Office of Solid Waste and
Emergency Response
(5102G)

EPA-542-R-11-012
April 2012
www.epa.gov/tio
www.clu-in.org/optimization

Optimization Evaluation
North Penn Area 6 Superfund Site

Lansdale, Montgomery County, Pennsylvania

OPTIMIZATION EVALUATION

NORTH PENN AREA 6 SUPERFUND SITE
LANSDALE, MONTGOMERY COUNTY, PENNSYLVANIA

Report of the Optimization Evaluation
Site Visit Conducted at the North Penn 6 Superfund Site
September 22, 2011

April 27, 2012

EXECUTIVE SUMMARY

Optimization Background

USEPA's working definition of optimization as of December 2011 is as follows:

"A systematic site review by a team of independent technical experts, at any phase of a cleanup process, to identify opportunities to improve remedy protectiveness, effectiveness, and cost efficiency, and to facilitate progress toward site completion."

An optimization evaluation considers the goals of the remedy, available site data, conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness, and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State, and Municipal governments. Consistent with this interest, optimization now routinely considers green remediation and environmental footprint reduction during optimization evaluations.

An optimization evaluation includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation, and represent the opinions of the evaluation team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance project plans (QAPP).

Site-Specific Background

The North Penn Area 6 Superfund Site (NPA6 Site) addresses multiple sources of contamination and a broad contaminant plume that underlies a large portion of Lansdale, Pennsylvania. Tetrachloroethene (PCE), trichloroethene (TCE), and associated degradation products are the primary contaminants of concern. EPA originally identified 26 facilities in the Lansdale area as possible sources of contamination due to their use of site-related solvents. These 26 properties were grouped into two operable units (OUs) for soil contamination that would address source control through soil remediation. OU1 addressed 20 properties where EPA would perform remedial activities. OU2 will address the six remaining properties where the owners/operators will complete the work with EPA oversight.

The groundwater contamination underlying the area is addressed in the OU3 Record of Decision (ROD) signed in August 2000. OU3 includes groundwater extraction and treatment of the contaminated groundwater at 10 source locations. Of these 10 locations, six are funded by Superfund (Fund-lead) and four are funded by potentially responsible parties (PRP). Groundwater remedies for five of the Fund-lead locations have been constructed and are the focus of this optimization evaluation report. These five locations are as follows:

- Keystone Hydraulics (system operating since 2004)
- Royal Cleaners (system operating since 2004)
- Westside Industries (system operating since 2008)
- Electra Products (system operating since 2008)
- Rogers Mechanical (former Tate Andale) (system began operation in 2011)

Summary of CSM

Contaminant releases from a variety of locations throughout the Lansdale area have resulted in subsurface contamination with volatile organic compounds (VOC). In several locations, including the five Fund-lead locations with active groundwater remediation, contamination has migrated through the shallow overburden to the fractured bedrock of the Brunswick Formation. The siltstone and mudstone that comprises the bedrock has a very low primary porosity (typically less than 1 percent [%]). Once the contamination is in the fractured bedrock, it migrates primarily through fractures. Horizontal and vertical contaminant migration through fractures is expected to be more pronounced along bedding planes. Hydraulic head gradients have changed over time due to changes in regional production well operation, causing groundwater flow directions (both horizontal and vertical) to potentially change over time. Since the time of many of the contaminant releases, contamination has migrated relatively far from the individual locations in various directions resulting in comingled contaminant plumes. Limited information is available between the various properties to help discern individual contaminant plumes. The premise for the selected remedy is that source control or removal would eventually result in the attenuation of the regional comingled plume.

The majority of contaminant mass at each location appears to be concentrated in the unsaturated zone or shallow groundwater where bedrock is weathered and there is more secondary porosity. Although contamination is present at deeper intervals, the concentrations at deeper intervals are generally lower than in the shallow intervals. Despite historic efforts to address soil contamination, there is likely source material remaining in relatively shallow intervals at several of the locations. With the exception of Westside Industries, where contamination is relatively evenly distributed with depth, the extraction wells at the various remedies appear to preferentially extract relatively deeper, cleaner water from major fractures rather than the highly contaminated shallow groundwater.

The extent of groundwater contamination at all five locations is relatively poorly delineated and there is insufficient hydraulic information to readily interpret the capture zone extent for each extraction well. At Rogers Mechanical (former Tate Andale), there is little or no groundwater water quality data in the vicinity of the source that was previously excavated, suggesting the potential for an unidentified, uncharacterized contaminant plume.

Summary of Findings

The following is a brief summary of the key findings from this optimization evaluation:

- The groundwater plumes at the five sites are not adequately delineated to evaluate plume or source control.

- Insufficient hydraulic information is available to reliably interpret the hydraulic capture zones for the five systems.

- Contaminant concentrations remain elevated at each of the five locations, particularly in the shallow zones. Groundwater extraction, however, predominantly comes from intermediate or deeper intervals.

- Significant contaminant mass is likely present in the unsaturated zone and shallow groundwater that is not adequately addressed by the existing remedies, such that significant improvements in water quality have not been observed and are not expected to occur with the current groundwater remedies.

- There is potential for vapor intrusion (VI) at three of the five locations reviewed.

- The treatment systems generally operate reliably. There is potential to streamline some of the treatment plants given current conditions. However, because the extraction systems do not adequately target the source areas, and improvements could significantly change the flow rates or mass loading to the treatment systems, streamlining the treatment systems at this time is not appropriate.

Summary of Recommendations

Recommendations are provided to improve remedy effectiveness, reduce cost, provide technical improvement, and assist with accelerating site closure. The recommendations in these areas are as follows:

Improving effectiveness – improve characterization of source areas and better delineate shallow groundwater contamination

Reducing cost – no specific recommendations are provided.

Technical improvement – no specific recommendations are provided.

Site closure – establish specific and achievable performance objectives for each of the five groundwater systems and then consider optimal remedial strategies given those performance objectives. Approximate cost information has been provided for multiple remedy options at each of the five sites with costs ranging from approximately $750,000 per groundwater remedy to over $6,000,000 per groundwater remedy.

No specific opportunities were identified for meaningful reduction of the remedy environmental footprint.

NOTICE

Work described herein was performed by Tetra Tech GEO (TtGEO) for the U.S. Environmental Protection Agency (EPA). Work conducted by TtGEO, including preparation of this report, was performed under Work Assignment #58 of EPA contract EP-W-07-078 with Tetra Tech EM, Inc., Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization from remedial investigation to site completion implemented by the EPA Office of Superfund Remediation and Technology Innovation (OSRTI). The project contacts are as follows:

Organization	Key Contact	Contact Information
U.S. EPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Kathy Yager	U.S. EPA Technology Innovation and Field Services Division 11 Technology Drive (ECA/OEME) North Chelmsford, MA 01863 yager.kathleen@epa.gov phone: 617-918-8362
Tetra Tech EM, Inc. (Contractor to EPA)	Jody Edwards	Tetra Tech EM Inc. 1881 Campus Commons Drive, Suite 200 Reston, VA 20191 jody.edwards@tetratech.com phone: 802-288-9485
Tetra Tech GEO (Contractor to Tetra Tech EM, Inc.)	Doug Sutton	Tetra Tech GEO 2 Paragon Way Freehold, NJ 07728 doug.sutton@tetratech.com phone: 732-409-0344

LIST OF ACRONYMS

%	percent
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
1,1,1-TCA	1,1,1-trichloroethane
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BMP	best management practices
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-dichloroethene
COC	contaminant of concern
CSM	conceptual site model
CVOC	chlorinated volatile organic chemicals
DNAPL	dense non-aqueous phase liquid
DPT	direct-push technology
EPA	U.S. Environmental Protection Agency
ESD	explanation of significant differences
ft	feet
ft^2	square feet
ft^3	cubic feet
GAC	granular activated carbon
gpm	gallons per minute
ISCO	*in situ* chemical oxidation
lbs	pounds
LGAC	liquid-phase granular carbon
LTM	long-term monitoring
LTMO	long-term monitoring optimization
MCL	maximum contaminant level
mg/L	milligrams per liter
mV	millivolts
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPWA	North Penn Water Authority
O&M	operation and maintenance
ORP	oxidation-reduction potential
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
P&T	pump and treat
PCE	Tetrachloroethene
PDB	passive diffusion bag
PRP	potentially responsible party
QAPP	Quality Assurance Project Plan
REC	renewable energy certificate

RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RSE	remediation system evaluation
scfm	standard cubic feet per minute
SERA	screening ecological risk assessment
SVE	soil vapor extraction
TCE	Trichloroethene
TIFSD	Technology Innovation and Field Services Division
TOC	total organic carbon
TtGEO	Tetra Tech GEO
USGS	United States Geological Survey
UST	underground storage tank
VGAC	vapor-phase granular activated carbon
VI	vapor intrusion
VIMS	vapor intrusion mitigation system
VOC	volatile organic compound

TABLE OF CONTENTS

List of Tables

Figures

Attachments

1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001 independent reviews called Remediation System Evaluations (RSE) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (i.e., those sites with P&T systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, the US Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI) has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies as documented in *Office of Solid Waste and Emergency Response (OSWER) Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. Concurrently, the EPA developed and applied the Triad Approach to optimize site characterization and development of a conceptual site model (CSM). The EPA has since expanded the definition of optimization to encompass investigation stage optimization using Triad Approach best management practices (BMP), optimization during design, and RSEs. The EPA's working definition of optimization as of December 2011 is as follows:

> *"A systematic site review by a team of independent technical experts, at any phase of a cleanup process, to identify opportunities to improve remedy protectiveness, effectiveness, and cost efficiency, and to facilitate progress toward site completion."*

As stated in the definition, optimization refers to a "systematic site review", indicating that the site as a whole is often considered in the review. Optimization can be applied to a specific aspect of the remedy (e.g., focus on long-term monitoring optimization [LTMO] or focus on one particular operable unit [OU]), but other site or remedy components are still considered to the degree that they affect the focus of the optimization. An optimization evaluation considers the goals of the remedy, available site data, CSM, remedy performance, protectiveness, cost-effectiveness, and closure strategy.

A strong interest in sustainability has also developed in the private sector and within Federal, State, and Municipal governments. Consistent with this interest, OSRTI has developed a Green Remediation Primer (www.clu-in.org/greenremediation), and now routinely considers green remediation and environmental footprint reduction during optimization evaluations. The evaluation includes reviewing site documents, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation, and represent the opinions of the evaluation team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance project plans (QAPP).

The national optimization strategy includes a system for tracking consideration and implementation of the optimization recommendations and includes a provision for follow-up technical assistance from the optimization team as mutually agreed upon by the site management team and EPA OSRTI.

Purpose of Optimization at the North Penn 6 Site

The North Penn Area 6 Superfund Site (NPA6 Site) addresses multiple sources of contamination and a broad contaminant plume that underlies a large portion of Lansdale, Pennsylvania. Tetrachloroethene (PCE), trichloroethene (TCE), and associated degradation products are the primary contaminants of concern. The EPA originally identified 26 facilities in the Lansdale area as possible sources of contamination due to their use of site-related solvents. These 26 properties were grouped into two OUs for soil contamination that would address source control through soil remediation. OU1 addressed 20 properties where the EPA would perform remedial activities. OU2 will address the six remaining properties where the owners/operators will complete the work with EPA oversight.

The groundwater contamination underlying the area is addressed in the OU3 Record of Decision (ROD) signed in August 2000. OU3 includes groundwater extraction and treatment of the contaminated groundwater at 10 source locations. Of these 10 locations, six are funded by Superfund (Fund-lead) and four are funded by potentially responsible parties (PRP). Groundwater remedies for five of the Fund-lead locations have been constructed and are the focus of this optimization evaluation report. These five locations are as follows:

- Keystone Hydraulics (system operating since 2004)
- Royal Cleaners (system operating since 2004)
- Westside Industries (system operating since 2008)
- Electra Products (system operating since 2008)
- Rogers Mechanical (former Tate Andale) (system began operation in 2011)

EPA Region 3 requested that an optimization evaluation be conducted to identify potential opportunities to improve these five OU3 systems and to identify potential options for replacing or supplementing the existing remedies.

1.2 TEAM COMPOSITION

The optimization team consists of the following individuals:

Table 1: Optimization Team Composition

Name	Affiliation	Phone	Email
Doug Sutton	Tetra Tech GEO	732-409-0344	Doug.Sutton@tetratech.com
Peter Rich	Tetra Tech GEO	410-990-4607	Peter.Rich@tetratech.com
Sandra Goodrow	Tetra Tech GEO	732-409-0344	Sandra.Goodrow@tetratech.com

In addition, the following individuals from the EPA OSRTI, Technology Innovation and Field Services Division (TIFSD) participated in the optimization site visit:

- Kirby Biggs, EPA TIFSD
- Ed Gilbert, EPA TIFSD

1.3 DOCUMENTS REVIEWED

The following documents were reviewed. The reader is directed to these documents for additional site information that is not provided in this report.

- *Draft Phase I Environmental Assessment North Penn Area 6 Site- OU1*, Black & Veatch Waste Science, Inc., March 1994
- *Remedial Investigation Feasibility Study Report, North Penn Area 6 Site, Source Control Operable Unit*, December 1994.
- *Record of Decision, OU1*, US EPA Region 3, September 29, 1995.
- *Review of Aquifer Test Results for the Lansdale Area, Montgomery County, Pennsylvania, 1980-95*, United States Geological Survey (USGS) Open-File Report 98-294, 1998.
- *Remedial Design Treatability Study Report, OU1*, January 1999.
- *Analysis of Geophysical Logs, at North Penn Area 6 Superfund Site*, Lansdale, Montgomery County, Pennsylvania, USGS, 1999.
- *Remedial Investigation/Feasibility Study (RI/FS) Report, OU3*, August 1999.
- *Ground-Water System, Estimation of Aquifer Hydraulic Properties, and Effects of Pumping on Ground-Water Flow in Triassic Sedimentary Rocks in and near Lansdale, Pennsylvania*, USGS Water-Resources Investigations Report 99-4228, 1999
- *OU1 Remedial Action Report for Soil Remediation at Electra Products, Keystone Hydraulics, and Tate Andale*, March 2000
- *Simulation of Aquifer Tests and Ground-Water Flowpaths at the Local Scale in Fractured Shales and Sandstones of the Brunswick Group and Lockatong Formation, Lansdale, Montgomery County, Pennsylvania*, USGS Open-File Report 00-97, 2000.
- *Record of Decision, OU 03,* US EPA Region 3, August 10, 2000.
- *Final Detailed Design Report, Volumes I and II, Former Keystone Hydraulic Property*, IT Corporation, August 3, 2001.
- *Operation & Maintenance Manual, Keystone Hydraulics Property*, Volumes I and II, ACOE, prepared by Shaw E & I, September 2002.
- *Operation & Maintenance Manual, Royal Cleaners Property*, Volumes I and II, ACOE, prepared by Shaw E & I, September 2002.
- *Case Study for Delineating a Contributing Area to a Well in a Fractured Siliciclastic-Bedrock Aquifer Near Lansdale, Pennsylvania*, USGS Water-Resources Investigation Report 02-4271, 2003.
- *Operation & Maintenance Manual for Electra Remediation System, Specialty Systems Integrator*, August 200.
- *Operation & Maintenance Manual for Westside Remediation System, Specialty Systems Integrator*, August 2007.

- *Vapor Extraction Feasibility Technical Memorandum*, EA Engineering, Science, and Technology, Inc., 28 February 2008.
- *2008 Annual Long Term Monitoring Report, North Penn Area 6 Sites*, EA Engineering, Science, and Technology, Inc., August 2009.
- *Explanation of Significant Differences, North Penn Area 6 Superfund Site, Operable Unit 3*, September 2009.
- *Geophysical Logs, Specific Capacity, and Water Quality of Four Wells at Rogers Mechanical (former Tate Andale) Property, North Penn Area 6 Superfund Site*, Lansdale, Pennsylvania, 2006-07, USGS Open-File Report 2010-1023, 2010.
- *2009 Annual Long Term Monitoring and Operations and Maintenance Report*, EA Engineering, Science, and Technology, Inc., August 2010.
- *North Penn Area 6 Current Site Information*, EPA Region 3, November 2010.
- *2010 Annual Long-Term Monitoring and Operations and Maintenance Report (Draft), Long Term Remedial Action at North Penn Area 6 (Operable Unit 3)*, EA Engineering, Science, and Technology, March 2011.
- *Operations & Maintenance for Former Rogers Mechanical Facility (generic O &M index, intro and sections with detailed As-Built Site Plans*, EA Engineering, Science and Technology, April 26, 2011)
- Various vapor intrusion data for the Keystone Hydraulics site provided by EPA
- *Draft USGS manuscript titled: Hydrogeology and Conceptual Groundwater-Flow System at and near Electra Products property, North Penn Area 6*, Lansdale, Pennsylvania

1.4 QUALITY ASSURANCE

This optimization evaluation utilizes existing environmental data to interpret the conceptual site model, evaluate remedy performance, and make recommendations to improve the remedy. The quality of the existing data is evaluated by the optimization team prior to using the data for these purposes. The evaluation for data quality includes a brief review of how the data were collected and managed (where practical, the site QAPP is considered), the consistency of the data with other site data, and the use of the data in the optimization evaluation. Data that are of suspect quality are either not used as part of the optimization evaluation or are used with the quality concerns noted. Where appropriate, this report provides recommendations made to improve data quality.

1.5 PERSONS CONTACTED

The following individuals associated with the site were present for the visit:

Table 2: Persons Contacted during Optimization Evaluation

Name	Affiliation	Phone	Email
Huu Ngo	EPA Region 3 (RPM)	(215) 814-3187	ngo.huu@epa.gov
Kristine Matzko	EPA Region 3 Section Chief		
Kathy Davies	EPA Region 3 Hydrogeologist		
Bruce Rundell	EPA Region 3 Hydrogeologist		
Lisa Senior	USGS		
Dan Goode	USGS		
Angela McGinty	EA Engineering, Science and Tech.		

2.0 SITE BACKGROUND

2.1 LOCATION

The NPA6 Site is located in and around the Borough of Lansdale in Montgomery County, Pennsylvania approximately 23 miles west of the Delaware River. This site is one of several National Priorities List (NPL) sites involving the North Penn Water Authority (NPWA) wells that supply drinking water to many people living northwest of Philadelphia. The area is primarily composed of a mixture of commercial, industrial, and residential land use, with 45,000 people living within a 3-mile radius of the Site. Approximately 100,000 people obtain drinking water from public and private wells within 3 miles of the site.

As part of the NPA6 Site, there are active groundwater extraction and treatment systems at five Fund-lead locations that are the focus of this optimization evaluation report. These five locations are as follows:

- Electra Products (200 W. Fifth Street), operating since 2008
- Keystone Hydraulics (834 W. Third Street), operating since 2004
- Rogers Mechanical (former Tate Andale) (135 E. Hancock Street), operating since April 2011
- Royal Cleaners (1315 N. Broad Street), operating since 2004
- Westside Industries (5^{th} and Mitchell Streets), operating since 2008

2.2 SITE HISTORY

2.2.1 HISTORIC LAND USE AND FACILITY OPERATIONS

The NPA6 Site includes some industries that have been operating since the 1940s, and other industries in the area began operations as late as the 1980s (Black and Veatch, 1994). Various solvents, degreasers, and other types of organic compounds such as TCE, 1,1,1-trichloroethane (1,1,1-TCA), and PCE were used at these industries.

The source control Remedial Investigation and Feasibility (RI/FS) Study Report, compiled in 1994 by Black and Veatch Waste Science, Inc. (1994 RI/FS) includes the following site histories for the five locations that are being discussed under this optimization evaluation:

- Electra Products
  Electra Products is presently occupied by Auto Care Center and several other tenants. Electra Products used a PCE-based product for the manufacture of industrial furnaces and ovens.

- Keystone Hydraulics
  The current Keystone Hydraulic plant was built in the 1940s and was operated by J.W. Rex Company until 1959 when it was sold to Allied Paint Company. Allied Paint operated the plant between 1959 and 1979. Keystone Hydraulics has owned and operated the facility since 1979. The currently inactive facility occupies one acre and is not currently in use. At various times, the following chemicals have been reportedly been used on site: TCE, alkyd resins, linseed oils, toluene, xylene, various alcohols, mineral spirits, napthas, and machine cleaners of unknown composition.

- <u>Royal Cleaners</u>
  Dry cleaning facilities have been located at the Royal Cleaners property for approximately 20 years. At the time of the 1994 Remedial Investigation (1994 RI), Royal Cleaners used approximately 50 gallons of PCE per month. Buried steel drums discovered at the facility in 1989 lead to an EPA removal action. In April of 1991, contaminated soils and waste drums were excavated, and later removed by the PRP. The pit was backfilled with clean fill under EPA oversight.

- <u>Westside Industries</u>
  Westside Industries has owned the 5th and Mitchell Streets property since the middle of the 1980's. Westside operates as a landlord to a roofing company, a pretzel baker, and other tenants. A cistern and three underground storage tanks (USTs) were reportedly used at this property, but no documented disposal of solvents exists. The cistern was previously reported to be leaking into the groundwater and once contained water with 2,600 micrograms per liter (µg/L) of 1,2-dichloroethene. The prior owner of this property was reportedly a company known as Weaver Steel.

The locations of these five properties are depicted in Figure 1.

2.2.2 CHRONOLOGY OF ENFORCEMENT AND REMEDIAL ACTIVITIES

NPWA first discovered elevated levels of contamination in their wells in 1979. The wells were immediately taken out of service and NPWA began sampling of several wells in the area, to determine the types and levels of contamination present in the groundwater. Primary contaminants identified in groundwater were TCE and PCE. The NPA6 Site was placed on the NPL in March of 1989. Table 3 provides a brief chronology of enforcement and remedial activities that primarily focuses on the five Fund-lead locations with active groundwater remedies.

Table 3: Brief Site Chronology

Event	Date
Detection of solvents in groundwater	1979
Site Proposed to NPL	18 September 1985
Final NPL Listing	31 March 1989
Source Control RI/FS Report Issued	August 1994
OU1 (source control for Fund-lead locations) ROD signed	September 1995
Groundwater RI/FS Report Issued	2 August 1999
Soil excavation at Rogers Mechanical (Tate Andale), Electra Products, and Keystone Hydraulics	October – November 1999
Proposed Plan identifying the EPA's preferred groundwater remedy presented to the public; start of public comment period	6 December 1999
OU3 (groundwater) ROD signed	10 August 2000
Construction completed for groundwater remedies at Keystone Hydraulics and Royal Cleaners	2002
Startup of treatment system at Keystone Hydraulics	2004
Startup of treatment system at Royal Cleaners	2004
Startup of treatment system at Westside Industries	2008
Startup of treatment system at Electra Products	2008
Explanation of Significant Differences (ESD) signed to modify remedy at Rogers Mechanical (former Tate Andale)	September 2009
Startup of treatment system at Rogers Mechanical (former Tate Andale)	2011

2.3 POTENTIAL HUMAN AND ECOLOGICAL RECEPTORS

Human and ecological risk assessments were performed following the completion of the 1994 and 1999 RIs to identify existing and future risks that could occur if conditions at the site do not change. These risk assessments demonstrated that actual or threatened releases of hazardous substances from this site, if not addressed by EPA's preferred alternative or one of the other cleanup alternatives considered, may present a current or potential threat to public health, welfare, or the environment.

Groundwater is a major drinking water source at the site. The NPWA treats the contaminated groundwater from several wells before being delivered to the public and has relocated many of the water supply wells outside the boundary of the NPA6 Site. There are also residents who depend on private wells for their drinking water supply. EPA arranged for the connection of a number of residences to public water supplies.

The OU3 ROD describes a screening ecological risk assessment (SERA) that was performed using results for surface water and sediments. The SERA performed on the headwaters located at the NPA6 Site indicated a potential risk to aquatic organisms. The ROD concluded that the risk (that was varied between the micro-watersheds) was caused primarily by contaminants that were typically related to urban development and are not believed to be related to the NPA6 Site.

2.4 EXISTING DATA AND INFORMATION

2.4.1 SOURCES OF CONTAMINATION

The historic land use and facility operations that were considered a potential contributor to the contamination of the soils and groundwater of the five Fund-lead locations with active groundwater remedies are discussed in Section 2.2.1 of this document.

Three of the five locations addressed by this optimization evaluation (Keystone Hydraulics, Electra Products, Rogers Mechanical/Tate Andale, and Royal Cleaners) had soils identified as a source. Buried drums and contaminated soil were removed from Royal Cleaners in 1991. Contaminated soils were excavated for off-site disposal in Fall 1999 from the other three properties with soil contamination.

The 1994 RI/FS reported soil contaminant concentrations at Royal Cleaners (after the 1991 Removal Action) and Westside Industries were low enough to be considered not a significant contaminant source to groundwater. Therefore, there was no requirement for excavation of soils from these properties.

Contaminant concentrations detected in the soils are discussed in Section 2.4.3.

2.4.2 GEOLOGY SETTING AND HYDROGEOLOGY

The 1999 USGS report entitled *Ground-Water System, Estimation of Aquifer Hydraulic Properties, and Effects of Pumping on Ground-Water Flow in Triassic Sedimentary Rocks in and near Lansdale, Pennsylvania* describes the groundwater flow system as follows:

> Ground-water in the rocks underlying Lansdale and the North Penn Area 6 site originates from infiltration of local precipitation. After infiltrating through soil and saprolite (extensively weathered rock), the water moves through near-vertical and horizontal fractures in the shale and siltstone bedrock. Depth to bedrock is commonly less than 20 feet (ft) (6 meters[m]) below land surface. The soil, saprolite, and individual beds of the sedimentary bedrock form a layered aquifer, with varying degrees of hydraulic connection between the layers. Hydraulic properties of the soil, saprolite, and individual beds of the underlying sedimentary bedrock differ. Primary porosity, permeability, and storage in the Triassic-age sedimentary bedrock is very low.
>
> Water in the shallowest part of the sedimentary-rock aquifer may be under unconfined (water table) or partially confined conditions; the unconfined part of the aquifer is thin and is difficult to delineate. In some areas, perched water is present at shallow depths (less than 50 ft [15 m]); in the deeper part of the aquifer, water generally is confined or partially confined, resulting in artesian conditions. Shallow and deep ground-water-flow systems may be present at the site. Water from the shallow system likely discharges locally to streams and leaks downward to the deep system. Deep and shallow ground-water generally flows in a direction similar to the topographic gradient. Deep ground water discharges to streams and to pumping wells. The natural direction of shallow and deep ground-water flow is altered by pumping, and pumping from deep zones may induce downward flow from shallow zones. In the Triassic-age sedimentary rocks of the Brunswick Group and the Lockatong Formation, cones of depression caused by pumping have been observed to extend preferentially along strike of bedding planes or in the direction of fracture orientation (Longwill and Wood, 1965).
>
> The conceptual model of the ground-water system in the study area consists of dipping, layered fractured rocks with ground-water flow within partings developed primarily along bedding planes. Vertical fractures generally do not cut extensively across beds but may provide local routes of ground-water flow or leakage between beds (Figure 7)

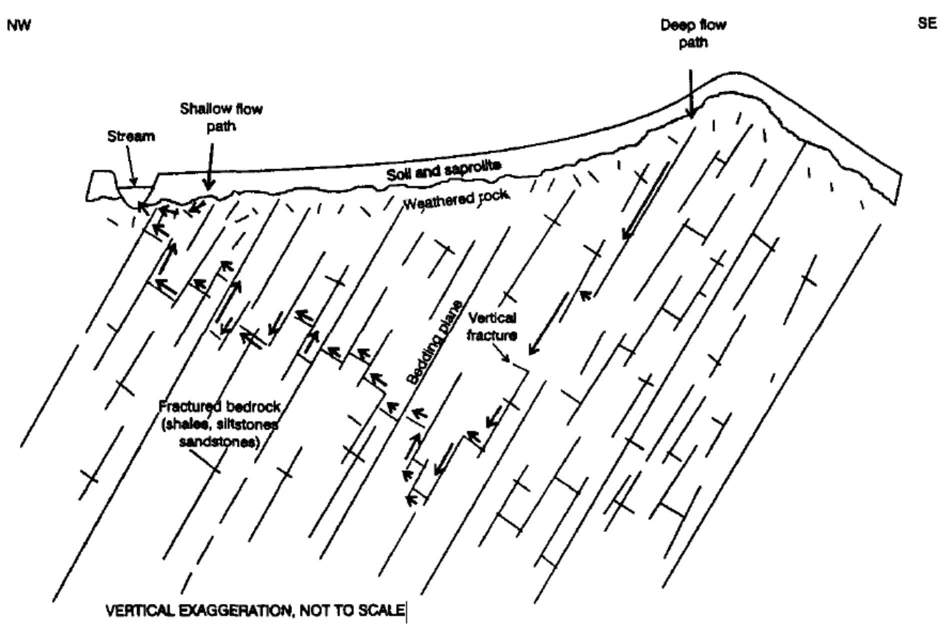


Figure 7. Conceptual ground-water flow system in a fractured sedimentary-rock aquifer with dipping beds.

The Brunswick and Lockatong in the area of the NPA6 Site generally strike to the northeast and dip at approximately 10° to 20° to the northwest. Transmissivity at the Site varies depending on location and depth interval and is typically approximately than 1,300 square feet (ft^2) per day. A USGS model (USGS, 2003) developed for estimating the zone that contributes water to a pumping well used hydraulic conductivities ranging from 0.161 ft per day to 5.35 ft per day.

A regional potentiometric map based on measured water levels indicates that ground water flows from Lansdale towards discharge areas in three drainages; the Wissahickon, Towamencin, and Neshaminy Creeks.

The depth to groundwater varies across the Site due to changes in surface elevation and water table drawdown due to production well pumping. Groundwater is approximately 10 ft below ground surface (bgs) at the Keystone Hydraulics and Westside Industries sites. Groundwater is approximately 50 ft bgs at the Electra Products, Royal Cleaners, and Rogers Mechanical sites.

Surface Water Hydrology

The Lansdale area is a relatively flat upland terrain which forms a surface water divide between the following surface water bodies:

- Wissahickon Creek (to the southeast)
- Towamencin Creek (to the west and southwest)
- Tributaries of the West Branch of the Neshaminy Creek (to the north and northeast)

The Wissahickon and the Towamencin Creeks and their tributaries flow generally southward to the Schuylkill River. The Neshaminy Creek and its tributaries flow generally eastward and discharge ultimately to the Delaware River. Surface elevations in the area generally vary from approximately 200 to 600 ft above mean sea level (amsl).

Surface water runoff in the vicinity of the Site is directed primarily toward the unnamed tributaries of the West Branch of Neshaminy Creek, toward Wissahickon Creek, or towards the tributaries of Towamencin Creek. Stormwater infrastructure in the area, however, may direct some runoff elsewhere (EPA, 2000).

2.4.3 SOIL CONTAMINATION

During the 1994 RI, soil investigations included the following:

- At Electra Products, soil gas samples were collected from nine locations and soil samples were collected from 18 locations. Soil samples were generally collected at the surface, 5 ft bgs, and 7 ft bgs. A soil sample from one location had concentrations of PCE, TCE, and *cis*-1,2-DCE at 1,100 micrograms per kilogram (µg/kg), 50 µg/kg, and 340 µg/kg, respectively. The investigation concluded that soil remediation was required to reduce the impact of soil contamination to groundwater.

- At Keystone Hydraulics, soil gas samples were collected from 10 locations and soil samples were collected from 49 locations. Soil samples were collected at 2.5 ft bgs, 5 ft bgs, or 7 ft bgs. The concentrations of PCE, TCE, and *cis*-1,2-DCE found in the soil samples were up to 60,000 µg/kg, 210,000 µg/kg and 180,000 µg/kg, respectively. The investigation concluded that soil remediation was required to reduce the impact of soil contamination to groundwater.

- At Rogers Mechanical (Former Tate Andale), soil gas samples were collected at 16 locations and soil samples were collected from 26 locations at depths ranging from 5 to 7 ft bgs. Of the 26 locations, 11 were collected in the old storage area in the southwestern part of the property, and 15 were collected in the northeastern part of the property. The soil sample from the southwestern part of the property with the highest concentrations had 1,1-dichloroethane (1,1-DCA) at 170 µg/kg, 1,1,1-TCA at 140 µg/kg, 1,1-dichloroethene (1,1-DCE) at 66 µg/kg, and *cis*-1,2-DCE at 54 µg/kg. PCE and TCE concentrations were lower. The soil sample from the northeastern part of the property with the highest concentrations contained TCE at 4,600 µg/kg and *cis*-1,2-DCE at 2,600 µg/kg. The investigation concluded that soil remediation was required in the northeastern portion of the property to reduce the impact of soil contamination to groundwater but not in the southwestern part of the property.

- At Royal Cleaners, soil samples were collected at nine locations at various depth intervals from 5 to 10 ft bgs. The highest concentrations of PCE and TCE were 42 and 35 µg/kg, respectively. This 1994 RI followed the 1991 Removal Action that resulted in the removal of buried drums and contaminated soil, and the 1994 RI concluded that no further soil remediation was required.

- At Westside Industries, soil samples were collected at 23 locations at various depth intervals from 4.5 ft bgs to 8 ft bgs. The highest concentrations of PCE and TCE were 100 and 16 µg/kg, respectively. The investigation concluded that no further soil remediation was required.

Soil remediation via excavation with off-site disposal was conducted at Electra Products, Keystone Hydraulics, and Rogers Mechanical (former Tate Andale). According to the 2001 OU1 RA Report, confirmation sampling conducted as part of this remediation was done in advance of the excavation by digging test pits and sampling at the 2 and 4 ft bgs intervals. If concentrations exceeded cleanup criteria, then additional test pits were conducted and sampled until cleanup criteria were met. Excavation was then conducted within the delineated area. The depth of the excavations is not readily apparent in the RA report. Some of the test pit samples indicated higher levels of contamination than those identified during the RI. No vertical confirmation samples were collected from the excavations to confirm removal of all contamination above the cleanup criteria.

2.4.4 SOIL VAPOR CONTAMINATION

Remedial Investigation

Soil gas samples were collected at some of the larger properties during the 1994 RI, where information was available, to help determine if any "hot spots" of contamination were present. Soil gas samples were collected from approximately the 4 to 5 ft bgs depth interval using a syringe pump to encapsulate the sample in a pre-evacuated glass vial and were analyzed for the target contaminants in an off-site laboratory within 24 hours of collection.

Nine soil gas samples were obtained from the Electra Products property, 10 samples were obtained from the Keystone Hydraulics property, and 19 samples were taken from the Tate Andale property. No soil gas samples were acquired for the Westside or Royal Cleaners property.

The highest concentration of contaminant compounds detected in the soil gas samples on the properties evaluated are presented in Table 4:

Table 4: Results from Soil Gas Sampling during 1994 RI

	Keystone Hydraulics (µg/L)	Tate Andale/ Rogers Mechanical (µg/L)	Electra Products (µg/L)
TCE	1,135	862	6.3
PCE	51	not reported	48
cis-1,2-DCE	8,388	96	1.1
trans-1,2-dichloroethene	41	8.1	not reported
1,1-dichloroethane	3.2	4	not reported

µg/L = mg/m^3

Additional Investigations

The potential for vapor intrusion (VI) in the area near Keystone Hydraulics was studied over seven sampling events. The first four sampling events, which were conducted during 2006, focused on the Keystone property and/or two residences near the Keystone property. The events included sampling of both subslab vapors and indoor air. In August 2008, subslab and indoor air were sampled at 13 residences near Keystone, and the remaining two events were follow-up events to the 2008 event. Of the 13 residences, sampling results suggested an increased life-time cancer risk of less than 1×10^{-4} at all 13 residences and less than 1×10^{-5} at 8 of the 13 residences. One household had non-cancer risk above the EPA threshold value, but this exceedance was predominantly due to 1,2-dichloropropane, which is not believed to be a site contaminant. The EPA documentation suggests that there may be quality issues with some of the data.

2.4.5 GROUNDWATER CONTAMINATION

Primary groundwater contaminants of concern (COC) identified in groundwater are chlorinated volatile organic chemicals (CVOCs) including TCE, PCE, *cis*-1,2-DCE, and vinyl chloride. TCE is the most widespread and has some of the highest concentrations among all contaminants. PCE contamination is also prevalent at Electra Products and Royal Cleaners. High levels of *cis*-1,2-DCE and vinyl chloride are most prevalent at Westside Industries.

Table 5 summarizes the maximum levels of CVOC groundwater contamination detected in a monitoring well from each of the properties during the 2010 March-April sampling event.

Table 5: Maximum VOC Detections in Monitoring Wells from the 2010 March-April Sampling Event

		Keystone	Electra	Westside	Royal	Rogers
	MCL	**KEY-2S**	**ELE-1S**	**WES-3I**	**ROY-3D**	**ROG-4S**
cis-1,2-DCE (µg/L)	70	9,900 L	27 L	350 K	250	18 K
PCE (µg/L)	5	1,200 J	360 L	1.1	100	21
TCE (µg/L)	5	34,000 L	100 L	2.9	1,800	67
Vinyl chloride (µg/L)	2	1,400 J	ND	310 K	9.9	ND

MCL = maximum contaminant level
J – estimated
K – estimated biased high
L – estimated biased low

Table 6 summarizes the maximum levels of groundwater contamination detected in the extraction well from each of the properties in April 2010.

Table 6: Maximum Detected Concentrations in Extraction Wells in April 2010

	MCL	Keystone	Electra	Westside	Royal	Rogers
cis-1,2-DCE (µg/L)	70	64	10	890	13	NS
PCE (µg/L)	5	66	36	10	170	NS
TCE (µg/L)	5	230	74	950	90	NS
Vinyl chloride (µg/L)	2	0.65	0.5 U	130	0.5	NS

U – Not detected at the indicated value.
NS – Not sampled

Site maps depicting groundwater sampling results from the 2010 sampling events are included in Attachment A. Graphs of the analytes detected in extraction wells for Electra, Keystone, Royal and Westside can be found in Attachment B. The wells are sampled quarterly. Attachment C provides graphs of analytes detected in the monitoring wells for all five locations. Note, however, that the graphs contain data collected with various sampling methods and interpretation of each result should consider how that sample was collected. For example, some results reflect sampling conducted with passive diffusion bags (PDB) set at various intervals within a well, and other results reflect whole-well sampling or low-flow sampling from reconstructed wells. The data are presented in electronic form as part of each annual report prepared by the site consultant.

2.4.6 SURFACE WATER CONTAMINATION

Surface water contamination is not a primary focus of this evaluation. All extraction and treatment systems that discharge treated water to surface waters abide by Pennsylvania National Pollutant Discharge Elimination System (NPDES) limits. The permit limits are discussed in Section 3.0 of this report, and compliance with those limits is discussed in Section 4.0 of this report.

3.0 DESCRIPTION OF PLANNED OR EXISTING REMEDIES

3.1 Remedy and Remedy Components

3.1.1 OU1

The original selected remedy for OU1 was in -place processing with hot air injection, with excavation and off-site disposal as the backup alternative if the original remedy could not obtain cleanup standards. Remediation levels were established in the 1995 ROD for OU1.

A treatability study was completed using a hot air process to treat the contaminated soils at the Rogers Mechanical (Tate Andale) site. The process treated approximately 800 cubic yards of soils that contained relatively low levels of contamination (EPA, 1999). Based on the results of the study, the project manager determined that although the hot air injection was somewhat effective at reducing soil contamination in the grids that were treated, this treatment would not be appropriate for treating the four properties due to site access, underground utilities, activities on site, and areas of debris and moisture at the sites. As a result, the contingent remedy was adopted.

According to the OU1 Remedial Action Report, the soil remedies were completed in 1999 at Electra Products, Keystone Hydraulics, and the northeastern area of Rogers Mechanical (former Tate Andale). The contaminated soil was excavated and shipped to an approved off-site disposal facility. The intended cleanup criteria for each of the three sites are as follows:

- Electra Products: 182 µg/kg of PCE
- Keystone Hydraulics: 769 µg/kg of TCE
- Tate Andale: 131 µg/kg of TCE

Confirmation sampling was conducted prior to excavation and was only conducted at intervals 2 and 4 ft bgs. The depths of the excavations are unclear in the RA report, and no vertical confirmation samples were collected.

3.1.2 OU2

The remedies associated with OU2 will be implemented by PRPs under EPA oversight and are not discussed further in this report.

3.1.3 OU3 – Electra Products

Active groundwater remediation at Electra Products consists of a P&T system with one extraction well and a treatment system that includes filtration with bag filters in multiple parts of the process stream, metals removal with greensand, addition of a sequestering agent to reduce metals precipitation within the system, an air stripper for organics removal, liquid-phase granular carbon (LGAC) to treat organic compounds in the air stripper effluent, and vapor-phase granular activated carbon (VGAC) for the treatment of the air stripper off-gas. An air-to-air heat exchanger is used to cool the air stripper off-gas prior to the VGAC. Based on the results of pre-design testing, this system was designed to treat groundwater at an average flow rate of 20 gallons per minute (gpm) and a peak nominal flow rate of 30 gpm.

The treated process water is discharged to a small tributary of the West Branch of Neshaminy Creek via a storm sewer and underground culvert near the treatment facility.

3.1.4 OU3 – Keystone Hydraulics

Active groundwater remediation at Keystone Hydraulics consists of a P&T system with a single extraction well and a treatment system that includes filtration with bag filters, ion exchange for metals removal, an air stripper for organics removal, LGAC to treat organic contaminants in the air stripper effluent, and VGAC for the treatment of the air stripper off-gas. A sequestering agent is added to reduce precipitation of metals in the air stripper and LGAC vessels. A duct heater is used to raise the temperature and reduce the humidity of the air stripper off-gas, and create optimum conditions for contaminant adsorption in the two VGAC vessels. The system is designed for an average flow rate of 15 gpm and a nominal peak flow rate of 30 gpm. In pre-design testing, a 15-gpm extraction rate was determined to be sufficient to create a capture zone that extends beyond the downgradient property line.

The treated process water is discharged to a small tributary of the West Branch of Neshaminy Creek via a storm sewer and underground culvert near the treatment facility.

3.1.5 OU3 – Rogers Mechanical (Tate Andale)

The Rogers Mechanical treatment system was a pre-fabricated system that was installed and began operation in April 2011. This system consists of a dual-phase extraction system that extracts and treats contaminated vapors and groundwater. The system includes one extraction point, a 120-gallon knockout tank, dilution air intake filter, two VGAC vessels for vapor treatment, and two LGAC vessels for water treatment. Long-term extraction rates for this system are not yet documented, but the vapor extraction is typically less than 100 standard cubic feet per minute (scfm) and groundwater extraction is typically less than 2 gpm.

3.1.6 OU3 – Royal Cleaners

Active groundwater remediation at Royal Cleaners is a P&T system with a single extraction well and a treatment system that includes filtration with bag filters in multiple parts of the process stream, addition of a sequestering agent to prevent metals precipitation in treatment equipment, CVOC removal with an air stripper, LGAC to treat organic contaminants in the air stripper effluent, and VGAC for the treatment of the air stripper off-gas. A duct heater is used to raise the temperature and reduce the humidity of the air stripper off-gas, and create optimum conditions for contaminant adsorption in the two VGAC vessels. The system is designed for an average flow rate of 20 gpm and a nominal peak flow rate of 30 gpm.

The treated process water is discharged to a small tributary of the West Branch of Neshaminy Creek via a storm sewer and underground culvert near the treatment facility.

3.1.7 OU3 – WESTSIDE INDUSTRIES

Active groundwater remediation at Westside Industries consists of P&T system with a single extraction well and a treatment system that includes filtration with bag filters in multiple parts of the process stream, metals removal with greensand, addition of a sequestering agent to reduce metals precipitation within the system, an air stripper for CVOC removal, LGAC for further CVOC removal, VGAC for treatment of the air stripper off-gas, and permanganate oxidation for treatment of the vinyl chloride in the VGAC discharge. An air-to-air heat exchanger is used to cool the air stripper off-gas prior to the VGAC units. The system is designed for an average flow rate of 20 gpm and a nominal peak flow rate of 30 gpm.

The treated process water is discharged to a small tributary of the West Branch of Neshaminy Creek via a storm sewer and underground culvert near the treatment facility.

Table 7 presents the extraction rates and contaminant removal for the four systems (excludes Rogers Mechanical) from 2008 through 2010.

Table 7: Facility Treatment Technology Statistics (from EA, 2011)

Facility	Gallons Pumped	Average Pump Rate (gpm)	Percent (%) Days Operational	Pounds Removed
2010				
Electra	11,055,937	23.4	90	8.82
Keystone	8,056,936	16.8	91	21.5
Royal	19,440,266	38.2	97	31.5
Westside	11,676,007	24.5	91	180
2009				
Electra	9,775,772	26.2	71	9.31
Keystone	8,878,264	18.4	92	32.6
Royal	15,934,503	37.4	81	36.4
Westside	6,405,984	12.2	44	348
2008				
Electra	1,200,920	6.8	33	1.57
Keystone	7,827,673	16.5	89	40.27
Royal	10,410,248	33	81	31.22
Westside	2,578,337	6.6	55	183.53

3.2 REMEDIAL ACTION OBJECTIVES AND STANDARDS

The implied goals of the OU3 groundwater remedy are to control contaminant migration from the source areas and restore the aquifer to its beneficial use as a potable use aquifer. The ROD, however, recognizes that restoration of the entire aquifer is not anticipated. The groundwater remedies are to continue operating until cleanup criteria are reached at points of compliance. The points of compliance include the

P&T extraction wells and various monitoring wells that would be established by EPA during "future activities". To date, additional points of compliance for the five groundwater treatment systems have not been established. The Applicable or Relevant and Appropriate Requirements (ARARs) for the COCs in groundwater are specified in Table 8 below.

Table 8: Chemical Specific ARARs as per OU3 ROD

Contaminant	Federal Human Health Drinking Water MCLS (milligrams per liter [mg/L])[1]	Freshwater Objectives[2]		MCL Goals[3] (mg/L)
		Fish & Water Ingestion (mg/L)	Fish Ingestion Only (mg/L)	
cis-1,2-Dichloroethene	0.07	--	--	0.07
Tetrachloroethene	0.005	0.0008	0.00885	--
Trichloroethene	0.005	0.0027	0.0807	0
Vinyl Chloride	0.002	0.002	0.525	0

1. Table taken from the USEPA Superfund ROD for North Penn Area 6; cleanup goal is defined in the ROD for the groundwater pump and treat systems as restoration of the aquifer to its beneficial use as a potable aquifer.
2. The Delaware River Basin Commission Water Quality Regulations. 18 CFR 430.7, 430.9, 430.11, 430.15-23.
3. 40 CFR 141.61, 141.62

As stated in the 2000 OU3 ROD, complete restoration of the entire contaminated portion of the aquifer associated with the NPA6 Site is not anticipated due to the potential presence of dense, non-aqueous phase liquids (DNAPL), the size of the plume both laterally and vertically, and the long and varied pumping history by both water supply and industrial wells in the affected aquifer. It is noted that during a future Five-Year Review assessment of the remedy, and once the extraction system has been operating and adequate hydrogeological and chemical data have been collected, an evaluation of the technical impracticability to meet ARARs for a limited area or areas of the aquifer will be made.

3.3 PERFORMANCE MONITORING PROGRAMS

Table 1-3 (see Attachment D) from the Draft 2010 Annual Long-term Monitoring and Operations and Maintenance Report (EA, 2011) provides the wells at the five locations that are sampled as part of the long-term monitoring (LTM) program. Sampling with analysis for VOCs is conducted at each of these wells semi-annually. In total, there are 50 monitoring wells distributed as follows among the five locations:

- Electra Products – 5 monitoring wells
- Keystone Hydraulics – 14 monitoring wells
- Rogers Mechanical – 10 monitoring wells
- Royal Cleaners – 12 monitoring wells
- Westside Industries – 9 monitoring wells

Due to varying sampling techniques and changes in well construction over time, comparisons between the data collected from 1997 through 2007 to data collected after 2008 may not be appropriate. Earlier sampling events were performed by low-flow sampling in the open boreholes and with PDBs placed next to fractures at various intervals within the open boreholes. The 2008/2009 and 2010 sampling events were conducted via low-flow sampling techniques at specific screened intervals in the new and reconstructed wells. As more data are collected in the new and reconstructed wells, it is expected that comparisons will be able to be made in future reports.

In addition to the above sampling at monitoring locations, the following sampling is also conducted in association with each treatment plant:

- Electra Products –
  - Quarterly sampling of the extraction well (which is the treatment plant influent) for VOCs and other NPDES parameters
  - Quarterly sampling after the greensand units for VOCs and metals
  - Quarterly sampling after the air stripper for VOCs
  - Quarterly sampling between the LGAC vessels for VOCs
  - Sampling twice per month of the treatment plant effluent for VOCs and other NPDES parameters
  - Monthly sampling of the VGAC influent for VOCs
  - Quarterly sampling between the VGAC vessels for VOCs
  - Monthly sampling of the VGAC effluent for VOCs

- Keystone Hydraulics –
  - Quarterly sampling of the extraction well (which is the treatment plant influent) for VOCs and other NPDES parameters
  - Quarterly sampling of the ion exchange backwash for metals
  - Quarterly sampling between the LGAC vessels for VOCs
  - Monthly sampling of the treatment plant effluent for VOCs and other NPDES parameters
  - Quarterly sampling of the VGAC influent for VOCs
  - Quarterly sampling between the VGAC vessels for VOCs
  - Monthly sampling of the VGAC effluent for VOCs

- Rogers Mechanical –
  - Monthly sampling of the extraction well (which is the treatment plant influent) for VOCs and other NPDES parameters
  - Monthly sampling between the LGAC vessels for VOCs
  - Monthly sampling of the treatment plant effluent for VOCs and other NPDES parameters
  - Monthly sampling of the VGAC influent for VOCs
  - Monthly sampling between the VGAC vessels for VOCs
  - Monthly sampling of the VGAC effluent for VOCs

- Royal Cleaners–
  - Quarterly sampling of the extraction well (which is the treatment plant influent) for VOCs and other NPDES parameters
  - Quarterly sampling between the LGAC vessels for VOCs
  - Monthly sampling of the treatment plant effluent for VOCs and other NPDES parameters
  - Quarterly sampling of the VGAC influent for VOCs
  - Quarterly sampling between the VGAC vessels for VOCs
  - Monthly sampling of the VGAC effluent for VOCs

- Westside Industries –
  - Monthly sampling of the extraction well (which is the treatment plant influent) for VOCs and other NPDES parameters
  - Quarterly sampling after the greensand units for VOCs and metals
  - Quarterly sampling after the air stripper for VOCs
  - Quarterly sampling between the LGAC vessels for VOCs
  - Sampling twice per month of the treatment plant effluent for VOCs and other NPDES parameters
  - Monthly sampling of the VGAC influent for VOCs
  - Quarterly sampling between the VGAC vessels for VOCs
  - Quarterly sampling before the permanganate vapor treatment for VOCs
  - Monthly sampling of the off-gas effluent for VOCs

Up to 20 residential wells throughout the site are also occasionally sampled for VOCs. The last sampling round was conducted in 2010.

3.3.1 TREATMENT PLANT OPERATION STANDARDS

The standards for discharging the treated water to surface water are based on NPDES permits with the monitoring and reporting requirements found in Table 9.

Table 9: North Penn Area 6 Long-Term Remedial Action NPDES Permit Limits

Constituent	Electra (mg/L) 2X per Month		Keystone (mg/L) 1X per Month		Royal (mg/L) 1X per Month		Westside (mg/L) 2X per Month	
Organics	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**
Benzene	0.001	0.002	0.001	0.002	NR	NR	0.001	0.002
Carbon Tetrachloride	0.0006	0.0012	NR	NR	NR	NR	NR	NR
1,2-Dichloroethane	0.0001	0.0002	NR	NR	NR	NR	0.005	0.01
1,1-Dichloroethene	0.0004	0.0008	0.007	0.014	NR	NR	0.007	0.014
-1,2-Dichloroethene	0.0013	0.0026	0.07	0.14	0.07	0.14	0.07	0.14
trans-1,2-Dichloroethene	0.0003	0.0006	NR	NR	NR	NR	NR	NR
Tetrachloroethene	0.0013	0.0026	0.005	0.01	0.005	0.01	0.005	0.01
Trichloroethene	0.0007	0.0014	0.005	0.01	0.005	0.01	0.005	0.01
Vinyl Chloride	0.0012	0.0026	0.002	0.004	NR	NR	0.002	0.004
Inorganics	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**
Aluminum	0.75	1.5	NR	NR	NR	NR	NR	NR
Iron, Total	1.5	3	0.43	0.86	R	R	0.3	0.6
Manganese, Total	0.3	0.6	0.1	0.2	NR	NR	1	2
Other	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**
Flow	Daily	Report	Daily	Report	Daily	Report	Daily	Report
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
pH (Std Unit)	6	9	6	9	6	9	6	9

The discharge criteria for Rogers Mechanical (former Tate Andale) were not reviewed in preparation of this draft report.

The treatment plants are each governed by an air permit equivalents that require 95 percent removal of VOCs in the air stripper off-gas. Monthly reporting is not required, but records are to be retained that demonstrate general compliance with the 95 percent removal requirement and maintenance of the off-gas treatment system.

4.0 CONCEPTUAL SITE MODEL

This section discusses the optimization team's interpretation of existing characterization and remedy operation data to explain how historic events and site characteristics have led to current conditions. This CSM may differ from that described in other site documents.

4.1 CSM OVERVIEW

Contaminant releases from a variety of locations throughout the Lansdale area have resulted in subsurface contamination with VOCs. In several locations, including the five Fund-lead locations with active groundwater remediation, contamination has migrated through the shallow overburden to the fractured bedrock of the Brunswick Formation. The siltstone and mudstone that comprises the bedrock has a very low primary porosity (typically less than 1%). Once the contamination is in the fractured bedrock, it migrates primarily through fractures. In all five locations with Fund-lead groundwater remediation systems, USGS interpretation of geophysical data collected from 1995 through 1997 suggest upward flow in borings under non-pumping conditions. This upward flow would presumably limit or mitigate downward contaminant migration across bedding planes. Horizontal and vertical contaminant migration through fractures is expected to be more pronounced along bedding planes with the most continuous flow paths along strike. The contaminant distribution at several of the sites suggests contaminant migration is potentially occurring in the down-dip direction. Despite relatively low aquifer transmissivity (e.g., approximately 1,000 ft^2 per day), groundwater flow and contaminant transport through fractures can result in relatively high seepage velocities. Hydraulic head gradients have changed over time due to changes in regional production well operation, causing groundwater flow directions (both horizontal and vertical) to potentially change over time. Since the time of many of the contaminant releases, contamination has migrated relatively far from the individual locations in various directions resulting in comingled contaminant plumes. Limited information is available between the various properties to help discern individual contaminant plumes. The premise for the selected remedy is that source control or removal would eventually result in the attenuation of the regional comingled plume.

The majority of contaminant mass at each location appears to be concentrated in the unsaturated zone or shallow groundwater where bedrock is weathered and there is more secondary porosity. Although contamination is present at deeper intervals, the concentrations at deeper intervals are generally lower than in the shallow intervals. This deeper contamination at a particular location may be more regional in nature (i.e., from another site or sites) or the result of historic localized pumping that may have drawn limited amounts of contamination downward. Despite historic efforts to address soil contamination, there is likely source material remaining in relatively shallow intervals (e.g., above 50 ft bgs) at several of the locations. With the exception of Westside Industries where contamination is relatively evenly distributed with depth, the extraction wells at the various remedies appear to preferentially extract relatively deeper, cleaner water from major fractures rather than the highly contaminated shallow groundwater.

The extent of groundwater contamination at all five locations is relatively poorly delineated, and there is insufficient hydraulic information to readily interpret the capture zone extent for each extraction well. At Rogers Mechanical (former Tate Andale), there are little or no groundwater water quality data in the vicinity of the source that was previously excavated, suggesting the potential for an unidentified, uncharacterized contaminant plume.

The CSM for each of the five Fund-lead locations with active groundwater remediation is presented in the following section.

4.2 CSM Details and Explanation

4.2.1 Electra Products

Soil contamination was characterized around the western, southern, and eastern edges of the building during the 1994 RI but not under the building. As stated in Section 2.4.3, soil samples were collected from the surface, 5 ft bgs, and 7 ft bgs. Contaminated soil was removed from a small area to the south of the building (see Figure 2) to a target cleanup level of 182 µg/kg for PCE. Horizontal confirmation samples met the cleanup level, but vertical confirmation samples below 4 ft bgs were not collected throughout the excavated area. The concentrations in one sample at 4 ft bgs were as high as 5,300 µg/kg for PCE, and 240 µg/kg for TCE. The depth of the excavation was not reported. Based on the boring log of ELE1S, the depth to weathered bedrock is approximately 10 ft bgs, and the depth to competent bedrock is approximately 15 ft bgs. Groundwater is present at approximately 50 ft bgs in the vicinity of Electra Products; therefore, contamination sufficient to cause continued dissolved groundwater contamination is likely present between the bottom of the excavation and the water table, with the majority of mass in the weathered bedrock where secondary porosity is highest. The P&T remedy that became operational in 2008 has removed low levels of contamination from groundwater, but this groundwater remedy has no effect on remaining unsaturated zone contamination. Unsaturated zone contamination likely continues to serve as a continuing source of dissolved groundwater contamination, particularly for PCE. The highest levels of groundwater contamination detected at Electra Products (640 µg/L PCE and 200 µg/L TCE) are in shallow well ELE1S, which is screened near the water table from 47 ft bgs to 67 ft bgs. ELE1S and a co-located well (ELE1I), which is screened from 98 to 118 ft bgs, were installed in previously open borehole ELE1. The deeper intervals of ELE1 historically had lower contaminant concentrations than the shallower intervals, and since construction of ELE1S and ELE1I and the initiation of remedy pumping, the concentrations in ELE1I are 1 to 2 orders of magnitude lower than the contaminant concentrations in ELE1S.

ELE1S has significantly higher PCE concentrations than TCE concentrations, which is consistent with the contamination identified in the characterized soil. However, nearby extraction well (ELEEX100) routinely has higher TCE concentrations than PCE concentrations. In addition, the PCE concentrations in ELEEX100 are approximately an order of magnitude lower than the PCE concentrations detected in ELE1S. This suggests that ELEEX100 (which is an open borehole over 187 ft deep) extracts the majority of its water from deeper, less contaminated intervals than ELE1S, and these deeper intervals happen to have a predominance of TCE contamination relative to PCE contamination. This higher TCE signature is consistent with historic groundwater analytical results from the ELELP borehole, which is located approximately 200 ft to the east near the southeastern corner of the building. Over time, the TCE concentrations in samples from ELE2I and ELE2D (similar in location to ELELP) have declined, perhaps as a result of remediation pumping, but the original source of the TCE in this southeast corner of the property has not been identified, and it is unclear if the TCE concentrations will rebound if remedy pumping continues. Historic TCE concentrations were also relatively high (330 µg/L) in the shallower intervals of ELELP. The highest TCE concentration in soil (71 µg/L) during the 1994 RI was collected along strike of this location approximately 200 ft to the northeast. This soil concentration was deemed sufficiently low to not merit remediation, but it is unclear if higher levels of soil contamination (perhaps within the building footprint) are in the area but were not identified in previous characterization efforts.

The relative lack of water extracted from the interval screened by ELE1S is likely due to low overall permeability in the shallower bedrock interval where ELE1S is screened, to low vertical permeability between the shallow and deeper zones, or both.

A draft report prepared by the USGS entitled *Hydrogeology and Conceptual Groundwater-Flow System at and near Electra Products Property* presents water quality data from sampling of MG79, MG81, Precision 1D, and PTC1S,I,D wells in the 1990s. The locations of these wells relative to the Electra Products source area and the water quality results are as follows:

- MG79 is an open borehole approximately 500 feet west of the source area (not directly down dip or along strike). PCE and TCE were detected a 15 and 17 µg/L, respectively.
- MG81 is an open borehole approximately 1,000 feet along strike from the source area to the southwest. PCE and TCE were detected at 11.2 and 72 µg/L, respectively.
- Precision 1D is an open borehole from approximately 200 to 350 ft bgs approximately 1,000 feet north-northwest (not exactly down dip) of the source area. PCE and TCE were detected at 0.8 and 3.3 µg/L, respectively.
- The PTC1S, PTC1I, and PTC1D are at various intervals approximately 1,000 feet to the northeast (along strike) of the source area. PCE and TCE were both detected below 5 µg/L in PTC1S and neither contaminant was detected in PTC1I and PTC1D.

The optimization review team was not able to determine the method of sampling or the depths of the samples collected in the open boreholes. Based on the USGS interpretation, the screened intervals of the PTC wells appear appropriate to evaluate potential contaminant migration from Electra Products. The above results suggest the potential for some contaminant migration toward MG79 and MG81, but a direct link of the detected contaminants cannot be firmly established given the potential for other regional sources of this contamination. The relative absence of contamination in groundwater at the PTC wells suggest contamination is not likely migrating northeast along strike from Electra Products or along strike from a northeasterly source toward Electra Products. No shallow, intermediate, or deep wells are installed closer to the Site in the directions of MG79, MG81, or immediately down dip of ELE1S to delineate the varying degrees of groundwater contamination and potentially link the contamination observed in these wells to the Site.

Insufficient information is available to prepare a potentiometric surface map or determine the extent of hydraulic capture offered by the Electra Products extraction well. It is noted that during pumping in 2009 that the shallow and intermediate wells were influenced by pumping but that the deep wells (ELE1D and PTC1D) were not strongly influenced by pumping. The hydraulic testing results also show that ELE1S still has a higher hydraulic head than many other wells involved in the 2009 hydraulic testing, suggesting that the pumping from ELEEX100 may not result in an inward gradient that is indicative of plume capture. The presence of contamination in MG79 and MG81 could suggest contaminant migration to the west and southwest.

4.2.2 KEYSTONE HYDRAULICS

Soil contamination was characterized extensively in all areas of the property during the 1994 RI with the exception of beneath the building that remains at the property. As stated in Section 2.4.3, samples were collected from 2.5 ft bgs, 5 ft bgs, and 7 ft bgs. The recommendation of the 1994 RI/FS was to excavate approximately 15,000 cubic feet (ft^3) of soils near an UST to the east of the on-site building (see Figure 3). The excavation and UST removal was conducted in 1999. The depth of the excavation is not reported. Based on the boring log for KEY2S, the depth to weathered bedrock is approximately 10 ft bgs, and the depth to competent bedrock is approximately 15 ft bgs. Soil concentrations more than an order of magnitude above the target cleanup level were not delineated horizontally to the east (off-property) due to residential structures or along the foundation of the building. In addition, it appears likely that contamination was not delineated vertically and that soil contamination may remain below the bottom of the excavation, with significant mass in the weathered bedrock where secondary porosity is highest. With two exceptions, soil sampling suggests that CVOC soil contamination in other portions of the site is limited and not indicative of additional sources. One exception is at a clustered set of soil borings northeast of the current location of the treatment building (SB16, SB24, and SB-39) where soil was contaminated with ethybenzene, xylenes, and TCE. Another exception is one soil gas sample near the southwestern corner of the property (SG05) with a TCE vapor concentration of 13 µg/L (13,000 µg per cubic meter). The soil borings surrounding SG05 did not indicate soil contaminated with TCE. One potential explanation for the elevated soil gas concentration is an off-property source in the alley to the south of the property that was not characterized by on-site soil samples.

Shallow groundwater concentrations (over 40,000 µg/L of total CVOCs) from monitoring well KEY2S, which is screened from 20 to 100 ft bgs, suggests source material remains in the area to the north of the former excavation. The depth to groundwater is approximately 10 to 15 ft bgs and is likely in contact with contamination in weathered bedrock. The vertical distribution of this contamination is relatively uniform between 30 and 100 ft bgs based on PDB sampling at multiple intervals in the borehole, and high levels of contamination may extend deeper. CVOC concentrations decline substantially at 150 ft bgs as evidenced by sampling results from KEY2I, but it is noted that KEY2I and KEY2S are perhaps 20 ft apart, and some of the decline in concentrations between KEY2S and KEY2I could be due to a difference in location.

USGS interpretation of the KEY2S boring suggests that under non-pumping conditions, flow enters the boring around 92 ft bgs, flows upward, and exits the borehole through a major fracture at approximately 76 ft bgs. The major fracture at 76 ft bgs was found to produce approximately 50 gpm, indicating it is a relatively high yield fracture. The interpreted upward flow under non-pumping conditions in this boring and other boring suggests an upward hydraulic gradient that would limit downward contaminant migration across bedding planes. This observed upward gradient in a single borehole, however, would not limit downward migration in the down-dip direction along bedding planes. The presence of several major, high-yield fractures however suggests the potential for significant contaminant migration if the contamination, hydraulic gradient, and fractures are oriented such that contamination is directed through the major fractures. The presence of water within the weathered bedrock also suggests the potential for groundwater flow and contaminant transport in the direction of the shallow hydraulic gradient. Given the location of a creek to the northwest of KEY2S, shallow groundwater contamination may migrate toward the creek within the weathered bedrock. The presence of historic CVOC concentrations of approximately 100,000 µg/L throughout the water column and an upward hydraulic gradient suggest the potential presence of DNAPL that has migrated vertically to a depth of 100 ft bgs or more.

Extraction well KEY7 is the only extraction well at Keystone Hydraulics. It is 156 ft deep and yields approximately 17 gpm. The hydraulic gradient is not uniform and does not allow a clear interpretation of the groundwater flow direction. Drawdown in monitoring wells caused by pumping is significant (approximately 2 ft) relative to the change in water levels across the site (a range of approximately 2 ft) suggesting that hydraulic capture from remedy pumping may be relatively extensive. Due to contaminant transport through fractures, concentrations in downgradient performance wells are expected to respond relatively quickly to remediation. It is unclear which direction groundwater flow is migrating through fractures, but concentration decreases (with occasional increases) in KEY1I and KEY3D suggest the potential for some degree of capture of the southern portion of the plume offered by extraction from KEY7.

The extraction well (KEY7) is located down-dip of the former excavation, but is not immediately down-dip of KEY2S. The distribution of influent concentrations among various contaminant parameters is consistent with the contamination observed at KEY2S, KEY4S, and KEY5S; however the concentrations are approximately 2 orders of magnitude lower than those observed at KEY2S. The contaminant concentrations at KEY2S, KEY4S, and KEY5S suggest that contamination from KEY2S may be migrating to the northwest (down-dip). Given the known regional dip in bedding planes, the screened intervals of KEY4S and KEY5S are likely to intercept the same bedding plane where shallow contamination in KEY2S is present, but insufficient information is available to confirm this potential relationship. The deeper wells at these locations have lower CVOC concentrations than the shallower wells by an order of magnitude. Given the uniform CVOC concentrations with depth at KEY2S, the deeper intervals at the KEY4 and KEY5 clusters would be expected to have higher levels of contamination if contamination from the deeper elevations of KEY2S was migrating to the northwest. Decreasing concentrations in the KEY4 and KEY5 clusters are not as significant as at KEY1I and KEY3D and may be associated with a lesser degree of capture at these locations. The extent of contaminant migration along strike from KEY2S has not been evaluated. An attempt to delineate contamination to the northeast may result in detecting contamination associated with Westside Industries, which is located approximately 1,000 to 2,000 ft to the northeast.

The persistent shallow groundwater contamination at KEY6S in the vicinity of the former excavation approximately 10 years after excavation suggests the possibility that the excavation did not remove all soil contamination that was causing groundwater contamination, that contamination present in groundwater is slowly flushed by groundwater flow, or that some contamination from KEY2S continues to affect water quality near KEY6S.

The potential for VI was evaluated for several structures near Keystone Hydraulics. Despite high levels of soil contamination, subsurface vapor concentrations and indoor air concentrations did not suggest an unacceptable risk from VI. This is likely in part due to the relatively low permeable soils that result in relatively low vertical and horizontal contaminant mass flux through soil vapor despite high levels of soil or groundwater contamination. The subslab soil vapor concentrations for the on-property building were high and of concern. EPA notes suggest there may have been data quality issues with some of the results from the nearby structures; therefore, the potential for VI, particularly for the residence adjacent to the property merits additional attention.

4.2.3 ROGERS MECHANICAL (FORMER TATE ANDALE)

Soil contamination was characterized extensively near the former storage area in the southwestern part of the property to the west of the former building and in the open area in the northeastern portion of the property to the east of the former building. As stated in Section 2.4.3, samples were collected between 5 and 7 ft bgs. Detected soil contamination was substantially higher in the open area to the east of the building compared to the soil contamination near the former storage area to the west of the building. TCE concentrations in soil as high as 4,600 µg/kg were detected, and concentrations were generally higher in deeper samples than in shallow samples. The conclusion of the 1994 RI/FS was to excavate almost 19,000 ft^3 of soils in the open area to the east of the former building (see Figure 4). No soil remediation west of the building was suggested. The depth of the excavation is not reported. Based on the boring log for ROG1S, the depth to weathered bedrock is approximately 5 ft bgs, and the depth to competent bedrock is approximately 10 ft bgs. The depth to groundwater is approximately 50 ft bgs. Soil confirmation sampling suggests that the 1999 soil excavation adequately met the target cleanup levels horizontally, but emphasis was not placed on vertical delineation, and it is unclear if deeper soil contamination remained in place following the excavation. In addition, there are no monitoring wells in the immediate area of the former excavation. ROG1S and ROG1I are the closest wells, and based on a review of various maps appear to be approximately 100 ft to the southwest of the highest levels of contamination. Therefore, based on the reviewed information, groundwater contamination may be present in the vicinity or down-dip of the former excavation but not identified or characterized. Monitoring wells ROG3S and ROG6 may intercept the southernmost fringe of a plume in this area. ROG4S is down-dip of the contamination in the former storage area that is being addressed by the DPE system, and the screen interval likely intercepts the bedding plane addressed by the DPE system.

Contaminant concentrations detected in existing monitoring wells generally have been within an order of magnitude of the cleanup standards for each contaminant of concern. One exception is ROG4S, which is approximately down-dip of the former storage area and existing remediation well. Concentrations at ROG4S can be monitored over time to determine if the dual-phase extraction occurring in the former storage area mitigates the amount of contamination that migrates toward ROG4S. In addition, continued monitoring of the groundwater and vapor influent to the treatment system will indicate the remedy performance in removing mass from the subsurface. At present, it appears that the majority of the contaminant mass is in the unsaturated zone rather than groundwater and that the vapor extraction portion of the remedy is removing a reasonable amount of contaminant mass (approximately 15 to 20 pounds of contamination per year). In contrast, groundwater extraction appears to be removing mass at a rate of less than 1 pound of contamination per year.

4.2.4 ROYAL CLEANERS

Shallow contaminated soil and buried drums were removed as part of a Removal Action in 1991 (see Figure 5). The depth of the excavation was not reported. Subsequent soil sampling during the 1994 RI identified remaining soil contamination in the shallow overburden (less than 10 ft bgs), but all detections were determined to be sufficiently low that additional remediation was not needed. The highest detected PCE concentration during the 1994 RI soil sampling was 42 µg/kg.

Historic sampling with PDBs in the ROY5 borehole (prior to reconstruction into ROY5S and ROY5I), the ROY3 borehole (further down-dip of the source area), and the ROYRD borehole (also further down-dip of the source area) confirm the high CVOC concentrations in shallow groundwater down-dip of the source area. Therefore, liquid contamination released in the shallow subsurface from the previously buried drums appears to have migrated down-dip through bedding plane fractures to the location of the ROY5, ROY3, and ROYRD boreholes. The open boreholes have since been reconstructed as monitoring wells, and the concentrations in samples pulled from new monitoring wells appear to be substantially lower than the historic sampling. For example, from 2002 through 2007, the PCE concentration in the shallow intervals of ROY3 ranged from 2,600 to 44,200 µg /L with no obvious trend. The last sample collected from the shallow interval of this borehole had a PCE concentration of 16,000 µg /L. By contrast, the PCE concentrations in ROY3S (a new well installed in 2008/2009 with a screened interval from 84 to 94 ft bgs), have ranged from 310 µg /L to 74 µg /L, with a discernible decreasing trend. It therefore appears that the screened interval of ROY3S is too deep to intercept the zone with the highest levels of contamination. Similarly, the shallowest well that was constructed from the previous ROYRD borehole (ROYRDI) may also be too deep to sample the depth interval with the highest concentrations. PCE concentrations in the shallowest interval of ROYRD were routinely above 1,000 µg/L with no discernible trend since October 2003. The concentrations in ROYRDI appear to be steadily decreasing since the well was constructed, perhaps indicating that the well screen has been somewhat separated from the depth interval with the highest concentrations but remains relatively well connected to fractures influenced by the remedy extraction well. By contrast, the shallowest well that was constructed from the former ROY5 borehole (ROY5S) has similar PCE concentrations to those detected in the shallowest intervals of the ROY5 borehole. That is, ROY5S (which is screened from 50.5 to 60.5 ft bgs, appears to be sufficiently shallow to sample the depth interval with the highest levels of contamination. Therefore, reconstructing the boreholes into monitoring wells has artificially reduced the apparent extent of PCE contamination over 1,000 µg/L. Rather than a source limited to the area around ROY5S, the source or zone of high concentrations appears to extend at least 100 ft to the northwest (likely beyond ROY3S) and more than 50 ft to the north-northwest (likely beyond ROYRDI). Source material or a zone of high concentration levels is also likely present in the 50 to 100-ft distance between the former excavation and ROY5S. There is also likely substantial contamination in the unsaturated zone between the floor of the excavation (presumed to be no deeper than 10 ft bgs) and the water table, which is at approximately 50 ft bgs. Assuming contamination enters competent bedrock at approximately 10 ft bgs and a regional dip of approximately 11 degrees, migration in the down-dip direction would increase in depth by approximately 20 ft for every 100 ft in horizontal distance to the northwest. The highest levels of contamination, therefore, are likely present in shallow groundwater and the deeper monitoring wells are likely intercepting cleaner water associated with the ROY1 cluster.

USGS interpretation of nearby boring ROY1I suggests water enters the borehole through fractures at 96, 114, 134, and below 150 ft bgs, moves upward, and exits the borehole through fractures at 50-68 ft bgs. The USGS further interprets a major fracture at 140 ft bgs capable of producing 50 gpm. The upward hydraulic gradient at this location suggests general resistance to downward contaminant migration across bedding planes. Comparably lower CVOC concentrations from historic PDB sampling in deeper portions of the open holes confirm that relatively high contamination levels generally remain shallow. Downward migration, if present, would more likely occur in the down-dip direction along bedding planes.

The extraction well at Royal Cleaners extracts groundwater from the water table to a depth of 118 ft bgs where a packer is installed in the open hole. The CVOC concentrations in the extraction well are typically 1 to 2 orders of magnitude lower than the CVOC concentrations from the 2010 sampling at ROY5S. The lower concentrations in the extraction well compared to ROY5S and other historic shallow sampling suggest that the contaminated water that is extracted is diluted by extraction of substantially more water from deeper, cleaner fractures. The USGS reports that the former production well nearby is an open borehole and is connected to the extraction well through fractures near 100 ft bgs, such that cleaner water from zones below 100 ft flow up and out to the extraction well. This hydraulic connection at depth is likely a large contributor to this dilution. Contaminant concentrations are decreasing at ROY3S, ROYRDI, and ROY4I, which suggests potential capture of contamination at these intervals; however, it is unclear if the higher contaminant concentrations in the shallower zones are being captured, especially if there is not a good hydraulic connection between the shallow intervals and the extraction well. During pumping and non-pumping conditions of the 2009 hydraulic testing, all site wells appeared to be influenced by pumping. ROY3S appeared to have the lowest measured water level under pumping conditions. Given this relatively low water level in ROY3S compared to the rest of the wells at Royal Cleaners, that the ROY3S location is the furthest monitoring well down-dip at Royal Cleaners , and the absence of a decreasing trend in historic shallow sampling in the ROY3 borehole despite remedy operation, it is reasonable to conclude that contamination at ROY3S is not being captured by the current remedy and that high levels of contamination are migrating uncontrolled to the northwest under North Broad Street.

The building on the lot to the north of the dry cleaners is sufficiently close to high levels of groundwater contamination that VI may be a concern. Depending on the extent of shallow contamination, VI in other buildings may also be a concern.

4.2.5 WESTSIDE INDUSTRIES

Shallow soil was investigated to the south and north of the building, but not to the northwest of the building, to the east of the building, or under the building. All detected concentrations were determined in the 1994 RI to be sufficiently low that soil remediation was not needed. The highest detected concentration of an individual CVOC was 100 µg/kg of PCE. Groundwater sampling between 1997 and 1999 from WES1VS (see Figure 6), which is screened near the water table, suggests it is located near a potential source based on TCE concentrations being detected repeatedly over 30,000 µg/L on several occasions. No sampling occurred from 1999 through 2005, and when sampling resumed in 2005, sampling was conducted with PDBs at multiple intervals in the open borehole or low-flow sampling was used. From 2005 onward, samples from three of the five sampling events in WES1VS had total CVOC concentrations less than 150 µg/L, and the total CVOC concentrations from the other two sampling events were approximately 1,360 and 3,760 µg/L. There is no discernible upward or downward trend in contaminant concentrations. Similar substantial decreases in contaminant concentrations between 1999 and 2005 were observed in WES1S. The cause of these substantial decreases is unclear because there is no documentation of remediation occurring during this period, and the P&T system began operation in 2008. One potential explanation is a change in the sampling method. From 1997 to 1999, the sampling was conducted with standard purge techniques, and from 2005 forward, the sampling was conducted with PDBs or low-flow sampling. The concentrations were the lowest with PDBs. This information suggests that a previous source of contamination has either attenuated naturally or that the current sampling approach does not provide a reasonable representation of the general water quality in the vicinity of the wells.

Contaminant concentrations along the full depth of several open boreholes were relatively evenly distributed, potentially indicating that contamination migrated vertically across bedding planes or through open boreholes. USGS interpretation of geophysical data from 1995 through 1997 of the WES1I boring suggests that under non-pumping conditions water enters the boring through fractures at 72-74, 119, and 140-148 ft bgs, moves upward, and exits the borehole through fractures at 19-28 and 40-55 ft bgs. The presence of upward flow during non-pumping conditions would seemingly have prevented or limited downward migration of contamination across bedding planes, but historic pumping from nearby production wells that might not have been active at the time of the geophysical investigation may have reversed the vertical gradient leading to downward migration. Other potential causes of the contamination at depth could be source material that is denser than water (e.g., DNAPL) or sources of contamination that are present at various locations that result in down-dip contaminant migration along several rock beds.

The contaminant concentrations in the extraction well at Westside Industries are relatively consistent with the concentrations detected in monitoring wells and is likely explained by the relatively even distribution of contamination with depth in the aquifer. The extent of contamination horizontally and vertically is not delineated, and insufficient hydraulic information is available to evaluate the extent of the extraction well capture zone.

Given the presence of relatively high proportions of *cis*-1,2-DCE and vinyl chloride and the negative oxidation reduction potential (ORP), it appears that significant contaminant degradation is occurring through reductive dechlorination. The sampling logs suggest that ORP is less than -100 millivolts (mV) in some locations.

If a contaminant source remains beneath the Westside Industries building, VI may be a concern for the Westside Industries building.

4.3 Data Gaps

Numerous data gaps are discussed in the above location-specific discussions. The data gaps that are most relevant to significantly improving the remedies are provided below:

Electra Products

- Horizontal and vertical extent of unsaturated zone contamination beneath the former excavation.
- Horizontal and vertical extent of groundwater contamination, particularly down-dip and along strike from the source area.
- Location and extent of TCE contamination identified at depth and the location and extent of the associated source area.
- Subsurface conditions in the vicinity of ELE1S that could affect targeted remediation in that area.
- Extent of the capture zone provided by the existing extraction well.
- Changes in contaminant concentrations at deeper intervals once shallow contamination is appropriately addressed.

Keystone Products

- Horizontal and vertical extent of soil contamination and shallow groundwater source material that was inadvertently or purposely not addressed by the former excavation, including near building foundations and near KEY2S.
- Horizontal extent of groundwater contamination, particularly down-dip and along strike from KEY4S and KEY5S and along strike from KEY2S.
- Subsurface conditions in the vicinity of KEY2S that could affect targeted remediation in that area.
- Extent of the capture zone provided by the existing extraction well.
- Changes in contaminant concentrations at deeper intervals once shallow contamination is appropriately addressed.

Rogers Mechanical (former Tate Andale)

- CVOC concentrations in groundwater underlying and down-dip of the previously excavated source area.
- Performance of the existing soil and groundwater remedy over time to address the localized source that was not excavated.

Royal Cleaners

- Horizontal and vertical extent of unsaturated zone and shallow groundwater contamination in the vicinity of ROY5S.
- Horizontal and vertical extent of contamination down-dip and along strike from the ROY3 and ROYRD clusters.

- Changes in contaminant concentrations at deeper intervals once shallow contamination is appropriately addressed.
- Subsurface conditions in the vicinity of the source area and ROY5S that could affect targeted remediation in that area.
- Extent of the capture zone provided by the existing extraction well.

Westside Industries

- Potential source area identification and characterization near and upgradient of WES1VS and WES1S, including under the building
- Role of reductive dechlorination in mass removal, and the potential for continuing or enhancing reductive dechlorination.
- Horizontal and vertical extent of contamination down-dip and along strike from the detected contamination.
- Extent of the capture zone provided by the existing extraction well.

In addition to the above location-specific data gaps, there are no specific performance criteria for these locations. The ROD specified the need to establish points of compliance during future activities. The existing extraction wells and monitoring wells are points of compliance, but additional points of compliance are merited. Furthermore, the governing principles for establishing the points of compliance for these individual locations in a regional co-mingled plume have not been developed.

4.4 IMPLICATIONS FOR REMEDIAL STRATEGY

The CSM and indicated data gaps have the following significant implications for the success of the remedy:

- Source material in the unsaturated zone, if present and not addressed, will serve as a continuing source of groundwater contamination for many decades making aquifer restoration impracticable in a timely manner.
- The lack of adequate plume delineation prevents EPA from establishing appropriate points of compliance for aquifer restoration as specified in the ROD.
- The lack of adequate plume delineation and the lack of information regarding the capture zone extent for each extraction well mean the degree of source control is uncertain.
- The existing groundwater remedies do not appear to be focused on the zones of high contaminant mass, suggesting that the groundwater remedies would continue indefinitely if not modified.

5.0 FINDINGS

5.1 General Findings

The observations provided below are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions in the best interest of the EPA and the public. These observations have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of groundwater remediation have changed over time.

5.2 Subsurface Performance And Response

5.2.1 Plume Capture

Plume capture cannot be adequately evaluated because the contaminant plumes are not delineated and because insufficient hydraulic information is available to evaluate the capture zone extent for each extraction well. More specifically, water level data are not routinely collected at a sufficient number of points or presented on maps to interpret capture from potentiometric surface maps or inward gradients. Hydraulic information from pumping tests is available, but well locations need to be more clearly established and described. In addition, given the complex hydrogeology, a groundwater model is likely appropriate for interpreting the data. More information related to plume capture is provided in Section 4.2.

5.2.2 Groundwater Contaminant Concentrations

Contaminant concentrations remain elevated at each of the five locations, particularly in the shallow zones. Significant contaminant mass is likely present in the unsaturated zone and shallow groundwater that is not adequately addressed by the existing remedies, such that significant improvements in water quality have not been observed and are not expected to occur with the current groundwater remedies. More information related to contaminant concentrations is provided in Section 4.2.

5.2.3 Soil Vapor and Potential for Vapor Intrusion

As discussed in Sections 4.2 and 4.3, the potential for VI is a data gap at Keystone Hydraulics, Royal Cleaners, and Westside Industries.

5.3 COMPONENT PERFORMANCE

The following sections provide findings related to performance of various treatment components for each extraction system and treatment system given current conditions. The following findings, however, are not intended to suggest the need for immediate improvements to the treatment systems. Improvements to better address the shortcomings identified in Section 4.2 and 5.2 could significantly change the flow rates or mass loading to the treatment systems; therefore, the optimization review team believes that streamlining the treatment systems is not appropriate until influent parameters are better understood.

5.3.1 EXTRACTION SYSTEMS FOR FIVE FUND-LEAD SYSTEMS

The extraction wells at the five Fund-lead groundwater remedies generally operate without problems. There is minimal fouling that is reported, and pumps and wells are maintained with routine cleaning. Based on the available data, however, it appears that the extraction systems are not appropriately designed to address the primary areas of contamination, with the potential exception of Westside Industries.

5.3.2 ELECTRA PRODUCTS

The optimization review team notes the following findings regarding the existing treatment system at the time of the optimization site visit:

- The system includes influent and effluent tanks that the optimization team believes may not be needed for reliable system operation but have not led to operational problems. If the system is streamlined in the future, the site team might evaluate the potential of the existing extraction pump (or a replacement) to convey water through the various process components directly to the air stripper.

- The permanganate addition to the greensand filters were not connected at the time of the optimization site visit. No metals removal was occurring. The variable nature of the historic process sampling for iron and the ORP and pH at the site suggest metals may be adequately removed by the bag filters to meet the discharge criteria for iron and manganese. Some of the historic exceedances may have been the result of metal precipitate transferring from the sample port to the sample port and not a true reflection of the influent water quality. Sampling after the bag filters but prior to the green sand over time would help evaluate the need for the green sand system.

- The air-to-air heat exchanger for the air stripper off-gas provides questionable benefit, primarily because of the very low mass loading to the VGAC units.

- The air stripper reliably meets discharge criteria, and the LGAC vessels are not needed to reliably meet discharge criteria.

5.3.3 KEYSTONE HYDRAULICS

The optimization review team notes the following findings regarding the existing treatment system at the time of the optimization site visit:

- The system includes influent and effluent tanks that the optimization review team believes may not be needed for reliable system operation but have not led to operational problems. If the system is streamlined in the future, the site team might evaluate the potential of the existing extraction pump (or a replacement) to convey water through the various process components directly to the air stripper.

- With the exception of one J-flag process sampling result out of nine effluent samples, the treatment plant influent meets metals effluent limits. The metals may be adequately removed by the bag filters, potentially allowing the ion exchange metals removal system to be bypassed. Sampling after the bag filters but prior to the ion exchange system over time would help evaluate the need for the ion exchange system.

- The optimization review team believes that under current conditions, the air stripper or LGAC vessels alone are sufficient to reliably meet discharge criteria and that both treatment processes are not needed. Both technologies are reliable at treating the contaminants of concern. Sampling of the air stripper effluent would confirm that current air stripper is capable of meeting discharge standards. The LGAC vessels would provide adequate treatment. Based on existing influent concentrations, an extraction rate of 30 gpm, and preliminary analysis, the optimization team estimates that less than 5,000 pounds (lbs) of LGAC would be needed per year.

5.3.4 ROGERS MECHANICAL (FORMER TATE ANDALE)

The system has not been operating for a sufficient amount of time for the optimization review team to comment on the performance of the individual system components.

5.3.5 ROYAL CLEANERS

The optimization review team notes the following findings regarding the existing treatment system at the time of the optimization site visit:

- The system includes an effluent tank and pump that are theoretically not required for operation but have not led to operational problems.

- The optimization review team believes that under current conditions, the air stripper or LGAC vessels alone are sufficient to reliably meet discharge criteria and that both treatment processes are not needed. Both technologies are reliable at treating the contaminants of concern. Sampling of the air stripper effluent would confirm that current air stripper is capable of meeting discharge standards. The LGAC vessels would provide adequate treatment. Based on existing influent concentrations, an extraction rate of 40 gpm, and preliminary analysis, the optimization review team estimates that less than 10,000 lbs of LGAC would be needed per year.

5.3.6 WESTSIDE INDUSTRIES

The optimization review team notes the following findings regarding the existing treatment system at the time of the optimization site visit:

- The air-to-air heat exchanger for the air stripper off-gas provides questionable benefit. Although VGAC efficiency may be improved by cooling extracted vapors from high vacuum blowers associated with soil vapor extraction (SVE) systems, the vapor from the air stripper off-gas has relatively high moisture content and is relatively cool. VGAC efficiency would likely be improved by either not cooling the air stripper off-gas or heating the air stripper off-gas.

5.3.7 DISCHARGE

The discharge limits for Electra Products, Keystone Hydraulics, Royal Cleaners, and Westside Industries are generally inconsistent with each other despite having the same general contaminants of concern and the same receiving water body. Discharge limits for Rogers Mechanical (former Tate Andale) were not available for review for preparation of this draft report. The following are examples of the inconsistencies:

- The discharge limits for individual VOCs at Electra Products are substantially lower than the discharge limits for the same VOCs at Keystone, Royal, Westside Industries. For example, the average monthly discharge limit for TCE at Electra Products is 0.7 µg/L whereas the discharge limit for TCE at the other three remedies is 5 µg/L.

- The average monthly discharge limit for iron at the four locations ranges from 300 µg/L (Westside Industries) to 1,500 µg/L (Electra Products) and “monitor and report” at Royal Cleaners.

- The average monthly discharge limit for manganese at the four locations ranges from 100 µg/L (Keystone Hydraulics) to 1,000 µg/L (Westside Industries) and “not reported” at Royal Cleaners.

5.4 REGULATORY COMPLIANCE

The treatment plants regularly comply with the established discharge limits. There are occasional lapses in the ability of the treatment plants to meet the 95% removal criteria for the air permit equivalents.

5.5 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

Table 10 provides a breakdown of the approximate annual costs for each of the five remedies based on the optimization review team’s interpretation of costs provided by the site team. The breakdown was provided in this manner to help reflect the costs of the remedies if operation of one or more remedies was discontinued.

Table 10: Summary of Annual Costs

Item	All	Westside	Electra	Keystone	Royal	Rogers
Project Management	$12,000	$4,000	$4,000	$4,000	$4,000	$4,000
Annual Report	$25,000					
Groundwater Sampling		$10,000	$5,000	$15,000	$10,000	$10,000
Analytical Support/Validation		$6,000	$6,000	$6,000	$6,000	$6,000
Operation and Maintenance (O&M) Labor		$30,000	$30,000	$30,000	$30,000	$20,000
Electric		$20,000	$17,500	$15,000	$15,500	$5,000
Granular activated carbon (GAC)		$26,000	$6,000	$7,000	$6,000	$3,000
Other		$15,000	$9,000	$8,000	$7,000	$5,000
Totals	**$37,000**	**$111,000**	**$77,500**	**$85,000**	**$78,500**	**$53,000**

5.5.1 UTILITIES

Utilities, primarily electricity, account for approximately 17percent of the O&M costs. The electricity costs are based on tracked electricity costs at each of the treatment systems, with the exception of Rogers Mechanical. For Rogers Mechanical, the optimization team estimated the electricity usage based on the installed equipment.

5.5.2 NON-UTILITY CONSUMABLES AND DISPOSAL COSTS

GAC, which consists of both LGAC and VGAC, is the primary contributor to non-utility consumable cost. GAC accounts for approximately 11 percent of the total annual costs. GAC use and cost is based on the documented GAC use and costs provided by the site team. GAC use is generally correlated to mass removed by the treatment system, which explains why Westside Industries has the highest GAC cost under current conditions. GAC costs for the other systems would expect to increase if mass loading to those treatment systems increased due to changes in groundwater extraction.

5.5.3 LABOR

Labor includes project management labor, reporting labor, analytical support/validation, groundwater sampling labor, and O&M labor. The optimization team estimates that a portion of project management costs and all of the annual report costs apply to the overall portfolio of groundwater remedies. Addition project management applies to each individual remedy. The optimization team estimates that approximately 60 percent of the groundwater sampling costs are labor. In sum, labor accounts for approximately 58 percent of the total annual costs.

5.5.4 CHEMICAL ANALYSIS

Chemical analyses are provided by the EPA Regional Laboratory and are not billed to the NPA6 Site. Costs for the laboratory’s services are not included in the above cost breakdown.

5.6 APPROXIMATE ENVIRONMENTAL FOOTPRINTS ASSOCIATED WITH REMEDY

5.6.1 ENERGY, AIR EMISSIONS, AND GREENHOUSE GASES

Based on professional experience, the optimization review team believes the primary contributors to the energy, air emissions, and greenhouse gas footprints are electricity usage, the production and transportation of GAC, and laboratory analysis. The site team has entered into a common pool of purchased renewable energy certificates (REC) organized by EPA Headquarters, indicating a high level of voluntarily purchased renewable energy. The majority of the energy and emissions footprints are associated with electricity usage, followed by the GAC and laboratory analysis.

Efforts to reduce footprints in this category could involve reducing electricity usage (which would also reduce the amount of RECs to be purchased), reducing GAC usage, and reducing laboratory analysis without compromising remedy effectiveness.

5.6.2 WATER RESOURCES

Groundwater in the Lansdale area is used for a variety of purposes, including industrial process water and drinking water. The groundwater extracted and treated by the P&T systems has the potential to provide beneficial uses; however, it is discharged to surface water where it blends with other surface water in an urban environment. The water footprint for these remedies is, therefore, predominantly associated with the potentially missed opportunity to use a treated water resource for beneficial use or for return to the aquifer for later use.

5.6.3 LAND AND ECOSYSTEMS

The operating groundwater remedies are located in urban environments and do not disturb land and ecosystems. The space occupied by the treatment plants may eventually be redeveloped and returned to beneficial use once the remedies are complete.

5.6.4 MATERIALS USAGE AND WASTE DISPOSAL

The primary materials usage is the associated with GAC for liquid and off-gas treatment. The GAC is regenerated such that the large majority of the GAC is reused. Waste generation requiring off-site is limited.

5.7 SAFETY RECORD

The site team did not report any safety concerns or incidents.

6.0 RECOMMENDATIONS

Several recommendations are provided in this section related to remedy effectiveness, cost control, technical improvement, and site closure strategy. Note that while the recommendations provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance project plans.

Cost estimates provided herein have levels of certainty comparable to those done for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Feasibility Studies (-30%/+50%), and these cost estimates have been prepared in a manner generally consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000. The costs and environmental footprint impacts of these recommendations are summarized in Tables 11 and 12. The costs presented do not include potential costs associated with community or public relations activities that may be conducted prior to field activities.

Sections 4.0 and 5.0 of this report highlighted several data gaps in the CSM and questioned the effectiveness of the existing remedies to control the source areas and meaningfully contribute to aquifer restoration. The recommendations related to improving effectiveness in Section 6.1 are focused on addressing the identified data gaps, but do not represent all of the information that may be needed to complete the CSM and appropriately modify the remedies. The recommendations in Section 6.1 do not discuss improving the ability of the existing remedies to restore groundwater because these recommendations are presented in Section 6.4 wherein various remedial strategies are considered for moving forward. Although the optimization review team identified recommendations to reduce cost of operating the existing groundwater remedies, the optimization review team believes that the current remedies are sufficiently ineffective and the existing CSM incomplete that providing cost reduction recommendations at this point would be premature. Therefore, no short-term recommendations for cost reduction are provided in Section 6.2. Rather, potential considerations for streamlining the systems are presented for the site team to consider if the P&T systems are modified as part of the remedial strategy moving forward. For the same reasons, no recommendations for technical improvement are presented in Section 6.3. Section 6.4 presents considerations for a remedial strategy at the Site once the CSM is improved based on information collected from implementing the recommendations in Section 6.1 and potential follow-up characterization activities. The use of alternate remedies, such as SVE or *in situ* chemical oxidation (ISCO), may merit a ROD Amendment or ESD. Given the specificity of the ROD, an ESD may also be needed if the treatment plants are significantly modified.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

Although the organization of Section 6.0 of this report suggests that the recommendations in this section are specifically related to the existing remedies at the five locations, the optimization review team believes that implementation of these recommendations is pertinent to the remedies discussed in Section 6.4. Therefore, the optimization review team encourages the site team to consider these recommendations before considering the recommendations in Section 6.4 related to site closure.

Proposed areas for investigation, proposed monitoring wells, and other key information for each of the five locations are presented in Figures 2 through 6. The recommendations provided below are based on analysis that is consistent with an optimization review. Additional evaluation of existing data by the site team is merited prior to implementing the recommendations.

6.1.1 EFFECTIVENESS RECOMMENDATIONS FOR ELECTRA PRODUCTS

Characterize Source Area Near ELE1S

Substantial contaminant mass likely remains from 4 to 50 ft bgs in the unsaturated zone below the former excavation. This unsaturated zone contamination is not directly addressed by the groundwater remedy and may continue to provide an ongoing source of contamination to groundwater. The optimization review team suggests installing several wells or borings in the vicinity of ELE1S and the former excavation and pilot testing SVE using these wells or borings. The testing would provide information about the radius of influence, flow rate, and mass removal from an SVE system. If mass removal is substantial, a longer term test or a modification to the selected remedy may be merited. The optimization review team recognizes the challenges of implementing an SVE system in this type of geology in a parking lot setting, but does not have a less-obtrusive alternative means of evaluating the subsurface and addressing the contamination. The optimization review team suggests conducting similar testing at other NPA6 locations. The testing at this location should be coordinated with the other NPA6 locations to reduce mobilization costs and improve cost efficiency of planning, equipment construction or rental, and analysis.

The optimization review team envisions a scope of work that would include the following:

- Work planning.
- Installation of three shallow SVE wells screened from 5 to 20 ft bgs to preferentially screen the shallow interval that is primarily overburden or weather bedrock.
- Installation of three deeper SVE wells open from 20 ft bgs to the water table (50 ft bgs) to extract vapors from bedrock fractures, if any.
- One or two days of SVE testing in which a mobile system including a knockout tank, blower (similar to that used in the Rogers Mechanical system), and VGAC vessels are used to extract soil vapor.
- Data analysis and recommendations.

The SVE testing would include extraction from one well at a time and monitoring the vacuum in the extraction well, the vacuum at the other wells, the flow rate, and contaminant concentration of the extracted vapors. Vapor concentrations with a photo ionization detector (PID) can be conducted at various points during testing in the observation wells (i.e., non-extraction wells). Testing should occur independently from at least one shallow well and one deep well. Locations of the borings should consider the know information about fracture orientation in the bedrock. Assuming this testing is coordinated with SVE testing the other locations, the optimization team estimates that this effort might cost approximately $50,000.

Improve Understanding of Contaminant Extent in the Vicinity of ELE1S

The highest groundwater concentrations observed at Electra Products are at ELE1S, and the CSM generally accepted by the site team and the optimization review team is that contamination is likely to move down-dip or along strike from this location. Referring to Section 4.2.1, additional bedrock monitoring wells are needed to determine the extent of high levels of contamination (e.g., above 100 µg/L) and potentially link contamination observed at MG79 and MG81 to the Electra Products. The park across the street to the northwest might serve as a reasonable location for monitoring wells to attempt to better understand the extent of contamination. There may also be room in the parking lot near the treatment plant to install a monitoring well. The optimization review team suggests installation of three wells in these areas to better understand the potential extent of contamination. Potential locations are identified on Figure 2. If the site team cannot confidently estimate the correct screen interval for the wells, the site team might consider leaving the boreholes open for a short duration and sampling multiple intervals with PDBs prior to completing the boreholes as monitoring wells. When constructing the monitoring wells, the site team should consider screening the interval with the highest contamination rather than screening the intervals with the highest producing fractures. Measuring water levels in these wells (along with existing wells) might also help better understand groundwater flow in the vicinity of the Electra Products location. Assuming the site team can confidently estimate the appropriate screen intervals based on existing information, the optimization team estimates that installing these wells and sampling them twice would cost approximately $30,000 if it is coordinated with other drilling and sampling activities.

Improving Understanding of TCE Contamination in Extraction well and Former Well ELELP

The TCE in the extraction well and the historic TCE data from ELELP suggest the potential for a separate source area where TCE is present in higher concentrations than PCE. This source may be in the vicinity of former ELELP, other areas of the western portion of the property, or off-property. If the remedy is going to be successful at reaching cleanup levels, this source of TCE should be identified and addressed. The optimization review team suggests installing two shallow groundwater wells in the eastern portion of the property to better understand water quality in this area and improve the understanding of groundwater flow in the area. One shallow well could be located near ELE2I, and the other could be located approximately 100 ft to the northeast. Potential locations are identified on Figure 2. The initial focus is on shallow groundwater because the optimization review team believes that the majority of contaminant mass is likely present at shallower intervals and that deeper intervals will cleanup over time if the on-property contamination is addressed, and will remain impacted if the contamination is more regional in nature. These two suggested shallow wells are only the initial suggestions for investigating this source area, especially if the source is off-property to the east. The optimization team estimates that installing these wells and sampling them twice would cost approximately $30,000, if it is coordinated with other drilling and sampling activities.

Defer Evaluations of Plume Capture

No recommendations are provided for further evaluating plume capture offered by the existing system at this point because of the suspected current inadequacy of the existing system and the lack of understanding of the extent of contamination meriting remediation. The optimization team believes that further evaluation of plume capture can be considered after the above information is collected and the site team has better defined the objectives of the remedy.

6.1.2 KEYSTONE HYDRAULICS

Characterize and Remediate Soil Contamination

The VOC concentrations at KEY2S indicate the continued presence of source material in the subsurface following the initial excavation in 1999. The optimization review team recommends revisiting the 1994 RI soil data and then conducting addition soil investigation as necessary to determine the horizontal extent of source area contamination (e.g., under the building) and in the alley near former soil gas sample SG05. Given the previous determination that excavation was not appropriate for some areas, the optimization team suggests the use of SVE. SVE would provide mass removal in the soil, could be implemented within the footprint of a building (if appropriate), and can help reduce the potential for vapor intrusion. The optimization team assumes that up to 3 days with direct-push technology (DPT) may be appropriate to collect overburden soil samples beneath the on-property building and in the alleyway near former soil gas sample SG05. Following this characterization, the site team could test SVE with the same equipment used for the suggested testing at Electra Products. The optimization team envisions a scope of work that would include the following:

- Work planning.
- Three days of DPT soil investigation (approximately 30 soil boring locations).
- Installation of three SVE wells in the vicinity of observed soil contamination.
- One or two days of SVE testing in which a mobile system including a knockout tank, blower (similar to that used in the Rogers Mechanical system), and VGAC vessels are used to extract soil vapor.
- Data analysis and recommendations.

The SVE testing would include extraction from one SVE well and monitoring the vacuum in the SVE well, the vacuum at the other borings, the flow rate, and contaminant concentration of the extracted vapors. Vapor concentrations with a PID can be conducted at various points during testing in the observation wells (i.e., non-extraction wells). Based on the known distribution of soil contamination (from DPT activities) and the SVE pilot test, the appropriateness of a full-scale SVE system can be considered. Assuming this testing is coordinated with SVE testing the other locations, the optimization review team estimates that this effort (soil sampling and SVE) might cost approximately $65,000.

Characterize Very Shallow Groundwater

The VOC concentrations at KEY2S indicate the continued presence of source material in the subsurface. The extent of this source material is not known, and the hydraulic connection of this source zone to contamination in other well is uncertain. The historic PDB sampling indicates uniform contamination throughout the borehole. To potentially refine the known vertical extent of contamination, the optimization team recommends packer testing KEY2S. The optimization review team also recommends installing several shallow wells (no more than 30 ft deep) to attempt to horizontally delineate the source material or related high areas of contamination (e.g., PCE or TCE over 1,000 µg/L). These wells would provide an indication of the extent of shallow contamination in weathered and shallow bedrock where the majority of contaminant mass is likely located. Additional deeper wells can be added for source area characterization if packer testing confirms contamination is as vertically extensive as the PDB sampling suggests. If P&T is to continue as the remedy at this location, groundwater extraction in the areas of higher contamination would be merited to accelerate mass removal and improve control of the areas of highest contaminant concentrations. Conducting packer testing of KEY2S and installing and sampling 5 shallow monitoring wells for VOCs would cost on the order $40,000 VOCs if coordinated with other drilling and sampling activities.

Delineate Plume to the Northwest, Southwest, and Northeast

The hydraulic gradient is relatively flat, and it is difficult to determine groundwater flow directions based on the current water level measurement points. However, given the contaminant distribution, geology, and the presence of creek to the northwest of the property, it is likely that contamination generally flows to the northwest. TCE in groundwater at concentrations exceeding 100 µg/L are present in KEY4S and KEY5S, and the extent and fate of this contamination should be better understood. Based on a regional dip of 11 degrees to the northwest, the optimization review team suggests the installation of a monitoring well cluster to the northwest of the property in the parking lot across the street. Based on a general understanding of the regional bedrock geology, the optimization team estimates that the screened intervals may be from 30 to 60 ft bgs and from 60 to 90 ft bgs, but defers to further evaluation of existing information from the site team. This location would provide an indication of the contamination that has left the property boundary, if the concentrations are higher or lower than those detected at KEY4S, and if the hydraulic gradient between the new wells and KEY4S is inward toward the extraction well or outward suggesting further contaminant migration. Additionally, the optimization review team suggests installing monitoring wells in locations approximately 100 to 200 ft to the northeast and southwest (along strike) from KEY2S or where access allows. The screened intervals for these wells should be determined by the site team after the KEY2S packer testing. Installation and sampling of these wells might cost approximately $60,000 if it is coordinated with other drilling and sampling activities. Continued monitoring and gauging of the existing wells and new wells coupled with the hydraulic response in the monitoring wells to pumping compared to the flat gradient should provide adequate information about the capture zone. Unlike the shutdown test results at Electra Products, the shutdown results at Keystone Hydraulics are fairly noisy with significant background trends that would make it difficult to use in calibrating and updating the groundwater model.

Defer More Extensive Evaluations of Plume Capture

Continued monitoring and gauging of the existing and new wells coupled with the hydraulic response in the monitoring wells to pumping compared to the flat gradient should provide adequate information about the capture zone. Unlike the shutdown test results at Electra Products, the shutdown results at Keystone Hydraulics are fairly noisy with significant background trends that would make it difficult to use in calibrating and updating the groundwater model. No recommendations are provided for further evaluating plume capture offered by the existing system because the optimization review team anticipates significant modifications to the extraction system if a P&T remedy is to continue at this location. The optimization review team believes that further evaluation of plume capture can be considered after the above information is collected and the site team has better defined the objectives of the remedy.

6.1.3 ROGERS MECHANICAL (FORMER TATE ANDALE)

Investigate Groundwater in the Vicinity of the Former Excavation

The existing groundwater remedy addresses the soil and groundwater in the vicinity of the former storage area in the southwestern part of the property, but as discussed in Section 4.2.3, there is no groundwater remedy or groundwater monitoring wells in the immediate vicinity of the former contaminated soil excavation that occurred in the northeastern part of the property. The optimization review team recommends that groundwater monitoring wells be installed in the area of the former excavation to determine if groundwater contamination is present, determine the approximate magnitude of that contamination, and to understand the approximate extent of contamination. Figure 4 presents a current aerial view of the property, the location of the existing groundwater remedy, the approximate area of the former excavation, and potential locations for new monitoring wells. The first round of wells should be installed to a depth of approximately 70 ft bgs to focus on areal coverage rather than depth. With these relatively shallow wells, the whole well can be sampled with standard purge techniques with discharge of purge water to the ground surface rather than low-flow sampling or PDB sampling at specified intervals. The wells should be surveyed and gauged for water levels with the other wells to improve the understanding of groundwater flow in the area. After one round of sampling, the site team can evaluate the potential need for further characterization, including deeper monitoring wells. If contamination that merits remediation is identified in groundwater, then the unsaturated bedrock overlying the contaminated groundwater should also be investigated for potential remediation with SVE pilot testing.

The optimization review team envisions that the initial round of well installation and sampling might cost $40,000 if the drilling and sampling is coordinated with other drilling and sampling activities and drill cuttings and purge water can be left at the ground surface. However, if contamination is identified in groundwater that merits further characterization and remediation, the costs for subsequent rounds of investigation will likely exceed $200,000.

Continue Evaluating the Performance of the DPE Remedy

The DPE remedy near the former storage area began operation in April 2011. Continued monitoring of the influent concentrations and the concentrations at ROG4S will provide information regarding the remedy's ability to control contaminant migration from this area and to remove contaminant mass.

Defer More Extensive Evaluations of Plume Capture

No recommendations are provided for further evaluating plume capture offered by the existing system at this point because of the significant lack of groundwater data near the former excavation. The optimization review team believes that further evaluation of plume capture can be considered after the above information is collected and the site team has better defined the objectives of the remedy.

6.1.4 ROYAL CLEANERS

Investigate and Remediate Contaminant Mass in the Unsaturated Zone

Substantial contaminant mass likely remains in the unsaturated zone; from the bottom of the excavation (assume 10 ft bgs) to the water table (approximately 50 ft bgs). This unsaturated zone contamination is not directly addressed by the groundwater remedy and may continue to provide an ongoing source of contamination to groundwater. The optimization review team recommends investigation of the unsaturated bedrock in the same manner as described for Electra Products. The optimization review team envisions the following scope of work:

- Work planning.
- Installation of six shallow SVE wells screened from 5 to 20 ft bgs (three between the former excavation and ROY5S and three between ROY5S and ROY3S) to preferentially extraction vapors from the weathered bedrock and upper competent bedrock.
- Installation of six deeper borings open from 20 ft bgs to the water table at 50 ft bgs (three between the former excavation and ROY5S and three between ROY5S and ROY3S) to address vapors in fractures of more competent bedrock, if any.

- Two to four days of SVE testing in which a mobile system including a knockout tank, blower (similar to that used in the Rogers Mechanical system), and VGAC vessels are used to extract soil vapor.
- Data analysis and recommendations.

The SVE testing would include extraction from one well at a time and monitoring the vacuum in the extraction well, the vacuum at the other wells, the flow rate, and contaminant concentration of the extracted vapors. Vapor concentrations with a PID can be conducted at various points during testing in the observation wells (i.e., non-extraction wells). Testing should occur independently from at least one shallow well and one deep well between the former excavation and ROY5S and at least one shallow well and one deep well between ROY5S and ROY3S. Locations of the wells should consider the know information about fracture orientation in the bedrock. Assuming this testing is coordinated with SVE testing the other locations, the optimization team estimates that this effort might cost approximately $100,000.

Improve Characterization of the Groundwater Plume

To better delineate areas high contamination at shallow depths discussed in Section 4.2.4, the optimization review team recommends the installation of shallow monitoring wells near ROY3S, ROYRDI, beneath the former excavation, near ROY4I, across North Broad Street to the northwest, and approximately 150 ft northeast of ROY5S as depicted in Figure 5. The wells should have similar screened intervals to ROY5S (i.e., from the water table to approximately 60 ft bgs) except for the well across North Broad Street. For this well, the optimization review team defers to further evaluation by the site team. Given the additional distance down-dip from the source, an appropriate depth may be to 90 ft bgs. These wells should be sampled for at least two events and the information used to improve the understanding of the geology and the extent of contamination that requires active remediation. The results from this initial phase of characterization may result in additional wells to further improve the understanding of contamination both horizontally and vertically. Assuming this well installation and sampling is coordinated with other drilling and sampling activities at the other locations, the optimization team estimates that this effort might cost approximately $60,000.

Defer Evaluations of Plume Capture

No recommendations are provided for further evaluating plume capture offered by the existing system at this point because of the suspected current inadequacy of the existing system and the lack of understanding of the extent of contamination meriting remediation. The optimization review team believes that further evaluation of plume capture can be considered after the above information is collected and the site team has better defined the performance criteria for the remedy.

6.1.5 WESTSIDE INDUSTRIES

Investigate Soil and Soil Vapor Contamination Near and Under the Building

The absence of an identified near surface source during the 1994 RI, the magnitude of contaminant concentrations, and the distribution of contamination suggest the potential for a source of contamination to be present beneath the building, up-dip from WES1VS, WES1S, and WES1I. The optimization review team suggests installing several vapor probes through the buildings slab to the southeast of WES1V and WES1S to determine subslab vapor concentrations. Samples could be collected with summa canisters, and the probes left in place for potential future use to evaluate the performance of an SVE system or vapor intrusion mitigation system (VIMS), if either type of remedy is installed employed. If soil vapor concentrations indicative of continuing source of contamination are present, the site team might consider conducting an SVE pilot test and potentially collecting shallow groundwater samples if the building is accessible for drilling. If the building is not accessible for drilling, and there is a source that merits remediation under the building, the site team could consider horizontal drilling under the building slab from outside of the building. If soil vapor concentrations are not indicative of a continuing source, but are of sufficient magnitude to be a concern for vapor intrusion, then the site team could consider a subslab depressurization system to mitigate vapors and remove some contaminant mass. The optimization team also recommends the use of a DPT for a soil investigation in the vicinity of WES1VS and WES1S. If the DPT can reach groundwater prior to refusal, groundwater samples should also be collected. For the initial installation of soil vapor probes and samples, the optimization team estimates a cost of approximately $15,000 for field work and analysis. For the DPT event, the optimization team assumes a cost of approximately $15,000 for a two-day investigation, including planning. Potential additional investigations as described above would be substantially higher in cost.

Further Characterize Shallow Groundwater

The optimization review team recommends conducting two rounds of groundwater sampling from WES1VS and WES1S with aggressive purging techniques (i.e., purging several well volumes prior to collecting a sample) in an attempt to reproduce the high levels of contamination previously identified in these wells. If high levels of contamination are observed, then additional “very shallow” or shallow wells are merited. These additional wells would be helpful for identifying the source area and could also be used to support remediation. The cost of this recommendation can be under $2,000 if it is limited to two rounds of sampling, but the recommendation could cost as much as $30,000 if additional wells and sampling are merited.

Include MNA Parameters in Next Sampling Round

The optimization review team recommends adding analysis for total organic carbon (TOC), nitrate, sulfate, ferrous iron, methane, ethane, and ethane to the next round of sampling to evaluate the extent of reducing conditions and if degradation of chlorinated VOCs to ethene is occurring. The optimization review team expects these analyses to add approximately $150 per sample or approximately $1,500 for one sampling event.

Defer Further Plume Delineation and Capture Zone Evaluation

Further delineation of the contaminant plume will be difficult given the limited access in the down-dip direction. Therefore, the optimization review team does not suggest further downgradient well installation at this stage. The extent of the capture zone is also unclear, and additional information to evaluate plume capture based on additional wells will be difficult to collect. The background hydraulic gradient and the response to pumping at various well suggests groundwater extraction may capture the contamination in the shallow and intermediate well locations, but the capture of contamination in deeper wells (e.g., WES4D) is less uncertain given the smaller response of deeper wells to pumping. Continued groundwater monitoring should provide valuable information for assessing capture of contamination detected at existing wells. The optimization review team defers further evaluation of plume capture until sampling data from the two 2011 sampling events is available and until the site team determines the remedial strategy on a move forward basis. If capture is to be further evaluated at this location, the optimization review team suggests the use of tracer tests in which a tracer is released at an existing well and monitored in the extracted groundwater.

6.1.6 Organize Borehole Information in a Software Package to Facilitate Data Interpretation

The optimization review team has learned that Region 3 is organizing site data into a software package (Rockware^{TM}) to better understand the geology and its role in contaminant migration. The optimization review team supports this effort to improve the CSM and believes that this effort will yield helpful information in implementing these optimization recommendations and improving overall site management in the future. The optimization review team defers to Region 3 for the costs of this effort.

6.1.7 Conduct Synoptic Water Level Events

This optimization report focuses on the five individual Fund-lead locations with operating groundwater remedies, but the optimization review team believes that substantial benefit would be realized from conducting synoptic water level events on a go-forward basis in which water levels from all surveyed NPA6 Site monitoring wells are measured within a 24-hour period. This information can be used to update potentiometric surface maps, which, together with an understanding of the regional hydrogeology and water quality data, will help better understand the regional plume. An improved understanding of the regional plume may help the site team develop specific remedial objectives and points of compliance for each remedy in a manner that improves the likelihood of restoring the regional aquifer in a timely manner. This effort might cost approximately $5,000 extra per event for coordination and appropriate staffing.

6.2 Recommendations to Reduce Costs

Although the optimization team identified recommendations to reduce cost of operating the existing groundwater remedies, the optimization team believes that the current remedies are sufficiently ineffective and the existing CSM sufficiently incomplete that providing cost reduction recommendations at this point would be premature. Due to concerns regarding a lack of effectiveness, the optimization review team does not recommend operation of the existing remedies without modifying the extraction networks. Changing the extraction networks would significantly change the flow rates and mass loading to the treatment systems such that any recommendations made based on the current system may not be appropriate. However, based on the observed treatment systems the optimization review team offers the following general considerations:

- Revisit the NPDES equivalent permits to obtain consistency among the various treatment systems. If higher discharge criteria are obtained for VOCs, this could reduce the need for multiple or redundant treatment processes. If higher criteria for metals are obtained, this could reduce the need for metals removal with greensand or ion exchange.

- Assuming sufficient mass loading to the off-gas treatment systems, attempt to optimize the relative humidity and temperature of the off-gas to maximize VGAC life. The current method of air-to-air heat exchangers to reduce the temperature of the off-gas at Electra Products and Westside Industries likely does not result in optimal conditions. Generally speaking, the goal should be to minimize the relative humidity while keeping temperature below 100° F. More specific information can be obtained from a VGAC vendor.

- Continuously review influent water quality data to identify opportunities to take treatment components off-line if they are no longer needed.

- Eliminate redundant process sampling.
- Avoid extra tanks and transfer pumps to reduce energy usage and maintenance requirements.
- If vinyl chloride and *cis*-1,2-DCE concentrations are below treatment standards consider the use of LGAC with no air stripping to avoid the costs of electricity usage for air stripping, electricity usage for off-gas heating, and GAC costs for VGAC. Note, however, that a cost comparison should be performed for each individual situation to confirm GAC will be the less costly option when considering electricity, materials, and labor costs.
- Reduce the NPDES and air sampling frequency in all treatment systems to once per month or perhaps once per quarter.

6.3 Recommendations for Technical Improvement

For similar reasons as discussed in Section 6.2, the optimization review team has not provided any technical improvement recommendations for the existing remedies.

6.4 Considerations for Gaining Site Close Out

6.4.1 Develop Achievable Objectives for each Active Groundwater System Based on Results from Implementing Effectiveness Recommendations

Implementation of the effectiveness recommendations in Section 6.1 (and potentially additional follow-up work) will provide valuable information with respect to source area size and magnitude, the presence of contaminant mass in the unsaturated zone, the general extent of areas with "high" concentrations in groundwater, and hydraulic information related to regional groundwater flow. The optimization review team recommends establishing objectives for each of the groundwater systems based on this information.

The optimization review team sees three general approaches (others may exist):

> Approach A: Aggressively treat areas of high contaminant mass at each location with the objective of restoring groundwater at each location to the levels comparable to elsewhere in the regional plume. This might require additional off-property wells to establish concentrations (above site-wide mandated cleanup levels) below which active remediation is no longer deemed appropriate.
>
> Approach B: Continue on-site treatment at each site until contaminant concentrations reach the mandated cleanup levels across each site, recognizing that treatment may need to continue if contamination migrates on-site from the regional plume.
>
> Approach C: Provide active treatment for all contamination associated with a particular location above an established level even if that contamination has already left the property boundary, and continue the treatment until concentrations decline to an agreed upon level, which may or may not be the mandated site-wide cleanup level.

Note that the approach for each location should be location specific, especially if remediating off-property contamination for some locations is deemed to be impracticable due to restricted access. The remedial strategy for each location will heavily depend on the approach that is chosen. The following recommendations are organized by location and present various considerations and remedial approaches for each location. The improved CSM that is developed as a result of additional data collection may be sufficiently different from the CSM assumed at the time of the ROD that revisiting the ROD may be merited. The recommendations are the technical opinions of the optimization review team based on existing information and do not fully account for the nine CERCLA criteria or various non-technical factors. In addition, the opinions are subject to change based on additional information.

The approximate costs below include general project management and reporting for each location, but do not include general project management, reporting, and consulting for the NPA6 Site as a whole.

6.4.2 Site Closure Considerations for Electra Products

Relative to the other locations, there is a significant amount of open space at and downgradient of Electra Products (i.e., the park to the northwest and the parking lot to the south and southwest), providing the opportunity to either monitor or remediate contamination underlying this open space. This makes remedial approaches A, B, and C possibilities for this location. One deciding factor from a technical perspective will be the horizontal and vertical extent of the contamination that merits remediation and the locations of the sources. The approximate location (but not extent) of one source (near ELE1S) is relatively well known. The location of the other source (TCE observed in ELELP) is not known. Potential remedial alternatives for each of the approaches are discussed below. Note that the outcomes of the implementing the various approaches differ and should be considered when comparing costs.

- Approach A: Remediation would likely address contamination in the unsaturated zone with SVE and would likely use ISCO to address groundwater on-property with PCE or TCE concentrations greater than 100 µg/L. The P&T system should be used to provide water for the injections and to help disperse ISCO reagents in the subsurface, but should be shut down shortly after each injection. Contaminant concentrations in groundwater would be substantially reduced but would likely remain above cleanup levels. Monitoring over a 10-year period of time would document concentration reductions on and off-property and would provide the information needed to determine if additional ISCO injections or other remedial measures are needed. Care would be needed to identify potential receptors of the injected ISCO reagents, design the injections appropriately, and monitor the migration of the reagents. Permanganate (sodium or potassium permanganate) is suggested as the oxidant because of its relatively low cost, ease of injection, and persistence in the subsurface. Concerns regarding permanganate migration to nearby groundwater receptors (if any) could lead the site team to choose a different ISCO reagent. One potential remedial strategy for this approach could involve the following:

General Scope Item	Estimated Potential Costs
Locate source of TCE detected at ELELP	See Section 6.1
Prepare designs and work plans and provide project management consulting	$100,000
Reduce contaminant mass in unsaturated zone with SVE (assume some infrastructure from P&T system is used)	$300,000
Establish the extent of the groundwater contamination to treat	See Section 6.1

General Scope Item	Estimated Potential Costs
Remediate the targeted groundwater with ISCO assuming the following: • 2 volumes of 100 ft x 100 ft x 50 ft (porosity <1%) • 4 new injection points, • 3 events for each targeted area • 2,000 pounds of permanganate for each of 3 events • approximately 2 days per event • monitoring up to 20 wells 6 months after each event	$185,000
Annual monitoring the targeted groundwater and the downgradient groundwater over a 10-year period to document remedy performance	$150,000
Total Estimated Additional Costs*	**$735,000**

** after implementing recommendations from Section 6.1*

- Approach B: Remediation would likely address contamination in the unsaturated zone with SVE and would likely use P&T to address groundwater on-property with the intent of reaching cleanup levels on-site over an extended period of time. The P&T extraction system would be improved to target source areas for improved mass removal and would include a more robust evaluation of hydraulic capture of contamination. Hydraulic information collected from implementing the recommendations in Section 6.1 and application of the USGS model could be used during design. Additional extraction wells would be installed and might be hydrofracked during installation to improve recovery rates. The P&T treatment system may or may not require capital improvements to handle increased flow or contaminant loading. Annual O&M costs would increase due to increased electricity and GAC use, but the amount of the increase is uncertain without more information. Contaminant concentrations in groundwater would eventually reach cleanup levels over a long period of time, and in the interim would control contaminant migration. The optimization review team expects that the time frame would be many decades before the remedial objectives are met. One potential remedial strategy for this approach could involve the following:

General Scope Item	Estimated Potential Costs
Design extraction system to provide improved mass removal and plume capture (assume model development and simulations are conducted as part of extraction system improvements)	$50,000
Improve extraction system and make capital improvements to the treatment system, including SVE wells and vapor treatment	$400,000
Operate, maintain, and monitor P&T system indefinitely (for costing purposes, assume 50 years at $100,000 per year not discounted to net present value)	$5,000,000
Annual groundwater monitoring (for costing purposes, assume 50 years at $15,000 per year not discounted to net present value)	$750,000
Total Estimated Additional Costs*	**$6,200,000**

** after implementing recommendations from Section 6.1*

- For Approach C, the approach would depend significantly on the concentration levels at which active remediation could be discontinued and the volume of aquifer to treat but would likely include ISCO, P&T, or both.

6.4.3 SITE CLOSURE CONSIDERATIONS FOR KEYSTONE HYDRAULICS

There is a significant amount of open space at Keystone Hydraulics to address the source areas, but there is limited access to address portions of the plume that have already left the property. The layout is therefore generally more conducive to approaches A and B, but approach C could also be implemented if access issues can be overcome.

- Approach A: Remediation would likely address contamination in the unsaturated zone with SVE and would likely use ISCO to address groundwater on-property with PCE or TCE concentrations greater than 100 µg/L. The P&T system should be used to provide water for the injections and to help disperse ISCO reagents in the subsurface, but should be shut down shortly after each injection. Contaminant concentrations in groundwater would be substantially reduced but would likely remain above cleanup levels. Monitoring over a 10-year period would document concentration reductions on and off-property and would provide the information needed to determine if additional ISCO injections or other remedial measures are needed. Care would be needed to identify potential receptors of the injected ISCO reagents, design the injections appropriately, and monitor the migration of the reagents. Permanganate (sodium or potassium permanganate) is suggested as the oxidant because of its relatively low cost, ease of injection, and persistence in the subsurface. Concerns regarding permanganate migration to nearby groundwater receptors (if any) could lead the site team to choose a different ISCO reagent. One potential remedial strategy for this approach could involve the following:

General Scope Item	Estimated Potential Costs
Identify sources to be treated by SVE	See Section 6.1
Prepare designs and work plans and provide project management consulting	$100,000
Reduce contaminant mass in unsaturated zone and reduce potential for vapor intrusion with SVE for three years (assume up to 20 shallow SVE wells and that some infrastructure from the P&T system is used)	$300,000
Establish the extent of the groundwater contamination to treat	See Section 6.1
Remediate the targeted groundwater with ISCO assuming the following: • target 25,000 ft^2 with a thickness of 50 ft (porosity <1%) • 6 new injection points • 3 events for targeted area plus additional 2 events in 5,000 ft^2 source area • total of 8,000 pounds of permanganate • total of 8 days of injections • monitoring up to 20 wells 6 months between injection events (3 monitoring events only)	$240,000
Annual monitoring the targeted groundwater and the downgradient groundwater over a 10-year period to document remedy performance	$150,000
Total Estimated Additional Costs*	**$790,000**

** after implementing recommendations from Section 6.1*

- Approach B: Remediation would likely address contamination in the unsaturated zone and the potential for VI by using SVE and would likely use P&T to address groundwater on-property with the intent of reaching cleanup levels on-property over an extended period of time. The P&T extraction system would be improved to target source areas for improved mass removal and would include a more robust evaluation of hydraulic capture of contamination. Hydraulic information collected from implementing the recommendations in Section 6.1 and application of the USGS model could be used during design. Additional extraction wells (particularly near KEY2S) would be installed and may be hydrofracked during installation to improve recovery rates. The P&T treatment system may or may not require capital improvements to handle increased flow or contaminant loading. Annual O&M costs would increase, but the amount of the increase is uncertain without more information. Contaminant concentrations in groundwater would eventually reach cleanup levels over a long period of time and would control contaminant migration in the interim. The optimization review team expects that the time frame would be decades before the remedial objectives are met. One potential remedial strategy for this approach could involve the following:

General Scope Item	Estimated Potential Costs
Design P&T extraction system to provide improved mass removal and plume capture (assume model development and simulations are conducted as part of extraction system improvements)	$50,000
Improve P&T extraction system and make capital improvements to the treatment system, including SVE wells and vapor treatment (assume 20 SVE wells and up to 3 years of operation)	$400,000
Operate, maintain, and monitor P&T system indefinitely (for costing purposes, assume 50 years at $100,000 per year not discounted to net present value)	$5,000,000
Annual groundwater monitoring (for costing purposes, assume 50 years at $15,000 per year not discounted to net present value)	$750,000
Total Estimated Additional Costs*	**$6,250,000**

** after implementing recommendations from Section 6.1*

- For Approach C, the approach would depend significantly on the concentration levels at which active remediation could be discontinued and the volume of aquifer to treat. Additional ISCO injection wells or P&T extraction wells could be placed near the property boundary or in the parking lots across the street if access is granted.

6.4.4 SITE CLOSURE CONSIDERATIONS FOR ROGERS MECHANICAL (FORMER TATE ANDALE)

There is too much uncertainty regarding the current CSM to consider various remedial approaches.

6.4.5 SITE CLOSURE CONSIDERATIONS FOR ROYAL CLEANERS

There is a significant amount of open space at Royal Cleaners to address the source areas, but there is very limited access to address portions of the plume that have already left the property. The layout is, therefore, generally more conducive to approaches A and B. Approach C would be difficult to implement without overcoming significant access issues.

- Approach A: Remediation would likely address contamination in the unsaturated zone with SVE and would likely use ISCO to address groundwater on-property with PCE or TCE concentrations greater than 100 µg/L. The P&T system should be used to provide water for the injections and to help disperse ISCO reagents in the subsurface, but should be shut down shortly after each injection. Remediation would reduce contaminant mass. Contaminant concentrations in groundwater would be substantially reduced but would likely remain above cleanup levels. Monitoring over a 10-year period of time would document concentration reductions on and off-property and would provide the information needed to determine if additional ISCO injections are needed. Care would be needed to identify potential receptors of the injected ISCO reagents, design the injections appropriately, and monitor the migration of the reagents. Permanganate (sodium or potassium permanganate) is suggested as the oxidant because of its relatively low cost, ease of injection, and persistence in the subsurface. Concerns regarding permanganate migration to nearby groundwater receptors (if any) could lead the site team to choose a different ISCO reagent. One potential remedial strategy for this approach could involve the following:

General Scope Item	Estimated Potential Costs
Identify sources to be treated by SVE	See Section 6.1
Prepare designs and work plans and provide project management consulting	$100,000
Reduce contaminant mass in unsaturated zone and reduce potential for vapor intrusion with SVE for 3 years (assume up to 20 shallow SVE wells and that some infrastructure from the P&T system is used)	$300,000
Establish the extent of the groundwater contamination to treat	See Section 6.1
Remediate the targeted groundwater with ISCO assuming the following: • target 30,000 ft^2 with a thickness of 50 feet • 6 new injection points • 3 events for targeted area plus additional 2 events in 10,000 ft^2 source area • total of 8,000 pounds of permanganate • total of 8 days of injections • monitoring up to 20 wells between injection events (3 monitoring events total)	$240,000
Annual monitoring the targeted groundwater and the downgradient groundwater over a 10-year period to document remedy performance	$150,000
Total Estimated Additional Costs*	**$790,000**

* *after implementing recommendations from Section 6.1*

- Approach B: Remediation would likely address contamination in the unsaturated zone and the potential for VI by using SVE and would likely use P&T to address groundwater on-property with the intent of reaching cleanup levels on-property over an extended period of time. The P&T extraction system would be improved to target source areas for improved mass removal and would include a more robust evaluation of hydraulic capture of contamination. Hydraulic information collected from implementing the recommendations in Section 6.1 and application of the USGS model could be used during design. Additional extraction wells would be installed and may be hydrofracked during installation to improve recovery rates. The P&T treatment system may or may not require capital improvements to handle increased flow or contaminant loading. Additional extraction wells would be installed for this purpose and may be hydrofracked during installation to improve recovery rates. The P&T system may or may not require capital improvements to handle increased flow or contaminant loading. Annual O&M costs would increase, but the amount of the increase is uncertain without more information. Contaminant concentrations in groundwater would eventually reach cleanup levels over a long period of time. One potential remedial strategy for this approach could involve the following:

General Scope Item	Estimated Potential Costs
Design P&T extraction system to provide improved mass removal and plume capture (assume model development and simulations are conducted as part of extraction system improvements)	$50,000
Improve P&T extraction system and make capital improvements to the treatment system, including SVE wells and vapor treatment (assume 20 SVE wells and up to 3 years of operation)	$450,000
Operate, maintain, and monitor P&T system indefinitely (for costing purposes, assume 50 years at $100,000 per year not discounted to net present value)	$5,000,000
Annual grou5ndwater monitoring (for costing purposes, assume 50 years at $15,000 per year not discounted to net present value)	$750,000
Total Estimated Additional Costs*	**$6,250,000**

** after implementing recommendations from Section 6.1*

- Application of Approach C would be limited due to the access restrictions associated with North Broad Street. Remediation of off-property contamination would likely be limited to injecting reagents at the property boundary that would migrate off-property or extracting groundwater from the property boundary that might pull back a portion of the plume.

6.4.6 SITE CLOSURE CONSIDERATIONS FOR WESTSIDE INDUSTRIES

There is limited space for remediation at Westside Industries, and contamination may be present under the active building, off-property at the active cement plant, or both. These restrictions pose a unique challenge for this location. The layout is therefore generally more conducive to approaches A and B. Approach C would be difficult to implement without overcoming significant access issues. The reducing conditions and evidence of reductive dechlorination suggest the use if enhanced bioremediation at this location.

- Approach A: Remediation would likely address contamination in the unsaturated zone with SVE and would likely use emulsified vegetable oil or another organic electron donor to address groundwater on-property with the concentration of any particular chlorinated VOC greater than 100 µg/L. Bioremediation is suggested at this location because there is already evidence of bioremediation occurring and because of the persistence of emulsified vegetable oil in the subsurface. The P&T system should be used to provide water for the injections and to help disperse water in the subsurface, but should be shut down shortly after each injection. Remediation would reduce contaminant mass. Contaminant concentrations in groundwater would be substantially reduced but would likely remain above cleanup levels. Monitoring over a 10-year period of time would document concentration reductions on and off-property and would provide the information needed to determine if additional bioremediation injections are needed. Care would be needed to identify potential receptors of the injected emulsified vegetable oil, design the injections appropriately, and monitor the migration of the reagents. One potential remedial strategy for this approach could involve the following:

General Scope Item	Estimated Potential Costs
Identify sources to be treated by SVE	See Section 6.1
Prepare designs and work plans and provide project management consulting	$100,000
Reduce contaminant mass in unsaturated zone and reduce potential for vapor intrusion with SVE for 3 years (assume up to 20 shallow SVE wells and that some infrastructure from the P&T system is used)	$400,000
Establish the extent of the groundwater contamination to treat	See Section 6.1
Remediate the targeted groundwater with *in situ* bioremediation assuming the following: • emulsified vegetable oil is injected into the various monitoring wells and dispersed throughout the aquifer for short period of time by the existing extraction system • two injection events • total of 1,000 pounds of emulsified vegetable oil • total of four days for injections • monitoring up to 20 wells 3 months and 6 months after each event for VOCs and bioremediation parameters	$125,000
Annual monitoring the targeted groundwater and the downgradient groundwater over a 10-year period to document remedy performance	$150,000
Total Estimated Additional Costs*	**$775,000**

** after implementing recommendations from Section 6.1*

- Approach B: The approach would likely be similar to that of Approach A, but injections would be made on a routine basis to maintain treatment over a longer period of time. One potential remedial strategy for this approach could involve the following:

General Scope Item	Estimated Potential Costs
Identify sources to be treated by SVE	See Section 6.1
Prepare designs and work plans and provide project management consulting	$100,000
Reduce contaminant mass in unsaturated zone and reduce potential for vapor intrusion with SVE for 3 years (assume up to 20 shallow SVE wells and that some infrastructure from the P&T system is used)	$400,000
Establish the extent of the groundwater contamination to treat	See Section 6.1

General Scope Item	Estimated Potential Costs

Remediate the targeted groundwater with *in situ* bioremediation assuming the following:
• emulsified vegetable oil is injected into the various monitoring wells and dispersed throughout the aquifer for short period of time by the existing extraction system
• 10 injection events
• total of 5,000 pounds of emulsified vegetable oil
• total of 20 days for injections
• monitoring up to 20 wells 1 month, 3 months, and 6 months after each of the first four events for VOCs and bioremediation parameters
• The following activities might also apply but are not included in the estimated costs:
  o additional injection wells may be needed if extraction system does not sufficiently distribute the emulsified vegetable oil
  o more injection events could be needed in emulsified vegetable does not last long enough or migrates off-property
	$400,000

Annual monitoring the targeted groundwater and the downgradient groundwater over an additional 10-year period to document remedy performance	$200,000
Total Estimated Additional Costs*	**$1,100,000**

** after implementing recommendations from Section 6.1*

- Application of Approach C would be limited due to the access restrictions associated with the active cement plant. Remediation of off-property contamination would likely be limited to injecting reagents at the property boundary that would migrate off-property.

6.5 RECOMMENDATIONS RELATED TO ENVIRONMENTAL FOOTPRINT REDUCTION

No specific recommendations for environmental footprint reduction are provided, but implementation of recommendations provided in Sections 6.1 and 6.4 should result in a more effective and efficient remedy, which would likely translate to a lower environmental footprint.

6.6 SUGGESTED APPROACH TO IMPLEMENTING RECOMMENDATIONS

The optimization review team suggests implementing the recommendations in Section 6.1 and then determining a remedial approach to each location as discussed in Section 6.4.1 before proceeding with the remedial activities discussed in Sections 6.4.2 through 6.4.6. Based on known information, the optimization review team would suggest the following items in Section 6.4.1 receive the highest priority:

- Soil vapor, potential VI, and source area remediation at Keystone Hydraulics
- Soil vapor and groundwater remediation at Royal Cleaners
- Soil vapor and groundwater remediation at Westside Industries
- Groundwater remediation at Keystone Hydraulics
- Soil vapor and groundwater remediation at Electra Products

The work discussed in Section 6.4 can be implemented in phases to provide more information to the site team and to learn from application. For example, lessons learned from the initial ISCO injections at Keystone Hydraulics and Royal Cleaners may be applicable to later injections at the same locations, the initial injections at other locations, or both. Similar lessons learned may apply for for improved P&T design information or for SVE extraction well installation.

Table 11: Recommendation Cost Summary

Recommendation	Category	Additional Capital Cost	Change in Annual Cost	Change in Life-Cycle Cost
6.1.1 Effectiveness Recommendations for Electra Products	Effectiveness	$110,000	$0	$110,000
6.1.2 Effectiveness Recommendations for Keystone Hydraulics	Effectiveness	$95,000	$0	$165,000
6.1.3 Effectiveness Recommendations for Rogers Mechanical (former Tate Andale)	Effectiveness	$40,000	$0	$40,000
6.1.4 Effectiveness Recommendations for Royal Cleaners	Effectiveness	$160,000	$0	$160,000
6.1.5 Effectiveness Recommendations for Westside Industries	Effectiveness	$33,500	$0	$33,500
6.1.6 Organize Borehole Information in a Software Package to Facilitate Data Interpretation	Effectiveness	Cost estimate deferred to EPA Region 3		
6.1.7 Conduct Synoptic Water Level Measurements	Effectiveness	$5,000	$0	$5,000
6.4.1 Develop Achievable Remedial Objectives for each Remedy Based on Results from Implementing Effectiveness Recommendations	Site Closure	No specific cost estimates provided		
6.4.2 Site Closure Considerations for Electra Products	Site Closure	Remedial options ranging from $735,000 to over $6,200,000		
6.4.3 Site Closure Considerations for Keystone Hydraulics	Site Closure	Remedial options ranging from $790,000 to over $6,250,000		
6.4.4 Site Closure Considerations for Rogers Mechanical (former Tate Andale)	Site Closure	No remedial options provided at this point.		
6.4.5 Site Closure Considerations for Royal Cleaners	Site Closure	Remedial options ranging from $790,000 to over $6,250,000		
6.4.6 Site Closure Considerations for Westside Industries	Site Closure	Remedial options ranging from $775,000 to over $1,100,000		

Table 12: Effect of Recommendations on the Environmental Footprint of the Remedies

Recommendation	Effect on Environmental Footprint
6.1.1 Effectiveness Recommendations for Electra Products	Implementation of these recommendations is expected to directly increase the environmental footprint of the remedies in all Green Remediation categories. However, the information gathered from implementing these recommendations could be important for reducing the overall environmental footprint of the remedies over time.
6.1.2 Effectiveness Recommendations for Keystone Hydraulics	
6.1.3 Effectiveness Recommendations for Rogers Mechanical (former Tate Andale)	
6.1.4 Effectiveness Recommendations for Royal Cleaners	
6.1.5 Effectiveness Recommendations for Westside Industries	
6.1.6 Organize Borehole Information in a Software Package to Facilitate Data Interpretation	
6.1.7 Conduct Synoptic Water Level Measurements	
6.4.1 Develop Achievable Remedial Objectives for each Remedy Based on Results from Implementing Effectiveness Recommendations	The environmental footprints for the various remedial approaches considered were not quantified.
6.4.2 Site Closure Considerations for Electra Products	
6.4.3 Site Closure Considerations for Keystone Hydraulics	
6.4.4 Site Closure Considerations for Rogers Mechanical (former Tate Andale)	
6.4.5 Site Closure Considerations for Royal Cleaners	
6.4.6 Site Closure Considerations for Westside Industries	

FIGURES

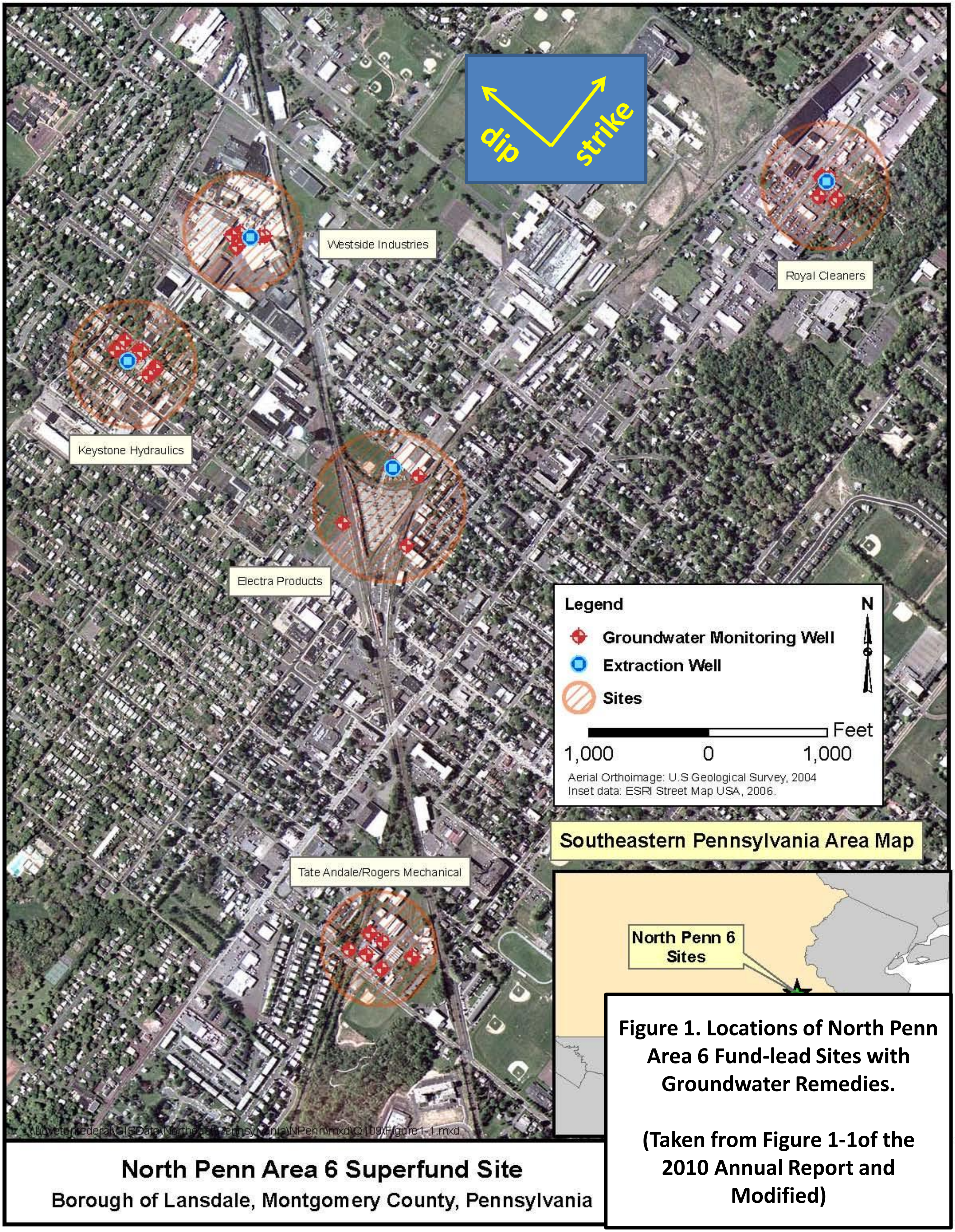
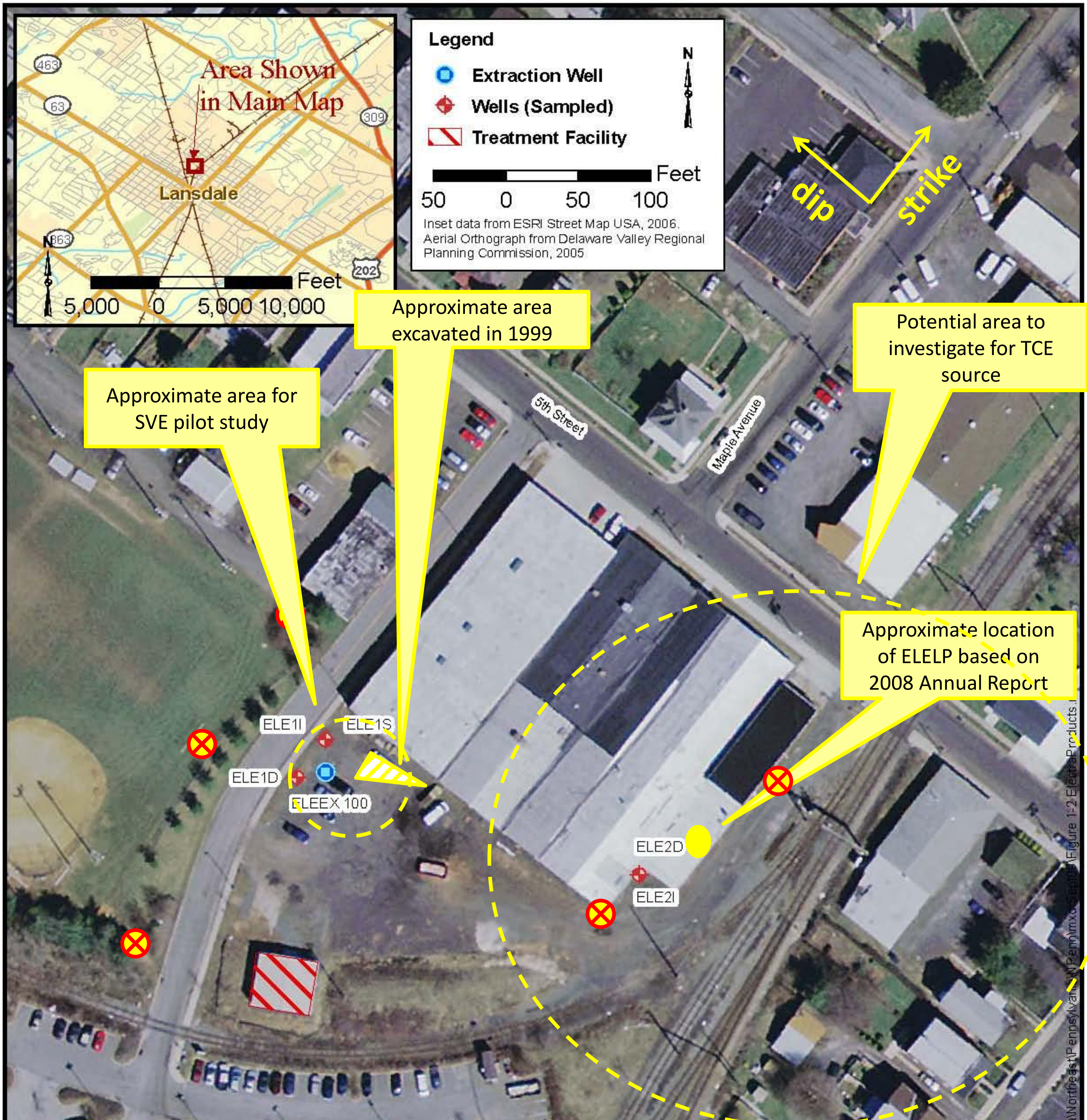


Figure 1. Locations of North Penn Area 6 Fund-lead Sites with Groundwater Remedies.

(Taken from Figure 1-1of the 2010 Annual Report and Modified)

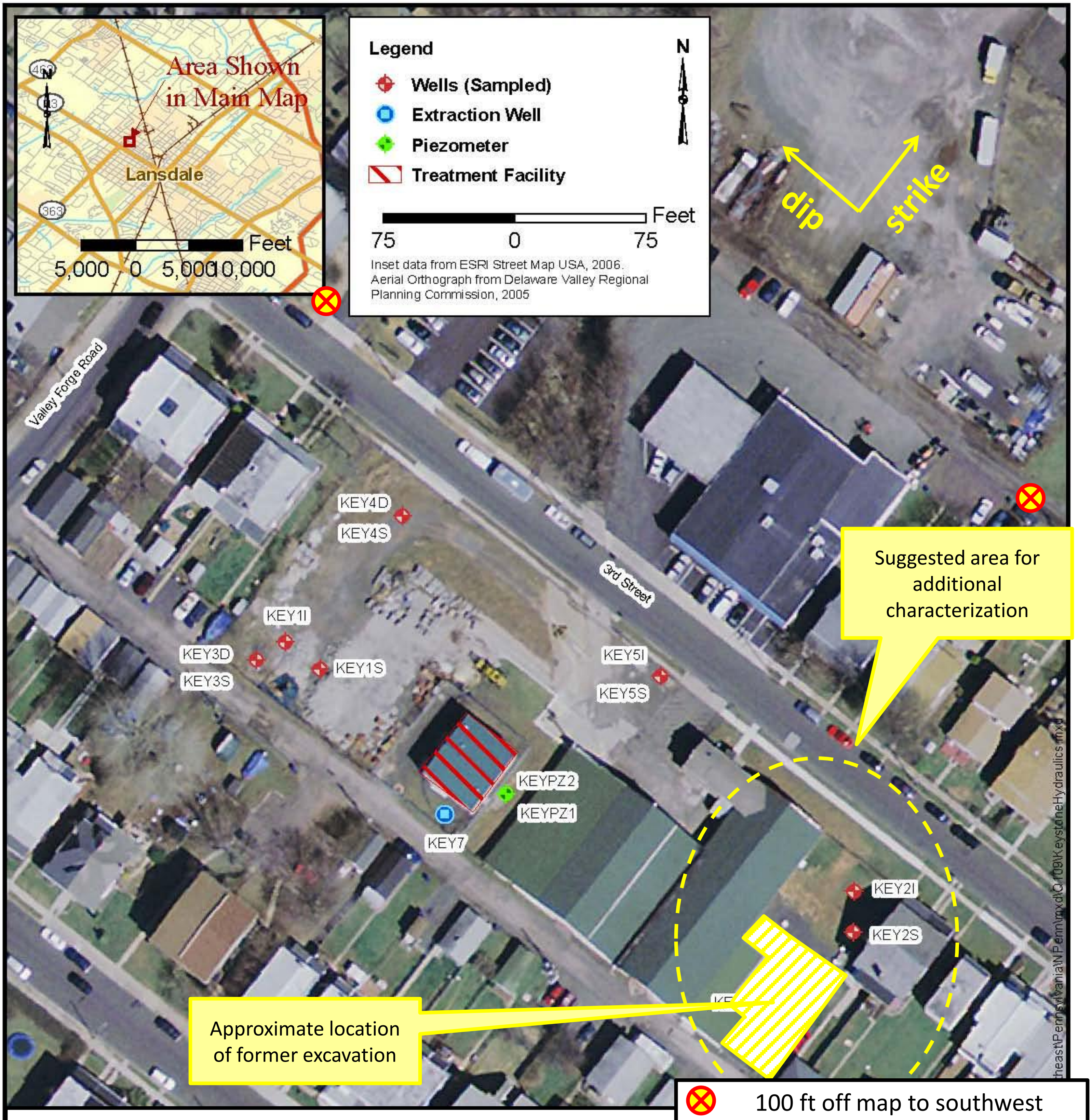


Proposed shallow monitoring well location

North Penn Area 6 Superfund Site
Electra Products
Borough of Lansdale, Montgomery County, Pennsylvania

Figure 2. Electra Products.

(Taken from Figure 1-2 of the 2010 Annual Report and Modified)



Proposed monitoring well locations

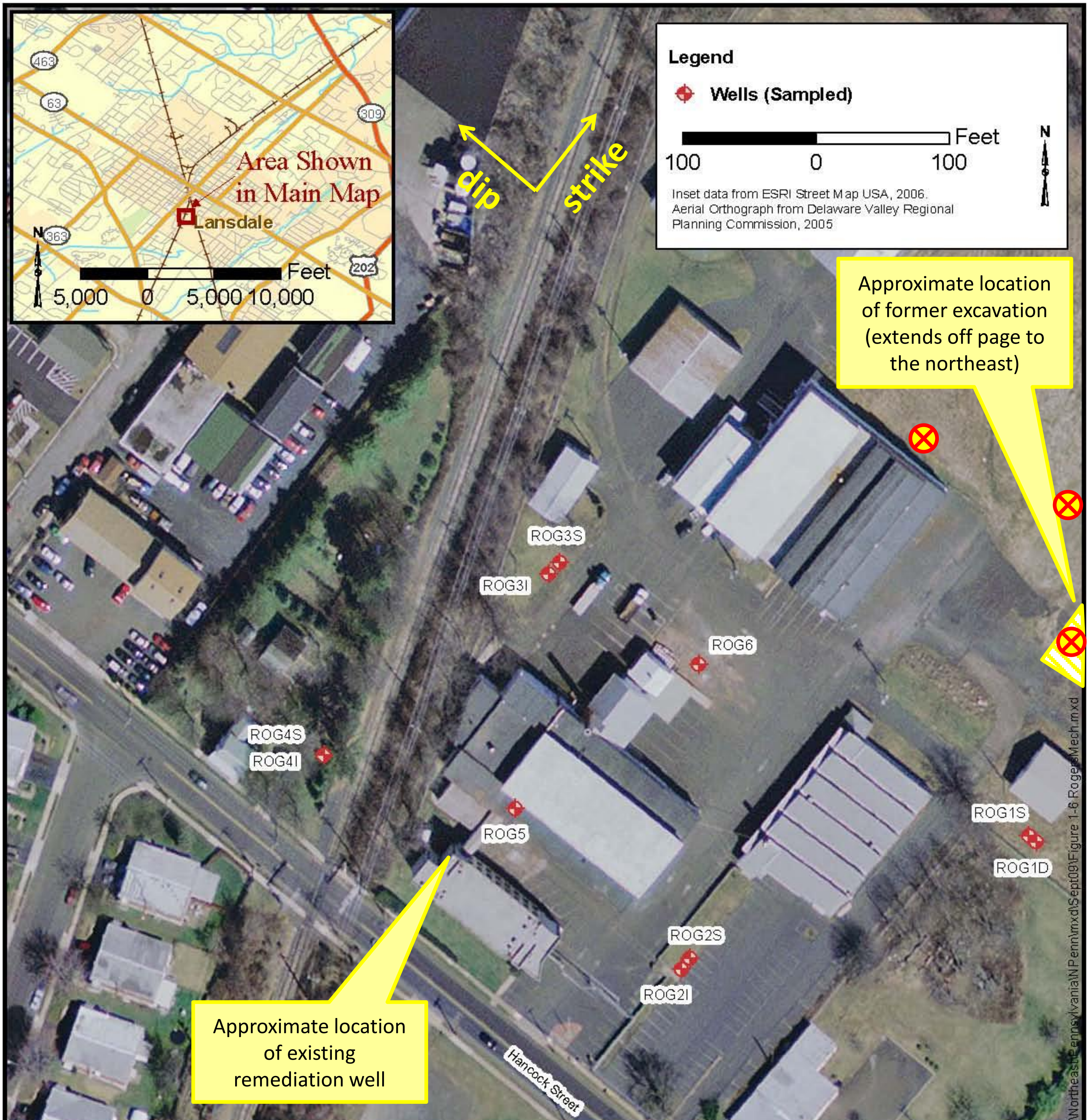
Figure 3. Keystone Hydraulics.

(Taken from Figure 1-3 of the 2010 Annual Report and Modified)

North Penn Area 6 Superfund Site

Keystone Hydraulics

Borough of Lansdale, Montgomery County, Pennsylvania

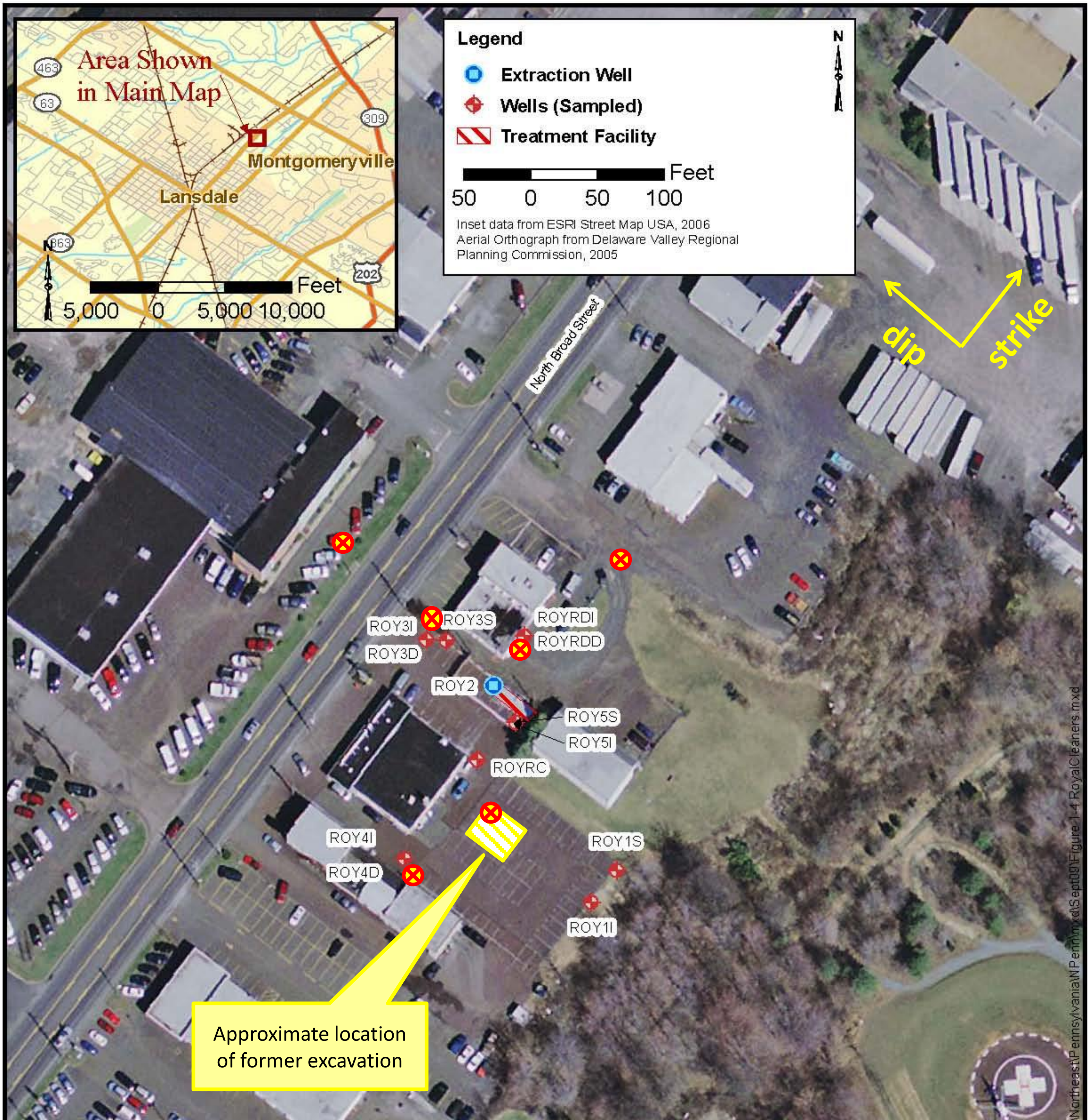


Proposed shallow monitoring well location

Figure 4. Rogers Mechanical (former Tate Andale)

(Taken from Figure 1-6 of the 2010 Annual Report and Modified)

North Penn Area 6 Superfund Site
Tate Andale/Rogers Mechanical
Borough of Lansdale, Montgomery County, Pennsylvania



Proposed shallow monitoring well location

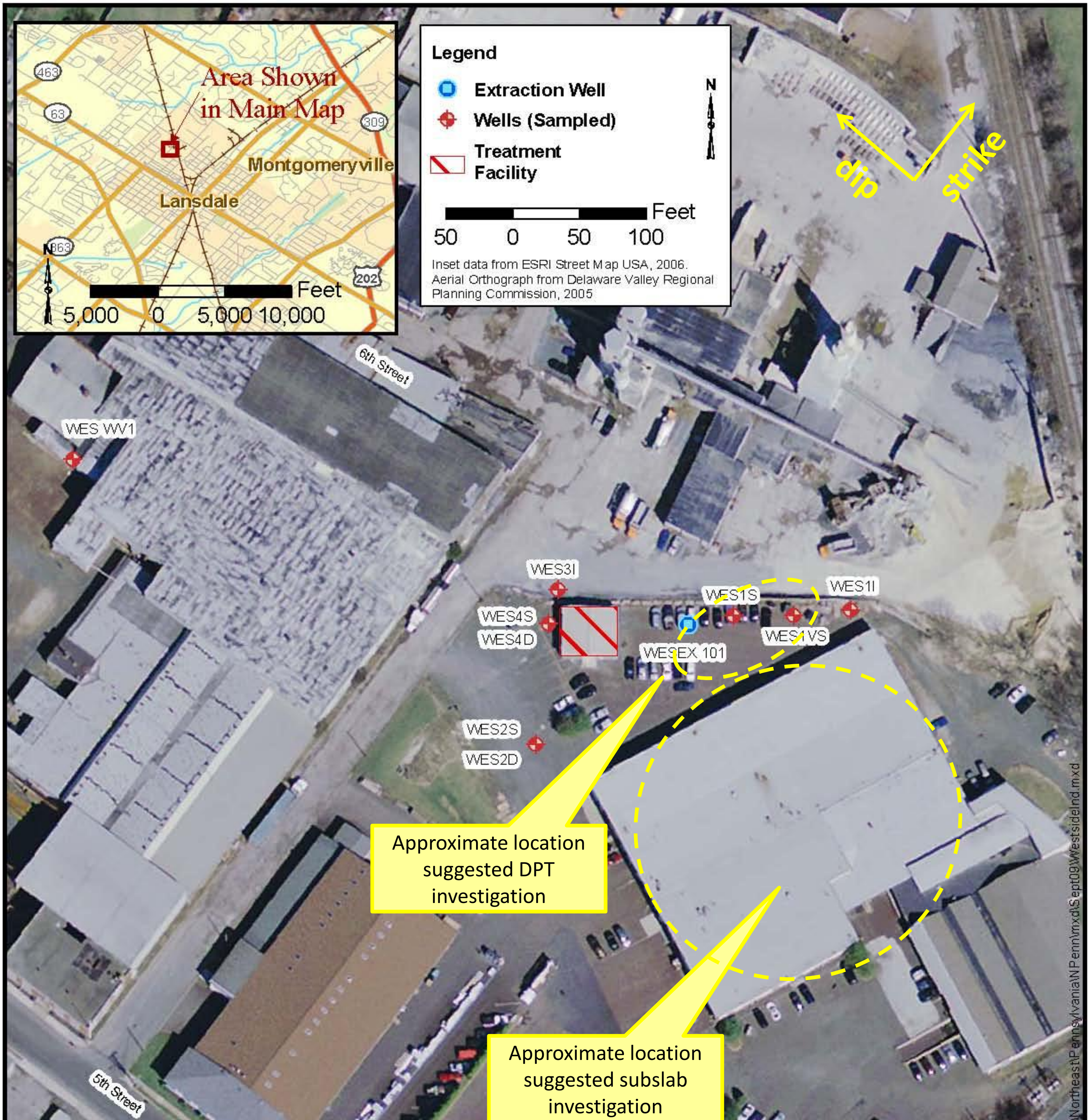
Figure 5. Royal Cleaners

(Taken from Figure 1-4 of the 2010 Annual Report and Modified)

North Penn Area 6 Superfund Site

Royal Cleaners

Borough of Lansdale, Montgomery County, Pennsylvania



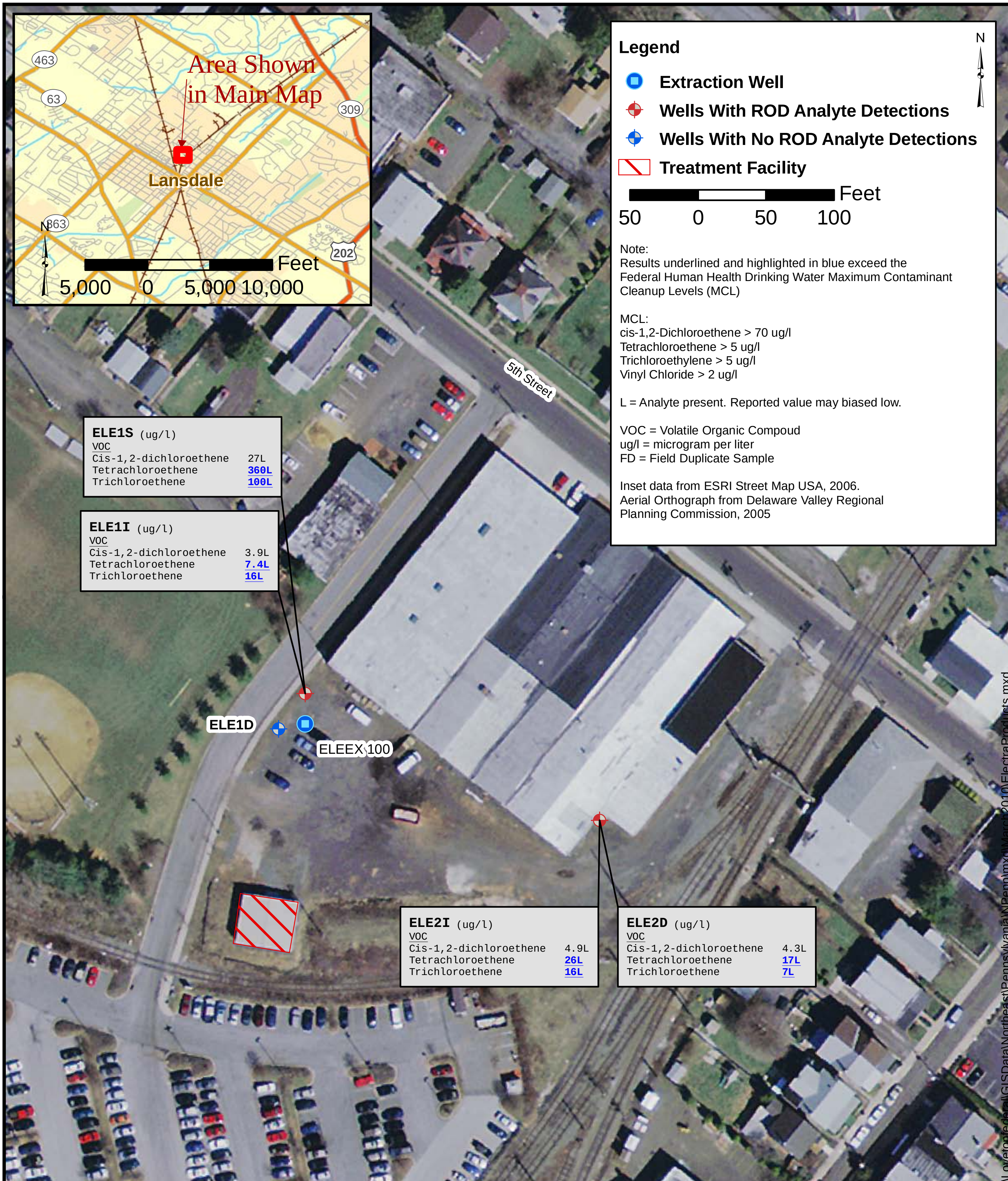
No former soil excavation

North Penn Area 6 Superfund Site
Westside Industries
Borough of Lansdale, Montgomery County, Pennsylvania

Figure 6. Westside Industries

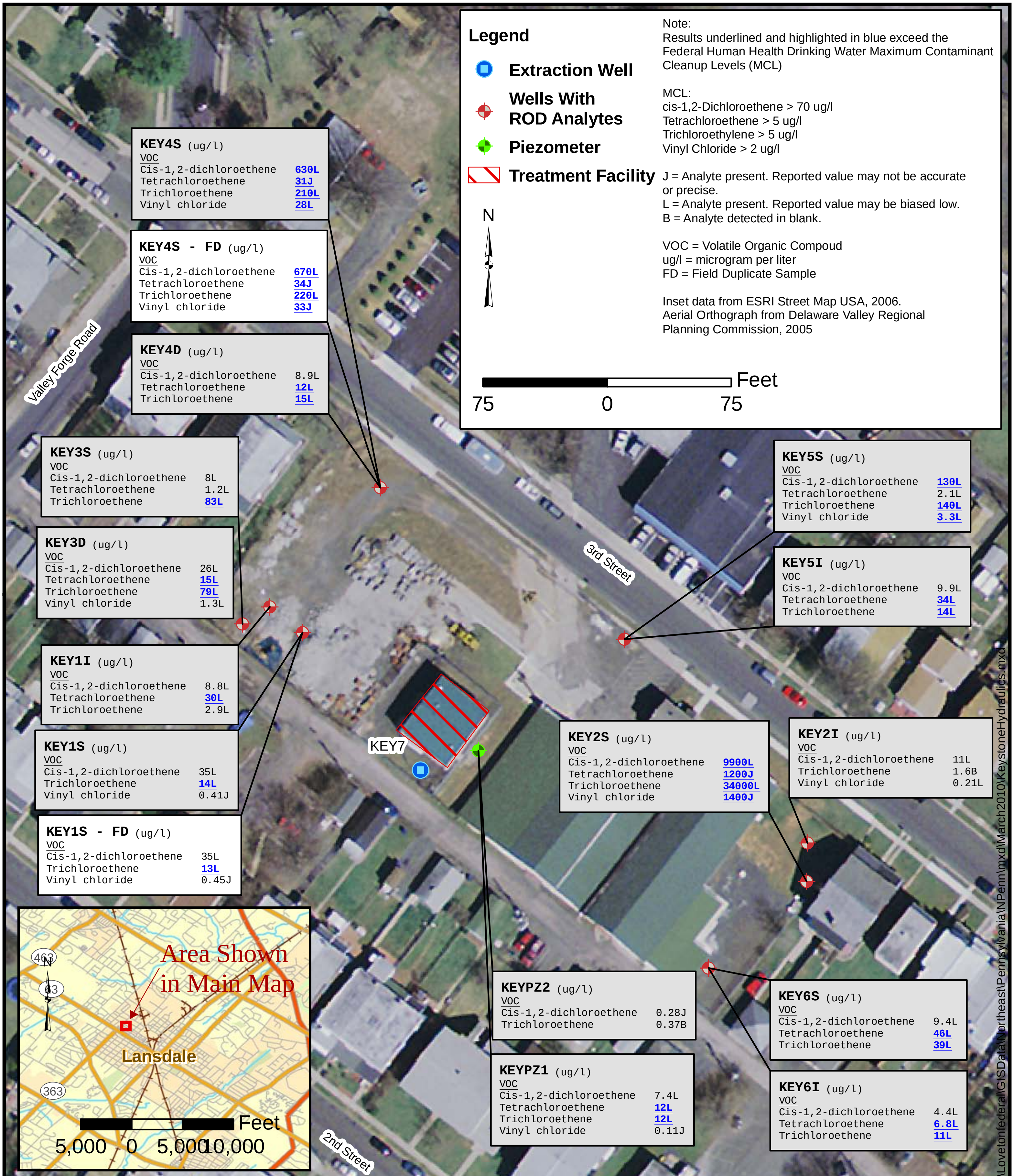
(Taken from Figure 1-5 of the 2010 Annual Report and Modified)

ATTACHMENT A:
Site Maps Depicting Groundwater Sampling Results from the 2010 Sampling Events



North Penn Area 6 Superfund Site
Electra Products
Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2 - 1
ROD ANALYTE DETECTIONS IN MARCH 2010

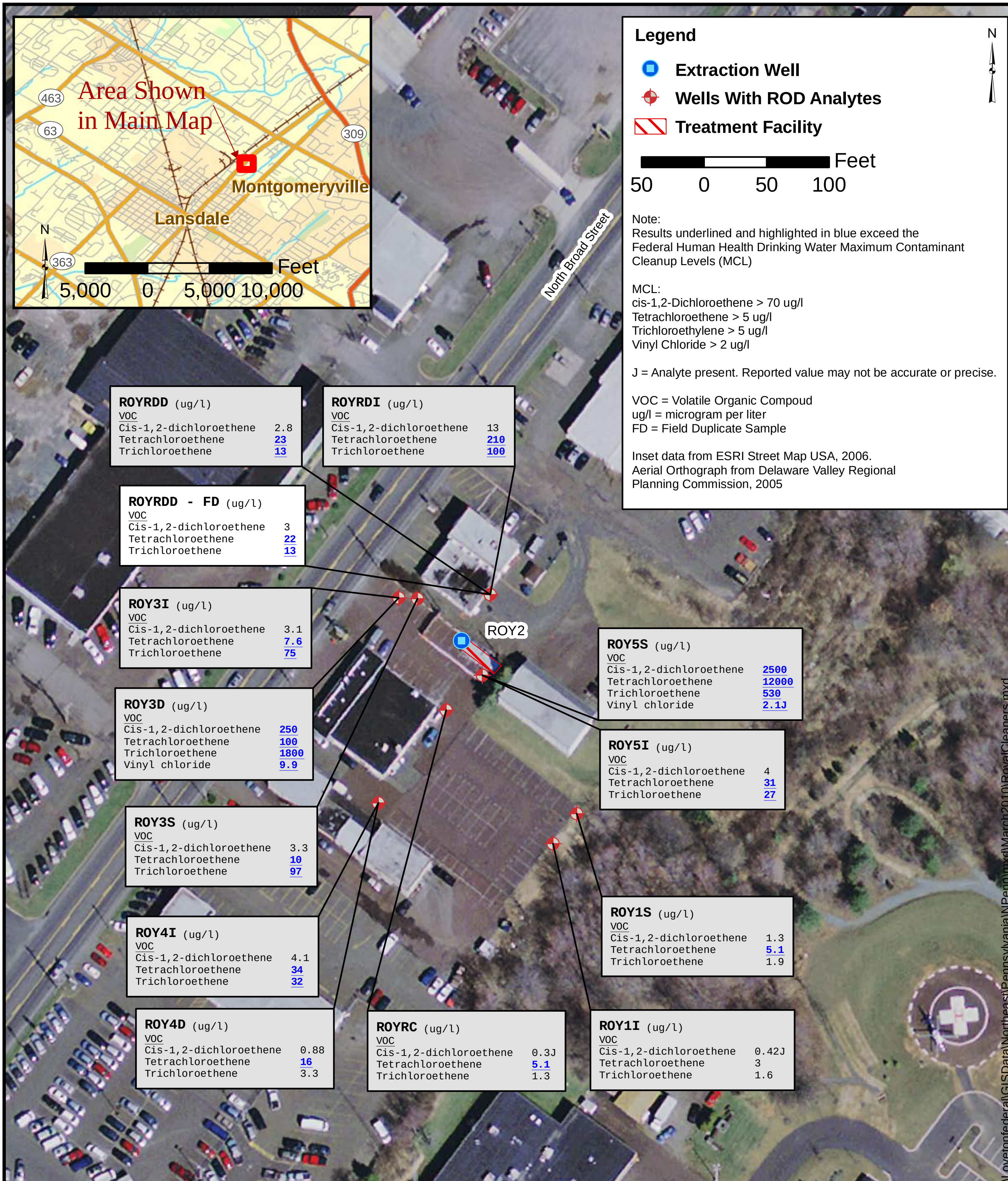


North Penn Area 6 Superfund Site

Keystone Hydraulics

Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2 - 2
ROD ANALYTE DETECTIONS IN MARCH 2010

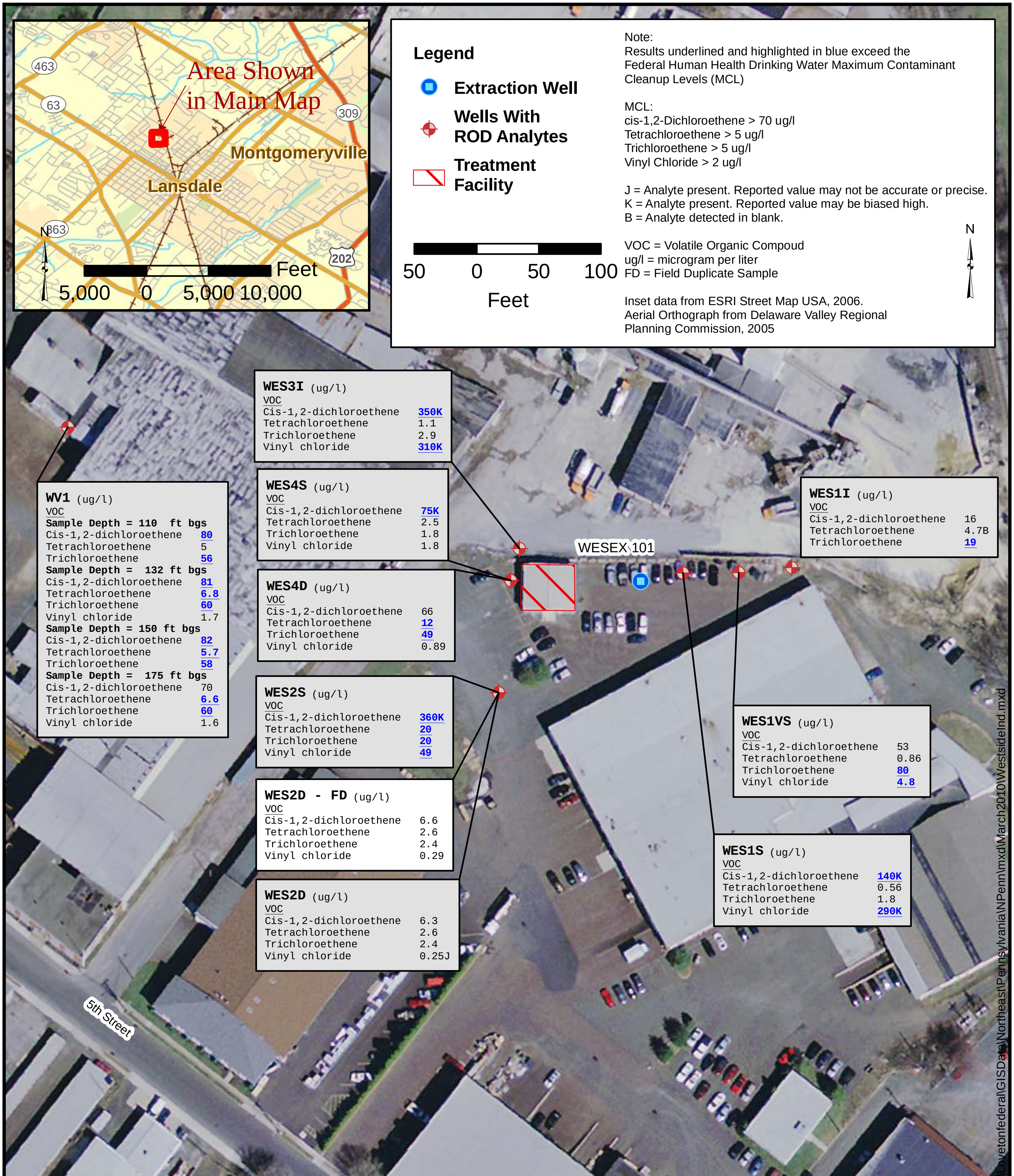


North Penn Area 6 Superfund Site

Royal Cleaners

Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2 - 3
ROD ANALYTE DETECTIONS IN MARCH 2010

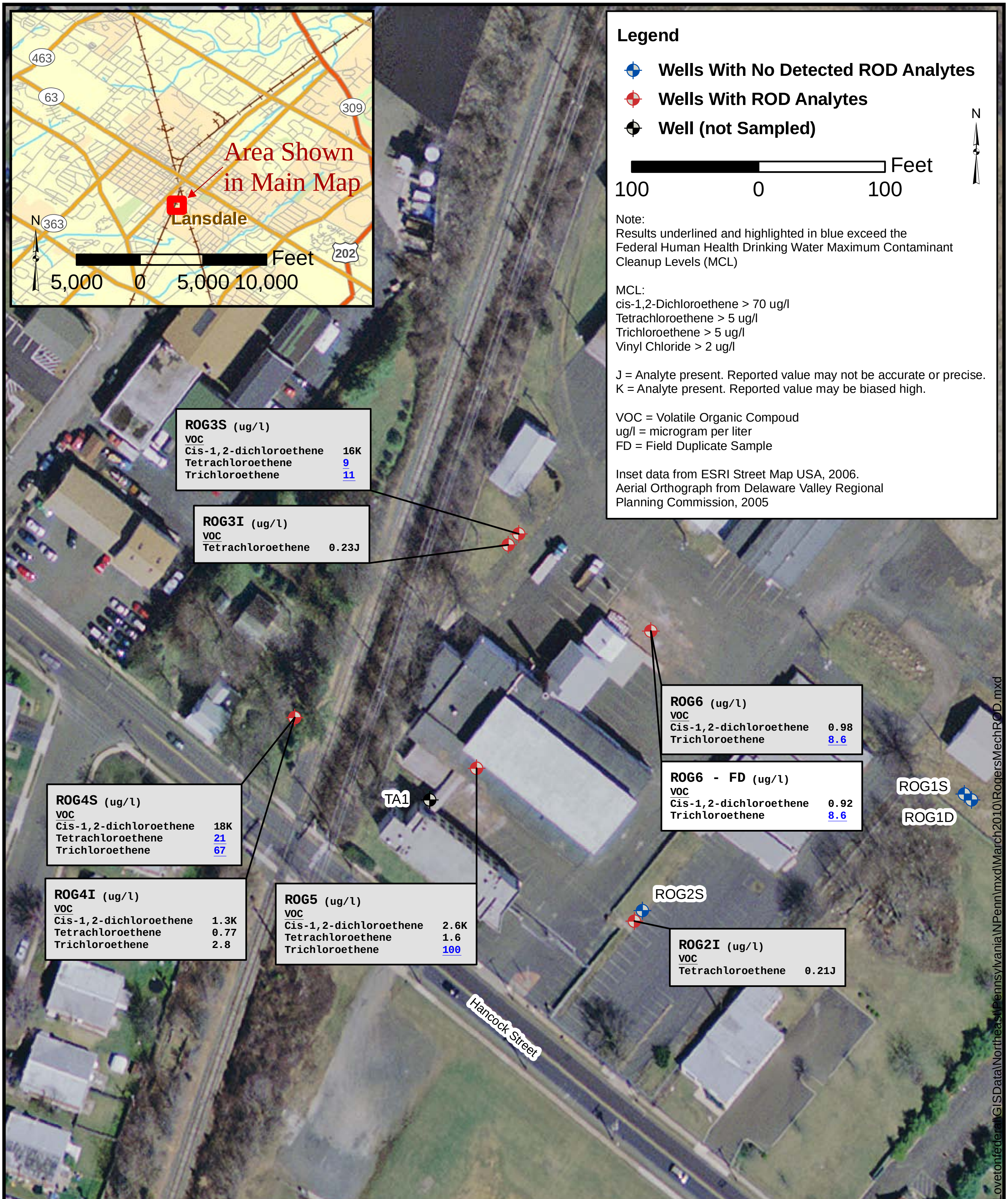


North Penn Area 6 Superfund Site

Westside Industries

Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2 - 4
ROD ANALYTE DETECTIONS IN MARCH 2010

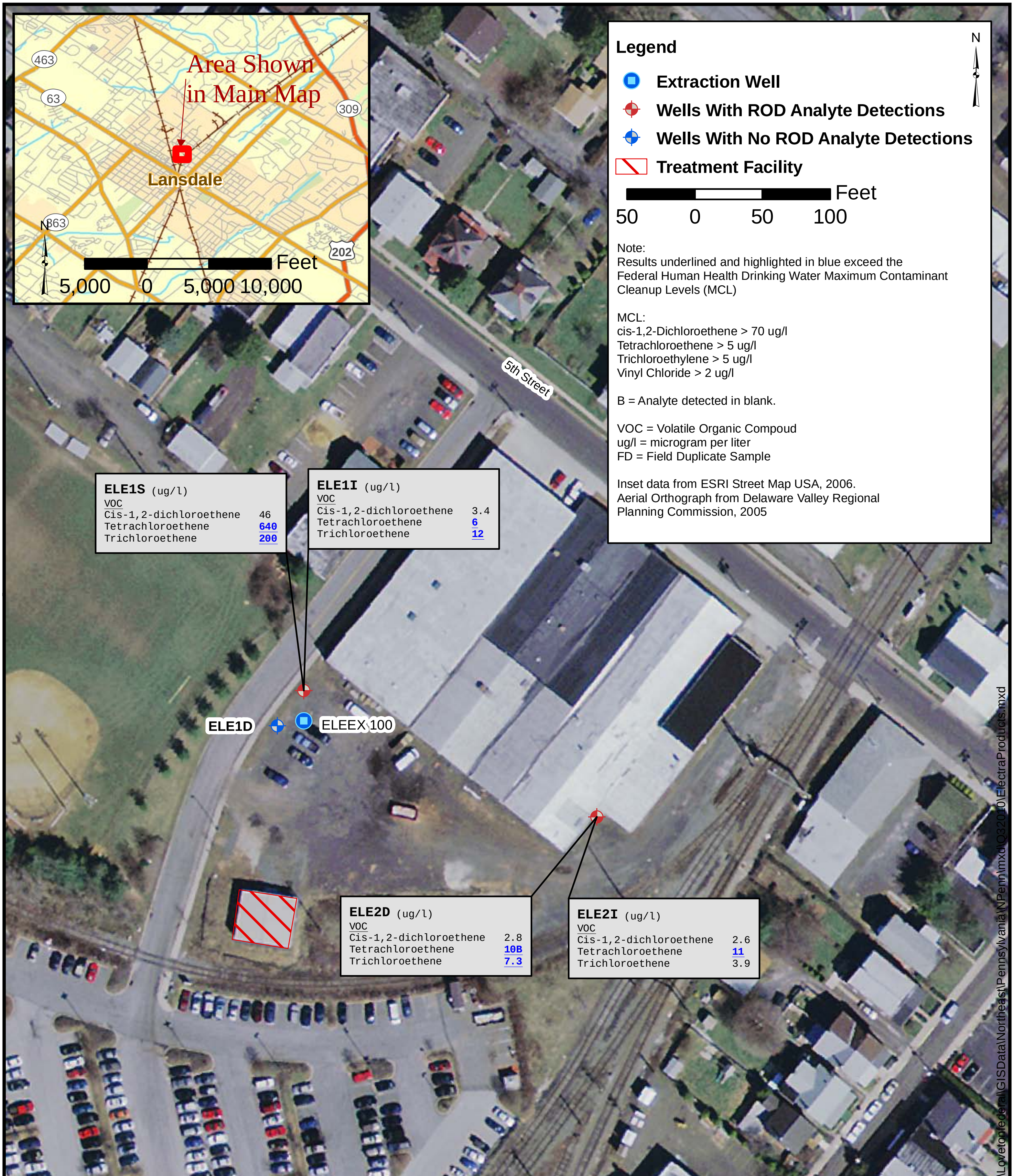


North Penn Area 6 Superfund Site

Rogers Mechanical

Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2 - 5
ROD ANALYTE DETECTIONS IN MARCH 2010

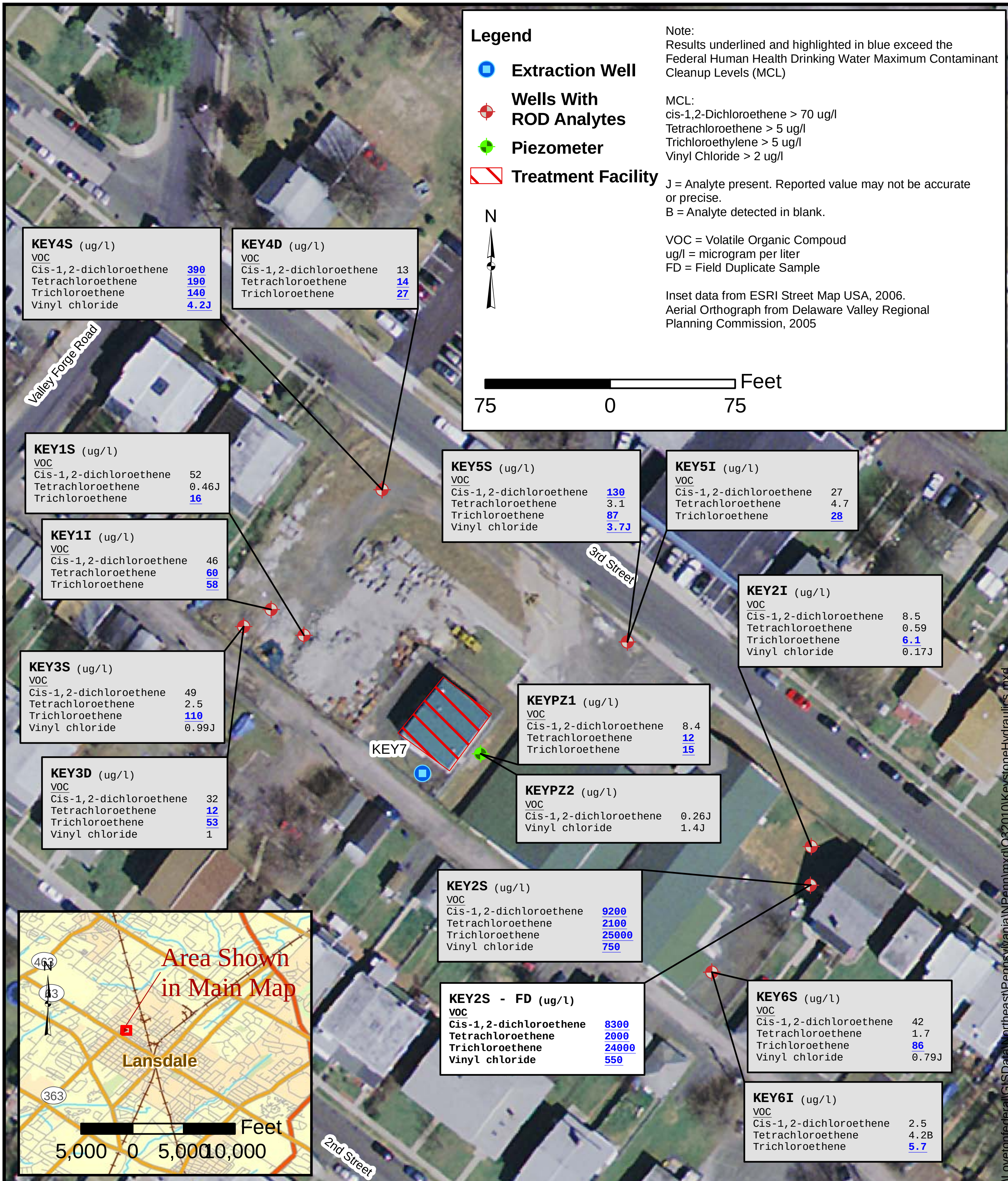


North Penn Area 6 Superfund Site

Electra Products

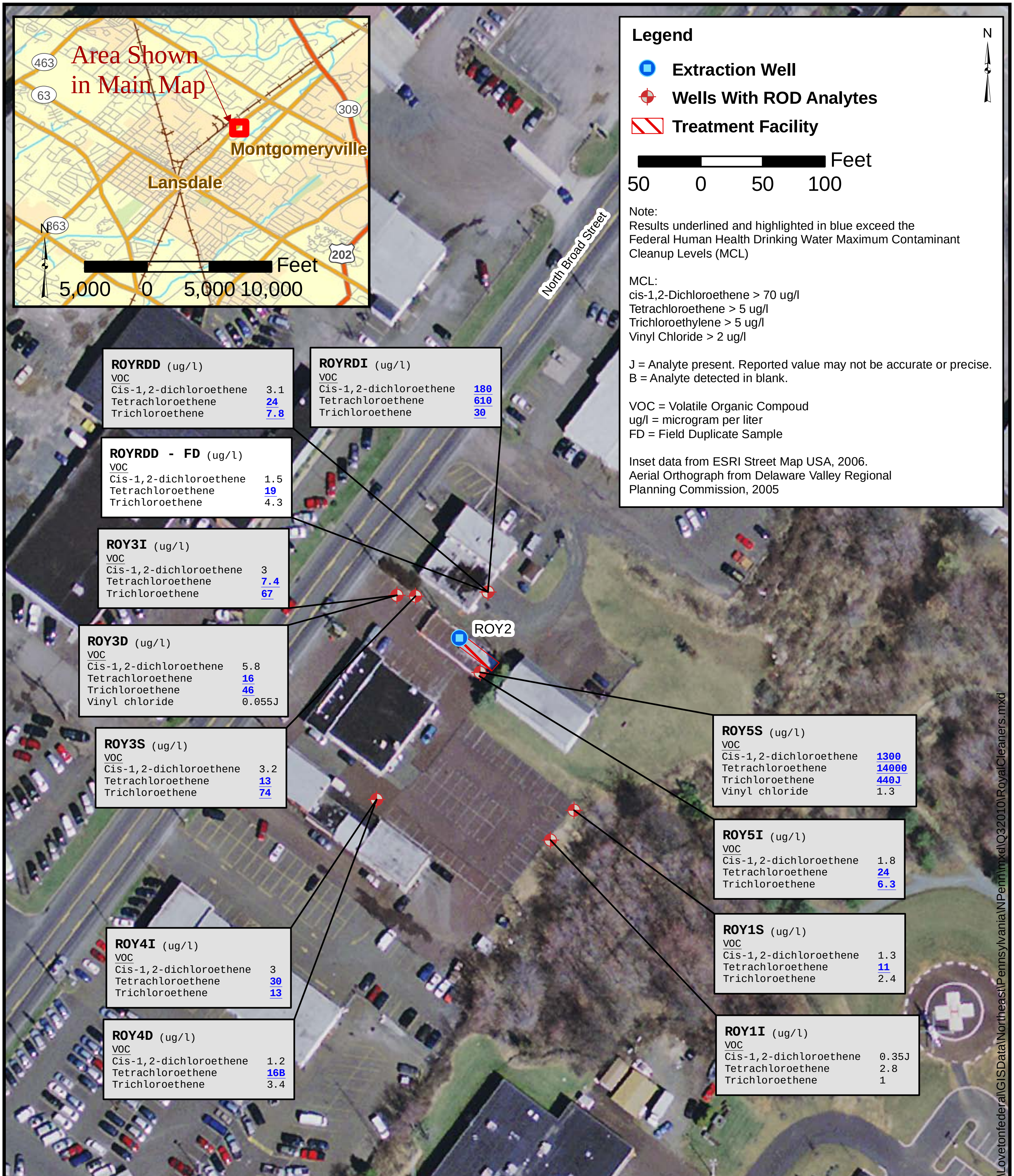
Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2 - 6
ROD ANALYTE
DETECTIONS IN OCTOBER 2010



North Penn Area 6 Superfund Site
Keystone Hydraulics
Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2 - 7
ROD ANALYTE DETECTIONS IN OCTOBER 2010

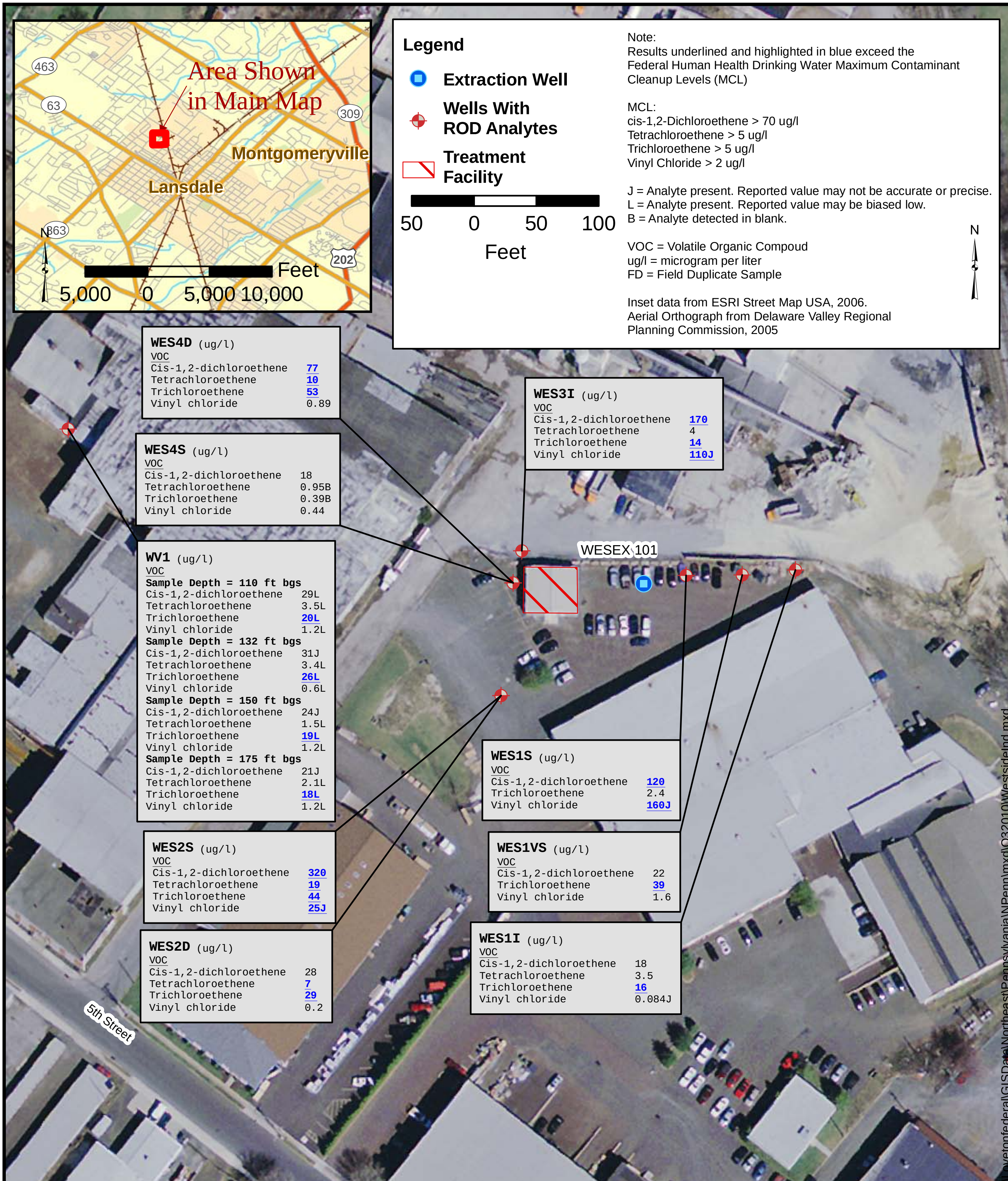


North Penn Area 6 Superfund Site

Royal Cleaners

Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2 - 8
ROD ANALYTE DETECTIONS IN OCTOBER 2010

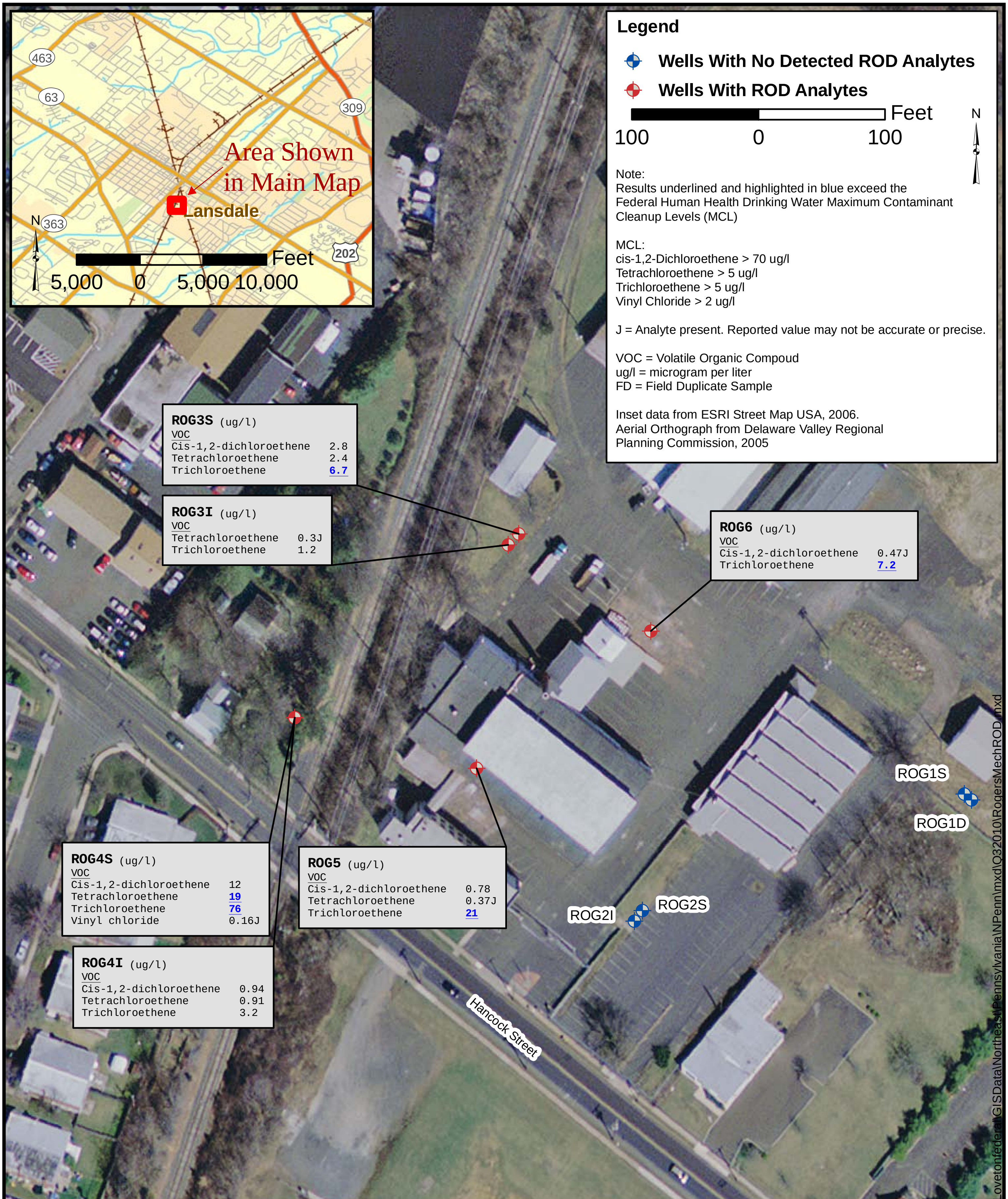


North Penn Area 6 Superfund Site

Westside Industries

Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2 - 9
ROD ANALYTE DETECTIONS IN OCTOBER 2010

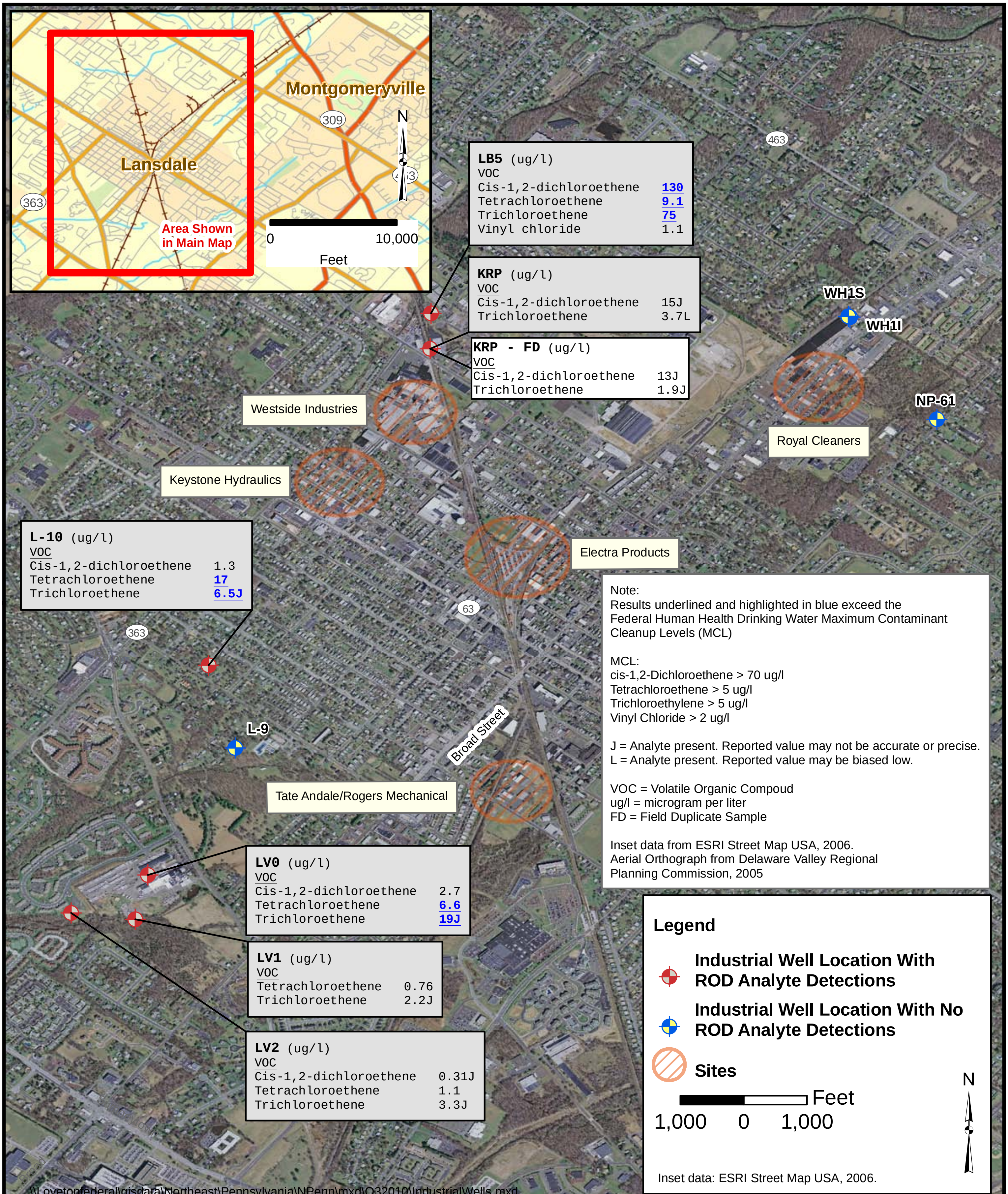


North Penn Area 6 Superfund Site

Rogers Mechanical

Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2 - 10
ROD ANALYTE DETECTIONS IN OCTOBER 2010



North Penn Area 6 Superfund Site

Borough of Lansdale, Montgomery County, Pennsylvania

FIGURE 2-11
ROD ANALYTE DETECTIONS FROM INDUSTRIAL WELLS IN NOVEMBER 2010

ATTACHMENT B:
Concentration Trends in Extraction Wells

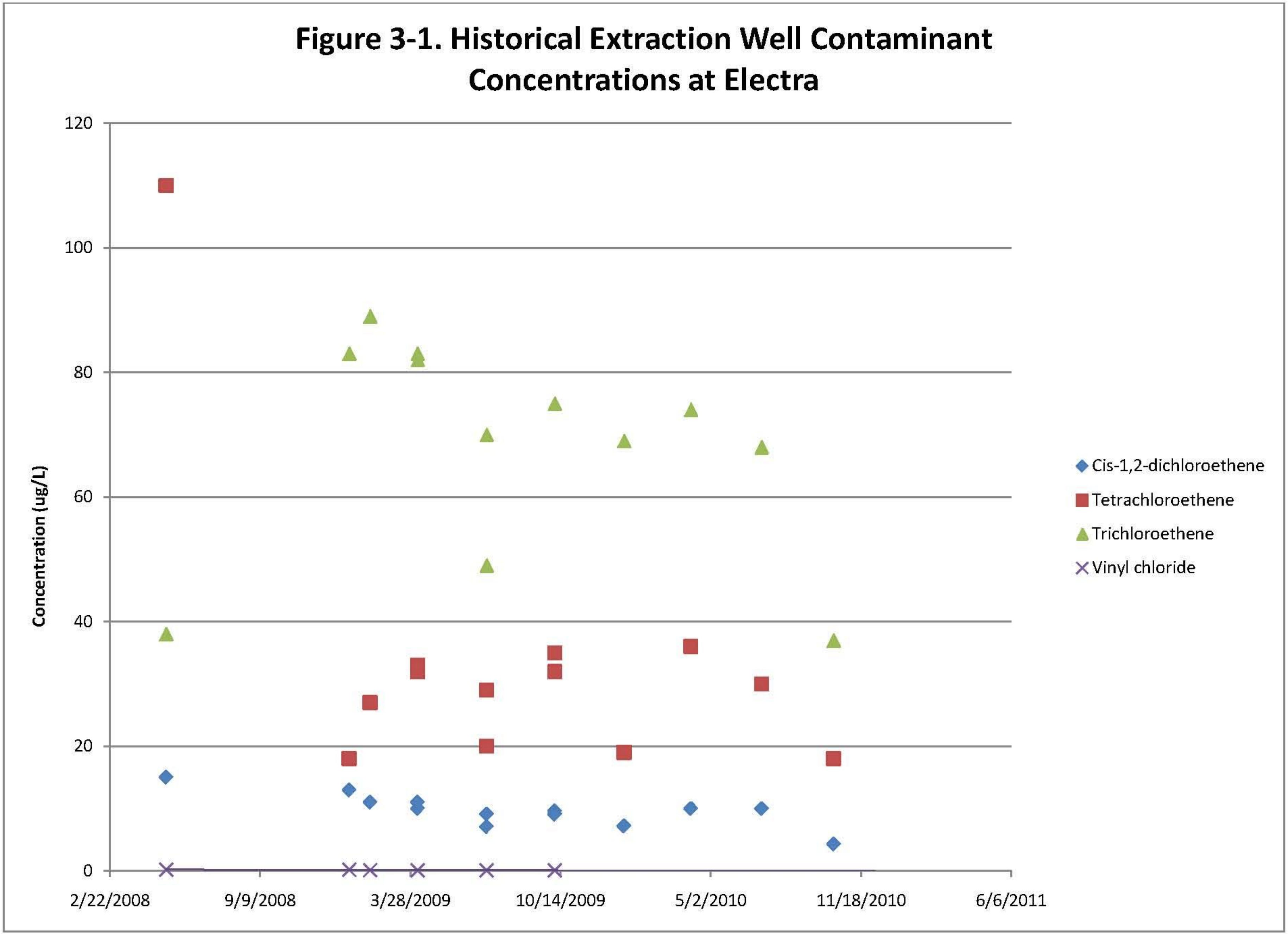


Figure 3-1. Historical Extraction Well Contaminant Concentrations at Electra
Concentration (ug/L)
120
100
80
60
40
20
0
2/22/2008
9/9/2008
3/28/2009
10/14/2009
5/2/2010
11/18/2010
6/6/2011
Cis-1,2-dichloroethene
Tetrachloroethene
Trichloroethene
Vinyl chloride

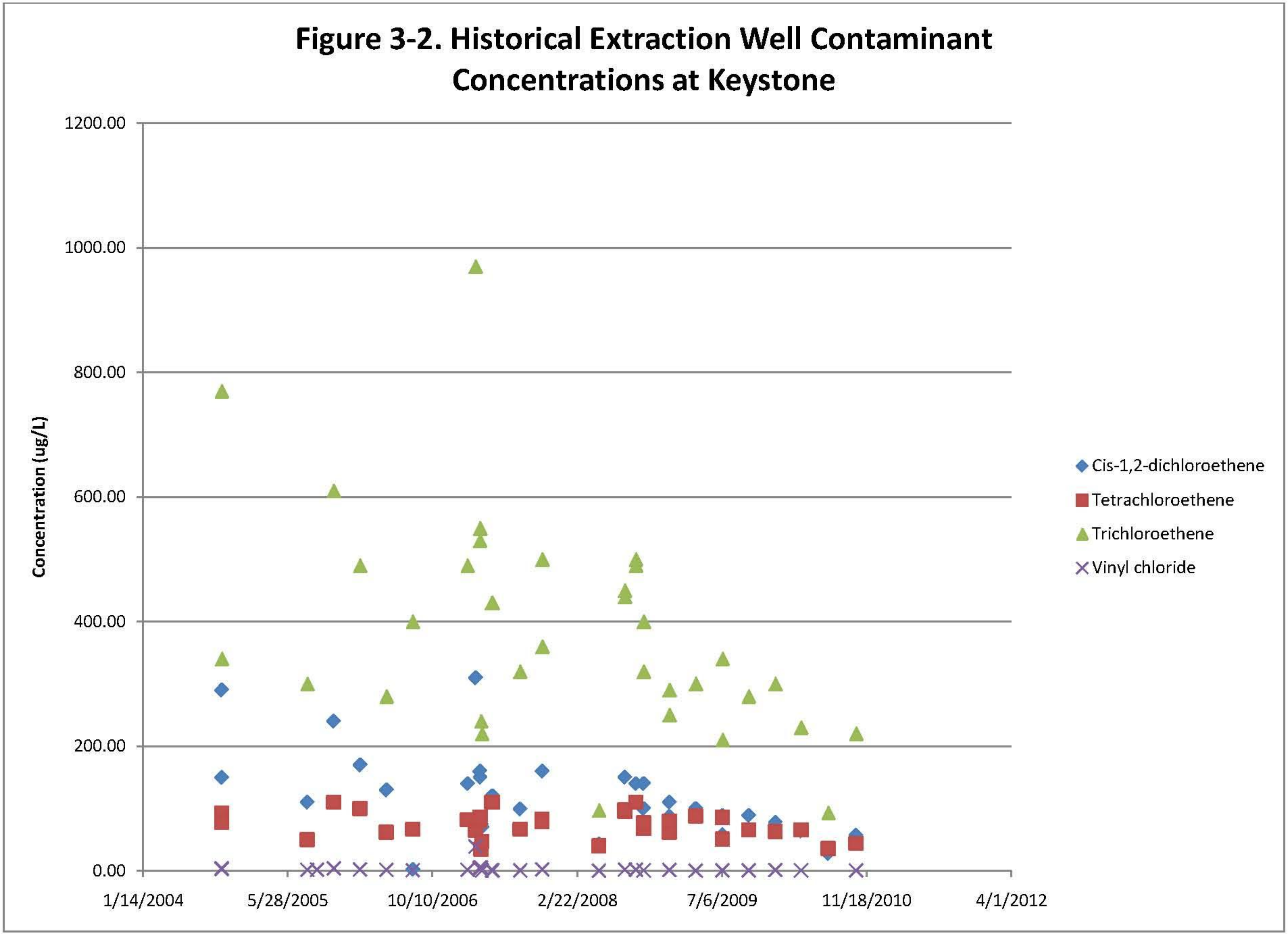


Figure 3-2. Historical Extraction Well Contaminant Concentrations at Keystone
Concentration (ug/L)
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
Cis-1,2-dichloroethene
Tetrachloroethene
Trichloroethene
Vinyl chloride

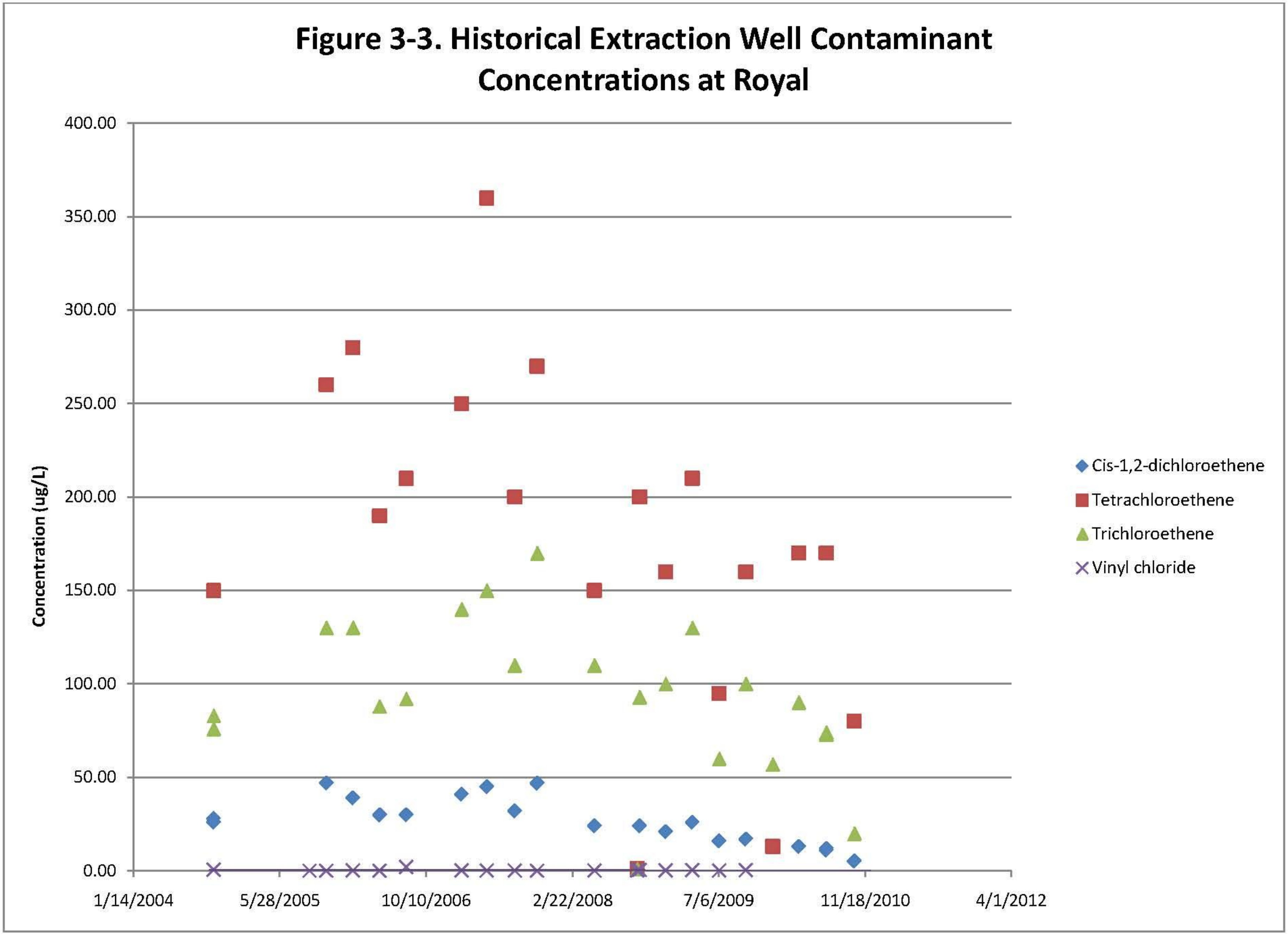
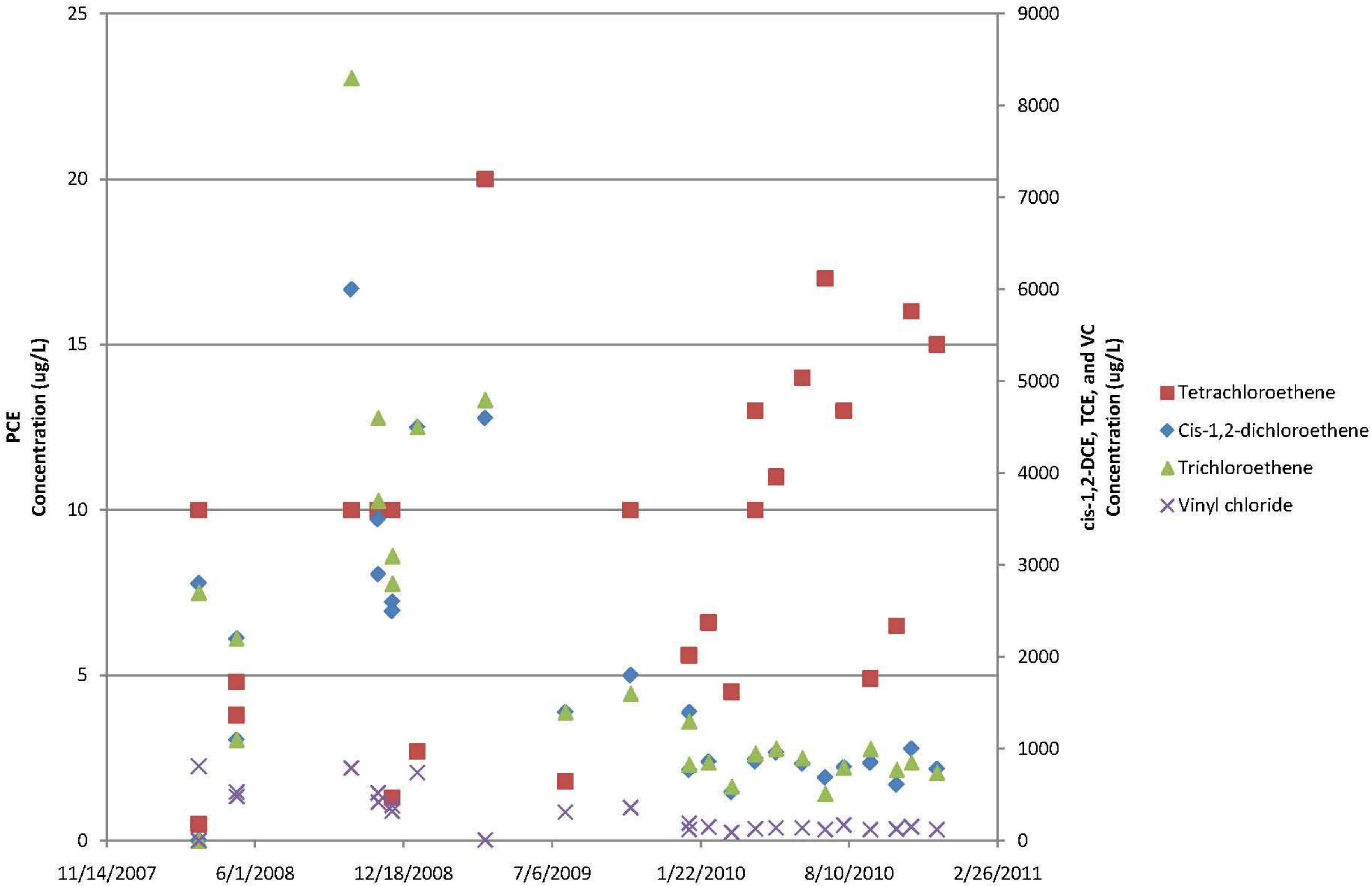
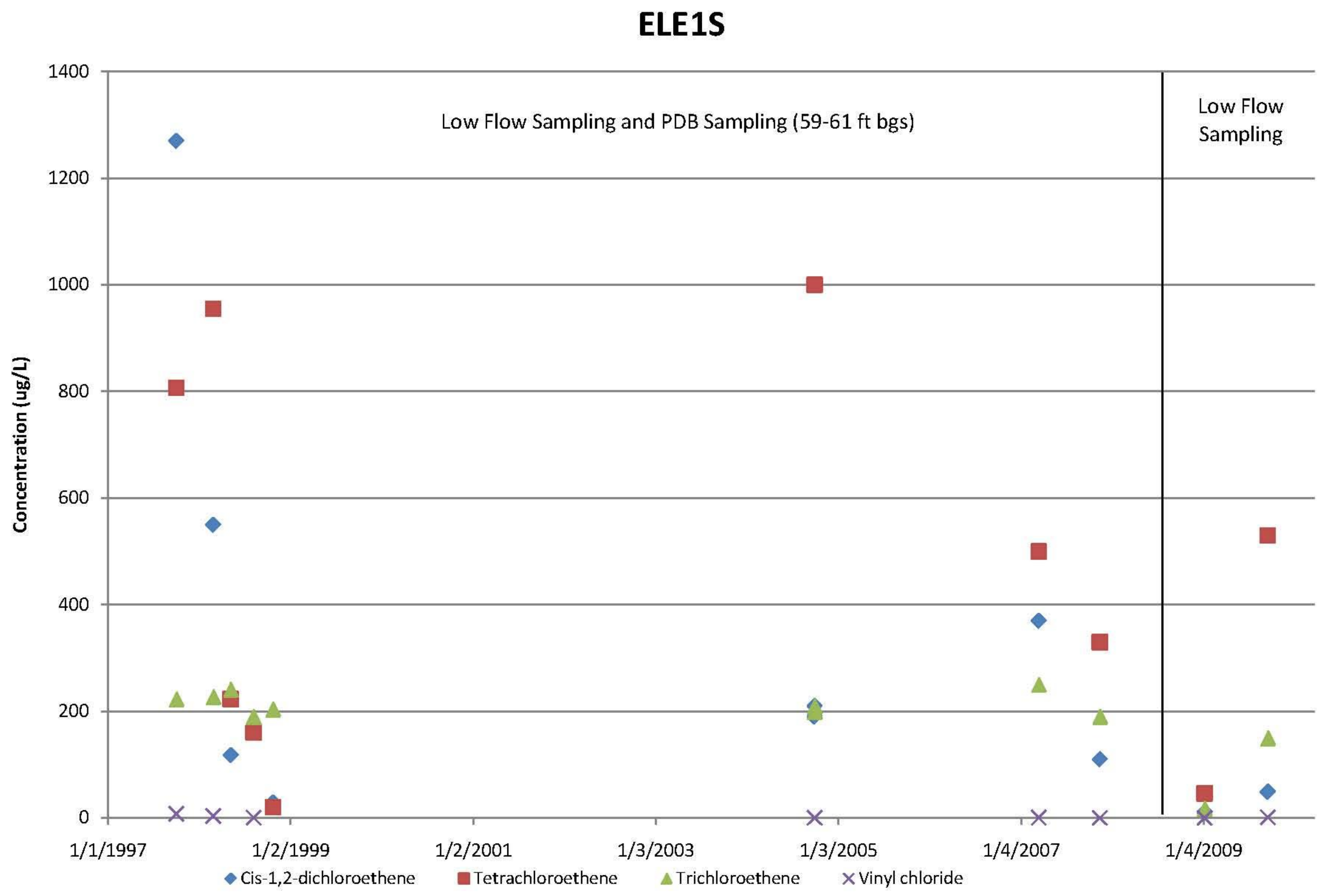


Figure 3-3. Historical Extraction Well Contaminant Concentrations at Royal
Concentration (ug/L)
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
Cis-1,2-dichloroethene
Tetrachloroethene
Trichloroethene
Vinyl chloride

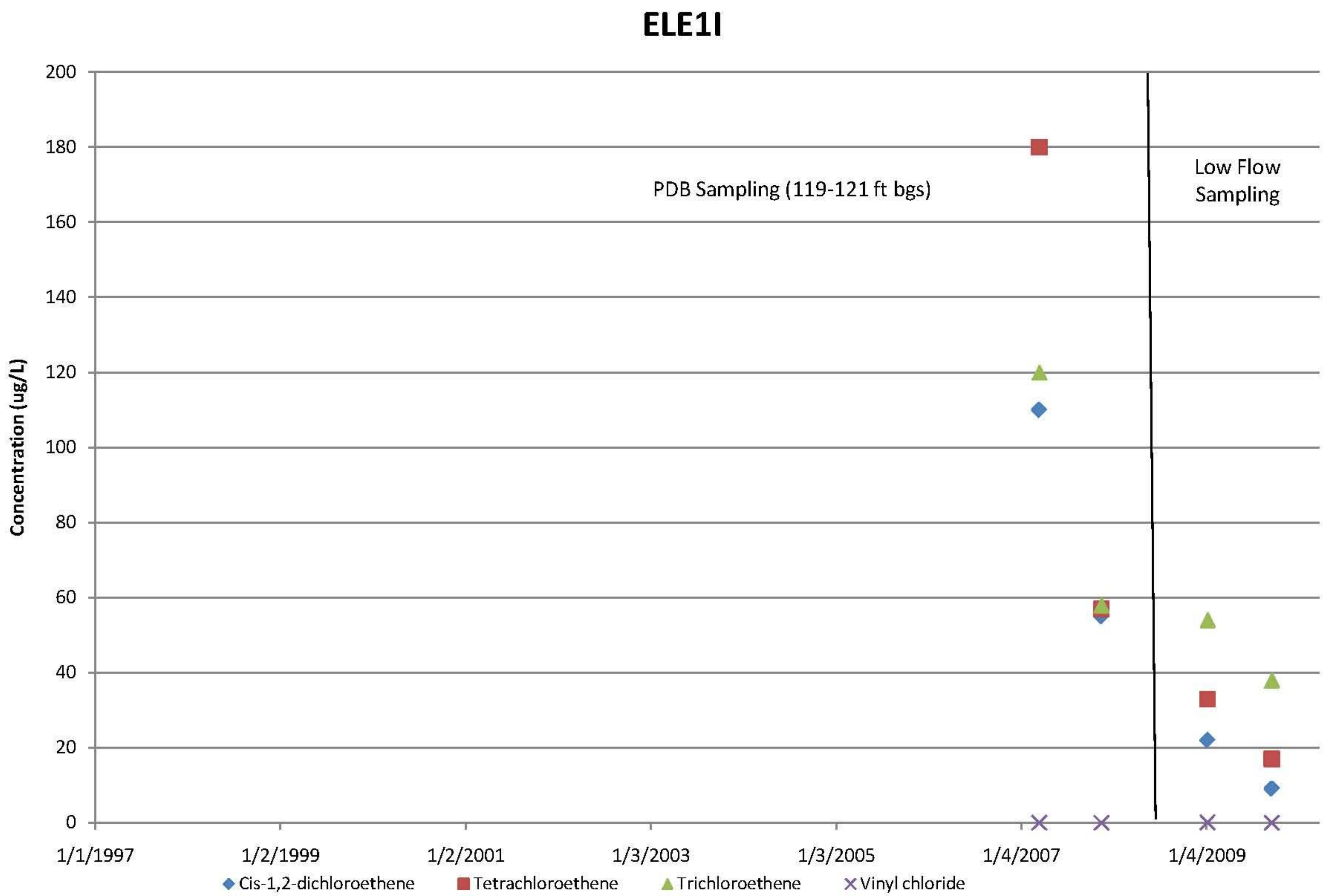
Figure 3-4. Historical Extraction Well Contaminant Concentrations at Westside



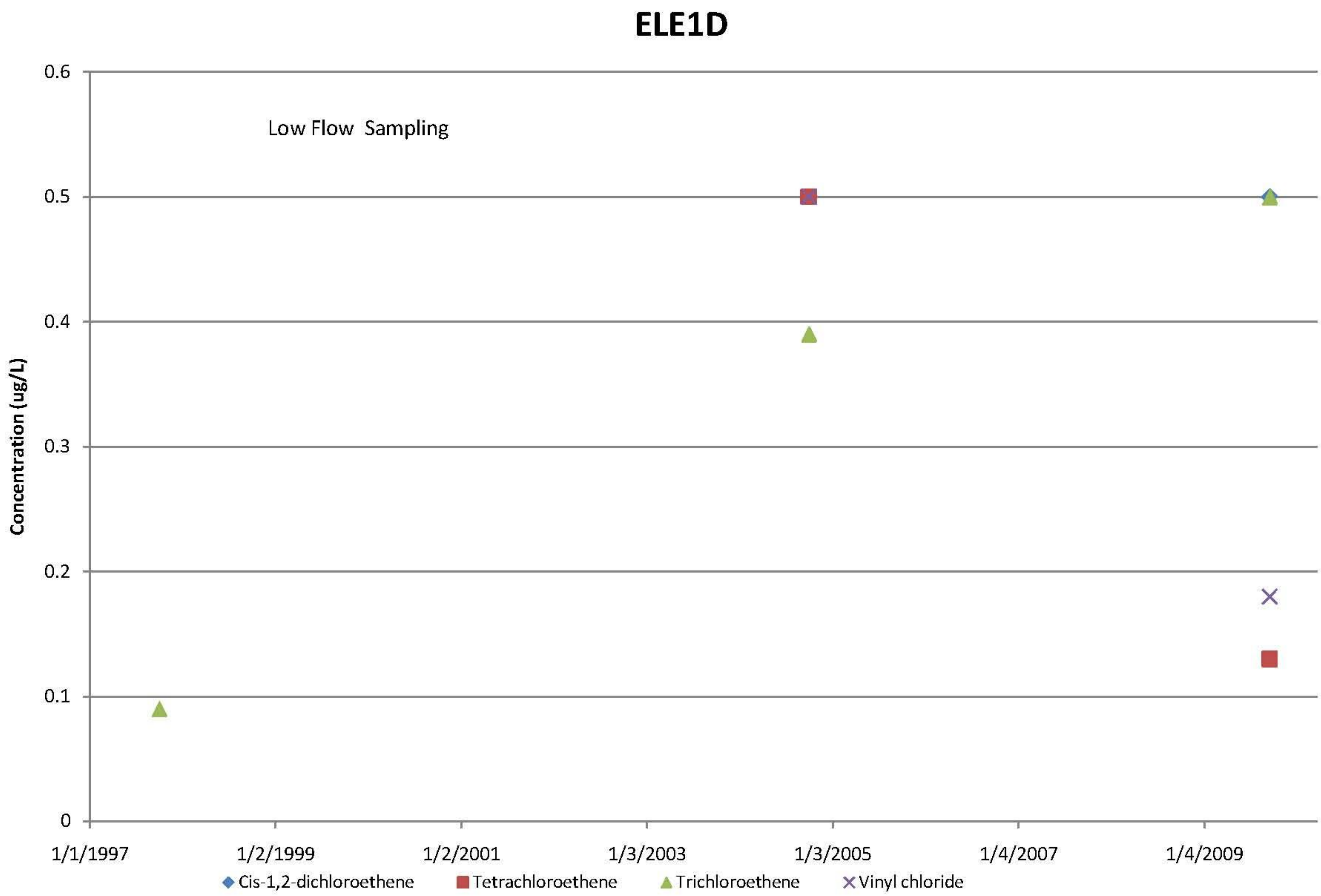
ATTACHMENT C:
Concentration Trends in Monitoring Wells



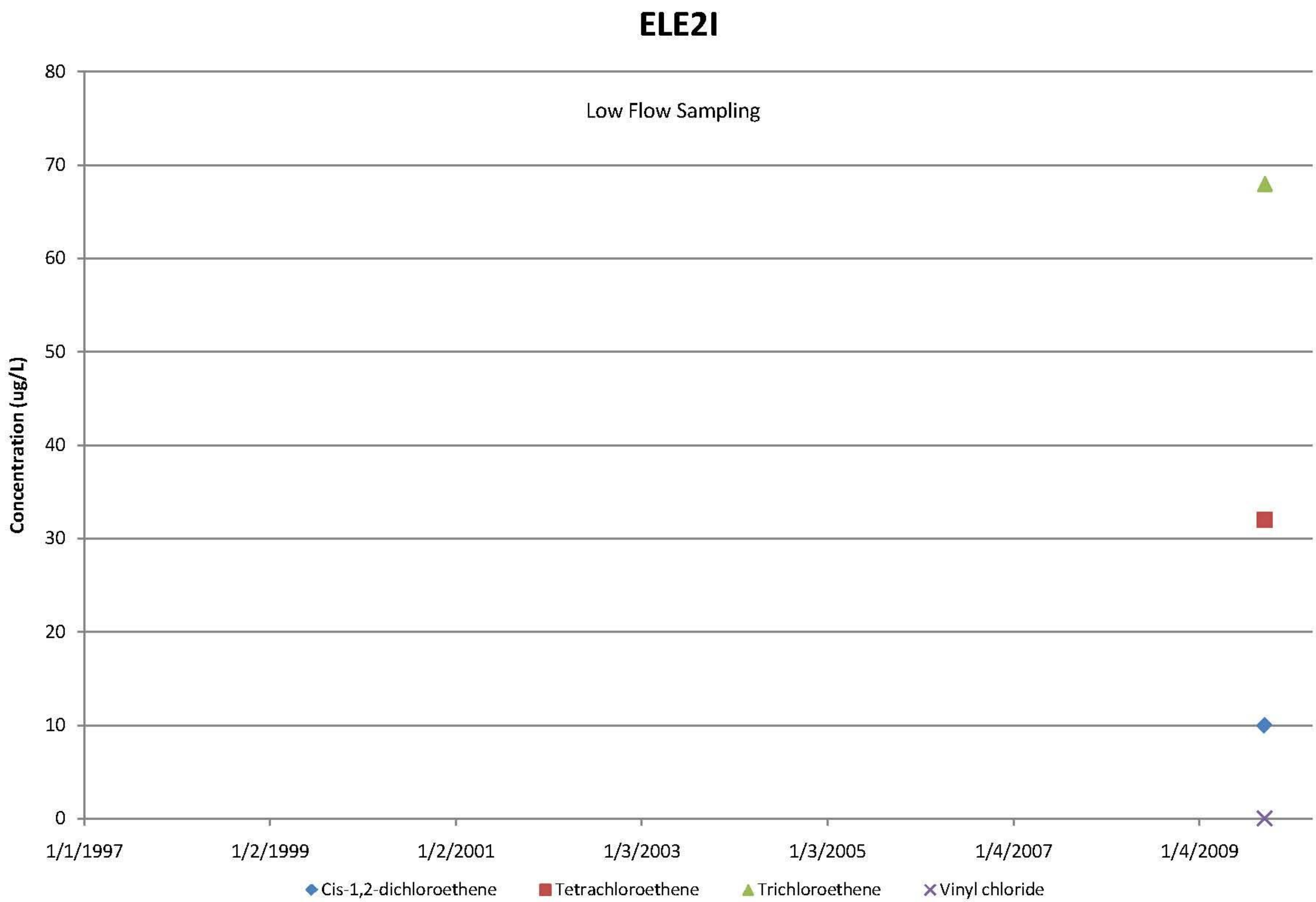
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



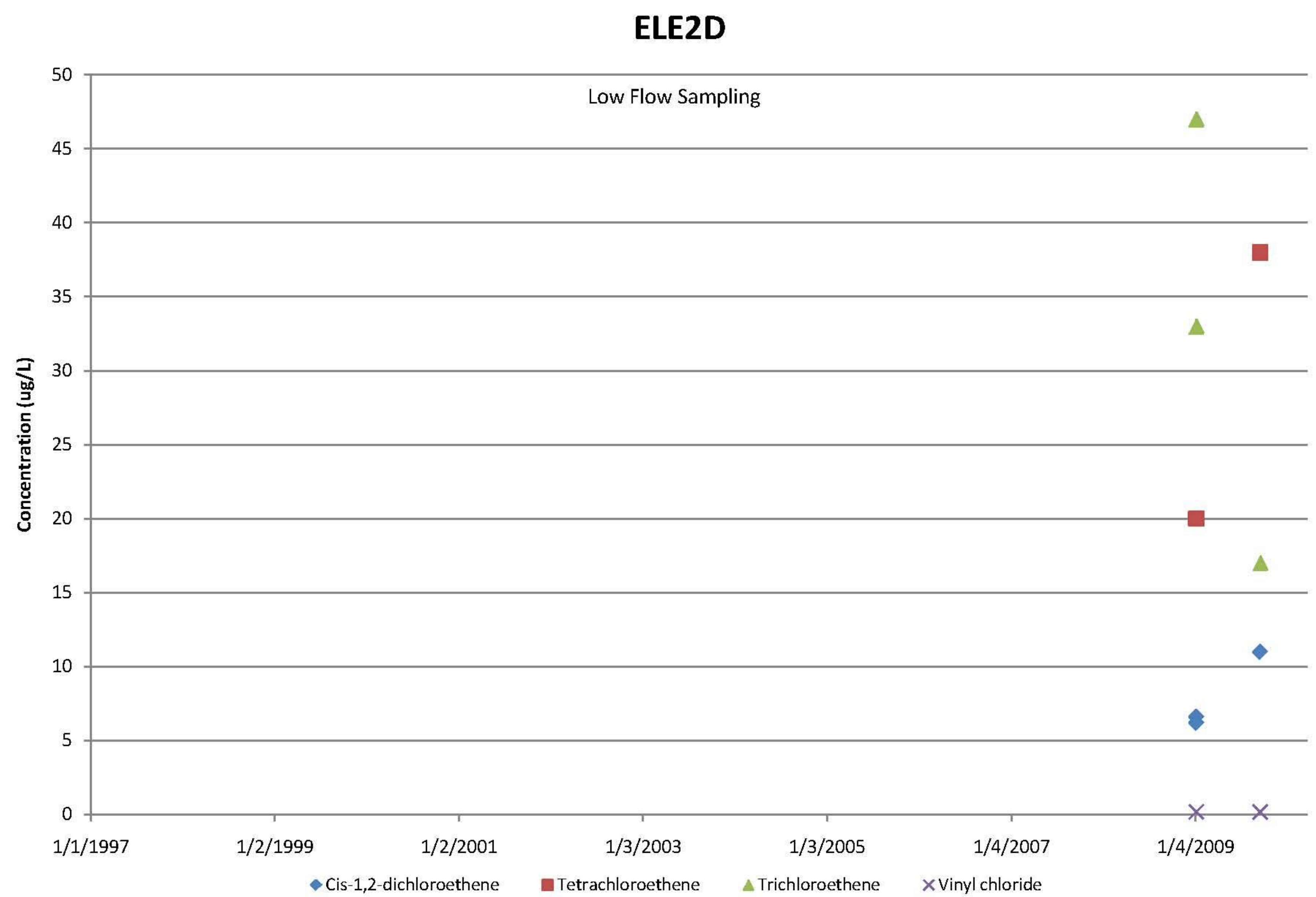
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



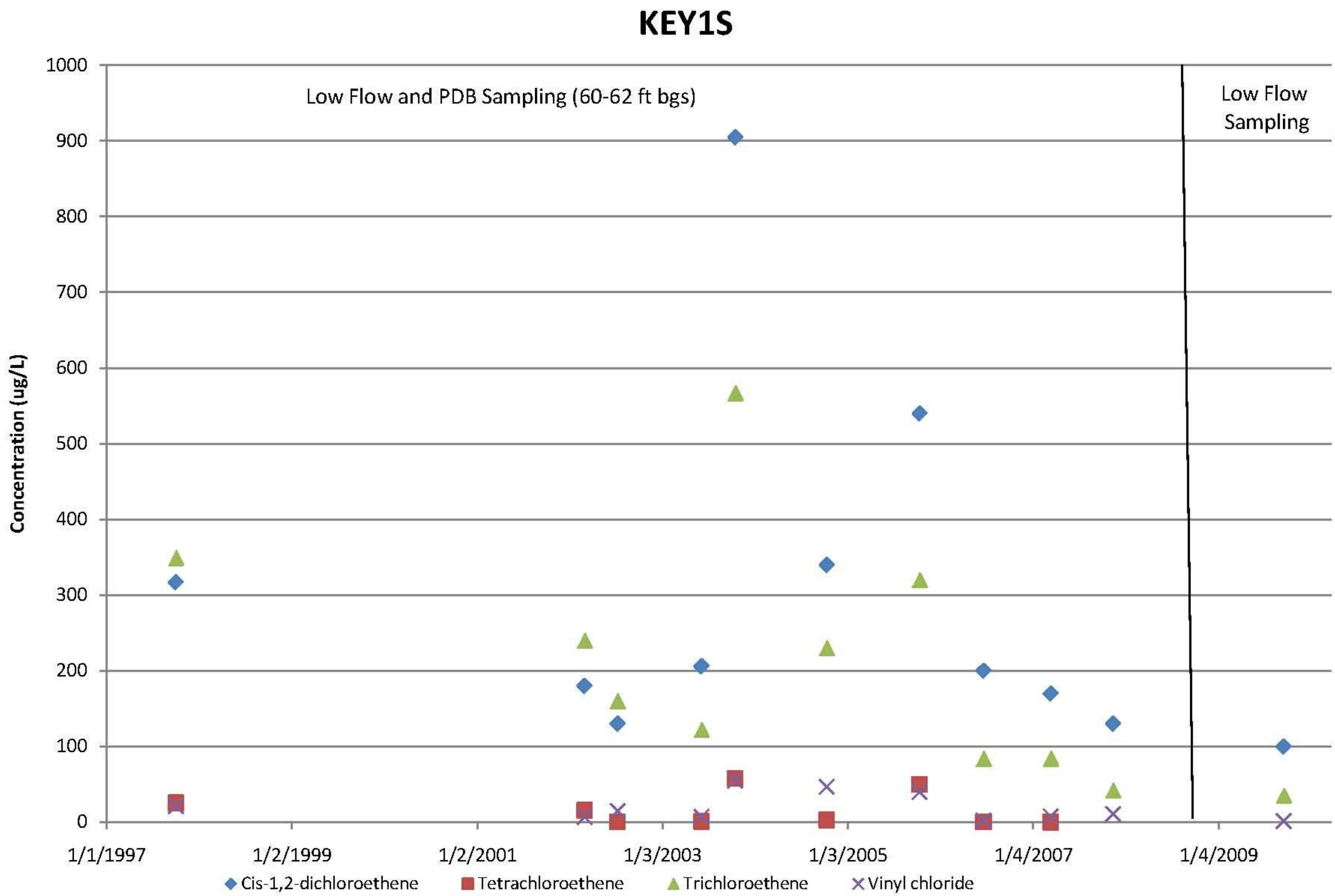
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



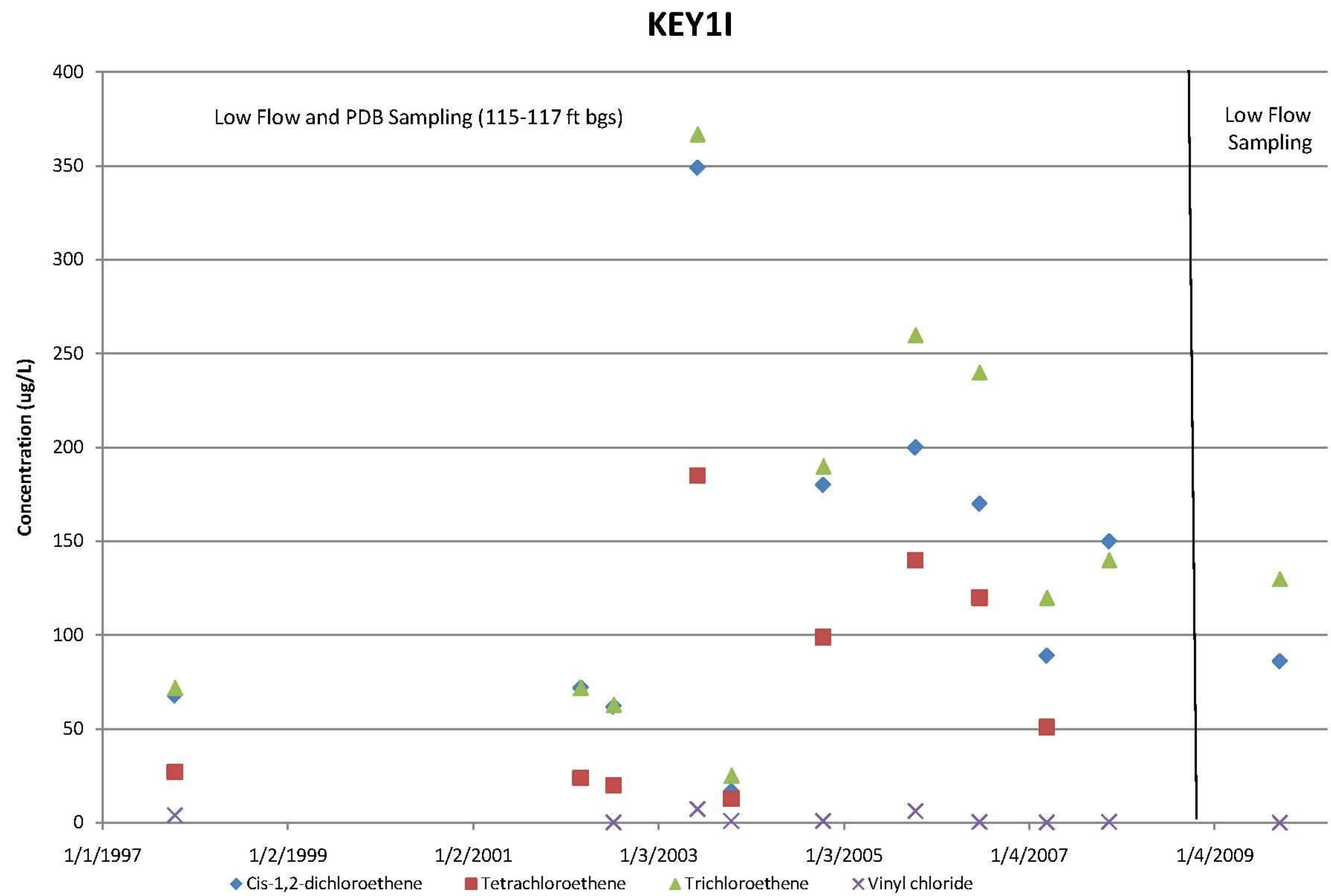
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



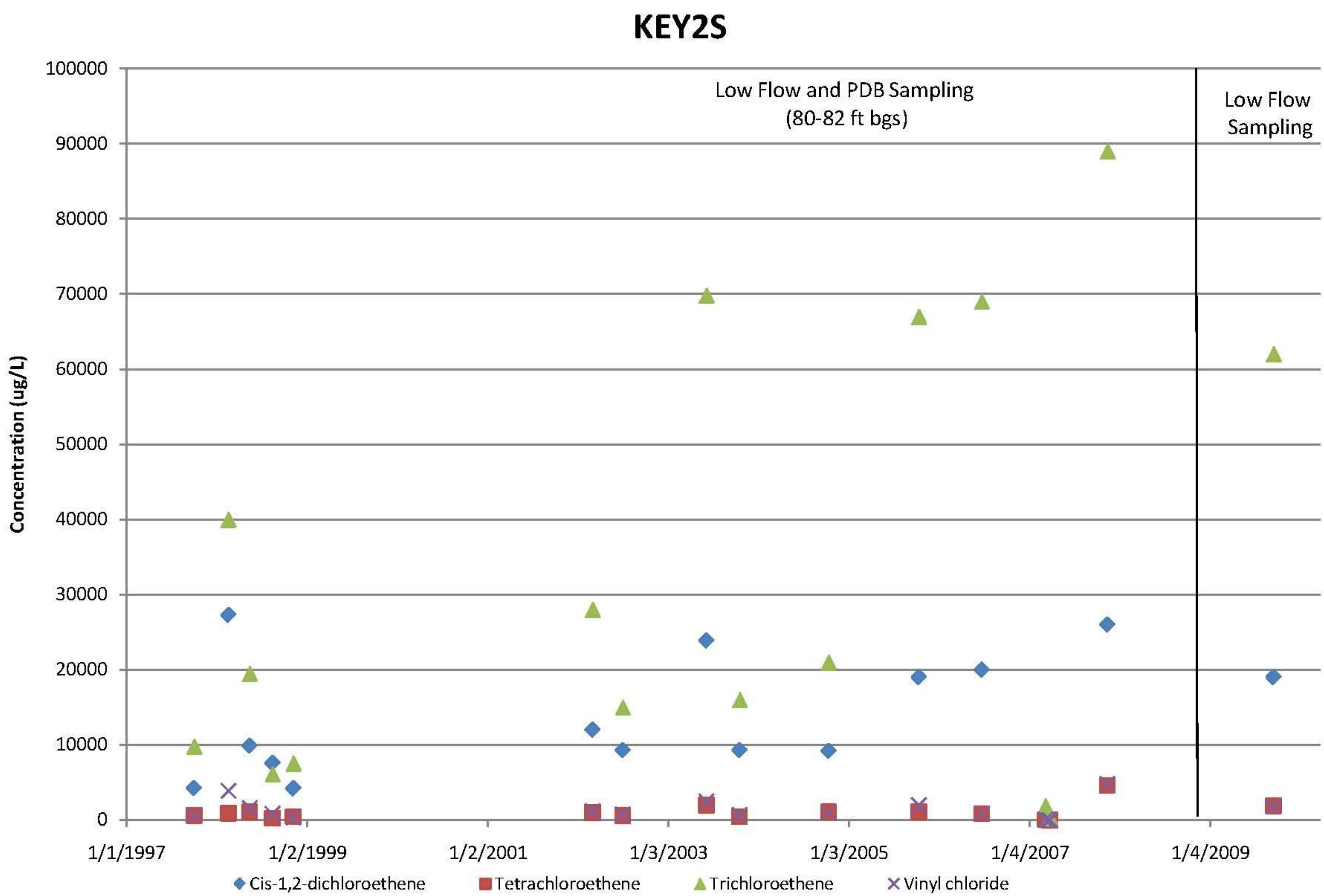
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



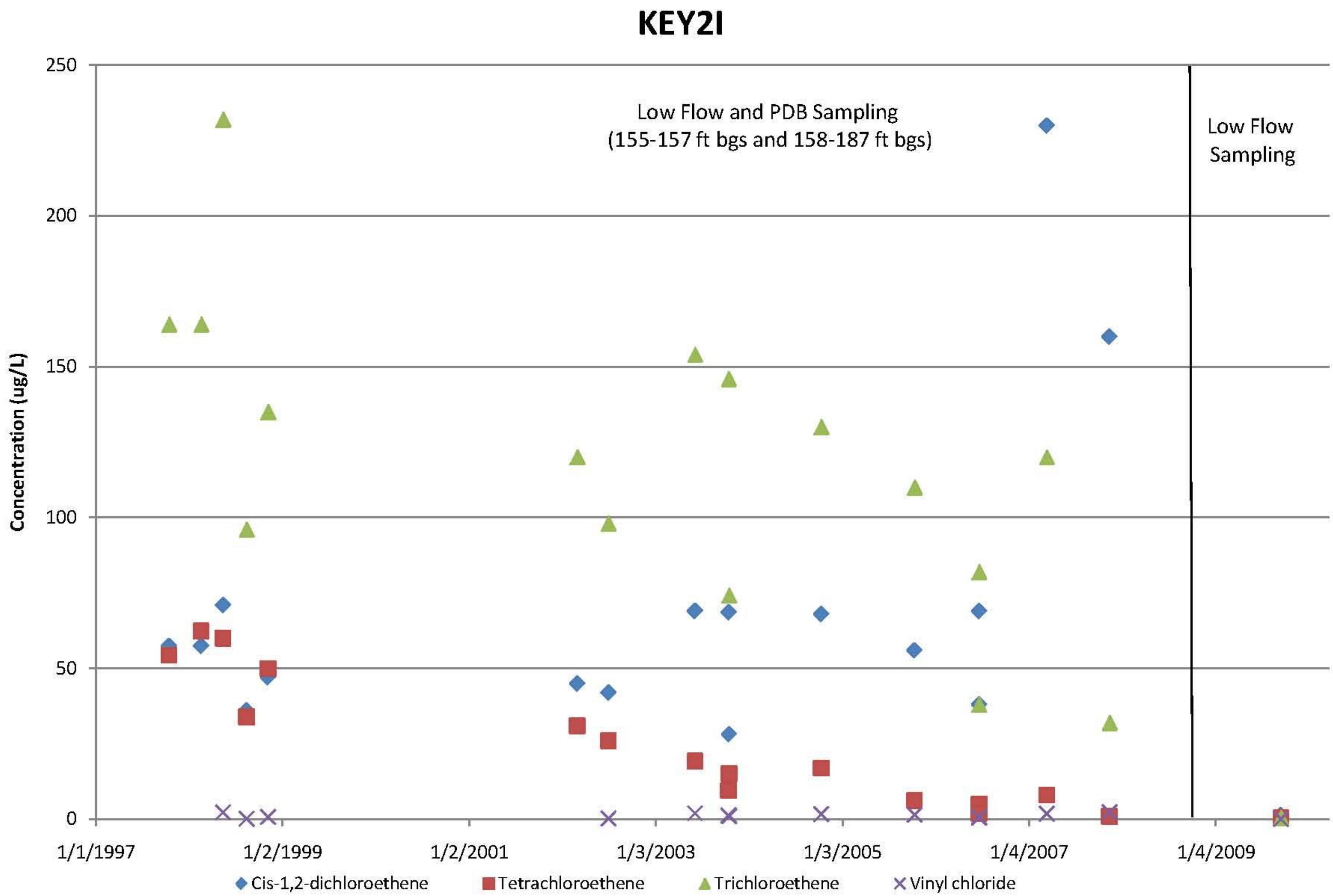
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value.R-qualified data and B-qualified data are not plotted.



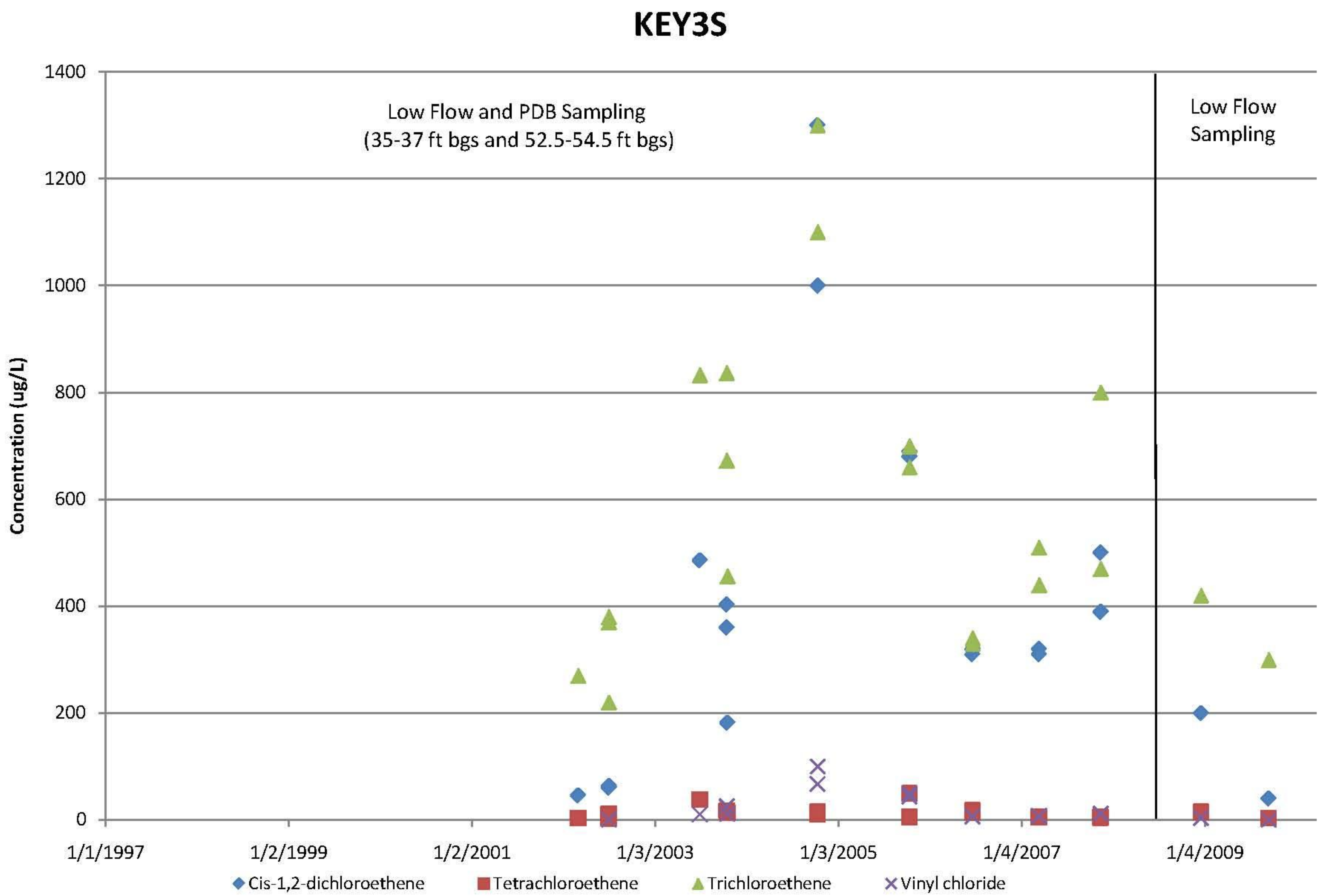
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



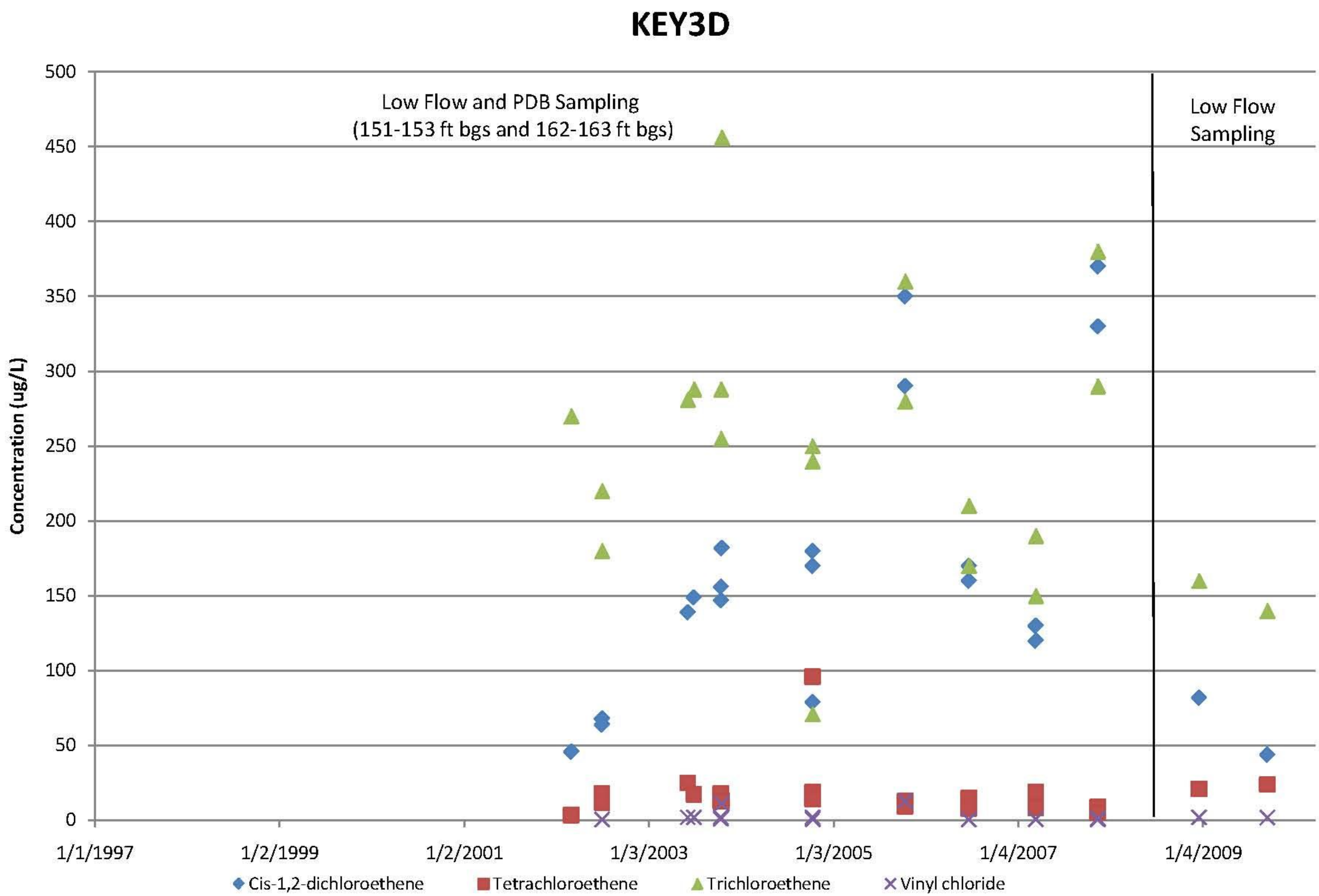
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value.R-qualified data and B-qualified data are not plotted.



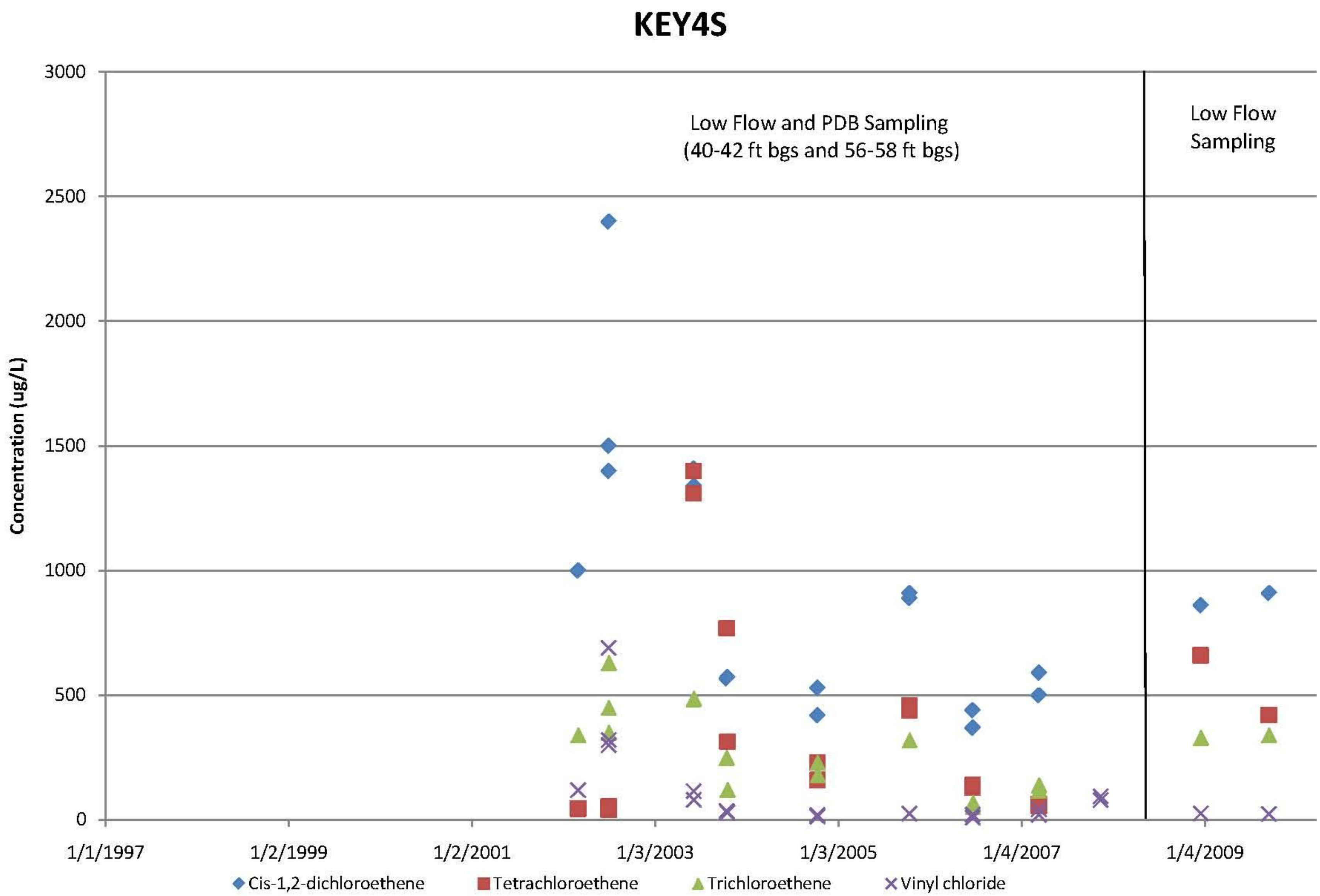
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.

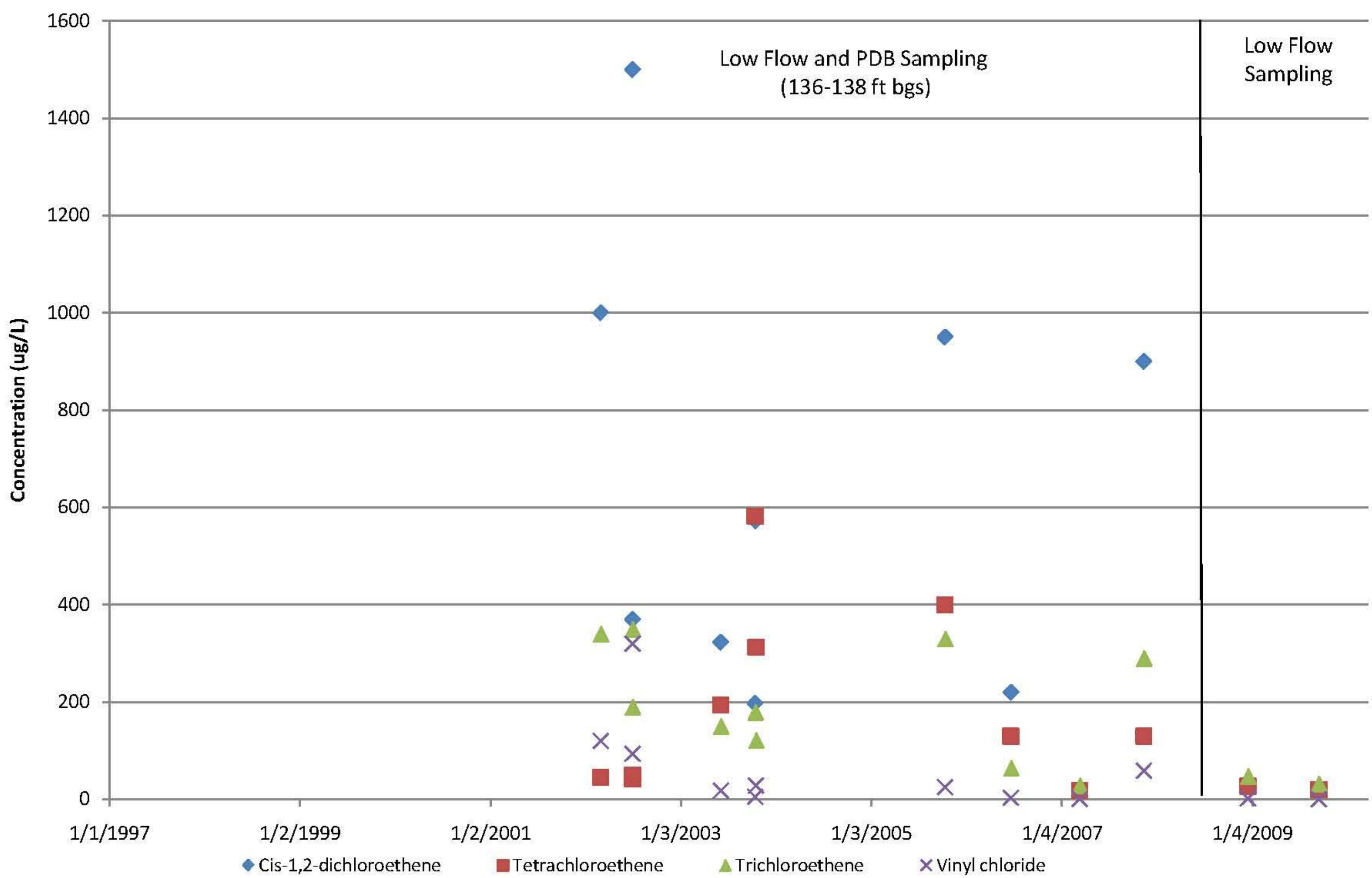


Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.

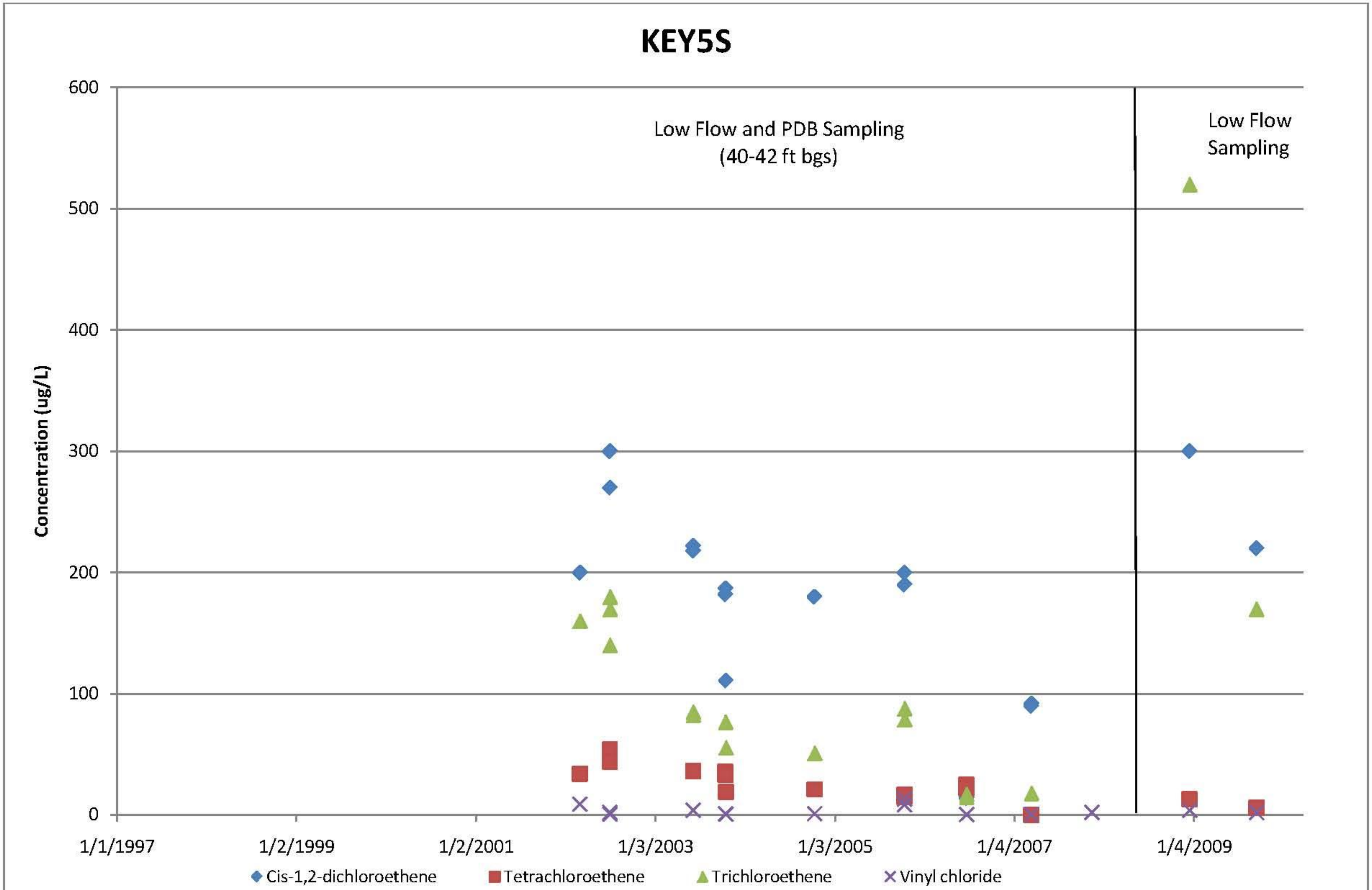


Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.

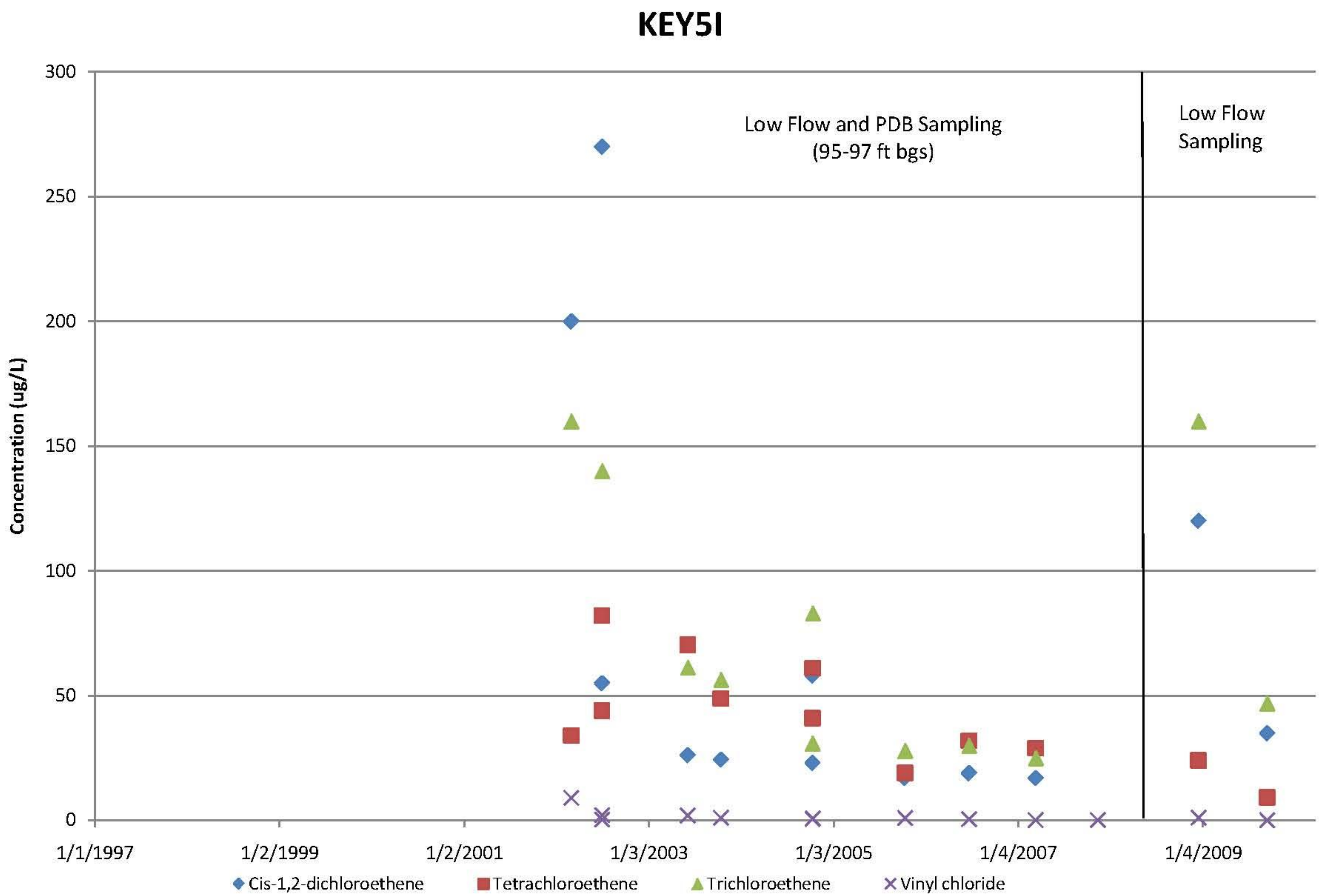
KEY4D



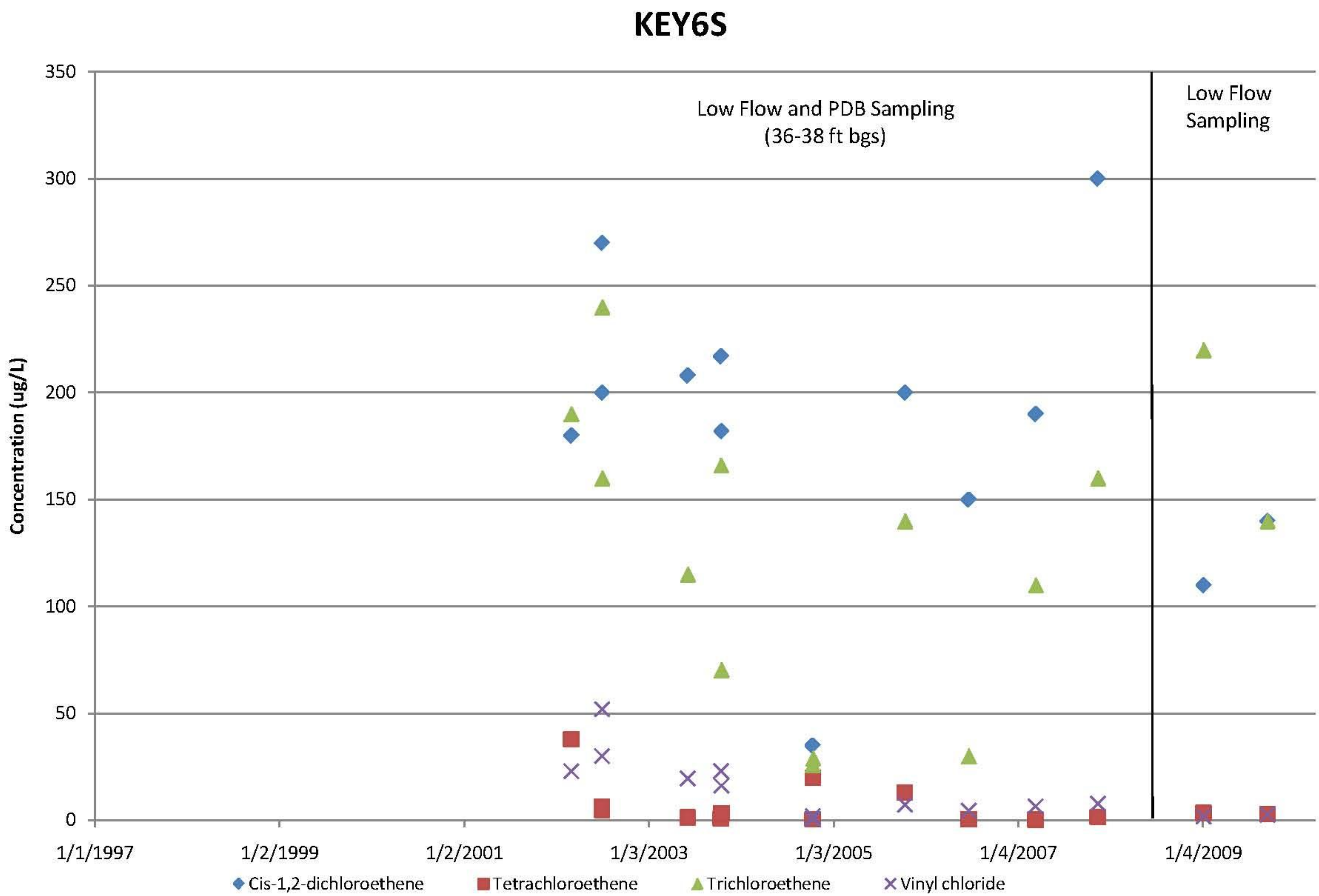
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



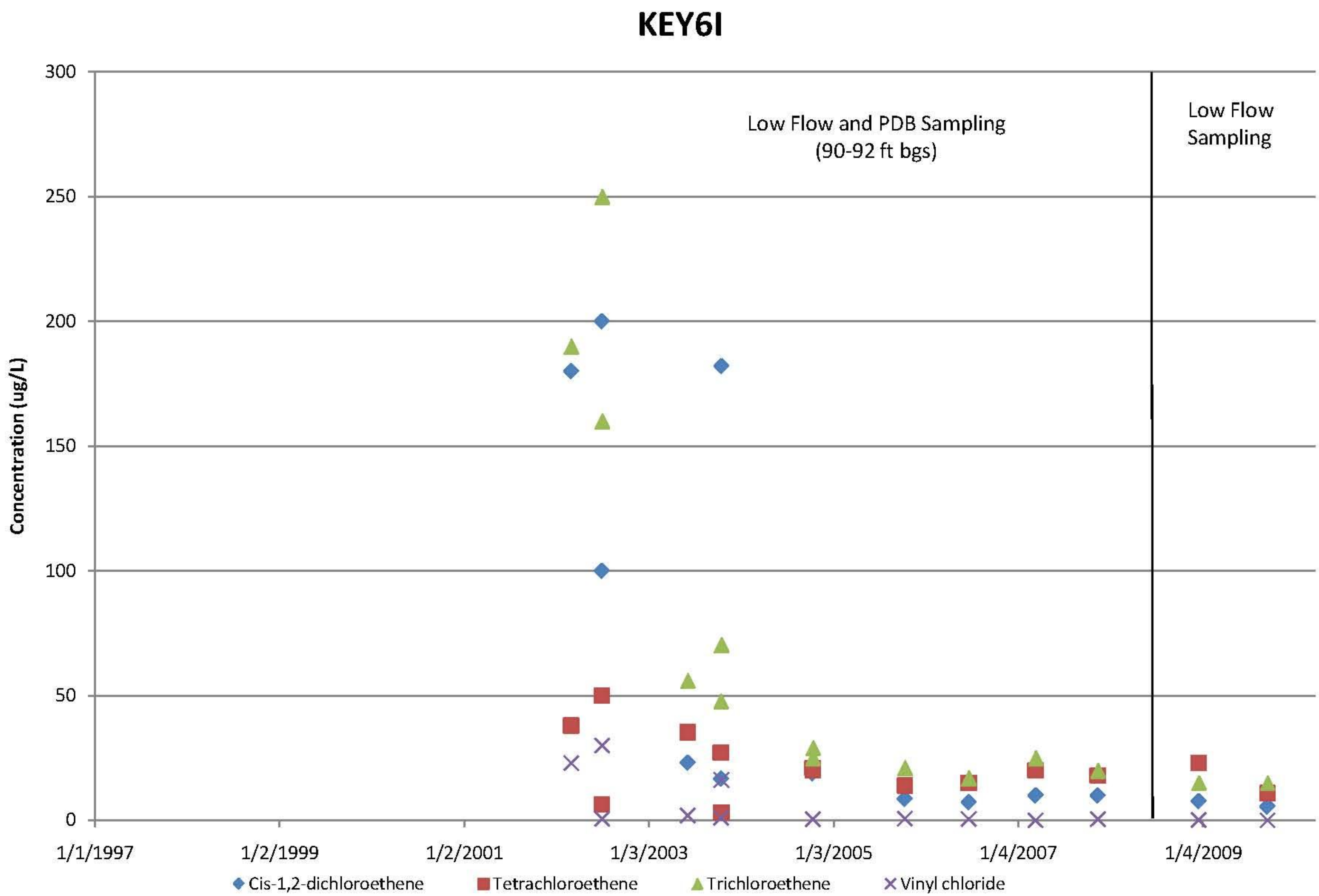
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



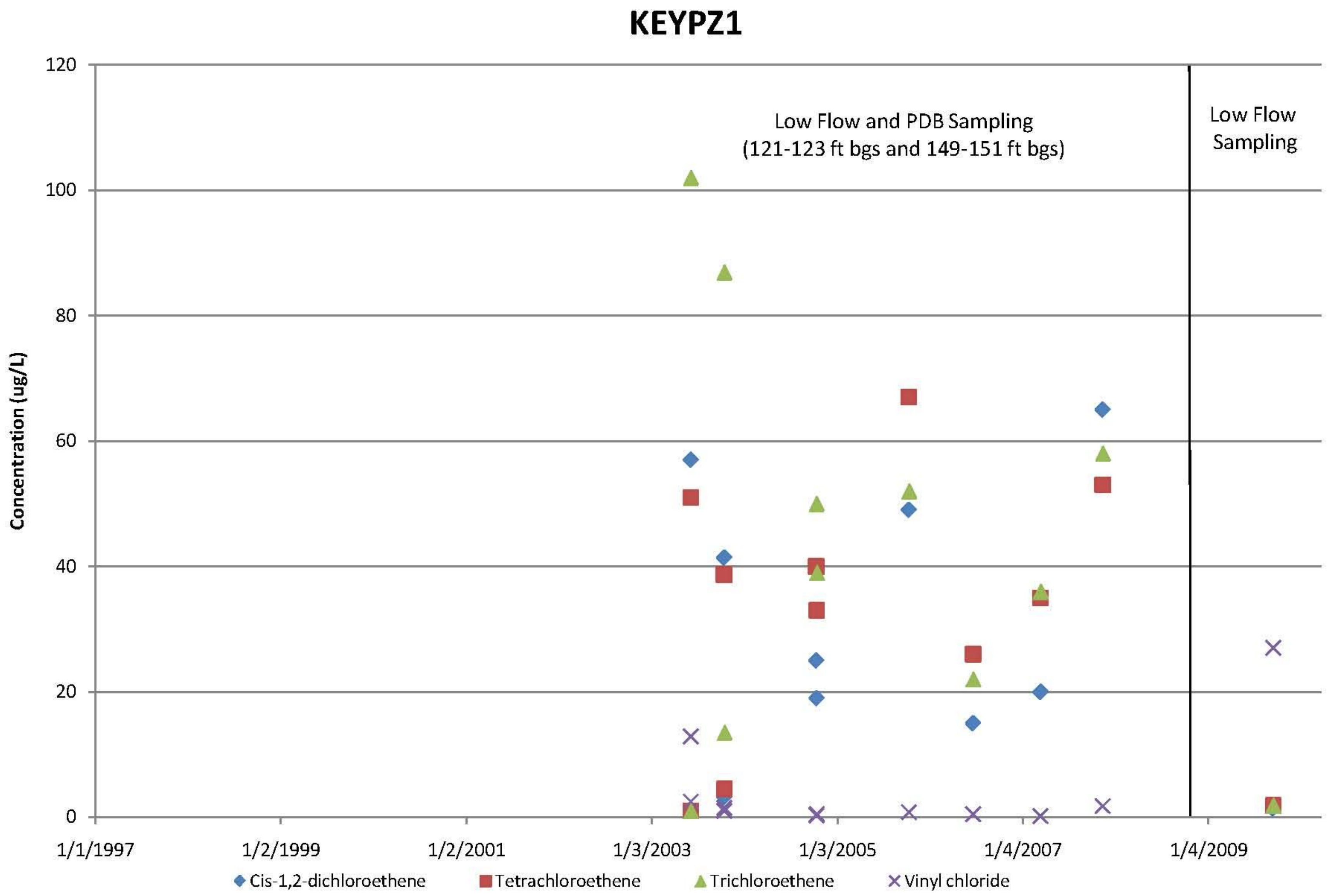
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



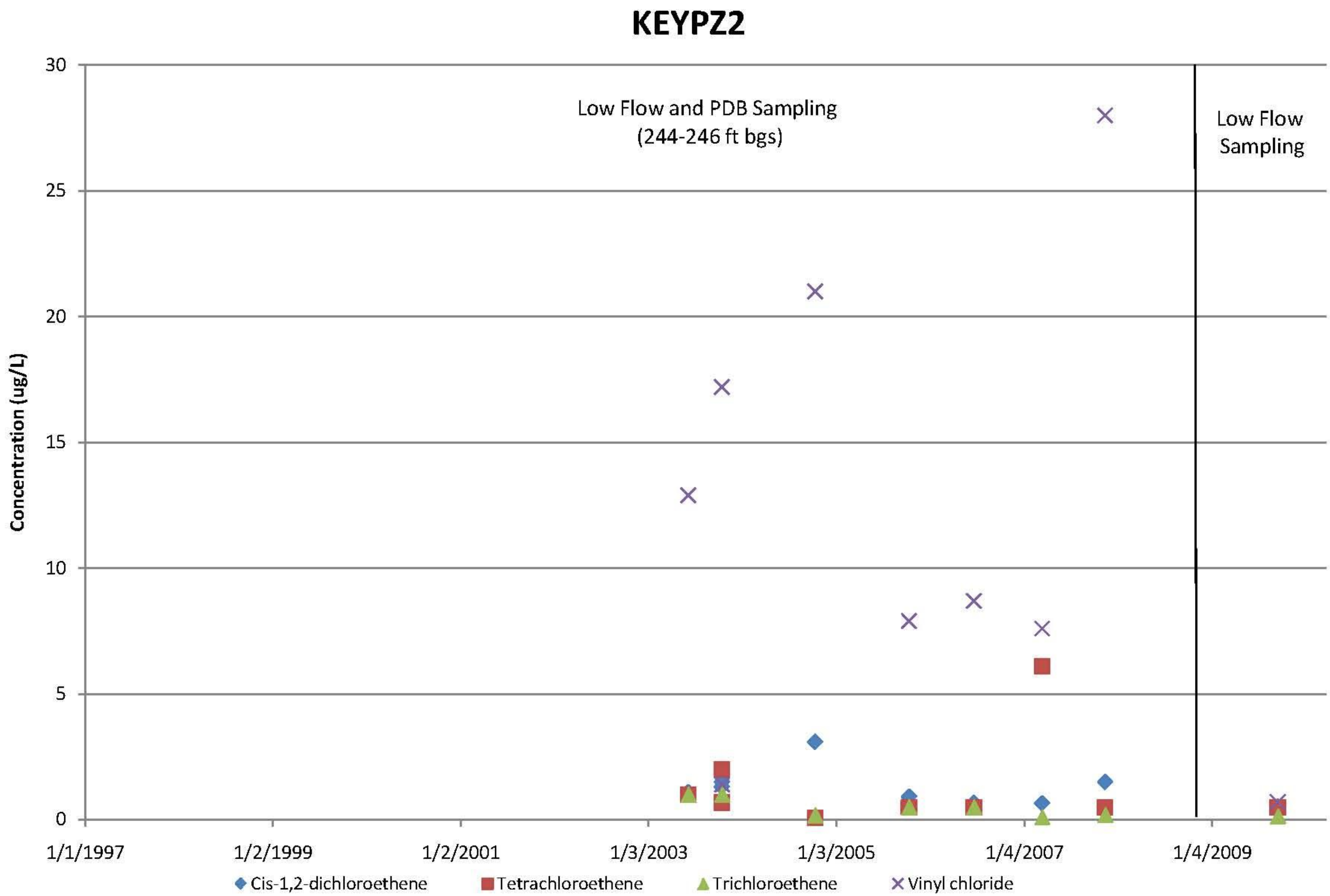
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



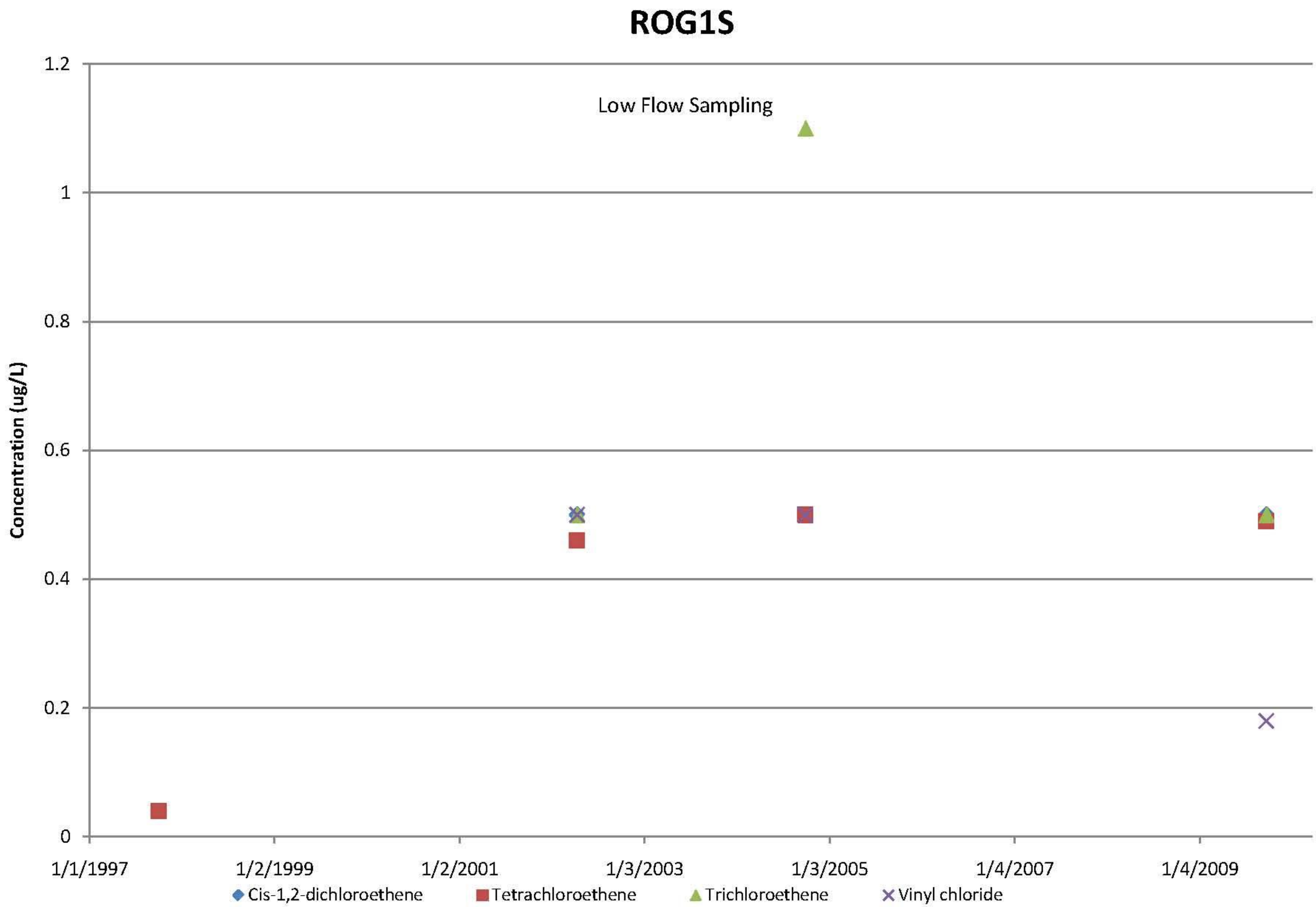
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



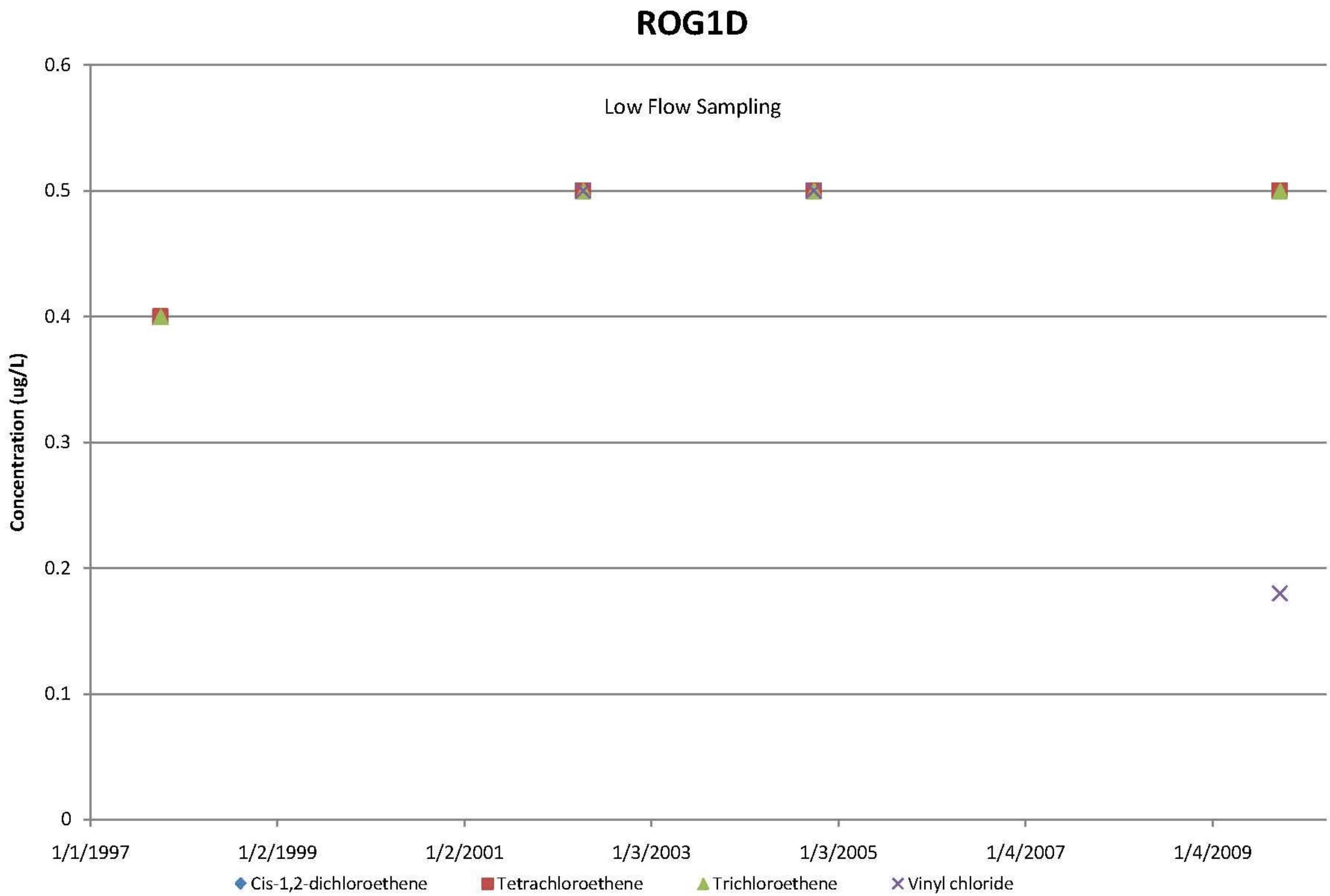
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



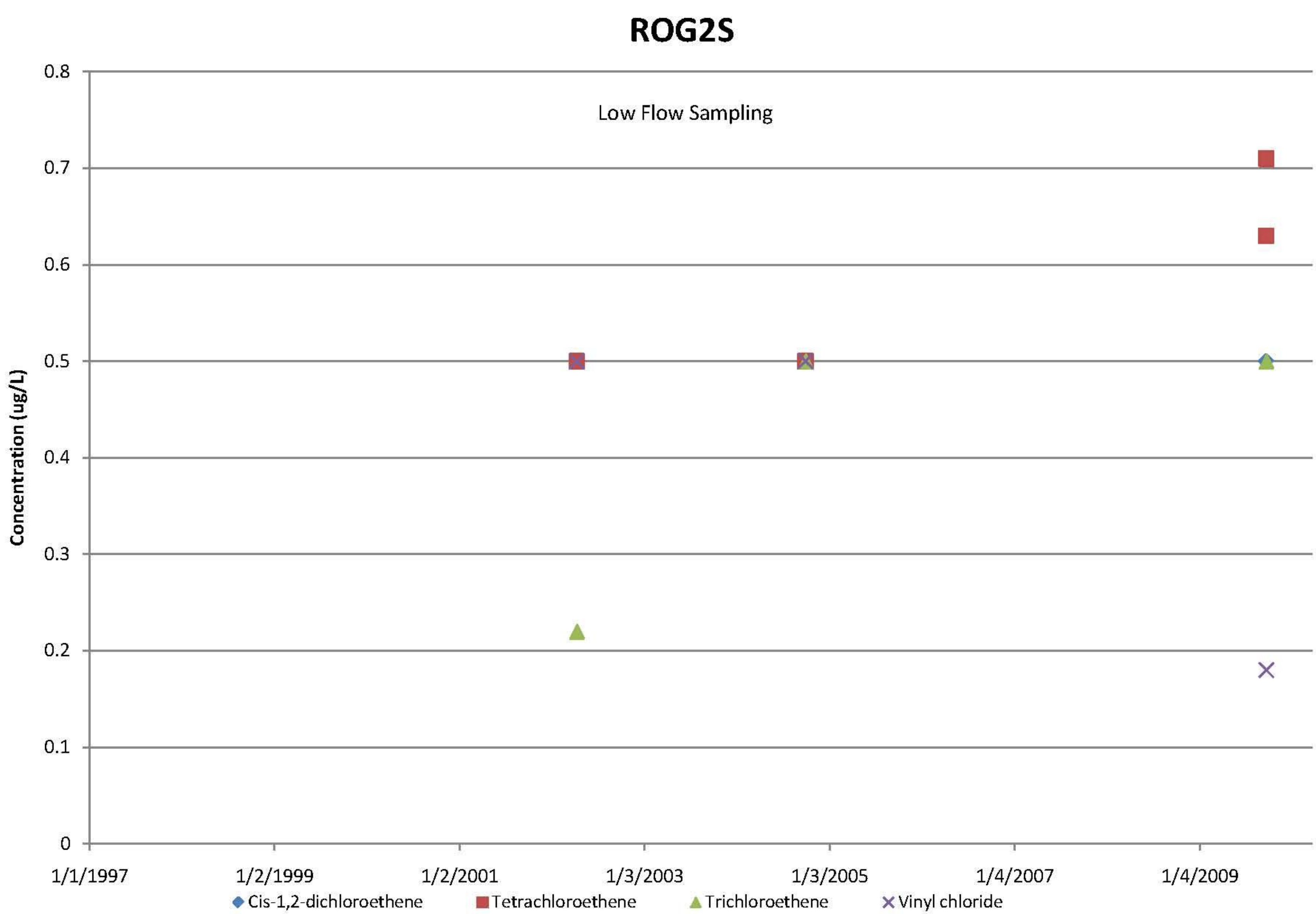
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



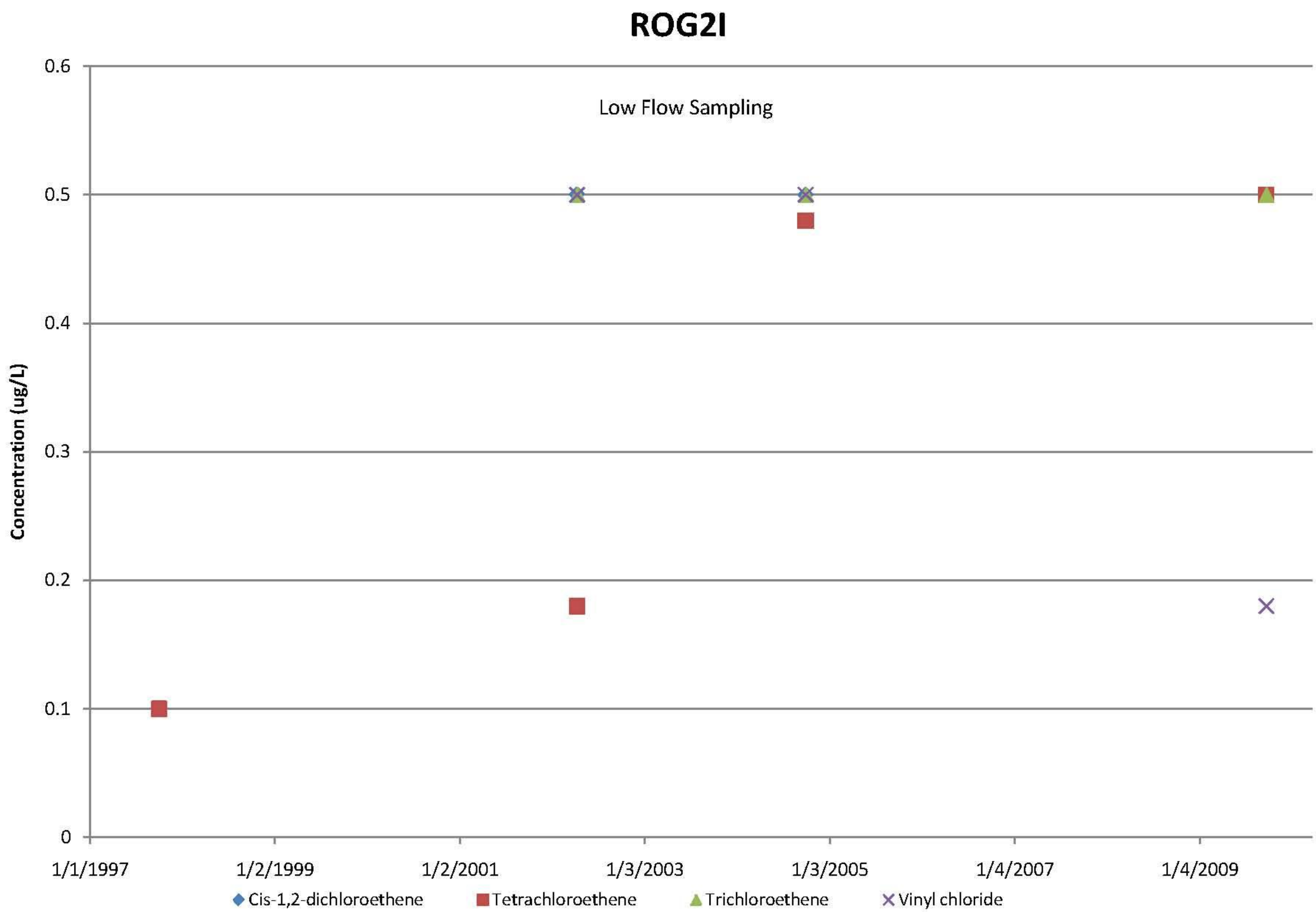
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



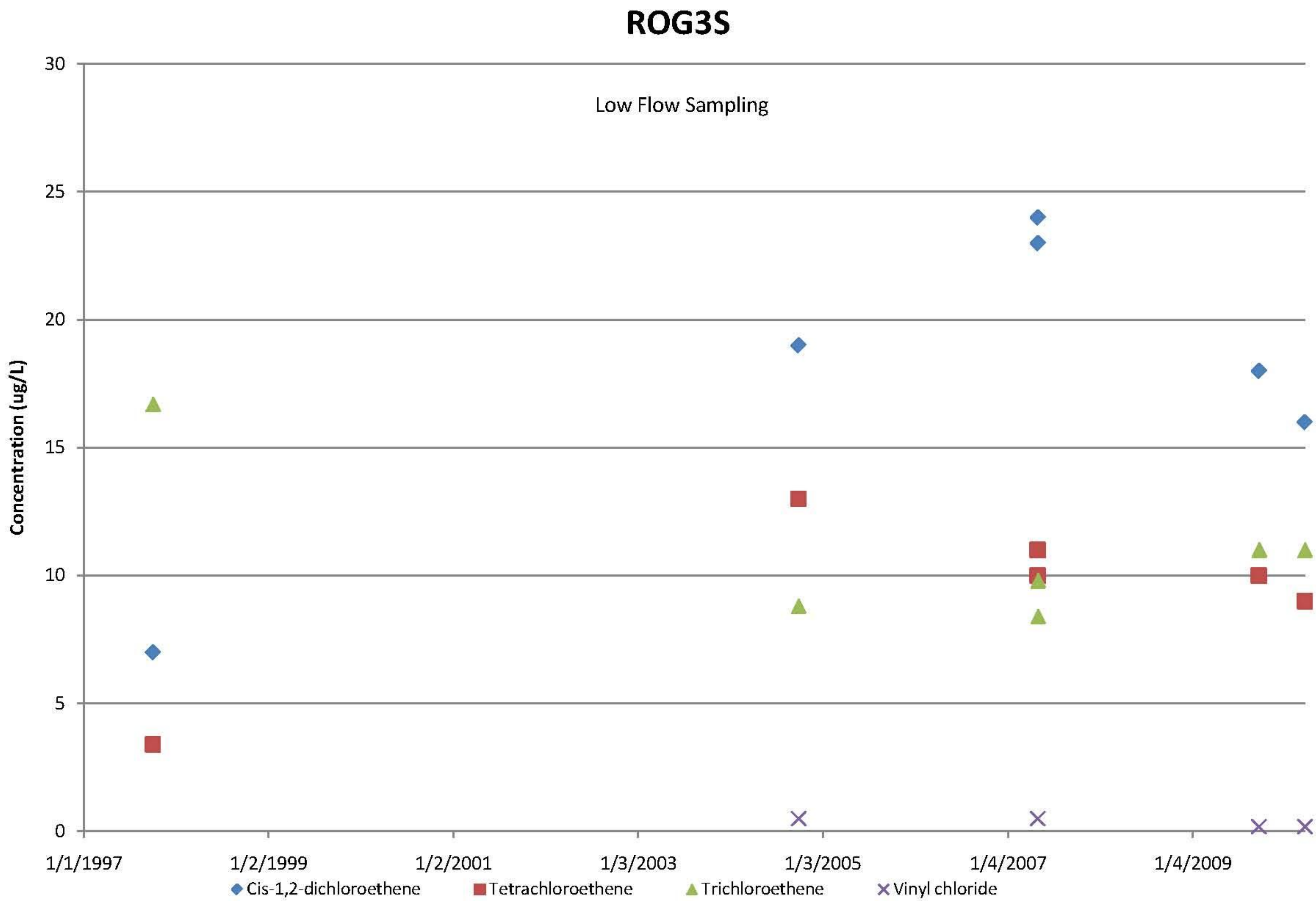
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



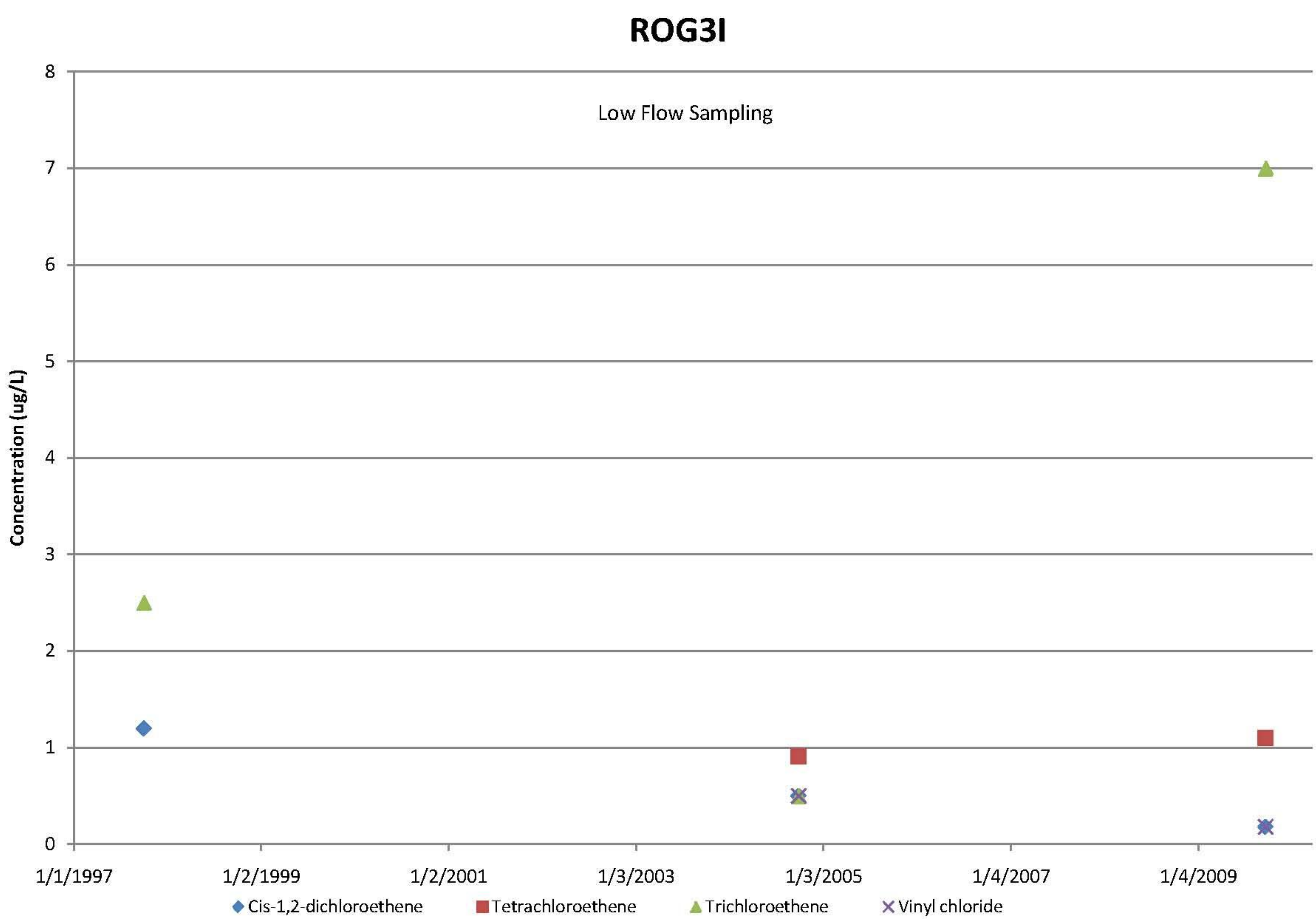
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



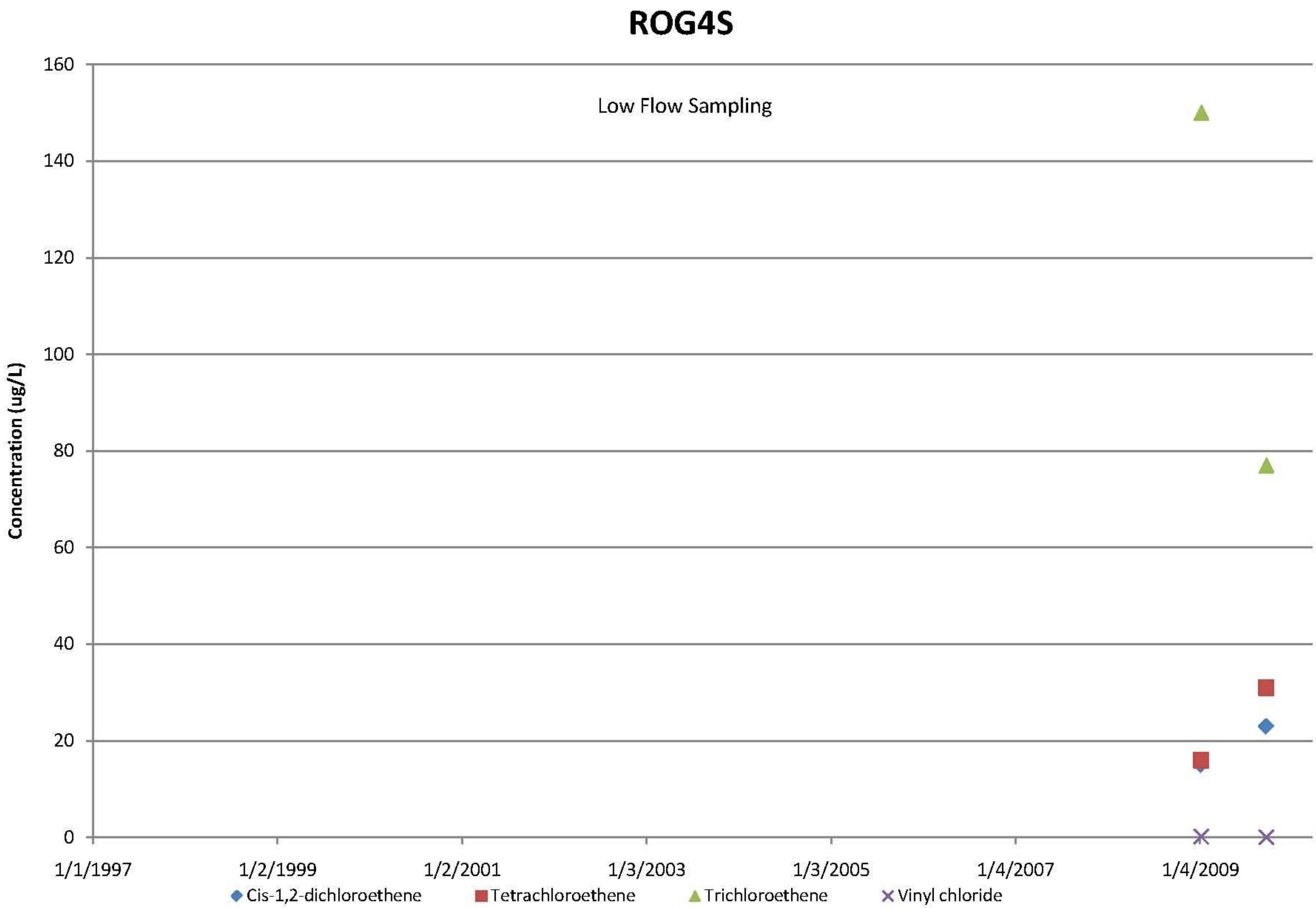
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



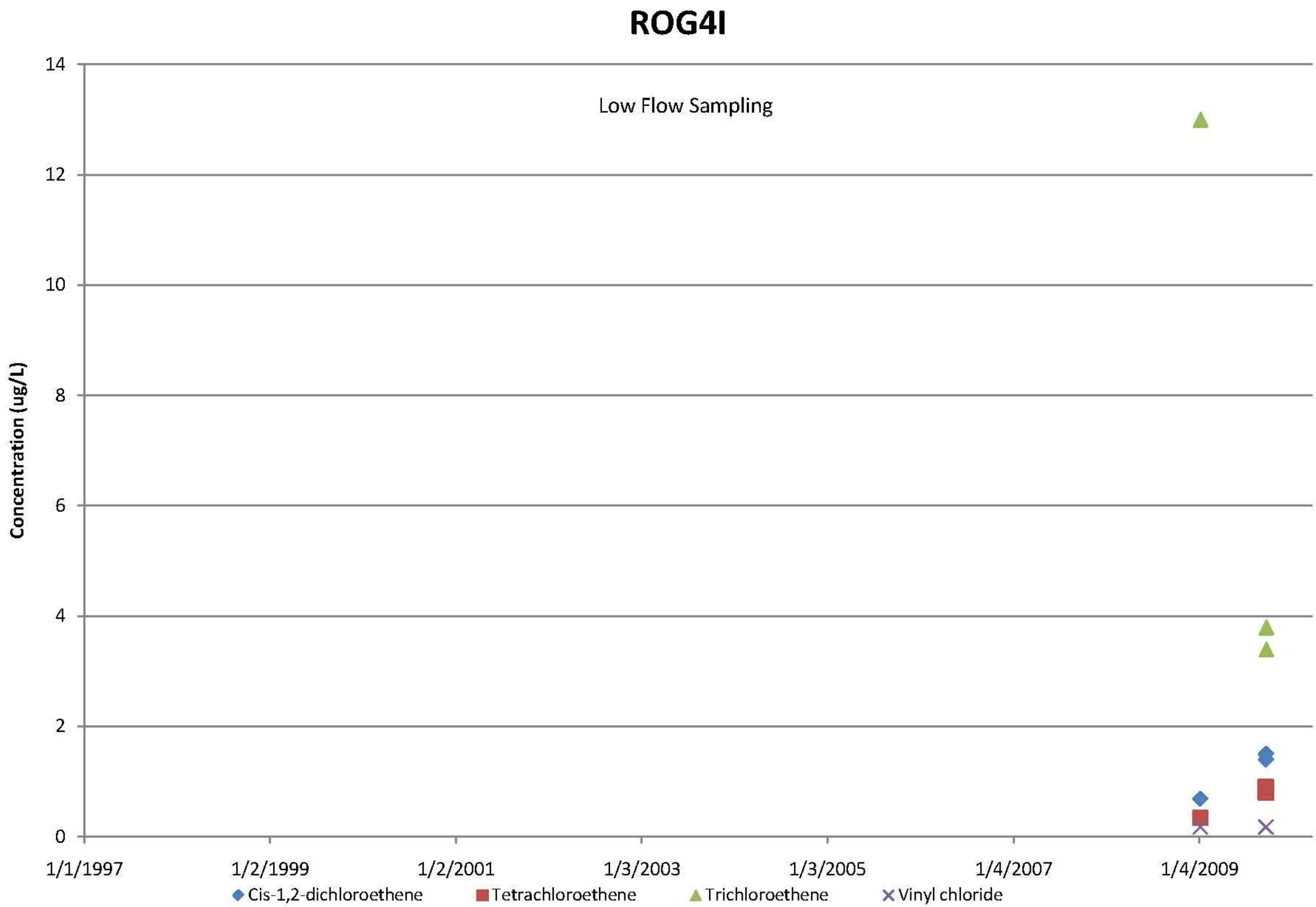
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



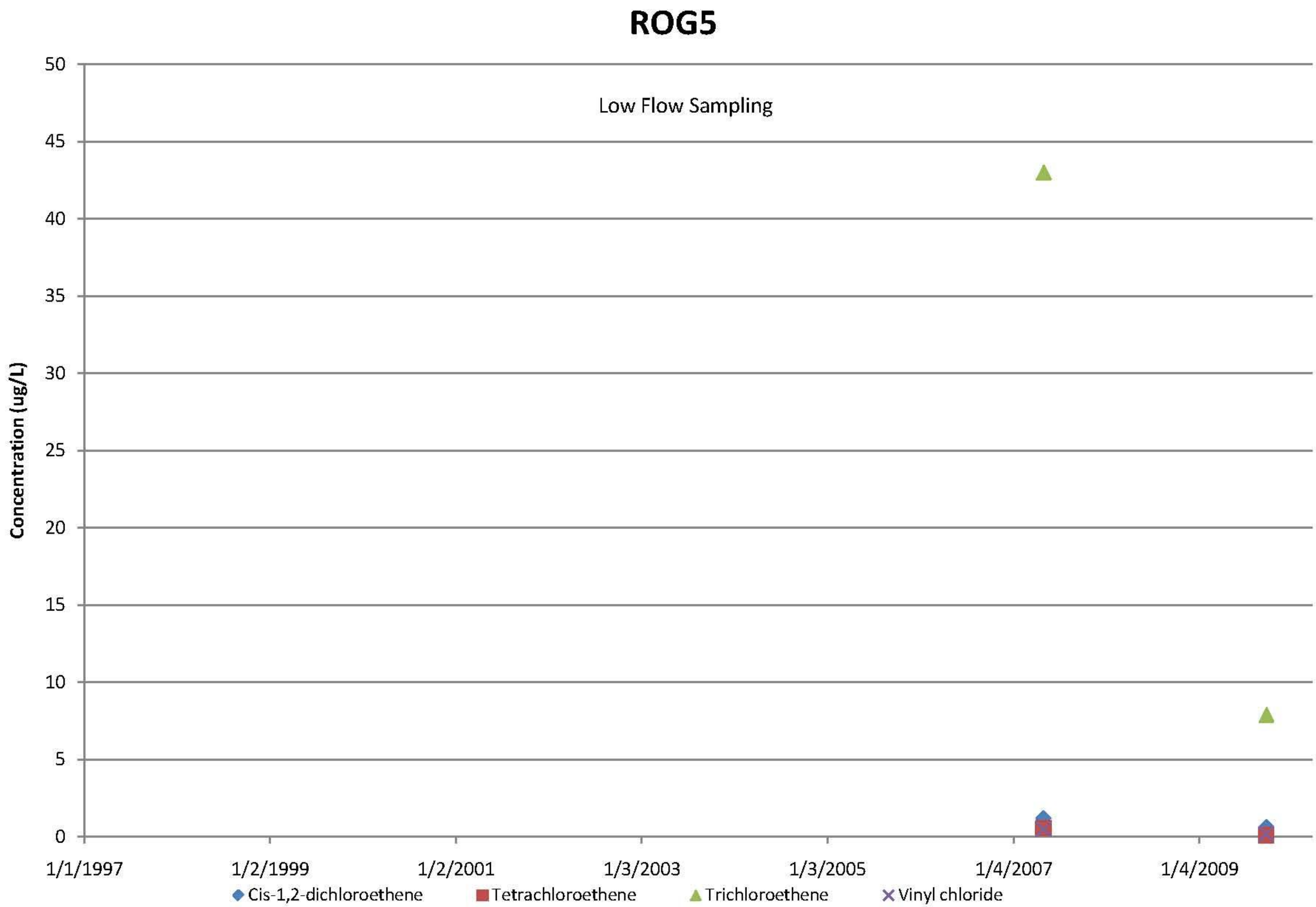
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



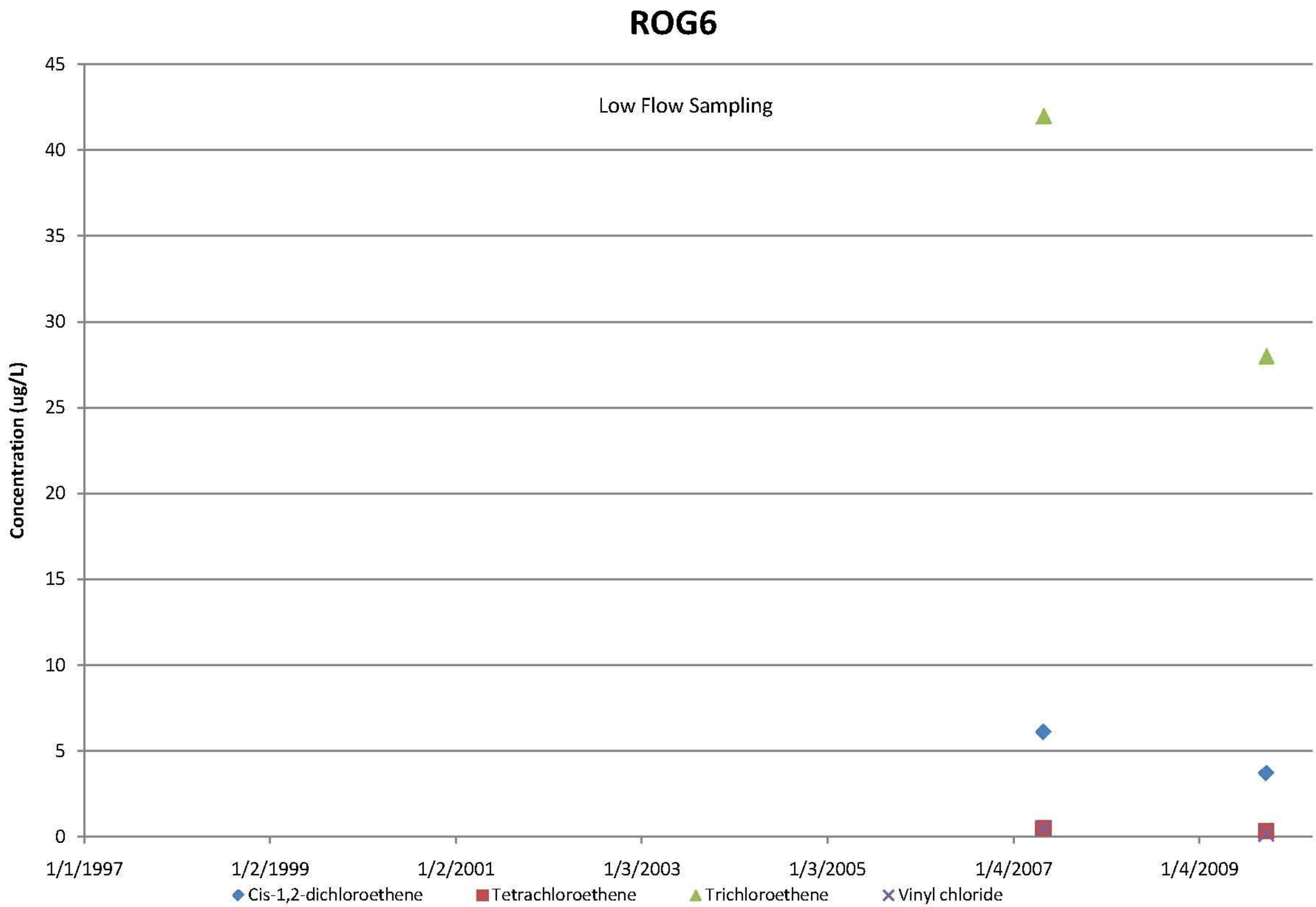
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



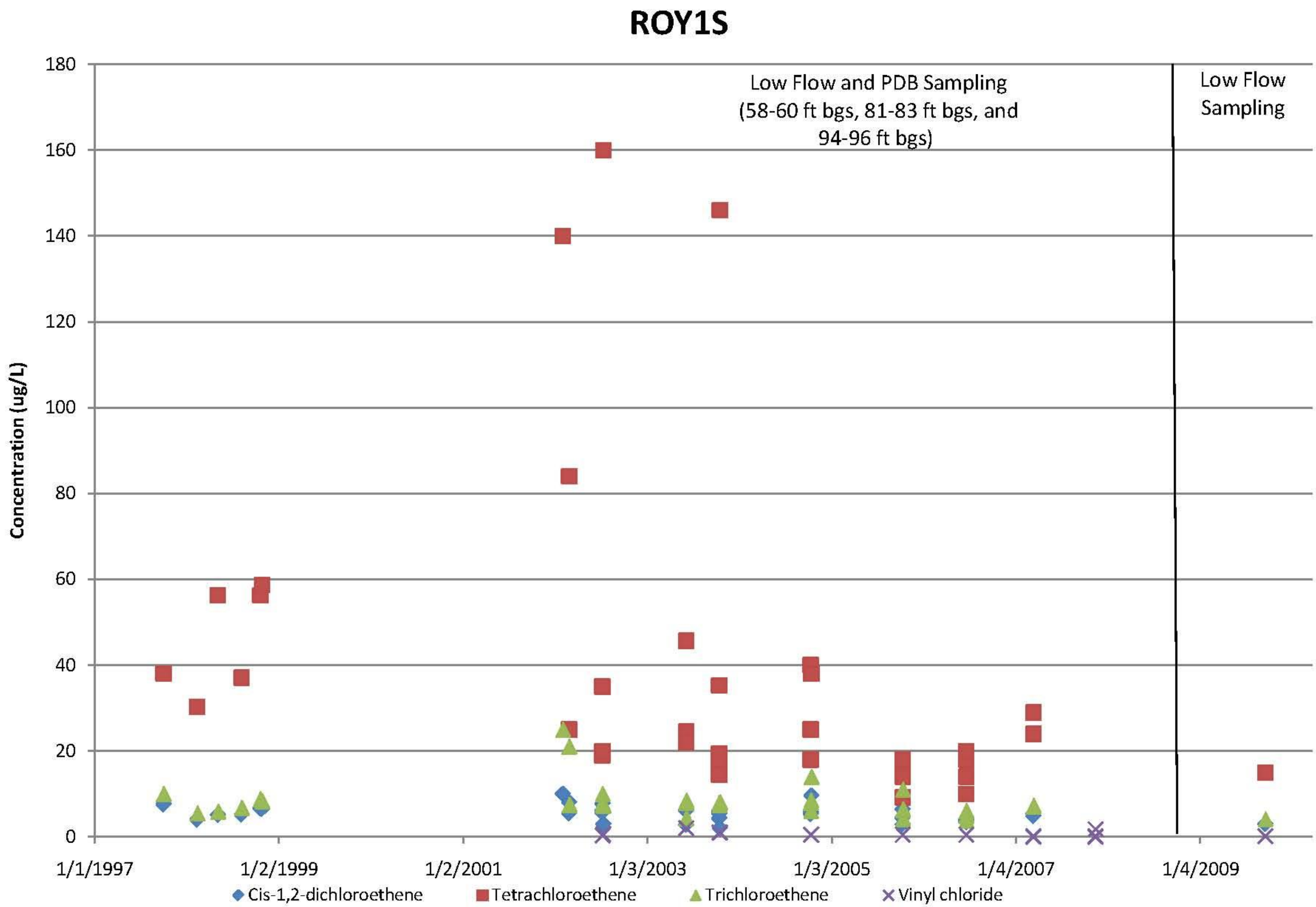
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



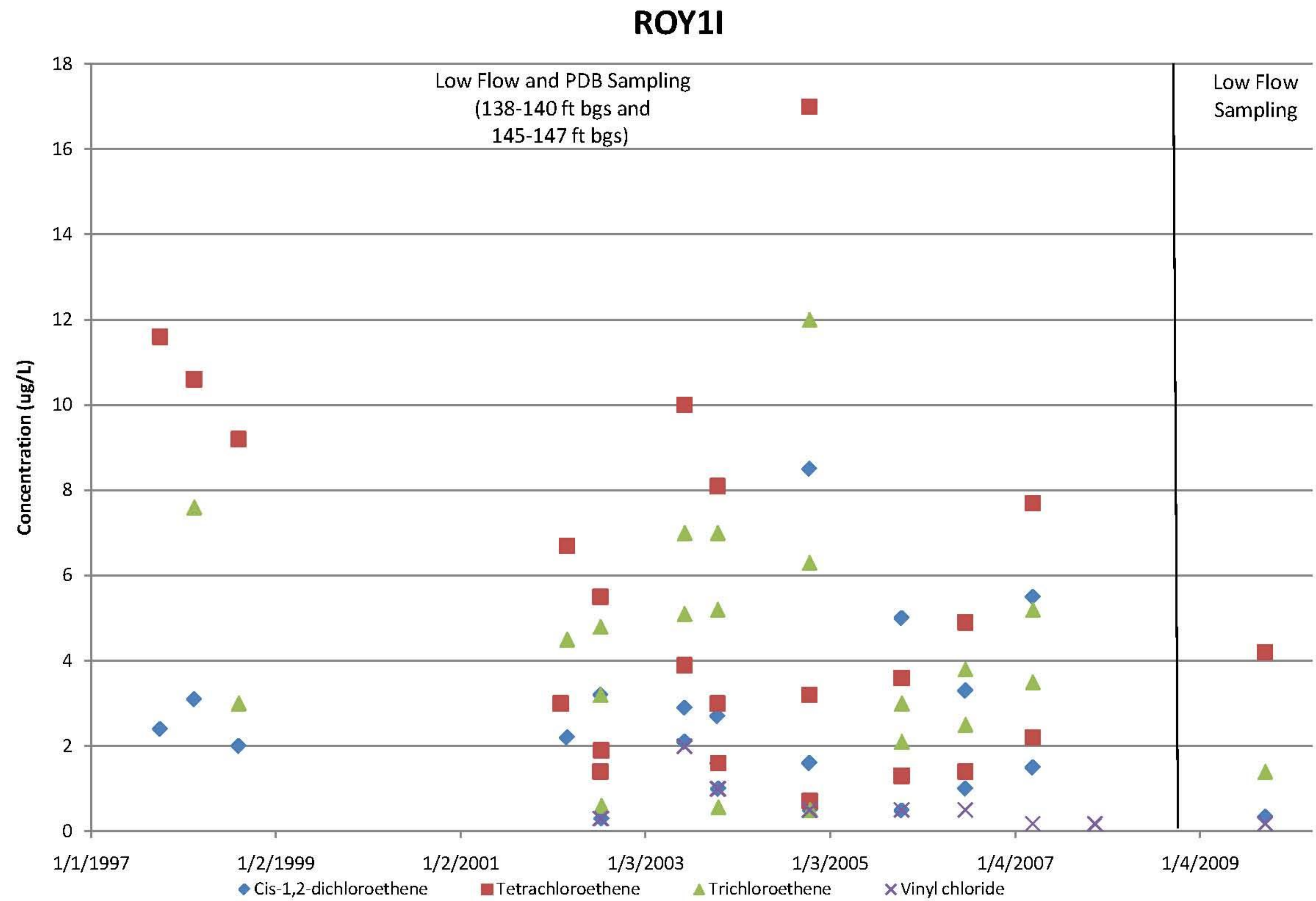
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



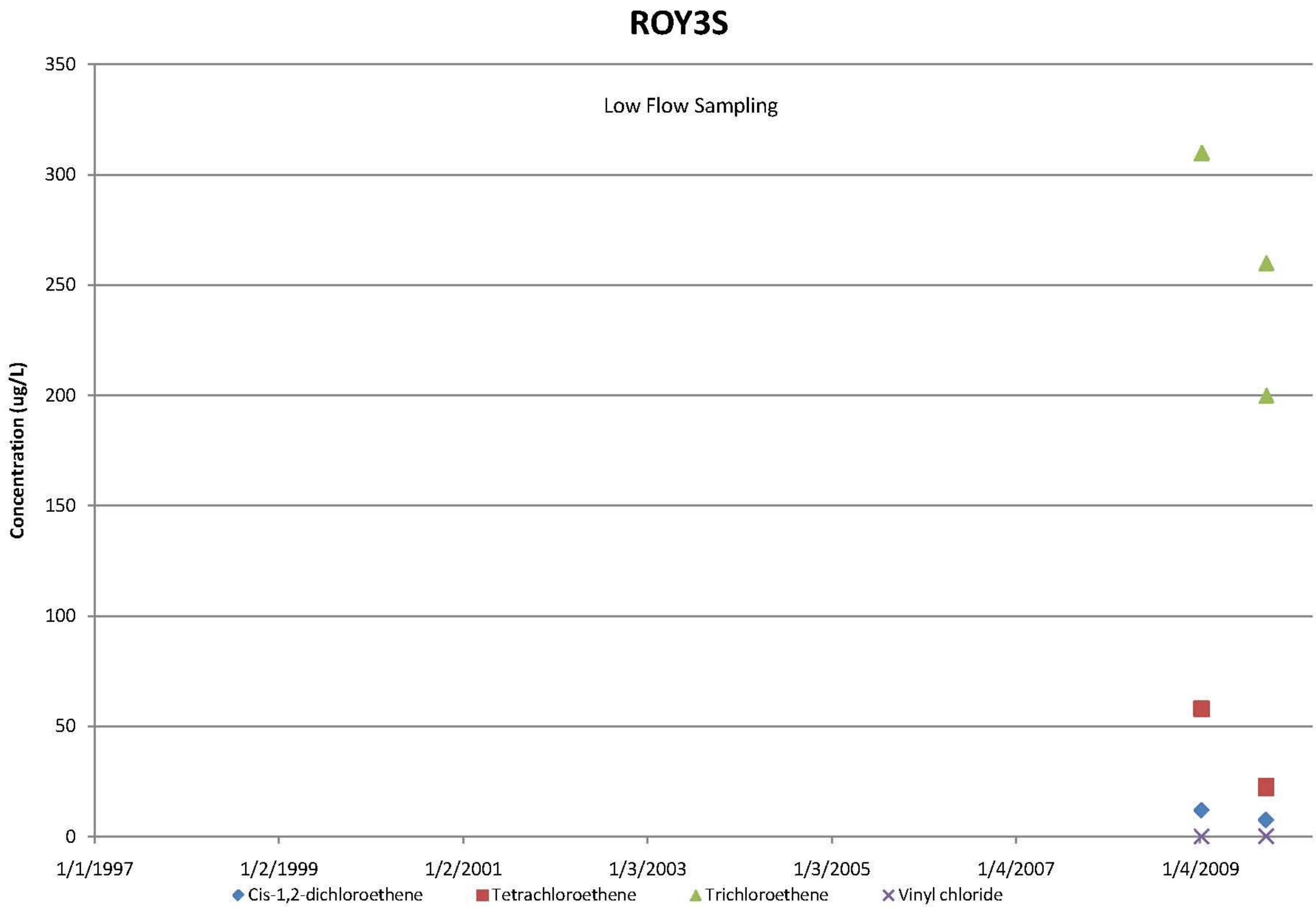
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



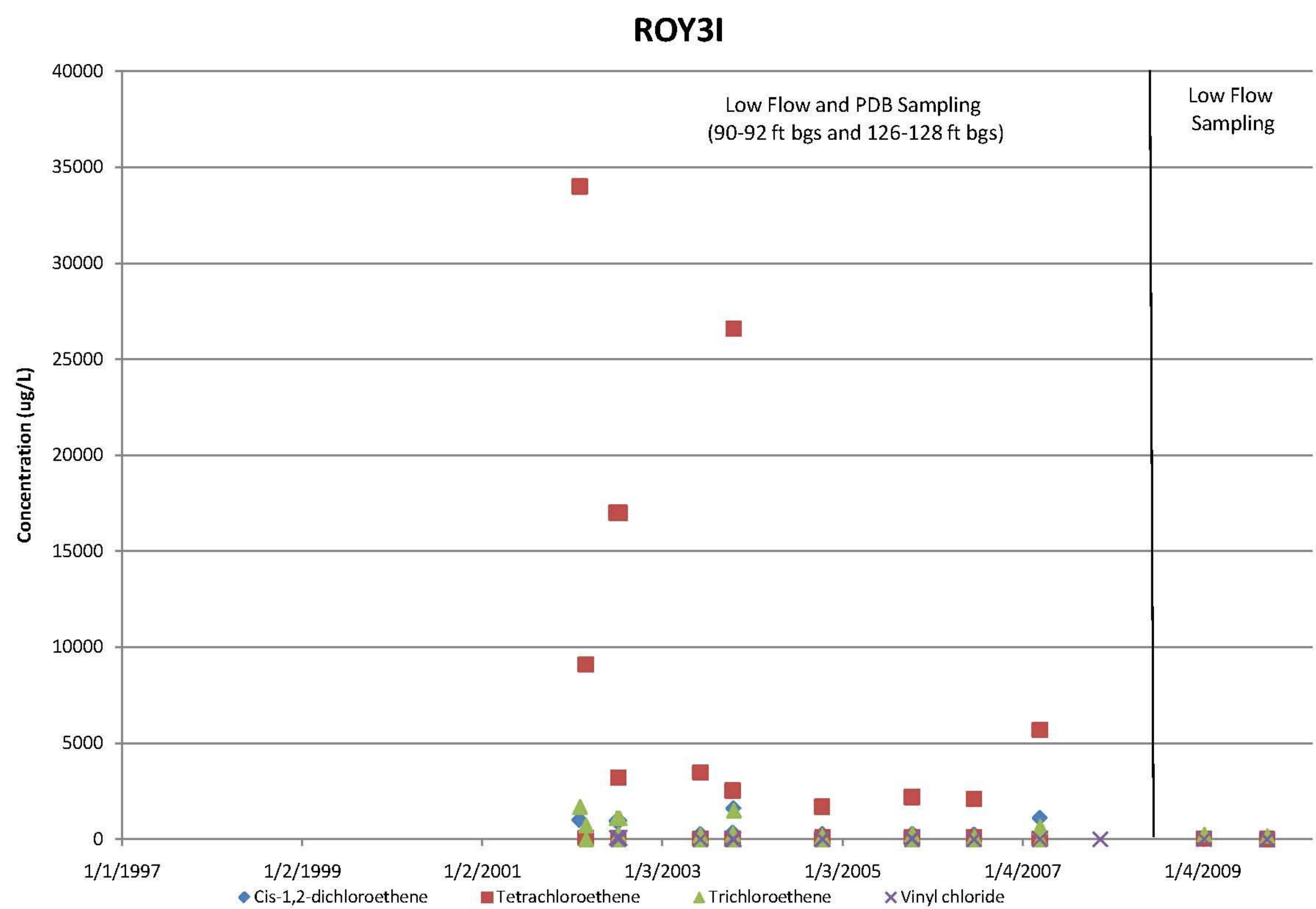
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



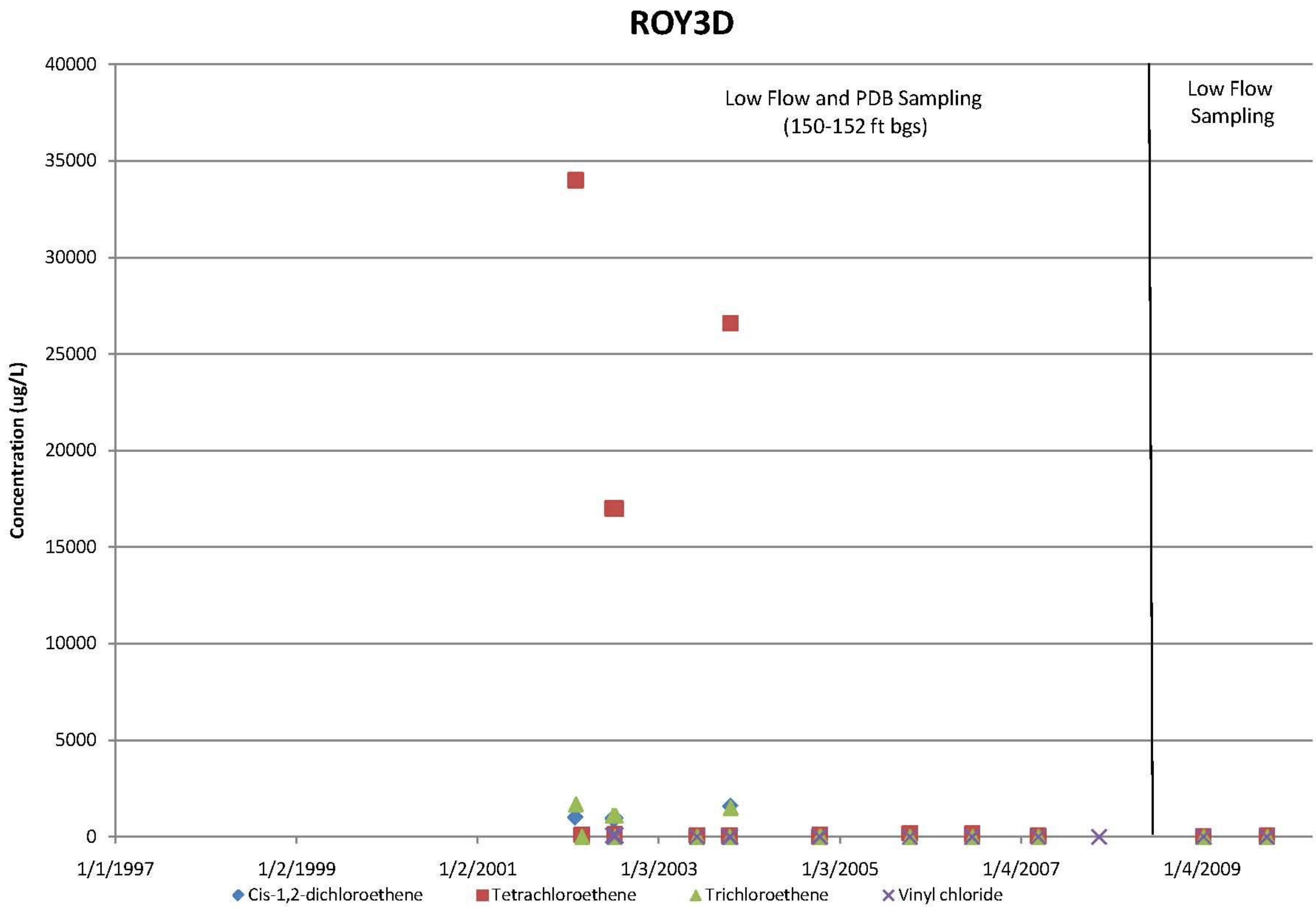
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



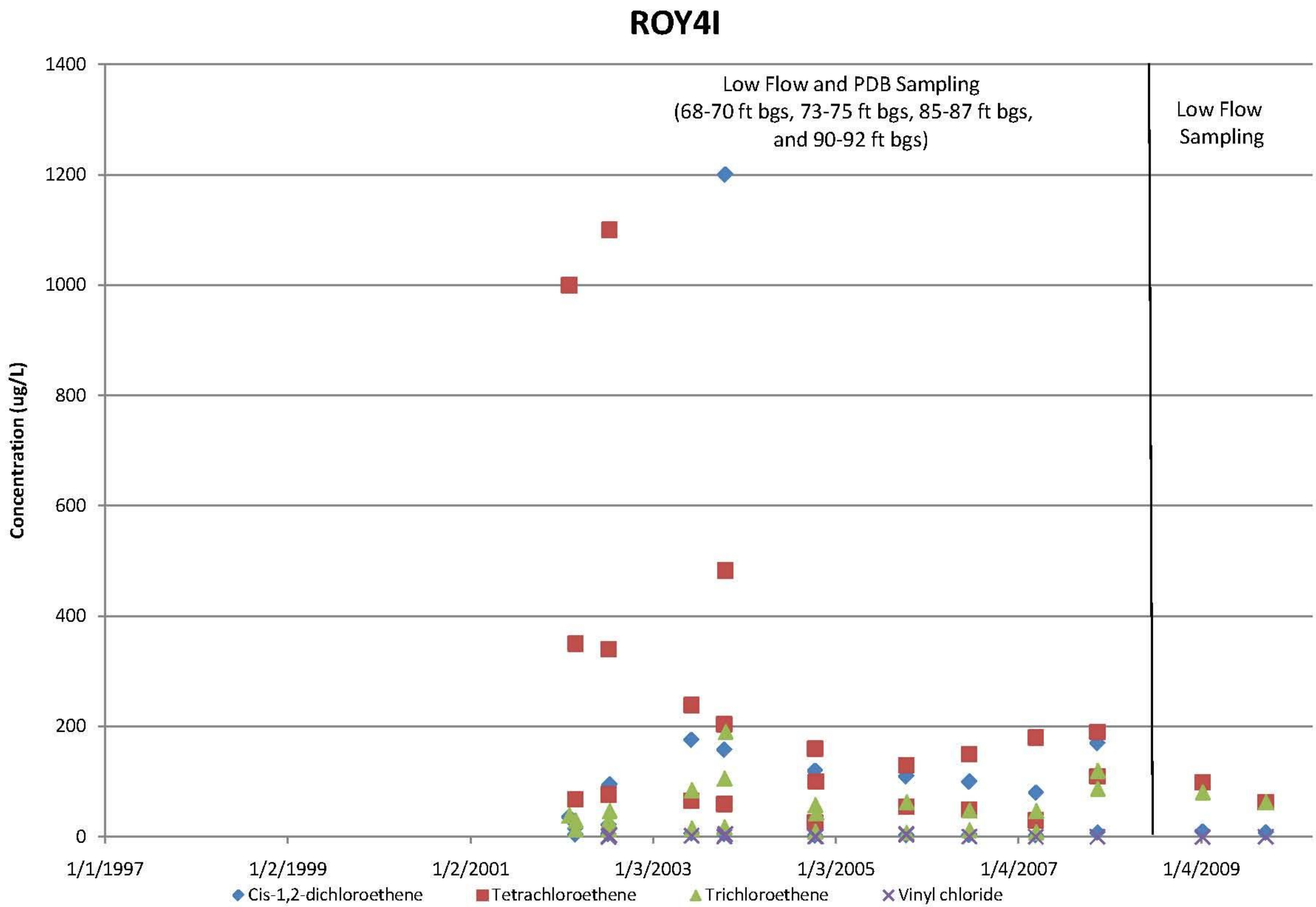
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



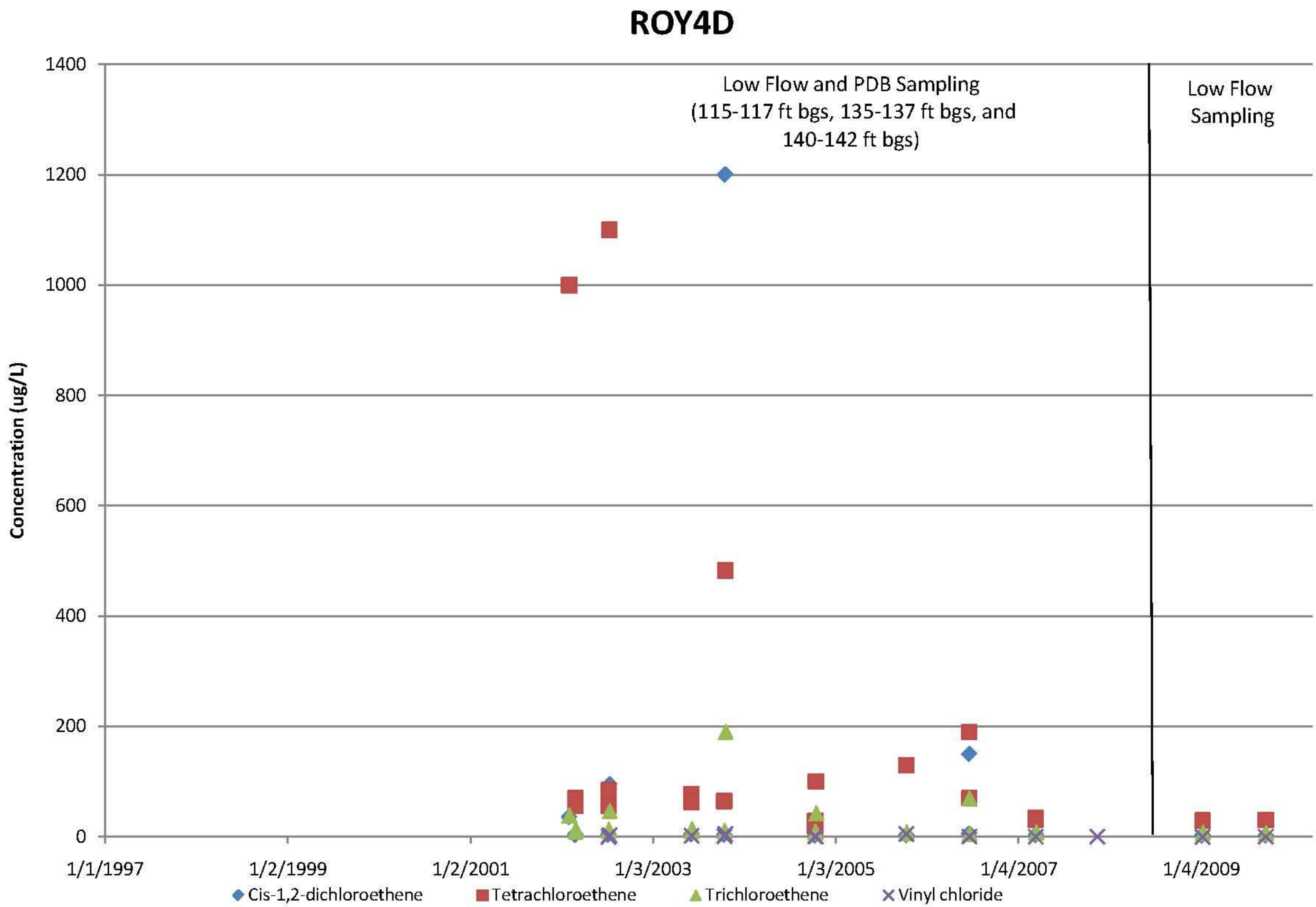
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



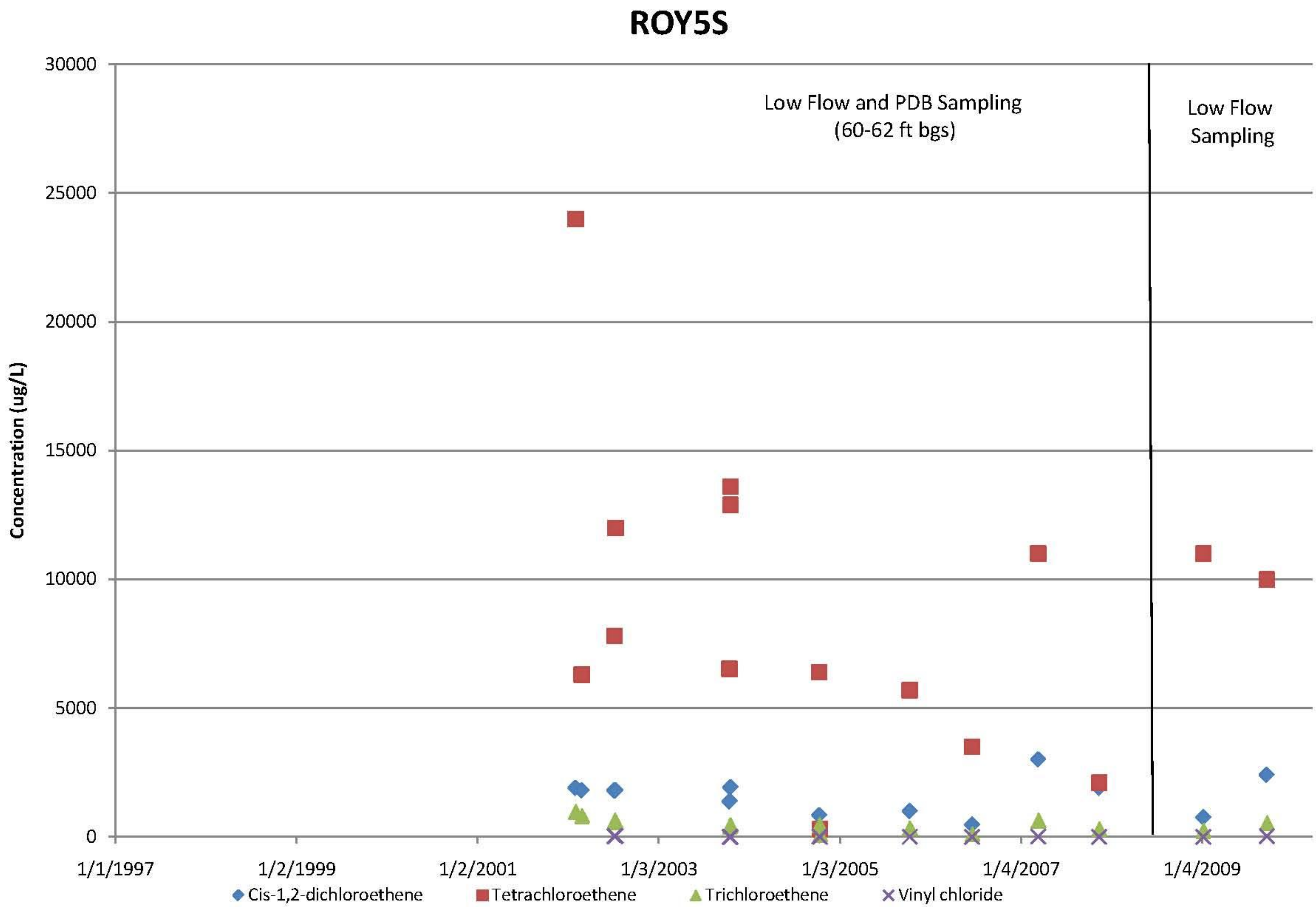
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



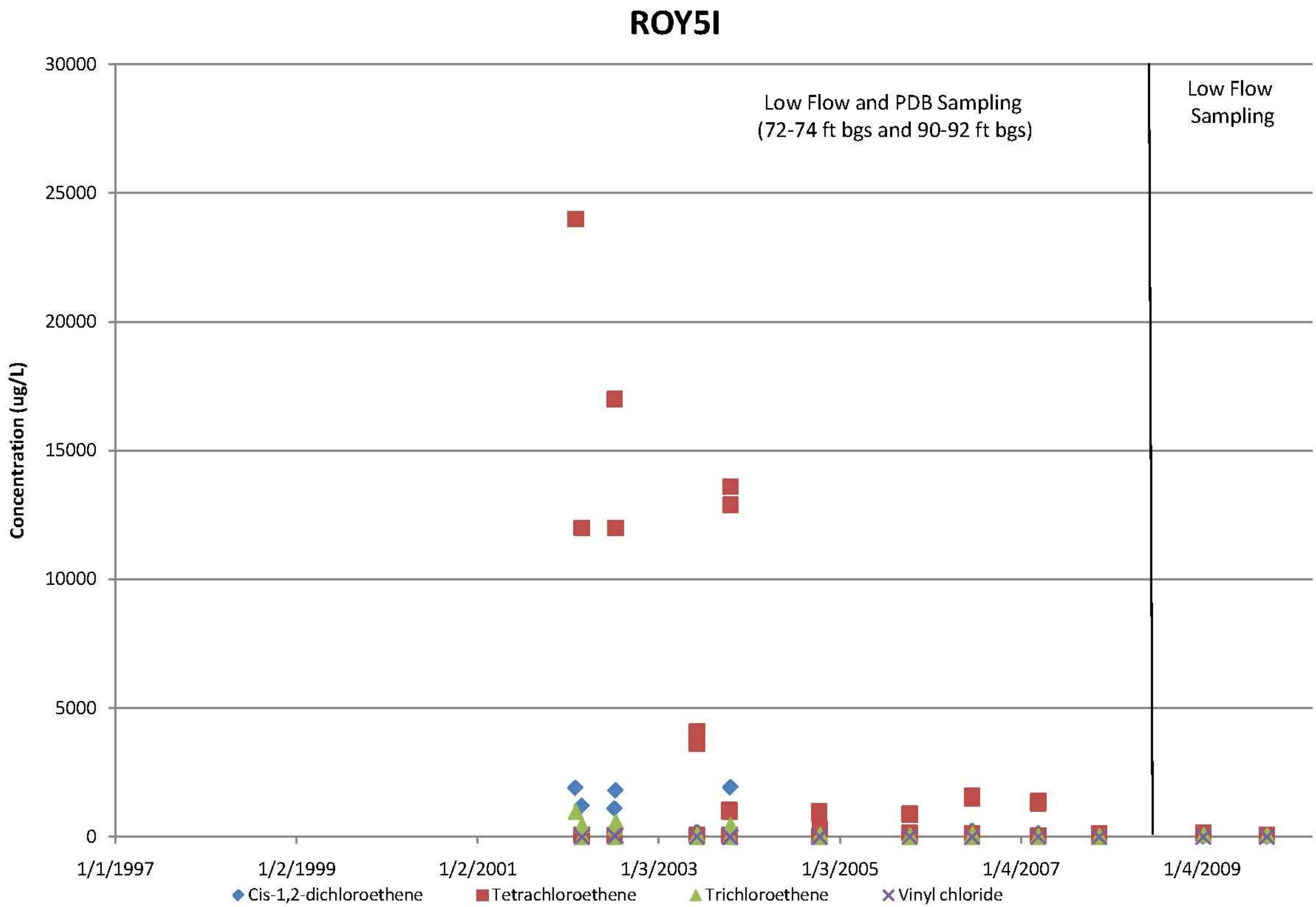
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



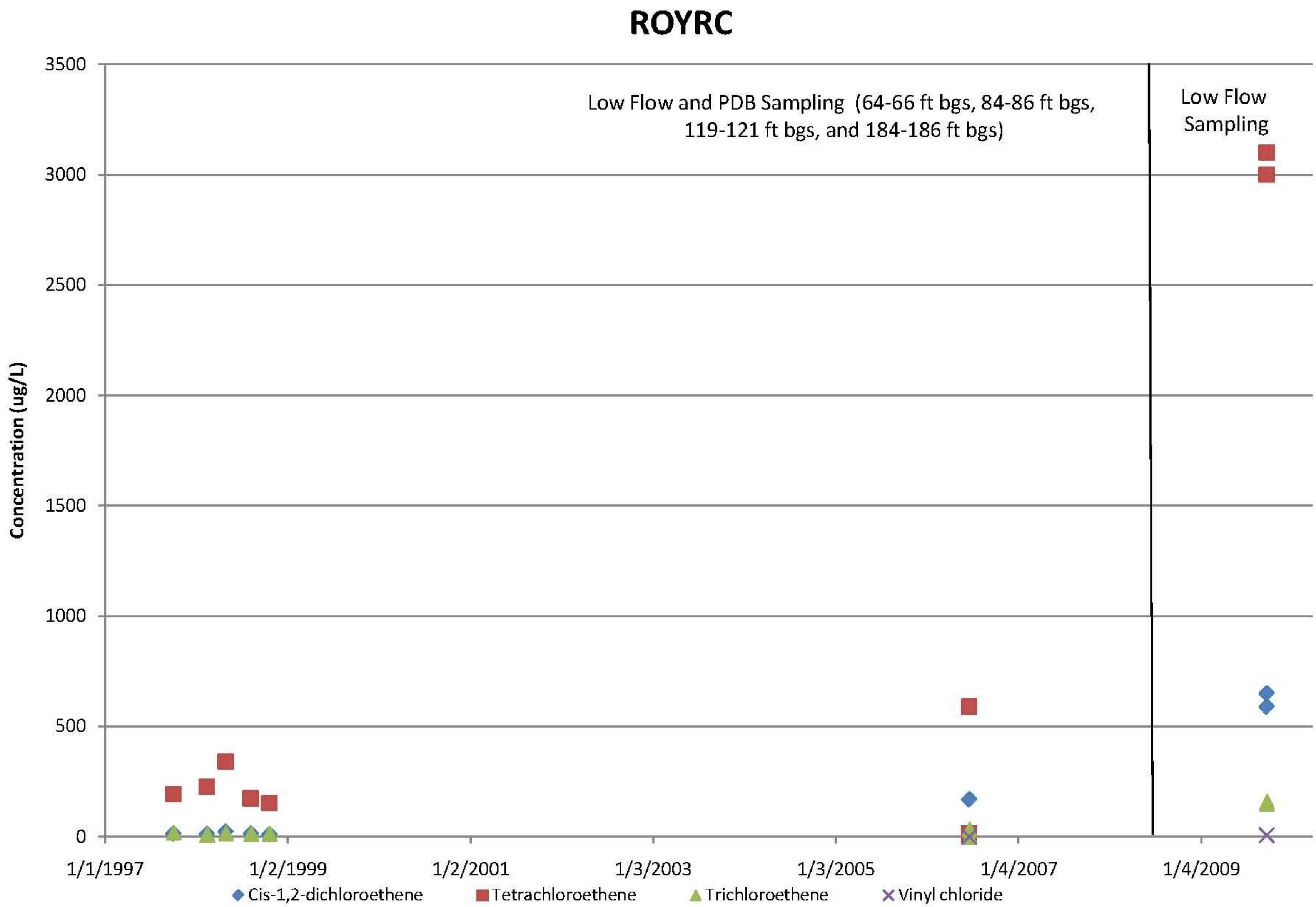
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



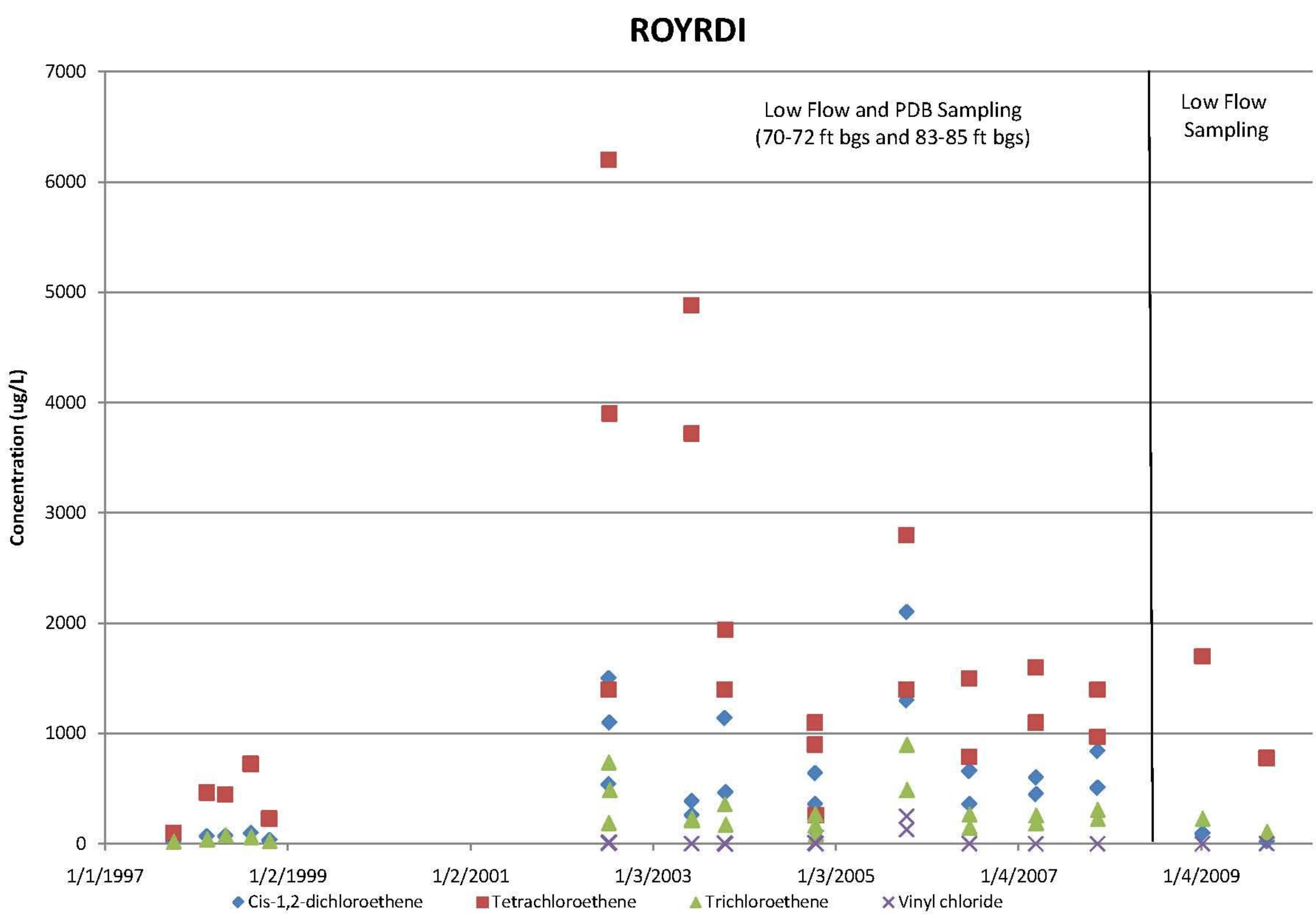
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



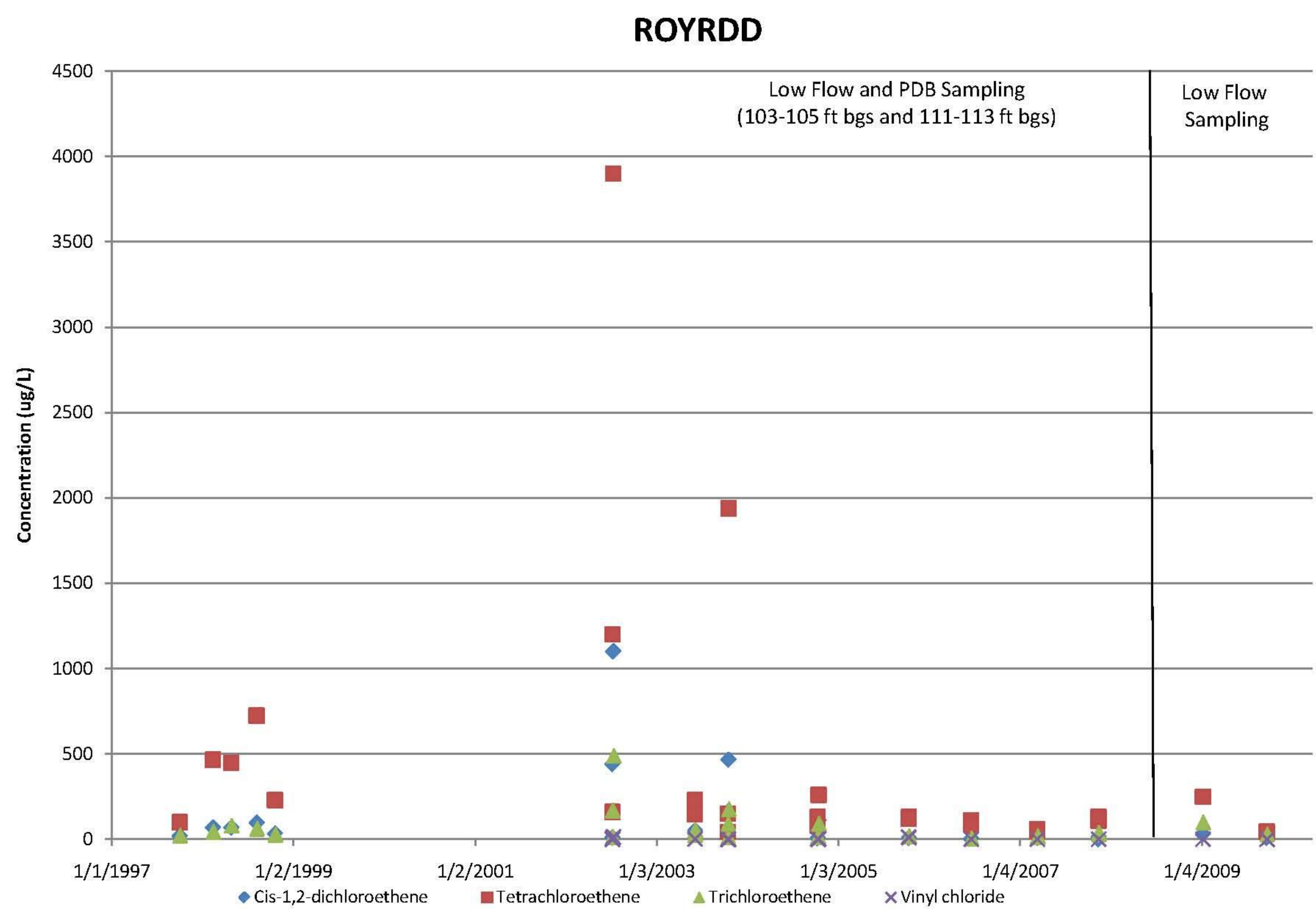
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



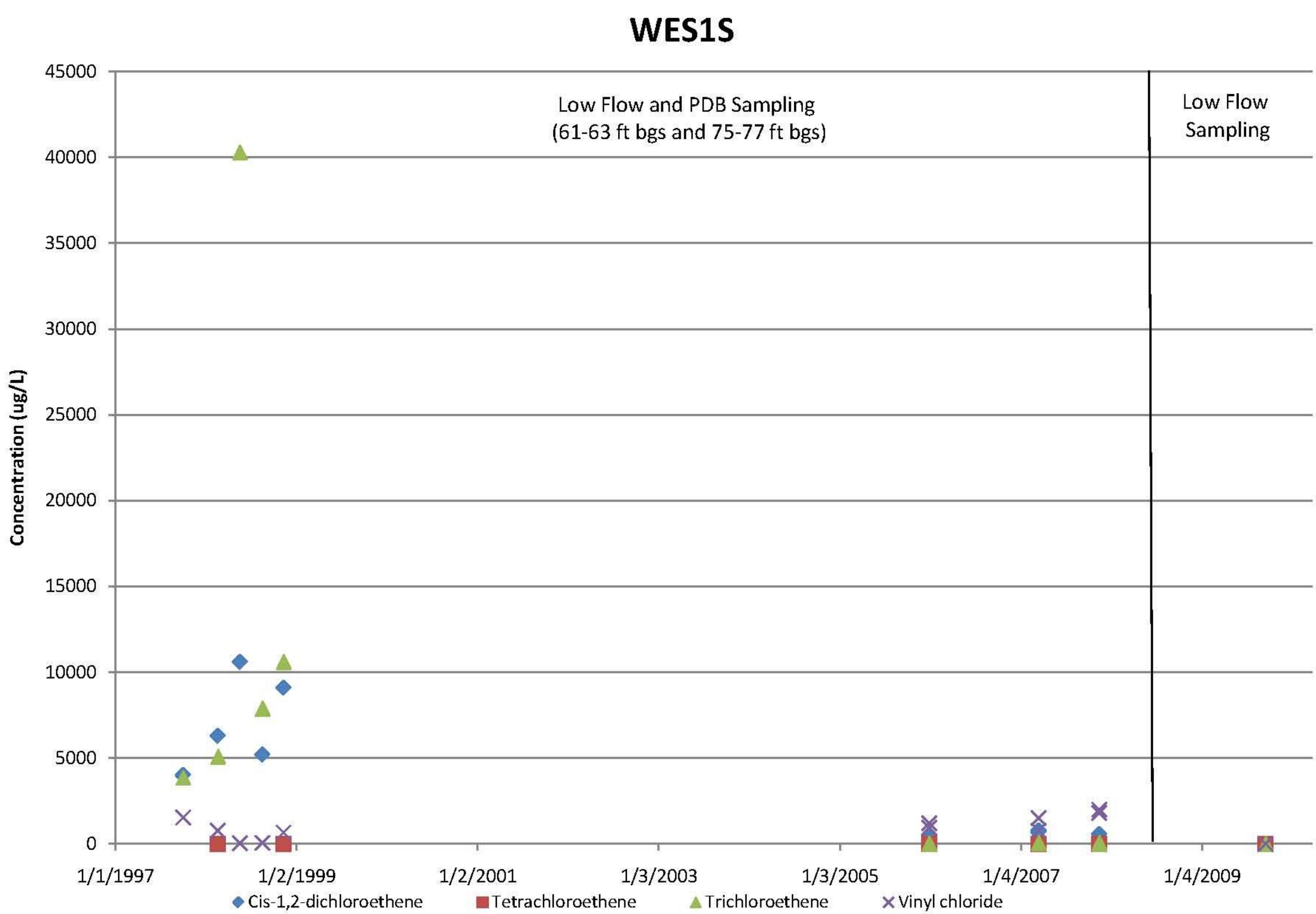
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



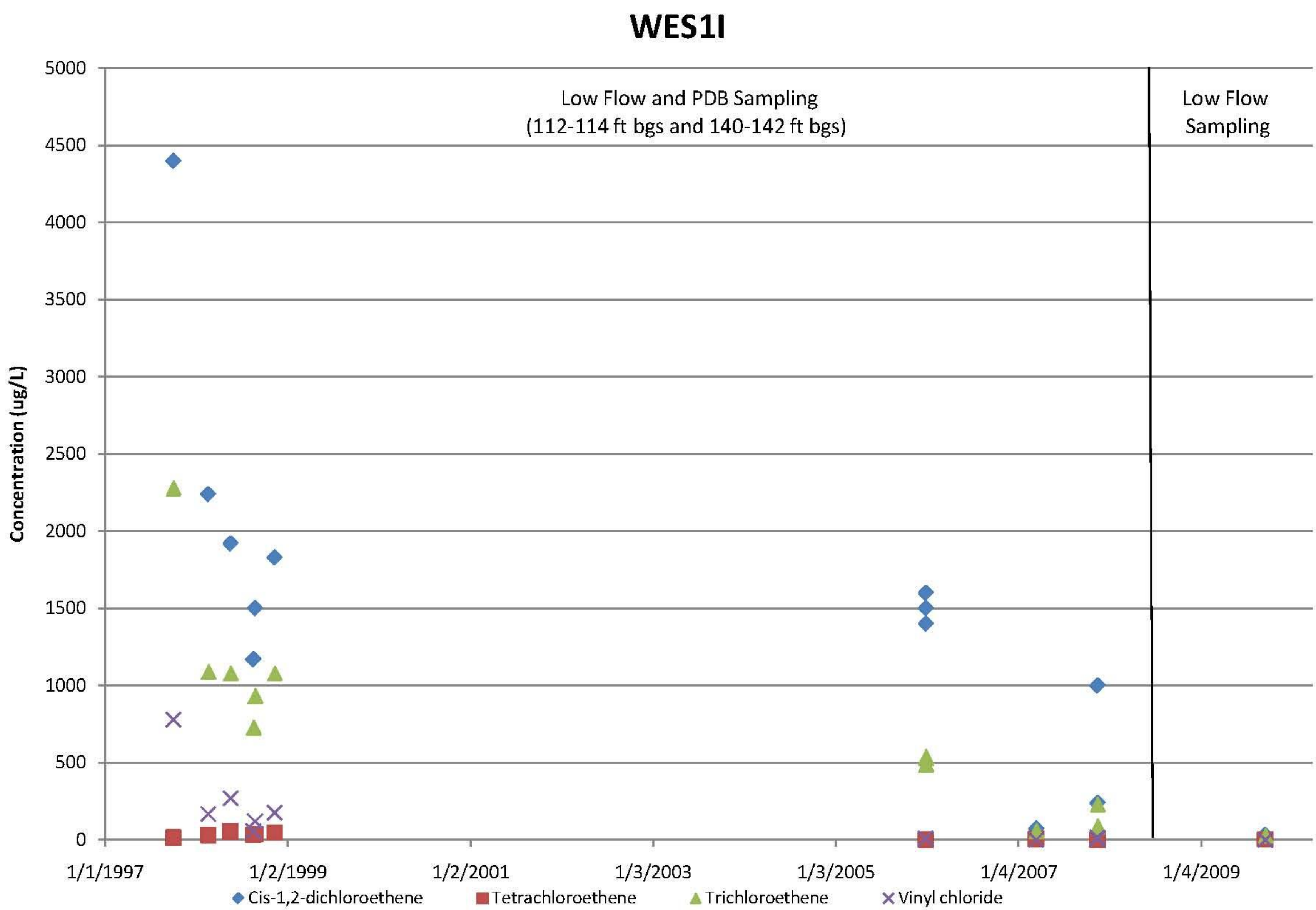
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



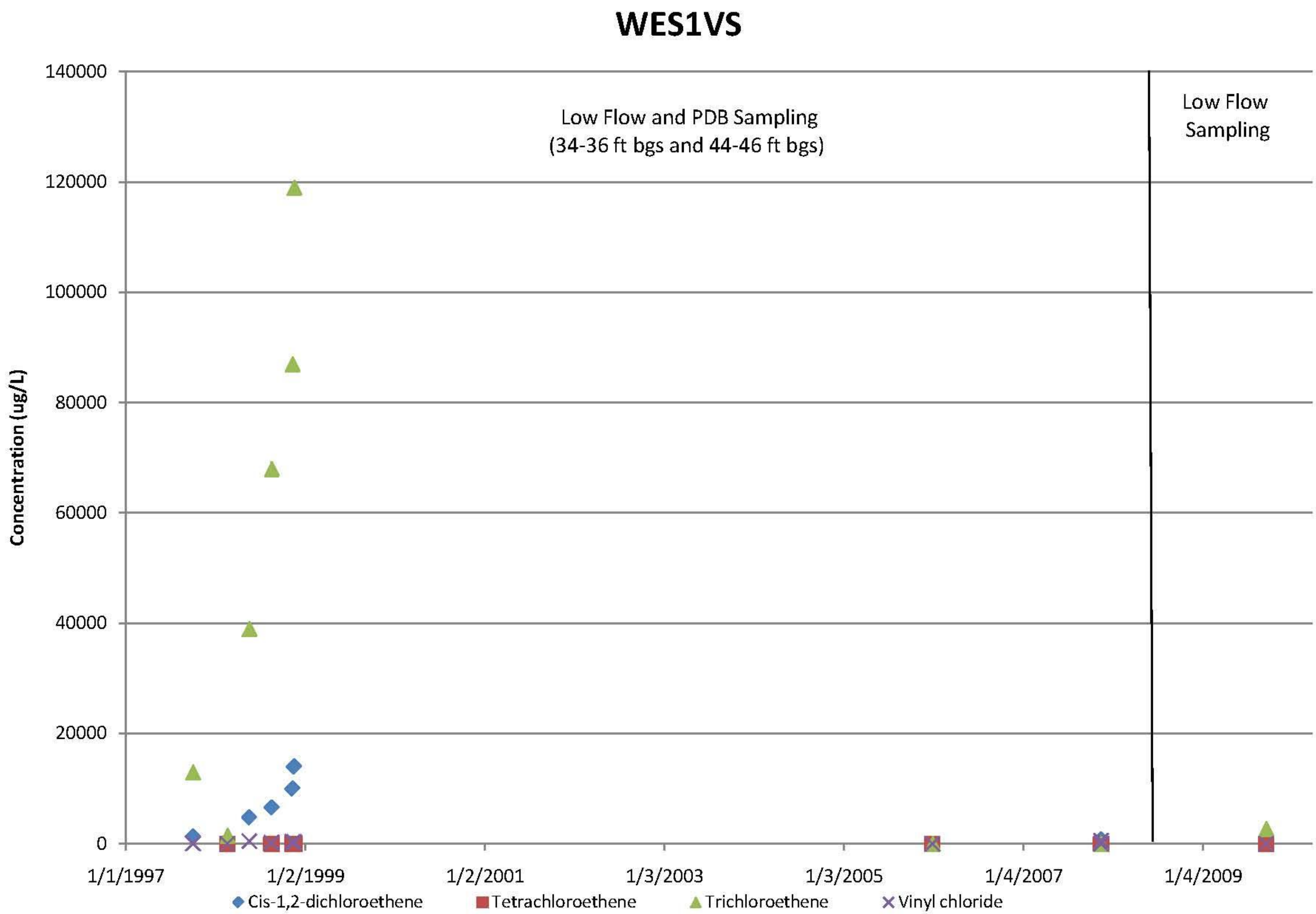
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



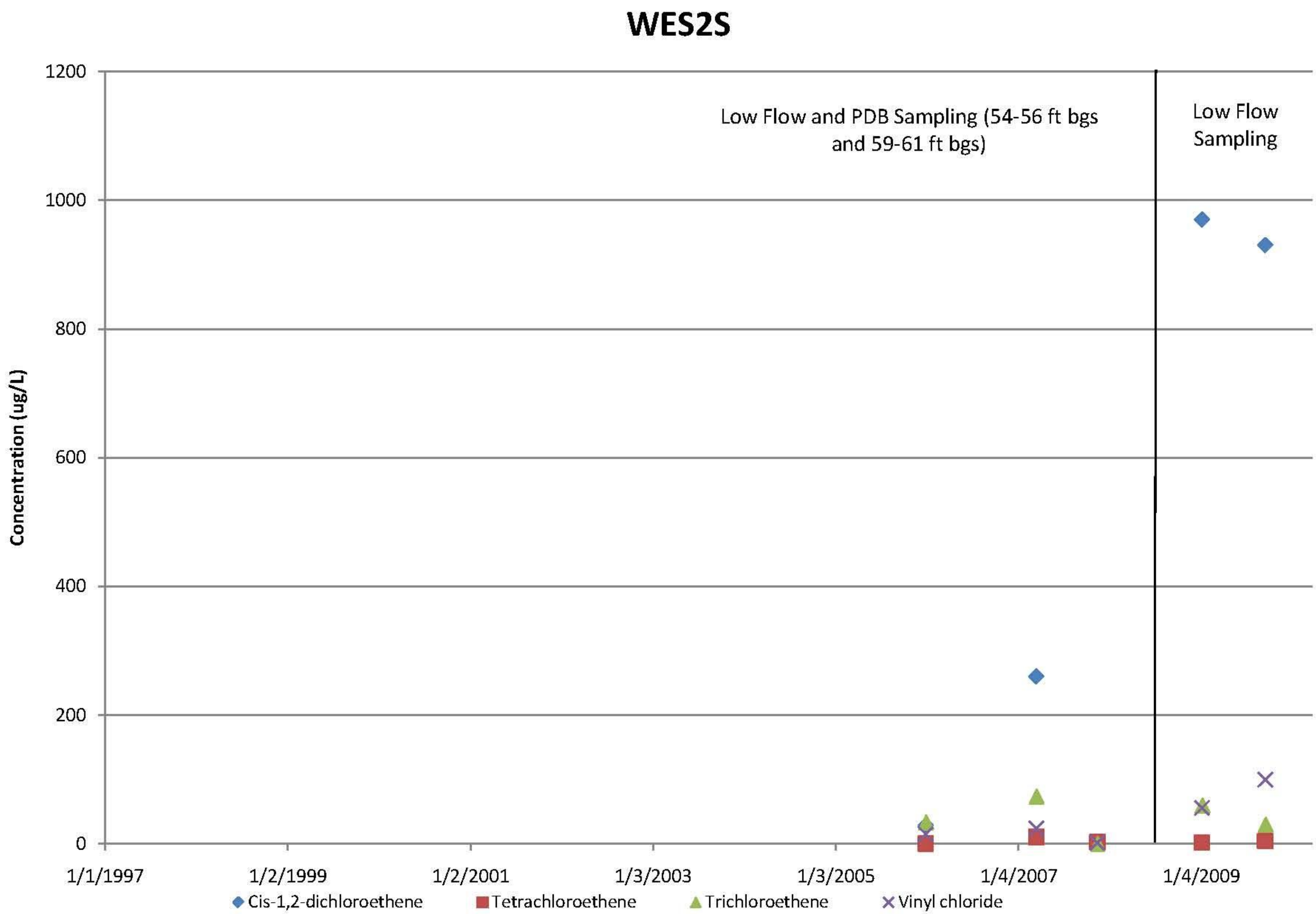
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



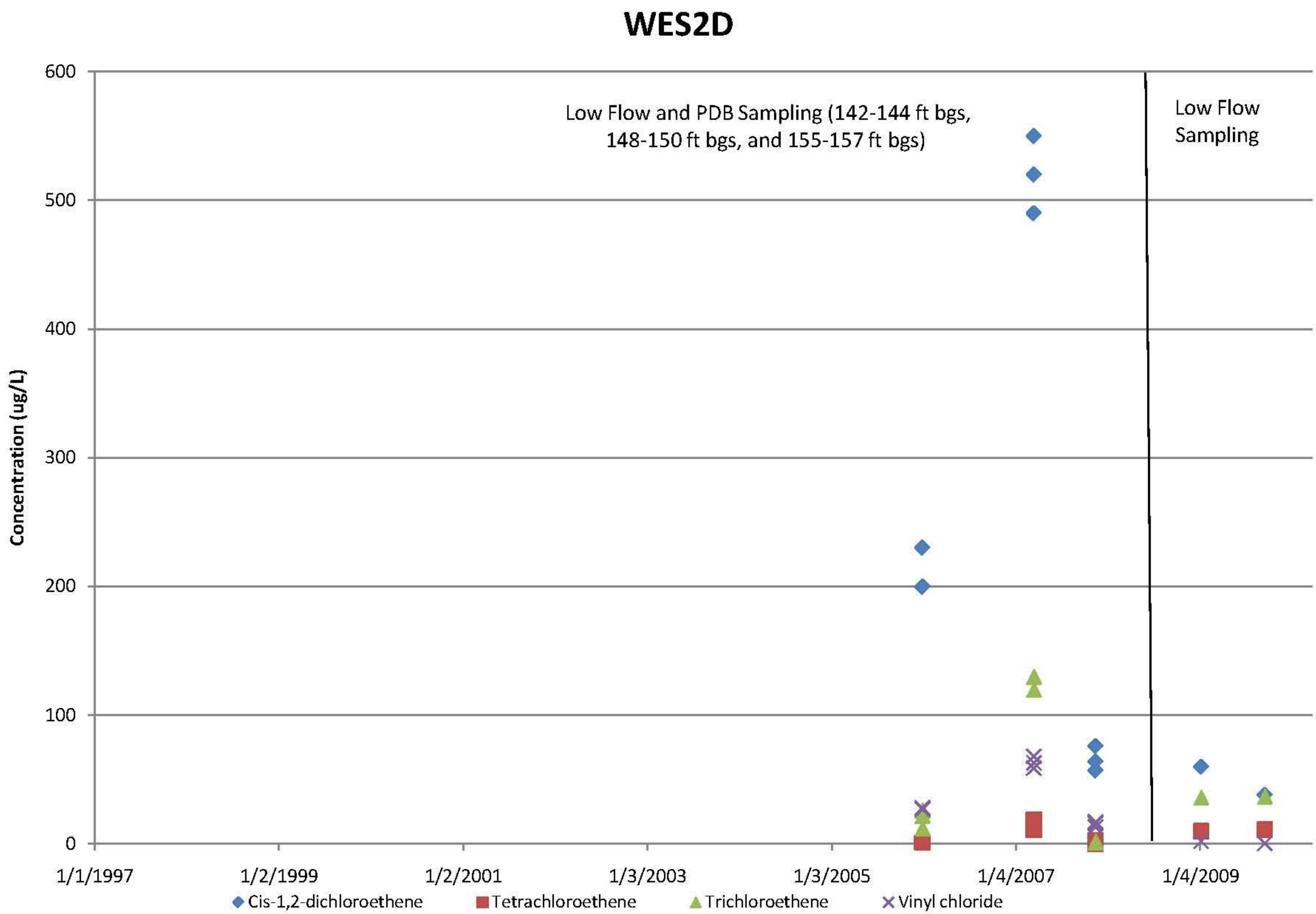
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



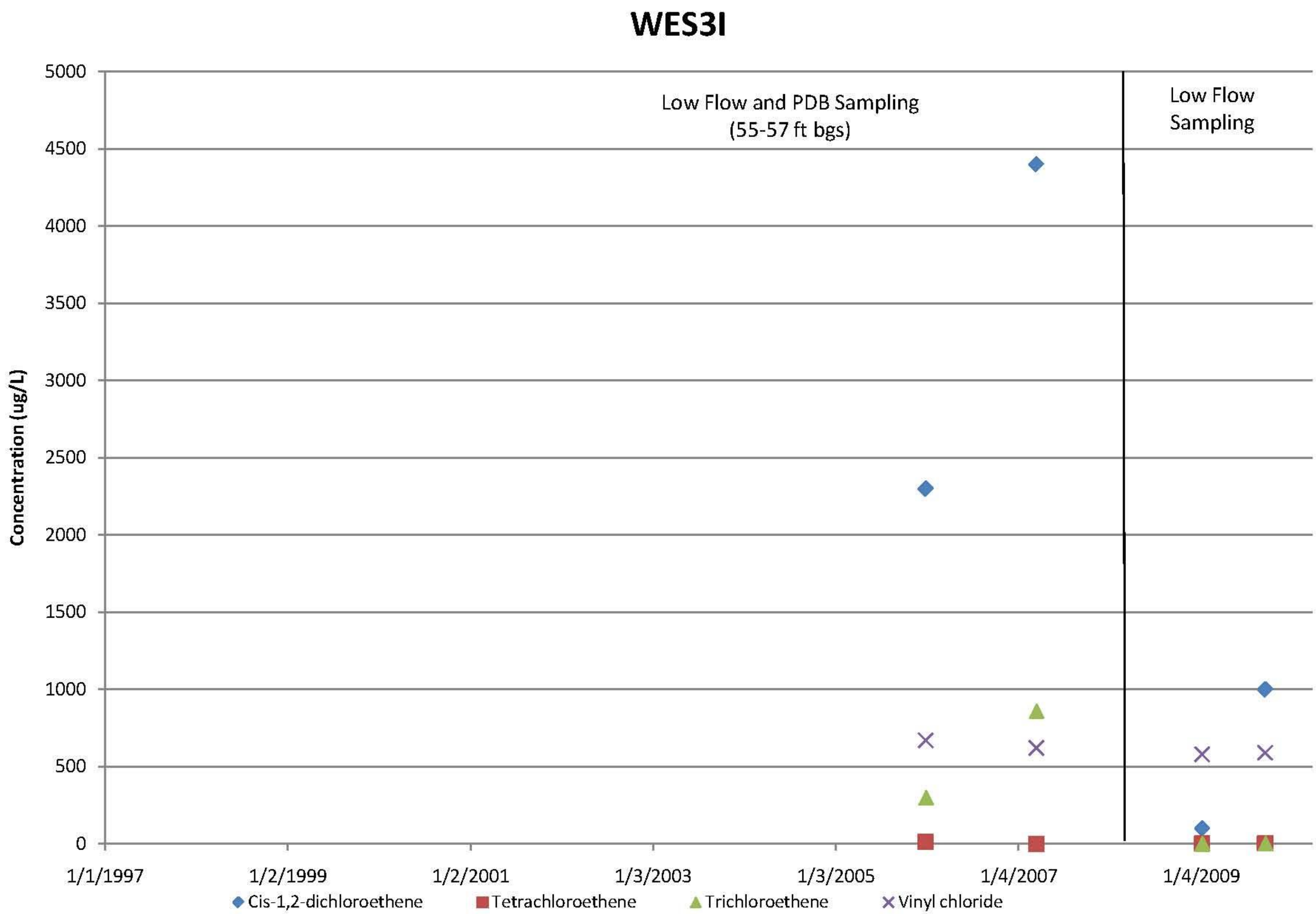
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



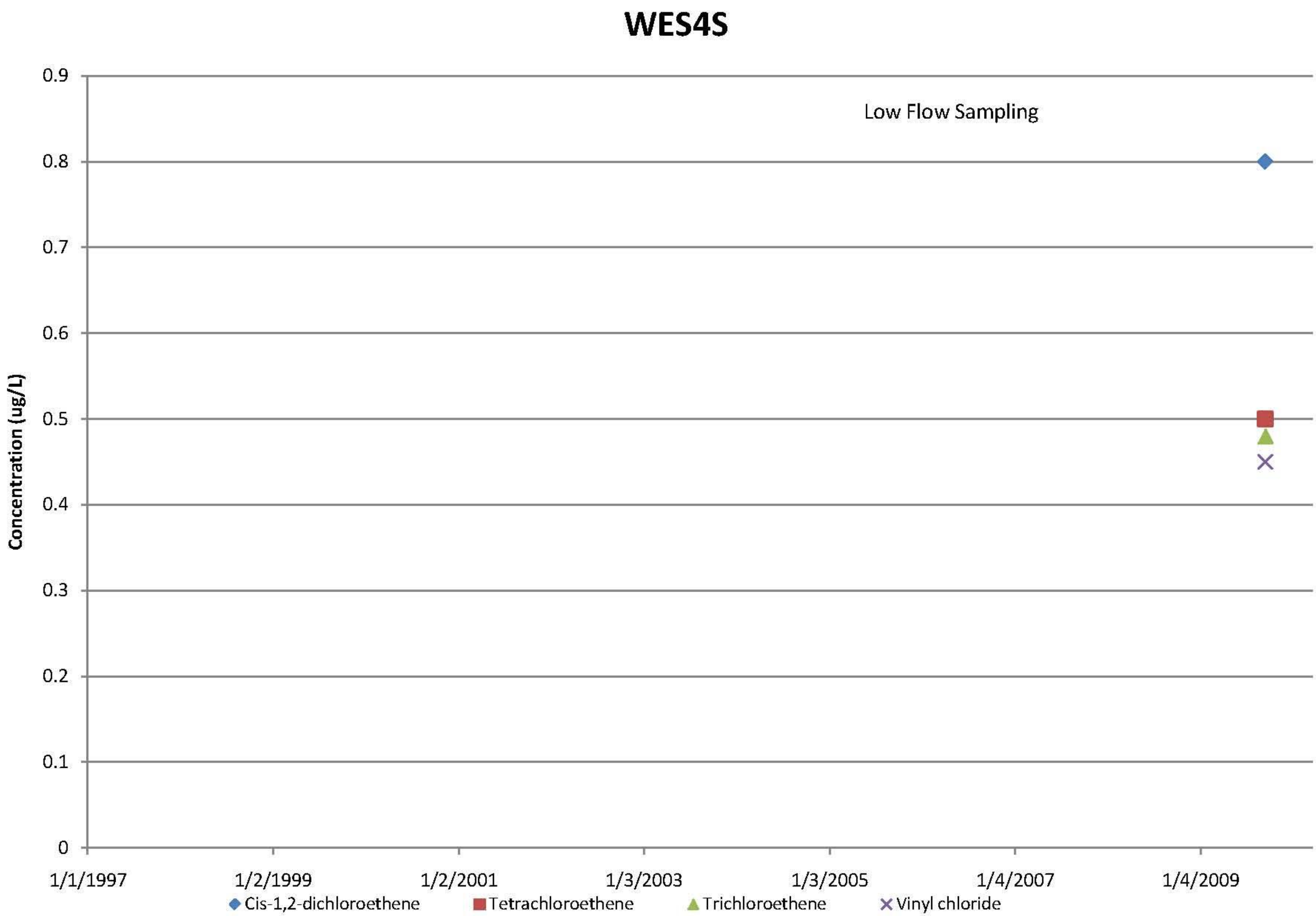
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



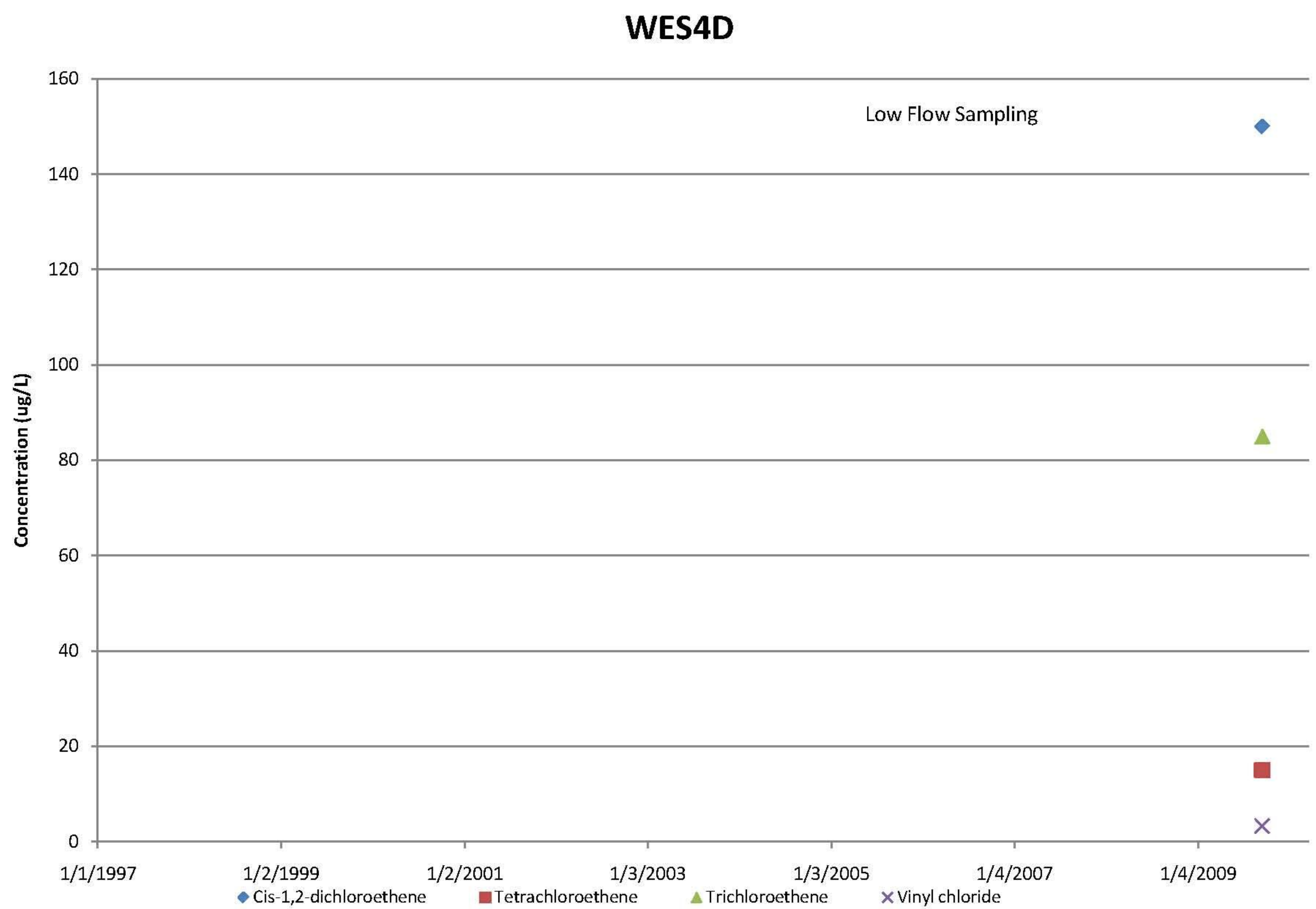
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



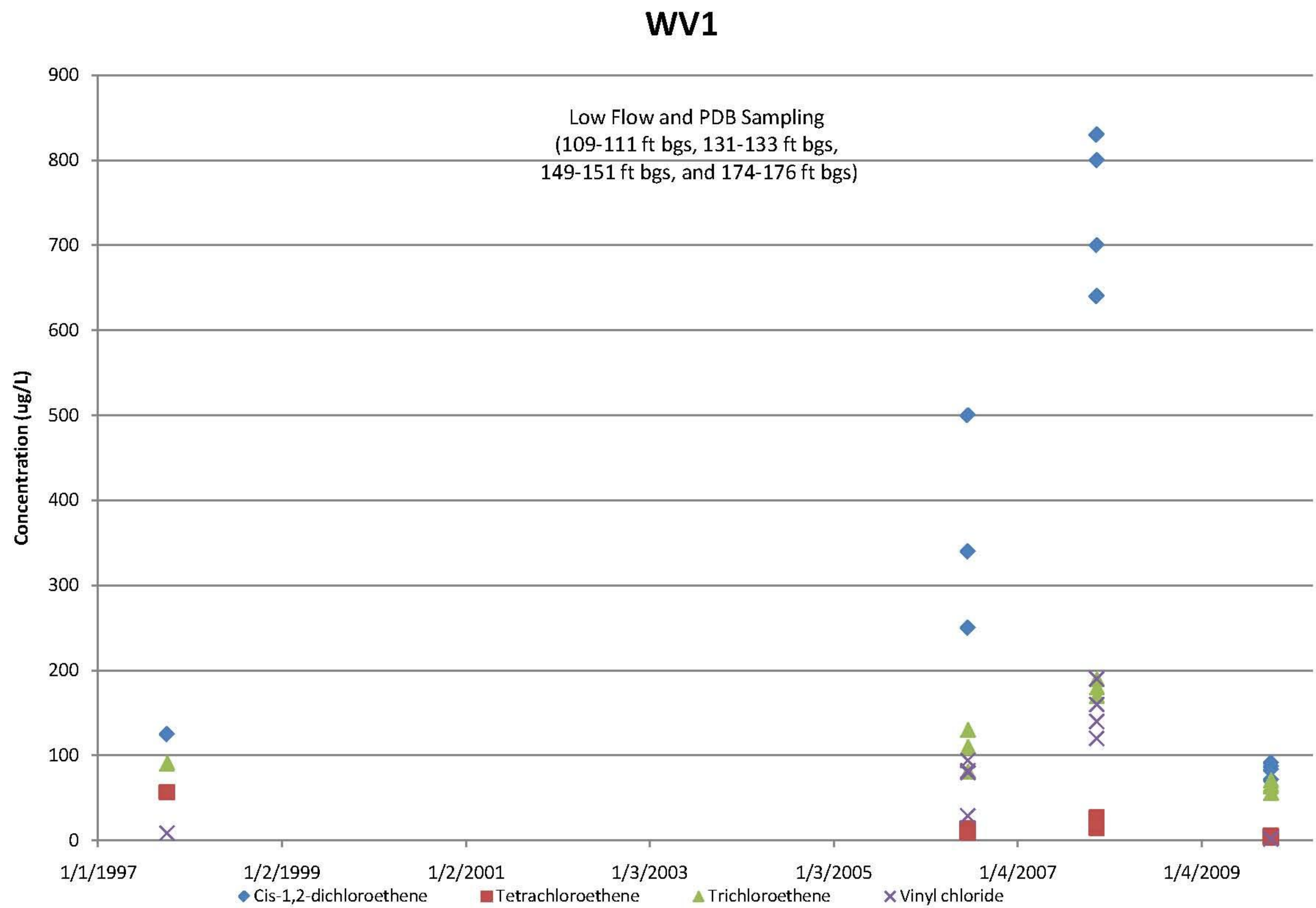
Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.



Note: U-qualified data are plotted at the Contract Required Quantitation Limit (CRQL). J-qualified data are less than the CRQL and are plotted at their reported value. R-qualified data and B-qualified data are not plotted.

ATTACHMENT D:
Well Construction Table

Table 1-3
North Penn Area 6 Monitoring Wells

Facility	Well ID	GPS Coordinates (UTM 18 N NAD 83) x coord (meters)	GPS Coordinates (UTM 18 N NAD 83) y coord (meters)	TOC Well Elevation feet	Depth to Top of Screen feet	Depth to Bottom of Screen feet	Well Depth feet	Diameter inches	NOTES
	ELE1S[1]	475782.06	4455171.75	354.16	47	67	122	2	Former ELE1S
	ELE1I[1]	475782.06	4455171.75	354.13	98	118	122	2	Former ELE1S
Electra	ELE1D	475776.01	4455163.84	354.16	306	386.5	386.5	6	
	ELE2I[2]	475848.07	4455143.29	355.06[3]	Open Borehole[4]		139	-	
	ELE2D[2]	475848.07	4455143.29	354.72	117	137	139	2	
	KEY1S	475084.90	4455461.57	325.84	15	90	90	6	
	KEY1I	475078.88	4455466.31	326.29	100	120	120	6	
	KEY2S	475177.72	4455415.82	323.81	20	100	100	6	
	KEY2I	475177.85	4455422.91	323.75	150	190	190	6	
	KEY3S[1]	475073.82	4455463.23	325.68	31	56	167.5	2	Former KEY3
	KEY3D[1]	475073.82	4455463.23	325.66	133	163	167.5	2	Former KEY3
	KEY4S[1]	475099.21	4455488.24	322.15	31	61	172.1	2	Former KEY4
Keystone	KEY4D[1]	475099.21	4455488.24	322.27	129.8	164.8	172.1	2	Former KEY4
	KEY5S[1]	475144.19	4455460.38	321.05	31	61	147.5	2	Former KEY5
	KEY5I[1]	475144.19	4455460.38	321.07	80	100	147.5	2	Former KEY5
	KEY6S[1]	475159.62	4455399.89	322.46	30	50	125	2	Former KEY6
	KEY6I[1]	475159.62	4455399.89	322.33	80	100	125	2	Former KEY6
	KEYPZ1	475117.30	4455439.89	326.62	144	154	NA	2	
	KEYPZ2	475117.30	4455439.89	326.61	240	258	NA	2	
	ROG1S	475832.47	4453917.77	383.17	15	100	100	6	
	ROG1D	475834.22	4453916.34	382.75	212	222	222	6	
	ROG2S	475754.97	4453889.74	375.62	15	100	100	6	
	ROG2I	475753.05	4453887.23	375.78	109	129	129	6	
	ROG3S	475725.18	4453980.33	365.22	18	102	102	6	AKA MG-1601
	ROG3I	475722.66	4453977.68	365.49	131.5	151.5	151.5	6	
Rogers	ROG4S	475671.24	4453936.14	361.65	304	78	181.1	2	Former ROG4; AKA MG-1795
	ROG4I	475671.24	4453936.14	361.59	274	113	181.1	2	Former ROG4; AKA MG-1795
	ROG5	475715.00	4453924.00	NA	Open Borehole		82	6	AKA MG-2147
	ROG6	475757.00	4453957.00	NA	Open Borehole		80	6	AKA MG-2148
	ROY1S	476917.28	4455852.14	352.17	20	100	100	6	
	ROY1I	476911.47	4455844.84	353.35	130	150	150	6	
	ROY3S[2]	476878.29	4455904.64	354.98	84	94	95.5	2	
	ROY3I[1]	476873.79	4455904.87	354.73	100	120	170.5	2	Former ROY3
	ROY3D[1]	476873.79	4455904.87	354.70	130	160	170.5	2	Former ROY3
	ROY4I[1]	476868.77	4455854.76	355.54	63.5	93.5	165.8	2	Former ROY4
Royal	ROY4D[1]	476868.77	4455854.76	355.50	115.5	145.5	165.8	2	Former ROY4
	ROY5S[1]	476894.17	4455885.91	354.54	50.5	60.5	150.9	2	Former ROY5
	ROY5I[1]	476894.17	4455885.91	354.53	70.5	105.5	150.9	2	Former ROY5
	ROYRDI[1]	476896.08	4455905.66	353.38	68	93	180.5	2	Former ROYRD
	ROYRDD[1]	476896.08	4455905.66	353.45	103.5	123.5	180.5	2	Former ROYRD
	ROYRC	476896.00	4455880.00	NA	NA	NA	240	NA	

Table 1-3
North Penn Area 6 Monitoring Wells

Facility	Well ID	GPS Coordinates (UTM 18 N NAD 83) x coord (meters)	y coord (meters)	TOC Well Elevation feet	Depth to Top of Screen feet	Depth to Bottom of Screen feet	Well Depth feet	Diameter inches	NOTES
Westside	WES1S	475429.47	4455753.83	325.55	60	80	80	6	
	WES1I	475456.26	4455755.19	326.24	110	150	150	6	
	WES1VS	475443.18	4455753.96	325.48	20	50	50	6	
	WES2S[1]	475384.28	4455724.48	323.76	55	75	164.5	2	Former WES2
	WES2D[1]	475384.28	4455724.48	323.80	138	163	164.5	2	Former WES2
	WES3I[1]	475389.36	4455759.85	321.93	60	90	163.5	2	Former WES3
	WES4S[2]	475389.25	4455752.01	323.09	20	40	150	2	
	WES4D[2]	475389.25	4455752.01	323.05	117	147	150	2	
	WV1	475278.57	4455789.57	319.51	45	268	268	8	

1 Reconstructed in 2008/2009 with a 2-inch piezometer with a discrete screened interval.
2 New well drilled and constructed in 2008/2009 with a 2-inch piezometer with a discrete screened interval..
3 Elevation reference point is the ground surface.
4 The well was reconstructed but the screen has not been placed yet.
AKA - Also known as
NA - information is not avaialable
Reference:
Well information for 6-inch wells was taken from the *North Penn Area 6 RI/FS Report, August 1999* .