg/l	8		20

Project Name: SRSNE
Project Number: B0054634.0000.01900

Lab Number: L1413864
Report Date: 07/01/14

Sample Receipt and Container Information

Were project specific reporting limits specified? YES

Reagent H2O Preserved Vials Frozen on: NA

Cooler Information Custody Seal

Cooler	
A	Absent

Container Information

Container ID	Container Type	Cooler	pH	Temp deg C	Pres	Seal	Analysis(*)
L1413864-01A	Vial H2SO4 preserved	A	N/A	4.8	Y	Absent	TOC-9060(28)
L1413864-01B	Vial H2SO4 preserved	A	N/A	4.8	Y	Absent	TOC-9060(28)
L1413864-01C	Plastic 120ml HNO3 preserved	A	<2	4.8	Y	Absent	CT-FE-6010S(180),CT-MN-6010S(180)
L1413864-01D	Plastic 120ml HNO3 preserved	A	<2	4.8	Y	Absent	CT-MN-6010T(180),CT-FE-6010T(180)
L1413864-01E	Plastic 120ml unpreserved	A	N/A	4.8	Y	Absent	ALK-T-2320(14)
L1413864-01F	Plastic 250ml unpreserved	A	8	4.8	Y	Absent	SO4-300(28),CL-300(28),NO3-4500(2),NO2-4500NO3(2)
L1413864-02A	Vial H2SO4 preserved	A	N/A	4.8	Y	Absent	TOC-9060(28)
L1413864-02B	Vial H2SO4 preserved	A	N/A	4.8	Y	Absent	TOC-9060(28)
L1413864-02C	Plastic 120ml HNO3 preserved	A	<2	4.8	Y	Absent	CT-FE-6010S(180),CT-MN-6010S(180)
L1413864-02D	Plastic 120ml HNO3 preserved	A	<2	4.8	Y	Absent	CT-MN-6010T(180),CT-FE-6010T(180)
L1413864-02E	Plastic 120ml unpreserved	A	N/A	4.8	Y	Absent	ALK-T-2320(14)
L1413864-02F	Plastic 250ml unpreserved	A	8	4.8	Y	Absent	SO4-300(28),CL-300(28),NO3-4500(2),NO2-4500NO3(2)
L1413864-03A	Vial H2SO4 preserved	A	N/A	4.8	Y	Absent	TOC-9060(28)
L1413864-03B	Vial H2SO4 preserved	A	N/A	4.8	Y	Absent	TOC-9060(28)
L1413864-03C	Plastic 120ml HNO3 preserved	A	<2	4.8	Y	Absent	CT-FE-6010S(180),CT-MN-6010S(180)
L1413864-03D	Plastic 120ml HNO3 preserved	A	<2	4.8	Y	Absent	CT-MN-6010T(180),CT-FE-6010T(180)
L1413864-03E	Plastic 120ml unpreserved	A	N/A	4.8	Y	Absent	ALK-T-2320(14)
L1413864-03F	Plastic 250ml unpreserved	A	8	4.8	Y	Absent	SO4-300(28),CL-300(28),NO3-4500(2),NO2-4500NO3(2)
L1413864-04A	Vial H2SO4 preserved	A	N/A	4.8	Y	Absent	TOC-9060(28)
L1413864-04B	Vial H2SO4 preserved	A	N/A	4.8	Y	Absent	TOC-9060(28)
L1413864-04C	Plastic 120ml HNO3 preserved	A	<2	4.8	Y	Absent	CT-FE-6010S(180),CT-MN-6010S(180)
L1413864-04D	Plastic 120ml HNO3 preserved	A	<2	4.8	Y	Absent	CT-MN-6010T(180),CT-FE-6010T(180)

*Values in parentheses indicate holding time in days

Project Name: SRSNE
Project Number: B0054634.0000.01900

Lab Number: L1413864
Report Date: 07/01/14

Container Information

Container ID	Container Type	Cooler	pH	Temp deg C	Pres	Seal	Analysis(*)
L1413864-04E	Plastic 120ml unpreserved	A	N/A	4.8	Y	Absent	ALK-T-2320(14)
L1413864-04F	Plastic 250ml unpreserved	A	>12	4.8	Y	Absent	SO4-300(28),CL-300(28),NO3-4500(2),NO2-4500NO3(2)

*Values in parentheses indicate holding time in days

Project Name:	SRSNE	**Lab Number:**	L1413864
Project Number:	B0054634.0000.01900	**Report Date:**	07/01/14

GLOSSARY

Acronyms

EDL - Estimated Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The EDL includes any adjustments from dilutions, concentrations or moisture content, where applicable. The use of EDLs is specific to the analysis of PAHs using Solid-Phase Microextraction (SPME).

EPA - Environmental Protection Agency.

LCS - Laboratory Control Sample: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.

LCSD - Laboratory Control Sample Duplicate: Refer to LCS.

LFB - Laboratory Fortified Blank: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.

MDL - Method Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The MDL includes any adjustments from dilutions, concentrations or moisture content, where applicable.

MS - Matrix Spike Sample: A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available.

MSD - Matrix Spike Sample Duplicate: Refer to MS.

NA - Not Applicable.

NC - Not Calculated: Term is utilized when one or more of the results utilized in the calculation are non-detect at the parameter's reporting unit.

NI - Not Ignitable.

RL - Reporting Limit: The value at which an instrument can accurately measure an analyte at a specific concentration. The RL includes any adjustments from dilutions, concentrations or moisture content, where applicable.

RPD - Relative Percent Difference: The results from matrix and/or matrix spike duplicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD). Values which are less than five times the reporting limit for any individual parameter are evaluated by utilizing the absolute difference between the values; although the RPD value will be provided in the report.

SRM - Standard Reference Material: A reference sample of a known or certified value that is of the same or similar matrix as the associated field samples.

Footnotes

1 - The reference for this analyte should be considered modified since this analyte is absent from the target analyte list of the original method.

Terms

Total: With respect to Organic analyses, a 'Total' result is defined as the summation of results for individual isomers or Aroclors. If a 'Total' result is requested, the results of its individual components will also be reported. This is applicable to 'Total' results for methods 8260, 8081 and 8082.

Analytical Method: Both the document from which the method originates and the analytical reference method. (Example: EPA 8260B is shown as 1,8260B.) The codes for the reference method documents are provided in the References section of the Addendum.

Data Qualifiers

A - Spectra identified as "Aldol Condensation Product".

B - The analyte was detected above the reporting limit in the associated method blank. Flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For MCP-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For DOD-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank AND the analyte was detected above one-half the reporting limit (or above the reporting limit for common lab contaminants) in the associated method blank. For NJ-Air-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte above the reporting limit.

C - Co-elution: The target analyte co-elutes with a known lab standard (i.e. surrogate, internal standards, etc.) for co-extracted analyses.

D - Concentration of analyte was quantified from diluted analysis. Flag only applies to field samples that have detectable concentrations of the analyte.

E - Concentration of analyte exceeds the range of the calibration curve and/or linear range of the instrument.

G - The concentration may be biased high due to matrix interferences (i.e, co-elution) with non-target compound(s). The result should be considered estimated.

Report Format: DU Report with 'J' Qualifiers

Project Name:	SRSNE	**Lab Number:**	L1413864
Project Number:	B0054634.0000.01900	**Report Date:**	07/01/14

Data Qualifiers

H - The analysis of pH was performed beyond the regulatory-required holding time of 15 minutes from the time of sample collection.

I - The lower value for the two columns has been reported due to obvious interference.

M - Reporting Limit (RL) exceeds the MCP CAM Reporting Limit for this analyte.

NJ - Presumptive evidence of compound. This represents an estimated concentration for Tentatively Identified Compounds (TICs), where the identification is based on a mass spectral library search.

P - The RPD between the results for the two columns exceeds the method-specified criteria.

Q - The quality control sample exceeds the associated acceptance criteria. For DOD-related projects, LCS and/or Continuing Calibration Standard exceedences are also qualified on all associated sample results. Note: This flag is not applicable for matrix spike recoveries when the sample concentration is greater than 4x the spike added or for batch duplicate RPD when the sample concentrations are less than 5x the RL. (Metals only.)

R - Analytical results are from sample re-analysis.

RE - Analytical results are from sample re-extraction.

S - Analytical results are from modified screening analysis.

J - Estimated value. The Target analyte concentration is below the quantitation limit (RL), but above the Method Detection Limit (MDL) or Estimated Detection Limit (EDL) for SPME-related analyses. This represents an estimated concentration for Tentatively Identified Compounds (TICs).

ND - Not detected at the method detection limit (MDL) for the sample, or estimated detection limit (EDL) for SPME-related analyses.

Report Format: DU Report with 'J' Qualifiers

Project Name:	SRSNE	**Lab Number:**	L1413864
Project Number:	B0054634.0000.01900	**Report Date:**	07/01/14

REFERENCES

1 Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. EPA SW-846. Third Edition. Updates I - IV, 2007.

30 Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WPCF. 18th Edition. 1992.

44 Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100, August 1993.

77 Connecticut DEP Quality Assurance and Quality Control Requirements for SW-846 Methods. CTDEP Reasonable Confidence Protocols (RCPs). Version 1.0, July 2005.

LIMITATION OF LIABILITIES

Alpha Analytical performs services with reasonable care and diligence normal to the analytical testing laboratory industry. In the event of an error, the sole and exclusive responsibility of Alpha Analytical shall be to re-perform the work at it's own expense. In no event shall Alpha Analytical be held liable for any incidental, consequential or special damages, including but not limited to, damages in any way connected with the use of, interpretation of, information or analysis provided by Alpha Analytical.

We strongly urge our clients to comply with EPA protocol regarding sample volume, preservation, cooling, containers, sampling procedures, holding time and splitting of samples in the field.

Certification Information

Last revised April 15, 2014

The following analytes are not included in our NELAP Scope of Accreditation:

Westborough Facility
EPA 524.2: Acetone, 2-Butanone (Methyl ethyl ketone (MEK)), Tert-butyl alcohol, 2-Hexanone, Tetrahydrofuran, 1,3,5-Trichlorobenzene, 4-Methyl-2-pentanone (MIBK), Carbon disulfide, Diethyl ether.
EPA 8260C: 1,2,4,5-Tetramethylbenzene, 4-Ethyltoluene, Iodomethane (methyl iodide), Methyl methacrylate, Azobenzene.
EPA 8330A/B: PETN, Picric Acid, Nitroglycerine, 2,6-DANT, 2,4-DANT.
EPA 8270D: 1-Methylnaphthalene, Dimethylnaphthalene,1,4-Diphenylhydrazine.
EPA 625: 4-Chloroaniline, 4-Methylphenol.
SM4500: Soil: Total Phosphorus, TKN, NO2, NO3.
EPA 9071: Total Petroleum Hydrocarbons, Oil & Grease.

Mansfield Facility
EPA 8270D: Biphenyl.
EPA 2540D: TSS
EPA TO-15: Halothane, 2,4,4-Trimethyl-2-pentene, 2,4,4-Trimethyl-1-pentene, Thiophene, 2-Methylthiophene, 3-Methylthiophene, 2-Ethylthiophene, 1,2,3-Trimethylbenzene, Indan, Indene, 1,2,4,5-Tetramethylbenzene, Benzothiophene, 1-Methylnaphthalene.

The following analytes are included in our Massachusetts DEP Scope of Accreditation, Westborough Facility:

Drinking Water
EPA 200.8: Sb,As,Ba,Be,Cd,Cr,Cu,Pb,Ni,Se,Tl; **EPA 200.7**: Ba,Be,Ca,Cd,Cr,Cu,Na; **EPA 245.1:** Mercury;
EPA 300.0: Nitrate-N, Fluoride, Sulfate; **EPA 353.2**: Nitrate-N, Nitrite-N; **SM4500NO3-F**: Nitrate-N, Nitrite-N; **SM4500F-C, SM4500CN-CE, EPA 180.1, SM2130B, SM4500Cl-D, SM2320B, SM2540C, SM4500H-B**
EPA 332: Perchlorate.
Microbiology: **SM9215B; SM9223-P/A, SM9223B-Colilert-QT, Enterolert-QT.**

Non-Potable Water
EPA 200.8: Al,Sb,As,Be,Cd,Cr,Cu,Pb,Mn,Ni,Se,Ag,Tl,Zn;
EPA 200.7: Al,Sb,As,Be,Cd,Ca,Cr,Co,Cu,Fe,Pb,Mg,Mn,Mo,Ni,K,Se,Ag,Na,Sr,Ti,Tl,V,Zn;
EPA 245.1, SM4500H,B, EPA 120.1, SM2510B, SM2540C, SM2340B, SM2320B, SM4500CL-E, SM4500F-BC, SM426C, SM4500NH3-BH, **EPA 350.1**: Ammonia-N, **LACHAT 10-107-06-1-B**: Ammonia-N, **SM4500NO3-F, EPA 353.2**: Nitrate-N**, SM4500NH3-BC-NES, EPA 351.1, SM4500P-E, SM4500P-B, E, SM5220D, EPA 410.4, SM5210B, SM5310C, SM4500CL-D, EPA 1664, SM14 510AC, EPA 420.1, SM4500-CN-CE, SM2540D.**
EPA 624: Volatile Halocarbons & Aromatics,
EPA 608: Chlordane, Toxaphene, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, Dieldrin, DDD, DDE, DDT, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin Aldehyde, Heptachlor, Heptachlor Epoxide, PCBs
EPA 625: SVOC (Acid/Base/Neutral Extractables), **EPA 600/4-81-045**: PCB-Oil.
Microbiology: **SM9223B-Colilert-QT; Enterolert-QT, SM9222D-MF**.

For a complete listing of analytes and methods, please contact your Alpha Project Manager.

1092

CHAIN OF CUSTODY

PAGE 1 OF 1

Serial No:07011420:53

Date Rec'd in Lab: 6/24/14

ALPHA Job #: L1413864

ALPHA ANALYTICAL
Mansfield, MA
"Data Quality Counts"

8 Walkup Drive
Westboro, MA 01581
Tel: 508-898-9220

320 Forbes Blvd
Mansfield, MA 02048
Tel: 508-822-9300

Client Information

Client: de maximis

Address: 90 Lazy Lane
Southington, CT

Phone:

Email: jessie@demaximis.com

Project Information

Project Name: SRSWE

Project Location: Southington, CT

Project #: B0054634.0000

Project Manager:

ALPHA Quote #:

Report Information - Data Deliverables

☐ ADEx ☒ EMAIL

Billing Information

☐ Same as Client info PO #:

Regulatory Requirements & Project Information Requirements

☐ Yes ☐ No MA MCP Analytical Methods ☐ Yes ☐ No CT RCP Analytical Methods
☐ Yes ☐ No Matrix Spike Required on this SDG? (Required for MCP Inorganics)
☐ Yes ☐ No GW1 Standards (Info Required for Metals & EPH with Targets)
☐ Yes ☐ No NPDES RGP
☐ Other State /Fed Program _____ Criteria _____

Turn-Around Time

☒ Standard ☐ RUSH (only confirmed if pre-approved!)

Date Due: 7/1/14

Additional Project Information:

Diss. metals Field Filtered

ANALYSIS

VOC: ☐ 8260 ☐ 624 ☐ 524.2
SVOC: ☐ ABN ☐ PAH
METALS: ☐ MCP 13 ☐ MCP 14 ☐ RCP 15
METALS: ☐ RCRA5 ☐ RCRA8 ☐ PP13
EPH: ☐ Ranges & Targets ☐ Ranges Only
VPH: ☐ Ranges & Targets ☐ Ranges Only
☐ PCB ☐ PEST
TPH: ☐ Quant Only ☐ Fingerprint

Alkalinity
Cl, SO4, NO2, NO3
Total Fe, Mn
Dissolved Fe, Mn
TOC

SAMPLE INFO
Filtration
☒ Field
☐ Lab to do
Preservation
☐ Lab to do

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler Initials	Sample Comments	TOTAL # BOTTLES
1386401	CPZ-7R-HS-06242014	6/24/14	1300	GW	MS/RT		6
02	CPZ-6A-HS-06242014	"	1320	"	"		6
03	CPZ-8R-HS-06242014	"	1340	"	"		6
04	PZ-906DR-HS-06242014	"	1430	"	"		6

Container Type	P	P	P	P	V
Preservative	A	A	C	C	D

Container Type
P= Plastic
A= Amber glass
V= Vial
G= Glass
B= Bacteria cup
C= Cube
O= Other
E= Encore
D= BOD Bottle

Preservative
A= None
B= HCl
C= HNO_3
D= H_2SO_4
E= NaOH
F= MeOH
G= $NaHSO_4$
H = $Na_2S_2O_3$
I= Ascorbic Acid
J = NH_4Cl
K= Zn Acetate
O= Other

Relinquished By:	Date/Time	Received By:	Date/Time
	6/24 15:47	Equinox	6/24/14 1547
	6/24/14 1820		6/24/14 1820

All samples submitted are subject to Alpha's Terms and Conditions. See reverse side.

FORM NO: 01-01 (rev. 12-Mar-2012)

ARCADIS

Attachment 3

Microseeps (Pace Analytical)
Laboratory Report

Microseeps/Pace Analytical Energy Services, LLC
220 William Pitt Way
Pittsburgh, PA 15238
Phone: (412) 826-5245
Fax: (412) 826-3433

July 9, 2014

John Hunt
De Maximis
40 Lazy Lane
Southington, CT 06489

RE: **SRSNE / B0054634.0000**
Microseeps Workorder: 12578

Dear John Hunt:

Enclosed are the analytical results for sample(s) received by the laboratory on Thursday, June 26, 2014. Results reported herein conform to the most current NELAC standards, where applicable, unless otherwise narrated in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Robbin Robl 07/09/2014
rrobl@microseeps.com

Customer Service Representative

Enclosures

As a valued client we would appreciate your comments on our service.
Please email info@microseeps.com.

Total Number of Pages 72

CERTIFICATE OF ANALYSIS

Microseeps/Pace Analytical Energy Services, LLC
220 William Pitt Way
Pittsburgh, PA 15238
Phone: (412) 826-5245
Fax: (412) 826-3433

LABORATORY ACCREDITATIONS & CERTIFICATIONS

Accreditor:	Pennsylvania Department of Environmental Protection, Bureau of Laboratories
Accreditation ID:	02-00538
Scope:	NELAP Non-Potable Water and Solid & Hazardous Waste
Accreditor:	South Carolina Department of Health and Environmental Control, Office of Environmental Laboratory Certification
Accreditation ID:	89009003
Scope:	Clean Water Act (CWA); Resource Conservation and Recovery Act (RCRA)
Accreditor:	NELAP: State of Louisiana, Department of Environmental Quality
Accreditation ID:	04104
Scope:	Solid and Chemical Materials; Non-Potable Water
Accreditor:	NELAP: New Jersey, Department of Environmental Protection
Accreditation ID:	PA026
Scope:	Non-Potable Water; Solid and Chemical Materials
Accreditor:	NELAP: New York, Department of Health Wadsworth Center
Accreditation ID:	11815
Scope:	Non-Potable Water; Solid and Hazardous Waste
Accreditor:	State of Connecticut, Department of Public Health, Division of Environmental Health
Accreditation ID:	PH-0263
Scope:	Clean Water Act (CWA) Resource Conservation and Recovery Act (RCRA)
Accreditor:	NELAP: Texas, Commission on Environmental Quality
Accreditation ID:	T104704453-09-TX
Scope:	Non-Potable Water
Accreditor:	State of New Hampshire
Accreditation ID:	299409
Scope:	Non-potable water
Accreditor:	State of Georgia
Accreditation ID:	Chapter 391-3-26
Scope:	As per the Georgia EPD Rules and Regulations for Commercial Laboratories, Microseeps is accredited by the Pennsylvania Department of Environmental Protection Bureau of Laboratories under the National Environmental Laboratory Approval Program (NELAC).

Microseeps/Pace Analytical Energy Services, LLC
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Pittsburgh, PA 15238
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Fax: (412) 826-3433

SAMPLE SUMMARY

Workorder: 12578 SRSNE / B0054634.0000

Lab ID	Sample ID	Matrix	Date Collected	Date Received
125780001	CPZ-7R-HS-06242014	Water	6/24/2014 13:00	6/26/2014 10:30
125780002	CPZ-6A-HS-06242014	Water	6/24/2014 13:20	6/26/2014 10:30
125780003	CPZ-8R-HS-06242014	Water	6/24/2014 13:40	6/26/2014 10:30
125780004	PZ-906DR-HS-06242014	Water	6/24/2014 14:30	6/26/2014 10:30

Microseeps/Pace Analytical Energy Services, LLC
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ANALYTICAL RESULTS

Workorder: 12578 SRSNE / B0054634.0000

Lab ID: **125780001** Date Received: 6/26/2014 10:30 Matrix: Water

Sample ID: **CPZ-7R-HS-06242014** Date Collected: 6/24/2014 13:00

Parameters	Results	Units	PQL	MDL	DF	Prepared	By	Analyzed	By	Qual
RISK - MICR										
Analysis Desc: AM20GAX			Analytical Method: AM20GAX							
Methane	**260**	ug/l	0.10	0.042	1			7/8/2014 07:42	BW	
Ethane	**3.2**	ug/l	0.025	0.0020	1			7/8/2014 07:42	BW	
Ethene	**30**	ug/l	0.025	0.0030	1			7/8/2014 07:42	BW	

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ANALYTICAL RESULTS

Workorder: 12578 SRSNE / B0054634.0000

Lab ID: **125780002** Date Received: 6/26/2014 10:30 Matrix: Water

Sample ID: **CPZ-6A-HS-06242014** Date Collected: 6/24/2014 13:20

Parameters	Results	Units	PQL	MDL	DF	Prepared	By	Analyzed	By	Qual
RISK - MICR										
Analysis Desc: AM20GAX			Analytical Method: AM20GAX							
Methane	**24000**	ug/l	0.10	0.042	1			7/8/2014 07:52	BW	
Ethane	**460**	ug/l	0.025	0.0020	1			7/8/2014 07:52	BW	
Ethene	**2.8**	ug/l	0.025	0.0030	1			7/8/2014 07:52	BW	

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ANALYTICAL RESULTS

Workorder: 12578 SRSNE / B0054634.0000

Lab ID: **125780003** Date Received: 6/26/2014 10:30 Matrix: Water

Sample ID: **CPZ-8R-HS-06242014** Date Collected: 6/24/2014 13:40

Parameters	Results	Units	PQL	MDL	DF	Prepared	By	Analyzed	By	Qual
RISK - MICR										
Analysis Desc: AM20GAX			Analytical Method: AM20GAX							
Methane	**240**	ug/l	0.10	0.042	1			7/8/2014 08:03	BW	
Ethane	**0.66**	ug/l	0.025	0.0020	1			7/8/2014 08:03	BW	
Ethene	**90**	ug/l	0.025	0.0030	1			7/8/2014 08:03	BW	

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ANALYTICAL RESULTS

Workorder: 12578 SRSNE / B0054634.0000

Lab ID: **125780004** Date Received: 6/26/2014 10:30 Matrix: Water

Sample ID: **PZ-906DR-HS-06242014** Date Collected: 6/24/2014 14:30

Parameters	Results	Units	PQL	MDL	DF	Prepared	By	Analyzed	By	Qual
RISK - MICR										
Analysis Desc: AM20GAX		Analytical Method: AM20GAX								
Methane	**39**	ug/l	0.10	0.042	1			7/8/2014 08:14	BW	
Ethane	**3.6**	ug/l	0.025	0.0020	1			7/8/2014 08:14	BW	
Ethene	**3.8**	ug/l	0.025	0.0030	1			7/8/2014 08:14	BW	

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ANALYTICAL RESULTS QUALIFIERS

Workorder: 12578 SRSNE / B0054634.0000

DEFINITIONS/QUALIFIERS

Disclaimer : The Pennsylvania Department of Environmental Protection (PADEP) has decided to no longer recognize analyses that do not produce data for primary compliance, for NELAP accreditation. The methods affected by this decision are AM20GAx, AM21G, SW846 7199 and AM4.02. The laboratory shall continue to administer the NELAP/TNI standard requirements in the performance of these methods.

MDL	Method Detection Limit. Can be used synonymously with LOD; Limit Of Detection.
PQL	Practical Quanitation Limit. Can be used synonymously with LOQ; Limit Of Quantitation.
ND	Not detected at or above reporting limit.
DF	Dilution Factor.
S	Surrogate.
RPD	Relative Percent Difference.
% Rec	Percent Recovery.
U	Indicates the compound was analyzed for, but not detected at or above the noted concentration.
J	Estimated concentration greater than the set method detection limit (MDL) and less than the set reporting limit (PQL).

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Fax: (412) 826-3433

QUALITY CONTROL DATA

Workorder: 12578 SRSNE / B0054634.0000

QC Batch: DISG/3894 Analysis Method: AM20GAX

QC Batch Method: AM20GAX

Associated Lab Samples: 125780001, 125780002

METHOD BLANK: 28852

Parameter	Units	Blank Result	Reporting Limit	Qualifiers
RISK				
Methane	ug/l	0.10 U	0.10	
Ethane	ug/l	0.025 U	0.025	
Ethene	ug/l	0.025 U	0.025	

LABORATORY CONTROL SAMPLE & LCSD: 28854 28856

Parameter	Units	Spike Conc.	LCS Result	LCSD Result	LCS % Rec	LCSD % Rec	% Rec Limit	RPD	Max RPD	Qualifiers
RISK										
Methane	ug/l	750	710	720	95	97	80-120	2.1	20	
Ethane	ug/l	38	37	38	98	99	80-120	1	20	
Ethene	ug/l	35	34	35	97	99	80-120	2	20	

Microseeps/Pace Analytical Energy Services, LLC
220 William Pitt Way
Pittsburgh, PA 15238
Phone: (412) 826-5245
Fax: (412) 826-3433

QUALITY CONTROL DATA

Workorder: 12578 SRSNE / B0054634.0000

QC Batch: DISG/3898 Analysis Method: AM20GAX

QC Batch Method: AM20GAX

Associated Lab Samples: 125780003, 125780004

METHOD BLANK: 28890

Parameter	Units	Blank Result	Reporting Limit	Qualifiers
RISK				
Methane	ug/l	0.10 U	0.10	
Ethane	ug/l	0.025 U	0.025	
Ethene	ug/l	0.025 U	0.025	

LABORATORY CONTROL SAMPLE & LCSD: 28891 28892

Parameter	Units	Spike Conc.	LCS Result	LCSD Result	LCS % Rec	LCSD % Rec	% Rec Limit	RPD	Max RPD	Qualifiers
RISK										
Methane	ug/l	40	42	41	103	102	80-120	0.98	20	
Ethane	ug/l	76	76	75	101	99	80-120	2	20	
Ethene	ug/l	71	71	69	100	98	80-120	2	20	

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Workorder: 12578 SRSNE / B0054634.0000

Lab ID	Sample ID	Prep Method	Prep Batch	Analysis Method	Analysis Batch
125780001	CPZ-7R-HS-06242014			AM20GAX	DISG/3894
125780002	CPZ-6A-HS-06242014			AM20GAX	DISG/3894
125780003	CPZ-8R-HS-06242014			AM20GAX	DISG/3898
125780004	PZ-906DR-HS-06242014			AM20GAX	DISG/3898

Pace Analytical
www.pacelabs.com
Microseeps

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

12578

Page: 1 of 1

001293

Section A Required Client Information:	Section B Required Project Information:	Section C Invoice Information:
Company: de maximis	Report To: Jessie McCusker	Attention:
Address: 90 Lazy Lane Southington CT	Copy To:	Company Name:
Email To: jessi-2@demaximis.com	Purchase Order No.:	Address:
Phone: Fax:	Project Name: SRSNE	Pace Quote Reference:
Requested Due Date/TAT: STD	Project Number: B0054634.0000	Pace Project Manager:
		Pace Profile #:

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☐ OTHER _____

Site Location STATE: CT

Section D Required Client Information

SAMPLE ID
(A-Z, 0-9 / ,-)
Sample IDs MUST BE UNIQUE

Matrix Codes (MATRIX / CODE)

Drinking Water	DW
Water	WT
Waste Water	WW
Product	P
Soil/Solid	SL
Oil	OL
Wipe	WP
Air	AR
Tissue	TS
Other	OT

Requested Analysis Filtered (Y/N)

ITEM #	SAMPLE ID	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED COMPOSITE START DATE	COLLECTED COMPOSITE START TIME	COLLECTED COMPOSITE END/GRAB DATE	COLLECTED COMPOSITE END/GRAB TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Preservatives: Unpreserved	H_2SO_4	HNO_3	HCl	TSP	BAK	Zink Acetate & NaOH	Other	Y/N	Analysis Test: Dissolved Gases	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1	CPZ-7R-MS-06242014	WT	G			6/24/14	1300		2					X				N	X		
2	CPZ-6A-MS-06242014	"	"			"	1320		"					"					"		
3	CPZ-8R-MS-06242014	"	"			"	1340		"					"					"		
4	PZ-906BR-MS-06242014	"	"			"	1430		"					"					"		
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS
		6/24/14	1547		6/24/14	1547	
		6/24/14	1800		6/25/14	1820	
		6/25/14	1332		6/24/14		
				PACE	6.26.14	1030	1 Y N Y

Temp in °C | Received on Ice (Y/N) | Custody Sealed Cooler (Y/N) | Samples Intact (Y/N)

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER: Michael Skowronek

SIGNATURE of SAMPLER: _____ DATE Signed (MM/DD/YY): 6/24/14

ORIGINAL

113 of 173

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days

Cooler Receipt Form

Client Name: DDMS Project: SRSNE/ B0054634.0000 Lab Work Order: 12578

A. **Shipping/Container Information** (circle appropriate response)

Courier: FedEx (UPS) USPS Client Other:_____ **Air bill Present:** (Yes) No

Tracking Number: 1Z E630 6540 1974 3683 3

Custody Seal on Cooler/Box Present: Yes (No) **Seals Intact:** Yes No

Cooler/Box Packing Material: (Bubble Wrap) Absorbent Foam Other:_____

Type of Ice: (Wet) Blue None **Ice Intact:** (Yes) Melted

Cooler Temperature: 1°C **Radiation Screened:** Yes (No) **Chain of Custody Present:** (Yes) No

Comments:_____

B. **Laboratory Assignment/Log-in** (check appropriate response)

	YES	NO	N/A	Comment Reference non-Conformance
Chain of Custody properly filled out	✓			
Chain of Custody relinquished	✓			
Sampler Name & Signature on COC	✓			
Containers intact	✓			
Were samples in separate bags	✓			
Sample container labels match COC Sample name/date and time collected	✓			
Sufficient volume provided	✓			
Microseeps containers used	✓			
Are containers properly preserved for the requested testing? (as labeled)	✓			
If an unknown preservation state, were containers checked? Exception: VOA's coliform			✓	If yes, see pH form.
Was volume for dissolved testing field filtered, as noted on the COC? Was volume received in a preserved container?			✓	

Comments:_____

Cooler contents examined/received by: CG **Date:** 6/26/14

Project Manager Review: RK **Date:** 6/27/14

Title: WATER-LHC's/Acetylene/Carbon Dioxide
Datasource: BIOREM12_local
Location: BIOREM_12\WATER 042814 MEEC.SEQ
Created: 4/28/2014 1:31:58 PM by RWilliams
Last Update: 4/28/2014 4:38:06 PM by RWilliams

Peak Table:

Use Recently Detected Retention Times: Off
Peak Retention Time Determination: Absolute
Dead time:
Delay Time of 2'nd Detector: <None>
Delay Time of 3'rd Detector: <None>

No.	Peak Name	Ret.Time	Ret.Time FID	Ret.Time TCD	Window	Standard	Int.Type	Cal.Type	Peak Type	Group
1	*Methane*	*0.475 min*	*0.475 min*		*0.050 AG*	*External*	*Area*	*Quad*	*Auto*	
2	Ethane	0.792 min	0.792 min		0.110 AG	External	Area	Quad	Auto	
3	Ethene	1.125 min	1.125 min		0.150 AG	External	Area	Quad	Auto	
4	Methane	1.505 min		1.505 min	0.150 AG	External	Area	Lin	Auto	
5	Carbon Dioxide	2.044 min		2.044 min	0.400 AG	External	Area	Lin	Auto	
6	Ethene	2.841 min		2.841 min	0.300 AG	External	Area	Lin	Auto	
7	Ethane	3.390 min		3.390 min	0.300 AG	External	Area	Lin	Auto	

Title: WATER-LHC's/Acetylene/Carbon Dioxide
Datasource: BIOREM12_local
Location: BIOREM_12\WATER 042814 MEEC.SEQ
Created: 4/28/2014 1:31:58 PM by RWilliams
Last Update: 4/28/2014 4:38:06 PM by RWilliams

Peak Table:

Use Recently Detected Retention Times: Off
Peak Retention Time Determination: Absolute
Dead time:
Delay Time of 2'nd Detector: <None>
Delay Time of 3'rd Detector: <None>

No.	Peak Name	Ret.Time	Comment
1	*Methane*	*0.475 min*	
2	Ethane	0.792 min	
3	Ethene	1.125 min	
4	Methane	1.505 min	
5	Carbon Dioxide	2.044 min	
6	Ethene	2.841 min	
7	Ethane	3.390 min	

Title: WATER-LHC's/Acetylene/Carbon Dioxide
Datasource: BIOREM12_local
Location: BIOREM_12\WATER 042814 MEEC.SEQ
Created: 4/28/2014 1:31:58 PM by RWilliams
Last Update: 4/28/2014 4:38:06 PM by RWilliams

Amount Table:

Dimension of Amounts:
Reference volume for amounts: Use inject volume of first standard
Number of Amount Columns: 13
Sample column used for amount column assignment: Sample Name

No.	Peak Name	Amount ICAL1 LHC	Amount ICAL2 LHC	Amount ICAL3 LHC	Amount ICAL4 LHC	Amount ICAL5 LHC	Amount ICAL6 LHC	Amount ICAL7 LHC	Amount ICAL8 LHC
1	*Methane*	*0.009720*	*0.024300*	*0.121490*	*0.485950*	*1.943810*	*9.719030*	*48.595140*	*242.975700*
2	Ethane	0.018870	0.047190	0.235930	0.943720	3.774870	18.874340	94.371680	471.858400
3	Ethene	0.021000	0.052510	0.262550	1.050210	4.200840	21.004200	105.021000	525.105000
4	Methane								
5	Carbon Dioxide								
6	Ethene								
7	Ethane								

Title: WATER-LHC's/Acetylene/Carbon Dioxide
Datasource: BIOREM12_local
Location: BIOREM_12\WATER 042814 MEEC.SEQ
Created: 4/28/2014 1:31:58 PM by RWilliams
Last Update: 4/28/2014 4:38:06 PM by RWilliams

Amount Table:

Dimension of Amounts:
Reference volume for amounts: Use inject volume of first standard
Number of Amount Columns: 13
Sample column used for amount column assignment: Sample Name

No.	Peak Name	Amount ICAL1 TCD	Amount ICAL2 TCD	Amount ICAL3 TCD	Amount ICAL4 TCD	Amount ICAL5 TCD
1	*Methane*					
2	Ethane					
3	Ethene					
4	Methane	96.228000	481.140000	2405.700000	12028.500000	24057.000000
5	Carbon Dioxide	0.870256	4.351280	21.756000	108.782000	435.128000
6	Ethene	208.950000	1044.750000	5223.750000	26118.750000	52237.500000
7	Ethane	186.912000	934.560000	4672.800000	23364.000000	46728.000000

Title: WATER DISSOLVED GAS 9 MINUTE RUN
Datasource: BIOREM12_local
Location: BIOREM_12
Timebase: BIOREM12
#Samples: 67

Created: 4/28/2014 11:08:10 AM by RWilliams
Last Update: 4/28/2014 4:51:05 PM by RWilliams

No.	Name	Type	Status	Program	Method	Inj. Date/Time	Comment
1	HE IN LOOP	Unknown	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 11:58:34 AM	
2	ICAL1 LHC	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 12:19:12 PM	201-17-1
3	ICAL2 LHC	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 12:28:36 PM	201-17-2
4	ICAL3 LHC	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 12:39:42 PM	201-17-3
5	ICAL4 LHC	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 12:56:25 PM	201-17-4
6	ICAL5 LHC	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 1:08:35 PM	201-17-5
7	ICAL6 LHC	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 1:19:50 PM	201-17-6
8	ICAL7 LHC	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 1:30:54 PM	201-17-7
9	ICAL8 LHC	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 1:41:00 PM	201-17-8
10	HE IN LOOP	Unknown	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 1:50:43 PM	
11	ICV FID	Unknown	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 2:01:14 PM	201-17-9
12	ICB FID	Unknown	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 2:10:37 PM	
13	ICAL1 TCD	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 3:39:49 PM	201-18-1
14	ICAL2 TCD	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 3:49:43 PM	201-18-2
15	ICAL3 TCD	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 3:59:40 PM	201-18-3
16	ICAL4 TCD	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 4:10:57 PM	201-18-4
17	ICAL5 TCD	Standard	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 4:20:16 PM	201-18-5
18	HE IN LOOP	Unknown	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 4:29:38 PM	
19	ICV TCD	Unknown	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 4:39:12 PM	201-18-6
20	ICB TCD	Unknown	Finished	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 4:51:15 PM	
▷	HE IN LOOP	Unknown	Running	AM20GAxMEEC	WATER 042814 MEEC	4/28/2014 5:00:20 PM	
22	HE IN LOOP	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
23	CCV1 FID 042914 5X	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		201-9-1
24	CCV1 TCD 042914 5X	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		201-9-2
25	CCB1 042914	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
26	27343-LCSHRF	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		201-9-3
27	27345-LCDHRF	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		201-9-3
28	27341-MBHRF	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
29	119180001	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
30	119180002	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
31	119180003	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
32	119180004	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
33	119360001	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
34	119360002	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
35	119360003	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
36	119360004	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
37	119360005	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
38	119360006	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
39	119360007	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
40	119370008	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		
41	CCV2 FID 042914 5X	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		201-9-1
42	CCV2 TCD 042914 5X	Unknown	Single	AM20GAxMEEC	WATER 042814 MEEC		201-9-2

BIOREM 12 9 Minute FID Calibration

RCW 042814

201-17-1 Injected 1.0cc of RA-11-09 and 39cc of UHP Nitrogen into a 160cc septum-capped serum bottle with UHP Nitrogen at 1ATM.

201-17-2 Injected 8.0cc of RA-11-09 and 32cc of UHP Nitrogen into a 160cc septum-capped serum bottle with UHP Nitrogen at 1ATM

201-17-3 ICAL1: Injected 2.0cc of 201-17-1 and 88cc of UHP Nitrogen into a 160cc septum-capped serum bottle with UHP Nitrogen at 1ATM.

201-17-4 ICAL2: Injected 1.0cc of 201-17-1 and 2.8cc of UHP Nitrogen into a 21cc septum-capped vial with UHP Nitrogen at 1ATM.

201-17-5 ICAL3: Injected 5.0cc of 201-17-1 and 24cc of UHP Nitrogen into a 21cc septum-capped vial with UHP Nitrogen at 1ATM.

201-17-6 ICAL4: Injected 2.5cc of 201-17-2 and 26.5cc of UHP Nitrogen into a 21cc septum-capped vial with UHP Nitrogen at 1ATM.

201-17-7 ICAL5: Injected 1.0cc of 201-17-2 and 8cc of UHP Nitrogen into a 21cc septum-capped vial with UHP Nitrogen at 1ATM.

201-17-8 ICAL6: Injected 2.0cc of RA-11-09 and 27cc of UHP Nitrogen into a 21cc septum-capped vial with UHP Nitrogen at 1ATM.

201-17-9 ICAL7: Injected 10.0cc of RA-11-09 and 8cc of UHP Nitrogen into a 21cc septum-capped vial with UHP Nitrogen at 1ATM.

201-17-10 ICAL8: Injected RA-11-09 as is.

201-17-11 ICV Injected 2.0cc of RA-11-09 into a 21cc septum capped vial with UHP Nitrogen at 1ATM.

201-17-12 ICB UHP Helium in 160cc

RCW

042814

BIOROM12 TCD Calibration
RAW 042814

201-18-1 Injected 5.0cc of RA-11-03, 5.0cc of RA-10-05, 5.0cc of RA-11-01, 5.0cc of RA-08-04 and 70.0cc of UHP Helium into a 160cc septum-capped serum bottle with UHP Helium at 1 ATM.

201-18-2 ICAL1: Injected 1.0cc of 201-18-1 and 28.0cc of UHP Helium into a 21.0cc septum-capped vial with UHP Helium at 1 ATM.

201-18-3 ICAL2: Injected 5.0cc of 201-18-1 and 24.0cc of UHP Helium into a 21.0cc septum-capped vial with UHP Helium at 1 ATM.
RAW 042814

201-18-4 ICAL3: Injected 25.0cc of 201-18-1 and 4.0cc of UHP Helium into a 21.0cc septum-capped vial with UHP Helium at 1 ATM.

201-18-5 ICAL4: Injected 2.5cc of RA-11-03, 2.5cc of RA-10-05, 2.5cc of RA-11-01, 2.5cc of RA-08-04 and 19.0cc of UHP Helium into a 21.0cc septum-capped vial with UHP Helium at 1 ATM.

201-18-6 ICAL5: Injected 5.0cc of RA-11-03, 5.0cc of RA-10-5, 5.0cc of RA-11-01, 10.0cc of RA-08-04 and 4.0cc of UHP Helium into a 21.0cc septum-capped vial with UHP Helium at 1 ATM.

201-18-7 ICV: Injected 21.0cc of RA-10-22 into a 21.0cc septum-capped vial with UHP Helium at 1 ATM.

201-18-8 ICB: Helium in Loop

RAW
042814

Dissolved Light Hydrocarbons 04/28/14

FID Detection - 9 Minute Run

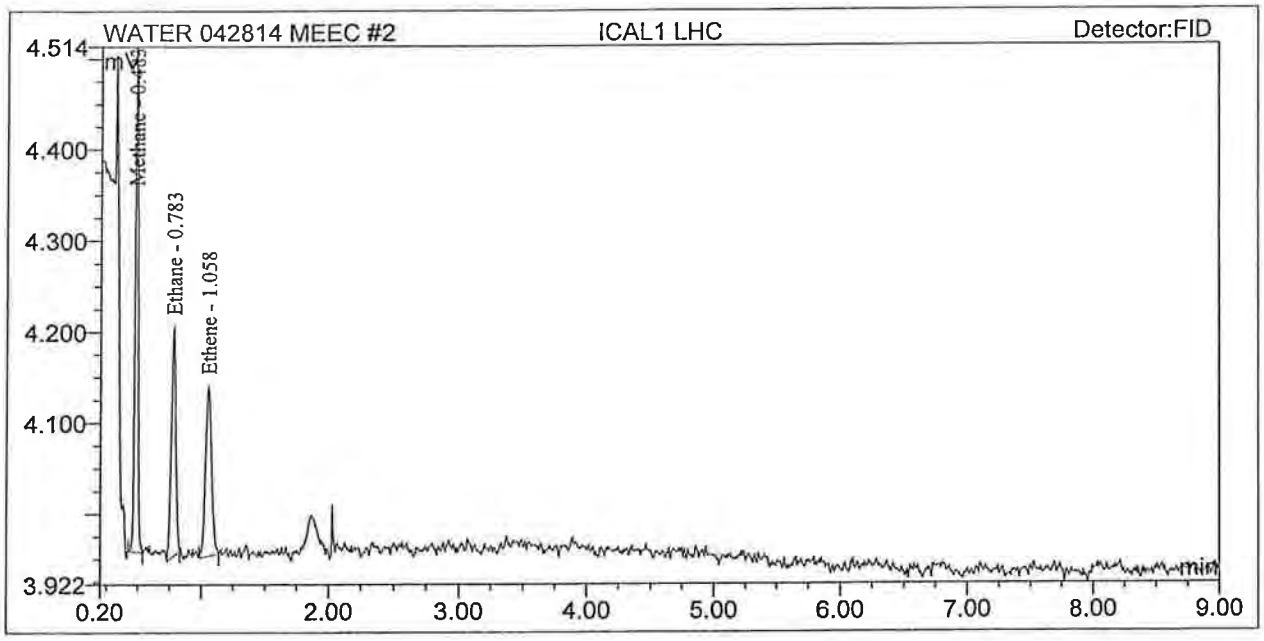
No.	Ret.Time min	Peak Name	Cal.Type	R-Square %	Corr.Coeff. %	#Points	Slope	Curve
1	0.48	Methane	Quad	100.000	99.9973	8	0.4960	0.0001
2	0.78	Ethane	Quad	100.000	99.9968	8	0.4831	0.0001
3	1.05	Ethene	Quad	100.000	99.9965	8	0.4368	0.0000

Sample Analysis Report

Sample Name:	ICAL1 LHC	**Sequence No:**	2
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 12:19	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-17-1

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.483	0.014	0.556	BMB	0.0290
2	Ethane	0.783	0.010	0.252	BMB	0.0209
3	Ethene	1.058	0.010	0.187	BMB	0.0239

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

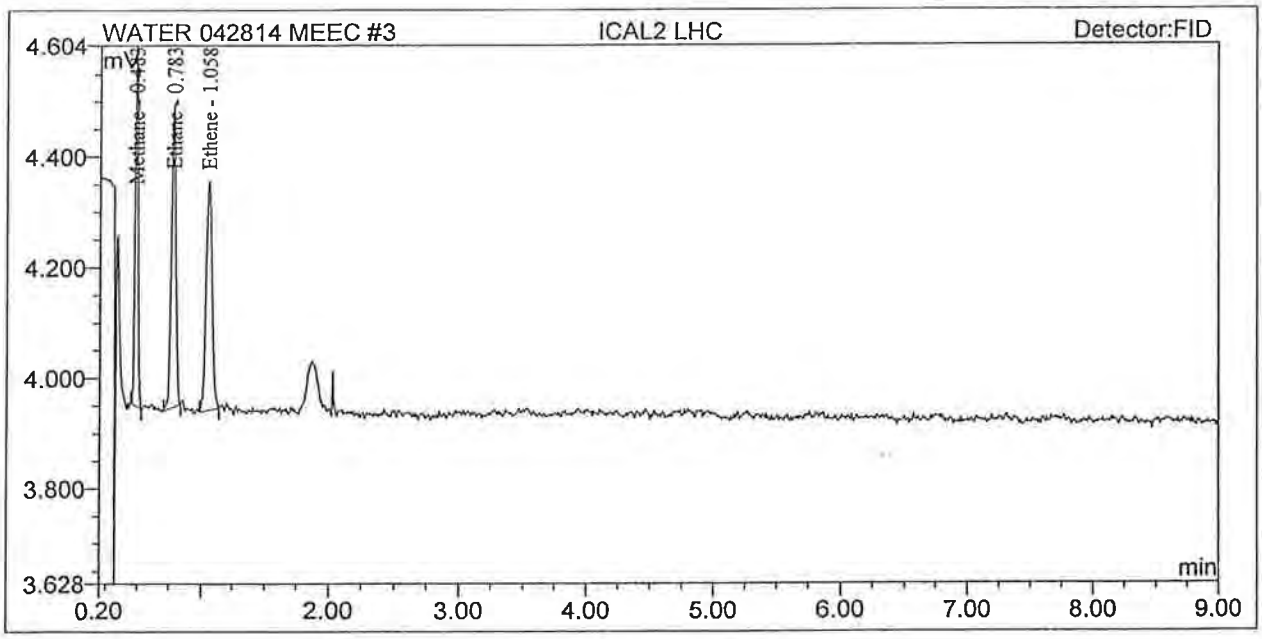


Sample Analysis Report

Sample Name:	ICAL2 LHC	**Sequence No:**	3
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 12:28	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-17-2

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.483	0.017	0.653	BMB	0.0333
2	Ethane	0.783	0.022	0.549	BMB	0.0453
3	Ethene	1.058	0.023	0.414	BMB	0.0522

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

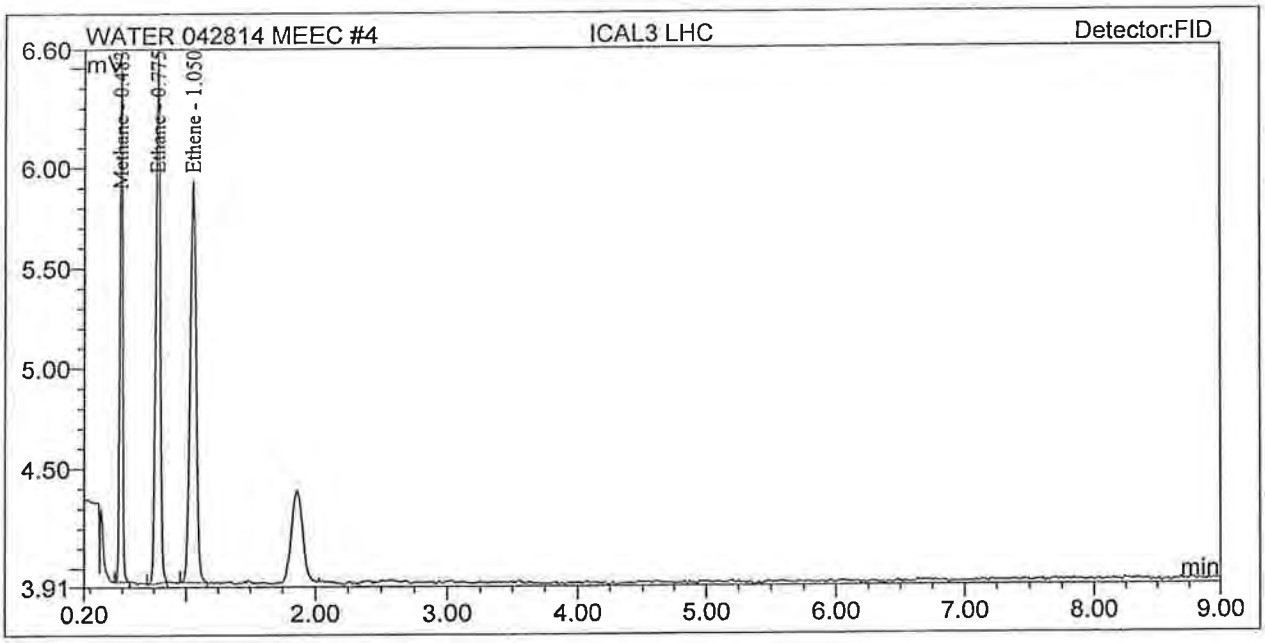


Sample Analysis Report

Sample Name:	ICAL3 LHC	**Sequence No:**	4
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 12:39	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-17-3

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.483	0.066	2.615	BMB	0.1332
2	Ethane	0.775	0.106	2.667	BMB	0.2195
3	Ethene	1.050	0.107	2.001	BMB	0.2445

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

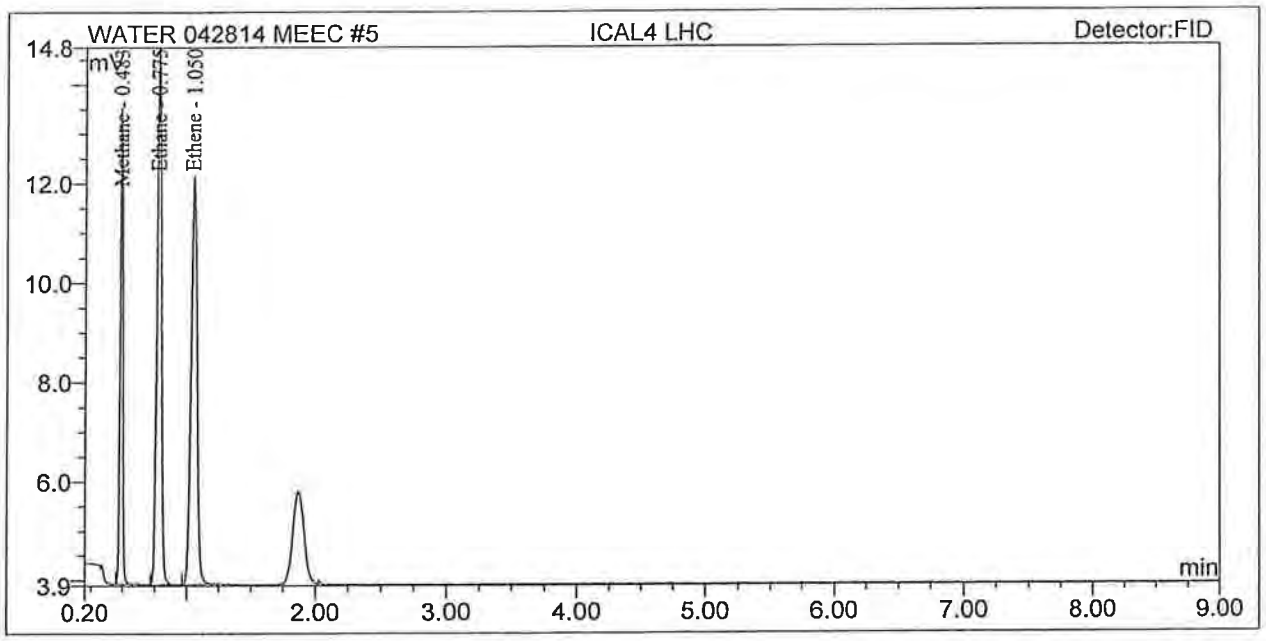


Sample Analysis Report

Sample Name:	ICAL4 LHC	**Sequence No:**	5
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 12:56	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-17-4

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.483	0.241	9.591	BMB	0.4867
2	Ethane	0.775	0.438	10.837	BMB	0.9066
3	Ethene	1.050	0.443	8.227	BMB	1.0142

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

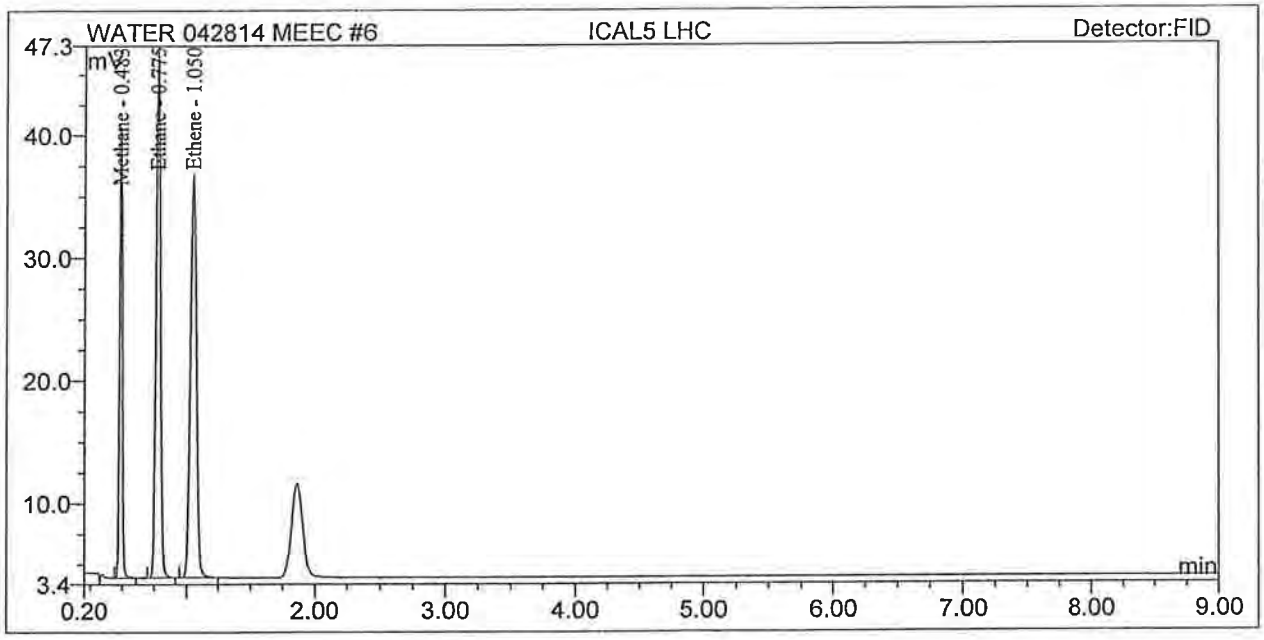


Sample Analysis Report

Sample Name:	ICAL5 LHC	**Sequence No:**	6
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 13:08	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-17-5

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.483	0.938	36.869	BMB	1.8912
2	Ethane	0.775	1.733	43.424	BMB	3.5854
3	Ethene	1.050	1.757	32.954	BMB	4.0205

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

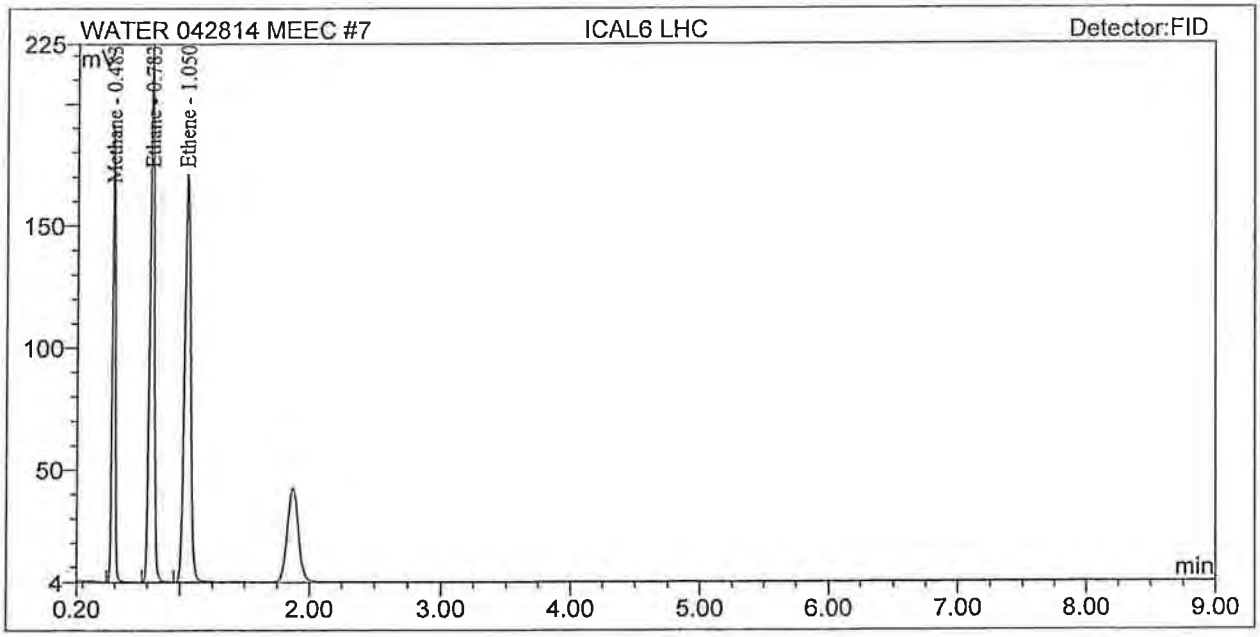


Sample Analysis Report

Sample Name:	ICAL6 LHC	**Sequence No:**	7
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 13:19	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-17-6

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.483	4.753	187.692	BMB	9.5642
2	Ethane	0.783	8.913	220.839	BMb	18.4127
3	Ethene	1.050	9.032	167.080	bMB	20.6318

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

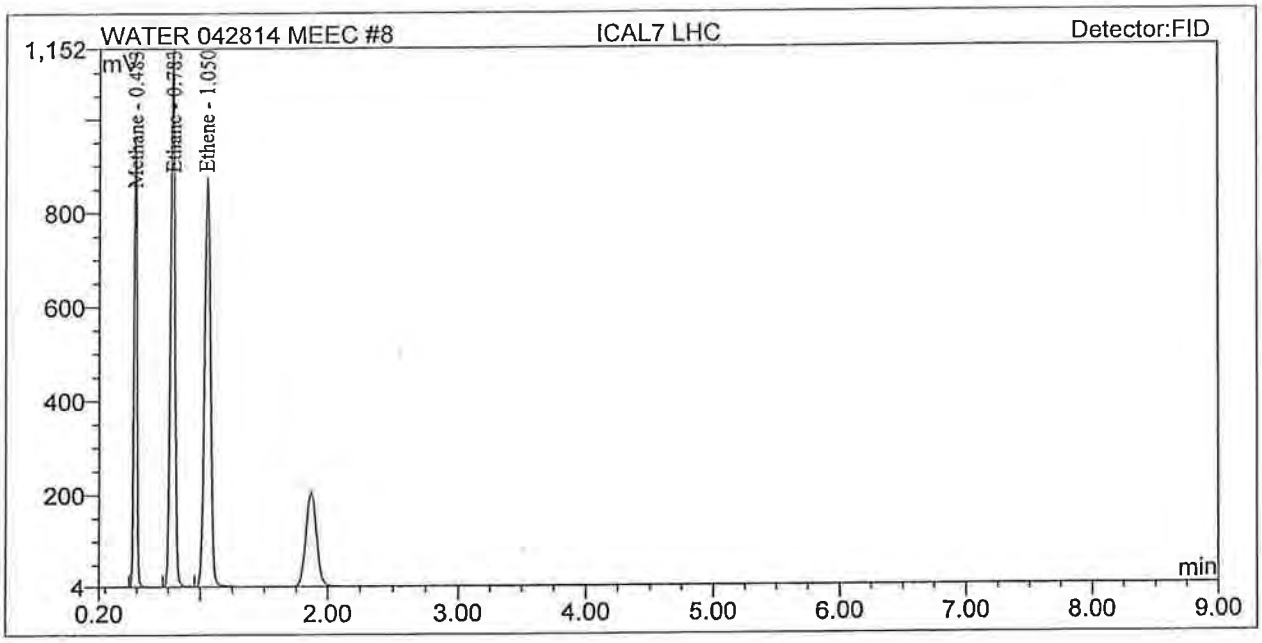


Sample Analysis Report

Sample Name:	ICAL7 LHC	**Sequence No:**	8
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 13:30	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-17-7

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.483	24.357	957.662	BMB	48.6342
2	Ethane	0.783	46.135	1147.411	BMb	94.4903
3	Ethene	1.050	46.433	871.043	bMB	105.1181

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

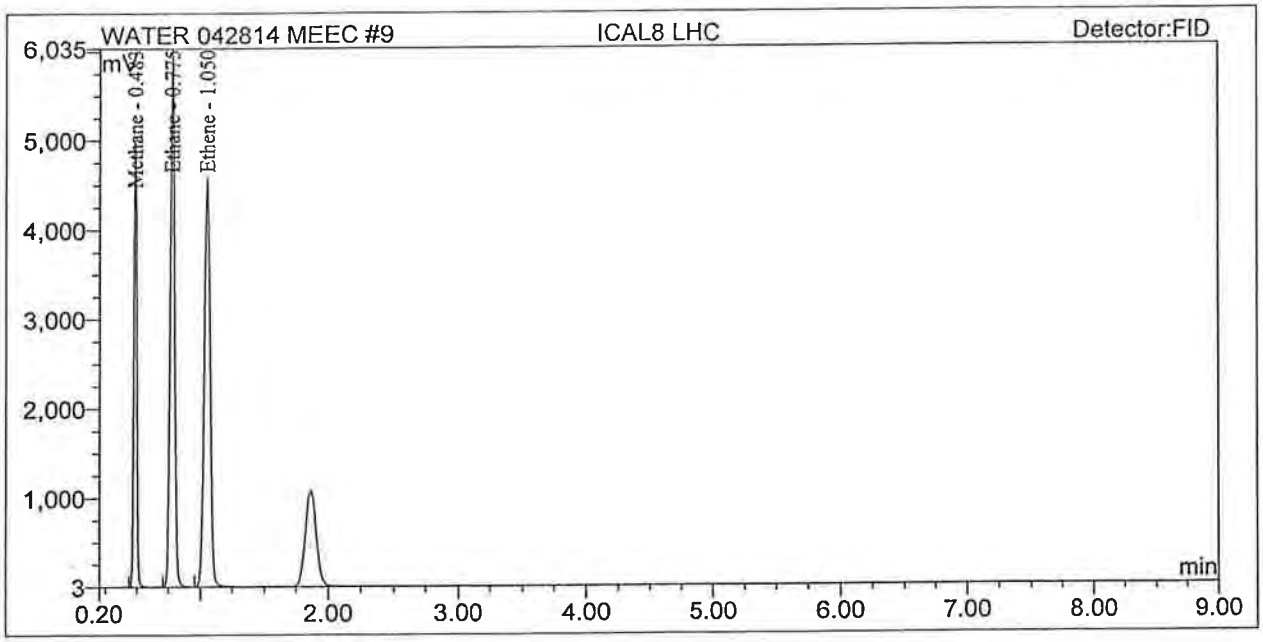


Sample Analysis Report

Sample Name:	ICAL8 LHC	**Sequence No:**	9
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 13:41	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-17-8

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.483	126.364	5006.107	BMB	242.9745
2	Ethane	0.775	240.163	6029.923	BMb	471.8547
3	Ethene	1.050	242.222	4580.851	bMB	525.1020

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

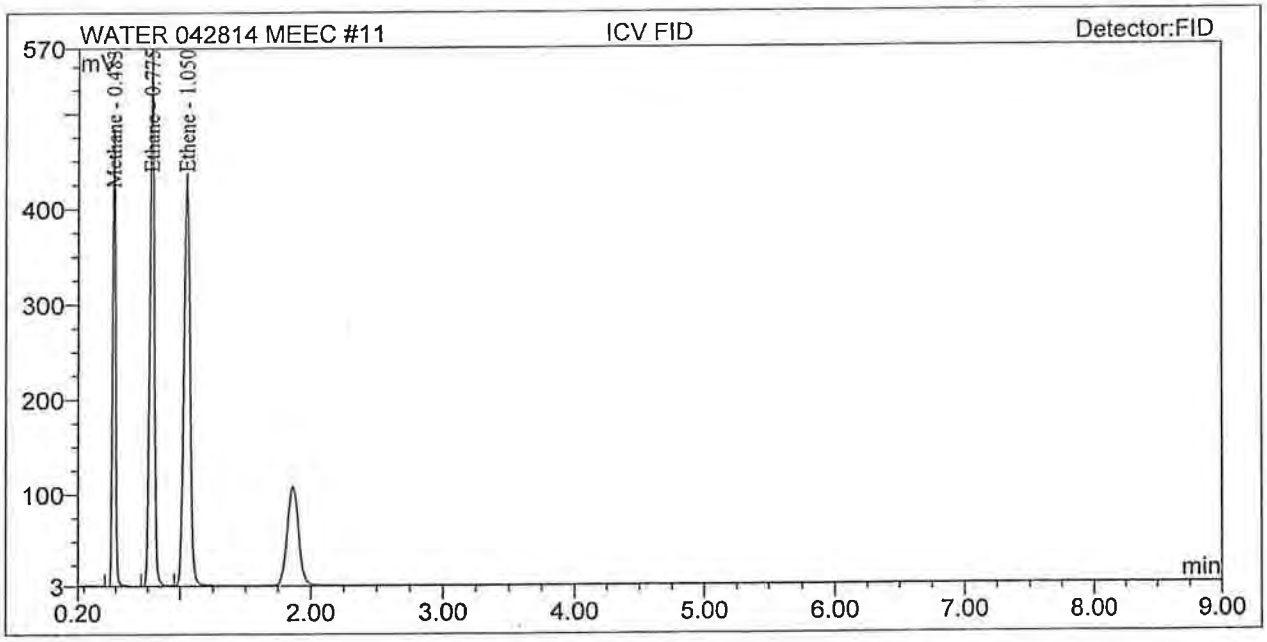


Sample Analysis Report

Sample Name:	ICV FID	**Sequence No:**	11
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 14:01	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-17-9

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount %R	Amount
1	Methane	0.483	12.289	481.371	BMB	100	24.6541
2	Ethane	0.775	22.656	565.665	bM	99	46.6547
3	Ethene	1.050	23.072	434.149	MB	100	52.5234

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

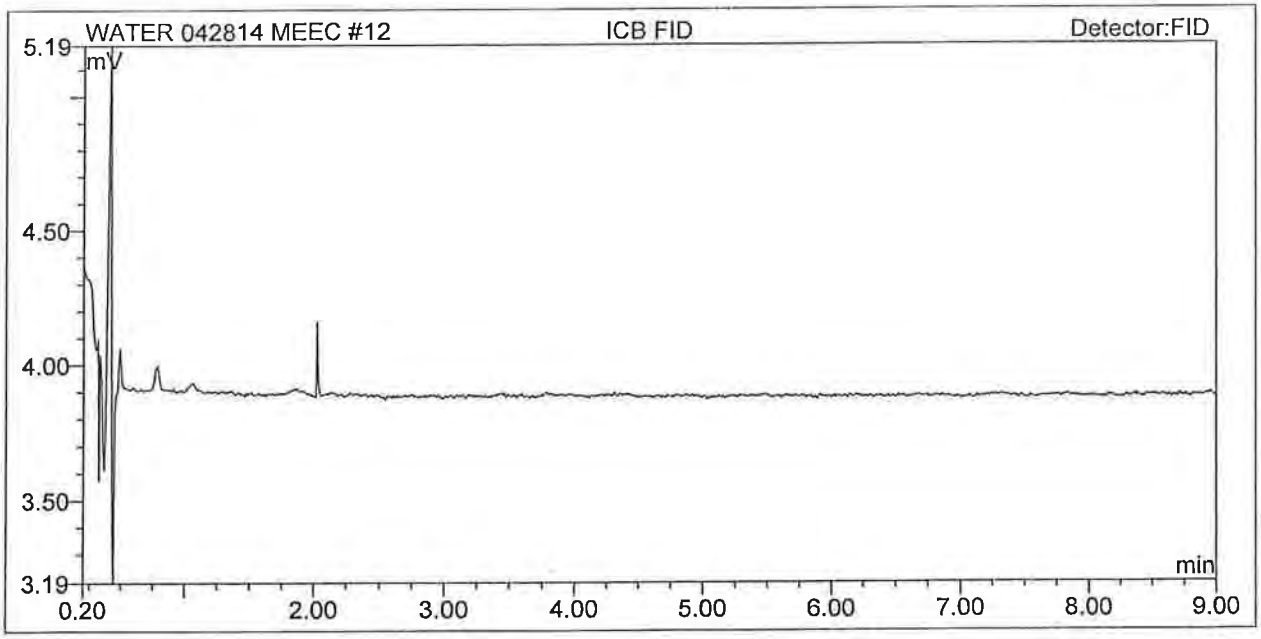


Sample Analysis Report

Sample Name:	ICB FID	**Sequence No:**	12
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 14:10	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)



Dissolved Light Hydrocarbons 04/28/14

TCD Detection - 9&12 Minute Run

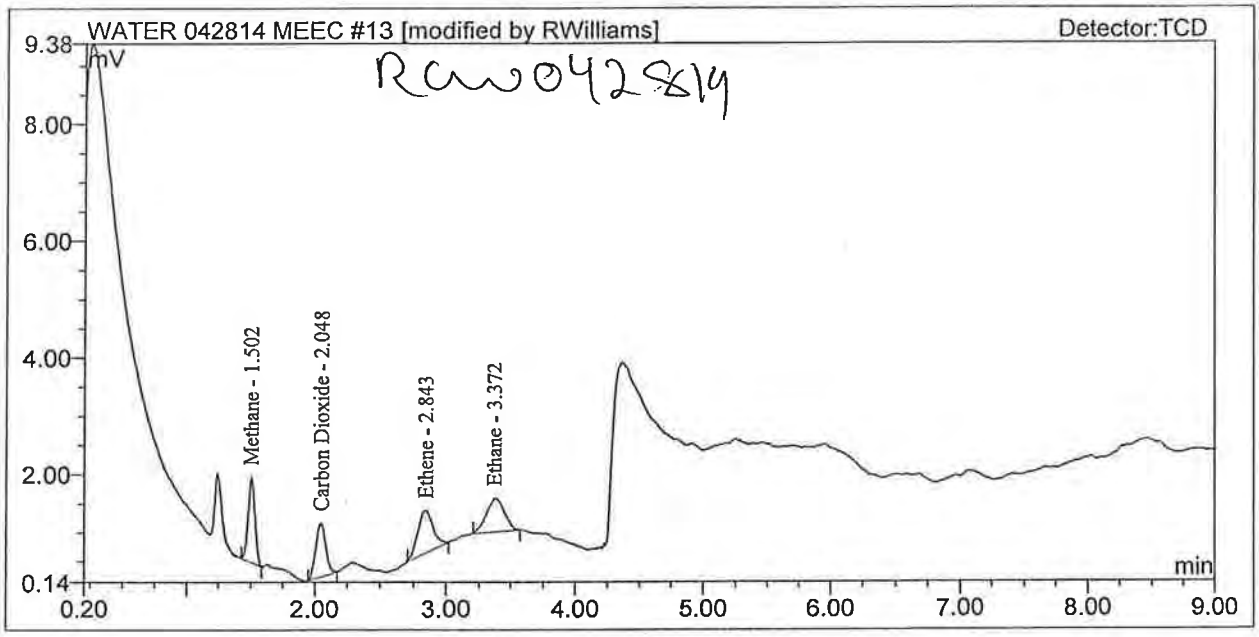
No.	Ret.Time min	Peak Name	Cal.Type	R-Square %	Corr.Coeff. %	#Points	Slope	Curve
1	1.50	Methane	Lin	99.970	99.9867	5	0.0009	0.0000
2	2.04	Carbon Dioxide	Lin	99.998	99.9998	5	0.1292	0.0000
3	2.84	Ethene	Lin	99.998	99.9989	5	0.0005	0.0000
4	3.39	Ethane	Lin	99.998	99.9993	5	0.0007	0.0000

Sample Analysis Report

Sample Name:	ICAL1 TCD	**Sequence No:**	13
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 15:39	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-18-1

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.502	0.090	1.472	BMB	100.6145
2	Carbon Dioxide	2.048	0.084	0.941	BMB	0.6500
3	Ethene	2.843	0.102	0.739	BMB	185.9328
4	Ethane	3.372	0.096	0.583	BMB*	144.7368

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

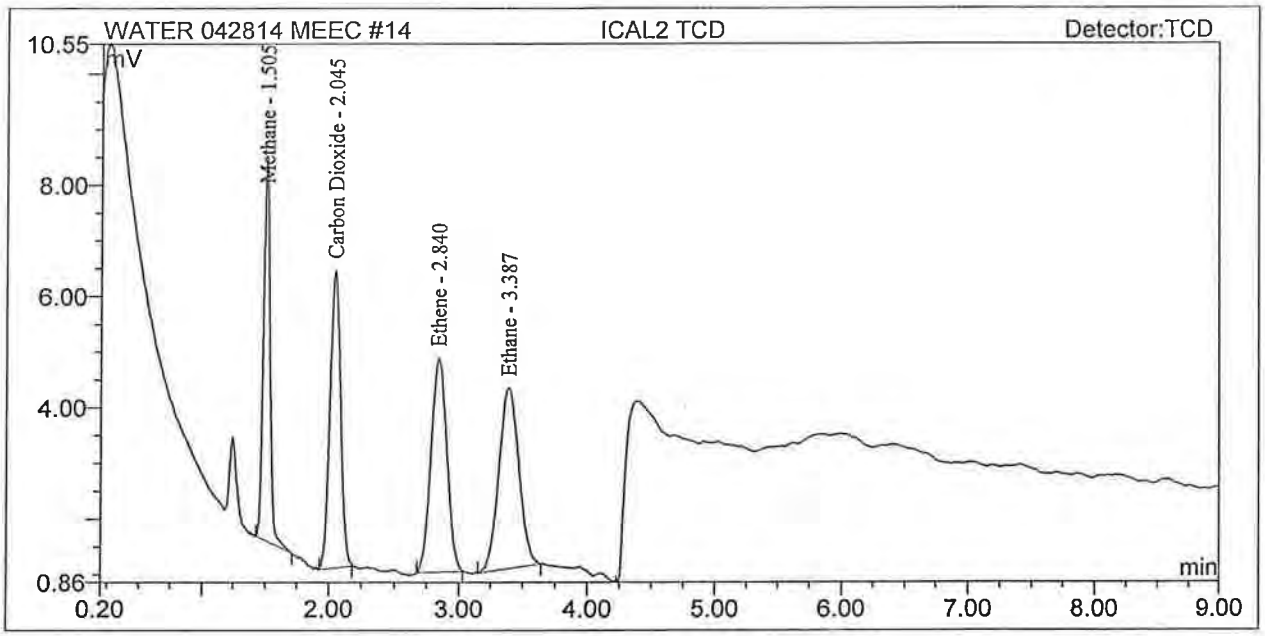


Sample Analysis Report

Sample Name:	ICAL2 TCD	**Sequence No:**	14
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 15:49	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-18-2

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.505	0.426	6.878	BMB	475.1396
2	Carbon Dioxide	2.045	0.512	5.354	BMB	3.9648
3	Ethene	2.840	0.547	3.844	BMB	995.7297
4	Ethane	3.387	0.589	3.244	BMB	884.6859

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

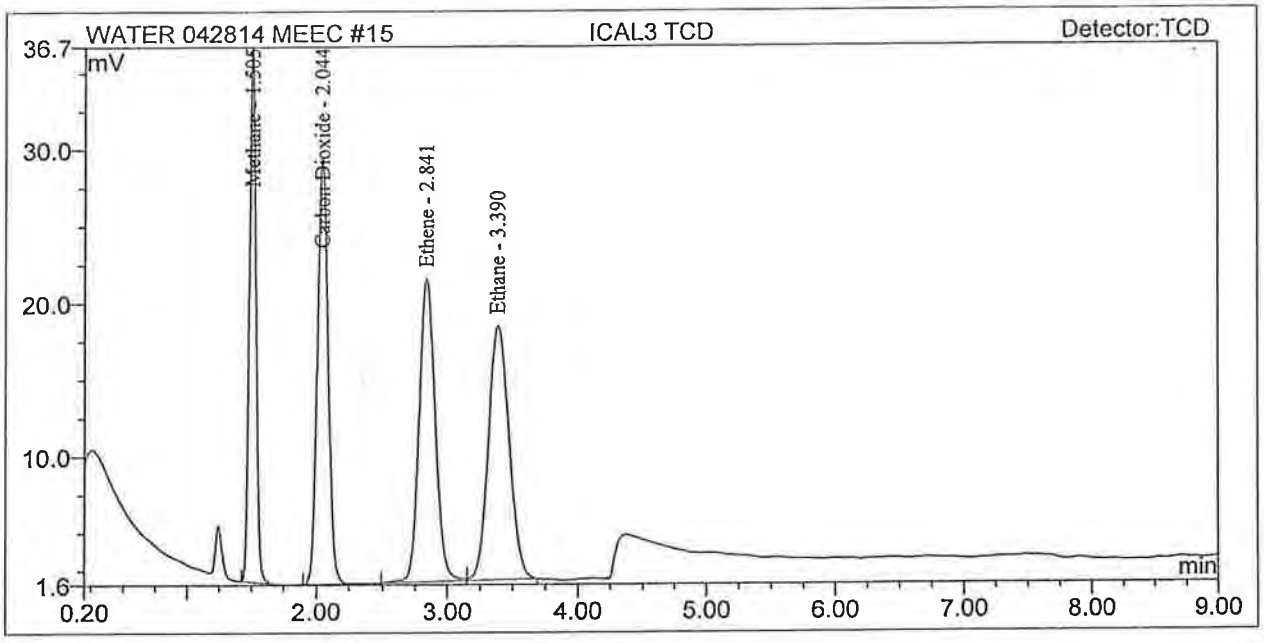


Sample Analysis Report

Sample Name:	ICAL3 TCD	**Sequence No:**	15
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 15:59	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-18-3

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.505	2.104	34.922	BMB	2348.4299
2	Carbon Dioxide	2.044	2.696	27.773	BMB	20.8681
3	Ethene	2.841	2.925	19.804	BM	5325.1459
4	Ethane	3.390	3.053	16.624	MB	4589.7859

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

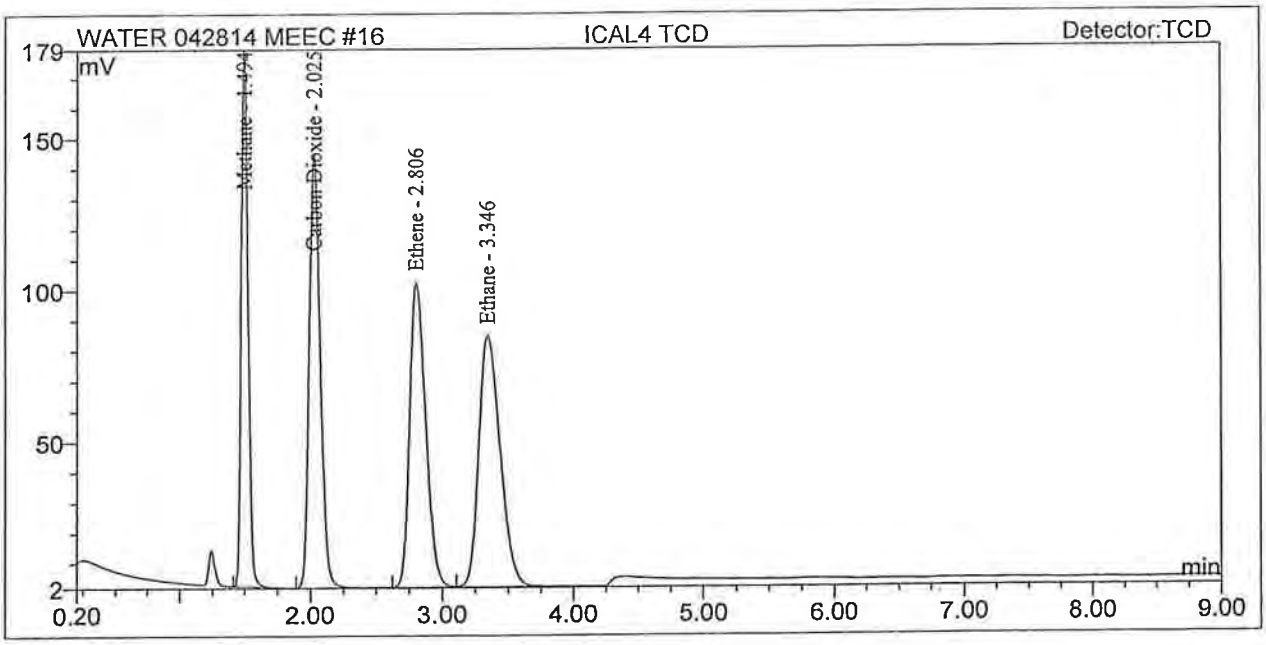


Sample Analysis Report

Sample Name:	ICAL4 TCD	**Sequence No:**	16
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 16:10	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-18-4

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.494	10.493	176.985	BMB	11714.0496
2	Carbon Dioxide	2.025	13.923	142.511	BMB	107.7785
3	Ethene	2.806	14.434	100.333	BM	26277.8535
4	Ethane	3.346	15.617	82.730	MB	23475.1914

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

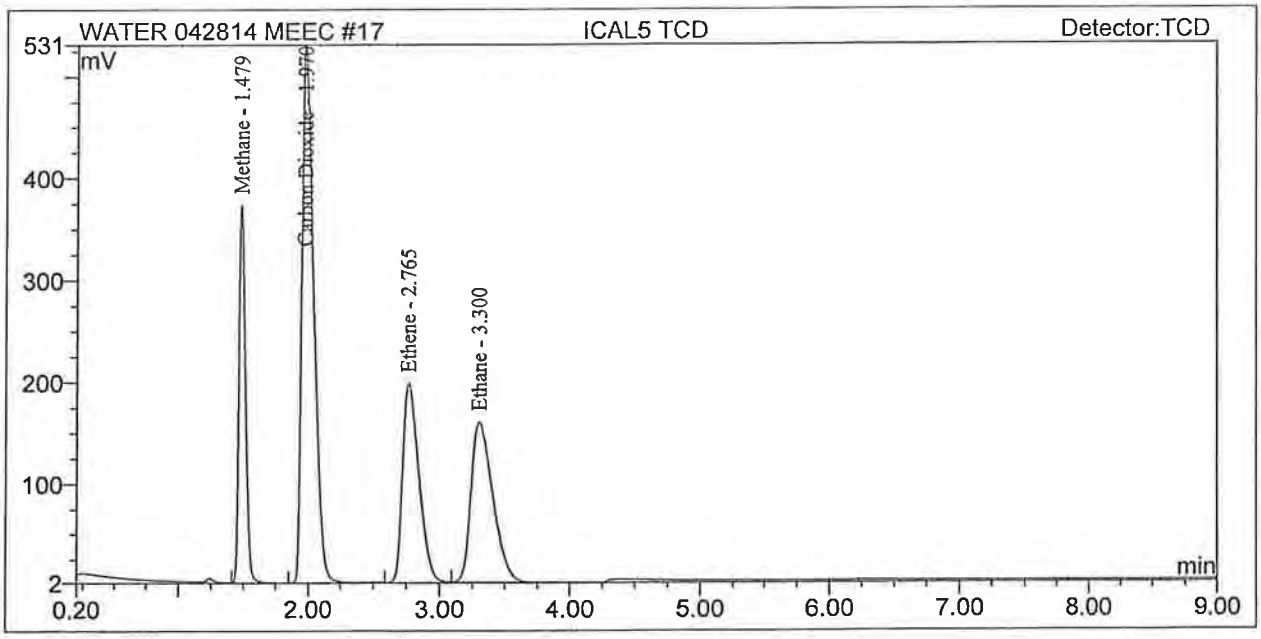


Sample Analysis Report

Sample Name:	ICAL5 TCD	**Sequence No:**	17
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 16:20	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-18-5

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.479	21.696	370.900	BMB	24220.0547
2	Carbon Dioxide	1.970	56.251	528.750	BMB	435.4276
3	Ethene	2.765	28.644	195.876	BM	52148.8811
4	Ethane	3.300	31.056	157.881	MB	46681.8719

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

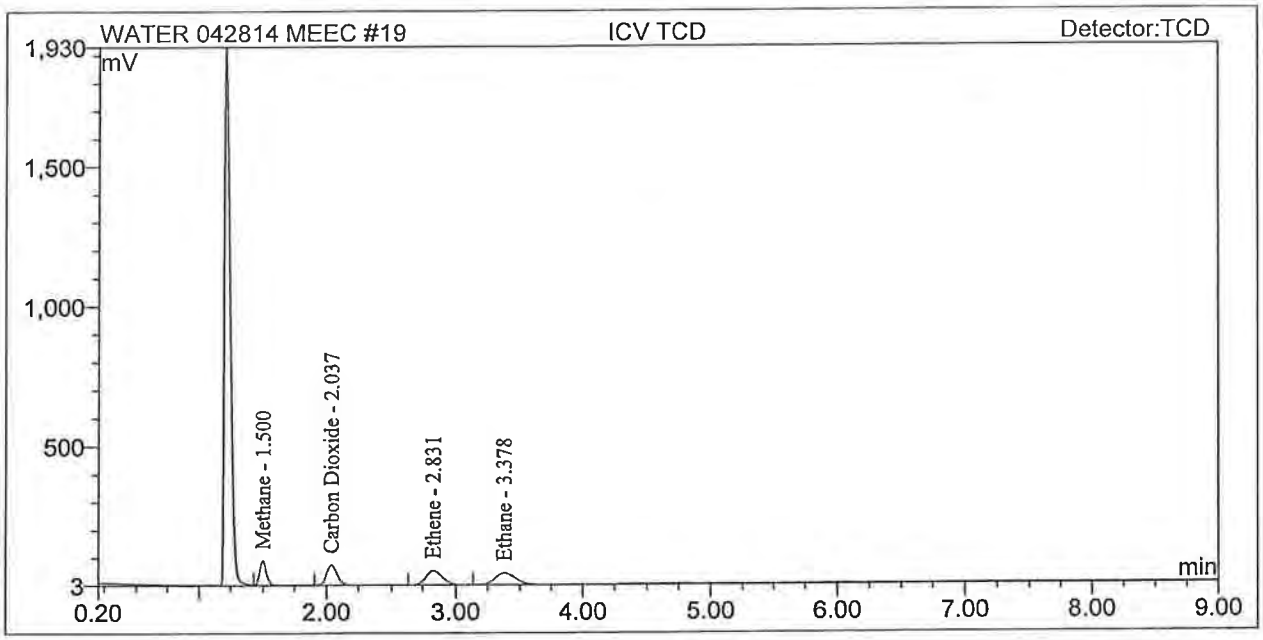


Sample Analysis Report

Sample Name:	ICV TCD	**Sequence No:**	19
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 16:39	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-18-6

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount %R	Amount
1	Methane	1.500	5.285	87.296	BMB	97	5899.4210
2	Carbon Dioxide	2.037	7.113	72.741	BMB	100	55.0636
3	Ethene	2.831	7.439	51.363	BM	103	13542.8498
4	Ethane	3.378	7.953	42.715	MB	101	11954.6552

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

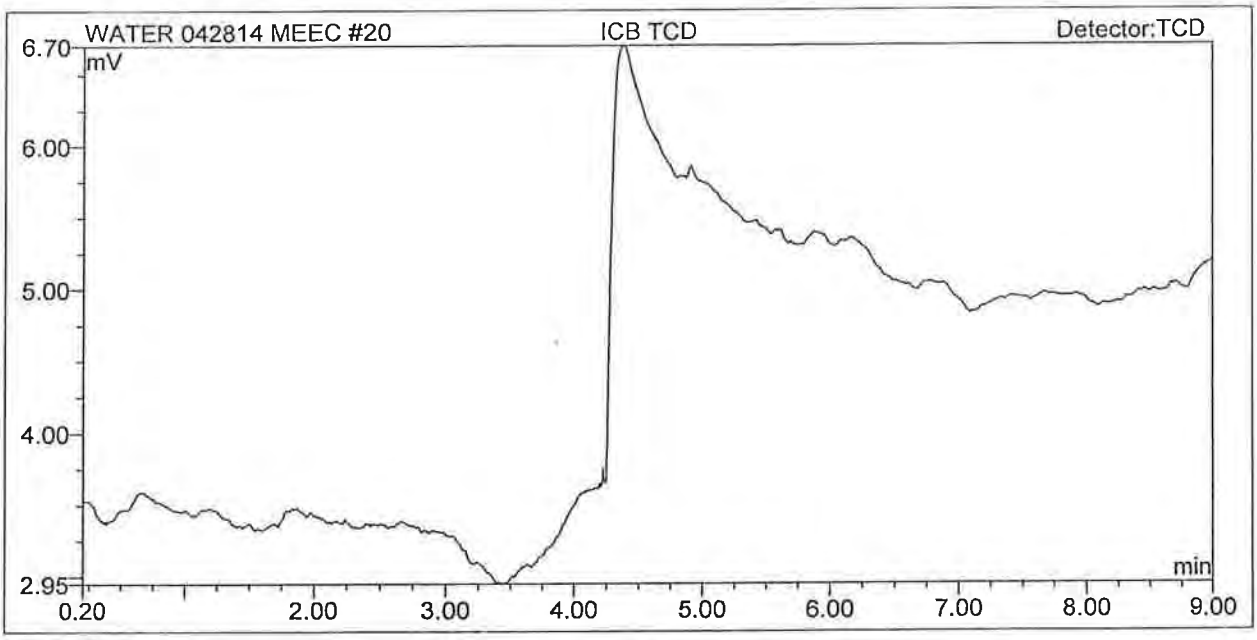


Sample Analysis Report

Sample Name:	ICB TCD	**Sequence No:**	20
Sequence Name:	WATER 042814 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	4/28/2014 16:51	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)



Microseeps, Inc.

Bioremediation/Natural Attenuation Raw Data Summary

ANALYSIS DATE: 07/08/14

Water Samples:

PROJECT:	Methane	Ethane	Ethene	C_3	C_4	CO_2
12578 (0001-0002) ^^^	X	X	X			
12579 (0001-0004)	X	X	X			
12603 (0001-0002)	X	X	X			X
12606 (0010-0014)						X
12607 (0001-0005)	X	X	X			
12585 (0001-0002) Reruns	X					

Water Samples:	Preparation/Analysis Method	Batch
Light Hydrocarbons (C1-C4)	PM01C/AM20GAx	**DISG/ 3894**
Permanent Gases (C1-C2, CO2)	PM01C/AM20GAx	

Attachments:Raw Data Summaries: Data File ID, Date/Time Analyzed, Laboratory Sample ID

Any Methane, Ethane or Ethene that saturates the FID or is overrange is reported from the TCD.

Printouts of diluted samples have not been corrected for the dilution.

*** Client requires a Full Data Package

+++ Client requires a Level 4 Data Package

^^^ Client requires a Level 3 Data Package with Carolawn Type High Level LCS/LCD.

Analyst Initials: ROW

Reviewer Initials: MM

Data reviewed: 070814

Entered By/Date: LIMS UPLOAD/ 070814

Microseeps, Inc.

Bioremediation/Natural Attenuation Raw Data Summary

ANALYSIS DATE: 07/08/14

Water Samples:

PROJECT:	Methane	Ethane	Ethene	C_3	C_4	CO_2
12578 (0003-0004) ^^^	X	X	X			

Water Samples:	Preparation/Analysis Method	Batch
Light Hydrocarbons (C1-C4)	PM01C/AM20GAx	**DISG/ 3898**
Permanent Gases (C1-C2, CO2)	PM01C/AM20GAx	

Attachments:Raw Data Summaries: Data File ID, Date/Time Analyzed, Laboratory Sample ID

Any Methane, Ethane or Ethene that saturates the FID or is overrange is reported from the TCD.

Printouts of diluted samples have not been corrected for the dilution.

*** Client requires a Full Data Package

+++ Client requires a Level 4 Data Package

^^^ Client requires a Level 3 Data Package with Carolawn Type High Level LCS/LCD. - See DISG/ 3894 for ICAL

Analyst Initials: RCW

Reviewer Initials: [illegible]

Data reviewed: 070814

Entered By/Date: LIMS UPLOAD/ 070814

Case Narrative/BIOREM 12

Analytical Method: AM20Gax **Batch Number** **Original Run Date:** 07/08/14

Light Hydrocarbons (C_1-C_4) DISG/ 3894
Permanent Gases (CH_4, CO_2)

1. **Sample numbers:**

12578 (0001-0002)
12579 (0001-0004)
12603 (0001-0002)
12606 (0010-0014)
12607 (0001-0005)
12585 (0001-0002)

2. Out of Control Event:

i. Manual integrations are due to the software not compensating for baseline fluctuations.

3. Corrective Action Taken:

i. None

4. Result:

i. Analysis OK

5. Observations to support use of data: NA

Manual Integration Checklist and Approval

- **Manual Integration approved?: Yes No**
- **Satisfactorily documented on this narrative?**
- **Manually integrated chromatogram initialed and dated by analyst?**

_____ _____
Signature Lead Analyst or Lab. Mgr. **Date**

Analyzed & Reviewed by:_RCW_Date: 070814
Manual Integration Conducted? **Yes**

Reviewed by: RM **Date:** 070814
Reviewed & Entered by: LIMS UPLOAD **Date:** 070814
Reviewed by: _____ **Date:** _____

Corrected by: _____ **Date:** _____

Case Narrative/BIOREM 12

Analytical Method: AM20Gax **Batch Number** **Original Run Date:** 07/08/14

Light Hydrocarbons (C_1-C_4) DISG/ 3898
Permanent Gases (CH_4, CO_2)

1. **Sample numbers:**

   2578 (0003-0004)

2. **Out of Control Event:**
   i. Manual integrations are due to the software not compensating for baseline fluctuations.

3. **Corrective Action Taken:**
   i. None

4. **Result:**
   i. Analysis OK

5. **Observations to support use of data:** NA

Manual Integration Checklist and Approval

- **Manual Integration approved?: Yes No**
- **Satisfactorily documented on this narrative?**
- **Manually integrated chromatogram initialed and dated by analyst?**

_____ _____
Signature Lead Analyst or Lab. Mgr. **Date**

Analyzed & Reviewed by: RCW **Date:** 070814

Manual Integration Conducted? Yes

Reviewed by: JM **Date:** 070814

Reviewed & Entered by: LIMS UPLOAD **Date:** 070814

Reviewed by: _____ **Date:** _____

Corrected by: _____ **Date:** _____

Microseeps, Inc.

PROJECTS:
12578 (0001-0002)
12579 (0001-0004)
12603 (0001-0002)
12606 (0010-0014)
12607 (0001-0005)
12585 (0001-0002)

----- BIOREM 12 -----
----- QUALITY CONTROL -----
----- DATE ANALYZED: 07/08/14 -----
----- MATRIX: WATER -----
Batch: DISG/ 3894
Methods: PM01/AM20GAx

Method File: WATER 042814 MEEC
Sequence File: WATER 060314 MEEC

	CCV1: FID 201-22-1 / TCD 201-22-2				CCB1		CCV2: FID 201-22-1 / TCD 201-22-2					CCB2	
COMPOUND	FILE ID	TRUE CONC.	MEASURED	%REC.	FILE ID	MEASURED	COMPOUND	FILE ID	TRUE CONC	MEASURED	% REC.	FILE ID	MEASURED
METHANE (FID)	905	9.817	9.484	97	907	ND	METHANE (FID)	923	9.817	9.622	98	925	ND
ETHANE (FID)	905	18.79	17.35	92	907	ND	ETHANE (FID)	923	18.79	17.72	94	925	ND
ETHENE (FID)	905	21.11	19.54	93	907	ND	ETHENE (FID)	923	21.11	19.94	94	925	ND
METHANE (TCD)	906	2440	2375	97	907	ND	METHANE (TCD)	924	2440	2407	99	925	ND
CARBON DIOXIDE	906	21.9	21.9	100	907	ND	CARBON DIOXIDE	924	21.9	22.3	102	925	ND
ETHENE (TCD)	906	5261	5456	104	907	ND	ETHENE (TCD)	924	5261	5516	105	925	ND
ETHANE (TCD)	906	4720	4818	102	907	ND	ETHANE (TCD)	924	4720	4936	105	925	ND

	CCV4: FID 201-22-5 / TCD 201-22-4				CCB4	
COMPOUND	FILE ID	TRUE CONC	MEASURED	%REC.	FILE ID	MEASURED
METHANE (FID)	940	49.086	50.761	103	941	ND
ETHANE (FID)	940	93.93	94.83	101	941	ND
ETHENE (FID)	940	105.53	105.44	100	941	ND
METHANE (TCD)	939	6099	6119	100	941	ND
CARBON DIOXIDE	939	54.8	56.3	103	941	ND
ETHENE (TCD)	939	13151	13912	106	941	ND
ETHANE (TCD)	939	11800	12308	104	941	ND

	LCS: 201-22-3 High Level					LCSD: 201-22-3 High Level					Method Blank	
COMPOUND	FILE ID	TRUE CONC.	MEASURED	% REC.	RPD	COMPOUND	FILE ID	TRUE CONC	MEASURED	% REC.	FILE ID	MEASURED
ETHANE (FID)	908	37.9	37.0	98	1.63	ETHANE (FID)	909	37.9	37.6	99	910	ND
ETHENE (FID)	908	35.3	34.4	97	1.21	ETHENE (FID)	909	35.3	34.8	99	910	ND
METHANE (TCD)	908	747	711	95	1.81	METHANE (TCD)	909	747	724	97	910	ND
CARBON DIOXIDE	908	117	132	113	0.32	CARBON DIOXIDE	909	117	133	113	910	ND

Initial/Continuing Calibration Verification accuracy : 85-115 % recovery
Laboratory Control Sample accuracy : 80-120% recovery
Duplicate Relative Percent Difference: RPD 0-20%
Initial/Continuing Calibration or Method Blank <PQL/LOQ

ANALYST: RCW 070814

REVIEW

Microseeps, Inc.

PROJECTS:
12578 (0003-0004)

----- BIOREM 12 -----
----- QUALITY CONTROL -----
----- DATE ANALYZED: 07/08/14 -----
----- MATRIX: WATER -----
Batch: DISG/ 3898
Methods: PM01/AM20GAx

Method File: WATER 042814 MEEC
Sequence File: WATER 060314 MEEC

	CCV1: FID 201-22-1 / TCD 201-22-2				CCB1		CCV2: FID 201-22-1 / TCD 201-22-2					CCB2	
COMPOUND	FILE ID	TRUE CONC.	MEASURED	%REC.	FILE ID	MEASURED	COMPOUND	FILE ID	TRUE CONC	MEASURED	% REC.	FILE ID	MEASURED
METHANE (FID)	905	9.817	9.484	97	907	ND	METHANE (FID)	923	9.817	9 622	98	925	ND
ETHANE (FID)	905	18.79	17.35	92	907	ND	ETHANE (FID)	923	18.79	17.72	94	925	ND
ETHENE (FID)	905	21.11	19.54	93	907	ND	ETHENE (FID)	923	21.11	19.94	94	925	ND
METHANE (TCD)	906	2440	2375	97	907	ND	METHANE (TCD)	924	2440	2407	99	925	ND
CARBON DIOXIDE	906	21.9	21.9	100	907	ND	CARBON DIOXIDE	924	21.9	22.3	102	925	ND
ETHENE (TCD)	906	5261	5456	104	907	ND	ETHENE (TCD)	924	5261	5516	105	925	ND
ETHANE (TCD)	906	4720	4818	102	907	ND	ETHANE (TCD)	924	4720	4936	105	925	ND

	CCV4: FID 201-22-5 / TCD 201-22-4				CCB4	
COMPOUND	FILE ID	TRUE CONC	MEASURED	%REC.	FILE ID	MEASURED
METHANE (FID)	940	49.086	50.761	103	941	ND
ETHANE (FID)	940	93.93	94.83	101	941	ND
ETHENE (FID)	940	105.53	105.44	100	941	ND
METHANE (TCD)	939	6099	6119	100	941	ND
CARBON DIOXIDE	939	54.8	56.3	103	941	ND
ETHENE (TCD)	939	13151	13912	106	941	ND
ETHANE (TCD)	939	11800	12308	104	941	ND

	LCS: 201-22-6 Low Level					LCSD: 201-22-6 Low Level					Method Blank	
COMPOUND	FILE ID	TRUE CONC.	MEASURED	% REC.	RPD	COMPOUND	FILE ID	TRUE CONC	MEASURED	% REC.	FILE ID	MEASURED
METHANE (FID)	936	40.4	41.7	103	1.11	METHANE (FID)	937	40.4	41.2	102	938	ND
ETHANE (FID)	936	75.8	76.5	101	1.56	ETHANE (FID)	937	75.8	75.3	99	938	ND
ETHENE (FID)	936	70.7	71.0	100	2.25	ETHENE (FID)	937	70.7	69.4	98	938	ND

Initial/Continuing Calibration Verification accuracy : 85-115 % recovery
Laboratory Control Sample accuracy : 80-120% recovery
Duplicate Relative Percent Difference: RPD 0-20%
Initial/Continuing Calibration or Method Blank <PQL/LOQ

ANALYST: RCW 070814

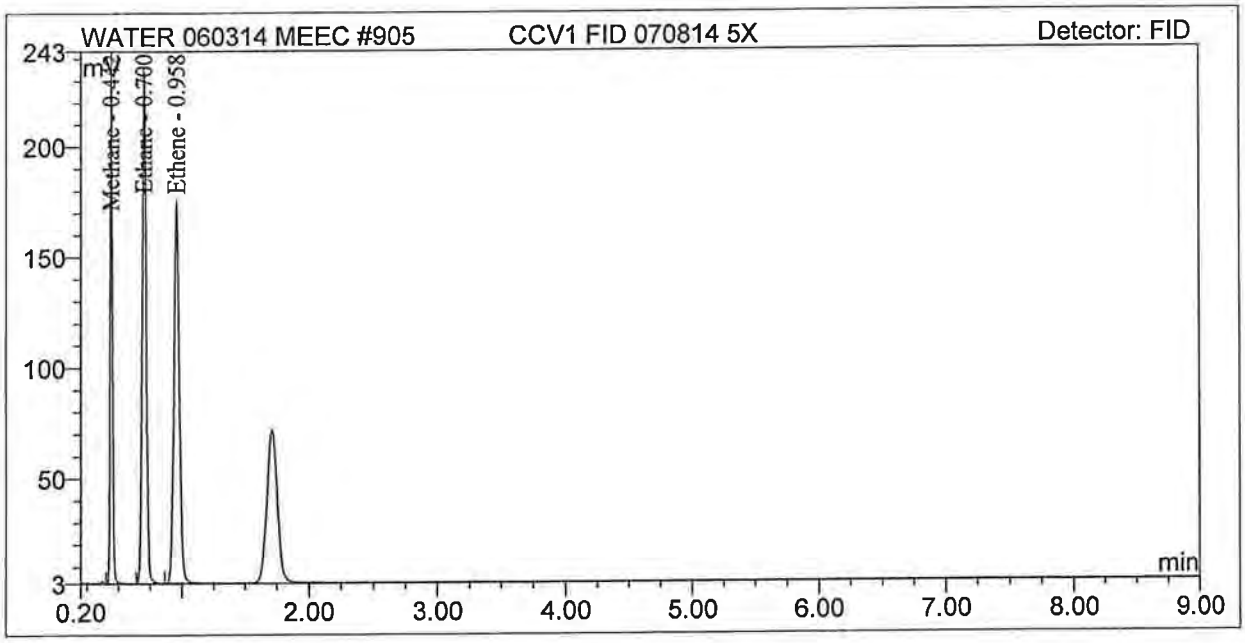
REVIEW

Sample Analysis Report

Sample Name:	CCV1 FID 070814 5X	**Sequence No:**	905
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 6:36	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-1

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.442	4.713	240.696	BMB	9.4842
2	Ethane	0.700	8.397	232.950	BMb	17.3480
3	Ethene	0.958	8.551	172.858	bMB	19.5358

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

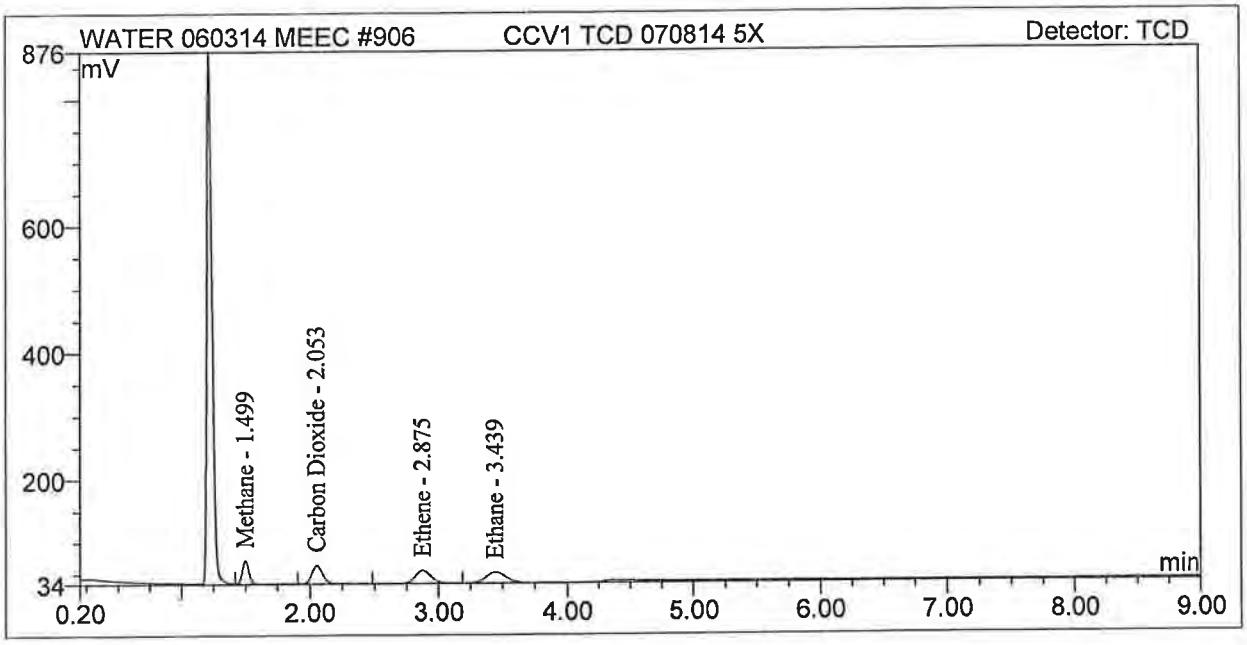


Sample Analysis Report

Sample Name:	CCV1 TCD 070814 5X	**Sequence No:**	906
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 6:47	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-2

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.499	2.127	36.363	BMB	2374.8205
2	Carbon Dioxide	2.053	2.827	29.282	BMB	21.8797
3	Ethene	2.875	2.997	20.677	BM	5456.2231
4	Ethane	3.439	3.205	17.436	MB	4817.7977

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

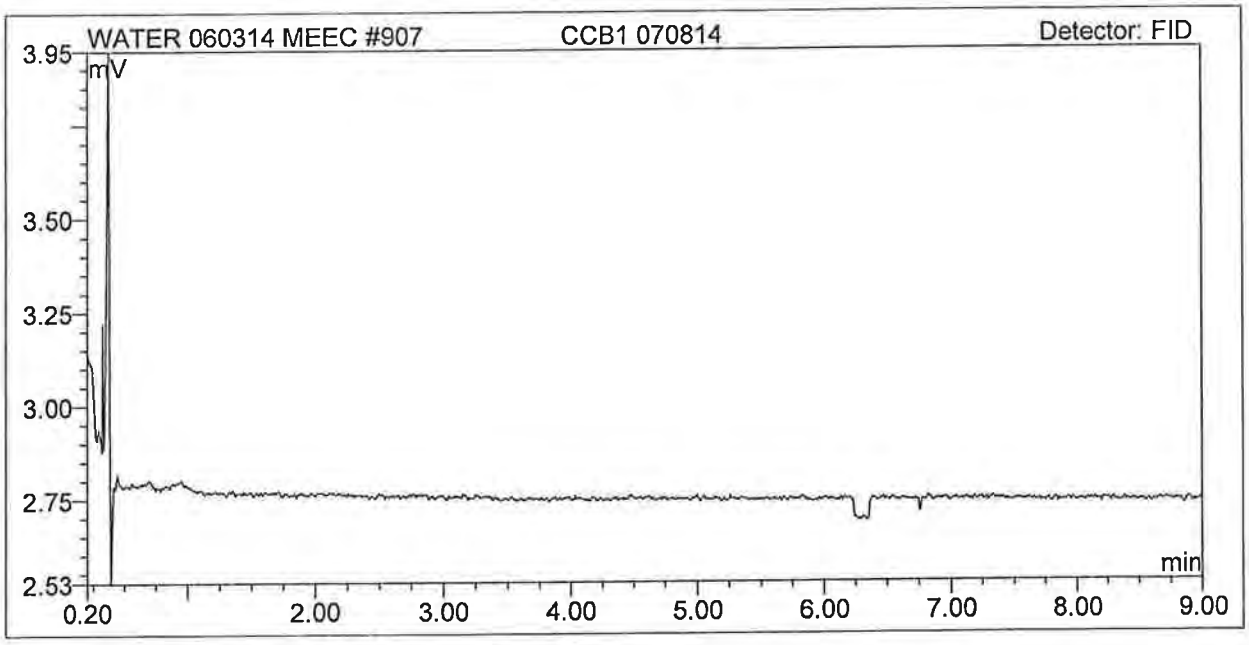


Sample Analysis Report

Sample Name:	CCB1 070814	**Sequence No:**	907
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 6:57	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

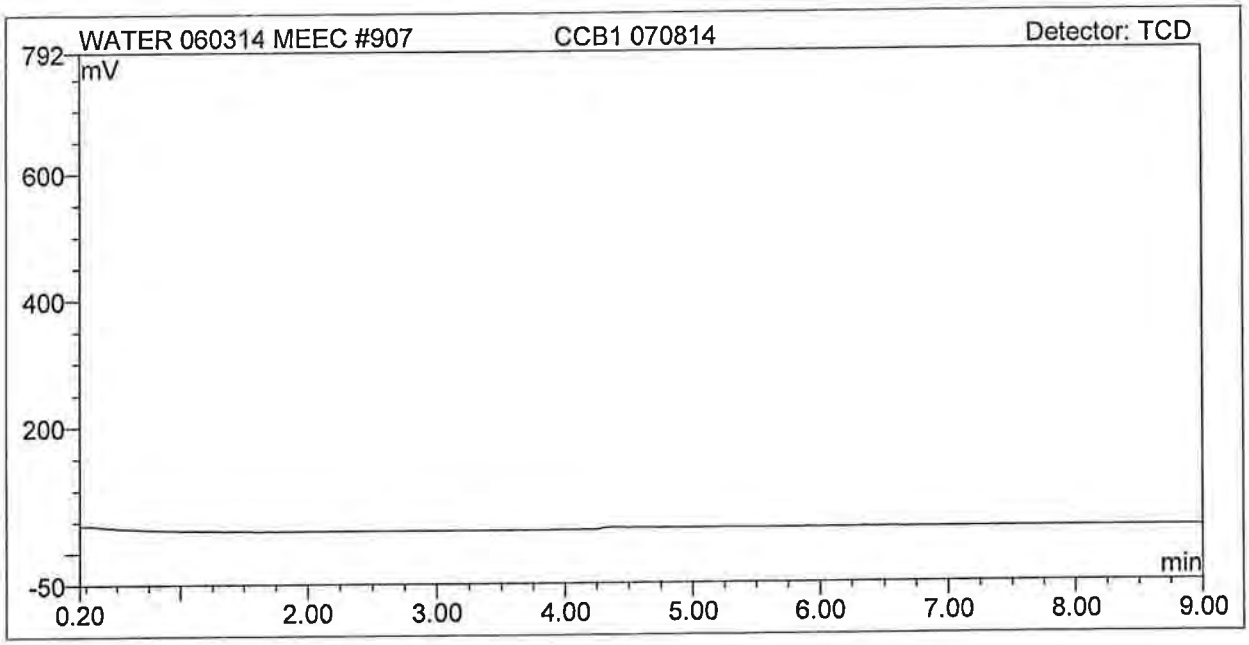


Sample Analysis Report

Sample Name:	CCB1 070814	**Sequence No:**	907
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 6:57	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)



MICROSEEPS

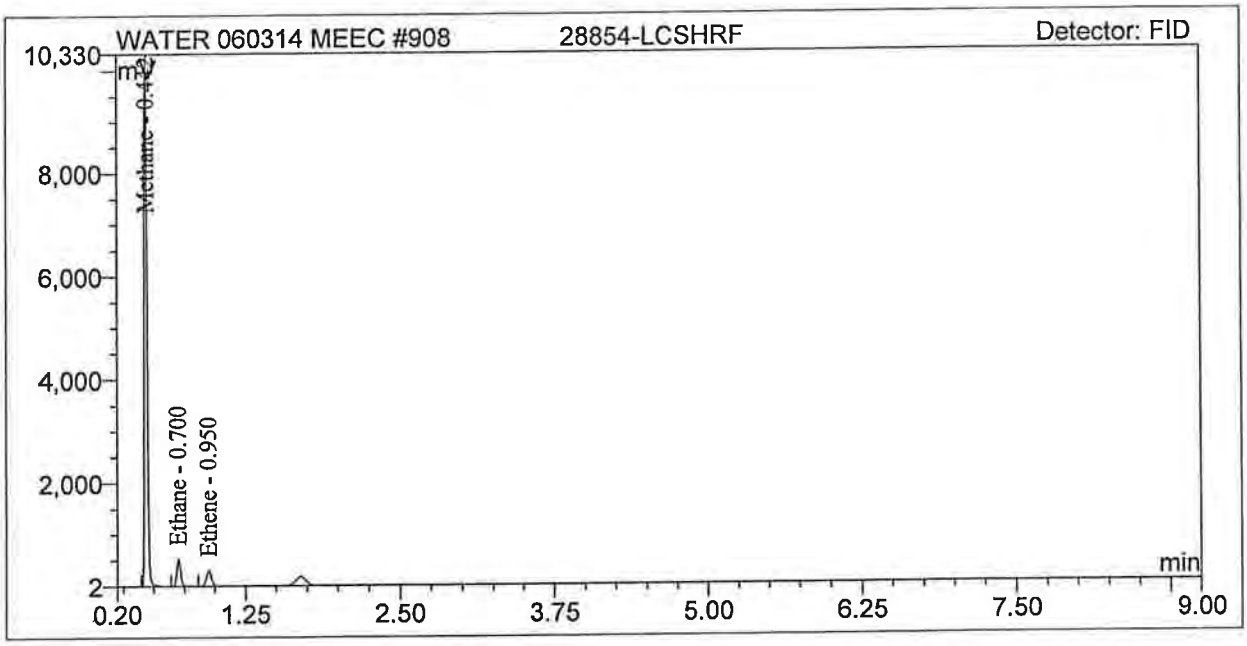
Sample Analysis Report

Sample Name:	28854-LCSHRF	**Sequence No:**	908
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 7:08	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-3

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.442	256.696	10327.387	BMb	~~472.8680~~
2	Ethane	0.700	17.959	525.785	bMB	37.0226
3	Ethene	0.950	15.087	312.263	BMB	34.4118

RCW 070814

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)



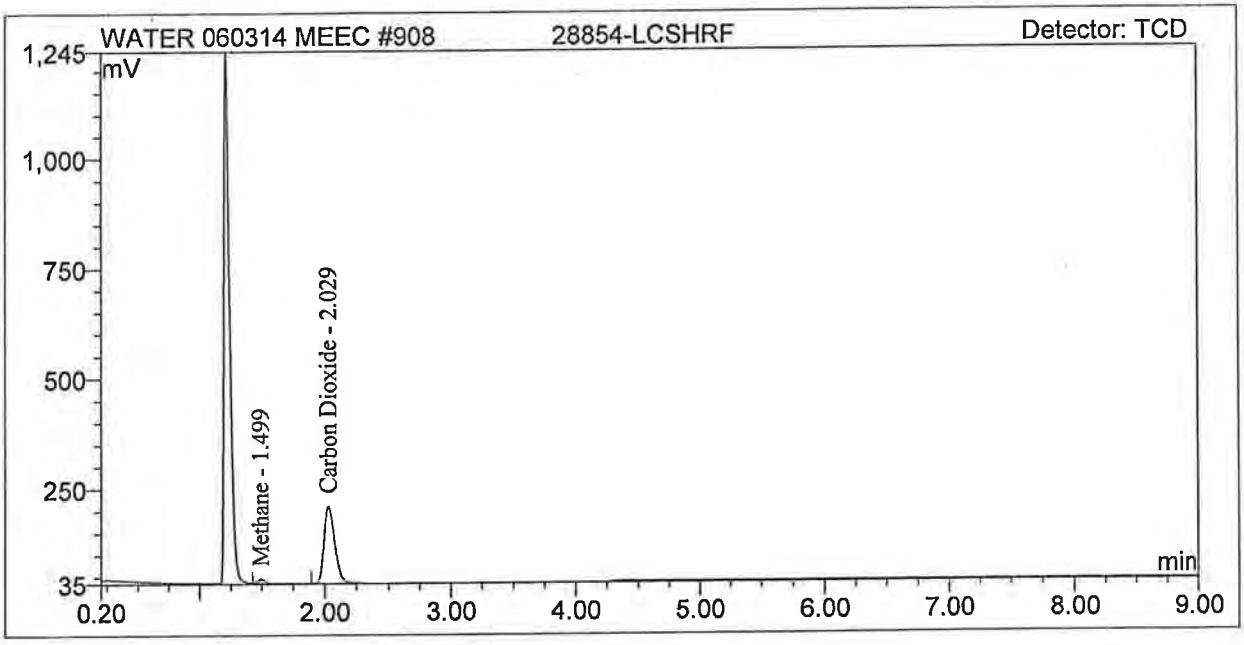
MICROSEEPS

Sample Analysis Report

Sample Name:	28854-LCSHRF	**Sequence No:**	908
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 7:08	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-3

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.499	0.637	11.246	BMB	710.7976
2	Carbon Dioxide	2.029	17.071	173.989	BMB	132.1443

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)



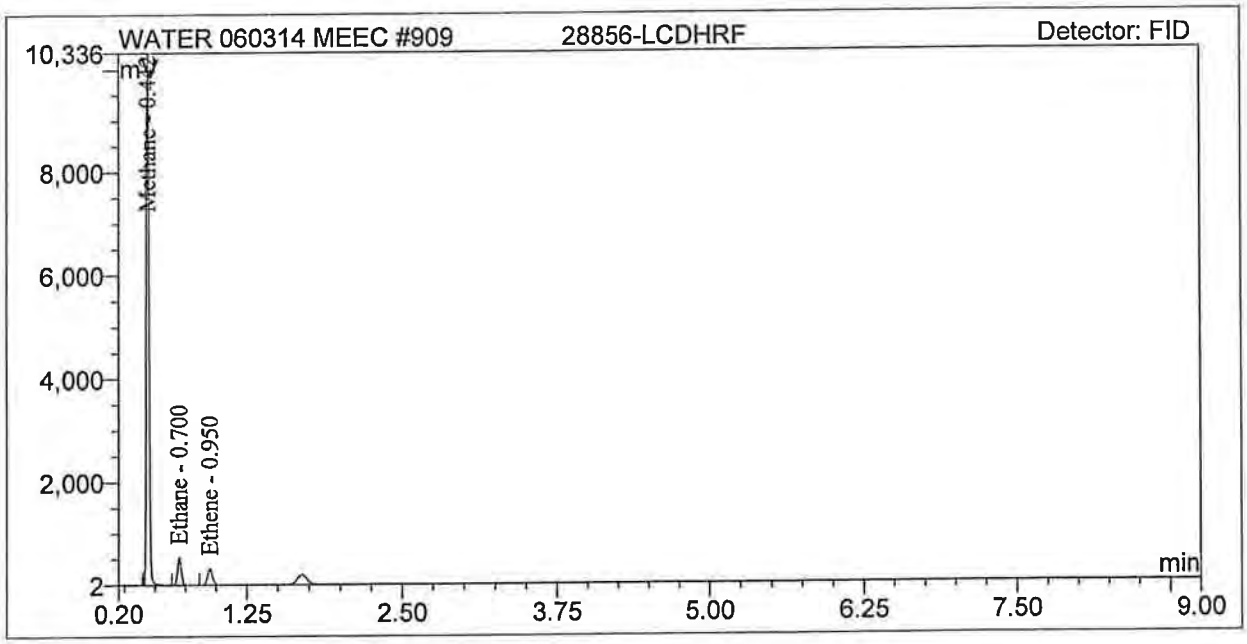
Sample Analysis Report

Sample Name:	28856-LCDHRF	**Sequence No:**	909
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 7:20	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-3

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.442	256.881	10333.210	BMb	~~473.1825~~
2	Ethane	0.700	18.255	536.217	bMB	37.6294
3	Ethene	0.950	15.272	316.932	BMB	34.8314

Raw 070814

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

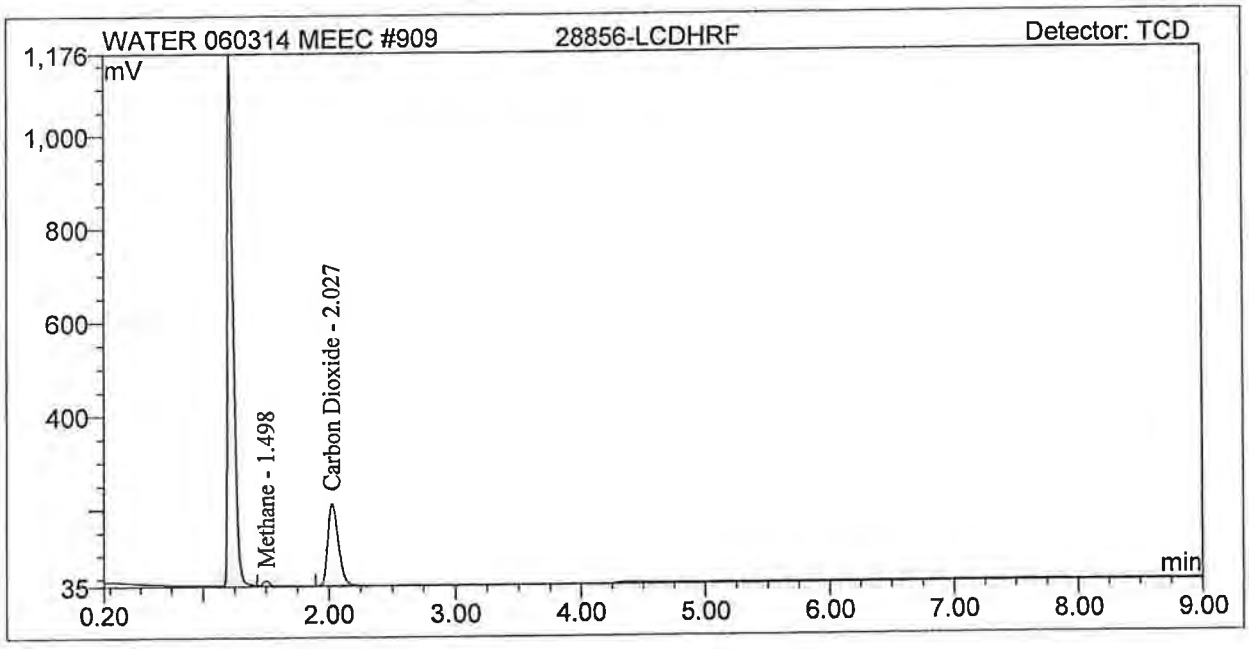


Sample Analysis Report

Sample Name:	28856-LCDHRF	**Sequence No:**	909
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 7:20	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-3

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.498	0.648	11.401	BMB	723.7870
2	Carbon Dioxide	2.027	17.126	174.889	BMB	132.5661

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

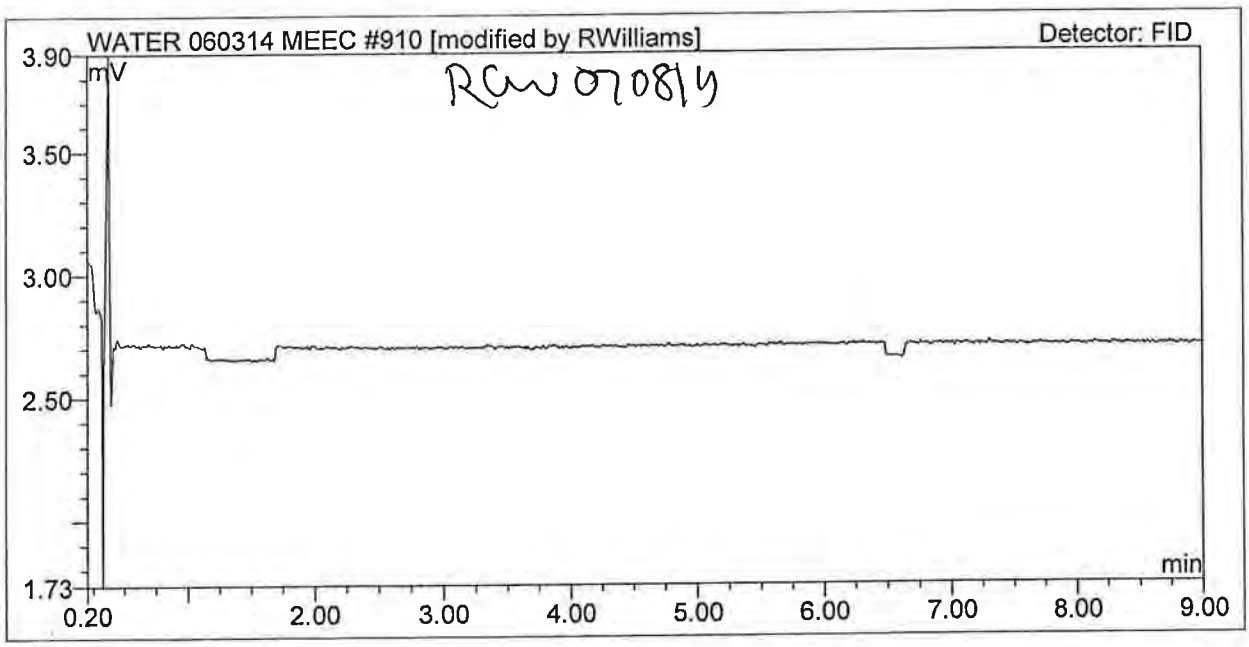


Sample Analysis Report

Sample Name:	28852-MBHRF	**Sequence No:**	910
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 7:30	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

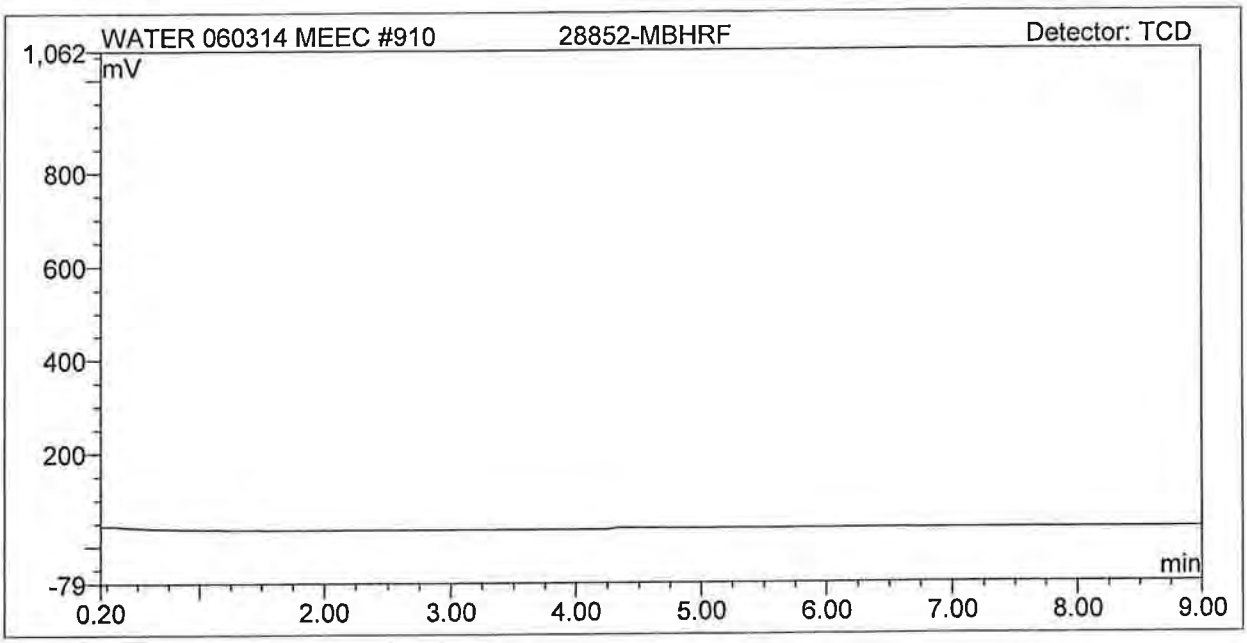


Sample Analysis Report

Sample Name:	28852-MBHRF	**Sequence No:**	910
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 7:30	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)



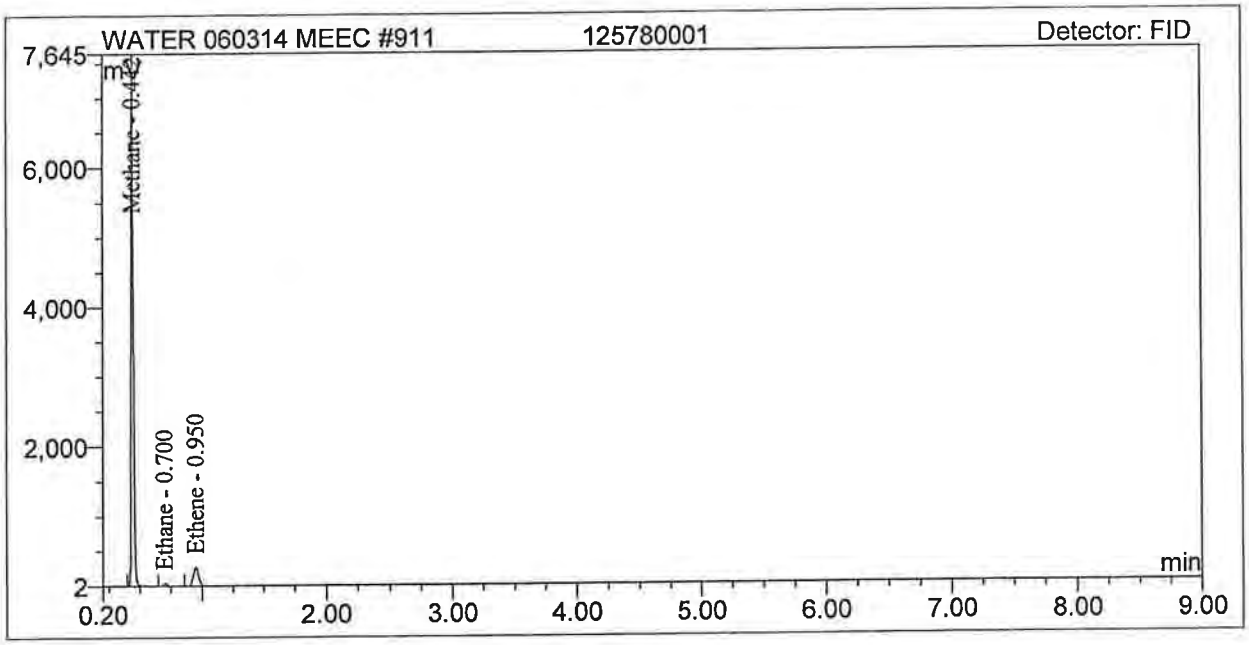
Sample Analysis Report

Sample Name:	125780001	**Sequence No:**	911
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 7:42	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.442	141.888	7642.230	BMb	~~271.3501~~
2	Ethane	0.700	1.555	45.003	bMB	3.2180
3	Ethene	0.950	13.269	273.494	BMB	30.2779

RCW 070814

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

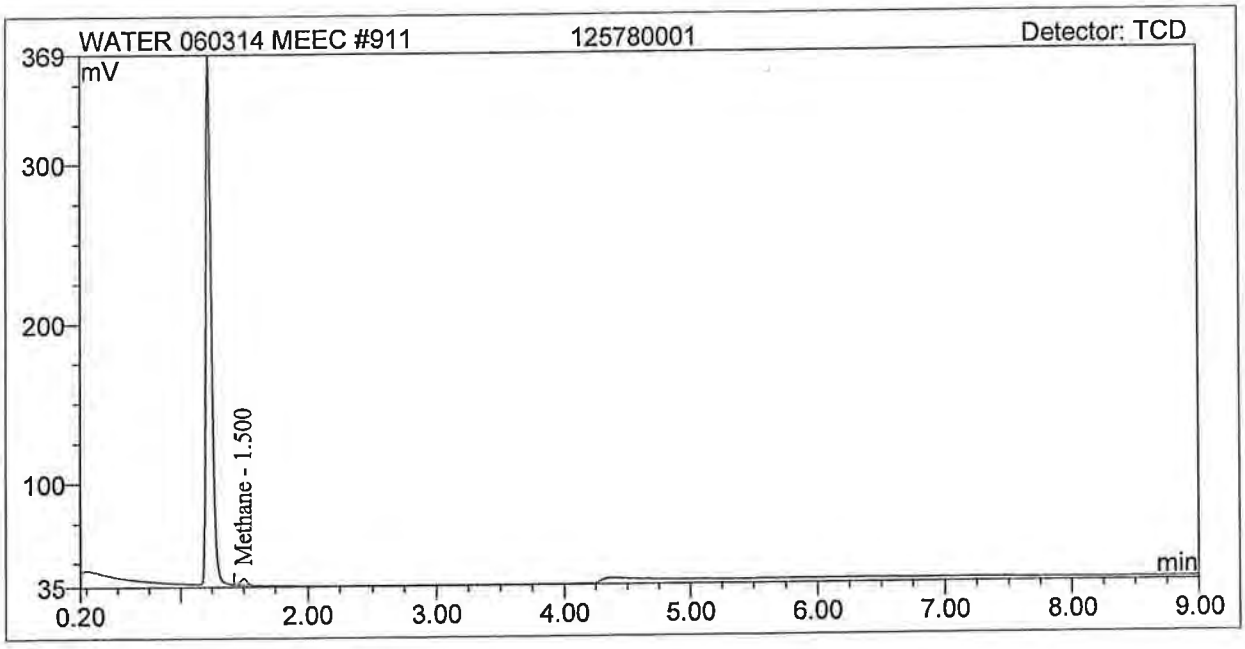


Sample Analysis Report

Sample Name:	125780001	**Sequence No:**	911
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 7:42	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.500	0.234	4.106	BMB	261.3086

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)



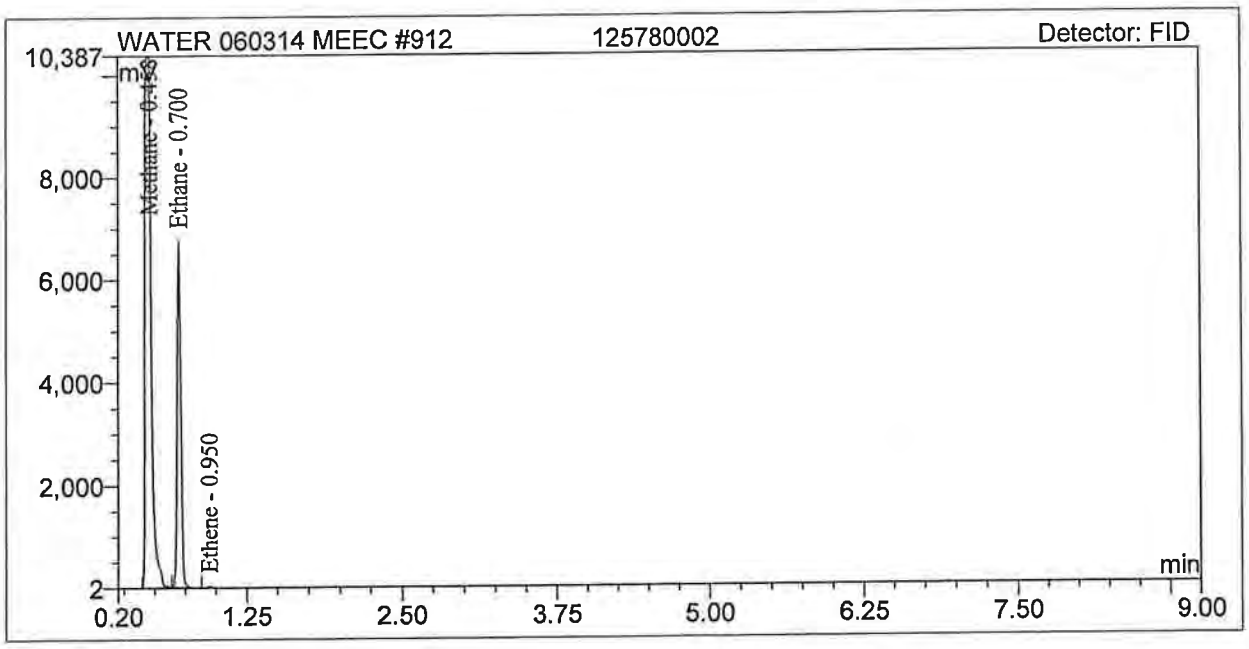
Sample Analysis Report

Sample Name:	125780002	**Sequence No:**	912
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 7:52	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.458	620.765	10378.343	BMb	~~1036.8183~~
2	Ethane	0.700	231.681	6744.368	bMB	455.9709
3	Ethene	0.950	1.249	26.409	BMB	2.8582

Raw 070814

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)



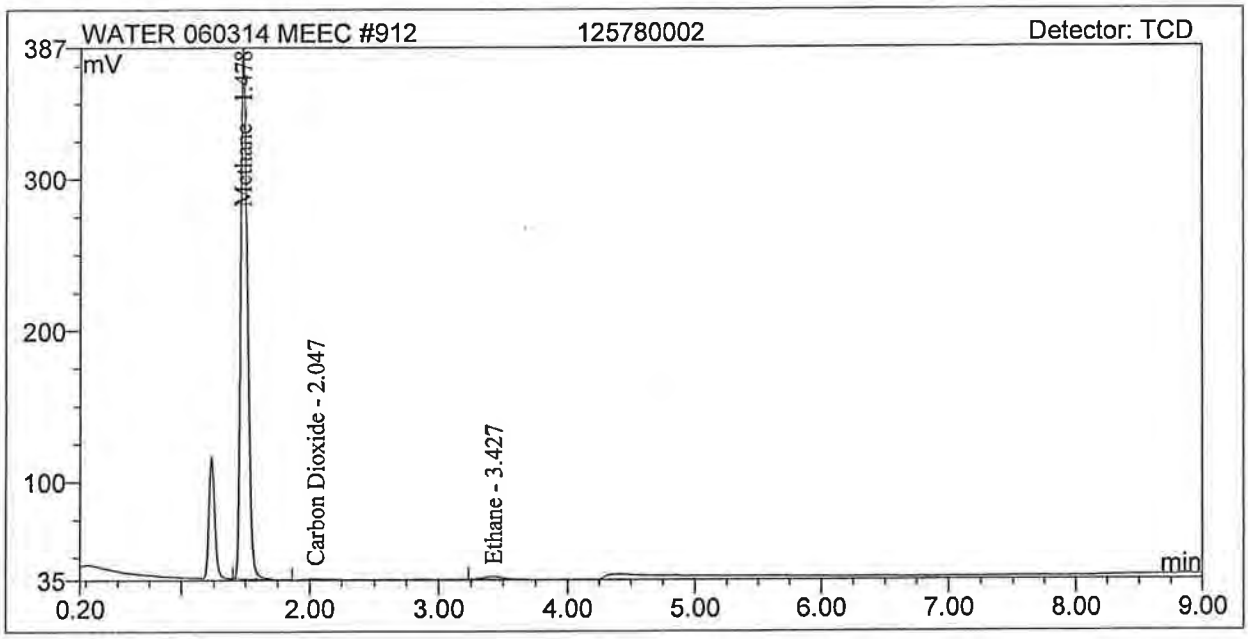
Sample Analysis Report

Sample Name:	125780002	**Sequence No:**	912
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 7:52	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.478	21.279	351.242	BMB	23754.9548
2	Carbon Dioxide	2.047	0.079	0.452	BMB	0.6133
3	Ethane	3.427	0.349	1.810	BMB	~~525.2855~~

RCW 070814

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

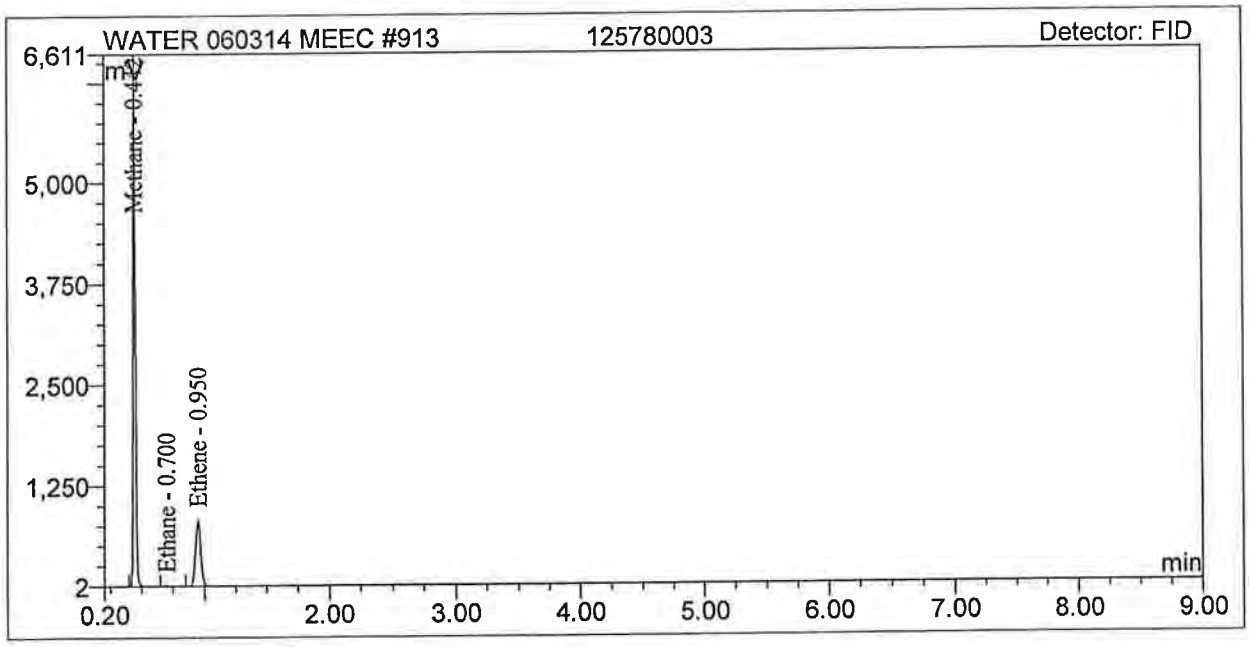


Sample Analysis Report

Sample Name:	125780003	**Sequence No:**	913
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 8:03	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.442	122.305	6608.717	BMb	235.5040
2	Ethane	0.700	0.319	9.299	bMB	0.6602
3	Ethene	0.950	39.674	820.916	BMB	89.9600

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

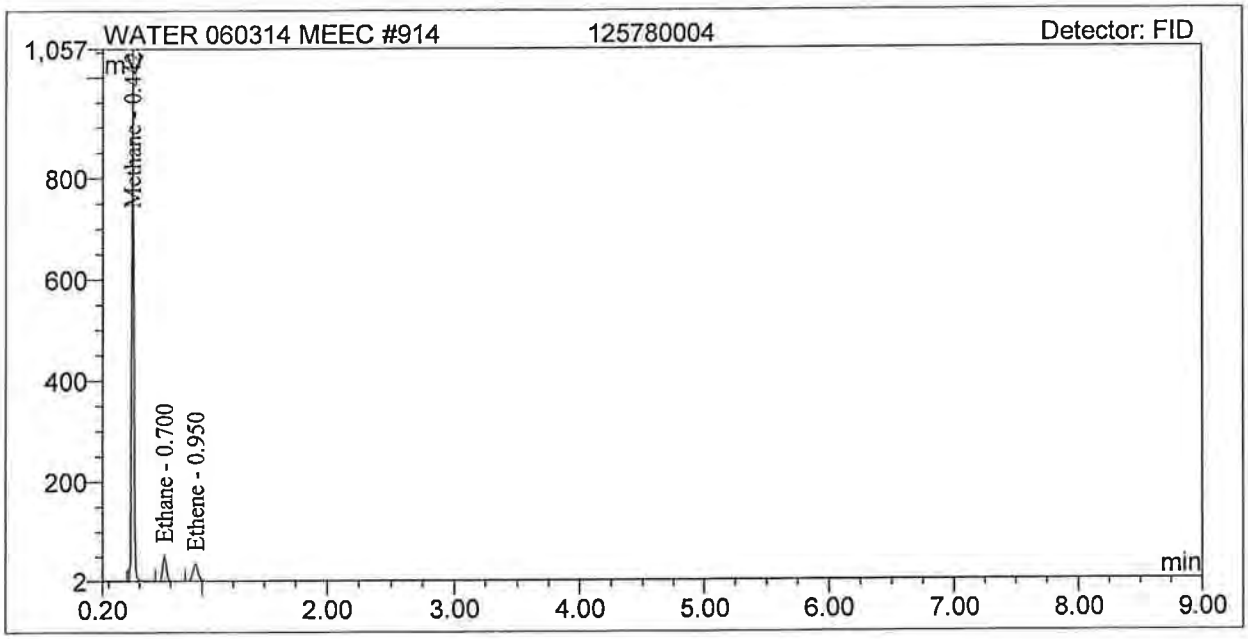


Sample Analysis Report

Sample Name:	125780004	**Sequence No:**	914
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 8:14	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.442	19.568	1054.872	BMb	39.1454
2	Ethane	0.700	1.745	50.546	bMB	3.6112
3	Ethene	0.950	1.681	34.133	BMB	3.8462

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

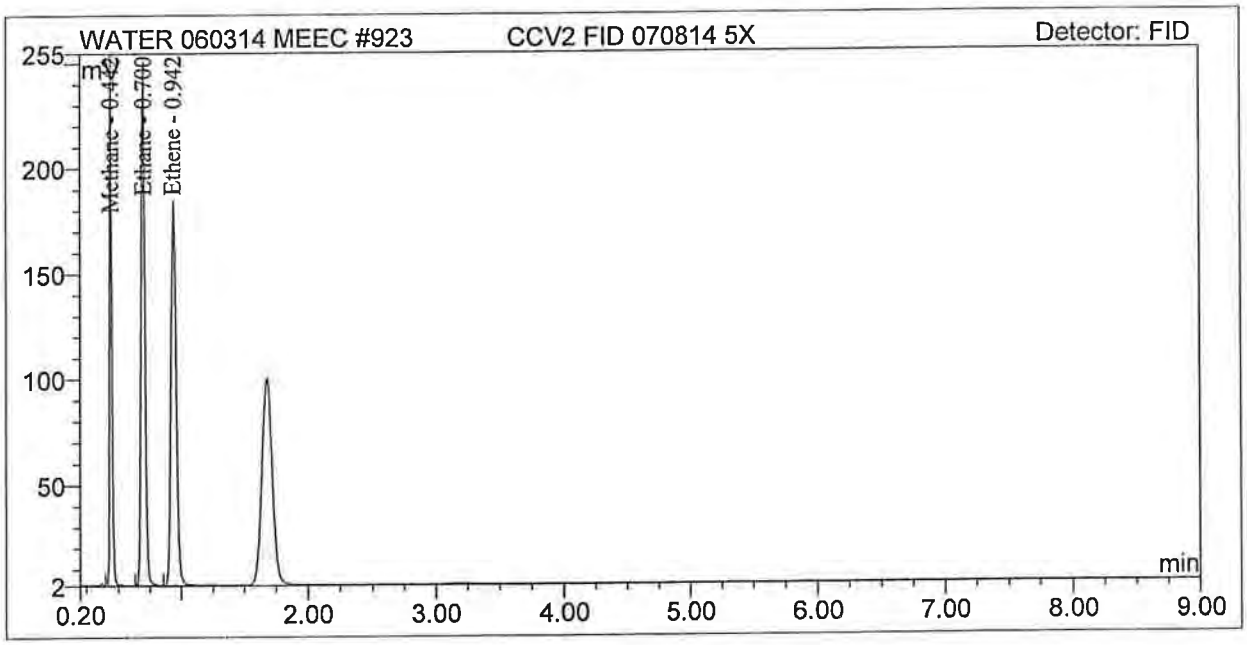


Sample Analysis Report

Sample Name:	CCV2 FID 070814 5X	**Sequence No:**	923
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 9:53	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-1

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.442	4.782	252.202	BMB	9.6219
2	Ethane	0.700	8.577	248.359	BMb	17.7203
3	Ethene	0.942	8.730	182.181	bMB	19.9431

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

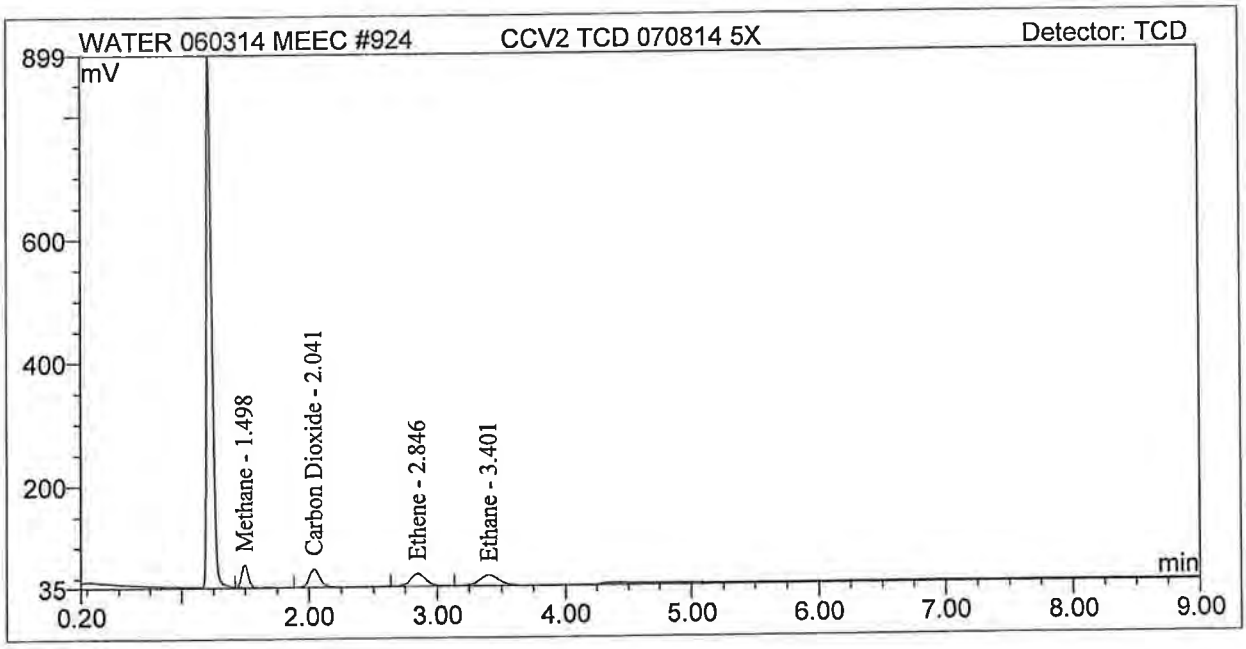


Sample Analysis Report

Sample Name:	CCV2 TCD 070814 5X	**Sequence No:**	924
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 10:04	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-2

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.498	2.156	36.918	BMB	2407.0687
2	Carbon Dioxide	2.041	2.886	29.911	BMB	22.3417
3	Ethene	2.846	3.030	21.205	BM	5516.3774
4	Ethane	3.401	3.284	17.984	MB	4935.8887

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

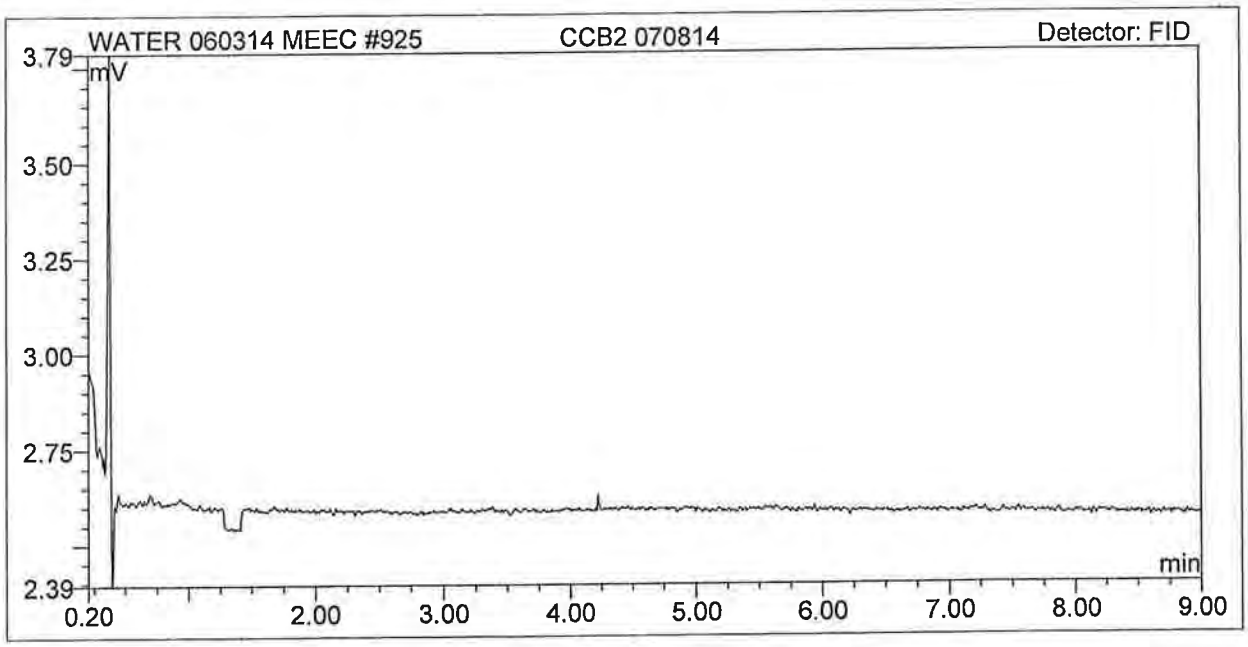


Sample Analysis Report

Sample Name:	CCB2 070814	**Sequence No:**	925
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 10:15	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

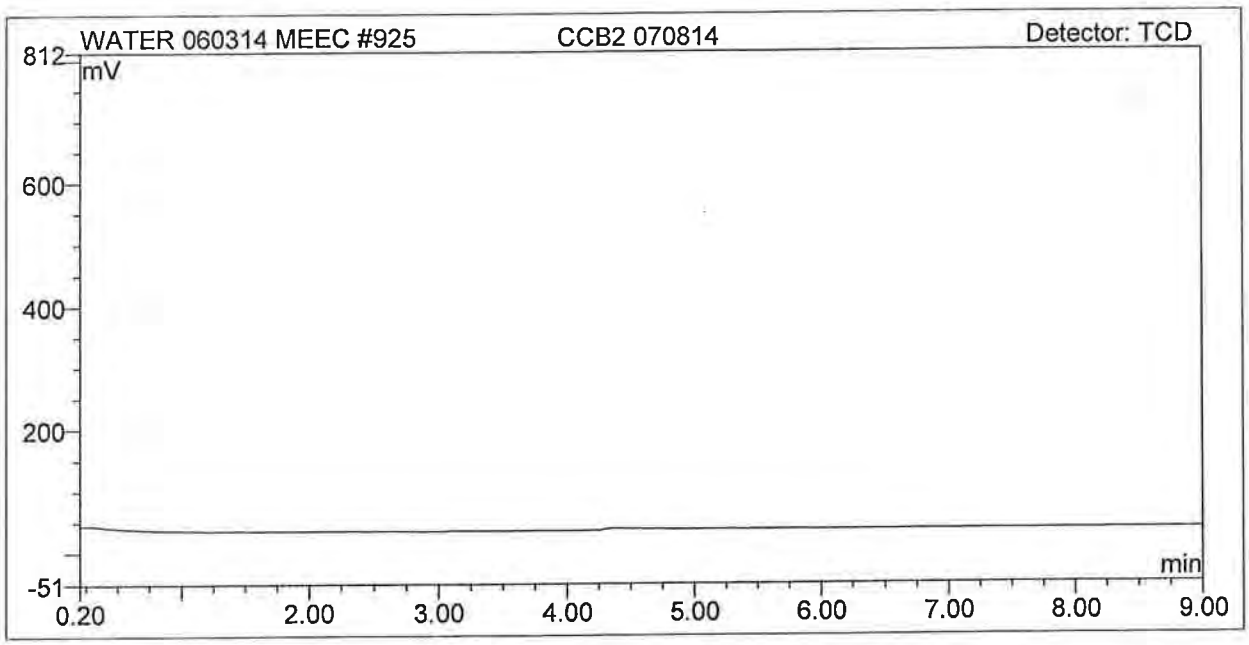


Sample Analysis Report

Sample Name:	CCB2 070814	**Sequence No:**	925
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 10:15	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

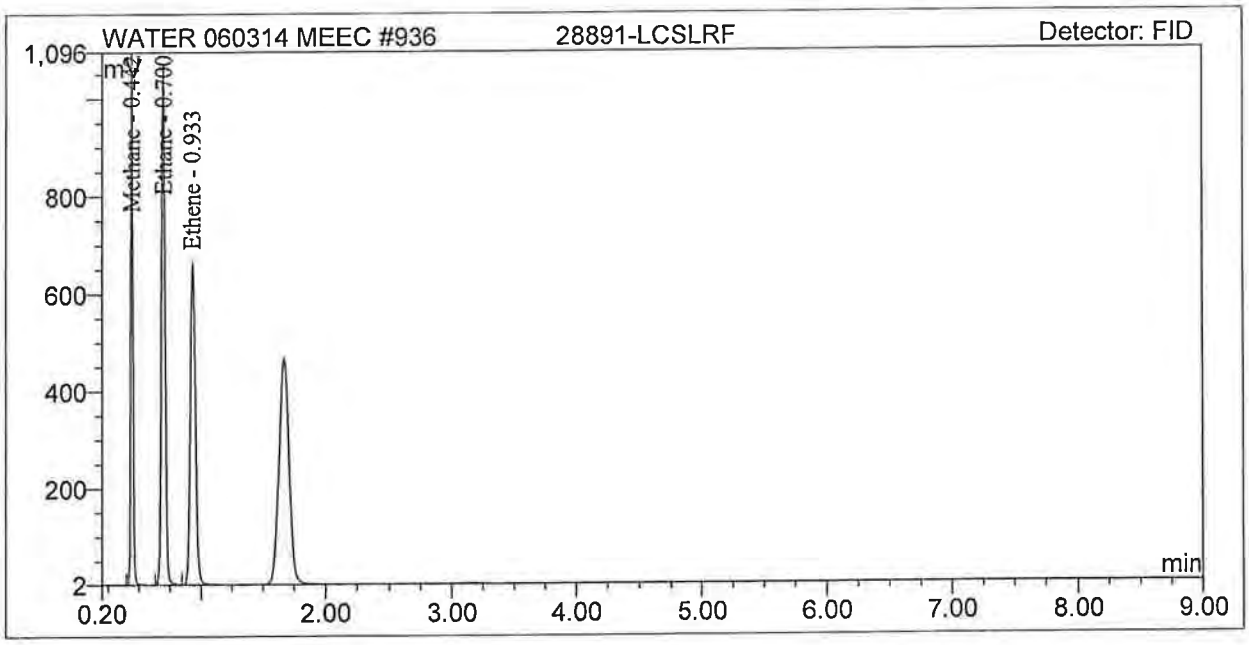


Sample Analysis Report

Sample Name:	28891-LCSLRF	**Sequence No:**	936
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 12:08	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-6

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.442	20.838	1093.755	BMB	41.6649
2	Ethane	0.700	37.288	1071.340	bMb	76.5256
3	Ethene	0.933	31.234	661.606	bMB	70.9644

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

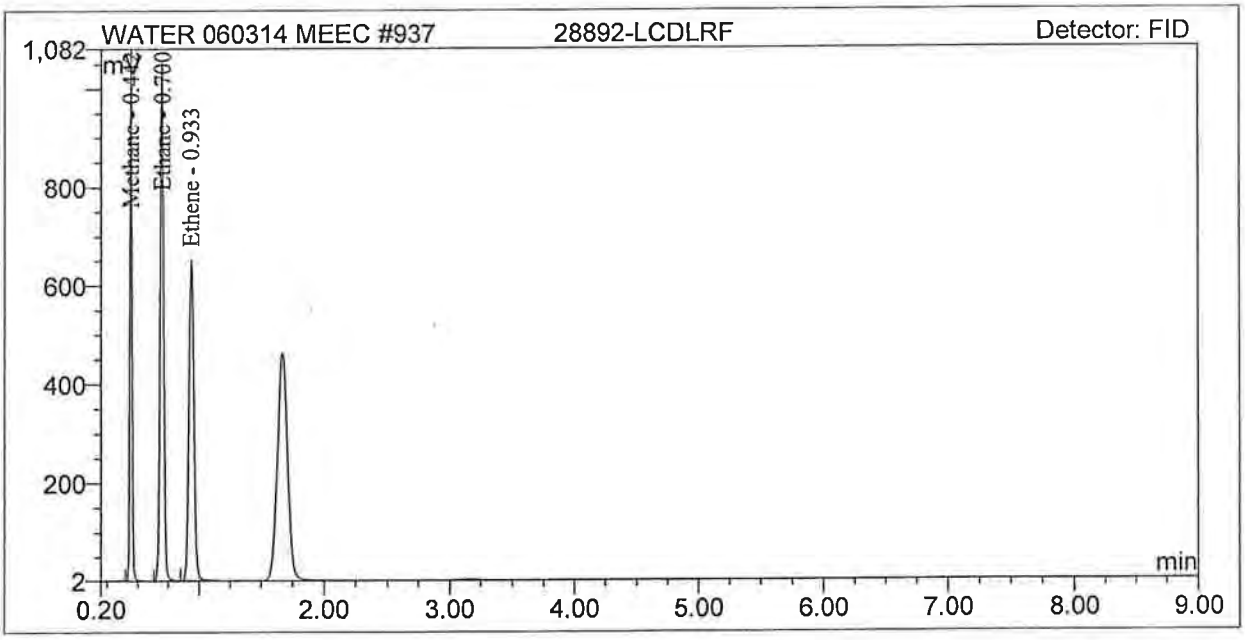


Sample Analysis Report

Sample Name:	28892-LCDLRF	**Sequence No:**	937
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 12:18	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-6

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.442	20.607	1079.916	BMb	41.2067
2	Ethane	0.700	36.706	1051.168	bMb	75.3424
3	Ethene	0.933	30.533	649.775	bMB	69.3849

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

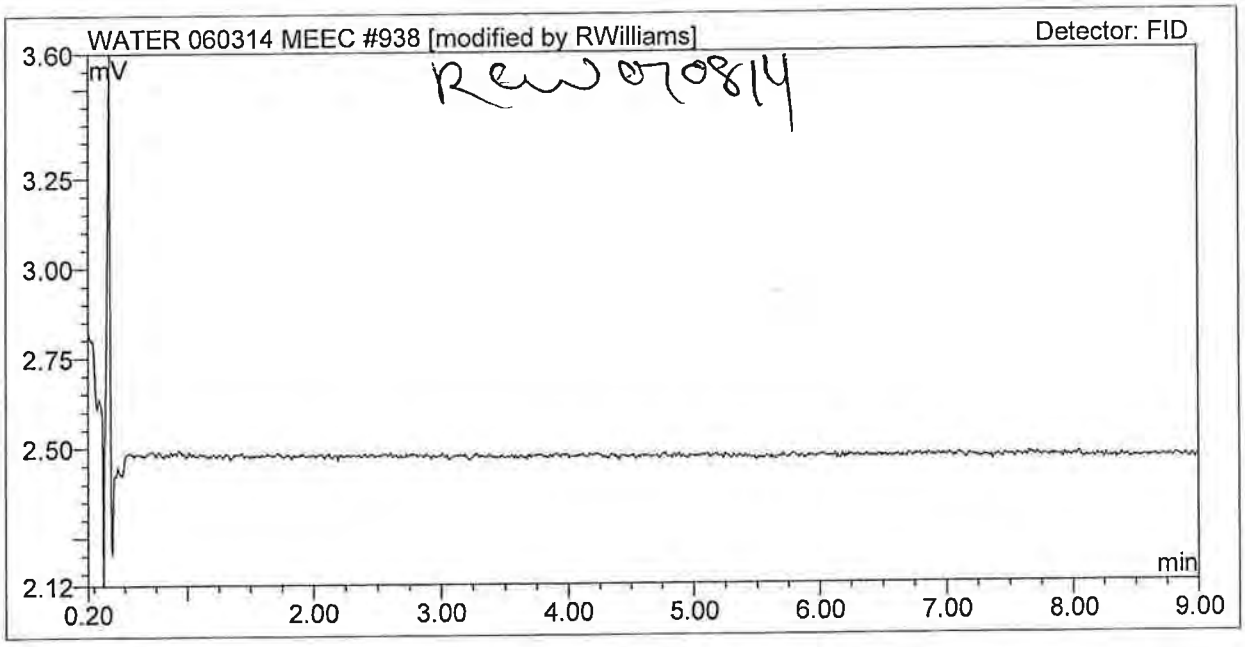


Sample Analysis Report

Sample Name:	28890-MBLRF	**Sequence No:**	938
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 12:28	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

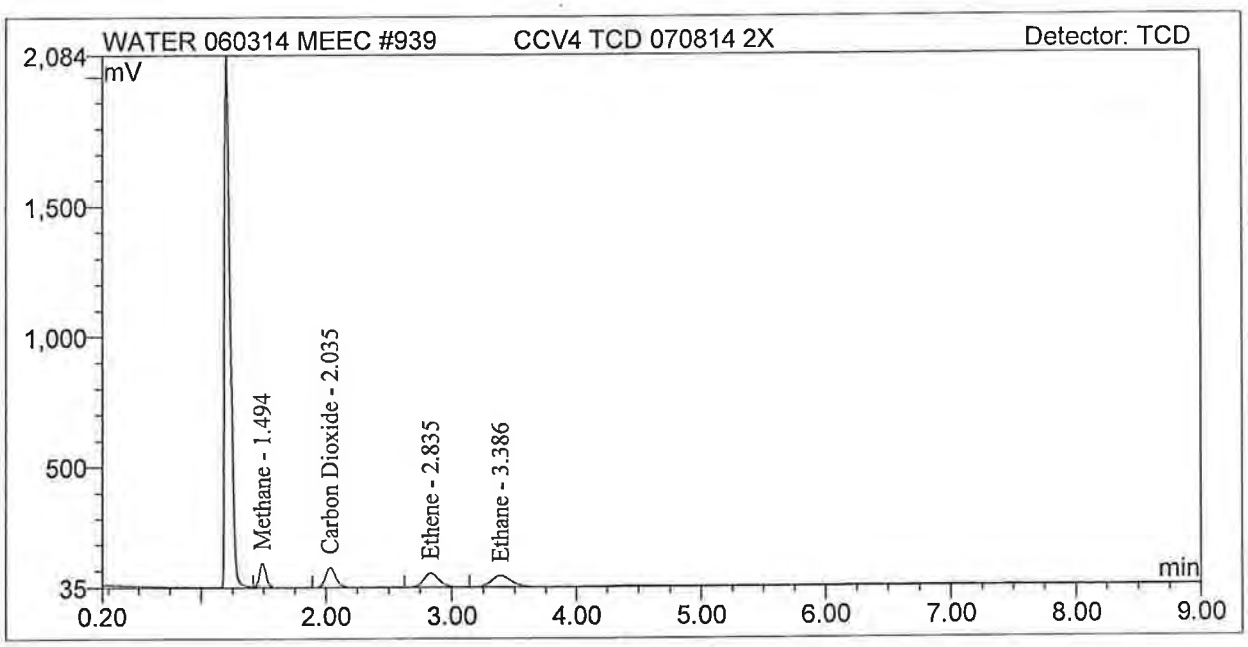


Sample Analysis Report

Sample Name:	CCV4 TCD 070814 2X	**Sequence No:**	939
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 12:40	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-4

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	1.494	5.482	92.726	BMB	6119.4176
2	Carbon Dioxide	2.035	7.275	75.964	BMB	56.3158
3	Ethene	2.835	7.642	53.825	BM	13912.4204
4	Ethane	3.386	8.188	44.670	MB	12307.5441

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

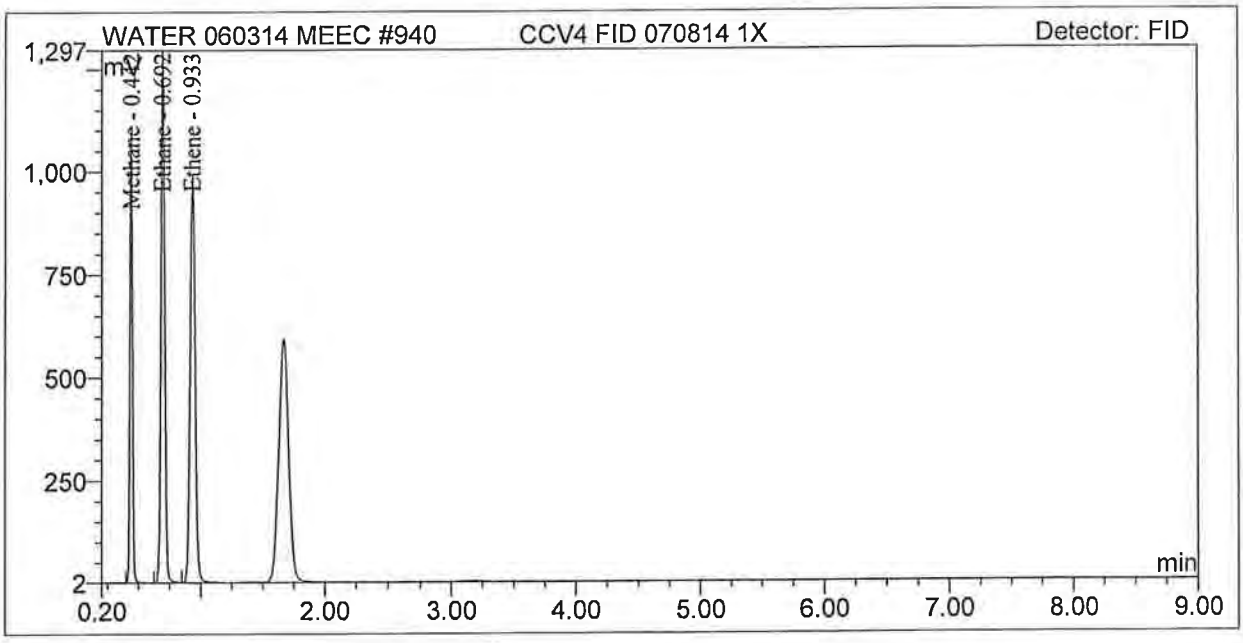


Sample Analysis Report

Sample Name:	CCV4 FID 070814 1X	**Sequence No:**	940
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 12:49	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	201-22-5

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount
1	Methane	0.442	25.433	1109.858	BMb	50.7611
2	Ethane	0.692	46.302	1294.055	bMb	94.8294
3	Ethene	0.933	46.578	989.264	bMB	105.4426

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)

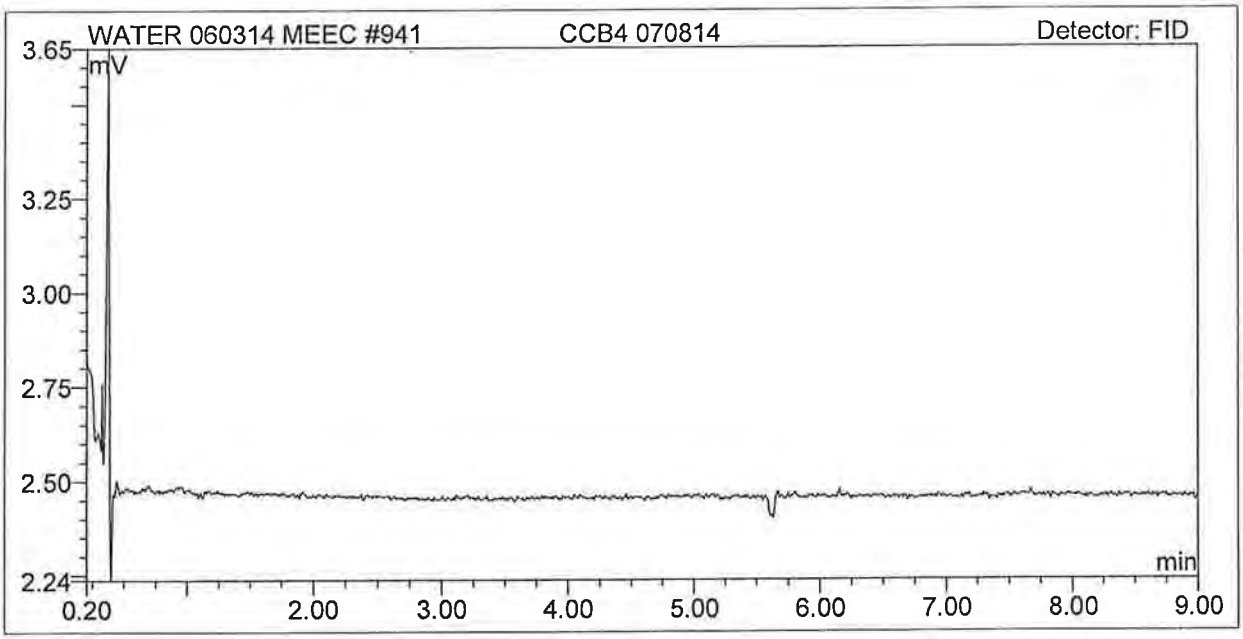


Sample Analysis Report

Sample Name:	CCB4 070814	**Sequence No:**	941
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 12:59	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)



Sample Analysis Report

Sample Name:	CCB4 070814	**Sequence No:**	941
Sequence Name:	WATER 060314 MEEC	**Instrument ID:**	BIOREM12
Program Method:	AM20GAxMEEC	**Injection vol.:**	1.0
Quantitation Method:	WATER 042814 MEEC	**Dilution Factor:**	1.0000
Date Time Collected:	7/8/2014 12:59	**Analytical Method:**	PM01C/AM20GAx
System Operator:	RWilliams	**Comment:**	

Peak No.	Component Name	Retention Time	Area mV*min	Height mV	Type	Amount

FID UNITS (Methane thru Acetylene ug/L)
TCD UNITS (Methane, Ethane, Ethene ug/L, CO2 mg/L)